



## **AME 455: Introduction to MEMS**

**Units: 3**

**Term: Spring 2020**

**Day-Time: M/W-9:30-10:50am**

**Section: 28861R**

**Location: VPDLL101**

**Instructor: Hangbo Zhao**

**Office: TBD**

**Office Hours: Thu 2-4pm, or by appointment**

**Contact Info: [hangbozh@usc.edu](mailto:hangbozh@usc.edu)**

**Teaching Assistant: TBD**

**Office: TBD**

**Hours: TBD**

**Contact Info: TBD**

## Course Description

This course introduces students to the multi-disciplinary, and exciting field of microelectromechanical systems (MEMS). Topics covered in this course include scaling laws involved in MEMS, material properties, structural mechanics, basic sensing and actuation principles, fabrication and device integration, modeling tools, typical MEMS devices and applications, and latest developments in the field.

## Learning Objectives

This course aims at providing a comprehensive understanding of science and technology of MEMS, with an emphasis on the underlying mechanics, structures, electrostatics, and dynamics in the design and fabrication of MEMS for real-world applications. After completing this course, students should be able to:

- (a) Understand fundamental principles of sensing and actuation and corresponding scaling laws in MEMS
- (b) Gain a comprehensive perspective of various fabrication processes and materials used in microfabrication
- (c) Understand the principle, design, and fabrication techniques of leading exemplary devices in the MEMS industry
- (d) Design basic MEMS devices using relevant mechanical/electrical/fluidic engineering principles

**Prerequisite(s):** background in undergraduate level solid mechanics and fluid mechanics is necessary.

## Course Notes

Letter grade. Copies of lecture slides and other class information will be provided.

## Technological Proficiency and Hardware/Software Required

N/A.

## Required Readings and Supplementary Materials

There is no required textbook for this course. The following textbooks are helpful resources:

- “Foundations of MEMS”, Chang Liu
- “Microsystem Design”, Stephen D. Senturia
- “Fundamental of Microfabrication”, Marc Madou
- “An Introduction to Microelectromechanical Systems Engineering”, Nadim Maluf
- “MEMS Handbook”, Mohamed Gad-el-Hak

## Grading Breakdown

Homework	35%
Midterm	35% (in class, closed book)
Final project	30%

## Assignment Submission Policy

- There will be a total of 9 homework assignments.
- Homework needs to be submitted as a hard copy (printout) in class.
- No late homework submission will be accepted.
- Discussion of homework assignments with your classmates is encouraged, but each student is required to submit their own solutions.
- Final project: students will form small teams to study and present on a pre-assigned topic. More details will be announced later.

## Tentative Course Schedule

Date	Topics	HW assigned	Deliverable/ Due dates
Mon 1/13	Course overview, introduction of MEMS		
Wed 1/15	Scaling laws: I	HW 1	
Mon 1/20	MLK Day, no lecture		
Wed 1/22	Scaling laws: II		
Mon 1/27	Scaling laws: III	HW 2	HW 1 due
Wed 1/29	Mechanics of materials for MEMS: I		
Mon 2/3	Mechanics of materials for MEMS: II	HW 3	HW 2 due
Wed 2/5	Beam mechanics: I		
Mon 2/10	Beam mechanics: II	HW 4	HW 3 due
Wed 2/12	Dynamics		
Mon 2/17	President's Day, no lecture		
Wed 2/19	Electrostatic sensing and actuation: I	HW 5	HW 4 due
Mon 2/24	Electrostatic sensing and actuation: II		
Wed 2/26	Capacitive and resistive sensing and actuation	HW 6	HW 5 due
Mon 3/2	Piezoelectric sensing and actuation		
Wed 3/4	Heat transfer/thermal sensing and actuation		
Mon 3/9	<b>Midterm exam</b>		HW 6 due
Wed 3/11	Microfluidics: I	HW 7	
Mon 3/16	Spring recess, no lecture		
Wed 3/18			
Mon 3/23	Microfluidics: II		
Wed 3/25	Fabrication methods: I	HW 8	HW 7 due
Mon 3/30	Fabrication methods: II		
Wed 4/1	Fabrication methods: III		
Mon 4/6	Circuits, noise, device packaging	HW 9	HW 8 due
Wed 4/8	Examples of MEMS/NEMS: design principles: I		
Mon 4/13	Examples of MEMS/NEMS: design principles: II		HW 9 due
Wed 4/15	Modeling tools		
Mon 4/20	Case study: optical and power MEMS		
Wed 4/22	Case study: bioMEMS		
Mon 4/27	Case study: emerging MEMS technologies		
Wed 4/29	<b>Final project presentation</b>		

## Statement on Academic Conduct and Support Systems

### Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, “Behavior Violating University Standards” [policy.usc.edu/scampus-part-b](http://policy.usc.edu/scampus-part-b). Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct>.

### Support Systems:

*Student Counseling Services (SCS) – (213) 740-7711 – 24/7 on call*

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. [engemannshc.usc.edu/counseling](http://engemannshc.usc.edu/counseling)

*National Suicide Prevention Lifeline – 1 (800) 273-8255*

Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. [www.suicidepreventionlifeline.org](http://www.suicidepreventionlifeline.org)

*Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call*

Free and confidential therapy services, workshops, and training for situations related to gender-based harm. [engemannshc.usc.edu/rsvp](http://engemannshc.usc.edu/rsvp)

*Sexual Assault Resource Center*

For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: [sarc.usc.edu](http://sarc.usc.edu)

*Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086*

Works with faculty, staff, visitors, applicants, and students around issues of protected class. [equity.usc.edu](http://equity.usc.edu)

*Bias Assessment Response and Support*

Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. [studentaffairs.usc.edu/bias-assessment-response-support](http://studentaffairs.usc.edu/bias-assessment-response-support)

*The Office of Disability Services and Programs*

Provides certification for students with disabilities and helps arrange relevant accommodations. [dsp.usc.edu](http://dsp.usc.edu)

*Student Support and Advocacy – (213) 821-4710*

Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. [studentaffairs.usc.edu/ssa](http://studentaffairs.usc.edu/ssa)

*Diversity at USC*

Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. [diversity.usc.edu](http://diversity.usc.edu)

*USC Emergency Information*

Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. [emergency.usc.edu](http://emergency.usc.edu)

*USC Department of Public Safety – UPC: (213) 740-4321 – HSC: (323) 442-1000 – 24-hour emergency or to report a crime.*

Provides overall safety to USC community. [dps.usc.edu](http://dps.usc.edu)