BODOLAND UNIVERSITY

Syllabus for
Five Year Integrated PG Programme
(with Multiple Entry and Exit Options)
in
PHYSICS

Framed According to National Education Policy (NEP 2020)

Effective from Academic Year 2024-25

Abbreviations used for Paper Code

Abbreviations used:

MAJ: Major

MIN: Minor

IDC: Inter Disciplinary Course

AEC: Ability Enhancement Courses

SEC: Skill Enhancement Course

VAC: Value Added Course

DIS: Dissertation

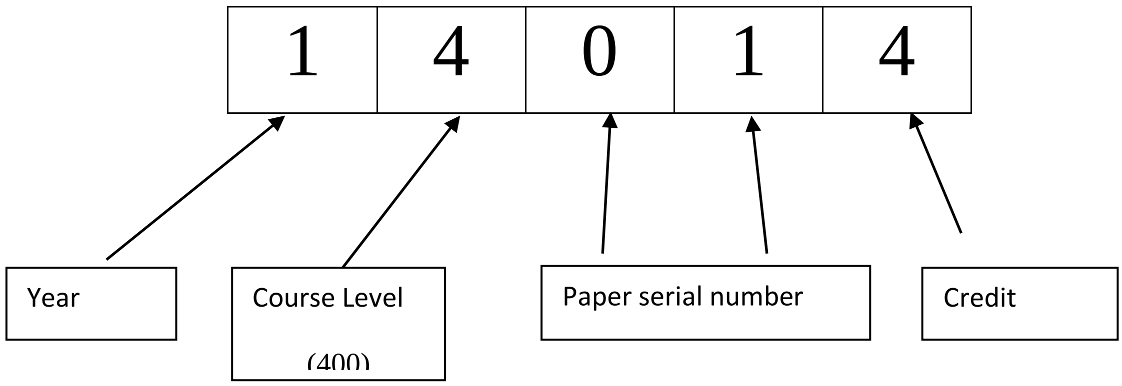
REM: Research Methodology

ADL: Advance Learning

SPL: Specialized Learning

RES: Research

Digit Explanation example:



Curriculum Structures
for
Integrated Programme

Total Credits= 200

SEMESTER - I							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ1014	Mechanics	4	(3+0+1)	50	30	20	100
PHYMIN1014	Mechanics	4	(3+0+1)	50	30	20	100
PHYIDC1013	Basics of Physical Bodies	3	(3+0+0)	50	00	00	50
AEC1012	Language	2	(2+0+0)	50	00	00	50
PHYSEC1013	Instrumentation Skills in Physics-I	3	(2+0+1)	40	00	10	50
VAC1014	VAC	4			30		100
Total Credits		**20**					**450**

SEMESTER - II							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ1024	Mathematical Physics - I	4	(3+0+1)	50	30	20	100
PHYMIN1024	Electricity, Magnetism and Electromagnetic Theory	4	(3+0+1)	50	30	20	100
PHYIDC1023	Electricity, Magnetism and Electronics	3	(3+0+0)	50	00	00	50
AEC1022	Language	2	(2+0+0)	50	00	00	50
PHYSEC1023	Instrumentation Skills in Physics-II	3	(2+0+1)	40	00	10	50
VAC1024	VAC	4			30		100
Total Credits		**20**					**450**

SEMESTER -III							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ2014	Electricity and Magnetism	4	(3+0+1)	50	30	20	100
PHYMAJ2024	Waves and Optics	4	(3+0+1)	50	30	20	100
PHYMIN2014	Thermal Physics and Statistical Mechanics	4	(3+0+1)	50	30	20	100
PHYIDC2013	Molecules, Photons and Nuclei	3	(3+0+0)	50	00	00	50
AEC2012	Language	2	(2+0+0)	50	00	00	50
PHYSEC2013	Electrical Network and Loads	3	(2+0+1)	40	00	10	50
Total Credits		**20**					**450**

SEMESTER - IV							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ2034	Mathematical Physics - II	4	(3+0+1)	50	30	20	100
PHYMAJ2044	Thermal and Statistical Physics	4	(3+0+1)	50	30	20	100
PHYMAJ2054	Analog systems and applications (Electronics -I)	4	(3+0+1)	50	30	20	100
PHYMIN2024	Waves and Optics	4	(3+0+1)	50	30	20	100
AEC2022	Language	2	(2+0+0)	50	00	00	50
Internship	Internship	2					
Total Credits		**20**					**500**

SEMESTER - V							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ3014	Classical Mechanics	4	(3+0+1)	50	30	20	100
PHYMAJ3024	Elements of Modern Physics	4	(3+0+1)	50	30	20	100
PHYMAJ3034	Digital System and Applications (Electronics -II)	4	(3+0+1)	50	30	20	100
PHYMAJ3044	Electromagnetic Theory	4	(3+0+1)	50	30	20	100
PHYMIN3014	**Mathematical Physics**	4	(3+0+1)	50	30	20	100
Total Credits		**20**					**500**

SEMESTER - VI							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYMAJ3054	Quantum Mechanics -I	4	(3+0+1)	50	30	20	100
PHYMAJ3064	Solid State Physics -I	4	(3+0+1)	50	30	20	100
PHYMAJ3074	Nuclear and Particle Physics -I	4	(3+0+1)	50	30	20	100
PHYMAJ3084	Mathematical Physics -III	4	(3+0+1)	50	30	20	100
PHYMIN3024	**Elements of Modern Physics**	4	(3+0+1)	50	30	20	100
Total Credits		**20**					**500**

SEMESTER - VII							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYADL14014	Atomic and Molecular Physics	4	(3+1+0)	70	30	00	100
PHYADL14024	Electronics	4	(3+1+0)	70	30	00	100
PHYADL14034	Quantum Mechanics - II	4	(3+1+0)	70	30	00	100
PHYADL14044	Research Methodology	4	(3+1+0)	70	30	00	100
PHYADL14054	**Physics Practical - I**	4	(0+0+4)	00	30	70	100
Total Credits		**20**					**500**

SEMESTER - VIII							
Paper Code	**Paper title**	**Credit**	**Credit Distribution (L+T+P)**	**End Semester Marks**	**Internal Marks**	**Practical**	**Total Marks**
PHYADL14064	Advanced Statistical Mechanics	4	(3+1+0)	70	30	00	100
PHYSPL15074	Nuclear and Particle Physics - II	4	(3+1+0)	70	30	00	100
PHYSPL15084	Condensed Matter Physics - I	4	(3+1+0)	70	30	00	100
PHYSPL15094	Advanced Optics - I	4	(3+1+0)	70	30	00	100
PHYSPL15104	Physics Practical - II	4	(0+0+4)	00	30	70	100
Total Credits		**20**					**500**

Options

Option 1: Course Work & Research	Course work: Sem. IX; Research: Sem. X
Option 2: Course work only	Course work: Sem. IX & X
Option 3: Only Research	Research: Sem. IX & X

Option 1: Course Work & Research

SEMESTER – IX					
Course Code	**Subject**	**Credit (L+T+P)**	**End Sem. Marks**	**Internal Marks**	**Total Marks**
PHYSPL25014	Advanced Nuclear and Particle Physics	4 (3+1+0)	70	30	100
PHYSPL25024	Condensed Matter Physics	4 (3+1+0)	70	30	100
PHYSPL25034	Experimental Techniques in Physics	4 (3+1+0)	70	30	100
PHYSPL25044	Computational Physics	4 (3+1+0)	70	30	100
PHYSPL25054	Physics Practical-III	4 (0+0+4)	70	30	100
Total Credits		**20**			**500**

SEMESTER – X			
Course Code	**Subject**	**Credit**	**Total marks**
PHYRES250120	Research	20	500
Total Credits		**20**	**500**

Option 2: Course Work only

SEMESTER – IX					
Course Code	**Subject**	**Credit (L+T+P)**	**End Sem. Marks**	**Internal Marks**	**Total Marks**
PHYSPL25014	Advanced Nuclear and Particle Physics	4 (3+1+0)	70	30	100
PHYSPL25024	Condensed Matter Physics	4 (3+1+0)	70	30	100
PHYSPL25034	Experimental Techniques in Physics	4 (3+1+0)	70	30	100
PHYSPL25044	Computational Physics	4 (3+1+0)	70	30	100
PHYSPL25054	Physics Practical-III	4 (0+0+4)	70	30	100
Total Credits		**20**			**500**

SEMESTER – X					
Code	Subject	Credit (L+T+P)	End Sem. Marks	Internal Marks	Total Marks
PHYSPL25064	Plasma Physics	4 (3+1+0)	70	30	100
PHYSPL25074	Advanced Optics - II	4 (3+1+0)	70	30	100
PHYSPL25084	Vacuum Science & Technology	4 (3+1+0)	70	30	100
PHYSPL25094	Nanoscience & Technology	4 (3+1+0)	70	30	100
PHYSPL25104	Literature survey on research topic	4 (0+0+4)	70	30	100
Total Credits		**20**			**500**

Option 3: Only Research

SEMESTER- IX			
Code	Subject	Credit	Total marks
PHYRES250120	Research	20	500
Total Credits		**20**	**500**
SEMESTER-X			
Code	Subject	Credit	Total marks
PHYRES250220	Research	20	500
Total Credits		**20**	**500**

List of minor courses in physics

Semester	Paper code	Credit	Paper title
I	PHYMIN1014	3+0+1=4	Mechanics
II	PHYMIN1024	3+0+1=4	Electricity, Magnetism and Electromagnetic Theory
III	PHYMIN2014	3+0+1=4	Thermal Physics & Statistical Mechanics
IV	PHYMIN2024	3+0+1=4	Waves & Optics
V	PHYMIN3014	3+0+1=4	Mathematical Physics
VI	PHYMIN3024	3+0+1=4	Elements of Modern Physics

List of SEC:

Semester	Paper code	Credit	Paper title
I	PHYSEC1013	2+0+1=3	Instrumentation Skills in Physics-I
II	PHYSEC1023	2+0+1=3	Instrumentation Skills in Physics-II
III	PHYSEC2013	2+0+1=3	Electrical Network and Loads

List of IDC:

Semester	Paper code	Credit	Paper title
I	PHYIDC1013	2+0+1=3	Basics of Physical Bodies
II	PHYIDC1023	2+0+1=3	Electricity, Magnetism and Electronics
III	PHYIDC2013	2+0+1=3	Molecules, Photons and Nuclei

Semester 1

Paper Title: Mechanics

Paper Code: PHYMAJ1014

Credit: 04 (3+0+1)

Lecture: 45

Course Objectives:

To give an idea of various frame of references.

To give concept of work, energy, conservation laws.

To offer knowledge of mechanical properties of matter.

To give basic concept of theory of relativity.

Course outcome: *On successful completion of the course students will be able to understand about the fundamental concept of dynamics, work and energy, Elasticity, motion under central force, waves & oscillations & special theory of relativity.*

Unit I

Fundamentals of Dynamics: Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass and Laboratory frames, Principle of conservation of momentum. **(6 Lectures)**

Work and Energy: Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Law of conservation of Energy. **(3 Lectures)**

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. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation**.** **(7 Lectures)**

Unit II

Elasticity: Relation between Elastic constants. Twisting torque on a Cylinder or Wire. **(2 Lectures)**

Fluid Motion: Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube. **(2 Lectures)**

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. **(3 Lectures)**

Motion of a particle under a central force field: Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). **(5 Lectures)**

Oscillations: SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation.

Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. **(6 Lectures)**

Unit III

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. **(4 Lectures)**

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Kinematics. **(7 Lectures)**

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
5. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
8. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
9. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
10. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
11. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Paper Title: Mechanics Lab

Paper Code: PHYMAJ1014

Class: 30 Hrs. Lab class

A minimum of 8 experiments is to be performed by the students during the semester

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

11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.

Reference Books:

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

Semester 1

Paper Title: Mechanics

Paper Code: PHYMIN1014

Credit: 04 (3+0+1)

Lecture: 45

Course Objectives: *The objective of the course is to impart a good foundation of the concepts of vector algebra and differential equations. This course begins with Newton's Laws of Motion and ends with the Special Theory of Relativity. The students will acquire knowledge of the mechanical properties of matter in the solid. It is designed to enhance the understanding of the Concept of Gravitation, rotational motion, and central forces. They will learn about Simple Harmonic Motion and energy associated with a body executing SHM. They will have a basic idea of the Special Theory of Relativity.*

Course Outcomes: *Upon completion of this course, students will be able to,*

Learn basics vector, vector algebra, and its Product.

Learn 1st and 2nd order differential equations.

Understand the concepts of laws of motion and their application to various dynamical situations and their applications to the conservation of momentum, angular momentum, and energy. Understand rotational motion and associated parameters.

Apply Kepler's laws to describe the motion of planets and satellites in a circular orbit.

The concept of geosynchronous orbits

Understand Simple Harmonic Motion and energy associated with SHM

Learn mechanical properties of matter and elastic constants

Concept of stress and strain and the relation between elastic constants

Understand Einstein's postulates of special relativity.

Apply Lorentz transformations to describe simultaneity, time dilation, and length contraction

Unit I

Vectors: Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **(4 Lectures)**

Ordinary Differential Equations:1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. **(4 Lectures)**

Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. **(4 Lectures)**

Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets. **(4 Lectures)**

Unit II

Rotational Motion: Angular velocity and angular momentum, Torque. Conservation of angular momentum. **(3 Lectures)**

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits.Weightlessness. Basic idea of global positioning system (GPS). **(8 Lectures)**

Unit III

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **(6 Lectures)**

Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants-Poisson's Ratio- Expression for Poisson's ratio in terms of elastic constants- Work done in stretching and work done in twisting a wire-Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum- Determination of Rigidity modulus and moment of inertia by Searles method . **(7 Lectures)**

Special Theory of Relativity: Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. **(5 Lectures)**

Reference books:

1. University Physics. FW Sears, MW Zemansky and HD Young 13/e, 1986. Addison- Wesley
2. Mechanics Berkeley Physics course, Vol1:Charles Kittel, et. al. 2007, Tata Mc Graw- Hill.
3. Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Paper Title: Mechanics Lab

Paper Code: PHYMIN1014

Class: 30 Hrs Lab class

A minimum of 8 experiments is to be performed by the students during the semester

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater's Pendulum.
9. To determine g and velocity for a freely falling body using Digital Timing Technique
10. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of g

Reference books:

1. Advanced Practical Physics for students, B.L.F lintand H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4thEdition, reprinted 1985, Heinemann Educational Publishers.
3. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
4. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

Semester 1

Paper Title: Basics of Physical Bodies

Paper Code: PHYIDC1013

Paper Credit: 03 (3+0+0)

Lecture: 45

Course Objective: *To familiar the students of other discipline the concept of motion from the points of view of two observers one in inertial and other in non inertial frame of reference. The law of universal gravitation and interpretation of lunar tides and various geophysical phenomena have been incorporated. Indian space programme also highlighted.*

Course Outcome: Students are expected to learn the basic physics. They are also expected to get the holistic scientific reason for different geophysical phenomena. Also it is expected that they will be interested to learn the contribution of ISRO has made so far for building India as a self reliant nation in Space research.

Unit I

Basic concepts: The units Centimetre and the Second, Weight and Mass. The SI systems and standards of measurement. Density. The law of conservation of mass. Action and Reaction. Addition of velocities. Force is a vector. Motion in inclined plane. **(5 Lectures)**

Laws Of Motion: Different points of view about motion. The law of Inertia. The motion is relative. Celestial observer's point of view. Acceleration and Force. Rectilinear motion with constant acceleration. Path of a bullet. Circular motion. Life at g=0. Motion from an unreasonable point of view. Centrifugal forces. Coriolis forces. **(8 Lectures)**

Unit II

Conservation Laws: Recoil. The law of conservation of momentum. Jet propulsion. Motion under the action of gravity. The law of conservation of mechanical energy. Work. Units of measurement of work and energy. Power and efficiency of machines. Energy loss. Collisions. **(5 Lectures)**

Oscillations: Equilibrium. Simple oscillations. Displaying (demonstration of) oscillations. Force and potential energy in oscillations. Spring vibrations. Resonance. **(5 Lectures)**

Motion Of Solid Bodies: Torque. Lever. Energy loss in path. Very simple machines. Method of addition of parallel forces acting on a body. Centre of gravity and centre of mass. Angular momentum. Law of conservation of angular momentum. Angular momentum as a vector. Tops. Flexible shaft. **(7 Lectures)**

Unit III

Gravitation: What holds the Earth up!. Law of universal gravitation. Weighing the earth. Measurement of g in the service of mankind. Weight underground. Gravitational energy. How planets move. Interplanetary travel. If there were no moon! India's Space Programme. ISRO's contribution in space exploration, communication and remote sensing. **(9 Lectures)**

Pressure: Atmospheric Pressure. How Atmospheric Pressure was discovered. Atmospheric pressure and weather. Change of weather with altitude. Archimedes' principle. Extremely low pressure. Vacuum. Pressure of millions of atmosphere. Hydrostatic pressure, Hydraulic press. **(6 Lectures)**

Reference Books:

1. Physics for Everyone. (BOOK1): PHYSICAL BODIES. L D Landau, A. I. Kitaigorodsky. Mir Publishers, Moscow. Translated from the Russian by (Martin Greendlinger, D. Sc., Math)
2. The Feynman Lectures on Physics (I, II & III) (Pearson Education Publication)

Semester 1

Paper Title: Instrumentation Skills in Physics-I

Paper Code: PHYSEC1013

Credit: 03 (2+0+1)

Lecture: 30

Course objective: *The objective of the course is to provide a basic understanding of electrical measurements and their applications in experimental physics. The course focuses on the principles, techniques, and instruments used for measuring and analysing electrical quantities.*

Course learning outcome: *Students will gain theoretical and hands-on experience on the important electronic measurements and will learn about basic circuit analysis, electronic components, multimeters, oscilloscopes, and sensors etc.*

Unit I

Introduction to Instrumentation and Measurement: Importance of instrumentation in physics research, Overview of different measurement techniques, units, standards, instruments accuracy, precision, sensitivity, and resolution range. **(3 Lectures)**

Electrical Measurements: Basic components and circuit, voltage, current, and resistance measurements, colour code of resistance, Multimeters: Specifications of a multimeter and their significance. Analogue and Digital, Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Amplifier-rectifier, and rectifier- amplifier. **(6 Lectures)**

Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. **(8 Lectures)**

Unit II

Signal Generators and Analysis Instruments: Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. Impedance Bridges & Q-Meters: Block diagram of bridge. working principles of basic RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges. **(8 Lectures)**

Sensors and Transducers: Principles of sensor operation, Types of sensors (temperature, pressure, strain, etc.), Selection and calibration of sensors, Sensor interfacing and signal conversion. **(5 Lectures)**

Paper Title: Instrumentation Skills in Physics-I Lab

Paper code: PHYSEC1013

Class: 30 Hrs. Lab. Class

A minimum of 5 experiments is to be performed by the students during the semester

1. Analog voltmeters and ammeters in a simple electrical circuits to measure voltage and current.
2. Digital panel meters in electrical circuits for current and voltage measurement.
3. Identifying resistance and capacitance from colour code/item code and compare the values using digital multimeter.
4. Use soldering iron to secure an electrical connection joint.
5. Design a LED chaser circuit using IC.
6. Determine the characteristics (frequency, peak to peak voltage, rms voltage) of a continuous signal using analog (CRO) /digital (DSO) oscilloscope.
7. Use an electrical drill machine to make a hole (6mm) on a wall/wood/metal plate.

Reference Books:

1. A text book in Electrical Technology; B L Theraja,
2. Electronic Devices and Circuits; S. Salivahanan & N. S.Kumar,
3. Electrical Measurements And Measuring Instruments; R.K. Rajput, (S. Chand)
4. Electrical And Electronics Measurements And Instrumentation; R.K. Rajput, (S. Chand)
5. Cathode Ray Oscilloscope: A Course for Students of Science, Medicine and Engineering; David T. Rees
6. Performance and design of AC machines; M G Say
7. Basic Electronics; J.B. Gupt

Semester 2

Paper Title: Mathematical Physics - I

Paper Code: PHYMAJ1024

Credit: 04 (3+0+1)

Lecture: 45

Course Objectives: *The main objective of this course is to offer the basic concepts of Calculus, differential equation, vector algebra & probability.*

Course outcome: *This part of the course includes mathematics so that students could understand Calculus, Vectors & their applications in various fields of physics, Differential Equation & its application, different coordinate systems & concept of probability & error. This will be helpful to students for their higher studies.*

Unit I

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). **(2 Lectures)**

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. **(9 Lectures)**

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(5 Lectures)**

Unit II

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. **(3 Lectures)**

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

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). **(10 Lectures)**

Unit III

Orthogonal Curvilinear Coordinates: Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(6 Lectures)**

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. **(2 Lectures)**

Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. **(2 Lectures)**

Reference books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, Goswami, 1st edition, Cengage Learning
8. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

Paper Title: Mathematical Physics - I Lab

Paper Code: PHYMAJ1024

Class: 30 Hrs. Lab class

Course objectives: *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.*

1. *Highlights the use of computational methods to solve physical problems*
2. *The course will consist of lectures (both theory and practical) in the Lab*
3. *Evaluation done not on the programming but on the basis of formulating the problem*
4. *Aim at teaching students to construct the computational problem to be solved*
5. *Students can use any one operating system Linux or Microsoft Windows*

Topics	**Description 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, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++/Python/Matlab/Mathematica Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, cin and cout, Manipulators for data formatting, Control statements (decision making and looping 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. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs	Sum & 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, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of pi (π)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha$; $I = I_0\left(\frac{\sin\alpha}{\alpha}\right)^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. $\sin\theta$, $\cos\theta$, $\tan\theta$, etc.

Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop
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 · Radioactive decay · Current in RC, LC circuits with DC source · Newton’s law of cooling · Classical equations of motion Attempt following problems using RK 4 order method: · Solve the coupled differential equations $\frac{dx}{dt}=y+x-\frac{x^3}{3}$; $\frac{dy}{dx}=-x$ 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 $0 \leq t \leq 15$ The differential equation describing the motion of a pendulum is $\frac{d^2\nu}{dt^2}=-\sin(\nu)$. The pendulum is released from rest at an angular displacement α, i. e. $\upsilon(0)=\alpha$ and $\upsilon'(0)=0$. Solve the equation for α = 0.1, 0.5 and 1.0 and plot υ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small υ (sin(υ)= υ

Reference Books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
3. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn., 2007, Cambridge University Press.
4. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
5. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
6. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
7. An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press
8. Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

Semester 2

Paper Title: Electricity, Magnetism and Electromagnetic Theory

Paper Code: PHYMIN1024

Credit: 04 (3+0+1)

Lecture: 45

Course Objectives: *The objective is to help the students to acquire the conceptual knowledge of electricity, Electric field, potential, Capacitance, and di-electric material. The student will have an idea of magnetism,the magnetic effect of current and magnetic materials.This course will facilitate to develop of the concept of electromagnetic induction and electromagnetic wave equations.*

Course Outcomes:

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

Enhance the idea of vector operation further.

Understand the concept of electric field and electric flux.

Learn to apply Gauss's theorem to find electric fields for different types of charge distribution.

Will develop the concept of capacitors and How to calculate the capacity of various types of capacitors.

Learn about magnetism due to current.

Will grasp the idea of Magnetic materials and their properties.

Understand the core concept of electromagnetic induction and Propagation of electromagnetic waves.

Unit I

Vector Analysis: Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only). **(6 Lectures)**

Magnetism: Magnetostatics: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials:Magnetic intensity, magnetic induction,permeability, magnetic susceptibility. Brief introduction of dia, para and ferro-magnetic materials. **(9 Lectures)**

Unit II

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(15 Lectures)**

Unit III

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. **(6 Lectures)**

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement Maxwell Equations Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium,transverse nature of EM waves, polarization. **(9 Lectures)**

Reference books:

1. ElectricityandMagnetism,EdwardM.Purcell,1986,McGraw-HillEducation.
2. Electricity and Magnetism, J.H. Fewkes& J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
3. ElectricityandMagnetism,DCTayal,1988,HimalayaPublishingHouse.
4. University Physics, Ronald Lane Reese, 2003, ThomsonBrooks/Cole.
5. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings

Paper Title: Electricity, Magnetism and Electromagnetic Theory LAB

Paper Code: PHYMIN1024

Class: 30 Hrs. Lab class

A minimum of 8 experiments is to be performed by the students during the semester

1. To use a Multimeter for measuring (a) Resistances (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
   i. Measurement of charge and current sensitivity
   ii. Measurement of CDR
   iii. Determine a high resistance by LeakageMethod
   iv. To determine Self Inductance of a Coil by Rayleigh’s Method.
3. To compare capacitances using De’Sauty’s bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx).
5. To study the Characteristics of a Series RC Circuit.
6. To study the a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and
1. (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster’s Bridge.
9. To verify the Thevenin and Norton theorem
10. To verify the Superposition, and Maximum Power Transfer Theorem

Reference books:

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, NewDelhi.
3. EngineeringPractical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt.Ltd.

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

Semester 2

Paper Title: Electricity, Magnetism and Electronics

Paper Code: PHYIDC1023

Credit: 03 (3+0+0)

Lecture: 45

Course Objective: *This course has been designed to give the students basic understanding of electricity, magnetism and electronics. The applications of electromagnetism; and it also includes Maxwell's equations which will be perfect for the students to understand the connectivity or similarity between electricity and magnetism. The paper also deals with microelectronics circuits, radio, television, radar, radio wave propagation etc.*

Course Outcome*: After successful completion of this paper students of other discipline will be able to comprehend the basics of electric current and magnetism. They will have the idea of electron flow in conductor, semiconductor. The students will also be able to gain ideas of working of Radio, television and some microelectronic devices.*

Unit I

Electricity: Stationary Electricity. Electric Current. What is basic? Electric Fields. Evolution of Electricity Theory. **(6 Lectures)**

Electrical Structure Of Matter: Minimum quantity of Electricity. Electron beam. Millikan's Experiment, Model of the atom. Quantizing energy. Dielectrics. Conduction in gases, Ion flow. Self maintained discharge. Matter in the Plasma State. Metals, Electron emission from metals. Thermoelectric Phenomena. Semiconductors. p-n junction. **(8 Lectures)**

Unit II

Electromagnetism: Measure of magnetic field intensity. Effect of Uniform Magnetic Field. Effect of non uniform magnetic field. Amperian currents. Electron cloud of the atom. Magnetic moments of the particles. Electromagnetic induction. Direction of induced current. Discovery of the law of electromagnetic induction. Induced Eddy Currents. Diamagnetic, Paramagnetic and Ferromagnetic materials. Earth's magnetic field. Magnetic fields of the star. **(14 Lectures)**

Unit III

Electromagnetic Fields: Maxwell's equations. Electromagnetic field. Photo-electric effect. Hertz's experiment. Mechanical model of radiation. Classification of electromagnetic radiation. **(10 Lectures)**

Radio: Some history. Vacuum tube triode and transistor. Radio transmission. Radio reception. Radio-wave propagation. J. C. Bose's contribution on wireless communication, Radar. Television. **(7 Lectures)**

Reference Books:

1. Physics for Everyone. (BOOK3): ELECTRONICS. A. I. Kitaigorodsky. Mir Publishers, Moscow. Translated from the Russian by (Nicholas Weinstein)
2. The Feynman Lectures on Physics (I, II & III) (Pearson Education Publication)

Semester 2

Paper Title: Instrumentation Skills in Physics-II

Paper Code: PHYSEC1023

Credit: 03 (2+0+1)

Lecture: 30

Course objective: *This course provides a scientific understanding of optical measurements and their applications in experimental physics. It explores the principles, techniques, and instruments used for optical analysis and measurements.*

Course Outcome: *Students will be able to learn about the fundamental concepts of geometrical and physical optics, light sources, detectors, and fiber optic sensors. After completion of this course, students will also be able to comprehend the practical skills in setting up optical experiments, collecting and analysing data, and interpreting experimental results.*

Unit I

Optical Measurements: Importance of optical measurements in physics research,Units and standards in optical measurements, Geometrical and physical optics: Reflection, refraction, and dispersion of light, Laws of geometrical optics, Optical systems: lenses, mirrors, and prisms, Ray tracing and image formation, Light sources and detectors, Interferometry and spectroscopy, Fibre optic sensors. **(9 Lectures)**

Detectors and Photodetection: Principles of photodetection, Photodetector types: photodiodes, photomultiplier tubes (PMTs), etc., Photodetector characteristics: sensitivity, response time, noise, etc., Photodetection circuitry and signal amplification. **(6 Lectures)**

Unit II

Error Analysis and Measurement Uncertainty: Types of errors in measurements, Propagation of errors and error analysis, Statistical methods in data analysis, Estimation and reporting of measurement uncertainty. **(4 Lectures)**

Instrument Maintenance and safety measurements: Common issues in instrument operation, Troubleshooting techniques, Preventive maintenance and calibration schedules, Safety considerations in instrumentation. **(4 Lectures)**

Calibration and Metrology: Principles of optical metrology and precision measurements, Traceability and calibration standards, Techniques for measuring length, angle, and displacement. **(7 Lectures)**

Paper Title: Instrumentation Skills in Physics-II Lab

Paper Code: PHYSEC1023

Class: 30 Hrs. Lab. Class

A minimum of 5 experiments is to be performed by the students during the semester

1. Using a DSO, do the fast Fourier transform (FFT) of a sinusoidal continuous signal.
2. Generate an amplitude modulated signal using DSO and signal generator.
3. Generate a frequency modulated signal using DSO and signal generator.
4. Use data storage option of the DSO to transfer the digital data to computer and reproduce the signal using any available software (MS Excel/Origin etc.)
5. Reflection, refraction and total internal reflection using laser source.
6. Diffraction of light through grating.

7. Designing a simple microscope using lenses.
8. Designing a simple telescope using lenses.

Reference Books:

1. Optics; Ajay Ghatak
2. Optics; Eugene Hecht and A. R. Ganesan
3. Lasers and Optical Instrumentation; N. Sathyanarayana S. Nagabhushana
4. Photonics: Optoelectronics, S L Kakani, S Kakani, CBS Publisher.
5. A text book on light, B Ghosh and K G Mazumdar

Semester 3

Paper Title: Electricity and Magnetism

Paper Code: PHYMAJ2014

Credit: 04 (3+0+1)

Lecture: 45

Course Objectives:*The objective of this paper is to give the basic concept of electricity, dielectric properties of matter, magnetic field & magnetic properties of matter, electrical circuits etc.*

Course outcome: *After completion of this paper students will be able to understand the electric & magnetic fields & their application ,Electromagnetic induction, applications of Kirchhof's laws in electrical circuits.*

Unit I

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. **(3 Lectures)**

Conservative nature of Electrostatic Field: Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. **(4 Lectures)**

Electrostatic energy of system of charges: Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. **(6 Lectures)**

Unit II

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics. **(6 Lectures)**

Magnetic Field: Magnetic force between current elements and definition of magnetic field. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform magnetic field. **(8 Lectures)**

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)**

Unit III

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current. **(4 Lectures)**

Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. **(4 Lectures)**

Network theorems: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. **(4 Lectures)**

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

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
5. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
6. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

Paper Title: Electricity and Magnetism Lab

Paper Code: PHYMAJ2014

Class: 30 Hrs. Lab class

A minimum of 10 experiments is to be performed by the students during the semester

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson's bridge.
10. 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.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer

13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute method.

Reference books:

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

Semester 3

Paper Title: Waves and Optics

Paper Code: PHYMAJ2024

Credit: 04 (3+0+1)

Lecture: 45

Course objectives:*The main objective of the paper is to give basic concepts of Simple Harmonic Motion, Wave Motion, Vibration of strings & air column. The paper also includes the concept of wave properties of light through interference & diffraction.*

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

Unit I

Superposition of Collinear Harmonic oscillations: 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. **(4 Lectures)**

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency 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. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. **(3 Lectures)**

Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **(4 Lectures)**

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. **(6 Lectures)**

Unit II

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(2 Lectures)**

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); Fringees 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 (5) Visibility of Fringes. Fabry-Perot interferometer. **(3 Lectures)**

Diffraction: Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only). **(2 Lectures)**

Unit III

Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. **(5 Lectures)**

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. **(7 Lectures)**

Reference Books:

1. Waves:Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications, 2011, R. Chand Publications.

Paper Title: Waves and Optics Lab

Paper Code: PHYMAJ2024

Class: 30 Hrs. Lab class

A minimum of 8 experiments is to be performed by the students during the semester

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.

Reference books:

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

Semester 3

Paper Title: Thermal Physics and Statistical Mechanics

Paper Code: PHYMIN2014

Credit: 04 (3+0+1)

Lecture: 45

Course Objectives: *This course is divided into two main parts. The first part deals with Thermal Physics and the second part pertains to Statistical Mechanics. The objective of the first part of the course is to infuse ideas of Thermodynamic systems, Thermodynamic variables, Thermodynamic processes, and allied phenomenons. It is designed to familiarise students with thermodynamic potentials, the Kinetic theory of gases, and the Theory of radiation. While the second part is devoted to givinga basic introduction to Statistical Mechanics and various types of Statistics.*

Course Outcomes: *Upon completion of this course, students will be able,*

To grasp the idea of 1st law of thermodynamics and its applications.

To learn different laws of thermodynamics and their significance.

To understand Maxwell's relations, Joule-thompson effect and Caussius-Clapeyron equation.

To learn the derivation of Maxwell's Law of distribution of velocities, Various Transport phenomena, and also the application of the law of equipartition of energy.

To understand Blackbody radiation and its Spectral distribution.

To learn to derive Plank's law and also derivation other laws like Wien's distribution law, Rayleigh-Jeans law,etc from Plank's Law.

To understand the basics of Statistical mechanics and the significance and applications of various types of statics.

Unit I

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP & CV, Work Done during Isothermal and Adiabatic Processes, Compressibility & Expansion Coefficient, Reversible & irreversible processes, Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainabilityof absolute zero. **(15 Lectures)**

Unit II

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations & applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations. **(8 Lectures)**

KineticTheoryofGases:Derivationof Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gasses; mono-atomic and diatomic gasses. **(8 Lectures)**

Unit III

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law. **(5 Lectures)**

Statistical Mechanics: Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law photon gas comparison of three statistics. **(9 Lectures)**

Reference books:

1. Thermal Physics, S.Garg, R.Bansal and C.Ghosh,1993,Tata McGraw-Hill.
2. A treatise on Heat, Meghnad Saha, and B.N. Srivastava,1969, Indian Press.
3. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
4. Heat and Thermodynamics, M.W. Zemasky and R. Dittman,1981, McGraw Hill
5. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W. Sears & G.L. Salinger. 1988, Narosa
6. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, Rich and Publications.

Paper Title: Thermal Physics and Statistical Mechanics Lab

Paper Code: PHYMIN2014

Class: 30 Hrs Lab class

A minimum of 8 experiments is to be performed by the students during the semester

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barnes constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan'sConstant.
4. To determine the coefficient of thermal conductivity of copper by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Leeand Charlton's disc method.
7. To determine the temperature coefficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature an object as function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Reference books:

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

Semester 3

Paper Title: Molecules, Photons and Nuclei

Paper Code: PHYIDC2013

Credit: 03 (3+0+0)

Lecture: 45

Course Objective: *This paper will explain the historical development of the building block of the universe to the physics of the universe. It includes energy and its conservation, discovery of laws of thermodynamics. The paper gives the basic ideas of soft and hard electromagnetic radiations. The nuclei, the mass energy equivalence. Preliminary ideas of radioisotopes, nuclear reactions, solar energy, wind energy. The nature of the universe, expanding , stars at their different ages, cosmic rays etc.*

Course Outcome: *Students are expected to understand the concept of energy and its conservation and different forms. They will also be able to understand the theory of relativity and the equivalence of mass and energy; the electromagnetic radiation, Solar energy and the thermonuclear reactions that are going on in the Star. They will also understand the Expansion of the Universe, the origin of cosmic rays etc.*

Unit I

Structure of Matter: Elements. Atoms and molecules. Intermolecular Bonds. Physical and Chemical properties. Interaction of molecules. What thermal motion looks like? Crystals and their shape. Structure of crystals. Polycrystalline substances. **(6 Lecture)**

Law of Thermodynamics: Conservation of energy at the molecular level. How heat is converted into work. Entropy. Fluctuations. 1st and 2nd laws of thermodynamics. **(6 Lecture)**

Electromagnetic Radiation (Soft And Hard): Exchange of energy by radiation. The theory of thermal radiation. Optical spectra. Laser radiation. Luminescence. The discovery of X-rays and applications. Radiography of materials. **(10 Lecture)**

Unit II

THE STRUCTURE OF ATOMIC NUCLEI: Properties of atomic nuclei, the mass and energy of an atomic nucleus. Isotopes. Radioactivity. Radioactive decay. Nuclear reactions and the discovery of neutron. The energy of nuclear reactions. A nuclear chain reaction. **(10 Lecture)**

Unit III

Energy Around Us: Sources of energy. Fuel. Electric power plants. Nuclear reactors. Thermonuclear energy. Solar energy. Power from the wind. **(6 Lecture)**

The Physics of the Universe: Measuring distance to the stars. The expanding universe. Basic theory of relativity. Life cycle of Stars: Chandrasekhar's contribution. Radio astronomy. Cosmic rays. **(7 Lecture)**

Reference Books:

1. Physics for Everyone. (BOOK2): MOLECULES. L. D. Landau, A. I. Kitaigorodsky. Mir Publishers, Moscow. Translated from the Russian by (Martin Greendlinger, D. Sc., Math)
2. Physics for Everyone. (BOOK4): PHOTONS & NUCLEI . A. I. Kitaigorodsky. Mir Publishers, Moscow. Translated from the Russian by (George Yankovosky)
3. The Feynman Lectures on Physics (I, II & III) (Pearson Education Publication)

Semester 3

Paper Title: Electrical Network and Loads

Paper Code: PHYSEC2013

Credit: 03 (2+0+1)

Lecture: 30

Course objective: *The objective of this course is to provides a broad understanding on electrical networks and loads, focusing on the principles, analysis techniques, and practical applications.*

Course learning outcome: *Students will be able to gain the skills necessary to analyze and design electrical networks, select appropriate loads, and understand the interplay between electrical systems and loads in various applications. Students will also acquire fundamental professional skills related to electrical wiring, splicing techniques, and shunting methods.*

Unit I

Introduction to electrical network: Introduction to electrical Power, Ohm's law. Passive and active components in electrical networks. AC and DC electricity.Understanding electrical circuits: Kirchhoff's laws and circuit analysis techniques, Series, parallel, and series-parallel combinations. Applications of series and parallel circuits in practical systems. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Three-phase power generation and transmission, Advantages and applications of three-phase systems. **(10 Lecture)**

Network Theorems: Thevenin's theorem and Norton's theorem, Superposition theorem and maximum power transfer theorem, Application of network theorems in circuit simplification and analysis, Theoretical and practical limitations of network theorems. **(5 Lecture)**

Unit II

Power, Energy and Loads: Active, reactive, and apparent power, Power factor and its significance, Energy consumption and efficiency calculations, Power measurement techniques and instruments. Types of electrical loads: resistive, inductive, capacitive, and mixed loads. Power electronic loads: rectifiers, inverters, and motor drives, Load selection and matching in practical applications. **(10 Lecture)**

Power Distribution Systems: Overview of power distribution systems. Types of transformers, Distribution transformers and substations. Transmission and distribution losses, Safety considerations and protective devices in power distribution. **(5 Lecture)**

Paper Title: Electrical Network and Loads Lab

Paper Code: PHYSEC2013

Class: 30 Hrs. Lab. class

1. Design a remote control ON/OFF switch for light using IR LED.
2. Design an extension board (4 nos. of 5/15 Amp socket) with switch, fuse and spike protection.
3. Design a prototype electrical connection for household AC power line distribution with circuit breakers, switches, LED tube, Led Bulb, 15/5 Amp socket.
4. Design a low pass and high pass filter circuit.
5. Measure the power consumption in a typical household AC operated load. Determine the current configuration for the main circuit breaker (MCB) for a typical laboratory hall/room when in full load.
6. Design a step-up/step-down transformer and measure the input/output voltage.

Reference Books:

1. Principles of Electronics; VK Mehta.
2. Handbook of Repair and Maintenance of Domestic Electronics Appliances, Shashi Bhushan Sinha
3. Modern Basic Electrical & House Wiring Servicing, M. Lotia
4. Performance and design of AC machines; M G Say
5. Op-Amp and Linear Integrated Circuits, R Gayakwad, Pearson Education.

Semester 4

Paper Title: Mathematical Physics - II

Paper Code: PHYMAJ2034

Credit: 04 (3+0+1)

Lecture: 45

Course objectives: *The main objective of this paper to give concepts about Fourier series, method of solution of ordinary and partial differential equations, special integrals and errors.*

Course outcomes: *After successful completion of this course, students will be able to:*

Expand functions in terms of Fourier series.

Solve second order ordinary differential equations using Frobenius method

Find the solutions of Legendre, Bessel, Hermite and Laguerre Differential Equations and their application in various problems related to physics.

Solve partial differential equations like Laplace's equation in various co-ordinate systems using separation of variables method.

Explain the properties of Beta and Gamma Functions and express integrals in terms of them.

Unit I

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non- periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. **(7 Lectures)**

Unit II

Frobenius Method and Special Functions: 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. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality. **(20 Lectures)**

Unit III

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). (**4 Lectures)**

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line. **(4 Lectures)**

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation. **(10 Lectures)**

Reference Books:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
6. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
7. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

Paper Title: Mathematical Physics – II Lab

Paper Code: PHYMAJ2034

Class: 30 Hrs. Lab class

The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem

Topics	**Description with Applications**
Introduction to Numerical computation softwares	Introduction to Scilab/Mathematica/Matlab/Python, Advantages and disadvantages, Scilab/Mathematica/Matlab/Python environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab/Mathematica/Matlab/Python, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab/Mathematica/Matlab/Python functions, Introduction to plotting, 2D and 3D plotting
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculate spring constant
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems	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 in Scilab/Mathematica/Matlab/Python	Generating and plotting Legendre Polynomials, Generating and plotting Bessel function

Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method Partial differential equations	First order differential equation · Radioactive decay · Current in RC, LC circuits with DC source · Newton's law of cooling · Classical equations of motion Second order Differential Equation · Harmonic oscillator (no friction) · Damped Harmonic oscillator · Over damped · Critical damped · Oscillatory · Forced Harmonic oscillator · Transient and Steady state solution · Apply above to LCR circuits also · Solve $x^2 \frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$ with the boundary conditions at $x=1$, $y = \frac{1}{2}e^2$, $\frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5$ in the range $1 \le x \le 3$. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph. Partial Differential Equation: · Wave equation · Heat equation · Poisson equation · Laplace equation

Reference Books:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
3. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett
4. Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
5. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
6. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
7. Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
8. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
9. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
10. www.scilab.in

Semester 4

Paper Title: Thermal and Statistical Physics

Paper Code: PHYMAJ2044

Credit: 04 (3+0+1)

Lecture: 45

Course Objectives: *This course is designed in view to give extensive knowledge about the relation among Heat energy , internal energy, Work done , Entropy . About different thermodynamic processes, about distribution of classical particles . This course also contains topics about the distribution of energy radiation and momentum.*

Course Outcome: *After successful completion of this course students are able to understand about the first and second laws of Thermodynamics, how heat, energy and work are related , about Isothermal and adiabatic processes about specific heat . about Heat engine and its efficiency, Concept of Entropy and the change of Entropy for different thermodynamic processes From Maxwell's Thermodynamics student will be able to learn about the distribution of classical particles , for Ideal and real gas and the Maxwell equation in thermodynamics are set of relations which is used in deriving the dependence of thermodynamic variables as the state variables of P,V and T. After study of Classical theory of radiation , students will learn about the time angular distribution of the radiation of energy and momentum connecting various laws like, Kirchhoff's law , Stefan-Boltzmann's law, Rayleigh-Jean's law etc.*

Unit I

Introduction to Thermodynamics: First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. **(3 Lectures**)

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. **(5 Lectures)**

Unit II

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **(7 Lectures)**

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

Unit III

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its

Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. **(14 Lectures)**

Classical Theory of Radiation: Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. **(9 Lectures)**

Reference books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Paper Title: Thermal and Statistical Physics Lab

Paper Code: PHYMAJ2044

Class: 30 Hrs. Lab class

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.
7. To calibrate a thermocouple to measure temperature in a specified Range using
   (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Reference books:

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

Semester 4

Paper Title: Analog Systems and Applications (Electronics -I)

Paper Code: PHYMAJ2054

Credit: 04 (3+0+1)

Lecture: 45

***Course Objective**: This course is introduced to give knowledge about Semiconductors, Diodes, Transistors and their circuits as an application. In this course students can learn about RC-Coupled amplifiers, Feedback-amplifiers, Operational Amplifiers, Oscillators. This course will help the students to switch to Digital World.*

***Course Outcome:** After successful completion of this course students will learn about Semiconductor and their types P and N. About PN junction Diode, their characteristic. Application of Diode as rectifier, stabilized power supply, different types of diode, LED, Photodiode etc. Students will learn about PNP and NPN transistors, their characteristics and application as an Amplifier.In this course students learn about different types of amplifiers RC-Coupled amplifiers and their frequency response, Feedback-amplifier-positive and negative type, Operational amplifier and their applications like, Adder, Substractor, Differentiator ,Integrator. This course also gives fear knowledge about Oscillators.*

Unit I

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Barrier Potential, Barrier width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode. **(6 Lectures)**

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. **(6 Lectures)**

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **(4 Lectures)**

Unit II

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. **(7 Lectures)**

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response. **(3 Lectures)**

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(3 Lectures)**

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(4 Lectures)**

Unit III

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. **(4 Lectures)**

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. **(5 Lectures)**

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation). **(3 Lectures)**

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
6. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
8. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
9. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

Paper Title: Analog systems and applications (Electronics -I) Lab

Paper Code: PHYMAJ2054

Class: 30 Hrs. Lab class

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitt`s oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
14. To design inverting amplifier using Op-amp (741,351) and study its frequency response
15. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
16. To study the zero-crossing detector and comparator
17. To add two dc voltages using Op-amp in inverting and non-inverting mode
18. To design a precision Differential amplifier of given I/O specification using Op-amp.
19. To investigate the use of an op-amp as an Integrator.
20. To investigate the use of an op-amp as a Differentiator.

21. To design a circuit to simulate the solution of a 1st/2nd order differential equation.

Reference books:

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
2. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
4. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson

Semester 4

Paper Title: Waves and Optics

Paper Code: PHYMIN2024

Credit: 04 (3+0+1)

Lecture: 45

Course Objectives: *This paper reviews the concept of waves and optics learned at the school level from a more advanced perspective and builds new concepts. This course is divided into two main parts. The first part deals with Sound and waves. The second part pertains to optics and provides the details of interference, diffraction, and polarization.*

Course Outcomes:

After the completion of this course, the students shall be able to learn the following-

The concept of superposition of waves and phenomena thus originated.

Learn waves traveling through different mediums and parameters involved.

Simple harmonic motion, superposition principle, and its application to find the resultant of superposition of harmonic oscillations.

Concepts of vibrations in strings.

Interference phenomenon arose out of the superposition of waves from coherent sources.

Basic concepts of Diffraction: Fraunhofer and Fresnel Diffraction.

Elementary concepts of the polarization of light.

Michelson's Interferometer and its Applications.

Unit I

Superposition of Two Collinear Harmonic oscillations: Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having differentFrequencies (Beats) **(3 Lectures)**

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(2 Lectures)**

Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves,Wave intensity. **(7 Lectures)**

Sound: Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to sawtooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria. **(7 Lectures)**

Unit II

Wave Optics: Electromagnetic nature of light. Definition and Properties Of Wavefront. Huygens Principle. **(3 Lectures)**

Interference: Interference: Division of amplitude and division of wave front. 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. **(9 Lectures)**

Unit III

Michelson's Interferometer: Idea of form fringes (no derivation needed), Determination of wavelength, Wavelength difference, Refractive Index and Visibility of fringes. **(3 Lectures)**

Diffraction: Fraunhofer diffraction: Single slit; Double Slit. Multiple slits & Diffraction grating. Fresnel Diffraction: Half-period zone Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **(8 Lectures)**

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(3 Lectures)**

Reference books:

1. Principle of optics, B.K. Mathur, 1995, Gopal Printing
2. FundamentalsofOptics,FAJenkinsandHEWhite, 1976,McGraw-Hill Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publication
3. University Physics. FW Sears, MW Zemansky and HD Young 13/e, 1986. Addison-Wesley

Paper Title: Waves and Optics Lab

Paper Code: PHYMIN2024

Class: 30 Hrs. Lab class

List of experiments:

1 To investigate the motion of coupled oscillators

2 To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ2 – T Law.

3 To study Lissajous Figures

4 Familiarization with Schuster`s focusing; determination of angle of prism.

5 To determine the Coefficient Viscosity of water by Capillary Flow Method (Poiseuille's method).

6 To determine the Refractive Index of the Material of a given Prism using Sodium Light.

7 To determine Dispersive Power of the Material of a given Prism using Mercury Light
8 To determine the value of Cauchy Constants of a prism.
9 To determine the Resolving Power of a Prism.
10 To determine wavelength of sodium light using Fresnel Biprism.
11 To determine wavelength of sodium light using Newton’s Rings.
12 To determine the wavelength of Laser light using Diffraction of Single Slit.
13 To determine wavelength of (1) Sodium & (2) spectrum of Mercury light using plane diffraction Grating
14 To determine the Resolving Power of a Plane Diffraction Grating.
15 To measure the intensity using photo sensor and laser in diffraction patterns of slits.

Reference books:

1. AdvancedPracticalPhysicsforstudents,B.L.Flint&H.T.Worsnop,1971,Asia PublishingHouse.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann EducationalPublishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

Semester 5

Paper Title: Classical Mechanics

Paper Code: PHYMAJ3014

Credit: 04 (4+0+0)

Lecture = 60

Course Objectives: *This course will teach about the motion of bodies under the influence of forces or with equilibrium of bodies when all the forces are balanced. This course develops the concepts of virtual work, D'Alemberts principle, Hamilton's principle, Lagrange formalism will help to learn how to solve the problems related to oscillatory systems, motion of rigid body, and nonlinear dynamics.*

Course Outcomes: *After learning this course, students will be able to (i) understand the basic principles of classical mechanics system using Lagrange and Hamilton's formalism (ii) apply methods of classical mechanics in solving various problems of like complicated oscillatory system, motion of rigid body, nonlinear dynamics (iii) idea of transition from classical to quantum mechanical approach.*

Unit I:

Classical Mechanics of Point Particles: Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyro radius and gyro frequency, motion in crossed electric and magnetic fields. Constraints, classification of constraints with examples, Generalised coordinates, Generalised velocities Generalised momenta. Principle of virtual work, D' Alembert's principle and its derivation. **(8 Lecture)**

Lagrangian formulation: Variational principle. From D' Alembert's principle Lagrange's equation for conservative and non conservative system of forces. Conception of Lagrangian. Application of Lagrange's equation for calculation of Lagrangian, derivation of equation of motion for a simple physical system, compound pendulum, simple harmonic oscillator. **(10 Lecture)**

Unit II:

Hamiltonian formulation: Concepts of phase space, principle of variation. Deduction of Hamilton's canonical equation from variational principle. Concept of Hamiltonian and its physical interpretation. Deduction of Hamilton's principle from D' Alembert's principle. Canonical momenta. Basic idea of Hamiltonian in quantum mechanics, Hamiltonian of simple pendulum, compound pendulum. Deduction of Hamilton's canonical equations in above cases. Euler-Lagrange equations- one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity. **(7 Lecture)**

Unit III:

Canonical transformations: Canonical transformation equation, conditions for canonical transformation, solution of harmonic oscillator problem using canonical equation, Generating functions, Properties of canonical transformations, Infinitesimal contact transformations, Poisson brackets, Fundamental Poison Bracket, Hamilton's equation in terms of Poisson bracket, Jacobi's identity, Liouvillie's theorem. **(12 Lecture)**

Unit IV:

Rigid bodies: Rigid body dynamics, Euler's theorem, concept of infinitesimal rotation, Euler's equation of motion, symmetric top motion. **(7 Lecture)**

Small Oscillations: Theory of small oscillations, normal coordinates, normal modes, coupled oscillations, diatomic and triatomic molecules. **(6 Lecture)**

Reference Books:

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
3. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
4. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
5. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
6. Classical Mechanics, P.S. Joag, N.C.Rana, Megraw Hills.
7. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
8. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
9. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

Semester 5

Paper Title: Elements of Modern Physics

Paper Code: PHYMAJ3024

Credit: 04 (3+0+1)

Lecture = 45

Course objective: *This course going to develop quantum mechanical approach from De Broglie matter wave to Quantum Tunneling. The concepts of Uncertainty principle will give fair knowledge of uncertainty of finding position and speed of a particle and wave function related to those. This course teaches about Structure of Atomic nucleus , Mass defect, Nuclear energy, and Radioactivity .*

Course outcome: *After completion of this course, students will be able to understand quantum mechanical explanation of Blackbody Radiation, matter wave, photoelectric effect which give the understanding of wave-particle duality. From Uncertainty principle students will understand the relation between position and momentum of a system. The wave equation like Schrodinger equation gives the understanding of the form of the probability waves that govern the motion of small particles. In this course, students will learn about the Scattering and Tunneling effect through the potential barrier.*

This course gives fair knowledge about the structure of atomic nucleus, Radioactivity, generation of energy from Fission and Fusion, and how the energy can be regulated by Nuclear reactor.

Unit I:

Blackbody Radiation, Planck's quantum, Planck's constant and light as a collection of photons, 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. Two-Slit experiment with electrons. **(9 Lectures)**

Position measurement: Gamma ray microscope thought experiment; Wave-particle duality, 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; Energy-time uncertainty principle- application to virtual particles and range of an interaction. **(7 Lectures)**

Unit II:

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; Wave amplitude and wave functions, physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. **(8 Lectures)**

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier. **(6 Lectures)**

Unit III:

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph. **(4 Lectures)**

Radioactivity: stability of the nucleus; 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 creation by gamma photons in the vicinity of a nucleus. **(7 Lectures)**

Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). **(4 Lectures)**

Note: Educational visit to the research institution and laboratories of National importance of India (eg. SINP, BARC, VECC, IUAC, CAT, ISER etc.)

A field visit report must be submitted as a part of internal evaluation.

Reference books:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
6. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan
7. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
8. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
9. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
10. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
11. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

Paper Title: Elements of Modern Physics Lab

Paper Code: PHYMAJ3024

Class: 30 Hrs. Lab class

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 (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

Reference Books

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

Semester 5

Paper Title: Digital System and Applications (Electronics -II)

Paper Code: PHYMAJ3034

Credit: 04 (3+0+1)

Lecture = 45

Course Objectives: *This course in physics curriculum is framed to introduce 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 Outcomes: *Upon successful completion of this course, students will be able to:*

Gain both theoretical and experimental knowledge about digital electronics.

Understand computer architecture.

Verify and design various logic gates.

Write programs using 8085 microprocessor.

Unit I:

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: Study of Waveform, Measurement of Voltage, Current, Frequency, and Phase Difference. **(3 Lectures)**

Integrated Circuits (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs. **(3 Lectures)**

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **(4 Lectures)**

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

Unit II:

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **(2 Lectures)**

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. **(3 Lectures)**

Sequential Circuits: 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.

(4 Lectures)

Timers: IC 555: block diagram and applications: Astable multivibrator, Monostable and bi-stable multivibrator. (**3 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). **(2 Lectures)**

Unit III:

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **(3 Lectures)**

Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

(4 Lectures)

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. **(6 Lectures)**

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

Reference books:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics G K Kharate ,2010, Oxford University Press
5. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
6. Logic circuit design, Shimon P. Vingron, 2012, Springer.
7. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
8. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
9. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Paper Title: Digital System and Applications (Electronics -II) Lab

Paper Code: PHYMAJ3034

Class: 30 Hrs. Lab class

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.
16. Write the following programs using 8085 Microprocessor
    a) Addition and subtraction of numbers using direct addressing mode
    b) Addition and subtraction of numbers using indirect addressing mode
    c) Multiplication by repeated addition.
    d) Division by repeated subtraction.
    e) Handling of 16-bit Numbers.
    f) Use of CALL and RETURN Instruction.
    g) Block data handling.
    h) Other programs (e.g. Parity Check, using interrupts, etc.).

Reference books:

1. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
3. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
4. Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.

Semester 5

Paper Title: Electromagnetic Theory

Paper Code: PHYMAJ3044

Credit: 04 (3+0+1)

Lecture = 45

Course Objective: *This course has been designed from review of Maxwell's electromagnetic equations and propagations in bound and unbound media. It also includes the phenomenon of polarization of electromagnetic waves in detail.*

Course Outcome*: The students are expected to conceptualize and able to solve*

Problems in bound and unbound media applying Maxwell's equations.

To learn the method of production of different types of polarization of Electromagnetic waves.

The nature of Propagation of light in different crystal structures.

To understand optical rotation calculation of angle of ration.

To learn Laurent's half shade polarimeter.

Unit I:

Maxwell Equations: Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **(10 Lectures)**

EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. **(10 Lectures)**

Unit II:

EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence) **(10 Lectures)**

Unit III:

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. 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. Analysis of Polarized Light. **(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. **(5 Lectures)**

Reference books:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
6. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
7. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
8. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
9. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
10. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

Paper Title: Electromagnetic Theory Lab

Paper Code: PHYMAJ3044

Class: 30 Hrs. Lab class

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 the Boltzmann constant using V-I characteristics of PN junction diode.

Reference books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Semester 5

Paper Title: Mathematical Physics

Paper Code: PHYMIN3014

Credit: 04 (3+0+1)

Theory: 45 Lecture

Course Objectives: *This course is designed to involve students to learn a few essential portions of mathematics which are readily used in physics. Broadly it incorporates differential equations of various kinds, the Frobenious method and its application in differential equations, and Partial differential equations. This paper also gives the idea of the Fourier series and its application and a good portion of Complex Analysis.*

Course Outcomes*: After the completion of this course, the students will be able -*

To do partial derivatives.

To expand periodic functions in a series of sine and cosine functions and be able to determine Fourier Coefficients

To expand functions with arbitrary periods and also the non-periodic functions.

To apply Frobenius methods in differential equations.

Understand Legendre, Bessel, Hermite, and Laguerre Differential Equations.

To learn Beta and Gamma functions and the relation between them.

To learn to apply Laplace's equation in problems of rectangular, cylindrical, and Spherical symmetry and Finally

To learn briefly complex analysis

Unit I:

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(5 Lectures)**

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non- periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series.

(8 Lectures)

Unit II:

Frobenius Method and Special Functions: 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. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality. Simple recurrence relations. **(11 Lectures)**

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **(3 Lectures)**

Unit III:

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. **(8 Lectures)**

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. **(10 Lectures)**

Reference books:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. An Introduction to Ordinary Differential Equations, Earl A Coddington, 1961, PHI Learning.
5. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
6. Essential Mathematical Methods, K.F. Riley and M.P. Hobson, 2011, Cambridge University Press
7. Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Publications.
8. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Books.

Paper Title: Mathematical Physics Lab

Paper Code: PHYMIN3014

Class: 30 Hrs. Lab class

1. Highlights the use of computational methods to solve physical problems
2. Useofcomputerlanguageasatoolinsolvingphysicsproblems(applications)
3. The course will consist of lectures (both theory and practical) in the Computer Lab
4. Evaluation done not on the programming but on the basis of formulating the problem
5. Aim at teaching students to construct the computational problem to be solved
6. Students can use any one operating system Linux or Microsoft Windows

Topics	**Description 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, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow-emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.

Review of fundamentals of C & C++ Programming	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping 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. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D&2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs: using C/C++ language	Sum & 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, Binary search
Random number generation	Area of circle, area of square, volume of sphere,value of pi **(π)**
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving α =tanα; $I = I_0 \left(\frac{\sin \propto}{\propto}\right)^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sinθ, cosθ, tanθ, etc.*
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice-versa. Find the data B-H Hysteresis loop.

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 ● Radioactive decay ● Current in RC, LC circuits with DCsource ● Newton's law of cooling ● Classical equations of motion Attempt following problems using RK 4 order method: ● Solve the coupled differential equations; $\frac{dx}{dt} = y + x - \frac{x^3}{3}$; $\frac{dy}{dx} = -x$ 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 $0 \le t \le 15$ • The differential equation describing the motion of a pendulum is $\frac{d^2 \nu}{dt^2} = -\sin(\nu)$ The pendulum is released from rest at an angular displacement α, i. e. υ(0)= α and υ′(0)=0. Solve the equation for α = 0.1, 0.5 and 1.0 and plot υ as a function of time in the range $0 \le t \le 8\pi$. Also plot the analytic solution valid for small υ (sin(υ)= υ)

Reference books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5thEdn., 2012, PHI Learning Pvt. Ltd.
2. Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Publications.
3. Numerical Recipes in C++: The Art of Scientific Computing, W.H. Pressetal., 3rdEdn., 2007, Cambridge UniversityPress.
4. A first course in Numerical Methods, Uri M. Ascher and Chen Greif, 2012, PHI Learning
5. Elementary Numerical Analysis, K.E. Atkinson, 3 rdE d n . , 2 007,Wiley India Edition.
6. Numerical Methods for Scientists and Engineers, R.W. Hamming, 1973, Courier DoverPub.
7. An Introduction to Computational Physics, T. Pang, 2ndEdn., 2006, Cambridge Univ.Press

Semester 6

Paper Title: Quantum Mechanics -I

Paper Code: PHYMAJ3054

Credit: 04 (3+0+1)

Lecture = 45

Course Objective: *The course has been introduced with a view to acquaint the students of physics major for smooth journey of quantum world starting from basics to applications.*

Course Outcome*: At the completion of the course, students are expected to solve*

Time independent and time dependent Schrodinger equations and simple problems related to those for arbitrary potential and various coordinate systems.

The Eigen function and Eigen values of a wave function.

Normalization and orthogonality conditions of a given wave function.Hydrogen atom and similar atoms by applying Quantum Mechanical Principles.

Unit I:

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 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. **8 Lectures)**

Unit II:

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. **(12 Lectures)**

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; ground state, zero point energy & uncertainty principle. **(13 Lectures)**

Unit III:

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; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d, … shells. **(12 Lectures)**

Reference books:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
7. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
8. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

Paper title: Quantum Mechanics – I Lab

Paper code: PHYMAJ3054

Class: 30 Hrs. Lab class

Use C/C^{++}/Scilab 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:

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

   Here, 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 ≈ -13.6 eV. Take e = 3.795 (eVÅ)$^{1/2}$, ħc=1973 (eVÅ) and m = 0.511x10^6 eV/c^2.

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

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

   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 ħc = 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:

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

   For the anharmonic 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 MeV fm^{-3}In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three case

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

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

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

$$V(r) = D\left(e^{-2\alpha r'} - e^{-\alpha r'}\right), \quad r' = (r - r_0)/r$$

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 = 940×10^6 eV/C^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349Å

Laboratory based experiments:

1. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
2. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
3. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Quantum efficiency of CCDs

Reference books:

1. Schaum's outline of Programming with C++. J.Hubbard, 2000 , McGraw-Hill Publication
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
3. An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
5. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
6. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
7. Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-6133459274

Semester 6

Paper Title: Solid State Physics

Paper Code: PHYMAJ3064

Credit: 04 (3+0+1)

Lecture = 45

Course Objective: *The course is a building block of Solid State, it has been designed to take care of the formation, structure, electrical and magnetic, thermal properties of solids.*

Course Outcome*:At the completion of the course, students are expected to:*

Grasps the idea of formation of a solid.

The classical explanation of specific heats of solids at high temperatures.

And conceptualize the existence of properties of magnetism in solids.

By quantum theory of solids at low temperatures.

To classify crystals, piezo and pyroelectric effects etc.

Unit I:

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **(12 Lectures)**

Unit II:

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. T3 law. **(10 Lectures)**

Unit III:

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **8 Lectures)**

Unit IV:

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. **(9 Lectures)**

Unit V:

Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. **(6 lectures)**

Reference books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
5. Solid State Physics, H. Ibach and H. Luth, 2009, Springer
6. Solid State Physics, Rita John, 2014, McGraw Hill
7. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
8. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Paper title: Solid State Physics Lab

Paper code: PHYMAJ3064

Class: 30 Hrs. Lab class

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 measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Reference Books:

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

Semester 6

Paper Title: Nuclear and Particle Physics - I

Paper Code: PHYMAJ3074

Credit: 04 (4+0+0)

Lecture = 60

Course Objective: *The goal of the course is to impart knowledge on basic nuclear properties, nuclear models, nuclear reaction and decays. It also highlights the basic principles of radiation detection, particle accelerators and fundamental concepts of particle physics.*

Course Outcome*: The students are expected to*

Revise and retain the contents of the basic properties of nuclei.

Predict nuclear stability using nuclear models.

Learn the process of radioactive decay, nuclear reactions, interaction of nuclear radiation with matter.

Learn about basic outlines of Particle Physics from conservation laws to quark model.

Unit I:

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **(8 Lectures)**

Unit II:

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. **(10 Lectures)**

Unit III:

Radioactivity decay:(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **(8 Lectures)**

Unit IV:

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **6 Lectures)**

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. **(6 Lectures)**

Unit V:

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. **(8 Lectures)**

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **(4 Lectures)**

Unit VI:

Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons. **10 Lectures)**

Reference books:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
4. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
5. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
6. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
7. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
8. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
9. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
10. Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

Semester 6

Paper Title: Mathematical Physics - III

Paper Code: PHYMAJ3084

Credit: 04 (3+0+1)

Lecture = 45

Course Objectives: *The course is designed to familiarise the students with the concepts complex analysis, Fourier and Laplace transforms and their applications.*

Course outcome*: Students who successfully complete the course will be able to:*

Use the residue theorem to calculate complex integrals

Apply Fourier and Laplace transforms to solve differential equations.

Unit-I

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals. **(23 Lectures)**

Unit-II

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. **(10 Lectures)**

Unit-III

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform. **(12 Lectures)**

Reference Books:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications

3. Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
4. Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
5. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
6. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

Paper title: Mathematical Physics – III Lab

Paper code: PHYMAJ3084

Class: 30 Hrs. Lab class

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

1. Solve differential equations:
   $dy/dx = e^{-x}$ with $y = 0$ for $x = 0$ $dy/dx + e^{-x}y = x^2$
   $d^2y/dt^2 + 2\, dy/dt = -y$ $d^2y/dt^2 + e^{-t}dy/dt = -y$
2. Dirac Delta Function:

   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{\frac{-(x-2)^2}{2\sigma^2}}(x+3)dx$, for σ=1, 0.1, 0.01 and show it tends to 5.

3. Fourier Series: Program to Sum: Summation n=1 to infinity (0.2)^n Evaluate the Fourier coefficients of a given periodic function (square wave)
4. Frobenius method and Special functions:

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

   Plot $P_n(x), j_v(x)$

   Show recursion relation
5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
7. Evaluation of trigonometric functions e.g. *sin θ,* Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.
8. Compute the nth roots of unity for n = 2, 3, and 4.
9. Find the two square roots of $-5+12j$.
10. Integral transform: FFT of exp(-x^2)

11. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.
12. Solve Kirchoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.
13. Perform circuit analysis of a general LCR circuit using Laplace's transform.

Reference Books:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
3. 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
4. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
5. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
6. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
7. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
8. https://web.stanford.edu/~boyd/ee102/laplace_ckts.pdf
9. ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

Semester 6

Paper Title: Elements of Modern Physics

Paper Code: PHYMIN3024

Credit: 04 (3+0+1)

Theory: 45 Lecture

Course Objectives: *This paper broadly comprises of Quantum Mechanics and Nuclear Physics. It aims to set a picture of the evolution of Quantum mechanics in the minds of students. It explains how light satisfies both wave and particle nature and why the concept of wave-particle duality is adopted. It is designed to introduce the idea of matter waves and the concept of wave function. The Nuclear physics part of this paper gives a clear idea of the Nucleus and thereby explains the phenomena of radioactivity in detail.*

Course Outcomes*: At the end of this course, students will be able–*

To learn proof particle nature of light.

To learn wave is associated with moving matter.

To justify why matter waves are not easily recognisable.

To learn the need for the concept of wavefunction.

To learn Schordingers wave equations and their importance.

To understand the Nucleus and its various properties.

To learn Radioactivity in detail.

VIII. To learn the processes of generation of Nuclear energy.

Unit - I

Planck's quantum, Planck's constant and lights collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer Experiment. **(6 Lectures)**

Problems with Rutherford model-instability atomsan observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atom and their spectra **(4 Lectures)**

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. **(4 Lectures)**

Unit - II

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction. **(8 Lectures)**

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization. **(2 Lectures)**

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature ofnuclear force,NZgraph. (**6 Lectures)**

Unit - III

Radioactivity: stability of nucleus; Law of radioactiv e decay; Mean life & half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. **(10 Lectures)**

Fission an dfusion-massdeficit relativity and generation of energy; Fission-nature of Fragments and emission of neutrons. Nuclear reactor slow neutrons interacting with Uranium235;Fusion and thermonuclear reactions. **(5 Lectures)**

Reference books:

1. Concepts of Modern Physics, Arthur Beiser, 2009,McGraw-Hill
2. Modern Physics, John R. Taylor, Chris D. Zafiratos, Michael A.Dubson,2009,PHI Learning

3. Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003, McGrawHill
4. Quantum Physics, Berkeley Physics Course Vol.4. E.H. Wichman, 2008, Tata McGraw-HillCo.
5. Modern Physics, R.A. Serway, C.J. Moses, and C.A.Moyer, 2005, Cengage Learning
6. Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGrawHill

Paper title: Elements of Modern Physics Lab

Paper code: PHYMIN6014

Class: 30 Hrs. Lab class

1 To determine value of Boltzmann constant using V-I characteristic of PN diode.
2 To determine work function of material of filament of directly heated vacuum diode.
3 To determine value of Planck's constant using LEDs of at least 4 different colours.
4 To determine the ionization potential of mercury.
5 To determine the wavelength of-alpha emission line Hydrogen atom.
6 To determine the absorption lines in the rotational spectrum of Iodine vapour.
7 To study the diffraction patterns of single and double lits using laser source and measure its intensity variation using Photosensor and compare with incoherent source – Na light.
8 Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9 To determine the value of e/m by magnetic focusing.
10 To se tup the Millikan oil drop apparatus and determine the charge of an electron.

Reference books:

1. Advanced Practical Physics for students, B.L.Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann EducationalPublishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

Semester 7

Paper Title: Atomic and Molecular Physics

Paper Code: PHYADL14014

Credit: 04 (3+1+0)

Total lecture: 48

Course Objective: *The course has been designed to provide idea on atomic and molecular structure, various interaction phenomena inside atoms and molecules.*

Course Outcome: *The students are expected to*

Get the evidence of stability of atoms by studying various atomic models.

Use spectroscopic techniques to identify elements present in a sample

Learn about the effect of electric and magnetic fields on atoms

Learn about spectra generated due to molecular behavior

Unit I:

Problems with Rutherford model, Hydrogen and Alkai spectra: Series in hydrogen, Bohr's correspondence principle, Sommerfeld model, Vector atom model, space quantization, Stern Gerlach experiment and intrinsic spin of electron. Spectra of sodium atom. Doublet structure of D lines of sodium, Coupling schemes: L-S, j-j and intermediate coupling, alkali spectra, fine and hyperfine structure in alkali spectra, Magnetic moment of electron, Lande g factor, selection rules, Lande's interval rule, intensity rules, regularities in complex spectra, Pauli exclusion principle, shell structure, Hund's rule, spectral terms from two equivalent electrons. **(13 lectures)**

Unit II

Normal and anomalous Zeeman effect, Classical and Quantum theory of Zeeman effect, Zeeman patterns of sodium and mercury, Zeeman pattern of various transitions, Paschen Back effects, Stark effect in hydrogen, hyperfine structure and determination of nuclear spin and nuclear g factors, radiative transition probabilities, line width: Doppler broadening, natural broadening, collision broadening and Stark broadening, X-Ray: Continuous and Characteristic X-rays, Mosley's law and its explanation. **(12 lectures)**

Unit III

Rigid rotator- energy levels, spectrum, intensity of rotational lines, energy levels, eigenfunctions, transition probabilities and selection rules, spectrum, Nonrigid rotator- energy levels, spectrum, isotope effect on rotational spectra.

Born and Oppenheimer approximation, Vibration of diatomic molecules, harmonic oscillator, energy levels, anharmonicity, Rotation-vibration spectra of diatomic molecules, PQR branching, isotope effect in vibrational bands, Frank-Condon principle. (**12 lectures)**

Unit IV

Classical and Quantum theory of Raman Effect, Vibrational Raman spectra, Stokes and anti-Stokes lines, rotational Raman spectra, Infra red spectra vs Raman spectra, Applications of Raman effect. NMR & ESR spectra: Magnetic properties of nuclei, nuclear resonance, Spin-spin & spin-lattice interaction, chemical shift, nuclear coupling. **(11 lectures)**

Reference Books:

1. Atomic Spectra: H.E. White (McGraw Hill) 1934.
2. Fundamentals of Molecular spectroscopy: Banwell and McCash (Tata McGraw Hill), 1994.
3. Physics of Atoms and Molecules, BH Bransden, CJ Joachain, Pearson, 2013
4. Atomic Spectra − JB Rajam , S Chand & Company Ltd.
5. Atomic & Molecular Spectra: Laser, Raj Kumar, Kedar Nath Ram Nath
6. Molecular Structure and Spectroscopy, G Aruldhas, PHI Learning Pvt Ltd, Delhi
7. Atomic, Molecular and Photons, Wolfgang Damtrodes (Springer), 2010.
8. Molecular Spectra and Molecular Structure I: G. Herzberg (Van-Nostrand Rein-hold), 1950.

Semester 7

Course Code: PHYADL14024

Course Title: Electronics

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course Learning Outcomes: *After completion of the course, the students will be equipped with required knowledge in electronic devices, circuits and their applications. The students will be able to learn about digital circuits and microprocessors. The students will get to know the basic concept of signal transmission, and the role of modulation and demodulation in signal transmission.*

Unit - I: MOS and CMOS devices and applications

Static & dynamic characteristics, depletion & enhancement modes, use of the devices in amplifiers and oscillators. **(4 lectures)**

Unit - II: Tunnel Diode and Applications

Tunneling effect, transfer coefficient, tunnel diode characteristics, use of tunnel diode as oscillator and amplifier. **(2 lectures)**

Unit - III: Gunn Diode and Applications

Transferred electron effect, modes of TE oscillations, Gunn diode in oscillation circuit. **(2 lectures)**

Unit - IV: Impatt / Avalanche Diode and Applications

Drift and scattering velocity, relation between field, current and terminal impedance, equivalent circuit of the diodes and their use in amplifiers and oscillators. **(4 lectures)**

Unit - V: OP-AMP Applications

Oscillators: Phase shift, Wien bridge and high frequency and voltage controlled oscillators, sawtooth generator. Filters: Active low and high pass filters, Butterworth filter (up to second order). Analog computation: Solution of differential equation (up to second order), solution of simultaneous equations. **(8 lectures)**

Unit - VI: Digital Circuits

Mapping of logic expression and function minimization: SOP, POS expressions and circuit configurations, Combinational Logic gates, working and configuration of TTL, DTL, RTL, CMOS, MOSFET, Sequential circuits: RS, JK, D and TFF; Register: serial, parallel and shift register-their design, Counter: synchronous counter and design (up to module–10 counter), Microprocessor: basic concept. **(10 lectures)**

Unit - VII: Signal Transmission & Devices

Transmission line: Basic concept of transmission of LF and HF in open wire and coaxial lines, wave equation, characteristic impedance, VSWR, Short and open circuit impedance, λ-matching and stub matching, Waveguides: fundamental concepts of signal propagation through a waveguide, relation between cutoff frequency and waveguide dimension of rectangular waveguide, Antenna: monopole and dipole antenna, antenna parameter, antenna array. **(10 lectures)**

Unit - VIII: Modulation and Demodulation:

Amplitude modulation: Bandwidth and frequency spectra, Frequency modulation: narrowband and wide band, power, bandwidth, improvement of S/N with emphasis and de-emphasis circuits, Pulse Modulation: PAM, PCM Basic idea of digital carrier modulation schemes and Channel capacity. **(8 lectures)**

Recommended Books:

1. Modern Digital Electronics – R.P. Jain
2. Electronic Communication Systems – Kennedy, Davis
3. Microwaves – K.C. Gupta
4. Op-Amps and Linear Integrated Circuits – R.A. GayaKwad
5. Digital Principles and Applications – A.P. Malvino and D.J. Leach
6. Electronic Devices – Thomas L. Floyd
7. Fundamentals of Digital Electronics – A. Kumar

Semester 7

Course Code: PHYADL14034

Course Title: Quantum Mechanics-II

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course objectives: *The objective of the paper is to provide exposer to the learners about some advanced concepts in both non-relativistic and relativistic quantum mechanics and their applications to solve the problems of the subatomic world.*

Course Learning Outcomes: *After learning this course, the learners will be able to (a) use Dirac's bra-ket algebra to derive generalized uncertainty principle and solve 1D harmonic oscillator problem (b) compare the different pictures in Quantum Mechanics (c) apply various approximation methods such as time-independent perturbation theory, variational principle and WKB approximation to solve quantum mechanical problems (d) write matrix representation of angular momentum and calculate eigenfunctions of orbital angular momentum (e) analyze orbital and spin angular momentum matrices and calculate Clebsch-Gordan coefficients, (f) illustrate continuous and discrete symmetries in QM and apply the identical particle QM to the collision of identical particles (g) use time-dependent perturbation theory for constant and harmonic perturbations and derive Fermi's Golden rule (h) derive KG and Dirac equation in presence of electromagnetic field.*

Unit - I: Operator method in Quantum Mechanics

Introduction to linear vector space, Hilbert space, observables and operators, Dirac notations – Properties of state vectors – Ket and Bra vectors, Orthogonal and Orthonormal states. Projection Operators, Commutator Algebra, Uncertainty principle for two arbitrary operators, One dimensional linear harmonic oscillator problem by operator method. **(8 lectures)**

Unit - II: Time evolution of states

Evolution of states, unitary time evolution operator, Schrodinger and Heisenberg pictures. Heisenberg's equation of motion, Dirac interaction picture. **(3 lectures)**

Unit - III: Symmetry and Identical Particles

Symmetry and conservation laws, Translation in space: conservation of linear momentum, Translation in time: Conservation of energy, Rotation in space: Conservation of angular momentum, Space Inversion: parity conservation, Time reversal. Meaning of identity and consequences; Symmetric and antisymmetric wave functions; Slater determinant; Symmetric and antisymmetric spin wave functions of two identical particles; Collisions of identical particles. **(7 lectures)**

Unit - IV: Angular Momentum

The orbital angular momentum operator, general formalism of angular momentum, matrix representation of angular momentum, eigenfunctions of orbital angular momentum, angular momentum in differential representation using spherical coordinates, spherical harmonics; Raising and lowering operators for angular momentum using Bra and Ket algebra. Spin angular momentum, experimental evidence for spin (Stern-Gerlach Experiment), spin-half and Pauli matrices. Addition of angular momenta and Clebsch-Gordon coefficients. **(8 lectures)**

Unit - V: Approximation Methods

Time independent perturbation theory: First and second order corrections to the energy eigenvalues; First order correction to the eigenvector; Degenerate perturbation theory; Applications to Zeeman Effect and isotopic shift. Variational methods and its applications. Wentzel - Kramers - Brillouin (WBK) Method and its application. **(9 lectures)**

Unit - VII: Scattering theory

Differential and total scattering cross-sections, scattering amplitude; Scattering by spherically symmetric potentials; Partial wave analysis and phase shifts; Scattering by a rigid sphere and square well; Coulomb scattering; Born approximation. **(7 lectures)**

Unit - VIII: Relativistic Quantum Mechanics

Single particle relativistic wave equation, Klein-Gordon equation, Dirac equation, prediction of antiparticles, non-relativistic limit and electron magnetic moment. **(6 lectures)**

Books recommended:

1. Introduction to Quantum Mechanics – David J Griffiths (2nd Ed. Pearson)
2. Principles of Quantum Mechanics – R. Shankar (3rd Ed. Springer)
3. Quantum mechanics – A. Ghatak and S. Lokanathan (Springer)
4. Quantum Mechanics – Concepts and Applications N. Zettili (2nd Ed. Wiley)
5. Quantum mechanics – G. Auletta, M. Fortunato, G. Parisi (Cambridge Univ. Press)
6. Quantum Mechanics: An Introduction – Walter Greiner (4th Ed. Springer)
7. Modern Quantum Mechanics – J .J. Sakurai (2nd Ed. Pearson)
8. The Principles of Quantum Mechanics –P. A. M. Dirac (B.N. Publishing)
9. The Feynman Lectures on Physics –R. Feynman, R. Leighton and M. Sands
10. Quantum Mechanics –C. Cohen-Tannoudji, B. Diu, and F. Lalo. (2nd Ed., Wiley-VCH)
11. Modern Particle Physics - Mark Thomson (Cambridge University Press)
12. Relativistic Quantum Mechanics – J.D. Bjorken and S.D. Drell
13. Introductory Quantum Mechanics – Richard L. Liboff.
14. Quantum Mechanics – C. Cohen-Tannoudji, B. Diu, and F. Lalo.
15. Modern Particle Physics - Mark Thomson (Cambridge University Press)

Semester 7

Course Code: PHYADL14044

Course Title: Research Methodology

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course Objective: *The objective of the course is to familiarize the students with the concepts of research, research design, ethics of research and consequences of plagiarism and how to write technical reports and papers.*

Course Outcome: *After this course, the candidates will have basic concepts of research, research design, organize and conduct research more appropriate way and able to write research report, thesis, project proposals. The candidates will have proper idea about research ethics, plgarims and its tools. .*

Unit I: Research Methodology: An introduction

Research concept, identification of research problem, Meaning of Research, Objectives of Research Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research. **(12 Lecture)**

Unit II: Research Design

Meaning of Research Design, Need for Research Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs. **(8 Lecture)**

Unit III: Scientific Writing

Forms of scientific writing i.e. research articles, notes, report, review, monograph, dissertation/thesis, popular article etc. components of research article, writing strategy for a research article. **(8 Lecture)**

Unit IV: Intellectual Property Right

Introduction to IPR, Patent laws, process of patenting a research finding, copyright. **(6 Lecture)**

Unit V: Philosophy and Ethics

Introduction to philosophy: definition, nature and scope, concept, branches, Ethics: definition, moral philosophy, nature of moral judgements and reactions. **(6 Lecture)**

Unit - VI: Scientific Conduct

Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), Redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data. **(8 Lecture)**

Reference books:

1. Kothari, C R. Research Methodology Methods and Techniques (New Age International Publishers, New Delhi, 2009).
2. Ackoff, Russell L. The Design of Social Research (Chicago Press, 1961).
3. Ackoff, Russell L. Scientific Method (New work: John Wiley & Sons,1962).
4. Bird, A. (2006). Philosophy of Science. Routledge.
5. MacIntyre, Alasdair (1967) A Short History of Ethics. London.
6. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped;ISBN:978-9387480865
7. Indian National Science Academy (INSA), Ethics in Science Education,
8. Research and Govemance (2019) , ISBN:978-81-939482-l-7
9. Pruzan and Pete. Research Methodology: The Aims, Practices and Ethics of Science
10. Fundamentals of Research Methodology and Statistics, Yogesh Kumar Singh (New Age International Publisher)

Semester 7

Course Code: PHYADL14054

Course Title: Physics Practical - I

Total Credit: 4 (0+0+4)

Duration: 48 Hours

Course Learning Outcomes: *General Physics Laboratory-I offers a number of optical and electronics practicals which enable the learners to understand the basic concept of electronic circuits through action and observation. After completion of this course, the students will have the ability to (i) understand the behaviour and operations of electronic components such as Integrated Circuit (IC), Operational Amplifier (OPAMP), Logic Gates etc. (ii) analysis and design various oscillators and electronic circuits for mathematical operations, (iii) calculate and determine self-inductance of a coil, unknown resistance of a wire etc. (iv) determine the wavelength of monochromatic light, radius of curvature of convex surface.*

List of Experiments:

1. To determine the wavelength of sodium light with the help of Fresnel Bi-prism.
2. Study the formation of Newton's rings in the air-film in between a plano-convex lens and a glass plate using nearly monochromatic light from a sodium-source and hence to determine the radius of curvature of the plano-convex lens.
3. To determine the value of an unknown resistance by using Carey-Foster bridge.
4. To determine the self-inductance of a coil using Anderson Bridge.
5. To design a Phase shift oscillator and compare its theoretical and practical frequency.
6. To design a Wien bridge oscillator and compare its theoretical and practical frequency of oscillation.
7. Using an IC 741C (a) design an integrating & differentiator circuit, (b) draw the input and output waveform, (c) measure the rise and fall time, (d) Compare the theoretical and practical value.
8. To solve a given simultaneous equation using OPAMP.

9. To design and study (a) Monostable Multivibrator, (b) Astable Multivibrator using IC555 timer.
10. To design and study Schmitt Trigger using IC 555 timer.
11. To design a CE amplifier circuit and obtain the frequency response curve of the amplifier and determine the mid frequency gain, lower and upper cut-off frequency and bandwidth of amplifier.
12. To design (a) RS flip flop (b) Gated RS flip flop and (c) D flip flop using logic circuits and verify their truth tables.

(List of practicals given above should be considered as suggestive of the standard. New practicals of similarstandard may be added and old problems may be deleted whenever considered it necessary)

Semester 8

Course Code: PHYADL14064

Paper Title: Advanced Statistical Mechanics

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course Learning Outcomes: *This course gives the insight of postulates of statistical physics and calculating probability for various statistical systems of particles. After completing this course students will be able to (i) distinguish between the types of ensembles and explain the behaviour of classical and quantum statistics, (ii) establish the connection between statistics and thermodynamics, and (iii) understand the concept of the Ising model and phase transitions.*

Unit I: Classical Statistical Mechanics

Classical Statistical mechanics: Statistical basis of Thermodynamics, the micro and macro states, postulates of equal a priori probability, connection between statistical mechanics and thermodynamics. Elements of ensemble theory: Micro canonical, canonical and grand canonical ensembles, partition and grand partition functions, particle density, energy fluctuations in grand canonical ensemble, equivalence to other ensembles. **(15 lectures)**

Unit - II: Quantum Statistical Mechanics

Basic principle, inadequacy of classical theory, quantum mechanical ensemble theory, density matrix, ensembles in quantum statistical mechanics. Maxwell-Boltzmann, Bose Einstein and Fermi-Dirac statistics, properties of ideal Bose gas system and ideal Fermi gas system, their equations of state, some applications – Black body radiations, white dwarf, Bose-Einstein condensation (BEC) and experimental evidence. **(14 lectures)**

Unit - III: Fluctuations

Thermodynamic fluctuations, Gaussian distribution, random walk and Brownian motion, approach to equilibrium, Fokker-Planck equation; introduction to non-equilibrium processes.

(7 lectures)

Unit - IV: Phase transition

Formulation of the problem, the theory of Lee and Yang. First and second order phase transitions; diamagnetism, paramagnetism and ferromagnetism; Liquid Helium, Two fluid hydrodynamics, second sound, theories of Landau and Feynman. **(8 lectures)**

Unit - V: Special topics

Ising model: partition function for one dimensional case; Chemical equilibrium and Saha ionisation formula. **(4 lectures)**

Recommended Books:

1. Foundations of Statistical and Thermal Physics, F Reif, Tata McGraw-Hill, IE, 2011.
2. Introduction to Statistical Physics, Silivio R.A. Salinas, Springer, 2010.

3. Statistical Mechanics, R. K. Pathria, Paul D. Beale, Elsevier, 3rd Edition, 2011.
4. Statistical and Thermal Physics, L. D. Landau and E.M. Lifshitz, Butterworth-Heinemann; 3rd Edition, 1996.
5. Statistical Physics- An Introductory course, Daniel J Amit and Yosef Verbin, World Scientific Co Pvt Ltd, 1999.
6. Elements of Non- Equilibrium Statistics, V Balakrishnan, ANE Books- New Delhi, 2009

Semester 8

Course Code: PHYSPL15074

Paper Title: Nuclear and Particle Physics-II

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course Objectives: *The aim of this course is to comprehend nuclear structure by studying collective nuclear models and nuclear reactions. It also emphasizes understanding the fundamental principles of radiation detection, while exploring significant aspects of both weak and strong interactions and the standard model.*

Course Learning Outcomes: *After learning this course, the students will be able to (i) apply the shell model and collective model to describe some basic nuclear properties, (ii) understand basics of nuclear reactions, compound nuclear reactions (iii) understand the role of symmetries in elementary particle interactions, (iv) get elementary idea of quark model, quark confinement, asymptotic freedom and standard model of particle physics*

Unit I:

Nuclear Models : (i) Shell Model: Review of shell model, Applications of shell model: Magnetic dipole moments of nucleon and nuclei - C-N Catastrophe, Schmidt's calculation of total angular momentum and total magnetic moment, electric quadrupole moments of various nuclei in the light of extreme single particle shell model. (ii) Collective Model: Failure of the nuclear shell model, Vibrational Model: Deformation parameters, Nuclear shapes with quadrupole, octupole and hexadecapole deformations, Nuclear shape vibrations, vibrational model predictions; Rotational Model: rotational energy states of a deformed nucleus. **(10 lectures)**

Unit II:

Nuclear Reaction :Different types of reactions, Direct Reaction, Kinematics of stripping and pick-up reactions, inelastic scattering. Resonance scattering and reactions: Breit-Wigner dispersion formula. Compound nucleus reaction, S. N. Ghoshal's experiment for verification of compound nuclear hypothesis. **(8 Lecture)**

Unit III:

Nuclear Radiation Detectors: General Properties of Radiation Detectors: Detector sensitivity, Energy Resolution, Detection Efficiency, Dead Time. Energy loss of charged particles: Mechanism, Stopping power and range, Bethe-Bloch formula, energy dependence of the stopping power, particle identification, Bragg curve, Radiation length. Solid State Detectors: Semiconductor detectors, Surface-barrier detectors. Scintillation counter, Solid State Nuclear Track Detectors (SSNTD). **(15 lectures)**

Unit IV:

Particle physics: The discrete symmetries C, P and T. the θ-τ puzzle, Parity violation in weak interaction: Wu experiment, CPT theorem, Quark model, Properties of quarks and their classification, Color degree of freedom, Elementary ideas of SU(2) and SU(3) symmetry groups, Gell-Mann – Okubo mass relation, Introduction to Standard Model, quark confinement, asymptotic freedom. **(9 Lectures)**

Recommended Books:

1. Introductory Nuclear Physics – Kenneth S Krane
2. Nuclear Physics (Vol.2) – SN Ghoshal
3. Radiation Detection and Measurement - Glenn F. Knoll
4. Techniques for Nuclear & Particle Physics Experiments – WR Leo
5. Introduction to Nuclear & Particle Physics –A Das & T Ferbel.
6. Nuclear Radiation Detectors- S.S. Kapoor & V.S. Ramamurthy
7. Introduction to Elementary Particles – David Griffiths
8. Nuclear and Particle Physics: An Introduction – B.R. Martin
9. Concepts of Nuclear Physics – Bernard L Cohen
10. Nuclear Physics: Theory and Experiment, – Roy and Nigam.
11. Introduction to Nuclear Reactions – GR Satchler
12. Nuclear Physics – Principles & Applications (John Lilley)
13. Nuclear & Particle Physics – WE Burcham & M Jobes.
14. Physics & Engineering of Radiation Detection, S. N. Ahmed (Academic Press 2007)

Semester 8

Paper Title: Condensed Matter Physics-I

Paper Code: PHYSPL15084

Credit: 04 (3+0+1)

Total Lecture = 48

Course Objective: *The objective of the course is to provide students with a comprehensive understanding of condensed matter physics, covering crystal structures, band theory in solids, semiconductors, phonon dynamics, and optical properties.*

Course Outcome*: On successful completion of this course, the students will develop strong foundation on (i) Students will review the fundamental elements of crystallography and learn about the free electron gas model, (ii) Students will develop an understanding energy bands in solids and fundamentals intrinsic and extrinsic semiconductors, their carrier dynamics,* *and related effects (iii) Students will learn about phonon spectra and scattering processes and understand the optical properties of materials and related phenomena.*

Unit I:

Crystal physics & free electrons in crystals: Review of elements of crystallography and crystal structures, symmetry operations, point groups and space groups, Imperfection in solids. **(8 Lectures)**

Introduction to free electron gas model. Free electron gas in one- and three-dimensional potential well, Density of states, The Fermi-Dirac distribution function. The electronic specific heat. Electrical conductivity of metals. Thermal conductivity of metals.
(8 Lectures)

Unit II:

Energy band theory:: The Bloch Theorem. The Kronig-Penny model. Brillouin zones. Energy vs Wave vector (E-K) diagram. Effective mass of an electron. Distinction between conductor, semiconductor and insulator. **(10 Lectures)**

Unit III:

Semiconductors: Intrinsic and Extrinsic semiconductors, Carrier concentration in intrinsic and extrinsic semiconductors. Fermi level and variation of carrier concentration with temperature, Law of mass action. Conductivity and mobility of semiconductors. Generation and recombination. Hall Effect. **(9 Lectures)**

Unit IV:

Phonon Spectrum: Phonon creation and annihilation operators, elastic scattering of electrons, inelastic scattering by phonons, inelastic scattering of neutrons by phonons, phonon scattering: normal and umklapp processes. **(6 Lectures)**

Unit V:

Optical properties of materials: Optical constants, Drude model, dispersion relation of optical constants from Maxwell's equations, Optical absorption and emission in semiconductors, Exciton absorption, Impurity and interband transitions, Luminescence, direct and indirect luminescence Activators, Photoluminescence and thermo-luminescence. Absorption process, Photoconductivity, photoelectric and photovoltaic effect. **(8 Lectures)**

Reference Books

1. Introduction to Solid State Physics, Charles Kittel (Wiley India Edition, 2019)
2. Solid State Physics, S.O. Pillai (NEW AGE International Pvt Ltd, 2022)
3. Solid State Physics, M.A. Wahab (Narosa Publishing House Pvt. Ltd. New Delhi, 2015)
4. Solid State Physics, A.J Dekker, (Laxmi Publications, 2008)
5. Elements of Solid State Physics, J.P. Srivastava (PHI, 2008)
6. Introduction to Solids, Leonid V. Azaroff (McGraw Hill Education, 2017)
7. Solid State Physics, N.W. Ashcroft and N.D. Mermin (Cengage, 2003)
8. Solid-state Physics, H. Ibach and H. Luth, (Springer, 2009)
9. Solid State Physics, Rita John, (McGraw Hill, 2014)
10. Solid State Physics, M.A. Wahab, (Narosa Publications, 2011)

Semester 8

Paper Title: Advance Optics-I

Paper Code: PHYSPL15094

Credit: 04 (3+1+0)

Total lectures: 48

Course Objective: *The objective of the course is to familiarise the students with optical phenomena, different concepts related laser physics*

Course outcome: *After successfully completing the course, student will be able to:*

Understand phenomenon of interaction of electromagnetic radiation with matter

Understand the lasing mechanism, types of Lasers, characteristics of Laser Light,

Understand and appreciate the applications of Lasers in various fields.

Familiarize with recent developments in Laser Spectroscopy

Have the idea of optical fibres, their properties and principle of propagation of electromagnetic waves through optical fibres

Unit I:

Interaction of Matter-radiation: Various spectroscopic techniques (Overview), absorption, spontaneous and stimulated emission of radiation, Einstein's coefficients, Coherent properties of radiation fields, Transition probabilities- weak and strong field approximation, Cavity radiation-counting the number of cavity modes, Plank's law for cavity modes, widths and profiles of spectral lines, overview of spectroscopic instrumentations-detection of light, interferometers, photo emissive detectors. **(Lecture 12)**

Unit II:

Basics of Lasers: Basic elements of lasers, saturation intensity, growth factor, properties of lasers- directionality, intensity, monochromaticity, coherence, light amplification, Population inversion, Pumping schemes, three and four level systems, threshold condition for laser oscillation, laser amplifiers, spectral characteristics, laser rate equations, laser resonators-longitudinal and transverse cavity modes. **(Lecture 13)**

Unit III:

Types and applications of Lasers: Types of lasers with examples: solid state, gas laser, Dye laser, and semiconductor lasers, liquid and chemical lasers, free-electron lasers, excimer lasers, X-ray laser, applications of lasers- Physics, Chemistry, Environmental Research, Material Science, Biology, Medical Science, communication, Atmospheric optics, industry, Holography. **(Lecture 11)**

Unit -IV:

Fibre optics: Introduction to fiber optics, Physics of light. Principles of fiber optics: Introduction, light propagation, Skew rays, meridional, optical fibre waveguides (step index, graded index, single mode), acceptance angle, numerical aperture, Signal distortion in optical fibers- Attenuation, Absorption, Scattering, Bending losses and joint losses, Core and

Cladding losses. Information capacity, Group delay, Dispersion - Material dispersion, Wave-guide dispersion, Intermodal dispersion, Fiber Birefringence, Polarization Mode Dispersion, couplers and connectors.**(lectures: 12)**

Recommended Books:

1. Principles of Lasers, O Svelto, Springer

2. Lasers and Non-linear Optics, B B Laud, New age international limited, publishers

3. Elements of Laser and Non-Linear Optics, G D Baruah, Prakashan, Meerut

4. Optical Fiber Communications Principles and Practice − John M. Senior, M. Yousif Jamro, Pearson

Semester 8

Course Code: PHYSPL15104

Course Title: Physics Practical - II

Total Credit: 4 (0+0+4)

Duration: 48 Hours

Course Learning Outcomes: *Physics Practical-II course is focusing on advanced techniques and experiments drawn from overall physics classes consisting of advanced electronics, solid state physics, nuclear physics and optics. The student will be able to grasp the role of experimental design, data analysis, error analysis, and the use of computers while investigating physical phenomena.*

List of experiments:

1. Design a triangular wave generator & compare its theoretical and practical frequency.
2. To Study Adder, Subtractor & Comparator circuit using IC-741 & verify theoretical and practical output.
3. Measure the resistivity & hence the band gap of a semiconductor sample with the use of four probe apparatus.
4. Determine the Hall-coecient, carrier density & carrier mobility of a given semiconductor by using Hall-coecient apparatus.
5. Using IC-741 (a) Design a 1st order & 2nd order low pass filter (b) Draw the frequency response curve (c) Find the roll o rate (d) Determine the gain & cut-o frequency theoretically and practically.
6. Verify the inverse square law for Gamma rays with the help of G.M. counter.
7. Measure the specic charge (e/m) of an electron using Helical method.
8. Determine the specic charge i.e. charge to mass ratio (e/m) of an electron using Thomson's bar magnet method.

9. Determine the value of Planck’s constant with the help of a photoelectric cell and monochromatic filter.
10. Study the bending loss in an optical fibre with dierent angles of bending of the fibre.
11. To measure the power-loss at a splice between two multi-mode fibre and study the power-loss for longitudinal and angular shift.
12. To sort a string of a number of bytes in descending/ascending order using the 8086 microprocessor.
13. Using microprocessor 8086 (a) Write a program to Add two binary numbers each 8 bytes long (b) Write a program to and maximum no. in a given string & store it in location 0310.
14. Using microprocessor 8085 (a) Write a program for Hexadecimal addition of two numbers (b) Write a program for decimal addition of two decimal numbers.

Semester 9

Course Code: PHYSPL25014

Course Title: Advanced Nuclear and Particle Physics

Total Credit: 4 (3+1+0)

Total Lecture: 48 Hours

Course Objectives: *This course aims to impart knowledge on essential aspects of gamma decay and its practical applications, while also offering foundational understanding of nuclear fission and fusion reactions. Additionally, it covers key concepts of radiation safety and explores neutrino physics, applying relativistic kinematics to particle production and decay..*

Course Learning Outcomes: *After learning this course, the students will be able to (i) apply angular momentum and parity selection rules to predict gamma transition, (ii) apply the basic principle of Mossbauer effect to measure the Isomer shift, determination of gravitational red shift. (iii) calculate important nuclear fission reactor parameters such as slowing down power, moderating ratio & diffusion length (iv) derive & solve Fermi Age Equation (v) compute fission and fusion barrier (vi) distinguish between stellar nucleosynthesis and big bang nucleosynthesis and Controlled fusion reaction (vii) Accumulate some radiological protection knowledge like effective Biological effect (RBE), shielding, Radiation safety in the laboratory for nuclear physics (viii) apply basic QM to explain the neutrino oscillation. (ix) apply relativistic kinematics in particle production and decay problems.*

Unit I: Gamma Rays

Multipole expansion of Radiation field, multipolarity, gamma-ray transition probability, Angular momentum and Parity selection rules, Nuclear Isomerism, Internal Conversion of gamma-rays; Mossbauer spectroscopy: Mossbauer effect, Experimental techniques, Applications of Mossbauer effect – Isomer shift, determination of gravitational red shift. **(8 lectures)**

Unit II: Nuclear Fission and Reactor Physics

Fission: spontaneous and induced fission, Q-value of fission, fission barrier, activation energy, condition for spontaneous fission, characteristics of fission - energy and mass distribution of fission product, number of emitted neutrons, cross-section of neutron induced fission, Bohr-Wheeler theory of fission; Reactor Physics: Sources of neutron, detection of neutrons, classification of neutrons, slowing down of neutrons, slowing down power, diffusion of thermal neutrons, Fermi Age equation, moderating ratio, fission chain reaction & multiplication factor, four-factor formula, reactor theory; Nuclear reactor programme in India. **(14 lectures)**

Unit III: Nuclear Fusion

Nuclear fusion: Basic fusion process, characteristics of fusion - Energy release, Coulomb barrier, cross-section, reaction rate, thermonuclear fusion in stars -pp chain & CNO cycle, Big Bang nucleosynthesis, nucleosynthesis beyond iron, r- and s-processes. Controlled fusion reaction, Debye length, Confinement of plasma - magnetic confinement and Toroidal confinement, Lawson criterion – Tokamak. **(8 lectures)**

Unit IV: Radiation Protection

Dosimetric units: The Roentgen, absorbed dose, relative biological effects (RBE), equivalent dose, effective dose; typical doses from sources in environment. Guiding principle of radiation safety (ALARA); Biological effects: high doses received in short time, low-level doses; dose limits; shielding; radiation safety in the nuclear physics laboratory. **(10 lectures)**

Unit V: Particle Physics

Solar and Atmospheric neutrino anomaly, neutrino oscillation, neutrino mass hierarchy, overview of neutrino oscillation experiments. Simple applications of relativistic kinematics in particle production and decay problem. Fixed target versus colliding beam experiments. **(8 lectures)**

Recommended Books:

1. Introductory Nuclear Physics – Kenneth S Krane (Wiley)
2. Atomic and Nuclear Physics (Vol. 2) – SN Ghoshal (2nd Ed. S Chand)
3. Introduction to Elementary Particles – David Griffiths (Wiley & Sons, Inc.)
4. Neutrino Physics – Kai Zuber (2nd Edn. CRC Press)
5. Techniques for Nuclear & Particle Physics Experiments – WR Leo (2nd Ed. Springer)
6. Radiation Detection and Measurement – Glenn F Knoll (4th Ed. Wiley)
7. Nuclear Moments – H. Kopferman
8. Nuclear Magnetic Resonance Spectroscopy – F. A. Bovey, P. A. Mirau and H. S. Gutowsky (2nd Edn. Academic Press)

Semester 9

Paper Title: Condensed Matter Physics-II

Paper Code: PHYSPL25024

Credit: 04 (3+0+1)

Total Lecture: 48

Course Objective: *The objective of this course is to provide students with a comprehensive understanding of the fundamental concepts and mathematical formulations of magnetic properties of solids, field of soft condensed matter physics, semiconductor devices concepts of superconductivity.*

Course Learning Outcomes: *At the end of the course, (i) the students will gain an understanding of the fundamental concepts and mathematical formulations related to magnetic properties of solids. (ii) Students will develop a comprehensive understanding of the behavior of electrons in a magnetic field, focusing on magneto-conductivity and the properties of the Fermi surface. (iii) Students will be introduced to the field of soft condensed* *matter physics. (iv) Students will gain a thorough understanding of semiconductor devices, including carrier transport phenomena and the characteristics of various junctions. (v) Students will also learn about the theory and phenomena of superconductivity and explore key concepts related to superconductivity.*

Unit I: Magnetic properties of Solids

Exchange interaction and exchange integral for a two-electron system, Heisenberg Hamiltonian for exchange interaction, relationship between exchange energy and molecular field, ferromagnetic spin waves and antiferromagnetic spin waves and their dispersion relations, magnons. **(12 Lectures)**

Unit II: Electrons in magnetic field

Magneto-conductivity, Fermi surface, cyclotron resonance, Landau levels and Landau cylinders, de Hass-Van Alphen effect. **(6 Lecture)**

Unit III: Soft condensed matter physics

Introduction to polymers, conducting polymers, biopolymers and biodegradable polymers, Liquid crystal, Van der Waals interaction and forces, colloidal dispersion. **(5 Lectures)**

Unit IV: Semiconductor devices

Carrier transport phenomena in semiconductors, Junctions: p-n junction in equilibrium, contact potential, space charge at the junction, forward and reverse biasing, p-n junction capacitance: depletion and charge storage capacitance, I-V characteristics; Metal-semiconductor junctions: Ohmic and Schottky junction, semiconductor homo and heterojunctions. **(12 Lectures)**

Unit I: Superconductivity

Thermodynamics of superconducting state, Type-I and Type-II superconductors, Meissner effect, London equations, Isotope effect, Frohlich interaction, London equation, BCS theory of superconductivity, flux quantization, Giaever tunneling and Josephson effects (d.c. and a.c.), superconducting quantum interference device (SQUID), Ginsburg-Landau theory, introduction to high temperature superconductors. **(13 Lectures)**

Reference Books

1. Introduction to Solid State Physics, Charles Kittel (Wiley India Edition, 2019)
2. Solid State Physics, S.O. Pillai (NEW AGE International Pvt Ltd, 2022)
3. Solid State Physics, M.A. Wahab (Narosa Publishing House Pvt. Ltd. New Delhi, 2015)
4. Physics of Semiconductor Devices, S.M. Sze and Kwok K. Ng (Wiley India, 2015)
5. Solid State Electronic Devices, Ben. G. Streetman and S. K. Banerjee (Pearson Education India; 2015)
6. Introduction to Superconductivity, Michael Tinkham (Medtech; Standard Edition, 2017)

7. Superconductivity, SL Kakani and Shubhra Kakani (NEW AGE International Pvt Ltd, 2020)
8. I. W. Hamley, Introduction to Soft Matter, (Wiley, Chichester, 2000).
9. R. A. L. Jones, Soft Condensed Matter, (OUP, Oxford, 2002).

Semester 9

Course Code: PHYSPL25034

Course Title: Experimental Techniques in Physics

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course Objective: *The aim of this course is to implement tools and techniques used by experimental physicists in the laboratory. Students will learn to analyze various error systems, industrial equipment's working principle and applications and insight into the preparation of nanomaterials.*

Course Outcome: *This course will provide a basic understanding about the scientific research and various techniques. After completion of the course, students will be able to familiarize with various research methodologies to address the contemporary research problems, investigate the data by using different scientific techniques.*

Unit I: Error Analysis and Numerical Methods:

Uncertainties in measurement: measuring errors, uncertainties, parent & sample distributions, mean & standard deviation; Probabilities distributions: binomial, Poisson, Gaussian, & Lorentzian distribution; Error analysis: instrumental & statistical uncertainties, propagation of errors; Estimates of mean & errors: statistical fluctuations, probability tests, reliability test of a distribution; Least-Squares Fit: Method of Least Squares χ & uncertainties in parameters, Limitations of the Least-Squares Method; Maximum likelihood. **(12 lectures)**

Unit II: Synthesis of thin solid films and nanomaterials

Thin Films, different methods of thin film preparation and nanomaterials: chemical and physical route, evaporation, sputtering, pulse laser deposition, lithography, solgel, hydrothermal, chemical bath deposition, spray pyrolysis, condensation, nucleation and growth. **(12 Lectures)**

Unit III: Material characterization tools and techniques

x-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), scanning tunnelling microscopy (STM),Optical properties using UV-Vis spectrometer, Photoluminescence. **(10 lectures)**

Unit IV: Advanced nuclear techniques

Nuclear Magnetic Resonance (NMR): Resonance condition, Experimental technique – Purcell and Bloch method, Applications of NMR – Determination of nuclear spin, Chemical shift.

Nuclear Electronics: Overview of pulse processing, pulse pile-up,electronic noise, baseline shift, triggers, Preamplifiers - voltage & charge sensitive configurations, noise characteristics, detector bias voltage. Pulse shaping; Pulse counting: Discriminator, scalars or counters; Pulse height analysis, Linear amplifier, ADC, TDC, MCA, Coincidence; Background and Detector Shielding: Sources of background, background in different detectors, Shielding materials, active methods of background reduction. **(14 lectures)**

Reference Books:

1. Research Methodology: Methods and Techniques – C. R. Kothari (Newage Publishers)
2. Data Reduction and Error Analysis for the Physical Sciences – P.R. Bevington and K. D Robinson (McGraw Hill, 2003)
3. Thin film Fundamentals –A Goswami
4. Thin film Phenomena – K L Chopra
5. Elements of X-ray diffraction – B D Cullity
6. Cryogenics Systems – R. F. Barron (2nd Edition, Oxford university Press 1985)
7. Nanotechnology: Principles and Practices – Sulbha Kulkarni (Springer)
8. Introduction to Nanotechnology – Jr. C. P. Poole, and F. J. Owens (Wiley)
9. Nanostructures and Nanomaterials: Synthesis, Properties and Applications - Guozhong Cao (Imperial College Press, 2004)
10. Radiation Detection and Measurement – Glenn F Knoll (4th Ed. Wiley)
11. Techniques for Nuclear & Particle Physics Experiments – WR Leo (2nd Ed. Springer)

Semester 9

Course Code: PHYSPL25044

Course Title: Computational Physics

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course Objectives: *Learning basic methods, tools, and techniques of computational physics and developing practical computational problem-solving skills.*

Course Learning Outcomes: *After learning this course, the students will be able to (i) solve nonlinear equations such as Bisection method, regula-falsi method, Newton Raphson method and Secant method. (ii) solve system of linear equations using both Gauss elimination and Gauss-Jordan method with and without pivoting, (iii) perform polynomial interpolation such as Newton-Gregory and lagrange interpolation method and least square curve fitting (iv) compute numerical integration using trapezoidal rule, Simpson's one third rule in Monte Carlo method (v) solve first and second order linear differential equation using Euler method and Runge-kutta method.*

Part – I : Numerical Methods (Theory)

Unit - I Introduction

Introduction to computational physics, computer architecture overview, tools of computational physics, Integer representation; floating-point representation on a computer, Errors: round off and truncation errors. **(3 lecture)**

Unit - II: Solution to nonlinear equations

Bisection method, Regula-Falsi Method, Newton-Raphson method, Secant method, advantages and disadvantages, errors in each of these methods. **(3 lectures)**

Unit - III: Solution of linear systems

Gauss elimination and Gauss-Jordan elimination, pivoting. **(3 lectures)**

Unit - IV: Interpolation and curve-fitting

Polynomial interpolation using Lagrange's method, construction of Newton-Gregory forward difference and backward difference tables, error estimation in these methods, curve-fitting and the principle of least square. **(5 lectures)**

Unit - V: Numerical Integration:

Integration by trapezoidal and Simpson's rule, Montecarlo integration. **(5 lectures)**

Unit - VI: Solution of differential equations

Euler's method for solving first order linear differential equations (initial value problem): limitations and discussion on its accuracy, Runge-Kutta method and its comparison with Euler's method, 4th order R-K method. **(5 lectures)**

Part – II : Computational Lab

1. Introduction to Linux and Computer Programming Language (FORTRAN /C++ / Python), Plotting with GNUPLOT/Matplotlib.
2. Solution of nonlinear equations: Bisection Method, Regula-Falsi Method, Newton-Raphson Method, Secant method.
3. Interpolation: Newton interpolation, Lagrange interpolation
4. Curve fitting and regression: Least squares fitting, polynomial curve fitting
5. Numerical integration: Trapezoidal rule, Simpson’s rule, Gaussian quadrature method
6. Differential equation: Solution of 1st and 2nd order differential equation using Euler’s and Runge-Kutta method: Simple harmonic oscillator problem with and without damping effects, Solution of Schrodinger’s equation under various standard potentials. Boundary value problems: Shooting method. Solution of partial differential equations (PDEs) with finite difference method.
7. Matrix methods: Determination of Eigenvectors of a system of linear equations, Finding eigenvalue and corresponding eigenvector, Solution of linear systems of equations through matrix inversion.
8. Monte Carlo Technique: Generation of random numbers, Monte Carlo evaluation of integrals, determination of the value of π. Monte Carlo technique to simulate nuclear decay phenomena, Simulation of random physics phenomena, Brownian Motion.

(List of programming given above should be considered as suggestive of the standard. New problems of similar standard may be added and old problems may be deleted whenever considered it necessary)

Recommended Books:

1. Introductory Methods of Numerical Analysis –S. S. Sastry (PHIL Pvt. Ltd.)
2. Numerical Methods –E. Balagurusamy (McGraw Hill Ed.)
3. Computer Oriented Numerical Methods –V. Rajaraman (PHIL Pvt. Ltd.)
4. Numerical Recipes –W. H. Press (Cambridge University Press)
5. Programming with C++ – Ravichandran (McGraw Hill Ed.)
6. Schaum's Outline of Programming with C++ – John Hubbard (McGraw Hill Ed.)

Semester 9

Course Code: PHYSPL15104

Course Title: Physics Practical - III

Total Credit: 4 (0+0+4)

Duration: 48 Hours

Condensed Matter Physics:

Course Learning Outcomes: *This course offers the advanced hand on experiments of advanced condensed matter physics. After completion of this course students will have a deeper understanding on the subject and they will be able to understand the phenomena practically.*

List of Experiments:

1. To determine the Lande g-factor of electrons by using the ES set up.
2. To study the temperature dependence of Hall coecient.
3. To determine magnetoresistance of the supplied material.
4. To determine the (i) Susceptibility arising due to water in the solution of MnCl2 (ii)
1. magnetic moment of Mn++ ions in terms of Bohr magneton and (iii) the ionic molecular
2. susceptibility of Mn++ ions by using Quink's method.
5. To study the I-V characteristics of the supplied solar cell and nd its spectral response.
6. To determine the transition temperature of the supplied ferroelectric materials (BaTiO3).
7. To determine the power law dependence of photocurrent on intensity of illumination in a thin lm sample.
8. To measure the transmission and absorption coecients of a given liquid and a solid thin lm with spectrophotometer.
9. To study the thermoluminescence of F-centres of alkali halides.

Nuclear Physics:

Course Learning Outcomes: *After learning this course, the students will be able to (i) Use GM counter in order to calculate the dead time and efficiency of the counter, (ii) use scintillation counter and analyze various peaks using single and multi channel analyzer, (iii) handle microscope (a) to calculate the average diameter of α-particle tracks, (b) will able to scan nuclear emulsion plates and can calculate mass of pion, scattering cross section, and range of tracks.*

List of Experiments

1. To determine the dead time of a GM counter using a single source.
2. To determine the eciency of a G.M. counter for β and γ-rays.
3. To study the absorption of beta rays emitted from dierent radioactive sources in Al, and hence to nd the range-energy relation for beta particles by Feather's method.
4. (a) To study the complete spectrum of dierent gamma sources and to locate the corresponding photo peak, Compton edge, using NaI (Tl) scintillation counter and single channel analyzer (SCA) and draw calibration curve. (b) To nd the resolution R for dierent energies and hence to draw log vs. logE curve.
5. To study the complete spectrum of dierent gamma sources and to locate the corresponding photo peak, Compton edge, using NaI (Tl) scintillation counter and Multi channel analyzer (MCA).
6. (i) To study the complete spectrum of Mn-54, using NaI (Tl) scintillation counter and multichannel analyser. (ii) To calibrate and determine the resolution R using the sources Cs-137, Ba-133 and Co-60 taking Na-22 as the unknown source.
7. To create the rough vacuum in a given small stainless steel chamber and nd out the resolution of an SSB detector inserting inside it using a 241Am α-source.
8. To determine the average diameter of α-particle tracks in SSNTD.
9. To study the "Thorium stars" produced in the nuclear emulsion and to measure the range of the tracks and to draw energy histograms.
10. To determine the mass of the pion by studying π-μ decay in nuclear emulsion.
11. (i) To scan a given nuclear emulsion plate to determine the number of prongs of the stars. (ii) To draw the Nn distributions of the interaction stars and hence calculate the excitation energy of the interaction. (iii) To determine the scattering cross-section for interaction.

1. To measure the excitation potential of mercury using the Franck-Hertz method.
2. To study the emission spectra of Hydrogen (Balmer series) and determination of Rydberg's constant
3. To determine the wavelength of He-Ne laser light.
4. To study Zeeman effect and determination of Bohr magneton
5. To determine the wavelength of light from a monochromatic source using interferometer and then to determine the difference of wavelength for Sodium D lines.

(List of practicals given above should be considered as suggestive of the standard. New practicals of similar standard may be added and old experiments may be deleted whenever considered it necessary)

Semester 10

Course Code: PHYSPL25064

Course Title: Plasma Physics

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course Objectives: *Plasma physics is a multidisciplinary and essential subject for a large number of research fields, including controlled thermonuclear fusion, space plasma physics, solar physics, astrophysics, high-power laser physics, plasma processing, and many areas of experimental physics. The primary learning outcome for this course is for the students to learn the basic principles and main equations of plasma physics, at an introductory level, with emphasis on topics of broad applicability.*

Course Learning Outcomes: *On completion of the course the student shall be able to: Define, using fundamental plasma parameters, under what conditions an ionised gas consisting of charged particles (electrons and ions) can be treated as a plasma. Distinguish the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena. Classify the electrostatic and electromagnetic waves that can propagate in magnetised and non-magnetised plasmas, and describe the physical mechanisms generating these waves. Define and determine the basic transport phenomena such as plasma resistivity, diffusion (classical and anomalous) and mobility as a function of collision frequency and of the fundamental parameters for both magnetised and non-magnetised plasmas. Formulate the conditions for a plasma to be in a state of thermodynamic equilibrium, or non-equilibrium, and analyse the stability of this equilibrium and account for the most important plasma instabilities. Explain the physical mechanism behind Landau damping and make calculations in this area using kinetic theory.*

Unit I: Introduction to plasma-charge particle motion

Definition and properties of plasma, Plasma production in laboratory and diagnostics. Microscopic description, Motion of a charged particle in electric and magnetic fields-curvature, gradient and external force drifts. **(12 lectures)**

Unit II: Plasma production and devices

Laboratory production methods and confinement schemes, Controlled thermonuclear devices, magnetically confined open and closed systems (linear pinch, mirror machine and Tokamak). Laser-plasmas: inertially confined system. **(7 Lectures)**

Unit III Statistical description of plasmas

B.B.G.K.Y. hierarchy of equations, Boltzmann-Vlasov equation, Equivalence of particle orbit theory and the Vlasov equation, Boltzmann and landau collision integral H-theorem, B.G.K. model, Fokker-Planck term, Solution of Boltzmann equation (brief outline), Transport coefficient-electrical conductivity, diffusion. **(16 Lectures)**

Unit IV: Waves and Instabilities

Small amplitude plasma oscillations. Oscillations in warm field free plasma. Landau damping. Nyquist method-Penrose criterion of stability. Two stream stability (linear and quasi linear theory). Vlasov theory of magnetized plasma. Loss cone instabilitly. Quasilinear theory of gently bump instability. Non-linear electrostatic waves, BCK waves. **(13 Lectures)**

Reference Books:

1. Introduction to Plasma Physics, F. F. Chen (Plenum Press, 1984)
2. Principles of Plasma Physics, N. A. Krall and Trivelpiece (San Fransisco Press, 1986)
3. Physics of High temperature Plasmas, G. Schimdt (2ndEd., Academic Press, 1979)
4. The framework of Plasma Physics, R.D. Hazeltine & F.L. Waelbroeck (Perseus Books, 1998)
5. Introduction to Plasma Physics, R.J. Goldston and P.H. Rutherford (IOP, 1995)
6. Fundamentals of Plasma Physics, J. A. Bittencourt (Springer Science & Business Media, 2013)
7. Fundamentals of Plasma Physics, Paul M. Bellan, (Cambridge University Press 2008)

Semester 10

Course Code: PHYSPL25074

Course Title: Advanced Optics-II

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course Objective: *The objective of the course is to familiarise the students with non-linear optical phenomena as well as various concepts related laser physics*

Course Outcomes*: At the end of the course, the students will be able to*

Learn the basic principles of non linear spectroscopy

Familiarize with principles and instrumentations in non linear spectroscopy

Learn the different techniques of laser Raman spectroscopy and applications

Familiarize with recent developments in Laser Spectroscopy

Unit I: Nonlinear Optics

Nonlinearities of the polarization, generation of second harmonic, D.C., sum and difference frequency generation, anharmonic oscillator model, Miller's rule, crystal symmetry, coupled amplitude equations, Manley-Rowe relation. **(Lecture 10)**

Unit II: Phase Matching

Basic idea of phase matching, quasi-phase matching method, various methods of phase matching, critical and noncritical phase matching, collinear and non-collinear phase matching, expression of angle band-width ($\Delta\theta$) and wavelength band-width ($\Delta\lambda$) in phase matched second harmonic generation, idea of tangential phase matching. **(Lecture 11)**

Unit III: Second Harmonic Generation Basic equation, conversion efficiency and parameters affecting doubling efficiency, various methods of enhancing conversion efficiency, second harmonic generation with Gaussian beam, intra cavity second harmonic generation. **(Lecture 10)**

Unit IV: Higher Order Nonlinear Processes

Four wave mixing processes-third harmonic generation, resonance enhancement of nonlinear susceptibilities, Nonlinear Raman spectroscopy- stimulated Raman scattering, Coherent Anti-Stokes Raman Spectroscopy (CARS), hyper Raman effect, inverse Raman scattering, photo-acoustic Raman spectroscopy, Applications of Laser Raman Spectroscopy. **(Lecture 9)**

Unit V: Time resolved laser spectroscopy

Q-switched lasers, mode locking of lasers, laser amplifiers, femtosecond pulses, measurement of ultrashot pulses, life-time measurements with lasers, pump and probe techniques. **(Lecture 8)**

Recommended Books

1. Lasers and Non-linear Optics, B B Laud, New age international limited, publishers
2. Principles of Lasers, Orazio Svelto, Springer
3. Elements of Laser and Non-Linear Optics, G D Baruah, Prakashan, Meerut
4. Tunable Lasers and Applications, A. Mooradian.T.,Jaeger and P. Stockseth
5. Tunable Solid State Lasers-II, A.B. Budgor, L. Esterowitz and L.G. Deshazer

Semester 10

Course Code: PHYSPL25084

Course Title: Vacuum Science and Technology

Total Credit: 4 (3+1+0)

Total Lecture: 48

Course Objectives: *This course provides the complete understanding of vacuum technology and vacuum measurements systems.*

Course Outcomes: *After learning this course students will have the knowledge about vacuum system, different ranges of vacuum creation system and mechanism and various vacuum measurement systems. At the end of the course, the students will be able to design and construct vacuum system to create high vacuum.*

Unit – I: Vacuum Science

Kinetic theory of gases: Atomistic concept of gas pressure and temperature, Molecular distribution functions, Impingement rate of molecules on a surface, Free path of gas molecules, Gas viscosity and flow, gas conductance of a vacuum line, gas impedance of a vacuum line, flow of gases through apertures, elbows, tubes etc. for viscous and molecular flow regimes. **(14 Lectures)**

Unit - II: Production of Vacuum

Meaning of vacuum and vacuum measuring units, vacuum ranges, pumping speed and pump down time. Explain the different ranges of pressure, Principles of pumping concept, Types of vacuum pumps and their working principle: Mechanical pumps (Oil sealed rotary pump, Roots Pump), Molecular drag, Diffusion, Cryogenic, Getter, Titanium sublimation, Sputter ion pump. **(14 Lectures)**

Unit-III: Vacuum Measurements

Understand different types of pressure gauges and their operating principles, Vacuum Gauges: Mc Leod, Thermocouple, Pirani, Penning, Hot cathode ionization (triode type), Vacuum system design and its operation steps. **(12 Lectures)**

Unit – IV: Applications of Vacuum Technology

Applications in science, technology, research, space science, medical science, day to day life. Vacuum system and components for electronics, metallurgy, chemical and nuclear fields. **(8 Lectures)**

Reference books:

1. Hand book of Thin Film Technology, L. I. Maissel and R. Glang, McGraw Hill Book Co. 1970, 07-039742-2
2. Vacuum Physics and Techniques, T. A. Delchar, Chapman and Hall (Springer)
3. Vacuum Technology, A. Roth, (North Holland, Elsevier Science B.V. 1990)
4. High Vacuum Techniques, J. Yarwood, (Chapman and Hall, London, 1967)
5. Online resources can be used for reference.

Semester 10

Paper Title: Nanoscience and Nanotechnology

Paper Code: PHYSPL25094

Credit: 04 (3+1+0)

Total Lecture: 48

Course Objective: The objective of this course is to provide students with a comprehensive understanding of nanoscience, nanotechnology, and its applications.

Course Learning Outcomes: *At the end of the course, (i) The students will be able to gain an understanding of the fundamental principles of the nanoscale regime, (ii) Students will learn the promising area of nanomaterials, understand the nature and prospects for the field. (iii) Students learn about the various types of nanomaterials such as semiconducting nanomaterials, carbon based nanomaterials thin solid films, (iv) Students will delve into the concept of quantum confinement and its implications for nanostructured materials and explore the diverse potential applications of nanomaterials in various fields, (v) Students will develop an understanding of nanomagnetism and learn about thin solid films technologies and their properties.*

Unit I:

Concept of nanoscale regime, Emergence of nanotechnology, Bottom up and top down approaches, Challenges of nanotechnology. **(4 Lecture)**

Unit - II: Introduction to nanostructured materials

Metal-oxide nanoparticles, nanorods and nanotubes; core-shell nanostructures: inorganic-inorganic, inorganic-organic, organic-organic and polymer-inorganic core shell structures; metal nanostructures; carbon fullerenes and single and multi-walled carbon nanotubes; micro and mesoporous materials: ordered mesoporous structure, random mesoporous structure, zeolites; Nanostructure fabrication techniques, Morphological studies of nanostructures. **(12 lectures)**

Unit III:

Idea of nano-structured materials; Quantum confinement: Quantum well Quantum dots and quantum wires, Density of states, Brus Equation: Effective bandgap of QDs, Opto-electronic properties of semiconductor nanomaterials, Structural properties of nanomaterials. **(10 lectures)**

Unit IV: Potential applications of nanomaterials

Nanoelectronics, Biological applications of nanoparticles, Band gap engineered quantum devices, Photonic crystals. **(4 Lecture)**

Unit V: Nanomagnetism

Origin of nanomagnetic behaviour, magnetic anisotropy, magnetic domain structure and magnetism in ferromagnetic nanomaterials, superparamagnetism. Spin dependent scattering. **(6 Lectures)**

Unit VI: Thin Solid Films

Thin films and preparation by physical and chemical methods, Condensation, nucleation and growth of thin films, size effect in electrical conductivity: Fuchs and Sondheimmer theory and comparison with experiments; Two-dimensional electron gas (2DEGS) systems, 2DEGS in hetero-structures, integral quantum hall effect (QHE) and fractional quantum hall effect. **(12 Lectures)**

Reference Books

1. Nanostructures and Nanomaterials, Guozhon Cao (World Scientific, 2011)
2. Nanotechnology: Principles and Practices, Sulbha Kulkarni (Springer, 2014)
3. Introduction to Nanotechnology, Jr. C. P. Poole, and F. J. Owens (Wiley, 2008)
4. Principles of Nanomagnetism, Alberto P. Guimarães (Springer, 2012)
5. Thin Film Fundamntals, A .Goswami (New Age International, 1996)
6. Thin Film Phenomena, Kasturi Lal Chopra (Krieger Pub Co., 1979)

Semester 10

Paper Title: Literature Survey on Research Topic

Paper Code: PHYSPL25104

Credit: 04 (0+0+4)

Total Lecture: 48

Course objective: *The literature review research course aims to equip M.Sc. students with the essential skills and knowledge required to critically analyze, synthesize, and evaluate existing scholarly literature within their respective fields of study.*

Course outcome: *After completion of the course Students will learn to identify key research themes, methodologies, and theoretical frameworks relevant to their research interests, fostering a deep understanding of the current academic discourse. Furthermore, students will have developed the proficiency to construct coherent and insightful literature reviews that lay the foundation for their own research endeavors, demonstrating advanced scholarly inquiry and engagement with contemporary academic scholarship.*

Guidelines:

1. Student has to do the literature survey on any research topic in physics and submit a report.

2. Student has to give a seminar presentation on the selected topic for both internal and final evaluation.