### Curriculum - B.S. Biomedical Engineering

<table>
<thead>
<tr>
<th>1st Semester</th>
<th>2nd Semester</th>
<th>3rd Semester</th>
<th>4th Semester</th>
<th>5th Semester</th>
<th>6th Semester</th>
<th>7th Semester</th>
<th>8th Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>APMA 1110</td>
<td>APMA 2120</td>
<td>APMA 2130</td>
<td>BME 2000</td>
<td>BME 3310</td>
<td>BME 3240</td>
<td>STS 4600</td>
<td>STS 4600</td>
</tr>
<tr>
<td>Single Variable Calculus</td>
<td>Multivariate Calculus</td>
<td>Ordinary Differential Equations</td>
<td>Intro to BME Design &amp; Discovery</td>
<td>BME Systems Analysis and Design</td>
<td>Biotransport</td>
<td>The Engr in Society</td>
<td></td>
</tr>
<tr>
<td>CHEM 1610</td>
<td>PHYS 1425</td>
<td>PHYS 2415</td>
<td>BME 2100</td>
<td>BME 3080</td>
<td>BME IDEAS Laboratory I</td>
<td>BME Capstone Design I</td>
<td>BME Capstone Design II</td>
</tr>
<tr>
<td>Introductory Chemistry for Engineers</td>
<td>General Physics I</td>
<td>General Physics II</td>
<td>Physiology I</td>
<td>BME IDEAS Laboratory II</td>
<td></td>
<td>Western Technology and Culture</td>
<td></td>
</tr>
<tr>
<td>CHEM 1611</td>
<td>PHYS 1429</td>
<td>PHYS 2419</td>
<td>BME 2102</td>
<td>Unrestricted Elective</td>
<td></td>
<td>HSS Elective</td>
<td></td>
</tr>
<tr>
<td>Intro Chemistry Lab</td>
<td>General Physics I Workshop</td>
<td>General Physics II Workshop</td>
<td>Physiology II</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGR 1620</td>
<td>CS 111x</td>
<td>BME 2101</td>
<td>BME 2104</td>
<td>BME Elective</td>
<td></td>
<td>Unrestricted Elective</td>
<td></td>
</tr>
<tr>
<td>Intro to Engineering</td>
<td>Intro to Computer Science</td>
<td>Physiology I</td>
<td>Cell and Molecular Biology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STS 1500</td>
<td>CS 111x</td>
<td>BME 2315</td>
<td>BME 2220</td>
<td>BME Elective</td>
<td></td>
<td>BME Elective</td>
<td></td>
</tr>
<tr>
<td>Lang, Comm &amp; Tech Society</td>
<td>Science Elective</td>
<td>Computational BME</td>
<td>Biomechanics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unrestricted Elective</td>
<td>STS Elective</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL 15</td>
<td>TOTAL 15</td>
<td>TOTAL 17</td>
<td>TOTAL 17</td>
<td>TOTAL 15</td>
<td>TOTAL 16</td>
<td>TOTAL 15</td>
<td>TOTAL 15</td>
</tr>
</tbody>
</table>

---

(1) **Science Elective I (3 credits)**
- Chosen from approved list of Science Elective I courses, available in A122 Thornton Hall. Recommended: MSE 2090 or CHEM 1620.

(2) **HSS Electives (9 credits)**
- Chosen from the SEAS Undergraduate Dean’s Office list of approved HSS Electives, available online and in Thornton A-122.

(3) **Unrestricted Electives (12 credits)**
- Chosen from any graded course in the University except mathematics courses below MATH 1310, including STAT 1100 and 1120, and courses that substantially duplicate any others offered for the degree, including PHYS 2010, PHYS 2020, CS 1010, CS 1020, or any introductory programming course. APMA 1090 is an unrestricted elective.

(4) **Technical Electives (3 credits)**
- Chosen from any 2000-level or higher science, math, or engineering course, unless it is a course for non-science majors, duplicates required BME course work, or is a research-for-credit or capstone design course. See list of excluded courses on page 8 of this guide.

(5) **Engineering Electives (6 credits)**
- Chosen from any 2000-level or higher engineering course, with the following exceptions: no course in APMA, STS, or ENGR may be used as engineering electives; no course that counts as a Science Elective may be used as an engineering elective; and no course that fulfills the Engineering Business Minor may be used as an engineering elective. If course does not count as a technical elective (see page 8), it will not count as an engineering elective (this includes research-for-credit and capstone design courses).

(6) **BME Electives (9 credits)**
- Chosen from any 3000-level or higher BME elective. One of the following non-BME courses may be included as a BME elective: CHE 3347, CHE 4448, or ECE 4750. Only 3 credits of BME 4995 may be used as a BME Elective.
<table>
<thead>
<tr>
<th>Planning Chart</th>
</tr>
</thead>
</table>
| **Eighth Semester**  
**Spring Year 4**  
BME 4064  
STS 4600 |
| **Seventh Semester**  
**Fall Year 4**  
BME 4063  
STS 4500 |
| **Sixth Semester**  
**Spring Year 3**  
BME 3090  
BME 3240 |
| **Fifth Semester**  
**Fall Year 3**  
BME 3080  
BME 3310 |
| **Fourth Semester**  
**Spring Year 2**  
BME 2102  
BME 2104  
BME 2220  
BME 2000 |
| **Third Semester**  
**Fall Year 2**  
BME 2101  
BME 2315  
PHYS 2415  
PHYS 2419  
APMA 2130 |
| **Second Semester**  
**Spring Year 1**  
Intro CS  
CS 111x  
You might choose: CS 1113 #300  
PHYS 1425  
PHYS 1429  
APMA 2120 |
| **First Semester**  
**Fall Year 1**  
CHEM 1610  
CHEM 1611  
ENGR 1620  
STS 1500  
APMA 1110 |

**Engineering Core (37 credits)**
- APMA 1110 Calculus I
- APMA 2120 Multivariate
- APMA 2130 Ordinary Diff Equations
- CHEM 1610 Intro Chem
- CHEM 1611 Intro Chem Lab
- Science Elec I
- PHYS 1425 Intro Physics I
- PHYS 1429 Intro Physics I Workshop
- PHYS 2415 Intro Physics II
- PHYS 2419 Intro Physics II Workshop
- ENGR 1620 Intro to Engineering
- CS 111x Intro Computer Science
- APMA 3100 or 3110 Prob or Prob/Stat

*APMA 1090 is an unrestricted elective

**STS (12 credits)**
- STS 1500 Lang & the Tech Society
- STS Elective
- STS 4500 Tech & Culture
- STS 4600 Ethics & Society

**Engineering & Technical (9 credits)**
- Engr Elective
- Tech Elective

**HSS & Unrestricted (21 credits)**
- HSS
- HSS
- HSS
- Unrestricted
- Unrestricted
- Unrestricted
- Unrestricted

**BME (47 credits)**
- BME 2000 Intro to BME
- BME 2101 Physiology I
- BME 2102 Physiology II
- BME 2104 Cell & Molecular Biology
- BME 2220 Biomechanics
- BME 2315 Computational BME
- BME 3080 IDEAS Lab I
- BME 3090 IDEAS Lab II
- BME 3240 Biotransport
- BME 3310 BME Systems Analysis
- BME 4063 Capstone Design I
- BME 4064 Capstone Design II
- BME Elective
- BME Elective
- BME Elective
**Variation #1: PREMED**

### PreMed Requirements:

- **2 semesters Chemistry Lecture & Lab.** Fulfilled by CHEM 1610, 1611 and CHEM 1620, 1621 (use your Science Elective I).
- **2 semesters Physics Lecture & Lab.** Fulfilled by PHYS 1425, 1429, 2415, 2419.
- **2 semesters Organic Chemistry Lecture & Lab.** Fulfilled by CHEM 2410, 2411, 2420, 2421 (use 1 technical and 3 unrestricted electives).
- **2 semesters Biology Lecture & Lab.** Most medical schools will accept BME 2101, 2102, 2104, 3080, 3090 as a substitute for BIOL 2010-2040. Talk with your BME advisor and the premed advisor about whether or not this is the right decision for your situation.

One semester each: Introductory Psychology and Introductory Sociology. New requirement for the 2015 MCAT Fulfilled by PSYC 1010 and SOC 1010 (HSS elective requirements).

When should BMEs take Orgo and MCAT? BME recommends that you take MCAT soon after completing the courses that are most relevant to the exam, namely: General Chemistry, Organic Chemistry lecture, Physics, Psychology and Sociology, and BME 2101, 2102, and 2104. In the schedule above, we recommend taking the Orgo lectures in 2nd year and preparing for and taking MCAT as soon as possible thereafter. The Orgo Labs can be taken any time before graduation, including during the summer. In the end, how you schedule these courses and the MCAT is a personal decision based on a number of factors, including AP credits/advanced standing, GPA and comfort level taking 5 technical courses in the same semester. Consider the advice of your academic advisor, research mentor, and/or more senior BMEs.

### When should BMEs take Orgo and MCAT?

When should BMEs take Orgo and MCAT? BME recommends that you take MCAT soon after completing the courses that are most relevant to the exam, namely: General Chemistry, Organic Chemistry lecture, Physics, Psychology and Sociology, and BME 2101, 2102, and 2104. In the schedule above, we recommend taking the Orgo lectures in 2nd year and preparing for and taking MCAT as soon as possible thereafter. The Orgo Labs can be taken any time before graduation, including during the summer. In the end, how you schedule these courses and the MCAT is a personal decision based on a number of factors, including AP credits/advanced standing, GPA and comfort level taking 5 technical courses in the same semester. Consider the advice of your academic advisor, research mentor, and/or more senior BMEs.
Here is a plan of study for BME Majors interested in Medical Imaging. This is a guide. Work with your advisor to design a plan of study that meets your specific objectives.

Here’s how the Medical Imaging Schedule fulfills the requirements of the BME Major (w/ prereqs):

**Recommended BME Electives:**

- BME 4783 Medical Imaging Modalities
- BME 4995 BME Advanced Projects
- BME 4550 Diagnostic Ultrasound Imaging  
  (BME 3310 or ECE 3750)
- BME 6550 Bio-optics
- ECE 6782 Digital Image Processing (will count as an ECE elective)
- Other BME graduate-level classes. Graduate-level courses require instructor permission.

**Complete the 19-credit ECE Minor by Adding Two Courses:**

Use ECE 4750 as a BME Elective. ECE 2630 is your Technical Elective. Add ECE 2330 and ECE 3630 as your Engineering Electives.
<table>
<thead>
<tr>
<th>Course</th>
<th>Instructor</th>
<th>Credits</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>第一年 第二学期</td>
<td>语言与技术选修</td>
<td></td>
<td>选修</td>
</tr>
</tbody>
</table>
HSS Elective Requirements

a. Instructional categories generally acceptable for HSS elective credit. A student may normally take any course under any one of these categories, with the exception of those listed under b.

HUMANITIES ELECTIVES
- Fine Arts
- ARH - Architectural History
- ARTH - Art History
- CCFA - Common Course Fine Arts*
- MDST - Media Studies
- MUSI - Music General
- PLPT - Political Theory
- STS - Science, Technology, and Contemporary Issues

History
- HIAF - African History
- HIEA - East Asian History
- HIEU - European History
- HILA - Latin American History
- HIME - Middle Eastern History
- HISA - South Asian History
- HIST - General History
- HIUS - United States History

Languages
- AMTR - Asian and Middle Eastern Language & Culture in Translation*
- ARAB - Arabic
- ARTR - Arabic in Translation
- ASL - American Sign Language
- BENG - Bengali
- CHIN - Chinese
  - CHTR - Chinese in Translation
  - CREO - Creole
  - CZ - Czech*
  - FREN - French
  - FRTR - French in Translation
  - GERM - German
  - GETR - German in Translation
  - GRE - Greek
  - HEBR - Hebrew
  - HIND - Hindi
  - ITAL - Italian
  - ITTR - Italian in Translation
  - JAPN - Japanese
  - JPTR - Japanese in Translation
  - KOR - Korean
  - LATI - Latin
  - MEST - Asian & Middle Eastern Languages & Culture in Translation
  - PERS - Persian
  - PETR - Persian in Trans*
  - Languages Cont'd
  - POL - Polish
  - PORT - Portuguese
  - PORTR - Portuguese in Trans*
  - RUSS - Russian
  - RUTR - Russian in Translation
  - SANS - Sanskrit
  - SATR - South Asian in Trans
  - SCAN - Scandinavian*
  - SLAV - Slavic
  - SLFK - Slavic Folklore and Lit
  - SLTR - Slavic in Translation*
  - SPAN - Spanish
  - SPTR - Spanish in Translation
  - SRBC - Servo-Croatian*
  - SWAH - Swahili
  - SWED - Swedish*
  - TBNT - Tibetan
  - TURK - Turkish*
  - UKR - Ukrainian*
  - UURU - Urdhu
  - YIDD - Yiddish*

- Literature
  - CCLT - Common Course Literature*
  - CPLT - Comparative Literature
  - ENAM - Am Lit to 1900
  - ENCR - Studies in Criticism
  - ENEC - Restoration and 18th Century Literature
  - ENGL - Miscellaneous English
  - ENGN - Genre Studies*
  - ENLS - Language Study*
  - ENLT - Intro Seminar in Lit
  - ENMC - Modern and Contemporary Lit
  - ENMD - Medieval Studies
  - ENNC - 19th Century British Literature
  - ENRN - Renaissance Lit
  - ENSP - Special Topics in Lit
  - ENWR - English Writing
  - Moral, Philosophical, & Religious Perspectives
  - PHIL - Philosophy
  - RELA - African Religions
  - RELB - Buddhism
  - RELC - Christianity
  - RELG - General Religion
  - RELH - Hinduism
  - RELI - Islam
  - RELJ - Judaism
  - RELS - Special Topic in Religion

SOCIAL SCIENCES ELECTIVES
- AAS - African American Studies
- AMEL - Asian & Middle Eastern Language & Culture*
- AMST - American Studies
- ANTH - Anthropology
- CCSS - Common Course
- Social Science*
- COMM - Communications; Only COMM 2600, cross-listed as SOC 2600
- CLAS - Classics (Greek and Roman Studies)
- EAST - East Asian Studies
- EDLF - Education-Leadership, Foundations and Policy; Only EDLF 5000, not EDLF 5001*
- ECON - Economics
- ETP - Environmental Thought and Practice; Only ETP 2030, 3870, 4800
- GDS - Global Development Studies
- LING - Linguistics
- LNGS - General Linguistics
- MESA - Middle Eastern and South Asian Studies
- MSP - Medieval Studies
- PLAD - Politics Department Seminar
- PLAP - American Politics
- PLCP - Comparative Politics
- PLIR - International Relations
- PSYC - Psychology
- SAST - South Asian Studies
- SOC - Sociology
- WGS - Women, Gender and Sexuality

b. Exceptions to 2.a., i.e., courses in the acceptable categories that are NOT suitable for HSS elective credit, generally because of their specialized nature for majors in that field or because they are predominantly skills courses.

- ANTH: 1090, 3810, 3820, 4991, 4993, 4998, 4999, 5080, 5800, 5870, 5880, 5989
- ECON: 3710, 3720, 4010, 4350, 4710, 5090, 5100
- ENSP: 1600
- GDS: 1100, 4951, 4952
- MUSI: 1310, 1993, 2993, 3310, 3320, 3360, 3390, 3993, 4575
- PSYC: 2200, 2210, 2220, 2302, 3005, 3006, 3210, 3870, 3590, 4111, 4125, 4200, 4290, 4330, 4500, 4910, 4970, 4930, 4940, 4980, 5200, 5210, 5260, 5330, 5350, 5401
- SOC: 4800, 4810, 4820, 4970, 5100, 5110, 5120, 5595, 5596
- STS: 4110

*may not offered every semester.
Technical Electives

3 credits

Chosen from any 2000-level or higher math, science, or engineering course, unless it is a course for non-science majors, it duplicates required BME class work, or it is a “research-for-credit” or capstone design course.

The list on page 8 (this page) shows all the courses that will not count as either a technical or an engineering elective in the BME Major.

| ASTR 3410 | CS 4980 | EVSC 5031 |
| ASTR 3420 | CS 4998 |            |
| ASTR 3460 | ECE 3750* (due to overlap with BME 3310) | MATH 2310 |
| ASTR 3470 | ECE 4907 | MATH 3100 |
| ASTR 3480 | ECE 4908 | MATH 3120 |
| ASTR 4998 | ENGR 4880 | MATH 3250 |
| BIOL 2900 | ENGR 4890 | MATH 3255 |
| BIOL 3000 | ENGR 4920 | MSE 2010 |
| BIOL 3200 |            | MSE 4960 |
| BIOL 3210 |            |            |
| BIOL 3230 |            |            |
| BIOL 4900 |            |            |
| BIOL 4910 |            |            |
| BIOL 4920 |            |            |
| BME 4995 |            |            |
| BET 2246* (due to overlap with BME 2104) |            |            |
| CHE 4995 |            |            |

| CHEM 3910 | EVSC 2010 | PHYS 2010 |
| CHEM 3920 | EVSC 2900 | PHYS 2020 |
| CHEM 3951 | EVSC 2050 | PHYS 2030 |
| CHEM 3961 | EVSC 2220 | PHYS 2040 |
| CHEM 4951 | EVSC 2030 | PHYS 2360 |
| CHEM 4961 | EVSC 3020 | PHYS 2640 |
| CE 4991    | EVSC 4030 | PHYS 2310 |
| CE 4995    | EVSC 4040 | PHYS 2320 |
| CS 4970    | EVSC 4050 | PHYS 2660 |
| CS 4971    | EVSC 4070 | PHYS 3040 |
| CS 4995    | EVSC 4995 | PSYC 2100 |
| EVSC 5030  |            |            |

No STS
### Engineering Electives

#### 6 Credits

Chosen from any 2000-level or higher engineering course, with the following exceptions: no course in APMA, STS, or ENGR may be used as an engineering elective; no course that counts as a Science Elective may be used as an engineering elective; and no course that fulfills the Engineering Business Minor may be used as an engineering elective. Additionally, if course does not count as a technical elective (see page 8), it will not count as an engineering elective. This includes research-for-credit and capstone design courses.

You may use BME courses as engineering electives, but your advisor may encourage you to look outside BME. You may need to minor in a given program, to be eligible to enroll in another program’s classes. Plan ahead!

**These SEAS courses will not count as Engineering Electives:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Code</th>
<th>Course Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO APMA</td>
<td>ECE 2066</td>
<td>SYS 4044</td>
</tr>
<tr>
<td>NO STS</td>
<td>ECE 3750</td>
<td>SYS 5044</td>
</tr>
<tr>
<td>NO ENGR</td>
<td>ECE 4907</td>
<td>SYS 4995</td>
</tr>
<tr>
<td></td>
<td>ECE 4908</td>
<td>SYS 3055</td>
</tr>
<tr>
<td>BME 4995</td>
<td>ECE 4991</td>
<td>SYS 4053</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SYS 4054</td>
</tr>
<tr>
<td>CHE 2246</td>
<td>MAE 4511</td>
<td>SYS 4055</td>
</tr>
<tr>
<td>CHE 4995</td>
<td>MAE 4512</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MAE 4513</td>
<td></td>
</tr>
<tr>
<td>CE 4000</td>
<td>MAE 4514</td>
<td></td>
</tr>
<tr>
<td>CE 4500</td>
<td>MAE 4990</td>
<td></td>
</tr>
<tr>
<td>CE 4990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE 4991</td>
<td>MSE 2010</td>
<td></td>
</tr>
<tr>
<td>CE 4995</td>
<td>MSE 2090</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MSE 4960</td>
<td></td>
</tr>
<tr>
<td>CS 4753</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS 4970</td>
<td>SYS 2055</td>
<td></td>
</tr>
<tr>
<td>CS 4971</td>
<td>SYS 2056</td>
<td></td>
</tr>
<tr>
<td>CS 4980</td>
<td>SYS 2057</td>
<td></td>
</tr>
<tr>
<td>CS 4993</td>
<td>SYS 4000</td>
<td></td>
</tr>
</tbody>
</table>
BME Electives

9 Credits

Chosen from any 3000-level or higher BME elective. One of the following non-BME courses may be included as a BME elective: CHE 3347, CHE 4448, or ECE 4750. Only 3 credits of BME 4995 may be used as a BME Elective.

Recent BME Electives (see pages 12-14 for course descriptions and prerequisites).


BME 4414 Biomaterials. Lawrence.

BME 4641 Bioelectricity. Helmke. Prerequisite:

BME 4890 Nanomedicine. Kelly.

BME 4280 Motion Biomechanics. Blemker.

BME 4417 Tissue Engineering. Munson.

BME 4783 Medical Imaging Modalities. Hossack/Epstein.

BME 4806 Biomedical Applications of Genetic Engineering. French.

BME 4995 BME Advanced Projects. Only 3 credits (total) of BME 4995 will count as BME elective.

BME 4993 Independent Study.

BME 4550 Special Topics in Biomedical Engineering:

Systems Bioengineering Modeling and Experimentation. Allen et al.


Nanomedicine Lab. Helmke and Lawrence.

BME Data Science. Civelek.

Microbial BME. Papin.

Rehabilitation Engineering. Chen.

May I use a graduate level BME course as a “BME” Elective? Yes, with instructor permission. The instructor will need to add you to his course roll in the SIS and you may need to fill a Dean’s Office form called “Undergraduate Request to Take Graduate Courses.”
What is an “Optional Bioengineering Focus Area?”
You have quite a few elective “buckets” to fill in the BME major (technical, engineering, BME, unrestricted, etc). One strategy is to use these electives to build depth in a certain focus area. This list will help you to do so.

Is this required?
No - it’s optional!

Do I take every class listed in a certain focus area?
No. The list is a guide.

Optional Bioengineering Focus Areas

This is an optional advising tool to help you build depth in a relevant area. Prerequisites are in parentheses.

**Biomaterials and Regenerative Medicine**
MSE 2090 Intro to the Science and Engineering of Materials
CHE 4449 Polymer Chemistry and Engineering (inst. permission)
BME 4414 Biomaterials
BME 4417 Tissue Engineering

**Pharmaceutical Biotechnology**
CHE 2215 Material and Energy Balances
CHE 3321 Transport Processes I (CHE 2215)
CHE 3347 Biochemical Engineering (CHE 3321)
CHE 4442 Applied Surface Chemistry
BME 4890 Nanomedicine
BME 4550 Systems Bioengineering Modeling and Experimentation

**Computational Systems Bioengineering**
SYS 3021 Deterministic Decision Models (SYS 2001)
CS 2102 Discrete Mathematics I (CS 2110)
BIOI 4160 Functional Genomics (Inst. permission)
APMA 3080 Linear Algebra
BME 4550 Systems Bioengineering Modeling and Experimentation

**Biomedical Software**
CS 2110 Software Development Methods
CS 2102 Discrete Mathematics I (CS 2110)
CS 2150 Program and Data Representation (CS 2110, 2102)
CS 3240 Advanced Software development Techniques (CS 2150)

**Musculoskeletal Biomechanics**
MAE/CE 2300 Statics
MAE/CE 2310 Strength of Materials (MAE 2300)
MAE 2320 Dynamics (MAE 2300)
BME 4280 Motion Biomechanics

**Neural Systems Engineering**
ECE 2630 Introductory Circuit Analysis
ECE 3630 Electronics I (ECE 2630)
BIOL 3170 Neurobiology
BME 3636 Neural Network Models
BME 4641 Bioelectricity

**Entrepreneurship**
BME 3030 Design and Innovation in Medicine
CS 4753, CE 4000, SYS 4044, SYS 5044

**Bioinstrumentation**
ECE 2630 Intro to Circuits
ECE 3630 Electronics I (ECE 2630)
ECE 2330 Digital Logic Design
ECE 3760 Signals and Systems II (ECE 2630, BME 3310)
ECE 3632 Electronics II (ECE 3630)

**Signal Processing**
ECE 2630 Intro Circuit Analysis
ECE 3760 Signals and Systems II (ECE 2630, BME 3310)
ECE 2066 Science of Information
ECE 5750 Digital Signal Processing (ECE 3750 or BME 3310, ECE 3760)

**Biomedical Imaging (see page 5!**
ECE 2630 Intro Circuit Analysis
ECE 3760 Signals & Systems II (ECE 2630, ECE 3750 or BME 3310)
ECE 5750 Digital Signal Processing (ECE 3750 or BME 3310, ECE 3760)
Graduate-level BME imaging courses, as appropriate
ECE 6782 Digital Image Processing

**Clinical Applications in Biomedical Engineering**
MAE 2300 Statics
BIOL 3030 Biochemistry (prereq organic chemistry)
Advanced Biology course, as appropriate, such as BIOL 3080, BIOL 3090, BIOL 3140, BIOL 3240
BME 4414 Biomaterials
BME 4280 Motion Biomechanics

**Nanomedicine Engineering**
BME 4890 Nanomedicine Engineering
MSE 4055 Nanoscale Science and Technology (MSE 3670, PHYS 2320, PHYS 2620, or CHEM 3410 or CHEM 3820)
Physical Chemistry (Organic Chemistry)
BME 4414 Biomaterials
Course Descriptions: BME 2000-3090

BME 2000 - (3) REQUIRED, Spring
Intro to BME Design & Discovery
Prerequisite: CS 1110, PHYS 1425, and ENGR 1620. Covers conceptual and detail design processes and the special challenges inherent to biomedical devices. Students will formulate and execute a major, semester-long design project.

BME 2101 - (3) REQUIRED, Fall
Physiology for Engineers I
Prerequisite: CHEM 1610, and PHYS 1425. Studies how excitable tissue, nerves and muscle, and the cardiovascular and respiratory systems work. Focuses on understanding mechanisms and includes an intro to structure, an emphasis on quantitative function, and integration of hormonal and neural regulation and control.

BME 2102 - (3) REQUIRED, Spring
Physiology for Engineers II
Prerequisite: BME 2101. Introduces the physiology of the kidney, salt and water balance, gastrointestinal system, endocrine system, and central nervous system, with reference to diseases and their pathophysiology.

BME 2104 - (3) REQUIRED, Spring
Cell & Molecular Biology for Engineers
Prerequisite: CHEM 1610 and BIOL 2101. Introduces the fundamentals of cell structure and function, emphasizing the techniques and technologies available for the study of cell biology. A problem-based approach is used to motivate each topic: cell structure and function includes cell chemistry, organelles, enzymes, membranes, membrane transport, intracellular compartments and adhesion structures; energy flow in cells concentrates on the pathways of glycolysis and aerobic respiration; information flow in cells focuses on modern molecular biology and genetic engineering, and includes DNA replication, the cell cycle, gene expression, gene regulation, and protein synthesis. Also presents specific cell functions, including movement, the cytoskeleton and signal transduction. Students may not receive credit for both CHE 2246 and BME 2104.

BME 2220 - (3) REQUIRED, Spring
Biomechanics
Prerequisite: APMA 2120, BME 2101. Introduces the principles of continuum mechanics of biological tissues and systems. Topics 1) review of selected results from statics and strength of materials, continuum mechanics, free-body diagrams, constitutive equations of biological materials, viscoelastic models, and fundamental concepts of fluid mechanics and mass transport; 2) properties of living tissue; 3) mechanical basis and effects of pathology and trauma, 4) introduction to mechanotransduction, circulatory transport, growth and remodeling, and tissue-engineered materials; 5) low Reynolds number flows in vivo and in microsystems.

BME 2315 - (3) REQUIRED, Fall
Computational BME
Prerequisite: APMA 2120 and CS 111x. APMA 2130 recommended co-req. Introduces techniques for constructing predictive or analytical engineering models for biological processes. Teaches modeling approaches using example problems in transport, mechanics, bioelectricity, molecular dynamics, tissue assembly, and imaging. Problem sets will include 1) linear systems and filtering, 2) compartmental modeling, 3) numerical techniques, 4) finite element / finite difference models, and 5) computational automata models.

BME 3310 - (3) REQUIRED, Fall
Biomedical Systems Analysis & Design
Prerequisites: APMA 2130, CS 111x, and PHYS 1425. Presents the analytical tools used to model signals and linear systems. Specific biomedical engineering examples include multicompartiment modeling of drug delivery, modeling of dynamic biomechanical systems, and electrical circuit models of excitable cells. Major topics include terminology for signals and systems, convolution, continuous time Fourier transforms, electrical circuits with applications to bioinstrumentation and biosystems modeling, and applications of linear system theory. Students may not receive credit for both ECE 3750 and BME 3310.

BME 3030 - (3) ELECTIVE, Spring
Design and Innovation in Medicine
Prerequisite: BME 2000 and instructor permission. A project-based grounding in biomedical product design, with emphasis on clinical immersion and topics including design fundamentals, product need identification, delineation of realistic constraints and product specifications, intellectual property, market analysis, entrepreneurship, specific advanced design topics, business plan development, venture funding, and medical product testing methods.

BME 3080, 3090 - (4+4) REQUIRED, Fall, Spring
BME IDEAS Lab I & II
Prerequisite: BME 2101, 2104, 2220, and 3rd year BME major. Year-long course to integrate concepts and skills from prior courses in order to formulate and solve problems in biomedical systems, including experimental design, performance, and analysis. Lab modules include testing in tissues/cells and manipulation of molecular constituents of living systems to determine their structural and functional characteristics for design of therapeutic or measurement systems. Methods include biochemical, physiological, cell biology, mechanical, electrical and computer, systems, chemical, imaging, and other approaches.

BME 3240 - (3) REQUIRED, Spring
Biotransport
Prerequisite: APMA 2120, 213, BME 2101, 2104 or equivalent, or instructor permission. Biotransport in biological living systems is a fundamental phenomenon important in all aspects of the life cycle. Course will introduce principles and applications of fluid and mass transport processes in cell, tissue and organ systems. Topics include introduction to physiological fluid mechanics in the circulation and tissue, fundamentals of mass transport in biological systems, effects of mass transport and biochemical interactions at the cell and tissue scales, and fluid and mass transport in organs.
BME 4063-4550

**Course Descriptions: BME 4063-4550**

**BME 4063, 4064 - (3+3) REQUIRED, Fall, Spring**

Biomedical Engineering Capstone Design I & II
Prerequisite: Fourth year standing in BME major or instructor permission. A year-long design project in biomedical engineering required for BME majors. Students select, formulate, and solve a biomedically relevant design problem whose deliverables include a device, therapeutic, and/or system. Projects may be sponsored by BME faculty, medical doctors, and/or companies. Students may work on their own with outside team members when appropriate or with other SEAS students in integrative teams.

**BME 4280 - (3) ELECTIVE, Spring**

Motion Biomechanics
Prerequisite: BME 2101, 2220. Focuses on the study of forces (and their effects) that act on the musculoskeletal structures of the human body. Based on the foundations of functional anatomy and engineering mechanics (rigid body and deformable approaches); students are exposed to clinical problems in orthopedics and rehabilitation.

**BME 4414 - (3) ELECTIVE, Fall**

Biomaterials
Prerequisite: BME 2101, 2220. This course will provide an introduction to biomaterials science and biological interactions with materials, focusing on clinical applications using FDA approved materials. Areas of concentration will include the use of polymers and ceramics in biomaterials today, tissue response to materials, and drug delivery & diagnostic applications.

**BME 4417 - (3) ELECTIVE, Spring**

Tissue Engineering
Prerequisite: APMA 2130, BME 2101, and 2104 or equivalent. Introduces the fundamental principles of tissue engineering. Topics include: tissue organization and dynamics, cell and tissue characterization, cell-matrix interactions, transport processes in engineered tissues, biomaterials and biological interfaces, stem cells and interacting cell fate processes, and tissue engineering methods. Examples of tissue engineering approaches for regeneration of cartilage, bone, ligament, tendons, skin and liver are presented.

**BME 4550 - (3+3) ELECTIVE, Fall, Spring**

Special Topics in Biomedical Engineering
Prerequisite: varies. Applies engineering science, design methods, and system analysis to developing areas and current problems in biomedical engineering.

**Recent BME 4550 courses**

**Systems Bioengineering Modeling and Experimentation (Fall)**
Prerequisite: Fourth year standing in BME Major. Introduces techniques for constructing mathematical and computational models of vascular biological processes and utilizing experimental methods to validate those models at many levels of organizational scale, from genome to whole-tissue. In each of three modules, teams complete group modeling projects that apply the modeling techniques specific to the particular module. Teams will also conduct experiments relevant to the biological question of each module. Topics to be covered include choice of modeling techniques appropriate to addressing particular biological problems at different scales, quantitative characterization of biological properties, assumptions and model simplification, parameter estimation and sensitivity analysis, model verification and validation, and integration of computational modeling with experimental approaches.

**Quantitative Biological Reasoning (Fall)**
Prerequisite: 4th year standing and instructor permission. Provides a quantitative framework for identifying and addressing important biological questions at the molecular, cell, and tissue levels. Covers methods, with an emphasis on the biochemical, biophysical, and mathematical themes that emerge repeatedly in quantitative experiments. Discussions preceded by primary literature that illustrates how in-depth understanding of such themes led to significant conceptual advances in biochemistry, molecular biology, and cell biology. Part II covers how quantitative methods combine to aid scientific logic. Topics include practical implementations of the scientific method, falsification of hypotheses and strong inference. Course concludes with an intro to how quantitative biological reasoning can be effectively presented through scientific writing and information design.

**Microbial BME (Fall)**
BME 2101, BME 2102, BME 2104, BME 2315. Overview of engineering methods to use “microbes as tools” for human wellbeing, to understand and combat “microbes as enemies” in infectious disease, and to characterize and manipulate “microbes as partners” in human health. Covers high-throughput technologies, computational modeling, drug delivery, and others to test hypotheses of human/microbe relationships and design strategies to understand and treat human disease and improve human wellbeing.

**BME Data Science (Spring)**
APMA 3110 or equivalent and CS 1110 or equivalent. Introduces genomics and bioinformatics theory and tools to analyze large scale biological data. Topics: intro to Linux and R statistical programming language, computations on the high performance computational cluster and cloud computing, analysis of sequencing data with applications in gene expression and protein/DNA interactions, differential expression analysis, pathway and co-expression network analysis. Students will bring laptops to class.

**Rehabilitation Engineering (Fall)**
Instructor Permission. Project-driven course focusing on the use of engineering science and principles to develop technological solutions and devices to aid the recovery of physical and cognitive functions lost because of disease or injury. Students will seek, investigate, and research a project of their own choosing. Held in partnership with the UVA School of Architecture, the UVA School of Medicine, and Veterans Association.

**Nanomedicine Lab (Spring)**
Instructor Permission.
BME 4641 - (3) ELECTIVE, Fall  
**Bioelectricity**  
Prerequisite: BME 3310 or ECE 2630, BME 2101. Studies the biophysical mechanisms governing production and transmission of bioelectric signals, measurement of these signals and their analysis in basic and clinical electrophysiology. Introduces the principles of design and operation of therapeutic medical devices used in the cardiovascular and nervous systems. Includes membrane potential, action potentials, channels and synaptic transmission, electrodes, electroencephalography, electromyography, electrocardiography, pacemakers, defibrillators, and neural assist devices.

BME 4783 - (3) ELECTIVE, Spring  
**Medical Imaging Modalities**  
Prerequisite: BME 3310 or ECE 3750. An overview of modern medical imaging modalities with regard to the physical basis of image acquisition and methods of image reconstruction. Topics cover the basic engineering and physical principles underlying the major medical imaging modalities: x-ray (plain film, mammography, and CT), nuclear medicine (PET and SPECT), ultrasound, and MRI.

BME 4806 - (3) ELECTIVE, Spring  
**Biomedical Applications of Genetic Engineering**  
Prerequisite: BME 2101, 2102, and 2104, and 3rd/4th year standing. Provides a grounding in molecular biology and a working knowledge of recombinant DNA technology, thus establishing a basis for the evaluation and application of genetic engineering in whole animal systems. Beginning with the basic principles of genetics, this course examines the use of molecular methods to study gene expression, deliver viral and non-viral vectors, and its critical role in health.

BME 4890 - (3) ELECTIVE, Fall  
**Nanomedicine Engineering**  
Prerequisite: BME 2104 or CHE 2246, BME 2220, or 4th year standing, BME 3240 or CHE 3321 recommended. Students will design treatment strategies for cancer and cardiovascular disease based on molecular bioengineering principles. Special topics will include design of nanoparticle drug and gene delivery platforms, materials biocompatibility, cancer immunotherapy, and molecular imaging.

BME 4993 - (1-3) ELECTIVE, Fall, Spring  
**Independent Study**  
Prerequisite: instructor permission. In-depth study of a biomedical engineering area by an individual student in close collaboration with a departmental faculty member. Requires advanced analysis of a specialized topic in biomedical engineering that is not covered by current offerings. Requires faculty contact time and assignments comparable to regular course offerings. See page 15.

BME 4995 - (1-3) ELECTIVE, Fall, Spring  
**BME Advanced Projects**  
Prerequisite: instructor permission and approval of the BME Undergrad Program Director. Use Form on pg 17. Research project in biomedical engineering conducted in consultation with a department faculty advisor, usually related to ongoing faculty research. Includes the design, execution, and analysis of experimental laboratory work and computational or theoretical computer analysis of a problem. Requires a comprehensive report of the results. Only 3 credits of BME 4995 will count as BME elective. Another 3 credits will count as an Unrestricted Elective.
Required Approval Form
BME Independent Study (BME 4993) - 3 credits maximum

Independent Study is an in-depth exploration of a technical area in biomedical engineering for which there is no formal course offering. It exhibits the hallmarks of a formal course offering - e.g. regular and significant faculty contact time, assigned reading, regular homework or projects, and a final exam or paper. Requires approval from the Undergraduate Program Director. Use this form to propose and describe your topic.

- Listed as BME 4993 "BME Independent Study."
- Up to 3 credits of BME 4993 will count as a BME Elective in the BME Major.
- Does NOT count toward the BME Minor.

Procedure:

Your Name: _______________________________________ BME Advisor: _______________

Today’s Date: _____________ Year of Graduation: _______ Your Email: ______________________

1) Instructor information. If the proposed instructor is not a primary BME primary faculty member, see the Undergrad Program Director for special instructions. Instructor’s Name (print): _____________________________

2) Attach a one-page COURSE MEMO. Include 1) a one-paragraph Course Description, 2) Planned Assignments for the semester, 3) Textbook and/or reading list, 4) and Meeting Times and Frequency.

3) SIGNATURES. Have the course instructor sign the Course Memo. Return the signed memo and this form to the BME Undergrad Coordinator, MR5 2010. You will be informed of the success of your petition via email.

Approved: _____________________________________

BME Undergraduate Program Director
Required Approval Form
Substituting a Core Course / Replacing a Requirement

Name: ___________________ Major: ___________________ BME Advisor: _______________
Today’s Date: ___________ Year of Graduation: ______ Email: ______________________

Procedure: Fill out this form (duplicate if necessary for multiple requests) and return to Undergrad Coordinator in MR5 2010. You will be informed of the success of your petition via email.

Course/Requirement #1
1) What course/requirement would you like to replace? _________________________
2) What would you like to replace it with? _________________________
3) Reason: _____________________________________

Approved: _____________________________________
BME Undergraduate Program Director

Course/Requirement #2
1) What course/requirement would you like to replace? _________________________
2) What would you like to replace it with? _________________________
3) Reason: _____________________________________

Approved: _____________________________________
BME Undergraduate Program Director
Required Approval Form for BME Advanced Projects (BME 4995, “Research- or Design-for-Credit”)

Consists of the design, execution, and analysis of lab work, computational modeling, or theoretical analysis in a biomedical engineering subject area. Requires a comprehensive final report describing methods and results. You may work with any BME primary faculty member. It is possible to work with non-BME faculty, if a BME primary faculty member agrees to co-advice your project. In this case, the BME faculty member is listed as the course instructor and assigns the grade, in consultation with the research mentor. Under certain circumstances, this rule may be waived. See the Undergrad Coordinator for details.

Use BME 4995 “BME Advanced Projects.” All projects must approved by the Undergraduate Program Director using this form.

- You must submit this form for approval EACH SEMESTER you plan to do research-for-credit (even for a continuing project).
- For each credit hour earned, you must spend at least 3-4 hours per week in the lab, for a minimum of 10 hours/week for 3 credit-hour course.
- Relationship between Advanced Projects & Capstone Projects: Unless the two projects are entirely separate, you may NOT earn credit for BME 4995 at the same time you are earning credit for BME 4063, 4064.
- BME Majors may count up to six credits (total) toward the degree. Three (3) credits can be used as a BME Elective, and the other three (3) credits can be used as an Unrestricted Elective.

Procedure

Your Name: ___________________________ Email: _______________________ Today’s Date: _______________________
Lab Name: ________________________________ Research Advisor’s name (print): ________________________________
If your research advisor is not a primary BME faculty member, which primary BME faculty member is co-advising this project? ________________________________

Will you be attending lab meetings? (circle one) Yes No If no, why not? ________________________________________

1) Attach a PROJECT PROPOSAL (half-page). The proposal should include i) Project Title and Study Name (more specific than title), ii) Purpose/Objective of your proposed project, iii) your Hypothesis (if applicable), iv) the Experimental Design (i.e. experimental conditions and measurable output), v) your Methods, and vi) the Significance of your research (what is the impact of your results in the field?)

2) Attach a PROJECT EXPECTATIONS STATEMENT (one paragraph). Here you describe the project guidelines worked out between you, your research mentor, and (if applicable) the BME primary faculty member co-advising your project. You must cover i) Days and times you are scheduled to work in the lab, ii) How often you will be meeting with your research mentor, iii) When your final report is due and iv) Other expectations, including required background literature, monthly progress reports, etc. If you are working in a non-BME lab, you must also report how often you plan to meet with your BME primary advisor.

3) SIGNATURES. Both you and your Research Advisor must sign the Project Proposal / Expectations Statement. If you plan to work in a non-BME lab, your BME primary advisor must sign, too. Return this form and the signed Project Proposal / Expectations Statement to the Undergraduate Coordinator (MR5 2010). You will be informed of the success of your petition via email.

Approved: __________________________________
BME Undergraduate Program Director