GENERAL INFORMATION

INSTRUCTOR: Pinshane Huang (office: MRL 258, email: pyhuang@illinois.edu)
LOCATION: 2:00 - 2:50 M,W,F 305 MSEB
OFFICE HOURS: 3:00-4:00 PM Wednesday, or by appointment

COURSE DESCRIPTION: This 3- or 4-credit course focuses on transmission electron microscopy, one of the most powerful and flexible tools to understand materials. The course will cover both theory and practical concepts, and work to build intuition for transmission electron microscopy. We will cover the basic operating principles of the microscope, the physics of electron diffraction and image formation, data interpretation, and electron microscopy experiment design.

COURSE OBJECTIVES: Enable students to…
- Understand the optical components of a TEM
- Interpret diffraction patterns
- Interpret images including bright and dark field TEM, HRTEM, and STEM
- Understand the key concepts in advanced TEM techniques including EELS, tomography, high-resolution TEM, X-ray microanalysis, and identify appropriate applications, advantages, and limitations of each technique
- Design a TEM experiment: evaluate which samples can be examined and what can be learned about them, chose which TEM techniques are appropriate, describe what the TEM data might look like and how to interpret it in terms of the experimental goals
- Describe modern TEM experiments and the frontiers of TEM

PREREQUISITES: MSE 405 (Microstructure Determination) or equivalent


*** This text is available free as an e-book through the University Library. This is a great reference to have, and I would recommend buying a softcover copy of the text, for the screamingly low price of $25 through Springer. To access the book, start at the library website, search “Williams and Carter”. Go to the heading “Ebooks by Title and Chapter”, then click “Springer Ebooks”. This should take you to the Springer site, where you should make sure to find the Second Edition, which is light blue. Many of the suggested references are available this way as well. ***

OTHER RECOMMENDED REFERENCES: (available online or as course reserves)

**Expectations:** This course is geared toward teaching you as a scientist to utilize the concepts of electron microscopy to empower your research. As much as possible, this course is centered around inquiry-based learning rather than memorization. I want you to know why, not just what. Interactivity in and out of class is important. If you don’t understand something, or the problem sets are unreasonably difficult, please tell me. Additionally, please read the assigned text before coming to class. Our class lectures are designed to complement, not substitute for the readings, and will generally be at a higher level than the textbook.

**Course Materials:** Course materials, including hand-outs and problem sets will be available online through the UIUC compass website.

**Problem Sets:**
*You are encouraged to collaborate and seek help. But, your write-ups must be in your own words, not copied or paraphrased from your classmates or any other sources. You must acknowledge in writing anyone who you talked to or worked with in order to help complete your work.*

Problem sets will be due on Fridays at the beginning of class. You will be issued one Late Homework Coupon, which can be stapled to and turned in along with one homework set for a 24-hour extension. Late homework should be placed in my mailbox on the 2nd floor of the MRL. Otherwise, late problem sets will not be accepted without permission from the instructor.

**3 vs 4 Credit Hours:** Students have the option of taking this course for either 3 or 4 credit hours. The additional activities for the 4-credit version of the course are designed to add a more hands-on and research-oriented component to the course. Students enrolled for 4 credit hours will be required to attend 5 of the 6 laboratory demonstrations, complete 1 additional problem on each problem set, and submit a final project.

**Evaluation:** (3) AND [4] CREDITS

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<tr>
<th>Component</th>
<th>(3) Credits</th>
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<tbody>
<tr>
<td>Problem sets</td>
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<tr>
<td>Midterm exam 1</td>
<td>(30%) [25%]</td>
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<td>Midterm exam 2</td>
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<td>Final project</td>
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COURSE TOPICS

THE BASICS:
1. Fundamentals of electron microscopy
2. Inelastic and elastic electron scattering
3. Electron optics
4. Practical Aspects: alignment, sample preparation, and instrumentation

DIFFRACTION:
1. Real and reciprocal space lattices
2. Diffraction indexing and simulation
3. Diffraction contrast imaging

IMAGING:
1. Incoherent imaging: STEM
2. Coherent imaging: TEM
3. Interpreting and simulating CTEM and STEM images

SPECTROSCOPY AND BEYOND:
1. X-ray microanalysis
2. EELS
3. Frontiers of electron microscopy