# SYLLABUS

Four Year Under Graduate Programme (FYUGP)

As per provisions of NEP-2020

SUBJECT: **PHYSICS (MJ/MN/MDC)**

To be implemented from the Academic Year 2023-24

(FROM SESSION 2023-27)

VINOBA BHAVE UNIVERSITY HAZARIBAG

# Vinoba Bhave University, Hazaribag

## B. Sc. HONOURS IN PHYSICS (under FYUGP) w.e.f. 2023-2027

## Course Structure (MAJOR)

| Course Name | | Full Marks |
|---|---|---|
| **SEM I** | | |
| PHY-MJ-1. | MATHEMATICAL PHYSICS & MECHANICS (04 Credits, 60 Lectures) | 100[75E+25I] |
| | | |
| **SEM II** | | |
| PHY-MJ-2. | ELECTRICITY AND MAGNETISM (04 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-3. | PRACTICAL (04 Credits) | 100E |
| | | |
| **SEM III** | | |
| PHY-MJ-4. | WAVES AND OPTICS(04Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-5. | PRACTICAL (4 Credits) | 100E |
| | | |
| **SEM IV** | | |
| PHY-MJ-6. | MATHEMATICAL PHYSICS (04 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-7 | THERMAL PHYSICS (04 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-8 | PRACTICAL (04 Credits) | 100E |
| | | |
| **SEM V** | | |
| PHY-MJ-9 | ANALOG AND DIGITAL ELECTRONICS (4 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-10 | ELEMENTS OF MODERN PHYSICS (04 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-11 | (PRACTICAL) (04 Credits) | 100E |
| | | |
| **SEM VI** | | |
| PHY-MJ-12 | QUANTUM MECHANICS AND APPLICATION (04 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-13 | SOLID STATE PHYSICS (04 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-14 | ELECTROMAGNETIC THEORY (04 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-15 | (PRACTICAL) (04 Credits) | 100E |
| | | |
| **SEM-VII** | | |
| PHY-MJ-16 | NUCLEAR AND PARTICLE PHYSICS (04 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-17 | CLASSICAL DYNAMICS (04 Credits, 60 Lectures) | 100[75E+25I] |

| | | |
|---|---|---|
| PHY-MJ-18 | PHYSICS OF DEVICES AND INSTRUMENT (04 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-MJ-19 | PRACTICAL (04 Credits) | 100E |
| | | |
| **SEM-VIII** | | |
| PHY-MJ-20 | STATISTICAL MECHANICS (4 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-AMJ-1 | ADVANCED QUANTUM MECHANICS (4 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-AMJ-2 | ATOMIC PHYSICS AND SPECTROSCOPY (4 Credits, 60 Lectures) | 100[75E+25I] |
| PHY-AMJ-3 | PRACTICAL (4 Credits) | 100E |

## Course Structure (MINOR)

| Course Name | | Full Marks |
|---|---|---|
| **SEM- I** | | |
| PHY-MN-1A | MECHANICS (04 Credits, 60 Lectures) | 100[75(60E+15I)+25P] |
| **SEM - III** | | |
| PHY-MN-1B | ELECTRICITY AND MAGNETISM (04 Credits, 60 Lectures) | 100[75(60+15)+25] |
| **SEM -V** | | |
| PHY-MN-1C | THERMAL PHYSICS (4 Credits, 60 Lectures) | 100[75(60+15)+25] |
| **SEM - VII** | | |
| PHY-MN-1D | WAVES AND OPTICS (4 Credits, 60 Lectures) | 100[75(60+15)+25] |

## Course Structure (MDC)

| Course Name | | Full Marks |
|---|---|---|
| **SEM- I/II/III** | | |
| PHY-MDC | MECHANICS, ELECTRICITY AND MAGNETISM, WAVE AND OPTICS, Modern Physics (3 Credits, 45 Lectures) | 75E |

**MAJOR PAPERS**:

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

**Instruction to Question Setter for SemesterInternal 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 group 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 shortanswer 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 group 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 5marks each. Group B will contain descriptive type six questions of fifteen marks each, out of which any four are to be answered.

**MINOR 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 SemesterInternal 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 group 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 group 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 5marks each. Group B will contain descriptive type five questions of fifteen 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 (1) = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

**Marks : Pr (ESE: 3Hrs) =100** Pass Marks: Pr (ESE) = 40

**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 (1) = 60 marks
Practical record notebook = 20 marks
Viva-voce = 20 marks

## SYLLABUS

## MAJOR COURSES (HONOURS IN PHYSICS)

## SEMESTER-I

### PHY-MJ-1.: MATHEMATICAL PHYSICS & MECHANICS

### (04 Credits, 60 Lectures)

***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. 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. He / she will learn the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- 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.
- 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.
- Learn the concepts of elastic in constant of solids and viscosity of fluids.
- Develop skills to understand and solve the equations central force problem.
- Acquire basic knowledge of oscillation. 6. About inertial and non-inertial systems and special theory of relativity

## COURSE CONTENT:

**Vector Calculus**: Vector triple product, Scalar triple product and their interpretation in terms of area and volume respectively.Scalar and Vector fields. **(3 Lectures)**

**Vector Differentiation**: Directional derivatives and normal derivative.Gradient of a scalar field and its geometrical interpretation.Divergence and curl of a vector field.Del and Laplacian operators.Vector identities. Expression for divergence and curl in cartesian coordinate. **(6 Lectures)**

**Vector Integration**: Ordinary Integrals of Vectors. Multiple integrals, Jacobian.Notion of infinitesimal line, surface and volume elements.Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications.**(9 Lectures)**

**Orthogonal Curvilinear Coordinates:** Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(4Lectures)**

**Elasticity**: Relation between Elastic constants. Twisting torque on a Cylinder or Wire, Bending moment, Cantiliver, beam supported at the end and loaded at middle and its application to determine young's modulus, Searle'e experiments. **(10 Lectures)**

**Fluid Motion**: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube, Mayer's equations, Rankine methods for measurement of viscosity of gas. **(8 Lectures)**

**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. **(10 Lectures)**

**Special Theory of Relativity**: Michelson-Morley Experiment and its outcome. Postulates of SpecialTheory of Relativity.Lorentz Transformations.Simultaneity and order of events.Length contraction.Time dilation.Relativistic addition of velocities.Variation of mass with velocity.Mass- energy Equivalence.Relativistic Doppler effect. **(10 Lectures)**

**Reference Books**:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
3. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
4. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning

5. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
6. Essential Mathematical Methods, K.F.Riley&M.P.Hobson, 2011, Cambridge Univ. Press
7. Mathematical Physics - H K Das
8. Mathematical Physics - B D Gupta
9. Mathematical Physics - B S Rajput
10. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
11. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
12. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
13. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
14. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
15. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
16. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
17. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

## SEMESTER-II

## PHY-MJ-2.: ELECTRICITY AND MAGNETISM

## (04 Credits, 60 Lectures)

**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.
- Describe the magnetic field produced by magnetic dipoles and electric currents.
- Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electric and magnetic fields.
- Understand the dielectric properties, magnetic properties of materials and the phenomena of electromagnetic induction.
- Describe how magnetism is produced and list examples where its effects are observed.
- 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 and magnetism such as Lenz's law, Faraday's law and 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 magnetism and their applications.
- Basic course in electrostatics will equips the student with required prerequisites to understand electrodynamics phenomena.
- Derive expression for a) Energy density, b) Momentum density, c) Angular momentum density of the electromagnetic field.

## Course Content:

**Electric Field and Electric Potential:** Conservative nature of Electrostatic Field.Electrostatic Potential.Laplace's and Poisson equations. Solution of Laplace's equation in Cartesian co-ordinates, Application of Laplaces equation,parallel plate capcity 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. **(10 Lectures)**

**Dielectric Properties of Matter**: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. **(5 Lectures)**

**Transients:-** Growth and decay of current in L-R circuit, Charging and discharging of capacitor in R-C, & L-C-R circuits. Time constant. **(5 Lectures)**

**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**.(10 Lectures)**

**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**. (4 Lectures)**

**A.C. bridge**:- Anderson's bridge, De- Sauty's bridge and Owen's bridge and their vector diagram representation. **(3 Lectures)**

**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 on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. **(10 Lectures)**

**Magnetic Properties of Matter**: Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, 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. **(10 Lectures)**

**Ballistic Galvanometer**: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. **(3 Lectures)**

**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 -3PRACTICAL:

## PRACTICALS:

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 study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self- inductance of a coil by Anderson's bridge.
9. 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.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
11. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer

**Reference Books**:


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

6. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
7. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
8. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

## SEMESTER-III

### PHY-MJ-4- WAVES AND OPTICS

### (04 Credits, 60 Lectures)

### 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.
- Understand the working of selected optical instruments like biprism, interferometer, and diffraction grating.
- In the laboratory course, student 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 firsthand.

**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.
- This course in basics of optics will enable the student to understand various optical phenomena, principles, workings and applications optical instruments.

## Course Content:

**Wave Motion**: Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Particle and Wave Velocities. Wave Equation, Differential Equation and its solution. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Relation between maximum pressure and intensity of wave. Theories of free, damped and forced vibration. Resonance, sharpness of resonance and quality factor. **(7 Lectures)**

**Velocity of Waves**: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.**(6 Lectures)**

**Superposition of Two Harmonic Waves**: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Longitudinal Standing Waves and Normal Modes. **(7 Lectures)**

**Acoustic of Building**: Reverberation of time, growth and decay of sound, Sabine's formula. **(5 Lectures)**

**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). Newton's Rings: Measurement of wavelength and refractive index. **(9 Lectures)**

**Interferometer:** Michelson Interferometer-(1) Idea of form of fringes,(2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5)Visibility of Fringes. Fabry-Perot interferometer, Determination of Wavelength. **(4 Lectures)**

**Fraunhofer diffraction**: Single slit, double slit. Multiple slits Diffraction grating. Circular aperture. **(8 Lectures)**

**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**. (5 Lectures)**

**Resolving power:** Rayleigh's criteria for limit of resolution, resolving power of Telescope and grating. **(2 Lectures)**

**Polarization:** Concept of polarization of light, theory of linear, circular and elliptical polarized light. Production and detection of plane, circularly and elliptically polarized light, double refraction, ordinary and extra ordinary ray, uniaxial and biaxial crystal, Nicol prism, Babinet compensator, rotatory polarization, Biot's law for rotatory polarization- Fresnel explanation, polarimeter-Introduction. Phase retardation plates, quarter wave and half wave plates**. (7 Lectures)**

**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. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1/e, 2021,Wiley/I. K. International Publishing House, New Delhi
8. Electromagnetic Theory, Chopra & Agarwal, Kedarnath Ramnath & Co.


**PHY- MJ 5-PRACTICAL**

**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 and Cauchy constants of the material of a prism usingmercury source.
4. To determine wavelength of sodium light using Fresnel Biprism.
5. To determine wavelength of sodium light using Newton’s Rings.
6. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using planediffraction grating.
7. To determine dispersive power and resolving power of a plane diffraction grating.
8. To verify the law of Malus for plane polarized light.
9. To determine the specific rotation of sugar solution using Polarimeter.

**Reference Books**:


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

# SEMESTER-IV

## PHY-MJ-6.: MATHEMATICAL PHYSICS

**(04 Credits, 60 Lectures)**

**Course Learning Outcomes:**

- Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
- Learn about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations and their applications in various physical problems such as in quantum mechanics which they will learn in future courses in detail.
- Learn the beta, gamma and the error functions and their applications in doing integrations.
- 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.
- He / she shall develop an understanding of how to model a given physical phenomenon such as pendulum motion, rocket motion, stretched string, etc., into set of ODE's, PDE's and solve them.
- 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 system/s.

**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'sInequality.Cauchy's Integral formula.**(10 Lectures)**

**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. **(15 Lectures)**

**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.
**(10 Lectures)**

**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.Isomorphisms.Inner product and Norm. Inner product of functions: the weight function. Triangle and Cauchy Schwartz Inequalities. **(10 Lectures)**

**Laplace Transforms**: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. Dirac Delta function, Periodic Functions.Convolution Theorem.
**(10 Lectures)**

**Beta and Gamma function**: Beta and Gamma function, relation between them and their properties. Expression of integrals in terms of Gamma function. **(5 Lectures)**

**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. Das
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-**7.: THERMAL PHYSICS**

**(04 Credits, 60 Lectures)**

## 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-Boltzman 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

## Course Content:

**Introduction to Thermodynamics Zeroth and First Law of Thermodynamics**: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, 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. **(7 Lectures)**

**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, $2^{nd}$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. **(8 Lectures)**

**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.Entropy Changes in Reversible and Irreversible Processes.Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics.Unattainability of Absolute Zero. **(8 Lectures)**

**Thermodynamic Potentials**: Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications.Surface Films and Variation of Surface Tension with Temperature. Concept of cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, ClausiusClapeyron Equation and Ehrenfest equations. **(10 Lectures)**

**Maxwell's Thermodynamic Relations**: Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) ClausiusClapeyron equation, (2) Values of Cp-Cv, (3) Tds Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. **(7 Lectures)**

**Kinetic Theory of Gases Distribution of Velocities**: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment.Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy, Specific heats of Gases. **(7 Lectures)**

**Molecular Collisions**: Mean Free Path. Collision Probability.Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. **(5 Lectures)**

**Real Gases:** Behavior of Real Gases: Deviations from the Ideal Gas Equation. Andrew's Experiments on $CO_2$ Gas. Critical Constants.Continuity of Liquid and Gaseous State.Vapour and Gas.Boyle Temperature. Van der Waal's Equation of State for Real Gases. From Virial theorem Values of Critical Constants. Law of Corresponding States.Comparison with Experimental Curves.p-V Diagrams. Joule's Experiment.Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment.Joule- Thomson Effect for Real and Van der Waal Gases.Temperature of Inversion.Joule- Thomson Cooling. **(8 Lectures)**

**Reference Books:**

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, MeghnadSaha, 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 (PRACTICAL)**

**PRACTICALS:**

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's disc method.
3. To determine the Temperature Coefficient of Resistance byPlatinum Resistance Thermometer (PRT).
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
5. To study the variation of Thermo-emf of a Thermocouple with Difference ofTemperature of its Two Junctions using a null method. And also calibrate theThermocouple in a specified temperature range.
6. To calibrate a thermocouple to measure temperature in a specified Range using Op-Amp difference amplifier and to determine Neutral Temperature.

**Reference Books**:


1. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal,1985, Vani Pub.
2. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. Elementary Numerical Analysis, K.E.Atkinson, 3 r d E d n . 2 0 0 7, Wiley India Edition
6. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
7. Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
8. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
9. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
10. Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.

## SEMESTER-V

PHY-MJ-**9.: ANALOG AND DIGITAL ELECTRONICS**

**(04 Credits, 60 Lectures)**

### 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 a insight into circuits using discrete components and also to learn about integrated circuits.
- About analog systems and digital systems and their differences, fundamental logic gates, combinational as well as sequential and number systems.
- Synthesis of Boolean functions, simplification and construction of digital circuits by employing Boolean algebra.
- Sequential systems by choosing Flip-Flop as a building bock- construct multivibrators, counters to provide a basic idea about memory including RAM, ROM and also about memory organization.
- In the laboratory he is expected to construct both combinational circuits and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Shift Registers, and multivibrators using 555 ICs. He is also expected to use μP 8085 to demonstrate the same simple programme using assembly language and execute the programme using a μP kit. At the end of the course the student is expected to assimilate the following and possesses basic knowledge of the following.
- N- and P- type semiconductors, mobility, drift velocity, fabrication of P-N junctions; forward and reverse biased junctions.
- Application of PN junction for different type 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.
- Operational amplifiers and knowledge about different configurations namely inverting and non- inverting and applications of operational amplifiers in D to A and A to D conversions.
- To characterize various devices namely PN junction diodes, LEDs, Zener diode, solar cells, PNP and NPN transistors. Also construct amplifiers and oscillators using discrete components. Demonstrate inverting and non-inverting amplifiers using op-amps.

**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 transistor 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.Static and Dynamic Resistance.Current equation Mechanism in Forward and Reverse Biased Diode.Derivation for Barrier Potential, Barrier Width and Current for Step Junction. **(6 Lectures)**

**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. **(5 Lectures)**

**Bipolar Junction transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains $\alpha$ and $\beta$ and Relations between $\alpha$ and $\beta$. Load Line analysis of Transistors.DC Load line and Q-point.Physical Mechanism of Current Flow.Active, Cutoff and Saturation Regions. **(6 Lectures)**

**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. **(7 Lectures)**

**Coupled Amplifier:** RC-coupled amplifier and its frequency response. **(4 Lectures)**

**Feedback in Amplifiers:** Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(4 Lectures)**

**Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency.Hartley&Colpitts oscillators. **(5 Lectures)**

**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 application as Parity Checkers. **(8 Lectures)**

**Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products.Idea of Minterms and Maxterms.Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.**(5 Lectures)**

**Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2's Complement.Half and Full Adders.Half& Full Subtractors, 4-bit binary Adder/Subtractor.**(5 Lectures)**

**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. **(5 Lectures)**

**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, Tata Mc-Graw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
6. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
7. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
8. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
9. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
10. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
11. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
12. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
13. Logic circuit design, Shimon P. Vingron, 2012, Springer.
14. Digital Electronics, SubrataGhoshal, 2012, Cengage Learning.
15. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

## PHY-MJ-10.: ELEMENTS OF MODERN PHYSICS (QUANTUM THEORY, NUCLEAR PHYSICS AND LASER )

**(04 Credits, 60 Lectures)**

### 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. Electron positron pair creation.
- 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.
- 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 determine the 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 (iii)Laser Physics
- Learn to apply basic quantum physics to Ruby Laser, He-Ne Laser

## Course Content:

## OLD 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-Germerexperiment.Wave description of particles by wave packets.Group and Phase velocities and relation between them. **(10 Lectures)**

**SCHRODINGER FORMULATION**

Wave-particle duality, Heisenberg uncertainty principle- (Derivation from Wave Packets) and its simple application. **(5 Lectures)**

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 densities in one dimension.**(10 Lectures)**

**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, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy. **(6 Lectures)**

**Radioactivity:** stability of the nucleus; Law of radioactive decay; Mean life and half-life, successive disintegration; Elementary idea of Alpha decay; Beta decay.**(6 Lectures)**

Fission and fusion- mass defect, and generation of energy; Fission - nature of fragments and emission of neutrons. **(6 Lectures)**

**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 eqution. Ruby Laser and He-Ne Laser.**(17 Lectures)**

**Reference Books:**


1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich 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**

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


## PHY-MJ-11: PRACTICAL(4 Credits)

## PRACTICALS:

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 wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To determine the wavelength of laser source using diffraction of single slit.
10. To determine the wavelength of laser source using diffraction of double slits.
11. To determine (1) wavelength and (2) angular spread of He-Ne laser by plane diffraction grating
12. Verification of truth tables of basic logic gates.
13. To study the characteristics of a Bipolar Junction Transistor in CE & CB configuration.
14. Half Adder, Full Adder and 4-bit binary Adder.
15. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
16. To verify and design AND, OR, NOT and XOR gates using NAND gates.

**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 Edn, 2011,Kitab Mahal

## SEMESTER-VI

### PHY-MJ-12.: QUANTUM MECHANICS AND APPLICATIONS

### (04 Credits, 60 Lectures)

**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.
- Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.
- The experiments using Sci-lab will enable the student to appreciate nuances involved in the theory.
- This basic course will form a firm basis to understand quantum many body problems.
- In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one-dimensional and three-dimensional potentials.

**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, hydrogen atom in electric fields.
- 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; General solution of the time independent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension.**(10 Lectures)**

**Time dependent Schrodinger equation**: Time dependent Schrodinger equation and dynamical evolution of a quantum state; 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. **(15 Lectures)**

**Operators:** Postulates of quantum mechanics, Position, momentum, Hamitonian,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**. (10 Lectures)**

**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 oscilator . **(15 Lectures)**

**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. **(10 Lectures)**

**Reference Books:**


1. **A Text book 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


**Additional Books for Reference:**


8. Quantum Mechanics, EugenMerzbacher, 2004, John Wiley and Sons, Inc.
9. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
10. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

## PHY-MJ-13: SOLID STATE PHYSICS

## (04 Credits, 60 Lectures)

**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 of knowledge of Einstein and Debye theory of specific heat of solids.
- At knowledge of different types of magnetism from diamagnetism to ferromagnetism and hysteresis loops and energy loss.
- Secured an understanding about the dielectric and ferroelectric a. properties of materials.
- Understanding above the band theory of solids and must be able to differentiate insulators, conductors and semiconductors.
- Understand the basic idea about superconductors and their classifications.
- To carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. 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, semiconductor 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.Miller Indices.Reciprocal Lattice.Types of Lattices.Brillouin Zones. Diffraction of X-rays by Crystals.Bragg's Law.**(14 Lectures)**

**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

**(16 Lectures)**

**Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom.Depolarization Field.Electric Susceptibility.Polarizability. Clausius-Mosotti Equation. Classical Theory of Electric Polarizability. Langevin-Debye equation.**(8 Lectures)**

**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 electrons, free electron gas in one dimensional box, Fermi level, Fermi energy.

**(6 Lectures)**

**Elementary band theory:** Periodic potential and Bloch theorem**,** Kronig Penny model. Band Gap.Conductor, Semiconductor (P and N type) and insulator.Conductivity of Semiconductor, mobility, Hall Effect & Hall coefficient. **(10 Lectures)**

**Super conductivity:** General properties of super conductors, effect of magnetic fields. Meissner effect. Type-I and type:- II super conductors. BCS theory of superconductivity. Properties of high temperature super conductors, applications of superconductors**. (6 Lectures)**

**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, 1/e 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

**PHY-MJ-14:ELECTROMAGNETIC THEORY**

**(04 Credits, 60 Lectures)**

**Course learning outcome**:

- Achieve an understanding of the 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 andtransmission coefficients at plane interface in bounded media.
- Understand the linear, circular and elliptical polarisations of em waves. Production as well as detection of waves in laboratory.
- Understand propagation of em waves in anisotropic media, uni-axial and biaxial crystals phase retardation plates and their uses.
- Understand the concept of optical rotation, theories of optical rotation and their experimental rotation, calculation of angle rotation and specific rotation.
- Understand the features of planar optical wave guide and obtain the Electric field components, Eigen value equations, phase and group velocities in a dielectric wave guide.
- Understand the fundamentals of propagation of electromagnetic waves through optical fibres and calculate numerical apertures for step and graded indices and transmission losses.
- 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.
- Demonstrate interference, Refraction and Diffraction using microwaves.
- Determine the refractive index of glass and liquid using total internal reflection of light. Verify the laws of Polarisation for plane polarised light.
- Determine Polarisation of light by Reflection and determine the polarization angle off or air-glass surface
- Determine the wavelength and velocity of Ultrasonic waves in liquids using diffraction.

- Study specific rotation of sugar using Polarimeter.
- Analyze experimentally the Elliptically Polarised light using Babinet's Compensator
- Study Experimentally the angle dependence of radiation for a simple dipole antenna Plan and Execute 2-3 group projects for designing new experiments based on the Syllabii.

**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
- Learn the basic physics associated with the polarization of electromagnetic waves by doing various experiments for: (i) Plane polarized light (ii) Circularly polarized light (iii) Circularly polarized light
- Learn the application of EM theory to (i) Wave guides of various types (ii) Optical fibers in theory and experiment

## COURSE CONTENTS:

**Maxwell Equations:** Derivation of Maxwell's equations. Displacement Current.Boundary Conditions at Interface between Different Media.Wave Equations.Plane Waves in Dielectric Media.Poynting Theorem and Poynting Vector. **(12 Lectures)**

**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, relaxation time, skin depth.

**(12 Lectures)**

**EM Wave in Bounded Media:** Boundary conditions at a plane interface between two 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.

**(12 Lectures)**

**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. **(12 Lectures)**

**Relativistics electrodynamics:** Review 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.**Covarience of Maxwell equations in terms of 4-vectors, Covarience of Maxwell equations in 4-tensor forms., **(12 Lectures)**

<u>**Reference Books**</u>**:**

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

<u>**Additional Books for Reference:**</u>

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

## PHY-MJ**-15: PRACTICAL.**

**PRACTICALS**:

1. To study V-I characteristics of PN junction diode, and verification of diode equation.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To design a digital to analog converter (DAC) of given specifications.
7. To study the analog to digital convertor (ADC) IC.
8. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
9. To design inverting amplifier using Op-amp (741,351) and study its frequency response

10. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
11. To add two dc voltages using Op-amp in inverting and non-inverting mode
12. To investigate the use of an op-amp as an Integrator.
13. To design a NOT gate switch using a transistor.
14. To design an astablemultivibrator of given specifications using 555 Timer.
15. To determined the hall coefficient of a semi conductor sample.
16. To verify the law of molus for plan polarized light.
17. To study the polarization of light by reflication and determined the polarizing angle for air –glass interface.

**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.

6. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.

7. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

8. Electronic Devices & circuit Theory, R.L. Boylestad& L.D. Nashelsky, 2009, Pearson

## SEMESTER-VII

### PHY-MJ-16.: NUCLEAR & PARTICLE PHYICS

### (04 Credits, 60 Lectures)

**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.
- Know about the nuclear models and their roles in explaining the ground state properties of the nucleus–(i) the liquid drop model, its justification so far as the nuclear properties are concerned, the semiempirical mass formula, (ii) the shell model, evidence of shell structure, magic numbers, predictions of ground state spin and parity, theoretical deduction of the shell structure, consistency of the shell structure with the Pauli exclusion principles.
- 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.
- Learn some basic aspects of interaction of nuclear radiation with matter- interaction of gamma ray by photoelectric effect, Compton scattering and pair production, energy loss due to ionization, Cerenkov radiation.
- The students are expected to learn about the principles and basic constructions of particle accelerators such as the Van-de-Graff generator, cyclotron, 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 decay, β decay 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. **(12 Lectures)**

**Two nucleon system**: Deuteron problem, binding energy. **(3 Lectures)**

**Nuclear detectors:** Detectors for charged particles; ion chamber, GM counter, resolving time, cloud chamber and bubble chamber. **(10 Lectures)**

**Accelerator:** Need for accelerators, linear accelerators, cyclotron, synchrocyclotron. **(10 Lectures)**

**Radioactivity:** α decay: basics of α decay processes, Geiger-Nuttal Law, Gamow's theory of α decay, introductory idea of $\beta$-decay: energy kinematics for $\beta$-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Introductory idea. **(10 Lectures)**

**Nuclear reactions:** Rutherford's experiments of nuclear transmutation, conservation theorems, Q-value, threshold energy, cross-section of nuclear reactions. **(5 Lectures)**

**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. **(10 Lectures)**

**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

K. Heyde (IOP- Institute of Physics Publishing, 2004).
8. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
9. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
10. Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

## PHY-MJ-17.: CLASSICAL DYNAMICS

## (04 Credits, 60 Lectures)

**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, LienardWiechert 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 generalised coordinates, generalised velocities, generalised force and write Lagrangianfor mechanical system in terms of generalised 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 ofmotion for simple mechanical systems.
- Formulate the problem of small amplitude oscillation and solve them to obtain normal modes ofoscillation and their frequencies in simple mechanical systems.
- Develop the basic concepts of special theory of relativity and its applications to dynamical systems ofparticles.
- Develop the methods of relativistic kinematics of one and two particle system and its application totwo particle decay and scattering.

**Course Content**:

**Classical mechanics of a particle and system of particles**:Generalised co-ordinate, Generalised displacement, generalized velocity, generalized acceleration, generalized momentum, generalized force, generalized potential, **(5 Lectures)**

**Langrangian 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. **(14 Lectures)**

**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, **(14 Lectures)**

**Motion under central force**: two body problems, Kepler's law and derivation. **(4 Lectures)**

**Rigid body dynamics:** Eulerian angles and Eulerian equation of motion, theory of spinning top. **(4 Lectures)**

**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 relation.Lagrangian formulation of relativistic mechanics. Hamiltonian formulation of relativistic mechanics. **(19 Lectures)**

**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. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
6. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
7. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

## PHY-MJ-18.: PHYSICS OF DEVICES & INSTRUMENT

## (04 Credits, 60 Lectures)

**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. **(14 Lectures)**

**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, inverving and non-inverting amplifiers, adder, subtractor, differentiator, integrator.

**(12 Lectures)**

Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters. **(10 Lectures)**

**Multivibrators:** Astable and Monostable Multivibrators using transistors. **(6 Lectures)**

**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. Sideband 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. **(18 lectures)**

**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-19: PRACTICAL

**PRACTICALS**:

1. Estimate the energy gap of a semiconductor using a PN junction.
2. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
3. To measure the Magnetic susceptibility of Solids.
4. To determine the Coupling Coefficient of a Piezoelectric crystal.
5. To measure the Dielectric Constant of a dielectric Materials with frequency
6. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
7. To determine the refractive index of a dielectric layer using SPR
8. To study the PE Hysteresis loop of a Ferroelectric Crystal.
9. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
10. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 oC) and to determine its band gap.
11. To determine the Hall coefficient of a semiconductor sample.
12. To design a precision Differential amplifier of given I/O specification using Op-amp
13. To investigate the use of an op-amp as an Integrator
14. To investigate the use of an op-amp as a Differentiator
15. To design a circuit to simulate the solution of simultaneous equation and 1st/2ndorder differential equation.
16. To design the active low pass and high pass filters of given specification.

17. To study the out put and tranfer charcteristics of a JFET.
18. To study the output characteristics of a MOSFET.
19. To show the tunneling effect in tunnel diode using I- V charcteristics.

**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.

## SEMISTER-VIII

**PHY-MJ-20.: STATISTICAL MECHANICS**

**(04 Credits, 60 Lectures)**

**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 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 system.
- 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 theparameters of the distribution functions:a. Maxwell-Boltzmann distributionb. Bose-Einstein distributionc. Fermi-Dirac distribution
- Do 3-5 assignments given by the course instructor to apply the methods of Statistical mechanics tosimple 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 classicaldistribution 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 statistic 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, SackurTetrode equation. Ideas of ensembles, micro-canonical, canonical and grand canonical ensembles. and expression for distribution function, partition function and and calculation of themodynamic quantities. **(25 Lectures)**

**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.
**(10 Lectures)**

**Bose-Einstein Statistics:** Bose -Einstein distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose derivation of Planck's law. **(12 Lectures)**

**Fermi-Dirac Statistics:** Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal. **(13 Lectures)**

**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. Press

## PHY-AMJ-1.: ADVANCE QUANTUM MECHANICS

## (04 Credits, 60 Lectures)

**Course Objective**

This course aims to describe quantum phenomena in terms of linear vector space formalism. The students will be able to learn to represent quantum states by ket vectors and physical observables as operators and their time evolution. Commutation relations between observables will be studied since it is fundamental to understanding uncertainty principle as well as deriving the eigen values of angular momenta. The complete set of commuting observables will be introduced. An understanding of identical particles like bosons and fermions will be developed. At the end of the syllabus, students will be able to learn angular momenta algebra and the computation of Clebsch-Gordan coefficients.

**Course Learning Outcomes**

This course will aim the B.Sc.(Hons.) physics students with modern analytical techniques sothat they can easily apply them to research areas involving lasers interacting withatoms/molecules, manipulate entangled quantum states like qubits, so necessary in the fieldof quantum information theory and quantum computation, deal effectively withsuperconductors and superfluidity, etc.

- The world is marching towards attainment of quantum computers, which in turn islikely to revolutionize the field of Artificial Intelligence (AI).
- After learning this course properly, our students would be adequately prepared toparticipate and innovate in the coming AI revolution.
- As this course starts with an introduction to matrix mechanics and thereafter angular momentum methods of quantum mechanics enabling the basic concepts and idea to solve quantum mechanical problems , the students will learn the approaches that are used in theoretical physics apart from mathematical methods.
- Intense problem-solving sessions including perturbative methods will enable the students to develop analytical and mathematical imagination that are necessary to be creative in physical sciences as wellas engineering research areas.
- The relativistic quantum dynamics will allow the students to understand the quantum mechanical properties associated with fundamental particles.
- 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.
- Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.
- The experiments using Sci-lab will enable the student to appreciate nuances involved in the theory.

## 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**. (12 Lectures)**

**Angular momentum and spin:** orbital angular momentum, eigen values and eigen function of $L^2$ , Eigen value and Eigen function of $L_z$ . spin angular momentum, total angular momentum operators. Commutation relations of total angular momentum with components.orbital angular momentum and rotations. Pauli theory of electron spin. Pauli spin matrices. Raising and lowering operator.

**(12 Lectures)**

**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.Einstien's A and B co-efficients. Rayleigh scattering, Raman scattering. **(12 Lectures)**

**System of identical particles:** Identical particles, symmetry of wave function. Pauli's exclusion principle.Heitler- London theory of hydrogen molecule.The helium atom. **(8 Lectures)**

**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.Existance of electron spin.Spin-orbit energy. **(16 Lectures)**

**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, PearsonEducation.
4. Quantum Mechanic Concepts and Applications, NouredineZettili, SecondEdition,2001, John Wiley & Sons, Ltd.
5. A Text book 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, PrenticeHall.

**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), AjoyGhatak and S. Lokanathan, Laxmi Publications, New Delhi.

3. Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak andAjoyGhatak, Viva Books Pvt. Ltd., 2019
4. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-WesleyPublications,
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.: ATOMIC AND MOLECULAR SPECTRA

## (04 Credits, 60 Lectures)

**Course Objective**

After learning the elements of modern physics, students would be poised to learn more advanced topics like how to solve the Schrodinger equation for spherically symmetric potentials. Then, in this course, eigenvalues and eigen functions of the Hamiltonian as well as the orbital angular momentum would be studied. Furthermore, application of Schrodinger equation to various quantum mechanical problems would be taken up. The spin angular momentum of electrons would also be introduced in the course.

**Course Learning Outcomes**

The Students will be able to learn the following from this course:

- Familiarization with quantum mechanics formulation.
- After an exposition of inadequacies of classical mechanics in explaining microscopicphenomena, quantum theory formulation is introduced through Schrodinger equation.
- The interpretation of wave function of quantum particle and probabilistic nature of itslocation and subtler points of quantum phenomena are exposed to the student.
- Methods to solve time-dependent and time-independent Schrodinger equation
- Through understanding the behavior of quantum particle encountering a barrierpotential, the student gets exposed to solving non-relativistic hydrogen atom, for itsspectrum and eigenfunctions.
- Study of influence of electric and magnetic fields on atoms will help inunderstanding Stark effect and Zeeman Effect respectively.
- Angular momentum: Orbital angular momentum and spin angular momentum.
- Bosons and fermions - symmetric and anti-symmetric wave functions.
- Application to atomic systemsIn the laboratory course, with the exposure in computational programming in thecomputer lab, the student will be in a position to solve Schrodinger equation for groundstate energy and wave functions of various simple quantum mechanical onedimensionaland three dimensional potentials.

**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. **(10 Lectures)**

**Vector atom model**:Angular momenta and magnetic moments. Space quantization of electron spin.Quantum numbers - a general account.Characteristics of vector atom model.Larmour'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.

**(15 Lectures)**

**Many electron 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. **(10 Lectures)**

**Molecular spectra**: Introduction, molecular spectra, experimental studies, Infra-red (IR) spectroscopy, ultra violet (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; nature experimental arrangement, 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. **(15 Lectures)**

**LASER**: semiconductor laser. Carbon dioxcide laser.Nd:YAG laser. Properties and uses of laser.

**(10 Lectures)**

**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. Lasers theory and Applications. – THYAGARAJAN GHATAK

**PHY-AMJ-3. : PRACTICAL**

**(04redits)**

1. Study of Grating Spectra : a) Determination of Grating Element using known wavelength of light.
   b) Meauserment of Unkown wavelength of light.
2. To Determine the dispersive power of material using white light Source.
3. To Determine the wavelength and angular spread of He-Ne laser using plane diffraction grating .
4. Study of Electron spin resonance – determine magnetic field as a function of the resonance frequency.
5. Study of Zeeman effect: with external magnetic field; Hyperfine splitting.

**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. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

# PHYSICS-(MINOR)

## Course Structure (MINOR)

| Course Name | | Full Marks | END SEM | INTERNAL |
|---|---|---|---|---|
| SEM I | | | | |
| PHY-MN-1A | MECHANICS (03 Credits, 45 Lectures) | 75 | 60 | 10+5 |
| PHY-MN-1A | (PRACTICAL) (01credits) | 25 | 25 | 00 |
| SEM III | | | | |
| PHY-MN-1B | ELECTRICITY & MAGNETISM (03 Credits, 45 Lectures) | 75 | 60 | 10+5 |
| PHY-MN-1B | (PRACTICAL) (01credits) | 25 | 25 | 00 |
| SEM V | | | | |
| PHY-MN-1C | THERMAL PHYSICS(03 Credits, 45 Lectures) | 75 | 60 | 10+5 |
| PHY-MN-1C | (PRACTICAL) (01 credits) | 25 | 25 | 00 |
| SEM VII | | | | |
| PHY-MN-1D | WAVES & OPTICS (03 Credits, 45 Lectures) | 75 | 60 | 10+5 |
| PHY-MN-1D | (PRACTICAL)(01 Credits) | 25 | 25 | 00 |

**SEMESTER - I**

**PHY-MN-1A: MECHANICS (03 Credits, 45 Lectures)**

**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 DifferentialEquations 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, theconcept of conservation of energy, momentum, angular momentum and apply them tobasic problems.
- Understand the analogy between translational and rotational dynamics, and applicationof 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 symmetryfor different uniform mass distributions.
- Understand the phenomena of elastic and in-elastic collisions
- Understand angular momentum of a system of particle.
- Apply Kepler's law to describe the motion of planets and satellite in circular orbitthrough 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 onthe mass and energy of a moving object.
- In the laboratory course, after acquiring knowledge of how to handle measuringinstruments (like screw gauge, verniercallipers, Travelling microscope) student shallembark on verifying

various principles learnt in theory. Measuring 'g' usingBar 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.**(8 Lectures)**

**Ordinary Differential Equations:** 1st order homogeneous differential equations. 2$^{nd}$order homogeneous differential equations with constant coefficients.**(5 Lectures)**

**Central force field:** Motion of a particle in a central force field –two body problem. Kepler's Laws and their deduction. **(3 Lectures)**

**Oscillations:** Simple harmonic motion. Differential equation of SHM and its solutions.Kinetic and Potential Energy, Total Energy and their time averages. **(5 Lectures)**

**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 Rigidity modulus by static torsion, Torsional pendulum. **(10 Lectures)**

**Fluids:** Surface Tension: Excess of pressure - Application to spherical and cylindrical drops and bubbles, variation of surface tension with temperature. Viscosity - Rate flow of liquid in a capillary tube, Poiseuille's formula, Determination of coefficient of viscosity of a liquid, Variations of viscosity of liquid with temperature.**(10 Lectures)**

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

**(4 Lectures)**

**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-MN-1A (PRACTICAL) (01 credits)**

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.

5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater's Pendulum.
9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

**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, 4$^{th}$ Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, InduPrakash and Ramakrishna, 11$^{th}$ Edition, 2011, KitabMahal, New Delhi.

**SEMESTER - III**

**PHY-MN-1B ELECTRICITY& MAGNETISM (03 Credits, 45 Lectures)**

**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 applyit to systems of point charges as well as line, surface, and volumedistributions of charges.
- Explain and differentiate the vector (electric fields, Coulomb's law) andscalar (electric potential, electric potential energy) formalisms ofelectrostatics.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Articulate knowledge of electric current, resistance and capacitance interms 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 tocurrents (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 usingFaraday'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.Polarisation, Displacement vector.Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

**(15 Lectures)**

**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.**(10 Lectures)**

**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. **(5 Lectures)**

**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.**(15 Lectures)**

**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-MN-1B (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.
7. To verify the Thevenin and Norton theorems
8. To verify the Superposition, and Maximum Power Transfer Theorems

**Reference Books**

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

**SEMESTER – V**

**PHY-MN-1C THERMAL PHYSICS (03 Credits, 45 Lectures)**

**Course Objective**

This course will introduce Thermodynamics, Kinetic theory of gases to the students. Th primary goal is to understand the fundamental laws of thermodynamics and it's applications to various thermo dynamical 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 ofthermodynamics, the concept of entropy and the associated theorems, thethermodynamic potentials and their physical interpretations. They are also expected tolearn Maxwell's thermodynamic relations.
- Know the fundamentals of the kinetic theory of gases, Maxwell-Boltzman distributionlaw, equipartition of energies, mean free path of molecular collisions, viscosity, thermalconductivity, diffusion and Brownian motion.
- Learn about the black body radiations, Stefan- Boltzmann's law, Rayleigh-Jean's lawand Planck's law and their significances.
- In the laboratory course, the students are expected to: Measure of Planck's constantusing black body radiation, determine Stefan's Constant, coefficient of thermalconductivity of a bad conductor and a good conductor, determine the temperature coefficientof resistance, study variation of thermo emf across two junctions of athermocouple 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 CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, 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. **(15 Lectures)**

**Thermodynamical Potentials:** Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations. **(10 Lectures)**

**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. **(10 Lectures)**

**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.**(5 Lectures)**

**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. **(5 Lectures)**

**Reference Books:**

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, MeghnadSaha, 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-MN-1C (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 Text Book of Practical Physics, InduPrakash and Ramakrishna, 11th Edition, 2011, KitabMahal, New Delhi.
2. A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal, 1985, Vani Publication.

**SEMESTER – VII**

**PHY-MN-1D WAVES & OPTICS (03 Credits, 45 Lectures)**

**Course Objective**

The 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 atequipping 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 simpleharmonic motions and their applications.
- Understand the importance of classical wave equation in transverse and longitudinalwaves 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: theirfrequencies and configurations
- Understand the concept of temporal and spatial coherence.
- Understand Interference as superposition of waves from coherent sources derived fromsame 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 fromapertures
- Understand Fraunhoffer Diffraction from a slit.

- In the laboratory course, student will gain hands-on experience of using various opticalinstruments and making finer measurements of wavelength of light using Newton Ringsexperiment, Fresnel Biprism etc. Resolving power of optical equipment can be learntfirst hand.
- The motion of coupled oscillators, study of Lissajous figures and behaviour oftransverse, 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 and (2) Oscillations having different frequencies (Beats). **(5 Lectures)**

**Waves Motion**: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. **(5 Lectures)**

**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. **(8 Lectures)**

**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. **(8 Lectures)**

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

**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.**(10 Lectures)**

**Polarization:** Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(4 Lectures)**

**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-MN-1D (PRACTICAL) (01 Credits)**

1. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda 2$ – T Law.
2. To determine the Coefficient of Viscosity of water by Capillary Flow Method

(Poiseuille's method).

3. To determine the Refractive Index of the Material of a Prism using Sodium Light.
4. To determine Dispersive Power of the Material of a Prism using Mercury Light
5. To determine the value of Cauchy Constants.
6. To determine the Resolving Power of a Prism.
7. To determine wavelength of sodium light using Fresnel Biprism.
8. To determine wavelength of sodium light using Newton's Rings.
9. To determine the wavelength of Laser light using Diffraction of Single Slit.
10. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
11. 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.

# PHYSICS-(MDC)

## Course Structure (MDC)

| Course Name | Full Marks |
|---|---|
| **SEM- I / II / III** | |
| PHY-MDC (PHYSICS:ELEMENTS OF MATHEMATICAL PHYSICS, MECHANICS, ELECTRICITY, MAGNETISM, WAVES, OPTICS, MODERN PHYSICS AND RELATIVITY) (3 Credits, 45 Lectures) | 75 |

**SEM-I / II / III**

PHY-MDC :(PHYSICS : ELEMENTS OF MATHEMATICAL PHYSICS, MECHANICS, ELECTRICITY, MAGNETISM, WAVES, OPTICS, MODERN PHYSICS AND RELATIVITY) (3 Credits)

**Course Learning Outcomes:**

On successful completion of this course the student should:

- Learn and revise the basics of mathematics and calculus needed in smooth understanding of elementary physics.
- Understand the principles of elasticity
- 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)
- Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
- Know Gauss's law of electrostatics and its uses.
- Understandmagnetism and magnetic field.
- Describe how magnetism is produced and list examples where its effects are observed.
- Apply basic knowledge of principles and theories about the behavior of light.
- Understand the principle of superposition of waves, so thus describe the formation of standing waves.
- Explain several phenomena we 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 and interference.

**Skills to be learned:**

- Training in Mathematical physics will prepare the student to formulate and solve various problems in physics.
- This course will help in understanding basic concepts of electricity and magnetism and their applications.
- Basic course in electrostatics will equip the student with prerequisites to understand electrodynamics phenomena.
- Student shall develop an understanding of various aspects of harmonic oscillations and waves, Various types of mechanical waves and their superposition.
- This course in basics of optics will enable the student to understand various optical phenomena, principles, workings and applications optical instruments.

- About inertial and non-inertial systems and special theory of relativity.

**Course content**:

**Mathematical Physics and Mechanics**: scalars and vectors, dot and cross product of two vectors, Elasticity, stress, strain, elastic constants, relation between elastic constants. Cantilever, Expression for depression. **(8 Lectures)**

**Electricity and Magnetism:** Electric field and potential, electric field intensity, electric flux, Gauss's law and its integral and differential forms. Laplaces and poisson equation.

magnetic force, Lorentz force, Biot-Savart law. Magnetic field due to a long straight conductor.Magnetic induction. **(8 Lectures)**

**Wavesand Optics**: Wave motion, type of wave motion. Equation of plane- progressive wave. Differential equation of wave motion and its solution (no derivation of solution).

Idea of Free vibration, damped oscillation, forced oscillation and resonance.

Interference of light, Condition for interference of light.

Idea of Polarisation, Plane, circularly and elliptically polarised light. **(15 Lectures)**

**Modern Physics:**Black body radiation. Photo electric effect. Wave-particle duality. de-Broglie wave length. Radioactivity: law of radioactive decay, mean life and half life . **(7 Lectures)**

**Relativity** : fundamental postulates of special theory of relativity. Lorentz transformation. Length contraction. Time dilation. Einstein mass-energy relation. **(7 Lectures)**

**Reference Books**

1. Mathematical Physics - H K Das
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
4. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
5. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
6. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
7. Electricity and Magnetism, P. K. Chakraborty, New Age International Pvt. Ltd.
8. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
9. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
10. Electromagnetic Theory, Chopra & Agarwal, Kedarnath Ramnath & Co.
11. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

12. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
13. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
14. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
15. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
16. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
17. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.