

**MENG 5340/4350 – Micro Electro Mechanical Systems (MEMS)**

**Course Syllabus**

Semester / Year	Spring / 2020
Catalog Description	This course introduces the students to principles, modeling, interfacing and signal conditioning of micro electro mechanical systems (MEMS) such as motion sensors and actuators. It also covers basic electronic devices, MEMS resonators, embedded microprocessor systems and control, power transfer components and mechanism design. The course provides knowledge in the analysis and design of hardware-in-the-loop through simulation and rapid prototyping of real-time closed-loop computer control of electromechanical systems.
Prerequisites	ENGR 2302 Dynamics, MATH 3305 or Graduate student standing
Instructor name	Dr. A. Ibrahim
Contact info	Email: <a href="mailto:aibrahim@uttyler.edu">aibrahim@uttyler.edu</a> Office: RBN 3008
Class Type / Location	Main Campus: face-to-face: RBN 3039 HEC: Zoom: Ctr 0A217
Class Time	<a href="#">Tuesday 5:00 pm – 7:45 pm</a>
Office Hours	<a href="#">Tuesdays/Thursday 10:30 am -12:00 pm</a>
Credits	3 credits
Required Textbook	MEMS Linear and Nonlinear Statics and Dynamics, Younis, Mohammad I., Springer, New York, 2011.
Additional requirements	Programming skills with MATLAB or Mathematica
Evaluation Method	<b>Assignments</b> 30%, <b>Project</b> 35% <b>Final Exam</b> 35%
Grading Policy / Scale	Letter grades: 90-100: A, 80-89: B, 70-79: C, 60-69:D, 0-59: F
Important events / dates	Project Abstract is due on: <b>TBD</b> Exam date: As per the schedule released by the University
Attendance / Makeup	Attendance is required / No makeup
Course Learning Objectives / ABET & PEOs relation	By the end of this course, the student should be able to: 1. Describe MEMS and their related design components. 2. Analyze nonlinear dynamic responses of MEMS devices. 3. Design MEMS resonators and analyze their static and dynamic behaviors. 4. Apply analytical and numerical techniques to model and simulate MEMS, considering nonlinear multi-physics interaction and actuation forces.

	5. Conduct a major project leading to a draft of a publishable level paper.
Tentative Topics	1. Introduction to MEMS and their modeling challenges laws of motion. 2. Sensing and Actuation in MEMS. 3. Elements of Lumped-Parameter Modeling in MEMS. 4. Introduction to Nonlinear Dynamics. 5. Continuous Systems: Microbeams.

### **Assignments:**

- A **group of students** (no more than two) can submit one copy of the homework.
- All assignments must be submitted in the due date as single scanned file in pdf format.  
**Phone pictures are not accepted.**
- Late HWs will be penalized 20% for each day of delay.

### **Course Project:**

- Projects can be done **individually** or in **groups of two**. Group projects are encouraged, but contribution of each person must be specified.
- The topics of the project should be about investigating the static or dynamic behavior of a MEMS device of your choice. It can be also a new idea of a MEMS device of improved performance or desired characteristics. Examples (suggested) of topics:
  - MEMS Sensors for human fall detection/prevention.
  - MEMS microphones and comparison with classical microphones.
  - MEMS devices based on Graphene or Carbon Nano Tubes CNTs.
  - RF MEMS Switches and their impact (bouncing) with the substrate.
  - MEMS energy harvesters.
- It is recommended to **consult with me** on the topic and your plans.
- **An abstract of the project is due on TBD.**
- **The abstract should include at least one schematic for the proposed design.**
- The report should be written using your own words only and following the ME writing report guide. All reports will be checked for plagiarism. Direct copying from any paper, web, or other sources is prohibited and will result in a **zero grade**.
- A report in the form of a research paper (10-15 pages) is **due before the last week of the semester**.
- The report should be written in a Journal paper format. It shall include a literature summary about the topic, section about the used model, simulation results and comparisons with literature results/ experiments, summary and conclusions, and recommendations (research ideas) for future works.

- Students will present their project in the last week of the classes.
- All codes used for generating the reported results should be submitted and .

## **Outline**

### **1-Introduction to MEMS and Their Modeling Challenges**

### **2-Refresher on Linear Vibrations**

- Free Vibration of Single-Degree-of-Freedom Systems
- Forced Harmonic Excitation of Single-Degree-of-Freedom Systems
- Vibrating MEMS Gyroscopes
- Base Excitations of SDOF Systems and Accelerometers Principles
- Vibrations of Two-Degree-of-Freedom Systems
- Numerical Integration
- MEMS Band-Pass Filters

### **3- Sensing and Actuation in MEMS**

- Electrothermal Actuation
- Piezoelectric Actuation and Detection
- Electromagnetic and Magnetic Actuation
- Piezoresistive Detection
- Electrostatic Actuation and Detection (simple parallel-plate, comb-drive, torsional mirrors)
- Resonant Sensors

### **4-Elements of Lumped-Parameter Modeling in MEMS**

- Stiffness of Microstructures
- Spring-Mass Models
  - Damping in MEMS (focus mainly on squeeze film damping and some gas fundamentals)

### **5-Introduction to Nonlinear Dynamics**

- Nondimensionalization
- Fixed Points and Linearization
- Bifurcations of Fixed Points
- Phase Portraits
- Step-Input Actuation of Capacitive RF Switches
- Dynamics of Torsional Actuators and Micromirrors
- Nonlinear Oscillations

### **6-Continuous Systems: Microbeams**

- Equation of Motion and Boundary Conditions
- Static Issues (residual stresses, non-ideal boundaries, buckling)

- Natural Frequencies and Mode shapes
- Forced Vibration and Modal Analysis

## **University Policies:**

### **UT Tyler Honor Code**

Every member of the UT Tyler community joins together to embrace: Honor and integrity that will not allow me to lie, cheat, or steal, nor to accept the actions of those who do.

### **Students Rights and Responsibilities**

To know and understand the policies that affect your rights and responsibilities as a student at UT Tyler, please follow this link: <http://www.utttyler.edu/wellness/rightsresponsibilities.php>

### **Campus Carry**

We respect the right and privacy of students 21 and over who are duly licensed to carry concealed weapons in this class. License holders are expected to behave responsibly and keep a handgun secure and concealed. More information is available at <http://www.utttyler.edu/about/campus-carry/index.php>

### **UT Tyler a Tobacco-Free University**

All forms of tobacco will not be permitted on the UT Tyler main campus, branch campuses, and any property owned by UT Tyler. This applies to all members of the University community, including students, faculty, staff, University affiliates, contractors, and visitors.

Forms of tobacco not permitted include cigarettes, cigars, pipes, water pipes (hookah), bidis, kreteks, electronic cigarettes, smokeless

tobacco, snuff, chewing tobacco, and all other tobacco products.

There are several cessation programs available to students looking to quit smoking, including counseling, quitlines, and group support.

For more information on cessation programs please visit [www.utttyler.edu/tobacco-free](http://www.utttyler.edu/tobacco-free).

### **Grade Replacement/Forgiveness and Census Date Policies**

Students repeating a course for grade forgiveness (grade replacement) must file a Grade Replacement Contract with the Enrollment Services Center (ADM 230) on or before the Census Date of the semester in which the course will be repeated. Grade Replacement Contracts are available in the Enrollment Services Center or at <http://www.utttyler.edu/registrar>. Each semester's Census Date can be found on the Contract itself, on the Academic Calendar, or in the information pamphlets published each semester by the Office of the Registrar.

Failure to file a Grade Replacement Contract will result in both the original and repeated grade being used to calculate your overall grade point average. Undergraduates are eligible to exercise grade replacement for only three course repeats during their career at UT Tyler; graduates are eligible for two grade replacements. Full policy details are printed on each Grade Replacement Contract.

The Census Date is the deadline for many forms and enrollment actions of which students need to be aware. These include:

- Submitting Grade Replacement Contracts, Transient Forms, requests to withhold directory information, approvals for taking courses as Audit, Pass/Fail or Credit/No Credit.
- Receiving 100% refunds for partial withdrawals. (There is no refund for these after the Census Date)
- Schedule adjustments (section changes, adding a new class, dropping without a "W" grade)
- Being reinstated or re-enrolled in classes after being dropped for non-payment
- Completing the process for tuition exemptions or waivers through Financial Aid

### **State-Mandated Course Drop Policy**

Texas law prohibits a student who began college for the first time in Fall 2007 or thereafter from dropping more than six courses during their entire undergraduate career. This includes courses dropped at another 2-year or 4-year Texas public college or university. For purposes of this rule, a dropped course is any course that is dropped after the census date (See Academic Calendar for the specific date).

Exceptions to the 6-drop rule may be found in the catalog. Petitions for exemptions must be submitted to the Enrollment Services Center and must be accompanied by documentation of the extenuating circumstance. Please contact the Enrollment Services Center if you have any questions.

### **Disability/Accessibility Services**

In accordance with Section 504 of the Rehabilitation Act, Americans with Disabilities Act (ADA) and the ADA Amendments Act (ADAAA) the University of Texas at Tyler offers accommodations to students with learning, physical and/or psychological disabilities. If you have a disability, including a non-visible diagnosis such as a learning disorder, chronic illness, TBI, PTSD, ADHD, or you have a history of modifications or accommodations in a previous educational environment, you are encouraged to visit <https://hood.accessiblelearning.com/UTTyler> and fill out the New Student application. The Student Accessibility and Resources (SAR) office will contact you when your application has been submitted and an appointment with Cynthia Lowery, Assistant Director of Student Services/ADA Coordinator. For more information, including filling out an application for services, please visit the SAR webpage at <http://www.uttyler.edu/disabilityservices>, the SAR office located in the University Center, # 3150 or call 903.566.7079.

### **Student Absence due to Religious Observance**

Students who anticipate being absent from class due to a religious observance are requested to inform the instructor of such absences by the second class meeting of the semester.

### **Student Absence for University-Sponsored Events and Activities**

If you intend to be absent for a university-sponsored event or activity, you (or the event sponsor) must notify the instructor at least two weeks prior to the date of the planned absence. At that time the instructor will set a date and time when make-up assignments will be completed.

### **Social Security and FERPA Statement**

It is the policy of The University of Texas at Tyler to protect the confidential nature of social security numbers. The University has changed its computer programming so that all students have an identification number. The electronic transmission of grades (e.g., via e-mail) risks violation of the Family Educational Rights and Privacy Act; grades will not be transmitted electronically.

### **Emergency Exits and Evacuation**

Everyone is required to exit the building when a fire alarm goes off. Follow your instructor's directions regarding the appropriate exit. If you require assistance during an evacuation, inform your instructor in the first week of class. Do not re-enter the building unless given permission by University Police, Fire department, or Fire Prevention Services.

### **Student Standards of Academic Conduct**

Disciplinary proceedings may be initiated against any student who engages in scholastic dishonesty, including, but not limited to, cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts.

i. "Cheating" includes, but is not limited to:

- copying from another student's test paper;
- using, during a test, materials not authorized by the person giving the test;
- failure to comply with instructions given by the person administering the test;

- possession during a test of materials which are not authorized by the person giving the test, such as class notes or specifically designed “crib notes”. The presence of textbooks constitutes a violation if they have been specifically prohibited by the person administering the test;
  - using, buying, stealing, transporting, or soliciting in whole or part the contents of an unadministered test, test key, homework solution, or computer program;
  - collaborating with or seeking aid from another student during a test or other assignment without authority;
  - discussing the contents of an examination with another student who will take the examination;
  - divulging the contents of an examination, for the purpose of preserving questions for use by another, when the instructors has designated that the examination is not to be removed from the examination room or not to be returned or to be kept by the student;
  - substituting for another person, or permitting another person to substitute for oneself to take a course, a test, or any course-related assignment;
  - paying or offering money or other valuable thing to, or coercing another person to obtain an unadministered test, test key, homework solution, or computer program or information about an unadministered test, test key, home solution or computer program;
  - falsifying research data, laboratory reports, and/or other academic work offered for credit;
  - taking, keeping, misplacing, or damaging the property of The University of Texas at Tyler, or of another, if the student knows or reasonably should know that an unfair academic advantage would be gained by such conduct; and
  - misrepresenting facts, including providing false grades or resumes, for the purpose of obtaining an academic or financial benefit or injuring another student academically or financially.
- ii. “Plagiarism” includes, but is not limited to, the appropriation, buying, receiving as a gift, or obtaining by any means another’s work and the submission of it as one’s own academic work offered for credit.
- iii. “Collusion” includes, but is not limited to, the unauthorized collaboration with another person in preparing academic assignments offered for credit or collaboration with another person to commit a violation of any section of the rules on scholastic dishonesty.
- iv. All written work that is submitted will be subject to review by plagiarism software.

**UT Tyler Resources for Students**

- UT Tyler Writing Center (903.565.5995), [writingcenter@uttyler.edu](mailto:writingcenter@uttyler.edu)
- UT Tyler Tutoring Center (903.565.5964), [tutoring@uttyler.edu](mailto:tutoring@uttyler.edu)
- The Mathematics Learning Center, RBN 4021, this is the open access computer lab for math students, with tutors on duty to assist students who are enrolled in early-career courses.
- UT Tyler Counseling Center (903.566.7254)

**NOTE**

The instructor reserves the right to make changes to this syllabus as necessary.