

**PD202 THERMAL PHYSICS**

(Credits:-04)

Theory: 60 Lectures

**A. Objective of the course:**

The objective of this course is to develop a working knowledge of the laws and methods of thermodynamics and elementary statistical mechanics and to use this knowledge to explore various applications. Many of these applications will relate to topics in materials science and the physics of condensed matter.

**B. Outline of the course:**

<p><b>Introduction to Thermodynamics</b>  <b>Zerth and First Law of Thermodynamics:</b> Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zerth Law of Thermodynamics &amp; Concept of Temperature, Concept of Work &amp; Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law &amp; various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.</p>	<p align="center"><b>8 Lectures</b></p>
<p><b>Second Law of Thermodynamics:</b> Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine &amp; efficiency. Refrigerator &amp; coefficient of performance, 2<sup>nd</sup> Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.</p>	<p align="center"><b>10 Lectures</b></p>
<p><b>Entropy:</b> Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature-Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.</p>	<p align="center"><b>7 Lectures</b></p>
<p><b>Thermodynamic Potentials:</b> Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations</p>	<p align="center"><b>7 Lectures</b></p>
<p><b>Maxwell's Thermodynamic Relations:</b> Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5)Energy equations, (6) Change of Temperature during Adiabatic Process.</p>	<p align="center"><b>7 Lectures</b></p>
<p><b>Kinetic Theory of Gases</b>  <b>Distribution of Velocities:</b> Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and</p>	<p align="center"><b>7 Lectures</b></p>

Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.	
<b>Molecular Collisions:</b> Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.	<b>4 Lectures</b>
<b>Real Gases:</b> Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO <sub>2</sub> Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.	<b>10 Lectures</b>

### C. Instructional Methods and Pedagogy:

The topics will be discussed in depth in an interactive class room environment using classical black-board teaching method and also power-point presentations will be used at times. Brain storming sessions on various topics will be conducted in order to develop problem solving skills in the students. The students are to be examined on the basis of problems, seen and unseen. Students will be trained to crack national level examinations such as JAM and similar exams. Continuous evaluation process will be adopted by conducting small quizzes, class tests, and seminars which will provide the students an opportunity to improve on their performances.

### D. Student Learning Outcomes:

On successful completion of the course students will be able to:

- Apply thermodynamic theory to real thermodynamic cycles and process and to apply the steady-flow energy equation or the Law of Thermodynamics to a system of thermodynamic components (heaters, coolers, pumps, turbines, pistons, etc.) to estimate required balances of heat, work and energy flow.
- Formulate and solve physics problems through the application of thermodynamics.

### E. Reference Books:

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.