Professor Claudio Chamon
Room 319
Tel. X3-5787
chamon@bu.edu

**PY 541 - STATISTICAL MECHANICS I**

**Fall 2019**

## Books:

### Required Texts:

• R. K. Pathria and P. D. Beale, *Statistical Mechanics*, 3rd edition (Academic Press). This is a comprehensive graduate level text.

### Recommended Texts:

There are many helpful references available to complement the text, including:

• M. Kardar, *Statistical Mechanics of Particles; Statistical Mechanics of Fields* (Cambridge). An excellent text.

• K. Huang, *Statistical Mechanics* 2nd edition (Wiley). A text with some flashes of elegance.

• L. D. Landau and E. M. Lifshitz, *Statistical Physics* (Pergamon). Contains a wealth of information, but can be very heavy reading.

• M. Plischke and B. Bergersen, *Equilibrium Statistical Mechanics* (Prentice-Hall). A relatively modern book with an emphasis on phase transitions.

Some good undergraduate-level references to be familiar with:

• F. Reif, *Statistical and Thermal Physics* (McGraw-Hill). A standard senior-level statistical mechanics text. Comprehensive and readable.

• C. Kittel & H. Kroemer, *Thermal Physics* (Freeman) A simpler, and often elegant treatment of undergraduate statistical mechanics.

A book with an excellent collection of problems and exercises.

• R. Kubo, *Statistical Physics* (North-Holland)

## Information:

### Problem Sets

There will be weekly assigned problem sets for this course. You can collaborate with other students in solving the problem sets. However, the write-up that you hand in should represent your own personal effort. Late homework will **not** be accepted.

Problem sets will be posted at `http://physics.bu.edu/~chamon/statmec.html`

### Exams

There will be three in class exams: Exam I on October 3rd, Exam II on November 14th, and the Final Exam on December 17th.

### Grading

This is how your final grade will be computed:

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|---|---|
| **Problem Sets** | **15%** |
| **Exam I** | **25%** |
| **Exam II** | **25%** |
| **Final Exam** | **35%** |

**COURSE OUTLINE**

1. Probability Theory
    - Motivation and basic ideas
    - The binomial distribution, Stirling's approximation, and the Gaussian approximation
    - Central limit theorem
2. Microcanonical Ensemble
    - Equal *a priori* probability principle
    - Definition of temperature and entropy
    - General conditions of equilibrium
3. Canonical Ensemble
    - Equivalence to the microcanonical ensemble; the distribution of energy
    - Helmholtz free energy
    - Computation of averages; distribution of energy and energy fluctuations
    - The equipartition theorem
4. Grand Canonical Ensemble
    - Gibbs factor, thermodynamic potential, and equation of state
    - Computation of averages; distribution of particle number and its fluctuations
5. The Ideal Classical Gas
    - Maxwell-Boltzmann distribution
    - Thermodynamic relations, equations of state
6. The Non-ideal Classical Gas
    - The cluster expansion of the partition function
    - The virial expansion
    - Derivation of leading corrections to ideal behavior and its physical interpretation
    - Van der Waals equation of state
7. Quantum Statistical Mechanics
    - General principles
    - Quantum distributions: Fermi-Dirac, Bose Einstein, Planck distributions, and the Maxwell-Boltzmann limit
8. Ideal Fermi Gas
    - Equation of state, mean energy, and heat capacity of a Fermi gas
    - Magnetic properties of an electron gas
    - White dwarf stars
9. Ideal Bose Gas
    - Basic thermodynamics and Bose-Einstein condensation
    - Black-body radiation
    - Thermodynamics of a photon gas
    - Stefan-Boltzmann law and its applications
    - Phonons in solids
10. Interacting systems and Phase Transitions
    - Phase Transitions in Spin Systems: introduction and basic phenomenology
    - Universality and critical exponents; role of spatial dimensionality
    - Weiss Mean-field theory
    - Landau-Ginzburg theory of phase transitions
    - Exact solution of the one-dimensional Ising model
    - Approximation methods for arbitrary spatial dimension
    - Scaling hypothesis
    - Introduction to basic ideas of the Renormalization Group