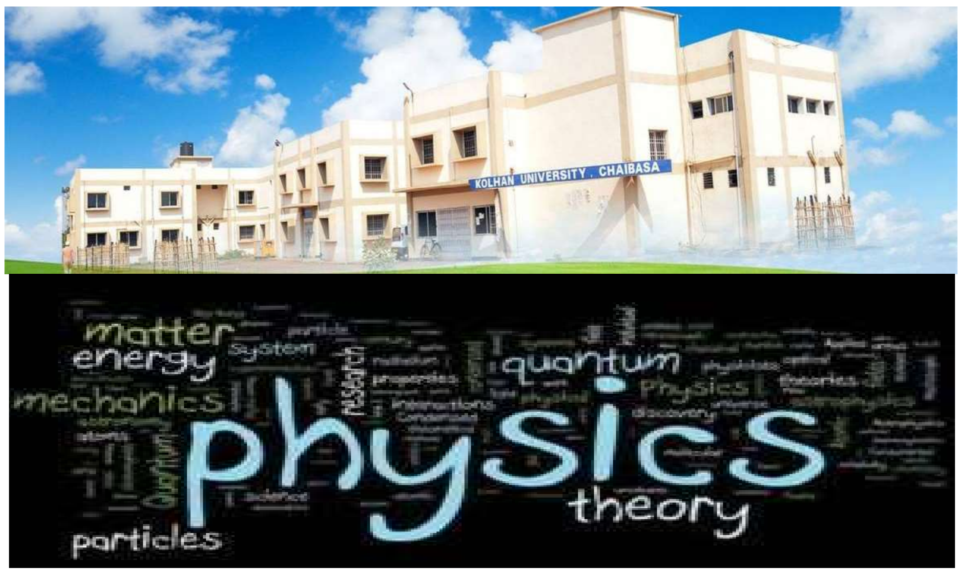
Department of Physics

Kolhan University, Chaibasa



Syllabus for

Four Years Undergraduate Program

in Physics

Under New Education Policy 2020

Effective from Academic Year 2025 onwards

Board of Studies (BoS)
University Department of Physics
Kolhan University, Chaibasa
Meeting Date: 26-07-2025

Sl. No	Member	Signature
1	Dr. Ranjeet Kr. Karn Chairman & HoD	Ranjeet
2	Dr. Amar Nath Gupta External Expert Associate Professor, Department of Physics IIT Kharagpur	[signature]
3.	Dr. Dharmendra Singh External Expert Associate Professor, Department of Physics Central University of Jharkhand Ranchi	
4	Dr. Kiran Dubey, Member Assistant Professor, Department of Physics, Jsr. Co-operative College, Jamshedpur	
5	Dr. Prakash Sarkar Special Invitee Assistant Professor, Department of Physics, Kashi Sahu College, Seraikella	[signature]
6	Dr. Maguni Mahakhud, Member Assistant Professor, University Department of Physics, K.U., Chaibasa	[signature]
7	Dr. Somnath Kar, Member Assistant Professor, University Department of Physics, K.U., Chaibasa	[signature]
8	Dr. Man Mohan Gupta, Member Assistant Professor, Department of Physics, Tata College, Chaibasa	[signature]

SEMESTER	COURSE CODE	TITLE OF THE PAPER	CREDITS Theory + Practical
I	MJ – 1	Mechanics	3+1
	AC – 1/2	Mechanics	3+1
	MDC -1/2/3	Elements of Modern Physics	3+0
II	MJ – 2	Basic Electronics	3+1
	AC – 1/2	Mechanics	3+1
III	MJ – 3	Mathematical Physics-I	3+1
	MJ – 4	Elements of Modern Physics	3+1
	AC – 3/4	Electrodynamics	3+1
IV	MJ – 5	Computational Physics	3+1
	MJ – 6	Heat and Thermodynamics	3+1
	MJ – 7	Electrodynamics	3+1
	AC – 3/4	Electrodynamics	3+1
V	MJ-8	Classical Mechanics	3+1
	MJ – 9	Quantum Mechanics-I	3+1
	MJ – 10	Mathematical Physics-II	3+1
	MJ – 11	Optics & Laser Physics	3+1
	AC-5/6	Solid State Physics	3+1
	IAP	Internship/Apprenticeship/Project	4+0
VI	MJ – 12	Atomic &Molecular Physics	3+1
	MJ – 13	Solid State Physics	3+1
	MJ – 14	Nuclear & Particle Physics	3+1
	MJ – 15	Statistical Mechanics	3+1
	AC-5/6	Solid State Physics	3+1
VII	MJ – 16	Quantum Mechanics-II	3+1
	MJ – 17	Mathematical Physics-III	3+1
	MJ – 18	Modern Experimental technique	3+1
	AC-7/8	Thermal Physics	3+1
VIII	MJ – 19	Advanced Characterization Techniques	3+1
	MJ – 20	Advanced Electronics	
	RC Or AMJ – 1 AMJ – 2 AMJ – 3	Dissertation Research Project OR Nano Science and Technology Fiber Optics and its applications Microprocessor and Microcontroller	12 (4+8) 3+1 3+1 3+1
	AC-7/8	Thermal Physics	3+1
Remarks: Honours students not undertaking research will do three courses (AMJ=Advance Major) for 12 credits in lieu of a Research/Dissertation.			

General Guidelines:

Problem solving (seen or unseen) may be emphasized in teaching-learning and evaluation process, so that students may be ready to face the real-life problem.

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 behaviour 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, centre 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, centre of mass &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 (05 HRS):

Elastic constants and their relations. Twisting torque on a cylinder or wire (derivation not required). Cantilever, bending of beams, flexural rigidity, Streamline and turbulence flow of fluid, Bernoulli's theorem, Viscosity, Poiseuille's equation for capillary flow.

Gravitation and Central Force Motion (06 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 (longitudinal & transverse) Doppler effect and kinematics. Energy-momentum transformation, Elementary introduction of GTR.

Reference Books:

1. Prospective of Modern Physics, Arthur Beiser.
2. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
3. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
4. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
5. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning
6. Feynman Lectures, Vol. I, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
7. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

8. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
9. Properties of matter D S Mathur
10. 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 study the Motion of Spring and calculate (a) Spring constant (b) g (c) Modulus of rigidity.
2. To determine the Moment of Inertia of a Flywheel.
3. To determine g and velocity for a freely falling body using Digital Timing Technique
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Young's Modulus of a Wire by Optical Lever Method.
6. To determine the elastic Constants of a wire by Searle's method.
7. To determine the value of g using Bar Pendulum.
8. To determine the value of g using Pohl's 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.

ASSOCIATED CORE COURSE-AC-1/2	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, centre of mass, conservative and non-conservative forces

Energy and Momentum (04 HRS): Conservation of energy and momentum, Elastic and inelastic collision, work-energy theorem, motion of rockets.

Rotational Motion (05 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 (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.

Elasticity and Fluid Motion (05 HRS): Elastic constants and their relations, twisting torque on a cylinder or wire, viscosity, 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. 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. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw HillEducation

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

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

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 behaviour 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:

(Derivations are not required)

Introductory Quantum Theory (30 HRS):

Blackbody Radiation, Nature of Light: Planck's quantum theory, 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.

Basic introduction of statistical physics.

Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Energy-time uncertainty principle application to virtual particles and range of an interaction.

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 current densities in one dimension.

Lasers & its applications: Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Application: LASIK, Defence, Mechanical, Barcoding etc

Introductory Nuclear Physics (15 HRS): (No derivation)

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	Basic Electronics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

The objective of this course is to provide a foundational understanding of electronic components, circuits, and systems that form the basis of modern electronic devices and applications.

Course Outcomes:

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

1. Understand the construction, operation, and characteristics of semiconductor diodes, and analyze their applications in rectifier and power supply circuits including filters and voltage regulators.
2. Explain the working principles, configurations, and characteristics of Bipolar Junction Transistors (BJT) and Field Effect Transistors (JFET, MOSFET), and perform DC analysis and biasing for amplifier applications.
3. Analyze the characteristics and parameters of operational amplifiers and design basic analog signal processing circuits such as amplifiers, integrators, differentiators, and voltage followers.
4. Demonstrate understanding of number systems, Boolean algebra, logic gates, and design basic combinational logic circuits including adders using standard procedures.
5. Describe the architecture and working of 8085 microprocessor and introduce the features and basic programming of microcontrollers such as Arduino Uno.

Course Contents:

Semiconductor Diodes (10 HRS): Introduction, PN Junction diode, Characteristics and Parameters, Diode Approximations. Diode Applications: Half Wave &Full Wave Rectification. Power Supply: Capacitor Filter Circuit, RC π Filter, Zener Diodes: Junction Breakdown, Circuit Symbol and Package, Equivalent Circuit, Zener Diode as Voltage Regulator.

Transistors (12 HRS): Introduction of BJT, its characteristic, CB, CE & CC modes, BJT Biasing: DC/AC Load line and Bias point.
Field Effect Transistor: Junction Field Effect Transistor, JFET Characteristics, MOSFETs: Enhancement MOSFETs, Depletion Enhancement MOSFETs. 12 Hrs

Operational Amplifiers (12 HRS): Schematic Symbol, Op-Amp characteristics, Op-Amp parameters - Gain, input resistance, Output resistance, CMRR, slew rate, Bandwidth, input offset voltage, Input bias Current and Input offset Current, Equivalent Circuit of Op-Amp, Open Loop Op-Amp configurations, Differential Amplifier, Inverting & Non-Inverting Amplifier. Op-Amp Applications: Adder & subtractor, Voltage Follower, Integrator, Differentiator, Logarithmic.

Boolean Algebra and Logic Circuits (06 HRS): Binary numbers, Number Base Conversion, Octal &Hexa-Decimal Numbers, Complements, Basic definitions, Axiomatic Definition of Boolean Algebra, Basic Theorems and Properties of Boolean Algebra, Boolean Functions, Canonical and Standard Forms, Other Logic Operations, Digital Logic Gates, Combinational logic: Introduction, Design procedure, Adders- Half adder, Full adder.

Microprocessor & Microcontroller (Arduino Uno) **(05 HRS)**: Introduction to microcontroller and microprocessors, evolution of microprocessor, Architecture of 8085 microprocessor.

Reference Books:

1. Electronic Devices and Circuits, David A Bell, 5th Edition, Oxford, 2016
2. Op-amps and Linear Integrated Circuits, Ramakanth A Gayakwad, Pearson Education, 4th Edition
3. Digital Logic and Computer Design, M. Morris Mano, PHI Learning, 2008 ISBN-978-81-203-0417-8
4. Electronic Instrumentation and Measurements (3rd Edition) – David A. Bell, Oxford University Press, 2013
5. Electronic Communication Systems, George Kennedy, 4th Edition, TMH
6. Ramesh S. Goankar, "Microprocessor Architecture, Programming and Applications with 8085", 5th Edition, Prentice Hall Press

MAJOR COURSE- MJ 2	Basic Electronics	(Practical Credit-01) (Total Marks=25)

Note: All the experiments must be performed on Breadboard.

1. To study V-I characteristics of PN junction diode and verification of diode equation.
2. To study the clipper and clamper circuits using p-n junction diode.
3. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
4. Half Wave and Full wave Rectifiers: Calculation of ripple factor and rectification efficiency.
5. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
6. To design an inverting and non-inverting amplifier using Op-amp (741).
7. Use of OP-Amp (741) as integrator.
8. Use of OP-Amp (741) as differentiator.
9. To study the characteristics of a FET.
10. Half Adder, Full Adder, and 4-bit binary Adder using Digital ICs.
11. Half Adder and Full Adder Truth table verification using IC.
12. Arduino Uno based experiments.

Reference Books:

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
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
8. Ramesh S. Goankar, “Microprocessor Architecture, Programming and Applications with 8085”, 5th Edition, Prentice Hall

Semester III

MAJOR COURSE- MJ 3	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.

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, Viva Book
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 3	Mathematical Physics-I	(Practical Credit-01) (Total Marks=25)

1. Programming Language (Python) :
   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; Error Handling, Basic Algorithms: Linear search, Binary search, Bubble sort, Insertion sort, Quick sort. Basic 2-D plotting using Pylab& Matplotlib
2. Plotting/Visualization: Python
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. Random number generator.
VIII. Fitting a Straight Line to a Data,
IX. Deviations About an Average,
X. Arrange a List of Numbers in Ascending and Descending Order,
XI. Binary Search.
XII. 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.
XIII. Write a program to visualize the divergence and curl of a vector field $\vec{F}(x, y) = (y, -x)$ in 2D.
XIV. 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. Let Us Python, Yashavant Kanetkar
2. Python in a Nutshell, Alex Martelli
3. Core Python Programming, Wesley J. Chun
4. An Introduction to computational Physics, T.Pang, 2nd Edn. ,2006,Cambridge Univ.

MAJOR COURSE- MJ 4	Elements of Modern Physics	(Theory Credit -03) (Total Marks=60+15)

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 behaviour in one-dimensional systems**, including probabilities, probability densities, and normalization of wave functions.
6. **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.
7. **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:

Blackbody Radiation, Planck's quantum theory, Photo-electric effect and Compton scattering. de Broglie wavelength and matter waves; Davisson-Germer experiment, Hydrogen Spectrum. **(6 HRS)**

Position measurement- gamma ray microscope thought experiment; Heisenberg uncertainty principle; Estimating minimum energy of a confined particle using uncertainty principle.

(04 HRS)

Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension. **(10 HRS)**

One dimensional infinite box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier. **(10 HRS)**

Introduction of Nucleus & Nuclear Forces. Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy. **(04 HRS)**

Radioactivity: Introduction to Radioactivity: α decay, β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. Introduction of Nuclear Reaction: Fission and fusion. **(07 HRS)**

(04 HRS) Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, colour, and gluons.

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.

MAJOR COURSE- MJ 4	Elements of Modern Physics	(Practical Credit -01) (Total Marks=25)

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colors.
5. Study of Zeeman effect using Fabry-Perot interferometer.
6. Use GM counter or simulation to measure decay rate, energy spectrum, and verify neutrino hypothesis

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

ASSOCIATED CORE- AC-3/4	Electrodynamics	(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. Explain the fundamental concepts of electrostatics, including Coulomb's law, electric field, electric potential, and Gauss's law, and apply them to calculate electric fields and potentials in symmetric charge distributions.
2. Solve Poisson's and Laplace's equations in one, two, and three dimensions with appropriate boundary conditions, and apply uniqueness theorems and the method of images for potential calculations.
3. Describe the behaviour of static magnetic fields using Biot–Savart and Ampère's laws, and compute magnetic fields and vector potentials for standard current configurations.
4. Analyze the full set of Maxwell's equations in vacuum and material media, and explain their implications in terms of field behaviour, energy, and momentum conservation.
5. Utilize scalar and vector potentials to solve electromagnetic field problems and explain gauge transformations and their physical significance in electrodynamics.
6. Derive and apply the electromagnetic wave equations in vacuum, linear media, and conducting media, and analyze wave reflection, transmission, and polarization.
7. Explain dispersion in different media (dielectrics, conductors, plasmas) and solve problems involving group and phase velocities.
8. Analyze the propagation of transverse electric (TE) waves in rectangular waveguides and interpret waveguide behaviour in guided media.

Course Contents:

Electrostatics (10 HRS): Coulomb's law, Electric field, Gauss's law, applications of Gauss's law, Electric Potential, Poisson's equation and Laplace's equation, Work and energy in electrostatics, Techniques for calculating potentials: Laplace's equation in one, two and three dimensions, boundary conditions and uniqueness theorems, Method of Images, Multipole expansion.

Magnetostatics (05 HRS): Biot-Savart Law, Divergence and Curl of B, Ampere's law and applications of Ampere's law, Magnetic vector potential, Multipole expansion of the vector potential.

Electrodynamics (15 HRS): Faraday's law, Energy in magnetic fields, Maxwell's equations, Maxwell's displacement current, Maxwell's equations and magnetic charge, Maxwell's equations inside matter, boundary conditions. Scalar and vector potentials, Gauge transformations, Coulomb and Lorentz Gauge; Lorentz force law in potential form, Energy and momentum in electrodynamics, Poynting's theorem Maxwell's stress tensor, Conservation of momentum.

Electromagnetic waves (15 HRS): Electromagnetic waves in non-conducting media: Monochromatic plane waves in vacuum, propagation through linear media, Reflection and transmission at interfaces. Fresnel's laws; Electromagnetic waves in conductors: Modified wave equation, monochromatic plane waves in conducting media. Polarization, Dispersion: Dispersion in non-conductors, free electrons in conductors and plasmas. Guided waves, TE waves in a rectangular wave guide.

Reference Books:

1. Introduction to Electrodynamics, David J Griffiths, 2nd Edition, Prentice Hall India, 1989.
2. Classical Electrodynamics, JD Jackson, 4th Edition, John Wiley & Sons, 2005.
3. Classical Electromagnetic Radiation, MA Heald and JB Marion, Saunders, 1983.
4. Electrodynamics, Gupta,Kumar, Singh, Pragathiprakashan,18 th edition, 2010.
5. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, TMH 10
6. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
7. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
8. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press
9. Electricity and Magnetism, J. H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
10. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
11. Fundamental of Magnetism and Electricity, by D. N. Vasudiva.

ASSOCIATED CORE- AC-3/4	Electrodynamics	(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 determine the frequency of A.C. main using Sonometer.
5. To determine the resistance of an electrolyte for AC current and study its concentration dependence.
6. 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.

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 5	Computational Physics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

The primary objective of this course is to equip students with the foundational computational tools and numerical techniques essential for solving complex physical problems.

Course Outcomes:

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

1. Grasp the significance of computational methods in modern physics and apply a structured problem-solving paradigm. Learn basic Linux-based programming tools, flowcharting, and algorithm development, with practical exposure to Python or SciLab.
2. Identify and evaluate truncation and round-off errors in floating-point computations. Understand precision issues, overflow/underflow conditions, and the stability and conditioning of numerical algorithms.
3. Apply numerical methods such as Bisection, Secant, and Newton-Raphson to find roots of algebraic and transcendental equations, and analyze their convergence and error behaviour.
4. Develop numerical solutions to systems of linear equations using Gauss elimination, matrix inversion, and iterative methods. Compute eigenvalues and eigenvectors through numerical techniques such as Singular Value Decomposition and power methods.
5. Use Lagrange and Newton interpolation methods for data approximation. Understand and apply curve fitting methods including least squares and B-splines for both linear and nonlinear datasets.
6. Employ interpolation-based and spline methods for numerical differentiation. Use standard quadrature rules—Trapezoidal, Simpson's, Weddle's, and Gauss quadrature formulas—for accurate numerical integration.
7. Implement Euler's and Runge-Kutta methods for initial value problems. Solve boundary value problems of second-order ODEs using finite difference methods.

Course Contents:

Introduction (03 HRS): Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of Linux as an Editor. Algorithms; Introduction to computer programming in Python/SciLab.

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): Solution of simultaneous linear equations: Gauss Elimination Method, Pivoting, Matrix Inversion, Singular Value Decomposition and Iterative Method, Convergence of solutions, 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.

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.

Reference Books

1. Computational Physics with Python by Dr. Eric Ayars
2. Numerical Methods in Engineering with Python by Jaan Kiusalaas, Cambridge UniversityPress.
3. Mathews, J. H., Numerical Methods for Mathematics, Science and Engineering, Prentice-Hall,(2000).
4. Introduction to Numerical Analysis, S.S. Sastry, PHI Learning Pvt. Ltd

.5. Schaum's Outline of Programming with C++., J. Hubbard, MCGraw-Hill Pub.

6. Numerical Recipes in C: The Art of Scientific Computing W.H Pressetal, Cambridge University Press.
7. A First Course in Numerical Methods, U.M Ascher& C. Greif, PHI Learning.
8. Elementary Numerical Analysis, K.E .Atkinson, Wiley India Edition.
9. Numerical Methods for Scientists & Engineers, R.W. Hamming, Courier Dover Pub.

10.An Introduction to Computational Physics, T. Pang, Cambridge Univ.
11.Simulation of ODE/PDE Models with Matlab® ,Octave and Scilab, Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernandez. 2014 Springer.
12.Scilab by Example: M. Affouf 2012, ISBN: 978-1479203444.
13.Scilab (A free Software to Matlab): H.Ramchandran, A.S. Nair. 2011, S.Chand& Company.
14.Scilab Image Processing, LamberrM.Surhone, 2010 Betascript Publishing.

MAJOR COURSE- MJ 5	Computational Physics	(Practical Credit-01) (Total Marks=25)

Note: Preparation and submission of lab report in LaTEX only.

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.

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. Introduction to Computational Science: Modelling and Simulation for the Sciences by Angela B. Shiflet, George W. Shiflet, 2009, Princeton University Press
7. Computational Methods for Physics by Joel L. Schiff, 2008, Cambridge University Press
8. 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 6	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 behaviour, 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:

Behaviour of Real Gases (10 HRS): 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. (5 Lectures)

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, Introduction to thermal electricity.

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 6	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 Planck's radiation formulae (in silico).

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 7	Electrodynamics	(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. Explain the fundamental laws of electrostatics including Coulomb's law, electric field, electric potential, and Gauss's law, and apply them to solve problems involving symmetric charge distributions.
2. Formulate and solve Poisson's and Laplace's equations in various coordinate systems with suitable boundary conditions, and use techniques such as the method of images and multipole expansion to compute electrostatic potentials.
3. Describe the concepts of magnetostatics and compute magnetic fields using Biot–Savart and Ampère's laws for simple current configurations; analyze the magnetic vector potential and perform multipole expansion of the vector potential.
4. Interpret and apply Maxwell's equations in free space and in matter to describe the behavior of time-varying electric and magnetic fields; understand the role of displacement current and magnetic charges.
5. Utilize scalar and vector potentials to represent electromagnetic fields; explain gauge transformations and distinguish between Coulomb and Lorentz gauges; apply the Lorentz force law in potential form.
6. Analyze energy and momentum in electromagnetic fields using Poynting's theorem and Maxwell's stress tensor, and apply conservation principles to electromagnetic systems.
7. Derive and solve wave equations for electromagnetic waves in non-conducting and conducting media; evaluate wave behavior including reflection, transmission, and polarization at material interfaces using Fresnel's laws.
8. Explain and analyze dispersion phenomena in dielectrics, conductors, and plasmas; derive wave propagation characteristics for guided waves, especially TE modes in rectangular waveguides.

Course Contents:

Electrostatics (10 HRS): Coulomb's law, Electric field, Gauss's law, applications of Gauss's law, Electric Potential, Poisson's equation and Laplace's equation, Work and energy in electrostatics, Techniques for calculating potentials: Laplace's equation in one, two and three dimensions, boundary conditions and uniqueness theorems, Method of Images, Multipole expansion.

Magnetostatics (05 HRS): Biot-Savart Law, Divergence and Curl of B, Ampere's law and applications of Ampere's law, Magnetic vector potential, Multipole expansion of the vector potential.

Electrodynamics (15 HRS): Faraday's law, Energy in magnetic fields, Maxwell's equations, Maxwell'sdisplacement current, Maxwell's equations and magnetic charge, Maxwell's equations inside matter, boundary conditions. Scalar and vector potentials, Gauge transformations, Coulomb and Lorentz Gauge; Lorentz force law in potential form, Energy and momentum in electrodynamics, Poynting's theorem Maxwell's stress tensor, Conservation of momentum.

Electromagnetic waves (15 HRS): Electromagnetic waves in non-conducting media: Monochromatic planewaves in vacuum, propagation through linear media, Reflection and transmission at interfaces. Fresnel's laws; Electromagnetic waves in conductors: Modified wave equation, monochromatic plane waves in conducting media. Polarization, Dispersion: Dispersion in non-conductors, free electrons in conductors and plasmas. Guided waves, TE waves in a rectangular wave guide.

Reference Books:

1. Introduction to Electrodynamics, David J Griffiths, 2nd Edition, Prentice Hall India, 1989.
2. Classical Electrodynamics, JD Jackson, 4th Edition, John Wiley & Sons, 2005.
3. Classical Electromagnetic Radiation, MA Heald and JB Marion, Saunders, 1983.
4. Electrodynamics, Gupta,Kumar, Singh, Pragathiprakashan,18 th edition, 2010.
5. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, TMH 10
6. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
7. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
8. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press
9. Electricity and Magnetism, J. H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
10. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
11. Fundamental of Magnetism and Electricity, by D. N. Vasudiva.

MAJOR COURSE- MJ 7	Electrodynamics	(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 determine the frequency of A.C. main using Sonometer.
5. To determine the resistance of an electrolyte for AC current and study its concentration dependence.
6. 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.
7. 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.