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 will meet on Tuesday and Thursday 11:00 to 12:15. We will convene in the Kuiper Space Sciences building room 312. Practical instruction will occur in the TEM lab in room 15 of the basement of the Kuiper Space Sciences building.

Instructor: (Prof.) Thomas (Tom) Zega, tzega@lpl.arizona.edu, 520-626-1356, Kuiper Space Sciences, Room 522. Office Hours: 12:15 to 1pm Tuesday/Thursday or by appointment.

Required Textbook: 'Transmission Electron Microscopy' by David Williams and C. Barry Carter (second edition). It is published by Springer and can be purchased through the bookstore at a discount or 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 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.

Absence and Class Participation Policies: Absences for any sincerely held religious belief, observance, or practice will be accommodated where reasonable. See http://policy.arizona.edu/human-resources/religious-accommodation-policy. Absences pre-approved by the UA Dean of Students (or dean's designee) will be honored.

Class website: All lectures and problem sets will be posted in PDF form to the class website https://www.lpl.arizona.edu/PMRG/teaching/ptys-526. Supplemental material for lectures, e.g., journal articles, figures, will also be posted. I will try to have each lecture uploaded prior to class, and I will alert you via email when the lecture is online.

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 is not given for assignments that are turned in late.

- See for http://registrar.arizona.edu/courses/final-examination-regulations-and-information?audience=students&cat1=10&cat2=31 final-exam regulations.
- See http://www.registrar.arizona.edu/students/courses/final-exams for the final exam schedule.
- The final exam for our class is scheduled for…

Classroom Behavior: No mobile phone use during class unless it is somehow involved in the lecture/discussion. Computers are allowed to take notes or otherwise for lecture-relevant content. No Facebook or other social media activities are permitted or anything else that might be construed as behavior that distracts from the lecture.

Threatening Behavior Policy: The UA policy on threatening behavior prohibits threats of physical harm to any member of the University community: policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Academic Integrity Policy: The Student Code of Academic Integrity prohibits plagiarism: deanofstudents.arizona.edu/policies-and-codes/code-academic-integrity.

Nondiscrimination and Anti-Harassment Policy: Please see University Policy 200E on prohibited behaviors: http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Accommodations for Students with Disabilities: For students with disabilities, reasonable accommodations will be provided by the Disability Resources Center: drc.arizona.edu/instructors/syllabus-statement

Disclaimer: 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.

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. These are indicated below.

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

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