

MASC 503 – Thermodynamics of Materials

Fall, 2022

Lectures

M/W 3:00 - 4:50 pm

OHE 100D or online (link provided on DEN/Desire2Learn)

Live Class Information

For the Fall 2022 term, we will use the Desire2Learn system for all class activities. All live sessions will be conducted via Webex. All students will have access to recorded lectures. On campus students are expected to attend classes in person. DEN@Viterbi students can also attend classes in person if desired. Please go to <https://courses.uscden.net> to access Desire2Learn. You will need to create a password if you have not used this system before. Click “Forgot your Password?”. Your username is your full USC email address. To access the Webex live class link, please go to the “Virtual Meetings” item in the course main menu. It is recommended to download and install the [WebEx Meetings app](#) for optimal viewing of lectures. Select your [audio and video settings](#) before joining your first meeting. Recordings will be available under My Tools > Panopto Videos and posted by the DEN team under the corresponding weekly modules. Please review the Panopto player for added interactive elements:

<https://demo.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=a459ffec-4937-4328-9d48-bd02d357ec53>

Course Description

Thermodynamics of Materials is intended for graduate students in Materials Science and Engineering. The course aims to introduce students to a broad treatment of classical and statistical thermodynamics and its applications to equilibrium properties of materials. The course will provide a thermodynamic framework for treating general phenomena in materials science, e.g., chemical reactions, diffusion, and point defects. A focus of the course will be maps of equilibrium states such as phase diagrams. Course topics include the laws of thermodynamics, statistical thermodynamics, solutions, phase equilibria, phase transformations, and phase diagrams of binary and ternary alloys.

Learning Objectives

Students at the end of the course will be equipped with a foundation in classical thermodynamics and statistical thermodynamics that will allow them to:

1. Understand the laws of thermodynamics and their application to mechanical and electromechanical systems and solutions.
2. Be familiar with both classical and statistical thermodynamics and be able to link macroscopic to microscopic properties.
3. Understand phase equilibrium of single component systems and mixtures.
4. Be able to describe the thermal behavior of solid materials and phase transitions.
5. Be able to read, analyze, and construct phase diagrams.

Instructor

Prof. Paulo Branicio

Mork Family Department of Chemical Engineering and Materials Science

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In-person/Online office hours: Wed 5 – 6 pm (email to book a time slot or request another time)

Teaching Assistant

Ms. Suyue Yuan

Office: VHE 609

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In-person/Online office hours: Wed 1 – 3 pm (email to book a time slot or request another time)

Required Readings and Supplementary Materials

Lecture notes will be provided and contain all required content. The books listed below are reference supplementary readings.

Introduction to the Thermodynamics of Materials, 6th edition, by David R. Gaskell & David E. Laughlin, CRC Press, Taylor and Francis Group, 2018.

Thermodynamics in Materials Science, 2nd edition, by Robert DeHoff, CRC Press, Taylor and Francis Group, 2006.

Statistical Mechanics, 1st edition, by Donald Allan McQuarrie, University Science Books, Sausalito, 2000.

Molecular Thermodynamics, Richard Dickerson, Benjamin, Menlo Park, 1969.

Principles of Phase Diagrams in Materials Science, by Paul Gordon, McGraw Hill, New York, 1968.

Fundamentals of Materials Science and Engineering: An Integrated Approach, 5th edition, William D. Callister and David G. Rethwisch, 2015, ISBN: 9781119234395.

Assessment

The learning outcome will be assessed by three midterm tests, an open book quiz, and a final exam. The midterms and the final test are closed books and closed notes. Midterm tests will be given roughly every four weeks about topics covered in the lectures during each period. The final exam is cumulative and includes topics covered in all lectures.

Grading Breakdown

Assignment	% of Grade
Midterm 1	15
Midterm 2	15
Midterm 3	15
Quiz	10
Final Exam	45

Important Dates

Midterm 1: Monday, September 19th

Midterm 2: Wednesday, October 12th

Midterm 3: Wednesday, November 16th

Quiz: Released on November 7 and due on November 16th

Final exam: Monday, December 12th, 2 - 4 pm

Attendance

Attendance at in-person/synchronous sessions is encouraged but not required.

Course Schedule: A Weekly Breakdown

	Topics	Readings	Exams
Week 1	Thermodynamics Introduction First Law of Thermodynamics	Gaskell and Laughlin Ch 1 and 2 DeHoff Ch 1-2, Ch 3 Dickerson: Ch 3	
Week 2	First/Second Law of Thermodynamics	Gaskell and Laughlin Ch 2 and 3 DeHoff Ch 3 and 4 Dickerson: Ch 3, 4	
Week 3	Second Law of Thermodynamics	Gaskell and Laughlin Ch 3 DeHoff Ch 3 and 4 Dickerson: Ch 3, 4	
Week 4	Thermodynamic Relations Third Law of Thermodynamics	Gaskell and Laughlin Ch 4 and 6 DeHoff Ch 3 and 4 Dickerson: Ch 3, 4	Mid Term 1
Week 5	Statistical Mechanics: Ensembles and Thermodynamic Connection	McQuarrie Ch 2 and 3	
Week 6	Statistical Mechanics: Boltzmann, Fermi-Dirac, and Bose Einstein Statistics	McQuarrie Ch 4	
Week 7	Statistical Mechanics: Ideal Monatomic and Diatomic Gases	McQuarrie Ch 5 and 6	
Week 8	Statistical Mechanics: Partition Functions and Ideal Polyatomic Gases	McQuarrie Ch 7 and 8	Mid Term 2
Week 9	Phase Equilibria of Single Component Systems	Gaskell and Laughlin Ch 7 and 8 DeHoff Ch 5 and 7	
Week 10	Thermodynamics of Solutions	Gaskell and Laughlin Ch 9 and 10 DeHoff Ch 8 Dickerson: Ch 6	
Week 11	Thermodynamics of Reactions	Gaskell and Laughlin Ch 11 and 12 DeHoff Ch 11 Dickerson: Ch 5	
Week 12	Phase Diagrams of Binary Systems	DeHoff Ch 9 Gordon: Ch 4 Callister and Rethwisch: Ch 10	
Week 13	Phase Diagrams of Binary Systems	DeHoff Ch 9 Gordon: Ch 4 Callister and Rethwisch: Ch 10	Mid Term 3 Quiz

Week 14	Phase Diagrams of Binary Systems	DeHoff Ch 9 Gordon: Ch 4 Callister and Rethwisch: Ch 10	
Week 15	Phase Diagrams of Ternary Systems	DeHoff Ch 10	
FINAL	Final Examination	Cumulative	Final

Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, “Behavior Violating University Standards” <https://policy.usc.edu/scampus-part-b/>. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on research and scholarship misconduct, <https://policy.usc.edu/research-and-scholarship-misconduct/>

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call

studenthealth.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call

suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press “0” after hours – 24/7 on call

studenthealth.usc.edu/sexual-assault

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 / Title IX – (213) 821-8298

equity.usc.edu, titleix.usc.edu

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

The Office of Disability Services and Programs - (213) 740-0776

dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test-taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Campus Support and Intervention - (213) 821-4710

campussupport.usc.edu

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call

dps.usc.edu

Non-emergency assistance or information.