**460 Electron Microscopy and Diffraction, 2023**

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**Lecture:** TuTh 2:00-3:20 PM, L150

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**Web page:** http://www.numis.northwestern.edu/460

The primary focus of this course is to provide both the fundamental theory as well as hands on practice with the use of transmission electron microscopy to study the structure of solids. Please note that there will be no coverage of scanning electron microscopy (SEM).

There are no prerequisites for this class beyond a basic knowledge of solid structures and typical defects. If you are not a Materials Science major, and have not had any prior exposure, I would strongly suggest that you borrow from the library an introductory text on materials science which explains about dislocations, grains, and a little about crystal structure.

***Strongly Suggest***

# Overview, with Chapters from Williams & Carter

**I. Basics Chpts 1-5,7,9-10 (approximately 1.5 weeks)**

Description of a microscope

Source, Lenses, Sample

Objective Lens

Detectors

Elastic Interactions, Inelastic Interactions

Sample Preparation

Waves:

Fourier Transforms, Fourier Series

Coherent and Incoherent waves; classical versus reality

**II. Diffraction Chpts 11-14, 16-19 (approximately 3 weeks)**

Real and Reciprocal Space

Diffraction from Crystals

Indexing Diffraction Patterns

Kinematical Theory

**III. Imaging Chpts 22-25, 28 (approximately 3 weeks)**

Basics

Thickness and Bending

Defects

HREM

Z-contrast

**IV. Microanalysis (approximately 2 weeks)**

Basics of EDX Chpts 32-34

Basics of EELS Chpts 37-38

**V. Introduction to more advanced methods**

Two-Beam dynamical Theory, Channeling, HREM, ADF/Z-contrast, Aberration Correction, Precession….

**Text: Transmission Electron Microscopy by Williams and Carter**

There is no true “textbook” for electron microscopy in the sense of textbooks that you are used to in other courses. This is the first new “textbook” for many, many years, and is about as close as one can come at present. The first edition had a lot of typographical mistakes, some of which may have been corrected.

**Additional Reading:**

**Electron Microscopy of Thin Films, Hirsch et al**

Golden oldie, often called “The Bible of Electron Microscopy”. Everything in this book is correct, but many contemporary techniques are not covered. Outstanding coverage of diffraction theory, not available from Norris

**Transmission Electron Microscopy, Reimer**

Vast coverage, and relatively recent. I think that it can be hard to use if you do not understand anything, but if you have some knowledge and want a better explanation then it is a good choice. (Some students have not found this to be a problem.) Very extensive list of references.

**Grading**

Homework: 30%

Class Problems 10%

Lab Reports 30%

Term Paper 30%

**Philosophy**

You will hopefully come out of this class with:

1) Some appreciation about how to use a TEM to get results relevant to your own research and understand results of others.

2) Some/improved understanding of basic concepts that are important for diffraction and in other areas, for instance reciprocal space, dislocation structures.

3) Some practice in "real" problem solving where you do not know for certain if there is an answer!

You will **NOT** get a recipe for how to understand any image -- this does not exist.

**Important Notes:**

*If you are looking for a simple linear class where the lectures follow a textbook and all details in the labs are explained first in class, you should drop this class. There is a deliberate, Socratic structure to this class where I will build up from the basics in the lectures at a different pace from the labs and different from textbooks. You will be expected to solve for yourself images in the class.*

*Depending upon how easily you can visualize in three dimensions, you may find parts of the class, particularly reciprocal space and how the orientation of the sample effects the diffraction pattern hard. If you do you should work on this and talk to the TA, it will come.*