PGP/PSP 5438 **THERMODYNAMICS & STATISTICAL PHYSICS** **4hrs/ 4 Cr**

This course helps students to understand the laws involving statistical techniques & its application to physics. Various quantum statistical models are proposed & their appropriate involvement in understanding physical behavior of system of particles is discussed.

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

i. solve problems related to heat and thermodynamics using the laws of thermodynamics and thermodynamic potentials
ii. define statistical ensembles and use partition function to derive the thermodynamic properties of two level system and ideal gas model
iii. explain the thermodynamic properties of Black body radiation, degenerate Fermi gas and Bose gases using quantum statistics
iv. identify the order of phase transitions, explain its properties using Clayperon latent heat equation and Landau theory and calculate the energy transfer involved in phase transitions
v. appreciate the role of non-equilibrium statistics in nature and explain its origin using physical laws

Unit I: Thermodynamics

Introduction- Review of Thermodynamic laws- Carnot Engines- Entropy- Approach to Equilibrium and Thermodynamic Potentials- Enthalpy, Helmholtz free energy and Gibb's free energy- Useful Mathematical Results: Extensivity, Maxwell's Relations- Gibb's Phase Rule- Stability Conditions- Consequences of the Third Law

Unit II: Classical Statistical Mechanics

The Microcanonical Ensemble- Two-Level Systems- Ideal Gas- Mixing Entropy And The Gibbs Paradox- Canonical Ensemble- Partition Function- Canonical Examples(Two-Level Systems and Ideal Gas)- Gibbs Canonical Ensemble- Grand Canonical Ensemble

Unit III: Quantum Statistical Mechanics

Black-Body Radiation- Quantum Microstates- Quantum Macrostates-Hilbert Space of Identical Particles- Canonical Formulation- Grand Canonical Formulation- Non-Relativistic Gas- Degenerate Fermi Gas- Degenerate Bose Gas – Bose Einstein Condensation- Superfluid He^4

Unit IV: Phase Transitions

First Order Phase Transition- Condition For Phase Co-Existence- Clayperon Equation-Van Der Waal's Equation of State- Virial Expansion- Critical Point- Maxwell's Construction- Order Parameter- Landau Theory- Relation To Microscopic Theory- Functional Integration And Differentiation- Second Order Phase Transition- Mean Field Theory- Critical Exponents- Correlation length.

Unit V: Elements of Non-Equilibrium Statistical Mechanics

Thermal Fluctuations- Nyquist Noise- Brownian Motion- Einstein Theory- Diffusion- Einstein's Relation- Ensemble of Paths- Ensemble Average- Power Spectrum And Correlation Function- Signal And Noise- Transition Probabilities- Markov Process- Fokker Planck Equation- Langevin Equation.

Text Books:

1. MehranKardar, *Statistical Physics Of Particles*, Cambridge University Press, 3 Edition (2010)
2. Kerson Huang, *Introduction To Statistical Physics*, Chapman and Hall/CRC,2 Edition, (2009)