Boston University College of Engineering

ME 306
Prerequisites: CH 131

Introduction to Materials Science

Fall 2023

Instructor:

Prof. James Chapman

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Phone: (office) 617-353-0130

Office Hours: Tuesday/Thursday from 12-1:30pm or by appointment

GSTA:

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Course Locations and Times:

Lectures @ PHO 210, Tuesday/Thursday 1:30-3:15pm

Discussion section B1 @ EPC 208, Friday 1:25-2:15pm

Discussion section B2 @ EPC 204, Thursday 3:35-4:25pm

Labs @ ENG 113C, TBD

Course Materials:

Textbook: *Materials Science and Engineering: An Introduction (Tenth edition)* by William Callister Jr., John Wiley and Sons, 2018 (available from bookstore if needed)

Blackboard: https://learn.bu.edu

Course Description:

Structure and properties of solids; crystalline structure; defect structures; diffusion of particles; nucleation and growth; deformation; phase diagrams; strengthening/failure mechanisms; ferrous/nonferrous alloys; ceramics; polymers; composites, computational materials informatics.

Course Outcomes:

As an outcome of this course, students will:

1. Gain and understanding of the fundamental principles of materials science.
2. Gain exposure to different classes of engineering materials.
3. Gain experience in communicating key engineering results in the form of written documents and class presentations.
4. Gain a clear understanding of laboratory safety issues and practices

Topics Covered (chapters based on book)**:**

- Chapter 1: Introduction to Materials Science
- Chapter 2: Atomic Structure and Bonding
- Chapter 3: Crystal Structure
- Chapter 4: Imperfections in Solids
- Chapter 5: Diffusion
- Chapter 6: Mechanics of Materials
- Chapter 7: Strengthening Mechanisms
- Chapter 8: Failure Mechanisms
- Chapter 9: Phase Diagrams
- Chapter 10: Phase Transformations
- Chapter 11: Metal Processing/Applications
- Chapter 12: Ceramics
- Chapter 13: Ceramics Processing/Applications
- Chapter 14: Polymers
- Chapter 15: Polymer Processing/Applications
- Chapter 16: Composites
- *Computational Materials Informatics (not in the book)*

Course Themes:

1. Mechanics of metals
2. Kinetics
3. Structure-property relationships of polymers, ceramics, and composites
4. Computational materials science

Class Policies and Components

Students with Disabilities

If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs can be addressed.

Religious Observation

I respect individual's rights to follow their own religious expressions. Please let me know if a religious observation conflicts with a due date.

Boston University's Academic Conduct Code

Honesty is a core value of Boston University. Any violations of the BU academic honesty and integrity standards will be pursued through appropriate university channels. This includes, but is not limited to, cheating, plagiarism, and misrepresentation. If you have any questions as to what constitutes an honor code violation, please ask. You are expected to understand these rules and your lack of understanding is not an excuse for violating them. You may access the BU Academic Conduct Code at: https://www.bu.edu/academics/policies/academic-conduct-code/

Communication

The website for this course is on Blackboard (https://learn.bu.edu). Electronic materials will be posted periodically throughout the semester on Blackboard. This material includes the course syllabus, homework and quiz solutions, and lab documents. It is important to note than while graded assignments will be posted on Blackboard for you to review, your final grade is not calculated on Blackboard. Therefore, please ignore and interpretation of your grade using Blackboard. If you are interested/concerned about your grade, please ask me directly during my office hours.

Quizzes

Quizzes will take place at the beginning of a class period and will last for 20 minutes. Quizzes will be composed of 5 questions and are designed to test your qualitative knowledge of concepts learned in the previous week(s) classes. Quizzes are closed book and notes. No cell phones are allowed. If you need to exit the room for whatever reason you must place your phone and your exam at the front of the room with your instructor while you are gone and pick them up when you return. Calculators are not allowed (you will not need to perform any numerical calculations on your exam).

Homeworks

Homeworks will have 5 questions. Material in the homework will be described generally during class, though not always in explicit detail. It will be up to you to fully understand the topic being discussed (visiting during office hours and discussion sections is greatly encouraged). You may work with others when completing the homework, though the final work submitted to me must represent your own thought process and work.

Exams

Exams will be taken during a class period. There will be 2 exams, 1 midterm and 1 final. The final will not be cumulative. The midterm exam will cover theme 1, while the final will cover themes 2-4.

Exams will consist of 5 sections: (1) multiple choice, (2) fill-in-the-blank, (3) complete-the-diagram, (4) open response, and (5) problem solving. All content on the exams will be covered in your quizzes, lecture slides, and/or HWs. **You will never need to search for answers outside of these items.**

Do not make travel plans for the exam dates.

Make-up exams will be given only in extreme circumstances. It is your responsibility to let your instructor know as far in advance as possible of an unavoidable conflict or medical emergency.

If you qualify for extended time on exams, per evaluation from the Office of Disability Services, it is your responsibility to present your documentation to you instructor at least a week before the first exam. If you expect to receive extended time based off previous semester, please let your instructor know at the beginning

of the semester, even if you haven't received your documentation yet. We cannot accommodate last-minute requests (less than a week prior to the first exam) for extended time.

Exams are closed book and notes. Cell phones are not allowed during exams. If you need to exit the room for whatever reason you must place your phone and your exam at the front of the room with your instructor while you are gone and pick them up when you return. Calculators are not allowed (you will not need to perform any numerical calculations on your exam). You will be given all necessary information in the exam questions. "Cheat sheets" are therefore not allowed.

There will be a review lecture prior to each exam. Everything that will be on the exam will be present in those lecture slides. However, the slides will also contain information not on the exam. It is up to you to ensure that you know all the material on these slides. You will not need to look elsewhere to study for the exams.

Individual Project

Your individual project will consist of leveraging ChatGPT (or equivalent large language model) to gather information on a specific application (to be chosen later), and then convey whether the information generated by the LLM is correct or incorrect. You will write up a paper consisting of several components: (1) Queries and answers from using the LLM, (2) 3-page maximum (2 page minimum) writeup consisting of you explaining which information from the LLM is correct vs incorrect, and how you know this, (3) a figure of your own creation (using powerpoint or equivalent: no hand-drawn figures) that summarizes the application you have chosen. It is important to understand that the purpose of this project is to understand how to check if the information you receive from machine learning models such as LLM is right or wrong, not whether you have the ability to write an essay. Despite what you may have heard, there is no reliable way to determine if your essay was written by an LLM such as ChatGPT, therefore if you use ChatGPT to write your essay I cannot know for certain. However, ChatGPT is not capable of telling you why it is right or wrong, it simply recalls information based on "closeness" in its feature space. Therefore, you will need to write that portion of your paper from scratch, and it will be obvious if you used ChatGPT to write it (and no, I do not consider using ChatGPT to write an initial essay and then you edit it to be cheating; how is that different from software such as Grammarly?).

Group Project

Your group project will be to take a specific material class and put together a presentation discussing its history. Topics, groups, and presentation slots will be assigned at random. Your presentation will be at most 10 minutes long, and a minimum of 7 minutes, and must contain information about the material class you've been assigned (structure/properties), its history, and its significance in both the past and present. Each group will present their project in front of the class on 12/5/2022. Each group's final video must be uploaded either to Blackboard or to me via email by 12/4/2023, 11:59pm. If there are groups that have not presented by the end of the class period on 12/7/2023, then we will use the beginning on class on 12/12/2022 to finish them. There is no written component of this project, only the presentation and slides. More information about the group project will be available on Blackboard.

Labs

There will be 2 labs for this course, 1 on diffusion, and the other on optics. Further information will be posted on Blackboard. Unless there are several people that cannot attend a lab section (>3), makeup sessions will not be offered. If you miss a lab section due to any reason, unfortunately you cannot receive credit for the lab. You may still submit a final report, but the maximum grade you can get will be a 50.

Discussion Sections

Attendance during these sections is not mandatory but is greatly encouraged. Topics can include anything from a deeper dive into the current week's material to questions about homework assignments. *The people that attend generally have a great time, and do better in the class*

Extra Credit

There will be 1 extra credit assignment worth 10 points onto your final grade. The assignment will be to perform a LAMMPS simulation of bulk Al melting, using an EAM potential. You may use any number of atoms in your simulation, but you must justify why the number you chose is physically reliable (or not). You will create several plots: (1) energy vs time, (2) max force vs time, (3) atomic mean square displacement vs time. You will write a 3-page report summarizing your findings, explaining your methodology, and must include your 3 figures (the figures are not included in the page limit). You must provide an estimate for the melting temperature in you report and justify why you chose that temperature. You must also

cite all references at the end of the report in whatever style you choose. This assignment is extremely difficult and without a background in these simulations you will need to come to me with questions. This assignment cannot be completed in a single weekend without prior background experience using LAMMPS/atomistic simulations. For comparison, it would take me a full day to complete this assignment (the exams would take me ~5-10 minutes). You will receive partial credit on this assignment; for example, if you get a 70/100 as a grade for this assignment, you will get 7 points added to your final grade. However, the assignment must be complete to receive any credit (you cannot write a paragraph and get 1 point added to your final grade).

Grading Policy

Grading for this course will be broken down as follows:

Quizzes	10%
Homeworks	10%
Exams	30% (2x15%)
Individual Project	15%
Group Project	15%
Lab Reports	15%
Participation	5%
Total	100%
Extra credit	+10 points

Further details regarding the grading policy are as follows:

Partial Credit: Partial credit is given on all open-ended problems such as open responses, equation-based problems, and writing/presentation assignments. These problems are graded on a 0-5-7-10 scale: 0 implies that your answer is either completely incorrect or that you did not attempt it, 5 implies you attempted the problem but most of what you provided is not correct (note that writing something random will result in a 0, to get 5 points you must actually attempt to answer the problem), 7 implies you attempted the problem and some information is correct but

not all, and 10 implies that you attempted the problem and your answer(s) were satisfactory. Fill-in-the-blank, and multiple-choice problems will either be right or wrong, and therefore no partial credit is given. Complete-the-diagram problems will typically have multiple parts to complete; each portion is graded as a fill-in-the-blank, but the problem as a whole will be graded out of the total number of items to complete.

Late Assignments: Any lab report or individual project not turned in at the designated deadline will lose 20 points per day that it is not submitted (until the numerical value of the assignment is 0). Homeworks are not accepted any time after the deadline and submissions after that point will result in a 0.

Group projects will be given in class, and each student is assigned a separate grade. If an individual student is not present for the group's presentation (or lab), they will receive at most half credit. If the group presentation is not turned in at the specified deadline the grading scheme is as follows: (1) missed deadline but submitted before class presentations, minus 25 points, (2) missed deadline, not submitted before class presentations, but presentation given in class, minus 50 points, (3) submitted before deadline but not given during class (no one from the group presents), minus 75 points, (4) missed deadline and not given during class, minus 100 points. These point deductions apply to all persons in the group.

For your individual project, lab reports, and extra credit assignment, if you are sick and cannot turn the assignment in on time you **must** tell me prior to the deadline. If you do not, you will be bound to the "20 points per day" rule. There are no exceptions outside of emergencies. In the event of an emergency (having food poisoning is not an emergency, a car accident is), the day that you notify me becomes the new deadline. If it is not turned in that day by 11:59pm then it will start to lose points based on the "20 points per day" rule. This obviously works off the honor system; I'm not here to judge your morality, but your grades will ultimately reflect the effort you put into the class.

Exams: Each exam will be worth 15% of your final grade.

Homeworks: There will be 7 homework assignments throughout the semester. The lowest homework grade will be dropped, so only the top 6 homework grades will count towards your final grade.

Quizzes: There will be 9 quizzes throughout the semester. The lowest quiz grade will be dropped, so only the top 8 quiz grades will count towards your final grade.

Participation: While your attendance in class is not always required, it is recommended so that you can take full advantage of the course. However, participation will be counted during quizzes, exams, labs, your group presentation, and your signed syllabus form at the end of this document. In total, there are 15 instances throughout the semester where your attendance is required. For every absence during those 15 instances, you will lose 1 point out of 15. Your final participation grade will be based on the number of absences during these instances. If you come to class after a quiz has been collected, you will lose 1 point. Participation for exams will depend on your ability to submit your exam at the end of the period (if you aren't here then you lose a point). For labs, if you are greater than 30 minutes late you will lose a point. For group presentations, if you are not present during your group's presentation you will lose a point.

Questions: If you ever have an issue with the grade that you've been given, please see me as soon as possible. Due to scheduling issues, especially towards the end of the semester, waiting too long will result in the grade being final. The sooner you bring it to my attention, the sooner we can both discuss it and determine a solution.

Course Schedule:

Date	Topic	Deadlines/Events
9/5	Introduction to Materials Science	
9/7	Atoms and Bonds	
9/12	Foundations of Crystallography	Quiz 1
9/14	Foundations of Crystallography	
9/19	Mechanics of Metals	Quiz 2, HW 1 due
9/21	Mechanics of Metals	
9/26	Strengthening and Failure	Quiz 3
9/28	Strengthening and Failure	
10/3	Guest Lecture: Joerg Werner	
10/5	Introduction to defects	Quiz 4, HW 2 due
10/10	No Class	
10/12	Metals Deep Dive	
10/17	Review Exam 1	Quiz 5, HW 3 due
10/19	Exam 1	
10/24	Diffusion	
10/26	Phase Transformations	
10/27		Lab Report 1 Due, 11:59pm
10/29		Individual Project Due, 11:59pm
10/31	Phase Transformations	
11/2	Phase Transformations	
11/7	Ceramics Deep Dive	Quiz 6, HW 4 due
11/9	Polymers Deep Dive	
11/14	Polymers Deep Dive	
11/16	Polymers Deep Dive	
11/21	Composites Deep Dive	Quiz 7, HW5 due
OFF	Thanksgiving Break	
11/28	Computational Materials Science	Quiz 8
11/30	Materials Informatics	
12/1		Lab Report 2 Due, 11:59pm
12/4		Group Project Due, 11:59pm
12/5	Group Presentations	Quiz 9, HW 6 due
12/7	Group Presentations	
12/12	Review Final	
Final	Final (not cumulative)	

***Upload a signed version of this page to Blackboard.**

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Fall 2023

I have read the entire syllabus and understand that I am responsible for following the policies and deadlines outlined in the syllabus.

Name: _____

BUID: _____