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. ∇ X ($\nabla\Phi$) = 0

b. ∇.(∇XV) = 0

c. ∇.($\nabla\Phi$) =$\nabla^2\Phi$

d. ∇.(ΦA) =$\nabla\Phi$.A+Φ(∇.A)

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

f. ∇.(AXB) = B.(∇XA) - A(∇X B)

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 = ∞) 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 2^{nd} 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

ii. Thermistor: PTC and NTC with characteristics

iii. Thermocouple: Seebeck effect and Peltier effect,
Types of Thermocouple

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, x^{n}
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.