Advanced Statistical Mechanics

Programme: M.Sc.	Year: 2nd	Semester: 3rd
Course: Science	Credits: 4	Hours (LTP): 40+12+0

Course Context and Overview (100 words):

This course is designed mainly for the third semester M.Sc. physics students. This course introduces various analytical methods of statistical mechanics and then uses them to develop the Bose-Einstein statistics, and Fermi-Dirac statistics. The course helps to develop concepts in various approximate methods used for studying the interacting systems in statistical mechanics, theory of phase transition, Ising model and fluctuations. The course introduces various sophisticated analytical techniques of statistical mechanics and then uses them to understand the complex physical systems. At the end of the course selected advanced topics of statistical mechanics will be discussed that includes thermodynamic fluctuations, diffusion, Brownian motion, the fluctuation-dissipation theorem and random walk.

Prerequisites Courses:

Classical mechanics, elementary thermodynamics, basic quantum mechanics, mathematical physics, statistical mechanics -I.

Course Outcomes (COs):

On completion of this course, students will have the ability to do:
CO1: Get an opportunity to develop their critical thinking and problem-solving skills related to equilibrium quantum statistical mechanics.
CO2: Use the sophisticated analytical techniques to study the interacting systems.
CO3: Use the basic concepts of statistical mechanics and thermodynamics to understand the theory of phase transitions.
CO4: Acquire a knowledge of developing analytical modelling for complex systems.
CO5: Learn and use the basic concepts of fluctuations and nonequilibrium processes.

Course Topics	Contact Hours (Including Tutorials)
Unit 1: Formulation of the quantum statistical mechanics Quantum mechanical ensemble theory: the density matrix, systems of identical, indistinguishable particles, spin, symmetry of wavefunctions, bosons, Pauli's exclusion principle, fermions, statistics of the various ensembles, Fermi systems,	**15(L) + 4(T)**

Bose systems, Blackbody radiation and Planck's distribution law, B-E condensation, Einstein model of lattice vibrations.	
Unit 2: Statistical mechanics of interacting systems: Approximate Methods Classical cluster expansion, virial expansion of the equation of state, evaluation of the virial coefficients	**6(L) + 2(T)**
Unit 3: Theory of Phase Transitions Phase diagrams, Phase equilibria, critical point, phase transitions, Landau's phenomenological theories	**5(L) + 1(T)**
Unit 4: The Ising model Definition of the Ising model, spontaneous magnetization, the one-dimensional Ising model	**4(L) + 1(T)**
Unit 5: Fluctuations Thermodynamic fluctuations, Principle of detailed balance, irreversible process, Diffusion equation, Brownian motion, the fluctuation-dissipation theorem, random walk.	**10(L) + 4(T)**

Highlighter parts in the CIF indicates the syllabus required for various competitive exams like NET, GATE, JEST etc. Further it helps to learn different analytical and numerical techniques. Also it helps to develop problem solving skills.

REFERENCES

This course does not follow a particular text. The following are useful reference books:

1. K. Huang, *Statistical Mechanics* (John Wiley & Sons, 2003)
2. R. K. Pathria, *Statistical Mechanics* (Pergamon Press, 1972)
3. D. Chowdhury and D. Stauffer, *Principles of Equilibrium Statistical Mechanics*, (Wiley-VCH, 2000).
4. L. D. Landau and E. M. Lifshitz, *Statistical Physics* (Part 1. 3rd ed. Pergamon Press, 1980)
5. Frederick Reif, ed. *Fundamentals of Statistical and Thermal Physics* (McGraw-Hill, 1965)
6. Richard Phillips Feynman, *Statistical Mechanics: A set of Lectures* (Westview Press, 1998)
7. Kadanoff, *Statistical Mechanics*, World Scientific.

Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.)