GOVERNMENT GENERAL DEGREE COLLEGE, KALNA-I

SYLLABUS
For

Semester-III

3-year Degree/ 4-year Honours Programme

in

Major-Physics

Under Curriculum and Credit Framework for Undergraduate Programmes (CCFUP)
as per NEP, 2020
(With effect from the session 2023-2024)

Semester-III

Course Type	Title of the Course	Credit	Full Marks	Lecture Hour
Major Course **PHYS3011**	**Electricity and Magnetism**	**5** (Theory-04, Practicals-01)	**75** (Theory-40, Practical–20, Internal Assessment–15)	**90** (Theory-60, Practical-30)
Major Course **PHYS3012**	**Waves and Optics**	**5** (Theory-04, Practicals-01)	**75** (Theory-40, Practical–20, Internal Assessment–15)	**90** (Theory-60, Practical-30)
Minor Course under Vocational Education & Training Course **MSR3021**	**Medical Sales Representative –Module 1**	**4** (Lecture -3, Tutorial -1)	**75** (Theory-60, Internal Assessment–15)	**60** (Lecture -45, Tutorial – 15)
Multi/ Interdisciplinary **ENGL3031:**	**Practical English Grammar and Usage**	**3** (Theory-03)	**50** (Theory-40, Internal Assessment–10)	**45**
AEC **(L2-1 MIL)** **BENG3041**	**বাংলা ছোটগল্প ও কবিতা**	**2** (Theory-02)	**50** (Theory-40, Internal Assessment–10)	**30**
SEC **PHYS3051**	**Basic Instruments and Their Usage**	**3** (Theory-03)	**50** (Theory-40, Internal Assessment–10)	**45**
		Total Credit = 22	**Total Marks = 375**	

MAJOR-PHYSICS COURSE
Semester III

MAJOR-III: PHYS3011: Electricity and Magnetism (Credits: Theory - 04, Practical - 01)
F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)

Course Objective: ***The objective of this paper is to give the basic concept as well as an in-depth understanding of the principles of electricity and magnetism and apply them to solve the problems related.*** **60 Hours**

Electrostatics

Unit I Quantization of electric charge, Coulomb's law, Principle of superposition, Electric field (Physical concept, quantitative definition and its source), Electric field of a point charge, Electric field lines and their properties, Charge density, Volume charge density, Surface charge density, Line charge density, Electric fields due to continuous charge distributions, Electric field due to a uniformly charged non-conducting rod at an axial point and at a point on the perpendicular bisector of that rod, Electric field due to a circular disc on the axial point.

5 Hours

Unit 2 Electric flux, Gauss' law, Differential form of Gauss' law, Equivalence of Coulomb's law and Gauss' law, Gaussian surface, Application of Gauss' law to evaluate the electric field at a point for charge distributions with spherical (A thin spherical shell of radius R with a charge +Q evenly distributed over its surface, thick shell, and a solid sphere of radius R with uniform volume charge density), planar (Infinitely large non-conducting plane with uniform surface charge density) and cylindrical symmetry (Infinitely long non-conducting rod of uniform line charge density).

6 Hours

Unit 3 Conservative nature of electrostatic field, Electric scalar potential, Relation between the electric field and the electric potential, Electric potential of a point charge and a group of point charges, Electric potential due to a continuous charge distribution, Electric potential, and field due to an electric dipole, Force and torque acting on an electric dipole in a uniform electric field, Laplace's and Poisson's equations, The Uniqueness theorem (Proof required).

5 Hours

Unit 4 Electrostatic potential energy, Electrostatic potential energy of a collection of point charges, Electrostatic potential energy of a continuous charge distribution (general expression and a charged sphere as an example), Self energy, Classical electron radius, Electrostatic potential energy of an electric dipole in a non-uniform electric field.

4 Hours

Unit 5 Equipotential surfaces, Electrostatic equilibrium properties (regarding electric charge, electric field and electric potential) of a conductor in a uniform electric field, Surface charge and force on a conductor, Boundary conditions on the electric field at the interface between a vacuum and a conductor, Capacitor as a charge storing device, Capacitance and the energy stored in a capacitor, Capacitance of a system of charged conductors, Parallel-plate capacitor, Capacitance of an isolated conductor, Method of Images and its application to: (1) Plane infinite sheet and (2) Sphere.

6 Hours

Unit 6 Dielectric properties of matter**:** Electric field inside a matter, Polarization, Polarization charges, Electrical susceptibility and dielectric Constant, Capacitor (parallel-plate, spherical, cylindrical) filled with dielectric, Displacement vector $\vec{D}$, Relations between $\vec{E}$, $\vec{P}$ and $\vec{D}$, Gauss' Law in dielectrics, Boundary conditions between two dielectric interfaces.

4 Hours

Steady Electric Current

Electric current, Current density, Continuity equation, Conductivity, Ohm's law, Electromotive force, Kirchhoff's first and second law- statement and applications, Thevenin′s, Norton′s and maximum power transfer theorems and their applications.

2 Hours

Magneto-statics

Unit 1 Electric current as a source of magnetic field, Definition and units (SI) of: Magnetic flux density $\vec{B}$, Magnetic field strength $\bar{H}$ and Magnetization vector ($\bar{M}$), Relation between $\bar{B}$, $\bar{H}$ and $\bar{M}$, Magnetic susceptibility and magnetic permeability, Boundary conditions between two magnetic media, Force (Lorentz force) on a moving charge in the simultaneous presence of both electric and magnetic fields, Trajectory of a charged particle in a crossed uniform electric and magnetic fields.

3 Hours

Unit 2 Biot Savart's Law and its applications: $\bar{B}$ due to current in (i) a long straight conductor, (ii) a circular loop, (iii) a solenoid, Current loop as a magnetic dipole and its dipole moment.

3 Hours

Unit 3 -Ampere's circuital law and its applications: $\vec{B}$ due to current in (i) a long straight conductor, (ii) a solenoid and (iii) a toroid.

2 Hours

Unit 4 Magnetic force on (i) a current element, (ii) a line current, Force between two current elements, Divergence and Curl of B (Gauss and Ampere's laws), Physical significance of the nature of the divergence and curl of B, Magnetic vector potential.

3 Hours

Transient current

Growth and decay of currents in LR, CR and LCR circuits, Time constant.

2 Hours

Alternating Current

Source of alternating current, Mean value, Peak value and RMS value of alternating voltage and current, Inductive and capacitive reactance, Real power, Reactive power and apparent power, Power triangle, Power factor, Series LCR circuit analysis, Phasor diagrams (AC voltage from a source (V), Current through the resistor R (i_R) and the voltage across R (V_R), Current through the capacitor C (i_c) and the voltage across C (V_c), Current through the inductor L(i_L) and the voltage across L (V_L), Calculation of total impedance of a series LCR circuit using the phasor diagram of V, V_R, V_L and V_c, Parallel LCR circuit analysis, Resonance in LCR circuits (series and parallel), LC oscillations.

7 Hours

Electromagnetic Induction

Faraday's law, Lenz's law and conservation of energy, Motional EMF, Eddy current, Principle of power generation, Self-inductance and mutual inductance, Induction oven, Induction brake, Reciprocity theorem, Energy stored in a magnetic Field, Introduction to Maxwell's equations, Continuity equation.

4 Hours

Electrical equipment

Moving coil ballistic and dead-beat galvanometers: Working principle, Derivation of the equation relating between the charge flowing through the coil and the ballistic throw of the galvanometer, Damping correction, Current, charge and voltage sensitivities of a moving coil galvanometer, Equation of motion of the coil, non-oscillatory, aperiodic or dead-beat motion, Critical damping, Light damping: Ballistic motion, Uses.

4 Hours

Course Outcome: ***At the end of this course, students will be able to comprehend the concept of electric field, electric flux, magnetic field, and their origin. They will learn to apply the Gauss's theorem to find the electric fields for different types of charge distribution. The students will develop a sound perception about Electrostatics, Magneto-statics, Electric current and electromagnetic induction.***

Reference Book

- Electricity and Magnetism, Purcell, M. Edward, David J. Morin, 2013, Cambridge University Press, 3rd edition.
- Electricity and Magnetism, R. Murugeshan, 2019, S. Chand Publishing, 10th Edition.
- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw-Hill.
- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
- Introduction to Electrodynamics, D.J. Griffiths, 1998, Benjamin Cummings, 3rd Edn.
- Feynman Lectures Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education.
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- Electricity and Magnetism Volume I, J.H. Fewkes & J. Yarwood, 1991, Oxford Univ. Press.

MAJOR-III: PHYS3011: Electricity and Magnetism
Practical: 30 Hours

List of Experiments

1. ***To verify the Thevenin's, Norton's and Maximum Power transfer theorems***
2. ***To determine the Self-inductance of a coil using Anderson's bridge***
3. ***To study the response curve of a series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor and (d) Band width***
4. ***To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor***
5. ***Measurement of Charge Sensitivity and CDR of a Ballistic Galvanometer***
6. ***Determination of a Ballistic Galvanometer Constant by Capacitor Charging-Discharging method***

7. ***Construction of a One Ohm coil***
8. ***Determination of a Ballistic Galvanometer Constant by the Solenoid method***
9. ***Determination of Mutual Inductance of two coils by Carey-Foster's method***

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani.
- B.Sc. Practical Physics, Harnam Singh, Dr. P.S. Hemne, 2018, S. Chand.
- Advanced Practical Physics, B. Ghosh and K. G. Majumdar, Shreedhar Publishers.
- Advanced Course in Practical Physics, D Chattopadhyay, P C Rakshit, New Central Book Agency.

MAJOR-PHYSICS COURSE
Semester III
MAJOR-III: PHYS3012: Waves and Optics (Credits: Theory - 04, Practical - 01)

F.M. = 75 (Theory - 40, Practical – 20, Internal Assessment – 15)

Course Objective: ***The objective of this course is to provide an in-depth understanding of the nature of waves in general, sound wave as an example of mechanical wave and light as an electromagnetic wave. It is also intended to provide a comprehensive idea of some phenomena like interference, diffraction and polarisation and their physical explanation in terms of the wave theory of light.***

60 Hours

Superposition of Collinear Harmonic Oscillations

Simple harmonic motion as a projection of a uniformly rotating vector on a reference axis, Linearity and superposition principle, Superposition of two collinear simple harmonic vibrations with different amplitudes, different initial phases and with: (1) same frequencies using both the analytical method and the vector method, (2) slightly different frequencies, Beats (graphical representation of beats), Superposition of a large number (N) of simple harmonic vibrations of equal amplitude and frequency but with (a) equal successive initial phase differences and (b) random phases by the vector method,

Superposition of a large number (N) of simple harmonic vibrations of equal amplitude and same initial phase but with equal successive frequency differences by the analytical method.

5 Hours

Superposition of two Perpendicular Harmonic Oscillations

Superposition of two perpendicular simple harmonic oscillations having (1) equal frequencies, different amplitudes and an initial phase difference δ (graphical representation for δ varying between 0 and 2π), and (2) two different frequencies, different amplitudes and an initial phase difference δ (Lissajous Figures) using the analytical method as well as the graphical method.

2 Hours

Coupled Oscillations

Stiffness coupled oscillators: two identical pendulums (each a light rigid rod of length l supporting a mass m) coupled by a weightless spring of stiffness ***s***, Normal coordinates, Degrees of freedom, Normal modes of vibration, A large number (N) of coupled oscillators *e.g.*, a light string fixed at both ends, supporting N equal masses spaced at equal distance along its length (Qualitative discussion without any mathematical details).

3 Hours

One Dimensional Waves

Unit I Transverse oscillations (in a plane) of a slightly extensible, uniform string of mass per unit length ρ under a constant tension (T) with free ends: Equation of motion - $\frac{\partial^2 y}{\partial x^2} = \frac{T}{\rho}\frac{\partial^2 y}{\partial t^2}$ ~ the one dimensional wave equation representing a travelling wave of velocity (c) equal to $\sqrt{\frac{T}{\rho}}$, $y = A\,sin\frac{2\pi}{\lambda}(ct \pm x)$ or $A\,cos\frac{2\pi}{\lambda}(ct \pm x)$ - a solution of the wave equation, $\frac{2\pi}{\lambda}(ct \pm x)$ - a dimensionless quantity for λ representing a length, Harmonic waves, Wavelength (λ), Wave or phase velocity ($c = \frac{\partial x}{\partial t}$), Frequency ($\nu = \frac{c}{\lambda}$), Oscillator or particle velocity ($\frac{\partial y}{\partial t}$).

4 Hours

Unit II Oscillations of a string of fixed length l under a constant tension (T) with both ends rigidly clamped: Equation of motion $\frac{\partial^2 y}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 y}{\partial t^2}$ (same) with the boundary conditions $y = 0$ at $x = 0$ and $x = l$ for all t, General solution $y = A\,sin\frac{2\pi}{\lambda}(ct - x) + B sin\frac{2\pi}{\lambda}(ct + x)$, The boundary condition $y = 0$ at $x = 0$ for all t implies $A = -B \rightarrow y = 2A\,sin\frac{2\pi}{\lambda}ct\,cos\frac{2\pi}{\lambda}x$ – superposition of a wave moving along positive or negative x-axis and the wave reflected at either fixed end (discontinuity) with a π phase change in amplitude, Nature of oscillations: (a) All particles of the string execute simple harmonic oscillation about their equilibrium positions (points on the string at rest) at the same frequency, (b) The amplitude varies along the length of the string, (c) Nodes with zero amplitude and antinodes with a peak amplitude, (d) The positions of the nodes and antinodes do not change with time, The boundary condition $y = 0$ at $x = l$ for all t gives $\frac{2\pi}{\lambda} = \frac{n\pi}{l}$ or $\nu_n = \frac{nc}{2l}$, the general solution

$$y(x,t) = \sum_{n=1}^{\infty}\left(a_n\,sin\,\frac{n\pi ct}{l}\,cos\,\frac{n\pi}{l}x\right) = \sum_{n=1}^{\infty}(a_n \sin\omega_n t\,cos\,\frac{\omega_n}{c}x)$$

Additional characteristics: $y(x,t)$ - superposition of an infinite number normal modes of different frequencies ($\nu_n = \frac{nc}{2l}$), The total energy of the vibrating string (derivation required) (E) $= \sum E_n$,

$E_n = \frac{1}{2} m\omega_n^2 a_n^2$, Wave group with a number of components of different frequencies, dispersive medium, Group velocity $= \frac{d\omega}{dk}$, Doppler Effect.

6 Hours

Sound Waves in Gases

Longitudinal disturbances in the pressure and density causing compressions and rarefactions of small volume elements of the gases, Deduction of the wave equation $\frac{\partial^2 y}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 y}{\partial t^2}$, Velocity of sound waves $c = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{\gamma P}{\rho}}$, The energy (kinetic, potential, total) distribution in space for a sound wave in a gas (qualitative idea), Intensity of sound waves and units.

3 Hours

Elastic Waves in Bulk Solids

Longitudinal and transverse modes, The wave equations for each mode, Velocity of waves in each mode.

2 Hours

Three Dimensional Waves

Wavefront-a surface of constant phase at a given instant of time, A plane wave $\psi(\vec{r}, t) = Ae^{i(\vec{k}\cdot\vec{r} - \omega t)}$ with a wavefront defined by $\vec{k}\cdot\vec{r}$ = constant, A spherical wave $\psi(r, t) = \frac{A}{r} e^{i(kr-\omega t)}$ with a wavefront defined by kr = constant, A cylindrical wave $\psi(\vec{r}, t) = \psi(r, \theta, z, t) = \frac{A}{\sqrt{r}} e^{i(kr-\omega t)}$ is θ-independent and z-independent and the wavefront is a right circular cylinder centered on the z-axis and having infinite length.

Light propagation explained as rays in geometrical optics (deals with an image formation in different optical instruments) whereas electromagnetic waves in physical optics (deals with different phenomena as interference, diffraction and polarization).

2 Hours

Superposition of Harmonic Waves

The wave equation supports the superposition principle, Superposition of electromagnetic waves treating the fields as scalar, Superposition of (a) Two harmonic plane waves of the same frequency – Idea of coherent sources and interference, (b) N harmonic waves with identical frequencies: (i) randomly phased sources of equal amplitudes, (ii) Coherent (constant phase relationship) sources of the same type) and in phase.

3 Hours

Interference

Unit 1 Conditions of interference, Spatial and temporal coherence, Realization of coherent sources by division of a wavefront: Young's double slit experiment, Fresnel's Bi-prism, Lloyd's Mirror.

Unit 2 Phase change on reflection: Stokes' treatment, Realization of coherent sources by division of amplitude, 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.

Unit 3 Michelson interferometer, Formation of the fringes, (No theory required), Applications: Determination of the (1) wavelength and (2) wavelength difference, (3) Refractive Index, Visibility of fringes.

Unit 4 Fabry-Perot interferometer, Formation of the fringes, Intensity distribution, Resolving Power, Superiority over Michelson interferometer.

10 Hours

Diffraction

The Huygens–Fresnel principle, Diffraction and interference, Fresnel diffraction and Fraunhofer diffraction.

Fraunhofer diffraction: Single slit diffraction, Double slit diffraction, N-slits diffraction or a diffraction grating, Rayleigh criterion for resolution, Resolving power of a grating, Grating spectra versus Prism spectra.

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, Fresnel's integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

10 Hours

Polarisation of Light

Types of polarized light: Plane polarized light, Circularly polarized light, Elliptically polarized light,

Production of polarized light (a) by reflection, Brewster angle, Malus law, (b) by dichroism, Pollaroids, (c) by double refraction, Doubly refracting crystals, Negative crystals, Positive crystals, Optic axis, Nicol prism, Huygen's theory of double refraction, Phase retardation plate: 1) Quarter wave plate 2) Half wave plate,

Detection of plane, circularly and elliptically polarized light.

Optical activity and its origin, Two types of optically active substance, Fresnel's theory of optical rotation, Polarimeter.

10 Hours

Course Outcome: ***The outcome of the paper includes the knowledge of vibrations, propagation of waves, vibrations of air column, and harmonics of the strings. The paper has another outcome of offering knowledge of wave properties of light & corresponding phenomena.***

Reference Books

- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N K Bajaj, 1984, Tata McGraw-Hill.
- Waves and Oscillations, N. Subramanyam and Brij Lal, 2010, Vikas Publishing House Pvt. Ltd.
- Waves and Optics: As per CBCS, M. N. Avadhanulu & TVS Arun Murthy, S. Chand Publishing.
- Optics, Eugene Hecht, 2019, Pearson.

- OPTICS at Graduate Level, Prof. Devanarayanan Sankara, 2019, Independently published.
- Optics An Introduction, Sarhan M. Musa, 2017, Mercury Learning and Information.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 2017, McGraw-Hill Education Ltd.
- Principles of Optics, Max Born and Emil Wolf, 1999, Pergamon Press.

MAJOR-III: PHYS3012: Waves and Optics
Practical: 30 Lectures

List of Experiments

1. ***To draw n-l curve with the help of a sonometer and hence find the frequency of an unknown fork***
2. ***Determination of the frequency of ac mains with a sonometer using a magnetic wire***
3. ***Determination of the velocity of ultrasonic waves in a given liquid***
4. ***To determine the refractive index of the material of a prism using sodium source***
5. ***To determine the dispersive power and Cauchy constants of the material of a prism***
6. ***To determine the wavelength of sodium light using Fresnel Biprism***
7. ***To determine the wavelength of sodium light using Newton's Rings***
8. ***Determination of the width of a single slit producing a Fraunhofer diffraction pattern***
9. ***To determine wavelength of (1) Na source and (2) spectral lines of Hg source using a plane diffraction grating***
10. ***Calibration of a polarimeter and determination of the concentration of an active solution***
11. ***To determine the resolving power of a plane diffraction grating***

Reference Books:

- Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani.
- B.Sc. Practical Physics, Harnam Singh, Dr. P.S. Hemne, 2018, S. Chand.
- Advanced Practical Physics, B. Ghosh and K. G. Majumdar, Shreedhar Publishers.

➢ Advanced Course in Practical Physics, D Chattopadhyay, P C Rakshit, New Central Book Agency.

SEC-PHYSICS
Semester-III

SEC-3: PHYS3051: Basic Instruments and their Usage (Credits: 03)
F.M. = 50 (Theory - 40, Internal Assessment – 10)

Course Objective: ***This course is designed to give the students an exposure with various aspects of electrical and optical instruments and their applications in experimental physics.***

Electrical/ Electronic Instruments

Unit 1 Voltage and current sources, Principles of measurement of dc voltage & current, ac voltage & current and a resistance, Specifications of an electronic voltmeter/ multi-meter and their significance, Advantages of electronic voltmeter over conventional multi-meter for the measurement of voltage, Instrumental accuracy, Precision, Sensitivity, Resolution, Range *etc*., Errors in measurements and loading effects.

Unit 2 Cathode Ray Oscilloscope: Block diagram of basic CRO, Time base operation, Synchronization, Front panel controls, Specifications of a CRO and their significance, Use of CRO for the measurement of voltage (dc and ac), frequency, Special feature of dual trace.

Unit 3 Signal Generators: Block diagram, Explanation and specifications of low frequency signal generators, Pulse generators and function generators.

Unit 4 Digital Instruments: Principle and function of a digital meter, Characteristics of a digital meter, Comparison of analog & digital instruments.

Optical Instruments

Unit 1 Optical microscope: Simple microscope, Compound microscope, Electron microscope: Principal components, Working principle and uses.

Unit 2 Telescope: Principal components, Working principle and uses of different types of telescopes (Astronomical telescope, Terrestrial telescope, Reflecting telescope).

Unit 3 An objective lens and an eyepiece or ocular lens: Elements, Angular magnification of a telescope, Angular magnification of a microscope, Huygens eyepiece, Ramsden eyepiece.

Unit 4 Spectrometer: Principal components, Role of individual components, Uses, Ultraviolet-Visible (UV-VIS), Near-infrared (NIR) and Raman spectrometers.

Suggested Activities

1. To realize the importance of grounding, earthing and the methods for earthing
2. To know about the telescopes used at different observatories in and outside India

Demonstration Experiments

1. Use of an oscilloscope for the measurement of voltage, frequency, time period and phase angle
2. An experiment for the determination of magnifying power of a microscope
3. Use of a digital multi-meter for measuring voltages (dc and ac), currents (dc and ac), resistances and its limitation for measuring high frequency voltage and current

Reference Books

- Modern electronic instrumentation and measurement techniques India, Albert D Helfrick & William D Cooper 1992, Prentice Hall India Learning Private Limited.
- Basic Electrical and Electronics Engineering, S. K. Bhattacharya, 2011, Pearson Education India.
- The Theory of Optical Instruments, E T Whittaker, 2023, Mjp Publishers

Course Outcome ***After completion of this course, the students will gain knowledge the in setting up electrical and optical experiments.***

Minor Course under Vocational Education & Training

Course Code: MSR3021

Course Title: Medical Sales Representative –Module 1

Total Credit: 4 (Lecture -3, Tutorial -1)

Duration: 60 Hours

Orientation Module (Duration: 4 Hrs.)

- Collect information of key persons at hospitals, pharmacies and dealers
- Summarize the healthcare ecosystem including relevant govt. scheme, social security benefits
- Gather information about health and other relevant standards and the possible company's tie up with various regulatory bodies and authorities
- Explain regulatory authorities and government policies, rules and regulations (CDSCO/NPPA/ MRTP Act) and their impact on business dynamics, relevant to Life Sciences industry.

Understand Role of MSR and Regulations for MSR (Duration: 6 Hrs.)

- Perform the occupation effectively as per company's standard guidelines
- Recall the organization structure and employment benefits in Life Sciences organizations
- Outline the role of MSR, required skills and knowledge (As per qualification pack) including its career path as well as identify the MCI code of conduct guidelines for MSR and UCP-MP Act
- Practice soft communication skills while communicating with doctors, physicians, pharmacists & cross functional colleagues.

Major Stakeholders and Sale & Distribution System in Pharma & Bio Pharma (Duration: 5Hrs.)

- Follow-up with key persons at hospitals, pharmacies and dealers to ensure smooth coordination with product distribution related stakeholders
- Describe drug distribution system of pharmaceutical, vaccines, ayurvedic and homeopathic products and role of various stakeholders involved like CFA, distributor, stockist, and liasioning agents.

Understanding of Human Body: Anatomy and Physiology (Duration:12 Hrs.)

- Summarize technical/ scientific data presentations and briefings about product andmarket
- Use the basics of general anatomy, physiology, and various systems of the humanbody while performing the product presentation to healthcare professionals
- Correlate medical specialties and their common diseases.

English Speaking and Personality Development Part 1 (Duration: 33 Hrs.)

- Understanding the communication process.
- The different types of communication methods.

•Communicating in English.
•First Language (Mother Tongue) Interference.
•Importance of Listening when learning English.
•Time Management.

<u>Reference Books on Medical Sales Representative</u>

1. Community Pharmacy Handbook - Jon Waterfield
2. Essential of Pharmaceutical Chemistry - Donald Cairns
3. Pharmaceutical Innovation and Access to Medicines- OECD 2018
4. Essential of Human Physiology for Pharmacy- Laurie Kelly
5. Textbook of Organic Medicinal and Pharmaceutical Chemistry 11th edition- Wilsonand Gisvold's
6. Review of Medical Physiology 26th Edition- Gannong
7. Soft Skill for everyone- Jeff Butterfeild

MULTI/ INTER DISCIPLINARY COURSE
Course Code: ENGL3031

Course Title: Practical English Grammar and Usage

Total Credit: 3 (Lecture -2, Tutorial -1)

Duration: 45 Hours

Full Marks: 50 (Theory-40, Internal Assessment- 10)

COURSE OBJECTIVES:

This course has been designed with a view to reinforcing the students' competency in Englishgrammar and usage as acquired at the secondary level. Already acquired linguistic skills in English will be consolidated and expanded so that students may competently use English in emerging domains of knowledge or in various socio-cultural circumstances.

Parts of Speech and Usage (LH: 20)
Nouns: Kinds of Nouns and their Usage
Pronouns: Kinds of Pronouns and their Usage
Adjectives: Kinds of Adjectives and their Usage
Articles and Determiners: Usage
Adverbs: Kinds of Adverbs and their Usage
Prepositions: Usage
Conjunctions: Usage
Verbs: Auxiliaries and Main Verbs, Modal and Semi-modal Verbs:
UsageTransitive and Intransitive Verbs: Usage
Finite and Non-Finite Verbs: Usage

Sentence (LH: 15)
Types of Sentences (Simple, Compound and Complex) and Clause and their
UsageTense and Time
Types of Simple Sentences (Declarative, Interrogative, Imperative, Optative, Exclamatory):
Form and Function

Concord (LH: 10)
Concord of Number, Number system of Nouns and Verbs, Concord of Person, Concord System in Different Constructions

COURSE OUTCOME:

This course of study will help the students to capitalize on their acquired knowledge of English and make them comfortable in using English effectively in different social, culturaland academic situations.

ABILITY ENHANCEMENT COURSE

AEC(L1-2)

Course Title: বাংলা ছোটোগল্প ও কবিতা

Course Code: BENG3041

Total Credit: 2 (Lecture -2, Tutorial -0)

Duration: 30 Hours

Full Marks: 50 (Theory-40, Internal Assessment- 10)

বাংলা ছোটোগল্প ও কবিতা

এই পাঠ্যসূচির উদ্দেশ্য হল বাংলা সাহিত্যের আধুনিক কালের বাংলা ছোটগল্প ও কবিতা সম্পর্কে শিক্ষার্থীদের অবহিত করা।

একক -১

বাংলা ছোটগল্প – রবীন্দ্রনাথ ঠাকুর – একরাত্রি, প্রভাত মুখোপাধ্যায় – আদরিনী, বনফুল – তাজমহল।

একক -২

একালের কবিতা – দিনেশ দাস – কেরাণী, পেমেন্দ্র মিত্র – মানে, শক্তি চট্টোপাধ্যায় – অবনী বাড়ি আছো।

Department of Physics
Government General Degree College, Kalna -I

Lesson Plan
for
B.Sc. Semester-III
Subject: Physics
Paper Name: Electricity and Magnetism
Paper Code: Major: PHYS3011

Credits: Theory-04, Practicals-01
F.M.=75 (Theory-40, Practical–20, Internal Assessment–15)

Course Objective: The objective of this paper is to give the basic concept as well as an in-depth understanding of the principles of electricity and magnetism and apply them to solve the problems related.

Module-I **Electrostatics** (30 lectures)
Contents **Unit-1**:Quantization of electric charge, Coulomb's law, Principle of superposition, Electric field (Physical concept, quantitative definition and its source), Electric field of a point charge, Electric field lines and their properties, Charge density, Volume charge density, Surface charge density, Line charge density, Electric fields due to continuous charge distributions, Electric field due to a uniformly charged non-conducting rod at an axial point and at a point on the perpendicular bisector of that rod, Electric field due to a circular disc on the axial point **Unit 2** Electric flux, Gauss' law, Differential form of Gauss' law, Equivalence of Coulomb's law and Gauss' law, Gaussian surface, Application of Gauss' law to evaluate the electric field at a point for charge distributions with spherical (A thin spherical shell of radius R with a charge +Q evenly distributed over its surface, thick shell, and a solid sphere of radius R with uniform volume charge density), planar (Infinitely large non-conducting plane with uniform surface charge density) and cylindrical symmetry (Infinitely long non-conducting rod of uniform line charge density). **Unit 3** Conservative nature of electrostatic field, Electric scalar potential, Relation between the electric field and the electric potential, Electric potential of a point charge and a group of point charges, Electric potential due to a continuous charge distribution, Electric potential and field due to an electric dipole, Force and torque acting on an electric dipole in a uniform electric field, Laplace's and Poisson's equations, The Uniqueness theorem (Proof required). **Unit 4** Electrostatic potential energy, Electrostatic potential energy of a collection of point charges, Electrostatic potential energy of a continuous charge distribution (general expression and a charged sphere as an example), Self energy, Classical electron radius, Electrostatic potential energy of an electric dipole in a non-uniform electric field. **Unit 5** Equipotential surfaces, Electrostatic equilibrium properties (regarding electric charge, electric field and electric potential) of a conductor in a uniform electric field, Surface charge and force on a conductor, Boundary conditions on the electric field at the interface between a vacuum and a conductor, Capacitor as a charge storing device, Capacitance and the energy stored in a capacitor, Capacitance of a system of charged conductors, Parallel-plate capacitor, Capacitance of an isolated conductor, Method of Images and its application to: (1) Plane infinite sheet and (2) Sphere. **Unit 6** Dielectric properties of matter**:** Electric field inside a matter, Polarization, Polarization charges, Electrical susceptibility and dielectric Constant, Capacitor (parallel-plate, spherical, cylindrical) filled with dielectric, Displacement vector Relations between D,E and P, Gauss' Law in dielectrics, Boundary conditions between two dielectric interfaces.

Module Objectives: To understand Coulomb's law of Electrostatics and its bi-products in free space. In this module, students would learn the origin and working principles in Electrostatics.	
Serial No.	**Topics of Discussion**
Lecture-1.	**Introduction and Overview:** In this lecture, we begin by visiting Coulomb's law for a single particle and hence the concept of Electric field is being discussed. Then it is extended for system of particles using principle of superposition.
Lecture-2.	**Electric fields from Coulomb's law** Building upon the concepts of previous lecture, expression of *E* is written for line, surface and volume charge distributions. Then the above expressions are used to compute *E* for few different geometries.
Lecture-3.	**Gauss's law (geometric derivation):** In this lecture, concept of solid angle and Electrostatic flux is introduced and then both concepts are merged to form Gauss's law in Electrostatics (Integral form).
Lecture-4.	**Gauss's law in differential form:** Since, the expression of *E has* been formulated from Coulomb's law we can use it to show. $\vec{\nabla}.E = \frac{\rho}{\epsilon_0}$ Which is known as Gauss's law in differential form. In this deduction, separate care was taken to show that $\vec{\nabla}.\left(\frac{\vec{r}}{r^3}\right) = 4\pi\delta^3(\vec{r})$.

Lecture-5.	**Gauss's law in integral form:** In this lecture, Gauss's law for Electrostatics is been observed in its most useful form i.e. $$\oint \vec{E}.d\vec{S} = \frac{q_{enc}}{\epsilon_0}$$ It is then applied for few symmetrical cases (infinite charged sheet, sphere, infinitely long charged sphere) to calculate *E*.
Lecture-6.	**Gauss's law continues:** More problems on application of Gauss's law for computing *E*are practiced to ensure that students do get proper hold on this calculation process.
Lecture-7.	**Electrostatic potential:** This lecture begins with showing that *E* is irrotational by nature. This is used to introduce a corresponding potential called Electrostatic potential.
Lecture-8.	**Superposition for potentials:** The superposition principle let us write Electrostatic potential for a system of particles. Which then is extended to write a closed form of potential for continuous charge distribution.
Lecture-9.	**Potential to *E* and vice versa** In this lecture, scalar nature of Electrostatic potential to generate the vector field *E* but at the same time, for specially symmetric conditions other way round is also an effective process.
Lecture-10.	**Electrostatic energy:** Electrostatic energy is discussed in this lecture from 1st principle and hence different equivalent forms of the same also being derived.
Lecture-11.	**Electrostatic energy 2:** For some symmetrical cases electrostatic self-energy is being calculated and consistency of different forms are also crosschecked.
Lecture-12.	**Conductors:** Free charges and their atomic origin is first discussed in this lecture. Then it is argued that *E* = 0 inside the conductor.
Lecture-13.	**Induced surface charge on conductor:** First, induced charge on surface of a conductor is understood and then Electrostatic pressure due to charge accumulation on conducting surface is computed.

Lecture-14.	**Capacitors:** Idea of capacitor and capacitance are also discussed in context of equipotential conducting surfaces. Few examples are practiced down the line.
Tutorial Assignment—1	
Lecture-15.	**Laplace and Poisson equation:** In this lecture, Electrostatic potential is discussed in context of two legendary equations: The Laplace's and Poisson's equation.
Lecture-16.	**Uniqueness theorem(s):** Few uniqueness theorems are thoroughly discussed in this class to prepare the stage for image problem in Electrostatics.
Lecture-17.	**Method of images 1:** Here, a charge in front of a grounded conducting plate is solved using method images and special stress is given for its connection with uniqueness theorem. Different quantities like potential, electric field and charge density on the plate, force and electrostatic is calculated.
Lecture-18.	**Method of images 2:** In this lecture, a grounded conducting sphere in front of a point charge is solved using method of images. It is then stressed that method of images do not solve Electrostatics problems for arbitrary problems.
Lecture-19.	**boundary conditions and boundary value problems 1:** Boundary conditions for Electrostatic quantities like E, potential is observed here. Then Laplace's equation is solved for problem in Cartesian co-ordinate.
Lecture-20.	**boundary value problems 2:** Here, Laplace's equation is solved in spherical and cylindrical co-ordinates.
Lecture-21.	**Multipole expansion:** Concepts of multipole is discussed here in context of both mathematical and physical origin. Very short introduction to Legendre Polynomial is also done here.
Lecture-22.	**Dipole and related quantities:** Here, potential, and electric field due to electric dipole are calculated. Also, force, torque and energy of a dipole in external electric field are calculated and orientation favourable configuration of a dipole in an external E are discussed.
Lecture-23.	**Quadrupole Moment:** Here, we computed Quadrupole moment of an arbitrary charge configuration and applied the same to some simple charge distributions. Few notes on zero Quadrupole moment are passed on.
Lecture-24.	**Dielectric material:** Orientational and induced polarization processes are discussed in this lecture and thus polarization vector is introduced.
Lecture-25.	**Polarized charge densities:** In this lecture, polarized volume and surface charge densities are related to polarization vector from both physical and direct mathematical formulation of potential.
Lecture-26.	**Displacement vector:** For few cases surface and volume polarized charge densities are calculated. Displacement vector (D) is defined in context of free charge density and a parallel form Gauss's law in vacuum is derived as. $$\vec{\nabla}.\vec{D} = \rho_f$$
Lecture-27.	**Gauss's law in dielectric:** In this lecture, integral form of Gauss's law in dielectric is computed and then applied on different symmetrical cases.
Lecture-28.	**Linear Dielectric:** Linear and non-linear types of dielectric mediums are first introduced and then linear medium is stressed with introduction of different quantities like susceptibility (χ), dielectric constant (ϵ). For linear

	dielectric medium, symmetric problems are solved using Gauss's law in dielectric medium.
Lecture-29.	**Boundary value problems in dielectric medium:** Boundary condition and boundary value problems are exercised in context for dielectric medium.
Lecture-30.	**Problems related to dielectric medium:** Energy stored in dielectric medium. Then different capacitors incorporating linear dielectrics are considered. Finally, the whole lesson on Electrostatics is being summarized.

Tutorial Assignment—2

Module-II

Magneto-statics (13 lectures)

Contents

Unit 1 Electric current as a source of magnetic field, Definition, and units (SI) of: Magnetic flux density B, Magnetic field strength H and Magnetization vector M, Relation between B, H and M, Magnetic susceptibility and magnetic permeability, Boundary conditions between two magnetic media, Force (Lorentz force) on a moving charge in the simultaneous presence of both electric and magnetic fields, Trajectory of a charged particle in a crossed uniform electric and magnetic fields.

Unit 2 Biot-Savart's Law and its applications: due to current in (*i*) a long straight conductor, a circular loop, a solenoid, Current loop as a magnetic dipole and its dipole moment.

Unit 3 -Ampere's circuital law and its applications: $\vec{}$ due to current in (*i*) a long straight conductor, a solenoid, and a toroid.

Unit 4 Magnetic force on (i) a current element, (ii) a line current, Force between two current elements, Divergence and Curl of B (Gauss and Ampere's laws), Physical significance of the nature of the divergence and curl of B, Magnetic vector potential

Module Objectives:

Magnetic field due to steady current i.e. Magnetostatics is the subject that students will learn from this module. Also in this module, the parallel construction of Magnetostatics with respect to Electrostatics is stressed in each step with would be justified latter since Electric and Magnetic fields are just two sides of a underlying coin (theory).

Serial No.	Topics of Discussion
Lecture-1.	**Lorenz force law:** Lorentz force law has two components: one that is covered in Electrostatics, the second part, i.e. magnetic component is dealt here. Charged particle in magnetic field is observed.
Lecture-2.	**Boit-Savart's law:** Biot-Savart's law gives an equation which dictates the origin of Magnetic fields. It is then written for different types of current sources and used for different configurations. Lorentz forces between current carrying loops are derived here.
Lecture-3.	$\nabla . B = 0$**:** In this lecture, magnetic field is shown to be solenoidal and it is interpreted physically.
Lecture-4.	**Continuity equation and Ampere's law)** Continuity equation id derived from principle of Charge conservation. Then, Ampere's law is obtained: $\nabla\times B = \mu_0 J$. Finally, Using Stokes's theorem, its integral counterpart is also derived.
Lecture-5.	**Application of Ampere's law**, Ampere's law in integral from is used to compute magnetic field for few symmetrical cases: Infinitely long straight current carrying wire, Current carrying infinite plane sheet, infinitely long Solenoid, Toroid.
Lecture-6.	**Vector potential in Magnetostatics:** Starting from Gauss law magnetic vector potential is proposed and gauge freedom is discussed. Finally, a closed form of A is calculated under Coulomb's gauge.

Lecture-7.	**More on potentials:** Magnetic vector potential is calculated for few current configurations and using them, magnetic fields are also computed. Magnetic scalar potential is defined and its limitations also being highlighted in terms of simply connected loops.
Lecture-8.	**Boundary conditions and multipole expansion:** In this lecture, magnetostatic boundary conditions are exercised. Then multipole expansion for a tiny current carrying loop is derived. First significant term in the expansion turns out to be dipolar which re-establishes the divergence free nature of magnetic field.
Lecture-9.	**Magnetic dipole:** Magnetic dipole moment is written in a form similar to that we used to get for electric dipoles (apart from the fact that one is a scalar and other is a vector quantity). Hence, dipole moment $m = I\triangle S$
Lecture-10.	**Dipoles continued:** Torque and energy of a magnetic dipole is computed in presence of external magnetic field. Then, assuming a simple model of electron spinning in a loop around nucleus, induced dipole moment is computed.
Lecture-11.	**Magnetostatics within matter:** Matters are classified according to their responses to external magnetic field: Dia, para, and Ferro magnetism. Bound surface and volume currents for a magnetized material is obtained using form of vector potential. Their physical meanings are also being discussed.
Lecture-12.	**Magnetostatics within matter II:** Physical origin of bound currents is analysed. Then concept of linear medium is introduced in this lecture.
Lecture-13.	**Magnetostatics within matter II:** Para and Dia magnetism are revisited with developed theories and ferromagnetism is explained with the help of domain theories. Then hysteresis loops have been discussed. Finally, a comparative table are formed to show parallel structures involving Electrostatics and Magnetostatics.

Tutorial Assignment—3

Module-III

Electromagnetic Induction (4 lectures)

Contents

Faraday's law, Lenz's law and conservation of energy, Motional EMF, Eddy current, Principle of power generation, Self-inductance and mutual inductance, Induction oven, Induction brake, Reciprocity theorem, Energy stored in a magnetic Field, Introduction to Maxwell's equations, Continuity equation.

Module Objectives:

To understand the mixing of Electric and Magnetic fields: The beginning of Electromagnetic theory.

Serial No.	Topics of Discussion
Lecture-1.	**Electromotive force:** Electromotive forces are discussed at the beginning and then its magnetic counterpart is analysed for a moving coil in a magnetic field. Faraday's law has been introduced in that context.
Lecture-2.	**Self and Mutual inductances** Self and mutual inductances are introduced here and those quantities are calculated for few configurations. Reciprocity theorem for Mutual-inductance is also highlighted.
Lecture-3.	**Energy stored in a Magnetic Field:** Magnetic field energy density is obtained in this lecture. Few problems related to that are also being solved.
Lecture-4.	**Maxwell's equations:** Correction in Ampere's law in dynamic situation is obtained mathematically using equation of continuity which incorporates a displacement current. Then the physical essence of the same is also discussed by taking a practical example of a parallel plate capacitor.

Module-IV **Transient current, Alternating Current, Network theorems, Electrical equipment** (11 lectures)	
Contents Growth and decay of currents in LR, CR and LCR circuits, Time constant AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. Network theorems: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.	
Module Objectives: To understand the circuits and related practical issues.	
Serial No.	**Topics of Discussion**
Lecture-1.	**AC vs DC circuits:** In this lecture, we apply our knowledge of Electromagnetism to differentiate between AC and DC circuits elements.
Lecture-2.	**Kirchoff's law in AC circuit:** Kirchoff's law has been used in context of AC circuit and idea of complex valued resistance which is called reactance is understood.
Lecture-3.	**Series LCR:** Different quantities like (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width of series LCR Circuit are analyzed.
Lecture-4.	**Parallel LCR:** Mechanical analog with spring-mass system is first clarified and then resonance criteria for parallel LCR circuit is obtained.
Lecture-5.	**Network theorems 1:** Concept of ideal Constant-voltage and Constantcurrent Sources being discussed. Then we discuss Thevenin's theorem.
Lecture-6.	**Network theorems 2:** In this lecture, Norton's and Maximum power transfer theorems are understood and applied for networks.
Lecture-7.	**Network theorems 3:** Reciprocity theorem, Maximum Power Transfer theorems are discussed here.
Lecture-8.	**Problem solving using Network theorems:** In this lecture different circuits are analyzed using theorems discussed in previous classes.
Lecture-9.	**Ballistic Galvanometer 1:** Galvanometers as measuring device and limitations of table Galvanometers are discussed. To begin understanding of Ballistic galvanometer, Torque on a current carrying loop due to external magnetic field is revisited
Lecture-10.	**Ballistic Galvanometer 2:** Current and Charge Sensitivity of Ballistic Galvanometer, its Electromagnetic damping, Logarithmic damping and CDR being introduced. Working with these galvanometers are demonstrated in laboratory (if possible).
Lecture-11.	**Concluding remarks** Here we finish this paper by summarizing different aspects that were discussed in classes and possible further readings of the same.

Tutorial Assignment—4

Course Outcome: At the end of this course, students will be able to comprehend the concept of electric field, electric flux, magnetic field, and their origin. They will learn to apply the Gauss's theorem to find the electric fields for different types of charge distribution. The students will develop a sound perception about Electrostatics, Magneto-statics, Electric current and electromagnetic induction.

Text books

1. Introduction to Electrodynamics - David J. Griffiths
2. Fundamentals of Electricity and Magnetism - Basudev Ghosh
3. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press

Reference books

1. The Feynman Lectures on Physics- Volume 2 - Feynman, Leighton, Sands.

Course Code: **PHYS3011**

Course Title: Electricity and Magnetism (Practical)

Module-I Electricity and Magnetism Practical
1. To verify the Thevenin's, Norton's and Maximum Power transfer theorems 2. To determine the Self-inductance of a coil using Anderson's bridge 3. To study the response curve of a series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor and (d) Band width 4. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor 5. Measurement of Charge Sensitivity and CDR of a Ballistic Galvanometer 6. Determination of a Ballistic Galvanometer Constant by Capacitor Charging-Discharging method 7. Construction of a One Ohm coil 8. Determination of a Ballistic Galvanometer Constant by the Solenoid method 9. Determination of Mutual Inductance of two coils by Carey-Foster's method.

Module Objectives:

1. To gain practical knowledge by applying the experimental methods to correlate with the theory of electricity and magnetism.
2. To apply the analytical techniques and graphical analysis to the experimental data.

Serial No.	Topics of Discussion
Lab-1.	1. To verify the Thevenin's, Norton's and Maximum Power transfer theorems
Lab-2.	2. To determine the Self-inductance of a coil using Anderson's bridge
Lab-3.	3. To study the response curve of a series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor and (d) Band width
Lab-4.	4. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor
Lab-5.	5. Measurement of Charge Sensitivity and CDR of a Ballistic Galvanometer
Lab-6.	6. Determination of a Ballistic Galvanometer Constant by Capacitor Charging-Discharging method
Lab-7.	7. Construction of a One Ohm coil
Lab-8.	8. Determination of a Ballistic Galvanometer Constant by the Solenoid method
Lab-9.	9. Determination of Mutual Inductance of two coils by Carey-Foster's method.

Department of Physics
Government General Degree College, Kalna -I

Lesson Plan
for
B.Sc. Semester-III
Subject: Physics
Paper Name: Waves and Optics
Paper Code: Major: PHYS3012

Credits: Theory-04, Practicals-01
F.M.=75 (Theory-40, Practical–20, Internal Assessment–15)

<table>
<tr><td colspan="2" align="center">Module-I
Superposition of Collinear Harmonic oscillations (5 lectures)</td></tr>
<tr><td colspan="2">Contents
Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.</td></tr>
<tr><td colspan="2">Module Objectives:
1. This unit aims to offer basic knowledge of linearity and superposition of multiple colinear SHM.
2. From this unit students can understand how the amplitude and phase of a resultant wave varies due to superposition of two or more colinear SHM.
3. Student can understand how Beats are formed</td></tr>
<tr><td>Serial No.</td><td>Topics of Discussion</td></tr>
<tr><td>Lecture-1.</td><td>Linearity and Superposition Principle: Linearity of SHM equation, Superposition principle, Superposition of harmonic oscillation, superposition of two colinear SHM with equal frequency. Determination of resultant amplitude and phase</td></tr>
<tr><td>Lecture-2.</td><td>Beats: superposition of two collinear SHM with different frequency, determination of amplitude and phase, condition of formation of beats, beat period, graphical representation of resultant amplitude variation with time and concept of wave packet</td></tr>
<tr><td>Lecture-3.</td><td>Superposition of N collinear Harmonic Oscillations: Superposition of N collinear SHM with equal amplitude, frequency and equal successive phase differences. Expression of the resultant wave, calculation of resultant amplitude and phase, Observation of the results for two terminal condition, $N >>$ and $N = 2$</td></tr>
<tr><td>Lecture-4.</td><td>Superposition of N collinear Harmonic Oscillations: Superposition of N collinear SHM with equal amplitude, phase constant and equal successive frequency differences, Expression of the resultant wave, calculation of resultant amplitude and phase</td></tr>
<tr><td>Lecture-5.</td><td>Discussion on few problems.</td></tr>
<tr><td colspan="2" align="center">Module-II
Superposition of two perpendicular Harmonic Oscillations (2 lectures)</td></tr>
<tr><td colspan="2">Contents
Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.</td></tr>
</table>

Module Objectives:
1. In This chapter Student can have an idea about how Lissajous figures are formed due to superposition of two perpendicular SHM, both analytically and graphically 2. They can get an idea about visualization of Lissajous figures in a CRO

Serial No.	Topics of Discussion
Lecture-1.	**Superposition of two perpendicular Harmonic Oscillations (Analytical method):** Analytical analysis of superposition of two perpendicular SHM with equal frequency, with frequency ratio 1:2 and 1:3 (Lissajous figure)
Lecture-2.	**Superposition of two perpendicular Harmonic Oscillations (Graphical method):** Graphical analysis of superposition of two perpendicular SHM with equal frequency, with frequency ratio 1:2 and 1:3 (Lissajous figure). Application of Lissajous figure.

Tutorial Assignment—1

Module-III **Coupled Oscillations** (3 lectures)	
Contents Stiffness coupled oscillators: two identical pendulums (each a light rigid rod of length l supporting a mass m) coupled by a weightless spring of stiffness s, Normal coordinates, Degrees of freedom, Normal modes of vibration, A large number (N) of coupled oscillators e.g., a light string fixed at both ends, supporting N equal masses spaced at equal distance along its length (Qualitative discussion without any mathematical details	
Module Objectives: 1. In this chapter Student can get clear idea about oscillation of two and large number of coupled oscillators.	
Serial No.	**Topics of Discussion**
Lecture-1.	**Two coupled oscillators**: two identical pendulums coupled by a weightless spring of stiffness s, Normal coordinates, Degrees of freedom, Normal modes of vibration,
Lecture-2.	**Large number of coupled oscillators:** Qualitative discussion about a large number (N) of coupled oscillators e.g., a light string fixed at both ends, supporting N equal masses spaced at equal distance along its length
Lecture-3.	Problems Discussion
Module-IV **One Dimensional Waves** (10 lectures)	
Contents Transverse oscillations (in a plane) of a slightly extensible, uniform string of mass per unit length ρ under a constant tension (T) with free ends: Equation of motion, Harmonic waves, Wavelength, Wave velocity or phase velocity, frequency, Group velocity, Particle velocity Oscillations of a string of fixed length l under a constant tension (T) with both ends rigidly clamped: Equation of motion, superposition of a wave moving along positive or negative x-axis and the wave reflected at either fixed end (discontinuity) with a π phase change in amplitude, Nature of oscillations: (a) All particles of the string execute simple harmonic oscillation about their equilibrium positions (points on the string at rest) at the same frequency, (b) The amplitude varies along the length of the string, (c) Nodes with zero amplitude and antinodes with a peak amplitude, (d) The positions of the nodes and antinodes do not change with time, superposition of an infinite number normal modes of different frequencies, The total energy of the vibrating string	

Module Objectives: 1. This chapter aims to understand how velocity of transverse waves is determined. 2. From this chapter one can understand the nature of oscillation of a string with both ends rigidly clamped 3. Student can understand clearly about normal modes of vibration for a stretched string	
Serial No.	**Topics of Discussion**
Lecture-1.	**Transverse waves**: Basic idea about transverse waves, equation of motion of transverse waves
Lecture-2.	**Velocity of transverse waves:** Frequency and Velocity of Transverse Vibrations of Stretched Strings,
Lecture-3.	**Velocity of transverse waves:** Alternative geometrical analysis for Velocity of Transverse Vibrations of Stretched Strings
Lecture-4.	**Oscillations of a string with both ends rigidly clamped**: Equation of motion or classical wave equation
Lecture-5.	**Oscillations of a string with both ends rigidly clamped:** superposition of a wave moving along positive or negative *x*-axis and the wave reflected at either fixed end (discontinuity) with a π phase change in amplitude,
Lecture-6	**Nature of oscillations:** (a) All particles of the string execute simple harmonic oscillation about their equilibrium positions (points on the string at rest) at the same frequency, (b) The amplitude varies along the length of the string, (c) Nodes with zero amplitude and antinodes with a peak amplitude, (d) The positions of the nodes and antinodes do not change with time
Lecture-7	superposition of an infinite number normal modes of different frequencies, The total energy of the vibrating string
Lecture-8	**Group velocity:** Wave group with a number of components of different frequencies, dispersive medium, Group velocity
Lecture-9	**Doppler Effect:** Fundamental principle of Doppler effect
Lecture-10.	Discussion on few problems

Module-V **Sound Waves in Gases, Elastic Waves in Bulk Solids** (5 lectures)	
Contents **Sound Waves in Gases**: Longitudinal disturbances in the pressure and density causing compressions and rarefactions of small volume elements of the gases, Deduction of the wave equation, Velocity of sound waves, The energy (kinetic, potential, total) distribution in space for a sound wave in a gas (qualitative idea), Intensity of sound waves and units, **Elastic Waves in Bulk Solids** Longitudinal and transverse modes, The wave equations for each mode, Velocity of waves in each mode	
Module Objectives: 1. This chapter aims to offer idea about stationary waves (both transverse and longitudinal). 2. Student can get clear idea about velocities of sound wave in gases. 3. Student can understand clearly about velocity of waves in Longitudinal and transverse modes	
Serial No.	**Topics of Discussion**
Lecture-1.	**Longitudinal Waves:** Longitudinal disturbances in the pressure and density causing compressions and rarefactions of small volume elements of the gases

Lecture-2.	**Velocity of Longitudinal Waves:** Deduction of the wave equation, Velocity of sound waves, Laplace's Correction (velocity of longitudinal waves in a gas in adiabatic condition
Lecture-3.	**Energy of Longitudinal Waves:** The energy (kinetic, potential, total) distribution in space for a sound wave in a gas
Lecture-4.	**Elastic Waves in Bulk Solids** Longitudinal and transverse modes, The wave equations for each mode,
Lecture-5.	**Velocity of elastic Waves in Bulk Solids** Velocity of waves in Longitudinal and transverse modes

Tutorial Assignment—2

Module-VI

Three-Dimensional Waves and Superposition of Harmonic Waves (5 lectures)

Three-Dimensional Waves

Wavefront-a surface of constant phase at a given instant of time, A plane wave, A spherical wave and cylindrical wave,

Superposition of Harmonic Waves

The wave equation supports the superposition principle, Superposition of electromagnetic waves treating the fields as scalar, Superposition of (a) Two harmonic plane waves of the same frequency – Idea of coherent sources and interference, (b) N harmonic waves with identical frequencies: (i) randomly phased sources of equal amplitudes, (ii) Coherent (constant phase relationship) sources of the same type) and in phase

Module Objectives:

1. This chapter aims to offer idea about wave front of different types of waves
2. One can understand Light propagation explained as rays in geometrical optics (deals with an image formation in different optical instruments) whereas electromagnetic waves in physical optics (deals with different phenomena as interference, diffraction, and polarization

Serial No.	Topics of Discussion
Lecture-1.	**Basic idea about wavefront:** Wavefront-a surface of constant phase at a given instant of time, Plane waves, Spherical waves, Cylindrical waves
Lecture-2.	**Huygens Principle:** Properties and classification of Wavefront. Huygens Principle and Propagation of Wavefronts
Lecture-3.	**Superposition of electromagnetic waves:** Two harmonic plane waves of the same frequency – Idea of coherent sources and interference
Lecture-4.	**Superposition of N harmonic waves with identical frequencies:** (i) randomly phased sources of equal amplitudes, (ii) Coherent (constant phase relationship) sources of the same type) and in phase
Lecture-5.	**Coherence:** Coherence time, Coherence length, The Temporal Coherence, The Spatial Coherence, Lateral coherence width

Module-VII **Interference** (10 lectures)
Contents Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. 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.
Module Objectives: 1. This module attempts to provide the fundamental idea of interference of light. 2. From this portion students can get a key idea about the division of amplitude and division of wavefront.

Serial No.	Topics of Discussion
Lecture-1.	**Introduction:** Superposition Principle, Spatial and temporal coherence, Condition for stable Intensity pattern. Methods of creating Interference. **Division of Wavefront:** Young's Double-Slit Experiment: Intensity Distribution.
Lecture-2.	**Young's Double-Slit Experiment:** The Interference Pattern, Shape of interference fringes,
Lecture-3.	**Fresnel Biprism:** Determination of wavelength through Fresnel Biprism experiment, Displacement of Fringes.
Lecture-4.	**Lloyd's Mirror & Stokes' treatment:** The Lloyd's Mirror arrangement and phase change on reflection, Stokes's relation.
Lecture-5.	**Division of Amplitude:** Interference Phenomenon in parallel thin film and wedge-shaped film. Cosine law. Fringe Width
Lecture-6.	**Haidinger Fringes:** Interference by a plane parallel film when illuminated by a point source and an extended source, Fringes of equal inclination.
Lecture-7.	**Fizeau Fringes:** Interference by a film with two non-parallel reflecting surface, Fringes of equal width.
Lecture-8.	**Newton's Rings:** Theory of Newton's rings, an arrangement for observing Newton's rings. Fringe width of Newton's Rings, Determination of wavelength of a monochromatic light and Determination of the refractive index of a liquid through Newton's Rings experiment
Lecture-9.	**Michelson Interferometer:** Michelson interferometer, Formation of the fringes, (No theory required), Applications: Determination of the (1) wavelength and (2) wavelength difference, (3) Refractive Index, Visibility of fringes.
Lecture-10	**Fabry-Perot interferometer:** Formation of the fringes, Intensity distribution, Resolving Power, Superiority over Michelson interferometer.

Tutorial Assignment—3

Module-VIII **Diffraction** (10 lectures)
Contents The Huygens–Fresnel principle, Diffraction and interference, Fresnel diffraction and Fraunhofer diffraction. Fraunhofer diffraction: Single slit diffraction, Double slit diffraction, N-slits diffraction or a diffraction grating, Rayleigh criterion for resolution, Resolving power of a grating, Grating spectra versus Prism spectra. 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, Fresnel's integral, Fresnel diffraction pattern of a straight edge, a slit and a wire

Module Objectives:
1. From this part, students can procure fundamental knowledge about the Fraunhofer diffraction pattern. 2. From this portion students can get a clear idea about diffraction grating. 3. This module attempts the basic knowledge on Fresnel diffraction which provides the clear idea of half-period zone, theory of zone plate as well as the multiple foci of a zone plate. 4. From this part, students can get an underlying idea about Fresnel diffraction pattern of a straight edge, a slit and a wire

Serial No.	Topics of Discussion
Lecture-1.	**Introduction:** The Huygens–Fresnel principle, Diffraction and interference, Fresnel diffraction and Fraunhofer diffraction.
Lecture-2.	**Single Slit Fraunhofer Diffraction Pattern:** Intensity distribution, Position of Maxima and Minima, Transcendental equation.
Lecture-3.	**Two-slit Fraunhofer Diffraction Pattern:** Intensity distribution, Position of Maxima and Minima, Missing order.
Lecture-4.	**N-slit Fraunhofer Diffraction Pattern:** Intensity distribution, Position of Maxima and Minima, Principal maxima, Missing order, Width of the Principal Maxima
Lecture-5.	**The Diffraction Grating:** Theory of grating, construction of grating, Spectrum of grating.
Lecture-6.	**Resolving Power of a Grating:** Rayleigh criterion, $R = mN$. Grating spectra versus Prism spectra.
Lecture-7.	**Fresnel Half-Period Zones:** Intensity calculation, Explanation of Rectilinear Propagation of Light, Diffraction by a circular aperture, The Poisson Spot
Lecture-8.	**The Zone Plate:** Principle of Zone Plate. Multiple Foci of a Zone Plate, Difference between convex lens and zone plate.
Lecture-9.	**Fresnel Diffraction at a Straight Edge:** Intensity distribution, Fringe width, Measurement of wavelength.
Lecture-10.	**Fresnel's Integral, Fresnel diffraction pattern of a slit and a wire** Intensity distribution.

Module-IX **Polarization of light** (10 lectures)
Contents Types of polarized light: Plane polarized light, circularly polarized light, elliptically polarized light, Production of polarized light (a) by reflection, Brewster angle, Malus law, (b) by dichroism, Polaroids, (c) by double refraction, doubly refracting crystals, Negative crystals, Positive crystals, Optic axis, Nicol prism, Huygen's theory of double refraction, Phase retardation plate: 1) Quarter wave plate 2) Half wave plate, Detection of plane, circularly and elliptically polarized light. Optical activity and its origin, Two types of optically active substance, Fresnel's theory of optical rotation, Polarimeter.
Module Objectives: 1. This module focusses on the fundamental idea of polarization of the electromagnetic waves which build up the clear idea of nature of the light. 2. From this portion student can get an elementary idea about the propagation of the E.M. Wave in an anisotropic media. 3. The phenomenon of double reflection helps the students to study how the E.M. Wave propagate in to the calcite crystal.

Serial No.	Topics of Discussion
Lecture-1.	**Nature of Polarized Wave:** Plane-polarized, Linear Polarized, Circular Polarized, Elliptical Polarized.

Lecture-2.	**Fresnel's Formula:** Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law.
Lecture-3.	**Production of polarized light:** Production of polarised light by reflection, Brewster angle, Malus law
Lecture-4.	**Birefringence:** Calcite, Optic axis, Ordinary rays, Extraordinary rays Uniaxial, Biaxial, Light Propagation in Uniaxial crystal,
Lecture-5.	**Polarizer:** Malus's Law, Polaroid
Lecture-6.	**Polarization by Double Refraction:** Construction of Nicol Prism, Ordinary & extraordinary refractive indices.
Lecture-7.	**Circularly and Elliptically Polarized Light:** Few problems on circular and elliptically polarized Light.
Lecture-8.	**Phase Retardation Plates:** Quarter-Wave and Half-Wave Plates.
Lecture-9.	**Optical Rotation:** Classical interpretation and Quantum interpretation, Biot's Laws for Rotatory Polarization.
Lecture-10.	**Fresnel's Theory of optical rotation:** Calculation of angle of rotation. Polarimeter

Tutorial Assignment—4

Course Outcome: The outcome of the paper includes the knowledge of vibrations, propagation of waves, vibrations of air column, and harmonics of the strings. The paper has another outcome of offering knowledge of wave properties of light & corresponding phenomena.

Text books

1. *Optics*, E. Hecht, and A. R. Ganesan, Pearson.
2. *Optics*, A. Ghatak, Mc Graw Hill Education

Reference books

1. *A Text Book on Light*, B. Ghosh, and K. G. Mazumdar, Sheedhar Publishers.

Course code: PHYS3012
Course Title: Waves & Optics (Practical)

Module-I Waves & Optics Practical
Contents 1. To draw n-l curve with the help of a sonometer and hence find the frequency of an unknown fork 2. Determination of the frequency of ac mains with a sonometer using a magnetic wire 3. Determination of the velocity of ultrasonic waves in a given liquid 4. To determine the refractive index of the material of a prism using sodium source 5. To determine the dispersive power and Cauchy constants of the material of a prism 6. To determine the wavelength of sodium light using Fresnel Biprism 7. To determine the wavelength of sodium light using Newton's Rings 8. Determination of the width of a single slit producing a Fraunhofer diffraction pattern 9. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using a plane diffraction grating 10. Calibration of a polarimeter and determination of the concentration of an active solution 11. To determine the resolving power of a plane diffraction grating
Module Objectives: 1. To obtain practical knowledge by applying the experimental methods to correlate with thetheory of waves. 2. To learn the usage of optical systems for various measurements.

Serial No.	**Topics of Discussion**
Lab-1.	To draw n-l curve with the help of a sonometer and hence find the frequency of an unknown fork
Lab-2.	Determination of the frequency of ac mains with a sonometer using a magnetic wire
Lab-3.	Determination of the velocity of ultrasonic waves in a given liquid
Lab-4.	To determine the refractive index of the material of a prism using sodium source
Lab-5.	To determine the dispersive power and Cauchy constants of the material of a prism
Lab-6.	To determine the wavelength of sodium light using Fresnel Biprism
Lab-7.	To determine the wavelength of sodium light using Newton's Rings
Lab-8.	Determination of the width of a single slit producing a Fraunhofer diffraction pattern
Lab-9.	To determine wavelength of (1) Na source and (2) spectral lines of Hg source using a plane diffraction grating
Lab-10.	Calibration of a polarimeter and determination of the concentration of an active solution
Lab-11.	To determine the resolving power of a plane diffraction grating

Department of Physics

Government General Degree College, Kalna -I

Lesson Plan

for

B.Sc. Semester-III

Subject: Physics

Paper Name: Basic Instruments and their Usage

Paper Code: SEC-3: PHYS3051

Credits: Theory-03

F.M.=50 (Theory-40, Internal Assessment-10)

Course Objective: This course is designed to give the students an exposure with various aspects of electrical and optical instruments and their applications in experimental physics.

Module-I

Electrical/ Electronic Instruments

Contents

Unit 1 Voltage and current sources, Principles of measurement of dc voltage & current, ac voltage & current and a resistance, Specifications of an electronic voltmeter/ multi-meter and their significance, Advantages of electronic voltmeter over conventional multi-meter for the measurement of voltage, Instrumental accuracy, Precision, Sensitivity, Resolution, Range *etc*., Errors in measurements and loading effects.

Unit 2 Cathode Ray Oscilloscope: Block diagram of basic CRO, Time base operation, Synchronization, Front panel controls, Specifications of a CRO and their significance, Use of CRO for the measurement of voltage (dc and ac), frequency, Special feature of dual trace.

Unit 3 Signal Generators: Block diagram, Explanation and specifications of low frequency signal generators, Pulse generators and function generators.

Unit 4 Digital Instruments: Principle and function of a digital meter, Characteristics of a digital meter, Comparison of Analog & Digital instruments.

Module Objectives:

1. Acquire Knowledge about fundamental electrical concepts
2. Analyze circuit components and Apply circuit analysis techniques

Lecture Serial	Topics of Discussion
Lecture-1.	Basic idea on Voltage, Current, Resistance, and Power.
Lecture-2.	Ohm's law. Series, parallel, and series-parallel combinations of resistance
Lecture-3.	Basic idea on AC Electricity and DC Electricity
Lecture-4.	Idea about Volmeter and ammeter
Lecture-5.	Measurment current and voltage with multimeter
Lecture-6.	Instrumental accuracy, Precision, Sensitivity, Resolution, Range *etc*.,
Lecture-7.	Errors in measurements and loading effects

Lecture-8.	Cathode Ray Oscilloscope: Block diagram of basic CRO, Basic Principle of CRT, Use of CRO for the measurement of voltage (dc and ac), frequency, Special feature of dual trace
Lecture-9.	Time base operation, Synchronization, Front panel controls, Specifications of a CRO
Lecture-10.	Significance of Time base operation, Synchronization, Front panel controls, Specifications of a CRO
Lecture-11.	Use of CRO for the measurement of voltage (dc and ac)
Lecture-12.	Use of CRO for the measurement of frequency
Lecture-13.	Special feature of dual trace in CRO
Lecture-14.	Signal Generators: Block diagram, Basic principle of operation
Lecture-15.	Explanation and specifications of low frequency signal generators,
Lecture-16	Pulse generators and function generators
Lecture-17	Digital Instruments: Principle and function of a digital meter
Lecture-18	Characteristics of a digital meter
Lecture-19	Comparison of Analog & Digital instruments
Lecture-20	To realize the importance of grounding, earthing, and the methods for earthing
Lecture-21	Recapitulation of Electrical/ Electronic Instruments
Lecture-22	Discussion of probable questions on Electrical/ Electronic Instruments

Module-II

Optical Instruments

Contents

Unit 1 Optical microscope: Simple microscope, Compound microscope, Electron microscope: Principal components, working principle and uses.

Unit 2 Telescope: Principal components, working principle and uses of different types of telescopes (Astronomical telescope, Terrestrial telescope, Reflecting telescope).

Unit 3 An objective lens and an eyepiece or ocular lens: Elements, Angular magnification of a telescope, Angular magnification of a microscope, Huygens eyepiece, Ramsden eyepiece.

Unit 4 Spectrometer: Principal components, Role of individual components, Uses, Ultraviolet-Visible (UV-VIS), Near-infrared (NIR) and Raman spectrometers.

Module Objectives:	
1. Grasp fundamental concepts of Ray Optics 2. Analyse and apply Optical analysis techniques for Optical instruments	
Lecture Serial	**Topics of Discussion**
Lecture-1.	Optical microscope: Simple microscope, Compound microscope, Electron microscope.
Lecture-2.	Principal components of different microscopes
Lecture-3.	working principle of different microscope and their uses.
Lecture-4.	Telescope: Principal components and fundamental concepts
Lecture-5.	working principle and uses of Astronomical telescope
Lecture-6.	working principle and uses Terrestrial telescope
Lecture-7.	working principle and uses Reflecting telescope
Lecture-8.	An objective lens and an eyepiece or ocular lens
Lecture-9.	Angular magnification of a microscope
Lecture-10.	Angular magnification of a telescope
Lecture-11.	Huygens eyepiece, Ramsden eyepiece
Lecture-12.	Spectrometer: Principal components
Lecture-13.	Role of individual components of a Spectrometer
Lecture-14.	Ultraviolet-Visible (UV-VIS) Spectrometer
Lecture-15.	Near-infrared (NIR) Spectrometer
Lecture-16	Raman effect
Lecture-17	Raman spectrometers
Lecture-18	To know about the telescopes used at different observatories in and outside India
Lecture-19	Recapitulation of Optical Instruments
Lecture-20	Discussion of probable questions on Optical Instruments

Course Outcome: After completion of this course, the students will gain knowledge the in setting up electrical and optical experiments

Reference Books:

1. Modern electronic instrumentation and measurement techniques India, Albert D Helfrick & William D Cooper 1992, Prentice Hall India Learning Private Limited.
2. Basic Electrical and Electronics Engineering, S. K. Bhattacharya, 2011, Pearson Education India.
3. The Theory of Optical Instruments, E T Whittaker, 2023, Mjp Publishers