STATISTICAL AND THERMAL PHYSICS

Phys 362 Spring 2019

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Office Hours:	M 2 – 3pm, T 1 – 2pm, W 9 – 10am, F 10 – 11am, 1 – 2pm
Class Meetings:	TTh 2:00pm – 3:15pm, WS 366
Course Website:	http://www.coloradomesa.edu/~dacollin/teaching/2019Spring/Phys362/index.html
Required Text:	H. Gould and J. Tobochnik, *Statistical and Thermal Physics,* Princeton (2010).
Prerequisites:	Phys 230, Phys 231, Math 260

Overview

Statistical and thermal physics describe systems that contain large numbers of individual constituents. Typical examples are gases and solids, which contain large numbers of identical atoms or molecules. The goal of thermal physics is to describe these systems in terms of bulk macroscopic quantities, such as temperature and pressure. The goal of statistical physics is to relate the bulk description to microscopic descriptions of the system constituents. Averaging over microscopic properties such as kinetic energies or dipoles moments of individual molecules or atoms can yield bulk properties such as temperature or magnetization.

Statistical physics and thermodynamics have been developed to the point where a wide range for phenomena can be described using the same small set of general principles. These subjects form a cornerstone of current physics and are frequently used in condensed matter physics, atomic and molecular physics, astrophysics, chemistry and elsewhere.

Phys 362 will introduce you to the framework and techniques of statistical and thermal physics as well as illustrating its applications throughout the physical sciences.

The course covers:

1. Microscopic and macroscopic systems, thermodynamic systems and states, thermodynamic equilibrium.
2. First law of thermodynamics, energy, heat capacities, enthalpy.
3. Thermodynamic processes, entropy, heat engines.
4. Fundamental thermodynamic relation.

5. Probability, microstates/macrostates, thermodynamic ensembles.
6. Magnetic systems.
7. Classical ideal gases, Bose and Fermi gases.

Assignments

An undergraduate student should expect to spend on this course a minimum of two hours outside the classroom for every hour in the classroom. The outside hours may vary depending on the number of credit hours or type of course. More details are available from the faculty member or department office and in CMU's Curriculum Policies and Procedures Manual.

1. **Homework:** There will typically be one homework assignment per week. This will be due by 5pm on the date indicated on the assignment. Late homework will be subject to a penalty of a 2% reduction in the maximum possible grade for each hour that the work is late. It is in your best interests to work by yourself on the homework problems but collaboration is acceptable. You can discuss the broad outlines of problem solutions with your colleagues but must write your final solutions independently. You are also encouraged to consult me for help with homework problems.

Exams and Quizzes

1. **Class Exams:** There will be two exams during class on the following days:

Exam 1:	**Tuesday 5 March 2019**
Exam 2:	**Thursday 18 April 2019**

   Exams will be closed book and closed notes although you will be able to bring a formula sheet. Calculators will be allowed.

2. **Final Exam:** There will be a final exam at **1:00 pm on Tuesday 14 May 2019**. The final will last one hour and 50 minutes and be comprehensive and closed book although a formula sheet will be allowed. Calculators will be allowed.

Grades

Individual assignments and exams will be graded using suitable scales. In general, to get full credit (100%) for a problem your solution must be correct and well justified. Partial credit will be given for incomplete or partly correct solutions. No credit (0%) will be given for problems not attempted, assignments not turned in or quizzes and exams missed without good reason.

The numerical grades for each component will be totaled and a final numerical grade will be computed according to the following distribution.

Homework	40%
Class Exams	30%
Final Exam	30%

The following final numerical scores will guarantee letter grades:

90%	A
80%	B
70%	C
60%	D

Policies

1. **Helpful Resources:** The Tutorial Learning Center (TLC) is a *free* academic service for all CMU students. Tutors are available in Houston Hall 113 on a walk-in basis for many courses. More information is available at www.coloradomesa.edu/tutoring or 248-1392.

   In coordination with Educational Access Services, reasonable accommodations will be provided for qualified students with disabilities. Students must register with the EAS office to receive assistance. Please meet with the instructor the first week of class for information and/or contact Dana VandeBurgt, the Coordinator of Educational Access Services, directly by phone at 248-1801, or in person in Houston Hall, Suite 108.

2. **Withdrawals:** There are several ways to drop this course. The deadline for dropping without penalty is **6 February 2019.** Please consult the MSC academic calendar and catalog for more details about adding and dropping courses.

3. **Attendance:** Attendance policies are described in the CMU catalog. You are expected to attend all the class meetings. In case of illness or other emergencies you must be able to produce the appropriate documentation. There are other circumstances under which you can be excused but you must discuss these with me in advance. If you miss a class or lab for a valid reason, turn in any assignments due before the start of the next class. Assignments turned in beyond your return to class will not be accepted.

   If there is an unavoidable conflict with one of the class exams or the final exam, please discuss it with me as soon as possible. In general I will assume that the final exam will have priority, since you know the dates of the exam.

4. **Academic integrity:** You are expected to present your own work in assignments, exams and quizzes. Fabrication of data, plagiarism, and copying from anyone else, particularly in closed book exams, are serious violation of academic norms. CMU has extensive policies on these matters and penalties for infringement can be severe. For more details, consult the academic integrity policies in the CMU catalog.

Objectives

A student who has taken this course will demonstrate the ability to:

1. Translate between verbal and mathematical descriptions of physical situations. Apply mathematical reasoning, using algebra, trigonometry and calculus, to analyze these situations.
2. Apply the First Law of Thermodynamics (including enthalpy and free energies) to thermodynamic situations.
3. State and use fundamental thermodynamic identities (e.g. temperature in relation to entropy and internal energy), via derivatives and differentials.
4. Apply the First and Second Laws of Thermodynamics to analyze thermodynamic process and heat engines.
5. Determine and use probabilities to relate thermodynamic variables to internal microscopic states of systems.
6. Distinguish between and use Boltzmann, Bose-Einstein and Fermi-Dirac statistics.
7. Use the partition function to determine thermodynamic quantities.

This course contributes to the fulfillment the following program learning objectives for the BS in Physics degree. A student will have demonstrated the ability to:

1. Show fluency with the major fields of physics (classical mechanics, electromagnetism, statistical physics and quantum theory).
2. Use mathematical representations to analyze physical scenarios. This requires translating back and forth between physical and mathematical problems and using appropriate mathematics to aid in the analysis of the scenario.

Schedule

The following schedule is tentative, except for the dates of the class exams.

Week	**Dates**	**Topic**
1	1/22– 1/24	Microscopic and macroscopic systems, thermodynamic systems (Ch 1, 2.1 – 2.5).
2	1/29 – 1/31	First law of thermodynamics, energy in thermal system, heat capacities, thermodynamic derivatives (Ch 2.6 – 2.9, 2.22).
3	2/5 – 2/7	Enthalpy, adiabatic processes, second law of thermodynamics (Ch 2.10 – 2.13).
4	2/12 – 2/14	Fundamental thermodynamic relation, heat engines (Ch 2.13, 2.15 – 2.18).
5	2/19 – 2/21	Heat engines, free energies (Ch 2.14 – 2.21).
6	2/26 – 2/28	Free energies, thermodynamic processes (Ch 2.21, 2.23).
7	3/5	**Exam I**.
7	3/7	Probabilities (Ch 3.1 – 3.6).
8	3/12 – 3/14	Microstates and macrostates (Ch 4.1 – 4.3).
9	3/19– 3/21	Spring break (no classes).
10	3/26 – 3/28	Systems with continuous degrees of freedom (Ch 4.3 – 4.4).
11	4/2 – 4/4	Thermodynamic ensembles (Ch 4.5 – 4.8).
12	4/9 – 4/11	Thermodynamic ensembles, spin systems (Ch 4.5 – 4.8,4.12, 5.1 – 5.3).
13	4/16	Ideal gases (Ch 6.1 – 6.2).
13	4/18	**Exam II**.
14	4/23 – 4/25	Oscillators, multiple particles (Ch 6.3).
15	4/30 – 5/2	Bose-Einstein and Fermi-Dirac statistics (Ch 6.3– 6.5).
16	5/7 – 5/9	Applications of statistical physics (Ch 6.6 – 6.8).