# Department of Mechanical Engineering
# ME EN 5620/6620 – Fundamentals of Microscale Engineering – Fall 2012

## Syllabus

**Instructor:** **Prof. B. Raeymaekers**, MEB 2122, bart.raeymaekers@utah.edu
**Office Hours:** TBD (MEB 2122), and by appointment.
**Units:** 3
**Meeting Times:** T, Th: 09:10am -10:30am, WEB L122
**Engineering Lab:** CADE Lab and Engman Lab
**Recommended Text:** *MEMS and Microsystems,* Tai-Ran Hsu
Occasional extra readings will be made available on the course website.
Note: using an older edition of the text book is acceptable.
**Reference Texts:** *Foundations of MEMS*, Liu
*Fundamentals of microfabrication: the science of miniaturization*, Madou
*Microsystem Design*, Senturia
**Course Website:** Hosted on CANVAS
**Pre-requisites:** **ME EN 3000, 3300 and Upper Division ME Status**

**Course summary:**

ME EN 5620/6620 is designed to introduce engineering students to the exciting field of microscale engineering. A broad spectrum of topics related to microsystem development will be introduced including scaling laws, microfabrication technologies, metrology techniques, thermal fluid phenomena, and applications. Students will be introduced to the microfabrication technologies of photolithography, dry etching techniques, additive techniques, bulk micromachining, surface micromachining, LIGA, laser ablation, and micromilling. Phenomena that become more significant at the microscale will be introduced.

**Course objectives:**

This course will provide the student with the tools and methods to solve real world engineering problems that involve the design of microscale systems. At the end of the course the student will be able to

1. apply basic science principles to microscale engineering design problems.
2. apply principles of strength of materials, fluid mechanics, and solid mechanics to calculate and design microscale systems.
3. understand, analyze, and select micromachining processes to manufacture microscale systems.

**Deliverables and grading:**

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|---|---|
| Homework | 30% |
| Midterm exam | 30% |
| Final exam | 40% |

The total score is the weighted average of the homework sets, the midterm exams, and the final exam. The total score will be curved. It is anticipated that the mean total score will result in a B+ letter grade.

**Exam dates:**

Midterm exam 1: Thu 10/04/2012 (in class)

Final exam: Thu 12/06/2012 (in class)

Exams cannot be taken at different times/dates, except for documented medical reasons.

All exams are "closed book". Midterm material will be specified in a timely manner. The final exam will be comprehensive.

**Homework hand in guidelines:**

- **WHERE:** Drop box in the ME front office, MEB 2110.
- **WHEN:** by 5:00 pm on the day the homework set is due.
- **HOW:** HARD COPY ONLY! Do not e-mail soft copies to the instructor.
- **Late HW** needs to be slid under the door of the instructor's office, and will be accepted until 9:00 am the day after the HW set was due. A 20% penalty will be applied to the grade of that homework set. No late HW will be accepted after 9 am the day after its due date. Note: If HW is due on Friday, the next day is Saturday, NOT Monday.

Each homework problem will contain a "hand in" section that details the intermediate and partial answers for which need to be solved. Partial credit is allotted according to the bullet points specified in the "hand in" section of each homework problem. It is suggested that students use it as a check-list prior to handing in their homework set.

***Academic dishonesty policy: ME EN 5620/6620 will strictly follow the standard academic policy outlined by the University and the College of Engineering.***

**Faculty and student responsibilities:**

***No laptops, cellular/smart phones are allowed during class meeting times.These can be disruptive and distracting to your class mates.***

All students are expected to maintain professional behavior in the classroom setting, according to the Student Code, spelled out in the Student Handbook. Students have specific rights in the classroom as detailed in Article III of the Code. The Code also specifies proscribed conduct (Article XI) that involves cheating on tests, plagiarism, and/or collusion, as well as fraud, theft, etc. Students should read the Code carefully and know they are responsible for the content. According to Faculty Rules and Regulations, it is the faculty responsibility to enforce responsible classroom behaviors, beginning with verbal warnings and progressing to dismissal from class and a failing grade. Students have the right to appeal such action to the Student Behavior Committee.

"Faculty…must strive in the classroom to maintain a climate conducive to thinking and learning." PPM 8-12.3, B.

"Students have a right to support and assistance from the University in maintaining a climate conducive to thinking and learning." PPM 8-10, II. A.

ADA statement: “The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Union Building, 581-5020 (V/TDD). CDS will work with you and the instructor to make arrangements for accommodations.” (www.hr.utah.edu/oeo/ada/guide/faculty/)

| Lecture | Date | Topic | Detail | Reading | |
|---|---|---|---|---|---|
| 1 | Tue 08/21 | Introduction to microscale engineering | Course administration + Chapter 1 in TR Hsu | Chapter 1 TR Hsu | Physics |
| 2 | Thu 08/23 | Working principles of microsystems | Microsensors + microactuation | 2.1 - 2.3 TR Hsu | |
| 3 | Tue 08/28 | Working principles of microsystems | Microactuators + microfluidics | 2.4 - 2.6 TR Hsu | |
| 4 | Thu 08/30 | Scaling effects | Scaling in nature, geometry, mechanical domain, how to make things small? | 6.1 - 6.3 TR Hsu | |
| 5 | Tue 09/04 | Scaling effects | Scaling in electrostatic, thermal and fluid domain | 6.4 - 6.8 TR Hsu | |
| 6 | Thu 09/06 | Engineering mechanics for microsystems design | Static bending of thin plates | 4.1 - 4.2 TR Hsu | Design |
| 7 | Tue 09/11 | Engineering mechanics for microsystems design | Mechanical vibration | 4.3 TR Hsu | |
| 8 | Thu 09/13 | Engineering mechanics for microsystems design | Thermomechanics | 4.4 TR Hsu | |
| 9 | Tue 09/18 | Engineering mechanics for microsystems design | Advanced methods | 4.5 - 4.7 TR Hsu | |
| 10 | Thu 09/20 | Engineering mechanics for microsystems design | Monte Carlo simulations | Handouts | |
| 11 | Tue 09/25 | Thermofluidic engineering and microsystem design | Continuum flow | 5.1 - 5.5 TR Hsu | |
| 12 | Thu 09/27 | Thermofluidic engineering and microsystem design | Lubrication problems, Reynolds eqn | Handouts | |
| 13 | Tue 10/02 | Thermofluidic engineering and microsystem design | Lubrication problems, Reynolds eqn | Handouts | |
| | Thu 10/04 | Midterm | | | |
| | Tue 10/09 | Fall Break | | | |
| | Thu 10/11 | Fall Break | | | |
| 14 | Tue 10/16 | Thermofluidic engineering and microsystem design | Surface tension, incompressible flow in microscale channels | 5.6 TR Hsu | |
| 15 | Thu 10/18 | Thermofluidic engineering and microsystem design | Heat conduction in solids | 5.7 - 5.9 TR Hsu | |
| 16 | Tue 10/23 | Materials for MEMS and microsystems | Substrates, wafers, silicon | 7.1 - 7.5 TR Hsu | Material selection |
| 17 | Thu 10/25 | Materials for MEMS and microsystems | GaAs, Quartz, Piezoelectric materials, polymers | 7.6 - 7.10 TR Hsu | |
| 18 | Tue 10/30 | Microsystem fabrication processes | Photolitoghraphy, diffusion, oxidation | 8.1 - 8.5 TR Hsu | Fabrication |
| 19 | Thu 11/01 | Microsystem fabrication processes | CVD, PVD, etching | 8.6 - 8.10 TR Hsu | |
| 20 | Tue 11/06 | Microsystem fabrication processes | Bulk micromachining | 9.1 - 9.2 TR Hsu | |
| 21 | Thu 11/08 | Microsystem fabrication processes | Surface micromachining, LIGA | 9.3 - 9.5 TR Hsu | |
| 22 | Tue 11/13 | Microscale surface roughness | Surface roughness description | Handouts | Characterization |
| 23 | Thu 11/15 | Microscale metrology | Surface profilometry, white light interferometry, atomic force microscopy | Handouts | |
| 24 | Tue 11/20 | Thanksgiving Break | | | |
| | Thu 11/22 | Thanksgiving Break | | | |
| 25 | Tue 11/27 | Introduction to nanoscale engineering | Nanotechnology versus microtechnology | Chapter 12 TR Hsu | |
| 26 | Thu 11/29 | Introduction to nanoscale engineering | There's plenty of room at the bottom | Handouts | |
| 27 | Tue 12/04 | Exam review | | | |
| | Thu 12/06 | Exam | | | |