

# Materials Thermodynamics

## EMA 6316

**Class Periods:** Monday/Wednesday/ Friday, Period 5, 11:45 am – 12:35 pm

**Location:** PSY 151

**Academic Term:** Fall 2024

### **Instructor:**

Prof. Richard G. Hennig

[rhennig@ufl.edu](mailto:rhennig@ufl.edu)

352-392-7327

Office Hours: Thursday, 6 - 7 pm, Zoom <https://ufl.zoom.us/j/93419474788>

### **Course Description**

Thermodynamics of materials systems, surfaces in solids, irreversible processes.

### **Course Pre-Requisites / Co-Requisites**

EMA 4314: Energetics and Kinetics in Materials Science or any equivalent thermodynamics course.

### **Course Objectives**

This course is one of the four key technical courses foundational to the MSE graduate program: Materials Thermodynamics (EMA 6316), Diffusion, Kinetics and Transport in Materials (EMA 6136), Structure and Mechanical Properties of Materials (EMA 6313), and Properties of Functional Materials (EMA 6114). As a core course, this class covers a significant amount of graduate-level material and is designed to challenge you to advance your knowledge and skills. Success will require a considerable investment in preparing for lectures by using textbooks and other sources that you seek out, solving problems, and studying for exams. It is expected that you will have to exhibit significantly more independence, initiative, and ownership of the learning process than what was required for success at the undergraduate level.

This class reviews the four laws of thermodynamics as the fundamental basis for thermal and chemical equilibrium and introduces a statistical mechanical viewpoint for fundamental thermodynamic variables and the relationships between them. The students will apply these principles to understanding phase equilibria, phase diagrams, heterogeneous reactions, solutions, surfaces, and defects. The use of thermodynamics for practical scientific and technical applications will be emphasized in the course.

### **Required Textbooks and Software**

Title: Thermodynamics in Materials Science, 2nd Edition

Author: Robert DeHoff

ISBN: 0-8493-4065-9

Supplementary reading and links to various other resources/websites are provided and updated throughout the semester.

### **Required Computer**

UF student computing requirement: <https://news.it.ufl.edu/education/student-computing-requirements-for-uf/>

### **Course Schedule**

Week	Class dates	Topics	Book chapter
1	August 23	History	1
2	August 26 August 28 August 30	Introduction to Thermodynamics Structure of Thermodynamics	1 2
3	September 4 September 6	The Four Laws	3
4	September 9 September 11 September 13	Variables and Relations	4

Homework 1 due on September 13			
5	September 16 September 18	Equilibrium Conditions Exam Review	5
Exam 1 on September 20			
6	September 23 September 25 September 27	Statistical Mechanics	6
7	September 30 October 2 October 4	Statistical Mechanics Unary Phase Diagrams	6 7
Homework 2 due on October 4			
8	October 7 October 9	Unary Phase Diagrams Exam Review	7
Exam 2 on October 11			
9	October 14 October 16	Partial Molar Quantities	8
10	October 21 October 23 October 25	Partial Molar Quantities Construction of Phase Diagrams	8 9
11	October 28 October 30 November 1	Construction of Phase Diagrams	9
Homework 3 due on November 1			
12	November 4 November 6	Thermodynamics of Phase Diagrams Exam Review	10
Exam 3 on November 8			
13	November 13 November 15	Thermodynamics of Phase Diagrams	10
14	November 18 November 20 November 22	Reactions	11
Homework 4 due on November 22			
15	December 2	Exam Review	
Exam 4 on December 4			

## ***Attendance Policy, Class Expectations, and Make-Up Policy***

### **Course Website**

The course website is on the Canvas system <https://ufl.instructure.com>, where you can find the announcements, syllabus, pre-recorded video lectures, lecture notes, and homework assignments. We will also use Canvas for the preparatory quizzes, the course exams, and your grades. Please check it frequently.

### **Flipped Classroom**

The course will utilize a flipped classroom model. A flipped classroom is a teaching approach where you will first explore new content outside the class by viewing a **pre-recorded video lecture** and completing a **preparatory quiz** on Canvas.

Our regularly scheduled online class time is organized around student engagement, inquiry, and assessment, allowing us to elaborate on thermodynamic concepts and apply them to material problems. The in-class sessions will typically entail structured discussions, collaborative problem-solving, and case studies. The in-class session will also be recorded and posted on Canvas.

Flipped classrooms improved the student performance and learning experience effectively (see, for example, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6852382/>). To take advantage of the in-class discussion and problem-solving requires everyone to watch the video lecture before the in-class activity and complete the quiz. Active participation and engagement in class will help you understand the material and acquire the skills to utilize thermodynamics to solve material problems you will encounter throughout your career. I expect attendance. Questions are highly encouraged. If you do not understand something, chances are that your classmates have missed that point, too. You are responsible for material presented in lectures, reading assignments, homework, and distributed notes.

### **Homework**

EMA6316

Prof. Richard Hennig, Fall 2024

Four homework exercises will be assigned. These homework questions are essential to your study and prepare you for the exams. Some exam questions will be adapted from homework. Homework is usually due back seven days before the corresponding exam. The homework submission dates will be posted on Canvas. The purpose of homework is to give you an opportunity to evaluate and apply your knowledge. You may collaborate on homework; however, the submitted assignment must represent your own work and preparation. Please ask during the online class to discuss homework problems.

**Homework in its entirety must be word-processed.** For some problems, you will require a suitable math package with graphing capability, e.g., Excel, MatLab, Python. Files have to be pdf, doc, docx, or pptx. Picture files (jpg, etc.) are not accepted.

Homework needs to be submitted online through Canvas. Email is not acceptable for the submission of homework. Hard copies are also not accepted.

Homework will be evaluated on the following basis:

	100	85	70	0
<b>Completion</b>	All assigned work is complete.	Most assigned work is complete.	Some assigned work is complete.	Assignment not complete.
<b>Accuracy</b>	All answers are correct.	Most answers are correct.	Some answers are correct.	Little to no answers are correct.
<b>Work shown (derivations and figures)</b>	All work shown in detail.	Most work shown in detail.	Several steps or figures missing.	Did not show any work.

No credit will be given for late unexcused submissions.

### Quizzes and Interactive Learning

We will have online preparatory quizzes covering current and recent lecture material. The quizzes will typically consist of ten questions that should take about 20 minutes to answer. The quizzes serve as feedback both for you and me that you understood the pre-recorded video lectures.

### Exams

We will have four Canvas exams. The exams will consist of concept questions to evaluate your familiarity with the course content and numerical problems designed to test your ability to apply concepts to new situations, i.e., to promote critical thinking. Unless otherwise informed, one sheet of prepared personal notes may be used to assist you in completing examinations. The exams will be on Canvas and use HonorLock. Exam work must be individual, and collaboration is never allowed. Observations of cheating will be promptly reported by the exam proctor. Please see UF's statement on academic honesty: <https://www.dso.ufl.edu/%20sccr/process/student-conduct-honor-code>.

There is no final exam in this class. Exam dates are provide in the course schedule above and will be posted in Canvas.

### EDGE Student Submission Policy

EDGE students must submit all homework assignments electronically by the given deadlines. Exams must be received no more than four days after the in-class exam date. Please scan documents as a pdf and submit them electronically or via fax. The exams will be on Canvas and use HonorLock. If any problems occur, please let me know early. No credit will be given for late unexcused submissions.

### Exam Conflicts with other course exams

The official UF policy on exam conflict resolution states that when two exams conflict, the course with the higher number will take priority.

### Make-up exams

Make-up exams will be provided only with the **prior approval of the instructor**. Excused absences must be consistent with university policies in the Graduate Catalog (<https://catalog.ufl.edu/graduate/regulations>) and require appropriate documentation. Additional information can be found here: <https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>. In general, acceptable reasons for excused absence from an exam include illness, serious family emergencies, special curricular requirements, military obligations, court-imposed legal obligations, and religious holidays. In all cases, you will be required to provide

written documentation and obtain prior instructor approval. You will not be excused from any exam without following the policy above, with no exceptions. Students not in attendance for the scheduled exam will receive a score of zero. **You must notify the instructor no less than 1 week of the scheduled exam of your intent and justification for missing the exam.** Make-up exams for excused absences, as well as exam conflicts, must occur within 1 week of the missed exam and may occur before the missed exam.

### ***Grading Policy***

<b>Assignment</b>	<b>Total Points</b>	<b>Percentage of Final Grade</b>
Homework Sets (4)	100	15%
Quizzes	variable	15%
Midterm Exams (4)	variable	70%
		100%

<b>Percent</b>	<b>Grade</b>	<b>Grade Points</b>
$92 \leq x \leq 100$	A	4.00
$88 \leq x < 92$	A-	3.67
$84 \leq x < 88$	B+	3.33
$80 \leq x < 82$	B	3.00
$76 \leq x < 80$	B-	2.67
$72 \leq x < 76$	C+	2.33
$68 \leq x < 72$	C	2.00
$65 \leq x < 68$	C-	1.67
$62 \leq x < 65$	D+	1.33
$59 \leq x < 62$	D	1.00
$56 \leq x < 59$	D-	0.67
$x < 56$	E	0.00

More information on UF grading policy may be found at:

[UF Graduate Catalog](#)  
[Grades and Grading Policies](#)

### ***Students Requiring Accommodations***

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

### ***Course Evaluation***

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.ua.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.ua.ufl.edu/public-results/>.

### ***In-Class Recording***

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript

of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

### ***University Honesty Policy***

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

### ***Commitment to a Safe and Inclusive Learning Environment***

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University’s core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- HWC OE Human Resources, 352-392-0904, [student-support-hr@eng.ufl.edu](mailto:student-support-hr@eng.ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

### ***Software Use***

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

### ***Student Privacy***

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

### ***Campus Resources:***

#### ***Health and Wellness***

#### **U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**Counseling and Wellness Center:** <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

**Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu).

**Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://elearning.ufl.edu/>.

**Career Connections Center**, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.  
<https://teachingcenter.ufl.edu/>.

**Writing Studio, 302 Tigert Hall**, 846-1138. Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus:** <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

**On-Line Students Complaints:** <https://distance.ufl.edu/getting-help/>; <https://distance.ufl.edu/state-authorization-status/#student-complaint>.