

B. SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC -16: STATISTICAL MECHANICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Statistical Mechanics DSC – 16	4	3	1	0	Class XII pass with Physics and Mathematics as main subjects	Thermal physics and quantum mechanics papers of this course or their equivalents. Basics of probability and statistics

LEARNING OBJECTIVES

Statistical Mechanics deals with the derivation of the macroscopic parameters (internal energy, pressure, specific heat etc.) of a physical system consisting of large number of particles (solid, liquid or gas) from knowledge of the underlying microscopic behaviour of atoms and molecules that comprises it. The main objective of this course is to introduce the techniques of statistical mechanics which has applications in various fields including astrophysics, semiconductor physics, plasma physics, biophysics etc. and in many other directions. All the problems of different units should be done in the tutorial classes.

LEARNING OUTCOMES

By the end of the course, students will be able to,

- Understand the concepts of phase space, macrostate, microstate, thermodynamic probability and partition function.
- Understand the use of thermodynamic probability and partition function for calculation of thermodynamic properties for physical systems (ideal gas, finite level system).
- Understand the difference between classical and quantum statistics and their applicability.
- Understand the properties and laws associated with thermal radiation.
- Apply the Fermi-Dirac distribution to model problems such as electrons in solids and white dwarf stars
- Apply the Bose-Einstein distribution to model problems such as blackbody radiation and liquid Helium.

SYLLABUS OF DSC – 16

THEORY COMPONENT

Unit - I

(22 Hours)

Classical Statistics: Phase space, macrostates and microstates, entropy and thermodynamic probability, concept of ensemble - Introduction to three types, Maxwell-Boltzmann distribution law, partition function, thermodynamic functions of an ideal gas, Gibbs paradox, Sackur-Tetrode equation. Saha's ionization formula, Law of equipartition of energy (with proof) – Applications to specific heat of gases (monoatomic and diatomic), solids and its

limitations, thermodynamic functions of a finite level system, negative temperature

Unit – II (5 Hours)

Radiation: Blackbody radiation and its spectral distribution. Kirchhoff law (No Proof), Planck's quantum postulates, Planck's law of blackbody radiation, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law and Wien's displacement law from Planck's law, ultraviolet catastrophe

Unit – III (9 Hours)

Bose-Einstein Statistics: Bose-Einstein distribution law, thermodynamic functions of a strongly degenerate Bose gas (non-relativistic), Bose-Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and thermodynamic functions of photon gas. Bose derivation of Planck's law

Unit – IV (9 Hours)

Fermi-Dirac Statistics: Fermi-Dirac distribution law, thermodynamic functions of a completely and strongly degenerate fermions (non-relativistic), specific heat of metals, relativistic Fermi gas, white dwarf stars, Chandrasekhar mass limit.

References:

Essential Readings:

- 1) Statistical Mechanics, R. K. Pathria and P. D. Beale, Academic Press
- 2) Introductory Statistical Mechanics, R. Bowley and M. Sanchez, Oxford Univ. Press
- 3) Statistical Physics, F. Mandl, Wiley
- 4) A treatise on Heat, M. N. Saha and B. N. Srivastava, Indian Press
- 5) Problems and Solutions on Thermodynamics and Statistical Mechanics, Lim Yung-Kou, Sarat Book House
- 6) An Introduction to Thermal Physics, D. Schroeder, Pearson
- 7) Statistical Physics, Berkeley Physics Course, F. Reif, McGraw-Hill

Additional Readings:

- 1) An Introduction to Statistical Physics, W. G. V. Rosser, Wiley
- 2) Thermal Physics, Kittel and Kroemer, CBS
- 3) Concepts in Thermal Physics, Blundell and Blundell, Oxford University Press
- 4) Statistical and Thermal Physics, Loknathan and Gambhir, PHI
- 5) Thermodynamics, Kinetic theory and Statistical thermodynamics, Sears and Salinger, PHI
- 6) Statistical Mechanics, G. Sanon, Alpha Science International Ltd.