PHYS 421 – Statistical Mechanics

Syllabus, Spring 2026

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Office hours:	TBD

Prerequisites: PHYS 217 or PHYS 317. PHYS 323. MATH 301. One of PHYS 301, MATH 342, or MATH 346. PHYS 321B strongly recommended.

Content: This one-semester course is an honours-level treatment of classical and quantum Statistical Mechanics. It is a lovely subject, and a remarkable development in the history of Physics. Of course the subject is too vast for us to cover all of it in a single term. We will focus on giving a proper introduction to equilibrium statistical mechanics. We will cover the basics of statistics; equilibrium ensembles and the emergence of thermodynamics; non-interacting quantum gases; and, if time allows, Bose-Einstein condensation and Ising models. The plan for the semester is roughly as follows:

Week	Topic
1: 05/01 - 09/01	Probability theory 1
2: 12/01 - 16/01	Probability theory 2
3: 19/01 - 23/01	Statistical description of physical systems
4: 26/01 - 30/01	Basics of statistical mechanics 1
5: 02/02 - 06/02	Basics of statistical mechanics 2
6: 09/02 - 13/02	Other ensembles
7: 16/02 - 20/02	Reading break
8: 23/02 - 27/02	Simple applications 1
9: 02/03 - 06/03	Simple applications 2
10: 09/03 - 13/03	Phase transitions
11: 16/03 - 20/03	Quantum statistical mechanics 1
12: 23/03 - 27/03	Quantum statistical mechanics 2
13: 30/04 - 03/04	Towards statistical field theory

Course materials:

1. The primary text for this course is Reif, *Fundamentals of Statistical and Thermal Physics, 2nd Edition*. It is available from the Library in the Reserve section, although I recommend acquiring a copy for yourself. We will go through roughly the first nine chapters of the text. There are many other books you may wish to consult from time to time. Landau & Lifshitz *Statistical Physics, Part I* is a classic text, but it is less pedagogical. An easier book is Schroeder's *An Introduction to Thermal Physics*.
2. University approved calculator for the Midterm Exam.
3. Access to a computer and the computational software of your choice. Some standard choices are Mathematica, Maple, Matlab, and Python.

Course format:

Lectures:	Monday/Thursday 0830 - 0950
Problem Sets:	Six problem sets, due every other Thursday by 2359.
Midterm Exam:	There will be an in-class exam on Thursday, February 12.
Final exam:	I will conduct 30 minute/student oral exams during the Final Examination period.

Grade:

1. Final: 30%
2. Midterm: 20%
3. Problem sets: 50%

Learning outcomes: Basic competence with physics-related results in statistics, both analytically and using numerical methods. Understanding of the postulates of statistical physics, especially those (e.g. ergodicity) underlying equilibrium statistical mechanics. Ability to predict thermal averages for simple classical and quantum systems, including the onset of phase transitions.

Accommodations

1. Accommodations can be made for missed exams/assignments due to illness or other severe affliction, as well as conflicts with classes and religious observances. Accommodations will also be made for issues documented through CAL.
2. Barring medical or family emergency, late assignments will *not* be accepted. If you do require an extension on account of an emergency, please let me know a reasonable time before the assignment is due.

General comments:

1. Problem sets will, with the exception of the first, be assigned on Thursdays, and are due two weeks later by the end of the day. You may scan and turn in your assignment in the Brightspace, or return a physical copy to my mailbox in the Physics Department office in Elliot 101.
2. The problem sets are *essential*. Physics is learned by doing. Indeed most of your learning in this course will take place in solving problems. Do not expect to succeed in this course without putting in significant effort. I encourage you to collaborate with your fellow students, however, you should independently write up your assignments, both because you owe it to yourself to properly learn the material and in the interest of academic integrity. Further, when you write up your assignment, ensure that it presents a clear and concise argument, starting from the information given and working step by step to a conclusion, which, ideally, should be boxed so as to indicate that you have obtained the desired result. A tangled mess of formulas without explanation will receive zero credit.
3. Please take advantage of my office hours.
4. Both the Midterm and Final exams will be in person. The Midterm will take the place of the February 12 Lecture, and the Final Exam will be oral, with details forthcoming, on a day to be determined during the Final Examination period. I will give you a sample exam and solutions a week before the Midterm so you will know roughly what to expect.

Academic integrity: Students are required to abide by all academic regulations set as set out in the University calendar, including standards of academic integrity. Violations of academic integrity (e.g. cheating and plagiarism) are considered serious and may result in significant penalties.