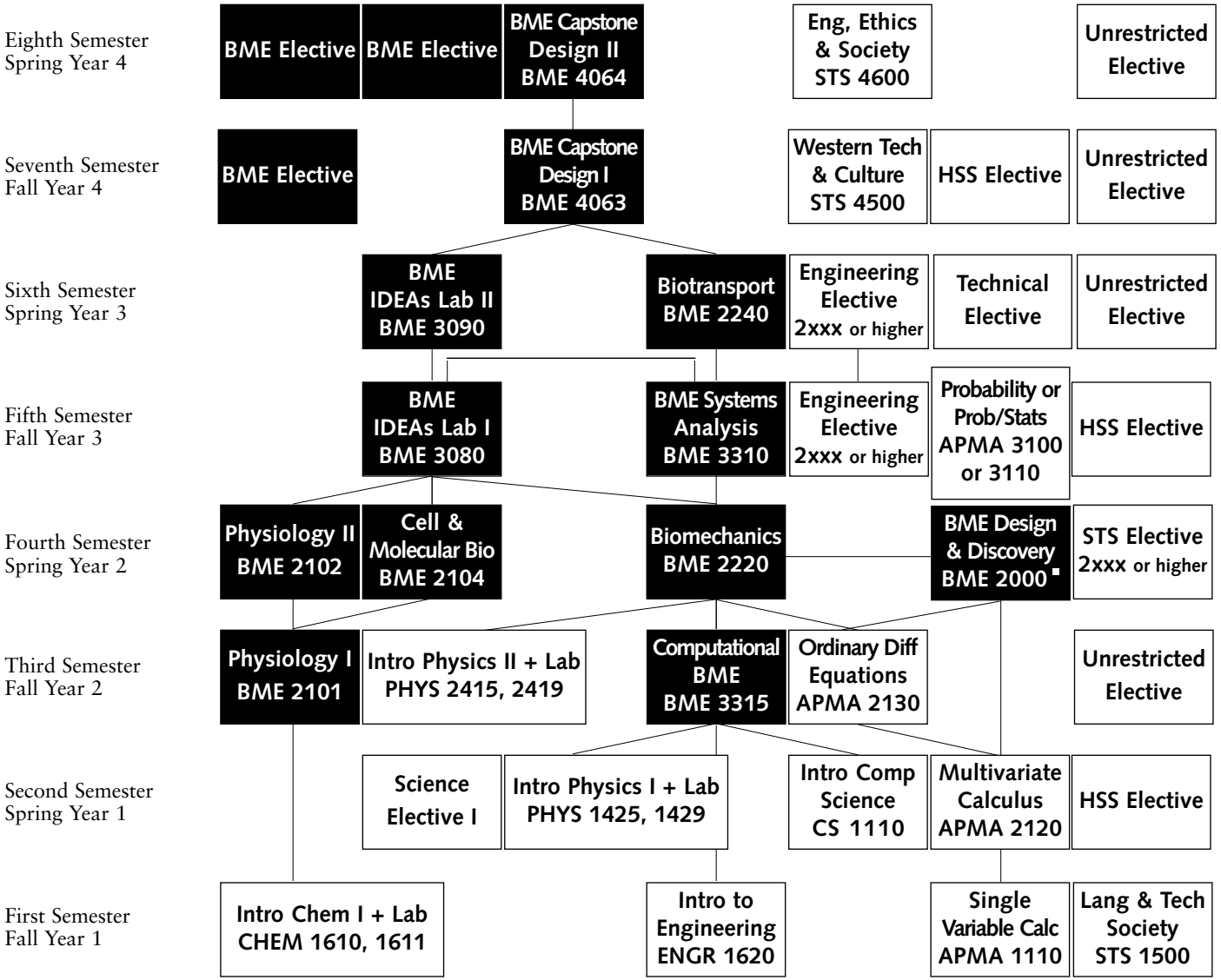
BME Student Guide *2011-2012*



Contents

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Curriculum - B.S. Biomedical Engineering

[1] Science Elective I (3 credits)

Suggested: CHEM 1620 or MSE 2090. Chosen from: ENGR 2500, BIOL 2101, 2102, CHEM 1620, ECE 2066, MSE 2090, or PHYS 2620.

[2] HSS Electives (9 credits)

Chosen from the approved list available in A-122 in Thornton Hall.

[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)

A two-course sequence of 2000-level or higher engineering courses in a single area of concentration. BME courses may not be used. Chose courses from the approved list on page 9 of this guide.

[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 5750. 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 1110	Intro to Computer Science	3
	Science Elective I [1]	3
	HSS Elective [2]	3
	TOTAL	**17**

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 3315	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 2240	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 2240				
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 3315	PHYS 2415	PHYS 2419	APMA 2130	
Second Semester Spring Year 1	CS 1110	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 1110 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 2240 Biotransport
- ❍ BME 3310 BME Systems Analysis
- ❍ BME 3315 Computational BME
- ❍ BME 3080 IDEAS Lab I
- ❍ BME 3090 IDEAS Lab II
- ❍ BME 4063 Capstone Design I
- ❍ BME 4064 Capstone Design II
- ❍ BME Elective _____
- ❍ BME Elective _____
- ❍ BME Elective _____

When you fill out the AMCAS Application Form, add Dr. Guilford as a "non-confidential" letter writer!
Dr. Bill has a boilerplate letter that explains how BME 2101, 2102, 2104, 3080, 3090 fulfill the one year general bio + lab requirement. This letter also explains what STS is all about.

Be sure to contact
Susan Salko
Rebecca Christy
Office of PreProfessional Services
Bryant Hall @ Scott Stadium
924-8900, salko@virginia.edu
www.career.virginia.edu/students/preprof/prehealth/

Attend walk-in advising hours for premeds, or make an 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.

About 2/3 of U.S. medical schools require one or two **English** courses. About 1/3 of U.S. medical schools require one or two semesters of math; a few specify that it must be **Calculus.**

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 2421	BME IDEAs Lab II BME 3090	Biotransport BME 2240	STS Elective 2xxx, 3xxx	Unrestricted Elective	HSS Elective
Fifth Semester Fall Year 3	Organic Chem I Lab CHEM 2411	BME IDEAs Lab I BME 3080	BME Systems Analysis BME 3310	Probability OR Prob/Stats, APMA 3100 or 3110		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 3315	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 1110	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

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: CHEM 2410, 2420 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 the summer after 2nd year. The Orgo Labs can be taken any time thereafter, including during the summer. They are generally not necessary as a prerequiste to the MCAT. An added benefit of taking the MCAT early is that there's time to re-take it, if needed.

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. Talk to your academic advisor, research mentor, and/or more senior BMEs, and consider their advice.

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 (prereqs in parentheses):

ECE 2630 is your technical elective
ECE 3750 (ECE 2630) replaces BME 3310
ECE 3760 (ECE 3750) & ECE 5750 (ECE 3750, 3760) are your two engineering electives
Take APMA 3100, not APMA 3110

Recommended BME Electives:

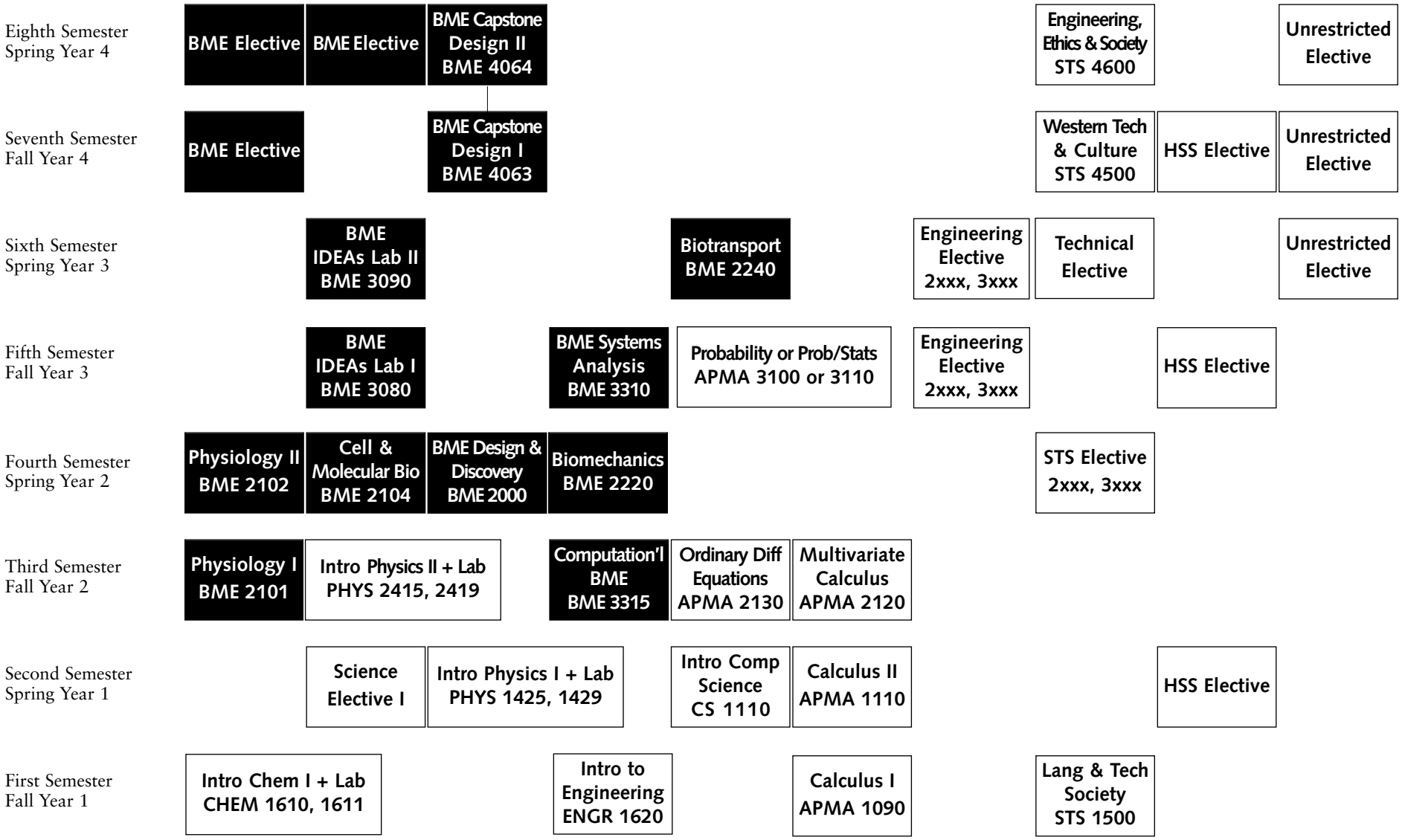
BME 4995 BME Advanced Projects
BME 7782 Medical Imaging Systems Theory (BME 3310 or ECE 3750)
BME 4550 Diagnostic Ultrasound Imaging (BME 3310 or ECE 3750)
ECE 6782 Digital Image Processing (will count as as BME elective)
Other BME graduate-level classes. Graduate-level courses require instructor permission.

Eighth Semester Spring Year 4	BME Capstone Design II BME 4064		BME Elective		Eng, Ethics & Society STS 4600	Unrestricted Elective	HSS Elective
Seventh Semester Fall Year 4	BME Capstone Design I BME 4063		BME Elective	Digital Signal Processing ECE 5750	Western Tech & Culture STS 4500	Unrestricted Elective	
Sixth Semester Spring Year 3	BME IDEAS Lab II BME 3090	Biotransport BME 2240	BME Elective	Signals & Systems II ECE 3760		Unrestricted Elective	
Fifth Semester Fall Year 3	BME IDEAS Lab I BME 3080		Signals & Systems I ECE 3750	Probability APMA 3100		Unrestricted Elective	HSS Elective
Fourth Semester Spring Year 2	Physiology II BME 2102	Cell & Molecular Bio BME 2104	Biomechanics BME 2220	BME Design & Discovery BME 2000	STS Elective 2xx, 3xxx		
Third Semester Fall Year 2	Computation'l BME BME 3315	Physiology I BME 2101	Ordinary Diff Equations APMA 2130	Intro Circuit Analysis ECE 2630	Intro Physics II + Lab PHYS 2415, 2419		
Second Semester Spring Year 1	Science Elective I	Intro Comp Science CS 1110	Multivariate Calculus APMA 2120		Intro Physics I + Lab PHYS 1425, 1429		HSS Elective
First Semester Fall Year 1	Intro Chem I + Lab CHEM 1610, 1611		Single Variable Calc APMA 1110	Intro to Engineering ENGR 1620	Lang & Tech Society STS 1500		

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

Use ECE 5750 as a BME Elective, add ECE 2330 (use as Technical Elective), use ECE 2630 as the 1st Engineering Elective, and add ECE 3630 (2nd Engineering Elective).

Variation #3: *APMA 1090*



HSS Electives
9 credits

With your advisor's approval, you may select your HSS electives from the list of courses on this page. 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.

AAS	CZ	FREN	KOR	PSYC	PTR
AMEL	EAST	FRTR	LATI	RELA	SRBC
AMST	ECON	GERM	LING	RELB	STS
AMTR	ENAM	GETR	LNGS	RELC	SWAG
ANTH	ENCR	GREE	MDST	RELG	SWAH
AR H	ENEC	HEBR	MEST	RELH	SWED
ARAB	ENGL	HIAF	MSP	RELI	TBTN
ARTH	ENGN	HIEA	MUSI	RELJ	TMP 3052
ARTR	ENLS	HIEU	PERS	RELS	TURK
ASL	ENLT	HILA	PETR	RUSS	UKR
BULG	ENMC	HIME	PHIL	RUTR	URDU
CCFA	ENMD	HIND	PLAD	SANS	YIDD
CCIA	ENNC	HISA	PLAP	SATR	
CCLT	ENRN	HIST	PLCP	SCAN	
CCSS	ENSP	HIUS	PLIR	SLAV	
CHIN	ENWR	ITAL	PLPT	SLFK	
CHTR	ETP 2030	ITTR	POL	SLTR	

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
ENWR 1505, 1506, 1510, 2510, 2520
MDST 2010, 3702
MUSI 1310, 1993, 2993, 3310, 3320, 3360, 3390, 3993, 4575
PSYC 2200, 2210, 2220, 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 3993

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 4440
ASTR 4988

BIOL 2060
BIOL 2061
BIOL 2070
BIOL 2071
BIOL 3000
BIOL 3200
BIOL 3210
BIOL 3230
BIOL 4911
BIOL 4912
BIOL 4913
BIOL 4914
BIOL 4915
BIOL 4916
BIOL 4917
BIOL 4918

BME 4311
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 4993

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

A two-course sequence of 2000-level or higher engineering courses in a single area of concentration. The two courses are chosen from the approved list on this page. Starting with the Class of 2014, you may NOT use a BME course in your sequence. Class of 2012 & 2013 may refer to prior versions of this Student Guide for allowed sequences.

MAY I CREATE MY OWN SEQUENCE? Yes, w/ approval of fthe UG Program Director. Use Form on page 16. Work through Kitter to code this exception in your SIS degree audit.

Engineering Elective Sequences. Choose any two (2) courses from a single group to create a pre-approved sequence. Prereqs in parentheses.

Area 1
CHE 2202. See also MAE 2100 Thermodynamics
CHE 2215 Material and Energy Balances
CHE 3xxx or higher
CHE 4561, 4562—permission required, use the form on p 16

Area 2
CHE 2215 Material and Energy Balances
CHE 2216 Modeling and Simulation in Chem Eng (CHE 2215)
CHE 3321 Transport Processes I (CHE 2215)
CHE 3xxx or higher
CHE 4561, 4562—permission required, use the form on p 16

Area 3
CS 2110 Software Development Methods
CS 2102 Discrete Mathematics
CS 2150 Program and Data Representation (CS 2110, 2102)
CS 4750 Database Systems (CS 2102, 2150)
CS 3xxx or higher
CS 4993, 4501, 5501—permission required, use the form on p 16
SYS 2202 or 2004 Data and Information Engineering (CS 2110)
SYS 3062 Discrete Event Simulation (CS 2110, APMA 3100, 3112)

Area 4
CS 2102 Discrete Mathematics I
CS 2150 Program and Data Representation (CS 2110, 2102)
APMA 5070 Numerical Methods
CS 3xxx or higher

Area 5
ECE 2630 Introductory Circuit Analysis
ECE 3630 Electronics I (ECE 2630)
ECE 3760 Signals and Systems II (ECE 2630 and ECE 3750 or BME 3310)
ECE 3xxx or higher—not ECE 3750 or BME/ECE 4641
ECE 5501, 5502—permission required, use the form on p 16

Area 6
ECE 2066 Science of Information
ECE/CS 2330 Digital Logic Design
ECE/CS 3330 Computer Architecture (CS 2110, ECE/CS 2330)
ECE 4435 Computer Organization and Design (ECE 3330)

Area 7
CE 2300 Statics. See also MAE 2300
CE/MAE 2310 Strength of Materials (CE/MAE 2300)
CE/MAE 2320 Dynamics (CE/MAE 2300)
CE 2210 or MAE 3210 Fluid Mechanics
CE 3xxx or higher—not CE 3000, 3100, 3400, 4000, 4030, 4100, 4110, 4400, 4410, 4810
CE 4500—permission required, use the form on p 16

Area 8
MAE 2100 Thermodynamics: See also CHE 2202
MAE 3120 Thermal Systems Analysis (MAE 2100)
MAE 3210 Fluid Mechanics (MAE 2100)
MAE 3xxx or higher—not BME/MAE 4280
MAE 4501, 4502—permission required, use the form on p 16

Area 9
MAE 2300 Statics: See also CE 2300
MAE 3xxx or higher—not BME/MAE 4280. Orthopedic Injury Biomechanics (if it's offered) may count, check with Dr. Guilford to be sure
MAE 4501-4502—permission required, use the form on p 16

Area 10
MSE 2090 Intro to the Science and Engineering of Materials
CHE 2202 / MAE 2100 Thermodynamics
MSE 3080 Corrosion (MSE 2090)
MSE 3xxx or higher
MSE 4960—permission required, use the form on p 16
CE/MAE 2310 Strength of Materials (CE/MAE 2300)
CHE 4442 Applied Surface Chemistry
ENGR 2500 Introduction to Nanoscience and Technology

Area 11
SYS 2001 Systems Engineering Concepts
SYS 2202 or 2004 Data and Information Engineering (CS 2110)
SYS 3021 Deterministic Decision Models (SYS 2001, APMA 3080)
SYS 3xxx or higher, except SYS 4081
SYS 4081—permission required, use the form on p 16

Area 12
SYS 2057 Management of E-Commerce Systems
CS 4753 Electronic Commerce Technologies

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 5750. Only 3 credits of BME 4995 may be used as a BME Elective.

BME Electives, 2011-2012

Fall 2011

BME 4414 Biomaterials. Botchwey. Prerequisite: BME 2101, BME 2104 or CHE 2246, 3rd or 4th year standing, or instructor permission.

BME 4280 Motion Biomechanics. Blemker. Prerequisite: BME 2101, BME 2220, or instructor permission.

BME 4641 Bioelectricity. Kim. Prerequisite: BME 3310 or ECE 2630, and BME 2101, or instructor permission.

BME 4890 Nanomedicine. Kelly. Prerequisite: BME 2104 or CHE 2246, BME 2220, 4th year standing, or instructor permission.

BME 4550 Systems Bioengineering Modeling & Experimentation. Allen, Papin, Peirce-Cottler. Prerequisite: BME 3080, BME 3315, and instructor Permission.

Spring 2012

BME 3636 Neural Network Models of Cognition and Brain Computation. Levy. Cross-listed as PSYC 5330. Prerequisite: BME 2101, and CS 1110, or instructor permission.

BME 4783 Medical Imaging Modalities. Hossack. Prerequsistes: BME 2101 and BME 3310.

BME 4806 Biomedical Applications of Genetic Engineering. French. Prerequisite: BME 2101, BME 2102, BME 2104 or CHE 2246, and 3rd/4th year standing, or instructor permission.

BME 4550 BME Electronics Lab. Kim. Prereq: 2nd year standing.

BME 4550 BME Advanced Design. Allen. Prerequisite: BME 2000 and instructor permission.

Fall/Spring 2010-2011

BME 4995 BME Advanced Projects. Varies. Prerequisite: instructor permission and approval of the BME Undergraduate Program Director. Only 3 credits (total) of BME 4995-454 will count as BME elective. Another 3 credits will count as an Unrestricted elective.

BME 4550 Special Topics in Biomedical Engineering. Prerequisite: 3rd or 4th year standing or instructor permission.

BME 4993 Independent Study. Prerequisite: Instructor permission and approval of the Undergrad Program Director.

May I use a graduate level BME course as "BME" Electives? 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 students use their various elective "buckets" to 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 4550 Spc Tpc BME Advanced Design
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 5010 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, or instructor permission. Provides an overview of the BME discipline and major sub-disciplines (biomechanics, genetic engineering, tissue engineering, bioelectricity, imaging, cellular engineering, computational systems biology), covers conceptual and detail design processes, and introduces quantitative tools utilized throughout the BME curriculum. Includes formulation and execution of a major design project.

BME 2101 - (3) REQUIRED, Fall
Physiology for Engineers I
Prerequisite: CHEM 1610, and PHYS 1425, or instructor permission. 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, or instructor permission. 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, or instructor permission. 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. Divided into three general sections: 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, 2130, and BME 2101, or instructor permission. Introduces the principles of continuum mechanics of biological tissues and systems. Topics include 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 2240 - (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 3310 - (3) REQUIRED, Fall
Biomedical Systems Analysis & Design.
Prerequisites: APMA 2130, CS 1110, and PHYS 1425, or instructor permission. 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 3315 - (3) REQUIRED, Fall
Computational BME
Prerequisite: BME 2101, 2104, and 2220, or instructor permission. 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 3080, 3090 - (4+4) REQUIRED, Fall, Spring
BME IDEAS Lab I & II
Prerequisite: BME 2101, 2104, and 2220, and 3rd year standing in the BME major, or Inst. permission. 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 3636 - (3) ELECTIVE, Spring
Neural Network Models of Cognition and Brain Computation. Cross-listed as PSYC 5330. Prerequisite: CS 1110, BME 2101, or instructor permission. Introduction to neural networks research, specifically biologically-based networks that reproduce cognitive phenomena. The goal is to teach the basic thinking and methodologies used in constructing and understanding neural-like networks.

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 design problem related to a device or a system. Projects use conceptual design, skills obtained in the integrated lab, and substantial literature and patent reviews. 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, or instructor permission. 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, 2104 or equivalent, 3rd or 4th year standing, or instructor permission. This course will provide an introduction to biomaterials science and biological interactions with materials, including an overview of biomaterials testing and characterization. The emphasis of this course, however, will be on emerging novel strategies and design considerations of biomaterials. Areas of concentration will include the use of polymers and ceramics in biomaterials today, drug delivery applications, tissue engineering from both an orthopaedic and vascular perspective, and nanotechnology related to biomaterials. Specific attention will also be paid to the in vitro and in vivo testing of biomaterials, and a review of current research in the field.

BME 4417 - (3) ELECTIVE, Spring
Tissue Engineering (not offered 2011-12)
Prerequisite: APMA 2130, BME 2101, and 2104 or equivalent, or instructor permission. 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.

BME 4550 - (3) ELECTIVE, Fall
Systems Bioengineering Modeling and Experimentation
Prerequisite: Fourth year standing in BME major, or instructor permission. 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.

BME 4550 - (3) ELECTIVE, Spring
BME Electronics Lab
Prerequisite: 2nd year standing. Course objectives: (1) To provide an understanding of basic techniques involving electrical and electronic circuit analysis; and (2) To enable students to apply the knowledge and techniques in electrical systems to problems in biomedical engineering. These goals will be achieved through lectures and labs in combination.

BME 4550 - (3) ELECTIVE, Fall
Medical Imaging Systems Theory (not offered 2011-12)
Prerequisite: ECE 3750 or BME 3310 or equivalent exposure to linear systems theory, and instructor permission. Develops an intuitive understanding of the mathematical systems theory needed to understand and design biomedical imaging systems, including ultrasound, magnetic resonance imaging and computed tomography. Emphasis is on 2D continuous systems, but 1D and discrete systems are also covered. Topics include multidimensional Fourier transform theory, image reconstruction techniques, diffraction theory, and Fourier optics.

BME 4550 - (3) ELECTIVE, Fall
Quantitative Biological Reasoning (offered 2012-2013)
rerequisite: 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.

BME 4550 - (3) ELECTIVE, Spring
BME Advanced Design
Prerequisite: BME 2000 and instructor permission. Project-driven course focusing on biomedical product design, with an emphasis on marketability, innovation, entrepreneurship, and business. Topics covered include design fundamentals, problem/needs identification, delineation of realistic constraints and product specifications, intellectual property, market analysis, entrepreneurship, specific advanced design topics (e.g. design for manufacturing, cradle-to-grave product lifecycle analysis, etc.), business plan development, venture funding, and medical product testing methods.

BME 4550 - (3) ELECTIVE, Spring
Orthopedic and Injury Biomechanics
Prerequisite: Instructor permission. In this course students will gain working knowledge of the functions and mechanical properties, including failure, of musculoskeletal tissues, how those tissue combine to form structures, the properties and behavior of those structures, the role of mechanical forces in the formation, morphology, nature, and injury of those material and structures, and the failure mechanics and thresholds of anatomical structures in the head, neck, thorax, abdomen, and extremities.

BME 4641 - (3) ELECTIVE, Fall
Bioelectricity
Prerequisite: BME 3310 or ECE 2630, BME 2101, or instructor permission. 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, or instructor permission. 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, or instructor permission. 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, or instructor permission. BME 2240 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 (a.k.a. Research- or Design-for-Credit)
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