PHY-303 Statistical Mechanics I

Credit Hours: 3-0

Pre-requisite: None

Course Objectives: The main goal of this course is to acquire fundamental knowledge of classical statistical mechanics, construct a bridge between macroscopic thermodynamics and microscopic statistical mechanics by using mathematical methods and fundamental physics for individual particles. Problem solving is stressed as a means of imparting physical understanding and intuition. We will study how general principles of statistical mechanics work in some simple and complex systems and what powerful notions and ideas have been developed to approach complex cases. In this course, we will be dealing with elements of equilibrium statistical thermodynamics. Applying Statistical mechanics to understand the Fermi Dirac and Bose Einstein statistics.

Core Contents: Introduction to statistical methods, Statistical description of system of particles, Statistical Thermodynamics, Macroscopic parameters and their measurement, Basic methods and results of statistical mechanics, Applications of statistical mechanics, Quantum statistics of ideal gases.

Detailed Course Contents: Introduction to classical probability, Random walk in one dimension, Binomial distribution, Specification of the microscopic state of quantum and classical system, Phase Space and the Ergodic Hypothesis, Microcanonical Ensemble, Statistical basis of Thermodynamics, Thermal and mechanical interaction between two systems, Connection between microcanonical ensemble and Thermodynamics, Probability calculation in canonical ensemble, Introducing partition functions, Thermodynamics from the canonical distribution, The partition function for classical ideal gas, Maxwell's Boltzmann distribution, Equipartition theorem of energy, Probability calculation for the grand canonical ensemble, Thermodynamics from the Grand canonical ensemble, Introduction to ideal quantum gas, Introducing occupation number of an ideal quantum gas, occupation number of Bose Einstein and Fermi Dirac statistics, Diluted gas of diatomic molecule, computation of partition function of diatomic molecules, Calculations of heat capacity of diatomic molecule.

Course Outcomes: Upon successful completion of the course, the student will:

- be able to use principles and ideas to calculate properties of simple statistical systems
- learn different statistical ensembles, their distribution functions
- apply classical and quantum distributions in circumstances varying from standard examples
- become aware of the richness and complexity of statistical behavior exhibited by interacting systems

Textbook: Silvio R.A. Salinas, Introduction to Statistical Physics, Springer Verlag, (2000). (referred as SS)

Reference Books:

R.K. Pathria and Paul.D. Beale, 3rd ed. Statistical Mechanics, Elsevier (2011) (referred as PB)

Daniel. V. Schroeder, An Introduction to Thermal Physics, Addison Wesley (1999).

Weekly Breakdown		
Week	Section	Topics
1	SS 1.1-1.2	Essentials of Probability theory, Random walk in one-dimension, Mean values and standard deviation.
2	SS 1.3-1.5	Mean and standard deviation of Binomial distribution, Gaussian limit of Binomial distribution, Distribution of several random variables, Continuous variables.
3	SS 2.1-2.3, PB 2.1	Specification of the microscopic state of quantum system, Specification of the microscopic state of classical system, Phase Space and the Ergodic Hypothesis.
4	PB 2.2, SS 4.1-4.2	Liouville's Theorem, Microcanonical Ensemble, Statistical basis of Thermodynamics, Thermal and mechanical interaction between two systems.
5	SS 4.3	Connection between microcanonical ensemble and Thermodynamics, Microstates for paramagnetic system, Microstates for Einstein solids, Computing the Equation of state for paramagnetic system and Einstein solids.

6	PB 1.6, SS 4.4	The ideal gas, The correct enumeration of the microstates, The ideal gas in the microcanonical ensemble.
7	SS 5.0-SS 5.0A	Probability calculation in canonical ensemble, Introducing partition functions, Thermodynamics from the canonical distribution.
8	SS 5.1-5.2	Revisit Paramagent and Einstien solids using canonical ensemble, Computing the Equation of state for paramagnetic system and Einstein solids in the framework of canonical ensemble.
		Midterm Exam
9	SS 6.0-6.1	The partition function for classical ideal gas, Partition function of classical and quantum harmonic oscillator, Calculating thermodynamical observables from the harmonic oscillator partition function.
10	SS 6.2-6.3	Maxwell's Boltzmann distribution, Equipartition theorem of energy
11	SS 7.2, 7.2	Probability calculation for the grand canonical ensemble, Thermodynamics from the Grand canonical ensemble, Fluctuations of energy and number of particles.
12	SS 7.2C, SS 8.1-8.2	Classical Ideal monoatomic gas, calculating grand potential of ideal gas, Calculating Equation of state, Introduction to ideal quantum gas, Introducing occupation number of an ideal quantum gas
13	SS 8.2-8.3	Occupation number of Bose Einstein and Fermi Dirac statistics, Classical limit of Bose Einstein and Fermi Dirac distribution, classical limit in the Heltzmholtz formalism,
14	SS 8.3-8.4	Classical limit of canonical partition function, Diluted gas of diatomic molecule.
15	SS 8.4	Computation of partition function of diatomic molecules, Calculations of heat capacity of diatomic molecule.