

ME 200: Thermodynamics

Spring 2024 – Section AL2

OVERVIEW

Thermodynamics is the study of the relationship between heat and work, and how properties and states of materials and systems influence their interactions with their surroundings. Thermodynamics is foundational to any well-rounded education in energy/water/power systems and in engineering as a whole. In this course, we will introduce thermodynamic properties and states, concepts of work and heat transfer, efficiency analysis, the three Laws of Thermodynamics, and common thermodynamic cycles and the systems that leverage them (refrigeration, IC engines, power plants, etc.)

Thermodynamics can be a challenging subject, both technically and conceptually, and often serves as a first exposure to higher-level engineering coursework for undergraduate students. Thus, active participation in the course—through attendance and interaction in lectures, honest attempts at homework assignments, and careful review of material for examinations—is critical to your success. My goal is for you to exit this class with a physical understanding and intuition of thermodynamic concepts, as well as a practical, technical skillset related to understanding and evaluating thermodynamic charts, properties, cycles, and systems.

PRE-REQUISITE: MATH 241 (Calculus III)

INSTRUCTOR

Vivek S. Garimella
PhD Candidate, Mechanical Science and Engineering
Office: 3240 Digital Computing Lab (DCL)
viveksg2@illinois.edu

TEACHING ASSISTANTS

Matt Bielawski (mbiela6@illinois.edu)
Yile Xu (yilex2@illinois.edu)

GRADERS

Philip Mackey (pmackey2@illinois.edu)
Rishi Shah (rishias2@illinois.edu)

SCHEDULE

Lectures: MWF, 12:00 PM - 12:50 PM, CIF 2035
Instructor Office Hours: TBD, DCL 3240, [or by appointment](#)
TA Office Hours: TBD, ROOM TBD (Matt)
TBD, ROOM TBD (Yile)

*A detailed lecture schedule can be found on page 7 of this document

TEXTBOOK

M. J. Moran, H. N. Shapiro, et al. [Fundamentals of Engineering Thermodynamics](#), 9th Edition, John Wiley and Sons, 2018

HOMEWORK

You will have 9 homework assignments over the semester. Homework will contain both conceptual/technical and problem-solving questions. Homework will be assigned roughly every week, **due via Gradescope by 11:59 PM one week after it is assigned** (with some deviations—see pg. 7 for full HW schedule). You will always have at least one week to complete a HW. **Please note, Gradescope assignments close after 11:58:59 PM (not 11:59:59PM)**. HW will be graded partially for completeness and partially for correctness. **I will drop your lowest homework grade.**

Your homework answers must be your own. Authorized collaboration includes discussing the interpretation of the problems, sharing ideas or approaches for solving problems, and explaining concepts involved in the problems. Any other aid, *including the use of Generative AI (such as, but not limited to, ChatGPT) and including any use of online forums/solutions (i.e., but not limited to, posting to, or accessing Chegg)*, would be considered a violation of the academic integrity policy.

EXAMS

There will be 2 midterm exams and 1 final exam. These exams will be **closed book** apart from:

- **Exam 1:** 1 sheet of Letter/A4 paper (double-sided)
- **Exam 2:** Exam 1 sheet + 1 new sheet (Letter/A4, double-sided)
- **Final Exam:** Exam 1 sheet + Exam 2 sheet + 1 new sheet (Letter/A4, double-sided)

Calculators are permitted on exams. The final exam will be comprehensive but will be weighted towards material covered after the second Midterm. If you must miss an exam due to a planned absence, **you must notify me within the first two weeks of class**. If an emergency occurs where you must miss an exam, please let me know as soon as you are able to. In both cases, a make-up exam will be administered **if and only if [proper documentation](#) is provided**.

ATTENDANCE AND CLASS ENVIRONMENT

Consistent attendance is an important element to your learning and success in this class. The class will be conducted in a lively, conversational manner and, while lecture notes will be posted after each class session, you will benefit from questions/discussions from your classmates and myself. While electronics are permitted for notetaking in class, studies show a variety of positive outcomes associated with taking hand-written notes¹. In class, please be respectful of me and your peers and limit the use of electronic devices for uses other than note-taking.

If Option 1 is chosen for the grade distribution system (see below), attendance will be measured using the iClicker phone app. Your attendance grade will be measured as **(number of classes)/(number of classes-3)**.

¹ Mueller P.A. and Oppenheimer D.M. *Psychological Science* 2014; 25:1159-1168

GRADE DISTRIBUTION AND CUTOFFS (subject to change)

During the first day of instruction, the grade distribution will be determined via a vote by the class between the following two options. This document will be updated with the chosen grade distribution scheme following the first day of instruction.

Option 1:

- Homework: 20%
- Midterm Exams: 45% ($0.25 \times H + 0.20 \times L$)*
- Final Exam: 30%
- Attendance: 5%

Option 2:

- Homework: 20%
- Midterm Exams: 50% ($0.27 \times H + 0.23 \times L$)*
- Final Exam: 30%

*H is your higher score between the two midterms, L is your lower score.

You are guaranteed the standard scale for grade cutoffs (see below). After reviewing class performance, I may alter these cutoffs, but only in a way that would help you.

97+	93-96	90-92	87-89	83-86	80-82	77-79	73-76	70-72	67-69	63-66	60-62	≤59
A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F

EXTRA CREDIT

While I will drop one homework assignment during the semester, each assignment is designed to help you build your understanding of important concepts and my goal is for you to have ample opportunity to learn the course concepts. To that end, if you choose to complete all 9 assignments (fairly attempting each problem to a solution), 2% extra credit will be added to your final grade in addition to dropping your lowest score. It is up to the sole discretion of the instructor, TAs, and graders as to what constitutes a “fair attempt to a solution.”

ACADEMIC INTEGRITY

As a student of this course, you are expected to follow fully the University of Illinois Academic Integrity policy, which can be found in the “Additional Information” section of this document. If you need any clarification on whether any external resource/aid is within the bounds of this policy, please contact me **before** consulting that external aid or resource.

COURSE MATERIALS

Course materials such as notes, exams, etc., may not be published or shared online without permission from the instructor. Additionally and specifically, publishing exam/homework problems, including any practice exams that may be provided, to online forums is considered a violation of the academic integrity policy (see below).

ADDITIONAL INFORMATION

COVID

Please refer to the University of Illinois Urbana-Champaign's COVID-19 website for detailed information: <https://covid19.illinois.edu/>.

Academic Integrity

The University of Illinois Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: <http://studentcode.illinois.edu/>

Academic dishonesty will result in a sanction proportionate to the severity of the infraction, with possible sanctions described in [1-404 of the Student Code](#). Every student is expected to review and abide by the Academic Integrity Policy as defined in the [Student Code](#).

As a student, it is your responsibility to refrain from infractions of academic integrity and from conduct that aids others in such infractions. A short guide to academic integrity issues may be found [here](#). Ignorance of these policies is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

The Grainger College of Engineering Anti-Racism and Inclusivity Statement

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community. The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (<https://bart.illinois.edu/>). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

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-of-care/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 McKinley Health Center (<https://mckinley.illinois.edu/>) or the Counseling Center (<https://counselingcenter.illinois.edu/>).

For urgent matters during business hours, no appointment is needed to contact the Counseling Center. For mental health emergencies, you can call 911.

Disruptive Behavior

Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem and may be reported to the [Office for Student Conflict Resolution](mailto:conflictresolution@illinois.edu) (conflictresolution@illinois.edu; 333-3680) for disciplinary action.

Emergency Response Recommendations

Emergency response recommendations can be found at the following website: <http://police.illinois.edu/emergency-preparedness/>. I encourage you to review this website and the campus building floor plans website within the first 10 days of class. <http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/>.

Family Educational Rights and Privacy Act (FERPA)

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 on FERPA.

Mental Health

Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.

- Counseling Center (217) 333-3704
- McKinley Health Center (217) 333-2700
- National Suicide Prevention Lifeline (800) 273-8255
- Rosecrance Crisis Line (217) 359-4141 (available 24/7, 365 days a year)

If you are in immediate danger, call 911.

*This statement is approved by the University of Illinois Counseling Center

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure [here](#) to request appropriate accommodations. **This should be done in the first two weeks of classes.**

Sexual Misconduct Reporting Obligation

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 Office. In turn, an individual with the Title IX 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 [here](#)

Other information about resources and reporting is available here: wecare.illinois.edu.

Students with Disabilities

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor as soon as possible and provide the instructor with a Letter of Academic Accommodations from Disability Resources and Educational Services (DRES). To ensure that disability-related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should apply for services with DRES and see the instructor as soon as possible.

If you need accommodations for any sort of disability, please speak to me after class, or make an appointment to see me or see me during my office hours. DRES provides students with academic accommodations, access, and support services. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 217-333-1970, e-mail disability@illinois.edu or visit the DRES website at <http://www.disability.illinois.edu/>. Here is the direct link to apply for services at DRES, <https://www.disability.illinois.edu/applying-services>.

Topic Outline and Tentative Lecture Schedule

Date	Topic	Sections (tentative)	HW Assigned	HW Due
01/17	Course Intro and Module 1 - Introductory Concepts: Systems, Properties, States	1.1-1.3.2		
01/19	Module 1 – Introductory Concepts: Process, Cycle, Properties, Equilibrium	1.3.3-1.5		
01/22	Module 1 – Introductory Concepts: Intensive Properties, Energy, Problem Solving	1.6-1.9	#1	
01/24	Module 2 - Energy and The First Law: Intro, Expansion/Compression Work	2.1-2.3		
01/26	Module 2 - Energy and The First Law: Heat Transfer, Energy of a Closed System	2.4-2.5		
01/29	Module 2 – Energy and The First Law: Energy Balances of Cycles	2.6-2.7	#2	#1
01/31	Module 3 - Evaluating Properties: States, Thermodynamic Charts, Phase Change	3.1-3.3		
02/02	Module 3 - Evaluating Properties: Retrieving + Evaluating Properties (Pressure, Temp, Enthalpy, Energy)	3.4-3.6		
02/05	Module 3 - Evaluating Properties: Energy Balance, Specific Heats, Approximating properties for liquids	3.8-3.9	#3	#2
02/07	Module 3 - Evaluating Properties: Incompressible Substance Model, Compressibility	3.10-3.11		
02/09	Module 3 - Evaluating Properties: The Ideal Gas Model, Polytropic Processes	3.12-3.15		
02/12	Module 4 - Control Volume Analysis: Introduction, Conservation of Mass, Mass Rate Balance	4.1-4.3	#4	#3
02/14	Module 4 - Control Volume Analysis: Conservation of Energy, Steady-State CV Analysis	4.4-4.5		
02/16	Module 4 - Control Volume Analysis: Devices (Nozzles, Diffusers, Turbines, Compressors, Pumps, Heat Exchangers, Throttling Devices)	4.6-4.10		
Week of 02/19	Special Optional Office Hours: Introduction to Engineering Equation Solver (EES) <i>Date, Time, Location TBD</i>			
02/19	Module 4 - Control Volume Analysis: System Integration and Transient Analysis	4.11-4.12	#5	#4
02/21	Module 5 – The Second Law of Thermodynamics: Introduction, Statements of the Second Law	5.1-5.2		
02/23	Module 5 – The Second Law of Thermodynamics: Irreversible, Reversible, and Internally Reversible Processes	5.3-5.4		
02/26	Module 5 – The Second Law of Thermodynamics: Cycle Analysis using the Second Law, Thermal Efficiency	5.5-5.7	#6	#5
02/28	Module 5 – The Second Law of Thermodynamics: Maximum Performance	5.9		

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	(Thermal Energy Reservoirs, Power Cycles, Refrigeration and Heat Pump Cycles)			
03/01	EXAM 1 (covers through Module 4, HW#5)			
03/04	Module 5 – The Second Law of Thermodynamics: The Carnot Cycle, The Clausius Inequality	5.10-5.11		
03/06	Module 6 – Entropy: Defining Entropy, Retrieving Entropy Data	6.1-6.2		
03/08	Module 6 – Entropy: The TdS Equations, Entropy Change in Incompressible Substances and Ideal Gases	6.3-6.5		#6
03/11- 03/15	Spring Break			
03/18	Module 6 – Entropy: Closed System Entropy Balance, Directionality	6.6-6.8		
03/20	Module 6 – Entropy: Open System Entropy Balance and Isentropic Processes	6.9-6.11		
03/22	Module 6 – Entropy: Isentropic Efficiency, Heat Transfer and Work in Internally Reversible Processes	6.12-6.13	#7	
03/25	Module 7 – Exergy: Introduction, “Dead State,” Exergy of a System	7.1-7.3		
03/27	Module 7 – Exergy: Exergy Balance and Exergetic Efficiency	7.4-7.6		
03/29	Module 8 – Vapor Power Systems: Introduction and the Rankine Cycle	8.1-8.2.2		#7
04/01	Module 8 – Vapor Power Systems: The Rankine Cycle (Cont’d), Improvements to the Rankine Cycle	8.2.2-8.3		
04/03	EXAM 2 (covers through Module 6, HW#7)			
04/05	Module 8 – Vapor Power Systems: Improvements to the Rankine Cycle (Cont’d)	8.3		
04/08	Module 8 – Vapor Power Systems: Regenerative Power Cycles, Other Aspects of Vapor Power Cycles	8.4-8.5	#8	
04/10	Module 9 – Gas Power Systems: Introduction, Air-Standard Otto Cycle	9.1-9.2		
04/12	Module 9 – Gas Power Systems: Air-Standard Diesel Cycle, Air-Standard Dual Cycle	9.3-9.4		
04/15	Module 9 – Gas Power Systems: Gas Turbine Power Plants, Air-Standard Brayton Cycle	9.5-9.6	#9	#8
04/17	Module 9 – Gas Power Systems: Regenerative Gas Turbines, Reheat, Intercooling	9.7-9.8		
04/19	Module 9 – Gas Power Systems: Combined Gas Power Cycles, Aircraft Propulsion	9.9-9.11		
04/22	Overflow Day/Guest Lecture			#9
04/24	Module 10 – Applications of Thermo: Vapor-Compression HVAC&R, Heat Pumps	10.1-10.2		

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04/26	Module 10 – Applications of Thermo: Thermal Storage	10.4-10.5		
04/29	Module 10 – Applications of Thermo: Desalination Guest Lecture: Prof. Akanksha Menon (Georgia Tech)			
05/01	Course Wrap-Up, Final Exam Review			
05/03	FINAL EXAM (Comprehensive), 1:30-4:30 PM, Location TBD			