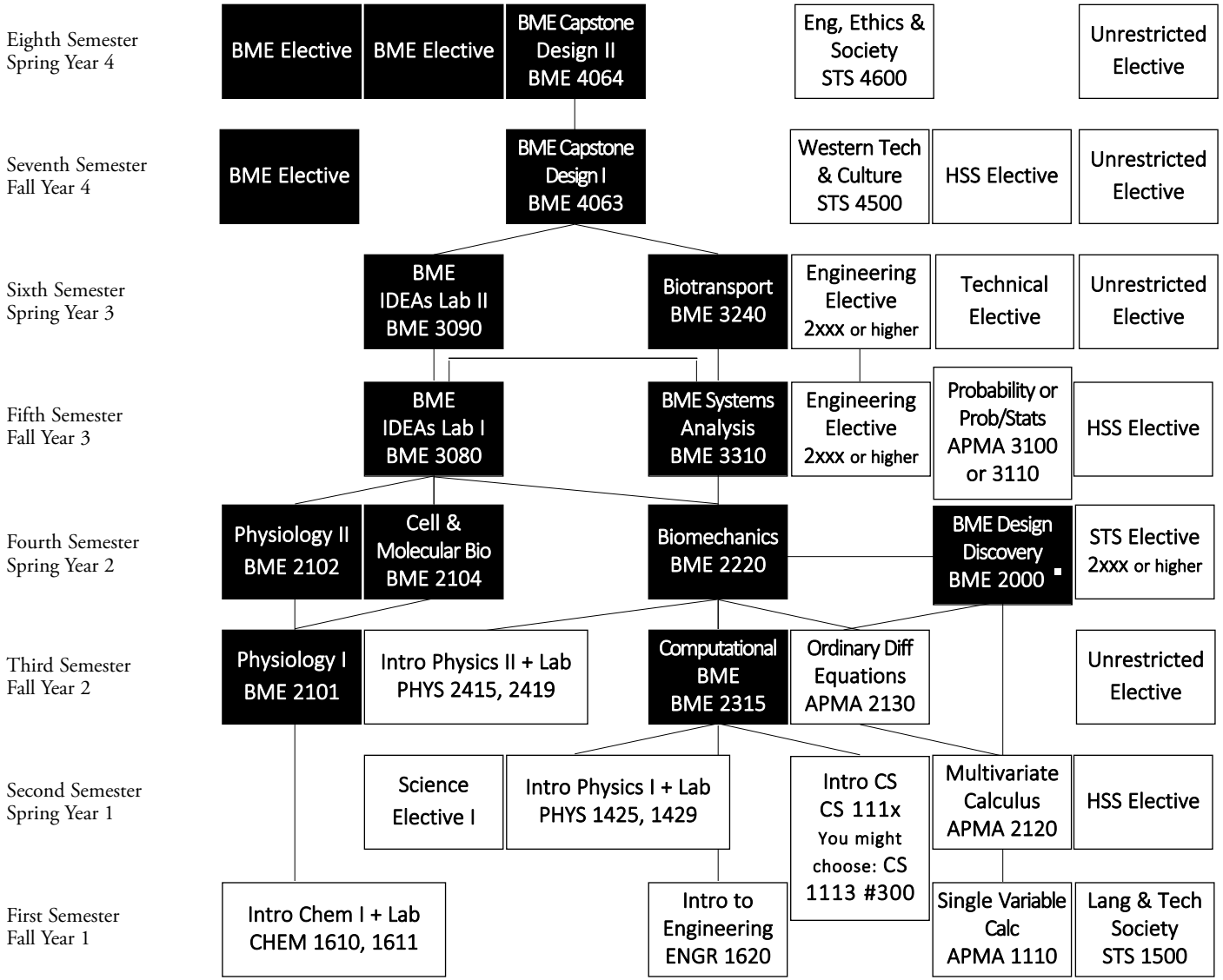
BME Student Guide



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Curriculum - B.S. Biomedical Engineering

[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.

1st Semester

APMA 1110	Single Variable Calculus	4
CHEM 1610	Introductory Chemistry for Engineers	3
CHEM 1611	Intro Chemistry Lab	1
ENGR 1620	Intro to Engineering	4
STS 1500	Lang, Comm & Tech Society	3
	TOTAL	15

2nd Semester

APMA 2120	Multivariate Calculus	4
PHYS 1425	General Physics I	3
PHYS 1429	General Physics I Workshop	1
CS 111x	Intro to Computer Science	3
	Science Elective I [1]	3
	HSS Elective [2]	3
	TOTAL	17

↓

You might choose CS 1113 Section #300

3rd Semester

APMA 2130	Ordinary Differential Equations	4
PHYS 2415	General Physics II	3
PHYS 2419	General Physics II Workshop	1
BME 2101	Physiology I	3
BME 2315	Computational BME	3
	Unrestricted Elective [3]	3
	TOTAL	17

4th Semester

BME 2000	Intro to BME Design & Discovery	3
BME 2102	Physiology II	3
BME 2104	Cell and Molecular Biology	3
BME 2220	Biomechanics	3
	STS Elective	3
	TOTAL	15

5th Semester

BME 3310	BME Systems Analysis and Design	3
BME 3080	BME IDEAS Laboratory I	4
APMA 3110	Stat/Prob or APMA 3100 Probability	3
	HSS Elective [2]	3
	Engineering Elective [5]	3
	TOTAL	16

6th Semester

BME 3240	Biotransport	3
BME 3090	BME IDEAS Laboratory II	4
	Unrestricted Elective [3]	3
	Technical Elective [4]	3
	Engineering Elective [5]	3
	TOTAL	16

7th Semester

BME 4063	BME Capstone Design I	3
STS 4500	Western Technology and Culture	3
	HSS Elective [2]	3
	Unrestricted Elective [3]	3
	BME elective [6]	3
	TOTAL	15

8th Semester

STS 4600	The Engr in Society	3
BME 4064	BME Capstone Design II	3
	Unrestricted Elective [3]	3
	BME Elective [6]	3
	BME Elective [6]	3
	TOTAL	15

Credits 126

Planning Chart

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 _____
- ❍ 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*

Our curriculum in BME often bears explaining to medical schools. Here's what you should do:

Students should ask their "primary" recommendation writer from among the BME faculty to include, as a part of his or her overall letter, the "BME boilerplate text" covering the English composition requirements and Biology requirements. It is the responsibility of the student to make sure that the BME faculty member understands that they should append the biolerplate text, and to ensure that it is appended to only one of the letters they've requested. kitter@virginia.edu with any questions!

Be sure to contact

Jessica Bowers

Rebecca Coulter

Office of PreProfessional Services
Bryant Hall @ Scott Stadium
924-8900, careercenter@virginia.edu
https://career.virginia.edu/pre-health

Attend open office hours or schedule an individual advising appointment.

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).

About 1/3 of U.S. medical schools require one or two semesters of math; a few specify that it must be **Calculus.**

About 2/3 of U.S. medical schools require one or two English classes; for most schools, your STS courses will fulfill this requirement.

Eighth Semester Spring Year 4	BME Elective		BME Capstone Design II BME 4064	Engineering Elective 2xxx, 3xxx	Eng, Ethics & Society STS 4600	HSS Elective
Seventh Semester Fall Year 4	BME Elective	BME Elective	BME Capstone Design I BME 4063	Engineering Elective 2xxx, 3xxx	Western Tech & Culture STS 4500	
Sixth Semester Spring Year 3	Organic Chem II Lab CHEM 2321	BME IDEAs Lab II BME 3090	Biotransport BME 3240	STS Elective 2xxx, 3xxx	Unrestricted Elective	PSYC 1010 or SOC 1010 (HSS Elective)
Fifth Semester Fall Year 3	Organic Chem I Lab CHEM 2311	BME IDEAs Lab I BME 3080	BME Systems Analysis BME 3310	Probability OR Prob/Stats, APMA 3100 or 3110		PSYC 1010 or SOC 1010 (HSS Elective)
Fourth Semester Spring Year 2	Organic Chemistry II CHEM 2420	Physiology II BME 2102	Cell & Molecular Bio BME 2104	Biomechanics BME 2220	BME Design and Discovery BME 2000	
Third Semester Fall Year 2	Organic Chemistry I CHEM 2410	Intro Physics II + Lab PHYS 2415, 2419		Physiology I BME 2101	Computation'l BME BME 2315	Ordinary Diff Equations APMA 2130
Second Semester Spring Year 1	Intro Chem II + Lab CHEM 1620, 1621		Intro Physics I + Lab PHYS 1425, 1429		Intro Comp Science CS 111x	Multivariate Calculus APMA 2120
First Semester Fall Year 1	Intro Chem I + Lab CHEM 1610, 1611			Intro to Engineering ENGR 1620	Lang & Tech Society STS 1500	Single Variable Calc APMA 1110

Consider taking PSYC & SOC 1010 earlier, if there is room in your schedule, or if you are able to take a summer course.

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.

Variation #2: *MEDICAL IMAGING*

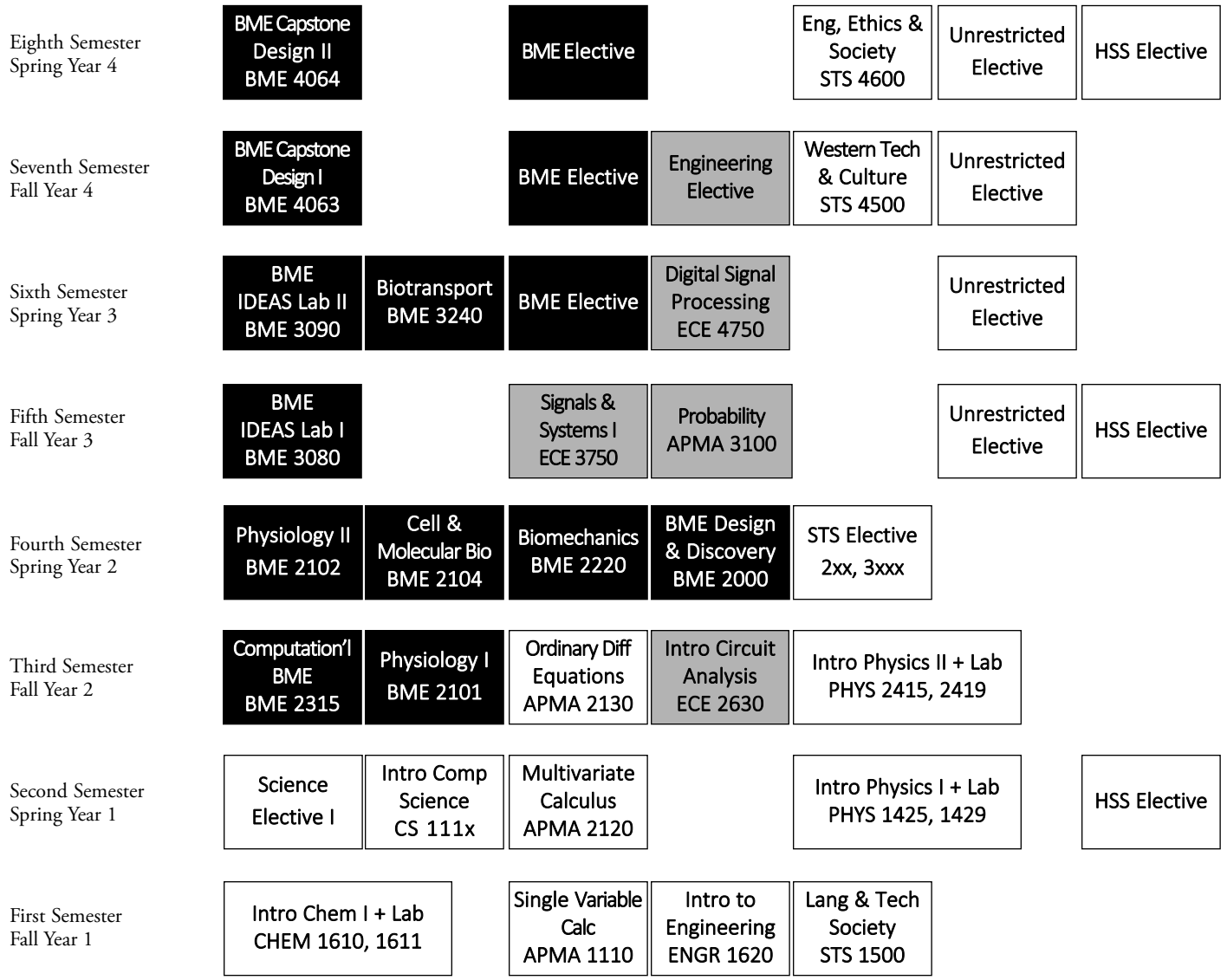
Here is a plan of study for BME Majors interested in Medical Imaging. This is a guide. Work with your advisor to design a plan of study that meets your specific objectives.

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

ECE 2630 is your technical elective
ECE 3750 (ECE 2630) replaces BME 3310
ECE 4750 (ECE 3750) is one of two engineering electives (or use as a BME elective).
Take APMA 3100, not APMA 3110

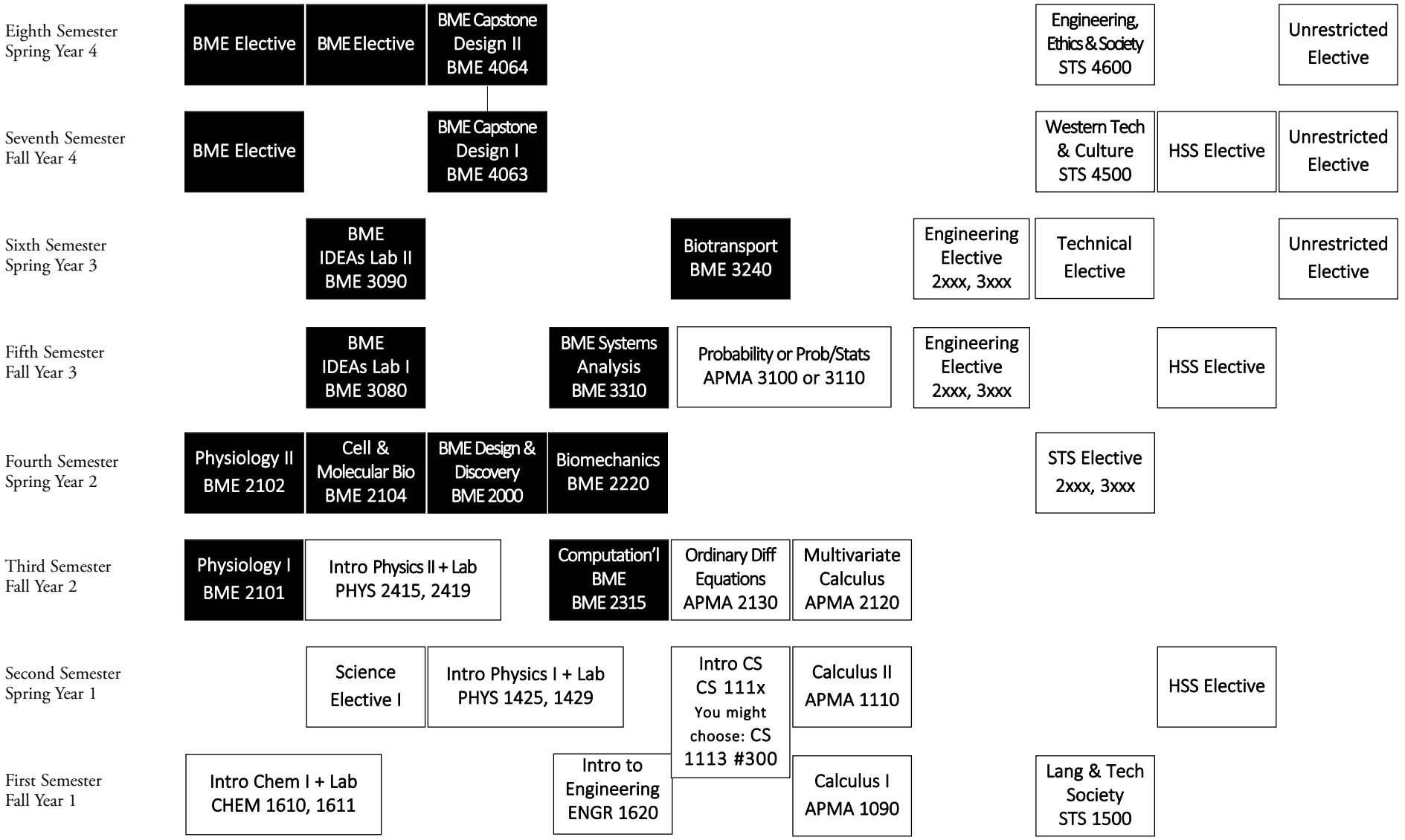
Recommended BME Electives:

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 as BME 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.


Eighth Semester
Spring Year 4
BME Elective
BME Elective
BME Capstone Design II BME 4064
Engineering, Ethics & Society STS 4600
Unrestricted Elective
Seventh Semester
Fall Year 4
BME Elective
BME Capstone Design I BME 4063
Western Tech & Culture STS 4500
HSS Elective
Unrestricted Elective
Sixth Semester
Spring Year 3
BME IDEAs Lab II BME 3090
Biotransport BME 3240
Engineering Elective 2xxx, 3xxx
Technical Elective
Unrestricted Elective
Fifth Semester
Fall Year 3
BME IDEAs Lab I BME 3080
BME Systems Analysis BME 3310
Probability or Prob/Stats APMA 3100 or 3110
Engineering Elective 2xxx, 3xxx
HSS Elective
Fourth Semester
Spring Year 2
Physiology II BME 2102
Cell & Molecular Bio BME 2104
BME Design & Discovery BME 2000
Biomechanics BME 2220
STS Elective 2xxx, 3xxx
Third Semester
Fall Year 2
Physiology I BME 2101
Intro Physics II + Lab PHYS 2415, 2419
Computation'l BME BME 2315
Ordinary Diff Equations APMA 2130
Multivariate Calculus APMA 2120
Second Semester
Spring Year 1
Science Elective I
Intro Physics I + Lab PHYS 1425, 1429
Intro CS CS 111x You might choose: CS 1113 #300
Calculus II APMA 1110
HSS Elective
First Semester
Fall Year 1
Intro Chem I + Lab CHEM 1610, 1611
Intro to Engineering ENGR 1620
Calculus I APMA 1090
Lang & Tech Society STS 1500

HSS Electives
9 credits

Chosen from the SEAS Undergraduate Dean's Office list of approved HSS Electives, available online and in Thornton A-122 (and copied here). Courses that instill cultural values are acceptable while skill development courses are not. Consequently, courses that involve performance must be accompanied by theory or history of the subject. Courses on communication in the student's native language, regardless of their level, may not be used to satisfy this requirement.

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 Hist
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 Lang
BENG - Bengali
CHIN - Chinese
CHTR - Chinese in Translation
CREO - Creole
CZ - Czech*
FREN - French
FRTR - French in Translation
GERM - German
GETR - German in Translation
GREE - Greek
HEBR - Hebrew
HIND - Hindu
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
POTR - 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*
TBTN - Tibetan
TURK - Turkish*
UKR - Ukrainian*
URDU - Urdu
YIDD - Yiddish*

Literature
CCLT - Common Course Literature*
CPLT - Comparative Lit
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 2020, 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

*may not offered every semester.

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

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.

Courses that do NOT count as Technical or Engineering electives:

ASTR 3410
ASTR 3420
ASTR 3460
ASTR 3470
ASTR 3480
ASTR 4998

BIOL 2900
BIOL 3000
BIOL 3200
BIOL 3210
BIOL 3230
BIOL 4900
BIOL 4910
BIOL 4920

BME 4995

CHE 2246* (due to overlap with BME 2104)
CHE 4995

CHEM 3910
CHEM 3920
CHEM 3951
CHEM 3961
CHEM 4951
CHEM 4961

CE 4991
CE 4995

CS 4970
CS 4971

CS 4980
CS 4998

ECE 3750* (due to overlap with BME 3310)
ECE 4907
ECE 4908

ENGR 4880
ENGR 4890
ENGR 4920

EVSC 2010
EVSC 2900
EVSC 2050
EVSC 2220
EVSC 2030
EVSC 3020
EVSC 4030
EVSC 4040
EVSC 4050
EVSC 4070
EVSC 4995
EVSC 5030
EVSC 5031

MATH 2310
MATH 3100
MATH 3120
MATH 3250
MATH 3255

MSE 2010
MSE 4960

MAE 4511
MAE 4512
MAE 4513
MAE 4514

PHYS 2010
PHYS 2020
PHYS 2030
PHYS 2040
PHYS 2360
PHYS 2640
PHYS 2310
PHYS 2320
PHYS 2660
PHYS 3040
PSYC 2100

PSYC 2150
PSYC 2210
PSYC 2300-3110
PSYC 3410-4180
PSYC 4300-5200
PSYC 5260
PSYC 5310
PSYC 5320
PSYC 5500-5650

SYS 3055
SYS 4053
SYS 4054
SYS 4055

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 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:

NO APMA
NO STS
NO ENGR

BME 4995

CHE 2246
CHE 4995

CE 4000
CE 4500
CE 4990
CE 4991
CE 4995

CS 4753
CS 4970
CS 4971
CS 4980
CS 4993

ECE 2066
ECE 3750
ECE 4907
ECE 4908
ECE 4991

MAE 4511
MAE 4512
MAE 4513
MAE 4514
MAE 4990

MSE 2010
MSE 2090
MSE 4960

SYS 2055
SYS 2056
SYS 2057
SYS 4000
SYS 4044
SYS 5044
SYS 4995
SYS 3055
SYS 4053
SYS 4054
SYS 4055

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 3030 Design and Innovation in Medicine. Allen and Chen.

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.

Quantitative Biological Reasoning. Janes.

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."

Optional Bioengineering Focus Areas

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.

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)
BIOL 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

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, and 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 recomended 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 multicompartment 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, problem/needs 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 application 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, 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 Enigneering (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-advise 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