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Chaudhary Charan Singh University, Meerut

Syllabus of:

M.Sc. (Physics)

(For fourth and fifth years of Higher education (PG))

(As per guidelines of U.P. Government according to National Education Policy-2020 w.e.f. the session 2022-2023)

(For both University Campus and Colleges)

M. Sc. PHYSICS (I SEMESTER): MATHEMATICAL METHODS IN PHYSICS

Course Objectives:

- To understand the various important mathematical methods in physics.
- To provide basic skills necessary for the application of mathematical methods in physics.
- To understand the mathematical methods in order to analyses theories, methods and interpretations.
- To develop understanding among the students how to use mathematical methods in their field of study of research and in the field of scientific knowledge to work independently

Course Outcomes:

- After completion of the course, students will have wide knowledge of Legendre, Hermite, Laguerre and Bessel polynomials, and their applications in physics and engineering.
- Students will be able to solve the research problems based on the complex variables, integral of complex functions,
- Students will earn the solution of various mathematical equations using Laplace transformation.
- Students will be able to use of Fourier series and transformation in some spectroscopic analysis.
- Students will understand the use of mathematical methods in their various branches of physics and engineering.
- The content given in ‘Special functions and polynomials’ of this course will impart skills for direct employability.

Unit 1. Special functions and polynomials: Graphical representation of basic mathematical functions.Solution of Legendre, Hermite and Laguerre differential equations. Generating function, Rodrigues’s formula, recurrence relations, and orthogonality for Legendre, Hermite and Laguerre functions. Introduction of Associated Legendre polynomials. Solution of Bessel differential equation, Bessel functions of first kind. Generating function, recurrence relations and orthogonality for Bessel function. Expansion and integral of Bessel functions, Applications of special functions.

Unit 2. Complex Variables: Brief overview of complex numbers. Functions of a complex variable. Derivative and Cauchy Reimann equations. Analytic and harmonic function, Integration in the Complex plane, Line integrals of complex functions. Cauchy’s integral theorem, Cauchy’s Integral Formula. Laurent expansion, Classification of Singularities, Principal value of an integral. Cauchy’s Residue theorem and evaluation of some typical real integrals using this theorem.

$\int_0^{2\pi} f(\sin\theta, \cos\theta)d\theta$, $\int_{-\infty}^{\infty} f(x)\, dx$, $\int_{-\infty}^{\infty} f(x)\, e^{iax}\, dx$

Unit 3. Laplace Transforms: Laplace Transform, Laplace transform of elementary Functions. First and second shifting theorems, Inverse Laplace transforms, Solutions of simple differential equations. Laplace transforms of derivative and integral of a function. Applications of Laplace Transform.

Unit 4. Fourier Series and Fourier Transform: Fourier series, Fourier series of even and odd functions. Half range expansion, Arbitrary period. Fourier integral and its complex form. Fourier transforms, Fourier sine and cosine transforms. Application of Fourier series and transformation.

Text and References Books

Mathematical method for Physics by G. Arfken
Advanced Engineering Mathematics by E. Kreyszig
Special Functions by E. D. Rainville
Special Functions by W.W. Bell
Complex Variables and Applications – Churchill
Mathematical Method for Physicists and Engineers by K.F.Reily, M.P.Hobson and S.J.Bence
Mathematical Physics by H.K. Das

M.Sc. PHYSICS (I SEMESTER): CLASSICAL MECHANICS

Course Objectives:

The primary objectives of classical mechanics course are:

- To study the mechanics of dynamical systems using Lagrange's equations of motion for conservative and non-conservative systems through Lagrangian formulation.
- To study variational principle and solve basic problems using calculus of variations.
- To understand the problem of two bodies moving under the influence of a mutual central force motion of the Lagrangian formulation.
- To understand the theory of small oscillations applied in many physical applications with the concept of stable and unstable equilibrium.
- To study and understand the Hamiltonian formulation for solving of mechanical problems using Hamilton's equations of motion.

Course Outcomes:

On the successful completion of classical mechanics, the students will able to learn and understand the fundamental concepts of dynamics of system of particles, related conservation theorems, equations of motion for mechanical systems using the Lagrangian and Hamiltonian formulation. The main course outcomes are as follows:

- Able to solve the mechanics of dynamical systems using Lagrange's equations of motion for conservative and non-conservative systems through Lagrangian formulation.
- Able to understand the variational principle and its application to solve mechanical problems using Lagrangian formulation.
- Able to deal with the problem of two bodies moving under the influence of a mutual central force motion.
- Able to understand the theory of small oscillations applied in many physical applications.
- Able to solve mechanical problems using Hamilton's equations of motion by Hamiltonian formulation.

Unit 1. Review of Elementary Principles and Lagrange's Equations of Motion: Overview of mechanics of a particle and system of particles, Types of Constraints on dynamical systems with suitable examples,Conservation theorems, D'Alembert's principle, generalized coordinates and generalized force, Derivation of Lagrange's equations, Velocity-Dependent potentials and the Dissipation function, Applications of Lagrangian formulation: single particle in space, Simple pendulum with rigid support, Atwood's machine, Time-dependent constraint-bead sliding on rotating wire.

Unit 2. Variational Principles and Lagrange's Equations: Hamilton's principle, Some techniques of the calculus of variations: Shortest distance between two points in a plane, Minimum surface of revolution and The brachistochrone problem, Derivation of Lagrange's equation from Hamilton's principle, advantages of variational principle formulation, Canonical or Conjugate momentum, Cyclic coordinates and conservation of conjugate momentum.

Unit 3. Two Body Central Force Problem and Small Oscillations: Reduction to the equivalent one-body problem, Equations of motion and first integrals, Equivalent one-dimensional problem and classifications of orbits, Virial theorem, The inverse square law of force, Kepler problem, Concept of small oscillations: stable and unstable equilibrium, Formulation of the problem: Expression of kinetic energy and potential energy for small oscillations.

Unit 4. Hamiltonian equations of motion: Legendre transformations and Hamilton equations of motion, Representation of Hamilton's equations of motion in matrix notation, Cyclic coordinates and conservation theorems, Derivation of Hamilton's equations from a variational principle, Principle of least action, Equations of canonical transformation, generating functions, Poisson brackets and canonical invariants, Relation of Poisson brackets, Hamilton-Jacobi Theory: Hamilton-Jacobi equation for Hamilton's principal function.

Text and Reference Books

Herbert Goldstein, Charles P. Poole, John Safko: Classical Mechanics
N.C. Rana and P.S. Joag : Classical Mechanics
A. Sommerfiel : Mechanics
Perceival and D. Richards: Introdution to Dynamics

M.Sc. PHYSICS (I SEMESTER): QUANTUM MECHANICS

Course Objectives:

The primary objectives are:

- To study time-independent and time-dependent Schrodinger wave approach.
- To solve a one-dimensional Schrodinger equation for simple problems.
- To develop theory of angular momenta and addition of angular momenta
- To understand the applicability of angular momenta in several branches of physics
- To understand the applicability of angular momenta in several branches of physics

Course Outcomes:

After completing this course, students will be able to

- To understand the physical and mathematical basis of quantum mechanics for non-relativistic systems.
- To learn mathematical tools needed to develop the formal theory of quantum mechanics.
- To understand the measurement process in quantum mechanics.
- Understand the connection between measurement of results and the uncertainty relation.
- Understand the application of wave function theory in quantum mechanics.
- Appreciate the amazing power and surprises of quantum mechanics in problems like free particle and particle in a potential.
- Recognize the applicability of angular momenta in several branches of physics.
- Appreciate the profound strength of approximate methods in problems like Stark effect, Zeeman effect, etc.
- Understand the scattering processes that take place in atomic, subatomic, and molecular systems.

Unit 1. Fundamental Concepts:
Wave packets,Commutator algebra and uncertainty relation,Motion of wave packets, Wave functions in position and momentum space. Operators, Hermitian operators,Degeneracy, Orthonormality and Completeness. Linear operators, Dirac notation,Matrix representations, Change ofbasis, Three dimensional potential well and Hydrogen atom, vector and Hilbert Spaces, Bases, Dimension, Subspaces, Dual spaces, Inner product of spaces, Dirac notations, matrix representation of operators,Linear harmonic oscillator in matrix formulation, Rotation generators, Transformations of dynamical variables, Symmetry and conservation laws. Symmetric and anti-symmetric wave-functions and Pauli Exclusion Principle.

Unit 2. Quantum Dynamicsand Approximate Methods: Time independent first and second order perturbation theory for non-degenerate and degenerate levels, Variational method, and its application for Helium atom, WKB Approximation. Application of electric field (Stark effect), Dipole Polarizability of ground state Hydrogen atom, normal and anomalous Zeeman Effect.

Unit 3. Theory of Angular momentum: Commutation relations involving angular momentum operators, the eigenvalue spectrum, Matrix representation of J , Addition of angular momentum, Clebsch- Gordon coefficients, Spin angular momentum, Spin wave functions, Addition of spin and orbital angular momentum.

Unit 4. Scattering Theory: Laboratory and centre-of-mass systems, scattering by potential field, scattering amplitude, differential and total cross sections, phase shift, Lippmann-Schwinger equation, and First Born approximation.

Text and References Books

R. Shankar, Principles of Quantum Mechanics, Second Edition, Springer.
E. Merzbacher, Quantum Mechanics, Third Edition, Wiley.
Quantum Mechanics by S. Gasiorowicz.
Quantum Mechanics by Zettlei
A text book of Quantum Mechanics by P.M. Mathews and K. Venkatesan
Introduction to Quantum Mechanics by E. Merzbacher
Quantum Mechanics by L.I. Schiff
Quantum Mechanics by I. S. Tyagi

M.Sc. PHYSICS (I SEMESTER): ELECTRONIC DEVICES

Course Objectives:

The primary objectives are:

- To study the transport mechanism of elemental and compound Semiconductors.
- To study the effect of dopant concentration and temperature on devices performance.
- To studythe junction characteristics of pn- and metal-semiconductor diodes.
- To learn and understand the FET transfer characteristics.
- To learn and understand the role of metal oxide layer in MOSFETs.
- To study the basic role of an amplifiers in modern devices.

Course Outcomes:

- To understand the conduction mechanism of elemental and compound semiconductors for designing the electronic components and circuits.
- Understanding the basic phenomenon of semiconductors, it can be used for the fabrication of modern devices.
- Having the knowledge of semiconductors, junction diodes, diode and transistor biasing, and amplifies, students can have the job in semiconductor and microelectronic Industries, communication and telecommunication government and private sectors.

Unit 1. Conduction Mechanism in Semiconductors
Basic carrier transport mechanisms in semiconductors;Direct and indirect bandgap,Electron and hole concentrations in bands for degenerate and nondegerate states, Elemental and compound, Amorphous and crystalline phase in Semiconductors; Carrier concentrations, Conductivity, mobility in Semiconductors; Fermi Level, electron and hole concentrations at equilibrium;Temperature dependence of carrier concentrations, drift and diffusion of charge carriers; Effect of dopant concentration and temperature on the mobility, The continuity equation.

Unit 2. P-N junction & Metal-semiconductor diode
Qualitative theory of P-N junction, Space charge at a junction, Capacitance of p-n junctions;Generation and recombinationcharge carriers, Diffusion capacitance; Breakdown mechanisms: Thermal instability, Tunneling andavalanche multiplication;Transient and noise behavior, device performance as the rectifier, voltage regulator; Device structure and energy band diagram, Schottky effect, Barrier height; Voltage dependence of semiconductor surface potential, Current transport mechanisms, Device capacitance, Ohmic contact.

Unit 3. Field Effect Transistors
JFETs: Drain, source and Gate, Transfer characteristics,Current equations, Pinch off voltage and its significance; The FET small signal model, Measurement of g_m and r_d, JFET fixed bias, Self-bias and voltage divider configurations, JFET source follower (common-Drain) configuration; JFET Common Gate configuration;MOSFET- Characteristics, Threshold voltage, Channel length modulation, D-MOSFET, E-MOSFETCharacteristics, Comparison of MOSFET with JFET; Depletion and enhancement type MOSFETs.

Unit 4. Feedback Amplifiers: The transistor as an Amplifier, Analysis of a Transistor amplifier circuit using h parameters, Hybrid π model, Ebers-Moll model, Transistor biasing and thermal stabilization;Classification of Amplifiers, Feedback concept, Ways to introduce negative feedback in Amplifiers, Effect of negative feedback, Method of analysis of a feedback amplifier, Volatge-series feedback, Current-series feedback, Volatge-shunt feedback, Current-shunt feedback, Nyquist criterion for stability of feedback amplifiers.

Text and Reference Books

Physics of Semiconductor Devices by S.M. Sze&Kwok K. Ng
Solid State Electronic Devices by B.G. Streetman
Electronic Devices and Circuit Theory by R.L. Boylested and L. Nashelsky
Integrated Electronics by J. Millman and C.C. Halkias
Introduction to Semiconductor Devices by M. S. Tyagi
Electronic Devices and Circuits by Balbir Kumar and S.B. Jain

M.Sc. PHYSICS (II SEMESTER): ADVANCED QUANTUM MECHANICS

Course Objectives:

- To teach the students various approximation methods in quantum mechanics.
- To teach Klein-Gordon and Dirac approaches to under Relativistic quantum theory
- To teach the importance of quantization of electromagnetic radiation in science
- To make the students understanding about introductory quantum field theory.

Course Outcome:

After completing this course, students will be able to

- Understand the time-dependent Schrodinger wave approach and its applications in real life
- Understand the importance of second quantization connection between symmetries, degeneracies, and conservation laws.
- Understand the importance of second quantization
- Differentiate between classical and quantum identical particles.
- Get basic information needed for advanced courses like quantum field theory.
- The course contents like quantum transitions process for solid-state and gas lasers, the process of second quantization and part of field theory are directly useful for employment.

Unit 1. Approximation Methods(Time Evolution): First order perturbation, Interaction of an atom with an electromagnetic field, Transition probabilities, Fermi Golden rule, Dipole approximation.Einstein's coefficients based on quantum mechanics, Induced and spontaneous emissions of radiations,Applications of transition quantum theory in gas and solid state lasers, adiabatic approximation.

Unit 2. Quantum Theory of Radiation: Classical radiation field, Fourier decomposition and electromagnetic radiation field, dipole approximation, Second Quantization, Creation, annihilation and number operators, Photon states, Basic matrix elements for emission and absorption, explanation of stimulated and Spontaneous emission on the bases of quantum mechanics, Importance of second quantization, Plank's radiation law.

Unit 3. Relativistic Quantum Theory: Klein-Gordon equation and its plane wave solution, Probability density in KG theory, Difficulties in KG equation, Dirac equation for a free electron, Dirac matrices and spinors, Plane wave solutions, Charge and current densities, Existence of spin and magnetic moment from Dirac equation of electron in an electromagnetic field. Dirac equation for central field with spin orbit interaction, Energy levels of Hydrogen atom from the solution of Dirac equation, covariant form of Dirac equation.

Unit:4 Introduction of Quantum Field theory:

Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem, canonical quantization of scalar field, Complex scalar field, electromagnetic field and Dirac field, Problem in quantizing electromagnetic field, Gupta & Bleuler method.

Text and Reference Books

Quantum Mechanics and Atomic Physics by S.P. Khare.
Quantum Mechanics by L.I. Schiff

Modern Quantum Mechanics by J.J. Sakurai
A Text Book of Quantum Mechanics by P.M. Mathews and K.Venkatesan
Quantum Mechanics by A. P. Messiah
Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal
Modern Quantum Mechanics: J.J.Sakurai.
Principles of Quantum Mechanic: R. Shankar.

M.Sc. PHYSICS (II SEMESTER): STATISTICAL MECHANICS

Course Objectives:

- To understand the analysis of the statistical macroscopic quantities of various systems in terms of constituents.
- To learn the ensemble theory and their macroscopic parameters.

- The application of Bose Einstein statistics and Fermi-Dirac statistics to analysis the properties of ideal Bose gas and Fermi-Dirac gas.
- To understand the various models of cluster expansion and fluctuations of thermodynamic variables.
- To learn the theoretical aspect of order-disorder phase transition in various systems.

Course Outcomes:

- After completion of the course, the students will have the basic knowledge of statistical mechanics.
- Students will be able to calculate the statistical quantities of various systems.
- Students will be able to eexplain the ensemble theory required for macroscopic properties of the matter in bulk in terms of its constituents.
- Students will understand the analysis of properties of ideal Bose gas, Bose- Einstein condensation, liquid helium and electron gas.
- Students will be able to understand the various theories and models of cluster expansion and fluctuations of thermodynamic variables.
- Students will have the knowledge to explain the theoretical aspect of order-disorder phase transition in various systems.

Unit 1. Ensembles and Statistics of Ideal Gas System. Scope and objective of statistical mechanics. Analysis of phase space, phase points, Mu and Gamma space, Ensemble. Density of phase points,Microstates and Macrostates, Number of accessible microstates.Detailed analysis of micro canonical, canonical and grand canonical ensembles and their properties. Partition function formulation. Fluctuation in energy and particle. Equilibrium properties of ideal systems: classical ideal gas, Harmonic oscillators, Para magnetism, concept of negative temperature. The entropy of mixing of ideal gas and Gibbs paradox, Sackur-Tetrode equation.

Unit 2. Quantum Statistical Mechanics: Transition from classical statistical mechanics to quantum statistical mechanics. Postulates of quantum statistical mechanics, Density matrix, Indistinguishability and quantum statistics, identical particles and symmetry requirements. Basic postulate and particle distribution function of Bose Einstein statistics. Energy, number of particles and pressure of B.E. gas. Bose Einstein Condensation, Thermal properties of B.E. gas, Transition in liquid He_4, Superfluidity in He_4. Basic postulate and particle distribution function of Fermi Dirac statistics. Energy, number of particles, temperature and pressure of F.D. gas. Properties of ideal electron gas, Thermionic Emission.

Unit 3. Statistical models for order-disorder phase transition: Cluster expansion for a classical gas, virial equation of state, ising model, mean-field and Heigenburg theories of Ising model, Exact solutions in one-dimension. Thermodynamic phase diagrams, Order parameter, Landau theory of phase transition, Landau theory of liquid He-II, critical exponents, Scale invariance, Critical dimensionality.

Unit 4. Fluctuations: Introduction to non-equilibrium processes, fluctuations and transport phenomena, Random walk and Brownian motion, Langevin theory of Brownian motion and relation with diffusion equation, The Fokker-Plank equation.

Text and Reference Books

Statistical and Thermal Physics by F. Reif
Statistical Mechanics by K. Huang
Statistical Mechanics by R. K. Pathria
Statistical Mechanics by R. Kubo
Statistical Physics by Landau and Lifshitz
Statistical Mechanics and properties of matter, theory and application by E.S.R. Gopal

M.Sc. PHYSICS (II SEMESTER): ATOMIC AND MOLECULAR PHYSICS

Course Objective

The study of atoms and molecules has played a major role in the development of physics and in the development of our understanding of the structures and properties of matter as it is encountered in everyday life. The main objectives of this course are

- To develop an understanding of the atomic emission/ absorption spectra of one electron and many electrons atoms.
- To understand the concept of molecular spectroscopy of diatomic molecules which includes Rotational, Vibrational and Electronic energy levels.
- To gain insight of important characterization techniques such as IR/FTIR, Raman, PES, NMR, ESR etc.

Learning outcomes:

On successful completion of this course, the student will:

- Develop the ability to conceptually understand the atomic spectra of Hydrogen atom and similar a valance electron atoms.
- Be able to understand and interpret the atomic spectra for many electron atoms.
- Also can also explain the change in behavior of atoms in external applied electric and magnetic field and corresponding changes in observed spectra.
- Gain sufficient understanding of rotational, vibrational, electronic and Raman spectra of molecules.
- Develop skill in important material characterization techniques like IR/FTIR, Raman, etc.
- Acquire ability to apply Nuclear Magnetic Resonance (NMR) for structure elucidation of synthesized materials.

Atomic Physics:

Unit 1. Introduction to Atomic spectra, Quantum states of an electron in Hydrogen atom.Relativistic corrections for energy levels of hydrogen atom.Concept of spin and fine structure of hydrogen atom. Singlet and triplet States of Helium.Broad features of spectra of alkali elements. Fine structure in Alkali Spectra.

Unit 2. Many electron atoms: Central field approximation, Atomic wave function, Hartree and Hartree–Fock approximations, Results of Hartree's theory, Spectroscopic Terms: LS coupling, Lande Interval rule, determination of spectral terms for atoms; with two or more Non-equivalent optical electrons, and two or more equivalent optical electrons. Breit's scheme. JJ coupling for many electron atoms.Atom in external field, Zeeman, Paschen-Bach & Stark effects.

Molecular Physics:

Unit 3. Born-Oppenheimer approximation,Classification of Molecules, Types of Molecular Spectra and Molecular Energy States: Pure Rotational Spectra, Vibrational-Rotational Spectra, Raman Scattering, Classical and Quantum theory of Raman effect. Selection rules, Isotope effect, Formation of electronic spectra, fine structure of electronic bands. Intensity distribution in electronic bands: Franck-Condon principle. Explanation of intensity distribution in absorption and emission bands from Franck-Condon principle.

Characterization Techniques:

Unit 4. Infrared/FTIR Spectroscopy, General description and working of dispersive and FTIR instrument. Interpretation of FTIR spectra. Raman spectroscopy. Nuclear Magnetic Resonance, Chemical Shift, NMR Spectrometer. NMR spectrum analysis.

Text and Reference Books

Introduction to atomic spectra by H.E. White
Spectra of diatomic molecules by Herzberg
Atoms and molecules by M. Weissbluth
Quantum theory of Atomic Structure Vol I by Slater
Quantum theory of molecules and Solids by Slater
Fundamentals of molecular spectroscopy by C.B.Banwell
Introduction to molecular spectroscopy by G.M.Barrow
Molecular spectroscopy by J.M.Brown
Infrared and Raman spectroscopy: Principles and spectral Interpretation by Peter J. Larkin
Lasers: Fundamentals and Applications by Ajoy Ghatak and K. Thyagarajan

M.Sc. PHYSICS (II SEMESTER): ELECTRODYNAMICS & PLASMA PHYSICS

Course Objectives:

- To teach the students about the basic phenomenon of electrostatics and magnetostatics for the application of electromagnetism.

- To study the transfer of energy in terms of electro-magnetic waves.
- To learn about the formation of plane electromagnetic waves for transmitting and receiving data in terms of photons.
- To learn about the work-energy theorem for data transfer mechanism.
- To study the fundamental of Plasma and used in communication.

Course Outcome:

After completing this course, students will

- Understand the electromagnetic phenomenon used for the wireless communication in terms of photons.
- Understand the importance of reflection, transmission, and absorption of electromagnetic waves.
- Understand the importance of work-energy phenomenon used for transmission of data by using plane electromagnetic waves.
- Studying this syllabus, the students can get a chance to utilize their skills in wireless and telecom industries for propagation/receiving signal/data/energy.

Unit 1. Electrostatics

Physical significance of Vector algebra and Calculus: divergence, gradient, and Curl; Electrostatic fields in matter, Dielectrics, Polarization; Field inside a dielectric, Electric displacement, Linear dielectrics;Gauss's divergence theorem and symmetry: planner (pillbox), co-axial (cylindrical), spherical (concentric); Laplace's and Poisson Equations, Methods of images, point charge near an infinite conducting plane, Point charge in the presence of grounded conducting sphere, Point charge in presence of charged insulated sphere.

Unit 2. Magnetostatics

Magnetic vector potential, Magnetostatic fields in Matter: Magnetization, Ampere's circuital law; field of a magnetized object, magnetic field inside matter, linear and nonlinear magnetic media.

Unit 3. Plane Electromagnetic Wave

Basic phenomenon of electromagnetic waves: Reflection, Refraction at an interface between dielectrics, transmission, absorption; Plane electromagnetic waves in free space, dielectrics and conducting media; Fresnel's relation of polarization by reflection and total internal reflection; Maxwell's displacement current, Maxwell's equations, Maxwell's equations in terms of vector and scalar potentials, Poynting theorem, Lienard- Wiechert potentials due to a point charge, Fields of a point charge in motion, Power radiated by an accelerated charge, Larmor's formula and its relativistic generalization.

Unit 4. Plasma

Definition of plasma, Concept of temperature, Debye shielding, Criteria for plasma, Single-particle motions in E and B fields, Magnetic mirrors and plasma confinement, Plasma as fluid, the fluid equation of motion, Equation of continuity and equation of state, Waves in plasmas, Plasma oscillations, Plasma frequency ω_p, Electron plasma waves, ion waves, Electron and ion oscillations perpendicular to B and parallel to B, Cutoffs and resonances.

Text and Reference Books;
Classical Electrodynamics by J.D. Jackson
Foundations of Electromagnetic theory by J.R. Reitz, F.J.Milford and R.W.Christy
Introduction to Electromagnetics by David J. Griffiths
Introduction to Plasma Physics and Controlled Fusion, Vol-1: Plasma Physics by Francis F. Chen
Plasma Physics by S.N. Sen.)

M.Sc. PHYSICS (III SEMESTER): CONDENSED MATTER PHYSICS

Course Objective

To study some of the basic properties of the condensed phase of matter especially solids. Condensed matter Physics is the study of the structure and behavior of the matter that makes up most of the usual stuff that surrounds us every day. Condensed Matter Physics is the fundamental science of solids and liquids. It has the greatest impact on our daily lives by providing foundations for technology developments.

Learning outcomes:

After completing this course, students will

- Be able to correlate real and virtual lattice which is the key of structure property relationship of any solid.
- Develop skill in X-ray diffraction techniques and its applications.
- Gain knowledge of various crystal imperfections and their impact of properties of the material.
- Also be able to explain electronic and magnetic properties. The knowledge may help them to design new materials with desired electronic and magnetic properties.
- Learn about the basic concept of super conductivity and its application in various fields.

Unit 1. Bravais lattice, primitive vectors, primitive unit cell, conventional unit cell, Wigner-Seitz cell; Sym- metry operations and classification of 2- and 3-dimensional Bravais lattices; point group and spacegroup (information only); Common crystal structures: NaCl and CsCl structure, close-packed structure, Zinc blende and Wurtzite structure, tetrahedral and octahedral interstitial sites, Spinel structure.
X-ray diffraction, The Laue, powder and rotating crystal methods, Reciprocal lattice and Brillouin zone; Ewald construction; Explanation ofexperimental methods on the basis of Ewald construction.Anomalous scattering; Atomic and geometric structure factors; systematic absences.Point defects (Schottky & Frankel Defects) Imperfections, Line defects (Edge& Screw dislocations), Burger vector & Burger Circuit Planer (stacking) faults.

Unit 2. Different types of bonding in solids, covalent, metallic, Vander Waal, hydrogen bonding & ionic bonding, Madelung constant of ionic crystals, cohesive energy. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power.

Unit 3. Electronics Properties of Solids: Electrons in a periodic lattice: Bloch theorem, The Kronig-Penny Model, Effective mass of an electron, Tight-binding approximation, Cellular and pseudopotential methods.
Superconductivity: Review of basic properties, Meissner effect, Type-I and Type-II superconductors, thermodynamics of superconductors, London's phenomenological theory, Flux quantization. Elements of BCS theory. Josephson junction and applications.

Unit 4.Magnetic Properties of Solids: Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, Ferromagnetic domains, The Bloch-wall, Spin waves and Magnons, Curie- Weiss law for susceptibility, Ferri and antiferro-magnetic order.

Text and References Books

Verma and Srivastava: Crystallography for SolidState Physics

Azaroff: Introduction to Solids
Solid State Physics by S O Pillai
Omar: Elementary Solid State Physics
Aschroff & Mermin: SolidState Physics
Kittel: SolidState Physics
Chaikin and Lubensky: Principles of Condensed Matter Physics

M. Sc. PHYSICS (III SEMESTER): OPERATIONAL AMPLIFIER AND DIGITAL CIRCUITS

Objectives:

- To learn about the basic and advanced knowledge of amplifier, operational amplifiers.
- To study voltage and current controlled Source, rectifiers, and gains.

- To study the CMOS technology and logic families.
- To study the digital numbers system, logic gates for mathematical operations and memories.
- To design the arithmetic logic circuits and storage data systems: flip-flop, registers. Counters and converters.

Learning outcomes:

At the completion of the course students will be able to:

- To learn for designing of amplifiers, operational amplifiers for various applications.
- To learn for CMOS technology, ICs designing for digital circuit operations.
- Having the knowledge of number systems and logic gates, students can develop the mathematical operations.
- To learn the actual role of Transistors for making ICs and data storage systems.
- After studied and practical learning of logic families, gates, and circuits, the students can get the job in microelectronic component industries, telecommunication industries for designing circuits and their functions.

Unit I: Operational Amplifier and their Application
Characteristics of an ideal operational amplifier, Op-Amp Specifications, DC Off-set parameter, Frequency parameters, Applications of operational amplifiers: Inverting and Non-inverting amplifiers, Unity follower, Voltage summing and subtraction, Integrator, Differentiator, multiple stage gain, Current controlled voltage source, Voltage controlled current source, Rectifiers and Limiters, Comparators and Schmitt Triggers, Active filters.

Unit II: Logic Families
Logic gate symbols and truth tables, Classes of digital integrated circuits (Diode logic, DTL, TTL, ECL, MOSFET, CMOS), Transistor- Transistor Logic (TTL), Single Input TTL Inverter (transfer characteristic), Multi- collector transistors, Propagation delays, Diode Logic, DTL NAND Gate (transfer characteristic, noise immunity, fan out), Emitter Coupled Logic (transfer characteristic of OR/NOR gate, practical implementation, MOSFET Logic, MOSFET Inverter, MOSFET NOR and NAND gates, Complementary MOS (CMOS)- CMOS inverter, CMOS NOR and NAND, Power dissipation in CMOS, Advantages/Disadvantages of CMOS.

Unit 3: Digital Electronics and Logic Gate
Number systems: Binary, Octal, Decimal and Hexadecimal, Base conversion systems, Basic logic gates: OR, AND and NOT, Bubbled gate, Boolean Algebra, De-Morgan's theorems, Boolean equations of Logic circuits, Combinational logic circuits, NOR and NAND Gates, Sum of Product (SOP) and Product of Sum (POS) methods, Karnaugh map (K-map), pairs, quads and octets, K-map simplifications, Don't care conditions, Product of Sum simplifications,Min-terms and Max-terms, Converting a truth table to an Equations, Exclusive-OR gate, BCD to decimal decoders, Excess-3 code, Gray code,.

Unit 4: Application of Digital Logic Gates
Arithmetic circuits: binary addition and subtraction, 1's and 2's complement arithmetic and representation; Arithmetic building blocks, Half adder and Full adder circuits; Multiplexers and

Demultiplexer, RS Flip-Flops: NOR and NAND gate latch, Clocked RF Flip-Flops, Edge-triggered D Flip-Flop, T-Flip Flop, JK Flip-Flop, Flip-Flop timing, JK Master-Slave Flip-Flops; Registers, Types of registers, Serial-in-serial out, Serial-in-parallel out, Parallel-in-serial out, Parallel-in parallel out; Counters: Asynchronous and synchronous counters, Mod-3 and Mod-5 counters, Shift counters; Digital-to-Analog and Analog-to-Digital Converters; Microprocessor-8085 microprocessor architecture, interfacing devices, BUS timing, Basic terms and ideas of memory.

Text and Reference Books

Electronic Device and Circuit: R. Boylested and L. Nashdsky
Analysis and Design of Digital Integrated Circuit: Hodges, Jackson and Saleh
Digital Principles and Implementation: A.P. Malvino and D.P. Leach
Op- Amp and Linear Integrated Circuit: Ramakant A. Gayakwad
Linear Integrated Circuit: Choudhary and Jain
Digital Principals and Applications: D.P. Leach & A.P. Malvino

M. Sc. PHYSICS (III SEMESTER): ELECTRONIC COMMUNICATION SYSTEMS

Course Objective

The fundamental objectives of this course are;

- To enable students to understand the basic concepts of circuits found in radio-communication.
- To interpret and analyze the characteristics of the main components of communication electronics.
- To impart in depth knowledge of different types of analog communication systems and different modulation techniques used in these systems.
- To be able to design the simplest devices and transmitting and receiving systems of radiofrequency series.
- To introduce the various types of transmission lines and to discuss the losses associated.
- To give thorough understanding about impedance transformation and matching.

Course Outcomes:

On completion, the student will be able to;

- Analyze analog communication signals in time domain and frequency domain.
- Distinguish between different analog modulation techniques.
- Analog signal generation techniques.
- Discuss the fundamental concepts of wave propagation in Transmission Lines.
- Analyze the line parameters and various losses in transmission lines.
- Apply smith chart for line parameter and impedance calculations

Unit 1. Amplitude Modulation Systems: Principles of Amplitude Modulation; AM envelope and Equation of AM wave, Modulation index and Percent Modulation, Frequency Spectrum and Bandwidth, AM Power Distribution, AM by Multiple Sine waves, Transmission efficiency, Double Side-Band Suppressed Carrier (DSB-SC), AM Modulator Circuits; Low-level AM Modulator, Medium Power AM Modulator

Unit 2. Single- Sideband Techniques: Evolution and Description of Single Sideband Modulation (SSB); Suppression of Carrier, Balanced Modulator, Suppression of Unwanted Sideband, The filter. System, The phase-shift method, System evaluation and comparison, Extensions of SSB, Vestigial-sideband Modulation

Unit 3. Frequency Modulation Systems: Theory of Frequency and Phase Modulation, Relationship between phase and frequency modulation, Mathematical Representation of FM, Phase and frequency deviation, Spectrum of an FM signal, Sinusoidal modulation, Bandwidth of a sinusoidally modulated FM signal, Generation of FM signal, Direct and Indirect Methods

Unit 4. Transmission Line Theory & Optical Fiber Communication Systems: Fundamental of Transmission lines, Different types of Transmission lines, Primary line constants, phase velocity and line wavelength, Characteristic impedance, Propagation Coefficient, Phase and group velocities, Standing waves, Lossless line at radio frequencies, Voltage standing wave ratio, Slotted line measurements at radio frequencies, Transmission lines as circuit elements, Drawbacks of Radio communication, Introduction to Optical Communication, Fiber index profiles, Modes of Propagation, Number of Propagated modes in Step-index Fibers, Losses in Fibers.

Text and Reference Books

Modern Electronic Communication by Gary M. Miller, 6th edition
Electronic Communication Systems by George Kennedy and Bernard Davis, 4th edition Principles of Communication Systems by H. Taub and Donald L. Schilling
Electronic communications by Dennis Roddy and John Coolen
Electronic Communication Systems-Fundamentals through Advanced by Wayne Tomasi, 4th edition

M. Sc. PHYSICS (III SEMESTER): NUCLEAR AND PARTICLE PHYSICS

Course Objectives:

- To impart knowledge about nuclear properties.
- To understand the nuclear decay, inter-nucleon forces and related facts.
- To understand the Nuclear reactions.

- To understand the different nuclear detectors.
- To understand the different nuclear modals to know fundamental principles and concepts governing nuclear structures.
- To understand the particle physics to construct nuclear reactions.

Course Outcomes:

- After completion of the course, students will learn about the nuclear angular momentum and dipole moment of nuclei.
- They will understand the concept of inter nucleon forces and related facts.
- Students will understand the parity violation in beta-decay.
- Students will understand nuclear reactions and detectors.
- Students will obtain the knowledge ofthe nuclear structure and various important nuclearmodels.
- They will be able to construct nuclear reactions using the conservation laws for elementary particles.
- The knowledge of various detectors will impart skills for direct employability.

Unit 1. Nuclear Structure andNuclear force: Nuclear structure and properties. Binding energy per nucleon, Proton and neutron separation energy. Analysis of nuclear angular momentum, nuclear magnetic dipole moment and nuclear electric quadruple moment, Parity quantum number. Overview of Deuteron properties. Theory of Deuteron ground state and excited states. Two-nucleon scattering at low energy, neutron-proton scattering, partial wave analysis, phase-shift, scattering length, proton- proton scattering (qualitative discussion). Charge symmetry and charge independence of nuclear forces, exchange nature of nuclear forces, saturation of nuclear forces.

Unit 2. Nuclear Models: Fermi gas model, Experimental evidence for shell structure in nuclei, Basic postulates of shell model, Single- particle energy levels in central potential, Spin-orbit potential and prediction of magic numbers, Extreme single- particle model, Prediction of angular momenta, Parities and magnetic moment of nuclear ground states, Semi- empirical mass formula, The unified model.

Unit 3. **Nuclear Decay, Reactions and Nuclear detectors:** Overview of alpha, beta and gamma-decay, Parity violation in beta decay, Neutrino, Wu’s experiment in beta decay, Internal conversion. Introduction and types of nuclear reactions, conserved quantities of nuclear reaction, energies of nuclear reaction, Q value, exoergic & endoergic reactions, nuclear fusion and fission reactions. Interaction of radiation with matter, Ge and Si solid state detectors. Calorimeters and their use for measuring jet energies. Scintillation and Cerenkov counters, hybrid detectors.

Unit 4. Particle Physics: Overview ofproperties, origin and classification of Elementary particles, type of interactions and conservation laws, Properties of mesons, Resonance particles, Strange particles and Strangeness quantum number, Simple ideas of group theory, Symmetry and conservation laws, CP and CPT invariance, Special symmetry groups SU (2) and SU (3) classification of hadrons, Quarks, Gell- Mann- Okubu mass formula.

Text and Reference Books

Introduction to nuclear Physics by H. Enge
Theoretical Nuclear Physics by J.M. Blatt and V.F. Weisskopf
Particle Physics: An introduction by M.Leon
Nuclear & Particle Physics: An Introduction by B.Martin
Introduction to Particle Physics by R. Ones.
Introducing Nuclear Physics by K. S. Krane
Nuclear Physics: Theory and Experiments by R.R. Roy and B. P. Nigam
Fundamentals of Nuclear Physics by B.B. Srivastava
Nuclear Physics by D.C. Tayal
Nuclear Physics in A Nutshell by C. A. Bertulani

M.Sc. PHYSICS (IV SEMESTER): PHYSICS OF NANOMATERIALS

Course Objectives:

The primary objectives of "Physics of Nanomaterials" course are:

- To understand the Physics of materials (especially engineering materials/IT materials: Semiconductors, insulators & metals) at nanometer scale.
- To understand the phenomena of QSE and Electron Confinement: Quantum well, Quantum wire & Quantum dot.

- To learn the different experimental techniques for determination of particle size: by XRD, Electron microscopy, absorption spectroscopy.
- To learn about the different methods of preparation of nanomaterials.

Course Outcomes:

On the successful completion of the course namely "Physics of Nanomaterials", the students will be able to understand the size, shape, and orientation dependent properties of different materials at the nanoscale (1 - 100 nm). In-addition, the student will also be able to acquire the ability to synthesize, and characterize of different materials for different solid state device applications. The main course outcomes are as follows:

- Able to understand the size dependent properties of materials.
- Able to determine the particle size of nanomaterials using different tools and techniques.
- Able to synthesize the desired NSM's for different applications using Top down and Bottom up approaches.

This course deals with the physics of nanostructured materials and determine the possible applications in medical and other industries related to device fabrication as far as the R&D of nanostructured materials is concern. Students may acquire skills to engineered the properties of materials by synthesizing the materials at nanometer scale. This course directly gives the employability towards the development of different devices and will be value-added course for others having interest in nanoscience & nanotechnology. The contents mentioned in Unit-3 and Unit-4 related to characterization and synthesis techniques will be helpful to generate the employability/skills/Start-up/self-employment.

Unit 1. Introduction to Nanoscience & Nanotechnology: Nanoscience & nanotechnology, Size dependence of properties, Moor's law, Surface energy and Melting point depression of nanoparticles, Measurement techniques of melting point depression, Qualitative idea of Free electron theory and band theory of solids, E-k diagrams, Energy gaps, Effective masses and Fermi surfaces, Localized particles, Donors, Acceptors and Deep traps, Exciton, Frenkel and Wannier-Mott exciton, Multiple exciton generation in semiconductor nanocrystals, Density of states, variation of density of states with energy and dimensions of crystal.

Unit 2. Quantum Confinement: Nanostructures & quantum physics, Quantum size effect, Nanomaterials structures, Quantum confinement of different nanostructures, Quantum well, Quantum wire and Quantum dot, Quantum mechanical treatment of nanostructures, Methods for fabrication of nanostructures.

Unit 3. Characterization techniques of Nanomaterials: Different techniques for determination of particle size, Determination of particle size using XRD, Diffraction under non-ideal conditions, Derivation of Scherrer's formula, Increase in width of XRD peaks of nanoparticles, Shift in absorption spectra peak of nanoparticles, Correlation between shift in absorption spectra peak and energy band gap of nanomaterials, Determination of energy band gap and particle size using absorption spectra of nanomaterials, shift in photoluminescence peaks, Electron-Specimen interaction, Electron microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe microscopy (SPM), Scanning Tunneling Electron Microscopy (STEM) and Atomic Force Microscopy (AFM).

Unit 4. Synthesis of Nanomaterials: Key issues in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches with examples of suitable techniques, capping agents, Cluster beam evaporation, Ball Milling, Carbon nanotubes (CNT)& graphene- Synthesis, Properties and Applications.

Text and References Books

Nanostructures & Nanomaterials, Synthesis, Properties & Applications by Guozhong Cao, Imperial College Press.
Introduction to Nanotechnology by Charles P. Poole, Jr. Frank J. Owens, John Wiley & Sons Inc. Publication.
Quantum Wells, Wires and Dots by Paul Harrison, John Wiley & Sons Ltd.
Quantum Mechanics for Nanostructures by Vlamidir V. Mitin, Dmitry I. Sementsov, Nizami Z. Vagidov (Cambridge University Press).
Quantum Dot Hetrostructures, by D. Bimberg, M. Grundman, N.N. Ledenstov.
Introduction to Nanoscience and Nanotechnology by Hornyak G.L., Tibbals H.F., Dutta J., Moore J.J., CRC Press.
Carbon Nanotechnology by Liming Dai
Carbon Nanotubes: Properties and Applications by Michael J. O'. Connell.

M. Sc. PHYSICS (IV SEMESTER): MATERIALS SCIENCE AND ENERGY DEVICES

Course objectives:

- To understand the phase diagrams to design and control of heat-treating procedures.
- To understand how materials structure is engineered from the knowledge of phase diagrams.
- To acquire a detailed knowledge of advanced engineering materials.
- To know the basics of photovoltaic energy conversion process.
- To acquire skills in materials selection and engineering design for various important solar cells.
- To learn construction of solar panels and their applications.

- To understand the fundamentals of hydrogen energy, hydrogen production and storage.
- To learn about various fuel cells and materials required for fuel cells.
- To learn the basics of energy storage in supercapacitors and batteries.
- To acquire detailed knowledge of important advanced supercapacitors and batteries.

Course Outcomes:

- Students will be able to design and interpret the phase diagrams.
- Students will have the knowledge of materials properties as function of microsructures.
- Student will get the fundamental knowledge of solar energy conversion process.
- Students will learn about the construction of solar panels and their domestic and industrial use.
- Students will understand about hydrogen energy and construction of various fuel cells and their applications.
- Student will be able to know the basics of energy storage in supercapacitors and batteries.
- Students will have the sufficient knowledge of construction of advance supercapacitors and batteries.
- Students will be able to select suitable materials and engineering use in solar energy system, hydrogen energy system, energy storage systems.
- All content of this course will impart skills for direct employability.

Unit 1. Classification of Materials and Phase Diagrams

Definitions and basic concepts of materials science, Overview of thermodynamic variables, quantities and equilibrium, Phase diagram, Gibbs Phase Rule, Lever Rule, Solubility Limit, microstucture, Interpretation of phase diagrams, Determination of phase amounts, Unary phase diagrams, Binary eutectic systems, Eutectoid and peritectic reactions, Iron-Carbon system, Homogeneous and heterogeneous nucleation.

Advanced Engineering materials, Alloys, Dielectrics, Polymers, Composites, Glasses, Ceramics and Biomaterials, Meta materials, Smart materials, Topological Insulators. Properties and applications.

Unit 2. Solar Energy and Materials Aspects

Importance of renewable energy, materials and devices in present technology, Basic of photovoltaic energy conversion, Optical properties of Solids, p-n junction solar cell, Transport equation, Current density, Open circuit voltage and short circuit current, Single crystal silicon and amorphous silicon solar cells, Elementary ideas of advanced solar cells (Tandem solar cells, Solid liquid junction solar cells, Dye sensitized, Organic solar cells), Introduction to PV panels, Domestic and industrial applications.

Unit 3. Hydrogen Energy

Photoelectrolysis and photocatalytic process, Brief discussion of various storage processes, Special features of solid hydrogen storage materials, New storage modes, Various factors relevant to safety, Hydrogen sensors, Use of hydrogen as fuel, Use in vehicular transport, Hydrogen for electricity generation, Fuel cells, Various type of fuel cells, Applications of fuel cell, Elementary concepts of hydride batteries.

Unit 4. Supercapacitors and Batteries

Capacitor principles, properties of capacitors, Electrochemical capacitors, Electrochemical interface, Double-layer capacitors: Li-ion based hybrid supercapacitors, applications of supercapacitors. Properties of batteries, introduction to battery technology, primary batteries, Secondary batteries, Li-ion and Ni-Ion based advanced batteries, applications of batteries.

Text and Reference Books:

1. Materials Science and Engineering by V. Raghavan.
2. Materials Science and Engineering: An Introduction byWilliam D. Callister Jr.
3. Fundamentals of Ceramics by M.W. Barsoum (Taylor & Francis).
4. Advanced Engineering materials by Sandra Kalveram.
5. Electrochemical Supercapacitors-Scientific Fundamentals and Technological Applications, by B. E. Conway.
6. Electrochemical Supercapacitors for Energy Storage and Delivery: Fundamentals and Applications, by Aiping Yu, Victor Chabot, Jiujun Zhang.
7. Supercapacitors: Materials, Systems, and Applications by François Béguin
8. Solar Cell Devices-Physics by Fonash.
9. Fundamentals of Solar Cells Photovoltaic Solar Energy by Fahrenbruch & Bube Phoptoelectrochemical Solar Cells by Chandra.
10. Hydrogen as an Energy Carrier Technologies Systems Economy by Winter & Nitch (Eds.).
11. Hydrogen as a Future Engery Carrier by A. Zuttel, A. Borgschulte and L. Schlapbach
12. Battery Reference book third edition by T.R. Crompton.
13. Advanced Batteries: Materials Science Aspects by Robert Huggins.
14. Handbook ofPhotovoltaic Scienceand Engineering byAntonio Luque.

M.Sc. PHYSICS (IV SEMESTER): NUMERICAL METHODS AND PROGRAMMING

Objectives:

The student should be made to:

- Be familiar with the MATLAB GUI and basic tool boxes
- Be familiar with arithmetic, logic and relational operations on matrix
- Aware about to find the roots of nonlinear equations by numerical methods
- Learn various methods to solve the matrices
- Learn about interpolation, least square fitting, Numerical differentiation, Integrations, ordinary and partial differential equations.

Outcomes:

At the completion of the course students will be able to:

- Perform data handling in MATLAB environment.
- Write arithmetic programs in MATLAB environment
- Solve the linear and non-linear algebraic equations, Eigen value problems, curve fitting and numerical solution of ordinary differential equations.
- Solve numerical integration & differentiation, curve fitting, Numerical solution of ordinary equations.

Unit 1. MATLAB: MATLAB environment, M-Files, Basic syntax and scalar arithmetic operations, variables, Working with formula, MATLAB control flow: if and loops, Functions, structured data types, file input output, defining functions, Graphics, 2D & 3D plotting in MATLAB, Linear algebra with MATLAB, solving a system of linear equations.

Unit 2. Roots of nonlinear equations: Linear and nonlinear algebraic and transcendental equations, Roots of functions, Bracketing and open end methods: Bisection method, Newton-Raphson method.
Matrices and solution of linear equations: Eigen values and eigenvectors of matrices, Power and Jacobi method, consistency of a system of linear equation, Gaussian elimination, LU decomposition method, matrix inversion, Jacobi iterative method, Gauss-Seidel method.

Unit 3. Interpolation and least square fitting: Finite differences, Newton's formula for interpolation, Gauss, Stirling, Divided differences, Newton's general interpolation formula, Lagrange's interpolation formula.Method of Least square curve fitting, straight line and quadratic equation fitting, curve fitting of curves $y = ax^b$, $y = ae^{bx}$, $xy^a = b$ and $y = ab^x$, curve fitting by sum of exponentials.

Unit 4. Numerical differentiation, integration and solution of ordinary differential equations: Differentiation of continuous functions, Trapezoidal rule, Simpson 1/3 and 3/8 rules, Boole's and waddles rules, Euler, Picard and Runge-Kutta methods, Finite element method (solve wave and heat equations).

Text and References Books

1. MATLAB programming for engineers, 4th edition by Stephen J. Chapman.
2. Introductory Methods of Numerical analysis by S.S. Shastri
3. Numerical Analysis by Rajaraman
4. Computational method in physics and engineering by Wong
5. Numerical Methods by E. Balagurusamy
6. MATLAB for Engineers, 3rd edition by Holly Moore

M.Sc. PHYSICS (IV SEMESTER): MICROWAVE ELECTRONICS, DIGITAL AND SATELLITE COMMUNICATION

Course Objective

The elemental objectives of this course are;

- To build up the concept from basics of microwave communications to modern applications
- To study digital communication systems (e.g., choose modulation scheme, coherent vs. non-coherent), constraints on data rate, bandwidth, power, and bit error rate

- To compute the power and bandwidth requirements of modern communication systems, including those employing Amplitude-Shift Keying (ASK), Phase-Shift Keying (PSK) and Frequency-Shift Keying (FSK modulation formats
- To enable the student to become familiar with satellites and satellite services.
- Study of satellite orbits and launching.
- Study of earth segment and space segment components

Course Outcomes:

Students will have achieved the ability to:

- Analyze microwave networks and measure their parameters.
- Explain the working of various microwave devices
- Identify the modern day applications of microwaves.
- Understand the performance of a baseband and pass band digital communication system in terms of error rate and spectral efficiency.
- Understand orbital mechanics and how to locate satellite w. r. t. Earth station
- Describe satellite subsystems
- Design link power budget for satellites

Unit 1. Microwave Tubes and Circuits: Generation of Microwaves by Vacuum Tubes; Limitations of Conventional Tubes, Microwave Linear Beam Tubes (O type); Klystrons amplifiers, Velocity Modulation, Basic principles of two cavity klystrons, Multicavity clystron amplifier and Reflex klystron oscillator and Travelling wave tube (TWT), Microwave Crossed Field Tube (M type) Magnetron, principles of operation of magnetrons

Unit 2. Semiconductor Microwave Devices and Circuits: Transferred electron devices, Ridley-Watkins-Hilsum (RWH) Theory, Gun effect diodes, Principles of operations, modes of operation, Avalanche Transit-Time Devices, Read diode, IMPATT diode, and TRAPATT diode.

Unit 3. Digital Communication: Pulse Modulation; Sampling theorem – Low Pass and Band Pass signals, Pulse Amplitude Modulation, Pulse Code Modulation, uniform and non-uniform Quantization of signals, Quantization error, Digital Modulation Schemes; Principle of Binary Phase Shift Keying (BPSK), Generation and Reception of BPSK, Bandwidth of BPSK Signal , Differential Phase Shift Keying (DPSK); DPSK Transmitter and Receiver, Bandwidth of DPSK Signal, Quadrature Phase Shift Keying (QPSK); QPSK transmitter and Receiver, Bandwidth of QPSK Signal, Binary Frequency Shift Keying (BFSK), BFSK Transmitter and receiver, Amplitude Shift Keying (ASK).

Unit 4. Satellite Communication: Introduction to Satellite Systems**,** Types of Satellites, Frequency Allocations, Orbital Mechanics; Laws governing satellite motion; Kepler's Laws, Describing the orbits of a Satellite, Locating the Satellite in the Orbit, Locating the Satellite with respect to the Earth, Orbital Elements, Antenna Look Angles determinations, Orbital

Perturbations, Satellite link power budget equation, system Noise, carrier to noise ratio for uplink and downlink, combined uplink and downlink carrier to noise ratio.

Texts and Reference Books

Microwaves by K.C. Gupta
Microwave Devices and Circuits by Samuel Y. Liao
Electronic Communication Systems by George Kennedy and Bernard Davis
Principles of Communication Systems by Taub and Schilling
Communication Systems by Simon Haykin
Digital Communications, second edition by J.S. Chitode
Satellite Communication by Timothy Pratt and Jeremy E. Allnutt

M.Sc. Physics (IV SEMESTER): DESIGN AND FABRICATION OF INTEGRATED CIRCUIT

Course Objectives:

- To understand the microelectronics.
- To know the process of preparation of electronic grade silicon and crystal growth.
- To understand the various process steps of silicon wafer fabrication.
- To learn the design of circuits using pattern transfer technology (lithography) on silicon wafer.
- To understand the process of ICs fabrication, Isolation, Contacts, Interconnections, and Packaging.

Course Outcomes:

- After completion of course, the students will learn about the integrated circuits (ICs) and technology.
- Students will understand the theory and experimental background of all the actual process like; wafer fabrication, doping, and pattern transfer, etc. used in IC fabrication.
- Students will also learn about exact deposition of thin films of metal, oxides and photoresists, wet/dry etching, and finally the isolation, interconnection, testing and packaging.
- The students will be able to design electronic circuits and devices for semiconductor/microelectronics industry purpose.
- All content of this course will impart skills for direct employability.

Unit 1. Semiconductor Subsrate for Integrated Circuits

An introduction to microelectronics fabrication, Classification of Integrated Circuits (IC), CMOS Process Overview. Metallurgical Grade Silicon (MGS) and Electronic grade silicon (EGS). Crystal growing methods, Silicon shaping, lapping, Polishing and wafer preparation,
Oxidation of silicon, Thermal dry oxidation and wet oxidation, Deal-Grove modal of oxidation, linear and parabolic rate coefficient, oxidation systems. Doping by Diffusion, Diffusion Process, Fick's Diffusion equation in one dimension, Analytic solution of Flick's law. Analysis of diffused profiles, Diffusion in SiO_2,Diffusion sources and systems., Ion implantation, Implantation system, Channeling, projected range, implantation damage, Junction formation, Annealing, Dopant Diffusion and Related Operations.

Unit 2. Thin Films: Metals and Nonmetals

Vacuum science and technology. Thin films and growth modes, Physical vapor deposition (PVD) methods: Thermal evaporation and electron beam evaporation systems, DC and RF sputtering system. Chemicals Vapor Deposition (CVD) methods: APCVD, LPCVD, PECVD and ALD technique, CVD Applications. Epitaxial growth, Epitaxy methods for thin film deposition: Vapor-Phase Epitaxy, Liquid Phase Epitaxy and Molecular Beam Epitaxy (MBE).

Unit 3. Photolithography, Photoresist Processing and Etching

Wafer Cleaning methods, Wafer Preparation method: HMDS Treatment for adhesion improvement of photoresist, photoresist spin coating method, soft and post backing of photo resist, Negative photoresist, Positive photoresist, Contrast and sensitivity of photoresist, Chemical Modulus Transfer Function (CMTF) of Photoresist, Resist Exposure (single, bi-layer and multi level photoresist exposure) and Resist Development, Hard Baking and Resist curing, Photolithographic Process Control.

Photolithography: An Overview, lithography, Photolithography source, Resolution and numerical aperture, Photolithographic methods: Contact, proximity and projection, Photo mask and mask Alignment, Limitations of optical lithography, Concept of phase-shift mask, Electron beam lithography, X-ray lithography and Ion Lithography. Dry etching and wet chemical for material removal, Reactive plasma etching, Ion milling.

Unit 4. Device Isolation, Contacts, Interconnections, Packaging and Yield

Junction and oxide isolation, LOCOS methods, Trench isolation, Ohmic Contact, Schottky Contact, Alloyed Contact, Multilevel Metallization, Planarization and advanced interconnects. Testing, Die Sepration, Die Attachment, Wire Bonding, Packages, Flip-Chip Process, Tape-Automated-Bonding Process, Yield, Uniform and Nonuniform Defect Densities.

Text and Refernece Books:

Integrated Electronics- Milliman and Taub
Microelectronics –Milliman and Gros
Thin Film Phenomena- K.L. Chopra
Hand Book of Thin Film- Marshel and Glang
VLSI Technology- S.M. Sze.
Silicon VLSI Technology: Fundamentals, Practice, and Modeling by J.D. Plummer