



MASC 503 – Thermodynamics of Materials

Units: 4

Fall, 2024 M/W 4:00 – 5:50 pm

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

Instructor: Paulo Branicio

Office: VHE 602

Office Hours: In-person/Online Wed 6-7pm. Email to book a time slot or request another time.

Contact Info: branicio@usc.edu. Emails are replied within 24 hours.

Teaching Assistant: Hadi Yazdani

Office: VHE 609

Office Hours: In-person/Online Mon 2-4pm. Email to book a time slot or request another time.

Contact Info: yazdanim@usc.edu. Emails are replied within 24 hours.

Live Class Information

For the Fall 2024 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.

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 two midterm tests, an open book quiz, and a final exam. The midterms and the final test are closed books and closed notes. The exams 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	20
Midterm 2	20
Quiz	10
Final Exam	50

Important Dates

Midterm 1: Monday, September 30

Midterm 2: Monday, October 28

Quiz: Released on November 25, due on December 2

Final exam: Wednesday, December 11, 4:30 pm – 6:30 pm

Attendance

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

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	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 Integrity:

The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, compromises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work

written by others or “recycle” work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see [the student handbook](#) or the [Office of Academic Integrity’s website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University’s educational programs. [The Office of Student Accessibility Services](#) (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

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

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

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers,

combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

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.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-5086 or (213) 821-8298

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

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

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

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

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) 442-1200 – 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.