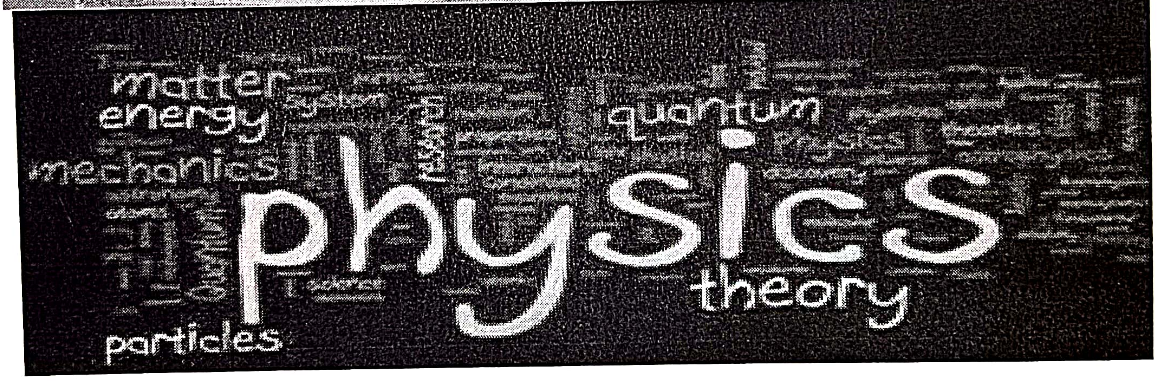
Department Of Physics

Kolhan University, Chaibasa



Syllabus For

Four Years Undergraduate Program in physics

Under New education policy 2020

Co-Ordinator IQAC
KU, Chaibasa

Total FYUGP (Honours/Research) Structure-NEP2020

Level of Courses	Semester	MJ: Discipline Specific Courses – Core or Major (80)	MN: Minor from discipline (16)	MN: Minor from vocational (16)	MDC: Multidisciplinary Courses [Life sciences, Physical Sciences, Mathematical and Computer Sciences, Data Analysis, Social Sciences, Humanities, etc.] (9)	AEC: Ability Enhancement Courses (Modern Indian Language and English) (8)	SEC: Skill Enhancement Courses (9)	VAC: Value Added Courses (6)	IAP: Internship/ Dissertation (4)	RC: Research Courses (12)	AMJ: Advanced Courses in lieu of Research (12)	Credits	Double Major (DMJ)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
100-199: Foundation or Introductory courses	I	4	4		3	2	3	4				20	4+4
	II	4+4		4	3	2	3					20	4+4
	Exit Point: Undergraduate Certificate provided with Summer Internship/ Project (4 credits)												
200-299: Intermediate-level courses	III	4+4	4		3	2	3					20	4+4
	IV	4+4+4		4		2		2				20	4+4
	Exit Point: Undergraduate Diploma provided with Summer Internship in 1st or 2nd year/ Project (4 credits)												
300-399: Higher-level courses	V	4+4+4.	4						4			20	4+4
	VI	4+4+4+4		4								20	4+4
	Exit Point: Bachelor's Degree												
400-499: Advanced courses	VII	4+4+4+4	4									20	4+4
	VIII	4		4						12	4+4+4	20	4+4
												160	224
	Exit Point: Bachelor's Degree with Hons. /Hons. with Research												

Note: Honours students not undertaking research will do 3 courses for 12 credits in lieu of a Research project / Dissertation.

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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	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 **(Vocational)**	3+1
III	MJ – 4	Waves and Optics	3+1
	MJ – 5	Electricity and Magnetism -II	3+1
	MN – 1B	Electricity and Magnetism	3+1
IV	MJ – 6	Mathematical Physics-II	3+1
	MJ – 7	Heat and Thermodynamics	3+1
	MJ – 8	Digital Electronics	3+1
	MN – 2B	Digital Systems **(Vocational)**	3+1
V	MJ – 9	Mathematical Physics-III	3+1
	MJ – 10	Solid State Physics I	3+1
	MJ – 11	Classical Mechanics	3+1
	MN – 1C	Solid State Physics	3+1
	IAP	Internship/Apprentiship/Project	4+0
VI	MJ – 12	Computational Physics	3+1
	MJ – 13	Quantum Mechanics-I	3+1
	MJ – 14	Electrodynamics	3+1
	MJ – 15	Analog Electronics	3+1
	MN – 2C	Renewable Energy and Energy Harvesting **(Vocational)**	3+1
VII	MJ – 16	Quantum Mechanics-II	3+1
	MJ – 17	Statistical Mechanics	3+1
	MJ – 18	Nuclear and Particle Physics	3+1
	MJ – 19	Solid state Physics II	3+1
	MN – 1D	Thermal Physics	3+1
VIII	MJ – 20	Atomic, Molecular and Laser Physics	3+1
	RC	Dissertation Research Project	12 (4+8)
	Or	OR	
	AMJ – 1	Nano Science and Technology	3+1
	AMJ – 2	Fiber Optics and its applications	3+1
	AMJ – 3	Microprocessor and Microcontroller	3+1
	MN – 2D	Applied Optics **(Vocational)**	3+1

Remarks: Honours students not undertaking research will do three courses (AMJ=Advance Major) for 12 credits in lieu of a Research/Dissertation.

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Semester I

MAJOR COURSE- MJ 1	Mechanics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

The objective of this course is to introduce students to the fundamental concepts and principles of classical mechanics, focusing on dynamics, work-energy relations, rotational motion, elasticity, fluid dynamics, gravitation, oscillations, and the basics of relativity. By the end of the course, students will develop a deep understanding of the physical laws governing motion and forces and be able to apply mathematical methods to solve complex physical problems. The course will also emphasize real-world applications and provide a foundation for more advanced studies in physics.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand and apply Newton's laws of motion** to describe the dynamics of particles and systems, including systems of variable mass.
2. **Analyze and solve problems related to the center of mass**, momentum conservation, and the motion of systems in inertial and non-inertial reference frames.
3. **Describe and solve problems in rotational dynamics**, including the concepts of angular momentum, torque, moment of inertia, and energy considerations in rotating systems.
4. **Apply principles of work and energy** to a wide range of mechanical systems, including both conservative and non-conservative forces, and understand the role of energy conservation in various mechanical contexts.
5. **Study elastic and fluid systems**, including the behavior of materials under stress (elasticity), and fluid dynamics with applications to capillary flow and Poiseuille's law.
6. **Understand the fundamentals of gravitation and central force motion**, including the laws of planetary motion, satellite orbits, and Kepler's laws.
7. **Examine oscillatory motion** in both undamped and damped systems, including the resonance phenomenon and real-world examples of oscillations.
8. **Explore the basic concepts of special relativity**, including Lorentz transformations, time dilation, length contraction, and the energy-momentum relation, and apply these to understand relativistic phenomena such as the Doppler effect.

Course Contents:

Fundamentals of Dynamics (08 HRS):

Reference frames: Inertial and non-inertial frames, Galilean transformations and invariance. Review of Newton's laws. Dynamics of a system of particles, center of mass, and conservation of momentum. Motion of a variable-mass system (rocket motion). Fictitious forces in non-inertial frames: Centrifugal and Coriolis forces with applications.

Work, Energy, and Collisions (06 HRS):

Work-energy theorem. Conservative and non-conservative forces with examples (gravity, friction). Potential energy and energy diagrams. Conservation of energy. Elastic and inelastic collisions in one and two dimensions, center of mass and laboratory frames.

Rotational Dynamics (06 HRS):

Angular momentum and torque. Conservation of angular momentum. Rotation about a fixed axis, moment of inertia (rectangular, cylindrical, and spherical bodies). Kinetic energy of rotation. Rolling motion.

Elasticity and Fluid Motion (04 HRS):

Elastic constants and their relations. Twisting torque on a cylinder or wire. Bending of beams, cantilever, flexural rigidity. Poiseuille's equation for capillary flow.

Gravitation and Central Force Motion (07 HRS):

Newton's law of gravitation. Gravitational potential and field. Motion under a central force: two-body problem and reduction to an equivalent one-body problem. Energy equation and energy diagram. Kepler's laws and their derivation. Satellite motion, geosynchronous orbits.

Oscillations (07 HRS):

Simple harmonic motion (SHM): Energy considerations, time-averaged values. Damped oscillations: Equation of motion, solutions, and physical interpretation. Forced oscillations: Transient and steady states, resonance, quality factor. Real-world examples of resonance.

Relativity (07 HRS):

Michelson-Morley experiment and its implications. Postulates of special relativity. Lorentz transformations, length contraction, time dilation, velocity transformation, and mass-energy equivalence. Relativistic Doppler effect and kinematics. Energy-momentum transformation.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning
5. Feynman Lectures, Vol. I, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
8. Concept of Physics, H C Verma
9. Properties of matter D S Mathur
10. Mechanics & Electrodynamics, by Brijlal & Subramaniam.
11. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw Hill Education

MAJOR COURSE- MJ 1	Mechanics	(Practical Credit-01) (Total Marks=25)

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 COURSE-MN1A	Mechanics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

The objective of this course is to introduce students to fundamental concepts in mechanics, including vector analysis, differential equations, laws of motion, energy and momentum conservation, rotational dynamics, gravitation, oscillations, elasticity, fluid motion, and special relativity. The course aims to build a solid foundation in classical mechanics and provide students with the mathematical tools needed to analyze physical systems. By the end of the course, students will be able to apply these concepts to solve problems in a variety of contexts and gain insight into both macroscopic and relativistic phenomena.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand the concept of vector algebra** and use scalar and vector products in solving problems related to forces, motion, and other physical quantities.
2. **Solve first and second-order ordinary differential equations**, particularly in the context of mechanical systems, and apply these solutions to model the behavior of physical systems.
3. **Understand and apply Newton's Laws of motion** to analyze the dynamics of particles and systems, including concepts such as the center of mass and conservation of momentum.
4. **Utilize the work-energy theorem** to solve problems involving conservative and non-conservative forces, and understand the principles of energy conservation and rocket motion.
5. **Analyze rotational motion**, including angular velocity, angular momentum, torque, and moment of inertia for simple bodies, and apply the concept of angular momentum conservation.
6. **Apply Newton's law of gravitation** to understand motion in central force fields, including the derivation of Kepler's laws, satellite motion, and the concept of weightlessness.
7. **Examine oscillatory motion**, including simple harmonic motion (SHM), damped and forced oscillations, and understand resonance and real-world applications of these phenomena.
8. **Understand the fundamentals of elasticity and fluid motion**, including the behavior of materials under stress (elasticity) and fluid dynamics, with applications to Poiseuille's equation for capillary flow.
9. **Grasp the principles of special relativity**, including Lorentz transformations, time dilation, length contraction, mass-energy equivalence, and the relativistic Doppler effect, and apply these concepts to relativistic kinematics and energy-momentum transformations.

Course Contents:

Vectors (03 HRS): Vector algebra, scalar and vector products, derivatives of a vector with respect to a parameter.

Ordinary Differential Equations (04 HRS): 1st order homogeneous differential equations, 2nd order homogeneous differential equations with constant coefficients.

Laws of Motion (03 HRS): Frames of reference, Newton's Laws of motion, dynamics of a system of particles, center of mass.

Momentum and Energy (04 HRS): Conservation of momentum, work-energy theorem, conservative and non-conservative forces, conservation of energy, motion of rockets.

Rotational Motion (04 HRS): Angular velocity and angular momentum, torque, conservation of angular momentum, moment of inertia for simple bodies**.**

Gravitation (06 HRS): Newton's law of gravitation, motion of a particle in a central force field (motion in a plane, angular momentum conservation, areal velocity constant), Kepler's laws, satellite motion, geosynchronous orbits, weightlessness**.**

Oscillations (08 HRS): Simple harmonic motion (SHM): Energy considerations, time-averaged values. Damped oscillations: Equation of motion, solutions, and physical interpretation. Forced oscillations: Transient and steady states, resonance, quality factor. Real-world examples of resonance.

Elasticity and Fluid Motion (05 HRS): Elastic constants and relations, twisting torque on a cylinder or wire, Poiseuille's equation for capillary flow.

Special Theory of Relativity (08 HRS): Michelson-Morley experiment and its implications. Postulates of special relativity. Lorentz transformations, length contraction, time dilation, relativistic addition of velocities, mass-energy equivalence. Relativistic Doppler effect and kinematics. Energy-momentum transformation.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow,1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al.2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G. R. Fowles and G. L. Cassiday. 2005, Cengage Learning.
5. Feynman Lectures, Vol.I, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
8. Concept of Physics, H C Verma
9. Properties of matter D S Mathur
10. Mechanics & Electrodynamics, by Brijlal & Subramaniam.
11. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw Hill Education

MINOR COURSE- MN1A	Mechanics	(Practical Credit-01) (Total Marks=25)

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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.
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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.

MDC-I/2/3:	ELEMENTS OF MODERN PHYSICS	(Theory Credit -03) (Total Marks=75)

Course Objective:

The objective of this course is to introduce students to the foundational concepts of modern physics, focusing on the nature of light, quantum theory, wave-particle duality, introductory nuclear physics, and the basics of laser technology. Students will develop a deep understanding of key quantum mechanical principles, such as wave functions, uncertainty relations, and the Schrodinger equation, and explore the phenomena of photoelectric effect, Compton scattering, and nuclear processes. The course aims to provide a solid grounding in the principles that govern atomic and subatomic phenomena, preparing students for advanced studies in quantum mechanics and nuclear physics.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand the nature of light** as both a wave and a particle, applying Planck’s constant, and explain phenomena such as blackbody radiation, photoelectric effect, and Compton scattering.
2. **Explain the concept of matter waves** and de Broglie’s hypothesis, and describe wave-particle duality, including the interpretation of wave functions and the Heisenberg uncertainty principle.
3. **Apply the principles of wave mechanics** to analyze phenomena like the two-slit experiment, and understand the concepts of phase velocity, group velocity, and the relation between them.
4. **Understand the basic principles of quantum mechanics**, including the Schrödinger equation for non-relativistic particles, energy and momentum operators, stationary states, and the interpretation of wave functions in terms of probabilities.
5. **Analyze quantum behavior in one-dimensional systems**, including probabilities, probability densities, and normalization of wave functions.
6. **Understand the physics of lasers**, including Einstein’s coefficients, spontaneous and stimulated emission, metastable states, population inversion, and the operation of Ruby and He-Ne lasers.
7. **Grasp the fundamentals of nuclear physics**, including the size, structure, and stability of the atomic nucleus, nuclear forces, binding energy, and the processes of nuclear fission and fusion.
8. **Understand radioactivity**, including the law of radioactive decay, half-life, and the various types of decay (alpha, beta, gamma), as well as the energy-momentum conservation in processes such as electron-positron pair creation.

Course Contents:

Unit-I (15 HRS):

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.

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.

Unit – II: Introductory Quantum Theory & Laser (15 HRS)

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.

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.

Unit – III: Introductory Nuclear Physics (15 HRS)

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.

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.

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
5. Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill
6. Quantum Mechanics: Theory & Applications, A. K. Ghatak & S. Lokanathan, 2004, Macmillan.
7. Quantum mechanics Gupta Kumar.
8. Quantum mechanics H C Verma.

Semester II

MAJOR COURSE- MJ 2	Mathematical Physics-I	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

The objective of this course is to equip students with the mathematical tools essential for solving physical problems. The course introduces fundamental concepts of calculus, differential equations, vector calculus, and special functions, which are widely applied in various branches of physics. Emphasis is placed on the physical interpretation of mathematical operations and their applications in real-world problems. By the end of the course, students will develop problem-solving skills necessary for advanced topics in theoretical and applied physics.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Apply calculus techniques** such as Taylor and binomial series expansions to approximate functions and solve problems in mathematical physics.
2. **Solve first and second-order differential equations**, including homogeneous equations with constant coefficients, and understand the significance of the Wronskian in determining the independence of solutions.
3. **Understand the fundamentals of vector calculus**, including vector algebra, triple products, and their physical interpretations in different coordinate systems.
4. **Compute derivatives of scalar and vector fields**, including directional and normal derivatives, and apply operators such as gradient, divergence, curl, and Laplacian with physical significance.
5. **Evaluate vector integrals** using multiple integration techniques, and apply Gauss' divergence theorem, Green's theorem, and Stokes' theorem to solve physics problems.
6. **Understand and derive vector differential operators** in orthogonal curvilinear coordinates, including Cartesian, spherical, and cylindrical systems.
7. **Grasp the concept of the Dirac delta function**, its representations, and its properties, and apply it in solving integral problems.
8. **Evaluate special integrals** involving Beta and Gamma functions, understand their interrelation, and use them in mathematical physics applications.
9. **Apply the error function** in statistical and probability distributions relevant to physics.

Course Contents:

Calculus (06 HRS): Functions and their graphical representation. Taylor and binomial series expansion. First-order differential equations and their solutions. Partial derivatives and applications. Exact and inexact differentials, integrating factor.

Second Order Differential equations (06 HRS): Homogeneous equations with constant coefficients, Wronskian and its significance, general solutions. Statement of existence and uniqueness theorem for initial value problems, Particular integrals.

Vector Calculus (05 HRS): Recapitulation of vector algebra, properties under rotations. Scalar and vector triple products with physical interpretation. Scalar and vector fields. **Vector Differentiation (05 HRS):** Directional derivative, normal derivative. Gradient, divergence, curl, and Laplacian with physical significance. Vector identities and their proofs.

Vector Integration (08 HRS): Ordinary Integrals of Vectors. Multiple integrals, Jacobian, Line, surface, and volume integrals, Gauss' divergence theorem, Green's theorem, and Stokes' theorem with applications in physics.

Orthogonal Curvilinear Coordinates (05 HRS): Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Dirac Delta function and its properties (05 HRS): Definition, Representation as limit of a Gaussian function and rectangular function, Properties of Dirac delta function.

Some Special Integrals (05 HRS): Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function.

Reference Books:

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

MAJOR COURSE- MJ 2	Mathematical Physics-I	(Practical Credit-01) (Total Marks=25)

1. Programming Language (C/C++/Python/Scilab) :
   Basic Syntax: Variables, data types, operators, Control Structures: if-else, loops (for, while), Functions, Arrays/Lists, Input/Output, Data Structures, String Manipulation, File Input/Output: Writing to a file in Python (open(), write()), C (fopen(), fprintf(), fclose()), Scilab (write()), Error Handling, Basic Algorithms: Linear search, Binary search, Bubble sort, Insertion sort, Quick sort.
2. Plotting/Visualization: Gnuplot/Python/Scilab
3. Programs:
   I. Roots of a Quadratic Equation,
   II. Sum and Average of Numbers,
   III. Sum, Difference and Product of Matrices,
   IV. Largest of Three Numbers,
   V. Factorial of an Integer by Normal Method and by Recursion,
   VI. Largest of a List of Numbers and its Location in the List,
   VII. Fitting a Straight Line to a Data,
   VIII. Deviations About an Average,
   IX. Arrange a List of Numbers in Ascending and Descending Order,
   X. Binary Search.
   XI. Implement a function that approximates $f(x)=e^x$ using a Taylor series expansion around x=0. Write a program to compute and plot the approximation for different numbers of terms and compare it with the exact function.
   XII. Write a program to visualize the divergence and curl of a vector field $\vec{F}(x,y) = (y,-x)$ in 2D.
   XIII. Write a program to compute the Gamma and Beta functions for various inputs using their integral definitions. Compare the results with the known analytical expressions and visualize these functions.

Reference Books:

1. The C Programming language, Brian W.Kernigham and Dennis M.Ritchie
2. Programming in ANSI C, E Balagurusamy
3. Let Us C, Yashavant Kanetkar
4. Python in a Nutshell, Alex Martelli
5. Core Python Programming, Wesley J. Chun
6. Scilab, from theory to practice, Perrine Mathieu and Philippe Roux, 2016
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. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
11. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw Hill Pub.
12. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn., 2007, Cambridge University Press.
13. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.

14. Elementary Numerical Analysis, K.E. Atkinson, 3 r d Edn., 2007, Wiley India Edition.
15. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
16. An Introduction to computational Physics, T. Pang, 2nd Edn. , 2006,Cambridge Univ.

MAJOR COURSE- MJ 3	Electricity and Magnetism-I	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course aims to develop a strong conceptual foundation in electricity and magnetism by introducing fundamental circuit elements, DC and AC circuits, network theorems, and measurement techniques. Emphasis is placed on analytical problem-solving, practical applications, and understanding the behavior of electrical circuits using mathematical techniques. The course also covers AC bridges and ballistic galvanometers, which are essential for precise electrical measurements.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand basic circuit elements** and apply Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) to analyze resistive networks using mesh and nodal methods.
2. **Analyze DC circuits**, including the growth and decay of current in CR, LR, and series LCR circuits.
3. **Solve AC circuit problems** by applying Kirchhoff's laws, calculating complex reactance and impedance, and analyzing series and parallel LCR circuits for resonance, power dissipation, quality factor, and bandwidth.
4. **Understand the working principles of a ballistic galvanometer**, including torque on a current loop, charge sensitivity, and logarithmic damping.
5. **Apply AC bridge techniques**, such as Anderson's, De Sauty's, Owen's, Schering's, and Carey-Foster's bridges, to measure electrical parameters accurately.
6. **Utilize network theorems**, including Thevenin's, Norton's, Superposition, Reciprocity, Maximum Power Transfer, Miller's, Wye-Delta transformation, and Tellegen's theorem, for circuit analysis and simplification.
7. **Analyze two-port networks** using T and π representations and understand parameter representations such as H, Y, Z, and ABCD matrices.

Course Contents:

Introduction (09 HRS): Review of ideal circuit elements, Kirchhoff's Voltage Law (KVL), Kirchhoff's Current Law (KCL), resistive networks, mesh and nodal analysis, delta and star connections.

DC circuits (06 HRS): growth and decay of current in CR, LR and Series LCR circuit.

AC Circuits (07 HRS): 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.

Ballistic Galvanometer (04 HRS): Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Logarithmic damping.

AC bridges (06 HRS): Anderson's, De Sauty's, Owen's, Schering and Carey-Foster's bridges with their vector diagrams.

Network theorems (12 HRS): Ideal Constant-voltage and Constant-current Sources, 2-port networks and its T and π representations, T and π equivalence, H, Y, Z and ABCD- parameters representations, Thevenin, Norton, Superposition, Reciprocity and Maximum power transfer theorems, Miller theorem, Wye-delta transformation, Tellegens theorem.

Reference Books

1. Hayt and Kermerley: ENGINEERING CIRCUIT ANALYSIS
2. Chua, Desoer, Kuh: LINEAR AND NON-LINEAR CIRCUITS.
3. Van Valkenburg: NETWORK ANALYSIS
4. Van Valkenburg: INTRODUCTORY NETWORK SYNTHESIS
5. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
6. A Text Book in Electrical Technology, B. L. Theraja.
7. Electricity and Magnetism, K. K. Tewari
8. Electricity and Magnetism, Rakshit and Chottopadhay

MAJOR COURSE- MJ 3	Electricity and Magnetism-I	(Practical Credit -01) (Total Marks=25)

1. To verify the Thevenin and Norton theorems.
2. To verify the Superposition and Maximum power transfer theorems.
3. To determine self-inductance of a coil by Anderson's bridge.
4. To determine an unknown Low Resistance using Potentiometer.
5. To compare capacitances using De'Sauty's bridge.
6. Determination of constants of a ballistic galvanometer.
7. Determination of figure of merit of a moving coil galvanometer.
8. To study a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor.
9. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
10. To study the Characteristics of a Series RC Circuit.

Reference Books

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

MINOR COURSE- MN 2A	ELECTRICAL CIRCUITS NETWORK & BASIC INSTRUMENTATION SKILLS	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course aims to provide students with a strong foundation in electrical circuits, network analysis, and basic instrumentation skills. It introduces fundamental electrical principles, circuit elements, power components, and protection mechanisms. The course also emphasizes practical aspects such as electrical schematics, wiring, measurement techniques, and the use of various electrical and electronic instruments, including multimeters, oscilloscopes, and signal generators.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand basic electrical principles** including voltage, current, resistance, power, and Ohm's law, and apply them to analyze AC and DC circuits.
2. **Analyze electrical circuits** by determining current and voltage drops across various elements, understanding real, imaginary, and complex power components, and calculating power factor.
3. **Interpret electrical drawings and schematics**, including symbols, power circuits, control circuits, and ladder diagrams, to track connections and identify current flow and voltage drops.
4. **Explain the working principles of generators and transformers**, including AC and DC generators, transformer construction, and operation.
5. **Understand the fundamentals of electric motors**, including single-phase and three-phase AC/DC motors, their design, speed, and power considerations.
6. **Identify and apply electrical protection mechanisms** such as relays, fuses, circuit breakers, overload devices, grounding, and phase reversal protection.
7. **Perform electrical wiring tasks**, including selecting and connecting conductors and cables, understanding star and delta connections, measuring voltage drop, and assembling extension boards.
8. **Develop basic measurement skills** by understanding accuracy, precision, sensitivity, resolution, and error analysis in electrical instruments.
9. **Operate measurement instruments** such as multimeters, voltmeters, and oscilloscopes to measure voltage, current, resistance, and signal characteristics.
10. **Use signal generators and analysis instruments**, including low-frequency signal generators, pulse/function generators, and wave analyzers, for testing and troubleshooting electrical circuits.
11. **Apply impedance measurement techniques** using RLC bridges, Q-meters, and digital LCR bridges for circuit analysis and component testing.
12. **Compare and utilize digital instruments**, including digital voltmeters and multimeters, and measure time intervals, frequency, and period using universal counters.

This outcome-based approach ensures that students acquire both theoretical knowledge and hands-on skills in electrical circuits and instrumentation, preparing them for advanced studies and practical applications in electrical engineering and physics.

Course Contents:

Basic Electricity Principles (02 HRS): Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC and DC current.

Electrical Circuits (03 HRS): Main electric circuit elements and their combination. Current and voltage drop across the DC circuit elements. Real, imaginary and complex power components of AC source. Power-factor.
Electrical Drawing and Symbols (02 HRS): Drawing symbols. 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.
Generators and Transformers (04 HRS): AC & DC generators. Principle, construction and working of transformers.
Electric Motors (03 HRS): Single-phase, three-phase connections, AC & DC motors. Basic design, Speed & power of AC/DC motor.
Electrical Protection (03 HRS): Relays. Fuses and disconnect switches. Circuit breakers, Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal.
Electrical Wiring (03 HRS): 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, Cable trays. Splices and solder. Preparation of extension board.
Basic of Measurement (05 HRS): 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.
Electronic Voltmeter (05 HRS): 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.
Cathode Ray Oscilloscope (05 HRS): Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), Specifications of a CRO and their significance. Uses of CRO , Digital storage Oscilloscope: Block diagram and principle of working.
Signal Generators and Analysis Instruments (03 HRS): Low frequency signal generators. Pulse generator, and function generator. Distortion factor meter, wave analysis.
Impedance Bridges & Q-Meters (04 HRS): Working principles ofbasic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & workingprinciples of a Q- Meter. Digital LCR bridges.
Digital Instruments (03 HRS): Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.
Digital Multimeter (03 HRS): 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.

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.
9. Essentials of Circuit Analysis, Robert L. Boylestad, Pearson Education (2004)
10. Introductory circuit analysis, R. Boylestead, 2016, Pearson

MINOR COURSE- MN 2A	ELECTRICAL CIRCUITS NETWORK & BASIC INSTRUMENTATION SKILLS	(Practical Credit -01) (Total Marks=25)

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
10. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
11. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
12. To measure Q of a coil and its dependence on frequency, using a Q- meter.
13. Measurement of voltage, frequency, time period and phase angle using CRO.
14. Measurement of rise, fall and delay times using a CRO.
15. Measurement of distortion of a RF signal generator using distortion factor meter.
16. Measurement of R, L and C using a LCR bridge/ universal bridge.

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.
4. Electronic circuits: Handbook of design and applications, U. Tietze, Ch. Schenk, 2008, Springer
5. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson.
6. Introductory circuit analysis, R. Boylestead, 2016, Pearson

Semester III

MAJOR COURSE- MJ 4	Waves and Optics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course aims to provide students with a comprehensive understanding of wave phenomena and optical principles. It covers harmonic oscillations, wave motion, interference, diffraction, and polarization, with a focus on both theoretical concepts and experimental applications. By the end of the course, students will develop a solid foundation in wave optics, enabling them to analyze and apply optical principles in various physical systems.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand and apply the principle of superposition** to analyze the superposition of harmonic oscillations, beat formation, and Lissajous figures with their applications.
2. **Describe the fundamental properties of wave motion**, including plane and spherical waves, longitudinal and transverse waves, wave equations, and energy transport in different media.
3. **Analyze stationary waves** and determine the velocity of transverse vibrations in stretched strings and longitudinal waves in fluids using Newton's and Laplace's formulas.
4. **Explain the principles of interference**, including temporal and spatial coherence, Young's double-slit experiment, Fresnel's biprism, and interference in thin films.
5. **Apply the concepts of interference in optical instruments**, including Newton's rings, Michelson and Fabry-Perot interferometers, and their applications in wavelength and refractive index measurement.
6. **Study diffraction phenomena**, including Fraunhofer and Fresnel diffraction, and analyze single-slit, double-slit, multiple-slit, and circular aperture diffraction patterns.
7. **Evaluate the resolving power of optical instruments**, such as telescopes and diffraction gratings, based on diffraction principles.
8. **Apply Fresnel's assumptions and zone plate theory** to explain rectilinear propagation of light and diffraction effects due to edges, slits, and wires.
9. **Understand the concept of polarization**, including linear, circular, and elliptical polarization, and study the propagation of electromagnetic waves in anisotropic media.
10. **Analyze double refraction in uniaxial and biaxial crystals** and explain the working of Nicol prisms and wave plates (quarter-wave and half-wave plates).
11. **Demonstrate an understanding of rotatory polarization**, including Biot's laws, Fresnel's theory of optical rotation, and the concept of specific rotation in optically active materials.
12. **Apply optical principles to real-world applications**, such as spectroscopy, laser optics, and optical communication systems.

This outcome-based approach ensures that students gain both conceptual and practical insights into wave and optical phenomena, preparing them for advanced studies and experimental research in optics.

Course Contents:

Superposition of Collinear and two perpendicular Harmonic oscillations (08 HRS): 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 and unequal frequencies and their applications.

Wave Motion (09 HRS): 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, 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. Stationary Waves, Properties of Stationary Waves, Velocity of a Particle at any Point in a Stationary Wave, Harmonics in Stationary Waves.

Interference (05 HRS): Temporal and Spatial Coherence. Division of amplitude and wavefront. Young's double slit experiment. Fresnel's Biprism. Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Haidinger and Fizeau Fringes. Newton's Rings: Measurement of wavelength and refractive index.

Interferometer (02 HRS): Michelson Interferometer, Fabry-Perot interferometer.

Fraunhofer diffraction (06 HRS): Single Slit, Double Slit, Multiple Slits, Diffraction Grating, Circular Aperture. Resolving Power of Telescope and Grating.

Fresnel Diffraction (06 HRS): Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Waves. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral. Fresnel Diffraction Pattern of a Straight Edge, Slit, and Wire.

Polarization of Electromagnetic Waves (06 HRS): Linear, Circular, and Elliptical Polarization. Propagation of EM Waves in Anisotropic Media. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystals. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & Extraordinary Refractive Indices. Production and Detection of Plane, Circularly, and Elliptically Polarized Light. Quarter-Wave and Half-Wave Plates.

Rotatory Polarization (03 HRS): Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Specific rotation.

Reference Books

1. Waves and Acoustics, P. K. Chakraborty and Satyabrata Chowdhury.
2. Introduction to Geometrical and Physical Optics, B. K. Mathur.
3. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
4. Geometrical and Physical Optics, P. K. Chakraborty.
5. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
6. Fundamentals of Optics: Jenkins and White, McGraw Hill
7. The physics of Vibrations and Waves: H. J. Pain, Wiley
8. Optics: E. Hecht and A R. Ganesan, Pearson, India

MAJOR COURSE- MJ 4	Waves and Optics	(Practical Credit -01) (Total Marks=25)

1. Understand the applications of CRO by measuring voltage and time period of a periodic waveform using CRO. And study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures).
2. Familiarization with: Schuster`s focusing; determination of angle of prism.
3. To determine refractive index of the Material of a prism using sodium source.
4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine wavelength of sodium light using Fresnel Biprism.
6. To determine wavelength of sodium light using Newton's Rings.
7. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
8. To determine dispersive power and resolving power of a plane diffraction grating.
9. To verify the law of Malus for plane polarized light.
10. To determine the specific rotation of sugar solution using Polarimeter.
11. To study diffraction due to straight edge.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia, Publishing House.
2. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
4. A Text Book of Practical Physics, Vol I and II, Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
5. An Introduction to Error Analysis: The study of uncertainties in Physical Measurements, J. R. Taylor, 1997, University Science Books List of experiments.

MAJOR COURSE- MJ 5	Electricity and Magnetism-II	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course aims to provide students with a deep understanding of advanced topics in electricity and magnetism, including electrostatics, electric fields in matter, magnetostatics, induction, and magnetic properties of materials. The emphasis is on mathematical formulations and physical interpretations, helping students develop problem-solving skills in classical electromagnetism.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand the fundamental principles of electrostatics**, including quantization, conservation, and invariance of electric charge.
2. **Apply Coulomb's Law and Gauss's Law** to solve problems related to electric fields from continuous charge distributions.
3. **Analyze electrostatic potential and energy**, solve Poisson's and Laplace's equations, and apply boundary conditions for electric fields.
4. **Apply the method of images** and multipole expansion to calculate electric potentials in various charge distributions.
5. **Describe the behavior of electric fields in matter**, including polarization, electric displacement, dielectric properties, and energy storage in dielectric systems.
6. **Solve boundary value problems** for dielectric interfaces and understand forces acting on dielectric materials.
7. **Understand magnetostatics and apply the Biot-Savart law and Ampere's law** to determine magnetic fields due to steady currents.
8. **Compare electrostatics and magnetostatics**, and analyze the concept of the vector potential, boundary conditions, and multipole expansion of magnetic fields.
9. **Apply Faraday's Law of induction** to analyze electromagnetic induction, RLC circuits, and the displacement current.
10. **Introduce Maxwell's Equations** and their role in unifying electricity and magnetism.
11. **Study magnetic fields in matter**, including magnetization in diamagnetic, paramagnetic, and ferromagnetic materials.
12. **Analyze torques and forces on magnetic dipoles** and understand the effect of magnetic fields on atomic orbits.
13. **Understand bound currents and their physical interpretation**, and apply Ampere's law in magnetized materials.
14. **Differentiate between linear and nonlinear magnetic media**, magnetic susceptibility, permeability, and ferromagnetic behavior.

This outcome-based structure ensures that students develop a strong foundation in electromagnetism, preparing them for advanced topics such as electrodynamics and applications in engineering and physics.

Course Contents:

ELECTROSTATICS (05 HRS): Quantization, conservation and invariance of electric charge, Electric field: Coulomb's Law, continuous charge distributions. Divergence and curl of electrostatic fields: field lines, flux, Gauss's Law, divergence of E, applications of Gauss's law, curl of E.

ELECTRIC POTENTIAL AND ENERGY (10 HRS): Poisson equation and Laplace's equation, potential of a localized charge distribution, electrostatic boundary conditions. Work and energy in electrostatics: work done to move a charge, energy of a point charge and continuous charge distribution. Conductors, induced charges, surface charge and force on a conductor, capacitors. Method of Images. Multipole expansion of scalar potential.

ELECTRIC FIELDS IN MATTER (10 HRS): Microscopic and Macroscopic fields, Polarization: dielectrics, induced dipoles, polarization. Field of a polarized object, electric displacement, Gauss's law in the presence of dielectrics, linear dielectrics, susceptibility, permittivity, dielectric constant, boundary value problems, boundary conditions at interface of dielectrics, energy in dielectric systems and forces on dielectrics.

MAGNETOSTATICS AND INDUCTION (10 HRS): Lorentz force law, Biot-Savart law: magnetic field of a steady current. Divergence and curl of B, applications of Ampere's law, comparison of magnetostatics and electrostatics. Magnetic vector potential boundary conditions, multipole expansion of the vector potential. Absence of magnetic monopoles. Faraday's Law of induction; RLC circuits, displacement current and introduction to Maxwell's equations.

MAGNETIC FIELDS IN MATTER (10 HRS): Magnetization: diamagnets, paramagnets, ferromagnets, torques and forces on magnetic dipoles, effect of magnetic field on atomic orbits, magnetization. Field of a magnetized object: bound currents, physical interpretation, magnetic field inside matter, auxiliary field H, Ampere's law in Magnetized materials, linear and nonlinear media: magnetic susceptibility and permeability, ferromagnetism.

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.
9. Fundamental of Magnetism and Electricity, by D. N. Vasudiva.

MAJOR COURSE- MJ 5	Electricity and Magnetism-II	(Practical Credit -01) (Total Marks=25)

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Measurement of field strength B & its variation in a Solenoid (Determine dB/dx).
3. Magnetic field in the centre of a current carrying wire.
4. Determination of Self-Induction Coefficient (L) of a Coil.
5. To study B-H curves for different ferromagnetic materials using C.R.O.
6. To determine the frequency of A.C. main using Sonometer.
7. To determine the resistance of an electrolyte for AC current and study its concentration dependence.
8. To study the magnetic field produced by a current carrying solenoid using a pick-up coil and to find the value of permeability of air.
9. To determine the dielectric constant of a liquid.

Reference Books:

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

MINOR COURSE- 1B	Electricity and Magnetism	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course provides students with fundamental concepts of electricity and magnetism, including electrostatics, dielectrics, magnetostatics, and electromagnetic wave propagation. It emphasizes problem-solving and mathematical techniques to understand electric and magnetic fields and their interaction with matter.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand electric fields and potentials**, including the derivation of Laplace's and Poisson's equations and their applications.
2. **Apply the Uniqueness Theorem** to solve electrostatic boundary value problems.
3. **Analyze electric dipoles**, their potential, field, force, and torque in an electrostatic field.
4. **Calculate electrostatic energy** for different charge distributions, including charged spheres and systems of charges.
5. **Explain the behavior of conductors in an electrostatic field**, including surface charge distributions and forces.
6. **Determine capacitance for different configurations**, such as parallel-plate, spherical, and cylindrical capacitors.
7. **Understand dielectric properties of matter**, including polarization, polarization charges, susceptibility, and dielectric constants.
8. **Apply Gauss's Law in dielectric materials** and analyze relations between **E, P, and D** fields.
9. **Describe the magnetic field using Biot-Savart's Law** and apply it to straight wires and current loops.
10. **Explain the concept of a current loop as a magnetic dipole** and its analogy with electric dipoles.
11. **Use Ampere's Law** to calculate magnetic fields in symmetric configurations.
12. **Analyze the properties of the magnetic field**, including divergence, curl, and the vector potential.
13. **Calculate magnetic forces on moving charges and current-carrying wires**, and understand torque on current loops.
14. **Understand magnetization and magnetic intensity** and their relation to **B, H, and M** in materials.
15. **Explain ferromagnetism and study the B-H curve and hysteresis phenomena.**
16. **Understand the principles of the ballistic galvanometer**, including torque, current sensitivity, damping, and logarithmic decay.
17. **Review Maxwell's equations** and apply them to derive the electromagnetic wave equation.
18. **Understand displacement current and gauge transformations** (Lorentz and Coulomb gauge).
19. **Analyze electromagnetic waves in dielectric media**, including boundary conditions.
20. **Apply the Poynting theorem** to understand electromagnetic energy density and energy flow.

This course provides a foundational understanding of electromagnetism, preparing students for advanced studies in electrodynamics, optics, and applied physics.

Course Contents:

Electric Field and Electric Potential (10 HRS). 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. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor.

Dielectric Properties of Matter (08 HRS): 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.

Magnetic Field (10 HRS): 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 Circuital Law and its application. Properties of B: curl and divergence. Vector Potential. Magnetic Force on point charge, current carrying wire and between current elements. Torque on a current loop in a uniform Magnetic Field.

Magnetic Properties of Matter (05 HRS): Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.

Ballistic Galvanometer (03 HRS): Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.

Maxwell Equations (09 HRS): 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.

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
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. Fundamental of Magnetism and Electricity, by D. N. Vasudiva.

MINOR COURSE- 1B	Electricity and Magnetism	(Practical Credit -01) (Total Marks=25)

1. Measurement of field strength B & its variation in a Solenoid (Determine dB/dx).
2. Magnetic field in the centre of a current carrying wire.
3. Determination of Self-Induction Coefficient (L) of a Coil.
4. To study B-H curves for different ferromagnetic materials using C.R.O.
5. To determine the frequency of A.C. main using Sonometer.
6. To determine the resistance of an electrolyte for AC current and study its concentration dependence.
7. To study the magnetic field produced by a current carrying solenoid using a pick-up coil and to find the value of permeability of air.
8. Determination of constants of a ballistic galvanometer.
9. Determination of figure of merit of a moving coil galvanometer.

Reference Books:

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

Semester IV

MAJOR COURSE- MJ 6	MATHEMATICAL PHYSICS- II	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course introduces students to advanced mathematical techniques essential for solving problems in physics. It covers Fourier series, special functions, partial differential equations, and integral transforms, providing a strong foundation for theoretical and applied physics.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand and apply Fourier series** to represent periodic functions, determine Fourier coefficients, and use orthogonality properties of sine and cosine functions.
2. **Utilize complex Fourier series representation** and expand functions with arbitrary periods, including even and odd function expansions.
3. **Apply Fourier series techniques** to solve physical problems in heat conduction, signal processing, and wave analysis.
4. **Solve differential equations using the Frobenius method**, particularly in cases where power series solutions are needed.
5. **Analyze special functions** such as Legendre, Bessel, Hermite, and Laguerre functions, which frequently appear in physics problems.
6. **Understand the properties of Legendre polynomials**, including Rodrigues' formula, generating functions, orthogonality, and recurrence relations.
7. **Expand functions in a series of Legendre polynomials** and apply them to solve physics problems, especially in electrostatics and quantum mechanics.
8. **Understand Bessel functions**, their generating functions, recurrence relations, orthogonality, and the significance of their zeros.
9. **Solve partial differential equations (PDEs) using separation of variables** in Cartesian, cylindrical, and spherical coordinate systems.
10. **Apply PDE techniques to solve Laplace's equation** in symmetric physical problems.
11. **Solve the wave equation for vibrational modes of a stretched string**, understanding the role of boundary conditions.
12. **Understand Fourier transforms and the Fourier integral theorem** and apply them to represent non-periodic functions.
13. **Compute Fourier transforms** for trigonometric, Gaussian, and finite wave train functions.
14. **Express the Dirac delta function** as a Fourier integral and compute the Fourier transforms of derivatives.
15. **Understand inverse Fourier transforms** and their properties, including translation, scaling, and conjugation.
16. **Apply Fourier transforms to solve differential equations**, particularly in wave and heat conduction problems.
17. **Understand and compute Laplace transforms** for elementary functions and use properties such as shifting and scaling theorems.
18. **Evaluate Laplace transforms of derivatives and integrals** and apply them to solve differential equations.
19. **Compute the Laplace transform of the unit step function and periodic functions**, and use the convolution theorem in problem-solving.

This course equips students with essential mathematical techniques for advanced studies in quantum mechanics, electrodynamics, fluid mechanics, and other branches of physics.

Course Contents:

Fourier Series (10 HRS): 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.

Frobenius Method and Special Functions (10 HRS): Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials, Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ($J_0(x)$ and $J_1(x)$) and Orthogonality, Hermite differential equation. Rodrigues formula. Generating function. Recurrence relations. Orthogonality Laguerre differential equation. Rodrigues formula. Generating function. Recurrence relations.

Partial Differential Equations (05 HRS): 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.

Integrals Transforms (10 HRS): 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.

Laplace Transforms (10 HRS): Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2^{nd} order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

Reference Books:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S. J. Farlow, 1993, Dover Publication
6.

MAJOR COURSE- MJ 6	MATHEMATICAL PHYSICS- II	(Practical Credit-01) (Total Marks=25)

1. Write a program to compute and plot the Fourier series of a given periodic function, such as a square wave, triangular wave, or sawtooth wave. Visualize the convergence of the Fourier series by increasing the number of terms (harmonics) in the series. Observe how the approximation improves with more terms, and plot the original function alongside its Fourier series for comparison.
2. Write a program to compute and plot the first few Legendre polynomials Pn(x) using the recurrence relation or Rodrigues' formula. Plot these polynomials for different values of n and observe their behaviour as n increases. Compare the results with known properties of Legendre polynomials, such as orthogonal.
3. Implement a program to compute and plot the first few Bessel functions Jn(x) for varying n using a recurrence relation or integral representation. Visualize their behaviour for different values of x and analyze their oscillatory nature. Investigate the zeros of $J_0(x)$ and $J_1(x)$ and plot them.
4. Write a program to compute and plot the error function erf(x) for different values of x. Investigate its significance in statistics and probability, particularly in the context of normal distribution, and plot its values over a range of x.
5. Solve Laplace's equation in 2D or 3D using finite difference methods. Apply boundary conditions to the domain and observe the steady-state solutions. Visualize the potential field and analyze the effects of different boundary conditions on the solution.
6. Solve the 1D wave equation for a vibrating string using separation of variables or numerical methods like finite differences. Visualize the modes of vibration for various boundary conditions (fixed, free, etc.), and analyze how the wave propagates over time.
7. Write a program to compute and plot the Fourier transform of simple functions, such as a Gaussian, sine wave, or square pulse. Implement the inverse Fourier transform and verify the accuracy by comparing the transformed signal with the original function.
8. Solve the 1D diffusion equation using Fourier transforms. Visualize the evolution of the temperature distribution over time in a rod and observe how the solution behaves as time progresses.
9. Write a program to compute the Laplace transform and inverse Laplace transform of common functions like exponential, sine, and cosine. Use these transforms to solve second-order differential equations, such as the damped harmonic oscillator, and visualize the solution in the time domain.
10. Use Laplace transforms to model an electrical circuit consisting of resistors, capacitors, and inductors. Solve for the voltage and current in the circuit and visualize the transient response over time. Investigate the effect of varying component values on the circuit's behaviour

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.

MAJOR COURSE- MJ 7	Heat and Thermodynamics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course provides a comprehensive understanding of the fundamental principles of heat and thermodynamics. It covers real gas behavior, thermodynamic laws, transport phenomena, thermodynamic potentials, and radiation theory. The course aims to develop problem-solving skills in classical thermodynamics and prepare students for advanced topics in statistical mechanics and thermal physics.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand the deviations of real gases from the ideal gas behavior** and analyze them using the Virial equation.
2. **Explain the concept of critical constants** and Boyle temperature and apply Van der Waals' equation of state to real gases.
3. **Interpret P-V diagrams and the Law of Corresponding States** to understand phase transitions in gases.
4. **Analyze free adiabatic expansion of a perfect gas** and study the Joule-Thomson effect for real and Van der Waals gases.
5. **Determine the Joule-Thomson coefficient** and understand the concept of the temperature of inversion.
6. **Explain transport phenomena in gases**, including mean free path, viscosity, thermal conductivity, and diffusion.
7. **Apply the First Law of Thermodynamics** to different thermodynamic processes, including isothermal and adiabatic processes.
8. **Derive relations between heat capacities (CP and CV)** and understand their implications in various thermodynamic systems.
9. **Calculate work done during isothermal and adiabatic processes** and apply these concepts to practical problems.
10. **Differentiate between reversible and irreversible processes** and understand their significance in thermodynamics.
11. **Explain the Second Law of Thermodynamics**, including the concepts of entropy, Carnot's cycle, and Carnot's theorem.
12. **Calculate entropy changes in reversible and irreversible processes** and interpret entropy-temperature diagrams.
13. **Understand the Third Law of Thermodynamics** and its implications on the unattainability of absolute zero.
14. **Define thermodynamic potentials** such as internal energy, enthalpy, Helmholtz free energy, and Gibbs free energy and explain their physical significance.
15. **Derive Maxwell's relations and apply them** to thermodynamic problems such as the Clausius-Clapeyron equation and TdS equations.
16. **Analyze first and second-order phase transitions** and their relevance in condensed matter physics.
17. **Explain the principles of black-body radiation** and the spectral distribution of radiation.
18. **Derive and apply laws of radiation**, including Stefan-Boltzmann law, Wien's displacement law, and Rayleigh-Jeans law.
19. **Understand Planck's hypothesis** and derive Planck's law of black-body radiation.

20. **Apply the concept of mean energy of an oscillator** to explain quantum aspects of thermal radiation.

This course builds a solid foundation in thermodynamics and heat transfer, preparing students for further studies in statistical mechanics, condensed matter physics, and thermal engineering.

Course Contents:

Behavior of Real Gases (12 HRS): 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.

Transport Phenomena in Gases (05 HRS): Mean Free Path, Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: Viscosity, Thermal Conductivity and Diffusion.

Laws of thermodynamics (13 HRS): Zeroth Law of thermodynamics, Concept of heat, Work done, Internal energy, First law of thermodynamics, conversion of heat into work, Various thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law, Entropy, Carnot's cycle & theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, unattainability of absolute Zero.

Thermodynamic Potentials & Maxwell's Relations (10 HRS): 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, derivations and applications of Maxwell's Relations, Maxwell's Relations :(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, TdS Equations.

Theory of radiation (05 HRS): Spectral Distribution of Black Body Radiation, Stefan-Boltzmann law, Wien's displacement law, Rayleigh-Jeans law, Planck's Hypothesis, Mean energy of an oscillator and Planck's law.

Reference Books:

1. Core Physics for Class 11, S B Mathur & A Kumar, Bharati Bhawan, Patna.
2. A Treatise on Heat, Meghnad Saha, and B. N. Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University
7. Heat and Thermodynamics, Brij Lal and Subramanian.

MAJOR COURSE- MJ 7	Heat and Thermodynamics	(Practical Credit-01) (Total Marks=25)

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 Resistance Thermometer (PRT).
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
5. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method and to determine Neutral Temperature.
6. Determination of Stefan's constant.
7. Verification of Planks radiation formulae.

Reference Books

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

MAJOR COURSE- MJ 8	Digital Electronics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

The course provides an introduction to digital electronics, focusing on digital circuits, logic gates, Boolean algebra, arithmetic circuits, sequential circuits, and memory systems. It aims to equip students with the knowledge of designing and analyzing digital systems, both combinational and sequential, using fundamental concepts such as logic gates, flip-flops, timers, shift registers, and counters. Additionally, the course will introduce memory systems and microprocessors, preparing students for further studies in digital system design and microprocessor-based systems.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Differentiate between analog and digital circuits** and understand the significance of binary, octal, and hexadecimal number systems.
2. **Convert numbers between decimal, binary, octal, and hexadecimal** and understand the importance of BCD (Binary-Coded Decimal) representation in digital systems.
3. **Understand the basic logic gates** such as AND, OR, NOT, NAND, NOR, XOR, and XNOR, and apply these gates to build simple digital circuits.
4. **Apply Boolean algebra** to simplify logical circuits using Boolean laws and De Morgan's Theorems, and convert truth tables into equivalent logic circuits using Sum of Products (SOP) method and Karnaugh Maps (K-map).
5. **Design and analyze binary arithmetic circuits** for addition and subtraction using 2's complement and implement half and full adders, subtractors, and a 4-bit binary adder/subtractor.
6. **Understand sequential circuits** and design flip-flops, including SR, D, and JK flip-flops, both level-triggered and edge-triggered, and resolve issues like race-around conditions in JK flip-flops.
7. **Apply IC 555 timers** in astable and monostable multivibrator configurations for practical applications.
8. **Design and implement shift registers** of various types (SISO, SIPO, PISO, PIPO) and understand their use in serial and parallel data storage and transfer.
9. **Design and work with 4-bit counters**, including ring counters, asynchronous counters, decade counters, and *synchronous counters.
10. **Understand the principles of A/D conversion** using resistive networks and successive approximation, and evaluate the accuracy and resolution in conversion systems.
11. **Gain knowledge of memory systems**, including ROM, RAM, and DRAM basics, and understand their roles in digital circuits.
12. **Familiarize with microprocessors**, including the evolution of microprocessors, registers in the 8085 microprocessor, and the concept of data and address bus multiplexing.

By the end of the course, students will be able to design and analyze both combinational and sequential digital systems and understand the essential components used in memory and microprocessor-based systems.

Course Contents:

Digital Circuits (07 HRS): Introduction to the difference between analog and digital circuits. Binary numbers, conversions between decimal to binary and binary to decimal. BCD, octal, and hexadecimal number systems. Logic gates: AND, OR, NOT, NAND, NOR (universal gates), XOR, and XNOR.

Boolean algebra (08 HRS): Introduction to Boolean algebra, including de Morgan's Theorems and Boolean laws. Simplification of logical circuits using Boolean algebra. Understanding fundamental products, minterms, and maxterms. Conversion of truth tables to equivalent logic circuits using: 1. Sum of Products (SOP) method, Product of Sum(POS) 2. Karnaugh Maps (K-map) for simplification of Boolean expressions.

Arithmetic Circuits (05 HRS): Binary arithmetic: Binary addition, subtraction using 2's complement. Construction and working of half and full adders, half and full subtractors. Design and working of a 4-bit binary adder/subtractor.

Sequential Circuits (07 HRS): Overview of sequential circuits and flip-flops: SR, D, and JK flip-flops. Level-triggered and edge-triggered flip-flops. Preset and clear operations. Race-around condition in JK flip-flops and its resolution. Master/Slave JK flip-flop.

Timers (03 HRS): Classification of ICs: Linear and Digital ICs. Introduction to the IC 555 timer: Block diagram and its applications in astable multivibrator and monostable multivibrator configurations.

Shift registers (04 HRS): Types of shift registers: Serial-in-Serial-out (SISO), Serial-in-Parallel-out (SIPO), Parallel-in-Serial-out (PISO), and Parallel-in-Parallel-out (PIPO) shift registers (up to 4 bits).

Counters (4 bits) (03 HRS): Design and working of 4-bit counters: Ring counter, Asynchronous counters, Decade counters, and Synchronous counters.

Conversion (02 HRS): Resistive networks (Weighted and R-2R Ladder). Accuracy and resolution in conversion. Principles of A/D conversion using successive approximation.

Memory & Microprocessor (06 HRS): Overview of memory types: ROM (Read Only Memory), RAM (Random Access Memory), and DRAM basics. Introduction to microprocessors: Evolution of microprocessors, registers in 8085, data and address bus multiplexing in 8085, RISC and CISC instruction sets.

Reference Books:

1. Digital Computer Electronics, Malvino and Brown, 3/e, McGraw Hill Education
2. Digital Electronics G K Kharate ,2010, Oxford University Press
3. Digital Systems: Principles & Applications, R. J. Tocci, N. S. Widmer, 2001, PHI Learning
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
7. Digital design, Moris Mano

MAJOR COURSE- MJ 8	Digital Electronics	(Practical Credit-01) (Total Marks=25)

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.
4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
5. To minimize a given logic circuit.
6. Half Adder, Full Adder and 4-bit binary Adder.
7. Half Adder and Full Adder Truth table verification using I.C.
8. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
9. To design an astable multivibrator of given specifications using 555 Timer.
10. To design a monostable multivibrator of given specifications using 555 Timer.

MINOR COURSE- MN 2B	Digital Systems	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To provide students with a fundamental understanding of digital circuits, including binary number systems and basic logic gates.
2. To familiarize students with Boolean algebra and its applications in simplifying and designing logic circuits.
3. To enable students to understand and work with data processing circuits such as multiplexers, de-multiplexers, decoders, and encoders.
4. To equip students with the knowledge of arithmetic circuits, including binary addition, subtraction, and design of adders and subtractors.
5. To teach the operation of sequential circuits and flip-flops (SR, D, and JK), focusing on their triggering methods and operations.
6. To give students an understanding of timers, shift registers, and counters, along with their practical applications in digital systems.

Course Outcomes:

1. Students will be able to distinguish between analog and digital circuits and perform conversions between different number systems.
2. Students will develop the ability to simplify and design logic circuits using Boolean algebra and Karnaugh maps.
3. Students will understand the role and operation of data processing circuits and will be able to design simple multiplexing and encoding circuits.
4. Students will be capable of designing and analyzing arithmetic circuits, including adders and subtractors, for binary operations.
5. Students will be able to design sequential circuits using flip-flops and will understand their clocking mechanisms, including race-around conditions.
6. Students will be proficient in designing and using timers, shift registers, and counters in digital systems, including the use of ICs like the 555 timer.

Course Contents:

Digital Circuits (10 HRS): Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates

Boolean algebra (10 HRS): De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Data processing circuits (04 HRS): Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits (04 HRS): Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders, 4-bit binary Adder.

Sequential Circuits (04 HRS): SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

Timers and Shift registers (05 HRS): IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in Parallel-out Shift Registers (only up to 4 bits).

Counters (4 bits) (04 HRS): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

Conversion (04 HRS): Resistive networks (Weighted and R-2R Ladder). Accuracy and resolution in conversion. Principles of A/D conversion using successive approximation.

Reference Books:

1. Digital Computer Electronics, Malvino and Brown, 3/e, McGraw Hill Education
2. Digital Electronics G K Kharate ,2010, Oxford University Press
3. Digital Systems: Principles & Applications, R. J. Tocci, N. S. Widmer, 2001, PHI Learning
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
7. Digital Systems and Applications, Nutan Lata, Pragati Prakashan, 1/e, 2019
8. Digital design, Moris Mano

MINOR COURSE- MN 2B	Digital Systems	(Practical Credit -01) (Total Marks=25)

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.
4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
5. To minimize a given logic circuit.
6. Half Adder, Full Adder and 4-bit binary Adder.
7. Half Adder and Full Adder Truth table verification using I.C.
8. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
9. To design an Astable multivibrator of given specifications using 555 Timer.
10. To design a Monostable multivibrator of given specifications using 555 Timer.

Semester V

MAJOR COURSE- MJ 9	Mathematical Physics-III	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

The objective of this course is to introduce students to advanced mathematical techniques essential for understanding complex physical systems. Topics covered will include the fundamentals of complex analysis, matrix theory, tensor analysis, and group theory. Emphasis will be placed on the application of these mathematical tools to solve real-world physics problems, including the evaluation of integrals, matrix diagonalization, the use of tensors in physical contexts, and the symmetry operations of physical systems.

Course Outcomes:

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

1. Understand and apply the principles of complex analysis, including the use of Cauchy's theorem, Cauchy's integral formula, and residue calculus to solve physical problems.
2. Perform matrix operations and apply matrix theory in physical contexts, including solving eigenvalue problems and diagonalization.
3. Grasp the concept of tensors and apply tensor operations in various physical situations, particularly in the context of Cartesian and covariant tensors.
4. Use group theory to analyze the symmetry properties of physical systems, construct character tables, and understand the significance of group representations in physics.
5. Solve problems involving branch cuts and principal value integrals, and use dispersion relations to extract physical insights.

These objectives and outcomes are designed to ensure that students gain both a theoretical understanding and practical skills for applying advanced mathematical methods in physics.

Course Contents:

Complex Analysis (12 HRS): Functions of complex variables, analytic functions, and Cauchy-Riemann conditions. Introduction to multivalued functions. Cauchy's Theorem and Cauchy's Integral Formula. Derivatives of analytic functions. Liouville's Theorem. Power series expansions: Taylor's theorem and Laurent's theorem. Calculus of residues and its applications to evaluate real definite integrals. Handling integrals involving branch cuts and using complex integration for summation of series. Principal value integrals and dispersion relations.

Matrices (10 HRS): Introduction to matrices through rotation of coordinate systems. Properties of Hermitian, orthogonal, and unitary matrices. Understanding null and unit matrices, singular and non-singular matrices. Inverse of a matrix and similarity transformations. Eigenvalue problems and diagonalization of matrices.

Tensor Analysis (12 HRS): Introduction to tensors: Cartesian, covariant, and contravariant tensors. Operations on tensors: contractions and direct products. Examples of special tensors: pseudo, dual, isotropic, symmetric, and anti-symmetric tensors.

Group Theory (11 HRS): Definition and examples of physically important finite groups, Basic symmetry operations and their matrix representations, Multiplication table, Cyclic groups and subgroups, Classes. Reducible and Irreducible representation, Schur's lemma, Orthogonality theorem, Character of a representation, Construction character tables.

References:

1. Mathematical Methods for Physicists, G. B Arfken, 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. Matrices and Tensors: A.W.Joshi
5. Mathematical Physics: Das and Sharma.
6. Mathematical Physics: A. K. Ghatak, I. C. Goya l&S.J.Chua.
7. Mathematical Methods for Physicist & Engineers: Pipes & Harvel.
8. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
9. Mathematical Methods for Scientists and Engineers: D. A. McQuarrie,2003, Viva Book.
10. Mathematical Physics, H. K. Dass, S Chand
11. Mathematical Physics, B.S. Rajput, Pragati Prakashan Meerut

MAJOR COURSE- MJ 9	Mathematical Physics-III	(Practical Credit -01) (Total Marks=25)

1. Plot $f(z)=e^{iz}$, on the complex plane. Show the real and imaginary parts, magnitude |f(z)|, and argument arg(f(z)) over a grid of complex numbers.
2. Write a program to check if a function satisfies the Cauchy-Riemann conditions. Given a function $f(z) = u(x, y) + iv(x, y)$ implement the conditions for analyticity and plot the real and imaginary parts of u(x,y) and v(x,y).
3. Write a program that numerically verifies Cauchy's Theorem by calculating the integral of an analytic function along different contours. Use the Cauchy Integral Formula to evaluate integrals of functions over simple closed contours and compare with direct integration.
4. Implement the Taylor series expansion of a complex function and compare the numerical results with the exact value. Write a program to compute the Laurent series of a function around a singularity and visualize the expansion.
5. Consider a 3x3 matrix, Check if its orthogonality. Compute numerically its eigenvalues, diagonalisation and inverse.
6. Write a program to perform the rotation of coordinate systems using rotation matrices. Visualize how a point in 2D or 3D space is transformed when the coordinate system is rotated by a given angle (using appropriate rotation matrices).
7. Consider two 2x2 matrix A=((1,2),(3,4)) and B=((5,6),(7,8)), Vector V =(2,3) and Transformation matrix T=((1,0), (0, -1)), calculate the following
   a. compute the **contraction**$A_{ij}B^{ij}$.
   b. Find its **covariant** and **contravariant** components of V under T
   c. compute the **symmetric** and **antisymmetric** parts of A and B.
8. Given a 2D vector V= (3,4) and a rotation matrix R= ((cos θ, −sin θ), (sin θ, cos θ)), where $\theta = 30°$, calculate the following:
9. Compute the new vector V′ after applying the rotation matrix R.
   a. Compute the covariant and contravariant components of the transformed vector.
   b. Verify the orthogonality of R, i.e., $R^TR=I$.
10. Let V be a vector space and G be a finite group. Let ρ be a representation of G on V.
    a. State and explain Schur's Lemma.
    b. Use Schur's Lemma to prove that if ρ is an irreducible representation and T is a linear operator on V that commutes with all elements of G, then T must be a scalar multiple of the identity operator.
    c. Apply Schur's Lemma to a specific example, such as the representation of S_3 on a 2D vector space.

11. Understand how symmetry operations (like rotations) can be represented by matrices, and verify the basic group rules.

Reference book

1. Computational Physics – Mark Newman (Python-based)
2. Computational Complex Analysis – Richard S. Palais
3. Numerical Linear Algebra – Lloyd N. Trefethen and David Bau III
4. Computational Group Theory and Applications – **Ákos Seress**
5. A Student's Guide to Python for Physical Modeling – Jesse M. Kinder and Philip Nelson

MAJOR COURSE- MJ 10	Solid State Physics-I	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce students to the fundamental concepts of crystallography, the structure of solids, and the types of crystal bonds that govern the physical properties of materials.
2. To explain the role of lattice vibrations and their effect on the heat capacity of solids, and provide a quantum mechanical description of phonons.
3. To introduce the free electron theory and band theory to understand the electrical properties of materials, including conductors, semiconductors, and insulators.
4. To explore the dielectric properties of materials, including polarization, electric susceptibility, and ferroelectric and piezoelectric effects.

Course Outcomes:

Upon completion of the course, students will be able to:

1. **Understand the basics of crystallography**, including the distinction between crystalline and amorphous materials, unit cells, Miller indices, and X-ray diffraction techniques for structure determination.
2. **Analyze crystal bonding** in materials, including ionic, covalent, and weak bonding, and calculate cohesive energy and compressibility of solids.
3. **Describe lattice vibrations** and their quantum mechanical properties, including the concept of phonons, and apply models such as Dulong-Petit, Einstein, and Debye for the heat capacity of solids.
4. **Apply free electron and band theory models** to understand the electrical properties of solids, specifically the conduction behavior of metals, semiconductors, and insulators.
5. **Examine dielectric properties**, including the concepts of polarization, electric susceptibility, and the classical theory of electric polarizability, as well as ferroelectric and piezoelectric behaviors.

These objectives and outcomes will ensure that students gain a thorough understanding of the physical principles that govern the properties of solid materials, both at a theoretical and practical level.

Course Contents:

Crystallography and Structure of Solids (10 HRS): Structure of solids: crystalline vs. amorphous materials, lattice translation and symmetry, unit cell and simple crystal structures, Miller indices and their significance, diffraction of X-rays by crystals, Bragg's Law and structure factor, methods for structure determination, point defects in crystals, dislocations and their role in crystal plasticity.

Crystal Binding and Cohesive Energy (08 HRS): ionic, covalent, and weak bonding, cohesive energy of solids, compressibility and its relationship with bonding, ionic and covalent bonding in solids, atomic interactions in crystals, bonding forces and their implications on crystal structures, lattice energy and its computation, elastic properties of solids, calculation of the bulk modulus.

Lattice Vibrations and Heat Capacity (10 HRS): Vibration of lattice: mono- and diatomic chains, periodic lattice and its implications, phonons and their quantum mechanical description, phonon spectrum and the density of states, heat capacity of solids: Dulong-Petit law, Einstein and Debye models of specific heat, T3 law and its significance in low temperatures, thermal expansion and resistivity, anharmonic effects in lattice vibrations.

Free Electron Theory and Band Theory (08 HRS): Free electron theory: assumptions and limitations, Drude's model and Sommerfeld model of conduction, concept of density of states, periodic potentials in one dimension, electrons in weak periodic potential, tight-binding approximation and its applications, band theory of solids: conductors, semiconductors, and insulators, Brillouin zone and its significance, motion of electrons in magnetic fields.

Dielectric Properties of Materials (09 HRS: Polarization, Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Ferroelectricity and Piezo electricity.

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, M.A. Wahab, 2011, Narosa Publications
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, Neil W. Ashcroft and N. David Mermin
10. Solid State Physics – S.O. Pillai
11. Solid State Physics, Dekker

MAJOR COURSE- MJ 10	Solid State Physics-I	(Practical Credit-01) (Total Marks=25)

1. X-ray Diffraction and Bragg's Law – Verification of Bragg's law using X-ray diffraction data.
2. Crystal Structure Determination – Analysis of simple cubic, FCC, and BCC structures using X-ray or optical diffraction methods.
3. Determination of Lattice Parameters – Measurement of lattice constants using X-ray diffraction patterns.
4. Study of Crystal Defects – Examination of point defects and dislocations using optical microscopy or simulations.
5. Measurement of Specific Heat – Verification of Dulong-Petit's law using calorimetry.
6. Phonon Dispersion Relation – Computational modeling of phonon dispersion in monoatomic and diatomic chains.
7. Thermal Expansion Coefficient – Measurement of linear thermal expansion of a metal rod.
8. Hall Effect in Conductors – Determination of carrier concentration and Hall coefficient in metals.
9. Resistivity of Materials – Measurement of temperature dependence of electrical resistivity in metals and semiconductors.
10. Magnetic Susceptibility – Determination of magnetic susceptibility of paramagnetic salts using Gouy's balance.
11. Hysteresis Loop – Study of B-H curve in ferromagnetic materials.
12. Curie Temperature Measurement – Determination of Curie temperature in a ferromagnetic material.
13. Free Electron Theory Verification – Study of the temperature dependence of resistivity in metals.
14. Tight Binding Approximation – Simulation of electronic band structure using computational tools.
15. Magnetoresistance in Metals – Measurement of resistance change under an applied magnetic field.

Reference books

1. Practical Physics – G.L. Squires
2. Advanced Practical Physics for Students – B.L. Worsnop & H.T. Flint
3. Experimental Solid State Physics – R. Srivastava

MAJOR COURSE- MJ 11	Classical Mechanics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. **Understand the Lagrangian formulation**: To provide students with a solid foundation in Lagrangian mechanics, focusing on the concept of generalized coordinates, constraints, and the principle of virtual work.
2. **Study the dynamics of systems under central forces**: To familiarize students with the theory of central force motion, including the two-body problem, effective potential, and Kepler's laws.
3. **Analyze rigid body motion**: To enable students to study the motion of rigid bodies, understanding concepts like moment of inertia, Euler's equations, precession, and nutation.
4. **Learn the Hamiltonian formalism**: To introduce students to Hamiltonian mechanics, including generalized momenta, Hamilton's equations, phase space, and cyclic coordinates.
5. **Explore canonical transformations**: To introduce and apply the theory of canonical transformations, Poisson brackets, and their relationship with conservation laws.
6. **Study the Hamilton-Jacobi theory**: To familiarize students with the Hamilton-Jacobi equation (HJE), action-angle variables, and its application in integrable systems.

Course Outcomes:

By the end of this course, students should be able to:

1. **Apply the Lagrangian formulation**: Derive and solve Lagrange's equations for simple mechanical systems, including systems with constraints and forces expressed in generalized coordinates.
2. **Solve central force problems**: Analyze and solve problems related to central forces, including the two-body problem, energy conservation, and the Rutherford scattering problem.
3. **Understand rigid body dynamics**: Solve problems involving rigid bodies, calculate the moment of inertia tensor, and analyze rotational motion, including precession and gyroscopic effects.
4. **Use the Hamiltonian formalism**: Understand and apply Hamilton's equations of motion, identify conserved quantities using cyclic coordinates, and work in phase space.
5. **Perform canonical transformations**: Identify and perform canonical transformations, use generating functions, and apply Poisson brackets to simplify complex systems.
6. **Analyze the Hamilton-Jacobi equation**: Apply the Hamilton-Jacobi equation and action-angle variables to solve problems in integrable systems and understand their significance in classical mechanics.

These objectives and outcomes should help guide students through key concepts in classical mechanics and develop the problem-solving skills necessary for advanced physics applications.

Course Contents:

Lagrangian Mechanics (12 HRS): Degrees of freedom, generalized coordinates, constraints, principle of virtual work, D'Alembert's principle, Lagrange's equation, Hamilton's variational principle, Euler-Lagrange equation. Simple applications of the Lagrangian formulation: 1) Single free particle in a) Cartesian and b) plane polar coordinates 2) Atwood's machine 3) Bead sliding on a uniformly rotating wire in a force-free space 4) Motion of a block attached to a spring 5) Simple pendulum. Symmetry and conservation laws.

Central Force Motion (10 HRS): Two-body problem, reduced mass, equation of motion under a central force, conservation of angular momentum and energy, effective potential, classification of orbits, Kepler's laws and their derivation, Virial theorem, scattering in a central force field, Rutherford scattering.

Rigid Body Dynamics (08 HRS): Definition of a rigid body, degrees of freedom, moment of inertia tensor, principal moments and principal axes, Euler's equations of motion. Torque-free motion, motion of a symmetric top, precession, nutation, and gyroscopic motion. Coriolis and centrifugal forces, stability of rotational motion.

Hamiltonian Mechanics (08 HRS): Generalized momenta and the Legendre transformation, Hamilton's equations of motion, applications of the Hamiltonian formulation, cyclic coordinates and conservation laws, phase space and Liouville's theorem. Velocity-dependent potentials (e.g., magnetic forces) and their modifications to Lagrange's and Hamilton's equations for velocity-dependent potentials.

Canonical Transformations (07 HRS): Definition and conditions for a transformation to be canonical, generating functions and their types, Poisson brackets and their invariance under canonical transformations, infinitesimal canonical transformations, relation to symmetries and conservation laws. Hamilton-Jacobi equation (HJE), action-angle variables.

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
12. Classical mechanics, Gupta and Kumar

MAJOR COURSE- MJ 11	Classical Mechanics	(Practical Credit-01) (Total Marks=25)

4. To determine the coupling coefficient of coupled pendulums
5. To determine the coupling and damping coefficient of damped coupled oscillator.
6. To study population models e.g. exponential growth and decay, logistic growth, species, competition, predator-prey dynamics, simple genetic circuits.
7. Computational visualization of trajectories in the Sinai Billiard
8. Write a program to verify that Kepler's first law.
9. Write a program to verify Kepler's second law
10. Write a program to verify Kepler's Third law
11. Write a program to view cannon shell trajectory neglect air friction.
12. Write a program to find the trajectory of base ball
13. To calculate Poisson brackets for various mechanical systems and study their properties.

Reference books

1. Advanced Physics Experiments – I.S. Grant and W.R. Phillips
2. Experimental Physics: Principles and Practice for the Laboratory" – Walter F. Smith
3. Python Libraries: NumPy (numerical solutions), Matplotlib (visualization), SciPy (ODE solvers), SymPy (Poisson brackets)
4. Scilab/Xcos: Modeling population dynamics and coupled oscillators
5. VPython: For visualizing projectile motion, billiard dynamics, and planetary orbits

MINOR COURSE-MN1C	Solid State Physics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce the basic concepts of solid-state physics, including the different types of materials, their structures, and properties.
2. To develop an understanding of crystal structures, including unit cells, Miller indices, and the diffraction of X-rays.
3. To introduce elementary band theory and its application to conductors, semiconductors, and insulators.
4. To study the magnetic properties of materials, with an emphasis on the classical and quantum mechanical treatment of paramagnetism and ferromagnetism.
5. To explore the dielectric properties of materials and their relationship with electric fields, polarization, and susceptibility.
6. To understand the phenomena of superconductivity, including critical temperatures, magnetic fields, and the Meissner effect, along with an introduction to the BCS theory.

Course Outcomes:

Upon successful completion of the course, students will be able to:

1. Identify and describe the different types of crystal structures and lattices, and apply Miller indices and Bragg's Law to analyze diffraction patterns.
2. Understand and explain the principles of elementary band theory and distinguish between conductors, semiconductors, and insulators.
3. Analyze the electrical properties of semiconductors, including the Hall effect and conductivity, and relate them to material properties.
4. Explain the magnetic behavior of materials, distinguishing between dia-, para-, ferri-, and ferromagnetic materials, and understand the classical and quantum treatments of magnetism.
5. Apply the concepts of dielectric properties to solve problems related to electric polarization, susceptibility, and the Clausius-Mossotti equation.
6. Understand and explain the phenomenon of superconductivity, including the Meissner effect, type I and type II superconductors, and an introduction to BCS theory.

Course Contents:

Crystal Structure (12 HRS): 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.

Elementary band theory (08 HRS): 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 of conductivity (04 probe method) & Hall coefficient.

Magnetic Properties of Matter (10 HRS): 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.

Dielectric Properties of Materials (10 HRS): Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant.

Superconductivity (05 HRS): Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Super-conductorsIdea of BCS theory (No derivation).

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

MINOR COURSE-MN1C	Solid State Physics	(Practical Credit-01) (Total Marks=25)

1. Measurement of resistivity using linear four probe and Van der Paw method.
2. Calibration of Lock-in- Amplifier and Measurement of small resistance using Lock – in Amplifier.
3. Measurement of magnetic susceptibility of a solid using phase sensitive detection.
4. Measurement of Dielectric Constant of a dielectric Materials with frequency
5. Determination of the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. Determination of refractive index of a dielectric layer using SPR
7. Study of PE Hysteresis loop of a Ferroelectric Crystal.
8. BH curve of Fe using Solenoid determine energy loss from Hysteresis
9. Measurement of resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 o C) and to determine its band gap.
10. Determination of Hall coefficient of a semiconductor sample.

Reference books

1. Practical Physics – G.L. Squires
2. Advanced Practical Physics for Students – B.L. Worsnop & H.T. Flint
3. Experimental Solid State Physics – R. Srivastava

IAP: Internship/ Apprenticeship /Project

Semester VI

MAJOR COURSE- MJ 12	Computational Physics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce students to the fundamentals of numerical errors, floating-point computations, and iterative methods in computational physics.
2. To provide practical knowledge of solving algebraic, transcendental, and linear system equations using various numerical techniques.
3. To develop an understanding of eigenvalue problems and techniques for finding eigenvalues and eigenvectors.
4. To teach students interpolation, approximation, and curve-fitting methods, with a focus on least-squares fitting and B-splines.
5. To provide skills in numerical differentiation, integration, and solving ordinary differential equations using different methods.
6. To expose students to Monte Carlo methods and their application in physics simulations and optimization techniques.

Course Outcomes:

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

1. Understand and apply the concepts of numerical errors, floating-point arithmetic, and iterative methods to solve physical problems.
2. Solve algebraic, transcendental, and linear systems of equations efficiently using appropriate numerical methods.
3. Apply eigenvalue problems and calculate eigenvalues and eigenvectors for physical systems.
4. Use interpolation and curve-fitting techniques to approximate functions and data in physics applications.
5. Perform numerical differentiation and integration on physical models and extract meaningful results.
6. Solve initial and boundary value problems of ordinary differential equations using numerical methods, and understand their error estimations.
7. Implement Monte Carlo methods for simulations and optimization, and apply these methods to real-world physics problems.

Course Contents:

Errors and Iterative Methods (03 HRS): Truncation and Round off Errors. Floating Point Computation. Overflow and Underflow. Single and Double Precision Arithmetic. Iterative Methods, error analysis, Condition and Stability.

Solution of Algebraic and Transcendental Equations (03 HRS): Bisection Method, Secant Method, Newton-Raphson Method. Comparison and Error Estimation.

Matrices and Linear System of Equations (06 HRS): Secant Method, False Position, Newton-Raphson Method; Convergence of solutions; Solution of simultaneous linear equations: Gauss Elimination Method, Pivoting, Matrix Inversion, Singular Value Decomposition and Iterative Method.

Eigen values and Eigenvectors (03 HRS): Computation of Eigen values and Eigenvectors of Matrices by using Iterative Methods.

Interpolation and Approximation (04 HRS): Introduction to interpolation, Lagrange approximation, Newton approximation formula.

Curve Fitting, B-Splines and Approximation (06 HRS): Curve Fitting by Least Square Methods: Fitting a Straight Line, Non-Linear Curve Fitting: Power Function, Polynomial of nth Degree, and Exponential Function, Linear Weighed Least Square Approximation. Cubic Splines fitting.

Numerical Differentiation (04 HRS): Numerical Differentiation using (1) Newton's Interpolation Formulas and (2) Cubic Spline Method. Errors in Numeric Differentiation. Maximum and Minimum Values of a Tabulated Function.

Numerical Integration (04 HRS): General Quadrature Formula. Trapezoidal Rule. Simpson's Rules. Weddle's Rule. Gauss Quadrature Formulas: (1) Gauss- Hermite and (2) Gauss-Legendre Formulas.

Solution of Ordinary Differential Equations (ODE's) First Order ODEs (04 HRS): Solution of Initial Value Problems: (1) Euler's Method, (2) Modified Eulers's Method, (3) Runge-Kutta Method of Second Order with Error Estimation.

Second Order ODEs. (03 HRS): Solution of 2-Point Boundary Value Problems. Finite Difference Approximation of Derivatives. Finite Difference Method.

Random Variables and Monte Carlo Methods (05 HRS): Random Walk, Random numbers, Pseudo-random numbers, Monte Carlo integration, Monte Carlo Simulations, The Metropolis algorithm, Variational Methods and Optimization Techniques; Applications of Computer Simulations in Physics.

Reference books:

1. Computational Physics: Problem Solving with Python by Mark Newman, 2013, Princeton University Press
2. Computational Physics: A Practical Introduction to Computing with Python by Kurtis A. Fisher, 2017, Cambridge University Press
3. Numerical Methods in Physics with Python by Alexandru Buca, 2018, Springer
4. An Introduction to Computational Physics by Tao Pang, 2006, Cambridge University Press
5. Computational Physics: Simulation of Physical Systems by David S. Yevick, 2009, Cambridge University Press
6. Mathematica for Physics and Engineering by M. L. Duffy, 2003, Springer
7. Introduction to Computational Science: Modeling and Simulation for the Sciences by Angela B. Shiflet, George W. Shiflet, 2009, Princeton University Press
8. Computational Methods for Physics by Joel L. Schiff, 2008, Cambridge University Press
9. A Student's Guide to the Study, Practice, and Tools of Modern Mathematics by David B. S. Lippman, 2014, Cambridge University Press.
10. The Art of Scientific Computing by William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, 2007, Cambridge University Press

MAJOR COURSE- MJ 12	Computational Physics	(Practical Credit-01) (Total Marks=25)

Algebraic & Transcendental Equations

1. To find the Roots of an Algebraic Equation by Bisection Method.
2. To find the Roots of an Algebraic Equation by Secant Method.
3. To find the Roots of an Algebraic Equation by Newton-Raphson Method.
4. To find the Roots of a Transcendental Equation by Newton-Raphson

Linear Equations & Eigenvalue Problem

1. To find the Roots of Linear Equations by Gauss Elimination Method.
2. To find the Roots of Linear Equations by Gauss-Seidal Iterative Method.
3. To find the Eigen value and Eigen vector of a Matrix by iterative Method

Interpolation

1. To form a Forward Difference Table from a given set of Data Values.
2. To form a Backward Difference Table from a Given Set of Data Values.
3. To find the value of y near the beginning of a Table of values of(x,y).
4. To find the value of y near the end of a Table of values of (x,y).

Curve Fitting, B-Splines & Approximation

1. To fit a Straight Line to a given Set of Data Values.
2. To fit a Polynomial to a given Set of Data Values.
3. To fit Power series to a given Set of Data Values
4. To fit a logarithmic Function to a given Set of Data Values
5. To fit an Exponential Function to a given Set of Data Values.
6. To fit a natural Cubic B-Spline to a given Data.

Differentiation

1. To find the First and Second Derivatives near the beginning of a Table of values of (x,y).
2. To find the First and Second Derivatives near the end of a Table of values of (x,y).

Integration

1. To evaluate a Definite Integral by Trapezoidal Rule.
2. To evaluate a Definite Integral by Simpson’s 1/3 Rule.
3. To evaluate a Definite Integral by Simpson’s 3/8Rule.
4. To evaluate a Definite Integral by Gauss Quadrature Formula.
5. To evaluate an Integral by Monte Carlo method.

Differential Equations

1. To solve a Differential Equation by Euler’s Method.
2. To solve a Differential Equation by Modified Euler’s Method.
3. To solve a Differential Equation by Second Order Runge Kutta Method.
4. To solve a Differential Equation by Fourth Order Runge Kutta Method.

Others

1. Fast Fourier Transform
2. Test of randomness for random numbers generators
3. Monte Carlo integration
4. Use of a package for data generation and graph plotting.

MAJOR COURSE- MJ 13	Quantum Mechanics-I	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. **Introduction to Quantum Concepts:** To introduce students to the fundamental concepts of quantum mechanics, including the limitations of classical physics, wave-particle duality, and the basic postulates of quantum mechanics.
2. **Mathematical Formulation:** To familiarize students with the mathematical formalism of quantum mechanics, including the Schrödinger equation, wave functions, operators, and Dirac notation, as well as their application to solving quantum systems.
3. **Applications of Quantum Mechanics:** To provide students with a deep understanding of the applications of quantum mechanics to real-world problems, such as the particle in a box, quantum tunneling, and the behavior of quantum systems like the harmonic oscillator and hydrogen atom.
4. **Development of Quantum Operators and States:** To explore the role of linear operators in quantum mechanics, their eigenvalues and eigenfunctions, and how these relate to observable physical quantities, such as energy and momentum.
5. **Understanding of Quantum Phenomena:** To explore quantum phenomena like the uncertainty principle, complementarity, and wave-particle duality through experiments like the Davisson-Germer experiment, and understand the relationship between classical and quantum descriptions of nature.
6. **Quantum Mechanical Representations:** To provide an understanding of various representations in quantum mechanics (Schrödinger and Heisenberg) and their applications to solving quantum systems.

Course Outcomes:

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

1. **Understand the Limitations of Classical Physics:** Explain the inadequacies of classical physics through phenomena like blackbody radiation, the photoelectric effect, and the Compton effect, and recognize the need for quantum theory.
2. **Apply Wave Mechanics:** Derive and solve the Schrödinger equation for simple systems such as a particle in a box, harmonic oscillator, and potential barriers, and understand the probabilistic nature of quantum states.
3. **Work with Quantum Operators:** Use the mathematical formalism of quantum mechanics to compute eigenvalues and eigenfunctions, apply commutation relations, and understand the significance of observables and their measurement.
4. **Interpret Wave Functions:** Understand and apply the physical interpretation of wave functions, including probability density, current density, and the normalization condition, in the context of quantum systems.
5. **Solve Problems Using Quantum Formalism:** Solve problems involving quantum states in both one-dimensional and three-dimensional potentials, applying the concepts of superposition and the uncertainty principle.
6. **Analyze Quantum Systems with Different Representations:** Apply Schrödinger and Heisenberg representations to analyze time-dependent and time-independent quantum systems, and compute physical observables using the corresponding operators.
7. **Explore Quantum Phenomena in Real-World Contexts:** Analyze and explain quantum mechanical phenomena such as tunneling, angular momentum quantization, and spin in various quantum systems, including the hydrogen atom.
8. **Master Quantum Mechanical Notation:** Utilize Dirac notation, bra-ket formalism, and the algebra of Hermitian operators to represent and solve quantum problems systematically.

Course Contents:

Limits of Classical Physics (02 HRS): Blackbody radiation (without derivation), Photoelectric effect, Compton effect.

Wave Packets and Uncertainty Relation (05 HRS): de Broglie hypothesis, Wave-particle duality, Davisson-Germer experiment, Wave packets, Group velocity and phase velocity, Uncertainty principle, Bohr's complementarity principle.

Wave Mechanics (15 HRS): Postulates of Quantum Mechanics, Time-dependent Schrödinger 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, Linear operators, Hermitian operators, Observables, Expectation values, Ehrenfest's theorem, Stationary states, Superposition principle, Commutation relations, Commuting observables and compatibility.

Application of Schrödinger Wave Equation (10 HRS): Particle in one-dimensional Box, Square well, Rectangular potential barrier and tunnelling, Linear harmonic oscillator, Spherically symmetric potential, Angular momentum operators and their eigenfunctions, Concept of spin, Hydrogen atom.

Mathematical Formalism of Quantum Mechanics (13 HRS): Dirac Notation, Representation of states and observables, Bra and ket vectors, Linear operators, Relation with wave mechanics, Algebra of Hermitian operators, Matrix representation, Unitary operators, Schrödinger and Heisenberg representations, Linear harmonic oscillator problem by operator method.

References:

1. Principles of Quantum Mechanics – R. Shankar (1994), Springer
2. Introduction to Quantum Mechanics – David J. Griffiths (2018), Pearson
3. Modern Quantum Mechanics – J. J. Sakurai and Jim Napolitano (2017), Addison-Wesley
4. Quantum Mechanics: Concepts and Applications – NouredineZettili (2009), Wiley
5. The Principles of Quantum Mechanics – Paul A. M. Dirac (1981), Oxford University Press
6. Introduction to Quantum Mechanics – Nikhil Ranjan Roy (2016), Vikash Publishing House Pvt. Ltd.
7. Quantum Mechanics, 2/e – V. Devanathan (2015), Narosa Publishing House
8. Quantum Mechanics – V. K. Thankappan (2012), New Age International Publishers

MAJOR COURSE- MJ 13	Quantum Mechanics-I	(Practical Credit -01) (Total Marks=25)

1. To verify the photoelectric effect and determine Planck's constant.
2. To observe electron diffraction and confirm the wave-particle duality of electrons.
3. Write a program to solve the Schrödinger equation for a particle in a one-dimensional infinite potential well and determine the energy eigenvalues and wavefunctions.
4. Write a program to study the energy levels and wavefunctions of a quantum harmonic oscillator.
5. Write a program to solve the Schrodinger equation for the ground state and the first excited state of the hydrogen atom.
6. Write a program to solve the Schrodinger equation for anharmonic oscillator potential,
$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$
7. To verify the Heisenberg uncertainty principle.
8. To observe the inelastic scattering of electrons and measure the energy loss due to electron collisions with mercury atoms, verifying the quantized nature of atomic energy levels.

Reference books:

1. Advanced Practical Physics for Students – B.L. Worsnop and H.T. Flint
2. Experiments in Modern Physics – Adrian C. Melissinos
3. Physics Laboratory Experiments – Jerry D. Wilson, Cecilia A. Hernández-Hall
4. Computational Quantum Mechanics – Joshua Izaac, Jingbo Wang

MAJOR COURSE- MJ 14	Electrodynamics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To understand the fundamental concepts and mathematical framework of electromagnetism through Maxwell's equations.
2. To explore the nature of electromagnetic waves, including their propagation in various media, and their interaction at boundaries between different materials.
3. To gain an understanding of the principles of electromagnetic radiation and its generation, particularly through dipole and point charge radiation.
4. To apply the concepts of relativity in electrodynamics, including Lorentz transformations and the covariant formulation of electromagnetism.
5. To develop the ability to solve problems involving wave propagation, reflection, refraction, and radiation in both unbounded and bounded media.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. Derive and solve Maxwell's equations and their boundary conditions in various media, including vacuum and dielectric materials.
2. Analyze and solve problems related to wave propagation in free space, dielectric media, and conducting media, including understanding the concept of skin depth and plasma frequency.
3. Apply the principles of reflection, refraction, and transmission at boundaries between different media and understand their physical implications.
4. Understand and calculate electromagnetic radiation from various sources, including electric and magnetic dipoles, as well as a moving point charge.
5. Utilize special relativity concepts in electromagnetism, including Lorentz transformations and the covariant formulation of electrodynamics to analyze electromagnetic field transformations.

Course Contents:

Maxwell Equations (10 HRS): 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, Maxwell’s stress tensor, Conservation of momentum. Electromagnetic (EM) Energy Density.

EM Wave Propagation in Unbounded Media (10 HRS): 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.

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

Electromagnetic radiation (05 HRS): 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.

Relativity (10 HRS): Review of special theory of relativity and 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.

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, Pragathi prakashan,18 th edition, 2010.

MAJOR COURSE- MJ 14	Electrodynamics	(Practical Credit -01) (Total Marks=25)

1. Experimentally verify the boundary conditions for electric and magnetic fields at the interface of two different dielectric media.
2. Analyze the power flow in an EM wave using the Poynting vector concept.
3. Determine the penetration depth of electromagnetic waves in conductors at different frequencies.
4. Measure the reflection and transmission coefficients and verify Fresnel’s equations.
5. Experimentally determine Brewster’s angle and study polarization effects.
6. Simulate the time-dependent electric and magnetic fields due to an oscillating dipole.
7. Compute and visualize the electric and magnetic fields of a moving charge.
8. Simulate the dispersion relation for EM waves in a plasma medium. (computational)
9. Study wave propagation characteristics in different media using computational techniques. (computational)
10. Simulate how electric and magnetic fields transform under Lorentz transformations. (Computational)

Reference book

1. Advanced Practical Physics for Students" – B.L. Worsnop and H.T. Flint
2. Experiments in Modern Physics" – Adrian C. Melissinos
3. Computational Electrodynamics: The Finite-Difference Time-Domain Method" – Allen Taflove, Susan C. Hagness

MAJOR COURSE- MJ 15	Analog Electronics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce students to the basic concepts and applications of two-terminal devices, including rectifiers, diodes, LEDs, and photodiodes.
2. To develop a deep understanding of the working principles, characteristics, and applications of Bipolar Junction Transistors (BJTs) in different configurations.
3. To familiarize students with transistor biasing techniques and the analysis of transistor circuits in various configurations.
4. To provide knowledge on the design and analysis of amplifiers, with a focus on frequency response, feedback effects, and gain.
5. To explore the concept of sinusoidal oscillators and their use in electronics, including RC, Hartley, and Colpitts oscillators.
6. To introduce Junction Field Effect Transistors (JFET) and MOSFET, including their principles of operation and characteristics.
7. To provide a detailed study of operational amplifiers (Op-Amps) and their applications in analog circuits, including inverting and non-inverting amplifiers, and specialized circuits like integrators and differentiators.

Course Outcomes:

1. Students will be able to analyze and design various rectifier circuits using diodes, understanding their efficiency and ripple factors.
2. Students will gain proficiency in analyzing and designing amplifier circuits, including biasing methods, and understand the effects of feedback on circuit performance.
3. Students will be able to design and analyze sinusoidal oscillators and apply Barkhausen's criterion for determining the frequency of oscillations.
4. Students will understand the characteristics and applications of BJTs, JFETs, MOSFETs, and Op-Amps in real-world analog circuits.
5. Students will acquire the ability to design practical circuits using BJTs, FETs, and Op-Amps, solving problems related to gain, stability, and frequency response.
6. Students will be able to evaluate the performance of transistors in different regions and use load line analysis to find the Q-point and predict the behavior of amplifiers.

Course Contents:

Two-terminal Devices and their Applications (10 HRS): 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.

Bipolar Junction Transistors (10 HRS): n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β, Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical mechanism of current flow, Active, Cutoff and Saturation Regions.

Amplifiers (10 HRS): 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. Two stage RC-coupled amplifier and its freq. response. Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

Sinusoidal Oscillators (04 HRS): Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

Junction field effect transistor (07 HRS); band structure; construction and working principle; current – voltage characteristics; Metal semiconductor contacts – Schottky and ohmic contacts with band structure; Depletion and Enhancement mode MOSFET: Principle and working; calculation of threshold voltage; V-I characteristics.

Operational Amplifiers and Applications (04 HRS): 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.

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. Operational Amplifiers and their Applications, Subir Kumar Sarkar.

MAJOR COURSE- MJ 15	Analog Electronics	(Practical Credit-01) (Total Marks=25)

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. Half Wave and Full wave Rectifiers: Calculation of ripple factor and rectification efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. Push-Pull Amplifier.
6. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain.
7. To design non-inverting amplifier using Op-amp (741,351) and study its frequency response.
8. Use of OP-Amp (741, 351) as an integrator and as a differentiator.
9. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
10. FET – characteristics, biasing and its applications as an amplifier.
11. MOSFET – characteristics, biasing and its applications as an amplifier.

Reference Books:

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-GrawHill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-GrawHill.
3. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
4. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
5. Electronic Devices & circuit Theory, R.L. Boylestad& L.D. Nashelsky, 2009, Pearson
6. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
7. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers

MINOR COURSE- MN 2C	Renewable Energy and Energy Harvesting	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. **To introduce the students** to the concepts of conventional and non-conventional energy sources, focusing on the need for renewable energy in the current energy landscape.
2. **To provide an understanding** of the different renewable energy sources such as solar, wind, ocean, geothermal, hydro, and biomass, with a focus on their working principles, technologies, and applications.
3. **To explore energy harvesting technologies** that enable efficient collection and storage of energy from natural sources, including piezoelectric, electromagnetic, and other innovative techniques.
4. **To develop critical understanding** of the environmental and social impacts of renewable energy systems and the importance of sustainability in energy harvesting.
5. **To equip students with knowledge** of the design and operation of energy systems such as solar photovoltaic systems, wind turbines, ocean energy devices, and hydroelectric power generation.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand the limitations of fossil fuels** and nuclear energy and appreciate the importance of renewable energy for sustainable development.
2. **Explain the working principles and technologies** behind different renewable energy systems, including solar, wind, tidal, geothermal, and biomass energy.
3. **Design and analyze basic renewable energy systems** such as solar water heaters, photovoltaic cells, wind turbines, and hydroelectric power plants.
4. **Analyze and compare energy harvesting methods** such as piezoelectric energy generation, electromagnetic energy harvesting, and bio-mass conversion systems.
5. **Evaluate the environmental impact** of different energy harvesting techniques and apply sustainability concepts in the design and implementation of energy systems.
6. **Understand the integration of renewable energy** into the grid, including challenges and solutions related to energy storage, power electronics, and interconnection topologies.
7. **Critically assess current trends** and future directions in renewable energy, including offshore wind energy, ocean thermal energy, and innovative energy harvesting solutions.

Course Contents:

Fossil fuels and Alternate Sources of energy (08 HRS): 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.

Solar energy (08 HRS): 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.

Wind Energy harvesting (04 HRS): Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

Ocean Energy (04 HRS): Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.

Tide characteristics and Statistics (04 HRS): Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

Geothermal Energy (02 HRS): Geothermal Resources, Geothermal Technologies.

Hydro Energy (03 HRS): Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

Piezoelectric Energy harvesting (07 HRS): 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.

Electromagnetic Energy Harvesting (05 HRS): Linear generators, physics mathematical models, recent applications. Carbon captured technologies, cell, batteries, power consumption, Environmental issues and Renewable sources of energy, sustainability.

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

MINOR COURSE- MN 2C	Renewable Energy and Energy Harvesting	(Practical Credit -01) (Total Marks=25)

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.
4. Performance testing of solar cooker.
5. Measurement of I-V characteristics of solar cell.
6. Study the effect of input light intensity on the performance of solar cell,
7. Study the characteristics of wind.
8. Study charge and discharge characteristics of storage battery.
9. Performance estimation of fuel cell.

Semester VII

MAJOR COURSE- MJ 16	Quantum Mechanics-II	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To deepen understanding of quantum mechanics through the formalism of linear vector spaces, Hilbert spaces, and Dirac notation.
2. To explore the theory of angular momentum in quantum systems and its connection to symmetry, invariance, and conservation laws.
3. To provide an in-depth study of scattering theory, including partial wave analysis, Born approximation, and the use of Green's function.
4. To introduce approximation methods in quantum mechanics, including perturbation theory, WKB approximation, and Fermi's Golden Rule.
5. To study the behavior of identical particles, including symmetrization postulates and the addition of angular momentum.
6. To analyze relativistic quantum mechanics using the Klein-Gordon and Dirac equations and understand their physical implications.
7. To understand the process of field quantization and apply it to scalar, electromagnetic, and Dirac fields.

Course Outcomes:

Upon completion of the course, students will be able to:

1. Apply the formalism of linear vector spaces and Dirac notation to quantum states, operators, and observables.
2. Analyze and solve problems involving angular momentum and understand its relationship to symmetry and conservation laws.
3. Calculate scattering cross-sections and apply partial wave analysis, Born approximation, and Green's function in scattering problems.
4. Utilize approximation methods like perturbation theory, WKB, and Fermi's Golden Rule for solving quantum mechanical systems.
5. Understand the behavior of identical particles, apply symmetrization, and use Clebsch-Gordon coefficients for angular momentum addition.
6. Solve the Klein-Gordon and Dirac equations and interpret their applications in relativistic quantum mechanics.
7. Quantize scalar, electromagnetic, and Dirac fields and understand the role of symmetries and conservation laws in field theory.

Course Contents:

Review of Linear Vector Spaces (03 HRS): Linear vector spaces, Hilbert space, basis and orthogonality, Dirac notation (bra-ket formalism), inner and outer products, completeness relation, and operator representation.

Theory of Angular Momentum (05 HRS): Symmetry, invariance, and conservation laws, relation between rotation and angular momentum, commutation relations, matrix representations.

Scattering Theory (10 HRS): Differential and total scattering cross-sections, partial wave analysis, simple applications (e.g., Rutherford scattering), Green's function and its use in scattering theory, Born approximation and its validity, and simple applications. Emphasis on partial wave expansion in scattering problems.

Approximation Methods (09 HRS): Time-independent perturbation theory (non-degenerate and degenerate), Zeeman effect (normal), Stark effect, variational method (applications to helium atom), WKB approximation; time-dependent perturbation theory, Fermi's Golden Rule.

Identical Particles (04 HRS): Permutation symmetry, symmetrisation postulates, Slater determinant, addition of angular momentum, Clebsch-Gordon coefficients.

Relativistic Quantum Mechanics (07 HRS): Klein-Gordon equation, Dirac equation, Dirac matrices, spinors, positive and negative energy solutions, non-relativistic limit of the Dirac equation.

Field Quantization (07 HRS): Lagrangian density and equation of motion for fields, symmetries and conservation laws, Noether's theorem, canonical quantization of scalar fields, complex scalar fields, electromagnetic field, and Dirac field; problems in quantizing the electromagnetic field.

Reference Books:

1. Relativistic Quantum Mechanics – J.D. Bjorken and S.D. Drell, 1964, McGraw-Hill.
2. Relativistic Quantum Fields – J.D. Bjorken and S.D. Drell, 1965, McGraw-Hill.
3. A First Book on Quantum Field Theory – Amitabha Lahiri and P.B. Pal, 2005, Narosa Publishing House.
4. Modern Quantum Mechanics – J.J. Sakurai and Jim Napolitano, 2nd Edition, 2017, Cambridge University Press.
5. Principles of Quantum Mechanics – R. Shankar, 2nd Edition, 1994, Springer.
6. Quantum Mechanics (Volume 1 & 2) – Claude Cohen-Tannoudji, Bernard Diu, and Frank Laloë, 1977, Wiley.
7. Quantum Field Theory in a Nutshell – A. Zee, 2nd Edition, 2010, Princeton University Press.
8. Advanced Quantum Mechanics – Franz Schwabl, 4th Edition, 2008, Springer.
9. Scattering Theory: The Quantum Theory of Nonrelativistic Collisions – John R. Taylor, 1972, Dover Publications.
10. Lectures on Quantum Mechanics – Ashok Das, 2nd Edition, 2012, World Scientific Publishing.

MAJOR COURSE- MJ 16	Quantum Mechanics-II	(Practical Credit -01) (Total Marks=25)

1. To perform computational simulations of quantum states, operators, and inner products using matrix representations.
2. To verify the commutation relations for angular momentum operators and compute matrix representations for spin systems.
3. To simulate and compute partial wave expansions for a scattering potential, calculating differential and total cross-sections.
4. To apply the Born approximation to a scattering potential and compare the results with exact solutions.
5. To calculate the energy shifts of an atom due to external magnetic and electric fields using time-independent perturbation theory.
6. To use the variational method to approximate the ground state energy of the helium atom.
7. To compute the transmission and reflection coefficients for quantum mechanical tunneling using the WKB approximation.
8. To calculate and visualize Clebsch-Gordon coefficients and use them in adding angular momentum for composite systems.
9. To solve the Dirac equation for a free particle and explore the physical significance of negative energy solutions.
10. To simulate the quantization of the electromagnetic field and study the creation and annihilation of photon states.

Reference book

1. Experiments in Modern Physics – Adrian C. Melissinos, Jim Napolitano
2. Advanced Practical Physics for Students – B.L. Worsnop, H.T. Flint
3. Computational Quantum Mechanics – Joshua Izaac, Jingbo Wang
4. Quantum Mechanics Using Computer Algebra – Willi-Hans Steeb, Yorick Hardy
5. A Student's Guide to Python for Physical Modeling – Jesse M. Kinder, Philip Nelson

MAJOR COURSE- MJ 17	Statistical Mechanics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce the fundamental principles of classical and quantum statistics, including probability theory, phase space, and statistical equilibrium.
2. To explore the Maxwell-Boltzmann distribution and its applications to thermodynamic quantities of ideal gases, including the equi-partition theorem and Gibbs' paradox.
3. To understand quantum statistics and study Bose-Einstein and Fermi-Dirac statistics, ideal gases, and applications like black body radiation and Bose-Einstein condensates.
4. To provide insight into irreversible processes, random walks, Brownian motion, and Langevin equation.
5. To analyze fluctuations, the fluctuation-dissipation theorem, and applications of quantum statistics in the classical limit.
6. To investigate the concept of thermodynamic fluctuations and their impact on physical systems through Fourier analysis and Onsager relations.

Course Outcomes:

Upon completion of the course, students will be able to:

1. Understand and apply classical statistical mechanics principles, including phase space, ensembles, and statistical equilibrium.
2. Derive and apply the Maxwell-Boltzmann distribution to ideal gases and paramagnetism, and calculate thermodynamic quantities using the canonical distribution.
3. Analyze quantum ideal gases using Bose-Einstein and Fermi-Dirac statistics, and understand applications such as Bose-Einstein condensates and white dwarf stars.
4. Study irreversible processes and the role of fluctuations in thermodynamics, including random walk theory and Brownian motion.
5. Apply the fluctuation-dissipation theorem and Fourier analysis of random functions to analyze the impact of fluctuations in physical systems.
6. Solve problems related to quantum statistics in the classical limit and interpret the behavior of systems in this regime.

Course Contents:

Classical Statistics (10 HRS): Probability calculations, Phase space, Ensembles and its classifications, Basic postulates, Behavior of density of states, Statistical Equilibrium, Liouville theorem, Irreversibility and conditions of equilibrium, Reversible and irreversible processes.

Maxwell Boltzmann Statistics (12 HRS): Maxwell-Boltzmann Distribution, Simple applications of the canonical distribution–Paramagnetism, Molecule of an ideal gas in the presence of gravity, Partition function of ideal gas and their properties, Calculation of thermodynamic quantities of ideal Mono atomic gas, Gibbs' paradox, Equi-partition theorem.

Quantum Statistics (08 HRS): Quantum ideal gas, Identical particles and symmetry requirements, Quantum distribution functions, Bose - Einstein statistics, Ideal Bose gas, black body radiation, Bose - Einstein condensate ion, specific heat of Ideal Bose gas.

Fermi-Dirac statistics (08 HRS): Fermi-Dirac distribution, Ideal Fermi gas, properties of simple metals, Pauli paramagnetism, electronic specific heat, White-Dwarf Star, Chandrasekhar Mass Limit, Quantum statistics in the classical limit.

Irreversible processes and fluctuations (07 HRS): Random walk in one dimension, Brownian motion, Langevin equation, Fluctuation dissipation theorem, Einstein relation, Fourier analysis of random functions, Wiener- Khintchine relations Nyquist's theorem, Fluctuations and Onsager relations.

Reference Books:

1. Fundamentals of Statistical and Thermal Physics, F Reif, First Indian Edition, Levant Books, 2010.
2. Statistical Mechanics, K Huang, Wiley Eastern Limited, New Delhi, 1963.
3. Statistical Mechanics, RK Pathria and PD Beale,3 rd Edition, Academic Press (Oxford), 2011.
4. Introduction to Statistical Physics, Silvio R A Salinas, Springer, 2001.
5. Fundamentals of Statistical Mechanics, BB Laud, 5 th Edition, New Age International Publication, 2015.
6. An introduction to statistical thermodynamics, Terrel Hill, Courier corporation, 1986.
7. Principles of statistical Mechanics, Richard Tollman Claredon Press, 1979.
8. An introduction to Thermodynamics and Statistical Mechanics, 2nd Edition, Cambridge Uni Press, 2013.
9. Statistical mechanics, McQuarrie, Donald A, New York: Harper & Row, 2nd edition, 2000.

MAJOR COURSE- MJ 17	Statistical Mechanics	(Practical Credit -01) (Total Marks=25)

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

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   b) Study of transient behavior of the system (approach to equilibrium)
   c) Relationship of large N and the arrow of time
   d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution.

2. Plot the probability of various macrostates in coin-tossing experiment (two level system) versus number of heads with 4, 8, 16 coins etc.
3. Computation of the partition function Z(b) for the systems with a finite number of single particle levels (e.g., 2 level, 3 level etc.) and finite number of non-interacting particles N under Maxwell-Boltzmann/ Fermi-Dirac/Bose Einstein statistics:
   a) Study the behavior of Z(b), average energy, Cv, and entropy and its dependence upon the temperature, total number of particles N and the spectrum of single particle energy states.
   b) Plot the probability of occupancy of all the states w.r.t. temperature.

4. Plot the Maxwell speed distribution function at different temperatures in a 3-dimension system. Calculate the average speed, root mean square and most probable speed
5. Plot Specific Heat of Solids w.r.t temperature
   a) Dulong-Petit law,
   b) Einstein distribution function
   c) Debye distribution function

6. Plot the following functions with energy at different temperatures
   a) Maxwell-Boltzmann distribution
   b) Fermi-Dirac distribution
   c) Bose-Einstein distribution

7. Plot the distribution of particles w.r.t. energy (dN/de versus e) in 3 Dimensions for
   a) Relativistic and non-relativistic bosons both at high and low temperature.
   b) Relativistic and non-relativistic fermions both at high and low temperature.

8. Plot Planck’s law of Black body radiation w.r.t. wavelength/frequency at different temperatures. Compare it with Rayleigh-Jeans Law and Wien’s distribution law for a given temperature.

MAJOR COURSE- MJ 18	Nuclear and Particle Physics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce the general properties of nuclei, including their intrinsic properties such as mass, radius, binding energy, and nuclear excitations.
2. To study various nuclear models, including the liquid drop model, semi-empirical mass formula, and the shell model, and understand nuclear stability and the concept of nuclear forces.
3. To understand the processes of radioactive decay, including alpha, beta, and gamma decays, and apply theories such as the Gamow factor and Geiger-Nuttall law.
4. To explore nuclear reactions, their kinematics, conservation laws, and reaction types, including compound and direct reactions, resonance, and Coulomb scattering.
5. To analyze the interaction of nuclear radiation with matter, including ionization energy loss, Cerenkov radiation, and gamma ray interaction mechanisms.
6. To introduce various nuclear radiation detectors, their principles, and applications, including gas detectors, scintillation detectors, and semiconductor detectors.
7. To study particle accelerators and their use in nuclear and particle physics experiments, with emphasis on accelerators available in India.
8. To explore particle physics, including particle interactions, symmetries, and conservation laws, and introduce the concept of quark models and color quantum numbers.

Course Outcomes:

Upon completion of the course, students will be able to:

1. Understand and explain the general properties of nuclei, including binding energy, angular momentum, parity, and nuclear magnetic moments.
2. Apply nuclear models such as the liquid drop model and shell model to explain nuclear stability and behavior, and interpret nuclear magic numbers and forces.
3. Analyze radioactive decay processes (alpha, beta, gamma) and their corresponding kinematics, and apply decay laws in practical scenarios.
4. Understand and compute the kinematics of nuclear reactions, Q-values, reaction rates, and cross-sections, and differentiate between various types of reactions.
5. Explain the interaction of nuclear radiation with matter and apply the Bethe-Bloch formula, Compton scattering, and pair production to various physical situations.
6. Identify and compare different types of nuclear radiation detectors and their applications in detecting charge particles, photons, and neutrons.
7. Describe the working principles of particle accelerators and their role in nuclear and particle physics research, with an understanding of accelerator facilities in India.
8. Understand the symmetries and conservation laws in particle physics, including concepts such as quark model, baryon and lepton numbers, iso spin, and gluons, and apply them to analyze particle interactions.

Course Contents:

General Properties of Nuclei (07 HRS): Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

Nuclear Models (06 HRS): 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.

Radioactive Decay (06 HRS): (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.

Nuclear Reactions (05 HRS): 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).

Interaction of Nuclear Radiation with matter (05 HRS): 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.

Nuclear Radiation Detectors (07 HRS): 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.

Particle Accelerators (03 HRS): Accelerator facility available in India: Van-de Graaff Generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

Particle Physics (06 HRS): Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, Parity, Baryon number, Lepton number, Isospin, Strangeness and Charm, Concept of quark model, Color quantum number and gluons.

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).

MAJOR COURSE- MJ 18	Nuclear and Particle Physics	(Practical Credit-01) (Total Marks=25)

1. Demonstration of presence of Static Electricity.
2. Demonstration of phenomenon of Corona Discharge.
3. To determine the plateau and optimal operating voltage of a Geiger-Müller.
4. To determining the resolving (dead) time τ of a Geiger – Muller counter.
5. determining the efficiency of a geiger-muller counter.
6. determining the half life of a radio isotope using geiger – muller counter.
7. Experiment with Alpha Scintillation Counter.

MAJOR COURSE- MJ 19	Solid State Physics – II	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce the basic concepts of semiconductors, including intrinsic and extrinsic semiconductors, energy bands, and carrier concentration.
2. To study the advanced phenomena in semiconductors, such as Schottky barriers, quantum Hall effect, optical properties, and photovoltaic effects, and their technological significance.
3. To explore the magnetic properties of materials, including diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, and ferrimagnetism, along with their underlying mechanisms and applications.
4. To understand the phenomenology of superconductivity, including critical temperature, Meissner effect, and the classification of Type I and Type II superconductors.
5. To discuss the microscopic theory of superconductivity (BCS theory) and its implications for understanding the behavior of superconducting materials.
6. To examine the thermodynamic and magnetic properties of superconductors, and explore applications of superconductivity in technology, including SQUIDs, Josephson effects, superconducting magnets, and cryogenic techniques.
7. To investigate the future prospects and challenges of superconductivity, particularly in relation to power transmission and technological advancements.

Course Outcomes:

Upon completion of the course, students will be able to:

1. Understand the fundamental properties of semiconductors, including the behavior of carrier concentration, mobility, Fermi levels, and temperature dependence in both intrinsic and extrinsic semiconductors.
2. Analyze and explain advanced semiconductor phenomena, such as Schottky barriers, quantum Hall effect, excitons, and the photovoltaic effect, and their practical applications in devices like solar cells.
3. Demonstrate a comprehensive understanding of magnetism in materials, including the concepts of diamagnetism, paramagnetism, ferromagnetism, and ferrimagnetism, and apply these to real-world magnetic materials.
4. Understand the phenomenology of superconductivity and explain the significance of the Meissner effect, critical temperature, and the differences between Type I and Type II superconductors.
5. Apply BCS theory to explain superconductivity and understand its implications for the behavior and properties of superconducting materials.
6. Analyze the thermodynamic and magnetic properties of superconductors, and apply this knowledge to understand the functioning of superconducting devices such as SQUIDs and Josephson junctions.
7. Evaluate the technological applications of superconductivity, including its use in magnetic resonance imaging (MRI), power transmission, and the challenges associated with the development of practical superconducting materials.
8. Investigate the future prospects of superconductivity in advanced technologies, and critically assess the challenges that need to be overcome for widespread practical application.

Course Contents:

Basics of Semiconductors (10 HRS): Introduction to semiconductors: intrinsic and extrinsic semiconductors, energy bands in semiconductors, carrier concentration and mobility, effective mass and its significance, impurity band conduction and doping effects, p-n junctions:

formation and behavior, electrical conductivity in semiconductors, Fermi level and its position in different semiconductors, temperature dependence of carrier concentration.

Advanced Semiconductor Phenomena (10 HRS): Schottky barrier and its applications, quantum Hall effect and its significance, optical properties of semiconductors, absorption and emission spectra, excitons and their role in semiconductors, photovoltaic effect and solar cells, dielectric properties of semiconductors, ferroelectric and displasive modes in semiconductors, magneto-optic effects in semiconductors.

Magnetism in Materials (10 HRS): Overview of magnetic properties in materials, dia- and para-magnetism: classical and quantum treatments, Curie-Weiss law and its extension to different materials, Van Vleck and Pauli paramagnetism, ferro- and anti-ferromagnetism: concepts and differences, ferrimagnetism: definition and materials, exchange interaction in magnetic materials, spin waves and their significance, magnetic resonance and its applications.

Superconductivity Phenomenology (08 HRS): Discovery and experimental results of superconductivity, critical temperature and its dependence on material, Meissner effect and its significance, Type I and Type II superconductors, London's equation and penetration depth, isotope effect in superconductors, high-temperature superconductivity: an overview, superconducting materials and their applications, microscopic theory of superconductivity (BCS theory).

Superconductivity and Applications (07 HRS): Thermodynamic properties of superconductors, magnetic properties in superconductors, superconducting devices: SQUIDs and applications, Josephson effect and its technological implications, superconducting magnets and their use in MRI, cryogenic cooling techniques for superconductors, application of superconductivity in power transmission, future prospects of superconductivity in technology, challenges in the development of practical superconductors.

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, M.A. Wahab, 2011, Narosa Publications
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.

MAJOR COURSE- MJ 19	Solid State Physics – II	(Practical Credit -01) (Total Marks=25)

1. Band Gap Determination – Measurement of the energy band gap of semiconductors using optical absorption.
2. Intrinsic and Extrinsic Semiconductor Conductivity – Study of temperature dependence of conductivity in intrinsic and extrinsic semiconductors.
3. Hall Effect in Semiconductors – Determination of carrier concentration, Hall coefficient, and mobility in doped semiconductors.
4. p-n Junction Characteristics – Study of I-V characteristics of a p-n junction diode in forward and reverse bias.
5. Schottky Barrier Characteristics – Measurement of the Schottky barrier height and its rectifying behavior.
6. Photoconductivity in Semiconductors – Study of photoconductivity and carrier recombination in a semiconductor.
7. Dielectric Constant Measurement – Determination of dielectric constant and loss tangent in ferroelectric materials.
8. Hysteresis in Ferroelectric Materials – Study of P-E loop and coercivity in ferroelectrics.
9. Magnetic Susceptibility of Paramagnetic Materials – Study of Curie-Weiss law using a paramagnetic salt.
10. Magnetization in Ferromagnetic Materials – Measurement of magnetization and saturation in ferromagnetic materials.
11. Resonance Absorption in Magnetic Materials – Study of electron spin resonance (ESR) or nuclear magnetic resonance (NMR).
12. Superconductivity – Critical Temperature Measurement – Determination of transition temperature in a superconducting material.
13. Meissner Effect Demonstration – Observation of the expulsion of magnetic field from a superconductor.

Reference books

1. Practical Physics – G.L. Squires
2. Advanced Practical Physics for Students – B.L. Worsnop & H.T. Flint
3. Experimental Solid State Physics – R. Srivastava

MINOR COURSE- MN 1D	Thermal Physics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To understand the behavior of real gases and the deviations from ideal gas behavior using the Virial Equation and Van der Waals Equation of State.
2. To explore the critical constants, Boyle temperature, and Joule-Thomson effect, and understand their practical significance in thermodynamics.
3. To study the transport phenomena in gases, including the mean free path and its impact on viscosity, thermal conductivity, and diffusion in ideal gases.
4. To provide a detailed understanding of the laws of thermodynamics, including the Zeroth, First, Second, and Third laws, and their applications to thermodynamic processes and entropy changes.
5. To learn about thermodynamic potentials such as internal energy, enthalpy, Helmholtz free energy, and Gibbs free energy, and their applications in various physical processes.
6. To analyze the phase transitions and derive Maxwell's relations, applying them to thermodynamic systems to explain various phenomena like cooling due to adiabatic demagnetization and phase transitions.

Course Outcomes:

Upon completion of the course, students will be able to:

1. Explain the behavior of real gases, the deviations from ideal gas behavior, and apply the Virial Equation and Van der Waals Equation to calculate real gas properties.
2. Understand the concept of critical constants, Boyle temperature, and the Joule-Thomson effect, and explain their significance in thermodynamic processes such as cooling and expansion.
3. Calculate and analyze transport phenomena like viscosity, thermal conductivity, and diffusion in gases, and understand their relationship with the mean free path and gas properties.
4. Apply the laws of thermodynamics to various thermodynamic processes, and understand the concept of entropy, including its changes in reversible and irreversible processes.
5. Understand the principles of thermodynamic potentials and apply them to calculate various properties such as work done, heat, and free energy in different physical processes.
6. Derive and apply Maxwell's relations to solve practical thermodynamic problems, including phase transitions and the relationship between various thermodynamic variables.

Course Contents:

Behavior of Real Gases (15 HRS): 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.

Transport Phenomena in Gases (05 HRS): Mean Free Path, Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: Viscosity, Thermal Conductivity and Diffusion.

Laws of thermodynamics (15 HRS): Zeroth Law of thermodynamics, Concept of heat, Work done, Internal energy, First law of thermodynamics, conversion of heat into work, Various thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law, Entropy, Carnot's cycle & theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, unattainability of absolute Zero.

Thermodynamic Potentials & Maxwell's Relations (10 HRS): 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, derivations and applications of Maxwell's Relations, Maxwell's Relations :(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, TdS Equations.

Reference Books:

1. Core Physics for Class 11, S B Mathur & A Kumar, Bharati Bhawan, Patna.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
7. Heat and Thermodynamics, A. B. Gupta and H. P. Roy.
8. Heat and Thermodynamics, P. K. Chakraborty.

MINOR COURSE- MN 1D	Thermal Physics	(Practical Credit-01) (Total Marks=25)

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 Resistance Thermometer (PRT).
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
5. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method and to determine Neutral Temperature.
6. Determination of Stefan's constant.
7. Verification of Planks radiation formulae.

Reference Books

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

Semester VIII

MAJOR COURSE- MJ 20	Atomic, Molecular and Laser Physics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To understand the principles behind atomic spectra, including space quantization, the relationship between angular momentum and magnetic moment, and the fine structure of spectral lines.
2. To study the coupling schemes like LS and JJ coupling and their applications in atomic spectra.
3. To analyze the quantum theory of the Zeeman and Paschen-Back effects, as well as the Stark effect and hyperfine structure in atomic transitions.
4. To learn about molecular rotation and vibration, and how isotopic substitution affects rotational spectra, with a focus on diatomic molecules and the Born-Oppenheimer approximation.
5. To understand the principles and techniques involved in molecular spectroscopy, including infrared and Raman spectroscopy of diatomic molecules.
6. To explore the fundamental concepts of resonance spectroscopy such as NMR, NQR, ESR, and Mossbauer spectroscopy, and their experimental studies and applications.
7. To introduce the theory of lasers, including the principles of spontaneous and stimulated emission, population inversion, and laser systems, with applications in holography and data storage.

Course Outcomes:

Upon successful completion of the course, students will be able to:

1. Understand and explain the principles behind atomic spectra, including space quantization, fine structure of spectral lines, and Zeeman and Stark effects, and apply these concepts to interpret atomic spectra.
2. Describe LS and JJ coupling schemes, and apply the quantum theory of the Zeeman effect to analyze atomic spectra.
3. Analyze molecular rotational and vibrational spectra, and understand the effects of isotopic substitution and the Born-Oppenheimer approximation in molecular systems.
4. Apply the principles of infrared and Raman spectroscopy to analyze the vibrational and rotational spectra of diatomic molecules, and understand the Frank-Condon principle in electronic transitions.
5. Understand the fundamentals of resonance spectroscopy (NMR, NQR, ESR, Mossbauer spectroscopy) and apply them to various experimental and practical scenarios in molecular and atomic physics.
6. Describe the basic principles of laser operation, including population inversion and the Einstein A and B coefficients , and understand the different types of lasers (Ruby, He-Ne, CO2, semiconductor lasers) and their applications.
7. Understand the principles and applications of holography, including its practical use in data storage and other technological applications.

Course Contents:

Atomic Spectra (12 HRS): Space quantization, Relation between angular momentum and magnetic moment, Bohr magnetron. Fine structure of spectral lines, Term symbols of alkali and alkaline earth atoms.LS and JJ coupling. 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.

The Rotation of the Molecule (10 HRS): 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.

Molecular Spectra (08 HRS): 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.

Resonance Spectroscopy (08 HRS): 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 structure of ESR, Experimental studies and applications, Mossbauer spectroscopy, Principle- Isomer shift, Quadrupole effect, effect of magnetic field, Instrumentation applications.

Laser and Holography (07 HRS): Spontaneous and stimulated emission, Einstein A and B coefficients, Basic Principles of Laser, Population Inversion-Two level and Three level Laser system, optical pumping-rate equation, modes of resonator and coherence length, The Ruby laser, The He-Ne laser, The CO2 Laser, Semi-conductor Laser, Principle of Holography, Theory Practical applications including data storage.

Reference Books:

1. Kuhn, “Atomic Spectctra”.
2. Arun Kumar, ``Introduction to Solid State Physics’’, PHI Learning Pvt. Ltd.
3. Ghatak&Loknathan, “Quantum Mechanics”.
4. Herzberg, Spectra of diatomic molecules
5. Elements of Spectroscopy: Gupta, Kumar and Sharma, PragatiPrakashan.
6. Fundamentals of Molecular Spectroscopy: Colin and Elaine, TMH.
7. Laser and Non-linear Optics: B.B.Laud, New Age Publications.

MAJOR COURSE- MJ 20	Atomic, Molecular and Laser Physics	(Practical Credit -01) (Total Marks=25)

1. Study of the Zeeman Effect – Observation of spectral line splitting in a magnetic field.
2. Frank-Hertz Experiment – Verification of quantized energy levels in mercury atoms.
3. Raman Spectroscopy – Study of vibrational modes of molecules using Raman scattering.
4. Measurement of Hyperfine Splitting Using Electron Spin Resonance (ESR) – Determining hyperfine interaction in a given sample.
5. Study of the Stark Effect – Observation of spectral line shifts in an external electric field.
6. Simulation of Hydrogen Atom Spectra – Computational plotting of energy levels and transitions.
7. Variational Method for the Helium Atom – Estimation of energy levels using numerical techniques.
8. Molecular Vibration and Rotation Spectra Simulation – Calculating and visualizing IR and Raman spectra.
9. Numerical Solutions of Schrödinger Equation for a Diatomic Molecule – Using finite difference or matrix methods.

ADVANCE MAJOR COURSE- AMJ 1	Nano Science and Technology	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce the fundamental principles of nanoscience and technology, focusing on nanoscale systems and their unique properties.
2. To provide students with an understanding of the various methods of synthesizing nanostructure materials using top-down and bottom-up approaches.
3. To familiarize students with state-of-the-art techniques used for the characterization of nanomaterials, including X-ray diffraction, electron microscopy, and atomic force microscopy.
4. To explore the optical properties and quantum behavior of nanostructures, including excitons, quasi-particles, and the impact of quantum confinement.
5. To discuss the electron transport phenomena in nanostructures, focusing on carrier transport mechanisms and the effects of defects and impurities.
6. To analyze the applications of nanomaterials in diverse fields such as photonic devices, single-electron devices, and nano-electromechanical systems (NEMS)

Course Outcomes:

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

1. **Understand and describe** the various types of nanostructures (1D, 2D, 3D), their formation, and the impact of quantum confinement at the nanoscale.
2. **Identify and differentiate** between the top-down and bottom-up approaches for the synthesis of nanomaterials and explain the techniques such as photolithography, PVD, CVD, and sol-gel synthesis.
3. **Employ characterization tools** such as X-ray diffraction, SEM, TEM, AFM, and STM to analyze nanostructures and interpret experimental data.
4. **Explain the optical properties** of nanostructures, including the role of Coulomb interactions, excitons, and radiative processes, and their applications in photonic devices.
5. **Analyze electron transport mechanisms** in nanomaterials, including Coulomb blockade, tunneling, and thermionic emission, as well as the effects of defects and impurities on conductivity.
6. **Assess and discuss** the various applications of nanomaterials in advanced devices such as quantum dot lasers, solar cells, MEMS, NEMS, and magnetic data storage.

Course Contents:

NANOSCALE SYSTEMS (08 HRS): Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nano dots, thin films, nano wires, nano rods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement:, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

SYNTHESIS OF NANOSTRUCTURE MATERIALS (08 HRS): Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.

CHARACTERIZATION (06 HRS): X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy.

Scanning Tunneling Microscopy.

OPTICAL PROPERTIES (08 HRS): Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures.

ELECTRON TRANSPORT (05 HRS): Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

APPLICATIONS (10 HRS): Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

Reference books:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
6. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004)

ADVANCE MAJOR COURSE- AMJ 1	Nano Science and Technology	(Practical Credit -01) (Total Marks = 25)

1. Synthesis of at least two different sizes of Nickel Oxide/ Copper Oxide/ Zinc Oxide Nano Particles Using Sol-Gel Method.
2. Polymer synthesis by suspension method / emulsion method
3. B-H loop of nanomaterials.
4. Magnetoresistance of thin films and nanocomposite, I-V characteristics and transient response.
5. Particle size determination by X-ray diffraction (XRD) and XRD analysis of the given XRD spectra.
6. Determination of the particle size of the given materials using He-Ne LASER.
7. Selective area electron diffraction: Software based structural analysis based on TEM based experimental data from published literature..
8. Surface area and pore volume measurements of nanoparticles (a standard sample and a new sample (if available)).
9. Spectroscopic characterization of metallic, semiconducting and insulating nanoparticles.

ADVANCE MAJOR COURSE- AMJ 2	Fiber Optics and its applications	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce the fundamental principles of fiber optics, focusing on light propagation, different fiber types, and key transmission characteristics such as attenuation, scattering, and polarization.
2. To provide a thorough understanding of the various modes of light propagation in optical fibers, with emphasis on mode coupling, intermodal and intramodal dispersion, and their impact on data rates and bandwidth.
3. To explore the principles of optical sources (LEDs, lasers) and detectors (photodiodes, phototransistors), their operation, and the technologies behind optical feedback, laser oscillation, and detector performance.
4. To examine the design and operation of optical communication systems, including multiplexing techniques (OTDM, WDM), system performance metrics (BER, eye pattern), and fiber optic measurement tools (OTDR, optical power meters).
5. To discuss advanced fiber optic applications, including their use in long-haul communication, sensor networks, LANs, and medical or military domains, and analyze the role of fiber optics in modern technologies.
6. To familiarize students with optical amplifiers and network systems, including the operation of semiconductor optical amplifiers (SOAs), EDFAs, and the integration of SONET/SDH networks for high-speed communication.

Course Outcomes:

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

1. **Understand the principles of light propagation** in optical fibers, including meridional and skew ray paths, and analyze key factors affecting fiber transmission such as attenuation, scattering, and polarization.
2. **Identify and analyze** the different modes of light propagation in optical fibers, and evaluate the effects of intermodal and intramodal dispersion, mode coupling, and their influence on data rate and bandwidth.
3. **Describe the operation of optical sources** such as LEDs and lasers, with an understanding of optical feedback, laser oscillation, and the characteristics of quantum-well lasers, including their applications in fiber optic communication systems.
4. **Understand the working principles of optical detectors** (e.g., PIN, avalanche photodiodes), and evaluate their performance in terms of detectability, noise, and bandwidth, along with the design of related detector circuitry.
5. **Design and analyze optical communication systems** utilizing OTDM and WDM techniques, and calculate key performance metrics such as bandwidth, rise time, Bit Error Rate (BER), and interpret eye patterns for system optimization.
6. **Apply fiber optic measurement techniques** and field testing equipment, such as optical power meters and OTDR, to evaluate and troubleshoot fiber optic systems.
7. **Understand the diverse applications of fiber optics** in areas such as long-haul communication, fiber optic sensors, local area networks (LANs), medical and military applications, and other modern technological fields.
8. **Analyze and explain the operation of optical amplifiers** (e.g., EDFAs, semiconductor optical amplifiers) and their use in modern high-speed optical networks, including SONET/SDH, and understand the key technologies that enable high-speed data transmission over optical fiber.

Course Contents:

Light propagation (12 HRS): Ray theory transmission-meridional rays, another alternative path –skew rays, Types, characteristics and data rate in optical fibers, Modes in fibers, Modes coupling, Transmission characteristics in optical fibers- attenuation, absorption, scattering, polarization, dispersion intermodal and intra modal , Bandwidth and data rate, Fiber materials-Fiber fabrication and preparation, splicing, connectors, couplers and switches, connection losses, Mechanical properties of fibers, Installation and handling considerations in fiber types.

Optical absorption and emission (08 HRS): Spontaneous and stimulated emission Optical sources -LED AND LASER-Optical feedback and laser oscillation Quantum –well lasers , their structures and characteristics, Drive Electronics LED drivers - digital and analog, Laser diode drivers.

Optical detectors (07 HRS): Principle of operation –photo detectors, P-N, PIN, Avalanche photodiode, Phototransistor, Delectability, Noise and bandwidth, Detector circuitry and receivers-preamplifier, Automatic gain control.

Fiber Optic communication system (10 HRS): Optical Time Division Multiplexing, Wave length Division Multiplexing- Demultiplexing, Bandwidth and rise time budgets, Noise and Bit Error Rate and eye Pattern, Optical Fiber measurement and field testing- Equipment used in field testing- Optical Power meter, Cut back method, Optical Time Domain Reflectometer (OTDR),Application of Fiber optics- Long –Haul communication, Fiber optic sensors, Local Area Networks, Fiber Distributed Data Interface Telephone communication, Medical and military applications, ISDN.

Optical amplifiers and networks (08 HRS): optical amplifiers, basic applications and types, semiconductor optical amplifiers, EDFA. Optical Networks: Introduction, SONET / SDH, Optical Interfaces, SONET/SDH rings, High – speed light – waveguides.

Reference Books

1. Optical Fiber Communication- Principle and practice John M. Senior, Prentice Hall of India.
2. Fiber optic communication and other applications Henry Zanger & Cynthia Zanger, Maxwell Macmillan International Edition.
3. An Introduction to Optical Fibers Allen H. Cherin, Mcgrow Hill International Edition.
4. Optical Fiber Communication Gerd Keiser, Mcgrow Hill International Edition.

ADVANCE MAJOR COURSE- AMJ 2	Fiber Optics and its applications	(Practical Credit -01) (Total Marks = 25)

1. Experiments on single mode optical fibers.
2. Experiments on multi mode optical fibers.
3. Study on spectral analysis of optical fiber using optical spectrum analyzer.
4. Measurement on end separation, axial misalignment and angular misalignment loss in optical fiber.
5. To Measure the Insertion Losses & Isolation Rate in Fiber Optic Isolator
6. Study of refractive index profile and numerical aperture of graded-index optical fibers using MATLAB.
7. To Measure the Attenuation in Fiber Optic Attenuator.
8. To study different types of fault detection in fiber using OTDR operating at two different wavelengths.
9. To observe and characterize Fiber Bragg gratings as an optical filter.
10. To Observe and characterize Fiber Bragg Grating (FBG) as an optical sensor.

ADVANCE MAJOR COURSE- AMJ 3	Microprocessor and Microcontroller	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To provide students with a comprehensive understanding of the architecture, operations, and components of microprocessors (8085, 8086) and microcontrollers (8051), including memory, I/O devices, and peripheral interfacing.
2. To equip students with the skills to write assembly programs for microprocessors and microcontrollers, covering data transfer, arithmetic operations, logic operations, and advanced techniques such as interrupts, timers, and serial communication.
3. To teach students how to interface peripheral devices (such as LCD, keyboard, ADC, DAC, sensors, and motors) with microprocessors and microcontrollers, including memory and I/O interfacing.
4. To enable students to understand and program the 8086 microprocessor, with an emphasis on addressing modes, memory segmentation, and peripheral interfacing.
5. To provide practical exposure to the 8051 microcontroller, its internal architecture, programming techniques, and interfacing with external devices.
6. To develop the ability to design and implement embedded systems using microprocessors and microcontrollers, with a focus on applications like data acquisition, control systems, and communication systems.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand Microprocessor Architectures:** Demonstrate a thorough understanding of the architecture, memory organization, and operations of the 8085, 8086, and 8051 microprocessor/microcontroller families.
2. **Write Efficient Assembly Programs:** Write and debug assembly language programs for performing basic arithmetic, logic, and data transfer operations, as well as implementing complex tasks such as time delays, counter operations, and interrupts.
3. **Interface Peripheral Devices:** Interface a variety of peripheral devices (LCD, keyboard, ADC, DAC, sensors, etc.) with microprocessors and microcontrollers, and program them effectively to perform desired operations.
4. **Design Systems with 16-bit Microprocessors (8086):** Design and program systems using the 8086 microprocessor, including memory addressing, segmentation, and peripheral device interfacing.
5. **Program the 8051 Microcontroller:** Write and execute assembly language programs on the 8051 microcontroller, including tasks like I/O operations, serial communication, and interrupt handling.
6. **Apply Microcontroller Knowledge in Embedded Systems:** Develop and implement practical embedded systems by using microprocessor and microcontroller systems, focusing on control, automation, and communication applications.
7. **Implement Practical Applications:** Interface and program external devices such as stepper motors, sensors, and displays, demonstrating the ability to work on real-world applications in embedded systems.

Course Contents:

Introduction to Microprocessor (08 HRS): Microprocessor architecture and its operations, Memory, Input & output devices, The 8085 MPU- architecture, Pins and signals, Timing Diagrams, Logic devices for interfacing, Memory interfacing, Interfacing output displays, Interfacing input devices, Memory mapped I/O.

Basic Programming concepts (09 HRS): Flow chart symbols, Data Transfer operations, Arithmetic operations, Logic Operations, Branch operation, Writing assembly language programs, Programming techniques: looping, counting and indexing. Additional data transfer and 16 bit arithmetic instruction, Logic operation: rotate, compare, counter and time delays, 8085 Interrupts.

16-bit Microprocessors (8086) (08 HRS): Architecture, Pin Description, Physical address, segmentation, memory organization, Addressing modes. Peripheral Devices: 8237 DMA Controller, 8255 programmable peripheral interface, 8253/8254 programmable timer/counter, 8259 programmable interrupt controller, 8251 USART and RS232C.

8051 Microcontroller Basics (10 HRS): Inside the Computer, Microcontrollers and Embedded Processors, Block Diagram of 8051, PSW and Flag Bits, 8051 Register Banks and Stack, Internal Memory Organization of 8051, IO Port Usage in 8051, Types of Special Function Registers and their uses in 8051, Pins Of 8051. Memory Address Decoding, 8031/51 Interfacing With External ROM And RAM. 8051 Addressing Modes.

Assembly programming and instruction of 8051 (10 HRS): Introduction to 8051 assembly programming, Assembling and running an 8051 program, Data types and Assembler directives, Arithmetic, logic instructions and programs, Jump, loop and call instructions, IO port programming. Programming 8051 Timers. Serial Port Programming, Interrupts Programming, Interfacing: LCD & Keyboard Interfacing, ADC, DAC & Sensor Interfacing, External Memory Interface, Stepper Motor and Waveform generation.

Reference Books:

1. Ramesh Gaonkar, "Microprocessor Architecture, Programming, and Applications with the 8085", 6th Edition, Penram International Publication (India) Pvt. Ltd.,2013
2. D. V. Hall : Microprocessors Interfacing, TMH 3rd Edition,
3. Mazidi Ali Muhammad, Mazidi Gillispie Janice, and McKinlay Rolin D., "The 8051 Microcontroller and Embedded Systems using Assembly and C", Pearson, 2nd Edition,2006
4. Kenneth L. Short, "Microprocessors and programmed Logic", 2nd Ed, Pearson Education Inc.,2003
5. Barry B. Brey, "The Intel Microprocessors, 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, PentiumPro Processor, PentiumII, PentiumIII, Pentium IV, Architecture, Programming & Interfacing", Eighth Edition, Pearson Prentice Hall, 2009.
6. Shah Satish, "8051 Microcontrollers MCS 51 Family and its variants", Oxford,2010

ADVANCE MAJOR COURSE- AMJ 3	Microprocessor and Microcontroller	(Practical Credit -01) (Total Marks = 25)

1. Write a program using 8085 Microprocessor for Decimal, Hexadecimal addition and subtraction of two Numbers. (Through Virtual Lab Link)
2. Write a program using 8085 Microprocessor for addition and subtraction of two BCD numbers. (Through Virtual Lab Link)
3. To perform multiplication and division of two 8 bit numbers using 8085. (Through Virtual Lab Link)
4. To find the largest and smallest number in an array of data using 8085 instruction set.
5. To write a program using 8086 to arrange an array of data in ascending and descending order. (Through Virtual Lab Link)
6. To convert given Hexadecimal number into its equivalent ASCII number and vice versa using 8086 instruction set.
7. To convert given Hexadecimal number into its equivalent BCD number and vice versa using 8086 instruction set.
8. To interface 8253 programmable interval timer and verify the operation of 8253 in six different modes.
9. To write a program to initiate 8251 and to check the transmission and reception of character.
10. Serial communication between two 8085 through RS-232 C port.
11. Write a program of Flashing LED connected to port 1 of the 8051 Micro Controller
12. Write a program to generate 10 kHz square wave using 8051.
13. Write a program to show the use of INT0 and INT1 of 8051.
14. Write a program for temperature & to display on intelligent LCD display.
15. Interfacing of Stepper motor to 8051. 16. Interfacing of ADC to 8051.

*__Virtual Lab Link:__
http://vlabs.iitb.ac.in/vlabsdev/labs_local/microprocessor/labs/explist.php

MINOR COURSE-MN 2D	Applied Optics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

1. To introduce students to the fundamental principles of interference, diffraction, and polarization, and their practical applications in optical systems.
2. To provide an understanding of laser physics, including spontaneous and stimulated emissions, laser action, Einstein's coefficients, and the characteristics of different types of lasers.
3. To explore the concept of holography, including the basic theory, types of holograms, and applications in microscopy, interferometry, and character recognition.
4. To study the principles and properties of optical fibers, including light propagation, numerical aperture, and attenuation, with a focus on single-mode and multi-mode fibers.
5. To introduce Fourier optics and optical image processing techniques, including optical filtering and the construction of optical systems like the 4f system for image processing.
6. To examine photonic devices such as LEDs, solar cells, infrared sensors, and optical components, and explore their applications in modern photonics and optical communication systems.

Course Outcomes:

Upon successful completion of the course, students will be able to:

1. Understand and explain the basic principles of interference, diffraction, and polarization, and apply these concepts in optical experiments and technologies.
2. Describe the mechanisms of laser operation, including the processes of spontaneous and stimulated emission, and analyze the characteristics and applications of He-Ne, CO2, and semiconductor lasers.
3. Understand the theory and practical applications of holography, including the construction and use of different types of holograms in fields like microscopy and interferometry.
4. Analyze the principles of light propagation in optical fibers, calculate the numerical aperture, and understand the attenuation limits and characteristics of single-mode and multi-mode fibers.
5. Apply Fourier optics principles to perform optical image processing tasks such as image addition/subtraction, differentiation, and filtering using optical systems.
6. Demonstrate knowledge of photonic devices such as LEDs, solar cells, IR sensors, and optical components, and understand their roles in modern technologies like optical communication, photovoltaic systems, and photonic crystal devices.

Course Contents:

Introduction (02 HRS): Basics of Interference, Diffraction and Polarization.

Lasers (08 HRS): Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, three and four level laser system, He-Ne laser, CO2 laser, Semiconductor lasers, Applications of lasers.

Holography (08 HRS): Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, Interferometry, and character recognition.

Fiber Optics (10 HRS): Optical fibers and their properties, Principal of light propagation through a fiber, The numerical aperture, Attenuation in optical fiber and attenuation limit, Single mode and multimode fibers.

Fourier optic and image processing (08 HRS): Optical image addition/subtraction, Optical image differentiation, Fourier optical filtering. Construction of an optical 4f system, Fourier Transform Spectroscopy.

Photonic Devices (09 HRS): LED, Solar Cell, Photovoltaic cell, IR Sensors, beam splitters, beam combiner, Mach-Zhender interferometer, optical couplers, Photonic crystals, Meta Materials.

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 thEdn., 1996, Cambridge Univ. Press

MINOR COURSE-MN 2D	Applied Optics	(Practical Credit -01) (Total Marks=25)

1. **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
2. **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
3. **Experiments on Holography and interferometry:**
   a) Recording and reconstructing holograms.
   b) Constructing a Michelson interferometer or a Fabry Perot interferometer.
   c) Measuring the refractive index of air.
   d) Constructing a Sagnac interferometer.
   e) Constructing a Mach-Zehnder interferometer.
   f) White light Hologram.
4. **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.

Research Course-RC (*This course will be offered for those students who opts B.Sc. Honors' with Research.)	Research Methodology	(Credit -04) (Total Marks=75+25) Theory 75 Marks Internal 25 Marks

Course Objective:

The course aims to equip students with essential skills in data analysis, research methodology, and scientific writing. It introduces concepts of uncertainties in measurements, probability distributions, and error analysis to enhance precision in experimental and computational research. The course also covers research theory, data collection techniques, statistical analysis, hypothesis testing, and report writing to develop a strong foundation for conducting scientific investigations.

Course Outcomes:

Upon successful completion of the course, students will be able to:

1. Understand and quantify uncertainties in measurements, distinguish between systematic and random errors, and apply significant figures in calculations.
2. Analyze probability distributions, including Binomial, Poisson, Gaussian, and Lorentzian distributions, and apply them to experimental and statistical data.
3. Perform error analysis using statistical and instrumental uncertainty methods, propagate errors, and assess numerical errors in iterative computations.
4. Develop a structured research project by understanding research theory, problem definition, research design principles, and ethical considerations.
5. Apply different data collection methods, measurement techniques, and scaling strategies to ensure accuracy in research.
6. Process and analyze data using statistical tools, including measures of central tendency, dispersion, skewness, regression, and correlation.
7. Conduct hypothesis testing using parametric tests, compare datasets, and evaluate statistical significance in research studies.
8. Develop scientific interpretation skills and write well-structured research reports with proper methodology and critical analysis.

Course Contents:

UNCERTAINTIES IN MEASUREMENTS, PROBABILITY DISTRIBUTIONS, ERROR ANALYSIS (10 HRS): Uncertainties in Measurements: Measuring Errors, accuracy and Precision, systematic errors, Random errors, Significant figures and Round off, Uncertainties, Parent and Sample Distributions, Mean, median and mode, Standard Deviation of Distributions. Probability Distributions: Binomial Distributions, Poisson distribution, Gaussian or Normal Error Distribution, Lorentzian Distribution. Selected problems and examples. Error Analysis: Instrumental and Statistical Uncertainties, Propagation of Errors, Specific Error Formulas withy examples, Application of Error Equations. Numerical Errors, Conditioning and Stability, Convergence of Iterative Processes.

RESEARCH THEORY (08 HRS): Research theory and practice: Research basics, Research theory, Structuring the research project, Research ethics, Finding and reviewing the literature. Defining the Research Problem: Selection of a research Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem: An Illustration. Research Design:

Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs.

DATA COLLECTIONS (08 HRS): Measurement in Research: Measurement Scales, Sources of Error in Measurement, Tests of Sound Measurement, Technique of Developing Measurement Tools. Scaling: Meaning of Scaling, Scale Classification Bases, Important Scaling Techniques, Scale Construction Techniques. Methods of Data Collection: Collection of Primary Data, Observation Method, Collection of Data through Schedules, Some Other Methods of Data Collection.

DATA ANALYSIS (08 HRS): Processing and Analysis of Data: Processing Operations, Some Problems in Processing. Elements/Types of Analysis: Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes.

HYPOTHESES (06 HRS): Testing of Hypotheses-I (Parametric or Standard Tests of Hypotheses): Basic Concepts Concerning Hypothesis and Testing of Hypotheses, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Measuring the Power of a Hypothesis Test, Tests of Hypotheses. Important Parametric Tests, Hypothesis Testing of Means, Hypothesis Testing for Differences between Means, Hypothesis Testing for Comparing Two Related Samples. Hypothesis Testing of Correlation Coefficients, Limitations of the Tests of Hypotheses.

WRITING (05 HRS): Interpretation and Report Writing: Technique of Interpretation, Precaution in Interpretation. Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report Types of Reports ,Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Reference Books:

1. Research Methods the Basics by Nicholas Walliaman, Taylor and Francis London& New York 2011.
2. Research Methodology- Methods and Techniques 2nd edition. By C R Kothari, New Age Int. Publ. 2004.
3. Data Reduction and Error Analysis for the Physical Sciences 3rd Ed by Philip R Bevington & D Keith Robinson, McGraw – Hill (2003.
4. Numerical Methods by Balagurusamy, Tata McGraw – Hill (2000).
5. Numerical Analysis, 2nd Ed. by Francis Scheid, McGraw-Hill (2009).