Nanomechanics
(E Mch 597A, SP 2007)

Class Times: M, W 4:40 - 5:55 PM
Class Location: 118 EES

Professor:
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Office Hrs.: Tu,W,Th 1:25-2:15 pm
I am also available by appointment. Please call or email to make an appointment. Be sure to include a few suggested meeting times in your initial email.
Feel free to drop-in to my office as well, but there are no guarantees with drop-ins. Calling just before a drop-in will keep you from being disappointed.

Course Objectives

The nature of Engineering Mechanics and its application continue on a trajectory of change driven by the necessities of Nanotechnology. In the past, investigations into Mechanics at the nanoscale were motivated by interest in the fundamental basis of more traditional Mechanics methods. This motivation is changing because nanoscale objects are no longer just subjects of scientific curiosity; they are themselves engineering components. This course will introduce the mechanical side of Nanotechnology, including advanced concepts and methods needed to apply Engineering Mechanics at the nanoscale. Specifically,

- Students will gain the background needed to pursue independent study in Nanomechanics.
- Students will be able to apply basic and advanced Mechanics concepts and methods to problems in Nanotechnology.
- Students will learn the state of ongoing developments in Nanomechanics.

Classes will focus on nanotechnology areas that drive Mechanics research at this tiny scale. Technologies impacted by Nanomechanics include sensors, nanoelectronics, nanooptoelectronics, nanomachines, and designer materials.

Course Philosophy

Nanomechanics is not a well defined field, but it is clear that much of the future of Engineering Mechanics will be applying existing Mechanics knowledge and techniques to nanotechnology and developing new Mechanics techniques required by this rapidly expanding area of research and development. The course topics have been chosen because they appear (to the instructor) as "obvious" areas of Engineering Mechanics applications within the realm of nanotechnology. This is the first offering of this course. There is no agreed upon definition of *Nanomechanics*, and political and funding issues will constantly get in the way of the Engineering community forming a consensus. As the instructor of this course, I hope that we will work together to create a semi-coherent picture of what *Nanomechanics* is. In so doing, we will help create the future of Engineering Mechanics and help form some of the conceptual tools with which future engineers approach Nanotechnology.

Classes, homework, and assigned readings will combine elements of technological application and intermediate and advanced Mechanics. Students will demonstrate that they can independently research topics in Nanotechnology and learn on their own any necessary advanced Mechanics methods. As the instructor, I hope to learn from your class discussions and independent projects to develop an appropriate Nanomechanics curriculum. I will always be interested in hearing your questions and ideas and learning from the diversity of backgrounds within this class. I hope that you all take advantage of the same opportunity.

<u>Text</u>

The topics and range of this course do not allow for the use of a single text. In fact, assigned reading will be completely from academic journal articles and handouts. Students will be largely responsible for finding these materials *on their own* (but without additional cost) from the University library web site. Although, it is possible to provide these materials in a more time efficient manor, students will learn more by finding the materials on their own. Thus, they will not be "spoon-fed" and will gain an appreciation for the dynamic and evolving nature of the course topic. They will learn how to pursue their own independent investigations.

<u>Grading</u>

There will be homework assignments, a term project, and an in-class presentation. Grades will be broken down as follows.

Homework assignments	(25%)
Part I of term project	(25%)
Part II of term project	(25%)
In-class presentation	(25%)

Class participation: A must for this course to be successful. Every student should view their participation in the class as part of a community effort to collectively explore Nanomechanics. Class participation will be taken into account for borderline grades.

Homework: When assigned, homework will be due on Tuesdays in class. Homework will play an important part in your keeping up with the technical content of the course and with developing your own skills. Homework grades will be based on effort. I also understand that it might be difficult to keep a rigid schedule, and some flexibility is needed. With this in mind, the lowest homework grade will be dropped when determining your final grade.

It is expected that you honestly try to complete every homework problem correctly and on time. This means that you should seek help from your instructor and fellow students if needed. Do not expect a half-baked scribbled problem to receive effort points. You must self-assess, and if you are unable to complete a problem, I want to know why. Imagine yourself in the work place. No one would accept incomplete work without any explanation. In short, you should think of each homework problem as a task to be performed, and conscientious effort is expected.

Projects: Further details of the project assignment will be given later in the course. The main idea, however, is that you must mimic your instructor. You must research a technology of interest. Find out what areas of Mechanics need to be applied to analyze and design the technology. Learn about it, and then teach the rest of us.

Topics

Planned topics for this course are:

- Nano-beams for molecular detection:
    - Surface stress and curvature
    - Vibration and resonance
- Carbon Nanotubes
    - Quasicontinuum method
    - Molecular dynamics and MD Acceleration
    - Van der Waals forces
- Self-Assembly of semiconductor heterostructures
    - Pattern formation: stability and multiscale/multitime analysis
    - Intro to noisy systems
- Molecular motors
    - Force measurement
    - Brownian Ratchets
    - Force-coupled Enzyme kinetics
- Nanostructured Materials for Strength
    - Dislocation Theory
    - Multiscale Modeling
- Mechanical Testing at the Nanoscale
    - Defining size effects
    - Oliver-Pharr Method
- Student Presentations