

Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B. Sc. Degree Program in Physics

(Faculty of Science & Technology)

S. Y. B. Sc. (Physics)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2020-2021

SEMISTER-III

Course code and title: PHY-231: Mathematical Methods in Physics-I

Total Lectures: 36 (Credits-02)

Learning Outcomes: After the completion of this course students will be able to

- Understand the complex algebra useful in physics courses.
- Understand the concept of partial differentiation.
- Understand the role of partial differential equations in physics.
- Understand vector algebra useful in mathematics and physics.
- Understand the concept of singular points of differential equations.

1. ComplexNumbers

(9L)

- **1.1** Introduction to complex numbers
- **1.2** Rectangular, polar and exponential forms of complex numbers
- 1.3 Argand diagram
- **1.4** Algebra of complex numbers using Argand diagram
- **1.5** De-Moivre's Theorem (Statement only)
- **1.6** Power, root and log of complex numbers
- **1.7** Trigonometric, hyperbolic and exponential functions
- **1.8** Applications of complex numbers to determine velocity and acceleration in curved motion.
- 1.9 Problems.

2. Partial Differentiation

(9L)

- **2.1** Definition of partial differentiation
- 2.2 Successive differentiation
- 2.3 Total differentiation
- 2.4 Exact differential
- 2.5 Chain rule
- **2.6** Theorems of differentiation
- **2.7** Change of variables from Cartesian to polar co-ordinates
- **2.8** Conditions for maxima and minima(without proof)
- 2.9 Problems.

3. Vector Algebra and Analysis

(12L)

3.1 Introduction to scalars and vectors,dot product and cross product of two vectors and their physical significance. (Revision)

- **3.2** Scalar triple product and its geometrical interpretation
- 3.3 Vector triple product and its proof
- 3.4 Scalar and vector fields
- **3.5** Differentiation of vectors with respect to scalar
- **3.6** Vector differential operator and Laplacian operator
- **3.7** Gradient of scalar field and its physical significance
- 3.8 Divergence of scalar field and its physical significance
- **3.9** Curl of vector field and its physical significance.
- 3.10 Vector Identities.

a.
$$\nabla X (\nabla \Phi) = 0$$

b.
$$\nabla . (\nabla XV) = 0$$

c.
$$\nabla \cdot (\nabla \Phi) = \nabla^2 \Phi$$

d.
$$\nabla .(\Phi A) = \nabla \Phi .A + \Phi (\nabla .A)$$

e.
$$\nabla X (\Phi A) = \Phi (\nabla X A) + (\nabla \Phi) X A$$

f.
$$\nabla$$
.(AXB) = B.(∇ XA) - A(∇ XB)

3.11 Problems.

1.1 **4. Differential Equation**

(6L)

- **4.1** Degree, order, linearity and homogeneity of differential equation.
- **4.2** Concept of Singular points. Example of singular points (x = 0, $x = x_0$ and $x = \infty$) of differential equation.
- 4.3 Problems.

1.2 **Reference Books:**

- 1. Methods of Mathematical Physics by Laud, Takwale and Gambhir.
- **2.** Mathematical Physics by B.D.Gupta.
- 3. Mathematical Physics by Rajput and Gupta.
- **4.** Mathematical Methods in Physical Science by Mary and Boas.
- **5.** Vector analysis by Spiegel and Murrey.
- **6.** Mathematical Methods for Physicists by Arfkenand Weber. (5th Edition)
- 7. Fundamentals of Mathematical Physics by A.B.Gupta.
- 8. Vector Analysis by Seymour Lipschutz and Dennis Spellman.

Course code and title: PHY-232: Electronics

Total Lectures: 36 (Credits-02)

N.B: This course is for students who have not taken Electronic Science as one of the subjects at F. Y. B. Sc.

Learning outcomes:

On successful completion of this course the students will be able to

- Apply different theorems and laws to electrical circuits.
- Understand the relations in electricity.
- Understand the parameters, characteristics and working of transistors.
- Understand the functions of operational amplifiers.
- Design circuits using transistors and applications of operational amplifiers.
- Understand the Boolean algebra and logic circuits.

1. Network Theorem (6L)

- 1.1 Krichhoff's Law
- 1.2 Voltage and current Divider Circuit
- 1.3 Thevenin's Theorem
- 1.4 Norton's Theorem
- **1.5** Superposition Theorem
- **1.6** Maximum Power transfer theorem (With proof)
- 1.7 Problems

2. Study of Transistor

(12L)

- **2.1** Bi-junction Transistor
 - 1. Revision of bipolar Junction Transistor, Types, Symbol and basic action.
 - 2. Configuration (Common Base, Common Emitter and Common Collector)
 - 3. Current Gain Factors (α and β) and their relations
 - 4. Input, Output and transfer Characteristic of CE Configuration
 - 5. Biasing method and Voltage Divider
 - **6.** DC Load line (CE), Operating Point (Q-point)
 - 7. Transistor as a switch
 - 8. Problems

2.2 Uni-Junction Transistor

- 1. Symbol, Types, Construction, Working Principle, I-V characteristics, Specifications and Parameters of Uni-Junction Transistor (UJT)
- **2.** UJT as a relaxation Oscillator.

3. Operational Amplifiers and Application

(12 L)

3.1 Operational Amplifiers

- 1. Introduction
- 2. Ideal and practical Characteristics
- 3. Operational Amplifier: IC741- Block Diagram and Pin diagram
- 4. Concept of Virtual Ground
- 5. Inverting and Non-inverting operational amplifiers with concept of gain
- **6.** Operational amplifier as an adder and subtractor
- 7. Problems
- 3.2 Oscillators
 - 1. Concept of Positive and negative feed back
 - 2. Barkhausein Criteria for an oscillator
 - 3. Construction, working and application of phase shift oscillator using IC741
 - 4. Problems

4. Number System and Logic Gates

(6 L)

- 1. Number System: Binary, Binary coded Decimal (BCD), Octal, Hexadecimal
- 2. Addition and Subtraction of binary numbers and binary fractions using one's and two's complement
- **3.** Basic Logic gates (OR, AND, NOT)
- 4. Derived gates: NOR, NAND, EXOR, EXNOR, with symbols and truth table
- 5. Boolean Algebra
- **6.** De Morgan's theorem and its verification
- 7. Problems

Reference Books-

- 1. Electronic Principles, Malvino, 7th Edition Tata Mc-Graw Hills publication.
- 2. Principles of Electronics, V.K. Mehta, S. Chand publication.
- **3. Op-amp and Linear Integrated Circuit**, Ramakant Gaikwad, Prentice Hall of India publication.
- **4. Integrated Circuit,** Botkar, Khanna Publication, New Delhi.
- **5. Digital Principles and Application**, Malvino and Leech, Tata Mc-Graw Hills publication.

Course code and title: PHY-232: Instrumentation

Total Lectures: 36 (Credits-02)

N.B: This course is for students who have taken Electronic Science as one of the subjects at F. Y. B. Sc.

Learning outcomes:

After successful completion of this course, the student will be able to

- Understand the concept of measurement.
- Understand the performance of measuring instruments.
- Design experiments using sensors.

1. Fundamental of measurement

(8L)

- 1.1 Aims of measurement
- 1.2 Functional elements of typical measurement system (Block diagram and its explanation).
- **1.3** Standards of measurement and its classification. (International, primary or national, secondary and working standards).
- **1.4** Static characteristics: Accuracy, Precision, Sensitivity, Linearity, Resolution, Drift and Hysteresis.
- 1.5 Dynamic characteristics concepts: First and Second order instruments, Examples of first order: Resistance thermometer and thermal element, Example of 2nd order: U-tube Manometer.
- **1.6** Errors in measurement and its classifications.
- 1.7 Problems

2. Transducers (12L)

2.1 Classification of Transducers and its characteristics

2.2 Displacement Transducer

- a) Resistive Type: Linear and Angular (Rotary) Potentiometer, Strain Gauge: Bonded and Unbonded
- **b)** Inductive Type: Self inductive: Variable number of turns, Variable Reluctance Mutual Inductive: LVDT
- c) Piezoelectric Type: Quartz Crystal
- **2.3 Force Transducer**: Cantilever beam, Column type devices

2.4 Temperature Measurement

Scales for temperature: Celsius, Kelvin and Fahrenheit

Temperature Measurement Techniques

- a. Non-electrical: Liquid filled thermometer and bimetallic thermometer
- **b.** Electrical Methods:

i. Platinum Resistance Thermometer

Types of Thermocouple

- **ii.** Thermistor: PTC and NTC with characteristics
- **iii.** Thermocouple: Seebeck effect and Peltier effect,

3. Measurement of Pressure

(8L)

- **3.1** Unit of pressure, Concept of vacuum, Absolute gauge and differential pressure,
- 3.2 Elastic Transducer- Diaphragm, Corrugated Diaphragm, Bellows, Bourdon Tube
- **3.3** Electric Type- LVDT, Strain gauge
- **3.4** Pressure Transducer- Calibration by dead weight tester Method
- 3.5 Problems

4. Signal Conditioning and Processing

(8L)

- **4.1** Current to voltage, Voltage to current convertors, buffer amplifier, S/H Amplifier and Characteristics, Acquisition time, Aperture time, Drop rate
- **4.2** Filters: First order LPF and HPF with design,
- **4.3** Instrumentation Amplifier (Using 3 op-amp)

Reference Books:

- 1. Instrumentation Device and System, Rangan, Mani and Sarma, Tata Mc Graw Hill
- **2. Instrumentation Measurement and Analysis**, Nakra, Choudhari, Tata Mc Graw Hill India publication.
- 3. Sensors and Transducers, D. Patranabis, PHI publications.
- **4. Op-Amps and Linear Integrated Circuits**, by Ramakant A. Gayakwad, Pearson India publications.
- 5. Process control Instrumentation Technology, C.D. Johnson, PHI publications.

Course code and title: PHY-233: Practical Course (Laboratory 2A)

Learning Outcome: (Credits-02)

After completing this practical course students will be able to

- Use various instruments and equipment.
- Design experiments to test a hypothesis and/or determine the value of an unknown quantity.
- Investigate the theoretical background of an experiment.
- Setup experimental equipment to implement an experimental approach.
- Analyze the data, plot appropriate graphs and reach conclusions from data analysis.
- Work in a group to plan, implement and report on a project/experiment.
- Keep a well-maintained and instructive laboratory logbook.

Total Experiments to be performed by a student: (A) 10 OR (B) 8 + Two Activities

- (A): At least 6 experiments from Section I and 2 experiments from Section II
- (B): At least 4 experiments from Section I and 2 experiments from Section II + Any Two Activities

Section I: Electronics/Instrumentation

- 1. Circuit Theorems (Thevenin's, Norton's and Maximum Power Transfer Theorems)
- 2. Transistor Characteristics(Input and Output characteristics of CE Configuration)
- 3. Single Stage Transistor Amplifier
- 4. Study f Rectifiers (Half, Full Wave and Bridge) with different filters
- 5. I-V Characteristics of UJT/ UJT as Relaxation Oscillator
- **6.** Zener as a Regulator (Line and Load Regulation)
- 7. Op-amp as inverting and non-inverting amplifier
- 8. Study of Wein Bridge / Phase Shift Oscillator using 741
- **9.** Op-amp as an adder and subtractor
- 10. Study of logic gates and verification of de Morgan's theorems
- 11. To measure displacement using potentiometer/variable inductor/ variable capacitor
- **12.** Use of CRO(AC/DC Voltage measurement, Frequency measurement)
- **13.** To measure force using load cell
- 14. To measure pressure using elastic diaphragm(In Variable Capacitor / Bourdon Tube)

15. To measure magnetic field using Hall Probe for a system of ring magnets

Section II: Use of Computer

- 1. Plotting of various trigonometric functions using spread sheet/any graphic software viz. Microsoft Excel, Origin: sinx, cosx, tanx,e^X, e^{-X}, logx, lnx, xⁿ
- 2. Plotting of conic sections using spreadsheet /any graphic software viz. Microsoft Excel, Origin: circle, ellipse, parabola, hyperbola
- **3.** Inverse, determinant of matrix, solution of linear equations using Microsoft Excel or Origin software

Additional Activities (Any two)

- 1. Plotting of any **two** graphs using spreadsheets (of data obtained from various experiments performed by the student)
- 2. Any two computer aided demonstrations (Using computer simulations or animations)
- **3.** Demonstrations-Any **two** demonstrations
- 4. Study tour with report
- 5. Mini project

SEMISTER-IV

Course code and title: PHY-241: Oscillations, Waves, and Sound

Total Lectures: 36 (Credits-02)

Learning Outcomes:

On completion of this course, the learner will be able:

- To study underlying principles of oscillations and it's scope in development.
- To understand and solve the equations / graphical representations of motion for simple harmonic, damped, forced oscillators and waves.
- To explain oscillations in terms of energy exchange with various practical applications.
- To solve numerical problems related to undamped, damped, forced oscillations and superposition of oscillations.
- To study characteristics of sound, decibel scales and applications.

1. Undamped Free Oscillations

(7L)

- **1.1** Different types of equilibria (static, dynamic, stable, unstable, and metastable equilibrium) definitions only with examples.
- 1.2 Definitions of linear Simple Harmonic Motion (S.H.M) and angular S.H.M.
- **1.3** Differential equation for linear S.H.M. and it's solution.
- **1.4** Composition of two perpendicular linear S.H.Ms. for frequency ratio 1:1 and 2:1 (analytical method).
- **1.5** Lissajous figures, their demonstration (optical and electrical method) and applications.
- 1.6 Problems.

2. Damped Oscillations

(7L)

- 2.1 Introduction
- **2.2** Differential equation for damped harmonic oscillator and it's solution, discussion of different cases.
- **2.3** Logarithmic decrement.
- **2.4** Average energy of damped harmonic oscillator.
- **2.5** Quality factor.
- **2.6** Application: LCR series circuit.
- 2.7 Problems.

3. Forced Oscillations

(**8L**)

- **3.1** Introduction.
- **3.2** Differential equation for forced oscillations and it's solution .
- **3.3** Resonance: mechanical, acoustic and electrical.
- **3.4** Velocity and Amplitude resonance.
- **3.5** Sharpness of resonance and half width.

- **3.6** Average energy of forced oscillator.
- **3.7** Quality factor of forced oscillator.
- **3.8** Relation between quality factor and bandwidth.
- **3.9** Application of forced oscillations- LCR series circuit.
- 3.10 Problems.

4. Wave Motion (6L)

- 4.1 Introduction.
- **4.2** Equation for longitudinal waves and it's solution (one dimension only).
- **4.3** Equation for transverse waves and it's solution (one dimension only).
- **4.4** Energy density and intensity of a wave.
- **4.5** Qualitative discussion of seismic waves and gravitational waves.
- 4.6 Problems.

5. Sound and Doppler Effect

(8L)

- **5.1** Definition of sound Intensity, Loudness, Pitch, Quality and timbre.
- **5.2** Reverberation time and reverberation of hall.
- **5.3** Sabine's formula (without derivation).
- **5.4** Doppler effect in sound, Expression for apparent frequency in different cases.
- **5.5** Asymmetric nature of Doppler effect in sound.
- **5.6** Doppler effect in light, Symmetric nature of Doppler effect in light.
- **5.7** Applications: Radar, Speed of distant star, Rotational speed of binary star, Red Shift and Width of spectral line.
- **5.8** Problems.

Reference Books:

- 1. Waves and Oscillations by Stephenson.
- 2. The Physics of Waves and Oscillations by N. K. Bajaj, Tata McGraw-Hill, publication.
- **3.** Fundamentals of Vibrations and Waves by S. P. Puri, Tata McGraw-Hill publication.
- **4. A Text Book of Sound** by Subramanyam and Brijlal, Vikas Prakashan.
- **5. Sound** by Mee, Heinmann Edition, London.
- **6.** Waves and Oscillations R.N. Chaudhari, New Age International (p) ltd.
- **7.** A Textbook on Oscillations, Waves and Acoustics by M. Ghosh, and D. Bhattacharya, S. Chand and Company Ltd.

Course code and title: PHY-242: Optics

Total Lectures: 36 (Credits-02)

Learning Outcomes:

On successful completion of this course the students will be able to

- Acquire the basic concept of wave optics.
- Describe how light can constructively and destructively interfere.
- Explain why a light beam spread out after passing through an aperture
- Summarize the polarization characteristics of electromagnetic wave
- Understand the operation of many modern optical devices that utilize wave optics
- Understand optical phenomenon such polarization, diffraction and interference in terms of the wave model
- Analyze simple example of interference and diffraction.

1. Geometrical optics

(8L)

- **1.1** Introduction to lenses and sign conventions.
- **1.2** Thin lenses: lens equation for convex lens
- 1.3 Lens maker equation
- **1.4** Concept of magnification, deviation and power of thin lens
- **1.5** Equivalent focal length of two thin lenses
- **1.6** Concept of cardinal points
- 1.7 Problems.

2. Lens Aberrations

(8 L)

- **2.1** Introduction
- **2.2** Types of aberration: Monochromatic and chromatic
- **2.3** Types of monochromatic aberrations and their reductions
- **2.4** Types of chromatic aberrations
- **2.5** Achromatism: lenses in contact and separated by finite distance
- 2.6 Problems.

3. Optical Instruments

(6L)

- **3.1** Introduction
- **3.2** Simple Microscope
- 3.3 Compound Microscope
- **3.4** Ramsden's eye piece
- 3.5 Huygens eye piece
- 3.6 Problems.

4. Interference and Diffraction

(8L)

4.1 Introduction

- **4.2** Phase change on reflection. (Stokes treatment)
- **4.3** Interference due to wedge shaped thin film
- **4.4** Newton's ring
- **3.5** Diffraction types: Fresnel's diffraction and Fraunhoffer's diffraction
- **4.6** Fraunhoffer's diffraction at single slit
- **4.7** Plane diffraction grating, Rayleigh criterion for resolution
- 4.8 Problems

5. Polarization (6L)

- **5.1** Introduction
- 5.2 Brewster's law
- 5.3 Law of Malus
- **5.4** Polarization by double refraction.
- **5.5** Nicol Prism
- 5.6 Problem

Reference Books:

- **1. Optics** by A. R. Ganesan, IVth edition, Pearson Education, E. Hetch.
- **2. A Textbook of Optics** by N Subhramanyam, Brijlal, M. N. Avadhanulu, S. Chand Publication
- 3. Physical Optics by A.K. Ghatak, McMillan, New Delhi
- **4. Fundamental of Optics** by F. A.Jenkins, H. E.White Mc Graw-Hilll International edition
- **5. Principles of Optics**, by D. S. Mathur, Gopal Press, Kanpur.

Course code and title: PHY-243: Practical Course (Laboratory 2B)

Learning Outcome: (Credits-02)

After completing this practical course students will be able to

- Use various instruments and equipment.
- Design experiments to test a hypothesis and/or determine the value of an unknown quantity.
- Investigate the theoretical background of an experiment.
- Setup experimental equipment to implement an experimental approach.
- Analyze the data, plot appropriate graphs and reach conclusions from data analysis.
- Work in a group to plan, implement and report on a project/experiment.
- Keep a well-maintained and instructive laboratory logbook.

Total Experiments: (A) 10 OR (B) 8 + Two Activities

- (A): 5 experiments from Section I and 5 experiments from Section II
- (B): 4 experiments from Section I and 4 experiments from Section II + Any Two Activities

Section I: Oscillations, Waves and Sound

- **1.** Logarithmic decrement (in air and water).
- 2. Study of coupled oscillators comprising two simple pendulum (Mechanical) and determination of coupling coefficient.
- 3. 'g' by bar pendulum.
- **4.** Study of musical scales using a signal generator and musical instruments.
- **5.** Measurement of coefficient of absorption of sound for different materials (cork, thermocol, mica, paper etc.).
- **6.** Study of Lissajous figures and determination of unknown frequency.
- 7. Determination of speed of sound by Quincke's method interferometer.
- **8.** Directional characteristics of Microphone.
- **9.** Velocity of sound by Phase shift method.
- **10.** To determine the frequency of an electrically maintained tuning fork by stroboscopic method.
- 11. To Determine the velocity of sound in air at room temperature with Kundt's Tube.

Section II: Optics

- 1. Newton's Ring: Determination of wavelength of monochromatic light source (λ).
- 2. Dispersive power of glass prism.
- 3. Total internal reflection using LASER beam and glass prism.
- **4.** Diffraction at the edge of a razor blade.
- **5.** Optical activity of sugar solution using polarimeter.
- **6.** Goniometer to determine cardinal points and focal length.
- **7.** To determine temperature of sodium flame.
- **8.** Double refracting prism.
- **9.** Determination of Cauchy.s constant.

1.3 Additional Activities (Any two)

- **1.** Plotting of any **two** graphs using spreadsheets (of data obtained from various experiments performed by the student).
- 2. Any two computer aided demonstrations (Using computer simulations or animations).
- **3.** Demonstrations –Any **two** demonstrations.
- **4.** Study tour with report.
- 5. Mini project.