TO: The Faculty of the College of Engineering

FROM: The Faculty of the School of Biomedical Engineering

RE: Changes in Undergraduate Program Degree Requirements for the Bachelor of Science in Biomedical Engineering

The Faculty of the School of Biomedical Engineering has approved the following changes to the curriculum for the B.S. degree in Biomedical Engineering effective for students entering the Weldon School for the Fall Semester 2012. This action is now submitted to the Engineering Faculty with a recommendation for approval. A revised Suggested Plan of Study is attached. New courses and changes in required courses are shown in bold.

The proposed changes are as follows:

A. **Require CHM 11600, General Chemistry as a science selective in the FYE program for BME applicants** – BME 20100, BME 20500, and subsequent courses in BME depend on a solid foundation in general chemistry.
B. **Remove COM 11400, Fundamentals of Speech Communication, as a required course** – This will free space in a heavy FYE program. Presentation skills are now taught in a new BME sophomore seminar course (BME 29000 described in modification H). Presentations are required in BME courses at each level of the program and we determined that most students have sufficient skills to master these presentations without COM 11400. We will continue to advise / encourage students with weaker communication skills to take this or another COM course.
C. **Require CS 15900, Programming Applications for Engineers, before Junior year** – CS 15600 was removed from the FYE curriculum and replaced by CS 15900 as a possible science selective in FYE; however CHM 11600 is the science selective that will be required for BME applicants (see A). Programming is an essential skill for Biomedical Engineers. Sufficient mastery is needed to be successful in BME 30100 and subsequent BME courses in the junior and senior year. Some programming is necessary to complete team projects in the second semester sophomore physiology course; BME 25600. We advise students to complete their programming course prior to second semester sophomore year if at all possible.
D. **Renaming of sophomore laboratory courses** – This change is necessary for a clearer and more descriptive indication of the content of these courses. The title of BME 20500 was changed from BME Lab I to Biomolecular and Cellular Systems Laboratory. The title of BME 20600, BME Lab II, was changed to Biomechanics and Biomaterials Laboratory.
E. **Require BME 25600, Physiological Modeling in Human Health**– This is a new course developed in 2007 in response to a clear need for BME students to have a deeper understanding of physiological principles from an engineering (mathematical modeling) perspective. We place this course in the second semester of sophomore year because in addition to being a prerequisite to upper-level BME courses, it also provides additional programming skills and applications of differential equations.

F. **Reduce the credit requirement for Life Sciences courses from 12 to 9 credits** – This change is in response to requiring a 3-credit physiology course (BME 25600, see E) for all BME students.

G. **Require IE 33000, Probability and Statistics in Engineering II or STAT 51100, Statistical Methods, instead of IE 23000** – A higher level of statistics was determined to be beneficial to Senior Design Projects course and to industry (internship supervisors' feedback). Students get most of the material covered in IE 23000 in their sophomore BME labs.

H. **Require BME 29000, Frontiers in Biomedical Engineering, in the sophomore year** – This is a new course (2008) designed and implemented in response to student end-of-year surveys and focus groups which consistently indicated that more information about the BME industry, research aspects of BME, and planning for careers in BME was important for students to have earlier in the program. This course also integrates communication skills with professional development.

I. **Increase the credit value of BME 30500, Bioinstrumentation Circuit and Measurement Principles, from 2 to 3 credits** – This change reflects the actual work load in this course which has a lecture section and a lab section to cover basic circuit design and bioinstrumentation.

J. **Change the content, title, and scheduled semester of BME 304000, Bioheat and Mass Transfer, to Biomedical Transport Fundamentals** – We have been evaluating the Biotransport series of BME for several years and have recently revised BME 30400 and the accompanying lab course, BME 30600, to reflect a more direct and clear application of fundamental transport principles to biomedical engineering problems and solutions. BME 30400 will be offered in the fall in place of ME 30900, Fluid Dynamics. BME 30600 will remain in the spring semester to follow the theory course.

K. **Change the content and credit value of BME 30600, Biotransport Laboratory, from 1 credit to 2 credits** – An additional credit hour worth of supporting theory and application (experiment design, programming and modeling skills) discussion and training will occur in a 50-minute lecture portion of the lab course. This final lab course in the curriculum before Senior Design Projects has been restructured to focus more specifically on problem based learning modules and open-ended laboratory sessions that better prepare the students for Senior Design Projects.

L. **Remove ME 30900, Fluid Dynamics, from the required course list** – This 4-credit course is no longer necessary to the BME Biotransport series due to the revisions of BME 30400 and BME 30600. This change in the series will reduce the total credit load for this portion from 8 to 5 which has been determined to be more aligned with the other 3 areas of core theory and skills in BME and with industry needs for BME training. ME 30900 will continue to be listed as an appropriate Engineering Technical Elective course.

M. **Change the requirement that only 3 credits of Technical Elective can be at the 300-level to only 6 credits can be at the 300-level** – This change is in response to the increase in number of required credits in Technical Electives (see S) and the need for students to take a broader range of prerequisite courses to get to the advanced Technical Electives important to BME.

N. **Change title and content of BME 39000 from BME Professional Seminar to Professional Development and Design in BME.** – This change is necessary for a clearer and more descriptive indication of the content of this course which has slowly evolved over the past 6 years to include more design elements. These design skills and the preliminary design proposal have become important preparatory work for the capstone senior design projects course.

O. **Require at least one 400-level Technical Elective course from BME** – In the past year 4 Technical Elective courses have been developed in BME and 2 more are planned. These "senior-level" electives are designed to incorporate learning from previous 200 and 300-level BME courses into advanced theory and applications directly related to Biomedical Engineering.

P. **Require successfully passing with a B- or better at least one 400-level Technical Elective course from BME before taking a 500-level BME course** – Many of the students in BME take a 500-level course to fulfill part of their technical electives. This pattern developed when there were no 400-level BME Technical Electives. In order to maintain the quality and intention of our 500-level BME courses, which as dual-level are for advanced undergraduates and graduate students, it has been determined that a prerequisite of successful performance (B- minimum) in a 400-level BME Technical Elective will ensure a better preparation for the dual-level courses.

Q. **Remove CS 490B, Bioinformatics, from the required course list** – This change was precipitated by a re-evaluation of the course and its place in the BME curriculum. It was determined that the course was not meeting the programming needs, nor the integration of biology and engineering needs of the students. In addition, this topic was determined to be of less general relevance to all undergraduate BME students and so will now be assigned to the Life Sciences elective course list.

R. **Remove ABE 591W, Non-Linear Dynamics of Biological Systems from the required course list** – This course is no longer required but is now listed as a BME Technical Elective for the Quantitative Engineering breadth requirement (see S). This enables the students to further tune their technical training relating to some specialization within biomedical engineering.

S. **Increase the credit requirement for Engineering Technical Electives from 9 to 15 credits** – This change is in response to two changes to our curriculum including i. changing the transport portion of the curriculum from an 8-credit series to a 5-credit series (see L) and ii. creating a quantitative engineering breadth requirement category within the technical elective requirements (see R). Students must choose one of their five technical electives from a list of courses approved by the Biomedical Engineering faculty for the Quantitative Engineering breadth requirement. This list is maintained by the undergraduate advising office.

T. **Change BME 40500, Senior Design Projects course from a 1-semester format to a flexible format that can accommodate one and two semester options with the introduction of new courses BME 48800, BME 48900 and BME 49000**– This change is needed to allow for several types of projects (e.g. tissue engineering and animal implants) that require longer development and preparation times. The original 4-credit course has been redesigned into three courses that divide up the components and allow for flexible scheduling and better assessment of mastery of required skills. The courses to be approved to replace BME 40500 are: BME 49000, Professional Elements of Design (1 credit), BME 48800, Preliminary Project Design (1 credit), and BME 48900, Senior Design Projects Lab (2 credits).

U. **Increase the unrestricted elective credits from 3 credits to 5 credits** – This change is allowed by the previous curricular changes and is intended to provide a more flexible curriculum for the training of innovative students in the Weldon School of Biomedical Engineering.

V. **Enhance the selection of Ethics courses that can meet the ethics requirement from the General Ed electives.** – The 3-credit ethics requirement can be satisfied by taking any course selected from a list maintained by the Undergraduate Advising Office.

Reason: The proposed program changes to degree requirements for the Bachelor of Science in Biomedical Engineering are to update the minimum requirements for this new program. The proposed program changes to degree requirements provide students with 1. The necessary basic science and engineering knowledge and skills, 2. Integration of engineering and life sciences early and continuously throughout the program, 3. An exposure to other related engineering disciplines, and 4. Exposure to the breadth of the field of biomedical engineering. The proposed changes to our degree program are intended to continue to satisfy ABET requirements for Biomedical Engineering. The revised suggested plan of study provides students with an integrated and efficient pathway of course selection, allowing for diversification before the final year depending on student interest.

George R. Wodicka

George R. Wodicka, Professor and Head
Weldon School of Biomedical Engineering

APPROVED FOR THE FACULTY
OF THE SCHOOLS OF ENGINEERING
BY THE ENGINEERING
CURRICULUM COMMITTEE

ECC Minutes #16

Date 4/6/11

Chairman ECC R. Cipra

[Current] B.S. BME Degree Program Requirements

Minimum Degree Requirements for Bachelor of Science in Biomedical Engineering (B.S. BME)

Credit Hours Required for Graduation: 130

Freshman Requirements:[1] (31 credit hours; see Freshman Engineering)

[1] No more than 8 credit hours of freshman calculus can be applied towards the BME degree.

Core Biomedical Engineering (BME) Courses (18 credit hours): **BME** 201, 204, 205, 206, 301, 304, 305, 306, 390.

BME Breadth Requirement (50 credit hours):

Core Life Sciences Requirement: BIOL 295E and three (3) additional Life Science courses* at the 300-level or above.

Core Engineering Requirement: ABE 591W; **ECE** 301; **IE** 230*; **ME** 200, 270, 309; and **MSE** 230. (*or **STAT** 503)

BME/Engineering Electives: Three (3) additional BME/Engineering courses* at the 400-level or above.

Senior Design Requirements: BME 405

Other Requirements: CS 490B

Advanced Physics (3 credit hours):

PHYS 241

Advanced Math (7 credit hours):

MA 261 and (**MA** 266 or **MA** 262)

General Education Electives (18 credit hours): Course selections must meet the General Education Program requirements. Refer to "*General Education Program*." Includes an ethics elective to be chosen from either **PHIL** 270 or **PHIL** 280.

Unrestricted Elective (3 credit hours): Additional coursework to bring the total to at least 130 hours.

GPA Requirement: A Graduation Index of 2.0 or better is required to fulfill the BSBME degree requirements. A minimum overall GPA of 2.0 is required in major-area (BME) courses to qualify for graduation with a BSBME degree.

* Selected from a list of courses approved by the Biomedical Engineering faculty and maintained by the undergraduate advising office.

Current Plan of Study

Credit Hours Required for Graduation: 130
Freshman Year, see Freshman Engineering

Sophomore Year

Third Semester	Fourth Semester
(4) MA 261 Multivariate Calculus	(3) MA 266 Ordinary Differential Equations
(3) PHYS 241 Electricity and Optics	(3) MSE 230 Structure and Properties Materials
(3) BIOL 295E Biology of the Living Cell	(3) BME 204 Biomechanics Hard/Soft Tissue
(3) BME 201 Biomolecules	(1) BME 206 BME Laboratory II
(1) BME 205 BME Laboratory I	(3) ME 200 Thermodynamics I
(3) ME 270 Basic Mechanics	(3) General education elective
17	16

Junior Year

Fifth Semester	Sixth Semester
(3) BME 301 Bioelectricity	(3) BME 304 Bioheat and Mass Transfer
(2) BME 305 Bioinstrumentation Lab	(1) BME 306 Biotransport Laboratory
(1) BME 390 BME Professional Seminar	(3) ECE 301 Signals and Systems
(4) ME 309 Fluid Mechanics	(3) IE 230 Probability and Statistics in Engr.
(3) Life Science elective	(3) CS 490B Introduction Bioinformatics
(3) General education elective	(3) Ethics elective
16	16

Senior Year

Seventh Semester	Eighth Semester
(3) ABE 591W Nonlinear Dyn. Biol. Sys.	(4) 405 BME Design Project
(3) BME/Engineering elective	(3) BME/Engineering elective
(3) BME/Engineering elective	(3) BME/Engineering elective
(3) Life Science elective	(3) Life Science elective
(3) General education elective	(3) General education elective
(3) Unrestricted elective	(3) General education elective
18	16

[Revised] B.S. BME Degree Program Requirements

Minimum Degree Requirements for Bachelor of Science in Biomedical Engineering (BSBME)

Credit Hours Required for Graduation: 130

All required First-Year Engineering courses * must be completed with a C- or above for entry into the BME undergraduate program = 30 credits

*No more than 8 credit hours of freshman calculus can be applied towards the BME degree.

Core Biomedical Engineering (BME) Courses (24 credit hours);
BME 20100, 20400, 20500, 20600, 25600, 29000, 30100, 30400, 30500, 30600, 39000

BME Breadth Requirement (43 credit hours):

Core Life Sciences Requirement: BIOL 23000 and two (2) additional Life Science courses† = 9 credits
Core Engineering Requirement: ECE 30100; **IE** 33000(or STAT 51100), **ME** 20000, 27000; and **MSE** 23000 = 15 credits
BME Technical Engineering Electives: Five (5) additional BME or other Engineering courses.†# At most 6 credits at the 300 level; must include at least one 3-credit 400-level BME course; must include at least one 3-credit course chosen from the Quantitative breadth list†. = 15 credits.
Senior Design Capstone Requirements: BME 48800, 48900, 49000 = 4 credits

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Advanced Physics and Math (10 credit hours):
PHYS 24100, **MA** 26100 and (**MA** 26600 or **MA** 26200)

General Education Electives (18 credit hours): Course selections must meet the General Education Program requirements. Refer to "*General Education Program.*"
Includes an ethics elective to be chosen from the Ethics list†.

Unrestricted Electives (5 credit hours): Additional coursework to fulfill the total number of credits required for graduation.

GPA Requirement: A minimum Graduation Index of at least 2.0 is required to qualify for graduation with a BSBME. A minimum BME Major GPA** of at least 2.0 is also required to qualify for graduation with a BSBME.
**Courses included in BME Major GPA: BME 20100, BME 20400, BME 20500, BME 20600, BME 25600, BME 29000, BME 30100, BME 30400, BME 30500, BME 30600, BME 39000, BME 48800, BME 48900, BME 49000, ME 20000, ME 27000, MSE 23000, ECE 30100, & IE 33000 (or STAT 51100).

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† Selected from a list of courses approved by the Biomedical Engineering faculty and maintained by the undergraduate advising office.
# must complete a 400-level BME elective with at least a B- before student can take a BME 500-level course as a technical elective.

[Revised] Suggested Plan of Study - Effective Fall 2011

Credit hours required for graduation: 130

Freshman Year

First Semester	*Second Semester*
(4) MA 16500 Analytical Geom. & Calc. I	(4) MA 16600 Analytical Geom & Calc. II
(4) CHM 11500 General Chemistry	(4) CHM 11600 General Chemistry
(4) PHYS 17200 Modern Mechanics	(3) CS 15900~ Programming Apps for ENGRS
(2) ENGR 13100 Transforming Ideas to Innov I	(2) ENGR 13200 Transforming Ideas to Innov II
(3/4) ENGL 10800/10600 Accelerated / Composition	(3) General Education Elective
17/18	16

Sophomore Year

Third Semester	*Fourth Semester*
(3) BME 20100 Biomolecules: Strct, Funct & Engr Apl	(3) BME 20400 Biomechanics Hard/Soft Tissue
(3) BIOL 23000 Biology of the Living Cell	(3) MSE 23000 Structure & Properties Materials
(1) BME 20500 Biomolec & Cellular Syst Lab	(1) BME 20600 Biomechanics & Biomaterial lab
(1) BME 29000 Frontiers in BME	(3) BME 25600 Physiol Modeling Human Health
(4) MA 26100 Multivariate Calculus	(3) MA 26600 Ordinary Differential Equations
(3)ME 27000 Basic Mechanics I	(3) ME 20000 Thermodynamics I
(3) PHYS 24100 Electricity and Optics	16
18	

Junior Year

Fifth Semester	*Sixth Semester*
(3) BME 30100 Bioelectricity	(2) BME 30600 Biotransport Laboratory
(3) BME 30500 Bioinstrumentation Circuit & Meas Princip	(1) BME 39000 Profes Devlp & Design in BME
(3) BME 30400 Biomedical Transport Fundamentals	(3) ECE 30100 Signals and Systems
(3) BME Technical Elective	(3) IE 33000 Probability and Stats in Engr. II
(3) Gen. Ed. or Ethics Elective (PHIL 28000)	(3) BME Technical Elective
15	(3) Gen. Ed. or Ethics Elective (PHIL 27000)
	15

Senior Year

Seventh Semester	*Eighth Semester*
(1) BME 49000 Professional Elements of Design Lab	(2) BME 48900Senior Design Project Lab*
(1) BME 48800 Preliminary Project Design	(*can be taken in the Fall)
(3) BME Technical Elective#	(3) BME Technical Elective
(3) BME Technical Elective	(3) Life Science Elective
(3) Life Science Elective	(3) General Education Elective
(3) General Education Elective	(3) General Education Elective
(2) Unrestricted Elective or BME 48900*	(3) Unrestricted Elective
16 (*Senior Project Design Lab, can be taken Spring)	17

~CS 15900 is required before junior year and recommended for the first year.
Taken from the list of Quantitative Breadth courses.