MSE 401: Thermodynamics of Materials

Syllabus version August 17, 2021

Fall 2021, Homepage https://campuswire.com/c/G20203993/feed

3 undergraduate credit hours, 3 graduate credit hours

Credit is not given for both MSE 401 and CHEM 444 or PHYS 427

Synchronous meeting times will be on MWF at 9:00-9:50 in MSEB 100. The lectures will also be recorded using the Kaltura system and made available in Media Space.

Instructor and TAs

Instructor:	Prof. David Cahill (he/him)
Office hours:	MWF 10-10:50, 1022 MRL
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TA:	Conan Huang (he/him)
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Course Description

Basic thermodynamic principles including energy, entropy, and free energy; macroscopic properties of hard and soft materials systems, such as equilibrium states, phases, and phase transitions. Application of phase diagrams. Statistical interpretation of thermodynamics on the atomistic level.

A theory is the more impressive the greater the simplicity of its premises, the more different kinds of things it relates, and the more extended its area of applicability. Therefore the deep impression that classical thermodynamics made upon me. It is the only physical theory of universal content which I am convinced will never be overthrown, within the framework of applicability of its basic concepts.

-A. Einstein

Lisa, get in here. In this house we obey the laws of thermodynamics!

-Homer Simpson

Course Objectives

Upon completion of the course, students will be able to:

- Define heat and work
- State the second law and describe its significance
- Use the laws of thermodynamics to define equilibrium
- Calculate the change in free energy associated with various processes
- Use the thermodynamics of heterogenous mixtures to construct multicomponent phase diagrams.

Prerequisites

Credit in MSE 201 or MSE 280
Credit or concurrent registration in MATH 285

Course Expectations and Teaching Philosophy

The focus of this course is on the use of classical thermodynamics for understanding the equilibrium properties of materials, their mixtures, and their interfaces. The primary textbook is "Thermodynamics in Materials Science," second edition, by Robert DeHoff. As he discusses in the preface to the text, Professor DeHoff has a "shut-up and calculate" approach. While this approach may be most efficient for students who are planning a career as a materials engineer, many of you will pursue other paths in your professional lives, and, in any case, I believe a deeper understanding of the conceptual framework of thermodynamics is a worthwhile intellectual journey. Thus, we will also read an elegant short text by Peter Atkins, "The Laws of Thermodynamics"; and a graphic novel developed by colleagues at Stanford University that takes place in a fantasy world where a team of young scientists are tasked with saving the world without violating the first and second laws.

The design of the course combines reading of texts, lectures, classroom discussion, discussion forums, weekly homework, and assessment by two midterm exams and one final exam. The homework will include short essay responses to the text and solving problems. We will strive to clearly articulate the assignments, due dates, and grading criteria.

MSE 401 is a 3 credit hour course and therefore requires a minimum commitment of 9 hours per week. I expect you to spend 2.5 hours per week attending lectures and discussions. You should spend a minimum of 6.5 hours per week reviewing lecture material, reading the texts, doing homework, contributing to asynchronous discussions, and studying for exams. I recommend that you schedule a regular time to study.

Web Applications

URL	**Purpose**
Campuswire.com	Discussion forum and posting of text-based resources, e.g., syllabus, required readings, homework solutions
Gadescope.com	Homework assignments, rubrics, and gradebook
Teamup.com	Course schedule
Mediaspace.illinois.com	Posting of recordings of the in-person lectures
iClicker	In-class polling

Academic Integrity Policy

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. According to the Student Code, "It is the responsibility of each student to refrain from infractions of academic integrity, from conduct that may lead to suspicion of such infractions, and from conduct that aids others in such infractions."

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: http://studentcode.illinois.edu/. Ignorance is not an excuse for academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

See also this quick reference guide to academic integrity:
https://provost.illinois.edu/policies/policies/academic-integrity/students-quick-reference-guide-to-academic-integrity/

Academic Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or e-mail a message to disability@illinois.edu. http://www.disability.illinois.edu

Family Educational Rights and Privacy Act

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa for more information.

Sexual Misconduct Policy and Reporting

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX and Disability Office. In turn, an individual with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options. A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found at
https://wecare.illinois.edu/resources/students/#confidential
Other information about resources and reporting is available at https://wecare.illinois.edu

Community of Care

As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the Student Assistance Center (217-333-0050 or http://odos.illinois.edu/community-ofcare/referral/). Based on your report, the staff in the Student Assistance Center reaches out to students to make sure they have

the support they need to be healthy and safe. Further, we understand the impact that struggles with mental health can have on your experience at Illinois. Significant stress, strained relationships, anxiety, excessive worry, alcohol/drug problems, a loss of motivation, or problems with eating and/or sleeping can all interfere with optimal academic performance. We encourage all students to reach out to talk with someone, and we want to make sure you are aware that you can access mental health support at the Counseling Center (https://counselingcenter.illinois.edu/) or McKinley Health Center (https://mckinley.illinois.edu/). For mental health emergencies, you can call 911 or walk into the Counseling Center, no appointment needed.

Required Readings

Thermodynamics in Materials Science, second edition, by Robert DeHoff, CRC Press, Taylor and Francis Group, 2006. We will refer to this text as "DeHoff"

The Laws of Thermodynamics: A Very Short Introduction, by Peter Atkins, Oxford University Press, 2010. We will refer to this text as "Atkins".

The Phoenix Corps, by Petr Johanes, Masami Kiyono, Alberto Salleo, and Colin Reeves-Fortney, copyright Stanford University, 2019. We will refer to this text as "TPC".

Prof. Salleo kindly made a digital copy of TPC available for use in our course at no charge. You can download a copy for your individual use from our class campuswire.com site**. Do not distribute this document electronically or in print to anyone outside of our class**.

Course Requirements

1. Use Campuswire for communicating with the instructor, TAs, and peers.
2. Complete all assigned readings.
3. Access the course materials and complete assignments within the guidelines established in the course calendar. Submit assignments via Gradescope.
4. Contribute questions, answers, or comments to the in-person class discussions or the Campuswire discussion forum. Participate in the in-class polling during lectures.
5. Adhere to assignment deadlines. The deadlines are firm unless a student is given special permission by the instructor. Late submissions are subject to partial credit.
6. Contact the instructor immediately if special circumstances cause interruption of course activities.
7. Keep backup copies of all of work.
8. Submit only original work. Any form of plagiarism is strictly prohibited, as required by University policy. Violation of this rule will result in "no credit" for an assignment or "no credit" for the course.

Course Communication

Please contact the instructor or the TAs via the Campuswire discussion forum if you have questions at any time. Zoom or telephone consultations can be arranged outside of regularly scheduled office hours. The instructor and TAs will respond within one business day.

Announcements. The instructor and TAs will use Campuswire to make announcements. The default settings of Campuswire are that announcements are also sent by email. You can change that default setting within Campuswire if you prefer.

Campuswire. The Campuswire forum is an important part of the course. Please minimize the use direct messaging and emphasize posting to the entire class. If you want clarification of an assignment or help in understanding the reading, then it is likely that many of your classmates will benefit from your question and will benefit from the responses of classmates, the TAs, or instructor. Feel free to carry on an extended discussion with your classmates independent of feedback from the instructor or TAs. The TAs will intervene if the discussion gets off track.

Netiquette. In any social interaction, certain rules of etiquette are expected and contribute to more enjoyable and productive communication. The following tips for interacting online are adapted from guidelines originally compiled by Chuq Von Rospach and Gene Spafford at UIS.

- Remember that the person receiving your message is someone like you, someone who deserves and appreciates courtesy and respect.
- Be brief; succinct, thoughtful messages have the greatest impact.
- Your messages reflect on YOU; take time to make sure that you are proud of their form and content.
- Use descriptive subject headings.
- Think about your audience and the relevance of your messages.
- Be careful with humor and sarcasm; without the voice inflections and body language of face-to-face communication, Internet messages can be easily misinterpreted.
- When making follow-up comments, summarize the parts of the message to which you are responding.
- Avoid repeating what has already been said; needless repetition is ineffective communication.
- Cite appropriate references whenever using someone else's ideas, thoughts, or words.

Assessment

Participation (10% of final grade): Participation will be assessed by in-class polling using iClicker. Points will be given for participation in the in-class poll. We will not deduct points for incorrect answers during the in-class polling. We anticipate approximately one poll per class session, i.e., approximately 40 polls during the semester. You will receive full credit for participation if you participate in 70% of the polls administered during the semester.

Homework (18% of final grade): homework is due by 5 pm on the assigned day. Late work will be accepted within 5 days of the due date. A penalty of 10% per day (linear, not compounded) will be applied for late submissions. Work submitted more than 5 days late will not be graded unless arrangements were made with the instructor prior to the original due date. If an emergency arises, contact Prof. Cahill.

Exam I (18% of final grade): This will cover material from weeks 1-5.

Exam II (18% of final grade): This exam will cover material from weeks 6-10.

Final Exam (36% of final grade): The final exam will cover the entire semester.

Grading Rubrics for Assignments

Grading rubrics will be posted in gradescope with each assignment.

Grading Scale

Percent Range	Letter Grade
100-93	A
92-90	A-
89-87	B+
86-83	B
82-80	B-
79-77	C+
76-73	C
72-70	C-
69-67	D+
66-63	D
62-60	D-
59 and below	F

Course Schedule

Lecture topics, reading assignments, assignment due dates, and times of exams are available through a teamup calendar. https://teamup.com/ks1hep39t754vhp6x9 The schedule is subject to change.

Week. Topic	Readings
1. The Laws of Thermodynamics	Atkins, Chapters 1-3
2. The Laws of Thermodynamics	Atkins, Chapters 4-5; DeHoff, Chapter 3
3. Thermodynamic Variables and Relations	DeHoff, Chapter 4
4. Thermodynamic Variables and Relations	DeHoff, Chapter 4
5. Equilibrium Criteria	DeHoff, Chapter 5
6. Statistical Thermodynamics	TPC, pp-1-37; DeHoff, Chapter 6
7. Statistical Thermodynamics	TPC, pp-38-85; DeHoff, Chapter 6
8. One Component Heterogeneous Systems	DeHoff, Chapter 7
9. One Component Heterogeneous Systems	DeHoff Chapter 7
10. Multicomponent Homogeneous Systems	DeHoff, Chapter 8
11. Multicomponent Homogenous Systems	DeHoff, Chapter 8
12. Multicomponent Heterogenous Systems	DeHoff Chapter 9
13. Multicomponent Heterogenous Systems	DeHoff Chapter 9
14. Thermodynamics of Phase Diagrams	DeHoff Chapter 10
15. Thermodynamics of Phase Diagrams	DeHoff Chapter 10