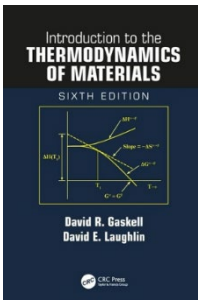
UNIVERSITY OF CALIFORNIA
UCMERCED

MSE 109: Materials Thermodynamics
Fall, 2020
4 units

Class Times	M 3:30pm – 4:20pm, Classroom Building 270 F: 11:30am –1:20pm, Classroom Building 274 We will not meet on Wednesdays. Lectures will be recorded. Watch on your own time and bring questions to class.
Instructor	Dr. Kara E. McCloskey Office: SE1 Room 344 Phone: (209) 228-7885 E-mail: kmccloskey@ucmerced.edu Office Hours: via zoom on M and R 11-12
TA:	Kishwar-E Hasin E-mail: khasin@ucmerced.edu

Catalog description
Thermodynamic laws and principles. Thermodynamics of solid solutions. Phase equilibria in materials systems of one, two, and three components. Nucleation and growth *vs* spinodal decomposition. Determination and interpretation of equilibrium binary and ternary phase diagrams for metals, ceramics, and polymers. Quantitative applications of Ellingham diagrams, phase diagrams, and Pourbaix diagrams.

Required Text:
Introduction to the Thermodynamics of Materials, 6th edition
David R Gaskell, David E Laughlin
ISBN-13: 978-1498757003, CRC Press 2018



Prerequisites
Junior standing and MATH 021 and PHYS 008 and CHEM 002 and ENGR 045, or consent of instructor.

Course objectives/student learning outcomes
After successful completion of this class, students will be able to:
• apply the thermodynamic principles that underpin phase transformations in materials, in the context

of controlling the structure of metals, polymers, ceramics and nanomaterials;
• apply these thermodynamic principles to achieve materials and/or devices with specified properties;
• apply thermodynamics-related diagrammatic and numerical data, quantitative techniques and critical thinking skills, to address materials processing problems.

Students will practice and demonstrate these abilities—and hone the appropriate information-gathering, computational and data-handling skills—in homework and discussion exercises. They will demonstrate their proficiency formally in the quizzes, midterms and final examinations. This course is also conceived as an opportunity for you to demonstrate a developing proficiency in the program learning outcomes that have been adopted by the MSE program, which include:

• an ability to apply mathematical, scientific, and engineering principles to materials systems;
• an integrated understanding of the scientific and engineering principles that underlie the four major elements of the field: structure, properties, processing, and performance related to materials systems appropriate to the field;
• an ability to apply and integrate knowledge from each of the above four elements of the field to solve materials selection and design problems;
• an ability to utilize experimental, statistical, and computational methods in the context of materials systems;
• demonstration of professional and ethical responsibility.

Course Outline:
Quizzes
There will be a short **quiz** at the beginning of discussion, largely based on the assigned reading or HW for the day. Your ideas and feedback on how best to make this all work well for you will be much appreciated.

Exams
• There will be **three in-class midterm exams**, plus a comprehensive **final exam**.
• One crib sheet (2-sided) and calculators will be allowed during the exams.

Grading:
Your **final grade** will be based on the following weights:
Quizzes = 15% total
Exams 15% each (3 of these) = 45%
Homework and participation = 20%
Final exam = 20%

Note: You should not leave a question completely unanswered, even if you know very little about how to answer it. That's not to say that complete garbage will win any points, but that if you can manage to say something correct and pertinent to the question, you are likely to earn partial credit and fair better than if you say nothing at all.

Dropping the course
• Please see the UCMerced General catalog, the Registrar's deadlines page, and/or the Students First dates and dealines page for details.

Lecture Schedule - Fall 2021			
	Date	**Live Class**	**Reading & Recorded Lectures**
Week 1	25-Aug	**Delayed start - No class**	
	27-Aug	**Delayed start - No class**	Course Intro & Definitions, Section 1.1
Week 2	30-Aug	Intro/Syllabus	
	1-Sep		Concepts: Sections 1.2-1.4
	3-Sep	Ch 1 Quiz	Concepts: Sections 1.4-1.8
Week 3	6-Sep	**Labor Day - No class**	**Labor Day - No class**
	8-Sep		1st Law: Sections 2.1-2.3
	10-Sep	HW Ch 1 Due	1st Law: Sections 2.4-2.6
Week 4	13-Sep	Ch 2 Quiz, Problems	
	15-Sep		1st Law: Sections 2.7-2.9
	17-Sep	HW Ch 2 Due	2nd Law: Sections 3.1-3.6
Week 5	20-Sep	Ch 2/3 Quiz, Problems	
	22-Sep		2nd Law: Sections 3.7-3.10
	24-Sep	HW Ch 3, part I Due	2nd Law: Sections 3.11-3.15
Week 6	27-Sep	Ch 3 Quiz, Problems	
	29-Sep		Statistical Interpretation: Sections 4.1-4
	1-Oct	HW Ch 3_part II Due	Statistical Interpretation: Sections 4.5-4
Week 7	5-Oct	*Practice Problems Ch 1-3*	
	7-Oct		Eq&Relationships: Sections 5.1-5.4
	9-Oct	**Exam I: Ch 1-3**	
Week 8	11-Oct	Ch 4 Quiz, Problems	
	13-Oct		Eq&Relationships: Sections 5.4-5.9
	15-Oct	HW Ch 4 Due	Eq&Relationships: Sections 5.10-5.12
Week 9	18-Oct	Ch 5 Quiz, Problems	
	20-Oct		Heat Capacity&Enthalpy: Sections 6.1-6
	22-Oct	HW Ch 5 Due	Entropy and 3rd Law: Sections 6.5-6.7
Week 10	25-Oct	Ch 6 Quiz, Problems	
	27-Oct		Phase Equlibrium: Sections 7.1-7.4
	29-Oct	HW Ch 6 Due	Phase Equlibrium: Sections 7.5-7.8
Week 11	1-Nov	*Practice Problems Ch 4-6*	
	3-Nov		Gas Behavior: Sections 8.1-8.4
	5-Nov	**Exam II: Ch 4-6**	
Week 12	8-Nov	Ch 7 Quiz, Problems	
	10-Nov		Gas Behavior: Sections 8.5-8.7
	12-Nov	HW Ch 7 Due	Solutions: Sections 9.1-9.5
Week 13	15-Nov	Ch 8 Quiz, Problems	
	17-Nov		Solutions: Sections 9.6-9.9
	19-Nov	HW Ch 8 Due	Solutions: Sections 9.10-9.12
Week 14	22-Nov	Ch 9 Quiz, Problems	
	24-Nov	**Thanksgiving Break - No class**	
	26-Nov	**Thanksgiving Break - No class**	
Week 15	29-Nov	Ch 9 Problems	
	1-Dec		
	3-Dec	HW Ch 9 Due	
Week 16	6-Dec	*Practice Problems Ch 7-9*	
	8-Dec		
	10-Dec	**Exam III: Ch 7-9**	
		Final Exam, 11:30am-2:30pm	

Course Policies:

1. Students are expected to attend each class as scheduled, and to be on time. Quizes and HWs are due in class most days.
2. Students may use during lectures: laptops, notebooks, handhelds, etc. for purposes related to the session content only.
3. All cell phones turned OFF or in silent mode.
4. Students are expected to read their e-mails at least once every 12 hours and are responsible for any class-related announcements or directives from the instructor that might be distributed on UCMCROPS.

Note: I am a single mother and may need to cancel class if my little girl is sick and I cannot make other arrangements. This may happen once per semester, so please check your emails regularly for potential notifications.

5. Students are expected to be attentive and respectful of all speakers and fellow students.

Discussion sections

• Learning a subject, especially in engineering requires interacting with the subject—which includes discussing concepts and working practice problems. I will treat the scheduled discussion section as a problem-solving section.

Homework

• Doing homework is a form of concentrated self-testing, and as such it is critical to developing a proper understanding of the subject. I will assign homework problems as they become relevant to our current material, usually due one week later.
• Individual homework sets will be accepted for full credit on the due date only (partial credit is possible after that due date).
• I encourage you to help each other in working through the stumbling blocks that inevitably occur when doing the homework, but it is extremely important that the work you turn in be your own. You must develop your own personal understanding of the material generally and the solutions to the homework problems in particular, or you will have wasted your time. Accordingly, I expect your homework solutions to reflect your unique approach, without duplicating the work of others.
• There is no better way to develop your understanding than by solving problems and writing them up carefully, with details explaining the motivations, assumptions, and justifications for the methods you use, the logical flow of your solutions, and conclusions that you draw from the results. This usually requires not only calculating an answer, but analyzing the process carefully after the fact in order to understand clearly why various steps were justified and effective in leading to the answer and to reflect on the significance of the result you obtained.
• The mathematical steps themselves can generally be communicated more effectively with verbal narration. This approach has many benefits: it enhances your understanding, it makes it easier for the grader to grasp what you have done, it makes it easier for you to review for exams and in the future, it is good practice in technical writing, and engaging in this process is very likely to improve the overall quality and correctness of your work.

Academic honesty:

1. Each student in this course is expected to abide by the University of California, Merced's Academic Honesty Policy. Any work submitted by the student in this course must be the student's own

work.
2. Note: you are encouraged to study together and to discuss information and concepts in lecture with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else (THIS INCLUDES ONLINE SOLUTIONS), in the form of an e-mail, and e-mail attachment, a diskette, or a hard copy. Should copying occur, both the student who copied work and the student who gave material to be copied will automatically receive a zero for the assignment. Penalty for violation of this Policy can also be extended to include failure of the course and University disciplinary action. If you aren't sure, you are expected to ask for clarification.

Disability Statement:
Accommodations for Students with Disabilities: The University of California Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances. Students are encouraged to register with Disability Services Center to verify their eligibility for appropriate accommodations.

Other Campus Resources:
Academic studies can be stressful intellectually as well as socially. Please know that we have resources for you on campus.
Counseling and psychological services
The mission of UC Merced Counseling and Psychological Services (CAPS) is to support the mental health and well-being of our students. It is the intention of all CAPS staff to provide a safe, confidential atmosphere of acceptance and accessibility to professionals in the field of psychology.
Contact information (confidential help)
Phone: 209-228-4266
counseling@ucmerced.edu
https://counseling.ucmerced.edu
Discrimination and sexual violence prevention
The University of California is committed to creating and maintaining a community where all individuals who participate in university programs and activities can work and learn together in an environment free of harassment, exploitation, or intimidation.
Contact information
Phone: 209-285-9510
msalvador2@ucmerced.edu, Michael Salvador, Director of Compliance
https://dvsp.ucmerced.edu
CARE office
Campus Advocacy, Resources, and Education (CARE) provides prevention education for the UC Merced community to achieve an environment free from the threat of sexual violence, dating/domestic violence, and stalking. They provide free and confidential assistance for all UC Merced affiliates (including undergraduate students, graduate students, staff, and faculty). Stop by KL 107.
Contact information (confidential help)
Campus Advocate: Lynna, 209-386-2051
Valley Crisis Center 24/7 Hotline: 209-722-4357

Other books that can supplement your thermodynamics studies.

B. S. Bokstein, M. I. Mendelev, and D. J. Srolovitz, *Thermodynamics and Kinetics in Materials Science: A Short Course* (Oxford University Press, New York, 2005) ISBN 9780198528043.

V. P. Carey, *Statistical Thermodynamics and Microscale Thermophysics* (Cambridge University Press, New York, 1999) ISBN 9780521654203 (paperback), 9780511825620 (ebook).

Y. A. Chang and W. A. Oates, *Materials thermodynamics* (Wiley, Hoboken, New Jersey, 2010) ISBN 9780470484142 (hardcover), 9780470549957 (ebook).

O. F. Devereux, *Topics in Metallurgical Thermodynamics* (Krieger, Malabar, Florida, 1989) ISBN 9780894643293.

K. Dill and S. Bromberg, *Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience*, 2nd ed. (CRC Press, Boca Raton, 2010) ISBN 9780815344308 (paperback), 9780203809075 (ebook).

D. R. Gaskell and D. E. Laughlin, *Introduction to the Thermodynamics of Materials*, sixth ed. (CRC Press, Boca Raton, 2018) ISBN 9781498757003 (hardcover), 9781315119038 (ebook).

L. A. Girifalco, *Statistical mechanics of solids* (Oxford University Press, New York, 2000) ISBN 9780195119657 (hardcover), 9780195167177 (paperback).

R. Hentschke, *Thermodynamics* (Springer, New York, 2014) ISBN 9783642367106 (paperback), 9783642367113 (ebook).

T. L. Hill, *An introduction to statistical thermodynamics* (Dover Publications, Mineola, NY, 1986) ISBN 9780486652429.

J. B. Hudson, *Thermodynamics of materials: a classical and statistical synthesis* (Wiley-Interscience, New York, 1996) ISBN 9780471311430.

Q. Jiang and Z. Wen, *Thermodynamics of Materials* (Springer, New York, 2011) ISBN 9783642147173 (print), 9783642147180 (ebook).

H.-G. Lee, *Materials thermodynamics: with emphasis on chemical approach* (World Scientific, Singapore, 2011) ISBN 9789814368056.

E. S. Machlin, *An Introduction to Aspects of Thermodynamics and Kinetics Relevant to Materials Science*, 3rd ed. (Elsevier, Burlington, Massachusetts, 2007) ISBN 9780080466156 (hardcover), 9780080549682 (ebook).

D. A. McQuarrie and J. D. Simon, *Molecular Thermodynamics* (University Science Books, Sausalito, CA, 1999) ISBN 9781891389054 (hardcover), 9781938787300 (ebook).

D. A. McQuarrie and J. D. Simon, *Physical Chemistry: A Molecular Approach* (University Science Books, Sausalito, CA, 1997) ISBN 9780935702996 (hardcover), 9781891389962 (ebook).

T. Nishizawa, *Thermodynamics of microstructures* (ASM International, Materials Park, Ohio, 2008) ISBN 9780871707161 (hardcover), 9781615031283 (ebook).

D. V. Ragone, *Thermodynamics of materials*, Vol. 1 (Wiley, Hoboken, New Jersey, 1995) ISBN

9780471308850.
D. V. Ragone, *Thermodynamics of materials*, Vol. 2 (Wiley, Hoboken, New Jersey, 1995) ISBN 9780471308867.
F. Reif, *Fundamentals of Statistical and Thermal Physics* (Waveland Press, Long Grove, Illinois, 2009) ISBN 9781577666127.
D. V. Schroeder, *An Introduction to Thermal Physics* (Addison-Wesley, San Francisco, CA, 2000) ISBN
9780201380279.
S. Stølen and T. Grande, *Chemical Thermodynamics of Materials: Macroscopic and Microscopic Aspects*
(Wiley, Hoboken, New Jersey, 2004) ISBN 9780471492306 (hardcover), 9780470092682 (obook), 9780470092675 (ebook).
K. Stowe, *An introduction to thermodynamics and statistical mechanics*, 2nd ed. (Cambridge University Press, New York, 2007) ISBN 9780521865579 (hardcover), 9780511271656 (ebook).
R. A. Swalin, *Thermodynamics*