

Physics 2541

Thermodynamics and Statistical Mechanics

Spring Term 2020

Welcome to the official syllabus of Physics 2541!

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Office Hours: See CourseWeb

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For TA/Grader's Office location and hours, phone, and email, please check the CourseWeb.

Course Information

- *Time and Place of Class*

TTh 9:30am---10:45am, 106 Allen

- *Course Plan*

- Thermodynamics:
 - Fundamental thermodynamic laws
 - Carnot engines; entropy; approach to equilibrium
 - Thermodynamic potentials
 - Applications of thermodynamics
- Classical statistical mechanics
 - Microcanonical ensemble
 - Equipartition theorem

- Classical idea gas
- Mixed entropy and Gibbs paradox
- Canonical and grand canonical ensembles
 - Canonical ensemble
 - Grand canonical ensemble
 - The chemical potential
 - Maxwell construction
- Quantum statistical mechanics
 - Fundamental postulates
 - Density matrix
 - Ensembles in quantum statistical mechanics
 - Third law of thermodynamics
 - The idea gases: approach by grand canonical ensemble
- Bose systems
 - An ideal Bose gas
 - Photons; Blackbody radiation
 - Phonons; Debye model for solids
 - Bose-Einstein condensation
- Fermi systems
 - Equation of state of an ideal Fermi gas
 - White dwarf stars
 - Landau diamagnetism
 - Pauli paramagnetism
- Interacting quantum systems
 - Formalism of second quantization
 - Weakly interacting dilute Bose gases
 - Superfluid order parameter
 - Vortex and superfluidity
 - Superfluid He-4*
 - Weakly interacting Fermi gases*
 - Magnetic properties of an interacting Fermi gas*
- Probability*
 - Random variables
 - Central limit theorem
 - Information, entropy and estimation

In case of a class that needs stronger coverage of basic subjects (or if time is too short for any other reason), the subjects marked with a* would be sacrificed.

• ***Textbooks***

- *main:* R.K. Pathria and P. D. Beale, Statistical Mechanics, 3rd edition, 2011;
- *auxiliary:* Kerson HUANG, Statistical Mechanics, Wiley & Sons; 2nd edition (1987). --- another widely used textbook.

• ***Supplementary texts***

1. L.D. Landau and E. M. Lifshitz, *Statistical Physics* --- a valuable reference
2. Mehran Kardar, Statistical Physics of Particles, Cambridge University Press, 2007. --- a textbook used in MIT and other fine schools in Boston area.
3. Mehran Kardar, Statistical Physics of Fields, Cambridge University Press, 2007. --- if you are

interested in preparing for advanced stat mech course.

Grading policy

The grades for this course will be based on homework (30%), one midterm (30%), and the final exam (40%). The final exam also counts as part of the Graduate Comprehensive Examination.

Change of Classes

See announcement.

Homework

Note: Please visit the "Homework" folder on the CourseWeb Main page of this course for assignments and solutions!

Homework Guidelines:

Homework will be assigned weekly and will be due a week later. Homework exercises are essential for understanding the course material. Often, due to the time pressure, I will explain the general theory in class and leave the examples for homework assignment.

- All homework sets are *due in class* on the date designated on each set (default **Thursdays**), unless there is emergency or the due date/time is extended uniformly for all students because of special circumstances.
- You are strongly encouraged to discuss all topics of statistical mechanics (SM), including homework problems, with others. A *direct* copy of other's homework, however, will receive zero credit for the particular problems. Who lends the homework may get less than full credit. Thank you for holding up a high standard for our SM course!
- Emails regarding homework are discouraged. Instead, you should bring SM questions during the office hours or right after the class.
- Homework must be turned in by paper, **not by email** or any other electronic format.

Exams

Midterm and Final Schedule: Please visit the Exam folder on the CourseWeb.

Guidelines:

- During each of the exams, you are permitted to open one (and only one!) textbook in statistical mechanics. This can be any one of your favorite books by Pathria and Beale, Huang, or any other one. You may also bring a summary sheet [double sided, single page of the standard letter paper size], which will be prepared by yourself in whatever format you choose. Any materials not specifically mentioned above (such as homework sets, lecture notes, previous exams, etc.) are not permitted.
- No makeup exams will be given to any student, except for special/extreme circumstances such as: attend a football game on behalf of the University with authorization from the coach, receive medical treatment in the emergency room at the time of exam, or equivalent. This "no makeup exam" policy will be applied uniformly to everybody, with no exception.

Tables and References

- [Physical constants](#) [Source: [Particle Data Group](#) in LBNL]