MSE 45 – Properties of Materials | Fall 2020

Instructor: Lane W. Martin
Lecture: Virtual/Online, Live on Zoom MWF 12:00-1:00PM, Recorded for asynchronous

Email: lwmartin@berkeley.edu
Office: 216 Hearst Mining Building (but I won't be there)
Office Hours: Monday 3:00-4:00PM, Wednesday 9:30-10:30AM
Course Website: bCourses

Graduate Student Instructors: Mallika Bariya (m.bariya@berkeley.edu; OH: Mon. 4:00-5:00P; 102|106)
Vishal Ravi (vishalravi@berkeley.edu; OH: Thur. 2:00-3:00P; 101|104)
Renjie Tao (tao_renjie@berkeley.edu; OH: Wed. 1:00-2:00P; 103|105)
All GSI office hours will be virtual

Text: *Materials Science and Engineering: An Introduction,* William D. Callister, Jr. and David G. Rethwisch, 9th or 10th Edition, Wiley: Hoboken, NJ (2014).
*The 9th Ed. was used in F/S 2016, F/S 2017, F/S 2018, F/S 2019, & S 2020.

References: A number of texts are on reserve at the Engineering Library, including:

- Materials Science and Engineering: An Introduction (9th Ed., 2014), W. D. Callister, Jr. and D. G. Rethwisch (our book)
- Materials Science and Engineering: An Introduction (8th Ed., 2010), W. D. Callister, Jr. and D. G. Rethwisch
- Introduction to Materials Science for Engineers (7th Ed., 2009), J. F. Shackelford (2 copies)

Prerequisites: Some basic chemistry, physics, and math is all that is required.

Description & Objectives: This 3-unit course consists of three (3) 50-minute lectures each week taught by the head instructor. The long-term objectives of this course are to sustain practicing engineers through a career of materials selection, materials design, materials synthesis, materials recycling, materials processing, materials remediation, and materials replacement. The course provides broad coverage of the field for non-majors who may not be able to take another course in materials science & engineering, and it serves as the introductory course in the major field, laying the foundation for understanding the relationship between the internal structure of matter and the properties of materials that make them attractive for engineering applications. This course will apply basic principles of physics and chemistry to the engineering properties of materials. Special emphasis will be devoted to the relationships between microstructure and the mechanical properties of metals, concrete, polymers, and ceramics, and the electronic, magnetic, and optical properties of materials.

Connection to MSE45L: MSE45, is a stand-alone, lecture-based course that supports an additional laboratory class MSE45L. MSE45L is a laboratory-based experience that augments the topics of the MSE45 lecture class with hands-on practical experiences. Students taking MSE45 are not required to take MSE45L (although it is recommended), but those taking MSE45L must have already completed or be taking MSE45 concurrently.

Proposed Class Outline and Schedule

Recall that a course is a flowing and changing thing. The following is a proposed outline and timeline for the semester. This will be subject to changes that will be announced well in advance in class.

Chap. 1: Introduction
- What is Materials Science and Engineering?
- Materials Tetrahedron

Chap. 2: Atomic Structure & Interatomic Bonding
- Atomic properties (review)
- Types of bonding – metallic, covalent, ionic, other

Chap. 3 & 12: Structure of Crystalline Solids
- Unit cells
- Metallic structures
- Ceramic structures
- Crystallographic Points, Directions, and Planes
- Introduction to X-ray Diffraction

Chap. 4: Imperfections in Solids
- Point defects
- Line defects
- Surface and volume defects
- Studying defects and microstructure

Chap. 5: Diffusion
- Diffusion mechanisms
- Steady-state diffusion (Fick's First Law)
- Non-steady state diffusion (Fick's Second Law)
- Factors that influence diffusion

Chap. 9: Phase Diagrams
- Basics – definitions, phases, components, etc.
- One-component (unary) phase diagrams
- Binary phase diagrams
- Lever rule and tie-lines
- Invariant points
- Gibbs Phase Rule
- Famous phase diagrams – Fe-C

Chap. 10: Phase Transformations: Development of Microstructure and Alteration of Mechanical Properties Kinetics of Phase Transformations
- Kinetics – nucleation and growth
- Homogeneous nucleation
- Heterogeneous nucleation
- Introduction to TTT diagrams and routes to engineering material properties

Chap. 6: Mechanical Properties
- Stress and Strain
- Elastic and Plastic deformation
- Toughness, hardness, etc.
- Properties of metals, ceramics, polymers

Chap. 7: Dislocations and Strengthening Mechanisms
- Role of dislocations
- Slip
- Strengthening mechanisms
- Recovery, recrystallization, grain growth

Chap. 8: Failure
- Ductile fracture
- Brittle fracture
- Stress concentration
- Fatigue
- Creep

Chap. 18: Electrical Properties
- Electrical conduction
- Metals, semiconductors, insulators
- Dielectric and other behavior

Chap. 20: Magnetic Properties
- Diamagnetism, paramagnetism
- Ferromagnetism, antiferromagnetism
- Temperature, domains, anisotropy
- Other effects

Chap. 21: Optical Properties
- EM radiation, light-matter interactions
- Refraction, reflection, absorption, transmission, color, opacity
- Applications

Materials Selection & Design Considerations
- How do we begin to pick the right material?
- Ashby plots
- Examples

Date	Activity	Assignments Due
Aug. 24	No School	
Aug. 25	No School	
Aug. 26	Lecture – Chap. 1	
Aug. 27		
Aug. 28	Lecture – Chap. 2	
Aug. 31	Lecture – Chap. 2	
Sep. 1		
Sep. 2	Lecture – Chap. 2	
Sep. 3		
Sep. 4	Lecture – Chap. 3	
Sep. 7	No Class – Academic & Administrative Holiday	
Sep. 8		
Sep. 9	Lecture – Chap. 3	
Sep. 10		
Sep. 11	Lecture – Chap. 3	HW 1
Sep. 14	Lecture – Chap. 3	
Sep. 15		
Sep. 16	Lecture – Chap. 3	
Sep. 17		
Sep. 18	Lecture – Chap. 4	HW 2
Sep. 21	Lecture – Chap. 4	
Sep. 22		
Sep. 23	Lecture – Chap. 4	
Sep. 24		
Sep. 25	Lecture – Chap. 5	HW 3
Sep. 28	Lecture – Chap. 5	
Sep. 29		
Sep. 30	Lecture – Chap. 5	
Oct. 1		
Oct. 2	Lecture – Chap. 9	HW 4
Oct. 5	Exam Review	
Oct. 6		
Oct. 7		Exam 1
Oct. 8		
Oct. 9	Lecture – Chap. 9	
Oct. 12	Lecture – Chap. 9	
Oct. 13		
Oct. 14	Lecture – Chap. 10	
Oct. 15		
Oct. 16	Lecture – Chap 10	HW 5
Oct. 19	Lecture – Chap. 6	
Oct. 20		
Oct. 21	Lecture – Chap. 6	

Oct. 22		
Oct. 23	Lecture – Chap. 7	HW 6
Oct. 26	Lecture – Chap. 7	
Oct. 27		
Oct. 28	Lecture – Chap. 8	
Oct. 29		
Oct. 30	Lecture – Chap. 8	HW 7
Nov. 2	Lecture – Chap. 18	
Nov. 3		
Nov. 4	Lecture – Chap. 18	
Nov. 5		
Nov. 6	Lecture – Chap. 18	HW 8
Nov. 9	Exam Review	
Nov. 10		
Nov. 11	No Class – Academic & Administrative Holiday	
Nov. 12		
Nov. 13		Exam 2
Nov. 16	Lecture – Chap. 18	
Nov. 17		
Nov. 18	Lecture – Chap. 20	
Nov. 19		
Nov. 20	Lecture – Chap. 20	HW 9
Nov. 23	Lecture – Chap. 20	
Nov. 24		
Nov. 25-27	No Class – Academic & Administrative Holiday	
Nov. 30	Lecture – Chap. 19	
Dec. 1		
Dec. 2	Lecture – Selection & Design	
Dec. 3		
Dec. 4	Lecture – Selection & Design	HW 10
Dec. 9-13	Reading Week	
Dec. 18	Final Exam – 3:00-6:00P	

Grading Policies

There are no individual thresholds assigned to the different components of your grade. All components are scored, weighted, pooled, and then **mapped onto a curve for a course grade determination at the end of the semester**. Student learning and growth will be assessed based on the following assignments:

- **Homework (20% of total grade)**
  - There will be 10 problem sets throughout the semester, you may drop one assignment. The total homework grade will be out of 9 assignments.
  - Homeworks may be completed in groups of 2 students or you may choose to work independently.
    - No more than 2 people may work together, but each individual student must turn in an individual version of each homework.

  - Homework pairs must clearly indicate which other student (if any) they worked with on the homework. This will be accomplished by providing the full name (first and last) of your partner below your name at the top of your assignment.
  - Similarities and correlation of solutions within the homework pair are expected, but verbatim copying of one another solutions is no allowed. If you work out how to do the problem together, then write-up your final solutions separately.
  - Strong correlation between the solutions of different pairs' homeworks will lead to additional scrutiny from the graders and instructor. Cases of academic dishonesty (*i.e.*, cheating, copying, etc.) will receive an automatic zero for that assignment.
- Homeworks are to be turned-in online via bCourses by the start of class (12:10PM) on each of the noted due dates.
- Homeworks must be turned-in in .pdf format; submissions must be converted to pdf to preserve formatting, which is common professional engineering practice. No raw word-processing file formats will be accepted. It is strongly suggested that homeworks be completed in a work-processing software with an appropriate equation-editor add-on as opposed to scanned versions of hand-written homeworks. Unreadable or corrupted files cannot be replaced later on – we will grade what is uploaded by the due date and time.
- No late homeworks will be accepted. No late versions to replace missing problems or unreadable or corrupt files will be accepted.
- A few words on the homeworks, solutions, and honesty:
  - The topmost objective of your homework assignments is to guide your self-learning.
  - Some of the questions may be available from various student organizations that maintain databases of previous year's solutions. If you choose to adopt or modify the solutions presented in any of the "Instructor's Manuals" available on line, or an instructor's previously distributed solutions to any of the problems assigned this semester, you MUST give a full citation of such resources; otherwise you are engaging in plagiarism. Such academic dishonesty yields NO points and risks a report to the Center for Student Conduct.

- Exams (45% of total grade, 22.5% for each exam)
  - There will be two (2) 50 minute, "in-class" exams, occurring on Oct. 7 and Nov. 13.
  - You are allowed one "Note Sheet" for each exam. This Note Sheet is a single side, 8 ½ x 11 inch piece of paper upon which you can write any equations, example problems, notes, constants, etc. to help you on the exam. This paper must be turned in with your exam. Failure to turn in your note sheet will result in a loss of points.
  - There will be no makeup exams. If you have a valid reason for missing an exam (e.g., doctor's excuse, death in the family, school-sponsored activity, etc.) I will work with you to reach an acceptable time to take the exam. Cases will be dealt with on a case-by-case process.
  - We will engage in Zoom-based remote proctoring for both exams. Details of the process will be shared with the class ahead of the exams.

- Final Examination (35% of total grade)
  - The final examination will be cumulative – covering all topics from the entire course.
  - The exam will take place on Dec. 18 from 11:30A-2:30P.
  - You are allowed one "Note Sheet" for the final exam. This Note Sheet for the final exam can be *filled on both sides*. Again, it is a 8 ½ x 11 inch piece of paper upon which you can write any equations, example problems, notes, constants, etc. to help you. This paper must be turned in with your exam. Failure to turn in your note sheet will result in a loss of points.

- There will be **no makeup exams**. If you have a valid reason for missing an exam (*e.g.*, doctor's excuse, death in the family, school-sponsored activity, etc.) I will work with you to reach an acceptable time to take the exam. Cases will be dealt with on a case-by-case process.
- We will engage in Zoom-based remote proctoring for the final exam. Details of the process will be shared with the class ahead of the exams.

Late Assignments

- **No late assignments will be accepted unless prior arrangements are made with the instructor for valid excuses.**
  - Valid excuses include, but are not limited to, deaths in the family, jury duty, hospitalization for illness, etc. Valid proof of absences can and will be requested.
  - Non-valid excuses include, but are not limited to, oversleeping, "my printer didn't work," "I wasn't here when you assigned it," etc.
- If you have concerns I am happy to discuss with you about your specific situation and clarify any questions you have.

Re-grading Policy

- Re-grading of exams, reports, and homeworks is a timely and serious undertaking. The Instructor takes the academic integrity of this course and your work very seriously. In turn, you will be asked to take a similar stance on these materials. In order to assure only valid cases come before the class staff, the following policies will be in place. Failure to adhere to these policies will mean that your requests will go unheeded:
  - All re-grading requests must be made within ***1 week (7 days)*** from the time the assignment grades/solutions are made available to the student.
  - Students are required to type up a written request for re-grading. This request should including the following information:
    - Student Name and ID
    - Assignment or Exam in question
    - Problem number in question
    - A written description, using complete sentences, out-lining the suspected mis-grading. This includes a detailed description of what you have done and why you think it merits a re-grade.
  - Re-grade request along with the original assignment/exam will first go to the Instructor (this is Prof. Martin for MSE 45 and your respective GSI with a cc to Prof. Martin for MSE 45L) for consideration. At this point the Instructor can reject re-grade requests that do not meet the above standards. Compliant requests will then go to the appropriate grader or GSI who will consider the request.
    - Simple fixes such as addition errors will be rectified immediately.
    - More extensive requests will go to the appropriate grader or GSI who will then consult with the Instructor with one of two outcomes: 1) a complete re-grade of the entire assignment or 2) rejection of the appeal. Note that complete re-grading may under other errors on other problems that could lower or increase your grade further.
  - The results of this re-grading will be final and binding.
  - Attempts to "doctor" or manipulate assignments after grading to enhance scores will be dealt with under the auspices of the Academic Code of Conduct.

Academic Code of Conduct

- This course will execute a "zero-tolerance" policy concerning cheating and plagiarism.

- Students are referred to the University of California, Berkeley Student Code for complete details on the Student Code. Special attention should be given to Section V and Appendix II of (http://sa.berkeley.edu/code-of-conduct).
- Cheating and plagiarism will be dealt with according to established campus policy. Students caught cheating will receive a failing grade.