Physics 7230: STATISTICAL MECHANICS

Spring 2025

Monday, Wednesday Friday 10:10-11am, Duane, XXX

Instructor: Prof. Leo Radzihovsky

Office Hours:	Monday 11am - Noon (or by appointment), Gamow Tower, Rm 623, phone: 492-5436, email: radzihov@colorado.edu
Grader:	
Content:	The course will cover the fundamentals of statistical mechanics (see course outline)
Pre/Corequisites:	PHYS 5250, PHYS 5260, basic thermo at PHYS 1110 level Interest and desire to learn
Text:	Pathria: *Statistical Mechanics*
Additional Suggested Reading:	• Landau and Lifshitz: *Statistical Physics, parts I & II* • Feynman: *Statistical Mechanics*
Homework:	Problem sets will be assigned every couple of weeks, to be uploaded to Canvas
Exams:	
Approximate Grading:	Homeworks: 30% Midterm: 30% Final: 40%

COURSE OUTLINE

1. Review of Basic Thermodynamics
   (a) Four laws of thermodynamics
   (b) Thermodynamic potentials: U, S, F, G, H
   (c) Maxwell Relations
   (d) Specific Heat, Compressibility, etc...
2. Fundamentals of Statistical Mechanics
   (a) Counting of microstates
   (b) Thermodynamic equilibrium and 0th law
   (c) Entropy and connection to thermodynamics
   (d) Microcanonical ensemble
   (e) Classical ideal (noninteracting) monatomic gas
3. Ensemble Theory
   (a) Ensemble average
   (b) Phase space and quantum states
   (c) Liouville's theorem
   (d) Canonical ensemble
   (e) Energy fluctuations and contact with microcanonical ensemble
4. Examples on Canonical Ensemble
   (a) Equipartion theorem
   (b) Ideal monatomic gas
   (c) Classical and quantum harmonic oscillators
   (d) Classical and quantum paramagnets
5. Quantum Statistical Mechanics
   (a) Bosons
   (b) Fermions
   (c) Examples (phonons, photons, metals, magnetism)
6. Phase Transitions
   (a) Mean-field theory (van der Waals, Bragg-Williams, Weiss)

(b) Landau theory

(c) Ferromagnets

(d) Liquid crystals

(e) Superfluids

(f) Superconductors

(g) Universality, scaling theory and critical exponents

(h) Breakdown of mean-field theory (Ginzburg criterion) and how to fix it

7. Equilibrium and Non-equilibrium Dynamics

(a) Brownian motion (Einstein, Smoluchowski, Langevin theories)

(b) Fokker-Planck equation

(c) Fluctuation-dissipation theorem