BIOMEDE 350: INTRODUCTION TO BIOMEDICAL ENGINEERING DESIGN
WINTER 2014

Bulletin Description:
This course uses problem-based learning to introduce students to biomedical engineering design concepts, tools, and methodologies. Students will work in small groups and use virtual design and computational tools to propose and validate feasible solutions to real-world biomedical engineering problems with industrial and/or clinical relevance.

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Location: **Lectures:** LBME 1121
Computer Lab: LBME 1310 (tentative)

Office Hours: By appointment, as needed.

Credits: 3
This course was recently approved to be a required part of the BME curriculum. However, before that requirement takes effect, the course can be counted towards the "concentration elective" requirements for each of the three concentrations in the BME major.

Course Description:
This course, intended for 3rd-year undergraduates majoring in biomedical engineering, will expose students to key aspects of the process of designing a biomedical device or biotechnology product, and provide them with the technical fundamentals to perform design. What the students learn in this course is foundational to the design experience in the 4th-year of the curriculum (BME 450/451/452).

The primary focus of this class will be a series of problem-based learning (PBL) modules used to provide students with practical experience through "virtual" solutions of biomedical engineering problems and design of biomedical devices and technologies. Students (or perhaps small groups of students) will pose feasible solutions to real-world biomedical problems and perform engineering analyses to substantiate their proposed solutions. These PBL vignettes will be open-ended problems with no single correct answer, but more constrained than typical design problems to reflect the more introductory nature of this course.

The course will rely more on active, experiential learning than on traditional didactic lectures and passive learning. Lecture time will be designed to impart some general knowledge of problem solving and design, present the engineering and physiology background relevant for specific PBL topics, and provide tutorials for relevant software packages commonly used in biomedical engineering. Students will then have dedicated time during the lecture periods to actively use the relevant software packages. Through

the PBL-based design vignettes, students will gain familiarity with three different software packages: **Matlab, SolidWorks, and COMSOL**. Mastery of these packages will only be attained through extensive self-study, and therefore ample time is allocated for independent study.

A midterm examination will test individual students and their knowledge of the various modules and their solution strategies.

Required Textbooks: There are no required textbooks.

Prerequisites: BIOMEDE 211 (Circuits and Systems for BME),
BIOMEDE 221 (Biophysical Chemistry and Thermodynamics)
BIOMEDE 231 (Intro to Biomechanics)
Corequisites: BIOMEDE 241 (Biomedical Engineering Undergraduate Lab)

Software Requirements: The three major software packages that we will use in this course are *Matlab, SolidWorks, and COMSOL.*

Matlab is a mathematics package that provides a high-level programming language, an interactive computing environment, and functions for algorithm development, data analysis/visualization and numeric computation. http://www.mathworks.com/

SolidWorks is a computer-aided design software package widely used in engineering in general, and biomedical industry in particular. http://www.solidworks.com/

COMSOL is a modeling package for the simulation of any physical process you can describe with partial differential equations (PDEs). It features state-of-the-art solvers that address complex problems quickly and accurately, while its intuitive structure is designed to provide ease of use and flexibility. http://www.comsol.com/

If you have no experience or familiarity with these software packages, do not fear – the point of this class is to teach you how to use them and give you the opportunity to become experts in them BEFORE senior design!

All 3 packages are available on CAEN Windows-based computers.

Tentative Lecture Topics (a more detailed schedule will be provided):

1. Introduction to engineering problem solving and algorithms.
2. Design cycle
3. Concept generation and brainstorming.
4. Intellectual property
5. Stakeholder analysis
6. Regulatory basics
7. Business plan development
8. Module #1: MATLAB
9. Module #2: SolidWorks
10. Module #3: COMSOL
11. Relevant background on engineering topics as they relate to our design modules:
    a. Diffusion, morphogen gradients, microscale devices

b. Biomechanics and mechanobiology
c. Biomaterials

The modules this semester will have distinctive emphasis on biochemical, biomaterials, and biomechanics problems, as these are the topics with which your instructor is most familiar. There are no plans for a dedicated bioelectric module at this time.

Course Outcomes:

Upon completion of this course, students should be able to:

1. Define and solve design-oriented problems to gain familiarity with state-of-the-art software packages that are commonly used in engineering design.
2. Formulate feasible design strategies based on model algorithms.
3. Document the problem identification and algorithmic design.
4. Translate algorithms into computational tools.
5. Use computational tools for virtual design, including development, validation, and optimization of prototypes.

Grading Criteria:

Module #1	**10% (MATLAB)**
Assignment 1	5%
Assignment 2	5%
Module #2	**20% (SolidWorks)**
Assignment 3	10%
Assignment 4	10%
Module #3	**15% (COMSOL)**
Assignment 5	15%
Midterm exam	**20%**
Design Report	**35%**
Oral presentation	10%
Written report	25%

Further details will be provided on the content of your assignments and the Design Report (i.e., what you have to hand in and when) as we move along.

Academic Honesty and the Honor Code:

The University of Michigan's College of Engineering Honor Code binds students enrolled in this course. For more details, please log onto the following URL:
http://www.engin.umich.edu/org/ehc/hcode.html

BIOMEDE 350: Introduction to Biomedical Engineering Design

Tentative Lecture Schedule, Version 2

Schedule may change as class progresses. Revised versions will be posted as necessary.

Week	Day	Date	Location	Lecture Topics, Computing Tutorials, and Activities	Deliverables
1	W	1/8/14	LBME 1121	Course overview (syllabus, expectations, grading, etc.) and Introduction to Design	
2	M	1/13/14	LBME 1121	Need Screening and Problem Definition	
	W	1/15/14	LBME 1121	Concept Generation; Ideation and Brainstorming	
3	M	1/20/14	N/A	*No lecture*: MLK, Jr. Day	
	W	1/22/14	LBME 1310	MATLAB: Using differential equation solver	
4	M	1/27/14	N/A	*No formal lecture: Work on MATLAB-based assignment on your own.*	
	W	1/29/14	LBME 1310	MATLAB: Using image processing capabilities	**Assignment #1: Due 1/31/14 at 5 PM**
5	M	2/3/14	LBME 1121	Diffusion, Morphogen Gradients, Microscale Devices	
	W	2/5/14	LBME 1310	SolidWorks tutorial - Part 1	
6	M	2/10/14	LBME 1310	SolidWorks tutorial - Part 2	**Assignment #2: Due 2/10/14 at 5 PM**
	W	2/12/14	N/A	*No formal lecture: Work on Solidworks-based assignment on your own.*	
7	M	2/17/14	LBME 1121	Intellectual Property Basics: Dr. Nadine Wong, Guest Lecturer, Office of Technology Transfer	
	W	2/19/14	LBME 1121	*No formal lecture: Work on Solidworks-based assignment on your own.*	**Assignment #3: Due 2/21/14 at 5 PM**
8	M	2/24/14	LBME 1121	Stakeholder Analysis, Regulatory Basics	
	W	**2/26/14**	**LBME 1121**	**Midterm Exam**	
9	M	3/3/14	N/A	***No Lecture: Spring Break!***	
	W	3/5/14	N/A	***No Lecture: Spring Break!***	
10	M	3/10/14	N/A	Medical Technology Business Models and Prototyping	
	W	3/12/14	LBME 1121	Background Information on Biomechanics and Mechanotransduction	
11	M	3/17/14	LBME 1310	COMSOL tutorial: Part 1	
	W	3/19/14	LBME 1310	COMSOL tutorial: Part 2	**Assignment #4: Due 3/19/14 at 5 PM**
12	M	3/24/14	LBME 1121	Biomaterials	
	W	3/26/14	N/A	*No formal lecture: Work on COMSOL-based assignment on your own*	
13	M	3/31/14	LBME 1121	Business Plan Development	
	W	4/2/14	N/A	*No formal lecture: Work on COMSOL-based assignment on your own*	**Assignment #5: Due 4/4/14 at 5 PM**
14	M	4/7/14	LBME 1121	Case study in medical technology development	
	W	4/9/14	N/A	*No formal lecture: Work on design project on your own*	
15	M	4/14/14	N/A	*No formal lecture: Work on design project on your own*	
	W	4/16/14	LBME 1121	Design Review 1 (Student Presentations)	
16	M	4/21/14	LBME 1121	Design Review 2 (Student Presentations)	**Final Design Report: Due 4/28/14 at 5 PM**