Faculty of Science

Bachelor of Science (B.Sc.)

SUBJECT: PHYSICS

B.Sc. II Semester

Paper-Major& Minor

COURSE OUTCOME

	Course Outcomes	Cognitive Level
CO-I	Learner will be able to recollect the Specific Contributions of Indians in thermodynamics and statistical mechanics.	U, C
CO-II	Learner will be able to make use of Basic concepts of thermodynamics & apply Maxwell's thermodynamic relations to derive various formulae.	U, R, E,Ap
CO-III	Learner will be able to use and apply the idea of Micro and Macro states, Ensembles, Statistical Probability and Phase Space.	R, U, An , Ap, E
CO-IV	Learner will be able to apply the idea of partition function and distribution function to classical and quantum statistics.	R , U , Ap, An, E

Credit and Marking Scheme

	Credits	Marks		Total Marks
		Internal	External	
Theory	4	40	60	**100**
Practical	2	40	60	**100**
Total	**6**	**200**		

Evaluation Scheme

	Marks	
	Internal	**External**
Theory	3 Internal Exams of 20 Marks (During the Semester) (Best 2 will be taken)	1 External Exams (At the End of Semester)
Practical	3 Internal Exams (During the Semester) (Best 2 will be taken)	1 External Exams (At the End of Semester)

Content of the Course

Theory

No. of Lectures (in hours per week): 4.5 Hrs. per week

Total No. of Lectures: 60 Hrs. **Maximum Marks:** 60

Units	Topics	No. of Lectures
I	**Historical background & Laws of Thermodynamics** **1.1 Historical background:** 1.1.1 A brief historical background of thermodynamics and statistical Physics in the context of India and Indian culture, Contribution of S.N Bose in thermodynamics & Statistical physics. **1.2 Laws of thermodynamics:** **1.2.1** Thermodynamical system and thermodynamical coordinates, Thermal equilibrium, Zeroth Law of thermodynamics, The concept of path function and point function, Work done by and on the system. **1.2.2** First law of thermodynamics ,Internal energy as a state function, Reversible and irreversible change, Heat engine and its efficiency, Carnot's cycle, Carnot's engine and its efficiency, Carnot's theorem, Otto engine, Otto cycle, Diesel engine, Diesel cycle. **1.2.3** Second law of thermodynamics, Statement of Kelvin-Planck and Clasius Clapeyron, Absolute scale of temperature: Zero of absolute scale, Size of degree, Identity of perfect gas scale and absolute scale. **Keywords/Tags :** Thermodynamics, Internal energy, Heat engine, Absolute scale.	12
II	**Entropy and Thermodynamic potentials** 2.1 Concept of entropy, Clausius theorem, Entropy as a point function, Second law of thermodynamics in terms of entropy, Change in entropy in reversible and irreversible processes. 2.2 Change in entropy of an ideal gas, Change in entropy when two liquids at different temperatures are mixed (or two bodies at different temperatures are kept in contact). 2.3 Principle of increase of entropy, Change in entropy of the universe in an irreversible process, connection of Entropy with Disorder, Entropy	12

	as unavailable energy for work, Entropy and heat death of universe. 2.4 Physical Significance of entropy, Temperature-entropy (T-S) diagram, third law of thermodynamics. 2.5 Thermodynamic potentials, Thermal equilibrium, Internal energy, Helmholtz free energy, Enthalpy and Gibbs free energy. 2.6 Derivation of Maxwell's relations from thermodynamic potentials, Gibbs-Helmholtz equation, Thermodynamic energy equation for ideal and van der Waal gas. **Keywords/Tags:** Reversible process, Entropy, Ideal gas, Thermodynamic potentials	
III	**Applications of Thermodynamic potentials and Kinetic theory of gases** **3.1 potentials:** 3.1.1 TdS equation, Derivation of expressions for C_p-C_v and their special cases for ideal and Van der Waal gases, derivation of the expression $E_s/E_t=C_p/C_v$. 3.1.2 Clausius-Clapeyron latent heat equation, Temperature change in adiabatic process, Principle of refrigeration, Joule-Thomson effect, cooling by adiabatic demagnetization, Production and measurement of very low temperatures. 3.2 **Kinetic theory of gases :** 3.2.1 Behavior of a real gas and its deviation from an ideal gas, Andrews experiment on CO_2 gas, Virial equation. 3.2.2 Critical constant, Continuity of the liquid and gaseous state, Vapor and gas state, Boyle temperature, Van der Waals equation for real gas, Values of critical constants, Laws of the corresponding state. **Keywords/ Tags:** Potential, Enthalpy, Adiabatic, Real gas, Critical constant.	**12**
IV	**Classical Statistics** **4.1** Probability, Distribution of N particles in two identical boxes, Probability of occurrence of either event, probability of composite events, Weightage probability. **4.2** Probability distribution and its narrowing with the increase in	**12**

	number of particles, Expression for average properties Constraints, Accessible and non-accessible microstates. **4.3** Ensemble theory (Micro-canonical, canonical and Grand canonical), Macro and micro states with examples, Principle of equal a prior probability, Concept of phase space. **4.4** Derivation of law of equipartition of energy from statistics. Equilibrium between two system in thermal contact and β parameter. Derivation of relation S = k log W (Boltzmann entropy probability relation) and Statistical interpretation of entropy. **4.5** Boltzmann Canonical distribution law: Application: average energy of one-dimensional harmonic oscillator. **4.6** Boltzmann partition function and derivation of expression for internal energy, Helmholtz free energy, Enthalpy and Gibbs free energy. **Keywords/ Tags:** Probability, micro states, Ensemble theory, Partition function	
V	**Quantum Statistics** 5.1 Distinguisable and Indistinguishable particles and its consequences (in terms of microstates). Maxwell-Boltzmann statistics and its distribution law (Classical Statistics), Maxwell- Boltzmann distribution law of velocity and speed. 5.2 **Quantum statistics**: **a)** Bose –Einstein statistics and distrtibution law, Derivation of Planck's radiation law from B-E statistics, Rayleigh-Jeans law, Wein's displacement law and Stefan's law. **b)** Fermi-Dirac statistics and its distribution law, Qualitative explanation of free electron theory, Fermi level and Fermi energy. **c)** Comparison between the Maxwell-Boltzmann, Bose-Einstein and **Keywords/ Tags:** Indistinguishability, classical and quantum statistics, velocity distribution, Fermi Level.	**12**

References

Test/Reference Books:

1. Zemansky M. W & Dittman R., "Heat and Thermodynamics", Tata McGraw Hill.
2. Sears and Salinger, "Thermodynamics, Kinetic Theory and Statistical Thermodynamics" Narosa.
3. Garg and Ghosh "Thermal Physics", Tata McGraw Hill.
4. Subrahmanyam, Brij Lal and Hemne, "Heat Thermodynamics and Statistical Physics" S. Chand.

Web Links:

Suggested equivalent online courses:

1. https://www.edx.org/course/thermodynamics **Thermodynamics course.**

Mode of Evaluation: Digital Assignments, Quiz, Class test / Mid Semester Exam, Final (end of the semester) examination.

List of Practical

1. Determination of the mechanical equivalent of heat by Callendar & Barne's method.
2. Determination of efficiency of electrical Kettle with variable voltages.
3. Determination of temperature coefficient of a resistance using platinum resistance thermometer.
4. Determination of electromotive force of a thermocouple.
5. Determination of thermal conductivity of a bad conductor by Lee's disc method.
6. Verification of Newton's law of cooling.
7. Determination of the ratio of specific heat of air by Clement-Desorme's method.
8. Determination of specific heat of a liquid with the help of Newton's law of cooling**.**
9. Determination of the coefficient of thermal conductivity of a metal by Searle's method.
10. Determination of thermal conductivity of the rubber using calorimeter.
11. Determination of mechanical equivalent of heat (J) using Joule calorimeter.
12. Determination of Stefan's constant using thermocouple.
13. Study of statistical distribution and determination of standard deviation with the help of black and white dice.
14. Determination of the temperature coefficient of a resistance with the help of Carey-Foster bridge.
15. Determination of the critical constant of a gas/vapour.
16. Thermo–EMF Analyser: Inversion temperature of Fe-Cu Thermocouple.**(SPONSARED BY DBT STAR)**
17. Relaxation (Thermal) Time of a Serial Light Bulb **.(SPONSARED BY DBT STAR)**

Other experiments of the same difficulty level may be added.
Student needs to perform at least 10 experiments.

Faculty of Science

Bachelor of Science (B.Sc.)

SUBJECT: PHYSICS

B.Sc. II Semester

Paper-Elective

THERMODYNAMICS AND STATISTICAL PHYSICS

COURSE OUTCOME

	Course Outcomes	Cognitive Level
COt-I	Learner will be able to make use of Basic concepts of thermodynamics	U, R, E
COt-II	Learner will be able to apply Maxwell's thermodynamic relations to derive various formulae.	U, R, E,Ap
COt-III	Learner will be able to use and apply the idea of Micro and Macro states, Ensembles, Statistical Probability and Phase Space.	R, U, An , Ap, E
COt-IV	Learner will be able to apply the idea of partition function and distribution function to classical and quantum statistics.	R , U , Ap, An, E

Credit and Marking Scheme

	Credits	Marks		Total Marks
		Internal	External	
Theory	3	40	60	**100**
Practical	1	40	60	**100**
Total	**4**	**200**		

Evaluation Scheme

	Marks	
	Internal	**External**
Theory	3 Internal Exams of 20 Marks (During the Semester) (Best 2 will be taken)	1 External Exams (At the End of Semester)
Practical	3 Internal Exams (During the Semester) (Best 2 will be taken)	1 External Exams (At the End of Semester)

Content of the Course

Theory

No. of Lectures (in hours per week): 3.5 Hrs. per week

Total No. of Lectures: 45 Hrs. **Maximum Marks:** 60

Units	Topics	No. of Lectures
I	**1. Laws of Thermodynamics** 1.1 Thermodynamical system and thermodynamical coordinates, Thermal equilibrium, Zeroth Law of thermodynamics, The concept of path function and point function, Work done by and on the system. 1.2 First law of thermodynamics ,Internal energy as a state function, Reversible and irreversible change, Heat engine and its efficiency, Carnot's cycle, Carnot's engine and its efficiency, Carnot's theorem, Otto engine, Otto cycle, Diesel engine, Diesel cycle. 1.3 Second law of thermodynamics, Statement of Kelvin-Planck and Clausius - Clapeyron, Absolute scale of temperature: Zero of absolute scale, Size of degree, Identity of perfect gas scale and absolute scale. **Keywords/Tags :** Thermodynamics, Internal energy, Heat engine, Absolute scale.	12
II	**2. Entropy and Thermodynamic Potentials and its application** 2.1 Concept of entropy, Clausius theorem, Entropy as a point function, Second law of thermodynamics in terms of entropy, Physical Significance of entropy, Temperature- entropy (T-S) diagram, third law of thermodynamics.Change in entropy in reversible and irreversible processes. 2.2 Change in entropy of an ideal gas, Change in entropy when two liquids at different temperatures are mixed (or two bodies at different temperatures are kept in contact). 2.3 Principle of increase of entropy, Change in entropy of the universe in an irreversible process, connection of Entropy with Disorder, Entropy as unavailable energy for work, Entropy and heat death of	12

	universe. 2.4 Thermodynamic potentials, Thermal equilibrium, Internal energy, Helmholtz free energy, Enthalpy and Gibbs free energy. 2.5 Derivation of Maxwell's relations from thermodynamic potentials, Gibbs-Helmholtz equation, Thermodynamic energy equation for ideal and van der Waal gas. 2.6 TdS equation, Derivation of expressions for C_p-C_v and their special cases for ideal and Van der Waal gases, derivation of the expression $E_s/E_t=C_p/C_v$. 2.7 Clausius-Clapeyron latent heat equation, Temperature change in adiabatic process, Principle of refrigeration, Joule-Thomson effect, cooling by adiabatic demagnetization, Production and measurement of very low temperatures. **Keywords/Tags:** Reversible process, Entropy, Ideal gas, Potentials	
III	**Classical Statistics** 3 Probability, Distribution of N particles in two identical boxes, b Probability of occurrence of either event, probability of composite events, Weightage probability. 3.2 Probability distribution and its narrowing with the increase in number of particles, Expression for average properties Constraints, Accessible and non-accessible microstates. 3.3 Ensemble theory (Micro-canonical, canonical and Grand canonical), Macro and micro states with examples, Principle of equal a prior probability, Concept of phase space. 3.4 Boltzmann Canonical distribution law: Application: average energy of one-dimensional harmonic oscillator. 3.5 Derivation of law of equipartition of energy from statistics, Equilibrium between two system in thermal contact and β parameter, Statistical interpretation of entropy and relation S = k log W. 3.6 Boltzmann partition function and derivation of expression for internal energy, Helmholtz free energy, Enthalpy and Gibbs free energy. **Keywords/ Tags:** Probability, micro states, Ensemble theory, Partition function	**12**
IV	**Quantum Statistics** 4.1 Distinguisable and Indistinguishable particles and its consequences (in terms of microstates). Maxwell-Boltzmann statistics and its	**12**

distribution law (Classical Statistics), Maxwell-Boltzmann distribution law of velocity and speed.

4.2 Quantum statistics:

a) Bose –Einstein statistics and distrtibution law, Derivation of Planck's radiation law from B-E statistics, Rayleigh-Jeans law, Wein's displacement law and Stefan's law.

b) Fermi-Dirac statistics and its distribution law, Qualitative explanation of free electron theory, Fermi level and Fermi energy.

c) Comparison between the Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.

Keywords/ Tags: Indistinguishability, classical and quantum statistics, velocity distribution, Fermi Level.

References

Test/Reference Books:

1. Zemansky M. W & Dittman R., "Heat and Thermodynamics", Tata McGraw Hill.
2. Sears and Salinger, "Thermodynamics, Kinetic Theory and Statistical Thermodynamics" Narosa.
3. Garg and Ghosh "Thermal Physics", Tata McGraw Hill.
4. Subrahmanyam, Brij Lal and Hemne, "Heat Thermodynamics and Statistical Physics" S. Chand.

Web Links:

Suggested equivalent online courses:

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List of Practicals

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2) Determination of efficiency of electrical Kettle with variable voltages.
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5) Determination of thermal conductivity of a bad conductor by Lee's disc method.
6) Verification of Newton's law of cooling.
7) Determination of the ratio of specific heat of air by Clement-Desorme's method.
8) Determination of specific heat of a liquid with the help of Newton's law of cooling.
9) Determination of the coefficient of thermal conductivity of a metal by Searle's method.
10) Determination of thermal conductivity of the rubber using calorimeter.
11) Determination of mechanical equivalent of heat (J) using Joule calorimeter.
12) Determination of Stefan's constant using thermocouple.
13) Study of statistical distribution and determination of standard deviation with the help of black and white dice.
14) Determination of the temperature coefficient of a resistance with the help of Carey-Foster bridge.
15) Determination of the critical constant of a gas/vapour.

Other experiments of the same difficulty level may be added.
Student needs to perform at least 6 experiments.

Learning Resources:

Suggested Readings:

1. Indu Prakash, Ram Krishna and A.K.Jha, "A text book of practical physics", Vol.1, Kitab Mahal.
2. Worsnop and Flint, "Advance practical physics ", Asia Publications.
3. Advanced Practical Physics (Vol. 1 & Vol. 2) B.Ghosh and K.G.Mazumder, Sreedhar Publ.
4. Practical Physics, G. L. Squires, Cambridge University press