Course Description: This course discusses the theory and practice of transmission electron microscopy as applied to heterogeneous material systems. Weekly lectures will be accompanied by key laboratory practical sessions (listed below) on diverse materials. Emphasis will be placed on training students how to use a state-of-the-art analytical STEM for analysis of material structure and composition down to the atomic level.

Schedule: We are scheduled to meet on Monday and Wednesday 9:30 AM to 10:45 AM in the Kuiper Space Sciences building room 312. This course also has a practical component to it, and we will discuss that schedule during the first week of class.

Instructor: (Prof.) Thomas (Tom) Zega, tzega@arizona.edu, 520-626-1356, Kuiper Space Sciences, Room 522. Office Hours: by appointment.

Required Textbook: 'Transmission Electron Microscopy' by David Williams and C. Barry Carter (2009, second edition). It is published by Springer and can be downloaded in ebook form from the university library. I will supplement my lectures with material from other resources as well, but I will provide those materials online or in reference form as available.

Course Format: Lecture and laboratory practical sessions.

Course Objectives and Expected Learning Outcomes: The objective of this course is to provide students with an understanding of the theory and practice of electron scattering, image formation, and X-ray and electron energy-loss spectroscopy in the transmission electron microscope. By the end of the course, it is expected that students will be able to align and operate the microscope with minimal assistance and to setup various optical modes to analyze heterogeneous materials. Learning outcomes will be assessed based on class participation, problem sets, laboratory practical work, a mid-term and final written exam.

Class website: All lectures and problem sets will be posted to d2L. Supplemental material for lectures, e.g., journal articles, figures, will also be posted. I will try to have each lecture uploaded prior to class.

Performance Metrics:
Mid-term exam: 30%
Final exam: 30%
Problem sets and laboratory practical work: 30%
Class participation: 10%

Grading Scale (%):

A	≥ 90
B	80 to 89
C	70 to 79
D	60 to 69
E	< 60

Credit will not be given for assignments that are turned in late.

Exam Schedule

We will have a mid-term exam on or about October 19, 2022. Our final exam is scheduled for Thursday, December 15, 2022 at 10:30 AM to 12:30 PM.

- See https://registrar.arizona.edu/faculty-staff-resources/room-course-scheduling/schedule-classes/final-exams/final-exams-fall-2022 for final-exam regulations and the final

Nondiscrimination and Anti-harassment Policy: The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. For more information, including how to report a concern, please see: http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

University Policies: All university policies related to the syllabus are available at https://academicaffairs.arizona.edu/syllabus-policies

Subject to Change Notice: The information contained in this course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.

Graduate Student Resources: https://asuatoday.arizona.edu/basic-needs.

Lecture Topics

There is not enough time to cover every chapter in detail. Instead, I will cover some chapters in their entirety, whereas others I will cover select topics. The chapters and topics are listed below. I recommend you read each chapter entirely.

Part 1 (Basics)

- Chapter 1: Introduction to the Transmission Electron Microscope
- Chapter 9: The Instrument
- Chapter 2: Scattering and Diffraction
- Chapter 3: Elastic Scattering
- Chapter 4: Inelastic Scattering and Beam Damage
- Chapter 5: Electron Sources
- Chapter 6: Lenses, Apertures, and Resolution

Part 2 (Diffraction)

- Chapter 11: Diffraction in the TEM
- Chapter 12: Reciprocal Space
- Chapter 16: Diffraction from Crystals
- Chapter 18: Obtaining and indexing parallel-beam diffraction patterns

Part 3 (Imaging)

- Chapter 22: Amplitude Contrast
- Chapter 23: Phase Contrast
- Chapter 25: Planar Defects
- Chapter 27: Weak beam Dark-field Microscopy

- Chapter 28: High-resolution TEM
- Chapter 31: Processing and Quantifying Images

Part 4 (Spectrometry)

- Chapter 32: X-ray Spectrometry
- Chapter 33: X-ray Spectra and Images
- Chapter 34: Qualitative X-ray Analysis and Imaging
- Chapter 36: Spatial Resolution and Minimum Detection
- Chapter 37: Electron energy-loss spectrometers
- Chapter 38: Low-loss Spectra
- Chapter 39: High-loss Spectra
- Chapter 40: Fine Structure

Not in Williams and Carter: Scanning Transmission Electron Microscopy

Practical Topics

1. Sample handling/loading, Instrument overview and alignment
2. Image formation and acquisition
3. Diffraction: Convergent beam and selected area
4. High-resolution (phase contrast) imaging
5. Scanning TEM and Aberration-corrected Imaging
6. Energy-dispersive X-ray Spectroscopy
7. Electron energy-loss spectroscopy