UNIT-1: LINEAR ALGEBRA AND MATRICES (PERIODS-8 Hours)

Vector spaces, basis vectors, the inner product, some inequalities, linear operators and their properties, Matrices- the Eigen value problem, determination of eigenvalues Eigen functions, diagonalisation, trace and normalization of matrix, Caley-Hamiltonian theorem.

(Reference: Riley and Joshi)

UNIT-2: SPECIAL FUNCTIONS (PERIODS-10 Hours)

Legendre equation, Reylining formula, generating function, orthogonality, hermits polynomial, Rodriguez formula, recurrence relation, generating function, orthogonality, Laguerres equation, Rodriguez formula, generating function, orthogonality, Bessel equation, generating function, recurrence relation, orthogonality

(Reference: Chow)

UNIT-3: FOURIER SERIES AND FOURIER AND LAPLACE TRANSFORM (PERIOD-9 Hours)

Fourier series- periodic function, Euler Fourier formula, Dirichilete conditions, half range Fourier series, change of interval, Parsevals identity, alternate forms of the Fourier series, application of Fourier series- vibrating string, RLC circuit

(Reference: Chow)

Integral transform- Fourier integral and Fourier transform, few examples, the Dirac delta function, properties of Fourier transform, odd and even function, convolution and deconvolution theorem, Parsevals therom, Laplace transform, Laplace transform of derivatives and integrals, properties of the Laplace transform,

(Reference: Riley)

UNIT-4: ELEMENTS OF COMPLEX ANALYSIS (PERIOD-5 Hours)

Analytic functions, Cauchy Riemann condition, contour integrals , Laurent series, the residue therem, method of finding the residues, evaluation of definite integrals

(Reference: M.L. Boase)

UNIT-5: ROOTS OF FUNCTION, INTERPOLATION AND EXTRAPOLATION (PERIODS-7 Hours)
Roots of the functions, the bisection method, the iteration methods, acceleration of convergence, the false position method, interpolation: errors in polynomial interpolation, finite differences, Newton’s formula for interpolation.

(Reference: Shashtri)

UNIT-6: INTEGRATION AND SOLUTION OF DIFFERENTIAL EQUATION

(PERIOD-4 Hours)

Numerical integration, trapezoidal rule, error calculations, Simpson 1/3 rule, solution of first order differential equation by Runge Kutta method.

(Reference: Shastri)

UNIT-7: ELEMENTARY PROBABILITY THEORY

(PERIOD-5 Hours)

A definition of the probability sample space, permutation and combination, fundamental probability theorems, random variables, and probability distributions, special probability distribution, binomial, Poisson, normal

(Reference: Chow)

REFERENCE BOOKS:-

1. Mathematical Methods for Physicists – Tai L. Chow


3. Mathematical Methods In Physical Sciences- M.L.Boas
   3rd Edition, 2006, Wily India Education

4. Matrices And Tensors In Physics- A.W. Joshi
   3rd Edition, New Age International (P) Ltd.

5. Complex Variables-M.R.Spiegel
   McGraw Hill Book Company

CLASSICAL MECHANICS

UNIT-1: ENERGY AND WORK (PERIOD-6 Hours)
Conservative force, potential energy, conservative momentum and angular momentum, conservative system of particles of mass, motion of CoM, conservation theorems, equation of motion under different types of forces, variational theorem

UNIT-2: THE LANGRANGIAN FORMULATION OF MECHANICS (PERIOD-8 Hours)
Generalized coordinates, DoF, configurational space, constraints, D'Alembert's principle and Lagrange's equations, kinetic energy in generalized coordinates, generalized momentum and energy, Jacobi integral.
Gauge function for the Lagrangian, gauge invariance, cyclic or ignorable coordinates, integral of motion, concept of symmetry, homogeneity and isotropy, invariance under Galilian transformation.

UNIT-3: HAMILTONIAN DYNAMICS (PERIOD-7 Hours)
Hamilton's principle and Lagrange's equations, Lagrange's equation for non-holonomic systems, few examples of Lagange's equation of motion, method of undetermined multipliers, the Hamiltonian of the dynamical system, Hamilton's canonical equations, Integrals of Hamilton's equations, canonical transformations, Poission bracket, equation of motion in Poission bracket form, phase space and Liouville's theorem, Lagrange from Hamiltonian, few application of Hamiltonian formulation.

UNIT-4: CENTRAL FORCE MOTION (PERIOD-7 Hours)
The two body problem and the reduced mass, general properties of central force motion, effective potential and classification of orbits, general solutions, inverse square law of the force, Kepler's law of planetary motion, applications, satellites and space craft, communication satellites, flyby mission to the outer planets, hyperbolic orbits and Rutherford scattering, elastic collisions: lab and cm system, inelastic collisions (Barger & Olsson).

UNIT-5: COUPLED OSCILATIONS (PERIOD-7 Hours)
Coupled pendulum, normal coordinates, coupled oscillators and normal oscillators, and normal modes, equation of motion of a coupled system, normal modes of oscillation, orthogonality of Eigen vectors, normal coordinates, forced oscillations of coupled oscillator, coupled oscillator circuits, vibration of loaded string, vibrating string and the wave equations.

UNIT-6: THE MOTION OF RIGID BODIES. (PERIOD-7 Hours)
The independent coordinates of rigid bodies, the Eulerian angles, rotational kinetic energy and angular momentum, inertia tensor, principle axis of inertia, Euler's equation of motion, motion of a torque free symmetrical top (pseudo force).
UNIT-7: THE SPECIAL THEORY OF RELATIVITY (PERIOD-6 Hours)

The Michelson – Morley experiment, the postulates of the special theory of relativity, the Lorentz transformations, 4-D space, relativistic

Reference Books:


2. Classical Mechanics – Takwale, Puranic


4. Classical Mechanics- Rana and Joag

5. Classical Mechanics: A Modern Perspective- Barger and Olsson
UNIT-1: PHYSICS OF SEMICONDUCTORs  (PERIOD – 5 Hours)

Density of states and and its application to the semiconductors, Fermi-Dirac distribution & its characteristics, equilibrium distribution of electrons and holes in intrinsic and extrinsic semiconductors, position of Fermi energy level, its variation with doping concentration and temperature.

(Reference: NEEMAN)

UNIT-2: THE P-N JUNCTION  (PERIOD – 7 Hours)

Basic structure of p-n junction, built in potential barrier, electronic field, space charge width, reverse applied bias, junction capacitance, diode characteristics: forward, reverse regions, current voltage relations, frequency response, load lines, diode applications: rectification, clipping-clamping circuits, Zener diode

(Reference: NEEMAN & MALVINO)

UNIT-3 BI-JUNCTION TRANSISTORS  (PERIOD – 8 Hours)

Introduction, working principle, current and voltage ratings, transistor characteristic curves: collector curve, transistor biasing: base bias, emitter bias, voltage divider bias, applications, BJT amplifiers, configurations: CE, CC, CB, load line analysis, amplifier AC equivalent circuits, H parameters.

(Reference: PAYNTER)

UNIT-4 FIELD EFFECT DEVICES  (PERIOD – 7 Hours)

The JFET biasing, working principle, drain curves, transcedeuctance curves, JFET approximations, the depletion and enhancement mode MOSFET, basic idea and device characteristics, applications, JFET amplifiers, JFET analog switch, MOSFET amplifiers and switches, introduction to CMOS.

(Reference: MALVINO)

UNIT-5 OPTOELECTRONIC DEVICES  (PERIOD – 7 Hours)

Optical absorption, photon absorption coefficient, electron hole pair generation, solar cell: the I-V characteristics, p-n junction solar cell, conversion efficiency, the heterojunction solar cell, photo detectors, photodiode, pin photodiode, avalanche photodiode, phototransistors, light emitting diodes, generation of light, internal and external quantum efficiency, laser diodes, stimulated emission and population inversion.
UNIT-6 OPERATIONAL AMPLIFIER (PERIOD - 7 Hours)

Operation overview, differential amplifiers and OPAMP specifications, modes of operations, input output parameters, frequency response, application, inverting amplifiers, non inverting amplifiers, voltage followers, comparators, integrators, differentiator, summing negative and positive feedback.

UNIT-7 DIGITAL ELECTRONICS (PERIOD - 7 Hours)

Logic gates, universal logic gates, D'Morgans theorem, flip-flops: RS, D, T, JK, MS., shift resistors, counting, synchronous and asynchronous counters, binary comparison, ADC and DAC, 2-2R network, binary ladder

Reference: J. D. RYTER

Reference Books:

UNIT -1: THE ORIGINE OF QUANTUM THEORY (PERIOD - 8 Hours)

Black body radiation, the photoelectric effect, the Compton effect, atomic spectra and the Bohr hydrogen atom, the Stern - Garlach experiment, angular momentum and spin, D'Broglie hypothesis, wave- particle duality, interpretation of wave function, wave function for particle momentum, wave packets, the Heisenberg’s uncertainty principle

(REFERENCE: BRANSDEN)

UNIT-2: THE SHRODINGER'S EQUATION (PERIOD - 8 Hours)

The time dependent Schrödinger’s equation, conservation of probability, expectation values and operator, Ehrenfest theorem, the time dependent Schrödinger’s equation, stationary states, Eigen functions and Eigen values.

(REFERENCE: BRANSDEN)

UNIT-3: 1-D PROBLEM AND THEIR EXTENSION TO 3-D CASE (PERIOD-9 Hours)

General formula, the free particle, the potential step, the potential barrier, the infinite square well, the linear harmonic oscillator.

(REFERENCE: BRANSDEN)

UNIT-4: FORMALISM OF QUANTUM MECHANICS AND MATHEMATICAL BACKGROUND (PERIOD - 7 Hours)

State of the system, dynamical variables and operators, momentum space, Direc’s bra-ket notation, Hermitian operators, adjoint, orthogonality, orthonormality, degeneracy, probability amplitude, commutation, unitary transformations, matrix representations, (application to LHO problem).

(REFERENCE: BRANSDEN)

UNIT-5: ANGULAR MOMENTUM-I (PERIOD - 8 Hours)

Orbital angular momentum, angular momentum algebra, the Eigen values and functions of L² & L_z, simultaneous eigenfunctions of L² & L_z, spherical harmonics, application to rotational energy levels of diatomic molecule,
UNIT-6: ANGULAR MOMENTUM-II  
(PERIOD - 8 Hours)

The spectrum of $J^2$, $J_z$, Matrix representation of angular momentum operators, spin angular momentum, spin one half, the Pauli's spin matrices, total angular momentum, the addition of angular momentum, C-G coefficients.

References:

1. Quantum Mechanics- B.H. Bransden and C. J. Joachain

2. Quantum Mechanics- L.I. Schiff

3. Quantum Mechanics-J.D.Powell and B. Crossman

4. Quantum Mechanics – S. Gasiorowicz
   Wiley International
UNIT-1: CENTRAL POTENTIAL (PERIOD - 6 Hours)
Separation of the SE in spherical polar coordinates, the hydrogen atom, energy levels, the Eigen function of the bound states.

UNIT-2: APPROXIMATION METHODS (TIME INDEPENDENT) (PERIOD-10 Hours)
Time independent perturbation theory, non degeneracy (perturbed harmonic oscillator), degeneracy (fine structure of hydrogen atom), the variational method (particle in 1-D infinite square well), the WKB approximations (alpha particle decay of the nuclei), approximation method (time dependent) Fermi Golden rule.

UNIT-3: SEMICLASSICAL THEORY OF THE RADIATION (PERIOD-10 Hours)
Transition probability for the absorption and induced emission, electronic dipoles and forbidden transition, selection rule, decay, lifetime, natural line width.

UNIT-4: COLLISION IN 3-D AND SCATTERING (PERIOD-10 Hours)
Scattering experiments and cross sections, general features, the method of partial waves and its application, the Born approximations its applications.

UNIT-5: IDENTICLE PARTICLES (PERIOD-5 Hours)
System of the identical particles, construction of totally symmetric and totally asymmetric wave functions, the Pauli’s exclusion principles, spins ½ particles in a box, the Fermi gas and its applications.

UNIT-6: RELATIVISTIC QUANTUM MECHANICS (PERIOD-7 Hours)
The Klein Gordon equation, free particles, charged particles in electromagnetic fields, interpretation of K-G equation, the Dirac equation, probability and current densities.

References:
1. Quantum Mechanics- B.H. Bransden and C. J. Joachain
2. Quantum Mechanics- L.I. Schiff
3. Quantum Mechanics-J.D.Powell and B. Crossman
4. Quantum Mechanics – S. Gasiorowicz

Wiley International
EXPERIMENTAL TECHNIQUES AND DATA ANALYSIS

UNIT 1: Measurement, interpretation and analysis: (PERIODS-08 Hours)

Basic definitions, Accuracy and precision, significant figures, types of errors: gross errors, systematic errors, random errors, statistical analysis: arithmetic mean, deviation from the mean, average deviation, standard deviation, probability of errors: Normal distribution of errors, probable errors, propagation of errors (Reference: Helfrick, Cooper)

UNIT 2: Curve fitting, cubic splines and approximations (PERIODS-08 Hours)

Introduction, least square fitting procedures: Fitting a straight line, Non-linear curve fitting, Curve fitting by a sum of exponentials; Data fitting with cubic splines: derivation of the governing equations, end conditions, minimizing property of cubic splines; Approximation of functions: Chebyshev polynomials, Economizing of power series, chi-square test (Shastry)

UNIT 3: Transducers: (PERIODS-10 Hours)

Classification of transducers, selecting a transducer Working principle and characteristics of the main transducers for measurement of: Temperature, pressure/vacuum, magnetic field, vibration, optical and particle detector (Rangan, Mani, Sharma)

UNIT 4: Signal conditioning: Processes (PERIODS-08 Hours)

Input/output impedance, Impedance matching, Amplification: the Differential amplifier, Instrumentation amplifiers, Modulation techniques: Amplitude modulation, Frequency modulation, phase modulation, (Ghosh)

UNIT 5: Signal Conditioning: Recovery and conversion (PERIODS-08 Hours)

Demodulation, Filters, Noise reduction, Lock-in-amplifiers, phase locked loop, Box car integrators, Fourier transforms, sample and hold unit, ADC: quantization, resolution, sampling frequency (Ghosh)

UNIT 6: Case Studies: (PERIODS-06 Hours)

Two Laboratory experiments as case studies: Block diagram of the experimental setup, specifications/characteristics of various blocks, measurement of data, data analysis, error analysis
Reference Books:

1. Modern Electronic And Measurement Techniques - A.D.Helfrick, W.D.Kooper

2. Instrumentation: Devices And Systems - Rangan, Mani, Sharma

3. Introductory Methods Of Numerical Analysis - S.S.Sastri

4. Introduction To Instrumentation And Control - A.K.Ghosh
STATISTICAL MECHANICS

UNIT 1: Laws of Thermodynamics

PERIODS-08 Hours

Necessity of Statistical Mechanics
The laws of thermodynamics and their consequences, the problem of kinetic theory: phase space, Gibbsian ensembles, Liouville’s theorem and its consequences
Maxwell’s relations and thermodynamic functions

UNIT 2: Statistical description of system of particles & Statistical thermodynamics

PERIODS-10 Hours

Statistical description of system of particles: state of a system, microstates, ensembles, basic postulates, behaviours of density of states, density of states for ideal gas in classical limit, thermal and mechanical interactions, quasistatic process
Statistical thermodynamics: Irreversibility and attainment of equilibrium, Reversible and irreversible processes, thermal interaction between macroscopic systems, approach to thermal equilibrium, dependence of DoS on external parameters, Statistical calculation of thermodynamic variables.

UNIT 3: Classical statistical mechanics

PERIODS-10 Hours

Microcanonical ensemble and their equivalence, canonical and grand canonical ensembles, partition function, thermodynamic variables in terms of partition and grand partition functions, ideal gas, Gibbs paradox, validity of classical approximation, equipartition theorem, MB gas velocity and speed distribution, Chemical potential, Free energy and connection with thermodynamic variables, 1st and 2nd order phase transition, phase equilibria.

UNIT 4: Formulation of quantum statistics

PERIODS-10 Hours

Formulation of quantum statistics, Density matrix, ensembles in quantum statistical mechanics, simple application of density matrix
The theory of simple gases: Maxwell Boltzmann, Bose-Einstein, Fermi-Dirac gases, Statistics of occupation numbers, Evaluation of partition functions, Ideal gases in the classical limit

UNIT 5: Ideal Bose and Fermi systems

PERIODS-10 Hours

Ideal Bose system: Thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation
Thermodynamics of Black-body radiation, Stefan-Boltzmann law, Wien’s displacement law, Specific heat of solids (Einstein and Debye models)
Ideal Fermi systems: Thermodynamic behaviour of an ideal Fermi gas, degenerate Fermi gas, Fermi Energy and mean energy, Fermi Temperature, Fermi velocity of a particle of a degenerate gas
Reference Books:

1. Fundamentals Of Statistical And Thermal Physics- F.Reif  
2. Statistical Mechanics- K. Huang  
   2nd Edition, Elsevier
4. Fundamentals Of Statistical Mecanics-B.B.Laud  
5. Statistical Physics – F.Reif.  
ELECTROMAGNETIC THEORY

UNIT-1: ELECTROSTATICS  (PERIODS-5Hours)

Coulomb’s law, the electric field, continuous charge distribution, divergence and curl of electrostatic fields, Gauss’s law and applications, electric potentials, Poisson’s equations and Laplace equation, the potential of localized charge distribution, electrostatic boundary condition, work and energy in electrostatics.

UNIT-2: MAGNETOSTATICS  (PERIODS-5 Hours)

Biot-savarts laws, divergence and curls of B, Amperes law and its applications, magnetic vectors potential

UNIT-3: ELECTRODYNAMICS  (PERIODS-10 Hours)

Electromotive force, electromagnetic induction, energy in magnetic fields, Maxwell’s equation’s, Maxwell’s equations in matter, boundary conditions, conservation laws, the continuity equation and Poyntings theorem.

UNIT-4: ELECTROMAGNETIC WAVES  (PERIODS-10 Hours)

Boundary conditions, reflection and transmission, polarization, electromagnetic waves in vacuum, wave equations for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, electromagnetic waves in matter, propagation in linear media, R and T at normal and oblique incidence, absorption and dispersion, electromagnetic waves in conductors, reflection at conducting surface, guided waves, wave guides, TE waves in rectangular waveguides, the co-axial transmission line.

UNIT-5: POTENTIAL FIELDS  (PERIODS-8 Hours)

The potential formulation, scalar and vector potentials, gauge transformations, Coulomb and Lorentz’s gauge, continuous distribution retarded potentials, point charges, Lienard-Wiechert potential, field of moving point charge.

UNIT-6: RADATION  (PERIODS-6 Hours)

Dipole radiation, electric dipole radiation and magnetic dipole radiations, power radiated by a point charge.

UNIT-7: THE SPECIAL THEORY OF RELATIVITY  (PERIODS-6 Hours)

The Michelson-Morley experiment, the postulates of the special theory of the relativity, the Lorentz transformations, four dimensional space, relativistic mechanics.
Reference Books.

1. Introduction To Electrodynamics- D.J. Griffith

2. Electromagnetic Field Theory Fundamentals- Guru And Hiziroglu

3. Introduction To Electromagnetic Fields-Paul And Nasar.

4. Classical Electrodynamics- J.D.Jackson
   3rd Edition,2007,Wiley India Pvt Ltd

5. Electricity And Magnetism- Edward Purcell( For Basic Readings)

6. Fundamentals Of Applied Electromagnetics- Fawwaz Ulaby
General Laboratory-I

1. Voltage to frequency converter using IC 741
2. Phase shift oscillator using IC 741
3. Study of differential amplifiers
4. Design of CE amplifier
5. PAM, PWM and PPM: modulation and demodulation
6. Study of multivibrators
7. Study of temperature to frequency convertor
8. Verification of De Morgan’s theorem using logic gates
9. Study of JFET as amplifier and switch
10. I-V characteristics of Solar cell
11. Computer Programming: Writing computer programs for various numerical methods for integration, solving differential equation, finding roots of equation, interpolation, extrapolation; straight line fitting, non-linear curve fitting

NOTE: Addition and deletion in the list of experiments may be made from time to time by the department.

General Laboratory-II

1. Straight line fitting,
2. non-linear curve fitting
3. Data fitting with cubic spline
4. Four probe method
5. Determination of bandgap of semiconductor
7. Study of GM tube
8. Determination of absorption coefficient of beta rays in Al
9. Hall effect
10. Conductivity of ionic conductors

NOTE: Addition and deletion in the list of experiments may be made from time to time by the department.