SYLLABUS

FYUGP [B.Sc.]

HONOURS/RESEARCH

&
ASSOCIATED CORE (AC) COURSE
&
ELECTIVE COURSE

IN PHYSICS

w.e.f. Academic Session: 2025-2029

For

All Constituent/Affiliated Colleges Under

Vinoba Bhave University, Hazaribag

VINOBA BHAVE UNIVERSITY, HAZARIBAG

B. Sc. HONOURS/RESEARCH IN PHYSICS (under FYUGP) w.e.f. 2025-2029

Course Structure (MAJOR)

Course Name	Full Marks
SEM I	
PHY-MJ-1-T. MATHEMATICAL PHYSICS & MECHANICS-1 (03 Credits)	**75[60E+15I]**
PHY-MJ-1-P. PRACTICAL (01 Credit)	**25[E]**
SEM II	
PHY-MJ-2-T. MATHEMATICAL PHYSICS & MECHANICS-2 (03 Credits)	**75[60E+15I]**
PHY-MJ-2-P. PRACTICAL (01 Credit)	**25[E]**
SEM III	
PHY-MJ-3-T. ELECTRICITY (03Credits)	**75[60E+15I]**
PHY-MJ-3-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-4-T. WAVES AND OSCILLATION (03Credits)	**75[60E+15I]**
PHY-MJ-4-P. PRACTICAL (01 Credit)	**25[E]**
SEM IV	
PHY-MJ-5-T. IKS AND MAGNETISM (03 Credits)	**75[60E+15I]**
PHY-MJ-5-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-6-T. THERMAL PHYSICS (03 Credits)	**75[60E+15I]**

PHY-MJ-6-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-7-T. OPTICS (03 Credits)	**75[60E+15I]**
PHY-MJ-7-P. PRACTICAL (01 Credit)	**25[E]**
SEM V	
PHY-MJ-8-T. PHYSICS OF THERMODYNAMICS (03 Credits)	**75[60E+15I]**
PHY-MJ-8-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-9-T. MATHEMATICAL PHYSICS-3 (03 Credits)	**75[60E+15I]**
PHY-MJ-9-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-10- T. ANALOG SYSTEM AND APPLICATIONS (03 Credits)	**75[60E+15I]**
PHY-MJ-10-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-11-T. MODERN PHYSICS (03 Credits)	**75[60E+15I]**
PHY-MJ-11-P. PRACTICAL (01 Credit)	**25[E]**
SEM VI	
PHY-MJ-12-T. DIGITAL SYSTEM AND APPLICATIONS (03 Credits)	**75[60E+15I]**
PHY-MJ-12-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-13-T. QUANTUM MECHANICS AND APPLICATIONS (03 Credits)	**75[60E+15I]**
PHY-MJ-13-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-14-T. SOLID STATE PHYSICS (03 Credits)	**75[60E+15I]**
PHY-MJ-14-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-15-T. PHYSICS OF DEVICES AND INSTRUMENTS (03 Credits)	**75[60E+15I]**
PHY-MJ-15-P. PRACTICAL (01 Credit)	**25[E]**
BACHELOR'S DEGREE [HONOURS]	

SEM-VII	
PHY-MJ-16-T. RESEARCH METHODOLOGY (04 Credits)	**100[75E+25I]**
PHY-MJ-17-T. ELECTROMAGNETIC THEORY (03 Credits)	**75[60E+15I]**
PHY-MJ-17-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-18-T. STATISTICAL MECHANICS (03 Credits)	**75[60E+15I]**
PHY-MJ-18-P. PRACTICAL (01 Credit)	**25[E]**
PHY-AMJ-1-T. ADVANCED QUANTUM MECHANICS (04 Credits)	**100[75E+25I]**
SEM-VIII	
PHY-MJ-19-T. NUCLEAR AND PARTICLE PHYSICS (03 Credits)	**75[60E+15I]**
PHY-MJ-19-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-20-T. CLASSICAL MECHANICS (03 Credits)	**75[60E+15I]**
PHY-MJ-20-P. PRACTICAL (01 Credit)	**25[E]**
PHY-AMJ-2-T. ATOMIC AND MOLECULAR SPECTROSCOPY (04 Credits)	**100[75E+25I]**
PHY-AMJ-3-T. ADVANCED SOLID STATE PHYSICS (04 Credits)	**100[75E+25I]**
BACHELOR'S DEGREE **[HONOURS WITH RESEARCH]**	
SEM-VII	
PHY-MJ-16-T. RESEARCH METHODOLOGY (04 Credits)	**100[75E+25I]**
PHY-MJ-17-T. ELECTROMAGNETIC THEORY (03 Credits)	**75[60E+15I]**
PHY-MJ-17-P. PRACTICAL (01 Credit)	**25[E]**

PHY-MJ-18-T. STATISTICAL MECHANICS (03 Credits)	**75[60E+15I]**
PHY-MJ-18-P. PRACTICAL (01 Credit)	**25[E]**
RC-01 RESEARCH PROPOSAL-PLANNING & TECHNIQUES (DISCIPLINARY/ INTERDISCIPLINARY MAJOR) (04 Credits)	**100** [ESE50+SIE25+Term Paper25]
SEM-VIII	
PHY-MJ-19-T. NUCLEAR AND PARTICLE PHYSICS (03 Credits)	**75[60E+15I]**
PHY-MJ-19-P. PRACTICAL (01 Credit)	**25[E]**
PHY-MJ-20-T. CLASSICAL MECHANICS (03 Credits)	**75[60E+15I]**
PHY-MJ-20-P. PRACTICAL (01 Credit)	**25[E]**
RC-02 RESEARCH INTERNSHIP/Field Work/Project **DISSERTATION/THESIS (08 Credits)**	**200[E]**

Course Structure (AC AND ELC)

Course Name	Full Marks
SEM- I/SEM-II	
PHY-AC-1/AC-2 MECHANICS (03 Credits)	**75(60E+15I)**
PHY-AC-1/AC-2 PRACTICAL (01 Credit)	**25E**
SEM – III/SEM-IV	
PHY-ELC-1/ELC-2 ELECTRICITY AND MAGNETISM (03 Credits)	**75(60E+15I)**
PHY-ELC-1/ELC-2 PRACTICAL (01 Credit)	**25E**
SEM –V/SEM-VI	
PHY-ELC-3/ELC-4 THERMAL PHYSICS (03 Credits)	**75(60E+15I)**
PHY-ELC-3/ELC-4 PRACTICAL (01 Credit)	**25E**
SEM – VII/SEM-VIII	
PHY-ELC-5/ELC-6 WAVES AND OPTICS (03 Credits)	**75(60E+15I)**
PHY-ELC-5/ELC-6 PRACTICAL (01 Credit)	**25E**

MAJOR PAPERS:

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100 Pass Marks: Th. (SIE + ESE) = 40

Instruction to Question Setter for Semester Internal Examination (SIE 20+5=25 marks):

. The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Class Attendance Score (CAS) including the behavior of the student towards teachers and other students of the college of 5 marks.

[For (SIE-20 marks) there will be two groups of questions. Group A is compulsory, which will contain two questions. Question No. 1 will be very short answer type (not MCQ) consisting of five questions of 1 mark each. Question No. 2 will be short answer type of 5 marks. Group B will contain descriptive type two questions of 10 marks each, out of which any one to be answered.]

End Semester Examination (ESE 75 marks): [for MAJOR & MDC]

There will be two groups of questions. Group A is compulsory which will contain three questions. Question No.1 will be very short answer type (not MCQ) consisting of five questions of 1 mark each. Question No.2 & 3 will be short answer type of 5 marks each. Group B will contain descriptive type six questions of 15 marks each, out of which any four are to be answered.

AC & ELC PAPERS:

Marks: 15 (5 Attd. + 10 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75(Th), Pass Marks: Th. (SIE + ESE) = 30

And PRACTICAL =25P (ESE)

Instruction to Question Setter for Semester Internal Examination (SIE 10+5=15 marks):

. The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks, (b) Class Attendance Score (CAS) including the behavior of the student towards teachers and other students of the college of 5 marks.

[For (SIE-10 marks) there will be two groups of questions. Question No. 1 will be very short answer type (not MCQ) in Group A consisting of five questions of 1 mark each. Group B will contain descriptive type two questions of 5 marks each, out of which any one to be answered.]

End Semester Examination (ESE 60 marks):

There will be two groups of questions. Group A is compulsory which will contain three questions. Question No.1 will be very short answer type (not MCQ) consisting of five questions of 1 mark each. Question No.2 & 3 will be short answer type of 5 marks each. Group B will contain descriptive type five questions of 15 marks each, out of which any three are to be answered.

PRACTICAL

Marks: Pr (ESE: 3Hrs) =25
Pass Marks: Pr (ESE) = 10

Instruction to Question Setter for End Semester Examination (ESE):

There will be one Practical Examination of **3Hrs** duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks

Practical record notebook = 05 marks

Viva-voce = 05 marks

General Instructions

- The **Semester Internal Theory Examination** will be of **1-hour duration**.
- There shall be **only one Practical Examination** of **3-hour duration** in each semester for each paper separately.
- **One external** and **one internal examiner** will conduct the Practical Examinations.
- There will be **only one Semester Internal Examination** in **Major, Minor, and Research Courses**, which will be organized at the **college/institution level**.
- Out of **100 marks**, the **Semester Internal Theory Examination** (each of 1 hour) will carry **15 marks** for **practical subjects** and **25 marks** for **non-practical subjects**.

- The **15 marks** in the Theory Examination of practical subjects may include **10 marks** from the **Written Examination/Assignment/Project/Tutorial**, wherever applicable, and **5 marks** based on **attendance/overall class performance** during the semester.
- The **25 marks** in the Theory Examination of non-practical subjects may include **20 marks** from the **Written Examination/Assignment/Project/Tutorial**, wherever applicable, and **5 marks** based on **attendance/overall class performance** during the semester.
- To convert **attendance into marks**, a **suggestive range** is provided below:
  - Attendance up to 45%: 1 mark
  - 45% < Attendance $\leq$ 55%: 2 marks
  - 55% < Attendance $\leq$ 65%: 3 marks
  - 65% < Attendance $\leq$ 75%: 4 marks
  - Attendance above 75%: 5 marks

SYLLABUS

MAJOR COURSES

SEMESTER-I

PHY-MJ-1-T: MATHEMATICAL PHYSICS& MECHANICAL PROPERTIES OF MATTER (03 Credits)

Course Objective:

On completion of this course students will be able to understand -

- Vector calculus and its application.
- Broad knowledge of vector differentiation, integration and differential equation as it is an important tool to understand advance physics.
- Remaining Topics included in this paper provide broad idea of the properties of matter.

Course Learning Outcomes:

On successful completion of this course the student should know:

- Revise the knowledge of calculus. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.
- Understand the principles of elasticity through the study of Young Modulus and Modulus of Rigidity.
- Understand simple principles of fluid flow and the equations governing fluid dynamics.
- Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation.
- Describe how fictitious forces arise in a non-inertial frame, e.g., why a person sitting in a merry-go-round experiences an outward pull.
- In the laboratory course, the student shall perform experiments related to mechanics (compound pendulum), rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity) and fluid dynamics (verification of Stokes' law, Searle's method) etc.

Skills to be learned:

- Training in calculus will prepare the student to solve various mathematical problems.
- He/ She shall develop an understanding of how to formulate a physics problem and solve given mathematical equation risen out of it.
- Learn the concepts of elastic constant of solids and viscosity of fluids.
- Develop skills to understand and solve the equations of central force problem.
- Acquire basic knowledge of inertial and non-inertial systems.

COURSE CONTENT:

Vector Algebra: Vector triple product, Scalar triple product and Geometrical interpretation of scalar triple product. Scalar and Vector fields.

Vector Differentiation: Directional derivatives and normal derivatives. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Physical significance of divergence and curl of a vector field. Del and Laplacian operators. Vector identities. Expression for divergence and curl in cartesian co-ordinate.

Vector Integration: Line, surface and volume integrals. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes' Theorems and their applications & Jacobians.

Elasticity: Elastic limit, Relation between Elastic constants. Twisting torque on a Cylinder or Wire, Bending moment, Cantilever, beam supported at the end and loaded at middle and its application to determine Young's Modulus, Searle's experiments.

Viscosity: Viscosity, co-efficient of viscosity, Effect of temperature & pressure on viscosity. Poiseuille's Equation for Flow of a Liquid through a Capillary Tube, Mayer's formula for gases, Rankine methods for measurement of viscosity of gases.

Surface Tension: Surface tension and surface energy, angle of contact, principle of virtual work and its use to obtain expression for the pressure on two sides of curved liquid surface. Ripples and Gravity waves, Determination of surface tension by Ripple tank method and Quincke's method.

Central Force Motion: Motion of a particle under a central force field: two body problem. Kepler's Laws and their deduction.

Reference Frames: Inertial & non-inertial reference frames. Coriolis and centrifugal forces. Effect of centrifugal force: reduction in the value of g. Effect of Coriolis force: deviation of freely falling bodies from the vertical.

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
3. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
4. Mathematical Physics - H. K. Das
5. Mathematical Physics - B. D. Gupta
6. Mathematical Physics - B. S. Rajput
7. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.

8. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
9. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, PearsonEducation
10. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
11. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
12. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

PHY-MJ-1-P. PRACTICAL (01 Credits)

1. To Measure the length (or diameter) using Vernier Caliper, Screw Gauge, Spherometer.
2. To Measure the length (or diameter) using travelling microscope.
3. To determine the value of g using Bar Pendulum
4. To determine the value of g using Kater's Pendulum.
5. To determine the elastic constants of wire by Searl's method.

Reference Books

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal
4. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021

SEMESTER-II

PHY-MJ-2-T.: MATHEMATICAL PHYSICS, MECHANICS & RELATIVITY (03 Credits)

Course Objective*:*

On completion of this course students will be able to understand-

- Vector calculus and its application.
- Broad knowledge of differential equation as it is an important tool to understand advance physics.
- Remaining Topics included in this paper provide broad idea of the properties of matter.

Course Learning Outcomes:

On successful completion of this course the student should know:

- Revise the knowledge of calculus. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering. a. Learn the curvilinear coordinates which have applications in problems with spherical and cylindrical symmetries.
- Understand laws of motion and their application to various dynamical situations, notion of inertial frames and concept of Galilean invariance.
- Explain the phenomena of simple harmonic motion and the properties of systems executing such motions.
- Describe special relativistic effects and their effects on the mass and energy of a moving object.
- Appreciate the nuances of Special Theory of Relativity (STR)
- In the laboratory course, the student shall perform experiments related to mechanics (compound pendulum), rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity) and fluid dynamics (verification of Stokes law, Searle method) etc

Skills to be learned:

- Training in calculus will prepare the student to solve various mathematical problems.
- He/ She shall develop an understanding of how to formulate a physics problem and solve given mathematical equation risen out of it.
- Acquire basic knowledge of inertial and non-inertial systems and special theory of relativity.

COURSE CONTENT:

Differential Equations: First Order and Second Order Differential Equations-Application to Physical problems, Integrating Factor. Homogeneous differential Equations with constant coefficients. Wronskian and general solution.

Partial Differential Equations: Solutions to partial differential equations, using separation of variables.

Orthogonal Curvilinear Co-ordinates: Orthogonal Curvilinear Co-ordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Co-ordinate Systems using curvilinear co-ordinate.

Beta and Gamma function: Beta and gamma function, relation between them and their properties. Expression for integrals in terms of gamma function.

Mechanics of Centre of mass: Centre of mass, velocity of Centre of mass, acceleration, reduced mass. Reduced two body problem to one body problem and equation of motion for equivalent one body. Elastic and inelastic collision brief ideas only. Laboratory and Centre of mass system. Elastic and inelastic collision between two particles in the laboratory frame and in the Centre of mass frame. Scattering cross section, differential scattering cross section, Rutherford scattering.

Oscillations: Simple harmonic oscillations. Differential equation of SHM and its solution, kinetic energy, potential energy, total energy and their time-average value. Damped oscillation: power dissipation in damped harmonic oscillation, relaxation time, quality factor, mean life time. Relation between quality factor and relaxation time. Forced oscillation: resonance, sharpness of resonance, power dissipation and quality factor.

Special Theory of Relativity: Galilean transformation, Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Length contraction. Time dilation. Relativistic addition of velocities, Variation of mass with velocity. Mass-energy Equivalence. Relativistic Doppler effect of light.

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
3. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
4. Mathematical Physics - H. K. Das
5. Mathematical Physics - B. D. Gupta
6. Mathematical Physics - B. S. Rajput
7. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
8. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
9. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
10. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
11. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
12. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

PHY-MJ-2-P. PRACTICAL (01 Credits)

1. To determine the height of a building using a Sextant.
2. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus of Rigidity.
3. To determine **g** and velocity for a freely falling body using Digital Timing Technique
4. Determination of Young's Modulus using bending beam method.

Reference Books

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal
4. Advanced Practical Physics (Vol. I & II), C.L. Arora, S. Chand Publishing, Latest Reprint, 2021.

SEMESTER-III

PHY-MJ-3-T: ELECTROSTATICS & CURRENT ELECTRICITY (03 Credits)

Course Learning Outcomes:

After going through the course, the student should be able to

- Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.
- Understand the dielectric properties of matter.
- Apply Kirchhoff's rules to analyze AC circuits consisting of parallel and/or series combinations of voltage sources and resistors and to describe the graphical relationship of resistance, capacitor and inductor.
- Apply various network theorems such as Superposition, Thevenin, Norton, Reciprocity, Maximum Power Transfer etc. and their applications in electronics, electrical circuit analysis and electrical machines.
- In the laboratory course the student will get an opportunity to verify various laws in

electricity learn about the construction, working of various measuring instruments.

- Should be able to verify of various circuit laws, network theorems elaborated above, using simple electric circuits.

Skills to be learned:

- This course will help in understanding basic concepts of electricity and their applications.
- Basic course in electrostatics will equips the student with required prerequisites to understand electrodynamics phenomena.

COURSE CONTENT:

Electric Field and Electric Potential: Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson's equations. Solution of Laplace's equation in Cartesian co-ordinates, Application of Laplace's equation, Gauss's law in integral and differential form, Potential and Electric Field of a dipole. Force and Torque on a dipole. Multipole expansion (monopole, dipole & quadrupole), Electrostatic energy of system of charges. Electrostatic energy of a charged sphere.

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization of Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**.

Transients: Growth and decay of current in L-R circuit, Charging and discharging of capacitor in R-C & L-C-R circuits. Time constant.

Alternating current: J-Operator & vector method, reactance and impedance, Theory of circuits containing L, C & R and their different combinations, Series L-C-R circuit, resonance, quality factor, sharpness of resonance, band width, Acceptor circuit, power dissipation, Parallel L-C-R circuit, dynamic resistance, antiresonance, rejector circuit, current magnification, quality factor.

Network theorem: Ideal constant voltage and constant current source, Network theorem, Thevenin's theorem, Norton's theorem and their applications, Maximum power transfer theorem and superposition theorem.

A.C. bridge: Anderson's bridge, De-Sauty's bridge and Owen's bridge and their vector diagram representation,

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw

2. Electricity and Magnetism, P. K. Chakraborty, New Age International Pvt. Ltd.

3. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
4. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
5. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
6. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
7. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
8. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
9. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
10. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill

PHY- MJ -3-P. PRACTICAL (01 Credit)

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To determine an unknown Low Resistance using Carey Foster's Bridge.
3. To compare capacitances using De-Sauty's bridge.
4. To verify the Thevenin's and Norton's theorems.
5. To verify the Superposition, and Maximum power transfer theorems.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
5. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

PHY-MJ-4-T: WAVES AND OSCILLATIONS (03 Credits)

Course Learning Outcomes:

This course will enable the student to

- Recognize and use a mathematical oscillator equation and wave equation and derive these equations for certain systems.
- Apply basic knowledge of principles and theories about the behavior of light and the physical environment to conduct experiments.

- Understand the principle of superposition of waves, so thus describe the formation of standing waves.
- Explain several phenomena we can observe in everyday life that can be explained as wave phenomena.
- Use the principles of wave motion and superposition to explain the Physics of polarization, interference and diffraction.

Skills to be learned:

- He / she shall develop an understanding of various aspects of harmonic oscillations and waves specially. Various types of mechanical waves and their superposition.

COURSE CONTENT:

Wave Motion: Plane Progressive Waves. Wave Equation. Particle and Wave Velocities. Differential Equation and its solution. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave.

Superposition of Two Harmonic Waves: Stationary Waves in a String: Fixed and Free Ends. Analytical Treatment. Changes with respect to position and time, energy of vibrating string, transfer of energy. Phase and Group Velocities.

Velocity of Waves: Velocity of Transverse Vibrations in a Stretched String, Velocity of Longitudinal waves in a fluid in pipe, Newton's Formula for Velocity of Sound, Laplace's Correction.

Acoustics of buildings: Reverberation, Growth and decay of sound, Sabine's formula

Addition of Simple Harmonic Motions: Addition of two SHM's having equal periods but different in phase and amplitude. Lissajous figures. Superposition of two simple harmonic vibrations of equal frequencies but different amplitudes, Lissajous figures for two simple harmonic vibrations in frequency ratio 2:1. Determination of unknown frequency by Lissajous's figure.

Ultrasonics: Audible, infrasonic and ultrasonic waves, production of ultrasonic piezo-electric method, magnetostriction method, detection, properties and applications of ultrasonic. Laboratory method to determine the velocity of ultrasonic waves in liquid.

Reference books:

1. Waves : Berkeley Physics, vol.3, Francis Crawford, 2007, Tata McGraw-Hill.
2. The Physics of waves and Oscillation: N. K. Bajaj, 1998, Tata McGraw Hill.
3. The Physics of Vibrations and Waves: H. J. Pain, 2013, John Wiley and Sons.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
5. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education.
6. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000

7. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley.
8. A text-book of sound, A. B Wood. 2021, Maxwell Press.

PHY- MJ -4-P. PRACTICAL (01 Credit)

1. To verify the laws of transverse vibration of stretched string using a sonometer.
2. To determine the velocity of sound in air by Kundt's tube.
3. To determine the velocity of ultrasonic waves in a given liquid.
4. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency (b) Impedance at resonance, (c) Quality factor Q and (d) Band width.
5. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant Frequency and (b) Quality factor Q.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
5. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

SEMESTER-IV

PHY-MJ-5-T: INDIAN KNOWLEDGE SYSTEM IN PHYSICS AND MAGNETISM (03 Credits)

COURSE OBJECTIVE

The course aims to explore the rich contributions of Indian knowledge systems (IKS) to the field of physics, including classical mechanics, optics, acoustics, and materials science, while integrating traditional Indian scientific principles with modern physics.

Also, this course intends to explore the historical contributions of Indian scholars to physics by analyzing scientific principles found in ancient Indian texts and examining their relevance to modern physics. Investigate traditional Indian perspectives on motion, optics, acoustics, materials science, and cosmology to understand how early thinkers conceptualized physical phenomena. Apply experimental methods to validate and interpret ancient Indian scientific theories, bridging historical knowledge with empirical

investigation. Encourage interdisciplinary research that integrates Indian scientific heritage with contemporary advancements, fostering a holistic understanding of physics across different eras and knowledge systems.

COURSE LEARNING OUTCOME

By the end of the course, students will be able to:

- Identify key Indian physicists and their contributions to fundamental physics concepts.
- Compare classical Indian scientific theories with modern physics principles.
- Demonstrate the application of traditional Indian knowledge in practical experiments.
- Analyze ancient Indian technological achievements in optics, acoustics, and metallurgy.
- Describe the magnetic field produced by magnetic dipoles and electric currents.
- Critically evaluate Indian cosmological models and their scientific interpretations.
- Develop interdisciplinary insights bridging ancient wisdom and modern technology.

SKILLS TO BE LEARNED

Students will gain skills in:

- Analytical Thinking – Evaluating historical and scientific perspectives critically.
- Experimental Application – Performing hands-on experiments inspired by ancient Indian discoveries.
- Interdisciplinary Research – Integrating traditional Indian knowledge into modern scientific frameworks.
- Scientific Writing & Communication – Presenting findings from comparative studies effectively.
- Problem-Solving – Applying ancient techniques to innovative modern solutions in physics**.**
- Derive expression for (a) Energy density, (b) Momentum density, (c) Angular momentum density of the electromagnetic field**.**

COURSE CONTENT

IKS: Introduction to IKS, meaning, scope and interdisciplinary nature, overview of Vedas, Upanishads, Vedangas, and Shastras, the Six Darshans and their scientific perspective, foundation of Indian knowledge system in Physics. Contribution of ancient Indian scholars such as Bhaskaracharya, Aryabhata, Brahmagupta, Acharya Kanada, Nagarjuna, Patanjali in the development of physics. Waves, optics, light and acoustics, Indian metallurgy and material science, Indian contribution to mechanics and astronomy.

Kanad's atomic theory, concepts of motion in the Vaisheshika sutra. Laws of motion, types of reality.

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force due to (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.

Magnetic Properties of Matter: Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H and M. Concept of Para, Dia and Ferro magnetism, Langevin's theory of diamagnetism and Paramagnetism, Weiss theory of Ferromagnetism, Curie-Weiss law, Curie temperature, ferromagnetic domain, Hysteresis and hysteresis loss.

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping.

Electromagnetic induction: Faraday's law of electromagnetic induction, vector and scalar potentials in time varying electromagnetic field. Self-inductance, calculation of self-inductance in solenoid and toroidal coil.

Reference books:

1. Ancient Indian Knowledge system of Physics, Dr. Anil Tiwari, Yajur publication House.
2. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.
3. Electricity and Magnetism, P. K. Chakraborty, New Age International Pvt. Ltd.
4. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
5. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

6. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
7. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
8. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
9. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
10. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning

PHY-MJ-5-P. PRACTICAL (01 Credits)

1. Experimentally validate the concept of projectile motion described in ancient Indian texts by measuring velocity and trajectory.
2. Determine the relationship between force, acceleration, and mass using traditional weighing and balancing methods.
3. Study rotational dynamics using spinning objects inspired by ancient Indian toys and devices.
4. To determine the ballistic reduction factor (ballistic constant) by steady deflection method.
5. To determine the charge sensitivity of a moving coil ballistic galvanometer using a known capacitor.
6. To find the logarithmic decrement for a Ballistic galvanometer.
7. To determine the co-efficient of self-inductance of a coil by Anderson's Bridge.

Reference books:

1. Physics Practical Manual for UG & PG, Dr. Dinesh V Kala, Paperback, InSc International Publisher, 2020, ISBN-10: 8194831768, ISBN-13: 978-8194831761, https://www.amazon.in/Physics-Practical-Manual-UG-PG/dp/8194831768.
2. AICTE Recommended Books for Undergraduate Courses, Includes Classical Mechanics, Optics, Materials Science, and other engineering subjects, AICTE, 2018, https://www.aicte-india.org/sites/default/files/list-suggested-books-indian-authors-publishers.pdf.
3. Guidelines for Training of Faculty on Indian Knowledge Systems, University Grants Commission (UGC), 2022, https://www.ugc.gov.in/pdfnews/5855891_Guidelines-for-Indian-Knowledge-System.pdf.
4. Ancient Indian Knowledge System of Physics, Covers practical applications of Indian

scientific principles, https://ijcrt.org/papers/IJCRT2405418.pdf.
5. Indian Knowledge Systems, Ministry of Education, Government of India, 2020, https://iksindia.org/.
6. Educational eBooks and Textbook Publishers in India, Pragati Prakashan, Established in 1955, Offers academic books for undergraduate and postgraduate courses, https://www.pragatiprakashan.co.in/.

PHY-MJ-6-T: THERMAL PHYSICS (03 Credits)

Course Learning Outcomes:

- Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzmann distribution law, equitation of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
- Learn about the real gas equations, Van der Waal equation of state, the Joule-Thompson effect.
- Learn to derive classical radiation laws of black body radiation. Wiens law, Rayleigh Jeans law, ultraviolet catastrophe. Saha ionization formula.

SKILLS TO BE LEARNED

- Variation of molecular velocity with pressure, temperature and density.
- Process of diffusion in gases.
- Black-body radiation.

COURSE CONTENT

Kinetic Theory of Gases: Basic assumption of the kinetic theory of an ideal gas, pressure of an ideal gas, kinetic interpretation of temperature. Important gas laws from kinetic theory. Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy, Specific heats of mono, di and tri atomic Gases.

Molecular Collisions: Mean Free Path, Collision Probability. Clausius and Maxwell Derivations of mean free path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion-Einstein's theory and experimental determination of Avogadro's number.

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of State. Boyle Temperature. Van der Waals Equation of

State for Real Gases using Virial theorem. Values of Critical Constants. Comparison with Experimental Curves. P-V Diagrams. Theory of Joule-Thomson effect, Porous Plug Experiment. J-T effect for perfect and van der Waal gases, Temperature of Inversion & Critical temperature. Joule-Thomson Cooling, Relation between Boyle temperature, Temperature of Inversion & Critical temperature.

Thermal radiation: Properties of thermal radiation, Black body radiation, Kirchhoff's law, pressure of radiation, pressure of diffuse radiation, Stefan's law and experimental verification, Wein's displacement law, Wein's distribution law, Rayleigh-Jeans law.

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
5. Advanced Text-book of Heat by P.K Chakraborty Calcutta Press 1999
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press

PHY-MJ-6-P. PRACTICAL (01 Credits)

1. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
2. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
3. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
5. To determine the thermal conductivity of rubber in the form of a tube.

Reference Books

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted

1985, Heinemann Educational Publishers

4. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal,1985, Vani Pub.

PHY-MJ-7-T. OPTICS (03 Credits)

COURSE OBJECTIVE

- The physics and mathematics of wave motion underlie many important phenomena. Light too, often displays properties that are wave-like. There are a number of phenomena in which light behaves as waves and displays wave properties such as interference, diffraction, and polarization, with emphasis on examples as seen in daily life.
- The course provides an in-depth understanding of wave phenomena of light, namely, interference and diffraction, with emphasis on practical applications of the same.

COURSE LEARNING OUTCOME

After going through the course, the student should be able to:

- Understand Interference as the superposition of waves from coherent sources derived from same parent source.
- Demonstrate understanding of Interference experiments: Young's Double Slit, Fresnel's biprism, Newton's Rings.
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from apertures.
- Understand Fraunhofer Diffraction from a slit.

SKILLS TO BE LEARNED

- This course in the basics of optics will enable the student to understand various optical phenomena, principles, workings, and applications of optical instruments.
- He/ She shall develop an understanding of Wave Motion and its properties.

COURSE CONTENT

Interference: Temporal and Spatial Coherence. Division of amplitude and wave front. Young's Double Slit experiment. Fresnel's Biprism. Phase change on reflection: Stokes' Treatment. Interference in Thin Films: Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes) and FECO (Fringes of equal chromatic order) Fringes, Newton's Ring: Measurement of wavelength and refractive index.

Interferometer: Michelson Interferometer (1) Idea of formation of fringes, (2) Determination of Wave length (3) Wave length Difference and (4) Refractive Index. Fabry-Perot interferometer (1) Intensity (2) visibility of fringes (3) Measurement of wave length.

Fraunhofer diffraction: Single slit, Double slit. Multiple slits Diffraction grating. Circular aperture.

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate**.**

Resolving power: Rayleigh's criteria for limit of resolution. Resolving power of Telescope and grating.

Polarization: Concept of polarization of light, theory of linear, circular and elliptical polarized light. Phase retardation plates, quarter wave and half wave plates**.** Production and detection of plane, circularly and elliptically polarized light, double refraction, ordinary and extra ordinary rays, uniaxial and biaxial crystal, Nicol prism, Babinet's compensator. Rotatory polarization, Biot's law for rotatory polarization. Fresnel explanation, polarimeter.

Reference Books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
4. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
5. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
6. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
7. Principle of Optics by B.K Mathur 1964 Gopala Printing Press.

PHY- MJ -7-P. PRACTICAL (01 Credit)

PRACTICALS:

1. Familiarization with: Schuster's focusing; determination of angle of prism.
2. To determine refractive index of the Material of a prism using sodium source.
3. To determine the dispersive power of the material of a prism using mercury source.
4. To determine the wavelength of sodium light by Newton's ring method.
5. To measure the wavelength of monochromatic light by using Fresnel's biprism and optical bench.

6. To determine the Cauchy's constant using different light sources.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

SEMESTER-V

PHY-MJ-8-T: THERMODYNAMICAL PHYSICS (03 Credits)

Course Learning Outcomes:

- Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations.
- Learn about Maxwell's thermodynamic relations.
- Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzmann distribution law, equitation of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
- Learn about the real gas equations, van der Waal equation of state, the Joule-Thompson effect.
- Learn to derive classical radiation laws of black body radiation. Wiens law, Rayleigh Jeans law, ultraviolet catastrophe. Saha ionization formula

Skills to be learned:

- thermodynamical concepts, principles.
- idea of IC and EC engines and their performances.
- idea of phenomenon of condensation and evaporation.
- idea of low temperature Physics.

COURSE CONTENT:

Zeroth and First Law of Thermodynamics: Zeroth Law of Thermodynamics, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes,

Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd 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.

Entropy: 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. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero

Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equation.

Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations: (1) Clausius Clapeyron equation (2) Value of C_p - C_v (3) TdS Equations (4) Joule-Kelvin coefficient for Ideal and van der Waal Gases (5) Energy equations (6) Change of Temperature during Adiabatic Process.

Reference Books:

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

PHY-MJ-8-P. PRACTICAL (01 Credits)

1. To determine the mechanical equivalent of heat by Callender and Barne's constant flow method.
2. To determine the value of ratio between two specific heats of gas by Clement and

Desorme's method.

3. To determine the specific heat of a solid by applying radiation correction
4. To determine the Stefan's Constant.

Reference Books

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal,1985, Vani Pub.

PHY-MJ-9-T: MATHEMATICAL PHYSICS (03 Credits)

Course Learning Outcomes:

- Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
- Acquire knowledge of methods to solve partial differential equations with the examples of important partial differential equations in Physics.
- Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems. They are also expected to learn the Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.

Skills to be learned:

- Training in mathematical tools like calculus, integration, series solution approach, special function will prepare the student to solve ODE, PDE's which model physical phenomena.
- These skills will help in understanding the behavior of the modeled system/s.
- Knowledge of various mathematical tools like complex analysis, integral transform

will equip the student with reference to solve a given ODE, PDE.

- These skills will help in understanding the behavior of the modeled systems.

COURSE CONTENT:

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula.
Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Analysis of saw tooth, triangular and square wave form.

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem.

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. Dirac Delta function, Periodic Functions. Convolution Theorem.
Linear Algebra: Vector Spaces: Vector Spaces over Fields of Real and Complex numbers. Examples. Vector space of functions. Linear independence of vectors. Basis and dimension of a vector space. Change of basis. Subspace. Isomorphism. Inner product and Norm. Inner product of functions: the weight function. Triangle and Cauchy Schwartz Inequalities.

Reference Books:

1. Mathematical Methods for Physicists and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
3. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
4. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
5. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

6. Mathematical physics-by H.K. Dass, S. Chand Publication
7. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
8. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
9. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
10. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
11. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
12. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

PHY- MJ-9-P. PRACTICAL (01 Credit)

1. To study the V-I characteristics of Zener diode and its use as a voltage regulator.
2. Study of V-I and power curves of solar cells and find maximum power present and efficiency.
3. To study the characteristics of Bipolar junction transistor in CE and CB configuration.
4. Use of Scilab, Matlab, Gnuplot, Origin etc. Softwares to visualize, solve and plot mathematical functions and equations.
5. To design a circuit to simulate the solution of simultaneous equation of 1st / 2nd order differential equation.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, KitabMahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.
5. Mathematica and Computer-Based Physics Experiments, Arvind Kumar & K.C. Gupta, Narosa Publishing House, 1st Edition, 2018.

PHY-MJ-10-T. ANALOG SYSTEMS AND APPLICATIONS (03 Credits)

Course Learning Outcomes:

As the successful completion of the course the student is expected to be conversant with the following.

- Secure first-hand Idea of different components including both active and passive components to gain an insight into circuits using discrete components and also to learn about integrated circuits.
- About analog systems.
- N- and P- type semiconductors, mobility, drift velocity, fabrication of P-N junctions; forward and reverse biased junctions.
- Application of PN junction for different types of rectifiers and voltage regulators.
- NPN and PNP transistors and basic configurations namely common base, common emitter and common collector and also about current and voltage gain.
- Biasing and equivalent circuits coupled amplifiers and feedback in amplifiers and oscillators.
- In laboratory : To characterize various devices namely PN junction diodes, LEDs, PNP and NPN transistors. Also construct amplifiers and oscillators using discrete components.

Skills to be learned:

- Learn the basics of IC and digital circuits and difference between analog and digital circuits. Various logic GATES and their realization using diodes and transmitters.
- Learn fundamental of Boolean algebra and their role in constructing digital circuits.
- Learn about combinatorial and sequential systems by building block circuits to construct multivibrators and counters.
- Learn basic concepts of semiconductor diodes and their applications to rectifiers.
- Learn about junction transistors and their applications.
- Learn about different types of amplifiers including operational amplifier. (Op-Amp) and their applications.
- Learn about sinusoidal oscillators of various types and A/D conversion.

Course Content:

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift Velocity. Current equation Mechanism in Forward and Reverse Biased Diode. Derivation for Barrier Potential, Barrier Width and Current for Step Junction.

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode and Voltage Regulation.

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β and Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response.

Feedback in Amplifiers: Positive and Negative feedback amplifiers, Effects of Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators, Wien Bridge Oscillator.

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G. Streetman & S.K. Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, TMH
5. Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk,2008, Springer
6. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
7. Electronic Devices, Thomas L. Floyd, 2008, Pearson India
8. A handbook of Electronics, Gupta and Kumar, S. Chand Publication

PHY-MJ-10-P. PRACTICAL (01 Credits)

1. To study V-I characteristics of PN junction diode and Light Emitting Diode.
2. To display the action of a junction diode as (a) Half wave rectifier, (b) Full wave rectifier

using CRO.

3. To calculate the h-parameters from the static characteristics of a transistor in CE configuration.
4. To determine the hybrid parameters of a transistor in common emitter configuration at low frequency.
5. To find the voltage gain and to study the frequency response of a common base transistor voltage amplifier.
6. To find the voltage gain and to study the frequency response of a common emitter transistor voltage amplifier.

Reference Books

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Textbook of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal,1985, Vani Pub.

PHY-MJ-11-T. MODERN PHYSICS (03 Credits)

Course Learning Outcomes:

- Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
- Understand the theory of quantum measurements, wave packets and uncertainty principle.
- Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier.
- Understanding the properties of nuclei like density, size, binding energy, nuclear forces

and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.

- Ability to calculate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.
- Understand fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
- Understand various interactions of electromagnetic radiation with matter.
- Understand the spontaneous and stimulated emission of radiation, optical pumping and population inversion. Three level and four level lasers. Ruby laser and He-Ne laser in details. Basic lasing.
- In the laboratory course, the students will get opportunity to perform the following experiments
- Measurement of Planck's constant by more than one method.
- Verification of the photoelectric effect and determination of the work Function of a metal.
- Determination of the charge of electron and e/m of electron.
- Determination of the ionization potential of atoms.
- Determine the wavelength of the emission lines in the spectrum of Hydrogen atom.
- Determine the absorption lines in the rotational spectrum of molecules.
- Determine the wavelength of Laser sources by single and Double slit experiments
- Determine the wavelength and angular spread of He-Ne Laser using plane diffraction grating.
- Verification of the law of the Radioactive decay and determination of mean life time of a Radioactive Source, Study the absorption of the electrons from Beta decay. Study of the electron spectrum in Radioactive Beta decays of nuclei.

- Plan and Execute 2-3 group projects in the field of Atomic, Molecular and Nuclear Physics in collaboration with other institutions, if, possible where advanced facilities are available.

Skills to be learned:

- Comprehend the failure of classical Physics and need for quantum Physics.
- Grasp the basic foundation of various experiments establishing the quantum Physics by doing the experiments in laboratory and interpreting them.
- Formulate the basic theoretical problems in one, two and three dimensional Physics and solve them.
- Learning to apply the basic skills developed in quantum physics to various problems in (a) Nuclear Physics (b) Atomic Physics (c) Laser Physics.
- Learn to apply basic quantum physics to Ruby Laser, He-Ne Laser

Course Content:

BASIC QUANTUM THEORY:

Planck's quantum, Planck's constant and light as a collection of photons, Blackbody Radiation: Quantum theory of Light, Photo-electric effect and Compton scattering. de Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them.

SCHRODINGER FORMULATION

Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables), Derivation from Wave Packets impossibility of a particle following a trajectory, Energy-time uncertainty principle

Matter waves and wave amplitude, Schrodinger equation for non-relativistic particles, Momentum and Energy operators, stationary states, physical interpretation of a wave function, probabilities and normalization, Probability and probability current density in one dimension.

NUCLEAR PHYSICS.

Size and structure of atomic nucleus and its relation with atomic weight, Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, Liquid Drop model, semi-empirical mass formula and binding energy.

Radioactivity: stability of the nucleus, Law of radioactive decay, Mean life and half-life, successive disintegration, Elementary idea of Alpha decay and Beta decay.

Fission and fusion, mass defect, Fission - nature of fragments and emission of neutrons. Fusion-Thermonuclear reaction.

Lasers: Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Einstein's A and B coefficients and derivation. Three-Level and Four-Level rate equation. Ruby Laser and He-Ne Laser.

Reference Books:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Ritch Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan

Additional Books for Reference

1. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
2. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
3. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
4. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
5. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

PHY-MJ-11-P.: PRACTICAL (01 Credits)

1. Measurement of Planck's constant using black body radiation and photo- detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the absorption lines in the rotational spectrum of Iodine vapour.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,

reprinted 1985, Heinemann Educational Publishers
3. A Textbook of Practical Physics, I.Prakash& Ramakrishna, 11th Edn, 2011,Kitab Mahal

SEMESTER-VI

PHY-MJ-12-T. DIGITAL SYSTEMS AND APPLICATIONS (03 Credits)

COURSE OBJECTIVE

- In this paper, students will explore the fundamentals of Digital Electronics and gain a comprehensive understanding of its principles.
- This paper introduces the concept of Boolean Algebra and basic digital electronics.
- In this course, students will be able to understand Arithmetic Circuits.

COURSE LEARNING OUTCOMES

At the end of this course, students will be able to develop following learning outcomes:

- Gaining a fundamental understanding of the principles of a Cathode Ray Oscilloscope (CRO).
- Differentiating between Analog and Digital circuits, the concepts of number systems like Binary, BCD, Octal, and hexadecimal are developed to elaborate on and focus on digital systems.
- Explains the concepts of logic states and logic gates AND, OR, NOT, NAND, NOR, XOR and XNOR as fundamental, universal, and derived gates with their utility.
- Covers the realisation of NOT, OR and AND gates using diodes and transistors.
- Students learn how to write logical Boolean statements using the truth table, its simplification using Boolean Algebra, De-Morgan's Theorem and Karnaugh Maps, specially the Sum of Products method, and realise the corresponding logic circuit.

- Understanding the Arithmetic circuits.
- Principles of Flip-Flops, timers, shift registers, and counters.
- In the laboratory course, the students will design a combinational logic system for a given equation, minimizing the logic circuit, Adder and Subtractor.

SKILLS TO BE LEARNED

- In this course, students should be able to learn the basics of IC and digital circuits, and the difference between analog and digital circuits. Various logic GATES and their realization using diodes and transistors.
- Learn the fundamental of Boolean algebra and their role in constructing digital circuits.
- Understand basic Arithmetic circuits.

COURSE CONTENT

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

Boolean Algebra: De-Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Karnaugh Map -Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Product of Sum Method**.**

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and their applications.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder & Subtractor.

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders,

Flip-Flop:- R-S Flip flop, clocked R-S flip flop, D- Flip Flop, Edge triggered D- flip flop, Edge triggered J-K flip flop. Pulse triggered (Master-slave J-K flip flop).

Reference Books:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
1. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
2. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
3. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
4. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
5. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

PHY-MJ-12-P. PRACTICAL (01 Credits)

1. To design a switch (NOT gate) using a transistor.
2. Verification of truth tables of basic logic gates.
3. To verify and design AND, OR, NOT and NOR gates using NAND gate.
4. To verify and design AND, OR, NOT and gates using NOR gate.
5. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
6. Half Adder, Full Adder and 4-bit binary Adder.
7. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
1. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011,Kitab Mahal
2. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
4. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson
5. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
6. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.

PHY-MJ-13-T. QUANTUM MECHANICS AND APPLICATIONS (03 Credits)

Course Learning Outcomes:

This course will enable the student to get familiar with quantum mechanics formulation.

- After an exposition of inadequacies of classical mechanics in explaining microscopic phenomena, quantum theory formulation is introduced through Schrodinger equation.
- The interpretation of wave function of quantum particle and probabilistic nature of its location and subtler points of quantum phenomena are exposed to the student.
- Through understanding the behavior of quantum particle encountering a (i) barrier, (ii) potential, the student gets exposed to solving non-relativistic hydrogen atom, for its spectrum and eigenfunctions.
- This basic course will form a firm basis to understand quantum many body problems.

Skills to be learned:

- This course shall develop an understanding of how to model a given problem such as particle in a box, hydrogen atom.
- Many electron atoms, L-S and J-J couplings.
- These skills will help in understanding the different Quantum Systems in atomic and nuclear physics

Course Content:

Time independent Schrodinger equation: Time independent Schrodinger equation, Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities, Conditions for Physical Acceptability of Wave Functions. Normalization, Eigenvalues and Eigenfunctions. Expectation values of position and momentum.

Time dependent Schrodinger equation- Time dependent Schrodinger equation; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension.

Operators: Postulates of quantum mechanics, Position, momentum, Hamiltonian and Energy operators; eigenvalues and eigenfunctions, commutator of position and momentum operators, angular momentum operator and commutation relation between them, Hermitian operator and properties of Hermitian operator**.**

General discussion of one-dimensional potential problems - One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, one-dimensional potential step, Quantum tunnelling &

rectangular potential barrier, one-dimensional square well potential. One dimensional harmonic oscillator.

Spherically Symmetric system: Schrodinger equation for spherically symmetric potentials**.** Three-dimensional harmonic oscillator. Rigid rotator with free axis. Hydrogen atom. Three-dimensional square well potential.

Reference Books:

1. A Textbook of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
7. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
8. Quantum mechanics by N.R. Roy, Vikash Publication 2021.

Additional Books for Reference:

1. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
2. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
3. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

PHY-MJ-13-P: PRACTICAL (01 Credits)

1. To study the Black-Body spectrum, using wavelength detector.
2. To verify Einstein's photoelectric equation using a photo-tube.
3. To study the interference pattern of double slit using electron source.
4. To study the electron diffraction pattern using single slit.
5. To determine the value of e/m by Brown's tube (Thompson method).
6. To determine the wavelength of the H-alpha emission line of the Hydrogen atom.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

3. A Textbook of Practical Physics, I. Prakash& Ramakrishna, 11th Edn, 2011,Kitab Mahal.

PHY-MJ-14-T. SOLID STATE PHYSICS (03 Credits)

Course Learning Outcomes:

At the end of the course the student is expected to learn and assimilate the following.

- A brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays by crystalline materials.
- Knowledge of lattice vibrations, phonons and in-depth knowledge of Einstein and Debye theory of specific heat of solids.
- Secure an understanding about the dielectric and ferroelectric properties of materials.
- Understanding above the band theory of solids and must be able to differentiate insulators, conductors and semiconductors.
- To carry out experiments based on the theory that they have learned to measure the dielectric constant . They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

Skills to be learned:

- Learn basics of crystal structure and physics of lattice dynamics
- Learn the physics of different types of material like magnetic materials, dielectric materials, metals and their properties.
- Understand the physics of insulators, semiconductors and conductors with special emphasis on the elementary band theory of semiconductors.
- Comprehend the basic theory of superconductors. Type I and II superconductors, their properties and physical concept of BCS theory.

Course Content:

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis– Central and Non-Central Elements. Unit Cell. Bravais lattice (2D and 3D), Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals.

Bragg's Law.

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids, T^3 law.

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius-Mossotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeier relations. Langevin-Debye equation.

Free electron theory of metals: classical free electron theory of metals, electrical conductivity, Summerfield's theory of electrical conductivity, thermal conductivity, Weidman-Franz law, quantum theory of free electron, free electron gas in one dimensional box, Fermi level, Fermi energy.

Elementary band theory: Periodic potential and Bloch theorem**,** Kronig-Penny model. Band Gap. Nearly free electron approximation, Tight binding approximation (Elementary Idea).

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
5. Solid state Physics, H. Ibach and H. Luth, 2009, Springer
6. Elementary Solid State Physics, M. Ali Omar, 1999, Pearson India
7. Solid State Physics, M.A. Wahab, 2011, Narosa Publications
8. Solid State Physics, M.K. Mahan and P. Mahto, 2008, Bharti Bhawan

PHY-MJ-14-P.: PRACTICAL (01 Credits)

1. Measurement of susceptibility of paramagnetic solution (Quincke's Tube Method)
2. To determine the Coupling Coefficient of a Piezoelectric crystal.
3. To measure the Dielectric Constant of a dielectric Materials with frequency
4. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
5. To study the BH curve of iron using a Solenoid and determine the energy loss.

6. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150^0 C) and to determine its band gap.
7. To determine the Hall coefficient of a semiconductor sample.

Reference Books:

1. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
2. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. B.Sc. Practical Physics, N. N. Ghosh, Bharati Bhawan Publishers.
4. Practical Physics, S.L. Gupta & V. Kumar, Pragati Prakashan, Reprint Edition, 2022.
5. Advanced Level Practical Physics, M.P. Poonia & S.C. Sharma, Hitech Publishing House, 1st Edition, 2020.
6. Practical Physics, S.P. Singh & M.K. Bagde, S. Chand Publishing, 4th Edition, 2021.
7. Advanced Practical Physics for Students, B.L. Worsnop & H.T. Flint, S. Chand Publishing (Indian Reprint), Reprint Edition, 2021.
8. Classical Mechanics and Fluid Dynamics (Lab Manual), J.C. Upadhyaya, Ram Prasad & Sons, Latest Edition, 2020.
9. Experimental Physics, R.K. Shukla & Anchal Srivastava, New Age International Publishers, 2nd Edition, 2019.
10. Laboratory Manual of Physics for UG & PG, K.K. Tiwari, Atmaram & Sons, 3rd Edition, 2021.

PHY-MJ-15-T. PHYSICS OF DEVICES AND INSTRUMENTS (03 Credits)

Course Learning Outcomes:

At the successful completion of the course the student is expected to master the following.

- Metal oxide semiconductors, UJT, JFET, MOSFET, Charge coupled Devices and Tunnel Diode.
- Power Supply and the role of Capacitance and Inductance filters.
- Active and passive filters and various types of filters.
- Multivibrators using transistors, Phase locked loops, voltage controlled oscillators
- Basics of photolithography for IC fabrication, about masks and etching.
- Concepts of parallel and serial communication and knowledge of USB standards and GPIB.
- Basic idea of communication including different modulation techniques.

Skills to be learned:

- Acquire knowledge and skills to understand the Physics of the following devices and instruments and practical knowledge to use them by doing experiments in laboratory.

- UJT
- BJT
- MOSFET
- CCD
- Tunnel Diodes
- Various types of Power Supplies
- Various types of Filters
- Multivibrators and oscillators

Course Content:

Devices: Characteristic and small signal equivalent circuits of UJT and JFET. Metal semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO_2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode.

Power supply and Filters: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. T and π section filters. Regulators, Line and load regulation, Short circuit protection

Linear integrated circuit: characteristics of an ideal and practical operational amplifier (IC-741), open loop and closed loop gain, frequency response, CMRR, slew rate and concept of virtual ground, inverting and non-inverting amplifiers, adder, subtractor, differentiator, integrator.

Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters.

Multivibrators: Astable and Monostable Multivibrators using transistors.

Digital Data Communication Standards: Introduction to communication systems: Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Side band frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. Basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.

Reference Books:

1. Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed.2008, John Wiley & Sons
2. Electronic devices and integrated circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.
3. Op-Amps & Linear Integrated Circuits, R.A. Gayakwad,4 Ed. 2000, PHI Learning Pvt. Ltd
4. Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
5. Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
6. Introduction to Measurements & Instrumentation, A.K. Ghosh, 3rd Ed., 2009, PHI Learning Pvt. Ltd.

7. Basic Electronics: Arun Kumar, Bharti Bhawan 2007

PHY-MJ-15-P: PRACTICAL (01 Credit)

1. To investigate the use of an op-amp as an Integrator
2. To investigate the use of an op-amp as a Differentiator.
3. To design the active low pass and high pass filters of given specification
4. To study the output and transfer characteristics of a JFET.
5. To study the output characteristics of a MOSFET.
6. To study the voltage regulation and a ripple factor of a (a) Half wave rectifier and (b) Full wave rectifier with filter circuits.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

SEMESTER-VII

PHY-MJ- 16-T. RESEARCH METHODOLOGY (04 Credits)

COURSE OBJECTIVES

- To introduce students to the basic concepts of research and research methodology.
- To develop an understanding of research design, data collection methods, and data analysis techniques.
- Develop skills in scientific writing, Literature review and data analysis.
- To enable students to write research proposals and reports ethically and systematically.

COURSE OUTCOMES

After completion of the course, students will be able to:

- Understand the fundamentals of research and its types.
- Formulate research problems and hypotheses.
- Conduct literature surveys using digital tools and databases.
- Apply qualitative and quantitative research techniques.
- Prepare research proposals, reports, and thesis.
- Understand ethical issues in research and plagiarism.

COURSE CONTENT

Fundamentals of computers:

Hardware and Software, operating system, M.S. Office and Linux operating system of Power point presentation. Development of skills in scientific writing, Data entry, Graph plotting.

Research Design – concept, component and types.

Basic, Applied, Descriptive, Analytical, quantitative, Qualitative, Exploratory, Experimental, Theoretical, Scientific method and Research Process identification and Formulation of Research Problem.

Literature Review and Research Design

Sources of Literature: Journals, Books, use of e- resources –Science direct (Elsevier, Springer Link, Scopus, Web of Science, Google scholar, Shodh Sindhu, Shodh Ganga. (INFLIBNET, JSTOR) Techniques of Review Writing and Referencing Styles (AIP/APA), Plagiarism and Academic Integrity: Use of Plagiarism Detection Tools (Turnitin, URKUND).

Data Analysis and Interpretation

Classification, Tabulation, and Presentation of Data (Charts, Graphs, Tables) Basics of software tools; Python, Excel, origin for data handling, Interpretation and Drawing Inferences, Poster, seminars, Power point presentation.

Research Reporting and Ethics

Structure of Research Report/Thesis, Referencing and Citation Management Tools (Zotero, Mendeley) Ethics in Research: Fabrication, Falsification, Plagiarism, Authorship Issues, IPR (Intellectual Property Rights), Patents, Copyright and Open Access Publishing.

Suggested Readings and Tools

1. Research Methodology: Methods and Techniques, C.R. Kothari and Gaurav Garg New Age International Published, 4th ed., 2019.

2. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Pearson Education, 5th ed., 2021.
3. Research Methodology: R. Panneerselvam, PHI Learning Pvt. Ltd., 2nd ed., 2014.
4. Research Methodology: Concepts and Cases, Deepak Chawla and Neena Sondhi, Vikas Publishing, 2nd ed., 2016.
5. Data Reduction and Error Analysis for the Physical Sciences, Philip R. Bevington and D. Keith Robinson, McGraw-Hill Education, 3rd ed., 2003.
6. How to Write and Publish a Scientific Paper, Robert A. Day and Barbara Gastel, Cambridge University Press,8th ed. 2016.
7. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell and J. David Creswell, SAGE Publication. 5th ed., 2018.
8. Technical Report Writing. Aditham Bhujanga Rao, PHI Learning Pvt. Ltd., 1st ed., 2012.

PHY-MJ-17-T. ELECTROMAGNETIC THEORY (03 Credits)

Course learning outcome:

- Achieve an understanding of Maxwell's equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media.
- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
- Analyse the phenomena of wave propagation in the unbounded, bounded, vacuum, dielectric, guided and unguided media.
- Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at plane interface in bounded media.
- In the laboratory course, the student gets an opportunity to perform experiments, Demonstrating principles of Interference, Refraction and Diffraction of light using monochromatic sources of light.
- Determine the refractive index of glass and liquid using total internal reflection of light. Verify the laws of Polarization for plane polarized light.
- Determine Polarization of light by Reflection and determine the polarization angle off or air-glass surface

Skills to be learned

- Comprehend the role of Maxwell's equation in unifying electricity and magnetism.
- Derive expression for (i) Energy density (ii) Momentum density (iii) Angular momentum density of the electromagnetic field
- Learn the implications of Gauge invariance in EM theory in solving the wave equations and develop the skills to actually solve the wave equation in various media like (i) Vacuum (ii) Dielectric medium (iii) Conducting medium (iv) Dilute plasma
- Derive and understand associated with the properties, EM wave passing through the interface between two media like (i) Reflection (ii) Refraction (iii) Transmission (iv) EM waves

COURSE CONTENTS:

Maxwell Equations: Derivation of Maxwell's equations. Displacement Current. Boundary Conditions at Interface between Different Media. Poynting Theorem and Poynting Vector.

EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectric medium, Transverse nature of plane EM waves, Refractive index and dielectric constant, Wave impedance. Propagation through conducting media, phase velocity, skin depth.

EM Wave in Bounded Media: Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law.

Interaction of EMW with matter on microscopic scale: Scattering and scattering parameters, scattering by a free electron: Thomson scattering, Scattering by a bound electron: Rayleigh scattering, Dispersion-Normal and anomalous: Dispersion in gases: Lorentz theory. Sellmeir's equation, Dispersion in liquids and solids.

Relativistic electrodynamics: purview of special theory of relativity, 4-vectors and tensors, transformation equations for charge and current densities, electromagnetic vector and scalar potentials, transformation equations for the electromagnetic potentials **A** & **φ**. Electromagnetic field tensor, transformation equations for the field vectors **E** & **B.** Covariance of Maxwell equations in terms of 4-vectors, Covariance of Maxwell equations in 4-tensor forms.

Reference Books:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
6. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
7. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 2021, Wiley/I. K. International Publishing House, New Delhi
8. Electromagnetic Theory, Chopra & Agarwal, Kedarnath Ramnath & Co.

Additional Books for Reference:

1. Electromagnetic Fields & Waves, P. Lorrain & D.Corson, 1970, W.H.Freeman& Co.
2. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
3. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

PHY-MJ-17-P.: PRACTICAL. (01 Credit)

1. To verify Cauchy's formula and determination of Cauchy's constant.
2. To determine the angle of polarization and hence verify Brewster's law.
3. To study the phenomenon of normal dispersion in liquids and gases.
4. To study the reflection, refraction of microwaves.
5. To determine the refractive index of a liquid by total internal reflection using Wollaston's air film.

Reference Books:

1. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
3. Microprocessor Architecture Programming and appls. with 8085, R.S. Goankar, 2002, Prentice Hall.
4. Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.

5. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

PHY-MJ-18-T. STATISTICAL MECHANICS (03 Credits)

Course Learning Outcomes:

- Understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability and partition function.
- Understand the combinatoric studies of particles with their distinguishably or indistinguishably nature and conditions which lead to the three different distribution laws e.g. Maxwell-Boltzmann distribution, Bose-Einstein distribution and Fermi-Dirac distribution laws of particles and their derivation.
- Learn to apply the classical and statistical mechanics to derive the law of equipartition of energy and specific heat.
- Understand the Gibbs paradox, equipartition of energy and concept of negative temperature in two level systems.
- Learn to derive classical radiation laws of black body radiation. Wiens law, Rayleigh Jeans law, ultraviolet catastrophe. Saha ionization formula.
- Learn to calculate the macroscopic properties of degenerate photon gas using BE distribution law, understand Bose-Einstein condensation law and liquid Helium. Bose derivation of Plank's law
- Understand the concept of Fermi energy and Fermi level, calculate the macroscopic properties of completely and strongly degenerate Fermi gas, electronic contribution to specific heat of metals.
- Understand the application of F-D statistical distribution law to derive thermodynamic functions of a degenerate Fermi gas, electron gas in metals and their properties.
- Calculate electron degeneracy pressure and ability to understand the Chandrasekhar mass limit, stability of white dwarfs against gravitational collapse.
- Compare the following distributions as a function of temperature for various energies and

the parameters of the distribution functions: (a) Maxwell-Boltzmann distributionb. (b) Bose-Einstein distributionc. (c) Fermi-Dirac distribution.

- Do 3-5 assignments given by the course instructor to apply the methods of Statistical mechanics to simple problems in Solid State Physics and Astrophysics
- Do the regular weekly assignments of at least 2-3 problems given by the course instructor.

Skills to be learned:

- Learn the basic concepts and definition of physical quantities in classical statistics and classical distribution law.
- Learn the application of classical statistics to theory of radiation.
- Comprehend the failure of classical statistics and need for quantum statistics.
- Learn the application of quantum statistics to derive and understand.
- Bose Einstein statistics and its applications to radiation.
- Fermi-Dirac statistics and its applications to quantum systems.

COURSE CONTENT:

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Boltzmann entropy relation, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation. Ideas of ensembles, micro-canonical, canonical and grand canonical ensembles and expression for distribution function, partition function and calculation of thermodynamic quantities.

Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. Steafan's Boltzmann law, statement, derivation and experimental verification.

Bose-Einstein Statistics: Bose -Einstein distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose derivation of Planck's law.

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely

and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal.

Reference Books:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, OXFORD UNIV. PRESSES.

PHY-MJ-18-P: PRACTICAL (01 Credits)

1. Study of Specific Heat of Solids at Low Temperatures (Debye and Einstein Models).
2. Measurement of Thermal Conductivity vs. Temperature (Phonon Transport).
3. Investigation of the Bose-Einstein Condensation Using Liquid Helium.
4. Study of the Lambda Transition in Liquid Helium Using a Cryostat.
5. Analyze the Equation of State for a Degenerate Electron Gas Using a Metal Sample.
6. Brownian Motion Experiment Using Microscopic Particles in a Liquid.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Textbook of Practical Physics, I. Prakash& Ramakrishna, 11th Edn, 2011,Kitab Mahal

SEMESTER-VIII

PHY-MJ-19-T. NUCLEAR AND PARTICLE PHYSICS (03 Credits)

Course Objectives:

- Learn the ground state properties of a nucleus – the constituents and their properties, mass number and atomic number, relation between the mass number and the radius and the mass number, average density, range of force, saturation property, stability curve, the concepts of packing fraction and binding energy, binding energy per nucleon vs. mass

number graph, explanation of fusion and fission from the nature of the binding energy graph.

- Learn the basic aspects of nuclear reactions, the Q-value of such reaction and its derivation from conservation laws, the reaction cross-sections, the types of nuclear reactions, direct and compound nuclear reactions, Rutherford scattering by Coulomb potential.
- The students are expected to learn about the principles and basic constructions of particle accelerators such as the Van-de-Graff generator, cyclotron, and synchrotron. They should know about the accelerator facilities in India.
- Gain knowledge on the basic aspects of particle Physics – the fundamental interactions, elementary and composite particles, the classifications of particles: leptons, hadrons (baryons and mesons), quarks, gauge bosons. The students should know about the quantum numbers of particles: energy, linear momentum, angular momentum, isospin, electric charge, colour charge, strangeness, lepton numbers, baryon number and the conservation laws associated with them.

Skills to be learned:

- Skills to describe and explain the properties of nuclei and derive them from various models of nuclear structure.
- To understand, explain and derive the various theoretical formulation of nuclear disintegration like α decays, β decays and γ decays.
- Develop basic understanding of nuclear reactions and decays with help of theoretical formulate and laboratory experiments.
- Ability to understand, construct and operate simple detector systems for nuclear radiation and training to work with various types of nuclear accelerators.
- Develop basic knowledge of elementary particles as fundamental constituent of matter, their properties, conservation laws during their interactions with matter.

Course Content:

Structure and properties of the nucleus: Composition, Basic properties, charge, mass, size, spin, magnetic moment, electric quadruple moment, binding energy, binding energy per nucleon and its observed variation with mass number of the nuclei.

Nuclear Force: Two nucleon systems, deuteron problem, binding energy.

Nuclear detectors: Detectors for charged particles, ion chamber, GM counter, resolving time, cloud chamber and bubble chamber.

Accelerator: Need for accelerators, linear accelerators, cyclotron, synchrocyclotron.

Radioactivity: α decay: basics of α decay processes, Geiger-Nuttal Law, Gamow's theory of α decay, β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) γ-emission: Introductory idea.

Nuclear reactions: Rutherford's experiments of nuclear transmutation, conservation theorems, Q-value, threshold energy, cross-section of nuclear reactions.

Cosmic rays and elementary particles: Discovery of cosmic rays: hard and soft components, discovery of muon, pion, heavy mesons and hyperons, mass and life-time determination for muon and pion. Primary cosmic rays: Extensive air showers, solar modulation of primary cosmic rays, effect of earth's magnetic field on the cosmic ray trajectories.

Reference Books:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
4. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
5. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
6. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
7. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by
8. K. Heyde (IOP- Institute of Physics Publishing, 2004).
9. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
10. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
11. Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)
12. Elements of Nuclear Physics, N.R. Roy, R.K. Pandey Atlantic Publication 2024.

PHY-MJ-19-P: PRACTICAL (01 Credits)

1. To study the working of G-M counter
2. To plot the count rate and voltage curve using GM counter for given radiation source
3. To find the absorption co-efficient of given material using GM counter
4. To draw the plateau (curve) for a GM counter.
5. To find the dead time of a GM counter.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011,Kitab Mahal

PHY-MJ-20-T. CLASSICAL MECHANICS (03 Credits)

Course Learning Outcomes:

- Revise the knowledge of the Newtonian, the Lagrangian and the Hamiltonian formulations of classical mechanics and their applications in appropriate physical problems.
- Learn about the small oscillation problems.
- Recapitulate and learn the special theory of relativity-postulates of the special theory of relativity, Lorentz transformations on space-time and other four vectors, four-vector notations, space-time invariant length, length contraction, time dilation, mass-energy relation, Doppler effect, light cone and its significance, problems involving energy-momentum conservations.
- Learn the basics of fluid dynamics, streamline and turbulent flow, Reynolds's number, coefficient of viscosity and Poiseuille's equation.
- Review the retarded potentials, potentials due to a moving charge, Lienard Wiechert potentials, electric and magnetic fields due to a moving charge, power radiated, Larmor's formula and its relativistic generalization**.**

Skills to be learned:

- Learn to define generalized coordinates, generalized velocities, generalized force and write Lagrangian for mechanical system in terms of generalized coordinates.
- Learn to derive Euler-Lagrange equation of motion and solve them for simple mechanical systems.

- Learn to write Hamiltonian for mechanical systems and derive and solve Hamilton's equation of motion for simple mechanical systems.
- Formulate the problem of small amplitude oscillation and solve them to obtain normal modes of oscillation and their frequencies in simple mechanical systems.
- Develop the basic concepts of special theory of relativity and its applications to dynamical systems of particles.
- Develop the methods of relativistic kinematics of one and two particle systems and its application to two particle decay and scattering.

Course Content:

Classical mechanics of a particle and system of particles: Generalized Co-ordinate, Generalized displacement, generalized velocity, generalized acceleration, generalized momentum, generalized force, generalized potential.

Lagrangian formulation of mechanics: calculus of variation, Euler-Lagrange's differential equation, Hamilton's principle, deduction of Lagrange's equation of motion from Hamilton's principle (conservative system), D' Alembert's principle, Lagrange's equation from D' Alembert's principle, conservative and non-conservative system, Applications of Lagrange's equation of motion: linear harmonic oscillator, simple pendulum, compound pendulum, particle moving under central force.

Hamiltonian formulation of mechanics: Hamiltonian, Hamilton's canonical equation of motion, physical significance of H, Applications: simple pendulum, compound pendulum, linear harmonic oscillator. Particle in a central field of force, canonical transformations, Poisson's brackets: definition and properties,

Special relativity in classical mechanics: Lorentz's transformation, Minkowski space, the invariant interval, light-cone and world-lines, space time diagram. Four vectors; space-like, time-like and light-like. Four velocity and acceleration, four momentum and energy momentum relations. Lagrangian formulation of relativistic mechanics. Hamiltonian formulation of relativistic mechanics.

Reference Books:

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.

3. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
4. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
5. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
6. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
7. Classical mechanics by N.R. Roy, Vikash Publication 2021.

PHY-MJ-20-P: PRACTICAL (01 Credits)

1. Verification of D'Alembert's principle using Atwood's machine.
2. To determine the coupling co-efficient of coupled oscillators.
3. To determine the damping co-efficient of a given liquid using damped oscillator.
4. To determine the logarithmic decrement of an oscillating disc in a liquid.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Textbook of Practical Physics, I. Prakash& Ramakrishna, 11th Edn, 2011, KitabMahal

PHY- AMJ-1-T. ADVANCED QUANTUM MECHANICS (04 Credits)

COURSE OBJECTIVE

After completing this course on Advanced Quantum Mechanics, students will gain an essential understanding necessary for theoretical formulation of physical phenomena at the quantum level in matter and radiation fields. This foundation will support further study in various advanced topics in quantum physics.

COURSE LEARNING OUTCOMES

- Develop a foundational understanding of Quantum Mechanics needed for various

quantum mechanical approaches.

- Understand the significance of quantum numbers in explaining atomic structures, including the hydrogen atom and multi-electron systems.
- Grasp the matrix formulation of quantum mechanics and the significance of the Schrödinger, Heisenberg and Interaction pictures.
- Comprehend space quantization, commutator algebra, and the theory of orbital and spin angular momenta.
- Use Clebsch-Gordon coefficients for unitary transformations.
- Apply stationary perturbation theory for approximate solutions to quantum mechanical problems.
- Understand the Klein-Gordon and Dirac equations, including their applications and limitations.
- Learn the principles of quantizing the electromagnetic field.

SKILLS TO BE LEARNED

- Grasp basic concepts and principles of quantum mechanics and their applications to systems like the simple harmonic oscillator.
- Master the matrix formulation of quantum mechanics.
- Apply the Schrödinger, Heisenberg and Interaction pictures, particularly to the linear harmonic oscillator.
- Understand and use commutation relations for angular momentum operators.
- Solve angular momentum problems using Clebsch-Gordon coefficients.
- Employ various approximation techniques to solve quantum systems.
- Distinguish between particles with half-integer and integer spin; understand the implications of symmetric and antisymmetric wave functions.
- Calculate energy levels and wave functions for quantum systems with conserved quantities.
- Explore the semi-classical theory of radiation, including the derivation and significance of Einstein's A and B coefficients.

COURSE CONTENT

Matrix formulation of Quantum mechanics: Review of matrix algebra. Transpose of matrix.

Conjugate of a matrix. Symmetric and Antisymmetric matrices. Hermitian and skew-Hermitian matrices. Determinant of matrix. Singular and non-singular matrices. Adjoint of matrix. Rank of matrix. Linear transformation. Eigen values and eigen vectors.

Angular momentum and spin: Orbital angular momentum, eigen values and eigen function, Eigen value and Eigen function of Spin angular momentum, total angular momentum operators. Commutation relations of total angular momentum with components. Orbital angular momentum and rotations. Pauli's theory of electron spin. Pauli spin matrices. Raising and lowering operators.

Approximation methods: Dirac's Ket and Bra notation. WKB Approximation. Time independent perturbation theory: First order perturbation, second order perturbation. Time dependent perturbation theory: first order perturbation. Einstein's A and B co-efficient. Rayleigh scattering, Raman scattering.

System of identical particles: Identical particles, symmetry of wave function. Pauli's exclusion principle. Heitler-London theory of hydrogen molecule. The helium atom.

Relativistic Quantum Mechanics: Introduction, Klein-Gordan equation, Klein Gordan equation in electromagnetic field. Dirac's relativistic equation. Dirac's free particle solutions. Probability density and current density. Electromagnetic potential. Magnetic moment of the electron. Existence of electron spin. Spin-orbit energy.

References

1. Modern Quantum Mechanics, J.J Sakurai, Revised Edition, 1994, Addision-Wesley.
2. The Principles of Quantum Mechanics, P. A. M. Dirac, Clarendon Press, 2004
3. Introduction to Quantum Mechanics, David J. Griffiths, Second Edition, 2006, Pearson Education.
4. Quantum Mechanic Concepts and Applications, NouredineZettili, SecondEdition,2001, John Wiley & Sons, Ltd.
5. A Textbook of Quantum Mechanics, P.M.Mathews & K.Venkatesan, 2nd Ed., 2010, McGraw Hill.
6. Quantum Mechanics, Brian H. Bransden and C. Charles Jean Joachain, 2000, Prentice Hall.

Additional Resources:

1. Introduction to Quantum Mechanics, Volume-I, C. Cohen-Tannoudgi, B. Diu, F. Laloe,1977, Wiley-VCH. Quantum Theory, David Bohm, Dover Publications, 1979.
2. QUANTUM MECHANICS: Theory and Applications, (2019), (Extensively revised6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi.

3. Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019
4. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications,
5. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
6. Quantum Mechanics, Eugene Merzbacher, 2004, John Wiley and Sons, Inc.

PHY-AMJ-2-T. ATOMIC AND MOLECULAR SPECTROSCOPY (04 Credits)

COURSE OBJECTIVE

The main objective is to teach students the basic atomic structures with quantum mechanical approach leading to their fundamental spectroscopies. The effect of magnetic and electric field on the atomic spectra is also highlighted. To teach the students the nature of molecular spectra (rotational, vibrational, electronic and Raman), polyatomic molecules (including diatomic) are classified on the basis of their topological symmetry. The fundamentals of electronic states will also be taught. Also, the LASER part of this course will enable the students to understand the two-three-and four- level laser systems also the non-linear interaction of light with matter.

COURSE LEARNING OUTCOMES

- Details of atomic and diatomic molecular (diatomic) structures in terms of quantum mechanical treatment elaborately beyond the basic models. It will give the descriptions of fine and hyperfine structure of atoms and molecules. Space quantization, commutator algebra, Theory of orbital and spin angular momenta. Clebsch-Gordon coefficients for unitary transformation.

- The various coupling schemes and interactions of fields with spectra will enrich the student's knowledge about transitions. The details of these spectroscopies would serve as the fundamentals for various concerned experimental studies.

- Analyzing the polyatomic molecules (including diatomic) and to predict the nature of their vibrational spectra depending on their symmetry using IR Raman Spectroscopy.

- The complete picture of rotational, vibrational and electronic spectra of polyatomic molecules will be comprehended. This kind of specialization is expected to provide a larger scope for research in the various related and interdisciplinary areas.
- Understanding fundamental physical processes of the laser.
- Understanding Einstein's postulates and laser field with unique properties not found in ordinary light.

SKILLS TO BE LEARNED

- Learn about the spectrum of 1 electron and many electron atoms, various important quantum-mechanical models to study the electronic structure of many electron systems, Spectroscopic terms which represent the states.
- Have an intuitive understanding about the outcomes of the interactions of the electromagnetic radiation with the various atoms and the molecules and the rules governing this process. They will learn about the rotational, vibrational, electronic, Raman and infrared spectrums arising due to this interaction.
- Gain in-depth knowledge about the molecular structure using various concepts.
- Learn the fundamentals and the principles of lasers. Also, they will learn about various types of lasers developed with time. Also, the principle of Holography.

COURSE CONTENT

Bohr-Sommerfield Atom model: Introduction, Bohr's atom model, origin of spectral series, energy levels, Bohr's correspondence principle. Spectra of hydrogenic atoms. Bohr's Sommerfield theory of hydrogen atom.

Vector atom model: Angular and magnetic moments. Space quantization of electron spin. Quantum numbers - a general account. Characteristics of vector atom models. Larmor's theorem. Spin angular momentum, Spin magnetic moment. Stern-Gerlach experiment, Zeeman effect. Normal and anomalous. Paschen-Back effect. Stark-effect. Gyromagnetic ratio. Bohr magneton.

Many electrons system: Pauli's exclusion principle, Symmetric and Antisymmetric wave function, Spectral notation for atomic states. Spin-orbit coupling in atoms. L-S and J-J coupling, spectra of

Hydrogen and Alkali atoms (Na). Spin –orbit interaction. Hydrogen fine structure.

Molecular spectra: Introduction, molecular spectra, experimental studies, Infra-red (IR) spectroscopy, ultraviolet (UV) spectroscopy. Pure rotational spectra-Salient features. The molecule as a rigid rotator, vibrational- rotational spectra- Salient features. The molecules as a harmonic oscillator. Raman spectra. Classical and Quantum theory of Raman effect. Electronic spectra. Franck-Conden Principle-Salient features. Observed intensity distribution in band system. Franck-Conden principle-Quantum mechanical formulation. Explanation of intensity distribution in absorption band and emission band. Conden parabola.

LASER: semiconductor laser. Carbon-dioxide laser. Nd: YAG laser. Properties and uses of laser.

References for Theory:

1. Introduction to Atomic Spectra, H. E. White.
2. Molecular Spectroscopy, Vol. 1 and 2, Herzberg
3. Atomic Spectra, H.G. Kuhn
4. Atomic Spectra by Raj kumar Jain.
5. Atomic Spectra by Gupta Kumar
6. Atomic Physics J.B. Rajam
7. Fundamentals of Molecular Spectroscopy- C.N. Banwell.
8. Laser theory and Applications. – THYAGARAJAN, GHATAK

PHY-AMJ-3-T. ADVANCED SOLID STATE PHYSICS (04 Credits)

COURSE OBJECTIVE

This course on Advanced Theoretical Physics-II aims to deepen understanding by integrating topics that have not been thoroughly covered in Condensed Matter Physics, Nuclear and Particle Physics. The Condensed Matter Physics section explores Transport Phenomena, Electronic Properties, Magnetism, Superconductivity, and Defects. The Nuclear and Particle Physics section addresses two-body problems, Nuclear β-Decay, Nuclear Reactions, and provides a basic understanding of Particle Physics.

COURSE LEARNING OUTCOMES

- Grasp the fundamentals of Boltzmann transport equation, relaxation time approximation, and Sommerfeld theory of electrical conductivity.

- Develop concepts related to electrons in a periodic lattice, free electron approximation, tight binding approximation, and Fermi surface topology.
- Learn about magnetic phenomena, including the Heisenberg model, spin waves, magnons and ferromagnetic domains.
- Understand superconductivity basics, including the BCS theory and Josephson effects.
- Gain knowledge about defects in crystals, liquid crystalline order, and quasi-crystals.

SKILLS TO BE LEARNED

- Gain insight into advanced topics like the De Haas-van Alphen Effect, superconductivity and magnetic domains.
- Solve the deuteron problem and understand the principles behind Nuclear β-Decay and other nuclear reactions.
- Obtain foundational knowledge of particle physics, including the classification of particles and the quark model.
- Will develop proficiency in experimental techniques such as four-probe conductivity measurements, X-ray diffraction, neutron-proton scattering, and superconductivity testing using a cryostat. Additionally, they will gain expertise in computational physics, implementing numerical simulations in Sci-lab and C++ to analyse quantum transport, phase transitions, spin dynamics and high-energy physics phenomena. These skills will enhance their ability to interpret experimental results, perform advanced simulations, and apply theoretical concepts to real-world systems in modern physics research.

COURSE CONTENT:

Bonding in Solids: Introduction, types of bonding, Ionic bonding (electrovalent bonding), properties of ionic bonding, covalent bonding, Heitler and London's theory of covalent bonding, Metallic bonding, properties of metallic bonding, van der Waal bonding, Hydrogen bonding Variation of interatomic force with inter atomic spacing. Cohesive energy of ionic crystals, Madelung constant, evaluation of Madelung constant, binding energy of inert gas crystals.

Theory of Semiconductors: Semiconductor, intrinsic and extrinsic semiconductors, effective mass of electron, drift velocity, mobility and conductivity of intrinsic semiconductors, electron

concentration of intrinsic semiconductor in the valence band, concentration of holes of intrinsic semiconductor in valence band. Fermi level. Electrical conductivity of intrinsic semiconductors, band gap, law of mass action, carrier concentration in N-type semiconductors, density of electrons in the conduction band, Hall effect, Hall co-efficient, measurement of Hall co-efficient, carrier concentration in P-type semiconductor, density of holes in the valence band of a P-type semiconductor.

Magnetic properties of solids: classification of magnetic materials, quantum approach, quantum numbers, origin of magnetic moment, orbital magnetic moment and spin angular momentum of electron. Quantum theory of diamagnetism, quantum theory of Para magnetism. Cooling by adiabatic demagnetization. Pauli's theory of Para magnetism. Domain theory of ferromagnetism. Antiferromagnetism.

Super Conductivity: introduction, general properties, effect of magnetic field, Meissner effect, Type-I and Type-II superconductors. Thermal properties, entropy, specific heat, London equation, penetration depth, comparison of type-I and type-II superconductor. The Ginzburg Landau theory. BCS- theory of superconductivity. BCS- ground state, occupation probability of the Cooper pair in the BCS ground state. Josephson effect, DC and AC Josephson effect. High temperature super conductor, SQUID (Superconducting Quantum Interference Device).

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley IndiaPvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
6. Elementary Solid State Physics, M. Ali Omar, 1999, Pearson India
7. Solid State Physics, M.A. Wahab, 2011, Narosa Publications
8. Solid State Physics, M.K. Mahan and P. Mahto, 2008, BhartiBhawan

RC -1 RESSEARCH PROPOSAL – PLANNING AND TECHNIQUES (04 Credits)

Instructions to Question Setters

Semester Internal Examination (SIE) -20Marks: The question paper will be divided into two groups: Group A and Group B. **Group A**: Group A is compulsory, which will contain two questions. Question No.1 will consist of five very short-answers type questions, each carrying 1 mark. All five questions are compulsory. Question No.2 will be the short-answer type of 5marks. This question is also compulsory. **Group B:** Contains two descriptive-type questions. Each carrying 10 marks. Candidates are required to answer only one question from this group.

End Semester Examination (ESE) - 50 **Marks:** The question paper will be divided into two groups: Group A and Group B. **Group A: (Compulsory):** Question 1: Five very short answer-type questions of 1 mark each. Questions 2 : Short answer-type questions, carrying 5marks.

Group B: Contains six descriptive-type questions, each carrying 10 marks. Candidates are required to answer any four questions from this group. Term Paper-25

Note: Question in the theory papers may have subdivisions.

COURSE OBJECTIVES

- To introduce students to the structure and components of research proposal.
- To train them in developing research objectives, questions, and methodologies.
- To provide skills in time and resource planning, budgeting, and ethical compliance.
- To prepare students to write and present professional research proposals.

COURSE OUTCOME

After completing the course, students will be able to:

- Understand the purpose and structure of a research proposal.
- Frame a feasible research problem and formulate objectives.
- Choose an appropriate research design and methodology.
- Plan research resources, time and budgets effectively.
- Write and present a research proposal suitable for academic or funding submission.

COURSE CONTENT

Introduction to Research Proposal

Research Proposals – Academic: Definition, purpose and types, Features of a Good Proposal: Clarity,

Feasibility, Innovation, Relevance. Stages of Proposal Development.

Research Problem, objectives and Questions

Identifying a Research Problem, Formulating Research Objectives, Hypothesis and Research Questions, Defining Scope and Limitations.

Proposal Structure and Methodology

Standard Components of a Proposal: Title, Abstract, Introduction, Literature Review, Objectives, Methodology, Expected outcomes, References. Research Design and Methods: Qualitative, Quantitative, Mixed Methods- Tools and Techniques of Data Collection.

Planning, Budgeting and Timeline

Time and Resource Planning: Gantt Chart, Activity Scheduling, Budgeting: Estimating Cost for Equipment, Travel, Contingency, Human Resources, Proposal Submission Process (UGC/MHRD/DBT/ICSSR formats).

Ethics and Writing Techniques

Research Ethics: Consent, Privacy, Confidentiality, Integrity, Plagiarism and Referencing (APA, MLA, Chicago) Language, Style and Formatting using Reference Managers: Zotero/ Mendeley Peer review and Revisions.

Proposal Presentation and Evaluation

Presentation Skills: Oral and Poster Formats, Evaluating Research Proposals: Rubrics (A set of Instructions) and Criteria Simulated Proposal Presentation and Peer Feedback.

Suggested Readings and Tools

1. Research Methodology: Methods and Techniques, C.R. Kothari and Gaurav Garg New Age International Published, 4th ed., 2019.
2. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kuma, Pearson Education, 5th ed., 2021.
3. Research Methodology: R. Panneerselvam, PHI Learning Pvt. Ltd., 2nd ed., 2014.
4. Research Methodology: Concepts and Cases, Deepak Chawla and Neena Sondhi, Vikas Publishing, 2nd ed., 2016.
5. Data Reduction and Error Analysis for the Physical Sciences, Philip R. Bevington and D. Keith Robinson, McGraw-Hill Education, 3rd ed., 2003.
6. How to Write and Publish a Scientific Paper, Robert A. Day and Barbara Gastel, Cambridge University Press,8th ed., 2016.
7. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W.

Creswell and J. David Creswell, SAGE Publication. 5th ed., 2018.

8. Technical Report Writing. Aditham Bhujanga Rao, PHI Learning Pvt. Ltd., 1st ed., 2012.
9. UGC Research Handbook, ICSSR/ ICMR Guidelines.

RC-2 REASEARCH INTERNSHIP & DISSERTATION/ THESIS (08 Credits)

This course will include laboratory work, practicums, field projects, survey analyses, or internship-based projects. Students must submit a comprehensive research report and defend their dissertation/ thesis.

The evaluation will consider the following:

- Project dissertation design
- Methodology and content depth
- Participation in an internship programme with a reputed organization
- Application of research techniques in data collection
- Data Analysis
- Report presentation
- Presentation style
- Results and discussion
- Future scope
- References

Marks distribution may be as follows or adjusted as appropriate:

- **Assessment of Project synopsis: 50 marks**
- **Assessment of Project Thesis: 100 marks**
- **Viva –voce: 50 marks**

PHYSICS-(AC & ELC)

Course Structure (AC & ELC)

Course Name		Full Marks	END SEM	INTERNAL
SEM I/SEM-II				
PHY-AC-1/2-T.	MECHANICS (03 Credits, 45 Lectures)	75	60	10+5
PHY-AC-1/2-P.	(PRACTICAL) (01credits)	25	25	00
SEM III/SEM-IV				
PHY-ELC-1/ELC-2-T.	ELECTRICITY & MAGNETISM (03 Credits, 45 Lectures)	75	60	10+5
PHY-ELC-1/ELC-2-P.	(PRACTICAL) (01credits)	25	25	00
SEM V/SEM-VI				
PHY-ELC-3/ELC-4-T.	THERMAL PHYSICS (03 Credits, 45 Lectures)	75	60	10+5
PHY-ELC-3/ELC-4-P.	(PRACTICAL) (01 credits)	25	25	00
SEM VII/SEM-VIII				
PHY-ELC-5/ELC-6-T.	WAVES & OPTICS (03 Credits, 45 Lectures)	75	60	10+5
PHY-ELC-5/ELC-6-P.	(PRACTICAL) (01 Credits)	25	25	00

SEMESTER – I/II

PHY-AC-1/AC-2-T: MECHANICS (03 Credits)

Course Objective

This course begins with the review of Vectors and Differential equations and ends with the Special Theory of Relativity. Students will also appreciate the Gravitation, Rotational Motion and Oscillations. The emphasis of this course is to enhance the basics of mechanics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in vectors, differential equations and mechanics.

Course Learning Outcomes

Upon completion of this course, students are expected to understand the following concepts which would help them to appreciate the application of the fundamental concepts to the analysis of simple, practical situations related to the real world:

- Understand the role of vectors and coordinate systems in Physics.
- Learn to solve Ordinary Differential Equations: First order, Second order Differential Equations with constant coefficients'
- Understand laws of motion and their application to various dynamical situations.
- Learn the concept of Inertial reference frames and Galilean transformations. Also, the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- Understand the analogy between translational and rotational dynamics, and application of both motions simultaneously in analyzing rolling with slipping.
- Understand variable mass system and dynamics of a system of particles.
- Able to write the expression for the moment of inertia about the given axis of symmetry for different uniform mass distributions.
- Understand the phenomena of elastic and in-elastic collisions
- Understand angular momentum of a system of particles.
- Apply Kepler's law to describe the motion of planets and satellites in circular orbit through the study of law of Gravitation.
- Understand concept of Geosynchronous orbits
- Explain the phenomenon of simple harmonic motion.
- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.
- In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, vernier Calipers, Travelling microscope). Student shall embark on verifying various principles learnt in theory. Measuring 'g' using Bar Pendulum,

Kater pendulum and measuring elastic constants of materials, viscous properties of liquids etc.

COURSE CONTENTS:

Vector Analysis: Triple Scalar product, Triple Vector product, gradient, divergence, Curl and their physical significance, scalar and vector fields, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem.

Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

Central force field: Motion of a particle in a central force field –two body problem. Kepler's Laws and their deduction.

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages.

Elasticity: Elastic constants and their interrelations, Poisson's ratio. Expression for Poisson's ratio in terms of elastic constants, Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder, Determination of Modulus of Rigidity by static torsion, Torsional pendulum.

Fluids: Surface Tension: Excess of pressure, Application to spherical and cylindrical drops and bubbles, variation of surface tension with temperature. Viscosity- Rate of flow of liquid in a capillary tube, Poiseuille's formula, Determination of co-efficient of viscosity of a liquid, Variations of viscosity of liquid with temperature.

Special Theory of Relativity: Galilean transformations. Postulates of Special Theory of Relativity. Lorentz transformation, Length contraction. Time dilation. Relativistic addition of velocities.

Reference Books:

1. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley.
2. Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
3. Physics – Resnick, Halliday& Walker 9/e, 2010, Wiley
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

PHY-AC-1/AC-2-P. PRACTICAL (01 credits)

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Young's Modulus of a Wire by Optical Lever Method.
3. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.

4. To determine the Elastic Constants of a Wire by Searle's method.
5. To determine g by Bar Pendulum.
6. To determine g by Kater's Pendulum.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Textbook of Practical Physics, InduPrakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

SEMESTER – III/IV

PHY-ELC-1/ELC-2-T. ELECTRICITY & MAGNETISM (03 Credits)

Course Objective

This course begins with elementary vector analysis, an essential mathematical tool for understanding static electric field and magnetic field. By the end of the course student should appreciate Maxwell's equations.

Course Learning Outcomes:

At the end of this course, students will be able to

- Demonstrate Gauss law, Coulomb's law for the electric field, and apply it to systems of point charges as well as line, surface and volume distributions of charges.
- Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.
- Demonstrate a working understanding of capacitors.
- Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)
- Have brief idea of dia- para- and ferro-magnetic materials

- Understand the concepts of induction and self-induction, to solve problems using Faraday's and Lenz's laws.
- Have an introduction to Maxwell's equations.

COURSE CONTENTS:

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Polarization, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro- magnetic materials.

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves.

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. Electricity & Magnetism, J.H. Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

PHY-ELC-1/ELC-2-P. PRACTICAL (01 Credits)

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.

2. To compare capacitances using De Sauty's bridge.
3. To study the Characteristics of a Series RC Circuit.
4. To study a series LCR circuit and determine its (a) Resonant frequency, (b) Quality factor.
5. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
6. To determine a Low Resistance by Carey Foster's Bridge.

Reference Books

1. Advanced Practical Physics for students, B.L.Flint&H.T.Worsnop, 1971, Asia Publishing House.
2. A Textbook of Practical Physics, I.Prakash& Ramakrishna, 11th Ed.2011, KitabMahal

SEMESTER – V/VI

PHY-ELC-3/ELC-4-T. THERMAL PHYSICS (03 Credits)

This course will introduce Thermodynamics and Kinetic theory of gases to the students. The primary goal is to understand the fundamental laws of thermodynamics and it's applications to various thermodynamical systems and processes.

Course Learning Outcomes

At the end of this course, students will

- Learn the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations. They are also expected to learn Maxwell's thermodynamic relations.
- Know the fundamentals of the kinetic theory of gases, Maxwell-Boltzmann distribution law, equipartition of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
- Learn about the black body radiation, Stefan- Boltzmann's law, Rayleigh-Jeans law and Planck's law and their significances.
- In the laboratory course, the students are expected to: Measure the Planck's constant using black body radiation, determine Stefan's Constant, co-efficient of thermal conductivity of a

bad conductor and a good conductor, determine the temperature co-efficient of resistance, study variation of thermo emf across two junctions of a thermocouple with temperature etc.

COURCE CONTENTS:

Laws of Thermodynamics: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics (statement only), Unattainability of absolute zero

Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for $(C_P - C_V)$, TdS equations.

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path, Transport Phenomena: Viscosity, Conduction and Diffusion, Law of equipartition of energy and its applications to specific heat of gases; mono-atomic and diatomic gases.

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction from Planck's law: Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law.

Statistical Mechanics: Maxwell-Boltzmann law, distribution of velocity, Quantum statistics: Phase space - Fermi-Dirac distribution law, electron gas, Bose-Einstein distribution law, photon gas, comparison of three statistics.

Reference Books:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W. Sears and G.L. Salinger. 1988, Narosa
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

PHY-ELC-3/ELC-4-P. PRACTICAL (01 Credits)

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

Reference Books:

1. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
2. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

SEMESTER – VII/VIII

PHY-ELC-5/ELC-6-T. WAVES & OPTICS (03 Credits)

Course Objective

Physics and mathematics of wave motion underlie many important phenomena. The water wave on the sea, the vibration of a violin string, etc. can all be described in a similar way. Light too, often displays properties that are wave-like. The course is aimed at equipping the students with the general treatment of waves. This begins with explaining ideas of oscillations and simple harmonic motion and go on to look at the physics of travelling and standing wav This understanding applies to have a more elaborate analysis for sound waves and this further considers a numb of phenomena in which the wave properties of light are important such as interference, diffraction, and polarization with emphasis of examples as seen in daily life.

Course Learning Outcomes

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

- Understand Simple harmonic oscillation and superposition principle.
- Understand superposition of a range of collinear and mutually perpendicular simple harmonic motion and their applications.
- Understand the importance of classical wave equation in transverse and longitudinal waves and solving a range of physical systems on its basis.
- Understand different types of waves and their velocities: Plane, Spherical, Transverse, Longitudinal.
- Understand Concept of normal modes in transverse and longitudinal waves: their frequencies and configurations
- Understand the concept of temporal and spatial coherence.
- Understand Interference as superposition of waves from coherent sources derived from same parent source
- Demonstrate understanding of Interference experiments: Young's Double Slit, Fresnel's biprism, Llyod's Mirror, Newton's Rings.
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from apertures
- Understand Fraunhoffer Diffraction from a slit.
- In the laboratory course, students will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt first hand.
- The motion of coupled oscillators, study of Lissajous figures and behavior of transverse, longitudinal waves can be learnt in this laboratory course

COURSE CONTENTS:

Superposition of Two Collinear Harmonic oscillations: Linearity & Superposition Principle. (1) Oscillations having equal frequencies. (2) Oscillations having different frequencies (Beats).

Waves Motion: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity.

Sound: Forced vibrations and resonance, Fourier's Theorem - Application to saw tooth wave and square wave, Acoustics of buildings, Reverberation and time of reverberation - Absorption

coefficient, Sabine's formula.

Interference: Interference: Division of amplitude and division of wavefront. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

Michelson's Interferometer: (1) Idea of formation of fringes (no theory needed), (2) Determination of wavelength, (3) Wavelength difference, (4) Refractive index, and (5) Visibility of fringes.

Diffraction: Fraunhofer diffraction- Single slit, Double Slit. Plane Diffraction grating.
Fresnel Diffraction- Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

Reference Books:

1. Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing
3. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
4. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley.

PHY-ELC-5/ELC-6-P. PRACTICAL (01 Credits)

1. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ^2–n(frequency) Law.
2. To determine Dispersive Power of the Material of a Prism using Mercury Light
3. To determine the Resolving Power of a Prism.
4. To determine wavelength of sodium light using Fresnel Biprism
5. To determine wavelength of sodium light using Newton's Ring.
6. To determine the wavelength of Laser light using Diffraction of Single Slit.
7. To determine wavelength of (1) Sodium light (2) Spectral lines of the Mercury light using plane diffraction Grating
8. To determine the Resolving Power of a Plane Diffraction Grating.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House.