MIE 1744 – Nanomechanics of Materials

Department of Mechanical & Industrial Engineering

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General Note: *Please check Quercus regularly for the most up-to-date information about the course.*

1. **Lectures:** MS 3278 – Tuesday, 13:10-15:30 (start Sept 12th, 2023)

2. **Assignments/Projects:**

   Reading Assignments/Discussions (ongoing throughout term)

   Project Outline (Due: Oct 20th, 2023)

   Final Project Report (Due: Dec 11th, 2023)

3. **Course Description:**

   Materials can exhibit dramatically altered mechanical properties and physical mechanisms when they have characteristic dimensions that are confined to small length-scales of typically below ~ 100 nm. These size-scale effects in mechanics result from the enhanced role of surfaces and interfaces, defects and material variations, and quantum effects. Nanostructured materials which exhibit these size-scale effects often have extraordinary mechanical properties as compared to their macroscopic counterparts. This course is designed to provide an introduction to nanomechanics and size-scale mechanical phenomena exhibited by nanostructured materials, and provide a platform for future advanced studies in the areas of computational/experimental nanomechanics and nanostructured materials design and application. Topics include: an introduction to nanomechanics; atomic/molecular structure of materials & nanomaterials synthesis; limitations of continuum mechanics, nanomechanical testing techniques (AFM, nanoindentation, in situ SEM/TEM); atomistic modeling techniques (DFT, MD, Course-grained MD); size-scale strength, plasticity, and fracture **;** Hall-Petch strengthening, superplasticity; nanotribology**,** atomistic origins of friction, nanoscale wear; nano-bio-mechanics; mechanics of nanocomposites.

4. References:

Useful Textbooks and References: (Not Required)

- A.N. Cleland. "*Foundations of Nanomechanics"*, Springer (2003)
- E. Gnecco & E. Meyer. "*Fundamentals of Friction and Wear on the Nanoscale",* Springer (2015)
- E. Meyer, H.J. Hug, R. Bennewitz, *"Scanning Probe Microscopy: The Lab on a Tip", Springer,* (2004)
- J.N. Israelachvili, *"Intermolecular and Surface Forces", Elsevier* (2011)
- K.L. Johnson, *"Contact Mechanics", Cambridge University Press* (1987)

5. Major Course Topics:

1. *Introduction to Nanomechanics*

2. *Atomic/molecular structure of nanomaterials*

3. *Surfaces, forces, and contacts at the nanoscale*

4. *Nanomechanical testing techniques*

- Atomic Force Microscopy & Friction Force Microscopy
- Nanoindentation
- In-situ SEM/TEM testing

5. *Computational nanomechanics*

6. *Nanoscale elasticity*

7. *Nanoscale strength & fracture*

8. *Nanotribology*

9. *Mechanics of nanocomposites*

10. *Bio-inspired nanostructured materials*