February 24, 2014

Gregory Fenves
Executive Vice President and Provost
The University of Texas at Austin
MAI 201
Campus Mail Code: G1000

Dear Dr. Fenves:

Enclosed for your consideration and action is a proposal to make changes to the Biomedical Engineering Degree Program (D 11258-11271) in the Cockrell School of Engineering section of the Undergraduate Catalog 2014-2016. The proposal was classified as being of general interest to more than one college or school, and was approved by the Faculty Council on a no-protest basis on February 21, 2014. The authority to grant final approval on these changes resides with UT System.

Please let me know if you have questions or if I can provide other information concerning this legislation.

Sincerely,

Dean P. Neikirk, Secretary
General Faculty and Faculty Council

DPN:dlr

Enclosure

xc: William Powers Jr., President
    Charles Roeckle, Deputy to the President

ec (letter only): Sharon Wood, dean, Cockrell School of Engineering
                 Alison Danforth, manager, IMA
                 Brenda Schumann, Associate Registrar
                 David Laude, Sr. Vice Provost, via Kati Pelletier
DOCUMENTS OF THE GENERAL FACULTY

PROPOSED CHANGES TO THE BIOMEDICAL ENGINEERING DEGREE PROGRAM IN THE COLLEGE OF ENGINEERING SECTION IN THE UNDERGRADUATE CATALOG, 2014-2016

Interim Dean Sharon Wood in the School of Engineering has filed with the secretary of the Faculty Council the following changes to the School of Engineering section in the Undergraduate Catalog, 2014-2016. On May 31, 2013, the faculty in the Department of Biomedical Engineering approved the changes. The faculty of the college and the dean approved the changes on August 23 and September 26, 2013, respectively. The secretary has classified this proposal as legislation as being of general interest to more than one college or school (but not for submission to the General Faculty).

The Committee on Undergraduate Degree Program Review recommended approval of the change on January 22, 2014, and forwarded the proposed changes to the Office of the General Faculty. The Faculty Council has the authority to approve this legislation on behalf of the General Faculty. The authority to grant final approval on this legislation resides with UT System.

If no objection is filed with the Office of the General Faculty by the date specified below, the legislation will be held to have been approved by the Faculty Council. If an objection is filed within the prescribed period, the legislation will be presented to the Faculty Council at its next meeting. The objection, with reasons, must be signed by a member of the Faculty Council.

To be counted, a protest must be received in the Office of the General Faculty by February 21, 2014.

Dean P. Neikirk, Secretary
General Faculty and Faculty Council

Posted on the Faculty Council website (http://www.utexas.edu/faculty/council/) on February 7, 2014.
PROPOSED CHANGES TO THE BIOMEDICAL ENGINEERING DEGREE PROGRAM IN THE COLLEGE OF ENGINEERING SECTION IN THE UNDERGRADUATE CATALOG 2014-2016

Type of Change Academic Change

1. IF THE ANSWER TO ANY OF THE FOLLOWING QUESTIONS IS YES, THE COLLEGE MUST CONSULT NEAL ARMSTRONG TO DETERMINE IF SACS-COC APPROVAL IS REQUIRED.
   • Is this a new degree program? No
   • Does the program offer courses that will be taught off campus? No
   • Will courses in this program be delivered electronically? No

2. EXPLAIN CHANGE TO DEGREE PROGRAM AND GIVE A DETAILED RATIONALE FOR EACH INDIVIDUAL CHANGE (include page numbers in the catalog where changes will be made):

A. Add requirement for portable computing device.
The Portable Computing Device (PDC) requirement has been added to ensure students have a laptop at their disposal should it be needed for individual courses. This is in line with Chemical Engineering and Mechanical Engineering's PDC requirement for new students.

B. Delete technical elective statement choices.
Students may not take technical electives across Technical Areas.

C. Adding new required core courses (203L, 214L, 344, 245L, 349, 355, 261L) to replace senior electives.
These two changes were done in response to student surveys, which suggested that they felt a lack of a biomedical engineering (BME) core expertise. They articulated that BME was a collection of various courses that did not reflect an engineering discipline. We reduced the number of electives from seven to four. This is more in line with the number of electives offered by other engineering departments. We have removed the designations "senior" and "technical" electives. We have included a greater number of required core classes including four laboratories, which will emphasize applied engineering principles.
   • 203L: Current freshman design lab (102L) goes from one hour to two hours. Replaces 102L.
   • 214L: Current sophomore level class (314) is switched from a lecture-based course to a sophomore design lab. Replaces 314.
   • 344: Biomechanics course is currently taught as an elective. This course has been determined as "core" to the BME undergraduate curriculum and will now be required.
   • 245L: Current first semester junior lab (221) will keep the same number of hours. But content will be changed significantly to synchronize with content in new junior-level core courses. Replaces 221.
   • 349: Instrumentation courses are currently taught as electives, but this topic has been determined as "core" to the BME undergraduate curriculum.
   • 355: Molecular engineering courses are not currently taught but additional faculty now allow for this to be taught as "core" to the BME undergraduate curriculum.
   • 261L: Current second semester junior lab (251) will keep the same number of hours, but content will be changed significantly to synchronize with the content in new junior-level core courses. Replaces 251.
   • EE 319K: Determined superfluous with the addition of new "core" topics to BME undergraduate curriculum.
   • Senior Electives: Greater number of required core classes emphasize applied engineering principles and replace the six credits of "senior electives".
D. Add Career Emphases to Technical Areas 1 and 2.
This was done to give students a greater opportunity to focus on specific skills that would be attractive
to industry, while still allowing flexibility within their technical area.

E. Add Technical Area 4, Biomechanics.
I. Delete internship statement.
Although these internships will still be available to students to gain valuable off campus
experience in the field, students will no longer be able to seek “senior elective” credit for
these experiences. This is because the senior electives have been removed.

II. Remove requirement for EE 319K.
As the BME department has grown, we are now able to offer the content of the course within
BME and focus on only BME-related content.

III. Added BIO 320, BIO 326M, and PHR 338 as Technical Area 2 elective options.
a. BIO 320 listed in the course catalog as not restricted to majors, as are other College of
Natural Sciences (CNS) courses that have historically been included in Technical Area 2
on past catalogs, e.g. BIO 325, CH 320N and 220C.
b. BIO 326M is listed in the course catalog as not restricted to majors, as are other CNS
courses that have historically been included in Technical Area 2 on past catalogs, e.g.
BIO 325, CH 320N and 220C
c. PHR 338 is listed in the course catalog as not restricted to majors, and

IV. Add BME 362 and KIN 326K as a Technical Area 4 elective option.
a. Add BME 362, which will be offered regularly by BME Graduate Studies Committee
(GSC) member Jonathan Dingwell.
b. KIN 326K is restricted to majors but is also taught by BME GSC member Jonathan
Dingwell.

V. Delete Organic Chemistry as a Technical Area 4 elective option.
Remove Organic Chemistry, which will not count toward Technical Area 4 electives.

VI. Delete EM 306 and 319 and M E 378K as Technical Area 4 elective options.
Remove EM 306: Mechanical engineering (M E) has agreed that BME 344 will meet the
requirements for EM 306 when listed as a prerequisite for upper-division M E courses.
Therefore, this course no longer needs to be included in this list for this technical area.
Remove EM 319: EM has not explicitly agreed that BME 344 will meet the requirements for
EM 319, therefore this course will be removed as a technical elective option.

3. SCOPE OF PROPOSED CHANGE
a. Does this proposal impact other colleges/schools? Yes
b. Will students in other degree programs be impacted (are the proposed changes to courses
commonly taken by students in other colleges)? No
c. Will students from your college take courses in other colleges? Yes

If 3 a, b, or c was answered with yes:
1. How many students do you expect to be impacted? Less than twenty per year.

Impacted schools must be contacted and their response(s) included:
Person communicated with: Dr. Sach Kopp for items III. a and III. b.
Date of communication: December 4, 2012

Response:
a. Professor Laura Suggs in BME confirmed with Natural Sciences Associate Dean Sacha Kopp
on December 4, 2013, that the expected number of BMEs who will choose these for an
elective from the list of Technical Area 2 electives should be less than twenty each year, and
that CNS can support this request.
b. Professor Laura Suggs confirmed with Natural Sciences Associate Dean Sacha Kopp on
December 4, 2013, that the expected number of BMEs who will choose these for an elective
from the list of Technical Area 2 electives should be less than twenty each year, and that CNS
2. How many students do you expect to be impacted? Less than ten per year.
   Impacted schools must be contacted and their response(s) included:
   Person communicated with: Dr. James Karboski for item III. c.
   Date of communication: December 2, 2012.
   Response:
   Professor Laura Suggs confirmed with Pharmacy professor James Karboski on December 2, 2013, that the expected number of BMEs who will choose this for an elective from the list of Technical Area 2 electives should be less than 10 each year, and that PHR can support this request.

3. How many students do you expect to be impacted? Less than five per year.
   Impacted schools must be contacted and their response(s) included:
   Person communicated with: Dr. John Bartholomew and Dr. John Dingwell for item IV. B.
   Date of communication: December 11, 2012.
   Response:
   Professor Laura Suggs confirmed with kinesiology Chair Dr. John Bartholomew, and Professor Jon Dingwell on December 11, 2013, that the expected number of BMEs who will choose this for an elective of Technical Area 4 electives should be less than 5 each year, and that KIN can support this request. Students wanting to take this course will go through the appropriate process to request registration in the class as a non-major.

   d. Does this proposal involve changes to the core curriculum or other basic education requirements (42-hour core, signature courses, flags)? No
   e. Will this proposal change the number of hours required for degree completion? No

4. COLLEGE/SCHOOL APPROVAL PROCESS
   Department approval date: Items A-E: November 15, 2012 Items I-VI: May 31, 2013
   College approval date: Items A-E: March 25, 2013 Items I-VI: August 23, 2013
   Dean approval date: Items A-E: April 8, 2013 Items I-VI: September 26, 2013
Bachelor of Science in Biomedical Engineering

The mission of the Department of Biomedical Engineering is to develop clinically translatable solutions for human health by training the next generation of biomedical engineers, cultivating leaders, and nurturing the integration of science, engineering, and medicine in a discovery-centered environment. The main educational objective is to provide a thorough training in the fundamentals of engineering, science, design, and biology. The curriculum is designed to provide concepts central to understanding living systems from the molecular and cellular levels to the tissue and organismal levels. The curriculum incorporates principles of vertical integration, leading to the choice of a technical area (biomedical imaging and instrumentation, cellular and biomolecular engineering, or computational biomedical engineering, or biomechanics), and culminates in a team capstone design experience. [Research, industrial, and clinical internships provide students with novel educational experiences and unique perspectives on biomedical engineering applications]. Students are expected to develop an understanding of industrial, research, and clinical biomedical engineering environments; an understanding of regulatory issues and biomedical ethics; the ability to create, identify, formulate, and solve biomedical engineering problems; the ability to design systems to meet needs in medical/life science applications; an understanding of life processes at the molecular, cellular, tissue, and organismal levels; the ability to use instrumentation and to make measurements and interpret data in living systems; and an appreciation of the interdisciplinary nature of biomedical engineering research.

Portable Computing Devices

Students entering biomedical engineering are required to have a laptop computer at their disposal. Laptops do not need to be brought to campus on a daily basis, but individual courses may require that a laptop be brought to certain lectures, labs, and/or exams. Minimum requirements for the laptop are listed on the department’s website.

Program Outcomes

[No changes to this section.]

Program Educational Objectives

[No changes to this section.]

Curriculum

Course requirements are divided into three categories: basic sequence courses, major sequence courses, and other required courses. In addition, each student must complete the University’s core curriculum. In some cases, a course that fulfills one of the following requirements may also be counted toward core curriculum or flag requirements; these courses are identified below.

To ensure that courses used to fulfill the social and behavioral sciences and visual and performing arts requirements of the core curriculum also meet ABET criteria, students should follow the guidance given in Degrees.

In the process of fulfilling engineering degree requirements, students must also complete coursework to satisfy the following flag requirements: one independent inquiry flag, one quantitative reasoning flag, one ethics and leadership flag, one global cultures flag, one cultural diversity in the US flag, and two writing flags. The independent inquiry flag, the quantitative reasoning flag, the ethics and leadership flag, and the two writing flags are carried by courses specifically required for the degree; these courses are identified below. Courses that may be used to fulfill flag requirements are identified in the Course Schedule.
The first [two-years] three long semesters of the curriculum consist of basic sequence and supporting courses for all biomedical engineering students. Subsequent enrollment in major sequence courses starting the fourth semester, and one of four (three) technical areas is restricted to students who have received credit for all of the basic sequence courses and have been admitted to the major sequence. Requirements for admission to a major sequence are given in Admission and Registration. Enrollment in other required courses is not restricted by completion of the basic sequence.

Prior to registration, students must receive approval from the Biomedical Engineering [Undergraduate] Academic Advising Office for courses to be used to fulfill technical and nontechnical course requirements. The student must take all courses required for the degree on the letter-grade basis and must earn a grade of at least C- in each, except for those listed as Remaining Core Curriculum Courses.

<table>
<thead>
<tr>
<th>Courses</th>
<th>Sem Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Sequence Courses</strong></td>
<td></td>
</tr>
<tr>
<td>• Biology 206L, 311C</td>
<td>5</td>
</tr>
<tr>
<td>• Biomedical Engineering [102L]203L, 303, 311, 113L, 214L,[3+4], 333T (Biomedical Engineering 333T carries a writing and an ethics and leadership flag.)</td>
<td>14</td>
</tr>
<tr>
<td>• Chemistry 301, 302, 204, and 320M or 328M</td>
<td>[8]11</td>
</tr>
<tr>
<td>[*Electrical Engineering 319K]</td>
<td>[3]</td>
</tr>
<tr>
<td>• Mathematics 408C, 408D, 427K (Mathematics 408C may also be used to fulfill the mathematics requirement of the core curriculum; Mathematics 408C and 427K each carry a quantitative reasoning flag)</td>
<td>12</td>
</tr>
<tr>
<td>• Physics 303K, 303L, 103M, 103N (Physics 303K and 303L may be used to fulfill the science and technology, part I, requirement of the core curriculum; both courses carry a quantitative reasoning flag)</td>
<td>8</td>
</tr>
<tr>
<td>• Rhetoric and Writing 306 (may also be counted toward the English composition requirement of the core curriculum)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Courses</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major Sequence Courses</strong></td>
<td></td>
</tr>
<tr>
<td>• Biomedical Engineering [221 (carries a writing flag)], 335, 343, 344, 245L (carries a writing flag), [348,] 349, 352 [351 (carries a writing flag)], 353, 355, 261L, 365R, 365S, 370 (carries a writing flag), 371 (carries an independent inquiry flag)</td>
<td>[28]37</td>
</tr>
<tr>
<td>• Approved technical area electives</td>
<td>[15-47]12</td>
</tr>
<tr>
<td>[*—Engineering electives](Note: The technical area option chosen by the student determines the minimum number of semester hours required for the approved technical area electives and the engineering electives. However, the total minimum number of semester hours required for the major sequence courses remains forty-nine.)</td>
<td>[4-6]</td>
</tr>
</tbody>
</table>
### Other Required Courses

- Chemistry 128K, 353 or 353M, 369

### Remaining Core Curriculum Courses

- English 316K (humanities)
- American and Texas government
- American history
- Social and behavioral sciences
- Visual and performing arts
- Undergraduate Studies 302 or 303 (some sections carry a writing flag)

### Minimum Required 133

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**Technical Area Options**

The technical area option allows the student to build on the biomedical engineering core curriculum by choosing [fifteen to seventeen] twelve semester hours of technical area coursework in biomedical imaging and instrumentation, cellular and biomolecular engineering, or computational biomedical engineering, or biomechanics. Within some technical areas, Career Emphases are available for students to focus coursework toward a particular career track. Students have flexibility to take technical elective coursework from more than one career emphasis under the same technical area. [Students may also choose to take technical elective coursework under more than one technical area, as long as courses taken are not outside of their own technical area and upper division engineering.] Each student should choose a technical area by the end of the sophomore year and plan an academic program to meet the area requirements during the next two years.

**Preparation for health professions.** Students who plan to attend medical, veterinary, or dental school in Texas must complete coursework in addition to that required for the BS in Biomedical Engineering in order to meet professional school admission requirements; those who plan to attend schools outside Texas may need additional coursework. The student is responsible for knowing and meeting these additional requirements, but assistance and information are available from full-time [Career Pre-Health Professions Coaches and part-time peer mentors in the Career Design Center Health Professions Office in the College of Natural Sciences, PAI 5.03. Additional information about preparation for health professions is available online at http://cns.utexas.edu/careers/health-professions/.

**Preparation for law.** There is no sequential arrangement of courses prescribed for a pre-law program. The Association of American Law Schools puts special emphasis on comprehension and expression in words, critical understanding of the human institutions and values with which the law deals, and analytical power in thinking. Courses relevant to these objectives deal with communication of ideas, logic, mathematics, social sciences, history, philosophy, and the physical sciences. Services for pre-law students are provided to students in all colleges by the Center for Strategic Advising & Career Counseling [Sanger Learning Center], JES A115
and to engineering students by the Engineering Career Assistance Center (ECAC) in ECI 2.400. Additional information about preparation for law is available online.

Plan II Honors Program. Students enrolled in the Plan II Honors Program are encouraged to contact the Biomedical Engineering [Undergraduate] Academic Advising Office, in addition to the Plan II Office to ensure that requirements for both programs are met. Plan II courses may count toward biomedical engineering program requirements.

Certificate programs. Biomedical engineering students may enrich their education through the following certificate programs.

Business Foundations Program. Students who wish to learn about fundamental business concepts and practices may take supplemental coursework that leads to the Business Foundations Certificate, awarded by the Red McCombs School of Business. The program is described in Degrees and Programs of the McCombs School. More information about the Business Foundations Program is available at http://new.mccombs.utexas.edu/bba/business-foundations and from the McCombs School [and from the Biomedical Engineering Undergraduate Advising Office.]

Elements of Computing. Students who wish to learn about computer science may take the coursework that leads to the certificate in the Elements of Computing, awarded by the Department of Computer Science. The program is described in Degrees of the College of Natural Science. More information about the Elements of Computing Program is available at http://www.cs.utexas.edu/academics/non_majors/elements, and from the Department of Computer Science [and from the Biomedical Engineering Undergraduate Advising Office.]

Technical Area 1, Biomedical Imaging and Instrumentation

This technical area is designed for students interested in the general area of medical imaging science and instrumentation design. Two career emphases are available in this area, A. Biomedical Imaging and B. Biomedical Instrumentation. [The main objective is to prepare students to design and use biomedical instrumentation for imaging, diagnostic, and therapeutic applications, with focus on the new fields of molecular engineering, cell and tissue engineering, and biotechnology. A solid foundation, practical knowledge, and skills are established in analog and digital network analysis, software and hardware programming, electronic circuits, sensors, data acquisition systems, image and signal processing, and computational analysis of data as it applies to living systems.]

[Students must complete the following

[1. The following three courses:

Electrical Engineering 312, Software Design and Implementation I
Electrical Engineering 438, Fundamentals of Electronic Circuits
Electrical Engineering 445S, Real-Time Digital Signal Processing Laboratory

[2. Six hours of coursework chosen from the following list:

Biomedical Engineering 347, Fundamentals of Biomedical Optics
Biomedical Engineering 357, Biomedical Imaging Modalities
Biomedical Engineering 374K, Biomedical Instrument Design; and Biomedical Engineering 374L, Applications of Biomedical Engineering Laboratory
Electrical Engineering 445L, Embedded Systems Design Laboratory; and Electrical Engineering 445M, Embedded and Real-Time Systems Laboratory
Electrical Engineering 347, Modern Optics]
Career Emphasis A: Biomedical Imaging

The main objective of this career emphasis is to prepare students for a career in biomedical imaging. A solid foundation, practical knowledge, and skills are established in optics, imaging modalities, and image and signal processing.

While students are required to select twelve hours from any of the Technical Area 1 electives, the following are recommended for the biomedical imaging career emphasis:

Biomedical Engineering 347, Fundamentals of Biomedical Optics
Biomedical Engineering 357, Biomedical Imaging Modalities
Electrical Engineering 347, Modern Optics
Electrical Engineering 351M, Digital Signal Processing
Electrical Engineering 371R, Digital Image and Video Processing

An approved upper-division biomedical engineering, electrical engineering or physics course

Career Emphasis B: Biomedical Instrumentation

The main objective of this career emphasis is to prepare students to design and use biomedical instrumentation for imaging, diagnostic, and therapeutic applications. A solid foundation, practical knowledge, and skills are established in analog and digital network analysis, software and hardware programming, electronic circuits, sensors, data acquisition systems, image and signal processing, and computational analysis of data as it applies to living systems.

While students are required to select twelve hours from any of the Technical Area 1 course options, the following are recommended for the biomedical instrumentation career emphasis:

Biomedical Engineering 374K, Biomedical Instrument Design
Biomedical Engineering 347L, Applications of BME Lab
Electrical Engineering 312, Software Design & Implementation I
Electrical Engineering 319K, Introduction to Embedded Systems
Electrical Engineering 438, Fundamentals of Electronic Circuits
Electrical Engineering 445L, Embedded Systems Design Lab
Electrical Engineering 445M, Embedded and Real-Time System Lab
Electrical Engineering 445S, Real-Time Digital Signal Processing Lab
Electrical Engineering 351M, Digital Signal Processing

Technical Area 2, Cellular and Biomolecular Engineering

The major objective of this area is to teach students how to integrate knowledge in cell and molecular biology with engineering analysis, so that they can address problems in molecular-based medicine. Two career emphases are available in this area: A. Biomaterials/Regenerative Medicine, and B. Nanotechnology. [Three disciplines within this technical area are tissue engineering as it relates to the underlying molecular biology issues; materials science, with an emphasis on bioactive materials and construction of nanoscale devices and probes; and bioengineering analysis of infectious diseases and immunological responses.]
Career Emphasis A: Biomaterials/Regenerative Medicine

The objective of this area is to prepare students for a career in biomaterials and regenerative medicine engineering. This emphasis includes solid foundation in cell and tissue engineering, biomaterials, and pharmacology. While students are required to select twelve hours from any of the Technical Area 2 course options, the following are recommended for the biomaterials/regenerative medicine career emphasis:

Biology 320, Cell Biology
Biology 325, Genetics
Biology 326M, Introductory Medical Microbiology and Immunology
Biomedical Engineering 339, Biochemical Engineering
Biomedical Engineering 376, Cell Engineering
Biomedical Engineering 379, Tissue Engineering
Chemical Engineering 379, Topic: Quantitative Analysis of Cellular and Molecular Biology
Pharmacy 338, Introduction to Pharmacology

An approved upper-division biomedical engineering, chemical engineering or mechanical engineering course

[Students must complete the following:

[The following two courses:

[1.] Biomedical Engineering 339, Biochemical Engineering
    Biomedical Engineering 352, Engineering-Biomedical

[2.] Nine hours of coursework chosen from the following list; at least three hours must be in biomedical engineering:
    Biomedical Engineering 344, Biomechanics
    Biomedical Engineering 354, Molecular Sensors and Nanodevices for Biomedical Engineering Applications
    Biomedical Engineering 376, Cell Engineering
    Biomedical Engineering 379, Tissue Engineering
    Chemical Engineering 350, Chemical Engineering-Materials
    Approved upper-division biology-courses

Career Emphasis B: Nanotechnology

The objective of this area is to prepare students for a career in nanotechnology. This emphasis includes solid foundation in nanodevices and sensors, biological physics, and nanocomposites. While students are required to select twelve hours from any of the Technical Area 2 course options, the following are recommended for the nanotechnology career emphasis:

Biomedical Engineering 346, Computational Biomolecular Engineering
Biomedical Engineering 354, Molecular Sensors and Nanodevices for Biomedical Engineering Applications
Chemical Engineering 322, Thermodynamics
Chemical Engineering 339P, Introduction to Biological Physics
Chemical Engineering 379, Topic: Macromolecular Chemistry
Mechanical Engineering 379, Topic: Polymer Nanocomposites
An approved upper-division biomedical engineering, chemical engineering or mechanical engineering course

Technical Area 3, Computational Biomedical Engineering

The objective of this area is to provide students with the knowledge and skills that will enable them to design and use computational algorithms to address problems in biomedical research and health care. Examples include (a) designing medical decision aids using statistical and machine learning models, (b) dynamic modeling and computer simulation to study the biomechanics and control of movement, (c) development of thermodynamic models of dynamic processes at the microscopic and macroscopic scales in biological systems, and (d) image processing techniques for quantitative measurement and interpretation of biomedical images.

Students must select twelve hours from the following:

Biomedical Engineering 341, Computational Genomics Laboratory
Biomedical Engineering 345, Graphics and Visualization Laboratory
Biomedical Engineering 346, Computational Biomolecular Engineering
Biomedical Engineering 348, Modeling of Biomedical Engineering Systems
Biomedical Engineering 358, Medical Decision-Making
Electrical Engineering 312, Software Design and Implementation I
Electrical Engineering 319K, Introduction to Embedded Systems
Electrical Engineering 422C, Software Design and Implementation II
Electrical Engineering 360C, Algorithms
Electrical Engineering 371K, Digital Image and Video Processing
Mathematics 325K, Discrete Mathematics
Mathematics 340L, Matrices and Matrix Calculations
A computer science course from an approved list

[All students must complete the following:

[1] The following four courses:
Electrical Engineering 312, Software Design and Implementation I
Electrical Engineering 422C, Software Design and Implementation II
Electrical Engineering 360C, Algorithms
Mathematics 325K, Discrete Mathematics; or Philosophy 313K, Logic, Sets, and Functions

[2] Three hours of coursework chosen from the following list:
Biomedical Engineering 341, Tools for Computational Biomolecular Engineering
Biomedical Engineering 342, Computational Biomechanics
Biomedical Engineering 344, Biomechanics
Biomedical Engineering 345, Graphics and Visualization Laboratory
Biomedical Engineering 346, Computational Biomolecular Engineering
Mathematics 340L, Matrices and Matrix Calculations
Approved computer science courses]

Technical Area 4, Biomechanics

The major objective of this area is to provide students with knowledge of the structure and function of biological systems by means of the methods of mechanics. Students will learn skills to apply engineering principles to understand how living systems function at all scales of organization and to translate this understanding to the design of devices and procedures that will improve diagnostic and therapeutic methods in health care.
Students must select twelve hours from the following:

Biomedical Engineering 342, *Biomechanics of Human Movement*
Biomedical Engineering 359, *Cell and Molecular Biomechanics*
Biomedical Engineering 362, *Introduction to Nonlinear Dynamics in Biological Systems*
Chemical Engineering 339P, *Introduction to Biological Physics*
Kinesiology 326K, *Biomechanical Analysis of Movement*
Mechanical Engineering 324, *Dynamics*
Mechanical Engineering 326, *Thermodynamics*
Mechanical Engineering 344, *Dynamic Systems and Controls*, and Mechanical Engineering 144L, *Dynamic Systems and Controls Lab*
Mechanical Engineering 354, *Introduction to Biomechanical Engineering*
Mechanical Engineering 3721, *Robotics and Automation*

An approved upper-division biomedical engineering or mechanical engineering course

Twelve hours of coursework chosen from the following list:

[†] Mechanical Engineering 326, *Thermodynamics*
[‡] Mechanical Engineering 354, *Intro-to-Biomechanical Engineering*, or an approved three-credit hour
[§] Mechanical Engineering or Mechanical Engineering-biomechanics course

**Engineering Electives**

Depending on which technical area is chosen, all students must complete four to six semester hours of engineering electives. At least three hours must be in a lecture or laboratory course. The remaining hours may be in a research project or an internship. The following may be counted toward this requirement:

[†] An engineering course in any one of the three technical areas. A course may not be counted toward both the technical area requirement and the engineering elective requirement.
[‡] An approved upper-division engineering, physics, mathematics, or computer science course. A course may not be counted toward both the technical area requirement and the engineering elective requirement.
[§] Three hours of coursework chosen from the following list:
[¶] Biomedical Engineering 325L, *Cooperative Engineering*, or Biomedical Engineering 325M, *Cooperative Engineering*
[∥] Biomedical Engineering 177, 277, Biomedical Engineering 377, *Undergraduate Research Project*
[∥] Biomedical Engineering 377M, *Medical Internship*
[∥] Biomedical Engineering 377P, *Integrated Clinical Research Internship*
[∥] Biomedical Engineering 377Q, *Integrated Clinical Medical Internship*
[∥] Biomedical Engineering 377R, *Research Internship*
[∥] Biomedical Engineering 377S, *Industrial Internship*

Suggested Arrangement of Courses

<table>
<thead>
<tr>
<th>Courses</th>
<th>Sem Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Year</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Fall</strong></td>
<td></td>
</tr>
<tr>
<td>Biology 311C, <em>Introductory Biology I</em></td>
<td>3</td>
</tr>
<tr>
<td>Biomedical Engineering [102L,203L], <em>Introduction to Biomedical Engineering Design Principles</em></td>
<td>12</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>[Biomedical Engineering 303, Introduction to Computing]</td>
<td>Undergraduate Studies 302 or Undergraduate Studies 303, First-Year Signature Course</td>
</tr>
<tr>
<td>[Chemistry 302, Principles of Chemistry II]</td>
<td>Biology 206L, Introductory Laboratory Experiments in Biology</td>
</tr>
<tr>
<td>[Chemistry 304, Introduction to Chemical Practice]</td>
<td>Chemistry 301, Principles of Chemistry I</td>
</tr>
<tr>
<td>Mathematics 408C, Differential and Integral Calculus</td>
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**Spring**

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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>[Biology 206L, Introductory Laboratory Experiments in Biology]</td>
<td>Biomedical Engineering 303, Introduction to Computing</td>
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<tr>
<td>[Undergraduate Studies 302 or Undergraduate Studies 303, First-Year Signature Course]</td>
<td>Chemistry 302, Principles of Chemistry II</td>
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<td>Mathematics 408D, Sequences, Series, and Multivariable Calculus</td>
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<td>Physics 303K, Engineering Physics I</td>
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<td>Physics 103M, Laboratory for Physics 303K</td>
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<td>Rhetoric and Writing 306, Rhetoric and Writing</td>
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**Second Year**

**Fall**

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<tbody>
<tr>
<td>[Biomedical Engineering 314, Engineering Foundations of Biomedical Engineering]</td>
<td>Biomedical Engineering 214L, Sophomore Design Laboratory</td>
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<tr>
<td>Chemistry 320M, Organic Chemistry I; or Chemistry 328M, Organic Chemistry I</td>
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<td>Chemistry 128K, Organic Chemistry Laboratory</td>
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<td>[English 316K, Masterworks of Literature]</td>
<td>Biomedical Engineering 311, Network Analysis in Biomedical</td>
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<tr>
<td>Mathematics 427K, Advanced Calculus for Applications I</td>
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<tr>
<td>Physics 303L, Engineering Physics II</td>
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<tr>
<td>Physics 103N, Laboratory for Physics 303L</td>
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**Spring**

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<tr>
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<tbody>
<tr>
<td>[Biomedical Engineering 311, Network Analysis in Biomedical Engineering]</td>
<td>Biomedical Engineering 333T, Engineering Communication</td>
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<td>Biomedical Engineering 115L, Introduction to Numerical Methods in Biomedical Engineering</td>
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<td>[Biomedical Engineering 333T, Engineering Communication]</td>
<td>Biomedical Engineering 343, Biomedical Engineering Signal and Systems Analysis</td>
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<td>Biomedical Engineering 335, Engineering Probability and Statistics</td>
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<td>Chemistry 353, Physical Chemistry I; or Chemistry 353M, Physical Chemistry I for Life Sciences</td>
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<td>Chemistry 369, Fundamentals of Biochemistry</td>
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**Third Year**

**Fall**

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<tr>
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### Biomedical Engineering 331, Measurement and Instrumentation–Laboratory

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<th>Course Description</th>
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<tbody>
<tr>
<td>Biomedical Engineering 245L, Junior Design Laboratory I</td>
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<tr>
<td>Biomedical Engineering 344, Biomechanics</td>
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<tr>
<td>Biomedical Engineering 349, Instrumentation</td>
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<tr>
<td>Biomedical Engineering 365R, Quantitative Engineering Physiology I</td>
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<tr>
<td>Biomedical Engineering 353, Transport Phenomena in Living Systems</td>
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<tr>
<td>Technical area elective</td>
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### Spring

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<tr>
<td>Biomedical Engineering 251, Biomedical Image, Signal, and Transport Process–Laboratory</td>
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<td>Biomedical Engineering 261L, Junior Design Laboratory II</td>
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<tr>
<td>Biomedical Engineering 348, Modeling of Biomedical Engineering Systems</td>
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<tr>
<td>Biomedical Engineering 355, Molecular Engineering</td>
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<tr>
<td>Biomedical Engineering 353, Transport Phenomena in Living Systems</td>
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<tr>
<td>Biomedical Engineering 352, Engineering Biomaterials</td>
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<tr>
<td>Biomedical Engineering 365S, Quantitative Engineering Physiology II</td>
<td>3</td>
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<tr>
<td>Technical area elective</td>
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<tr>
<td>[American history] English 316K, Masterworks of Literature</td>
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### Fourth Year

#### Fall

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<tbody>
<tr>
<td>Biomedical Engineering 370, Principles of Engineering Design</td>
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<tr>
<td>Government 310L, American Government</td>
<td>3</td>
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<tr>
<td>Technical area elective</td>
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<tr>
<td>[Engineering elective] American history</td>
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<tr>
<td>[Visual and performing-arts] Social and behavioral sciences</td>
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<tr>
<td>[Social and behavioral sciences]</td>
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#### Spring

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<tbody>
<tr>
<td>Biomedical Engineering 371, Biomedical Engineering Design Project</td>
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<td>[Engineering elective] Visual and performing arts</td>
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<td>Technical area elective</td>
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<tr>
<td>American history</td>
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