Fall 2020

MTEN 610-101: Foundations of Materials Science and Engineering

Joshua Young

MTEN 610 – Foundations of Materials Science and Engineering

Instructor: Dr. Joshua Young
- email: joshua.a.young@njit.edu
- office: York 322

Office Hours: Tuesdays, 1 to 3 pm, or by appointment, York 322

Date, Time, and Location: Thursdays, 6 to 9 pm, Faculty Memorial Hall 205

Textbook: Required: *Materials Science and Engineering: An Introduction, 9th Edition* – William D. Callister and David G. Rethwisch (2013), ISBN 9781118477700

This will also be supplemented with material from other textbooks and peer-reviewed literature. These books are not required, and any supplemental material will be provided to you. Material may come from:
- *Materials Engineering: Bonding, Structure, and Structure-Property Relationships* – Susan Trolier-McKinstry, Robert E. Newnham
- *Understanding Solids: The Science of Materials* – Richard Tilley
- *Physical Properties of Crystals: Their Representation by Tensors and Matrices* – J. F. Nye
- *Structure of Materials* – Samuel M. Allen, Edwin L. Thomas

Course Overview: This is an introductory course for Materials Engineering graduate students. This course will introduce materials from an atomistic point of view and describe the relationship between their underlying structure and properties. We will first cover chemical bonding and crystal structure, and how this results in differences between families of materials (metals, ceramics, and polymers). We will then discuss phase transformations and use phase diagrams to describe the compositions and microstructure of solid solutions. Finally, we will discuss important properties of materials, including electronic, magnetic, optical, and thermal, and how they are selected and used in various modern engineering applications.

Prerequisites: graduate standing

Course Objectives: During this course, students will:

(1) analyze the fundamental link between materials' atomistic structure, processing, and properties.
(2) represent the crystal structures of materials using crystallographic points, directions, and planes.
(3) understand the differences between families of materials (metals, ceramics, and polymers).
(4) utilize phase diagrams to describe transformations and microstructure of solid solutions.
(5) predict elastic and plastic behavior and failure using fundamental relationships between stress and strain.
(6) calculate and understand the origin of electrical, thermal, magnetic, and optical properties of materials.
(7) understand how these are applied in modern areas of materials engineering research.
(8) write a report and give an oral presentation detailing materials issues facing a specific area of engineering.

Attendance Policy: Attendance is expected at all classes. In lieu of formal attendance, however, participation in in-class activities will count towards your final course overall grade (see below).

Academic Integrity: Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment

by knowing and following the academic code of integrity policy that is found at: http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf.

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu.

Grading: The final grade for the course is divided as follows:

- Homework Sets = 15% of grade
- Midterm Exam = 30% of grade
- Final Written Report = 30% of grade
- Final Presentation = 25% of grade

Grades will be assigned with the following rubric:

90% and above	A
85-89%	B+
80-84%	B
75-79%	C+
70-74%	C
60-69%	D
Below 60%	F

Homework: Students will be assigned 10 homework sets of exercises, each equally weighted. Homework sets can be turned in electronically formatted and printed *or* legibly handwritten at the start of the class in which they are due or emailed to the instructor *before* class begins. Homework turned in after 6 pm on the due date will be automatically reduced by 50%. *You should begin problem sets early.* Working with your peers on the homework is allowed and encouraged. You should acknowledge your collaborators when submitting your assignments. Each student must provide their own solutions to problems and submit their own assignment, with their own written answers to the questions. It is not acceptable (and a violation of course policies) to use the same written answers as your collaborators.

Exams: There will be one exam during the semester. The exam will be based on lecture material and homework problems. The midterm exam will cover all material from weeks 1 through 6. There will be no makeup midterm exam baring extreme extenuating circumstances.

Final Project: The final project will involve selecting an engineering application and researching the materials used for it. This will involve determine the properties required for the application, what materials were used in the past and why, what materials constitute cutting edge technology in this area, and what improvements that can be made. The final project consists of two parts: (1) a written report and (2) an oral presentation. The written report will be a minimum of 7 pages and constitute 30% of your final grade; a more detailed rubric will be given after the midterm. The final presentation will be 15 minutes to the class describing your findings and constitute 25% of your grade. The presentation will be in the style of a Materials Research Society meeting, with 12 minutes for the presentation and 3 minutes for questions. Potential topics and further details will be provided the week after the midterm exam.

Schedule of Topics:

Week	Topics	Assignment
1 – Sep. 3, 2020	- Course Objectives - Introduction - Atomic Structure and Bonding	
2 – Sep. 10, 2020	- Atomic Structure and Bonding - Crystal Structure Basics	
3 – Sep. 17, 2020	- Advanced Crystal Structure Topics - Symmetry and Tensor Properties	HW1 due
4 – Sep. 24, 2020	- Electronic Structure - Metals and Ceramics	HW2 due
5 – Oct. 1, 2020	- Defects - Diffusion	HW3 due
6 – Oct. 8, 2020	- Polymers - Molecular Solids - Review for Midterm	HW4 due
7 – Oct. 15, 2020	**Midterm Exam**	
8 – Oct. 22, 2020	- Phase Transformations I: Phase Diagrams and Microstructure - Project Topics assigned	
9 – Oct. 29, 2020	- Phase Transformations II: Solidification, Nucleation and Growth	HW5 due
10 – Nov. 5, 2020	- Mechanical Properties - Dislocations - Failure	HW6 due
11 – Nov. 12, 2020	- Electronic Properties - Electronic Devices	HW7 due
12 – Nov. 19, 2020	- Magnetic Properties - Optical Properties	HW8 due
13 – Nov. 26, 2020	NO CLASS – THANKSGIVING	
14 – Dec. 3, 2020	- Thermal Properties - Corrosion and Degradation of Materials	HW 9 due
15 – Dec. 10, 2020	- Modern areas of research in materials engineering	HW 10 due
16 – Dec. 17, 2020	**Final Presentations**	