Principles of MEMS Transducers

EEL 5225

Class Periods: T-TR, Periods 7-8 (1:55 pm – 3:50 pm)

Location: LAR 0239

Academic Term: Fall 2021

Instructor:

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- Office Phone Number: 352-846-3017
- Office Hours: Thursday, 9:30 am – 10:30 am, LAR 217

Course Description

This course introduces the principles of micro-electro-mechanical-systems (MEMS). The course focuses on the principle physics governing multi-domain transduction mechanisms, and introduces integrated transducers for creation of MEMS. The course also provides an overview of design, fabrication, and characterization of MEMS for various applications in sensing and actuation, frequency control, and signal processing. Credits: 3.

Course Pre-Requisites / Co-Requisites

Differential and integral calculus, introductory statics and dynamics, introductory circuit theory, semiconductor theory (e.g., EEL 3396), introductory microfabrication (e.g., EEE4331), or with permission of the instructor.

Course Objectives

To introduce MEMS transducers through exploration of sensing/ actuation mechanisms, materials, and microfabrication technologies and to model multi-energy-domain systems using lumped-element models.

Materials and Supply Fees

None.

Required Textbooks and Software

The course notes are developed by the instructor.

- Title: **Microsystem Design**
- Author: Stephen D. Senturia
- Publisher: Springer, 2001 (or later editions)
- ISBN number: 978-0792372462

Software: COMSOL Multiphysics (available through)

Recommended Materials

Books:

V. Kaajakari, *Practical MEMS*, Small Gear Publishing, 2009

D. Zielke, *MEMS: Micro-Electro-Mechanical Systems*, Independently Published, 2021

Informative Websites:

www.kaajakari.net/~ville/research/tutorials/tutorials.shtml (MEMS tutorials)

Course Schedule

Week	Topic	Due Dates (estimated)
1	Course overview, Intro to MEMS and applications, approaches to MEMS design	
2	Micro-fabrication and integration of MEMS	HW1
3	Analytical modeling of MEMS (principles and dynamics)	HW2
4	Integrated transducers (Capacitive and piezoelectric)	
5	Integrated transducers (Thermal, piezoresistive and magnetic)	HW3
6	Resonant MEMS	
7	Analytical modeling of MEMS with integrated transducers	HW4
8	Numerical modeling of MEMS (COMSOL: introduction)	
9	Numerical modeling of MEMS (COMSOL: hands-on)	HW5
10	Micro-fabrication of integrated transducers	
11	Applications of MEMS: Sensors and actuators – Part 1	HW5
12	Applications of MEMS: Sensors and actuators – Part 2	
13	Applications of MEMS: Oscillators and filters	HW7
14	Implementation of MEMS: Process design and tape-out	
15	Implementation of MEMS: Characterization	HW8

Attendance Policy, Class Expectations, and Make-Up Policy

Students are expected to attend class lectures and arrive on time. Please turn off cell-phones, pagers, and other electronic devices.

Evaluation of Grades

Assignment	Per. of Final Grade
Homework Sets (8)	20%
Midterm Exam	20%
Final Exam	25%
Presentation	35%
TOTAL	100%

Grading Policy

Percent	Grade	Grade Points
90 - 100	A	4.00
87 - 89	A-	3.67
83 - 86	B+	3.33
80 - 82	B	3.00
77 - 79	B-	2.67
73 - 76	C+	2.33
70 - 72	C	2.00
67 - 69	C-	1.67
63 - 66	D+	1.33
60 - 62	D	1.00
57 - 59	D-	0.67
0 - 56	E	0.00

In order to graduate, graduate students must have an overall GPA and a major GPA of 3.0 or better (B or better). Note: A "B-" average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement.

More information on UF grading policy may be found at:
http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020

Students Requiring Accommodations
Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation
Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at https://evaluations.ufl.edu/evals. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at https://evaluations.ufl.edu/results/.

University Honesty Policy
UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Software Use
All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Campus Resources:

Health and Wellness

U Matter, We Care:
If you or a friend is in distress, please contact umatter@ufl.edu or 352-392-1575 so that a team member can reach out to the student.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.