Shiksha Mandal's

Bajaj College of Science, Wardha (Autonomous)

Proposed Syllabus for Four Year Multidisciplinary UG Program with DSC as Major (e.g. Four Year B.Sc. Honors/Research Program)

Program: B.Sc.
(Academic Session 2023-24)
Syllabus

THERMAL PHYSICS AND STATISTICAL MECHANICS

A Semester IV course in
Physics
Syllabus under Autonomy

Shiksha Mandal's

Bajaj College of Science, Wardha (Autonomous)
Syllabus for B. Sc. II (SEM-IV) w.e.f. 2024-25
PHYSICS MAJOR DSC IV: THERMAL PHYSICS AND STATISTICAL MECHANICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Course Description:

This course is designed for students of undergraduate course with Physics as subject in B.Sc. Programme. This course is designed for 60 hours theory and 60 hours practical. 4 credits are allotted to the theory course whereas 2 credits are allotted for laboratory course.

Course Objectives:

The course aims to provide students with a comprehensive understanding of Kinetic theory of gases, Thermodynamics and Statistical Physics. The course will cover theoretical concepts and practical experiments to help students develop a strong foundation in the subject. The objectives of this course are:

- To understand the concepts of real gas and ideal gas and associated phenomenon.
- To learn about the kinetic theory of gases and various transport phenomenon.
- To understand the laws of thermodynamics and Carnot cycle.
- To learn about concept of entropy, the Clausius Clapeyron equation and Maxwell's equation and their applications.
- To understand the basics of statistical Physics
- To develop understanding about MB, BE and FD statistics and its applications.

Course learning outcomes: Upon completion of this course student will be able to

CO1: Understand the properties of gases and use kinetic theory to explain gas behaviour.

CO2: Understand the kinetic theory of gases and various transport phenomenon associated with the gases.

CO3: learn about the various laws of thermodynamics, application of these laws to various thermodynamic process and Carnot cycle.

CO4: Use thermodynamic relations like Maxwell's relation, Clausius Clapeyron equation to explain various thermodynamic processes.

CO5: Develop understanding about the basics of Statistical mechanics especially those involving many-particle systems.

CO6: understand quantum and classical statistical mechanics for ideal systems and will be able to apply MB, BE and FD statistics to different systems.

Theory (04 Credit) **(60 Hrs)**

UNIT-I **(10 Hrs)**

Ideal Gas: Kinetic Model, Boyle's law, interpretation of Temperature, estimation of rms speed of molecules, Brownian Motion, Estimate of Avogadro Number, equipartition of energy and its applications to specific heat of gases; monatomic and diatomic gases, Isothermal and Adiabatic expansion of an ideal gas, Application to atmospheric physics.

Real Gas: Van der Waals' Gas, Equation of state, Nature of Van der Waals' forces, The critical Constants.

UNIT-II **(10 Hrs)**

Real Gas: Joule Thomson Effect, Joule Thomson Porous Plug Experiment, Distinction between Joule Expansion, Joule Thomson Expansion, and Adiabatic Expansion.

Transport Phenomenon in Gases: molecular collision, mean free path and collision cross section, estimate of molecular diameter, and mean free path, Transport of mass, momentum, energy and their relationship, dependence on temperature and pressure.

UNIT-III **(10 Hrs)**

The Laws of Thermodynamics-I: Thermodynamic variables, Extrinsic and intrinsic variables, Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Applications of First Law to various thermodynamical Processes, General Relation between C_P & C_V, Work Done during Isothermal and Adiabatic Processes, Reversible & irreversible processes, Carnot's Cycle and its Efficiency, Carnot's Theorem, The Second law of Thermodynamics.

UNIT-IV **(10 Hrs)**

The Laws of Thermodynamics-II: Entropy, Entropy changes in reversible & irreversible processes, Entropy-Temperature diagrams, The thermodynamic scale of temperature, Third law of thermodynamics, Unattainability of absolute zero.

Thermodynamic Relationships: Maxwells general relationships, application to Joule-Thomson Cooling, Joule Thomson Coefficient, Temperature of inversion, Clausius-Clapeyron heat equation, Thermodynamic potentials and their significance, Relation of thermodynamic potentials with their variables, Refrigeration, Air conditioning (concept only)

UNIT-V **(10 Hrs)**

The Statistical Basis of Thermodynamics: Probability and thermodynamic probability, Principal of equal a priori probability, Probability distribution and narrowing with increase in number of particles.

Universal Laws in Statistical Mechanics: Degrees of Freedom, Position Space, Momentum Space, Phase Space, The μ-space and γ-space, Division of phase space into cell, Macrostates and Microstate, Fundamental postulates of statistical mechanics, Density of states, Boltzmann entropy relation, .

UNIT-VI **(10 Hrs)**

Classical Statistics: Three kinds of particles, Maxwell Boltzmann energy distribution law, Applications of Maxwell Boltzmann Distribution law, Mean, RMS and Most Probable Speeds.

Quantum Statistics: Need of Quantum Statistics, Development of Quantum Statistics, Indistinguishability of particles and its consequences, Bose-Einstein Distribution Law (No Derivation), Fermi Dirac Distribution Law and its application to free electrons in the metals, Fermi level , Fermi temperature and Fermi Energy, Fermi energy at absolute zero E_{F_0} for electrons in a metal, Comparison between MB, BE and FD statistics.

Reference Books:

- Heat Thermodynamics and Statistical Physics, Brijlal, N. Subrahmanyam, P.S. Hemne, 2007, S. Chand Publications
- Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
- Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
- Heat and Thermodynamics, M.W. Zemasky and R. Dittman, 1981, McGraw Hill 14
- Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W. Sears & G.L. Salinger. 1988, Narosa
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications

Laboratory (02 Credits) **60 Hrs**

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Experimental Determination of ratio of specific heat (γ) using Clement and Desormes Method
3. Measurement of Planck's constant using black body radiation.
4. To determine Stefan's Constant.
5. To determine the coefficient of thermal conductivity of copper by Searle's Apparatus.
6. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
7. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
8. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.

9. To study the variation of thermo-emf across two junctions of a thermocouple with temperature.
10. To record and analyse the cooling temperature of a hot object as a function of time using a thermocouple and suitable data acquisition system.
11. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge.
12. To determine the efficiency of electric kettle.
13. Study of statistical distribution from given data and to find the most probable, average and RMS value.
14. Statistical determination of possible macrostates and their deviation (10 coin system)

Reference Books:

- Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
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PHYSICS MINOR IV: THERMAL PHYSICS AND STATISTICAL MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Course Description:

This course is designed for students of undergraduate course without Physics as subject in B.Sc. Programme. This course is designed for 60 hours theory and 60 hours practical. 4 credits are allotted to the theory course whereas 2 credits are allotted for laboratory course.

Course Objectives:

The course aims to provide students with a comprehensive understanding of Kinetic theory of gases, Thermodynamics and Statistical Physics. The course will cover theoretical concepts and practical experiments to help students develop a strong foundation in the subject. The objectives of this course are:

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Theory (04 Credit) **(60 Hrs)**

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