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North Carolina State University  
Department of Mechanical and Aerospace Engineering

**MAE 536: Micro and Nano Electromechanical Systems**  
Fall 2024

**Instructor:** Prof. Yong Zhu, office: EB3-3238, phone: 919-513-7735, Email: yzhu7@ncsu.edu

**Lectures:** TTh 10:15-11:30AM, Engineering Building 3 – 2220

**Office Hours:** T 1:00-2:00 PM (virtual), Meeting ID: 964 1299 0920, Passcode: 256839, [meeting link](#)

T 2:00-3:00PM (in person), Engineering Building 3 – 3238

**Website:** Moodle

**Engineering online:** <https://www.engineeringonline.ncsu.edu/course/mae-536-micro-nano-electromechanical-systems/>

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**Objectives:**

This course is designed for students who wish to learn fundamentals and applications of micro/nano sensors and actuators. The course focuses on MEMS/NEMS design, micro-fabrication techniques, and case studies of typical MEMS devices. It also covers the recent progress in nanomaterials and NEMS device development.

**Student Learning Outcomes:**

By the end of the course, the students will be able to:

- Familiarize with the fundamentals and applications of micro/nano systems.
- Understand the basic actuation and sensing principles.
- Apply commercial software for design and simulation of MEMS/NEMS devices.
- Design simple MEMS/NEMS devices for relevant applications
- Realize device design using micro/nano-fabrication techniques.

**Textbook:**

- “Foundations of MEMS,” C. Liu, Prentice Hall, 2011, 2<sup>nd</sup> edition, ASIN: B005C4Z51S (recommended but not required).

*Reference books* (available in the library)

- “Microsystem Design,” S. D. Senturia, Kluwer, 2001, ISBN: 0792372468 (e-book available).
- "Micromachined Transducers Sourcebook," G.T.A. Kovacs, McGraw Hill, 1998, ISBN: 0071164626.
- "Fundamental of Microfabrication," Marc Madou, CRC Press, 2002, ISBN: 0849308267.

### Course Schedule and Outline:

1. 8/20 Topic 1 - Introduction (lecture 1)
2. 8/22 Topic 2 - Scaling laws and overview of microfabrication (lecture 2)
3. 8/27 – 8/29 Topic 3 - Review of electrical and mechanical concepts (lectures 3-4)
4. 9/3 **Labor Day (no class)**
5. 9/5 – 9/10 Topic 4 - Electrostatic sensing and actuation (lectures 5-6)
6. 9/12 – 9/17 Topic 5 - Piezoresistive sensing (lectures 7-8)
7. 9/19 – 9/24 Topic 6 - Piezoelectric sensing and actuation (lectures 9-10)
8. 9/26 – 10/1 Topic 7- Thermal actuation and sensing (lectures 11-12)
9. 10/3 **Midterm #1 (in class)**
10. 10/8 Topic 8 - Magnetic actuation (lecture 13)
11. 10/10 Project overview / demonstration of MEMS simulations (lecture 14)
12. 10/15 **Fall Break (no class)**
13. 10/17 – 10/22 Topic 9 - Bulk micromachining (lectures 15-16)
14. 10/24 Topic 10a - Surface micromachining (lectures 17)
15. 10/29 Guest lecture on unconventional nanofabrication
16. 10/31 Tour of NCSU Nanofabrication Facility
17. 11/5 – 11/7 Topic 10b - Surface micromachining (lectures 18-19)
18. **Midterm #2 (take home)**
19. 11/12 Topic 11 - Mechanical behavior of thin films (lecture 20)
20. 11/14 Topic 12 – Microfluidics (lecture 21)
21. 11/19 Topic 13- Nanomaterials and devices (lectures 22)
22. 11/21 Topic 14 - Nanomaterial-enabled flexible electronics (lecture 23)
23. 11/28 **Thanksgiving Holiday (no class)**
24. 11/26, 12/3 Final presentations

*Note: Midterm 1 will be administrated by the individual proctors for DE students. It will be open book, open notes, but no computer/internet access.*

<b>Grading:</b>	Midterm #1	30%	Midterm #2	30%
	Final project	30%	Homework	10%

**Final Project:** A small-group project based on paper review. Term paper and presentation are required. Potential topics will be suggested. More instructions will be provided later.

- 1-page abstract per team due by Oct. 22
- Term paper and powerpoint (electronic files) due by Nov. 25 midnight
- Powerpoint presentation on Nov. 26 and Dec. 3 in class
- Requirements on term paper: single space, margin (1"×1"), font size 12.

### Related Journals

- Journal of Microelectromechanical Systems, “JMEMS”
- Journal of Micromechanics and Microengineering
- Sensors and Actuators
- Nano Letters
- ACS Nano

- Nature Nanotechnology

**Policy on Absences:**

Missed exams need to be justified by the student with written corroboration (doctor's note or similar).

**Students with Disabilities:**

Reasonable accommodations will be made for students with verifiable disabilities.

In order to take advantage of available accommodations, students must register with the Disability Services for Students. For more information on NC State's policy on working with students with disabilities, please visit: <http://www.ncsu.edu/dso/>

**Note:**

This syllabus is not a contract and can be altered at any point with advanced notice to accommodate the educational goals of the course.