KOLHAN UNIVERSITY, CHAIBASA
JHARKHAND

Revised Curriculum and Credit Frame Work
As Per FYUGP, NEP- 2020
For UG Physics (w.e.f. 2020)

University Department of Physics
Kolhan University, Chaibasa
West Singhbhum, Jharkhand - 833202

05/02/2024 05/02/2024 05/02/2024

Dr. Maguni Mahakhud **Dr. S. K. Gorai** **Dr. Somnath Kar**

Head
University Department of Physics
Kolhan University
Chaibasa

Kolhan University, Chaibasa
Semester wise Course Code and Credit Point for single Major
Department of Physics

SEMESTER	COURSE CODE	TITLE OF THE PAPER	CREDITS Theory + Practical
I	MJ – 1	Mechanics	3+1
	MN – 1A	Mechanics	3+1
	MDC -1/2/3	Natural Science: Elements of Modern Physics	3+0
II	MJ – 2	Mathematical Physics-I	3+1
	MJ – 3	Electricity and Magnetism-I	3+1
	MN – 2A	Electrical Circuits Network & Basic Instrumentation Skills	3+1
III	MJ – 4	Waves & Optics	3+1
	MJ – 5	Electricity and Magnetism -II	3+1
	MN – 1B	Electricity and Magnetism	3+1
IV	MJ – 6	Math Method -II	4
	MJ – 7	Thermal and Statistical Physics	4
	MJ – 8	Practicals- Mathematical, Thermal And Statistical Physics	4
	MN – 2B	Applied Optics	4
V	MJ – 9	Analog And Digital Electronics	4
	MJ – 10	Elements Of Modern Physics	4
	MJ – 11	Practicals- Electronics And Modern Physics	4
	MN – 1C	Electronics	4
	IAP	Internship/Apprentiship/Project	4
VI	MJ – 12	Quantum Mechanics And Applications	4
	MJ – 13	Solid State Physics	4
	MJ – 14	Nuclear And Particle Physics	4
	MJ – 15	Practicals- Quantum And Solid State Physics	4
	MN – 2C	Renewable Energy Harvesting & Radiation Safety	4
VII	MJ – 16	Classical Dynamics	4
	MJ – 17	Advance Mathematical Methods In Physics	4
	MJ – 18	Advance Quantum Mechanics-I And Advance Solid State Physics	4
	MJ – 19	Practicals- Optics And Laser	4
	MN – 1D	Solid State Physics	4
VIII	MJ – 20	Spectroscopy	4
	RC Or AMJ – 1 AMJ – 2 AMJ – 3	Dissertation Research Project Or Advanced Quantum Mechanics-Ii Advanced Nuclear Physics Practicals- General Electronics, Atomic And Nuclear Physics	12 4 4 4
	MN – 2D	Embedded System: Introduction To Microcontrollers	3+1

SEMESTER I

I. MAJOR COURSE –MJ 1:

PHYSICS-MJ-01: MECHANICS

(Credits: Theory-03, Practicals-01)

Theory: 45 Lectures Course learning outcome:

1. Understand laws of motion and their application to various dynamical situations, notion of inertial frames and concept of Galilean invariance. He / she will learn the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
2. Understand the principles of elasticity through the study of Young Modulus and modulus of rigidity.
3. Understand simple principles of fluid flow and the equations governing fluid dynamics.
4. Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation.
5. Explain the phenomena of simple harmonic motion and the properties of systems executing such motions.
6. Describe how fictitious forces arise in a non-inertial frame, e.g., why a person sitting in a merry-go-round experiences an outward pull.
7. Describe special relativistic effects and their effects on the mass and energy of a moving object.
8. Appreciate the nuances of Special Theory of Relativity (STR)
9. In the laboratory course, the student shall perform experiments related to mechanics (compound pendulum), rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity) and fluid dynamics (verification of Stokes law, Searle method) etc.

Skills to be learned:

1. He / she shall develop an understanding of how to formulate a physics problem and solve given mathematical equation risen out of it.
2. Learn the concepts of elastic constant of solids and viscosity of fluids.
3. Develop skills to understand and solve the equations central force problem.
4. Acquire basic knowledge of oscillation.
5. About inertial and non-inertial systems and special theory of relativity.

Course Content:

UNIT-I

Rotational Dynamics: Centre of Mass, Motion of CoM, Centre of Mass and Laboratory frames, Angular momentum of a particle and system of particles, Principle of conservation of angular momentum, Rotation about a fixed axis, Moment of Inertia, Perpendicular and Parallel Axis Theorems, Routh Rule, Calculation of moment of inertia for cylindrical and spherical bodies, Kinetic energy of rotation, Eulers Equations of Rigid Body motion, Motion involving both translation and rotation. Moment of Inertia of a Flywheel.

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.

(11 Lectures)

UNIT-II

Elasticity: Relation between Elastic constants, Twisting torque on a Cylinder or Wire, Bending of beams, External bending moment, Flexural rigidity, Cantilever.

Fluid Motion: Kinematics of Moving Fluids Poiseuilles Equation for Flow of a Liquid through a Capillary Tube, Surface tension, Gravity waves and ripple .

Viscocity: Poiseuilles Equation for Flow of a Liquid with corrections.

(11 Lectures)

UNIT-III

Gravitation and Central Force Motion: Law of gravitation, Gravitational potential energy, Inertial and gravitational mass, Potential and field due to spherical shelland solid sphere, Motion of a particle under a central force field, Two-body problem and its reduction to one-body problem and its solution, Differential Equation of motion with central force and its solution, The first Integrals (two), Concept of power Law Potentials, KeplersLaws of Planetary motion, Satellites:. Geosynchronous orbits, Weightlessness, Basic idea of global positioning system (GPS), Physiological effects on astronauts.

(11 Lectures)

UNIT-IV

Oscillations: Simple Harmonic Oscillations. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Equation of motion and solution(,cases of oscillatory, critically damped and over damped) Forced oscillations: Transient and steady states; Resonance, sharpness of resonance , power dissipation, QualityFactor, Bar Pendulum, Katers Pendulum.

(6 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, Mass less Particles, Mass-energy Equivalence, Relativistic Doppler effect, Relativistic Kinematics, Transformation of Energy and Momentum.

(6 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.

Additional Books for Reference:

1. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000.
2. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley. 3. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning.
4. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

PHYSICS MJ-01 LAB, Mechanics
Contact Hour: 30 Hours

1. To determine the height of a building using a Sextant.
2. To study the Motion of Spring and calculate (a) Spring constant (b) g (c) Modulus of rigidity.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine g and velocity for a freely falling body using Digital Timing Technique
5. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Young's Modulus of a Wire by Optical Lever Method.
7. To determine the elastic Constants of a wire by Searle's method.
8. To determine the value of g using Bar Pendulum.
9. 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.

Minor I (MN-1): MECHANICS
(Credits: Theory-03, Practicals-01)
Theory: 45 Lectures
Course learning outcome:

- Understand laws of motion and their application to various dynamical situations, notion of inertial frames and concept of Galilean invariance. He / she will learn the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- Understand the principles of elasticity through the study of Young Modulus and modulus of rigidity.
- Understand simple principles of fluid flow and the equations governing fluid dynamics.
- Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation.
- Explain the phenomena of simple harmonic motion and the properties of systems executing such motions.
- Describe how fictitious forces arise in a non-inertial frame, e.g., why a person sitting in a merry-go-round experiences an outward pull.
- Describe special relativistic effects and their effects on the mass and energy of a moving object.

Vectors: Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.

(3 Lectures)

Ordinary Differential Equations: 1st order homogeneous differential equations. 2 nd 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.

(6 Lectures)

Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets .

(4 Lectures)

Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum.

(4 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. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.

(7 Lectures)

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

(5 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 ,Y by Searles method.ηmodulus and moment of inertia - B,

(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)

Note: Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate

Reference Books:

1. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison Wesley.
2. Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
3. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
4. Engineering Mechanics, Basudeb Bhattacharya, 2 nd edn., 2015, Oxford University Press
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Minor I- LAB: MECHANICS
30 Lectures

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 study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

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, 4 th Edition, 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, 11 th Edition, 2011, Kitab Mahal, New Delhi.

Multi Disciplinary Course –I (MDC-I)
Natural Science: Elements of Modern Physics

(i) Course learning outcome:

- Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
- Understand the theory of quantum measurements, wave packets and uncertainty principle.
- Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier.
- Understanding the properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
- Ability to calculate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.
- Understand fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
- Understand various interactions of electromagnetic radiation with matter. Electron positron pair creation.
- Understand the spontaneous and stimulated emission of radiation, optical pumping and population inversion. Three level and four level lasers. Ruby laser and He-Ne laser in details. Basic lasing.
- In the laboratory course, the students will get opportunity to perform the following experiments
- Measurement of Planck's constant by more than one method.
- Verification of the photoelectric effect and determination of the work Function of a metal.

(ii) Broad contents of the course:

1. One dimensional potential problem of bound states and scattering.
2. Elementary introduction of nuclear physics with emphasis on
   (i) Nuclear Structure
   (ii) Nuclear Forces
   (iii) Nuclear Decays
   (iv) Fission and Fusion

3. Introduction to Lasers.

Skills to be learned

Comprehend the failure of classical physics and need for quantum physics. Formulate the basic theoretical problems in one, two and three dimensional physics and solve them. Learning

to apply the basic skills developed in quantum physics to various problems in
(i) Nuclear Physics (ii) Atomic Physics (iii) Laser Physics

4. Learn to apply basic quantum physics to Ruby Laser, He-Ne Laser.

MDC-I: ELEMENTS OF MODERN PHYSICS
(Credits: Theory-03 Theory: 45 Lectures)

Unit - I: Nature of Light Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.

(10 Lectures)

Position measurement- gamma ray microscope thought experiment; Wave particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Energy-time uncertainty principle application to virtual particles and range of an interaction.

(5 Lectures)

Unit – II: Introductory Quantum Theory & Laser
Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Schrodinger equation for nonrelativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

(10 Lectures)

Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

(5 Lectures)

Unit – III: Introductory Nuclear Physics
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, binding energy, Fission and fusion- mass deficit, relativity and generation of energy.

(8 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)

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.

Additional Books for Reference

1. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
2. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
3. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
4. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
5. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill
6. Quantum Mechanics, R. Eisberg and R. Resnick, John Wiley & Sons.

SEMESTER II

MJ-02: MATHEMATICAL PHYSICS-I

(Credits: Theory-03, Practicals-01) Theory: 60 Lectures

The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

Course Learning Outcome:

1. *Revise the knowledge of calculus. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.*
2. *Learn the curvilinear coordinates which have applications in problems with spherical and cylindrical symmetries.*
3. *Learn about Dirac Delta function and its properties.*
4. Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
5. *Learn the beta, gamma and the error functions and their applications in doing integrations.*

Skills to be learned:

1. Training in mathematical tools like calculus, integration, series solution approach, special function will prepare the student to solve ODE, PDE's which model physical phenomena.
2. He / she shall develop an understanding of how to model a given physical phenomenon such as pendulum motion, rocket motion, stretched string, etc., into set of ODE's, PDE's and solve them.
3. These skills will help in understanding the behavior of the modelled system/s
4. Knowledge of various mathematical tools like complex analysis, integral transform will equip the student with reference to solve a given ODE, PDE.

Course content:

Differential Equations: First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. **(8 Lectures)**

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. **(4 Lectures)**

Vector Calculus: Scalar and Vector fields. 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. **(8 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. **(10 Lectures)**

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates, Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

(6 Lectures)

Dirac Delta function and its properties: Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

(4 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. Term-by-Term differentiation and integration of Fourier series. Parseval Identity.

(14 Lectures)

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

(6 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 Differential Equations, George F. Simmons, 2007, McGraw Hill.
3. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
4. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
5. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
6. Mathematical Physics, Goswami, 1st edition, Cengage Learning
7. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
8. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
9. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.
10. Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.

PHYSICS LAB- MJ -02 LAB: 60 Lectures

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.

- Highlights the use of computational methods to solve physical problems
- The 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
- Aim at teaching students to construct the computational problem to be solved
- 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 & overflowemphasize 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 Python & Scilab Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if 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 θ, cos θ, tan θ, 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 cach of thc four initial conditions on the same screen for $0 \leq t \leq 15$ The differential equation describing the motion of a pendulum is $\frac{d^2\vartheta}{dt^2} = -sin(\vartheta)$. The pendulum is released from rest at an angular displacement α, i.e. $\vartheta(0) = \alpha$ and $\vartheta'(0) = 0$. Solve the equation for α= 0.1, 0.5 and 1.0 and plot ϑ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small $\vartheta(sin(\vartheta)) = \vartheta$

Referred Books:

1. Computational Physics with Python by Dr. Eric Ayars
2. Numerical Methods in Engineering with Python by Jaan Kiusalaas, Cambridge University Press.
3. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
4. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
5. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. , 2007, Cambridge University Press.
6. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
7. Elementary Numerical Analysis, K.E. Atkinson, 3 r d E d n . , 2 0 0 7 , Wiley India Edition.
8. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
9. An Introduction to computational Physics, T.Pang, 2nd Edn. , 2006,Cambridge Univ. Press
10. Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

ELECTRICITY AND MAGNETISM-1
Paper Title: Major Paper -3-Electricity and Magnetism-1 (MJ-3)
(Credits: Theory-03, Practicals-01)

LEARNING OUTCOMES:
At the end of this course, students will be able to,
• Understand Gauss' law, Coulomb's law for the electric field, and apply them to systems of point charges as well as line, surface, and volume distributions of charges. Also to use the knowledge to solve some simple problems
• Express electric current and capacitance in terms of electric field and electric potential.
• Calculate the force experienced by a moving charge in a magnetic field
• Determine the magnetic force generated by a current carrying conductor
• Have brief idea of magnetic materials, understand the concept of electromagnetic induction, solve problems using Faraday's and Lenz's laws

Full Marks - 60 **Credit-03**
Instruction to Question Setter for End Semester Examination (ESE): There will be two groups of questions. Five Questions to be answered out of Nine Questions. Group A is compulsory and will 6 contain two questions. Question No.1 (A) will be MCQ of 1 mark each (six questions). Question No.1 (B) will be short answer type to be answered in about 50 words of 3 marks (2 Questions). Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to answer. Each question carries 12 marks.

UNIT-1 Electric Field and Electric Potential:
Conservative nature of Electrostatic Field. Electrostatic Potential . Laplace's and Poisson equations & its solution in Cartesian coordinates, The Uniqueness Theorem. Gauss' law in integral and differential form. Multipole expansion (monopole, dipole & quadrapole), energy density in an electric field. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. **(10 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)

UNIT-III Transients:
Growth and Decay of currents in LR, CR , LC and LCR circuits .
(4 Lectures)

UNIT-IV 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.
(8 Lectures)

UNIT-V Electrical 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. Anderson's bridge, De Sauty's Bridge and Owen's bridge & their vector diagram representation. Three phase electrical power supply, delta and star connections.
(10 Lectures)

UNIT-VI Network theorems:
Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Maximum Power Transfer theorem and Superposition Theorem. Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping.

(7 Lectures)

Reference Books:
1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, TMH 10
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.
7. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
8. Electricity and Magnetism K K Tewary S. Chand and Company.

Practical Paper: MJ2 + MJ3 Practical:
Credit: 02 **60 Hours**
Here is a list of experiments that cover a range of instruments, circuits, and data recording and analysis techniques:
To use a multimeter for measuring resistances, a.c and d.c voltages, d.c. current, capacitance and for checking electrical fuses. Ballistic Galvanometer:
(a) Measurement of charge and current sensitivity
(b) Measurement of critical damping resistance
(c) Determine a high resistance by leakage method
(d) Determine self-inductance of a coil by Rayleigh's Method.
- To compare capacitances using de Sauty's bridge.
- Measurement of field strength B and its variation in a Solenoid
- To study the Characteristics of a Series RC Circuit.
- To study a series LCR circuit and determine its resonant frequency and quality factor.
- To study a parallel LCR circuit and determine its anti-resonant frequency and quality factor
- To determine a low resistance by Carey Foster bridge.
- To verify the Thevenin, superposition and maximum power transfer theorems
- To verify Norton theorem Remember, each student should perform at least 6 experiments from the above list, so you can choose the ones that align with your curriculum and available resources.

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, KitabaMahal
3. Advanced level Physics Practicals, Micheal Nelson and Jon M. Ogborn, 4 th Edition, reprinted 1985, Heinemann Educational Publisers
4. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learing.
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.
6. B.Sc. Practical Physics, N.N. Ghosh, Bharati Bhawan Publishers.
7. B.Sc. Practical Physics, C.L. Arora, S. Chand & Company, 19th Edition, 1995, reprint 2014.

Computer programming and numerical analysis: Paper-MJ3

It emphasizes in solving problems in Physics. The course will include practical sessions and lectures covering the related theoretical aspects of the laboratory. Assessment will be based not only on the programming skills but also on the ability to formulate problems.

Each student is required to complete a minimum of 12 programs, covering all the units. The list of recommended programs serves as a guide, and students are encouraged to engage in additional practice. It is important to prioritize the formulation of physics problems as mathematical ones and solve them using computational methods.

The implementation can be done in either Python, C++, or Scilab.

Unit 1: Root Finding:

Bisection, Newton- Raphson and secant methods for solving roots of equations,Convergence analysis. Recommended List of Programs (At least two):

(a) Determine the depth up to which a spherical homogeneous object of given radius and density will sink into a fluid of given density.

(b)Solve transcendental equations like $\alpha = \tan(\alpha)$.

(c) To approximate nth root of a number up to a given number of significant digits.

Unit 2: Least Square fitting (At least one):

Algorithm for least square fitting and its relation to maximum likelihood for normally distributed data. (a) Make a function for least square fitting, use it for fitting given data (x, y) and estimate the parameters a, b as well as uncertainties in the parameters for the following cases 9

i. Linear ($y = ax + b$)

ii. ii. Power law ($y = ax^b$)

iii. iii.Exponential ($y = ae^{bx}$)

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

Unit 3: Generating and plotting of a function using series representation (At least one):

a) To approximate the elementary functions (e.g. exp(x), sin(x), cos(x), ln (1+x), etc.) by a finite number of terms of Taylor's series and discuss the truncation error. To plot the function as well the nth partial sum of its series for various values of n on the same graph and visualize the convergence of series.

b) Generating and plotting Legendre Polynomials using series expansion and verifying recurrence relation

Unit 4: Interpolation:

Concept of Interpolation, Lagrange form of interpolating polynomial, Error estimation, optimal points for interpolation. Recommended List of Programs (At least one)

(a) Write program to determine the unique polynomial of a degree n that agrees with a given set of (n+1) data points (xi, yi) and use this polynomial to find the value of y at a value of x not included in the data.

(b) Generate a tabulated data containing a given number of values (xi, f(xi)) of a function f(x) and use it to interpolate at a value of x not used in table.

References for (for Laboratory work):

1) Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
2) Documentation of NumPy and Matplotlib: https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/
3) Computational Physics, Darren Walker, 1st Edn., Scientific International Pvt. Ltd (2015).
4) Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn., 2007, Wiley India Edition. 10
5) An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
6) Introduction to Numerical Analysis, S. S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
7) Applied numerical analysis, Cutis F. Gerald and P. O. Wheatley, Pearson Education, India (2007). 8) Numerical Recipes: The art of scientific computing, William H. Press, Saul A. Teukolsky and William Vetterling, Cambridge University Press; 3rd edition (2007)
9) Computational Problems for Physics, R. H. Landau and M. J. Páez, 2018, CRC Press.

The distribution of practical marks is as follows (25Marks)
(a) Experiment-15 Marks, (b)Viva Voce-05 Marks,(c) Practical Record-05 Marks
The distribution of 15 Marks is as follows
(a) Class room participation and attendance-05 Marks, (b) Internal test-10Marks.

Minor - 2A

ELECTRICAL CIRCUITS NETWORK & BASIC INSTRUMENTATION SKILLS

(Credits: 04) Theory: 60 Lectures

ELECTRICAL CIRCUITS AND NETWORK SKILLS

(Credit: 02)

Theory: 30 Lectures

The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode.

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter. **(2 Lectures)**

Understanding Electrical Circuits: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **(3 Lectures)**

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

(3 Lectures)

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

(2 Lectures)

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

(3 Lectures)

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources (3 Lectures)

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)

(3 Lectures)

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

(4 Lectures)

Reference Books:

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

BASIC INSTRUMENTATION SKILLS

(Credits: 02)

Theory: 30 Lectures

This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.

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

(3 Lectures)

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

(3 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.

(5 Lectures)

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.

(3 Lectures)

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.

(4 Lectures)

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

(3 Lectures)

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

(2 Lectures)

Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time-base stability, accuracy and resolution. **(2 Lectures)**

Lab: 30 Contact Hours

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

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Laboratory Exercises:

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

Open Ended Experiments:

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

Reference Books:

1. Text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3 rd Ed., 2012, Tata Mc-Graw Hill.
7. Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer
8. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson

SEMESTER III

I. MAJOR COURSE- MJ 4

WAVES AND OPTICS

(Credits: Theory-03, Practicals-01)

(Credits: Theory-03) **45 Hours**

Course Learning Outcomes:

This course will enable the student to

1. Recognize and use a mathematical oscillator equation and wave equation, and derivethese equations for certain systems.
2. Apply basic knowledge of principles and theories about the behavior of light and thephysical environment to conduct experiments.
3. Understand the principle of superposition of waves, so thus describe the formation ofstanding waves.
4. Explain several phenomena we can observe in everyday life that can be explained aswave phenomena.
5. Use the principles of wave motion and superposition to explain the Physics ofpolarisation, interference and diffraction.
6. Understand the working of selected optical instruments like biprism, interferometer,diffraction grating, and holograms.
7. In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Ringsexperiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt firsthand.
8. The motion of coupled oscillators, study of Lissajous figures and behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

Skills to be learned:

1. He / she shall develop an understanding of various aspects of harmonic oscillations andwaves specially.
   a. Superposition of collinear and perpendicular harmonic oscillations
   b. Various types of mechanical waves and their superposition.
2. This course in basics of optics will enable the student to understand various opticalphenomena, principles, workings and applications optical instruments.

Course Content:

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. Water Waves: Ripple and Gravity Waves.

(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.

(5 Lectures)

Superposition of Collinear and two perpendicular 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. Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(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. **(5 Lectures)**

Interference: Temporal and Spatial Coherence. Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(6 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. **(4 Lectures)**

Fraunhofer diffraction: Single slit, Double slit. Multiple slits, Diffraction grating. Circular aperture. Resolving Power of telescope and 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 ZonePlate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. **(5 Lectures)**

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. 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 **(5 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. **(3 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. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1/e, 2021, Wiley/I. K. International Publishing House, New Delhi
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. ChandPublications.
7. Electromagnetic Theory, Chopra & Agarwal, Kedarnath Ramnath & Co.

I. MAJOR COURSE- MJ 4:
PRACTICALS-II : WAVES AND OPTICS

(Credits: Practicals-01) 30Hour

Practicals:

1. Familiarization with: Schuster`s focusing; determination of angle of prism.
2. To determine refractive index of the Material of a prism using sodium source.
3. To determine the dispersive power and Cauchy constants of the material of a prism usingmercury source.
4. To determine wavelength of sodium light using Fresnel Biprism.
5. To determine wavelength of sodium light using Newton’s Rings.
6. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using planediffraction grating.
7. To determine dispersive power and resolving power of a plane diffraction grating.
8. To verify the law of Malus for plane polarized light.
9. To determine the specific rotation of sugar solution using Polarimeter.
10. To study diffraction due to straight edge.

Reference Books:

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

Physics MJ-05: Electricity and magnetism -II (Credits: 3+1)
Theory: 45 Lectures

Course Learning Outcomes:

After going through the course, the student should be able to

1. Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
2. Apply Gauss's law of electrostatics to solve a variety of problems.
3. Describe the magnetic field produced by magnetic dipoles and electric currents.
4. Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electric and magnetic fields.
5. Understand the dielectric properties, magnetic properties of materials and the phenomena of electromagnetic induction.
6. Describe how magnetism is produced and list examples where its effects are observed.
7. Achieve an understanding of the Maxwell's equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media.
8. Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
9. Analyse the phenomena of wave propagation in the unbounded, bounded, vacuum, dielectric, guided and unguided media.
10. Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at plane interface in bounded media.
11. Understand the principles of electromagnetic radiation, retarded potentials.
12. Learn about the relativistic formulation of electrodynamics.

Skills to be learned:

1. This course will help in understanding basic concepts of electricity and magnetism and their applications.
2. Basic course in electrostatics will equips the student with required prerequisites to understand electrodynamics phenomena.
3. Comprehend the role of Maxwell's equation in unifying electricity and magnetism.
4. Derive expression for
   a. Energy density
   b. Momentum density
   c. Angular momentum density of the electromagnetic field
5. Learn the implications of Gauge invariance theory in solving the wave equations and develop the skills to actually solve the wave equation in various media like
   a. Vacuum
   b. Dielectric medium
   c. Conducting medium

6. Derive and understand associated with the properties, EM wave passing through the interface between two media like

   a. Reflection
   b. Refraction
   c. Transmission

Course Content:

Unit-I Electrodynamics: Magnetostatics: Biot-Savart Law, Divergence and Curl of B, Ampere's law and applications of Ampere's law, Magnetic vector potential, Multipole expansion of the vector potential.

Faraday's law, Energy in magnetic fields, Maxwell's equations, Maxwell's displacement current, Maxwell's equations and magnetic charge, Maxwell's equations inside matter, boundary conditions. Scalar and vector potentials, Gauge transformations, Coulomb and Lorentz Gauge; Lorentz force law in potential form, Energy and momentum in electrodynamics, Poynting's theorem Maxwell's stress tensor, Conservation of momentum.

(10 L + 5T)

Unit –III Electromagnetic waves: Electromagnetic waves in non-conducting media: Monochromatic plane waves in vacuum, propagation through linear media, Reflection and transmission at interfaces. Fresnel's laws; Electromagnetic waves in conductors: Modified wave equation, monochromatic plane waves in conducting media. Dispersion: Dispersion in non-conductors, free electrons in conductors and plasmas. Guided waves, TE waves in a rectangular wave guide. **(10 L + 5 T)**

Unit-IV Electromagnetic radiation: Retarded potentials, Electric dipole radiation, magnetic dipole radiation, Radiation from a point charge: Lienard-Wiechart potentials, fields of a point charge in motion, power radiated by a point charge. Electrodynamics and Relativity: Review of special theory of relativity, Lorentz transformations, Minkowski four vectors, energy-momentum four vector, covariant formulation of mechanics, Transformation of electric and magnetic fields under Lorentz transformations, field tensor, invariants of electromagnetic field, covariant formulation of electrodynamics.

(10 L + 5 T)

References :

1. Introduction to Electrodynamics, David J Griffiths, 2 nd Edition, Prentice Hall India, 1989.
2. Classical Electrodynamics, JD Jackson, 4 th Edition, John Wiley & Sons, 2005.
3. Classical Electromagnetic Radiation, MA Heald and JB Marion, Saunders, 1983.
4. Electrodynamics, Gupta, Kumar, Singh, Pragathiprakashan,18th edition, 2010.

Physics MJ -05 - Lab:

LAB: Electricity and Magnetism -II

30 Lectures

1.(a) 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 Leakage Method

(iv) To determine Self Inductance of a Coil by Rayleigh's Method.

3. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)

4. To determine self inductance of a coil by Anderson's bridge.

5. To study the Characteristics of a Series RC Circuit.

6. To study a series LCR circuit 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 (b) Quality factor Q

8. To determine the specific rotation of sugar solution using Polarimeter.

9. To study Polarization and double slit interference in microwaves.

10. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.

11.To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece

12. To verify the Stefan`s law of radiation and to determine Stefan's constant.

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

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, 4 th Edition, reprinted 1985, Heinemann Educational Publishers

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

4. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

II. Minor- 1B

Electricity and Magnetism

(Credits: Theory-03) 45 Hours

Course Learning Outcomes:

After going through the course, the student should be able to

1. Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electricpotential, electric potential energy) formalisms of electrostatics.
2. Apply Gauss's law of electrostatics to solve a variety of problems.
3. Articulate knowledge of electric current, resistance and capacitance in terms of electricfield and electric potential.
4. Describe the magnetic field produced by magnetic dipoles and electric currents.
5. Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electricand magnetic fields.
6. Understand the dielectric properties, magnetic properties of materials and thephenomena of electromagnetic induction.
7. Describe how magnetism is produced and list examples where its effects are observed.
8. Apply Kirchhoff's rules to analyze AC circuits consisting of parallel and/or series combinations of voltage sources and resistors and to describe the graphical relationship of resistance, capacitor and inductor.
9. Apply various network theorems such as Superposition, Thevenin, Norton, Reciprocity, Maximum Power Transfer, etc. and their applications in electronics, electrical circuit analysis, and electrical machines.
10. In the laboratory course the student will get an opportunity to verify various laws in electricity and magnetism such as Lenz's law, Faraday's law and learn about theconstruction, working of various measuring instruments.
11. Should be able to verify of various circuit laws, network theorems elaborated above, using simple electric circuits.
12. Achieve an understanding of the Maxwell's equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media.
13. Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
14. Analyse the phenomena of wave propagation in the unbounded, bounded, vacuum, dielectric, guided and unguided media.
15. Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at plane interface in bounded media.
16. Plan and Execute 2-3 group projects for designing new experiments based on the Syllabi.

Skills to be learned:

1. This course will help in understanding basic concepts of electricity and magnetism andtheir applications.
2. Basic course in electrostatics will equips the student with required prerequisites tounderstand electrodynamics phenomena.
3. Comprehend the role of Maxwell's equation in unifying electricity and magnetism.
4. Derive expression for
    a. Energy density
    b. Momentum density
    c. Angular momentum density of the electromagnetic field
5. Learn the implications of Gauge invariance in EM theory in solving the wave equationsand develop the skills to actually solve the wave equation in various media like
    a. Vacuum
    b. Dielectric medium
    c. Conducting medium
6. Derive and understand associated with the properties, EM wave passing through theinterface between two media like
    a. Reflection
    b. Refraction
    c. Transmission

Course Content:

Electric Field and Electric Potential

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. Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductorsin an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor.
(5 Lectures)

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. **(4 Lectures)**

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. 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 CircuitalLaw 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.
(7 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. **(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)**

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. **(2 Lectures)**

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 Vector and Poynting Theorem. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density. **(7 Lect.)**

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. **(6 Lectures)**

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. **(6 Lectures)**

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, TataMcGraw
2. Concepts of Electromagnetic Theory, K. Mamta, Raj Kumar Singh and J. N. Prasad, 1st Edn 2021, Wiley/I. K. International Publishing House, New Delhi
3. Electricity and Magnetism, P. K. Chakraborty, New Age International Pvt. Ltd.
4. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
5. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
6. Feynman Lectures Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
7. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
8. Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
9. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
10. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
11. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
12. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
13. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
14. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
15. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

II. Minor 1B Practicals:

PRACTICALS-I: MECHANICS and Electricity Magnetism

(Credits: Practicals-01) 30 Hours

Practical:

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations of simple pendulum oscillations.
3. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus ofrigidity.
4. To determine **g** and velocity for a freely falling body using Digital Timing Technique
5. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille'smethod).
6. To determine the Young's Modulus of a Wire by Optical Lever Method.
7. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
8. To determine the elastic Constants of a wire by Searle's method.
9. To determine the value of g using Bar Pendulum.
10. To determine the value of g using Kater's Pendulum.
11. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current,
    a. (d) Capacitances, and (e) Checking electrical fuses.
12. To determine an unknown Low Resistance using Potentiometer.
13. To compare capacitances using De' Sauty's bridge.
14. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency,
    a. (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
15. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.

Reference Books

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse
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, reprinted1985, 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.
6. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse.
7. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers
8. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
9. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

---

SEMESTER IV

I. MAJOR COURSE- MJ 6:
MATHEMATICAL PHYSICS- II

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

1. Learn the Fourier analysis of periodic functions and their applications in physicalproblems such as vibrating strings etc.
2. Learn about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations, applications in various physical problems such as in quantum mechanics which they will learn in future courses in detail.
3. Learn the beta, gamma and the error functions and their applications in doing integrations.
4. Acquire knowledge of methods to solve partial differential equations with the examples of important partial differential equations in Physics.
5. Apply the Scilab software in curve fittings, in solving system of linear equations, generating and plotting special functions such as Legendre polynomial and Bessel functions, solving first and second order ordinary and partial differential equations.
6. Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems. They are also expected to learn the Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.
7. In the laboratory course, the students should apply their C++/Scilab programming language to solve the following problems:
   a. Solution 1^{st} and 2^{nd} order ordinary differential equations with appropriate boundary conditions,
   b. Evaluation of the Fourier coefficients of a given periodic function,
   c. Plotting the Legendre polynomials and the Bessel functions of different orders and interpretations of the results, Least square fit of a given data to a graph

Skills to be learned:

1. Training in mathematical tools like calculus, integration, series solution approach, special function will prepare the student to solve ODE, PDE's which model physicalphenomena.
2. He / she shall develop an understanding of how to model a given physical phenomenon such as pendulum motion, rocket motion, stretched string, etc., into set of ODE's, PDE's and solve them.
3. These skills will help in understanding the behavior of the modeled system/s.

Course Content:

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, 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 and its applications **(8 Lectures)**

Frobenius Method and Special Functions: Frobenius method and its applications to differentialequations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simplerecurrence 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. **(14 Lectures)**

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral) **(2 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. **(4 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 ComplexVariables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles, order of singularity. 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. **(14 Lectures)**

Integrals Transforms: 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, 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. **(9 Lectures)**

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1^{st} and 2^{nd} order Derivatives and Integralsof Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2^{nd}order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits. **(9 Lectures)**

Reference Books:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3^{rd} ed., 2006, Cambridge University Press
2. Complex Variables, A.S. Fokas & M.J. Ablowitz, 8^{th} 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, 1^{st} Edn., 2015, Scientific International Pvt. Ltd.
5. A Guide to MATLAB, B.R.Hunt, R.L.Lipsman, J.M. Rosenberg, 2014, 3^{rd} Ed^{n} , Cambridge Univ. 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/textbook_companion/generate_book/291
11. Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications
12. Complex Variables, A.S.Fokas & M.J.Ablowitz, 8^{th} Ed., 2011, Cambridge Univ. Press
13. Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
14. Complex Variables and Applications, J.W.Brown & R.V.Churchill, 7^{th} Ed. 2003, TataMcGraw-Hill
15. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones& Bartlett

---

II. MAJOR COURSE- MJ 7:
THERMAL AND STATISTICAL PHYSICS

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

1. Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations.
2. Learn about Maxwell's thermodynamic relations.
3. Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzman distribution law, equitation of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
4. Learn about the real gas equations, Van der Waal equation of state, the Joule- Thompson effect.
5. Understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability and partition function.
6. Understand the combinatoric studies of particles with their distinguishably or indistinguishably nature and conditions which lead to the three different distribution laws e.g. Maxwell-Boltzmann distribution, Bose-Einstein distribution and Fermi-Dirac distribution laws of particles and their derivation.
7. To apply classical statistical mechanics to derive the law of equipartition of energy and specific heat.
8. Understand Gibbs paradox, equipartition of energy & concept of negative temp. in two level system.
9. Learn to derive classical radiation laws of black body radiation. Wiens law, Rayleigh Jeans law, ultraviolet catastrophe. Saha ionization formula.
10. Learn to calculate the macroscopic properties of degenerate photon gas using BE distribution law, understand Bose-Einstein condensation law and liquid Helium. Bose derivation of Plank's law
11. Understand the concept of Fermi energy and Fermi level, calculate the macroscopic properties of completely and strongly degenerate Fermi gas, electronic contribution to specific heat of metals.
12. Understand the application of F-D statistical distribution law to derive thermodynamic functions of a degenerate Fermi gas, electron gas in metals and their properties.
13. Calculate electron degeneracy pressure and ability to understand the Chandrasekhar mass limit, stability of white dwarfs against gravitational collapse.
14. Use Computer simulations to study:
    a. Planck's Black Body Radiation Law and compare with the Wien's Law and Raleigh -Jean's Law in appropriate temperature region.
    b. Specific Heat of Solids by comparing, Dulong-Petit, Einstein's and Debye's Lawsand study their temperature dependence
15. Compare the following distributions as a function of temperature for various energiesand the parameters of the distribution functions:
    a. Maxwell-Boltzmann distribution b. Bose-Einstein distribution
    b. Fermi-Dirac distribution
16. Do 3-5 assignments given by the course instructor to apply the methods of Statisticalmechanics to simple problems in Solid State Physics and Astrophysics

Skills to be learned:

1. Thermodynamical concepts, principles.
2. Learn the basic concepts &definition of physical quantities in classical statistics andclassical distribution law.
3. Learn the application of classical statistics to theory of radiation.
4. Comprehend the failure of classical statistics and need for quantum statistics.
5. Learn the application of quantum statistics to derive and understand.
    a. Bose Einstein statistics and its applications to radiation.
    b. Fermi-Dirac statistic and its applications to quantum systems.

Course Content:

THERMAL PHYSICS

Introduction to Thermodynamics: Zeroth Law and First Law of thermodynamics and its differential form. Internal energy. Reversible and Irreversible process with examples. Interconversion of Work and Heat. Carnot's Theorem. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. **(4 Lectures)**

Entropy: Concept of entropy, Clausius theorem, Clausius inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Entropy Changes in Reversible and Irreversible processes with examples. Principle of Increase of Entropy. Entropy of the Universe. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **(5 Lectures)**

Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples. **(5 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 Lectures)**

Kinetic Theory of Gases

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. **(4 Lectures)**

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Critical Constants. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. P-V diagrams. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling. **(6 Lectures)**

STATISTICAL PHYSICS

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, GibbsParadox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications toSpecific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. **(9 Lectures)**

Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation. Inadequacy of classical radiation theory. Planck's Quantum Postulates. Planck's Law of Black body Radiation: Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. **(8 Lectures)**

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. **(7 Lectures)**

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of aCompletely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit **(7 Lectures)**

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. Heat and Thermodynamics, P. K. Chakraborty, New Age International Pvt.
3. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
4. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
6. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988,Narosa.
7. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, OxfordUniversity Press
8. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.
9. Thermal Physics, B.K. Agrawal, Lok Bharti Publications.
10. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, OxfordUniversity Press.
11. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
12. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
13. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears andGerhard L. Salinger, 1986, Narosa.
14. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
15. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, OxfordUniv. Press

---

III. MAJOR COURSE- MJ 8:
PRACTICALS-III MATHEMATICAL, THERMAL AND STATISTICAL PHYSICS

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

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 software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2).
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculate spring Constant
Inverse of a matrix, Eigen vectors, eigen values problems	System of algebraic equation
Generation of Special functions usingUser defined functions in Scilab	Generating and plotting Legendre PolynomialsGenerating and plotting Bessel function

Solution of ODE First order Differential equation Euler,modified Euler and Runge-Kutta second order methods Second order differential equationFixed 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 • Forced Harmonic oscillator • Transient and • Steady state solution

Use C/C^{++}/Scilab/Matlab/other numerical simulations for solving the problems based on Statistical Mechanics like

- Solve the differential equations: $dy/dx = e^{-x}$ with $y = 0$ for $x = 0$

$$\frac{dy}{dx} + e^{-x}y = x^2$$

$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$$

$$\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$$

- Fourier series: Program to sum $\sum_{n=1}^{\infty}$ n
  Evaluate the Fourier coefficients of a given periodic function (square wave)
- Frobenius method and Special functions:
- $\int_{-1}^{1} Pn(\mu)Pm(\mu)\ d\mu = \delta n, m$
  Plot *Pn(x), jv(x)* Show recursion relation
- Calculation of error for each data point of observations recorded in experiments donein previous semesters (choose any two).
- 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.
- Compute the n^{th} roots of unity for $n = 2, 3,$ and 4.
- Find the two square roots of $-5+12j$.
- Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.
- Solve Kirchoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.
- Perform circuit analysis of a general LCR circuit using Laplace's transform.
- Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
- Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debyedistribution function for high temperature and low temperature and compare them for these cases.
- Plot the following functions with energy at different temperatures

Maxwell-Boltzmann distribution, Fermi-Dirac distribution, Bose-Einstein distribution

1. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
2. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee's disc method.
3. To determine the Temperature Coefficient of Resistance by Platinum ResistanceThermometer (PRT).
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature ofits Two Junctions.

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
10. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal,1985, Vani Pub.
11. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse
12. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
13. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers
14. Elementary Numerical Analysis, K.E.Atkinson, 3 rd E d n . 2 0 0 7, Wiley India Edition
15. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, OxfordUniversity Press.
16. Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
17. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears andGerhard L. Salinger, 1986, Narosa.
18. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
19. Statistical and Thermal Physics with computer applications, Harvey Gould and JanTobochnik, Princeton University Press, 2010.

Minor – 2B: APPLIED OPTICS

(Credits: 3+1)

THEORY: 45 Lectures

Theory includes only qualitative explanation. Minimum five experiments should be performed covering minimum three sections.

(I) **Sources and Detectors**

(15 Lectures)

Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers.

(ii) Fourier Optics

(10 Lectures)

Concept of Spatial frequency filtering, Fourier transforming property of a thin lens

Experiments on Fourier Optics:

a. Fourier optic and image processing

1. Optical image addition/subtraction
2. Optical image differentiation
3. Fourier optical filtering
4. Construction of an optical 4f system

b. Fourier Transform Spectroscopy

Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science.

(iii) Holography

(10 Lectures)

Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition

(iv) Photonics: Fibre Optics

(10 Lectures)

Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, **Fibre optic sensors:** Fibre Bragg Grating

Reference Books:

1. Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
2. ASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
3. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
4. Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier.
5. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
6. Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
7. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
8. Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4 th Edn., 1996, Cambridge Univ. Press

LAB: Applied Optics
30 Hours

Experiments on Lasers:

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

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

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

d. Thermal expansion of quartz using laser

Experiments on Semiconductor Sources and Detectors:

a. V-I characteristics of LED

b. Study the characteristics of solid state laser

c. Study the characteristics of LDR

d. Photovoltaic Cell

e. Characteristics of IR sensor

Experiment:

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

Experiments on Holography and interferometry:

1. Recording and reconstructing holograms
2. Constructing a Michelson interferometer or a Fabry Perot interferometer
3. Measuring the refractive index of air
4. Constructing a Sagnac interferometer
5. Constructing a Mach-Zehnder interferometer
6. White light Hologram

Experiments on Photonics: Fibre Optics

a. To measure the numerical aperture of an optical fibre

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

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

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

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

---

SEMESTER V

I. MAJOR COURSE- MJ 9:
ANALOG AND DIGITAL ELECTRONICS

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

As the successful completion of the course the student is expected to be conversant with thefollowing.

1. Secure first-hand idea of different components including both active and passive components to gain an insight into circuits using discrete components and also to learn about integrated circuits.
2. About analog systems and digital systems and their differences, fundamental logic gates, combinational as well as sequential and number systems.
3. Synthesis of Boolean functions, simplification and construction of digital circuits by employing Boolean algebra.
4. Sequential systems by choosing Flip-Flop as a building bock- construct multivibrators, counters to provide a basic idea about memory including RAM, ROM and also about memory organization.
5. In the laboratory he is expected to construct both combinational circuits and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Shift Registers, and multivibrators using 555 ICs. He is also expected to use μP 8085 todemonstrate the same simple programme using assembly language and execute the programme using a μP kit.
   At the end of the course the student is expected to assimilate the following and possessesbasic knowledge of the following.
6. N- and P- type semiconductors, mobility, drift velocity, fabrication of P-N junctions; forward and reverse biased junctions. Application of PN junction for different type of rectifiers and voltage regulators.
7. NPN and PNP transistors and basic configurations namely common base, common emitter and common collector, and also about current and voltage gain.
8. Biasing and equivalent circuits, coupled amplifiers and feedback in amplifiers and oscillators.
9. To characterize various devices namely PN junction diodes, LEDs, Zener diode, solar cells, PNP and NPN transistors. Also construct amplifiers and oscillators using discrete components. Demonstrate inverting and non-inverting amplifiers using op-amps.

Skills to be learned:

1. Learn the basics of IC and digital circuits, and difference between analog and digitalcircuits. Various logic GATES and their realization using diodes and transmitters.
2. Learn fundamental of Boolean algebra and their role in constructing digital circuits.
3. Learn about combinatorial and sequential systems by building block circuits toconstruct multivibrators and counters.
4. Learn basic concepts of semiconductor diodes and their applications to rectifiers.
5. Learn about junction transistor and their applications. Learn about different types of amplifiers including operational amplifier.(Op-Amp) and their applications. Learn about sinusoidal oscillators of various types and A/D conversion.

Course Content:

ANALOG ELECTRONICS:

Two-terminal Devices and their Applications: Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, Zener Diode and Voltage Regulation. Principle and structure of LEDs, Photodiode and Solar Cell. **(4 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 andSaturation Regions. **(4 Lectures)**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. **(5 Lectures)**

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

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(2 Lecture)**

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(3 Lectures)**

Operational Amplifiers and Applications: 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. Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier. **(6 Lectures)**

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

DIGITAL ELECTRONICS:

Digital Circuits: Difference between analog and digital circuit, Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates, NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. **(5 Lectures)**

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

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

Timers: Classification of ICs. Examples of Linear and Digital ICs, IC 555: Block diagram and applications: Astable multivibrator and Monostable 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). **(4 Lectures)**

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

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. A first Course in Electronics, Khan & Dey, PHI, 1/e, 2006
3. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
4. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
5. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
6. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
7. Basic Electronics, Arun Kumar, Bharati Bhawan, 1/e, 2007
8. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford Univ Press.
9. Analog Systems and Applications, Nutan Lata, Pragati Prakashan
10. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
11. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
12. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
13. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
14. Digital Computer Electronics, Malvino and Brown, 3/e, McGraw Hill Education
15. Digital Electronics G K Kharate ,2010, Oxford University Press
16. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
17. Logic circuit design, Shimon P. Vingron, 2012, Springer.
18. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
19. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
20. Digital Systems and Applications, Nutan Lata, Pragati Prakashan, 1/e, 2019

II. MAJOR COURSE- MJ 10:
ELEMENTS OF MODERN PHYSICS

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

1. Understand the theory of quantum measurements, wave packets and uncertainty principle.
2. Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier.
3. Understanding the properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
4. Ability to calculate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.
5. Understand fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
6. Understand various interactions of electromagnetic radiation with matter. Electron positron pair creation.
7. Understand the spontaneous and stimulated emission of radiation, optical pumping and population inversion. Three level and four level lasers. Ruby laser and He-Ne laser in details. Basic lasing.
8. In the laboratory course, the students will get opportunity to perform the following experiments
9. Measurement of Planck's constant by more than one method.
10. Verification of the photoelectric effect and determination of the work Function of a metal.
11. Determination of the charge of electron and e/m of electron.
12. Determination of the ionization potential of atoms.
13. Determine the wavelength of the emission lines in the spectrum of Hydrogen atom.
14. Determine the absorption lines in the rotational spectrum of molecules.
15. Determine the wavelength of Laser sources by single and Double slit experiments
16. Determine the wavelength and angular spread of He-Ne Laser using plane diffraction grating.
17. Verification of the law of the Radioactive decay and determine the mean life time of a Radioactive Source, Study the absorption of the electrons from Beta decay. Study of the electron spectrum in Radioactive Beta decays of nuclei.
18. Plan and Execute 2-3 group projects in the field of Atomic, Molecular and Nuclear Physics in collaboration with other institutions, if, possible where advanced facilities areavailable.

Skills to be learned:

1. Comprehend the failure of classical Physics and need for quantum Physics.
2. Grasp the basic foundation of various experiments establishing the quantum Physics bydoing the experiments in laboratory and interpreting them.
3. Formulate the basic theoretical problems in one, two and three dimensional Physics and solve them.
4. Learning to apply the basic skills developed in quantum physics to various problems in
   a. Nuclear Physics b. Atomic Physics c. Laser Physics
5. Learn to apply basic quantum physics to Ruby Laser, He-Ne Laser

Course Content:

Quantum theory of Light: Planck's concept of light as a collection of photons; Photo-electric effect and Compton scattering. Wave particle duality, de Broglie wavelength and matter waves; Two-Slit experiment with electrons. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Probability. Wave amplitude and wave functions. Davisson-Germer experiment. Discreteness of energy. Frank-Hertz Experiment. **(14 Lectures)**

Quantum Uncertainty- Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables), gamma ray microscope thought experiment; 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 various physical problems. **(5 Lectures)**

Matter waves and wave amplitude: Schrodinger equation for non-relativistic particles; Physical observables as operators, Position, Momentum and Energy operators; stationary states; Physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

(10 Lectures)

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantummechanical scattering and tunnelling in one dimension- across a step potential & rectangular potential barrier.

(10 Lectures)

Atomic nucleus: General properties of nuclei. Nature of nuclear force, Nuclear radius and its relation with atomic weight. Nucleus as a Liquid drop, Semi-empirical mass formula of Weiszaker and its significance.

(6 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 rayemission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

(8 Lectures)

Fission and fusion- Mass deficit 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). **(3 Lectures)**

Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser.

(4 Lectures)

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, Nikhil Ranjan Roy, 2016, Vikash Publishing House Pvt. Ltd.
4. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
5. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, CengageLearning.
6. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
7. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan

Additional Books for Reference

1. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
2. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2ndEdn, Tata McGraw-Hill Publishing Co. Ltd.
3. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
4. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
5. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

---

III. MAJOR COURSE- MJ 11:
PRACTICALS-IV ELECTRONICS AND MODERN PHYSICS

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

1. To study V-I characteristics of PN junction diode, and verification of diode equation.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
5. To design non-inverting amplifier using Op-amp (741,351) and study its frequency response
6. Use of OP-Amp (741, 351) as an integrator and as a differentiator.
7. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
8. To design a NOT gate switch using a transistor.
9. To verify and design AND, OR, NOT and XOR gates using NAND gates.
10. Half Adder, Full Adder and 4-bit binary Adder.
11. To design an astable multivibrator of given specifications using 555 Timer.
12. Measurement of Planck's constant using black body radiation and photo-detector
13. Photo-electric effect: photo current versus intensity and wavelength of light; maximumenergy of photo-electrons versus frequency of light
14. To determine the Planck's constant using LEDs of at least 4 different colours.
15. To determine the wavelength of laser source using diffraction of single slit.
16. To determine wavelength of He-Ne laser using plane diffractiongrating

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-GrawHill.
3. Microprocessor Architecture Programming and appls. with 8085, R.S. Goankar, 2002,Prentice Hall.
4. Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa, 2010, PHILearning.
5. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-GrawHill.
6. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
7. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
8. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson
9. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse
10. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers
11. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Mahal

---

MN- 1C

Minor – 1C : ANALOG AND DIGITAL ELECTRONICS

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

As the successful completion of the course the student is expected to be conversant with thefollowing.

17. Secure first-hand idea of different components including both active and passive components to gain an insight into circuits using discrete components and also to learn about integrated circuits.
18. About analog systems and digital systems and their differences, fundamental logic gates, combinational as well as sequential and number systems.
19. Synthesis of Boolean functions, simplification and construction of digital circuits by employing Boolean algebra.
20. Sequential systems by choosing Flip-Flop as a building bock- construct multivibrators, counters to provide a basic idea about memory including RAM, ROM and also about memory organization.
21. In the laboratory he is expected to construct both combinational circuits and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Shift Registers, and multivibrators using 555 ICs. He is also expected to use µP 8085 todemonstrate the same simple programme using assembly language and execute the programme using a µP kit.
    At the end of the course the student is expected to assimilate the following and possessesbasic knowledge of the following.
22. N- and P- type semiconductors, mobility, drift velocity, fabrication of P-N junctions; forward and reverse biased junctions. Application of PN junction for different type of rectifiers and voltage regulators.
23. NPN and PNP transistors and basic configurations namely common base, common emitter and common collector, and also about current and voltage gain.
24. Biasing and equivalent circuits, coupled amplifiers and feedback in amplifiers and oscillators.
25. To characterize various devices namely PN junction diodes, LEDs, Zener diode, solar cells, PNP and NPN transistors. Also construct amplifiers and oscillators using discrete components. Demonstrate inverting and non-inverting amplifiers using op-amps.

Skills to be learned:

6. Learn the basics of IC and digital circuits, and difference between analog and digitalcircuits. Various logic GATES and their realization using diodes and transmitters.
7. Learn fundamental of Boolean algebra and their role in constructing digital circuits.
8. Learn about combinatorial and sequential systems by building block circuits toconstruct multivibrators and counters.
9. Learn basic concepts of semiconductor diodes and their applications to rectifiers.
10. Learn about junction transistor and their applications. Learn about different types of amplifiers including operational amplifier.(Op-Amp) and their applications. Learn about sinusoidal oscillators of various types and A/D conversion.

Course Content:

ANALOG ELECTRONICS:

Two-terminal Devices and their Applications: Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, Zener Diode and Voltage Regulation. Principle and structure of LEDs, Photodiode and Solar Cell. **(4 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 andSaturation Regions. **(4 Lectures)**

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. **(5 Lectures)**

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

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(2 Lecture)**

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(3 Lectures)**

Operational Amplifiers and Applications: 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. Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier. **(6 Lectures)**

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

DIGITAL ELECTRONICS:

Digital Circuits: Difference between analog and digital circuit, Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates, NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. **(5 Lectures)**

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

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

Timers: Classification of ICs. Examples of Linear and Digital ICs, IC 555: Block diagram and applications: Astable multivibrator and Monostable 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). **(4 Lectures)**

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

Reference Books:

21. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
22. A first Course in Electronics, Khan & Dey, PHI, 1/e, 2006
23. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
24. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
25. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
26. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
27. Basic Electronics, Arun Kumar, Bharati Bhawan, 1/e, 2007
28. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford Univ Press.
29. Analog Systems and Applications, Nutan Lata, Pragati Prakashan
30. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
31. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
32. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
33. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
34. Digital Computer Electronics, Malvino and Brown, 3/e, McGraw Hill Education
35. Digital Electronics G K Kharate ,2010, Oxford University Press
36. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
37. Logic circuit design, Shimon P. Vingron, 2012, Springer.
38. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
39. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
40. Digital Systems and Applications, Nutan Lata, Pragati Prakashan, 1/e, 2019

IAP: Internship/ Apprenticeship/Project

SEMESTER VI

I. MAJOR COURSE- MJ 12**:**
QUANTUM MECHANICS AND APPLICATIONS

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:
This course will enable the student to get familiar with quantum mechanics formulation.

1. After an exposition of inadequacies of classical mechanics in explaining microscopic phenomena, quantum theory formulation is introduced through Schrodinger equation.
2. The interpretation of wave function of quantum particle and probabilistic nature of its location and subtler points of quantum phenomena are exposed to the student.
3. Through understanding the behavior of quantum particle encountering a i) barrier, ii) potential, the student gets exposed to solving non-relativistic hydrogen atom, for its spectrum and eigenfunctions.
4. Study of influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.
5. The experiments using Sci-lab will enable the student to appreciate nuances involved in the theory.
6. This basic course will form a firm basis to understand quantum many body problems.
7. In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one- dimensional and three-dimensional potentials.

Skills to be learned:

1. This course shall develop an understanding of how to model a given problem such asparticle in a box, hydrogen atom, hydrogen atom in electric fields.
2. Many electron atoms, L-S and J-J couplings.
3. These skills will help in understanding the different Quantum Systems in atomic andnuclear physics.

Course Content:

Time dependent Schrodinger equation: Postulates of Quantum mechanics, Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function. Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **(6 Lectures)**

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, Position-momentum uncertainty principle. **(10 Lectures)**

General discussion of bound states in an arbitrary potential- continuity of wavefunction, 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. **(12 Lectures)**

Quantum theory of hydrogen-like atoms: Angular momentum operator and commutation relation between them. 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. **(10 Lectures)**

Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern- Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). **(12 Lectures)**

Single and Many electron atoms: Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms-L-S and J-J couplings. Hund's Rule. **(10 Lectures)**

Reference Books:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010,McGraw Hill
2. Introduction to Quantum Mechanics, Nikhil Ranjan Roy, 2016, Vikash Publishing House Pvt. Ltd.
3. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
4. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
5. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
6. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
7. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
8. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge UniversityPress

Additional Books for Reference

1. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
2. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
3. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

---

II. MAJOR COURSE- MJ 13: **SOLID STATE PHYSICS**

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

At the end of the course the student is expected to learn and assimilate the following.

1. A brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays bycrystalline materials.
2. Knowledge of lattice vibrations, phonons and in depth of knowledge of Einstein and Debye theory of specific heat of solids.
3. At knowledge of different types of magnetism from diamagnetism to ferromagnetism and hysteresis loops and energy loss.
4. Secured an understanding about the dielectric and ferroelectric properties of materials.
5. Understanding above the band theory of solids and must be able to differentiate insulators, conductors and semiconductors.
6. Understand the basic idea about superconductors and their classifications.
7. To carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determinethe hall coefficient of a semiconductor.

Skills to be learned:

1. Learn basics of crystal structure and physics of lattice dynamics
2. Learn the physics of different types of material like magnetic materials, dielectricmaterials, metals and their properties.
3. Understand the physics of insulators, semiconductor and conductors with specialemphasis on the elementary band theory of semiconductors.
4. Comprehend the basic theory of superconductors. Type I and II superconductors, theirproperties and physical concept of BCS theory.

Course Content:

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)**

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Mono-atomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law **(10 Lectures)**

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)**

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. DepolarizationField. 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. **(8 Lectures)**

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)**

Elementary band theory: Periodic potential and Bloch theorem. Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement ofconductivity (04 probe method) & Hall coefficient. **(10 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, Isotope effect. Idea of BCS theory (No derivation) **(6 Lectures)**

Reference Books:

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

---

III. MAJOR COURSE- MJ 14:
NUCLEAR AND PARTICLE PHYSICS

(Credits: Theory-04) **60 Hours**

Course Objectives:

1. Learn the ground state properties of a nucleus – the constituents and their properties, mass number and atomic number, relation between the mass number and the radius and the mass number, average density, range of force, saturation property, stability curve,the concepts of packing fraction and binding energy, binding energy per nucleon vs. mass number graph, explanation of fusion and fission from the nature of the binding energy graph.
2. Know about the nuclear models and their roles in explaining the ground state properties of the nucleus –(i) the liquid drop model, its justification so far as the nuclear properties are concerned, the semi-empirical mass formula, (ii) the shell model, evidence of shell structure, magic numbers, predictions of ground state spin and parity, theoretical deduction of the shell structure, consistency of the shell structure with the Pauli exclusion principles.
3. Learn the basic aspects of nuclear reactions, the Q-value of such reaction and itsderivation from conservation laws, the reaction cross-sections, the types of nuclear reactions, direct and compound nuclear reactions, Rutherford scattering by Coulomb potential.
4. Learn some basic aspects of interaction of nuclear radiation with matter- interaction of gamma ray by photoelectric effect, Compton scattering and pair production, energy loss due to ionization, Cerenkov radiation.
5. The students are expected to learn about the principles and basic constructions ofparticle accelerators such as the Van-de-Graff generator, cyclotron, synchrotron. They should know about the accelerator facilities in India.
6. Gain knowledge on the basic aspects of particle Physics – the fundamental interactions, elementary and composite particles, the classifications of particles: leptons, hadrons (baryons and mesons), quarks, gauge bosons. The students should know about the quantum numbers of particles: energy, linear momentum, angular momentum, isospin, electric charge, colour charge, strangeness, lepton numbers, baryon number and the conservation laws associated with them.

Skills to be learned:

1. Skills to describe and explain the properties of nuclei and derive them from variousmodels of nuclear structure.
2. To understand, explain and derive the various theoretical formulation of nucleardisintegration like α decay, β decay and γ decays.
3. Develop basic understanding of nuclear reactions and decays with help of theoreticalformulate and laboratory experiments.
4. Ability to understand, construct and operate simple detector systems for nuclearradiation and training to work with various types of nuclear accelerators.
5. Develop basic knowledge of elementary particles as fundamental constituent of matter, their properties, conservation laws during their interactions with matter.

Course Content:

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitativefacts 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)**

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. **(8 Lectures)**

Radioactive 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)**

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). **(8 Lectures)**

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Bloch formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. **(8 Lectures)**

Nuclear Radiation Detectors: Behavior of ion pairs in electric field, 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)**

Particle Physics: Particle interactions; basic features, types of particles and itsfamilies. 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. **(8 Lectures)**

Reference Books:

1. Nuclear Physics-An introduction, W. E. Burcham, 2/e, Longman Group Limited 1973
2. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
3. Concepts of nuclear Physics by Bernard L. Cohen. (Tata McGraw Hill, 1998).
4. Introduction to the Physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
5. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
6. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
7. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
8. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).
9. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
10. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press,Elsevier, 2007).
11. Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

IV. MAJOR COURSE- MJ 15:
PRACTICALS-V QUANTUM AND SOLID STATE PHYSICS

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment	*= 60 marks*
Practical record notebook	*= 15 marks*
Viva-voce	*= 25 marks*

Practicals:

Use C/C^{++}/Scilab/Matlab for solving the following problems based on QuantumMechanics like

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

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

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:

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

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

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

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= 100MeV 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 cases.

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

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

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

$$V(r) = D(e^{-2\alpha r^F} - e^{-\alpha r^F}), r' = \frac{r-r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of threesignificant digits. Also plot the corresponding wave function. Take: m = 940x10^6 eV/C^2, D = 0.755501 eV, α = 1.44, ro = 0.131349 Å

5. Estimate the energy gap of a semiconductor using a PN junction.
6. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
7. To measure the Magnetic susceptibility of Solids.

8. To determine the Coupling Coefficient of a Piezoelectric crystal.
9. To measure the Dielectric Constant of a dielectric Materials with frequency
10. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
11. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^oC) and to determine its band gap.
12. To determine the Hall coefficient of a semiconductor sample.

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., CambridgeUniversity Press
7. Scilab Image Processing: L. M. Surhone.2010 Betascript Publishing ISBN:978-6133459274
8. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse.
9. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers.
10. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
11. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Minor- 2C

MN – 2C: RENEWABLE ENERGY HARVESTING & RADIATION SAFETY

(Credits: 04)

RENEWABLE ENERGY AND ENERGY HARVESTING (Credit: 02)

Theory: 30 Lectures

The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible

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

(2 Lectures)

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

(3 Lectures)

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

(2 Lectures)

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.

(2 Lectures)

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. **(2 Lectures)**

Geothermal Energy: Geothermal Resources, Geothermal Technologies. **(2 Lectures)**

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. **(2 Lectures)**

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric Energy harvesting applications, Human power.

(3 Lectures)

Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications **(2 Lectures)**

Carbon captured technologies, cell, batteries, power consumption

(2 Lectures)

Environmental issues and Renewable sources of energy, sustainability.

(1 Lecture)

Demonstrations and Experiments

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

Reference Books:

1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
2. Solar energy - M P Agarwal - S Chand and Co. Ltd.
3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
4. Godfrey Boyle, “Renewable Energy, Power for a sustainable future”, 2004, Oxford
5. University Press, in association with The Open University.
6. Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
7. J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
8. http://en.wikipedia.org/wiki/Renewable_energy

RADIATION SAFETY

(Credits: 02)

Theory: 30 Lectures

The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics

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

(2 Lectures)

Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles-Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation. **(5 Lectures)**

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

(5 Lectures)

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

(5 Lectures)

Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection

Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation.

(5 Lectures)

Experiments:

1. Study the background radiation levels using Radiation meter Characteristics of Geiger Muller (GM) Counter:
2. Study of characteristics of GM tube and determination of operating voltage and plateau
3. length using background radiation as source (without commercial source).
4. Study of counting statistics using background radiation using GM counter.
5. Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
6. Study of absorption of beta particles in Aluminum using GM counter.
7. Detection of α particles using reference source & determining its half life using spark counter
8. Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books

1. W.E. Burcham and M. Jobes – Nuclear and Particle Physics – Longman (1995)

2. G.F.Knoll, Radiation detection and measurements

3. Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)

4. W.J. Meredith and J.B. Massey, "Fundamental Physics of Radiology". John Wright and Sons, UK, 1989.

5. J.R. Greening, "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.

6. Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001

7. A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.

8. NCRP, ICRP, ICRU, IAEA, AERB Publications.

9. W.R. Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981

SEMESTER VII

I. MAJOR COURSE- MJ 16: CLASSICAL DYNAMICS

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

1. Revise the knowledge of the Newtonian, the Lagrangian and the Hamiltonian formulations of classical mechanics and their applications in appropriate physical problems. Learn about the small oscillation problems.
2. Recapitulate and learn the special theory of relativity- postulates of the special theory ofrelativity, Lorentz transformations on space-time and other four vectors, four-vector notations, space-time invariant length, length contraction, time dilation, mass-energy relation, Doppler effect, light cone and its significance, problems involving energy- momentum conservations. Learn the basics of fluid dynamics, streamline and turbulent flow, Reynolds's number, coefficient of viscosity and Poiseuille's equation.
3. Review the retarded potentials, potentials due to a moving charge, Lienard Wiechert potentials, electric and magnetic fields due to a moving charge, power radiated, Larmor's formula and its relativistic generalization.

Skills to be learned:

1. Learn to define generalised coordinates, generalised velocities, generalised force and write Lagrangian for mechanical system in terms of generalised coordinates.
2. Learn to derive Euler-Lagrange equation of motion and solve them for simplemechanical systems.
3. Learn to write Hamiltonian for mechanical systems and derive and solve Hamilton'sequation of motion for simple mechanical systems. Formulate the problem of small amplitude oscillation and solve them to obtain normalmodes of oscillation and their frequencies in simple mechanical systems.
4. Develop the basic concepts of special theory of relativity and its applications todynamical systems of particles.
5. Develop the methods of relativistic kinematics of one and two particle system and itsapplication to two particle decay and scattering.

Course Content:

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 gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler- Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one- dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators Canonical momenta & Hamiltonian. Hamilton'sequations of motion. Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy. **(22 Lectures)**

Small Amplitude Oscillations: Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) - identical springs. **(10 Lectures)**

Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space- time diagrams. Time -dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four- momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle. **(18 Lectures)**

Fluid Dynamics: Density and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number. **(10 Lectures)**

Reference Books:

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
2. Intoduction to Classical mechanics, Nikhil Ranjan Roy, 2016, Vikash Publishing House Pvt. Ltd.
3. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
4. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
5. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
6. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
7. Classical Mechanics, J. C. Upadhyaya, Himalay Publishing House
8. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
9. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
10. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
11. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

---

II. MAJOR COURSE- MJ 17: ADVANCE MATHEMATICAL METHODS IN PHYSICS

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Revise the knowledge of Mathematical Physics. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in Engineering.
2. Learn Green's function and its application to one, two, and three-dimensional problem.
3. Understand Electrodynamics and Relativity and apply them to basic problems.

Skills to be learned:

1. Training in Mathematical Physics will prepare the student to solve various mathematical problems.
2. He / she shall develop an understanding of how to formulate a physics problem and solve given mathematical equation rising out of it.
3. Learn the concepts of Electrodynamics and Relativity.
4. Develop skills to solve the equations of central electrodynamics and Relativity force problem.
5. Acquire basic knowledge of Advance Mathematical Physics .

Course Content:

Matrices and Tensors: Introduction of matrices through rotation of co-ordinate systems, Orthogonal, Hermitian, Unitary, Null and Unit matrices, Singular and Non-singular matrices, Inverse of a matrix, Trace of a matrix, Eigenvalues and Eigenvectors, Diagonalization. Tensorial character of physical entities, Covariant, Contravariant and Mixed tensors, Contraction, Quotient rule, Differentiation, Kronecker tensor, Pseudo-tensor, Symmetric and Anti symmetric tensors. **(20 Lectures)**

Green's Function: Introduction Construction of the Green's function for 1d, 2d and 3d problems.Solution of some standard problems using Green's function technique. **(10 Lectures)**

Abstract group theory: Definition. Group postulates. Finite and infinite groups, order of a group, subgroup; rearrangement theorem, multiplication table. Cosets, Lagrange's theorem. Order of an element.. Conjugate elements and classes. Invariant subgroups, factor groups. Generators. Isomorphism and homomorphism. Cyclic and other distinct groups. Permutation and alternating groups. Cayley's theorem. **(15 Lectures)**

Representation theory: Definition of representation. Faithful and unfaithful representations. Invariant subspaces and reducible representations. Reducible and irreducible representations. Schur's lemmas, great orthogonality theorem and its geometrical interpretation. Character. First and second orthogonality theorems of characters and its geometrical interpretation. Regular representation, celebrated theorem and its implication. Projection operators; determination of basis functions. Direct product groups and their representations Direct product representations and their reduction. Construction of character tables of simple group**.** **(15 Lectures)**

Books Suggested:

1. Mathematical Methods for Physicists, G.BArfken, H.J.Waber, E.E. Harris, 2013, 7thEdn., Elsevier.
2. Boas, M.L., "Mathematical Methods in Physical Sciences", Wiley International Editions.
3. Group Theory and Quantum Mechanics, M.Timkham.
4. Mathematical Physics: Das and Sharma.
5. Mathematical Methods for Physicist & Engineers: Pipes & Harvel.
6. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
7. Mathematical Methods for Scientists and Engineers: D.A.McQuarrie, 2003, Viva Book.
8. Advanced Engineering Mathematics: D.G.Zill and W.S.Wright, 5-Ed, 2012, Jones and Bartlett Learning.
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.
11. Classical Electrodynamics, J.D.Jackson, 3rd Edn, 1988, Wiley.
12. The Classical Theory of Fields, L.D.Landau, E.M.Lifshitz, 4th Edn. 2003, Elsevier.
13. Electromagnetic Field Theory for Engineers & Physicsts, P.Lorrain & D.Corson, 1970.

III. MAJOR COURSE- MJ 18:
ADVANCE QUANTUM MECHANICS-I AND ADVANCE SOLID STATE PHYSICS

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:
On successful completion of this course the student should know:
1. Revise the knowledge of advance Quantum Mechanics and Solid State Physics.
2. Learn different Quantum Dynamics and apply them to solve standard Quantum mechanical problems.
3. Understand Invariance Principle and Conservation laws for linear momentum, angular momentum, energy and parity.

Skills to be learned:
1. Training in advance Quantum Mechanics and Solid State Physics will prepare the student to solve various mathematical problems.
2. He / she shall develop an understanding of how to formulate a physics problem and solve given mathematical equation rising out of it.
3. Learn the concepts of advance Quantum Mechanics and Solid State Physics.
4. Develop skills to understand and solve the equations of central advance Quantum Mechanics and Solid State Physics problem.
5. Acquire basic knowledge of Advance Mathematical Physics

Course Content:
ADVANCE QUANTUM MECHANICS-I
Mathematical Foundation of Quantum Mechanics: Vectors and Linear vector space, Closure property, Linear independence of vectors, Bases and dimensions. Some examples of linear vector spaces, Dirac's notations, Bra and Ket vectors, Combining bras with kets, Inner product and inner product space, Orthonormality of vectors, Completeness condition,Outer product, Hilbert spaces, Operator on a linear vector space, Algebra of linear operators. **(15 Lectures)**

Quantum Dynamics: The equation of motion- The Schrodinger; Applications to linear harmonic oscillator and the hydrogen atom. Linear harmonic oscillatorusing Creation and annihilation operator. (**10 Lectures)**

Angular Momentum: Commutation relations for angular momentum operators, Eigenvalues and eigenvectors, Pauli spin matrices and spin eigenvectors, Motion in a centrally symmetric field. **(5 Lectures)**

Invariance Principle and Conservation Laws: Space-time symmetries and conservation Laws forlinear momentum, Angular momentum, Energy and Parity. **(5 Lectures)**

SOLID STATE PHYSICS
Crystal Physics: Laue theory of X-ray diffraction, Geometrical structure factor and intensity of diffraction maxima. (**5 Lectures)**

Electronic Properties: Electron in a Periodic lattice, Band Theory, Tight Binding, Cellular and Pseudopotential method, Fermi surface, de Haas van Alphen Effect. **(10 Lectures)**

Magnetism: Exchange interaction, Heisenberg model and molecular field theory, spin waves and magnons, Domains and Bloch Wall energy. **(6 Lectures)**

Superconductivity: Basic properties of superconductors, BCS theory **(4 Lectures)**

Books Suggested:

1. Mathews, P.M., &Venkatesan, K., "A Text Book of Quantum Mechanics", TMH.
2. Merzbacker, E., "Quantum Mechanics", John Wiley
3. Messiah, A., "Quantum Mechanics", North-Holland Publishing Co.
4. Schiff, L.I., "Quantum Mechanics", Tata McGraw-Hill, 3rd Edition 2010
5. Ghatak, A., Quantum Mechanics", Narosa Publishing House, New Delhi.
6. Agarwal, B. K., "Quantum Mechanics', PHI
7. Landau, L.D. & Lifshitz, E.M., "Quantum Mechanics", Pergman Press
8. Quantum Mechanics for Scientists and Engineers, D. A. B. Miller 2008, Cambridge UniversityPress
9. Introductory Quantum Mechanics, Richard L. Liboff, Pearson Education, New Delhi.
10. Quantum Mechanics, B.H. Bransden and C.J.Joachin, Pearson Education, New Delhi.
11. Kittel,C., "Solid-State Physics",
12. Arun Kumar, "Introduction to Solid State Physics", PHI Learning
13. Aschroft, N.W. and Mermin, N. D., "Solid-State Physics"
14. Verma and Srivastava, Crystallography for Solid State Physics.
15. S. O. Pillai, "Solid State Physics", New Age International.

IV. MAJOR COURSE- MJ 19:
PRACTICALS-VI: OPTICS AND LASER

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

Practicals:

1. Studies with Michelson's Interferometer.
   a. Determination of wavelength separation of sodium D-lines.
   b. Determination of thickness of mica sheet.
2. Studies with Fabre-Perot Etalon.
3. Studies with Edser-Butler Plate.
4. Studies of phenomena with polarized light:
   a. Verification of Brewster's law.
   b. Verification of Fresnel's law of reflection of plane polarized light.
   c. Analysis of elliptically polarized light using $\lambda/4$ plate and Babinet's compensator.
5. Verification of Rayleigh's criterion for the limit of resolution of spectral lines using
   a. prism spectrum and (b) grating spectrum.
6. Studies on Zeeman effect.
7. Experiments using He-Ne laser source:
   a. Determination of grating pitch using phenomena of self-imaging.
   b. Determination of wavelength with a vernier caliper.

MN- 1D

Minor: 1D: SOLID STATE PHYSICS

(Credits: Theory-03, Practicals-01)

Course Learning Outcomes:

At the end of the course the student is expected to learn and assimilate the following.

1. A brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays bycrystalline materials.
2. Knowledge of lattice vibrations, phonons and in depth of knowledge of Einstein and Debye theory of specific heat of solids.
3. At knowledge of different types of magnetism from diamagnetism to ferromagnetism and hysteresis loops and energy loss.
4. Secured an understanding about the dielectric and ferroelectric properties of materials.
5. Understanding above the band theory of solids and must be able to differentiate insulators, conductors and semiconductors.
6. Understand the basic idea about superconductors and their classifications.
7. To carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determinethe hall coefficient of a semiconductor.

Skills to be learned:

5. Learn basics of crystal structure and physics of lattice dynamics
6. Learn the physics of different types of material like magnetic materials, dielectricmaterials, metals and their properties.
7. Understand the physics of insulators, semiconductor and conductors with specialemphasis on the elementary band theory of semiconductors.
8. Comprehend the basic theory of superconductors. Type I and II superconductors, theirproperties and physical concept of BCS theory.

Course Content:

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)**

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Mono-atomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law **(10 Lectures)**

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)**

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. DepolarizationField. 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. **(8 Lectures)**

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)**

Elementary band theory: Periodic potential and Bloch theorem. Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement ofconductivity (04 probe method) & Hall coefficient. **(10 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, Isotope effect. Idea of BCS theory (No derivation) **(6 Lectures)**

Reference Books:

10. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
11. Introduction to Solid State Physics, Arun Kumar, PHI
12. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
13. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
14. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
15. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
16. Solid State Physics, Rita John, 2014, McGraw Hill
17. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
18. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

---

SEMESTER VIII

V. MAJOR COURSE- MJ 20:
SPECTROSCOPY

(Credits: Theory-04)

Course Learning Outcomes:

On successful completion of this course the student should know:

a. Revise the knowledge of Spectroscopy.
b. Learn different spectroscopy Physics and apply them to solve standard spectroscopy problems.
c. Understand Rotation of molecules, Born Oppenheimer approximation, Techniques and Instrumentation applications.

Skills to be learned:

a. Training in Spectroscopy will prepare the student to solve various spectra problems.
b. He / she shall develop an understanding of how to formulate a physics problem and solve given mathematical equation rising out of it.
c. Learn the concepts of Spectroscopy including the concept of molecular spectra, resonance spectroscopy.
d. Develop skills to understand and solve the equations of Lasers and Holography.
e. Acquire basic knowledge of Spectroscopy.

Course Content:

Atomic Spectra: Quantum theory of Zeeman effect (normal and anamolous), Paschen-Back effect, Stark effect (linear and non-linear). Hyperfine structure of spectral lines, X-ray spectra characteristics and absorption. **(8 Lectures)**

The Rotation of the Molecule: Rotational spectra-Rigid diatomic molecule, The intensities of spectral lines, Effect of isotopic substitution, the non-rigid rotator, Simple harmonic oscillator, The an-harmonic oscillator, Diatomic vibrating rotator, Born Oppenheimer approximation, Techniques and instrumentation applications. **(15 Lectures)**

Molecular Spectra: Infrared and Raman spectra of diatomic molecules using an-harmonic oscillator,non-rigid rotator and vibrating rotator as models. Electronic states and electronic transitions in diatomic molecules, Frank Condon principle. **(15 Lectures)**

Resonance Spectroscopy: Nature of spinning particle, Interaction between spin and a magnetic field,Larmor Precession, Theory of NMR, Chemical shift-relaxation Mechanism, experimental study of NMR, Theory and experimental study of NQR, Theory of ESR, Hyperfine structure and fine structureof ESR, Experimental studies and applications, Mossbauer spectroscopy, Principle-Isomer shift, Quadrupole effect, effect of magnetic field, Instrumentation applications. **(15 Lectures)**

Laser and Holography: Modes of resonator and coherence length, The Nd, YAG laser, The Neodymium Glass laser, The CO_2 Laser, Organic Dye lasers, Semi-conductor Laser, Liquid Laser. Principle of Holography, Theory-practical applications including data storage. **(7 Lectures)**

Books Suggested:

1. Kuhn, “Atomic Spectctra”.
2. Ghatak & Loknathan, “Quantum Mechanics”.
3. Herzberg, Spectra of diatomic molecules
4. Elements of Spectroscopy: Gupta, Kumar and Sharma, Pragati Prakashan.
5. Fundamentals of Molecular Spectroscopy: Colin and Elaine, TMH.
6. Laser and Non-linear Optics: B. B. Laud, New Age Publications.

Dissertation Research Project

(Credit -12) 360 hours

VI. ADVANCED MAJOR COURSE- AMJ 1:

ADVANCED QUANTUM MECHANICS-II

(Credits: Theory-04) 60 Hours

Course Learning Outcomes:

On successful completion of this course the student should know:

a. Revise the knowledge of advance Quantum Mechanics-II.
b. Learn different Quantum Approximation methods and apply them to solve standard Quantum mechanical problems.
c. Understand theory of scattering and relativistic quantum mechanics.

Skills to be learned:

a. Training in advance Quantum Mechanics-II will prepare the student to solve various quantum problems.
b. He / she shall develop an understanding of how to formulate a physics problem and solve given mathematical equation rising out of it.
c. Learn the concepts of advance Quantum Mechanics-II.
d. Develop skills to understand and solve the equations of central advance Quantum Mechanics-II.

Course Content:

Approximation Methods: The WKB approximation and its applications to one dimensional bound system, The vibrational method (Ritz method) and its application to linear harmonic oscillator, Stationary perturbation theory, non-degenerate and degenerate cases and applications to an-harmonic oscillator. Time-dependent perturbation theory, constant perturbation and Fermi Golden rule, harmonic perturbation (Einstein's A and B co-efficient). **(26 Lectures)**

Theory of Scattering: Scattering amplitude and cross-section, Partial wave analysis, Born approximation. **(8 Lectures)**

Identical Particles: Many particle Schrodinger equation, The Indistinguishability principle, Symmetric and anti-symmetric wave functions, Pauli exclusion principle. **(13 Lectures)**

Relativistic Quantum Mechanics: Klein-Gordon equation for free particle, Dirac equation, Properties of Dirac matrices, Probability and current densities, Covariance of Dirac equation, Freeparticle solution and negative energy states, magnetic moment and spin of electron. **(13 Lectures)**

Books Suggested:

1. Thankappan, V.K., "Quantum Mechanics", Wiley Eastern
2. Mathews, P.M., &Venkatesan, K., "A Text Book of Quantum Mechanics", TMH.
3. Merzbacker, E., "Quantum Mechanics", John Wiley
4. Messiah, A., "Quantum Mechanics", North-Holland Publishing Co.
5. Schiff, L.I., "Quantum Mechanics", McGraw-Hill
6. Ghatak, A., Quantum Mechanics", Narosa Publishing House, New Delhi.
7. Agarwal, B. K., "Quantum Mechanics', PHI
8. Landau, L.D. & Lifshitz, E.M., "Quantum Mechanics", Pergman Press
9. Introduction to Quantum Mechanics by D. J. Griffiths. II Edn., pearson Education

Also the books recommended earlier in Quantum Mechanics Course – I

VII. ADVANCED MAJOR COURSE- AMJ 2: **ADVANCED NUCLEAR PHYSICS**

(Credits: Theory-04) **60 Hours**

Course Learning Outcomes:

On successful completion of this course the student should:

a. Revise the knowledge of advance Nuclear Physics-1.
b. Learn different aspects of advance nuclear physics, viz. nuclear radiation detectors, nuclear reactor theory etc.
c. Understand the theory of nuclear reactor right from the fundamentals of nuclear fission and upto criticality of an infinite homogeneous reactor.

Skills to be learned:

a. Training in advance nuclear physics-I will prepare the student to solve various nuclear reactor and detectors problems.
b. He / she shall develop an understanding of how to formulate a physics problem and solve given mathematical equation rising out of it.
c. Learn the concepts of advance nuclear physics-I.
d. Develop skills to understand and solve the problems of advance nuclear physics-I.

Course Content:

Nuclear Radiation Detectors

Detection: Simple model of detector, energy measurement, position and time measurement.

Solid State Detectors: Surface barrier detectors, Scintillation counters: Organic and inorganic scintillators, Gamma Ray Scintillation Spectrometer.

High Energy Particle Detectors: General principles, Nuclear emulsions, Cloud chambers, Bubble chamber. **(15 Lectures)**

Nuclear Reactor Theory

Fundamentals of Nuclear Fission: Fission fuels, Prompt and delayed neutrons, Chain reaction, Multiplication factor, Condition for criticality, Breading phenomena.

Diffusion of neutrons: Neutron current density, The equation of continuity, Fick's law, The diffusion equation, Measurement of diffusion parameters. **(15 Lectures)**

Neutron Moderation: Moderation without absorption, Energy loss in elastic collisions, Average logarithmic energy decrement, slowing down power and moderating ratio of a medium. Slowing down densities, Moderation- Space dependent slowing down, Fermi's age theory, Moderation with absorption **(15 Lectures)**

Criticality of an Infinite Homogenous Reactor: The critical equation, Optimum reactor shapes,Material and geometrical bucklings, Neutron balance in a thermal reactor, Four factor formula, Calculation of critical size and composition in simple cases **(15 Lectures)**

Books Suggested:

1. Segre, E., "Experimental Nuclear Physics", John Wiley
2. Singru, R.M., "Introduction to Experimental Nuclear Physics", John Wiley & Sons, 1974.
3. W.R. Leo, "Techniques for Nuclear and Particle Physics Experiments"
4. Kapoor S.S and Ramamurthy V.S., "Nuclear Radiation Detectors", New Age International Publishers 1986.
5. Syed Naeem Ahmed, "Physics and Engineering of Radiation Detection", Academic Press, Elsevier, 2007.
6. Glasstone, S. and Edlund, M. C., "The Elements of Nuclear Reactor Theory", Van Nostrand Co., 1953.
7. Stacey, W. M., "Nuclear Reactor Physics"
8. Lamarsh, J. R., "Introduction to Nuclear Reactor Theory', Addison Wesley, 1966
9. Murray, L., "Introductions of Nuclear Engineering".
10. Varma, J. "NUCLEAR Physics Experiments", New Age International Publishers 2001.
11. Singru, R.M., "Introduction to Experimental Nuclear Physics" Wiley Eastern Pvt. Ltd.

VIII. ADVANCED MAJOR COURSE- AMJ 3:
PRACTICALS-VII: GENERAL ELECTRONICS, ATOMIC AND NUCLEAR PHYSICS

(Credits: Theory-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

1. 'e/m' measurement by Braun's tube and by Magnetron valve method.
2. 'e' measurement by Millikan oil drop apparatus.
3. Design and characteristics of passive attenuators (T- and π-types)
4. BJT based voltage amplifier: design and performance study with and without negative feedback.
5. JFET based voltage amplifier: design and performance study.
6. Half- and Full wave rectifier with and without filters
7. Series and shunt voltage regulators using Zener diode.
8. Characterization of Photo –resister.
9. Determine the plateau characteristics of the given GM counter.
10. Verification of Inverse Square Law for Gamma-rays.
11. To measure the absorption coefficient of gamma rays in Aluminum or Copper.
12. To plot the Gaussian or normal distribution curve for background radiation.
13. Determination of dead time of the GM Counter.

Minor- 2D

MN – 2D : EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS

(Credits: Theory-03, Practicals-01)

Theory: 45 Lectures

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges & design issues in embedded systems, operational and nonoperational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers.

(4 Lectures)

Review of microprocessors: Organization of Microprocessor based system, 8085μp pindiagram and architecture, concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts. **(4 Lectures)**

8051 microcontroller: Introduction and block diagram of 8051 microcontroller,architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions. **(08 Lectures)**

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation. **(2 Lectures)**

Programming: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions. **(08 Lectures)**

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

(2 Lectures)

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

(3 Lectures)

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing. **(2 Lectures)**

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. **(2 Lectures)**

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

(6 Lectures)

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

(4 Lectures)

Reference Books:

1. Embedded Systems: Architecture, Programming & Design, R. Kamal, 2008, Tata McGraw Hill
2. The 8051 Micro controller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
3. Embedded micro computor system: Real time interfacing, J.W.Valvano, 2000, Brooks/Cole
4. Microcontrollers in practice, I. Susnea and M. Mitescu, 2005, Springer.
5. Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson Education India
6. Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, C engage Learning.

LAB: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS

30 Lectures

8051 microcontroller based Programs and experiments

1. To find that the given numbers is prime or not.
1. To find the factorial of a number.
2. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
3. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's .
4. Program to glow the first four LEDs then next four using TIMER application.
5. Program to rotate the contents of the accumulator first right and then left.
6. Program to run a countdown from 9-0 in the seven segment LED display.

7. To interface seven segment LED display with 8051 microcontroller and display ‘HELP’ in the seven segment LED display.
8. To toggle ‘1234’ as ‘1324’ in the seven segment LED display.
9. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
10. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard. Arduino based programs and experiments:
11. Make a LED flash at different time intervals.
12. To vary the intensity of LED connected to Arduino
13. To control speed of a stepper motor using a potential meter connected to Arduino
14. To display “PHYSICS” on LCD/CRO.
15. Arduino UNO based application for smart controlling of home appliances.

(At least 8 experiments from above or instructor may design its own set of experiments using microcontroller / Arduino UNO.)

Reference Books:

1. Embedded Systems: Architecture, Programming& Design, R.Kamal,]2008,Tata McGraw Hill
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India. UGC Document on LOCF Physics 173
3. Embedded Microcomputor System: Real Time Interfacing, J.W.Valvano, 2000, Brooks/Cole
4. Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.
5. Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011,Cengage Learning