

# MASC 503 – Thermodynamics of Materials

Fall, 2020

## Online Lectures

M/W 3:30 - 5:20 pm

Zoom link provided on DEN/D2L

## Course Description

Thermodynamics of Materials is intended for graduate students in Materials Science and Engineering. The goal of the course is 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 the treatment of 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 on 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 to 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

Email: [branicio@usc.edu](mailto:branicio@usc.edu)

Online office hours: Tue 2 – 4 pm (book a time slot or request another time by email)

Teaching Assistant: Ms. Suyue Yuan ([suyueyan@usc.edu](mailto:suyueyan@usc.edu))

TA Online office hours: Thu 3 – 5 pm (book a time slot or request another time by email)

## 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, 6<sup>th</sup> edition, by David R. Gaskell & David E. Laughlin, CRC Press, Taylor and Francis Group, 2018.

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

Statistical Mechanics, 1<sup>st</sup> 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, 5<sup>th</sup> 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 book 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 include topics covered in all lectures.

### **Grading Breakdown**

<b>Assignment</b>	<b>% of Grade</b>
Midterm 1	20
Midterm 2	20
Midterm 3	20
Quiz	10
Final Exam	30

### **Important Dates**

Midterm 1: Monday, September 21<sup>st</sup>

Midterm 2: Monday, October 12<sup>th</sup>

Midterm 3: Monday, November 11<sup>th</sup>

Quiz: Released on November 4 and due on November 8<sup>th</sup>

Final exam: Monday, December 7<sup>th</sup>, 2 - 4 pm

### **Attendance**

Attendance at synchronous Zoom sessions is encouraged, but not required.

### **Netiquette**

"Netiquette" or "internet etiquette" expected in this course is described below.

- Students can log in to synchronous sessions using a computer, tablet, or phone.
- Students should update their display name in Zoom to reflect how they would like to be addressed by the instructor and peers.
- Students should mute themselves when not speaking.
- Students are encouraged to unmute to ask questions at any time during synchronous sessions, and/or use the raise hand and chat features in Zoom.
- Students can eat, drink, and leave for bathroom breaks at any time during synchronous sessions
- Chat acronyms, emoticons, etc. are permitted in chat and on discussion boards.

### **Camera-on policy**

To facilitate class dynamics and interaction students are encouraged to turn on their cameras while in synchronous sessions and exams. To minimize privacy concerns students are free to use virtual backgrounds and earphones or headsets to improve audio quality. However, during exams virtual backgrounds should be turned off. It is understood that some students may be facing challenging situations, such as internet connectivity, technical problems, illness, or

home environments that may make the use of a camera difficult or impossible. Accommodations can be arranged to students who contact the instructor directly with reasonable requests.

### Synchronous session recording notice

Synchronous Lecture sessions with transcripts and chat will be recorded and made available to students via DEN/D2L.

### Sharing of course materials outside of the learning environment

Per university policy, recordings of synchronous sessions as well as all asynchronous course materials (notes, assignments, etc.) cannot be shared outside of the MASC 310 learning environment. SCampus Section 11.12(B) Distribution or use of notes or recordings based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study is a violation of the USC Student Conduct Code. This includes, but is not limited to, providing materials for distribution by services publishing class notes. 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. (See Section C.1 Class Notes Policy).

### Course Schedule: A Weekly Breakdown

	Topics	Readings	Exams
<b>Week 1</b>	Thermodynamics Introduction First Law of Thermodynamics	Gaskell and Laughlin Ch 1 and 2 DeHoff Ch 1-2, Ch 3 Dickerson: Ch 3	
<b>Week 2</b>	First/Second Law of Thermodynamics	Gaskell and Laughlin Ch 2 and 3 DeHoff Ch 3 and 4 Dickerson: Ch 3, 4	
<b>Week 3</b>	Second Law of Thermodynamics	Gaskell and Laughlin Ch 3 DeHoff Ch 3 and 4 Dickerson: Ch 3, 4	
<b>Week 4</b>	Thermodynamic Relations Third Law of Thermodynamics	Gaskell and Laughlin Ch 4 and 6 DeHoff Ch 3 and 4 Dickerson: Ch 3, 4	<b>Mid Term 1</b>
<b>Week 5</b>	Statistical Mechanics: Ensembles and Thermodynamic Connection	McQuarrie Ch 2 and 3	
<b>Week 6</b>	Statistical Mechanics: Boltzmann, Fermi-Dirac, and Bose Einstein Statistics	McQuarrie Ch 4	
<b>Week 7</b>	Statistical Mechanics: Ideal Monatomic and Diatomic Gases	McQuarrie Ch 5 and 6	
<b>Week 8</b>	Statistical Mechanics: Partition Functions and Ideal Polyatomic Gases	McQuarrie Ch 7 and 8	<b>Mid Term 2</b>
<b>Week 9</b>	Phase Equilibria of Single Component Systems	Gaskell and Laughlin Ch 7 and 8 DeHoff Ch 5 and 7	

<b>Week 10</b>	Thermodynamics of Solutions	Gaskell and Laughlin Ch 9 and 10 DeHoff Ch 8 Dickerson: Ch 6	
<b>Week 11</b>	Thermodynamics of Reactions	Gaskell and Laughlin Ch 11 and 12 DeHoff Ch 11 Dickerson: Ch 5	
<b>Week 12</b>	Phase Diagrams of Binary Systems	DeHoff Ch 9 Gordon: Ch 4 Callister and Rethwisch: Ch 10	
<b>Week 13</b>	Phase Diagrams of Binary Systems	DeHoff Ch 9 Gordon: Ch 4 Callister and Rethwisch: Ch 10	<b>Mid Term 3 Quiz</b>
<b>Week 14</b>	Phase Diagrams of Binary Systems	DeHoff Ch 9 Gordon: Ch 4 Callister and Rethwisch: Ch 10	
<b>Week 15</b>	Phase Diagrams of Ternary Systems	DeHoff Ch 10	
<b>FINAL</b>	Final Examination	Cumulative	<b>Final</b>

### 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 scientific misconduct, <http://policy.usc.edu/scientific-misconduct>.

### Support Systems:

*Student Counseling Services (SCS) - (213) 740-7711 – 24/7 on call*

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. <https://engemannshc.usc.edu/counseling/>

*National Suicide Prevention Lifeline - 1-800-273-8255*

Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. <http://www.suicidepreventionlifeline.org>

*Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on call*

Free and confidential therapy services, workshops, and training for situations related to gender-based harm. <https://engemannshc.usc.edu/rsvp/>

*Sexual Assault Resource Center*

For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: <http://sarc.usc.edu/>

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

Works with faculty, staff, visitors, applicants, and students around issues of protected class. <https://equity.usc.edu/>

*Bias Assessment Response and Support*

Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. <https://studentaffairs.usc.edu/bias-assessment-response-support/>

*The Office of Disability Services and Programs*

Provides certification for students with disabilities and helps arrange relevant accommodations. <http://dsp.usc.edu>

*Student Support and Advocacy – (213) 821-4710*

Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. <https://studentaffairs.usc.edu/ssa/>

*Diversity at USC*

Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. <https://diversity.usc.edu/>

*USC Emergency Information*

Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible, <http://emergency.usc.edu>

*USC Department of Public Safety – 213-740-4321 (UPC) and 323-442-1000 (HSC) for 24-hour emergency assistance or to report a crime.*

Provides overall safety to USC community. <http://dps.usc.edu>