



Boston University College of Engineering

ME 306
Prerequisites: CH 131

Introduction to Materials Science

Spring 2025

Instructor:

Prof. James Chapman

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Office Hours: Mondays from 11am-12pm, Wednesdays from 3-5pm, and Tuesdays from 10-11am.

GSTA:

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Office hours will be listed on Blackboard.

Course Locations and Times:

Lectures @ EPC 207, Monday/Wednesday 12:20-2:05pm

Discussion section B1-B4 See your schedules for times and locations

Labs @ ENG-113C, see course schedule at the end of this document

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 science, materials informatics.

Course Outcomes:

As an outcome of this course, students will:

1. Gain an 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.

By the end of the semester, students should be able to:

- a. Derive analytical representations for materials behavior under specific conditions.
- b. Define and write fundamental structure-property-processing-performance relationships for different materials classes.
- c. Compare and contrast the behavior of different materials classes and identify the underlying structure-property relationships that drive these differences.
- d. Analyze new materials situations and predict how the system will behave given knowledge of similar systems.

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 Science (not in the book)*

Course Themes:

1. Mechanics of metallic crystals
2. Diffusion and phase transformations
3. Deep dive into 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. If you need an extension on an assignment for any medical condition you **must** get a letter from disability services. **Do not send me doctor's notes.** Please provide said note to disability services and ask them for documentation regarding your extension.

Religious Observation

I respect an individual's rights to follow their own religious expressions. Please let me know if a religious observation conflicts with a due date. I cannot guarantee accommodations with notice less than 72 hours prior to a conflict.

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/>

AI/ML Policy

This course requires AI/ML for your semester project. You are encouraged to use AI/ML to assist with your learning activities/homeworks when appropriate, however all final writeups should be in your own words. Any use of AI/ML outside of these specified tasks is prohibited and will be considered plagiarism and subject to discipline.

Communication

The website for this course is on Blackboard (<https://learn.bu.edu>). **No, the course will not be on Gradescope.** Electronic materials will be posted periodically throughout the semester on Blackboard. It is important to note that 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.

Homeworks

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. You are encouraged to use AI tools to help solve HW questions. However, your final writeup must be your own words/equations. Please note, that AI tools can be incorrect, so relying on these tools to understand concepts will likely result in you misunderstanding course content (and ultimately performing poorly on exams).

Homeworks are not graded for credit, but they are greatly encouraged. See the grading policy later in this document for more detail regarding course credit. The content in your homeworks will be like those seen on the exams. The purpose of the homeworks is to prepare you for the exams. Therefore, you will use the homeworks to prepare your cheat sheet for the exam.

Weekly Summary

Every week you will be required to provide a 1-page writeup summarizing the lectures. These writeups will have prompts to help guide your thoughts. You can add additional information to your summary, but you must answer the prompts. These assignments are graded based on participation and will help you construct your exam cheat sheets and identify areas where you need help.

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 4 sections: (1) multiple choice, (2) reading/understanding diagrams, (3) open response problem solving, and (4) analytical problem solving. All content on the exams will be covered in your lecture slides, HWs, and/or labs.

Do not make travel plans for the exam dates. Travel plans are not considered an excused absence. Illness with less than 24-hour notice will not be excused.

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 your instructor as soon as possible. I cannot accommodate last-minute requests for exam accommodations.

Exams are closed book. Cell phones are not allowed during exams (ex: using them as a calculator). 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 allowed, and it is encouraged that you build them using the homeworks as guidance. You are allowed 1 page, handwritten, one side (cannot use both sides of the paper), standard 8x11 paper. Anything greater than these specifications will result in a zero. Your cheat sheet cannot include solved problems (ex: an entire HW problem solution), but you may include concepts from any course content. Cheat sheets with solved problems will lose credit for whatever problem is on both the cheat sheet and the exam. You will turn in your cheat sheet with your exam so please put your name on them. You will also submit your cheat sheet on Blackboard as an assignment prior to the exam. If you intend to use a cheat sheet during the exam you must submit it to Blackboard prior to the exam and turn in the physical copy with the exam. Turning in only the physical copy will result in a zero on the exam. Using a cheat sheet and not turning it in with your exam will result in a zero. Due dates for the Blackboard submission will be made available closer to the exam date. Any use of electronic mediums for your cheat sheet during the exam will result in a zero and disciplinary action. While I cannot be 100% certain in every case if you were or were not using an electronic medium to cheat, suspicion is enough to warrant an investigation, and the burden of proof is on you.

Semester Project

Throughout the semester you will work on a group project that aims to enhance your knowledge of materials science further than what we can cover in this course. This project is composed of 2 parts: (1) Using LLMs to discover knowledge about a new (to you) materials science problem and validate its answers using factual literature, and (2) do a deep dive into a material science problem to understand how materials science can be used to address the challenge.

There is a list of available topics to choose from on Blackboard. Please follow the directions to selecting topics on Blackboard. Once topics have been chosen, your group will consist of the people that also chose your topic. The project is composed of 2 components: (a) written portion, and (b) presentation portion. The written portion requires that everyone write at least one section (see Blackboard for more details), though the final written document will be uploaded “as a group”. The presentations require that each member present at least 2 slides (again, see Blackboard for more details).

The total length of the written component must be at least 10 pages and no more than 15 pages. It must contain the following sections: Application challenge background including historical approach to application, current materials used to address challenge and why they have been chosen, economic/environmental concerns surrounding both the application and the materials used, future outlook for the application challenge, and finally your LLM analysis.

Presentation and written assignment are due at the end of the semester. There will be no extensions. Each person is graded individually. The final project grade is half written assignment and half presentation.

More information will be provided 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. If you miss a lab section due to any reason, unfortunately you cannot receive credit for the lab (unless enough prior notice has been given; at least 1 week). You may still submit a final report, but the maximum grade you can get will be a 50. It is up to you to obtain the lab data from your group members. Notification of missing a lab less than a week from the lab date cannot be rectified due to time constraints with the room.

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.

Extra Credit

There will be 1 extra credit assignment which will replace your lowest exam grade. The assignment must be complete to receive any credit (ex: you cannot perform half of the assignment and get 50% of the points; you perform all work and then I grade it accordingly). Note, if the assignment ends up with a grade lower than any exam grade then I will keep your original exam grades.

The assignment will be to perform a series of LAMMPS MD simulations of metal surface melting on the (111), (110), and (100) surfaces, using an interatomic 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, (4) radial distribution function changes over time, for each material/structure required. You will also be required to calculate several properties: (1) melting temperature for each surface, (2) self-diffusion constant for each surface, (3) surface energy over time for each surface.

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).

More information will be provided on Blackboard.

Grading Policy

Grading for this course will be broken down as follows:

Exams	50% (2x25%)
Semester Project	20%
Weekly reports	10%
<u>Lab Reports</u>	<u>20% (2x10%)</u>
Total	100%

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.

Late Assignments: Any assignment not turned in at the designated deadline will lose 15 points per day that it is not submitted (until the numerical value of the assignment is 0). Note, the clock starts when the assignment is due, not when you reach out to me asking for an extension after the deadline.

For any assignment, if you are sick/injured 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 “15 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 “15 points per day” rule.

Homeworks: Homeworks are not graded numerically. Each HW assignment will help you practice what you learned over a given period in the class. These assignments are designed to help you prepare for the exams. Each HW that you complete in full will add 5/3 points on to your exam grade. There are 3 HW assignments prior to each exam, so if you complete each group of 3 then you will

get 5 points added to each exam (not cumulative). Answer keys will be provided so you can see where you went wrong.

Weekly reports: These are graded based on completion. To receive credit the assignment must be completed in-full. Partial credit will not be assigned for this. Reports are to be hand-written and turned in every Monday that we have class (Wednesday otherwise).

Participation: While your attendance in class is not required, it is recommended so that you can take full advantage of the course. Not everything in class will be provided after the class, so it is imperative that you take notes if you want to get the most out of the course. For labs, if you are greater than 30 minutes late you will lose half credit on your lab report.

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
1/22	Introduction to Materials Science	
1/27	Atoms and Bonds	
1/29	Foundations of Crystallography	
2/3	Foundations of Crystallography	
2/5	Mechanics of Metals	
2/10	Mechanics of Metals *No Class: video recording*	
2/12	Defects in metals	
2/17	*No Class*	
2/18	Defects in metals (substitute Monday classes)	
2/19	Strengthening and Failure of metals	
2/24-2/28	Lab 1: Diffraction	
2/24	Strengthening and Failure of metals	
2/26	Strengthening and Failure of metals	
3/3	Review exam 1	
3/5	*No lecture*	Exam 1
3/8-3/16	Spring break	
3/17	Diffusion Theory	
3/19	Phase Diagrams	
3/24	Phase Diagrams	
3/26	Phase transformations	
3/28	Lab report 1 due	Blackboard: 11:59pm
3/31	Polymer Theory	
4/2	Polymer Properties	
4/7-4/11	Lab 2: Diffusion	
4/7	Polymer Applications	
4/9	Ceramics Theory *No Class: video recording*	
4/14	Ceramics Applications	
4/16	Composites Deep Dive	
4/21	*No Class*	
4/23	Computational Materials Science	
4/27	Project content due (paper and presentation)	Blackboard: 11:59pm
4/28	Group presentations	
4/30	Group presentations/Review exam 2	
5/1	Extra credit due/Lab report 2 due	Blackboard: 11:59pm

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

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

Name: _____

BUID: _____