

Design of MEMS Transducers EEE 6465 ("MEMS 2")

Class Periods: Monday, Wednesday, Friday 9:35 to 10:25am
Location: Online
Academic Term: Spring 2021

Instructor:

Philip Feng

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Office Phone Number: (352) 294-6320

Office Hours: TBD + Appointment

Teaching Assistant/Peer Mentor/Supervised Teaching Student:

None

Course Description

(3 credits): Design and modeling of micro/nano devices and systems, particularly MEMS/NEMS transducers in the context of physical, technological, and economic constraints, as well as their mainstream and emerging applications.

Course Pre-Requisites / Co-Requisites

An understanding of microfabrication processes or permission from the instructor.

Course Objectives

Teach how to analyze MEMS/NEMS transducers and to explore design tradeoffs, device/circuit/system issues, device- and system-level performance, noise, scaling effects, and engineering metrics and figures of merit (FoM) for benchmarking and applications.

Materials and Supply Fees

None

Required Textbooks and Software

1. S. D. Senturia, *Microsystem Design*, Kluwer Academic Publishers: Boston, 2001.
2. MATLAB, MathCAD, Excel, or equivalent may be needed for homework.
3. Finite-Element software (*e.g.*, COMSOL, ANSYS, etc.).

Recommended Materials

1. Books:
 - G. Kovacs, *Micromachined Transducers Sourcebook*, McGraw-Hill, 1998
 - M. Madou, *Fundamentals of Microfabrication*, 2nd Ed., CRC Press, 2002.
 - R.C. Jaeger, *Introduction to Microelectronic Fabrication*, 2nd ed., Prentice Hall, 2002.
 - J. A. Pelesko and D. H. Bernstein, *Modeling of MEMS and NEMS*, Chapman & Hall/CRC, 2003.
 - T. B. Jones and N. G. Nenadic, *Electromechanics and MEMS*, Cambridge University Press, 2013.
2. Primary Journals:
 - *J. Microelectromechanical Systems* (IEEE/ASME)
 - *J. Micromechanics and Microengineering* (IoP)
 - *Sensors and Actuators* (Elsevier)
 - *Microsystems and Nanoengineering* (Nature)
3. Major Conferences:

- Transducers 'XX, Int. Conf. on Solid-State Sensors and Actuators, odd-numbered years since 1983, proceedings available from IEEE (US meetings), Elsevier (European meetings), IEE Japan (Japanese meetings).
 - IEEE MEMS 'XX, annual since 1989, proceedings available from IEEE.
 - IEEE Sensors 'XX, annual since 2002, proceedings available from IEEE.
 - Hilton Head 'XX, Solid-State Sensors and Actuators Workshop, Hilton Head, SC, even-numbered years since 1984, proceedings available from Transducer Research Foundation.
 - Eurosensors 'XX, annual since 1987, proceedings published in special issues of Sensors and Actuators.
 - Napa 'XX, Topical meetings, Napa, CA, held in odd-numbered years annual since 2011.
 - ... plus many more area-specific conferences, e.g. PowerMEMS, μ TAS, Optical MEMS, BioMedical, etc.
4. Informative Websites:
- www.memsjournal.com (Premiere online journal of MEMS-related news)
 - www.semi.org/en/msig-information-hub (MEMS & Sensors Industry Group)
 - www.memsnet.org (General MEMS and Nanotechnology Information)
 - www.mems-exchange.org (MEMS Exchange – MEMS Foundry Services)

Course Schedule

Week	Topics	HW (estimated)
Week 1:	Introduction & Review of "MEMS 1"	
Week 2:	Mechanical Systems	HW 1
Week 3:	IEEE MEMS 2021	
Week 4:	Thermal / Fluidic Systems	HW 2
Week 5:	Acoustic Systems	
Week 6:	Optimization	HW 3
Week 7:	Finite Element Modeling	Midterm 1
Week 8:	Interface Electronics / Optics	HW 4
Week 9:	Interface Electronics / Optics	
Week 10:	Noise	HW 5
Week 11:	Device Manufacturing & System Integration	
Week 12:	Characterization & Measurement (Electrical, Optical)	Midterm 2
Week 13:	Design Project	
Week 14:	Design Project	

Online Course Recording

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

Attendance Policy, Class Expectations, and Make-Up Policy

This class will be presented online using Zoom and requires access to a working webcam and stable internet connection. We prefer that students keep their cameras on during the class so that we can see you as we would during normal face-to-face classes. Studies show that if we can see each other's faces then we will have more engagement, more student success, and more faculty success. However, this is not a requirement. We understand if on certain days you can't have your camera on due to internet bandwidth limitations, other family members, health issues, etc.

Excused absences must be in compliance with university policies in the Graduate Catalog (<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance>) and require appropriate documentation.

Evaluation of Grades

****Assessment Guidance from the ECE Graduate Committee:** Course evaluation components should include:

1. At least one component that individually evaluates each student's understanding of course material and ability to apply concepts.
2. At least one evaluation activity that takes place in class.
3. When a project is involved, evaluation rubrics should be explicitly stated.
4. When team work is expected, individual student contribution verification method should be explicitly stated.

If an in-class exam is administered then 1 and 2 are fulfilled. In the case of a project, a project report that is graded per the stated evaluation rubrics and states which work was done by each student in the project team will address both 3 and 4.

Evaluation of Grades

Assignment	Percentage of Final Grade
Homework Sets	20%
Midterm Exam 1	20%
Midterm Exam 2	20%
Design Project	40%
Total:	100%

Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-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.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students 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.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing

staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

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 Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

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 support, 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://care.dso.ufl.edu>.

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