FYUG(Physics) Course Curriculum Structure and syllabus for 1st Semester

Year	Semester	Major (Credit)	Minor (Credit)	MDC (Credit)	AEC (Credit)	SEC*/ Dissertation (Credit)	Experiential Learning (Credit)	VAC (Credit)	Total Credits	Additional Summer Internship
I	I	Major – 1 (4) (Level 100) MJC45PHY101(T)25 : Mechanics (Credit: 03) MJC45PHY101(P)25 : Mechanics (Credit: 01)	Minor – 1 (4) (Level 100) MNC45PHY101(T)25: Mechanics (Credit: 03) MNC45PHY101(P)25: Mechanics (Credit: 01)	MDC - 1 (3) MDC45PHY101 (T)25 Introduction to Physics: (Credit:03)	AEC – 1 (Communication Skills) (4)	SEC – 1 (3) Computational Physics: SEC45PHY101a(T) 25 (Credit: 02) + SEC45PHY101a(P) 25 (Credit: 01) **Or** Electrical Circuits and Network Skills: SEC45PHY101b(T) 25 (Credit: 02) + SEC45PHY101b(P) 25 (Credit: 01)		VAC – 1 (2)	20	Additional for Bachelor's Certificate (4)

Course title: Mechanics
Credit: 04 (3+1)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

This course introduces the foundational theories, concepts, and principles of mechanics from a more advanced perspective. The topics covered include Newton's Laws of Motion, Rotational Dynamics, Gravitation and Central Force Motion, Non-inertial Systems, Special Theory of Relativity, etc. The students will be able to apply the concepts learnt to several real world problems.

Course Learning Outcomes

Upon completion of this course, students are expected to

- Understand laws of motion and their applications to various dynamical situations.
- Learn the concept of inertial reference frames and Galilean transformations. Also, the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- Understand translational and rotational dynamics of a system of particles.
- ApplyKepler'slaws to describe the motion of planets and satellite in circular orbit.
- Explain the phenomenon of simple harmonic motion (SHM).
- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.

In the practical component, the student shall perform experiments related to mechanics: compound pendulum, rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity), fluid dynamics, estimation of random errors in the observations, etc.

MJC45PHY101(T)25: Mechanics
Credit: 03
Theory: 45 Hours

Unit 1

Fundamentals of Dynamics: Reference frames, Inertial frames, Galilean transformations, Galilean invariance, Review of Newton's Laws of Motion. Momentum of variable mass system: motion of rocket. Determination of Centre of Mass of discrete and continuous objects having cylindrical and spherical symmetry (1-D, 2-D & 3-D).

(5 Lectures)

Unit 2

Work and Energy: Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Work done by non-conservative forces. Law of conservation of Energy.

(4 Lectures)

Unit 3

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of inertia, theorem of parallel and perpendicular axes. Determination of moment of inertia of discrete and continuous objects having cylindrical and spherical symmetry (1-D, 2-D & 3-D). Kinetic energy of rotation. Motion involving both translation and rotation.

(8 Lectures)

Unit 4

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Two-body problem, its reduction to one- body problem and its solution. Reduction of angular momentum, kinetic energy and total energy. The energy equation and energy diagram. Kepler's Laws.

(8 Lectures)

Unit 5

Oscillations: Idea of SHM. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Compound pendulum. Damped oscillations. Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor.

(6 Lectures)

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications.

(4 Lectures)

Unit 6

Special Theory of Relativity: Michelson-Morley Experiment (only qualitative description) and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity, Length contraction, and Time dilation. Relativistic transformation of velocity, acceleration, frequency and wave number. Mass of relativistic particle, massless particles, mass-energy equivalence and relativistic Doppler effect (transverse and longitudinal).

(10 Lectures)

MJC45PHY101(P)25: Mechanics
Credit: 01
Practical: 30 Hours

Practical: 30 Hours

Demonstration cum laboratory sessions on the construction and use of Vernier callipers, screw gauge and travelling microscope, and necessary precautions during their use.

Sessions and exercises on the least count errors, their propagation and recording in final result up to correct significant digits, linearization of data and the use of slope and intercept to determine unknown quantities.

Session on the writing of scientific laboratory reports, which may include theoretical and practical significance of the experiment performed, apparatus description, relevant theory, necessary precautions to be taken during the experiment, proper recording of observations, data analysis, estimation of the error and explanation of its sources, correct recording of the result of the experiment, and proper referencing of the material taken from other sources (books, websites, research papers, etc.)

At least 06 experiments from the following

1. Measurements of length (or diameter) using Vernier Calliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the value of g using Bar Pendulum.
4. To determine the value of g using Kater's Pendulum.
5. To determine the height of a building using a Sextant.
6. To study the motion of the spring and calculate (a) Spring constant and, (b) g.
7. To determine the Moment of Inertia of a Flywheel.
8. To determine g and velocity for a freely falling body using Digital Timing Technique.
9. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
10. To determine the Young's Modulus of a Wire by Optical Lever Method.
11. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
12. To determine the elastic Constants of a wire by Searle's method.

References for Theory- Essential Readings:

1. An Introduction to Mechanics (2/e), Daniel Kleppner & Robert Kolenkow, 2014, Cambridge University Press.
2. Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education.
3. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw Hill Education.
4. Intermediate Dynamics, Patrick Hamill, 2010, Jones and Bartlett Publishers.
5. Analytical Mechanics, G. R. Fowles and G. L. Cassiday, 2005, Cengage Learning.

Additional Readings:

1. Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson

   Education.
2. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
3. University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.
4. Fundamentals of Physics, Resnick, Halliday & Walker 10/e, 2013, Wiley.
5. Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press.
6. Physics for Scientists and Engineers, R. A. Serway, J. W. Jewett, Jr, 9/e, 2014, Cengage Learning.
7. Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.

References for Laboratory Work:

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11/e, 2011, Kitab Mahal.

Course Title: Computational Physics
Credit: 03 (2+1)
Theory: 30 Hours
Practical: 30 Hours

Course Objectives:

This course is designed to introduce students to the fundamental concepts of computer programming using the Python language. It aims to develop computational thinking, logical reasoning, and problem-solving abilities by engaging students in writing simple programs, understanding program flow, and working with basic data structures. The course also seeks to build confidence in coding and lay a strong foundation for further study in programming or data science.

Course learning outcomes:

By the end of this course, students will be able to understand the basic structure and syntax of Python programming, including the use of variables and fundamental data types such as strings, integers, floats, and booleans. They will be able to apply arithmetic and logical operations to solve simple problems and write Python programs using control structures like conditional statements (if, else, elif) and loops (for, while). Students will also learn to work with essential data structures such as lists, tuples, and dictionaries, and use both built-in and user-defined functions to create modular and reusable code. They will gain proficiency in handling input and output operations, debugging common errors, and developing algorithmic thinking.

Course Code: SEC45PHY101a(T)25
Credit: 02
Theory: 30 Hours

Unit 1: Introduction

Basics of Programming Languages, Interpreter and Compiler, Algorithms and Flowcharts, History and features of Python, Python 3 vs. Python 2, Installing Python and IDEs (Anaconda, PyCharm, Jupyter Notebook etc.)

Basics of Python: Python Keywords, Identifiers and Variables, Data Types, Backslash Character Constants.

Operators and Expressions: Arithmetic Operators, Relational Operators, Logical/Boolean Operators, Assignment Operators, interactive mode and Script mode, Order of Operations, Comments in Python, Common Errors, Managing Input and Output Operations, Frequently used Formatting Specifiers.

(**7 lectures)**

Unit 2: Control Structures

Decision making and Branching: Conditional statements (Simple if, if-else, else-if ladder, nested-if statements), Boolean values.

Decision making and Looping: The while loop statement, The for loop statement, The range () function, Jumps in Loops, Skipping a part of a Loop, The else Clauses on Loops.

Functions: Types of Functions, Nesting of Functions, Boolean Function, Recursion Function, Default Arguments, Lambda function.

(7 lectures)

Unit 3: Data Structures

List: Definition, The in operator, Traversing in a List, Nested List, List Operations, List Slices, List Functions, List Methods, Copying Lists, Sorting Lists, Two-Dimensional Lists, Multidimensional Lists.

Dictionaries: Definition, Creating a Dictionary, Adding, Modifying, and Retrieving Values, The Dictionary Methods.

Sets : Accessing Sets with common functions**,** Subset and Superset in Sets, Relational operators in Sets, Set Operations.

Tuples : Definition, Tuple Assignment, Tuples as Return Values, The Basic Tuple operations, Relationship between Lists and Tuples, Relationships between Dictionaries and Tuples.

(**7 lectures)**

Unit 4: File Handling

Introduction, Text files and Binary files, Absolute and Relative filename, Opening a File, Writing Data, Some commonly used methods for File handling

Writing and Reading Numeric Data. Data visualization with matplotlib.

(4 lectures)

Unit 5: Applications to Computational Physics

What is computational physics? Oscillatory Motion (SHM), Damped pendulum dynamics, Basics of Fractals, Random Numbers in Computer Simulation, Applications of Monte Carlo Method.

(**5 lectures)**

Course Code: SEC45PHY101a(P)25
Credit: 01
Practical: 30 Hours

1. Write Python programs for the following with and without recursive functions:
    - A. To convert decimal numbers to binary numbers.
    - B. Write a Python program to reverse the digits of an integer
    - C. To find the Greatest common divisor (GCD) of two numbers
2. Write a Python program to verify a given number is prime or not.
3. Write a Python program to generate prime numbers between any two given numbers.
4. Write a Python program to organize a given set of numbers in ascending and descending orders.
5. Write a Python program to generate Fibonacci series.
6. Write a Python program to find out the Prime numbers from a sequence of Fibonacci series.
7. Write a Python program to check a given number is an Armstrong number or not.
8. Write a Python program to check a given year is a Leap year or not.
9. Write a Python program to print Pascal Triangle.

10. Write a Python program to solve the Tower of Hanoi.

References:

1. M. Shubhakanta Singh, *Programming with Python and its applications to Physical Systems*, Taylor and Francis, 2024.
2. Allen B. Downey, *Think Python,* Green Tea Press, 2014.
3. Hans Peter Langtangen, *A Primer on Scientific Programming with Python*, Springer, 2012.
4. S. Hilborn, R.C., *Chaos and Nonlinear Dynamics, An Introduction for Scientists and Engineers,* Ed. 2, Oxford University Press, USA, 2004.
5. Pang, Tao, *Introduction to Computational Physics, Ed. 2.,* Cambridge University Press, NY, 2006,
6. Landau, Rubin H., *Computational Physics: Problem solving with Computers,* John Wiley and Sons, Inc.,1997.

Course Title: Electrical circuits and Network Skills
Credit: 03 (2+1)
Theory: 30 Hours
Practical: 30 Hours

Course Objectives

To develop an understanding of basic principles of electricity and its household applications. To impart basic knowledge of solid state devices and their applications, understanding of electrical wiring and installation.

Course Leaning Outcomes

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

- Demonstrate good comprehension of basic principles of electricity including ideas about voltage, current and resistance.
- Develop the capacity to analyze and evaluate schematics of power efficient electrical circuits while demonstrating insight into tracking of interconnections within elements while identifying current flow and voltage drop.
- Gain knowledge about generators, transformers and electric motors. The knowledge would include interfacing aspects and consumer defined control of speed and power.
- Acquire capacity to work theoretically and practically with solid-state devices. Delve into practical aspects related to electrical wiring like various types of conductors and cables, wiring-Star and delta connections, voltage drop and losses.
- Measure current, voltage, power in DC and AC circuits, acquire proficiency in fabrication of regulated power supply.
- Develop capacity to identify and suggest types and sizes of solid and stranded cables, conduit lengths, cable trays, splices, crimps, terminal blocks and solder.

Course Code: SEC45PHY101b(T)25
Credit: 02
Theory: 30 Hours

Unit 1

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.

(3 Lectures)

Electrical Circuits: Basic electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

(4 Lectures)

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

(4 Lectures)

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

(2 Lectures)

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed & power of ac motor.

(3 Lectures)

Unit 2

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

(3 Lectures)

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Relay protection device.

(3 Lectures)

Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, and solder. Preparation of extension board.

(5 Lectures)

Network Theorems:(1) Thevenin theorem (2) Norton theorem (3) Superposition theorem (4) Maximum Power Transfer theorem.

(3 Lectures)

Course Code: SEC45PHY101b(P)25
Credit: 01
Practical: 30 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

At least 08 Experiments from the following

1. Series and Parallel combinations: Verification of Kirchoff's law.
2. To verify network theorems: (I) Thevenin (II) Norton (III) Superposition theorem (IV) Maximum power transfer theorem
3. To study frequency response curve of a Series LCR circuit.
4. To verify (1) Faraday's law and (2) Lenz's law.
5. Programming with Pspice/NG spice.
6. Demonstration of AC and DC generator.
7. Speed of motor
8. To study the characteristics of a diode.
9. To study rectifiers (I) Half wave (II) Full wave rectifier (III) Bridge rectifier
10. Power supply (I) C-filter, (II) π- filter
11. Transformer – Step up and Step down
12. Preparation of extension board with MCB/fuse, switch, socket-plug, Indicator.
13. Fabrication of Regulated power supply.

It is further suggested that students may be motivated to pursue semester long dissertation wherein he/she may do a hands-on extensive project based on the extension of the practicals enumerated above.

References Essential Readings:

1. Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
2. A text book in Electrical Technology - B L Theraja - S Chand & Co.
3. Performance and design of AC machines - M G Say ELBS Edn.
4. Electronic Devices and Circuits, A. Mottershead,1998, PHI Learning Pvt. Ltd.
5. Network, Lines and Fields, John D. Ryder, Pearson Ed. II, 2015.

Additional Readings:

1. Electrical Circuit Analysis, K. Mahadevan and C. Chitran, 2nd Edition, 2018, PHI learning Pvt. Ltd.

Introduction to Physics: MDC45PHY101(T)25
Credit:03
Theory: 45 Lectures

Course Objective

- To give an introduction to the fundamentals of Physics.
- To give introductory concepts on units and measurement, scalar and vectors, laws of motion, work, power and energy, electricity and magnetism, geometry and wave optics, gravity and planetary motion, wave and oscillation, and electronics.

Course learning Outcomes

- They will understand the basic concepts of units and measurements, motion, optics, electricity and magnetism, energy, waves and oscillation and the concept of electronics which are the fundamental parts of Physics and its application in everyday life.
- On successful completion of the course, students will be able to understand the preliminary idea of the concept of Physics and its phenomena in our daily lives.

UNIT 1
Mechanics

Physical quantities, Units of measurement, SI units, Scalars and Vectors, Speed and Velocity, Linear momentum and Acceleration. Laws of motion, friction and lubrication, uniform circular motion.
Work, energy, power; principle of conservation of energy.
Newton's law of gravitation, acceleration due to gravity. **(15 Lectures)**

UNIT 2
Heat and Thermodynamics

Concept of heat and temperature, specific heat, Latent heat.
Laws of thermodynamics (zeroth, first and second), Heat transfer: conduction, convection and radiation. **(5 Lectures)**

UNIT 3
Waves and Optics

Introduction to waves and its characteristics, Longitudinal and transverse waves, Simple harmonic motion, simple pendulum.
Dual nature of light, Reflection, refraction and total internal reflection (simple examples), Interference, diffraction, and polarization (Simple idea only)
Principle of optical fibers and LASER **(8 Lectures)**

UNIT 4

Electricity and Magnetism

Electric charge, current, Coulomb's law. Electric field Intensity and Electric potential (simple idea). Capacitance and Capacitors.
Ohm's law, resistances and their combination. Kirchoff's laws.
Alternating currents, Electromagnetic induction, Faraday's laws and Lenz law.
Applications to transformer, generator and motor (no derivation). (**10 Lectures)**

UNIT 5

Electronic and modern Physics

Semiconductors, diodes and transistors, Solar cell, digital mobile data communication.
Radioactivity, half life and mean life.Nuclear fission and fusion. (Elementary idea).

(7 Lectures)

Reference Books:

1. Elements of Properties of Matter, D.S. Mathur, 2008, S. Chand and Company Limited
2. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
3. Concept of Physics (I &II), H.C Verma.
4. NCERT Physics Textbooks (Class 9,10 11 &12)
5. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
6. Optics, Ajay Ghatak, 6th ed., 2017, Tata McGraw Hill.
7. Electricity and Magnetism, D.C.Tayal, 1993, Himalaya Publishing House.
8. Electricity and Magnetism, J H Fewkes & J Yarwood, Oxford University Press, Calcutta, 1985
9. SWAYAM/NPTEL modules on basic physics

FYUG(Physics) Course Curriculum Structure and syllabus for 2nd Semester

Year	Semester	Major (Credit)	Minor (Credit)	MDC (Credit)	AEC (Credit)	SEC*/ Dissertation (Credit)	Experiential Learning (Credit)	VAC (Credit)	Total Credits	Additional Summer Internship
I	I	Major – 2 (4) (Level 100) MJC45PHY102(T)25 : Electricity and Magnetism (Credit: 03) MJC45PHY102(P)25 : Electricity and Magnetism (Credit: 01)	Minor – 2 (4) (Level 100) MNC45PHY102 (T)25: Electricity and Magnetism: 03) MNC45PHY102(P)25: Electricity and Magnetism (Credit: 01)	MDC - 2(3) MDC45PHY102 (T)25 Introduction to Physics: (Credit:03)	AEC – 2 (Academic Writing) (4)	SEC – 2 (3) Renewable Energy and Energy harvesting: SEC45PHY102a (T)25 (Credit: 02) + SEC45PHY102a (P)25 (Credit: 01) **Or** Radiation Safety: SEC45PHY102b (T)25 (Credit: 02) + SEC45PHY102b (P)25 (Credit: 01)		VAC – 2 (2)	20	Additional for Bachelor's Certificate (4)

Course Title: Electricity and Magnetism
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective: This course reviews the concepts of electromagnetism learnt at school from a more advanced perspective and goes on to build new concepts. The course covers static and dynamic electric and magnetic fields, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. The students will be able to apply the concepts learnt to several real-world problems.

Course Learning Outcomes: At the end of this course the student will be able to • Demonstrate the application of Coulomb's law for the electric field, and also apply it to systems of point charges as well as line, surface, and volume distributions of charges.

• Demonstrate an understanding of the relation between electric field and potential, exploit the potential to solve a variety of problems, and relate it to the potential energy of a charge distribution.

• Apply Gauss's law of electrostatics to solve a variety of problems.

• Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)

• Understand the concepts of induction and self-induction, to solve problems using Faraday's and Lenz's laws.

• Understand the basics of electrical circuits and analyze circuits using Network Theorems.

• In the laboratory course the student will get an opportunity to verify network theorems and study different circuits such as RC circuit, LCR circuit. Also, different methods to measure low and high resistance, capacitance, self-inductance, mutual inductance, strength of a magnetic field and its variation in space will be learnt.

MJC45PHY102(T)25: Electricity and Magnetism
Credit: 03
Theory: 45 Hours

UNIT 1
Vectors: Scalar and vector quantities, scalar and vector product. Scalar triple product and its interpretation in terms of area and volume, vector triple product. Differentiation and integration of vectors, scalar and vector fields, gradient of a scalar field in Cartesian coordinates and its physical significance, divergence and curl of a vector field and their physical significances, curl of a vector in Cartesian coordinates. **6 Lectures**

UNIT 2
Electric Field and Electric Potential: Electric field: Electric field lines. Electric flux, Gauss Law with applications to charge distributions with cylindrical and planar symmetry. **4 Lectures**
Electrostatic Potential, Laplace's and Poisson equations, The Uniqueness Theorem, Potential and Electric Field of a dipole. Force and Torque on a dipole. **5 Lectures**

Electrostatic energy of system charge: Electrostatic energy of a charged sphere. Conductors in an electrostatic Field, Capacitance of a system of charged conductors, Parallel-plate capacitor, Capacitance of an isolated conductor.
Method of Images and its application to Plane Infinite Sheet and Sphere. **7 Lectures**

UNIT 3
Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple application to straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to Solenoid and Toroid. Properties of B: curl and divergence. Vector Potential. **7 Lectures**

UNIT 4
Magnetic Properties of Matter: Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis. **3 Lectures**

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. **4 Lectures**

UNIT 5
AC Circuits: Complex Reactance and Impedance. Series LCR Circuit: Resonance, Power Dissipation and Quality Factor and Band Width. Parallel LCR Circuit. **4 Lectures**

Network theorems: Ideal constant-voltage and constant-current Sources. Review of Kirchhoff's Current and Voltage Laws. Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum Power Transfer theorem. **5 Lectures**

MJC45PHY102(P)25: Electricity and Magnetism
Credit: 01
Practical: 30 Hours

Practical:

Dedicated demonstration cum laboratory sessions on the construction, functioning and uses of different electrical bridge circuits, and electrical devices like the ballistic galvanometer. Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.

Sessions on least square fitting and computer programme to find slope and intercept of straight-line graphs of experimental data. Application to the specific experiments done in the laboratory.

At least 6 experiments from the following:

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using CareyFoster’s Bridge.
4. To compare capacitances using De’Sauty’s bridge.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self-inductance of a coil by Anderson’s bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) Antiresonant frequency and (b) Quality factor Q.
11. Measurement of charge sensitivity, current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh’s method.
14. To determine the mutual inductance of two coils by Absolute method.

References for Theory: Essential Readings:

1. Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGrawHill.
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education 3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Electricity and Magnetism, J.H.Fewkes& J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
5. Network, Lines and Fields, John D. Ryder, 2 nd Edn., 2015, Pearson.

Additional Readings:

1. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
2. Electricity, Magnetism & Electromagnetic Theory, S.Mahajanand Choudhury, 2012, Tata McGraw
3. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
4. Problems and Solutions in Electromagnetics (2015), Ajoy Ghatak, K Thyagarajan & Ravi Varshney.
5. Schaum’s Outline of Electric Circuits, J. Edminister & M. Nahvi, 3rd Edn., 1995, McGraw Hill.

References for Laboratory Work:

1. Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia 30 Publishing House

2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

4. Engineering Practical Physics, S. Panigrahi and B. Mallick,2015, Cengage Learning.

5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press

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Course Learning Outcomes: At the end of this course the student will be able to • Demonstrate the application of Coulomb's law for the electric field, and also apply it to systems of point charges as well as line, surface, and volume distributions of charges.

• Demonstrate an understanding of the relation between electric field and potential, exploit the potential to solve a variety of problems, and relate it to the potential energy of a charge distribution.

• Apply Gauss's law of electrostatics to solve a variety of problems.

• Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)

• Understand the concepts of induction and self-induction, to solve problems using Faraday's and Lenz's laws.

• Understand the basics of electrical circuits and analyze circuits using Network Theorems.

• In the laboratory course the student will get an opportunity to verify network theorems and study different circuits such as RC circuit, LCR circuit. Also, different methods to measure low and high resistance, capacitance, self-inductance, mutual inductance, strength of a magnetic field and its variation in space will be learnt.

MNC45PHY102(T)25: Electricity and Magnetism
Credit: 03
Theory: 45 Hours

UNIT 1

Vectors: Scalar and vector quantities, scalar and vector product. Scalar triple product and its interpretation in terms of area and volume, vector triple product. Differentiation and integration of vectors, scalar and vector fields, gradient of a scalar field in Cartesian coordinates and its physical significance, divergence and curl of a vector field and their physical significances, curl of a vector in Cartesian coordinates. **6 Lectures**

UNIT 2

Electric Field and Electric Potential: Electric field: Electric field lines. Electric flux, Gauss Law with applications to charge distributions with cylindrical and planar symmetry. **4 Lectures**

Electrostatic Potential, Laplace's and Poisson equations, The Uniqueness Theorem, Potential and Electric Field of a dipole. Force and Torque on a dipole. **5 Lectures**

Electrostatic energy of system charge: Electrostatic energy of a charged sphere. Conductors in an electrostatic Field, Capacitance of a system of charged conductors, Parallel-plate capacitor, Capacitance of an isolated conductor.
Method of Images and its application to Plane Infinite Sheet and Sphere. **7 Lectures**

UNIT 3
Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple application to straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to Solenoid and Toroid. Properties of B: curl and divergence. Vector Potential. **7 Lectures**

UNIT 4
Magnetic Properties of Matter: Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis. **3 Lectures**

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. **4 Lectures**

UNIT 5
AC Circuits: Complex Reactance and Impedance. Series LCR Circuit: Resonance, Power Dissipation and Quality Factor and Band Width. Parallel LCR Circuit. **4 Lectures**

Network theorems: Ideal constant-voltage and constant-current Sources. Review of Kirchhoff's Current and Voltage Laws. Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum Power Transfer theorem. **5 Lectures**

MNC45PHY102(P)25: Electricity and Magnetism
Credit: 01
Practical: 30 Hours

Practical:
Dedicated demonstration cum laboratory sessions on the construction, functioning and uses of different electrical bridge circuits, and electrical devices like the ballistic galvanometer.
Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
Sessions on least square fitting and computer programme to find slope and intercept of straight-line graphs of experimental data. Application to the specific experiments done in the laboratory.
At least 6 experiments from the following:
1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using CareyFoster's Bridge.
4. To compare capacitances using De'Sauty's bridge.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self-inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.

10. To study the response curve of a parallel LCR circuit and determine its (a) Antiresonant frequency and (b) Quality factor Q.
11. Measurement of charge sensitivity, current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh's method.
14. To determine the mutual inductance of two coils by Absolute method.

References for Theory: Essential Readings:

1. Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGrawHill.
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education 3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Electricity and Magnetism, J.H.Fewkes& J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
5. Network, Lines and Fields, John D. Ryder, 2 nd Edn., 2015, Pearson.

Additional Readings:

1. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
2. Electricity, Magnetism & Electromagnetic Theory, S.Mahajanand Choudhury, 2012, Tata McGraw
3. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol.I, 1991, Oxford Univ. Press.
4. Problems and Solutions in Electromagnetics (2015), Ajoy Ghatak, K Thyagarajan & Ravi Varshney.
5. Schaum's Outline of Electric Circuits, J. Edminister & M. Nahvi, 3rd Edn., 1995, McGraw Hill.

References for Laboratory Work:

1. Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia 30 Publishing House
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. Engineering Practical Physics, S. Panigrahi and B. Mallick,2015, Cengage Learning.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press

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Course Title: Renewable energy and energy harvesting
Credit: 03 (2+1)
Theory: 30 Hours
Practical: 30 Hours

Course Objective

To impart knowledge and hands on learning about various alternate energy sources to teach the ways of harvesting energy using wind, solar, mechanical, ocean, geothermal energy etc. To review the working of various energy harvesting systems which are installed worldwide.

Course Learning Outcomes

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

• Knowledge of various sources of energy for harvesting
• Understand the need of energy conversion and the various methods of energy Storage.
• A good understanding of various renewable energy systems, and its components.
• Knowledge about renewable energy technologies, different storage technologies, distribution grid, smart grid including sensors, regulation and their control.
• Design the model for sending the wind energy or solar energy plant.
• The students will gain hand on experience of:
(i) different kinds of alternative energy sources,
(ii) conversion of vibration into voltage using piezoelectric materials,
(iii) conversion of thermal energy into voltage using thermoelectric modules.

Course Code: SEC45PHY102a(T)25
Credit: 02
Theory: 30 Hours

Unit 1
Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, bio-gas generation, geothermal energy tidal energy, Hydroelectricity.

(3 Lectures)

Unit 2
Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photo-voltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

(3 Lectures)

Unit 3
Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. **(6 Lectures)**

Unit 4
Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave characteristics and and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

(3 Lectures)

Geothermal Energy: Geothermal Resources, Geothermal Technologies.
Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. Rain water harvesting.

(6 Lectures)

Unit 5

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezo-electricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power

Electromagnetic Energy Harvesting: Linear generators, physical/mathematical models, recent applications Carbon captured technologies, cell, batteries, power consumption Environmental issues and Renewable sources of energy, sustainability. Merits of Rain Water harvesting. **(9 Lectures)**

Course Code: SEC45PHY102a(P)25
Credit: 01
Practical: 30 Hours

Teacher may give long duration project based on this paper.
Sessions on the use of equipment used in the workshop, including necessary precautions.
Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

Demonstrations and Experiments:

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage-driven thermo-electric modules.

References

1. Non-conventional energy sources, B.H. Khan, McGraw Hill 60
2. Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
3. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rd Edn., 2012, Oxford University Press.
4. Solar Energy: Resource Assessment Handbook, P Jayakumar, 2009
5. J.Balfour, M.Shaw and S. Jarosek, Photo-voltaics, Lawrence J Goodrich (USA).

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Course Title: Radiation Safety
Credit: 03 (2+1)
Theory: 30 Hours
Practical: 30 Hours

Course Objective

This course focusses on the applications of nuclear techniques and radiation protection. It will not only enhance the skills towards the basic understanding of the radiation but will also provide the knowledge about the protective measures against the radiation exposure. It imparts all the skills required by a radiation safety officer or any job dealing with radiation such as X-ray operators, nuclear medicine dealing jobs: chemotherapists, PET MRI CT scan, gamma camera etc. operators etc.

Course Learning Outcomes

This course will help students in the following ways:

• Awareness and understanding the hazards of radiation and the safety measures to guard against these hazards.

• Learning the basic aspects of the atomic and nuclear Physics, specially the radiations that originate from the atom and the nucleus.

• Having a comprehensive knowledge about the nature of interaction of matter with radiations like gamma, beta, alpha rays, neutrons etc. and radiation shielding by appropriate materials.

• Knowing about the units of radiations and their safety limits, the devises to detect and measure radiation.

• Learning radiation safety management, biological effects of ionizing radiation, operational limits and basics of radiation hazards evaluation and control, radiation protection standards, 'International Commission on Radiological Protection' (ICRP) its principles, justification, optimization, limitation, introduction of safety and risk management of radiation, nuclear waste and disposal management, brief idea about Accelerator driven Sub- Critical System' (ADS) for waste management.

• Learning about the devices which apply radiations in medical sciences, such as MRI, PET.

• Understanding and performing experiments like Study the background radiation levels using Radiation detectors, Determination of gamma ray linear and mass absorption coefficient of a given material for radiation shielding application.

Course Code: SEC45PHY102b(T)25
Credit: 02
Theory: 30 Hours

Unit 1

Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron. The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and halflife, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission. **(6 Lectures)**

Unit 2

Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photoelectric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channelling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation. **(7 Lectures)**

Unit 3

Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.

Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter and Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermoluminescent Dosimetry. **(7 Lectures)**

Unit 4

Radiation safety management: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitations, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

(5 Lectures)

Unit 5

Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

(5 Lectures)

Course Code: SEC45PHY102b(P)25
Credit: 01
Practical: 30 Hours

Teacher may give long duration project based on this paper.

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

Experiments:

Minimum five experiments need to be performed from the following,

1. Estimate the energy loss of different projectiles/ions in Water and carbon, using SRIM/TRIM etc. simulation software.
2. Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H as projectile/ion.
3. Comparison of interaction of projectiles with $Z_P = 1$ to 92 (where Z_P is atomic number of projectile/ion) in a given medium (Mylar, Carbon, Water) using simulation software (SRIM etc).
4. SRIM/TRIM based experiments to study ion-matter interaction of heavy projectiles on heavy atoms. The range of investigations will be $Z_P = 6$ to 92 on $Z_A = 16$ to 92 (where Z_P and Z_A are atomic numbers of projectile and atoms respectively). Draw and infer appropriate Bragg Curves.
5. Calculation of absorption/transmission of X-rays, γ-rays through Mylar, Be, C, Al, Fe and $Z_A = 47$ to 92 (where Z_A is atomic number of atoms to be investigated as targets) using XCOM, NIST (https://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html).
6. Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Data may be taken from the Department of Physics & Astrophysics, University of Delhi and gamma ray energies are available in the website http://www.nndc.bnl.gov/nudat2/).
7. Study the background radiation levels using Radiation meter.
8. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
9. Study of counting statistics using background radiation using GM counter.
10. Study of radiation in various materials (e.g. KSO_4 etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
11. Study of absorption of beta particles in Aluminum using GM counter.
12. Detection of α particles using reference source & determining its half-life using spark counter.
13. Gamma spectrum of Gas Light mantle (Source of Thorium).

References for Theory: Essential reading:

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
3. Nuclear Physics: Principles and Applications by J Lilley, Wiley Publication, 2006.
4. Fundamental Physics of Radiology by W J Meredith and B Massey John Wright and Sons, UK,1989.
5. An Introduction to Radiation Protection by A Martin and Sam Harbison, John Willey & Sons, Inc. New York, 1981.

Additional reading:

1. Radiation detection and measurement by G F Knoll, 4th Edition, Wiley Publications, 2010.
2. Techniques for Nuclear and Particle Physics experiments by W R Leo, Springer, 1994.
3. Thermoluminescence dosimetry by A F McKinlay, Bristol, Adam Hilger (Medical Physics Hand book 5.
4. Medical Radiation Physics by W R Hendee, Year book Medical Publishers, Inc., London, 1981.
5. Physics and Engineering of Radiation Detection by S N Ahmed, Academic Press Elsevier, 2007.
6. Nuclear and Particle Physics by W E Burcham and M Jobes, Harlow Longman Group, 1995.

7. IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interium) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).

References for Laboratory Work:

2. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
3. Schaum's Outline of College Physics, by E. Hecht, 11th edition, McGraw Hill, 2009.
4. Modern Physics by K Sivaprasath and R Murugeshan, S Chand Publication, 2010.
5. AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities, 2011
6. AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources., 2007.

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Introduction to Physics: MDC45PHY102(T)25
Credit:03
Theory: 45 Lectures

Course Objective

- To give an introduction to the fundamentals of Physics.
- To give introductory concepts on units and measurement, scalar and vectors, laws of motion, work, power and energy, electricity and magnetism, geometry and wave optics, gravity and planetary motion, wave and oscillation, and electronics.

Course learning Outcomes

- They will understand the basic concepts of units and measurements, motion, optics, electricity and magnetism, energy, waves and oscillation and the concept of electronics which are the fundamental parts of Physics and its application in everyday life.
- On successful completion of the course, students will be able to understand the preliminary idea of the concept of Physics and its phenomena in our daily lives.

UNIT 1
Mechanics

Physical quantities, Units of measurement, SI units, Scalars and Vectors, Speed and Velocity, Linear momentum and Acceleration. Laws of motion, friction and lubrication, uniform circular motion.
Work, energy, power; principle of conservation of energy.
Newton’s law of gravitation, acceleration due to gravity. **(15 Lectures)**

UNIT 2

Heat and Thermodynamics

Concept of heat and temperature, specific heat, Latent heat.
Laws of thermodynamics (zeroth, first and second), Heat transfer: conduction, convection and radiation. **(5 Lectures)**

UNIT 3

Waves and Optics

Introduction to waves and its characteristics, Longitudinal and transverse waves, Simple harmonic motion, simple pendulum.
Dual nature of light, Reflection, refraction and total internal reflection (simple examples), Interference, diffraction, and polarization (Simple idea only)
Principle of optical fibers and LASER **(8 Lectures)**

UNIT 4

Electricity and Magnetism

Electric charge, current, Coulomb's law. Electric field Intensity and Electric potential (simple idea). Capacitance and Capacitors.
Ohm's law, resistances and their combination. Kirchoff's laws.
Alternating currents, Electromagnetic induction, Faraday's laws and Lenz law. Applications to transformer, generator and motor (no derivation). **(10 Lectures)**

UNIT 5

Electronic and modern Physics

Semiconductors, diodes and transistors, Solar cell, digital mobile data communication.
Radioactivity, half life and mean life.Nuclear fission and fusion. (Elementary idea).
(7 Lectures)

Reference Books:

10. Elements of Properties of Matter, D.S. Mathur, 2008, S. Chand and Company Limited
11. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
12. Concept of Physics (I &II), H.C Verma.
13. NCERT Physics Textbooks (Class 9,10 11 &12)
14. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
15. Optics, Ajay Ghatak, 6th ed., 2017, Tata McGraw Hill.
16. Electricity and Magnetism, D.C.Tayal, 1993, Himalaya Publishing House.
17. Electricity and Magnetism, J H Fewkes & J Yarwood, Oxford University Press, Calcutta, 1985
18. SWAYAM/NPTEL modules on basic physics

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FYUP(Physics) Course Curriculum Structure and syllabus for 3rd, 4th, 5th and 6th Semester

Year	Semester	Major (Credit)	Minor (Credit)	MDC (Credit)	AEC (Credit)	SEC*/Dissertation(Credit)	Experiential Learning (Credit)	VAC (Credit)	Total Credits	Additional Summer Internship
II	III	Major – 3 (4) (Level 200) Major – 4 (4) (Level 200)	Minor – 3 (4) (Level 200 & above)	MDC – 3 (3)		SEC – 3 (3)		VAC – 3 (2)	20	Additional for Bachelor's Diploma, if not done in 1st Year (4)
	IV	Major – 5 (4) (Level 200) Major – 6 (4) (Level 200) Major – 7 (4) (Level 200) Major – 8 (4) (Level 200)	Minor – 4 (4) (Level 200 & above)						20	
							II Year Credit		**80**	
Students exiting at 2 Year will be awarded **Bachelor's Diploma** after earning minimum credit in the concerned discipline provided the student earned additional **4 credits** in work-based vocational courses offered during first year or second year summer internship or apprenticeship.										
III	V	Major – 9 (4) (Level 300) Major – 10 (4) (Level 300) Major – 11 (4) (Level 300)	Minor - 5 (4) (Level 200 & above)				Internship/ Community engagement and service/ Field Project (4)		20	
	VI	Major – 12 (4) (Level 300) Major – 13 (4) (Level 300) Major – 14 (4) (Level 300) Major – 15 (4) (Level 300)	Minor - 6 (4) (Level 200 & above)						20	
	Total	**60 Credits**	**24 Credits**	**9 Credits**	**8 Credits**	**9 Credits**	**4 Credits**	**6 Credits**	**120**	

SEMESTER-WISE DISTRIBUTION OF COURSES

A. Major Core Courses

All the courses have 4 credits with 3 credits of theory (3 hours per week) and 1 credit of practicals (2 hours per week).

Sl No	CC Paper Code	Semester	Course name
1.	MJC45PHY101(T)25	I	Mechanics(Theory+Lab)
2.	MJC45PHY102(T)25	II	Electricity and Magnetism(Theory + Lab)
3.	**MJC50PHY203(T)25**	**III**	**Mathematical Physics-I (Theory + Lab)**
4.	**MJC50PHY204(T)25**	**III**	**Waves and Optics (Theory + Lab)**
5.	**MJC50PHY205(T)25**	**IV**	**Mathematical Physics – II (Theory + Lab)**
6.	**MJC50PHY206(T)25**	**IV**	**Thermal Physics (Theory + Lab)**
7.	**MJC50PHY207(T)25**	**IV**	**Elements of Modern Physics (Theory + Lab)**
8.	**MJC50PHY208(T)25**	**IV**	**Digital Systems and Applications (Theory + Lab)**
9.	**MJC55PHY309(T)25**	**V**	**Quantum Mechanics and Applications (Theory + Lab)**
10.	**MJC55PHY310(T)25**	**V**	**Mathematical Physics III (Theory + Lab)**
11.	**MJC55PHY311(T)25**	**V**	**Analogue Systems and Applications(Theory+Lab)**
12.	**MJC55PHY312(T)25**	**VI**	**Solid State Physics (Theory + Lab)**
13.	**MJC55PHY313(T)25**	**VI**	**Electromagnetic Theory (Theory + Lab)**
14.	**MJC55PHY314(T)25**	**VI**	**Statistical Mechanics (Theory + Lab)**
15.	**MJC55PHY315(T)25**	**VI**	**Embedded Systems-Introduction to microcontroller (Theory+Lab)**

B. MINOR COURSES

All the courses have 4 credits with 3 credits of theory (3 hours per week) and 1 credit of practicals (2 hours per week).

Sl No	CC Paper Code	Semester	Course name
1.	**MNC45PHY101(T)25**	**I**	**Mechanics (Theory+Lab)**
2.	**MNC45PHY102(T)25**	**II**	**Electricity and Magnetism (Theory + Lab)**
3.	**MNC50PHY203(T)25**	**III**	**Mathematical Physics, Waves and Optics (Theory + Lab)**
4.	**MNC50PHY204(T)25**	**IV**	**Heat and Thermodynamics (Theory + Lab)**
5.	**MNC55PHY205(T)25**	**V**	**Quantum Mechanics and Applications (Theory + Lab)**
6.	**MNC55PHY206(T)25**	**VI**	**Solid State Physics (Theory + Lab)**

C. MULTI DISCIPLINARY COURSES

All the courses have 3 credits.

Sl No	MDC Paper Code	Semester	MDC Name
1	**MDC45PHY101(T)25**	**I**	**Introduction to Physics**
2	**MDC45PHY102(T)25**	**II**	**Introduction to Physics**
3	**MDC50PHY203(T)25**	**III**	**Introduction to Physics**

Skill Enhancement Courses

All courses have 3 credits with 2 credits of theory and 1 credit of Practical/Tutorials/Projects and Field Work to be decided by the College.

S.No.	SEC Paper Code	Semester	SEC Name
1	SEC45PHY101a(T)25	I	Computational Physics(Theory+lab)
2	SEC45PHY101b(T)25	I	Electrical circuit and Network skills (Theory+lab)
3	SEC45PHY102a(T)25	II	Renewable Energy and Energy harvesting(Theory+lab)
4	SEC45PHY102b(T)25	II	Radiation Safety(Theory+lab)
5	SEC50PHY203a(T)25	III	Basic Instrumentation Skills(Theory+lab)
5	SEC50PHY203b(T)25	III	Applied Optics (Theory+lab)

C. Ability Enhancement Compulsory Courses

MJC50PHY203(T)25:Mathematical Physics-I
Credit:04 (Theory-03, Practical-01)
Theory:45 Hours
Practical:30 Hours

Course Objective

The emphasis of course is to equip students with the mathematical and critical skills required in solving problems of interest to physicists. The course will also expose students to fundamental computational physics skills enabling them to solve a wide range of physics problems. The skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

Course Learning Outcomes

After completing this course, student will be able to

- Draw and interpret graphs of various functions.
- Solve first and second order differential equations and apply these to physics problems.
- Perform line, surface and volume integration and apply Green's, Stokes' and Gauss's Theorems to compute these integrals.
- Apply curvilinear coordinates to problems with spherical and cylindrical symmetries.
- Represent a periodic function by a sum of harmonics using Fourier series and their applications in physical problems such as vibrating strings etc.
- Solve linear partial differential equations of second order with separation of variable method.
- In the laboratory course, the students will be able to design, code and test simple programs in C++ in the process of solving various problems.

Unit 1

First Order Differential Equations:

First order differential Equations: Variable separable, homogeneous, non-homogeneous, exact and in exact differential equations and Integrating Factors. Application to Physics like Radioactive decay, Charging and Discharging in RC circuit, etc)

(9 Lectures)

Unit 2

Second Order Differential Equations:

Homogeneous Equations with constant coefficients. Wronskian and general solution. Particular Integral with operator method, method of undetermined coefficients and method of variation of parameters. Cauchy-Euler differential equation and simultaneous differential equations of First and Second order.

(9 Lectures)

Unit 3

Vector Integration and Orthogonal Curvilinear Coordinates:

Line, surface and volume integrals of Scalar and Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems, their verification (no rigorous proofs) and applications.

Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

(9 Lectures)

Unit 4

Fourier Series:

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions (Fourier Cosine Series and Fourier Sine Series). Parseval's theorem

(9 Lectures)

Unit 5

Partial Differential Equations:

Solutions to second order linear partial differential equations (2or 3 independent variables) using separation of variables: (i) Laplace's Equation in problems of rectangular geometry, (ii) Wave equation for vibrational modes of a stretched string, rectangular and circular membranes, (iii) One Dimensional heat flow equation. (Note: Do not establish the equation).

(9 Lectures)

MJC50PHY203(P)25: Mathematical Physics-I
Credit: 01
Practical: 30 Hours

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- The course will consist of practical sessions and lectures on the related theoretical aspects of the Laboratory. The recommended group size is not more than 15 students.
- Evaluation to be done not only on the programming but also on the basis of formulating the problem.
- Aim at teaching students to construct the computational problem to be solved.

- Students can use anyone operating system: Linux or Microsoft Windows.
- At least 12programs must be attempted from the following covering the entire syllabus.
- The list of programs here is only suggestive. Students should be encouraged to do more practice. Emphasis should be given to assess student's ability to formulate a physics problem as mathematics and solve by computational methods.

Topics	Descriptions with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices,
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, single and double precision arithmetic, underflow and overflow – emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Algorithms and Flow charts	Purpose, symbols and description,
Introduction to C++	Introduction to Programming: Algorithms: Sequence, Selection and Repetition, Structured programming, basic idea of Compilers. Data Types, Enumerated Data, Conversion & casting, constants and variables, Mathematical, Relational, Logical and Bit wise Operators. Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables. Programs: ● To calculate area of a rectangle ● To check size of variables in bytes (Use of size of Operator) ● Converting plane polar to Cartesian coordinates and vice versa
C++Control Statements	if-statement, if-else statement, Nested if Structure, Else-if statement, Ternary operator, Goto statement, switch statement, Unconditional and Conditional looping, While loop, Do-while loop, Forloop, nested loops, break and continue statements Programs: ● To find roots of a quadratic equation ● To find largest of three numbers ● To check whether a number is prime or not ● To list Prime numbers up to 1000
Random Number generator	Generating pseudo random numbers To find value of pi using MonteCarlo simulations. To integrate using Monte Carlo Method
Maclaurin andTaylor'sseries	Approximate functions likes sin(x),cos(x) by a finite number of terms of Taylor's series.
Arrays and Functions	Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order using Bubble sort and Sequential sort, Binary search, 2-dimensional arrays, matrix operations (sum, product, transpose etc)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha=\tan\alpha; I=I0[(\sin\alpha)/\alpha]^2$ in optics, square root of a number.
Data Analysis and Least Square Fitting(Linear case)	Uncertainty, error and precision, mean, standard deviation and error in the mean. Combining uncertainties, Least squares method for fitting data: linear (y= ax+b), power law ($y= ax^b$) and exponential ($y= ae^{bx}$). To find parameters a, band errors in them using method of least squares. Ohms law-calculate R, Hooke's law-Calculate Spring constant.

Numerical differentiation(Forward and Backward and central difference formulae- Using basic definition)	Given Position with equidistant time data calculate velocity and acceleration

References for Theory:

Essential Readings:

1. Advanced EngineeringMathematics, Erwin Kreyszig, 2008, WileyIndia.
2. An introduction to ordinarydifferential equations,E. A. Coddington, 2009,PHI learning.
3. Vector Analysis: SchaumOutlineSeries, M.R Spiegel, McGraw Hill Education (2017).
4. Statistical dataAnalysis for ThePhysical Sciences byAdrian Bevan, Cambridge UniversityPress (2013).
5. Advanced Mathematics for Engineersand Scientists: Schaum Outline Series, M. R Spiegel, McGrawHill Education (2009).

Additional Readings:

1. AdvancedEngineeringMathematics,D.G.ZillandW.S.Wright,5Ed.,2012,Jones and BartlettLearning.
2. MathematicalPhysics(1995),A.K.Ghatak,ICGoyalandS.J.Chua,MacmillanIndia, New Delhi.
3. EssentialMathematicalMethods,K.F.Riley&M.P.Hobson,2011,CambridgeUniv. Press.
4. Differential Equations, GeorgeF. Simmons, 2007, McGrawHill.
5. IntroductiontoVectorAnalysis,H.F.DavisandA.D.Snider,Wm.C.Brown Publishers; 6th edition (1991).
6. Statistics–AGuidetotheUseofStatisticalMethodsnthePhysicalSciences,R.J. Barlow, Wiley(1993).

References forLaboratoryWork:

1. Schaum'sOutlineofProgrammingwithC++’,J.Hubbard,2000,McGraw-HillEducation.
2. C++HowtoProgram’,PaulJ.DeitelandHarveyDeitel,Pearson(2016).
3. Introduction to Numerical Analysis, S.S. Sastry, 5thEdn., 2012, PHILearningPvt.Ltd.
4. ComputationalPhysics,DarrenWalker,1stEdn.,ScientificInternationalPvt.Ltd (2015).
5. ElementaryNumerical Analysis, K.E. Atkinson, 3rdEdn., 2007, WileyIndiaEdition.

MJC50PHY204(T)25: Waves and Optics
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

This course reviews the concepts of waves and optics learnt at school from a more advancedperspective and goes on to build new concepts. It begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. The course also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

Course Learning Outcomes

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

- Understand Simple harmonic oscillation and superposition principle.
- Understand different types of waves and their velocities: Plane, Spherical, Transverse, Longitudinal.
- Understand Concept of normal modes in transverse and longitudinal waves: their frequencies and configurations.
- Understand Interference as superposition of waves from coherent sources derived from same parent source.
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from aperture, understand Fraunhoffer and Fresnel Diffraction.
- In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt first-hand. The motion of coupled oscillators, study of Lissajous figures and behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

Unit 1

Superposition of Collinear Harmonic oscillations: Simple harmonic motion (SHM). 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.

(6 Lectures)

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies and their uses.

(2 Lectures)

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. **(3 Lectures)**

Unit 2

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. **(8 Lectures)**

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front, Huygens Principle. Temporal and Spatial Coherence.

(2 Lectures)

Unit 3

Interference: 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.

(7 Lectures)

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) wavelength difference ,(4) refractive index and (3) Visibility of Fringes. Fabry-Perot interferometer.

(3 Lectures)

Unit 4

Fraunhofer diffraction: Single slit. Rectangular and Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

(6 Lectures)

Unit 5

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, Cornu`s spiral and its applications. Straight edge, a slit and a wire.

(8 Lectures)

MJC50PHY204(P)25: Waves and Optics
Credit: 01
Practical: 30 Hours

Dedicated demonstration cum laboratory session on the construction, and use of spectrometer and lasers, and necessary precautions during their use.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.

Application to the specific experiments is to be done in the lab.

At least 06 experiments from the following experiments is to be selected :

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2–T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source

using plane diffraction grating.

12. To determine dispersive power and resolving power of a plane diffraction grating.

References for Theory: Essential Readings:

1. Vibrations and Waves, A.P. French, 1 st Edn., 2003, CRC press.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
4. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
5. Optics, Eugene Hecht, 4 th Edn., 2014, Pearson Education.

Additional Readings:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
3. Optics, (2017), 6th Edition, Ajoy Ghatak, McGraw-Hill Education, New Delhi.
4. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

References for Laboratory Work:

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

MNC50PHY203(T)25: Mathematical Physics, Waves and Optics

Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

The emphasis of course is to equip students with the mathematical and critical skills along with the concepts of waves and optics that is relevant to many interdisciplinary areas. The skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers. This course is an extension above the introductory level and provides a deeper understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

Course Learning Outcomes

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

- Understand solving first order and second order differential equations
- Perform line, surface and volume integration and apply Green's, Stokes' and Gauss's Theorems to compute these integrals.
- Simple harmonic oscillation and superposition principle.
- Understand different types of waves and their velocities: Plane, Spherical, Transverse, Longitudinal.
- Understand concept of normal modes in transverse and longitudinal waves: their frequencies and configurations.
- Understand the concepts of Interference and diffraction.
- In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt first-hand. The motion of coupled oscillators, study of Lissajous figures and behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

Unit 1

First Order Differential Equations and Second Order Differential Equations:

First order differential Equations: Variable separable, homogeneous, non-homogeneous, exact and in exact differential equations and Integrating Factors.

Second order differential Equation of Homogeneous kind with constant coefficients. Wronskian and general solution. Particular Integral with operator method, method of undetermined coefficients and method of variation of parameters.

(9 Lectures)

Unit 2

Vector Integration and Orthogonal Curvilinear Coordinates:

Line, surface and volume integrals of Scalar and Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems, their verification (no rigorous proofs) and applications.

Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

(9 Lectures)

Unit 3

Superposition of two collinear oscillations having equal frequencies and different frequencies (Beats). Normal modes.

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave.

(9 Lectures)

Unit 4

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front.

Huygens Principle. Temporal and Spatial Coherence.

Interference: 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. Newton's Rings:

(9 Lectures)

Unit 5

Fraunhofer diffraction: Single slit, double slit. Diffraction grating. Resolving power of grating.

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.

(9 Lectures)

MNC50PHY203(P)25: Mathematical Physics, Waves and Optics

Practical: 30 Hours

Dedicated demonstration cum laboratory session on the construction, and use of spectrometer and lasers, and necessary precautions during their use.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.

At least 06 experiments from the following list of experiments can be chosen:

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2–T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.

6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

References for Theory: Essential Readings:

1. Vibrations and Waves, A.P. French, 1 st Edn., 2003, CRC press.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
4. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
5. Optics, Eugene Hecht, 4 th Edn., 2014, Pearson Education.

MDC-3
INTRODUCTION TO PHYSICS :MDC50PHY203(T)25

• To give an introduction to the fundamentals of Physics.
• To give introductory concepts on units and measurement, scalar and vectors, laws of motion, work, power and energy, electricity and magnetism, geometry and wave optics, gravity and planetary motion, wave and oscillation, and electronics.

Course learning Outcomes
• They will understand the basic concepts of units and measurements, motion, optics, electricity and magnetism, energy, waves and oscillation and the concept of electronics which are the fundamental parts of Physics and its application in everyday life.
• On successful completion of the course, students will be able to understand the preliminary idea of the concept of Physics and its phenomena in our daily lives.

UNIT 1
Mechanics
Physical quantities, Units of measurement, SI units, Scalars and Vectors, Speed and Velocity, Linear momentum and Acceleration. Laws of motion, friction and lubrication, uniform circular motion. Work, energy, power; principle of conservation of energy. Newton's law of gravitation, acceleration due to gravity. **(15 Lectures)**
UNIT 2
Heat and Thermodynamics
Concept of heat and temperature, specific heat, Latent heat. Laws of thermodynamics (zeroth, first and second), Heat transfer: conduction, convection and radiation. **(5 Lectures)**
UNIT 3
Waves and Optics
Introduction to waves and its characteristics, Longitudinal and transverse waves, Simple harmonic motion, simple pendulum. Dual nature of light, Reflection, refraction and total internal reflection (simple examples), Interference, diffraction, and polarization (Simple idea only) Principle of optical fibers and LASER **(8 Lectures)**
UNIT 4
Electricity and Magnetism
Electric charge, current, Coulomb's law. Electric field Intensity and Electric potential (simple idea). Capacitance and Capacitors. Ohm's law, resistances and their combination. Kirchoff's laws. Alternating currents, Electromagnetic induction, Faraday's laws and Lenz law. Applications to transformer, generator and motor (no derivation). **(10 Lectures)**
UNIT 5
Electronic and modern Physics
Semiconductors, diodes and transistors, Solar cell, digital mobile data communication. Radioactivity, half life and mean life.Nuclear fission and fusion. (Elementary idea).

(7 Lectures)

Reference Books:
1. Elements of Properties of Matter, D.S. Mathur, 2008, S. Chand and Company Limited
2. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
3. Concept of Physics (I &II), H.C Verma.
4. NCERT Physics Textbooks (Class 9,10 11 &12)
5. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
6. Optics, Ajay Ghatak, 6th ed., 2017, Tata McGraw Hill.
7. Electricity and Magnetism, D.C.Tayal, 1993, Himalaya Publishing House.
8. Electricity and Magnetism, J H Fewkes & J Yarwood, Oxford University Press, Calcutta, 1985
9. SWAYAM/NPTEL modules on basic physics

MJC50PHY205(T)25:Mathematical Physics-II

Credit: 04(Theory-03, Practical-01)

Theory: 45 Hours

Practical:30 Hours

Course Objective

The emphasis of course is to equip students with the mathematical tools required in solving problems interest to physicists and expose them to fundamental computational physics skills thus enabling them to solve a wide range of physics problems. This course will aim at introducing the concepts of, special functions, linear partial differential equations by separation of variable method.

Course Learning Outcomes

On successfully completing this course, the students will be able to

- Understand elementary probability theory and the properties of discrete and continuous distribution functions.
- Learn about gamma and beta functions and their applications.
- Obtain power series solution of differential equation of second order with variable coefficient using Frobenius method.
- Understand properties and applications of special functions like Legendre polynomials, Bessel functions, Associate Legendre Function, Hermite and Laguerre Polynomials and their differential equations and apply the set of various physical problems such as in quantum mechanics.
- In the laboratory course, the students will learn the basics of the Scilab software/Python interpreter and apply appropriate numerical method to solve selected physics problems bothusinguserdefinedandinbuiltfunctionsfromScilab/Python.Theywillalsolearn

  To generate and plot Legendre polynomials and Bessel functions and verify their recurrence relation.

Unit 1

Probability and statistics:

Independent and dependent events, Conditional Probability, Bayes'Theorem, Independent random variables, Probability distribution functions, special distributions: Binomial, Poisson and Gauss' Normal. Sample mean and variance and their confidence intervals for Normal distribution.

(9 Lectures)

Unit 2

Some Special Integrals and Frobenius method:

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

Frobenius Method: Regular point, Singular Points of Second Order Linear Differential

Equations and their importance. Frobenius method and its applications to differential equations: Legendre, Bessel, Hermite and Laguerre Differential Equations.

(9 Lectures)

Unit 3

Legendre functions: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Associate Legendre function and the spherical harmonics.

(9 Lectures)

Unit 4

Bessel Functions: Bessel Functions of the First Kind, Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality.

(9 Lectures)

Unit 5

Hermite and Laguerre Polynomials: Rodrigue formula for Hermite polynomials, generating function and orthogonality relation. Rodridue formula for Laguerre polynomial, generating function and orthogonality relation,

(9 Lectures)

MJC50PHY205(P)25:Mathematical Physics-II
Credit: 01
Practical: 30 Hours

The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of practical sessions and lectures on the related theoretical aspects. The recommended group size for the lab is not more than15 students. Evaluation done not only onthebasisofprogrammingbutalsoonthebasisofformulatingtheproblem.Minimum12 programs must be attempted taking at least one from each programming section. The instructor may choose to use Python in place of Scilab covering all features as mentioned.

Topics	Description with Applications
Introduction to Numerical computation softwareusingScilab or Python	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initializing variables in Scilab, Multidimensional arrays, Sub-array, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Builtin Scilab functions, Introduction to plotting, 2D and 3D plotting, Branching Statements and program design, Relational and logical operators, the whileloop, forloop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization. User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program.
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation. Lagrange Interpolation.	Evaluation of trigonometric functions e.g. *sin(x), cos(x)*,*tan(x)*etc–Given the values at n points in a tabulated form, evaluate the value at an intermediate point.
Numerical Integration: Newton Cotes Integration methods (Trapezoidal and Simpson rules)for definite integrals	Given acceleration with equidistant time data calculate position and velocity and plot them. Application to other mathematical and physical problems
Solution of Linear system of equations: Solve system of linear equations using Gauss elimination method and Gauss Seidal method. Inverse of a matrix(by Gauss elimination)	Application to Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)
Generation of Special functions using user defined functions and compare with Scilab built in functions	Generating and plotting Legendre Polynomials Generating and plotting Bessel functions Verification of recurrence relation Use the data obtained above for Legendre polynomials or Bessel's function at N points and find its value at an intermediate point using Lagrange interpolation.
Solution of Ordinary Differential Equations (ODE)First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation (Initial value problems) Radioactive decay Current in RC, LC circuits with DC source Newton's law of cooling Classical equations of motion

System of First order Differential Equations	Attempt following problems using RK 4 order method: • Solve the coupled differential equations $\frac{dx}{dt} = y + x - \frac{x^3}{3}; \frac{dy}{dt} = -x$ for four initial conditions: $x(0)=0, y(0) = -1, -2, -3, -4$. Plot x vs y for each of the four initial conditions on the same screen for $0 \le t \le 15$ Application to linear electric networks

Second order differential equation (Euler and RK Methods)	Second Order Differential Equations: Harmonic oscillator(no friction) Damped Harmonic oscillator(Overdamped, Critically damped and Oscillatory behaviour) Forced Harmonic oscillator(Transient and Steady state solution) Apply above to LCR circuits also The differential equation describing the motion of a pendulum is$\frac{d^2\theta}{dt^2} = -sin\theta$. The pendulum is released from rest at an angular displacement a, i.e.$(0) = a$ and $\theta'(0) = 0$. Solve the equation for a=0.1, 0.5 and1.0 and plotθ ,$\frac{d\theta}{dt}$as a function of time in the range $0 \ll t \ll 8\pi$.Also plot the analytic solution valid for small$\theta(sin\theta \approx \theta)$. Solve $x^2\frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$ with initial condition at x=1 as $y(1) = \frac{1}{2}e^2, \frac{dy}{dx}(x=1) = -\frac{3}{2}e^2 - 0.5$ in the range 1<x<3. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph
Using Scicos/xcos	Generating sine wave, square wave, saw tooth wave Solution of harmonic oscillator Phase space plots

References for Theory:

Essential Readings:

1. Advanced EngineeringMathematics, Erwin Kreyszig, 2008, WileyIndia.
2. Advanced Mathematics for Engineersand Scientists: Schaum Outline Series, M. R Spiegel, McGrawHill Education (2009).
3. Dfferential Equations, GeorgeF. Simmons, 2006, Tata McGraw-Hill.
4. Mathematical Methods for Physicists, Arfken,Weber andHarris, Elsevier
5. Applied Mathematics for Engineers and Physicists,L.A. Pipes and L.R. Harvill, Dover Publications (2014).

Additional Readings:

1. Mathematical methods for Scientists &Engineers,D.A.McQuarrie, 2003,VivaBooks
2. MathematicalMethodsforPhysicsandEngineers,K.FRiley,M.P.HobsonandS.J. Bence, 3rded., 2006, CambridgeUniversityPress
3. MathematicalPhysics,A.K.Ghatak,I.C.GoyalandS.J.Chua,LaxmiPublications PrivateLimited (2017)
4. PartialDifferentialEquationsforScientistsandEngineers,S.J.Farlow,Dover Publications (1993).
5. FourierAnalysiswithApplicationstoBoundaryValueProblems: SchaumOutline Series, M. R Spiegel, McGraw Hill Education (1974).

References for Laboratory Work:

1. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.Vande Wouwer, P.Saucez, C.V.Fernández. 2014 Springer ISBN: 978-3319067896.
2. Documentation at the Scilab homepage:https://www.scilab.org/andthePythonhome pagehttps://docs.python.org/3/
3. Computational Physics, Darren Walker, Scientific International Pvt. Ltd (2015).
4. Applied numerical analysis, Cutis F.Gerald and P.O.Wheatley, Pearson Education, India(2007).
5. An Introduction to Computational Physics, T.Pang, CambridgeUniversityPress (2010).

MJC50PHY206(T)25: Thermal Physics
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Unit 1

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: Work Done during Isothermal and Adiabatic Processes. 2^{nd} Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

(9 lectures)

Unit 2

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

(9 lectures)

Unit 3

Thermodynamic Potentials and Maxwell's Relations: Internal energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. First and second order Phase Transitions with examples, Clausius Clapeyron Equation. Derivation of Maxwell's thermodynamic Relations and their applications, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Value of Cp-Cv, (3) TdS Equations, (4) Energy equations.

(9 lectures)

Unit 4

Kinetic Theory of Gases Distribution of Velocities & Molecular Collisions: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification, Law of Equipartition of Energy (No derivation) and its application to Specific heats of Gases. Mean Free Path, Collision Probability. Estimation of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and Diffusion. Brownian Motion and its Significance.

(9 lectures)

Unit 5

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. Andrew's Experiments on CO_2 Gas. Virial Equation. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gases. Boyle Temperature. van der Waal's Equation of State for Real Gases. Values of Critical Constants. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

(9 lectures)

MJC50PHY206(P)25: Thermal Physics
Credit: 01
Practical: 30 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the thermal physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least six experiments should be performed in the lab:

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions using a null method. And also calibrate the Thermocouple in a specified temperature range.
7. To calibrate a thermocouple to measure temperature in a specified Range using Op- Amp difference amplifier and to determine Neutral Temperature.

References for Theory: Essential Readings:

1. Heat and Thermodynamics: M.W. Zemansky and R. Dittman, (Tata McGraw-Hill.)
2. A Treatise on Heat: M.N. Saha and B.N. Srivastava, 1958 (Indian Press.)
3. Thermal Physics: S. C. Garg, R. M. Bansal and C. K. Ghosh (Tata McGraw-Hill.)
4. Statistical Mechanics: Kerson Huang (Wiley Eastern Ltd)
5. Thermal Physics: A B Gupta, H P Roy (Books & Allied Ltd)

Additional Readings:

1. Thermodynamics for Engineers; Schaum's outline, M C Potter & C W Somerton; McGraw Hill
2. An Introduction to Thermal Physics: D. Schroeder (Pearson)
3. Thermal Physics: C. Kittel and H. Kroemer (W. H. Freeman)

References for Laboratory work:

1. Advanced Practical Physics for students: B. L. Flint and H.T. Worsnop (Little Hampton Book)
2. A Text Book of Practical Physics: Indu Prakash& Ramakrishna (Kitab Mahal)
3. Advanced level Practical Physics: Nelkon and Ogborn (Heinemann Educational Publ.)
4. An Advanced Course in Practical Physics: D. Chattopadhyay& P. C. Rakshit, (New Central Book Agency)
5. Advanced Practical Physics: B Ghosh & K G Majumdar (Shreedhar Publishers)

MJC50PHY207(T)25: Elements of Modern Physics
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Unit 1

Origin of quantum theory:

Blackbody Radiation: Plank’s Quantum hypothesis; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Double- slit experiment with electrons. Wave amplitude and wave functions.

(9 Lectures)

Unit 2

Position measurement:

Gamma ray microscope thought experiment; Wave-particle duality leading to Heisenberg uncertainty principle; Uncertainty relations involving canonical pair of variables. Derivation from Wave Packets; Impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Energy-time uncertainty principle: application to virtual particles and range of interaction.

(9 Lectures)

Unit 3

Schrödinger equation and operators:

Two-slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Schrödinger equation (time-dependent and time-independent). Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

(9 Lectures)

Unit 4

One dimensional infinitely rigid box and Lasers:

Energy eigenvalues, eigenfunctions and their normalization; Quantum mechanical scattering and tunneling in one dimension: across a step potential & across a rectangular potential barrier.

Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion (Basic ideas only). **(9 Lectures)**

Unit 5

Nucleus and Radioactivity:

Size and structure of atomic nucleus and its relation with atomic weight; Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula, mass defect and binding energy. Fission: generation of energy; Fusion and thermonuclear reactions driving stellar evolution**.**

Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair production

(9 Lectures)

MJC50PHY207(P)25: Elements of Modern Physics
Credit: 01
Practical: 30 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the modern physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 05 experiments from the following:

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine angular spread of He-Ne laser using plane diffraction grating

Reference for Theory: Essential Readings

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Theory & Problems of Modern Physics, Schaum's outline, R Gautreau & W. Savin, McGraw Hill
3. Modern Physics: R. Murugeshan & K Sivaprasathi; S. Chand Publishing.
4. Quantum Physics, Robert Eisberg and Robert Resnick, 2nd Edition., 2002, Wiley.
5. An Introduction to lasers: M N Avadhanulu, P S Hemne; S. Chand Publishing

Additional Readings:

1. Modern Physics for Scientists and Engineers by S T Thornton and A Rex, 4th edition, Cengage Learning, 2013.
2. Thirty years that shook physics: the story of quantum theory, George Gamow, Garden City, NY: Doubleday, 1966.
3. Quantum Physics; H. C Verma. Surya Publications
4. Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy

Ghatak, Viva Books Pvt. Ltd., 2019

5. Quantum Mechanics: Theory and Applications, (2019),(Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi

Reference for Laboratory

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

2. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition,2011, Kitab Mahal, New Delhi.

4. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

MJC50PHY208(T)25: Digital Systems and Applications
Credit : 04 (Theory-03, Practical-01)
Theory : 45 Hours
Practical : 30 Hours

Course Objective:
This is one of the core papers in physics curriculum which introduces the concept of Boolean algebra and the basic digital electronics. In this course, students will be able to understand the working principle of CRO, Data processing circuits, Arithmetic Circuits, sequential circuits like registers, counters etc. based on flip flops. In addition, students will get an overview of microprocessor architecture and programming.

Course Learning Outcomes
This course lays the foundation for understanding the digital logic circuits and their use in combinational and sequential logic circuit design. It also imparts information about the basic architecture, memory and input/output organization in a microprocessor system. The students also learn the working of CRO.

• Course learning begins with the basic understanding of active and passive components.
• Differentiating the Analog and Digital circuits, the concepts of number systems like Binary, BCD, Octal and hexadecimal are developed to elaborate and focus on the digital systems.
• Sequential Circuits: Basic memory elements Flips-Flops, shift registers and 4-bits counters leading to the concept of RAM, ROM and memory organization.
• Timer circuits using IC 555 providing clock pulses to sequential circuits and develop multivibrators. • Introduces to basic architecture of processing in an Intel 8085 microprocessor and to Assembly Language.
• Also impart understanding the working of CRO and its usage in measurements of voltage, current, frequency and phase measurement in practicals.
• In the laboratory students will learn to construct both combinational and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Shift Registers, and multivibrators using 555 ICs. They are also expected to use µP 8085 to demonstrate the same simple programme using assembly language and execute the programme using a µP kit.

Unit 1

Digital Circuits

Number Systems: Binary Numbers, Decimal to Binary and Binary to Decimal Conversion, BCD, Octal and Hexadecimal numbers. 1’s and 2’s complement representation.
(2 Lectures)

Digital Circuits: Difference between Analog and Digital Circuits, AND, OR and NOT Gates (realisation using Diodes and Transistor), NAND and NOR Gates as Universal Gates.
(3 Lectures)

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

Unit 2

Combinational Circuits

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

Data processing circuits: Multiplexers, De-multiplexers, Decoders, Encoders. **(3 Lectures)**

Unit 3

Sequential Circuits

Flip-flops: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop, M/S JK Flip-flop.

(5 Lectures)

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). **(3 Lectures)**

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

(3 Lectures)

Timers: IC 555 block diagram and applications: Astable multivibrator and Monostable multivibrator. **(3 Lectures)**

Unit 4

Computer Organisation

Input / Output Devices, Data storage (idea of RAM and ROM). Computer memory, Memory organization and addressing, Memory Interfacing and Memory Map. **(5 Lectures)**

Unit 5

Intel 8085 Microprocessor Architecture

Main features of 8085, Block diagram, Components, Pin-out diagram, Buses, Registers. ALU, Memory and Stack memory. **(5 Lectures)**

Introduction to Assembly Language: 1 byte, 2 byte and 3 byte instructions. **(2 Lectures)**

MJC50PHY208(P)25: Digital Systems and Applications

Credit: 01

Practical: 30 Hours

Session on the construction and use of CRO, and other experimental apparatuses used in the laboratory including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 04 experiments each from section A and Section B

Section-A: Digital Circuits Hardware design/Verilog Design

1. To design a combinational logic system for a specified Truth Table.
(a) To convert Boolean expression into logic circuit & design it using logic gate ICs
(b) To minimize a given logic circuit.
2. Half Adder, Full Adder and 4-bit binary Adder.
3. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
4. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
5. To build JK Master-slave flip-flop using Flip-Flop ICs
6. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
7. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
8. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO and to design an astable multivibrator of given specifications using 555 Timer.
9. To design a monostable multivibrator of given specifications using 555 Timer.

Section-B: Programs using 8085 Microprocessor:

1. Addition and subtraction of numbers using direct addressing mode
2. Addition and subtraction of numbers using indirect addressing mode
3. Multiplication by repeated addition.
4. Division by repeated subtraction.
5. Handling of 16-bit Numbers.
6. Use of CALL and RETURN Instruction.
7. Block data handling.
8. Other programs (e.g. using interrupts, etc.).

References for Theory: Essential Readings:

1. Digital Principles and Applications, A.P.Malvino, D.P.Leach and G. Saha, 8th Ed., 2018, Tata McGraw Hill Education.
2. Fundamentals of Digital Circuits, Anand Kumar, 4 th Edn, 2018, PHI Learning Pvt. Ltd. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill
3. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.
4. Digital Computer Electronics, A.P. Malvino, J.A. Brown, 3rd Edition, 2018, Tata McGraw Hill Education.
5. Digital Design, Morris Mano, 5th Ed. Pearson.

Additional Readings:

1. Digital Electronics G K Kharate ,2010, Oxford University Press
2. Logic circuit design, Shimon P. Vingron, 2012, Springer
3. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill

References for Laboratory Work:

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

MNC50PHY204(T)25: Heat and Thermodynamics
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Unit 1

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: Work Done during Isothermal and Adiabatic Processes. 2^{nd} Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

(9 lectures)

Unit 2

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

(9 lectures)

Unit 3

Thermodynamic Potentials and Maxwell's Relations: Internal energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. First and second order Phase Transitions with examples, Clausius Clapeyron Equation. Derivation of Maxwell's thermodynamic Relations and their applications, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Value of Cp-Cv, (3) TdS Equations, (4) Energy equations.

(9 lectures)

Unit 4

Kinetic Theory of Gases Distribution of Velocities & Molecular Collisions: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification, Law of Equipartition of Energy (No derivation) and its application to Specific heats of Gases. Mean Free Path, Collision Probability. Estimation of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and Diffusion. Brownian Motion and its Significance.

(9 lectures)

Unit 5

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. Andrew's Experiments on CO_2 Gas. Virial Equation. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gases. Boyle Temperature. van der Waal's Equation of State for Real Gases. Values of Critical Constants. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

(9 lectures)

MNC50PHY204(P)25: Heat and Thermodynamics
Credit: 01
Practical: 30 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the thermal physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least six experiments should be performed in the lab:

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions using a null method. And also calibrate the Thermocouple in a specified temperature range.
7. To calibrate a thermocouple to measure temperature in a specified Range using Op- Amp difference amplifier and to determine Neutral Temperature.

References for Theory: Essential Readings:

1. Heat and Thermodynamics: M.W. Zemansky and R. Dittman, (Tata McGraw-Hill.)
2. A Treatise on Heat: M.N. Saha and B.N. Srivastava, 1958 (Indian Press.)
3. Thermal Physics: S. C. Garg, R. M. Bansal and C. K. Ghosh (Tata McGraw-Hill.)
4. Statistical Mechanics: Kerson Huang (Wiley Eastern Ltd)
5. Thermal Physics: A B Gupta, H P Roy (Books & Allied Ltd)

Additional Readings:

1. Thermodynamics for Engineers; Schaum's outline, M C Potter & C W Somerton; McGraw Hill
2. An Introduction to Thermal Physics: D. Schroeder (Pearson)
3. Thermal Physics: C. Kittel and H. Kroemer (W. H. Freeman)

References for Laboratory work:

1. Advanced Practical Physics for students: B. L. Flint and H.T. Worsnop (Little Hampton Book)
2. A Text Book of Practical Physics: Indu Prakash& Ramakrishna (Kitab Mahal)
3. Advanced level Practical Physics: Nelkon and Ogborn (Heinemann Educational Publ.)
4. An Advanced Course in Practical Physics: D. Chattopadhyay& P. C. Rakshit, (New Central Book Agency)
5. Advanced Practical Physics: B Ghosh & K G Majumdar (Shreedhar Publishers)

MJC55PHY309(T)25: Quantum Mechanics &Applications
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

After learning the elements of modern physics, in this course students would be exposed to more advanced concepts in quantum physics and their applications to problems of the sub atomic world.

Course Learning Outcomes

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

- Methods to solve time-dependent and time-independent Schrodinger equation.
- Quantum mechanics of simple harmonic oscillator.
- Non-relativistic hydrogen atom: spectrum and eigenfunctions.
- Angular momentum: Orbital angular momentum and spin angular momentum.
- Bosons and fermions - symmetric and anti-symmetric wave functions.
- Application to atomic systems
- In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one- dimensional and three-dimensional potentials.

Unit 1

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function: Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

(10 Lectures)

Unit 2

Time independent Schrodinger equation: Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(10 Lectures)

Unit 3

General discussion of bound states in an arbitrary potential: continuity of wave function, boundary condition and emergence of discrete energy levels; application to one- dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator: energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials.

(7 Lectures)

Unit 4

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator, quantum numbers & shells; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground and first excited states.

(7 Lectures)

Unit 5

Atoms in Electric and Magnetic Fields: Electron angular momentum. Angular momentum quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal Zeeman Effect: Electron Magnetic Moment and Magnetic Energy.

(6 Lectures)

Many electron atoms: Pauli's Exclusion Principle. Symmetric and Anti-symmetric Wave Functions. Spectral Notations for Atomic States. Total angular momentum. Spin-orbit coupling in atoms-L-S and J-J couplings.

(5 Lectures)

MJC55PHY309(P)25: QuantumMechanics& Applications
Credit: 01
Practical: 30 Hours

Use C/C++/Scilab/Python for solving the following problems based on Quantum Mechanics like:

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = (r)u(r),\ A(r) = \frac{2m}{\hbar}[V(r) - E]\ where\ V(r) = \frac{-e^2}{r}$$

where m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is $\approx -13.6\ eV$. Take e = 3.795 (eVÅ)1/2, $\hbar c$ = 1973 (eVÅ) and m = 0.511x10^6 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = (r)(r),\ A(r) = \frac{2m}{\hbar^2}[(r) - E]$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

$$V(r) = \frac{-e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVÅ)1/2, m = 0.511x10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units $\hbar c$ = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2y}{dr^2} = (r)(r),\ A(r) = \frac{2m}{\hbar^2}[(r) - E]$$

For a harmonic oscillator potential

$$(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940\ MeV/c^2$, $k = 100\ MeV\ fm^{-2}$, $b = 0, 10, 30\ MeV fm^{-3}$. In these units, $c\hbar = 197.3\ MeV\ fm$. The ground state energy expected to lie between 90 and 110 MeV for three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = (r)(r),\ A(r) = \frac{2m}{\hbar^2}[(r) - E]$$

where m is the reduced mass of the two-atom system for the Morse potential

$$(r) = (e^{-2ar'} - e^{-ar'}), r' = \frac{r - r'}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take $m = 940 \times 10^6\ eV/\ c^2, D = 0.755501\ eV, \alpha = 1.44, r_0 = 0.131349A$

where µ is the reduced mass of the two-atom system for the Morse potential

Laboratory based experiments (Optional):

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. Quantum efficiency of CCD

References for Theory Essential Readings

1. Quantum Mechanics, B. H. Bransden and C. J. Joachain; 2nd Ed., Prentice Hall, 2000.
2. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed.,2010, McGraw Hill.
3. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press.
4. Quantum Mechanics: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi.
5. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education.

Additional Readings

1. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966.
2. Quantum Mechanics, Leonard I. Schiff, 3^{rd} Edn. 2010, Tata McGraw Hill.
3. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2ndEdn., 2002, Wiley.
4. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
5. Quantum Mechanics, Walter Greiner, 4^{th} Edn., 2001, Springer.
6. Introductory Quantum Mechanics, R. L. Liboff; 4th Ed., Addison Wesley, 2003.
7. Quantum Mechanics: Concepts and Applications, 2nd Edition, Nouredine Zettili, A John Wiley and Sons, Ltd., Publication

References for Laboratory Work:

1. Schaum’s outline of Programming with C++. J. Hubbard, 2000, McGraw Hill Publication
2. An introduction to computational Physics, T. Pang, 2nd Edn.,2006, Cambridge Univ. Press
3. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
4. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
5. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.

MJC55PHY310(T)25:Mathematical Physics III
Credit: 04 (Theory-03,Practical-01)
Theory: 45 Hours
Practical: 30 ours

Course Objective

The emphasis of the course is on applications in solving problems of interest to physicists. Students will be examined on the basis of problems, seen and unseen. The course will develop understanding of the basic concepts underlying complex analysis and complex integration and enable student to use Fourier and Laplace Transform to solve real world problems.

Course Learning Outcomes

After completing this course, students will be able to

- Determine continuity, differentiability and analyticity of a complex function, find the derivative of a function and understand the properties of elementary complex functions.
- Work with multi-valued functions (logarithmic, complex power, inverse trigonometric function) and determine branches of these functions
- Evaluate a contour integral using parametrization, fundamental theorem of calculus and Cauchy'sintegral formula.
- Find the Taylor series of a function and determine its radius of convergence.
- Determine the Laurent series expansion of a function in different regions, find the residues and use the residue theory to evaluate a contour integral and real integral.
- Understand the properties of Fourier and Laplace transforms
- In the laboratory course, the students will learn the basics of the Scilab software/Python interpreter and apply appropriate numerical method to solve selected physics problems both using user defined and inbuilt functions from Scilab/Python.

Unit 1

Complex Analysis:

Functions of Complex Variables. Analyticity and Cauchy-Riemann Equations. Singularities: poles, removable singularity, essential singularity, branch points, branchcut.

(9 Lectures)

Unit 2

Complex Integration:

Integration of a function of a complex variable. Cauchy-Goursat Theorem, Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. **(9 Lectures)**

Unit 3

FourierTransforms:

Fourier Integral theorem (Statement only). Fourier Transform(FT), Fourier Sine Transform (FST) and Fourier Cosine Transform (FCT) Example: single pulse, exponential and Gaussian functions. FT of derivatives, Inverse FT, Convolution theorem. Properties of FTs (translation, change of scale, complex conjugation, etc.).

(9 Lectures)

Unit 4

LaplaceTransforms:

LaplaceTransform(LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, ShiftingTheorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs .LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT.

(9 Lectures)

Unit 5:

Contour Integration and Dirac delta Function:

Residues and Residue Theorem. Application of Contour Integration in solving Definite Integrals.

Definition and properties of Dirac delta function, Representation of Dirac delta function as a Fourier Integral. Laplace and Fourier Transform of Dirac delta function.

(9 Lectures)

MJC55PHY310(P)25: Mathematical Physics III
Credit: 01
Practical: 30 Hours

The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of practical sessions and lectures on the related theoretical aspects of the Laboratory course. Evaluation done not only on the basis of programming but also on the basis of formulating the problem. **At least ten** programs must be attempted taking at least one from each programming section. The program list is only suggestive and students should be encouraged to do more problems.

C^{++}/C/Scilab/Python based simulations experiments on Mathematical Physics problems like

1. Boundary Value Problems:
   A. Solution to Ordinary Differential equation (Boundary Value Problems using finite Difference and shooting methods):
      i. Solve$y''(x) + y(x) = 0$ with $y(0) = 1$, $y\left(\frac{\pi}{2}\right) = 1$ for $0 < x < \pi$.
      ii. Solveforthesteadystateconcentrationprofiley(x)inthereaction-diffusion problem given by Solve $y''(x) - y(x) = 0$ with $y(0) = 1$, $y'(1) = 0$.
   B. Solution to Partial Differential equation: Finite Difference and Crank-Nicholson methods to solve Laplace equation, wave equation, and Heat Equation.
2. Gauss Quadrature Integration Method: Gauss Legendre, Gauss Lagaurre and Gauss Hermite:
   i. Verification of Orthogonality of Legendre polynomials.

$$\int_{-1}^{+1} (\mu) P_m(\mu) d\mu = \frac{2}{(2n+1)} \delta_{n,m}$$

ii. Complex analysis: Integrate $\int_0^\infty \frac{1}{(x^2+2)} dx$ numerically using Gauss Lagurre method and check with contour integration.

3. Dirac delta Function: representations of Dirac delta function as a limiting sequence of functions. Verify the properties of Dirac delta function. e.g. Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}} \int exp\,(\frac{-(x-2)^2}{2\sigma^2})\,(x+3)x$, for σ=1, 0.1, 0.01 and show that it tends to5. Use Hermite Gauss quadrature method and also Simpson method with appropriate limits.

4. Fourier Series:

   Evaluate the Fourier coefficients of a given periodic function (e.g.square wave, triangle wave, halfwave and fullwave rectifier etc.)

5. Weighted Least square fitting of given data(x, y) with known error/uncertainty-values using user defined function.

6. Integral transform:

   i. Discrete and Fast Fourier Transform of given function in tabulated or mathematical form e.g. function exp^{-x^2}

   ii. Perform circuit analysis of a general LCR circuit using Laplace's transform.

References for Theory: Essential Readings:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S.J. Bence, 3rd Edition., 2006, Cambridge University Press
2. Complex Variables and Applications, J.W.Brown & R.V.Churchill, 7th Edition.2003,Tata McGraw-Hill.
3. Laplace Transform: Schaum's Outline, M.R> Speigel, McGraw Hill Education.
4. Complex Variables: Schaum's Outline, McGraw Hill Education.
5. Fourier Analysis and Its Applications (Wadsworthand Brooks/Cole Mathematics Series), Gerald B. Folland, Thomson Brooks/Cole (1992).

Additional Readings:

1. Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications.
2. Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
3. Mathematical Physics with Applications, Problems and Solutions, V.Balakrishnan, Ane Books (2017).
4. Fourier Analysis with Applications to Boundary Value Problems: Schaum Outline Series, M. R Spiegel, McGraw Hill Education (1974).
5. Fourier Transform and its Applications, 2ndEd.,Ronald New Bold Bracewell,McGraw Hill (1978).

References for Laboratory Work:

1. AnintroductiontocomputationalPhysics,T.Pang,2ndEdn.,2006,CambridgeUniv.

   Press.
2. Applied numerical analysis, Cutis F.Gerald and P.O.Wheatley, PearsonEducation, India(2007).

3. Friendly Introduction to Numerical Analysis, Brian Bradie, Pearson Education (2007).
4. Introduction to Numerical Analysis, S.S.Sastry,5thEdn., PHI LearningPvt.Ltd. (2012).
5. Partial Differential Equations for Scientists and Engineers, S.J. Farlow, Dover Publications (1993).

MJC55PHY311(T)25: Analogue Systems and Applications Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

This course introduces the concept of semiconductor devices and their applications. It also emphasizes on understanding of amplifiers, oscillators, operational amplifier and their applications.

Course Learning Outcomes

At the end of this course, the following concepts will be learnt

- Characteristics and working of p-n junction.
- Two-terminal devices: Rectifier diodes, Zener diode, photodiode, etc.
- NPN and PNP transistors: Characteristics of different configurations, biasing, stabilization and their applications.
- CE and two stage RC coupled transistor amplifier using h-parameter model of the transistor.
- Designing of different types of oscillators and their stabilities.
- Ideal and practical op-amps: Characteristics and applications.
- In the laboratory course, the students will be able to study characteristics of various diodes and BJT.

They will be able to design amplifiers, oscillators. Different applications using Op-Amp will also be designed.

Unit 1

Diodes and Rectifiers

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram. Current Flow Mechanism in Forward and Reverse Biased Diode. Barrier Formation in PN Junction Diode. Derivation for Barrier Potential, Barrier Width and Current for abrupt Junction. Principle, structure and characteristics of (1) LED, (2) Photodiode and (3) Solar Cell. Qualitative idea of Schottky diode and Tunnel diode. **(8 Lectures)**

Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency for C-filter. **(4 Lectures)**

Zener Diode and Voltage Regulation. **(2 Lectures)**

Unit 2

Transistors and Amplifiers

Bipolar Junction transistors: n-p-n and p-n-p Transistors. I-V characteristics of CB and CE Configurations. Physical Mechanism of Current Flow. Active, Cut-off and Saturation Regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. **(6 Lectures)**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. **(8 Lectures)**

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response. **(2 Lectures)**

Unit 3

Feedback Amplifiers

Positive and Negative Feedback. Effect of negative feedback on Input Impedance, Output Impedance, Gain and Stability. **(4 Lectures)**

Unit 4

Sinusoidal Oscillators:

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

Unit 5

Operational Amplifiers (Black Box approach):

Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. CMRR. Slew Rate and concept of Virtual ground. **(3 Lectures)**

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Wein bridge oscillator. **(3 Lectures)**

MJC55PHY311(P)25:Analog systems and Applications
Credit:01
Practical: 30 Hours

Session on the construction and use of specific analogue devices and experimental apparatuses used in the laboratory including necessary precautions. Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
2. Study of V-I & power curves of solar cells and find maximum power point & efficiency.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a two stage RC-coupled transistor amplifier.
7. To design a Wien bridge oscillator for given frequency using an op-amp.
8. To design a phase shift oscillator of given specifications using BJT.
9. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
10. To design inverting amplifier using Op-amp (741,351) & study its frequency response
11. To design non-inverting amplifier using Op-amp (741,351) and study frequency response
12. To investigate the use of an op-amp as an Integrator.
13. To investigate the use of an op-amp as a Differentiator.

References for Theory: Essential Readings:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
2. Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
3. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
4. Electronic Principles, A. Malvino, D.J. Bates, 7th Edition, 2018, Tata Mc-Graw Hill 52 Education.
5. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson

Additional Readings:

1. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI
2. Learning Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill OP-Amps
3. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
4. Microelectronic Devices & Circuits, David A.Bell, 5th Edn.,2015, Oxford University Press
5. Basic Electronics: Principles and Applications, C.Saha, A.Halder, D.Ganguli, 1st Edition, 2018, Cambridge University Press.

References for Laboratory Work:

1. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1994, McGraw Hill. OP-Amps

MNC55PHY205(T)25: Quantum Mechanics &Applications
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

After learning the elements of modern physics, in this course students would be exposed to more advanced concepts in quantum physics and their applications to problems of the sub atomic world.

Course Learning Outcomes

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

- Methods to solve time-dependent and time-independent Schrodinger equation.
- Quantum mechanics of simple harmonic oscillator.
- Non-relativistic hydrogen atom: spectrum and eigenfunctions.
- Angular momentum: Orbital angular momentum and spin angular momentum.
- Bosons and fermions - symmetric and anti-symmetric wave functions.
- Application to atomic systems
- In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one- dimensional and three-dimensional potentials.

Unit 1

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function: Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

(10 Lectures)

Unit 2

Time independent Schrodinger equation: Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(10 Lectures)

Unit 3

General discussion of bound states in an arbitrary potential: continuity of wave function, boundary condition and emergence of discrete energy levels; application to one- dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator: energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials.

(7 Lectures)

Unit 4

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator, quantum numbers & shells; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground and first excited states.

(7 Lectures)

Unit 5

Atoms in Electric and Magnetic Fields: Electron angular momentum. Angular momentum quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal Zeeman Effect: Electron Magnetic Moment and Magnetic Energy.

(6 Lectures)

Many electron atoms: Pauli's Exclusion Principle. Symmetric and Anti-symmetric Wave Functions. Spectral Notations for Atomic States. Total angular momentum. Spin-orbit coupling in atoms-L-S and J-J couplings.

(5 Lectures)

MNC55PHY205(P)25: Quantum Mechanics & Applications
Credit: 01
Practical: 30 Hours

Use C/C++/Scilab/Python for solving the following problems based on Quantum Mechanics like:

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r),\ A(r) = \frac{2m}{\hbar}[V(r) - E]\ where\ V(r) = \frac{-e^2}{r}$$

   where m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is $\approx -13.6\ eV$. Take e = 3.795 (eVÅ)1/2, $\hbar c$ = 1973 (eVÅ) and $m = 0.511\text{x}10^6$ eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r),\ A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

   where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

$$V(r) = \frac{-e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVÅ)1/2, m = 0.511x10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units $\hbar c$ = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2y}{dr^2} = A(r)u(r),\ A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

For a harmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940\ MeV/c^2$, $k = 100\ MeV\ fm^{-2}$, $b = 0, 10, 30\ MeVfm^{-3}$. In these units, $c\hbar = 197.3\ MeV\ fm$. The ground state energy expected to lie between 90 and 110 MeV for three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = A(r)u(r),\ A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

where m is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D\left(e^{-2ar'} - e^{-ar'}\right), r' = \frac{r - r'}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take $m = 940 \times 10^6\ eV/\ c^2, D = 0.755501\ eV, \alpha = 1.44, r_0 = 0.131349A$

where μ is the reduced mass of the two-atom system for the Morse potential

Laboratory based experiments (Optional):

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. Quantum efficiency of CCD

References for Theory Essential Readings

1. Quantum Mechanics, B. H. Bransden and C. J. Joachain; 2nd Ed., Prentice Hall, 2000.
2. Quantum Mechanics, HC Verma, Wordpress.
3. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press.
4. Quantum Mechanics: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi.
5. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education.

Additional Readings

1. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966.
2. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
3. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2ndEdn., 2002, Wiley.
4. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
5. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer.
6. Introductory Quantum Mechanics, R. L. Liboff; 4th Ed., Addison Wesley, 2003.
7. Quantum Mechanics: Concepts and Applications, 2nd Edition, Nouredine Zettili, A John Wiley and Sons, Ltd., Publication

References for Laboratory Work:

1. Schaum's outline of Programming with C++. J. Hubbard, 2000, McGraw Hill Publication
2. An introduction to computational Physics, T. Pang, 2nd Edn.,2006, Cambridge Univ. Press
3. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
4. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
5. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.

MJC55PHY312(T)25: Solid State Physics
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. The gained knowledge helps to solve problems in solid state physics using relevant mathematical tools. It also communicates the importance of solid-state physics in modern society.

Course Learning Outcomes

On successful completion of the module students should be able to

- Elucidate the concept of lattice, crystals and symmetry operations.
- Understand the elementary lattice dynamics and its influence on the properties of materials.
- Describe the main features of the physics of electrons in solids: origin of energy bands, and their influence electronic behavior.
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids.
- Understand preliminary concept and experiments related to superconductivity in solid.
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity

  and the hall set up to determine the hall coefficient of a semiconductor.

Unit 1

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Types of Lattices. Unit Cell, Symmetry and Symmetry Elements. Miller Indices. Reciprocal Lattice. Brillouin Zones. Diffraction of X-rays: single crystal and powder method. Bragg's Law, Laue Condition. Edward's construction. Atomic and Geometrical Factor. Simple numerical problem on SC, BCC, FCC.

(10 Lectures)

Unit 2

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

(7 Lectures)

Unit 3

Electrons in Solids: Electrons in metals- Introduction to Drude Model, Density of states (1- D, 2-D, 3-D) (basic idea), Elementary band theory: Kronig Penney model. Band Gap, direct and indirect bandgap. Effective mass, mobility, Hall Effect (Metal and Semiconductor).

(8 Lectures)

Unit 4

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Para- magnetic domains. Quantum Treatment of Paramagnetism, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Curie's law. B-H Curve, soft and hard material and Energy Loss Hysteresis.

(8 Lectures)

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation).

(5 Lectures)

Unit 5

Dielectric Properties of Materials: Polarization. Local Electric Field in solids. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mossotti Equation. Classical Theory of Electric Polarizability. AC polarizability, Normal and Anomalous Dispersion. Complex Dielectric Constant. Langevin-Debye equation.

(7 Lectures)

MJC55PHY312(P)25: Solid State Physics
Credit: 01
Practical: 30 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the solid-state physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of solids.
3. To determine the Coupling Coefficient of a piezoelectric crystal.
4. To study the dielectric response of materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
6. To determine the refractive index of a dielectric material using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Iron (Fe) using solenoid & determine the energy loss from Hysteresis loop.

9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 150^0C) by four-probe method and determine its band gap.

10. To determine the Hall coefficient of a semiconductor sample.

11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.

12. Measurement of change in resistance of a semiconductor with magnetic field.

References for Theory: Essential Readings:

1. Introduction to Solid State Physics, Charles Kittel, 8^{th} Ed., 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2^{nd} Ed., 2006, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.

Additional Readings

1. Elementary Solid State Physics, M.Ali Omar, 2006, Pearson
2. Solid State Physics, Rita John, 2014, McGraw Hill
3. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

References for Practical:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
4. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
5. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

MJC55PHY313(T)25: Electromagnetic Theory
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

This core course develops further the concepts learnt in the electricity and magnetism course to understand the properties of electromagnetic waves in vacuum and different media.

Course Learning Outcomes

At the end of this course the student will be able to:

- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
- Understand electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma.
- Understand electromagnetic wave propagation in bounded media: reflection and transmission coefficients at plane interface in bounded media.
- Understand polarization of Electromagnetic Waves: Linear, Circular and Elliptical Polarization. Production as well as detection of waves in laboratory.
- Learn the features of planar optical wave guide.
- Understand the fundamentals of propagation of electromagnetic waves through optical fibres.
- In the laboratory course, the students get an opportunity to perform experiments with Polarimeter, Babinet Compensator, Ultrasonic grating, simple dipole antenna. Also, to study phenomena of interference, refraction, diffraction and polarization.

Unit 1

Maxwell Equations: Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Poynting's Theorem and Poynting's Vector. Electromagnetic(em) Energy Density. Physical Concept of Electromagnetic Field Energy Density. Momentum Density and Angular Momentum Density.

(7 Lectures)

Unit 2

EM Wave Propagation in Unbounded Media: Plane em waves through vacuum and isotropic dielectric medium: transverse nature, refractive index, dielectric constant, wave impedance. Plane em waves through conducting medium: relaxation time, skin depth, attenuation constant. Wave propagation through dilute plasma: electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth.

(8 Lectures)

Unit 3

EM Waves in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane em waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence)

(8 Lectures)

Unit 4

Polarization of EM Waves: Propagation of em waves in an Anisotropic Media. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Description of Linear, Circular and Elliptical Polarization. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses.

(10 Lectures)

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

(4 Lectures)

Unit 5

Wave Guides: Planar optical wave guides. Planar dielectric wave guide ($-d/2 < x < d/2$). Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.

(5 Lectures)

Optical Fibres: Acceptance Angle, Numerical Aperture. Step and Graded Index fibres (Definitions Only). Single and Multiple Mode Fibres.

(3 Lectures)

MJC55PHY313(P)25: Electromagnetic Theory
Credit: 01
Practical: 30 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments from the following

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves.
7. To study Polarization and double slit interference in microwaves.

8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan's law of radiation and to determine Stefan's constant.
12. To determine Boltzmann constant using V-I characteristics of PN junction diode.
13. To find Numerical Aperture of an Optical Fibre.
14. To verify Brewster's Law and to find Brewster's angle.

References for Theory: Essential Readings:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd Ed., 2003, CBS Publisher.
3. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 2010, Wiley
4. Principle of Optics, M. Born and E. Wolf, 6th Edn., 1980, Pergamon Press
5. Optics, (2017), 6th Edition, Ajoy Ghatak, McGraw-Hill Education, New Delhi

Additional Readings:

1. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
2. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
3. Problems and solution in Electromagnetics (2015), Ajoy Ghatak, K Thyagarajan & Ravi Varshney.
4. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
5. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
6. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.

References for Laboratory Work:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
3. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Pres.
4. Engineering Practical Physics, S. Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.

MJC55PHY314(T)25: Statistical Mechanics
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

Statistical Mechanics deals with the derivation of the macroscopic parameters (internal energy, pressure, specific heat etc.) Of a physical system consisting of large number of Particles (solid, liquid or gas) from knowledge of the underlying microscopic behaviour of atoms and molecules that comprises it. The main objective of this course work is to introduce the techniques of Statistical Mechanics which has applications in various fields including Astrophysics, Semiconductors, Plasma Physics, Bio-Physics etc. and in many other directions.

Course Learning Outcomes

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

- Understand the concepts of microstate, macrostate, phase space, thermodynamic probability and partition function.
- Understand the use of Thermodynamic probability and Partition function for calculation of thermodynamic variables for physical system (Ideal gas, finite level system). Difference between the classical and quantum statistics.
- Understand the properties and Laws associated with thermal radiation.
- Apply the Fermi- Dirac distribution to model problems such as electrons in solids and white dwarf stars
- Apply the Bose-Einstein distribution to model problems such as blackbody radiation and Helium gas.
- In the laboratory course, with the exposure in computer programming and computational techniques, the student will be in a position to perform numerical simulations for solving the problems based on Statistical Mechanics.

Unit 1

Classical-Statistics: Macrostates and Microstates, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox.

(8 Lectures)

Unit 2

Sackur-Tetrode equation, Saha's Ionization Formula, Law of Equipartition of Energy (with proof)-Applications to Specific Heat of gas and solids and its Limitations, Thermodynamic Functions of a Finite Level System, Negative Temperature.

(7 Lectures)

Unit 3

Bose-Einstein Statistics: B-E Distribution law, Thermodynamic functions of a strongly degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. **(9 Lectures)**

Unit 4

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly degenerate Fermi Gas, Fermi Energy Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

(10 Lectures)

Unit 5

Theory of Radiation: Properties of Thermal Radiation and Radiation Pressure. Blackbody Radiation and its spectral distribution. Kirchhoff law. Stefan-Boltzmann law and its thermodynamic proof. Wien's Displacement law. Wien's Distribution law. Rayleigh-Jean's Law. Ultraviolet Catastrophe. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation, Deduction of Wien's Distribution Law, Rayleigh-Jean's Law, Stefan-Boltzmann Law and Wien's Displacement law from Planck's law.

(11 Lectures)

MJC55PHY314(P)25: Statistical Mechanics
Credit: 01
Practical: 30 Hours

Use C/C++/Scilab/Python/other numerical simulations for solving the problems based on Statistical Mechanics like:

1. Computational analysis of the behaviour of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:

   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations

   b) Study of transient behaviour of the system (approach to equilibrium)

   c) Relationship of large N and the arrow of time

   d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution.

2. Plot the probability of various macrostates in coin-tossing experiment (two level systems) versus number of heads with 4, 8, 16 coins etc.

3. Computation of the partition function Z (b) for the systems with a finite number of single particle levels (e.g., 2 level, 3 level etc.) and finite number of non-interacting particles N under Maxwell-Boltzmann/ Fermi-Dirac/Bose Einstein statistics:

   a) Study the behaviour of Z, (b) average energy, C_v, and entropy and its dependence upon the temperature, total number of particles N and the spectrum of single particle energy states.

   b) Plot the probability of occupancy of all the states w.r.t. temperature.

4. Plot the Maxwell speed distribution function at different temperatures in a 3-dimension system. Calculate the average speed, root mean square and most probable speed.

5. Plot Specific Heat of Solids w.r.t temperature

   a) Dulong-Petit law,

   b) Einstein distribution function

   c) Debye distribution function

6. Plot the following functions with energy at different temperatures
    a) Maxwell-Boltzmann distribution
    b) Fermi-Dirac distribution
    c) Bose-Einstein distribution
7. Plot the distribution of particles w.r.t. energy ($\frac{dN}{de}$ versus e) in 3 Dimensions for
    a) Relativistic and non-relativistic bosons both at high and low temperature.
    b) Relativistic and non-relativistic fermions both at high and low temperature.
8. Plot Planck's law of Blackbody radiation w.r.t. wavelength/frequency at different temperatures. Compare it with Rayleigh-Jean's Law and Wien's distribution law for a given temperature.

References for Theory: Essential Readings:

1. Statistical Mechanics: R.K. Pathria and P. D. Beale (Academic Press)
2. Introductory Statistical Mechanics: R. Bowley and M. Sanchez (Oxford Univ. Press)
3. Statistical Physics: F. Mandl (Wiley)
4. A treatise on Heat: M.N. Saha and B.N. Srivastava (Indian Press)
5. Problems and Solutions on Thermodynamics and Statistical Mechanics: Lim Yung-Kou (Sarat Book House)

Additional Readings:

1. Statistical Physics: Berkeley Physics Course, F. Reif, (McGraw-Hill)
2. An Introduction to Statistical Physics: W.G.V. Rosser (Wiley)
3. An Introduction to Thermal Physics: D. Schroeder (Pearson)
4. Concepts in Thermal Physics: Blundell and Blundell (Oxford Univ. press)
5. Statistical and Thermal Physics: Loknathan and Gambhir (PHI)

References for Laboratory work:

1. Elementary Numerical Analysis: K.E. Atkinson (Wiley)
2. Introduction to Modern Statistical Mechanics: D. Chandler (Oxford University Press)
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamics: F. W. Sears and G. L.Salinger (Narosa)
4. Modern Thermodynamics with Statistical Mechanics: Carl S. Helrich (Springer)
5. Statistical and Thermal Physics with Computer Applications: H. Gould and J.Tobochnik (Princeton University Press).

MJC55PHY315(T)25: Embedded systems - Introduction to microcontroller
Credit:04 (Theory-03, Practical-01)
Theory: 45Hours
Practical: 30Hours

Course Objective

This course familiarizes students to the designing and development of embedded systems. This course gives a review of microprocessor and introduces microcontroller 8051.

Course Learning Outcomes

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

- Know the major components that constitute an embedded system.
- Understand what is a microcontroller, microcomputer embedded system.
- Describe the architecture of a8051 microcontroller.
- Write simple programs for 8051 microcontroller in C language.
- Understand key concepts of 8051 microcontroller systems like I/O operations, interrupts, programming of timers and counters.
- Interface8051 microcontroller with peripherals
- Understand and explain concepts and architecture of embedded systems
- Implement small programs to solve well-defined problems on an embedded platform.
- Develop familiarity with tools used to develop an embedded environment
- Learn to use the Arduino Uno (an open source microcontroller board) in simple applications.
- In the laboratory, students will program 8051microcontroller and Arduino to perform various experiments.

Unit 1

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems.

(3 Lectures)

8051microcontroller: Introduction and block diagram of 8051microcontroller, architecture of 8051, 8051assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions.

(8 Lectures)

Unit 2

8051 I/O port programming: Introduction of I/O port programming, pin-out diagram of 8051microcontrollers, I/O port pins description & their functions, I/O port basic programming in 8051 (using assembly language), I/O programming: Bit manipulation.

(4 Lectures)

Programming: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 basic programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.

(8 Lectures)

Unit 3

Timer and counter programming: Programming 8051 timers, counter programming.

(2 Lectures)

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051. (**6 Lectures**)

Unit 4

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. **(3 Lectures)**

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry.

(7 Lectures)

Unit 5

Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming and applications.

(4 Lectures)

MJC55PHY315(P)25: Embedded systems - Introduction to microcontroller
Credit: 01
Practical: 30Hours

8051microcontroller-based Programs and experiments (at least 06 experiments):

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8bit) on LED's.
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle'1234'as'1324'in the seven segment LED display.
10. Interface stepper motor with 8051andwrite a program to move the motor through a given angle in clockwise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

Arduino based programs and experiments:

12. Make a LED flash at different time intervals.
13. To vary the intensity of LED connected to Arduino
14. To control speed of a stepper motor using a potential meter connected to Arduino
15. To display "PHYSICS" on LCD/CRO.

References for Theory: Essential Readings:

1. Embedded Systems: Architecture, Programming &Design, Raj Kamal, 2008,Tata McGrawHill
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi,J.G. Mazidi, and R.D. McKinlay, 2ndEd., 2007, Pearson EducationIndia.
3. Introduction to embedded system, K.V. Shibu, 1st edition, 2009, McGrawHill
4. Microprocessors and Microcontrollers, Krishna Kant, 2ndEdition,2016.PHIlearning Pvt.Ltd.

Additional Readings:

1. Embedded Systems & Robots, Subrata Ghoshal,2009, CengageLearning
2. Embedded System, B.K.Rao, 2011, PHILearning Pvt.Ltd.

References for Laboratory Work:

1. Microcontrollers in practice, I.Susneaand M.Mitescu, 2005, Springer.

Embedded Microcomputer systems: Real time interfacing, J.W.Valvano 2011, CengageLearnin

MNC55PHY206(T)25: Solid State Physics
Credit: 04 (Theory-03, Practical-01)
Theory: 45 Hours
Practical: 30 Hours

Course Objective

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. The gained knowledge helps to solve problems in solid state physics using relevant mathematical tools. It also communicates the importance of solid-state physics in modern society.

Course Learning Outcomes

On successful completion of the module students should be able to

- Elucidate the concept of lattice, crystals and symmetry operations.
- Understand the elementary lattice dynamics and its influence on the properties of materials.
- Describe the main features of the physics of electrons in solids: origin of energy bands, and their influence electronic behavior.
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids.
- Understand preliminary concept and experiments related to superconductivity in solid.
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity

  and the hall set up to determine the hall coefficient of a semiconductor.

Unit 1

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Types of Lattices. Unit Cell, Symmetry and Symmetry Elements. Miller Indices. Reciprocal Lattice. Brillouin Zones. Diffraction of X-rays: single crystal and powder method. Bragg's Law, Laue Condition. Edward's construction. Atomic and Geometrical Factor. Simple numerical problem on SC, BCC, FCC.

(10 Lectures)

Unit 2

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

(7 Lectures)

Unit 3

Electrons in Solids: Electrons in metals- Introduction to Drude Model, Density of states (1- D, 2-D, 3-D) (basic idea), Elementary band theory: Kronig Penney model. Band Gap, direct and indirect bandgap. Effective mass, mobility, Hall Effect (Metal and Semiconductor).

(8 Lectures)

Unit 4

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Para- magnetic domains. Quantum Treatment of Paramagnetism, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Curie's law. B-H Curve, soft and hard material and Energy Loss Hysteresis.

(8 Lectures)

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation).

(5 Lectures)

Unit 5

Dielectric Properties of Materials: Polarization. Local Electric Field in solids. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mossotti Equation. Classical Theory of Electric Polarizability. AC polarizability, Normal and Anomalous Dispersion. Complex Dielectric Constant. Langevin-Debye equation.

(7 Lectures)

MNC55PHY206(P)25: Solid State Physics
Credit: 01
Practical: 30 Hours

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the solid-state physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of solids.
3. To determine the Coupling Coefficient of a piezoelectric crystal.
4. To study the dielectric response of materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
6. To determine the refractive index of a dielectric material using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Iron (Fe) using solenoid & determine the energy loss from Hysteresis loop.
9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 150^0C) by four-probe method and determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.
12. Measurement of change in resistance of a semiconductor with magnetic field.

References for Theory: Essential Readings:

1. Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.

Additional Readings

1. Elementary Solid State Physics, M.Ali Omar, 2006, Pearson
2. Solid State Physics, Rita John, 2014, McGraw Hill
3. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

References for Practical:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
4. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
5. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

Basic Instrumentation Skills: SEC50PHY203a(T)25
Credit:03(Theory-02, Practical-01)
Theory : 30 Hours
Practical : 30 Hours

Course Objective
To expose the students to various aspects of instruments and their usage through hands-on mode. To provide them a thorough understanding of basics of measurement, measurement devices such as electronic voltmeter, Oscilloscope, signal and pulse generators, Impedance bridges, digital instruments etc.

Course Learning Outcomes
At the end of this course the students will learn the following:

- The student is expected to have the necessary working knowledge on accuracy, precision, resolution, range and errors/uncertainty in measurements.
- Course learning begins with the basic understanding of the measurement and errors in measurement. It then familiarizes about each and every specification of a multimeter, multimeters, multivibrators, rectifiers, amplifiers, oscillators and high voltage probes and their significance with hands on mode.
- Explanation of the specifications of CRO and their significance. Complete explanation of CRT.
- Students learn the use of CRO for the measurement of voltage (DC and AC), frequency and time period. Covers the Digital Storage Oscilloscope and its principle of working.
- Students learn principles of voltage measurement. Students should be able to understand the advantages of electronic voltmeter over conventional multimeter in terms of sensitivity etc. Types of AC millivoltmeter should be covered.
- Covers the explanation and specifications of Signal and pulse Generators: low frequency signal generator and pulse generator. Students should be familiarized with

  testing and specifications.
- Students learn about the working principles and specifications of basic LCR bridge.
- Hands on ability to use analog and digital instruments like digital multimeter and frequency counter.

Unit 1

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

(4 Lectures)

Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance.AC millivoltmeter: Type of AC millivoltmeters. Block diagram ac millivoltmeter, specifications and their significance.

(4 Lectures)

Unit 2

Oscilloscope: Block diagram of basic CRO. CRT, electrostatic focusing and acceleration (Explanation only–no mathematical treatment), brief discussion on screen phosphor, visual persistence. Time base operation, synchronization. Front panel controls. Specifications of CRO and their significance.

(6 Lectures)

Use of CRO: for the measurement of voltage (dc and ac), frequency and time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: principle of working.

(3 Lectures)

Unit 3

Signal and pulse Generators: Block diagram, explanation and specifications of low frequency signal generator and pulse generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

(4 Lectures)

Impedance Bridges: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram and working principles of a Q-Meter. Digital LCR bridges.

(3 Lectures)

Unit 4

Digital Instruments: Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.

(3 Lectures)

Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution.

(3 Lectures)

Basic Instrumentation Skills Lab: SEC50PHY203a(P)25

Practical: 30 Hours

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis and its application to specific experiments done in the lab.

The test of lab skills will be of the following test items:

1. Use of an oscilloscope.
2. Oscilloscope as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,

6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Practical:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase using Oscilloscope.
5. Measurement of time period, frequency, average period using universal counter/frequency counter.
6. Measurement of rise, fall and delay times using a Oscilloscope.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using LCR bridge/ universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter).

It is further suggested that students may be motivated to pursue semester long dissertation wherein he/she may do a hands-on extensive project based on the extension of the practicals enumerated above.

References Essential Readings:

1. Logic circuit design, Shimon P. Vingron, 2012, Springer.
2. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
3. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
4. Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.
5. Electronic Instruementation, H.S. Kalsi, 3rd Ed. Tata McGraw Hill.

Additional Readings:

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.

Applied Optics: SEC50PHY203b(T)25
Credit:03 (Theory-02, Practical-01)
Theory: 30 Hours
Practical: 30 Hours

Course Objective

This paper provides the conceptual understanding of various branches of modern optics to the students. This course introduces basic principles of LASER, Holography and signal transmission via optical fiber.

Course Learning Outcomes

Students will be able to:

- Understand basic lasing mechanism qualitatively, types of lasers, characteristics of laser light and its application in developing LED, Holography.
- Gain concepts of Fourier optics and Fourier transform spectroscopy.
- Understand basic principle and theory of Holography.
- Grasp the idea of total internal reflection and learn the characteristics of optical fibers.

Unit 1
Photo-sources and Detectors

Lasers: an introduction, Planck's radiation law (qualitative idea), Energy levels, Absorption process, Spontaneous and stimulated emission processes, Theory of laser action, Population of energy levels, Einstein's coefficients and optical amplification, properties of laser beam, Ruby laser, He-Ne laser, and semiconductor lasers; Light Emitting Diode (LED) and photo-detectors.

(9 lectures)

Unit 2

Fourier Optics and Fourier Transform Spectroscopy (Qualitative explanation) Concept of Spatial frequency filtering, Fourier transforming property of a thin lens, Fourier Transform Spectroscopy (FTS): measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry, and forensic science.

(6 lectures)

Unit 3

Holography
Introduction: Basic principle and theory: recording and reconstruction processes, Requirements of holography- coherence, etc. Types of holograms: The thick or volume hologram, Multiplex hologram, white light reflection hologram; application of holography in microscopy, interferometry, and character recognition.

(6 lectures)

Unit 4

Photonics: Fibre Optics
Optical fibres: Introduction and historical remarks, Total Internal Reflection, Basic characteristics of the optical fibre: Principle of light propagation through a fibre, the coherent bundle, The numerical aperture, Attenuation in optical fibre and attenuation limit; Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating.

(9 lectures)

Applied Optics Lab: SEC50PHY203b(P)25
Practical: 30 Hours

Teacher may give long duration project based on this paper

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors. Application to the specific experiments done in the lab.

Experiments on Lasers:

a. To determine the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid-state laser.

b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid-state laser.

c. To find the polarization angle of laser light using polarizer and analyzer.

d. Thermal expansion of quartz using laser.

e. To determine the wavelength and angular spread of laser light by using plane diffraction grating.

Experiments on Semiconductor Sources and Detectors:

a. V-I characteristics of LED

b. Study the characteristics of solid-state laser.

c. Study the characteristics of LDR

d. Characteristics of Photovoltaic Cell/ Photodiode. e. Characteristics of IR sensor

Experiments on Fourier Optics:

a. Optical image addition/subtraction.

b. Optical image differentiation

c. Fourier optical filtering

d. Construction of an optical 4f system

Experiments on Fourier Transform Spectroscopy

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

Experiments on Holography and interferometry:

a. Recording and reconstruction of holograms (Computer simulation can also be done).

b. To construct a Michelson interferometer or a Fabry Perot interferometer.

c. To determine the wavelength of sodium light by using Michelson's interferometer.

d. To measure the refractive index of air.

Experiments on Fibre Optics

a. To measure the numerical aperture of an optical fibre.

b. To measure the near field intensity profile of a fibre and study its refractive index profile.

c. To study the variation of the bending loss in a multimode fibre.

d. To determine the power loss at a splice between two multimode fibre.

e. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern.

References

1. Introduction to Fourier Optics, Joseph W. Goodman, The McGraw- Hill, 1996.
2. Introduction to Fiber Optics, A. Ghatak & K. Thyagarajan, Cambridge University Press.
3. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
4. Optical Electronics, Ajoy Ghatak and K. Thyagarajan, 2011, Cambridge University Press.
5. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.

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