St. Aloysius College (Autonomous), Jabalpur
DEPARTMENT OF PHYSICS
SYLLABUS 2023-24

Programme Specific Outcomes for B.Sc Program

PSO No.	Programme Specific Outcomes Upon completion of these courses the student would be able to:
PSO-1	Analyse the concepts and theories of Physics.
PSO-2	Analyse real world problems and develop mathematical equations to find acceptable solutions.
PSO-3	Develop problem solving skills and scientific reasoning by learning laboratory skills.
PSO-4	Develop written and oral communication skills in communicating with diverse stakeholders.
PSO- 5	Create and collaborate in emergent physical, mathematical and computing technologies leading to innovative solutions for industry and academia.
PSO- 6	Crack various competitive exams for higher studies and employment.

B. Sc. I Semester

2023-24

Mechanics and General Properties of Matter

Major & Minor

Course Code: S1PHYST

Pre-requisite: To study this course, a student must have had the subject Physics in 12th class.

Max. Marks: 40+60
Min. Passing Marks: 35
Credit Value: 4 (60 hrs)

Course Objectives (CO)

The objectives of the course are:

	Course Objectives	Cognitive Level
CO-I	To become aware of the contribution to science by Indians.	R,U, Ap,E
CO-II	To develop required mathematical skills to analyse simple , damped and forced harmonic oscillation	R,U, Ap,E
CO-III	To study Rigid body, Centre of mass, Moment of inertia, Poisson's ratio and various elastic constant	U, Ap, R, E

CO-IV	To study the concept of stress/strain and in its relation to force/displacement. To determine axial forces, shear forces and bending moments in relation to rigid bodies.	R, U, An, Ap, E
CO-V	To acquire knowledge of Moment of Inertia for various regular bodies. To study, viscosity, surface tension and Bernoulli's theorem	R , U, An, Ap, E, R
CO-VI	To study Conservative force field, Gravitational potential, Gravitational self-energy, Central force, reduced mass, Kepler's law, Scattering.	U,R,Ap,An
CO-VII	To introduce students to the concept of AstroPhysics, special theory of relativity and its consequences	Ap, E, C

Course Learning Outcome (CLO)

	Course Learning Outcomes	**PSOs Addressed**	**Cognitive Level**
CLO-I	The learner will use second order linear differential equations to study and solve problems in Harmonic oscillations	1,2,3,6	U, R, Ap,E
CLO-II	Learner will be able to understand / recall Rigid body, Centre of mass, the connection between Rotational Dynamics and moment of inertia. Learner will be able to determine the Moment of inertia about a given axis of symmetry for different uniform mass distributions.	1,2,3,6	R, ,U, Ap, An, R, E
CLO-III	Learner will be able to understand and apply the law of conservation of linear momentum and understand the concept of center of mass, Elasticity and various elastic moduli	3,4,5,6	R, U, An, Ap, E
CLO-IV	Learner will be able to understand Principles of fluid flow and the equations governing fluid dynamics such as equation of continuity, Bernoulli's Theorem etc.	3,4,5,6	R , U , Ap, An, E
CLO-V	Learner will be able to understand / recall Conservative force field, Gravitational potential, Gravitational self-energy, Central force, reduced mass, Kepler's law, Scattering.	1,2,6	U,R,Ap,An
CLO-VI	Learner will be able to understand the concept of Astro Physics, special theory of relativity.	3,4,5,6	U,Ap, E, C

CO-Course Objectives; CLO – Course Learning Outcome; R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

UNIT-I

Historical background and Oscillations

1.1 Historical background [12 Lectures]

1.1.1 A brief historical background of mathematics and mechanics in the context of India and Indian culture.

1.1.2 A brief biography of Varahamihira and Vikram Sarabhai with their major contribution to science and society.

1.2 Oscillations

1.2.1 SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; Power dissipation and Quality factor.

Keywords: SHM, Gravitation, Oscillation, Quality factor.

UNIT-II

Mechanics of Rigid and deformable bodies

2.1 Rigid body mechanics [12 Lectures]

2.1.1 System of particles and concept of Rigid body, Torque, Centre of mass: position of the centre of mass, Motion of the centre of mass, Conservation of linear & angular momentum with examples, Systems of variable mass : Single stage and multistage rocket, Conveyor belt - hoppert.

2.1.2 Rotatory motion and concept of moment of inertia, Theorems on moment of inertia: theorem of addition, theorem of perpendicular axis, theorem of parallel axis, Calculation of moment of inertia of rectangular lamina, disc, solid cylinder, solid sphere.

2.2 Mechanics of deformable bodies:

2.2.1 Hook's law, Young's modulus, Bulk modulus, Modulus of rigidity and Poisson's ratio, Relationship between various elastic moduli.

2.2.2 Possible values of Poisson's ratio, Finding Poisson's ratio of rubber in the laboratory, Torsion of a cylinder, Strain energy of twisted cylinder.

2.2.3 Finding the modulus of rigidity of the material of a wire by Barton's method, Torsional pendulum and Maxwell's needle, Searle's method to find Y,ηand σ of the material of wire, Bending of beam, Cantilever, Beam supported at its ends and loaded in the middle.

Keywords/Tags: Rigid body, Centre of mass, Moment of inertia, Poisson's ratio.

UNIT-III
Fluid mechanics

3.1 Surface Tension **[12 Lectures]**

3.1.1 Inter- molecular forces and potential energy curve, force of cohesion and adhesion.

3.1.2 Surface tension, Explanation of surface tension on the basis of intermolecular forces, Surface energy, Effect of temperature and impurities on surface tension, Daily life application of surface tension.

3.1.3 Angle of contact, The pressure difference between the two sides of a curved liquid surface, Excess pressure inside a soap bubble ,Capillarity, determination of surface tension of a liquid –capillary rise method, Jaeger's method .

3.2 Viscosity

3.2.1 Ideal and viscous fluid, Streamline and turbulent flow, Equation of continuity, Rotational and irrotational flow, Energy of a flowing fluid, Euler's equation of motion of a non-viscous fluid and its physical significance.

3.2.2 Bernoulli's theorem and its applications (Velocity of efflux, shapes of wings of airplane, Magnus effect, Filter pump, Bunsen's burner)

3.2.3 Viscous flow of a fluid, Flow of liquid through a capillary tube, Derivation of Poiseuille's formula and limitations, Stoke's formula, Motion of a spherical body falling in a viscous fluid.

Keywords/Tags: Inter-molecular force, Surface tension, Angle of contact, Capillarity, Viscosity, Euler's equation, Poiseuille's formula.

UNIT-IV

Gravitational potential and central forces

4.1 Gravitational potential **[12 Lectures]**

4.1.1 Conservative and non-conservative force field, Conservation of energy in motion under the conservative and non-conservative forces, Potential energy.

4.1.2 Conservative force, Conservation of energy, Gravitational potential and gravitational potential energy, Gravitational potential and intensity of gravitational field due to a uniform spherical shell and a uniform solid sphere.

4.1.3 Gravitational self-energy, Gravitational self-energy of a uniform spherical shell and a uniform solid sphere.

4.2 Central forces

4.2.1 Motion under Central forces, Conservative characteristics of central forces.

4.2.2 The motion of a two particles system in central force, Concept of reduced mass, Reduced mass of positronium and hydrogen.

4.2.3 Motion of particle in an inverse-square central force, Motion of celestial bodies and derivation of Kepler's laws

4.2.4 Elastic and inelastic scattering (elementary idea).

Keywords/Tags: Conservative force field, Gravitational potential, Gravitational self-energy, Central force, reduced mass, Scattering.

UNIT-V

Relativistic Mechanics and Astrophysics

5.1 Relativistic Mechanics: [12 Lectures]

5.1.1 Frame of references, Galilean transformation, and Michelson-Morley experiment.

5.1.2 Postulates of special theory of relativity, Lorentz Transformation, Simultaneity and order of events, Length contraction, Time dilation, Relativistic transformation of velocities, Variation of mass with velocity.

5.1.3 Mass-energy equivalence and its experimental verification.

5.2 Astrophysics

5.2.1 Introduction to the universe, Properties of the Sun, Concept of Astronomical Distance.

5.2.2 Life cycle of stars, Chandrasekhar Limit, H-R diagram, Red giant star, White dwarf star, Neutron star, Black hole.

5.2.3 Big Bang Theory (elementary idea).

Keywords/Tags: Transformation, Mass-energy equivalence, Astronomical distance, Chandrasekhar limit, Black hole.

Learning Resources:

Suggested Readings:

1) Spiegel M. R., "Vector Alalysis: Schaum Outline Series ", McGraw Hill Education, 2017.
2) Mathur D. S., "Mechanics ", S.Chand, 2012.
3) Mathur D. S., "Properties of Matter ", Shyamlal Charitable trust, New Delhi.
4) Ghatak A. K., Goyal I. C., and Chua S. J. "Mathematical Physics", Laxmi Publications Private Limited, 2017.
5) Hans and Puri , "Mechanics " Tata McGraw Hill
6) Sears and Zeemansky, "University Physics", Pearson Education.
7) Kleppner and Kolenkov ," An Introduction to Mechanics" Tata McGraw Hill.
8) Resnick and Halliday "Fundamentals of Physics", 1966.

Digital resources:

Suggested equivalent online courses:

1. **https://nptel.ac.in/courses/115/103/115103036/** Mathematical Physics by Dr. Saurabh Basu, IIT, Guwahati.
2. **https://nptel.ac.in/courses/115/106/115106090/** Mechanics, Heat, Oscillations and Waves by Prof. V. Balakrishanan, IIT, Chennai.

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

Evaluation Scheme:

Internal Assessment : 15+15+10 =40 Marks

Main (End Semester) Written Exam: 60 Marks

Total : 100 Marks

Written Exam: 3 hours

Very Short answer type question (50 words) : 5 Marks (05 X 01= 05 Marks)

Short answer type question (200 words) : 10 Marks (05 X 02= 10 Marks)

Long answer type question (500 words) : 45 Marks (05 X 9 = 45 Marks)

List of Experiments

Credit Value: 2

No. of Practical hours: 30

1. Determination of Young's modulus, modulus of rigidity and Poisson's ratio of material of wire using Searle's method.

2. Determination of Young's modulus of material of a metallic bar by bending of beam method.

3. Determination of acceleration due to gravity (g) using bar pendulum.

4. Determination of acceleration due to gravity (g) using Kater's reversible pendulum.

5. Determination of modulus of rigidity of a rod with the help of Barton's apparatus.

6. Determination of coefficient of viscosity of liquid using Poiseuille's method.

7. Determination of moment of inertia of a fly wheel about its axis of rotation.

8. Determination of the moment of inertia of a given body (irregular body) with the help of inertia table.

9. Verification of the theorem of parallel/perpendicular axes of moment of inertia.

10. Determination of modulus of rigidity of material of wire with the help of Maxwell's needle.

11. Determination of Young's modulus of a rod using Cantilever method.

12. Determination of modulus of rigidity of material of wire with the help of torsional pendulum.

13. Determination of force constant of a spring.

14. Determination of Poisson's ratio of rubber.

15. Determination of surface tension of a liquid by Jaeger's method.

16. Determination of Young modulus of brass bar using Flexural Vibration.**(SPONSARED BY DBT STAR)**

17. Determination of Rigidity of Brass .**(SPONSARED BY DBT STAR)**

Other experiments of the same difficulty level may be added.
Student needs to perform at least 10 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 Pub.
4. Practical Physics ,G. L. Squires, Cambridge University press
5. Instruction Manual for doing experiments in Physics by R.Shrinivasan and K.R. Pariolkar

Evaluation Scheme: Practical Examination

(A) **Internal Assessment** :

Question answer during class (Oral): 15 Marks

Attendance : 10 Marks

Assignment/Presentation/Sessional viva: 15 Marks

Total (Each Paper) : 40 Marks

(B) Ex**ternal Assessment** :

Practical Viva : 15 Marks

Practical File/Record: 05 Marks

Experimental work: 40 Marks

Total (Each Paper): 60 Marks

Grand Total: 100 Marks

Min. Passing Marks:35 Marks

Mode of Evaluation: Digital Assignments, Quiz, CCE, Presentation, Tutorial, Class / Lab Activity, Final examination.

B. Sc. I Semester

2023-24

Mechanics and General Properties of Matter

Elective

Course Code: S1PHYSET

Pre-requisite: To study this course, a student must have had the subject Physics in 12th class.

Max. Marks: 40+60

Min. Passing Marks: 35

Credit Value: 3(45 hrs)

Course Objectives (CO)

The objectives of the course are:

	Course Objectives	Cognitive Level
CO-I	To develop required mathematical skills to analyse simple, damped and forced harmonic oscillation. To introduce students to the concept of AstroPhysics.	U, R, E,C
CO-II	To study Rigid body, Centre of mass, Moment of inertia, Poisson's ratio and various elastic constant	U, Ap, R, E
CO-III	To study the concept of stress/strain and in its relation to force/displacement. To determine axial forces, shear forces and bending moments in relation to rigid bodies.	R, U, An, Ap, E
CO-IV	To acquire knowledge of Moment of Inertia for various regular bodies. To study, viscosity, surface tension and Bernoulli's theorem	R , U, An, Ap, E, R
CO-V	To study Conservative force field, Gravitational potential, Gravitational self-energy, Central force, reduced mass, Kepler's law, Scattering.	U,R,Ap,An

Course Learning Outcome (CLO)

	Course Learning Outcomes	PSOs Addressed	Cognitive Level
CLO-I	The learner will use second order linear differential equations to study and solve problems in Harmonic	1,2,3,6	U, R, E,C

	oscillations		
CLO-II	Learner will be able to understand / recall Rigid body, Centre of mass, the connection between Rotational Dynamics and moment of inertia. Learner will be able to determine the Moment of inertia about a given axis of symmetry for different uniform mass distributions.	1,2,3,6	R, ,U, Ap, An, R, E
CLO-III	Learner will be able to understand and apply the law of conservation of linear momentum and understand the concept of center of mass, Elasticity and various elastic moduli	3,4,5,6	R, U, An, Ap, E
CLO-IV	Learner will be able to understand Principles of fluid flow and the equations governing fluid dynamics such as equation of continuity, Bernoulli's Theorem etc.	3,4,5,6	R , U , Ap, An, E
CLO-V	Learner will be able to understand / recall Conservative force field, Gravitational potential, Gravitational self-energy, Central force, reduced mass, Kepler's law, Scattering.	1,2,6	U,R,Ap, An

CO-Course Objectives; CLO – Course Learning Outcome; R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

UNIT-I

Oscillations and Introduction to Astrophysics

1.1 Oscillations

1.1.1 SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; Power dissipation and Quality factor.

1.2 **Astrophysics**

1.2.1 Introduction to the universe, Properties of the Sun, Concept of Astronomical Distance.

1.2.2 Life cycle of stars, Chandrasekhar Limit, H-R diagram, Red giant star, White dwarf star, Neutron star, Black hole.

1.2.3 Big Bang Theory (elementary idea).

Keywords: SHM, Gravitation, Oscillation, Quality factor ,Astronomical distance, Chandrasekhar limit, Black hole.

UNIT-II

Mechanics of Rigid and deformable bodies

2.1 Rigid body mechanics: [11 Lectures]

2.1.1 System of particles and concept of rigid body, Torque, Centre of mass: position of the centre of mass, Motion of the centre of mass, Conservation of linear & angular momentum with examples, Systems of variable mass: Single stage and multistage rocket, Conveyor belt - hoppert.

2.1.2 Rotatory motion and concept of moment of inertia, Theorems on moment of inertia: theorem of addition, theorem of perpendicular axis, theorem of parallel axis, Calculation of moment of inertia of rectangular lamina, disc, solid cylinder, solid sphere.

2.2 Mechanics of deformable bodies:

2.2.1 Hook's law, Young's modulus, Bulk modulus, Modulus of rigidity and Poisson's ratio, Relationship between various elastic moduli.

2.2.2 Possible values of Poisson's ratio, Finding Poisson's ratio of rubber in the laboratory, Torsion of a cylinder, Strain energy of twisted cylinder.

2.2.3 Finding the modulus of rigidity of the material of a wire by Barton's method, Torsional pendulum and Maxwell's needle, Searle's method to find Y,ηand σ of the material of wire, Bending of beam, Cantilever, Beam supported at its ends and loaded in the middle.

Keywords/Tags: Rigid body, Centre of mass, Moment of inertia, Poisson's ratio.

UNIT-III

Fluid mechanics

3.1 Surface Tension: [11 Lectures]

3.1.1 Inter- molecular forces and potential energy curve, force of cohesion and adhesion.

3.1.2 Surface tension, Explanation of surface tension on the basis of intermolecular forces, Surface energy, Effect of temperature and impurities on surface tension, Daily life application of surface tension. Angle of contact, The pressure difference between the two sides of a curved liquid surface, Excess pressure inside a soap bubble ,Capillarity, determination of surface tension of a liquid –capillary rise method, Jaeger's method .

3.2 **Viscosity**

3.2.1 Ideal and viscous fluid, Streamline and turbulent flow, Equation of continuity, Rotational and irrotational flow, Energy of a flowing fluid, Euler's equation of motion of a non-viscous fluid and its physical significance

3.2.2 Bernoulli's theorem and its applications (Velocity of efflux, shapes of wings of airplane, Magnus effect, Filter pump, Bunsen's burner)

3.2.3 Viscous flow of a fluid, Flow of liquid through a capillary tube, Derivation of Poiseuille's formula and limitations, Stoke's formula, Motion of a spherical body falling in a viscous fluid.

Keywords/Tags: Inter-molecular force, Surface tension, Angle of contact, Capillarity, Viscosity, Euler's equation, Poiseuille's formula.

UNIT-IV

Gravitational potential and central forces

5.1 Gravitational potential: [12 Lectures]

5.1.1 Conservative and non-conservative force field, Conservation of energy in motion under the conservative and non-conservative forces, Potential energy.

5.1.2 Conservative force, Conservation of energy, Gravitational potential and gravitational potential energy, Gravitational potential and intensity of gravitational field due to a uniform spherical shell and a uniform solid sphere.

5.1.3 Gravitational self-energy, Gravitational self-energy of a uniform spherical shell and a uniform solid sphere.

5.2 Central forces :

5.2.1 Motion under Central forces, Conservative characteristics of central forces.

5.2.2 The motion of a two particles system in central force, Concept of reduced mass, Reduced mass of positronium and hydrogen.

5.2.3 Motion of particle in an inverse-square central force, Motion of celestial bodies and derivation of Kepler's laws

5.2.4 Elastic and inelastic scattering (elementary idea).

Keywords/Tags: Conservative force field, Gravitational potential, Gravitational self-energy, Central force, reduced mass, Scattering.

Learning Resources:

Suggested Readings:

1) Spiegel M. R., "Vector Alalysis: Schaum Outline Series ", McGraw Hill Education, 2017.
2) Mathur D. S., "Mechanics ", S.Chand, 2012.
3) Mathur D. S., "Properties of Matter ", Shyamlal Charitable trust, New Delhi.
4) Ghatak A. K., Goyal I. C., and Chua S. J. "Mathematical Physics", Laxmi Publications Private Limited, 2017.
5) Hans and Puri , "Mechanics " Tata McGraw Hill
6) Sears and Zeemansky, "University Physics", Pearson Education.
7) Kleppner and Kolenkov," An Introduction to Mechanics" Tata McGraw Hill.
8) Resnick and Halliday "Fundamentals of Physics", 1966.

Digital resources:

Suggested equivalent online courses:

1. **https://nptel.ac.in/courses/115/103/115103036/** Mathematical Physics by Dr. Saurabh Basu, IIT, Guwahati.
2. **https://nptel.ac.in/courses/115/106/115106090/** Mechanics, Heat, Oscillations and Waves by Prof. V. Balakrishanan, IIT, Chennai.

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

Evaluation Scheme:

Internal Assessment : 15+15+10 =40 Marks

Main (End Semester) Written Exam: 60 Marks

Total : 100 Marks

Written Exam: 3 hours

Very Short answer type question (50 words) : 5 Marks (05 X 01= 05 Marks)

Short answer type question (200 words) : 10 Marks (05 X 02= 10 Marks)

Long answer type question (500 words) : 45 Marks (05 X 09 = 45 Marks)

List of Experiments

Credit Value: 1

No. Of Practical hours: 15

1. Determination of Young's modulus, modulus of rigidity and Poisson's ratio of material of wire using Searle's method.

2. Determination of Young's modulus of material of a metallic bar by bending of beam method.

3. Determination of acceleration due to gravity (g) using bar pendulum.

4. Determination of acceleration due to gravity (g) using Kater's reversible pendulum.

5. Determination of modulus of rigidity of a rod with the help of Barton's apparatus.

6. Determination of coefficient of viscosity of liquid using Poiseuille's method.

7. Determination of moment of inertia of a fly wheel about its axis of rotation.

8. Determination of the moment of inertia of a given body (irregular body) with the help of inertia table.

9. Verification of the theorem of parallel/perpendicular axes of moment of inertia.

10. Determination of modulus of rigidity of material of wire with the help of Maxwell's needle.

11. Determination of Young's modulus of a rod using Cantilever method.

12. Determination of modulus of rigidity of material of wire with the help of torsional pendulum.

13. Determination of force constant of a spring.

14. Determination of Poisson's ratio of rubber.

15. Determination of surface tension of a liquid by Jaeger's method.

16. Determination of Young modulus of brass bar using Flexural Vibration.

Other experiments of the same difficulty level may be added.
Student needs to perform at least 06 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 Pub.
4. Practical Physics ,G. L. Squires, Cambridge University press

Evaluation Scheme: Practical Examination

(A) **Internal Assessment** :

Question answer during class (Oral): 15 Marks

Attendance : 10 Marks

Assignment/Presentation/Sessional viva: 15 Marks

Total (Each Paper) : 40 Marks

(B) Ex**ternal Assessment** :

Practical Viva : 15 Marks

Practical File/Record: 05 Marks

Experimental work: 40 Marks

Total: 60

Grand Total: 100 Marks

Min. Passing Marks:35 Marks

Mode of Evaluation: Digital Assignments, Quiz, CCE, Presentation, Tutorial, Class / Lab Activity, Final examination.

B. Sc.II Semester

2023-24

Major & Minor

Thermodynamics and Statistical Physics

Course Code: S2PHYST

Pre-requisite: To study this course, a student must have had the subject Physics in 12th class.

Max. Marks: 40+60

Min. Passing Marks: 35

Credit Value: 4(60 hrs)

Course Objectives (CO)

The objectives of the course are:

	Course Objectives	Cognitive Level
CO-I	To know the important contributions of various physicist in the field of Physics	U,R
CO-II	To understand the basic concepts of thermodynamics and to have an idea about conversion of heat in to work.	U, R, E
CO-III	To learn the idea of entropy, Maxwell's relation and their applications.	U, Ap, R, E
CO-IV	To apply the principles of probability in distribution of particles in various systems and to calculate thermodynamic probability. To create basic ideology of phase space, microstate, macrostate.	R, U, An, Ap, E,C
CO-V	To provide insight of postulates of statistical physics. To learn the different types of statistical distribution (which particles follow which statistics and why).	R , U, An, Ap, E, R

Course Learning Outcome(CLO)

	Course Learning Outcomes	**PSOs Addressed**	Cognitive Level
CLO-I	Learner will be able to recollect the Specific Contributions of Indians in thermodynamics and statistical mechanics.	3,5,6	U, C
CLO-II	Learner will be able to make use of Basic concepts of thermodynamics & apply Maxwell's thermodynamic relations to derive various formulae.	1,2	U, R, E,Ap
CLO-III	Learner will be able to use and apply the idea of Micro and Macro states, Ensembles, Statistical Probability and Phase Space.	1,3,6	R, U, An , Ap, E
CLO-IV	Learner will be able to apply the idea of partition function and distribution function to classical and quantum statistics.	4,5,6	R , U , Ap, An, E

COb-Course Objective; COt – Course Outcome; R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

UNIT-I

Historical background & Laws of Thermodynamics

1.1 Historical background: **[12 Lectures]**

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

UNIT-II

Entropy and Thermodynamic potentials [12 Lectures]

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 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

UNIT-III

Applications of Thermodynamic potentials and Kinetic theory of gases [12 Lectures]

3.1 Applications of Thermodynamic 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.

UNIT –IV

Classical Statistics [12 Lectures]

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 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

UNIT –V

Quantum Statistics [12 Lectures]

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 Fermi-Dirac statistics.

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

Learning Resources:

Suggested Readings:

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.

Digital resources:

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.

Evaluation Scheme:

Internal Assessment : 15+15+10 =40 Marks

Main (End Sem) Written Exam: 60 Marks

Total : 100 Marks

Written Exam: 3 hours

Very Short answer type question (50 words) : 5 Marks (05 X 01= 05 Marks)

Short answer type question (200 words) : 10 Marks (05 X 02= 10 Marks)

Long answer type question (500 words) : 45 Marks (05 X 09 =45 Marks)

**** Question paper must contain Numerical/conceptual questions of 10 marks.**

List of Experiments

Credit Value: 2

No. of Practical hours: 30

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.

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.
5. Instruction Manual for doing experiments in Physics by R.Shrinivasan and K.R. Pariolkar

Evaluation Scheme: Practical Examination

(A) **Internal Assessment** :

Question answer during class (Oral): 15 Marks

Attendance : 10 Marks

Assignment/Presentation/Sessional viva: 15 Marks

Total (Each Paper) : 40 Marks

(B) Ex**ternal Assessment** :

Practical Viva : 15 Marks

Practical File/Record: 05 Marks

Experimental work: 40 Marks

Total (Each Paper): 60 Marks

Grand Total: 100 Marks

Min. Passing Marks: 35 Marks

Mode of Evaluation: Digital Assignments, Quiz, CCE, Presentation, Tutorial, Class / Lab Activity, Final examination.

B. Sc.II Semester

2023-24

Elective

Thermodynamics and Statistical Physics

Course Code: S2PHYSET

Pre-requisite: To study this course, a student must have had the subject Physics in 12th class.

Max. Marks: 40+60

Min. Passing Marks: 35

Credit Value: 3(45 hrs)

Course Objectives (CO)

The objectives of the course are:

	Course Objectives	Cognitive Level
CO-I	To understand the basic concepts of thermodynamics and to have an idea about conversion of heat in to work.	U, R, E
CO-II	To learn the idea of entropy, Maxwell's relation and their applications.	U, Ap, R, E
CO-III	To learn the idea of entropy, Maxwell's relation and their applications.	U, Ap, R, E
CO-IV	To apply the principles of probability in distribution of particles in various systems and to calculate thermodynamic probability. To create basic ideology of phase space, microstate, macrostate.	R, U, An, Ap, E,C
CO-V	To provide insight of postulates of statistical physics. To learn the different types of statistical distribution (which particles follow which statistics and why).	R , U, An, Ap, E, R

Course Learning Outcome(CLO)

	Course Learning Outcomes	PSOs Addressed	Cognitive Level
CLO-I	Learner will be able to make use of Basic concepts of thermodynamics	1,2,6	U, R, E
CLO -II	Learner will be able to apply Maxwell's thermodynamic relations to derive various formulae.	1,2	U, R, E,Ap
CLO-III	Learner will be able to use and apply the idea of Micro and Macro states, Ensembles, Statistical Probability and Phase Space.	1,3,6	R, U, An , Ap, E
CLO-IV	Learner will be able to apply the idea of partition function and distribution function to classical and quantum statistics.	4,5,6	R , U , Ap, An, E

CO-Course Objective; CLO – Course Learning Outcome; R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

UNIT-I

1. Laws of Thermodynamics [11 Lectures]

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.

UNIT-II

2. Entropy and Thermodynamic Potentials and its application [11 Lectures]

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 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.

UNIT –III

Classical Statistics [12 Lectures]

3.1 Probability, Distribution of N particles in two identical boxes, 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

UNIT –IV

Quantum Statistics [11 Lectures]

4.1 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.

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.

Learning Resources:

Suggested Readings:

5. Zemansky M. W & Dittman R., "Heat and Thermodynamics", Tata McGraw Hill.
6. Sears and Salinger, "Thermodynamics, Kinetic Theory and Statistical Thermodynamics" Narosa.
7. Garg and Ghosh "Thermal Physics", Tata McGraw Hill.
8. Subrahmanyam, Brij Lal and Hemne, "Heat Thermodynamics and Statistical Physics" S. Chand.

Digital resources:

Suggested equivalent online courses:

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.

Evaluation Scheme:

Internal Assessment : 15+15+10 =40 Marks

Main (End Sem) Written Exam: 60 Marks

Total : 100 Marks

Written Exam: 3 hours

Very Short answer type question (50 words) : 5 Marks (05 X 01= 05 Marks)

Short answer type question (200 words) : 15 Marks (05 X 02= 10 Marks)

Long answer type question (500 words) : 45 Marks (05 X 09 =45 Marks)

**** Question paper must contain Numerical/conceptual questions of 10 marks.**

List of Experiments

Credit Value: 1

No. of Practical hours: 15

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.

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.

Evaluation Scheme: Practical Examination

(A) **Internal Assessment** :

Question answer during class (Oral): 15 Marks

Attendance : 10 Marks

Assignment/Presentation/Sessional viva: 15 Marks

Total (Each Paper) : 40 Marks

(B) Ex**ternal Assessment** :

Practical Viva : 15 Marks

Practical File/Record: 05 Marks

Experimental work: 40 Marks

Total (Each Paper) : 60 Marks

Grand Total: 100 Marks

Min. Passing Marks: 35 Marks

Mode of Evaluation: Digital Assignments, Quiz, CCE, Presentation, Tutorial, Class / Lab Activity, Final examination.

Paper – (Open elective)

Non-Conventional Energy Sources

Course Code: S2-PHYSOE

Pre-requisite: Open to all.

Max. Marks: 40+60

Min. Passing Marks: 35

Credit Value: 4 (60 hrs)

UNIT-I

Introduction to non-conventional energy sources [12 lectures]

1. Classification of energy resources, Consumption trend of primary energy resources, Importance of non-conventional energy resources.
2. Energy chain, Common form of energy, Limitations of non-conventional energy resources.
3. Salient features of non-conventional energy resources, Environmental aspect of energy.
4. World energy status, Energy scenario in India.

Keywords/ Tags: Energy resources, Energy chain, Non-conventional energy.

UNIT-II

Solar Energy

[12 lectures]

1. The sun as a source of energy, solar radiation at the Earth's surface.
2. Photo-thermal applications: Solar collectors, solar drying, solar cooker (box type), solar distillation, solar water heating systems, solar thermo-mechanical system.
3. Photovoltaic system : Photovoltaic principle, Basic photovoltaic system for power generation , Solar cells, Types of solar cells, Concentrator cells, Sun-tracking systems, Limitations and environmental aspect of cells.
4. Photovoltaic applications: Solar cell Panels, Solar light, solar pump, solar power plants, Solar cell in transportation, solar refrigeration and air conditioning.

Keywords/ Tags: Solar radiation, Photo-thermal, Photovoltaic, Solar cells.

UNIT-III

Biomass Energy

[12 lectures]

1. Biomass resources, Biomass conversion technology, Biomass generation.
2. List of factors affecting bio-digestion, Working of biogas plant (with block diagram), Biogas from plant waste.
3. Methods of obtaining energy from Biomass, Thermal gasification of biomass.
4. Biomass energy programme in India, Biodiesel production from non-edible oil seeds.

Keywords/ Tags: Biogas, Biomass, Thermal gasification, Bio-digestion.

UNIT-IV
Wind Energy

[12 lectures]

1. Concept of wind, Origin of wind climate, Wind profile, Limitations of extracted power from a wind turbine.
2. Wind resource map and site identification, Land requirement.
3. Wind turbine setting, Wind turbine aerodynamics, Wind turbine type: Upwind and downwind turbines, Blade count, Constant and variable speed wind turbines, Onshore and offshore wind turbines.
4. Wind turbine rotor, working of wind turbine, Drag principle, Lift principle.
5. Effect of wind turbine on environment, Wind energy storage, Wind energy program in India.

Keywords/ Tags: Wind climate, Wind energy, Wind turbine.

UNIT-V
Geothermal and Ocean Energy

[12 lectures]

1. Geothermal Energy: Origin and distribution of geothermal energy, Types of geothermal resources, Analysis of geothermal resources.
2. Exploration and development of geothermal energy.
3. Advantages and disadvantage of geothermal energy, Possibilities and limitations.
4. Ocean Energy: Tidal energy- origin and nature of tidal energy, Environmental impact, Energy and power in waves, Advantages and dis advantages of wave energy.
5. Ocean thermal energy, Ocean thermal conservation technology (OTEC), Environmental impact.

Keywords/ Tags: Geothermal Energy, Ocean Energy, Tidal Energy, OTEC.

Learning Resources:

Suggested Readings:

1. Rai G. D., "Non-conventional energy sources", Khanna Publishers.
2. Rai G. D., "Solar energy utilization", Khanna Publishers.
3. Sukhatme S. P. and Nayak J. K., "Solar energy: Principles of thermal collection and storage", Tata McGraw Hill Publications.
4. Khan B. H., "Non-conventional energy resources", McGraw Hill Publications.

Digital Resources:

1. **https://mnre.gov.in** Ministry of New and Renewable Energy**.**

Suggested equivalent online courses:

1. **https://nptel.ac.in/cources/121/106/121106014/** By Prof. Pratap Haridoss, IIT, Chennai.

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

Evaluation Scheme:

Internal Assessment : 15+15+10 =40 Marks

Main Written Exam: 60 Marks

Total : 100 Marks

Written Exam: 3 hours

Very Short answer type question (50 words) : 05 Marks (05 X 01= 05 Marks)

Short answer type question (200 words) : 10 Marks (05 X 02= 10 Marks)

Long answer type question (500 words) : 45 Marks (05 X 9 = 45 Marks)

Mode of Evaluation: Digital Assignments, Quiz, CCE, Presentation, Tutorial, Class / Lab Activity, Final examination.