

PHYS 408, Thermodynamics and Statistical Mechanics -- Fall, 2021 Syllabus
Department of Physics and Astronomy, Texas A&M University

This course will include a survey of thermodynamics and statistical mechanics, including quantum as well as classical gases, thermal properties from a statistical perspective including entropy and partition functions, crystals and other dense systems, phase transformations, heat engines and refrigerators, and thermal properties of interacting gases and systems.

Learning Goals: Students in this course will

1. Understand the thermodynamic potentials and the conditions under which they are used.
2. Become familiar with the most important ensembles used to treat thermodynamic systems.
3. Learn to apply the fundamental variables in describing the mathematical properties of such systems.
4. Master the statistical approach to essential thermal problems from a microscopic viewpoint.
5. Gain an understanding of quantum gases and their behavior, and of how these properties contribute to the behavior of physical systems from nuclear matter to crystals and astronomical systems.
6. Become familiar with heat engines and other cycles, including the Carnot cycle and its relation to the second law of thermodynamics.
7. Understand some of the essential thermal physics underlying phase transformations, and interacting particle systems.

Class Meetings: TR 9:35-10:50, and W 4:10-5:00, MPHY 213

Instructor: J. H. Ross, email: ross@physics.tamu.edu

Office: 448 MPHY. Research Lab: B03 ENPH/lab phone 979-845-7823

Office hours TR 11-12, W 5-6 PM (either by Zoom or in 448 MPHY, to be pre-arranged in class, and perhaps adjusted as the semester proceeds). I will often be available to meet at other times; email me to see if I am available.)

Course Website: <http://rossgroup.tamu.edu/408page.html>

Text: Course Text: Callen, Thermodynamics and an Introduction to Thermostatistics (2nd ed.).
Some additional materials will be provided in class to supplement the text readings.

Prerequisites: PHYS 221, PHYS 412, MATH 311 or equivalent

Grading:	Homework	37%
	Hourly Exam	30%
	Final Exam	33%

Assignment of final grades according to point totals calculated using the percentages above is expected to follow the scale, 80-100 A, 70-80 B, 55-70 C, 45-55 D, <45 F. See also the Student Rules regarding Academics at <http://student-rules.tamu.edu>.

HW presentations: There will be a possibility for extra credit, equal to 4 extra percentage points for the homework part of the grades, for in-class presentations of homework solutions. These will be done most Wednesdays, more details in class.

Honors contract: To take this course under honors credit requires an extra research paper and presentation. This involves investigating a topic related to this course beyond what is covered in the textbook and regular lectures, preparing a paper on this subject, and giving a short presentation to the class (about 15 minutes) summarizing the results. The paper should include a description of some of the relevant physics, showing how the results connect to what is covered in class. Also you should include at

least some references to recent research papers showing one or more current research directions related to your topic. I will provide suggestions for topics as the course proceeds.

Covid Protection: To help protect Aggieland from the scourge of COVID-19, Texas A&M University urges students to be vaccinated and to wear masks in classrooms and all other academic facilities on campus, including labs. Doing so exemplifies the Aggie Core Values of responsibility, respect for others, leadership, integrity, and selfless service, by putting community safety above individual preferences. COVID-19 vaccines and proper masking — regardless of vaccination status — are established as safe and effective at reducing rates of infection, hospitalization, and death.

Schedule of topics to be covered: (Chapters are from the text; specific chapter sections will be given as we go along in class.)

General thermodynamic properties; Internal Energy, First Law of Thermodynamics; Entropy Maximum Principle (chapter 1)

Statistical Mechanics of Entropy - Microcanonical Formalism; Einstein Model of Solids; Two State systems, other examples (chapter 15)

Thermal Equilibrium and Equations of State (chapter 2)

Euler Equations and Gibbs-Duhem Relation; Simple Thermodynamic Systems (chapter 3)

Reversible and Irreversible Processes; Maximum Work Theorem; Heat Engines and Refrigerators; Carnot Cycle (chapter 4)

Alternative Formulations and Legendre Transformations; Thermodynamics Potentials (chapter 5)

Extremum Principles; Application of Enthalpy, Helmholtz and Gibbs Free Energies (chapter 6)

Maxwell Transformations (chapter 7)

Canonical Formalism; Internal Modes in a Gas; Density of States; Debye Model and Electromagnetic Radiation (chapter 16)

Grand Canonical Formalism (chapter 17)

Stability Conditions of Thermodynamic Systems (chapter 8)

Phase Transitions (chapter 9)

Quantum Fluids -Bose and Fermi Gases (chapter 18)

Exams:

Exam 1: Oct. 29 6 PM (covering approximately the first half of the semester, specific chapters to be announced).

Final Exam: Dec. 10 12:30-2:30 PM (comprehensive).

Further Information:

Attendance Policy: The university views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments. Please refer to [Student Rule 7](#) in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy: Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in Student Rule 7, or other reason deemed appropriate by the instructor. Please refer to [Student Rule 7](#) in its entirety for information about makeup work, including definitions, and related documentation and timelines. Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" ([Student Rule 7, Section 7.4.1](#)). "The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" ([Student Rule 7, Section 7.4.2](#)). Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. ([See Student Rule 24.](#))

Academic Integrity Statement and Policy: “An Aggie does not lie, cheat or steal, or tolerate those who do.” “Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that student. Students must keep appropriate records at all times. The inability to authenticate one’s work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case” ([Section 20.1.2.3, Student Rule 20](#)).

ADA Policy: Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact the Disability Resources office on your campus (resources listed below) Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible. Disability Resources is located in the Student Services Building or at (979) 845-1637 or visit disability.tamu.edu.

Honor Code: The Aggie Honor Code states, “An Aggie does not lie, cheat, or steal or tolerate those who do.” Further information regarding the Honor Council Rules and Procedures may be found on the web at <http://aggiehonor.tamu.edu>

Title IX and Statement on Limits to Confidentiality: Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit gender-based discrimination and sexual harassment, including sexual assault, sexual exploitation, domestic violence, dating violence, and stalking. With the exception of some medical and mental health providers, all university employees (including full and part-time faculty, staff, paid graduate assistants, student workers, etc.) are Mandatory Reporters and must report to the Title IX Office if the employee experiences, observes, or becomes aware of an incident that meets the following conditions (see [University Rule 08.01.01.M1](#)):

- The incident is reasonably believed to be discrimination or harassment.
- The incident is alleged to have been committed by or against a person who, at the time of the incident, was (1) a student enrolled at the University or (2) an employee of the University.

Mandatory Reporters must file a report regardless of how the information comes to their attention – including but not limited to face-to-face conversations, a written class assignment or paper, class discussion, email, text, or social media post. Although Mandatory Reporters must file a report, in most instances, a person who is subjected to the alleged conduct will be able to control how the report is handled, including whether or not to pursue a formal investigation. The University’s goal is to make sure you are aware of the range of options available to you and to ensure access to the resources you need.

Students wishing to discuss concerns in a confidential setting are encouraged to make an appointment with [Counseling and Psychological Services](#) (CAPS). Students can learn more about filing a report, accessing supportive resources, and navigating the Title IX investigation and resolution process on the University’s [Title IX webpage](#).

Statement on Mental Health and Wellness: Texas A&M University recognizes that mental health and wellness are critical factors that influence a student’s academic success and overall wellbeing. Students are encouraged to engage in healthy self-care by utilizing available resources and services on your campus. Students who need someone to talk to can contact Counseling & Psychological Services (CAPS) or call the TAMU Helpline (979-845-2700) from 4:00 p.m. to 8:00 a.m. weekdays and 24 hours on weekends. 24-hour emergency help is also available through the National Suicide Prevention Hotline (800-273-8255) or at suicidepreventionlifeline.org.