

BME-451: Fundamentals of Biomedical Microdevices Fall 2018

Instructor: Dr. Kee Scholten, kscholte@usc.edu
MCB-464, Office hours by appointment
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Time/Place: Tues/Thurs 9:30am – 10:50am DRB-351

Prerequisites: EE 202L (or concurrent)

Textbook: Biomedical Microsystems (E. Meng), CRC Press, 2010.
Additional reading material may also be posted to course website or handed out in class.

Class Website: <https://blackboard.usc.edu> (follow link to BME 451)

Be sure to change your email to the one you use most frequently as we will send out email messages during the semester using your Blackboard listed email address

Course Learning Outcomes

The main goal is to introduce students to the diverse and highly interdisciplinary field of biomedical microdevices with an emphasis on biomedical microelectromechanical systems (bioMEMS) and microtechnologies. Students will learn the building blocks of these devices, how they are constructed, and the principles governing their operation and performance. Emphasis is placed on learning the fundamental principles of these microdevices so that students can appreciate the technical challenges and opportunities that biomedical microdevices brings to life and medical sciences. Finally, students will be able to engage in hands-on activities featuring fabrication and design of biomedical microdevices.

Learning Objectives and relation to BME Program Outcomes:

After successfully completing this course, you should be able to:

1. Integrate knowledge of life and medical science learned in previous courses to create implementable solutions to microengineering problems at the interface of engineering, medicine, and biology, and independently acquire through new reading, practice exercises, and self-initiated research technical knowledge related to the course content and projects, including emerging applications of biomedical microdevices (outcomes a, f, h, i, j, k)
2. Select appropriate materials for the construction of biomedical microdevices (outcomes a, c, f, k)
3. Develop and design simple layouts and fabrication process flows for created biomedical microdevices (outcomes c, e, f, k)
4. Construct simple microfluidic systems and perform experiments using these devices (outcome b, e, k)
5. Describe different biosensing mechanisms and choose the appropriate method for a particular application (outcomes a, c, k)
6. Function effectively as a part of a group of student engineers working on a multi-week project & document in writing and orally exercises and projects performed individually and as part of a team of student engineers (outcomes d, f, g, j, k)

Relationship of Course to Program Outcomes¹

This course contributes strongly to Program Outcomes a, c, d, e, g, h, i, and k, and moderately to Program Outcomes b, f, and j.

Course Topics and Outline

The course plan below reflects the course goal and objectives. Note that there are more topics than can be covered and special topics are rotated from year to year such that the latter half of the class can be significantly different than in previous years.

The material will be covered in the following tentative order:

Introduction and Overview: Why miniaturization? Dimensions and scaling challenges in bioMEMS

BioMEMS Materials: From silicon to polymers, the need for biocompatibility

Microfabrication for BioMEMS:

- Introduction to micropatterning, micromachining, and micromolding with consideration given to device/system design

- Surface and bulk micromachining, etching and thin film processes

System Integration: Bonding, assembly, packaging, and other microfabrication techniques

Biosignal Transduction Mechanisms:

- Challenges of biosensing, principles: mechanical, thermal, optical, acoustic, electrochemical, conductometric, potentiometric, amperometric

BioSensors: Examples and applications

Cell Manipulation: Governing forces and manipulation strategies

Microfluidics: Introduction, properties of biological fluids in microchannels, devices

Lab-on-a-Chip: Microanalytical systems in chemistry and biology

MEMS Implants and Bioelectric Interfaces: Implantable microelectrodes, shunts, etc.

Microengineering in Biotechnology: PCR, microarray technology, optical detection

Biomedical Microdevice Research at USC: Guest speakers and instructors research

What's next? Frontiers in BioMEMS

- Nanolithography, biomimetic nanodevices, nanotubes

- Commercialized devices, in depth look at specific topics in biomedical microdevices

Assessment

Learners are assessed based on their grades from homework and a course project using the following:

(1) Homework and Laboratory Exercises (60%)

Regular homework sets (~8) will be assigned and are due at the beginning of class on Thursdays. You will have 1-2 weeks to complete the assignments as indicated. Assignments test your understanding of material presented in class and your ability to apply that knowledge to engineering problems. From time to time, you may also be asked to do your own research and discover new material as part of your homework assignment. Some homework problems will be completed in groups. Please bring a physical copy to class (do not use the digital drop box). All derivations must be included with symbols before numbers are "plugged in." Units must accompany numerical results when applicable.

Collaboration is permitted on HW, however copying is not. You may **not** refer to materials from previous offerings of the class (homework, exams, notes, etc.) unless specifically allowed (i.e. final project papers). Collaboration is highly encouraged and includes discussions of concepts, exchange of information, and working together. Each student is responsible for individually preparing and fully understanding the work they submit. **Late homework is not accepted.** Legitimate medical excuses and emergency circumstances are the only exceptions.

Hands-on activities involving the design and fabrication of biomedical microdevices are integrated into the homework

(2) Final Project (40%) = Milestones (10%) + Paper (15%) + Presentations (15%)

Students will work in teams of 2 or 3 (depending on class size) to research a special topic of their choice in bioMEMS. A list of possible topics will be provided. Groups may also choose a topic of their own with instructor approval.

Final project milestones will be assigned and be used in the calculation of your final project grade (each point earned typically equates to one percentage point of your overall grade).

A jointly written final paper reviewing the selected topic will account for 15% of the final grade.

Final papers are due on **Nov 21** and will be checked using Turnitin. *There is a no-tolerance policy on plagiarism; any plagiarism will result in a "zero" grade for the final paper.*

The remaining 15% of the grade will be determined by the joint presentation prepared using Microsoft Powerpoint or similar software. Presentations will be given to the rest of the class on **Dec 7**. There will be a sign-up for presentation times.

There is no final exam for this class – instead we will use that time for the final presentations.

(3) How to get help:

The teaching assistant will hold office hours every week. The instructor will hold office hours by appointment. Also, the course uses the "Discussion Board" feature on Blackboard for posting questions on the course and homework. You are encouraged to use this tool as much as possible. Both the instructor and teaching assistant will regularly post responses that are available to the entire class. Students are also encouraged to post responses. Anonymous posting is enabled. Please plan ahead when posting questions related to homework; there is no guarantee that questions posted the night before the HW due date will be answered.

(4) Notes on Grading:

Final project grades will be determined by considering individual and team contributions. Final course grades are first computed as percentages and then curved.

(5) Notes on Cheating:

The policy is simple: Just don't do it! There is a no-tolerance policy on cheating. In this class, cheating is primarily copying HW from other students, current or past.

Other MEMS Classes

This introductory course will prepare students for advanced MEMS courses including BME-551, EE-607, and EE-608L. (AME-455, 537; BME-551; EE-438L, 480, 504L, 507, 508, 607, 608L; MASC-438L, 439, 512, 514L, 534 are also recommended for those interested in pursuing a MEMS career) There are new courses constantly being introduced and students are encouraged to look beyond this list.

Additional MEMS References

The following text may be useful for finding supplemental information. There are also many other texts not listed here but available in our USC libraries that may be useful for your projects and homework. Nguyen N.T. & Wereley S. Fundamentals and Applications of Microfluidics, 2nd edition, Artech House, 2006.

Madou, M. Fundamentals of Microfabrication: the science of miniaturization, 2nd edition, CRC Press, 2002.

Saliterman, S. Fundamentals of BioMEMS and Medical Microdevices, Wiley/SPIE, 2006.

Kovacs, G.T.A. Micromachined Transducers Sourcebook, McGraw Hill, 1998.

Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to the TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. – 5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Disclaimer

Taking this course **will not** guarantee or prepare you for a MEMS job in industry. MEMS is a tool and not a replacement for firm grounding in engineering fundamentals.

¹ BME Program Outcomes

Students who successfully complete the USC BME program should be able to demonstrate:

- a. an ability to apply knowledge of mathematics, sciences, and engineering
- b. an ability to design and conduct experiments, as well as to analyze and interpret data
- c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- d. an ability to function on multidisciplinary teams
- e. an ability to identify, formulate, and solve engineering problems
- f. an understanding of professional and ethical responsibility
- g. an ability to communicate effectively
- h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- i. a recognition of the need for, and ability to engage in life-long learning
- j. a knowledge of contemporary issues
- k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice