EMA6518: Transmission Electron Microscopy
Fall 2013
3 Credits
Prerequisites: EMA 3513C or equivalent
Classroom location: CSE E122
Meeting times: MWF period 2 (8:30 – 9:20 am)

I. Instructor information

Dr. Nicholas G. Rudawski
Office location: MAE (building #719) 109
Office phone: (352) 392-3077
E-mail: ngr@ufl.edu (preferred contact method)
Office hours: TBD and by appointment
Class website: run through e-learning support services at https://lss.at.ufl.edu/

II. Course description and objectives

This course provides an introduction and overview of transmission electron microscopy (TEM) as emphasized for materials scientists and those studying the physical sciences with emphasis placed heavily electron scattering, diffraction, and analysis of inorganic materials (metals, semiconductors, ceramics, etc.); very little emphasis will be placed on TEM for organic and biological materials applications. This course also will provide students with a theoretical background required prior to training on the TEMs at the Major Analytical Instrumentation Center (MAIC); successful completion of this course completes the basic prerequisite necessary to start training on the TEMs at MAIC. By the end of the course, students will be able to understand the following:

Basics of microscopy and lenses
Basic construction and modes of operation of a TEM
Typical TEM sample preparation methods
Basics of electron scattering
Electron diffraction patterns
Amplitude contrast in TEM images
Fault analysis using TEM
Phase contrast in images
High-resolution imaging
Scanning TEM
Use of TEM for chemical analysis

III. Required textbooks

1. “Transmission electron microscopy: a textbook for materials science” by Williams and Carter; second edition (ISBN: 978-0-387-76500-6)
2. “Transmission electron microscopy and diffractometry of materials” by Fultz and Howe; third edition (ISBN: 978-3-540-73885-5)

Both of these textbooks are available online, fully downloadable, and completely free of charge at www.springerlink.com when accessed through the UF network. Additionally, print black and white hard copies may be ordered for $25 through www.springerlink.com when the website is accessed through the UF network; if you are planning on doing a lot of TEM work, I strongly recommend you invest in hardcopies of these books as both are excellent TEM reference texts, particularly for materials scientists.

IV. Course outline

A. Tentative course schedule and assigned reading (subject to change)

Lectures	Topic(s)	Assigned reading
1, 2	Introduction to TEM	Williams and Carter: chapter 1
3 – 5	Working with lenses; the optics of TEMs	Williams and Carter: sections 5.1 – 5.5 Fultz and Howe: sections 2.1 – 2.4, 2.7, and 2.8
6	TEM sample preparation	Williams and Carter: chapter 10
7 – 12	Basics of electron scattering; single atoms and whole crystals	Fultz and Howe: chapter 5
13	**Mid-term exam 1**	N/A
13 – 15	Indexing diffraction patterns; intensity of diffracted beams using kinematical theory	Fultz and Howe: sections 6.1 – 6.4, 7.1 – 7.3
16 – 21	Amplitude contrast in two-beam images	Williams and Carter: sections 22.1 and 22.3 Fultz and Howe: sections 7.4 – 7.8, 7.10 – 7.12
22 – 23	Dynamical treatment of scattering	Williams and Carter: chapters 13 and 14
24	**Mid-term exam 2**	N/A
25 – 31	High-resolution phase contrast imaging	Williams and Carter: sections 27.1 – 27.4, 28.1 – 28.7 Fultz and Howe: section 10.3
32, 33	Processing high-resolution images	Williams and Carter: sections 30.1 – 30.5.B

34 – 36	Scanning TEM	Williams and Carter: section 9.4 Fultz and Howe: sections 11.1 – 11.5
37	**Mid-term exam 3**	N/A
38	Scanning TEM	Williams and Carter: section 9.4 Fultz and Howe: sections 11.1 – 11.5
39 – 41	Analytical TEM	Williams and Carter: chapter 34, sections 36.1 – 36.4, chapter 38, sections 40.1 and 40.1.A

B. Putting theory into practice: live TEM demos

The laboratory counterpart course (EMA 6518L) will be offered next term (so it is not run concurrently with this course). That being said, I do feel it is important for all of you to at least observe some live demonstrations of TEM principles discussed in class so as to start to put theory into practice and gain some basic practical familiarity with TEM. Tentatively, I am planning to hold 4 or 5 live demos spaced regularly throughout the term. Attendance of the demos will be entirely voluntary, but will be very useful to help to start to bridge the gap between theory and practice. Demos will be held outside of class and enough demo sessions will be offered such that all interested students will be able to attend.

C. Assigned reading

Assigned reading from both textbooks for each week is specified in the above tentative schedule (subject to change). All information that is part of the assigned reading may be considered as potential material for inclusion on any assessment, so you need to be sure to keep up with the reading assignments.

D. List of assessments

1. 3 in-class mid-term exams and a final out-of-class exam (17% of final score for each mid-term, 34% of final score for the final exam)

   <u>The exams will be entirely true/false and multiple choice</u>; there will be no computational ("number crunching") or essay questions on exams. This is due to feedback from teaching the class last year when students overwhelmingly felt I was too arbitrary with grading of computational/essay questions on exams.

   Tentative mid-term exam dates: 09/20; 10/16; 11/20

Final exam date and time: 12/12 at 3:00 PM (room TBD)

2. Short weekly (approximately) homework assignments (15% of final score)

   Unlike exams, the weekly homework assignments will usually be comprised of computational and/or essay questions. Also unlike the exams, the grading of the homework assignments will be "effort" based; in other words, if you make a reasonable effort on a homework assignment, you will receive full credit for it. You may work together in groups on the homework assignments, but each student must turn in his or her own homework. All homework will be assigned and turned in through the group website; homework not turned in through the group website will not be graded.

E. Make-up assessments policy

In general, make-ups for missed exams or extensions for late homework will not be given except in cases of extenuating circumstances. If you feel you will be unable to be present for an exam or turn in a homework assignment on time due to extenuating circumstances, you should contact me BEFORE the exam date or homework due date for me to evaluate the situation and determine if something can be worked out.

V. Attendance and classroom conduct

Attendance is not required, but regular attendance will probably be necessary in order to be successful in this course; my experience from last year was that students with poor attendance tended to receive poorer grades. If you choose to attend class (and I hope you do, because I would like to get to know all of you), please be respectful and pay attention; silence your cell phones and put them away; please do not bring in newspapers and read them during class; you may bring in your laptop computers to take digital notes, but please do not use your computers for leisurely activities (aimlessly surfing the internet, accessing social networking sites, etc.).

VI. Grading procedure

At the end of the term, students will be ranked in terms of final scores. Different letter grades will be assigned to distinct groupings of scores (i.e., the top group will receive A and A- grades, the next group will receive B+ through B- grades, etc.); thus, you are effectively been graded relative to the performance of the rest of the students in the case. There is no predetermined or preset scale for grading, but I will give a projected final grade for everyone after each mid-term exam. Greater information on current UF policies for assigning grade points may be found at: http://gradcatalog.ufl.edu/.

VII. Academic misconduct

Academic misconduct (cheating, plagiarism, etc.) is a very serious matter and will not be tolerated in any capacity; I expect you all to abide by the Student Honor Code and

Student Code of Conduct as specified at http://www.dso.ufl.edu/sccr/honorcodes/conductcode.php. If I feel that any academic misconduct is occurring, it will be referred to the Division of Student Affairs for further action and consideration and will be reported to academic services in the MSE department.

VIII. Accommodations for students with disabilities

Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the instructor when requesting accommodation.