SPRING 2022
PHYS 711: **Statistical Mechanics**

Thursday 4:30 – 7:10 pm
Instructor: Fereshte Ghahari, fghahari@gmu.edu
Office Hours: 9:00 am-10:00 am Tuesday, or by appointment

Course text:
This course does not follow a particular text and heavily relies on lecture materials. The following are useful reference books:

- Pathria, R. K. Statistical Mechanics. Pergamon Press, 1972. ISBN: 9780080189949.
- L. D. Landau and E. M. Lifshitz "Statistical Physics", Part 1 (Course of Theoretical Physics, Volume 5), Third Edition, Butterworth-Heinemann, 2000, Oxford, ISBN 0-7506 -3372-7 The course will approximately cover Chapters I-VI;
- W. Greiner, L. Neise and H. Stocker " Thermodynamics and Statistical Mechanics", Springer- Verlag, NY, 1995. ISBN 0-387-94299-8

Lecture:

- Lectures and office hours will be conducted through an online platform via BlackBoard zoom
- Lectures can be accessed via this link: https://gmu.zoom.us/j/93847484376
- Attendance of lectures is required. The course heavily relies on lecture materials.

Homework:

- Homework assignments are 15% of your total Grade.
- You will have 2-4 problems per week
- Homework is due before class the following week. Late homework will **not** be accepted.
- You may consult with classmates in "study groups," as long as you write out your own answers. However, copying homework from other students constitutes cheating and will be treated as violation of the Academic Integrity rules.

Exams:

- Midterm exam (35% of grade): 4:30-7:10 pm March 10th, 2022.
- Final exam (50% of grade): 4:30-7:10 pm, Exam week, May 2022.

Syllabus: Topics covered:

Lecture 1
Statistical Mechanics/Thermodynamics definition
Thermodynamics

- Laws of thermodynamics
    - Internal energy and entropy
- Thermodynamic engines
- Thermodynamic temperature scale

- Clausius theorem

Lecture 2
Postulates of statistical mechanics
Equilibrium conditions

Lecture 3
Method of Lagrange multipliers
Thermodynamic potentials
- Enthalpy
- Helmholtz free energy
- Gibbs free energy
- Other general thermodynamic variables

Extensivity (Gibbs-Duhem relation)
Maxwell relations

Lecture 4
Relation to second derivatives of thermodynamic properties
General conditions of equilibrium
Stability of thermodynamic systems

Lecture 5
Multicomponent systems
- Extensivity (Generalized Gibbs-Duhem equation)
- Electric systems
    - Electric thermodynamic properties
- Magnetic systems
    - Magnetic thermodynamic properties

Lecture 6
Microcanonical ensemble
- General two level system
    - Paramagnetic two level system
- N non-interacting harmonic oscillators

Lecture 7
Canonical ensemble
- Formalism
- General thermodynamic properties
- General two level system
    - Paramagnetic two level system
- N non-interacting harmonic oscillators
- N non-interacting rotators

Lecture 8
Thermodynamics of solids

- Density of states
- Einstein model/Debye model
    - Thermodynamic properties

Thermodynamics of blackbody radiation

- Density of states
- Thermodynamic properties

Lecture 9

Grand canonical ensemble

- Formalism
- General thermodynamic properties
- System in contact with gas molecules
- Fluctuations

Lecture 10

Classical statistical mechanics

- Formalism
- Liouville's theorem
- Connection with quantum mechanics

Lecture 11

Classical ideal gas

- Microcanonical
    - Formalism
    - Thermodynamic properties
    - Mixing of two gases
- Canonical
    - Formalism
    - Thermodynamic properties
    - Paramagnetic two level system

Lecture 12/Lecture 13

Quantum statistical mechanics

- Boson vs Fermion classifications
    - Bosons grand canonical formalism
    - Fermions grand canonical formalism
- Density of states
- Statistics of occupation number
- General thermodynamic properties
- Degenerate Fermi gas
    - Formalism
    - Thermodynamic properties
- Bose gas
    - Formalism
    - Thermodynamic properties

- Bose-Einstein condensation