LOCF (M.Sc. Physics)

Semester I

Title of Course: Advanced Mathematical Physics	**Course Code: 12M11PH102**

L-T Scheme: 3-1-0 **Course Credit: 4**

Objective: To provide students the ability to hone the mathematical skills necessary to approach problems in advanced physics courses. The course will review and develop the theory of: complex analysis and applications to special functions; asymptotic expansions; ordinary and partial differential equations, in particular, characteristics, integral transform and Green function techniques; Dirac delta and Integral transforms.

Unit I: Theory of Functions of a Complex variable
Function of a Complex variable, Exponential functions, Logarithmic functions, Analyticity and Cauchy condition, Cauchy-Riemann equations, necessary and sufficient conditions for a function to be analytic, Harmonic functions, Cauchy's Integral Theorem, Cauchy's Integral Formula, Taylor's Series and Laurent's series and expansion, Zeroes and Singular Points, Multi valued functions, Residues, Cauchy's Residue Theorem, Jordon's Lemma, Evaluation of real definite integrals. **(Lectures : 12)**

Unit II: Special Functions (12 hrs.) Bessel Functions: Bessel functions of the first kind Jn(x), Generating function, Recurrence relations, Expansion of Jn(x) when n is half an odd integer, Integral representation; Legendre Polynomials Pn(x): Generating function, Recurrence relations and special properties, Rodrigues' formula, Orthogonality of Pn(x); Hermite and Laguerre Polynomials: generating function & recurrence relations only. **(Lectures: 10)**

Unit III: Matrices and Group Theory
Matrices: Orthogonal, Unitary and Hermitian Matrices with examples, Independent elements of orthogonal and unitary matrices of order 2, Matrix diagonalization, eigenvalues and eigenvectors; Fundamentals of Group theory: Definition of a group and illustrative examples, cyclic groups. **(Lectures: 10)**

Unit IV: Integral Transforms
Fourier Integral theorem, Fourier Sine, Cosine and Complex transforms with examples, Properties of Fourier transform, Fourier transforms of Derivatives, Parseval's theorem, Convolution theorem, Fourier transform of Integrals. Laplace Transforms, Transforms of some Elementary Functions, Properties of Laplacetransform, Transform of Derivatives, Transform of Integrals, Convolution theorem, and its applications, Inverse Laplace Transform by partial fractions method. **(Lectures: 12)**

REFERENCE BOOKS:
1. Mathematical methods for Physicists, Arfken, 4th edition, Academic Press Inc. 1995.
3. Mathematical Physics, AK Ghatak, Trinity Press-Laxmi Publications, 1st Edition, 1995.
4. Mathematical Physics by H.K. Dass, S. Chand Publications, 5th edition, 2017.
5. Schaum's Outlines Complex Variables by M. R. Spiegel, Mc-Graw hill publications, 2015.
6. Group theory and Quantum Mechanics by M. Tinkam, Dover Publications, 2012.
7. Schaum's Outlines Group Theory by B. Baumslag, B. Chandler, Mc-Graw Hills, 2012.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Derive Cauchy integral theorem and Cauchy integral formula and find Taylor and Laurent series expansion of functions of complex variable.
CO2	Understand the calculus of residue and evaluate some typical definite integral using the method of contour integration
CO3	Apply the knowledge of matrices for solving linear algebraic equations and Learn basics of group theory and prepare group multiplication tables for understanding crystallography
CO4	Find explicit expressions of Hermite, Laguerre, Bessel and Legendre polynomials using the corresponding generating functions and derive orthogonality relations and various recurrence relations among these special functions for their applications in solving quantum mechanical systems
CO5	Learn properties of Fourier and Laplace transforms and evaluate the Fourier and Laplace transforms of functions and derivatives.

Title of Course: Electrodynamics	Course Code: 12M11PH101

L-T Scheme: 3-1-0 **Course Credit: 4**

Objective: To impart knowledge on the concepts of electrostatics, electric potential, energy density and their applications. To understand the Maxwell's equations, Magnetic dipoles, and radiating system. To impart knowledge on the concepts of Concepts of electromagnetic waves and Transmission lines.

Unit I

Electrostatics: Poisson and Laplace equations, Green's Theorem, Uniqueness of the solution with the Dirichlet or Neumann boundary conditions, Formal solutions of electrostatics boundary value problem with Green's function, Electrostatics potential energy density. Boundary value problems in Electrostatics: Method of images, Point charge in the presence of grounded conducting sphere, Point charge in the presence of a charge insulated conducting sphere, Point charge near a conducting sphere at fixed potential, Conducting sphere in uniform electric field by method of images. . **(Lectures :10)**

Unit II

Maxwell Equations, Vector and scalar potentials, Gauge transformations, Lorentz gauge, Coulomb gauge, Green functions for wave Equation, Derivation of equations of macroscopic electromagnetism, Poynting theorem and conservation of energy and momentum for a system of charged particles, Poynting theorem in linear dispersive media with losses, Poynting theorem for harmonic field. . **(Lectures :08)**

Unit III

Radiating Systems, Multipole Fields and Radiation: Fields and radiation of a localized oscillating source, Electric dipole fields and radiation, Magnetic dipole and electric quadrupole fields, Center fed linear antenna, Multipole expansion of the electromagnetic fields, Properties of multipole fields. Collisions, Energy Loss and Scattering of Charged Particles: Energy transfer in a Coulomb collision between heavy incident particle and stationary free electron, Energy transfer to a harmonically bound charge, Thomson scattering, Cherenkov radiation. **(Lectures : 08)**

Unit IV

Radiation by Moving Charges: Retarded time and retarded potential, Lienard–Wiechert potentials and fields for a moving point charge, Electromagnetic fields of a uniformly moving point charge, Total power radiated by an accelerated charge: Larmor's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary and extremely relativistic motion, Distribution in frequency and angle of energy radiated by accelerated charges. **(Lectures : 08)**

Unit V

Dynamics of Relativistic Charged Particle: Lagrangian and Hamiltonian for a relativistic charged particle in external electromagnetic fields, Covariance of equation of motion, Euler-Lagrange equation, Motion of charged particle in uniform static magnetic field, Combined uniform static electric and magnetic fields, Motion of charged particle in non uniform static magnetic fields. Adiabatic invariance of flux through the orbit of particle. **(Lectures : 08)**

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Understand the fundamental concepts of electrodynamics and describe the propagation of electromagnetic waves through different media.
CO2	Enhance skills for solving Boundary value problems especially using Method of images
CO3	Understand the laws of reflection and transmission of electromagnetic waves at the interfaces of different media for normal and oblique incidence.
CO4	Understand the Non-uniqueness of Electromagnetic potentials with concept of Gauge and get familiarize with concept of retarded time for charges undergoing acceleration and evaluate fields and power corresponding to Lienard-Wiechert Potentials.
CO5	To understand the Lagrangian and Hamiltonian for a relativistic charged particle in external electromagnetic fields.

Text Books/ Suggested Reading:

1. J.D. Jackson: *Classical Electrodynamics*, 2nd edition, John Wiley, 1985.
2. D.J. Griffith: *Introduction to Electrodynamics*, 3rd edition, Pearson Pub., New Delhi, 2003
3. Panofsky and Phillips: *Classical Electricity and Magnetism, 2nd edition*, Addison Wesley, 1962.
4. L.D. Landau and E.M. Lifshitz: *Classical Theory of Field, 4th edition*, Pergamon Press, 2003.
5. L.D. Landau and E.M. Lifshitz: *Electrodynamics of Continuous Media*, Pergamon Press, 1995.
6. J.R. Reitz, F.J. Milford R.W. Christry: *Foundation of Electromagnetic Theory*, 4th edition, Pearson Education, 2009.

Title of Course: Classical Mechanics	Course Code: 17M11PH103

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: The course is to revise Newtonian mechanics and introduce Lagrangian formulation of mechanics. To emphasis the understanding of Classical Mechanics using Lagrangian and Hamiltonian Approach. To realize the reduction of a two-body problem to a one-body problem in a central force system. Also study the rigid body problems and canonical transformations.

Unit I

Langrangian Dynamics: Constraints, Generalized coordinates, Concept of virtual work, D'Alembert principle, Langrange equation from D'Alambert principle, Velocity dependent potential, Expression for kinetic energy of a system in terms of Generalized coordinates, Cyclic coordinates, Symmetry properties and conservation theorems. **(Lectures: 8)**

Unit II

Hamiltonian dynamics: Hamiltonian function H and conservation of energy: Jacobi's integral and its significance, Hamilton's equation, Routhian. Hamiltons variation principle, Derivation of Langrange equation, Extension of Hamilton's Principle, to non-holonomic system, A hoop rolling without slipping on an inclined plane, Modified Hamilton's Variation principle, Derivation of Hamilton's equation from variation principle, Δ- variations, Principle of least actions in various forms. **(Lectures: 8)**

Unit III

The Two Body Central Force Problem: Central force and motion in a plane, Reduction of a two body central force to equivalent one body problem, Equation of motion and first integral, Differential equation for an orbit, Equivalent one dimensional problem and classification of orbits for some specific potential. Integral power law potential, Virial theorem, Relation between kinetic and potential energy. Keplers Problems: Equation of orbit and the kind of the orbit, Motion in time. **(Lectures: 8)**

Unit IV

The kinematics of rigid body motion: Independent co-ordinate of a rigid body, Orthogonal transformation, Formal properties of transformation matrix, Eular angles, Eular's theorem, Finite rotation, Infinitesimal rotations (contact transformation). Angular momentum, Moment of inertia tensor, Product of inertia, Inertia tensor, Principal moment of inertia: Principal axis, Kinetic energy of motion of a rigid body about a point. **(Lectures: 8)**

Unit V

Canonical transformation and Hamilton Jacobi theory: Canonical transformation, Legendre transformation, Generating functions, Conditions for canonical transformation, Bilinear invariant condition. Poisson's brackets, Langrange brackets, Invariance of Poission bracket under canonical transformation, Angular momentum Poission bracket relation. Hamilton Jacobi equation for Hamilton's principal function, Harmonic oscillator problem by Hamilton Jacobi method, Hamilton's characteristic function. **(Lectures :10)**

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Introduction of Generalized coordinates/. To understand the Concept of virtual work, D'Alembert principle, Langrange equation from D'Alambert principle, Cyclic coordinates, Symmetry properties and conservation theorems.
CO2	Apply the formalism of Lagrangian and Hamiltonian in generating equations of motion for complicated mechanical systems of classical mechanism, Variational Principle
CO3	To solve the Two Body Central Force Problem: Central force and motion in a plane, Differential equation for an orbit, Equivalent one dimensional problem and classification of orbits for some specific potential Virial theorem,
CO4	To understand the kinematics of a rigid body. orthogonal transformations.
CO5	To formulize the Canonical transformation and Hamilton Jacobi theory. To understand Poisson's brackets and Lagrange brackets.

Suggested Readings:

1. H. Goldsteen: *Classical Mechanics*, Narosa Publishing House, 2001.
2. N. C. Rana and P. S. Joag: *Classical Mechanics*, Tata Mc-Graw Hill, New Delhi, 1991.
3. J. C. Upadhyaya: *Classical Mechanics*, Himalaya Publishing, 2006.
4. P. V. Panat: *Classical Mechanics*, Narosa Publishing House, 2000.
5. S. L. Gupta, V. Kumar, H. V. Sharma: *Classical Mechanics*, Pragati Prakashan, Meerut, 2000.

Title of Course: Programming Language C	Course Code: 12M11CI101

L-T Scheme: 3-1-0 **Course Credit: 4**

COURSE OBJECTIVES: To understand the constructs of C Language. To develop C Programs using basic programming constructs. To develop C programs using arrays and strings. To develop modular applications in C using functions. To develop applications in C using pointers and structures. To do input/output and file handling in C

UNIT I BASICS OF C PROGRAMMING

Introduction to programming paradigms – Applications of C Language - Structure of C program - C programming: Data Types - Constants – Enumeration Constants - Keywords – Operators: Precedence and Associativity - Expressions - Input/Output statements, Assignment statements – Decision making statements - Switch statement - Looping statements – Preprocessor directives - Compilation process

UNIT II ARRAYS AND STRINGS

Introduction to Arrays: Declaration, Initialization – One dimensional array – Two dimensional arrays - String operations: length, compare, concatenate, copy – Selection sort, linear and binary search.

UNITIII FUNCTIONS AND POINTERS

Modular programming - Function prototype, function definition, function call, Built-in functions (string functions, math functions) – Recursion, Binary Search using recursive functions – Pointers – Pointer operators – Pointer arithmetic – Arrays and pointers – Array of pointers – Parameter passing: Pass by value, Pass by reference.

UNI IV STRUCTURES AND UNION

Structure - Nested structures – Pointer and Structures – Array of structures – Self referential structures – Dynamic memory allocation - Singly linked list – typedef – Union - Storage classes and Visibility.

UNIT V FILE PROCESSING

Files – Types of file processing: Sequential access, Random access – Sequential access file - Random access file - Command line arguments.

COURSE OUTCOMES: Upon completion of the course, the students will be able to
CO1: Demonstrate knowledge on C Programming constructs
CO2: Develop simple applications in C using basic constructs

CO3: Design and implement applications using arrays and strings
CO4: Develop and implement modular applications in C using functions.
CO5: Develop applications in C using structures and pointers.
CO6: Design applications using sequential and random access file processing.

TEXT BOOKS:

1. ReemaThareja, "Programming in C", Oxford University Press, Second Edition, 2016.
2. Kernighan, B.W and Ritchie,D.M, "The C Programming language", Second Edition, Pearson Education, 2015.

REFERENCES:

1. Paul Deitel and Harvey Deitel, "C How to Program with an Introduction to C++", Eighth edition, Pearson Education, 2018.
2. Yashwant Kanetkar, Let us C, 17th Edition, BPB Publications, 2020.
3. Byron S. Gottfried, "Schaum's Outline of Theory and Problems of Programming with C", McGraw-Hill Education, 1996.
4. Pradip Dey, Manas Ghosh, "Computer Fundamentals and Programming in C", Second Edition, Oxford University Press, 2013.
5. Anita Goel and Ajay Mittal, "Computer Fundamentals and Programming in C", 1st Edition, Pearson Education, 2013.

Title of Course: Data Structure	Course Code: 12M11CI102

L-T Scheme: 3-1-0 **Course Credit: 4**

Objective: The course is intended to provide the foundations of the practical implementation and usage of Algorithms and Data Structures.

Hashing – General Idea, Hash Function, Separate Chaining, Hash Tables without linked lists: Linear Probing, Quadratic Probing, Double Hashing, Rehashing, Hash Tables in the Standard Library, Universal Hashing, Extendible Hashing.

Priority Queues (Heaps) – Model, Simple implementations, Binary Heap: Structure Property, Heap Order Property, Basic Heap Operations: insert, delete, Percolate down, Other Heap Operations. Binomial Queues: Binomial Queue Structure, Binomial Queue Operations, Implementation of Binomial Queue, Priority Queues in the Standard Library.

Trees – AVL: Single Rotation, Double Rotation, B-Trees. Multi-way Search Trees – 2-3 Trees: Searching for an Element in a 2-3 Tree, Inserting a New Element in a 2-3 Tree, Deleting an Element from a 2-3 Tree. Red-Black Trees – Properties of red-black trees, Rotations, Insertion, Deletion.

Graphs Algorithms – Elementary Graph Algorithms: Topological sort, Single Source Shortest Path Algorithms: Dijkstra's, Bellman-Ford, All-Pairs Shortest Paths: Floyd-Warshall's Algorithm.

Disjoint Sets – Equivalence relation, Basic Data Structure, Simple Union and Find algorithms, Smart Union and Path compression algorithm. String Matching – The naive string-matching algorithm, The Rabin-Karp algorithm, The Knuth-Morris-Pratt algorithm.

Text / Reference Books:

1. Data Structures and Algorithm Analysis in C++, Mark Allen Weiss, 4 th Edition, 2014, Pearson.
2. Introduction to Algorithms, Thomas H Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, 3 rd Edition, 2009, The MIT Press.
3. Fundamentals of Computer Algorithms, Ellis Horowitz, SatrajSahani and Rajasekharam, 2nd Edition, 2009, University Press Pvt. Ltd.
4. Advanced Data Structures, Reema Thareja, S. Rama Sree, Oxford University Press, 2018.

COURSE OUTCOMES: Upon successful completion of the course, Student will be able to

Course Outcome	Description
CO1	Understand the basic principles and operations of data structures
CO2	Apply Hashing, Disjoint sets and String Matching techniques for solving

	problems effectively
CO3	Apply the concepts of advanced Trees and Graphs for solving problems effectively
CO4	Analyze the given scenario and choose appropriate Data Structure for solving problems

Title of Course: Advanced Quantum mechanics	Course Code: 12M11PH103

L-T Scheme: 3-1-0 **Course Credit: 4**

Objective: To impart knowledge of advanced quantum mechanics for solving relevant physical problems. To provide an understanding of the formalism and language of non-relativistic quantum mechanics. To understand the concepts of time-independent perturbation theory and their applications to physical situations.

UNIT-I: Fundamentals of Quantum Mechanics

Need of Quantum Mechanics, Two slit experiment with radiation and matter particles, Ehrenfest theorem, Postulates of quantum mechanics, Wave function and Schrödinger wave equation, Orthonormality of eigenfunctions, Reality of eigenvalues, Closure property, Probability density, Expectation values, Uncertainty principle for two arbitrary observables, Solution of Schrödinger equation for three dimensional problems: Harmonic oscillator, Hydrogen atom Problem (radial wave functions and energy eigenvalues). **(Lectures: 10)**

UNIT-II: Matrix formalism of Quantum Mechanics

Overview of Linear Vector Space, Basis, Operators, Dirac Notations of Bra and Ket, Matrix Representation of Observables and States, Determination of Eigenvalues and Eigenfunctions of Observables, orthogonality, closure, completeness. Matrix theory of the harmonic oscillator: Spectrum of eigenvalues and eigenfunctions, Hilbert space representation, Change of Representation, Hermitian and Unitary Transformation, Time-development of quantum system: Schrödinger, Heisenberg and Interaction pictures. **(Lectures: 12)**

UNIT-III: Theory of Angular Momentum

Orbital angular momentum operator L, Cartesian and spherical polar coordinate representation, Commutation Rules for Angular Momentum, Eigenvalues and Eigenfunctions of L^2 and Lz, General angular momentum operator J, Eigenvalues and Eigenfunctions of J^2 and Jz Matrix Representation of Angular Momentum Operators, Spin angular momentum, Wavefunction including spin (Spinor), Spin one half: Spin eigenfunctions and Pauli Spin Matrices. **(Lectures: 12)**

UNIT-IV: Perturbation Theory Perturbation Theory of Non-degenerate Systems with first and second order corrections to energyeigenvalues and eigenfunctions, Application to He Atom, Zeeman Effect without electron spin, Perturbation Theory for Degenerate Systems, First order correction, First Order Stark Effect in H-Atom, Time Dependent Perturbation Theory (First Order), Transition probability for constant and harmonic perturbations, Fermi Golden Rule. **(Lectures: 12)**

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Realize the basic quantum-mechanical view point, and learn its wave mechanical formulation for a non-relativistic situation, Solve the 3

	dimensional Schrödinger wave equation for eigenfunctions and eigenvalues for harmonic oscillator and Hydrogen atom.
CO2	Construct matrices for observables and wave functions in different representations, and apply the matrix theory for calculating eigenvalues and eigenfunctions
CO3	Describe the time-development of a quantum system in Schrödinger, Heisenberg and Interaction pictures, and to envisage the same in Hilbert space.
CO4	Calculate the eigenvalues and eigenfunctions for the orbital and general angular momenta, along with the matrix representation of angular momentum
CO5	Have an understanding of the perturbation theory and apply the same for degenerate and non-degenerate systems.

REFERENCE BOOKS:

1. Quantum Mechanics by L. I. Schiff, McGraw-Hill Education
2. Quantum Mechanics - A Modern Introduction by A. Das and A. C.Melissinos, Gordan and Breach Science Publishers
3. Modern Quantum Mechanics by J. J. Sakurai, Pearson publishers.
4. Principles of Quantum Mechanics by P. Dirac, Oxford University Press.
5. Principles of Quantum Mechanics by R. Shankar, Plenum Press.
6.Quantum Mechanics by A. K. Ghatak& S. Lokanathan, Kluwer Publications.

Semester II

Course Description

Title of Course: Solid state physics	Course Code: 12M11PH201

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: The course gives an introduction to solid state physics, and will enable the student to employ classical and quantum mechanical theories needed to understand the physical properties of solids. Emphasis is put on building models able to explain several different phenomena in the solid state.

Unit I

Crystal Physics: Diffraction of waves by crystals, Reciprocal lattice and its application to diffraction technique, Laue, Powder and rotating crystal method, Crystal structure factor and atomic form factor. Lattice Vibrations: Quantization of elastic waves, Phonon momentum and inelastic scattering by phonons. Defects in Crystal: Point defects, Colour centres, F-centres, Line defects and planer defects, Role of dislocations in crystal growth. **(Lectures: 10)**

Unit II

Ferroelectrics: Classification of ferroelectric crystals, Theory of the ferroelectric displacive transitions: Polarization catastrophe, Soft optical phonon, Thermodynamics of ferroelectric transition, Ferroelectric domains, Antiferroelectric, Piezoelectric and pyroelectric material. Phase Transition: First and second order transition, Long range order, Short range order and Bragg William model. **(Lectures: 10)**

Unit III

Superconductivity: Basic phenomena, Meissner effect, Critical field, Type- I and Type-I superconductors, Heat capacity, Isotope effect, London equations, Coherence length, BCS theory of superconductivity, Flux quantization, Normal tunneling, dc and ac Josephson Effect, SQUID, High temperature superconductors. **(Lectures: 08)**

Unit IV

Ferromagnetism: Weiss theory of ferromagnetism, Exchange interaction: Heisenberg model, Ferromagnetic domains, Origin of domains, Anisotropy energy, Bloch wall, Curie-Weiss law for susceptibility, Antiferromagnetic, Ferrimagnetic order, Spin wave and magnons. **(Lectures: 08)**

Unit V

Band Theory of Solids: Electrons in periodic lattice, Bloch theorem, Nearly free electron model, Tight binding approximation, Fermi surface, de Hass-Van Alphen effect, Cyclotron resonance, Magnetoresistance, Quantum Hall effect. Optical Properties: Refractive index, Electronic polarization, Optical absorption, Photoconductivity, Relationship between absorption coefficient and band gap recombination. **(Lectures: 10)**

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Analyze the structure of a crystalline solid in terms of lattice, basis, unit cell, reciprocal lattice, Brillouin zone and symmetry elements.
CO2	To understand the Ferroelectric materials to be applied for devices.

CO3	To understand the phenomenon of Superconductivity, HTSC and their applications in Squids, MAGLEV etc.
CO4	understand the magnetic properties of solids, semiconductors and superconductors.
CO5	Learn Bloch's theorem, its application to the KP model, solve the one-electron Schrödinger equation for a periodic potential to see the emergence of energy bands, and classify materials into conductors, semiconductors and insulators.

Suggested Reading:

1. C. Kittel: *Introduction of Solid State Physics*, 7th edition, John Wiley & Sons, 2004.
2. J.P. Shrivastava: *Elements of Solid State Physics, 2nd edition,* PHI, New Delhi, 2006.
3. L.V. Azaroff*: Introduction to Solids,* TMH edition, 1996.
4. N.W. Ashcroff N.D. Mermin: *Solid State Physics,* Holt, Rinehart and Winston, 1976.
5. A.J. Dekker: *Solid State Physics*, Prentice Hall, 1957.

Title of Course: Statistical physics	Course Code: 12M11PH302

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: The course helps to understand and use of probability theory to determine the distribution of molecular motions and states in a many-molecule system and provides a method to average the states to obtain the macroscopic (bulk) properties. To understand the properties of macroscopic systems using the knowledge of the properties of individual particles.

Unit I: Classical Statistical Mechanics

Foundations of Statistical Mechanics: The macroscopic and microscopic states, Postulate of equal a priori probability, Contact between statistics and thermodynamics; Ensemble theory: Concept of ensemble, Phase space, Density function, Ensemble average, Liouville's theorem, Stationary ensemble; The microcanonical ensemble, Application to the classical ideal gas; The canonical and grand canonical ensembles, Canonical and grand canonical partition functions, Calculation of statistical quantities; Thermodynamics of a system of non-interacting classical harmonic oscillators using canonical ensemble, and of classical ideal gas using grand canonical ensemble, Energy and density fluctuations; Entropy of mixing and the Gibbs paradox, Sackur-Tetrode equation. **(Lectures: 12)**

Unit II: Quantum Statistical Mechanics

Quantum-mechanical ensemble theory: Density matrix, Equation of motion for density matrix, Quantum-mechanical ensemble average; Statistics of indistinguishable particles, Two types of quantum statistics- Fermi-Dirac and Bose-Einstein statistics, Fermi-Dirac and Bose-Einstein distribution functions using microcanonical and grand canonical ensembles (ideal gas only), Statistics of occupation numbers; Ideal Bose gas: Internal energy, Equation of state, Bose-Einstein Condensation and its critical conditions; Bose-Einstein condensation in ultra-cold atomic gases: its detection and thermodynamic properties; Ideal Fermi gas: Internal energy, Equation of state, Completely degenerate Fermi gas. **(Lectures: 12)**

Unit III: Non-Ideal Systems

Cluster expansion method for a classical gas, Simple cluster integrals, Mayer-Ursell relations, Virial expansion of the equation of state, Van der Waal's equation, Validity of cluster expansion method; Phase transitions: Construction of Ising model, Solution of Ising model in the Bragg-William approximation, Exact solution of the one-dimensional Ising model; Critical exponents, Landau theory of phase transition, Scaling hypothesis. **(Lectures: 12)**

Unit IV: Fluctuations

Thermodynamic fluctuations and their probability distribution law, Spatial correlations in a fluid, Connection between density fluctuations and spatial correlations; Brownian motion, the Langevin theory of the Brownian motion (derivations of mean square displacement and mean square velocity of Brownian particle), Auto-correlation function and its properties, The fluctuation-dissipation theorem, Diffusion coefficient; the Fokker-Planck equation; Spectral analysis of fluctuations: the Wiener-Khintchine theorem. **(Lectures: 12)**

REFERENCE BOOKS

1. Statistical Mechanics by R. K. Pathria and P. D. Beale (2011), United States: Elsevier/Academic Press. (3rd edition)
2. Statistical and Thermal Physics by F. Reif (2010) Waveland Press.
3. Statistical Mechanics by K. Huang (1963). New York: Wiley.
4. Statistical Mechanics by L. D. Landau and I. M. Lifshitz (1980), USSR Academy of Sciences.
5. Statistical Mechanics by R. Kubo (1965) Amsterdam: North-Holland.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Learn the ensemble formulation of statistical mechanics, and apply these to calculate important thermodynamical quantities for simple systems.
CO2	Formulate the quantum mechanical ensemble theory and use it to derive the laws of quantum statistics, viz. Fermi-Dirac (FD) and Bose-Einstein (BE) statistics.
CO3	Grasp the basics of cluster expansion method for a classical real gas to obtain its equation of state and simple cluster integrals.
CO4	Construct and solve the Ising model, along with the Landau theory of phase transition and understand fluctuations.
CO5	Understand fluctuations, their spectral analysis and connection with spatial correlations. Describe the theoretical basis of Brownian motion on the basis of Enistein Smoluchowski, and Langevin approaches.

Course Description

Title of Course: Atomic and molecular spectroscopy	Course Code: 12M11PH203

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: The course introduces students to the basic physics of atoms, molecules, their spectra and the interaction of light with matter. Theoretical understanding of diffrent spectroscopic techniques.

Unit I

Atomic Spectroscopy: General discussion in Hydrogen spectra, Relativistic correction to spectra of Hydrogen atom, Spectra of monovalent atoms, quantum defect, Introduction to electron spin, Spin-orbit interaction and fine structure, Spectra of divalent atoms: Singlet and triplet states of divalent atoms, LS and j-j coupling, Branching rule, Hyperfine structure in spectra of monovalent atoms. **(Lectures: 10)**

Unit II

Microwave Spectroscopy: Pure rotational spectra of diatomic molecules, Isotopic effect, Non-rigid rotator, Poly-atomic molecules, Study of linear molecules and symmetric top molecules, Stark effect, Quadrupole hyperfine interaction, Microwave spectrometer, Information from rotational spectra. **(Lectures: 10)**

Unit III

Infrared Spectroscopy: Vibrational spectroscopy of diatomic and simple polyatomic molecules, Harmonic Oscillator, Anharmonic Oscillator, Rotational vibrators, Normal modes of vibration of polyatomic molecules, IR spectrometer: FTIR Spectrometer, Applications of infrared spectroscopy: H_2O and CO_2 molecules. **(Lectures: 10)**

Unit IV

Raman Spectroscopy: Raman effect, Classical and Quantum theory of Raman effect, Vibrational Raman spectra, Rotational Raman spectra, Vibrational-Rotational fine structure, Raman Spectrometer, Structure determinations from Raman and Infra-red spectroscopy. Electronic Spectra: Electronic structure of diatomic molecules, Intensity of spectral lines, Frank- Condon principle, Dissociation energy and dissociation products, Rotational fine structure of electronic-vibration transitions. **(Lectures: 10)**

Unit V

NMR and ESR Techniques: Theory of NMR, Relaxation effect, Theory of dipolar interaction and chemical shifts, Indirect spin-spin interactions, Experimental set up of NMR, Applications of NMR to quantitative measurements (Idea only). ESR: Quantum mechanical treatment of ESR, Nuclear interaction and hyperfine structure, Relaxation effects, ESR spectrometer, Applications of ESR method. **(Lectures: 10)**

Suggested Reading:

1. Willard, Merritt, Dean, Settle: *Instrumental Methods of Analysis*, CBS Publishers & Distributors, Delhi, 6th Ed. 1986.

2. Colin N. Banwell and Elaine M. McCash*: Molecular Spectroscopy*, Mc-Graw Hill College; 4th Sub. Ed., 1994.
3. B. H. Bransden and Joachain: *Physics of Atoms and Molecules*, Longman, 1983.
4. V. Rajendran and A. Marikani: *Applied Physics*, TMH publication, 4th Ed., 2002.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	On completion of the course the student will learn about the origin of different fine spectra for hydrogen , helium atom etc.
CO2	Explain the change in behavior of atoms in external applied electric and magnetic field. To understand microwave spectroscopy.
CO3	Explain rotational, vibrational, electronic and Raman spectra of molecules.
CO4	Leaarn aspects of Raman spectroscopic techniques and their applications in research field.
CO5	It describe electron spin and nuclear magnetic resonance spectroscopy and their applications

Title of Course: Nuclear and particle physics	Course Code: 12M11PH204

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: The goal of this course is to provide wide coverage on Nuclear and Particle Physics by which the students can continue their exploration in nuclear science. To introduce properties of nuclei and details of popular nuclear models. To derive and discuss properties of nuclear decays and nuclear reactions.

Unit I: Nuclear Properties and Nuclear decay

Properties of Nuclei (Charge, Mass, size, binding energy, spin, parity), Basic parameters of radioactivity (Decay constant, Activity, Half-life, Average life time), Laws of radioactive decay (Soddy-Fajans, radioactive disintegration and successive transformation), Types of decay: Alpha decay (Properties, charge to mass ratio, range, Geiger Nuttall law, energy, Gamow's Theory of Alpha-Decay), Beta decay (Types, energetics, Fermi's Theory of Beta-Decay), Neutrino theory: origin of continuous beta spectrum, and Gamma decay (Energetics of Gamma decay, selection rules), Internal conversion. **(Lectures: 12)**

Unit II: Nuclear Forces and Models

Properties of nuclear forces, Deuteron problem (Binding energy, spin parity, magnetic dipole moment, electric quadrupole moment); Nucleon-nucleon scattering (General formalism) neutronproton scattering at low energies (Partial wave analysis, scattering length and effective length); proton-proton scattering at low energies. Types of Nuclear Models, liquid drop model (Basics, semi empirical mass formula, Binding energy, Asymmetry energy, Odd-Even effect) Shell model (Basics, success and failure), Unified model (General Idea). **(Lectures: 12)**

Unit III: Interaction of Radiation with Matter and Nuclear Detectors

Types of Nuclear Radiations and their interaction processes, Interaction of light charged Particles, Interaction of heavy charged Particles (Bohr's formula for Stopping power of heavy charged particles, Bethe-Bloch relation, Range and Straggling), Interaction of Gamma-Rays (Photoelectric effect, Compton effect and Pair production), Absorption of gamma rays and its applications, linear and mass absorption coefficients of gamma rays. Neutron interaction (basic concepts), classification of detectors on basis of interaction and operation. Construction and working of Gas filled detectors, Ionization chambers, Proportional counters (MWPC), GM counter. **(Lectures: 12)**

Unit IV: Particle Physics

Classification and properties of elementary particles, Fundamental interactions, conservation laws (Energy, charge, mass, angular momentum and linear momentum) and properties of elementary particles, Gell-Mann Nishijima Scheme, SU(2) and SU(3) symmetries, Properties of quarks and their classifications. **(Lectures: 12)**

REFERENCE BOOKS:

1. Nuclear Physics by D.C. Tayal., (Himalaya Publishing House, 2009)
2. Introductory Nuclear Physics. By Kenneth S. Krane. (John Wiley & Sons, 1989)
3. Fundamentals of Nuclear physics by Jahan Singh (PragatiPrakashan)

4. Theory of Nuclear Structure by M. K. Pal (Affiliated East-West Press,1982).
5. Nuclear Reaction and Nuclear Structure by P.E. Hodgson (Clarendon Press, 1971)
6. Nuclear Physics by R. Prasad, (Pearson, 2014)

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Basic understanding about the nucleus and its constituents. Nuclear decay is also understood in detail.
CO2	The students gather advanced knowledge in models of the nucleus at very high energy, the nucleus looks like a solid core (rigid) at the centre. The nuclear force is a mixture of different types of exchange force. The Compound model of the nucleus and its statistical analysis which was experimentally verified thereafter by Indian Scientist S. N. Ghosal is learned.
CO3	The nuclear force is spin dependent and confirmed from the study of scattering of low energy neutrons from ortho and para hydrogen. The inelastic scattering at very high energy which herald the concert of pion production is also learned.
CO4	Student learns different elementary particles and their interactions as well as their classifications.

Title of Course: Digital Electronics	Course Code: 12M11EC201

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: To acquire the basic knowledge of digital logic levels and application of knowledge to understand digital electronics circuits.

Unit 1

Arithmetic Circuits: Combinational Circuits- Implementing Combinational Logic- Arithmetic Circuits – Basic Building BlocksHalf-Adder- Full Adder- Half-Subtractor- Full Subtractor-Controlled Inverter- Adder–Subtractor- BCD Adder- Carry Propagation–Look-Ahead Carry Generator- Arithmetic Logic Unit (ALU)- MultipliersMagnitude Comparator- Cascading Magnitude Comparators- Application-Relevant Information. Multiplexers and Demultiplexers: Multiplexer- Inside the Multiplexer- Implementing Boolean Functions with Multiplexers-Multiplexers for Parallel-to-Serial Data Conversion- Cascading Multiplexer Circuits- Encoders-Priority EncoderDemultiplexers and Decoders- Implementing Boolean Functions with Decoders-Cascading Decoder Circuits- Application- Relevant Information . **[Lectures: 12]**

Unit 2 Programmable Logic Devices Fixed Logic Versus Programmable Logic- Advantages and Disadvantages- Programmable Logic Devices – An Overview- Programmable ROMs-Programmable Logic Array- Programmable Array Logic- Generic Array Logic- Complex Programmable Logic Device- Field-Programmable Gate Array- Programmable ROMs-Programmable Logic Array- Programmable Array Logic- PAL Architecture- PAL Numbering System- Generic Array Logic- Complex Programmable Logic Devices- Internal Architecture-ApplicationsField-Programmable Gate Arrays- Internal Architecture- Applications-Programmable Interconnect Technologies- Fuse- Floating-Gate Transistor Switch- Static RAM Controlled Programmable SwitchesAntifuse- Design and Development of Programmable Logic HardwareFlip-Flops and Related Devices: Multivibrator- Bistable Multivibrator- Schmitt Trigger- Monostable Multivibrator- Astable MultivibratorIntegrated Circuit (IC) Multivibrators-Digital IC-Based Monostable Multivibrator- IC Timer-Based Multivibrators- R-S Flip-Flop- RS Flip-Flop with Active LOW Inputs- R-S Flip-Flop with Active HIGH Inputs- Clocked R-S Flip-Flop- Level-Triggered and Edge-Triggered Flip-Flops- J-K Flip-Flop- J-K FlipFlop with PRESET and CLEAR Inputs- Master–Slave Flip-Flops- Toggle Flip-Flop (T Flip-Flop)- J-K FlipFlop as a Toggle Flip-Flop- D Flip-Flop- J-K Flip-Flop as D Flip-Flop- D Latch-Synchronous and Asynchronous Inputs- Flip-Flop Timing Parameters- Set-Up and Hold Times-Propagation Delay- Clock Pulse HIGH and LOW Times- Asynchronous Input Active Pulse Width- Clock Transition Times- Maximum Clock Frequency- Flip-Flop Applications- Switch Debouncing- Flip-Flop Synchronization- Detecting the Sequence of Edges- Application-Relevant Data. **[Lectures: 12]**

Unit 3 Counters and Registers:

Ripple (Asynchronous) Counter- Propagation Delay in Ripple Counters- Synchronous Counter-Modulus of a Counter- Binary Ripple Counter – Operational Basics- Binary Ripple Counters with a Modulus of Less than 2N- Ripple Counters in IC Form- Synchronous (or Parallel) Counters- UP/DOWN Counters- Decade and BCD Counters- Presettable Counters- Variable Modulus with Presettable Counters- Decoding a CounterCascading Counters- Cascading Binary

Counters- Cascading BCD Counters- Designing Counters with Arbitrary Sequences- Excitation Table of a Flip-Flop- State Transition Diagram- Design Procedure- Shift Register- Serial-In Serial-Out Shift Register- Serial-In Parallel-Out Shift Register- Parallel-In Serial-Out Shift Register- Parallel-In Parallel-Out Shift Register- Bidirectional Shift Register- Universal Shift RegisterShift Register Counters- Ring Counter- Shift Counter- IEEE/ANSI Symbology for Registers and CountersCounters- Registers- Application-Relevant Information. **[Lectures: 12]**

Unit 4 Basics of 8085

The 8085 CPU- Functional description- pin description- 8085A timing processes- addressing modes 8085A Instruction Set-Data transfer group- Arithmetic group- Branch group- Logic group- Stack operations- I/O and- machine control instructions. Memory- interrupt and programming techniques Looping- Counting and Indexing- Counter and time delays- Stack and subroutines- Code conversion- BCD arithmetic- and 16-bit data operators. The 8085 interrupts- Restart as software instruction- Additional I/O concern and processor. Memory- Bussed architecture- and examples. **[Lectures: 12]**

Recommended Books:

1. Digital Electronics: Principles and Integrated Circuits by Anil K Maini- Wiley Precise Text Book
2. “0000 to 8085: Introduction to Microprocessor for Engineers and Scientists” by P R Shridhar & P. K. Ghosh. PHI

Reference Books:

1. “Microprocessor Architecture- Programming and Application with 8085” by R S Gaonker. Wiley Easter ltd.
2. Digital Design by M. Moris Mano 3rd edition PHI publication
3. Digital system principles and Applications by Ronald J. Tocci Neal S. Wildmer and Gregorg L. Moss 10th edition Pearson publication

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Became familiar with the digital signal, positive and negative logic, Boolean algebra, logic gates, logical variables, the truth table, number systems, codes, and their conversion from to otherT
CO2	To understand the Logic gates and Applications.
CO3	Use of Counters and Flip Flops.
CO4	Familiarity with microprocessors , Basics of 8085 etc.

Course Description

Title of Course: IC Fabrication Technology	Course Code: 12M14EC202

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: This course deals with various fabrication processes that go into the making of a single device in detail. To study various optical, electrical and structural characterization techniques are discussed in detail. It gives an overall insight into the process requirements for the device made, their integration and control at the micro / nano level.

Unit-1 Introduction of Semiconductor Process Technology (Line width – 10 nm technology), Semiconductor materials, single crystal, polycrystalline and amorphous, Crystal growth techniques: Si from the Czochralski technique, starting material, Distribution of dopants, Effective Segregation Coefficient. Silicon Float Zone Process, GaAs from Brigdman techniques. Wafer preparation. Epitaxy Deposition: Epitaxial growth by vapor phase epitaxy (VPE) and molecular beam epitaxy (MBE). Characterization: Various characterization methods for structural, electrical and optical properties. Basic idea of X-ray diffractometer, Scanning electron microscope, Transmission electron microscope and UV-VIS-NIR spectrophotometer. **(15 Lectures)**

Unit-2 Oxidation: Thermal Oxidation Process: Kinetics of Growth for thick and thin Oxide, Dry and Wet oxidation. Effects of high pressure and impurities, Impurity Redistribution during Oxidation, Masking property of Silicon Oxide, Oxide Quality, Chemical vapour deposition of silicon oxide, properties of silicon oxide, step coverage, P-glass flow. Diffusion: Basic Diffusion Process: Diffusion Equation, Diffusion Profiles. Extrinsic Diffusion Concentration Dependent Diffusivity, Lateral Diffusion, Doping through Ion Implantation and its comparison with diffusion. **(12 Lectures)**

Unit-3 Lithographic Processes: Clean room, Optical lithography, exposure tools, masks, Photoresist, Pattern Transfer, Resolution Enhancement Technique. Electron Beam Lithography, X-ray Lithography and Ion Beam Lithography. Comparison between various lithographic techniques. Etching: Wet Chemical Etching-basic process and few examples of etchants for 65 semiconductors, insulators and conductors; Dry etching using plasma etching technique.; Metallization: Uses of Physical Vapor Deposition and Chemical Vapor Deposition technique for Aluminum and Copper Metallization. **(12 Lectures)**

Unit-4 Process Integration: Passive components- Integrated Circuit Resistor, Integrated Circuit Inductor, Integrated Circuit Capacitor. Bipolar Technology: Basic fabrication process, Isolation techniques. MOSFET Technology: Basic fabrication process of NMOS, PMOS and CMOS technology. **(10 Lectures)**

References

1. Gary S.May and S.M.Sze , Fundamentals of Semiconductor Fabrication, John Wiley& Sons(2004)
2. Ludmila Eckertova, Physics of Thin films, 2nd Edition, Plenum Press (1986).

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Summarize the developments in the field of microelectronics technologies
CO2	Explain the semiconductor material characterization techniques like SEM, TEM, UVVis.
CO3	Describe the lithography, etching and various film deposition processes
CO4	Explain the process sequence for BJT, CMOS and BiCMOS fabrication Processes.

Title of Course: **HDL programming lab**	**Course Code:12M17CI271**

L-T Scheme: 0-0-2 **Course Credit: 1**

Objectives: Familiarize with the CAD tool to write HDL programs. Understand simulation and synthesis of digital design.

Laboratory Experiments

Programming:

1. Write Verilog program for the following combinational design along with test bench to verify the design:
a. 2 to 4 decoder realization using NAND gates only (structural model)
b. 8 to 3 encoder with priority and without priority (behavioural model)
c. 8 to 1 multiplexer using case statement and if statements
d. 4-bit binary to gray converter using 1-bit gray to binary converter 1-bit adder and subtractor

2. Model in Verilog for a full adder and addfunctionality to perform logical operations of XOR, XNOR, AND and OR gates. Write test bench with appropriate input patterns to verify the modeled behavior.

3. Verilog 32-bit ALU shown in figure below and verify the functionality of ALU by selecting appropriatetest patterns. The functionality of the ALU is presented in Table 1.
a. Write test bench to verify the functionality of the ALU considering all possible input patterns
b. The enable signal will set the output to required functions if enabled, if disabled all the outputs are set to tri-state
c. The acknowledge signal is set high after every operation is completed Result[32:0]
4. Write Verilog code for SR, D and JK and verify the flip flop.
5. Write Verilog code for 4-bit BCD synchronous counter.
6. Write Verilog code for counter with given input clock and check whether it works asclock divider performing division of clock by 2, 4, 8 and 16. Verify the functionality of the code.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Familiarize with the CAD tool to write HDL programs.
CO2	Understand simulation and synthesis of digital design
CO3	Program FPGAs/CPLDs to synthesize the digital designs
CO4	Interface hardware to programmable ICs through I/O ports
CO5	Choose either Verilog or VHDL for a given Abstraction level.

Title of Course: **Physics lab-1**	**Course Code: 12M17PH271**

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: Collect data and revise an experimental procedure iteratively and reflective. Evaluate the process and outcomes of an experiment quantitatively and qualitatively.

Experiments:
Students assigned the electronic laboratory work will perform at least 8 experiments of the following sections

1. To study Zener diodes as a voltage regulator.
2. To study the common emitter transistor using NPN transistors.
3. To design basic comparator and Zero crossing detector using 741 op-amp.
4. Application of op-amp as an integrator/differentiator amplifier.
5. To study negative feedback in op-amp (summing/difference).
6. To design a full adder and full subtractor and verify its truth table using logic gates.
7. To design a JK Flip flop and realize an up-down counter using it.
8. To design a 4-bit shift register using JK Flip flop.
9. To construct an astablemultivibrator using a transistor and to determine the frequency of oscillation.
10. To design an astable and monostablemultivibrator using a 555 timer.
11. To design a multiplexer/demultiplexer.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Understanding of different electronics experiments such as Zener diode etc
CO2	To learn the working of NPN transistor and Operational amplifiers
CO3	To learn about the working principles of Flip Flops
CO4	Different types of Multivibrators and multiplexer

Semester III

Title of Course: Condensed Matter Physics	Course Code: 12M11PH301

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: To study some of the basic properties of the condensed phase of matter especially solids.

Crystal Structure: Fundamental types of lattices-two and three dimensional lattice types, SC, BCC and FCC unit cells, Miller indices, Diffraction of x-rays by crystals, Scattered wave amplitude-Fourier analysis, Reciprocal lattice vectors, Diffraction conditions, Laue equations, Brillouin Interpretation, Structure factor and Atomic form factors. **(08 Lectures)**

Electrical Conductivity and Free Electron Fermi gas: Drude theory, DC conductivity, Hall effect and magneto-resistance, AC conductivity, thermal conductivity, Fermi-Dirac distribution, Free electron gas in three dimension, thermal properties of an electron gas, Wiedemann-Franz law. **(06 Lectures)**

Lattice Vibrations and Thermal Properties: Vibration of lattice with monoatomic and diatomic basis: Dispersion relation, optical and acoustical branches. Quantization of elastic waves: Phonon, Classical theory of Specific heat. Average energy of harmonic oscillator, Phonon Density of states. Einstein and Debye models of specific heat. Electronic contribution to specific heat. Anharmonic effect: thermal expansion, Phonon collision process, Thermal conductivity. **(06 Lectures)**

Concept of Energy Band: Nearly free electron model and origin of energy gap, magnitude of gap, Bloch function, Kronig-Penny model, Wave equation of electron in periodic potential, Bloch theorem and crystal momentum, Classification of metal, insulator and semiconductors. **(04 Lectures)**

Dielectrics: Dielectric properties of insulators, Types of polarizations, Local field, ClaussiusMossotti equation, Dielectric constant and loss. **(08 Lectures)**

Magnetism: Types of magnetism, Susceptibility, Permeability and their relation. Diamagnetism: Langevin Quantum theory of Diamagnetism. Paramagnetism: Quantum Theory, Paramagnetism of rare earth and iron group ions, Crystal field Splitting and quenching of orbital angular momentum. Paramagnetism of conduction electrons. Ferromagnetism, Ferrimagnetism and Antiferromagnetism: Curie point and exchange integral, saturation magnetization. Ferromagnetic Domains and their origin. **(08 Lectures)**

Superconductivity: Superconductivity, critical temperature, Meissner effect, Destruction of superconductivity by magnetic field, Type I and type II superconductors, Isotope effect, energy gap, London equation, London penetration depth, BCS theory of superconductivity, Coherence length. **(06 Lectures)**

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	differentiate between different Lattice types and explain the concepts of reciprocal lattice and crystal diffraction
CO2	predict electrical and thermal properties of solids and explain their origin
CO3	explain the concept of energy bands and effect of the same on electrical properties
CO4	describe the dielectric properties of insulators
CO5	explain various types of magnetic phenomenon, physics behind them, their properties and applications
CO6	explain superconductivity, its properties, important parameters related to possible applications.

Recommended Books

1. Kittel, C., Introduction to Solid State Physics, John Willey, (2007).
2. Omar, M.A., Elementary Solid State Physics, Pearson Education, (1999).
3. Srivastava, J.P., Elements of Solid State Physics, Prentice Hall of India, (2008).
4. Ashcroft, N.W. and Mermin, N.D., Solid State Physics, Cengage Learning, (2008).
5. Dekker, A.J., Solid State Physics, Macmillan, (2003).
6. Solid State Physics, S O . Pillai.

Title of Course: Non-linear optics and applications	Course Code: 12M11PH303

L-T Scheme: 3-1-0 **Course Credit: 4**

Course objectives: Nonlinear optics plays a pivotal role in developing modern communication systems. The present course aims to provide a fundamental understanding of nonlinear optics and its possible applications in fiber optics.

Fundamental Concepts: Review of electromagnetic field theory, in particular electromagnetic waves in vacuum and linear media, energy of electromagnetic waves. Origin of refractive index through simple classical Lorentz Oscillator model, normal and anomalous dispersion. Propagation of light in anisotropic media, electro-optic, acousto-optic and magneto-optic effects.

Elementary Nonlinear Optics: Lorentz model and its in the nonlinear domain, description of nonlinear optical interactions, nonlinear susceptibility. Second harmonic generation, sum and difference frequency generation, properties of nonlinear susceptibility, Self-focussing phenomenon etc.

Fiber Optics: Geometrical optics description of light propagation through a fiber, numerical aperture its physical significance. Propagation of electromagnetic waves in medium with variable refractive index. Explicit analytical treatment of parallel plate wave guide, TEM, TE and TM modes of a fiber. Material dispersion and attenuation of pulses, pulse broadening. Single and multimode fibers, fiber bandwidth and dispersion management, Erbium-doped fiber amplifier. Isolators, connectors and splices. Characterization techniques including Optical time-domain reflectometer (OTDR).

Contemporary Developments: Optical solitons in nonlinear optical fibers, cross-phase modulation (XPM) self-phase modulation (SPM), group velocity dispersion (GVD), four wave mixing (FWM) etc. A brief introduction to materials with negative index of refraction.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Understanding of Electromagnetic field theory and propagation of light
CO2	Learning of Lorentz model and Second harmonic generation
CO3	To understand the Optical fiber optics and propagation
CO4	Underatnding the application of Optical solitons in nonlinear optical fibers, cross-phase modulation (XPM) self-phase modulation (SPM)

Text & Reference Material:

1. An Introduction To Fiber Optics, A.K. Ghatak, K. Thyagarajan, Cambridge University Press 1998
2. Nonlinear Optics, R.W. Boyd, Academic Press
3. Optical Fiber Communications: Principles and Practice, J.M. Senior, Prentice Hall Publication
4. Optical Fiber Communication, G. Keiser, McGraw Hill Publications
5. Fundamentals of Photonics, B.E.A. Saleh and M.C. Teich, John Wiley \& Sons Inc.
6. Nonlinear Fiber Optics, G. P. Agrawal, Academic Press

Title of Course: Plasma Physics	Course Code: 17M11PH303

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: This course provides an introduction to plasma physics and is aimed at studying how ionized particles interact among themselves and with electromagnetic fields. Electromagnetic fields and charged particles obey Maxwell equations and the Lorentz equation of motion. The primary objective is to study these equations and to learn the interaction of electromagnetic fields and charged particles, leading to various electrodynamics phenomena.

Unit I

Occurrence of Plasma in Nature: Criteria for plasma behavior, Plasma oscillation, Quasi-neutrality and Debye Shielding, Plasma parameters, Natural occurrence of plasma, Astrophysical plasmas, Plasma in Magnetosphere and Ionosphere, Brief discussion of Plasma production and diagnostics.

(Lectures: 6)

Unit II

Thermal ionization, Saha equation, Electrostatic and magnetic probes, Single particle motion in uniform and non uniform electric (E) and magnetic (B) fields, Time varying E and B field, Adiabatic invariants, Fluid equation of motion. Fluid drifts parallel and perpendicular to B. Plasma Oscillations, Electron Plasma waves, Ion Waves, Validity of Plasma approximation.

(Lectures: 10)

Unit III

Electrostatic electron and ion perpendicular to B, Electromagnetic waves with B_0=0. Propagation Vector (K) perpendicular and parallel to B_0. Alfven waves, Diffusion in weakly and fully ionized plasma, Collision and diffusion parameters, Decay of Plasma by Diffusion. Ambipolar diffusion, Diffusion across magnetic field, Collision in fully ionized plasma, Plasma resistivity, Solution of diffusion equation.

(Lectures: 12)

Unit IV

Derivation of the Fluid Equations, Landau damping, Ion acoustic shock waves, The pondermotive Force, Parametric Instabilities-Frequency matching, Instability threshold, Oscillating two stream instability, Plasma Echoes, Equilibrium and Stability, Hydro-magnetic equilibrium, , Classification instabilities, Two stream instability, Gravitational Instability, Weibel instability, Resistive drift waves.

(Lectures: 12)

Unit V

Concept of magnetic pressure, Equilibrium of cylindrical pinch, Benner pinch, Diffusion of magnetic field into plasma The Problem of controlled Fusion, Magnetic confinement-Torous, Mirrors, Pinches, Plasma Heating and Laser induced Fusion.

(Lectures: 8)

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Introduction of plasma and its occurrence in nature, To understand plasma as the state of an ionized gas and relevant parameters
CO2	Understanding the interaction of charged particles with magnetic fields through the Lorentz force, acknowledging the force of interaction as a long-range force typically many times stronger than gravity
CO3	To understand the diffusion and collisions in plasma, solving diffusion equation and studying the decay mechanism of plasma though diffusion
CO4	To derive fluid equations and solving those to understand key instabilities, damping mechanisms and Pondermotive force
CO5	To understand the technology of plasma generation, confinement and studying its application in heating and laser induced fusion

Suggested Readings:

1. F.F.Chen , Introduction to Plasma Physics and Controlled Fusion-Volume-I
2. D.R. Nicholson, Introduction to Plasma Theory
3. David J. Griffiths: *Introduction to Electrodynamics*, Pearson Education, 2003

Title of Course: Laser and its applications	Course Code: 12M14PH302

L-T Scheme: 3-0-0 **Course Credit: 3**

Objectives: The basic aim of this Course is to make students appreciate the fundamentals of lasers and their diversified applications. The approach will stress more on the concepts & fundamentals with very simple or sometimes no mathematical equations. The outcome of this Course will make the students/trainees more excited to more about lasers and their applications in specific fields of their interest.

Unit I

Characteristic of laser light, Directionality, Intensity, Mono-chromaticity as key features of Laser, Concept of Coherence, Spatial and Temporal coherence, Spontaneous and stimulated emission, Population inversion, Einstein coefficients and possibility of amplification

(Lectures: 6)

Unit II

Momentum transfer & life time of a level absorption, Kinetics of optical pumping, Laser amplification, Oscillation condition, Line broadening mechanism, Spectral narrowing in a laser, Gain clamping. Spatial and spectral hole burning and their consequences, Power in Laser Oscillator, Optimum coupling.

(Lectures: 10)

Unit III

Theory of optical resonators, Concept of cavity models, Stability criterion, Gaussian beams and their propagation. Quality factor, Geometry of resonators, Resonant frequency of resonators, unstable resonators, Time dependence of laser emission, Rate equations for three and four level systems, Normal mode oscillations, Q-switching and mode locking techniques of laser pulse generation.

(Lectures: 10)

Unit IV

Some specific laser systems:Ion lasers (Ar), Atomic and molecular gas lasers (He-Ne, CO_2), Solid State lasers (Ruby, Nd:YAG & Nd:Glass), Dye lasers (one example).

(Lectures: 4)

Unit V

Basic Difference in Linear and Nonlinear optics, Wave propagation in nonlinear media, Phase matching and second harmonic generation, Optical parametric oscillator. Third order effects-optical Kerr effect, Self focusing, Elements of Optical communication.

(Lectures: 6)

Course Outcome	Description
CO1	Introduction of basic features of laser and fundamental properties
CO2	Understanding the basic idea of light amplification and line broadening and oscillations
CO3	To understand the theory of resonators, geometry of resonators, and cavity modes and pulsed oscillations
CO4	Introduction of basic construction and working of various laser systems

CO5	To understand the non linear optics and relevant fundamentals, Introduction of optical communication

Suggested Readings

1. Lasers: P.W. Miloni & J.H. Eberly
2. Principles of Lasers: Svelto
3. Introduction to Quantum Electronics: A. Yariv
4. Non linear Optics: Baldwin
5. Lasers: Theory and Applications by Ghatak & Thyagrajan.
6. Laser Principles, Types & Applications: K R Nambiar, New Age International, 2004.

Title of Course: Sensors and transducers	Course Code: 12M14PH301

L-T Scheme: 3-0-0 **Course Credit: 3**

Objectives: To make students familiar with the constructions and working principle of different types of sensors and transducers. To make students aware about the measuring instruments and the methods of measurement and the use of different transducers.

Unit I: Sensor Transducers fundamentals and performance characteristics
Introduction: Units and standards of measurement, functional elements of measurement system, static and dynamic characteristics or performance characteristics of transducer, Measurement and calibration systems - Requirements, Transducer terminology, Transducer classification, Performance Characteristics, Criteria for transducer selection. **(Lectures: 12)**

Unit II: Principles of Sensors and Transducers
Displacement Transducers - Working principle of Resistance type, Capacitance type, Digital and Pneumatic (Flapper-Nozzle) type displacement transducers Level Transducers - Working principle of Float, Displacer, Bubbler, Diaphragm box, DP cell, Ultrasonic, Capacitive, Radioactive, Resistance, Thermal, optical level sensors, solid level detectors Pressure Transducers - Primary pressure sensors, Electrical / Secondary Pressure Transducers, Manometers, High Pressure Measurement and Differential Pressure Measurement, Low pressure (Vacuum) transducers Flow Transducers - Working principle of Head Type, Variable Area Type, Electromagnetic flow sensor, Open channel flow measurement Temperature Transducers - Working principle of Thermometers, Resistance temperature detector (RTD), Thermistors, Thermocouples, and Pyrometers Optical sensors - Working principle of PMT, Photodiodes, CCD, LDR Electro-chemical Sensors - pH measurement, Conductivity measurement, ORP (Oxidation Reduction Potential) Measurement, Humidity measurement, Intelligent Sensors. **(Lectures: 12)**

Unit III: Signal conditioning
Need for signal conditioning, Current and Voltage standards. Signal conditioning for Resistive sensors - RTD, Thermister, load cell, potentiometric sensors Signal conditioning for capacitive sensors - Level sensor, displacement sensor, proximity detector, humidity sensor, differential pressure cell ,Signal conditioning for inductive sensors - Displacement transducer (LVDT/RVDT) proximity detector, inductive pick-up. **(Lectures: 12)**

Unit IV: Signal conditioning case studies
Signal conditioning for - Optical devices like Photo diode, LDR, PIN diode, photo transistor, photo cell, optical proximity switch Signal conditioning schemes for - RTD with Three wire compensation and Thermocouple with cold junction compensation Signal conditioning schemes for - Ultrasonic detector for displacement, level (single and multiple liquid), pH and conductivity measurement, Hall sensor, Electromagnetic flow meter, etc. **(Lectures: 12)**

Reference Books:

1. E. O. Doebelin - Measurement System Application and Design
2. D. Patranabis - Principles of Industrial Instrumentation
3. R. K. Jain - Mechanical and Industrial Measurement
4. C. D. Johnson - Process Control Instrumentation Technology
5. Sawhney A. K - A Course in Electrical and Electronics Measurements and Instrumentation
6. D. V. S. Murthy - Transducers and Instrumentation
7. B. G. Liptak - Process Measurement and Analysis 8. B. E. Noltingk - Jone's Instrument Technology (Vol. 1 and Vol. 2)

Title of Course: Solid state lab	Course Code: 12M17PH371

L-T Scheme: 0-0-2 **Course Credit: 1**

Objectives: To Collect data and revise an experimental procedure iteratively and reflectively. Evaluate the process and outcomes of an experiment quantitatively and qualitatively.

1. To verify the existence of different harmonics and measure their relative amplitudes in a complex wave using CRO (square, clipped sine wave, triangular wave, etc.)
2. Determination of Energy Band Gap of Silicon, Germanium, etc. using light-emitting diodes (LED's).
3. Demonstration of energy quantization using the Franck-Hertz Experiment.
4. To determine wavelength, spot size, a divergence of LASER, Power distribution within the beam, Grating element of the grating.
5. To determine the wavelength of laser light using Michelson interferometer experiment.
6. To study the Magnetostriction effect in a metallic rod.
7. To determine the charge to mass ratio of an electron by using Magnetron.
8. To determine the Dielectric constant of dielectric material by varying frequency.
9. To find out the g-value using Electron spin resonance (ESR).

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	To understand the working principle of solid state electronic instruiments
CO2	To learn the measurements of Band gap, Use of CRO etc
CO3	Energy quantization verification by Frank Hertz Expt
CO4	Magnetostriction and magnetic properties
CO5	To stuidy dielectric properties and its variation with frequency

Semester IV

Title of Course: Solid State Electronics	**Course Code: 17M11PH401**

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: To have fundamental knowledge about structure of devices, VI characteristics of devices like PN Junction diode, Zener diode, MOSFET, BJT and Opto electronic devices.

UNIT I CRYSTAL PROPERTIES AND GROWTH OF SEMICONDUCTORS
Semiconductor materials- Periodic Structures- Crystal Lattices- Cubic lattices – Planes and Directions-The Diamond lattice- Bulk Crystal Growth-Starting Materials-Growth of Single Crystal lngots-Wafers-Doping- Epitaxial Growth –Lattice Matching in Epitaxial Growth –Vapor –Phase Epitaxy-Atoms and Electrons-Introduction to Physical Models-Experimental Observations-The Photoelectric Effect-Atomic spectra-The Bohr model- Quantum Mechanics – Probability and the Uncertainty Principle-The Schrodinger Wave Equation –Potential Well Equation –Potential well Problem-Tunneling. **[Lectures:08]**

UNIT II ENERGY BANDS AND CHARGE CARRIERS IN SEMICONDUCTORS
Bonding Forces and Energy bands in Solids-Bonding Forces in Solids-Energy Bands-Metals, Semiconductors, and Insulators – Direct and Indirect Semiconductors –Variation of Energy Bands with Alloy Composition-Charge Carriers in Semiconductors-Electrons and Holes-Effective Mass-Intrinsic Material-Extrinsic Material – Electrons and Holes in Quantum Wells-Carrier Concentrations-The Fermi Level-Electron and Hole Concentrations at Equilibrium-Temperature Dependence of Carrier Concentrations-Compensation and Space Charge Neutrality-Drift of Carrier in Electric and Magnetic Fields conductivity and Mobility-Drift and Resistance –Effects of Temperature and Doping on Mobility-High –Field effects-The Hall Effect -invariance of the Fermi level at equilibrium -Excess Carrier in Semiconductors-Optical Absorption-Luminescence-Photoluminescence-Electro luminescence-Carrier Lifetime and Photoconductivity –Direct Recombination of Electrons and Holes – Indirect Recombination ; Trapping –Steady State Carrier Generation ; Quasi-Fermi Levels-Photoconductive Devices-Diffusion of Carriers-Diffusion of Processes-Diffusion and Drift of Carrier; Built-in Fields-Diffusion and Recombination; The Continuity Equation –Steady state Carrier Injection; Diffusion Length-The Haynes- Shockley Experiment –Gradients in the Quasi-Fermi levels. **[Lectures:12]**

UNIT III: JUNCTIONS

Fabrication of P-N Junctions-Thermal Oxidation-Diffusion –Rapid Thermal Processing-Ion Implantation-Chemical Vapor Deposition Photolithography-Etching –Metallization-Equilibrium Conditions-The Contact Potential-Equilibrium Fermi Levels –Space Charge at a Junction-Forward –and Reverse –Biased Junctions; -Steady state conditions-Qualitative Description Of current flow at a junction-Carrier Injection-Reverse Bias-Reverse –Bias Breakdown-Zener Breakdown –Avalanche Breakdown-Rectifiers-The Breakdown Diode-Transient and AC Conditions –Time variation of stored charge-Reverse Recovery Transient –Switching Diodes –Capacitance of P-N Junctions-The Varactor Diode-Deviations from the Simple Theory-Effects of contact Potential on carrier injection-Recombination and Generation in the Transition Region-

Ohmic Losses –Graded Junctions-Metal –Semiconductor Junctions-Schottky Barriers-Rectifying contacts-Ohmic Contacts-Typical Schottky Barriers-Hetrojunction. **[Lectures:12]**

UNIT IV THE METAL –SEMICONDUCTOR-FET

The GaAS MESFET-The High Electron Mobility Transistor –Short channel Effects-The Metal Insulator Semiconductor FET-Basic Operation and Fabrication –THE ideal MOS Capacitor-Effects of Real Surfaces-Threshold Voltage –MOS capacitance Measurements- current –Voltage Characteristics of MOS Gate Oxides -The MOS Field –Effect Transistor –Output characteristics-Transfer characteristics- Mobility Models-Short channel MOSFET I-V characteristics –Control of Threshold Voltage –Substrate Bias Effects-Sub threshold characteristics –Equivalent Circuit for the MOSFET-MOSFET Scaling and Hot Electron Effects-Drain –Induced Barrier Lowering –short channel and Narrow Width Effect-Gate –Induced Drain Leakage-BJT Fabrication –Minority carrier distribution and Terminal currents-Solution of the Diffusion Equation in the Base Region-Evaluation of the Terminal currents –Current Transfer Ratio-Generalized Biasing –The coupled –Diode Model-Charge control analysis-Switching –cut off –saturation-The switching cycle-Specifications for switching Transistors-other Important Effects-Drift in the base Narrowing –Avalanche Breakdown –Injection level; Thermal Effects-Base Resistance and Emitter Crowding – Gummel –Poon Model-Kirk Effect-Frequency Limitations of Transistors-Capacitance and Charging Times-Transit Time Effects-Webster Effect-High –Frequency Transistors - Heterojunction Bipolar Transistors. **[Lectures:12]**

UNIT V OPTOELCTRONIC DEVICES

Photodiodes-Current and Voltage in illuminated Junction-Solar Cells-Photo detectors-Noise and Bandwidth of Photo detectors-Light-Emitting Diodes-Light Emitting Materials-Fiber Optic Communications Multilayer Heterojunctions for LEDs- Lasers-Semiconductor lasers-Population Inversion at a Junction Emission Spectra for p-n junction-The Basic Semiconductor lasers-Materials for Semiconductor lasers-Integrated Circuits –Background –Advantages of Integration –Types of Integrated circuits-Monolithic and Hybrid Circuits-Evolution of Integrated Circuits-Monolithic Device Elements CMOS Process Integration –Silicon –on – Insulator (SOI)-Integration of other Circuit Elements –Charge Transfer Devices –Dynamic Effects in MOS capacitors –The basic CCD-Improvements on the Basic Structure –Applications of CCDs-Ultra Large –Scale Integration (ULSI) –Logic devices –Semiconductor Memories-Testing. **[Lectures:08]**

TEXT/REFERENCE BOOKS

1. Ben.G.Streetman & Sanjan Banerjee Solid State Electronic Devices (5th Edition) PHI Private Ltd, 2003

1. Yannis Tsividis: Operation & Mode line of The MOS Transistor (2nd Edition) Oxford University Press, 1999

2. Nandita Das Gupta &Aamitava Das Gupta- Semiconductor Devices Modeling a Technology, PHI, 2004.

Learning Outcomes/Course Outcome

Course Outcome	**Description**
CO1	Develop the ability to understand the concepts of crystal structures foe semiconductor materials
CO2	Understand the charge carriers, band theory of solids to understand the band gap..
CO3	Fabrication and understanding Junction diodes, transistor and heterojuctions.
CO4	To understand the FET, MOSFET and their a[applications.
CO5	Understanding of CMOs Technology and different optoelectronic devices.

Title of Course: Communication systems	Course Code: 12M11EC402

L-T Scheme: 3-1-0 **Course Credit: 4**

Objectives: To understand the basics of signal-space analysis and digital transmission l To understand the coherent and non coherent receivers and its impact on different channel characteristics l To understand the different equalizers l To understand the different block coded and convolutional coded digital communication systems l To understand the basics of multicarrier and multiuser communications

UNIT I COHERENT AND NON-COHERENT COMMUNICATION

Coherent receivers – Optimum receivers in AWGN – IQ modulation & demodulation – Non coherent receivers in random phase channels; MFSK receivers – Rayleigh and Rician channels – Partially coherent receivers – DPSK; M-PSK; M-DPSK - BER Performance Analysis, Carrier Synchronization- Bit synchronization. **[Lectures:12]**

UNIT II EQUALIZATION TECHNIQUES

Band Limited Channels- ISI – Nyquist Criterion- Controlled ISI-Partial Response signals- Equalization algorithms – Viterbi Algorithm – Linear equalizer – Decision feedback equalization – Adaptive Equalization algorithms. **[Lectures:08]**

UNIT III BLOCK CODED DIGITAL COMMUNICATION

Architecture and performance – Binary block codes; Orthogonal; Bi orthogonal; Transorthogonal – Shannon's channel coding theorem; Channel capacity; Matched filter; Concepts of Spread spectrum communication – Coded BPSK and DPSK demodulators– Linear block codes; Hamming; Golay; Cyclic; BCH ; Reed – Solomon codes –Space time block codes.

[Lectures:10]

UNIT IV CONVOLUTIONAL CODED DIGITAL COMMUNICATION

Representation of codes using Polynomial, State diagram, Tree diagram, and Trellis diagram – Decoding techniques using Maximum likelihood, Viterbi algorithm, Sequential and Threshold methods– Error probability performance for BPSK and Viterbi algorithm, Turbo Coding and LDPC codes. **[Lectures:10]**

UNIT V MULTICARRIER AND MULTIUSER COMMUNICATIONS

Single Vs multicarrier modulation, Orthogonal Frequency Division Multiplexing (OFDM), Modulation and demodulation in an OFDM system, FFT algorithmic implementation of an OFDM system, Bit and power allocation in multicarrier modulation, Peak-to-average ratio in multicarrier modulation. Introduction to CDMA systems, multiuser detection in CDMA systems – optimum multiuser receiver, sub optimum detectors, successive interference cancellation.

[Lectures:10]

REFERENCES:

1. Bernard Sklar, "Digital Communications", second edition, Pearson Education, 2001.
2. John G. Proakis, "Digital Communication", Fifth Edition, McGraw Hill Publication, 2008.

3. M.K.Simon, S.M.Hinedi and W.C.Lindsey, “Digital communication techniques; Signal Design and Detection”, Prentice Hall of India, New Delhi, 1995.
4. Richard Van Nee & Ramjee Prasad, “OFDM for Multimedia Communications”, Artech House Publication, 2001.
5. Stephen G. Wilson, “Digital Modulation and Coding”, First Indian Reprint, Pearson Education, 2003.
6. Simon Haykin, “Digital communications”, John Wiley and sons, 1998.
7. Theodore S.Rappaport, “Wireless Communications”, 2nd edition, Pearson Education, 2002.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Develop the ability to understand the concepts of signal space analysis for coherent and non- coherent receivers
CO2	Conceptually appreciate different equalization techniques.
CO3	Possess knowledge on different block codes and convolutional codes
CO4	Comprehend the generation of OFDM signals
CO5	Describe the techniques of multiuser detection.

Title of Course: Nanomaterials	Course Code: 17M11PH403

L-T Scheme: 3-0-0 **Course Credit: 3**

Objectives: Understand (i) the influence of dimensionality of the object at nanoscale on their properties; (ii) size and shape controlled synthesis of nanomaterials and their future applications in industry.

Introduction to Nanomaterials: Features of nanosystems, Characteristic length scales of materials and their properties, Density of states in 1-D, 2-D and 3-D bands, Variation of density of states and band gap with size of crystal.

Quantum Size Effect: Electron confinement in infinitely deep square well, Confinement in one dimensional well, Idea of quantum well structure, Formation of quantum well, Quantum dots and quantum wires.

Synthesis Methods: Top-down and bottom-up approach, cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques, mechanical milling, chemical methods and self-assembly.

Properties of Nanomaterials: Size and shape dependence of optical, electronic, photonic, mechanical, magnetic and catalytic properties.

Nanomaterials and their applications: Nanoparticles, Nanocoatings and Nanocomposites, Nanotubes, Fullerenes, Thin film chemical sensors, gas sensors, biosensors, Carbon fullerenes and Carbon nanotubes, Thin film chemical sensors, biosensors, Solar cells, Drug deliveries and optoelectronic devices. Course learning outcomes: Students will have achieved.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Understanding of the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale.
CO2	choose appropriate synthesis technique to synthesize quantum nanostructures of desired size, shape and surface properties
CO3	correlate properties of nanostructures with their size, shape and surface characteristics.
CO4	appreciate enhanced sensitivity of nanomaterial based sensors and their novel applications in industry.

Text Books/Reference Books:

1. NANOSTRUCTURES AND NANOMATERIALS: Synthesis, Properties, and Applications by GuozhongCao, Imperial College Press.
2. Nanomaterials and Nanocomposites, R . K. Goyal, Taylor and Francis.
3. Nanoscale materials in chemistry, 2 ndedition, by Kenneth J. Klabundeand Ryan M. Richards, John Wiley & Sons.

Title of Course: Physics of Thin film Technology	Course Code: 12M14PH404

L-T Scheme: 3-0-0 **Course Credit: 3**

Objectives: The course specific goals are to (i) acquire knowledge in processing of different thin film structures); (ii) develop and engineer thin film materials, and contribute in advancement of thin film technologies that are applicable in industry, research, and science; (iii) to develop students' ingenuity in experiment design and material processing as well as development of novel technologies.

Unit I

Preparation of Thin Films: Study of thin film vacuum coating unit, Construction and uses of vapor sources wire, Sublimation Furnaces and Crucible sources. Physical Vapor Deposition: Hertz Knudsen equation, Mass evaporation rate, Knudsen cell, Evaporation of elements, Compounds, Alloys, Raoult's law, Electron beam, Pulsed laser, Ion beam evaporation, Glow Discharge and plasma.

Unit II

Sputtering: Sputtering mechanisms and yield, DC and RF sputtering, Magnetron sputtering, Bias sputtering, Reactive sputtering, Evaporation versus Sputtering, Hybrid and modified PVD processes- Ion plating, Reactive Evaporation, Ion beam assisted deposition.

Unit III

Chemical Vapor Deposition: Thermodynamics of CVD, Gas transport, Film growth kinetics, Thermal CVD, LPCVD, MOCVD, laser and Plasma-enhanced CVD processes. Chemical Methods: Qualitative study of preparation of thin films by electroplating, Anodization, Spray pyrolysis, Electro-deposition, Sol-Gel and LB techniques.

Unit IV

Nucleation and Growth: Homo, heterogeneous nucleation, Capillarity theory, Nucleation rate, Atomistic and kinetic models of nucleation, Basic modes of thin film growth, Amorphous thin films. Epitaxy: Homo, Hetero epitaxy, Lattice misfit and imperfections in epitaxial films, Epitaxy of compound semiconductors, Methods for depositing Epitaxial semiconductor thin films.

Unit V

Deposition Monitoring and Control: Microbalance, Crystal oscillator thickness monitor, Thickness measurement: Fringes of equal thickness (FET) method-Multiple beam interferometer, Fringes of equal chromatic order (FECO) method-Ellipsometry. Scope of Devices and Applications: Thin film resistors, Thin film capacitors, Thin film field effect transistors, Thin film solar cells, Antireflection coatings.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	To understand the synthesis of thin films by Physical and chemical

	deposition techniques.
CO2	Basic understanding of sputtering process , and to learn about the CVD techniques.
CO3	Different CVD techniques of thin film growth
CO4	Nucleation and Growth process to create thin films of semiconductor materials and their applications
CO5	To measure the thickness of thin films during the deposition processes and their applications in devices

Books Suggested:

1. Milton Ohring: The *Materials Science of Thin Films,* Academic Press, California 1992.
2. K. L Chopra: *Thin Film Phenomena,* Krigger publishing company, Huntington, New York 1979.
3. L.I. Maissel and R. Glange: *Hand Book of Thin Film Technology*, Mc-Graw Hill, New York, 1970.
4. Donald Smith: *Thin-Film Deposition: Principles and Practice*, Mc-Graw Hill**,** 1st Ed., 1995

Title of Course: Antenna and Wave Propagation	Course Code: 12M14EC402

L-T Scheme: 3-0-0 **Course Credit: 3**

OBJECTIVES Understand basic terminology and concepts of Antennas. To attain knowledge on the basic parameters those are considered in the antenna design process and the analysis while designing that. Analyze the electric and magnetic field emission from various basic antennas and mathematical Formulation of the analysis. To have knowledge on antenna operation and types as well as their usage in real time filed. Aware of the wave spectrum and respective band based antenna usage and also to know the propagation of the waves at different frequencies through different layers in the existing layered free space environment structure.

UNIT -I: Antenna Basics: Introduction, Basic Antenna Parameters – Patterns, Beam Area, Radiation Intensity, Beam Efficiency, Directivity-Gain-Resolution, Antenna Apertures, Illustrative Problems. Fields from Oscillating Dipole, Field Zones, Front - to-back Ratio, Antenna Theorems, Radiation, Retarded Potentials – Helmholtz Theorem. Thin Linear Wire Antennas – Radiation from Small Electric Dipole, Quarter Wave Monopole and Half Wave Dipole – Current Distributions, Field Components, Radiated Power, Radiation Resistance, Beam Width, Directivity, Effective Area, Effective Height, Natural Current Distributions, Far Fields and Patterns of Thin Linear Centre-fed Antennas of Different Lengths, Illustrative Problems. **[Lectures :10]**

UNIT –II: VHF, UHF and Microwave Antennas - I : Arrays with Parasitic Elements, Yagi-Uda Array, Folded Dipoles and their Characteristics, Helical Antennas – Helical Geometry, Helix Modes, Practical Design Considerations for Monofilar Helical Antenna in Axial and Normal Modes, Horn Antennas – Types, Optimum Horns, Design Considerations of Pyramidal Horns, Illustrative Problems. VHF, UHF and Microwave Antennas - II: Microstrip Antennas – Introduction, Features, Advantages and Limitations, Rectangular Patch Antennas – Geometry and Parameters, Characteristics of Microstrip Antennas. Impact of Different Parameters on Characteristics, Reflector Antennas – Introduction, Flar Sheet and Corner Reflectors, Paraboloidal Reflectors – Geometry, Pattern Characteristics, Feed Methods, Reflector Types – Related Features, Illustrative Problems. Lens Antennas – Introduction, Geometry of Non-metallic Dielectric Lenses, Zoning, Applications. **[Lectures :10]**

UNIT -III: Antenna Arrays: Point Sources – Definition, Patterns, arrays of 2 Isotropic Sources - Different Cases, Principle of Pattern Multiplication, Uniform Linear Arrays – Broadside Arrays, Endfire Arrays, EFA with Increased Directivity, Derivation of their Characteristics and Comparison, BSAs with Non-uniform Amplitude Distributions – General Considerations and Binomial Arrays, Illustrative Problems. Antenna Measurements: Introduction, Concepts - Reciprocity, Near and Far Fields, Coordinate System Patterns to be Measured, Pattern Measurement Arrangement, Directivity Measurement, Gain Measurements (by Comparison, Absolute and 3- Antenna Methods) **[Lectures :10]**

UNIT -IV: Wave Propagation – I: Introduction, Definitions, Categorizations and General Classifications, Different Modes of Wave Propagation, Ray/Mode Concepts, Ground Wave Propagation (Qualitative Treatment) – Introduction, Plane Earth Reflections, Space and Surface Waves, Wave Tilt, Curved Earth Reflections. Space Wave Propagation – Introduction, Field Strength Variation with Distance and Height, Effect of Earth's Curvature, Absorption, Super Refraction, M-Curves and Duct Propagation, Scattering Phenomena, Tropospheric Propagation. **[Lectures :10]**

UNIT -V: Wave Propagation – II: Sky Wave Propagation – Introduction, Structure of Ionosphere, Refraction and Reflection of Sky Waves by Ionosphere, Ray Path, Critical Frequency, MUF, LUF, OF, Virtual Height and Skip Distance, Relation between MUF and Skip Distance, Multihop Propagation. **[Lectures :08]**

TEXT BOOKS: 1. Antennas and Wave Propagation – J.D. Kraus, R.J. Marhefka and Ahmad S. Khan, TMH, New Delhi, 4th ed., (Special Indian Edition), 2010.
2. Electromagnetic Waves and Radiating Systems – E.C. Jordan and K.G. Balmain, PHI, 2nd ed., 2000.

REFERENCE BOOKS: 1. Antenna Theory - C.A. Balanis, John Wiley & Sons, 3rd Ed., 2005.
2. Antennas and Wave Propagation – K.D. Prasad, Satya Prakashan, Tech India Publications, New Delhi, 2001.
3. Transmission and Propagation – E.V.D. Glazier and H.R.L. Lamont, The Services Text Book of Radio, vol. 5, Standard Publishers Distributors, Delhi.
4. Antennas – John D. Kraus, McGraw-Hill (International Edition), 2nd Ed. 1988.
5. Electronic and Radio Engineering – F.E. Terman, McGraw-Hill, 4th edition, 1955.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Student will be able to Aware of antenna parameter considerations Capable to analyze the designed antenna and field evaluation under various conditions and formulate the electric as well as magnetic fields equation set for far field and near field conditions
CO2	Understand the array system of different antennas and field analysis under application of different currents to the individual antenna elements
CO3	Understand the design issues, operation of fundamental antennas and their operation methodology in practice.
CO4	Design a lens structure and also the bench set up for antenna parameter measurement of testing for their effectiveness
CO5	Knowledge about the means of propagation of electromagnetic waves

Course Description

Title of Course: Solar photovoltaic, principles and applications	**Course Code:** 12M14PH402

L-T Scheme: 3-0-0 **Course Credit: 3**

Objectives: To understand the solar power generation, working principles and power generation from PV panels. To understand different applications of photovoltaic devices.

Unit I

Basics of solar cell; Intrinsic, extrinsic and compound semiconductor; Energy levels; Electrical conductivity; Determination of Fermi energy level; Probability of occupation of allowed states; Dynamics of energy density of allowed states; Density of electrons and holes. Carrier transport: Drift, diffusion, continuity equations; Absorption of light; Recombination process; Basic equations of semiconductor devices physics.

Unit II

Solar Cell Physics: pn junction: homo and hetro junctions, Metal semiconductor interface; Dark and illumination characteristics; Figure of merits of solar cell; Variation of efficiency with band-gap and temperature; Spectral response of solar cell, parasitic resistance effect, Working and Efficiency limits: Thermodynamic limit and detailed balance limit of solar cell.

Unit III

Silicon; Physical and chemical properties relevant to photovoltaic. Preparation of metallurgical; Refining, Casting and crushing. Preparation of semiconductor grade silicon (Polysilicon); Siemens process, Union Carbide Process. Solar grade Silicon; Crystallization, Simplification and Polysilicon method. Growth of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method, Multicrystalline Silicon; Ingot fabrication, Doping, Crystal defect, Impurities. Wafering; Multiwire and microscopic process, Saw damage, Description and manufacturing technology.

Unit IV

Solar PV Cell and modules: Cell structure, Front and back surface, optical properties of solar cell, Different losses and mitigation, Anti reflective coating; properties and materials, Surface passivation with back surface, Passivation with Hydrogen, Optical confinement. The layers of PV modules, Cell matrix, Lamination and curing, Encapsulation and framing, Testing, Electrical and thermal properties, Module mismatching, Shading and hot-spot formation, Environmental effect on PV module performance.

Unit V

High efficiency III-V, II-VI multi-junction solar cell; Photo conversion efficiency, Theoretical limits, spectral splitting, Cell configuration; Four-terminal, three terminal voltage-matched interconnections, two terminal series-connected. Current and voltage characteristics, efficiency and band gap. Deposition of GaAs, GaInP, Ge cells. Amorphous Silicon-based solar cell; fabrication techniques and material properties. StaeblerWronski effect. Module manufacturing;

Using different substrate, safety and cost. Dye-sensitized solar cells; Introduction, fabrication and development.

References:

1. Silicon solar cells: advanced principles and practice. Sydney, M. Green, Bridge Printery, 1995.
2. Third Generation Photovoltaics. Berlin, Germany, M. Green, Springer-Verlag, 2003.
3. Crystalline silicon solar cells: advanced surface passivation and analysis, Aberle A. G., Sydney, Centre for Photovoltaic Engineering, UNSW, 1999.
4. The physics of solar cells, J. Nelson, Imperial college press, 2006.
5. Thin-film crystalline silicon solar cells: Physics and technology, R. Brendel, WileyVCH, Weinheim, 2003.
6. John A Duffie& William A Beckman "Solar energy Thermal Processes" Wiley Inter science publication, New York.
7. Seminconductors for solar cells, H. J. Moller, Artech House Inc, MA, USA, 1993. Solid State electronic devices, Ben G. Streetman, , Prentice-Hall of India Pvt. Ltd., New delhi 1995.
8. Clean electricity from photovoltaics, M. D. Archer, R. Hill, Imperial college press, 2001.
9. Solar Photovoltaics: Fundamentals, Technologies and Applications, C. S. Solanki, Prentice Hall of India, 2011.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	To get an exposure to different cell technologies.
CO2	An exposure to advanced cell technology and usage of different materials
CO3	Knowledge of manufacturing processes of various types of solar cell is imparted.
CO4	Solar module manufacturing process in detail is learnt.
CO5	An exposure to advanced cell technology and usage of different materials

Course Description

Title of Course: MATLAB	Course Code: 12M17PH471

L-T Scheme: 0-0-2 **Course Credit: 1**

Objectives: Computation is as essential to physics as analytic theory and experiment. The matrix-based MATLAB language is the most natural way to express computational mathematics. Built-in graphics make it easy to visualize and gain insights from data. The desktop environment invites experimentation, exploration, and discovery.

Create lectures with the MATLAB Live Editor that combine explanatory text, mathematical equations, code, and results. Step through lecture topics one section at a time. Create live scripts with MATLAB code that students can use to explore complex material.

- Topic 1: Desktop, Variables, and Data Types.
- Topic 2: Script Files.
- Topic 3: Plotting.
- Topic 4: Good Programming Practices.
- Topic 5: Input and Output Statements.
- Topic 6: Conditional Statements.
- Topic 7: Loops.
- Topic 8: Nested Loops

Text Books:

1. A Guide to MATLAB for Beginners and Experienced Users Brian R. Hunt Ronald L. Lipsman Jonathan M. Rosenberg with Kevin R. Coombes, John E. Osborn, and Garrett J. Stuck, Cambridge University Press.
2. .MATLAB: An Introduction with Applications, by Amos Gilat, 2nd edition, Wiley, 2004
3. C.B. Moler, Numerical Computing with MATLAB, SIAM, 2004.

Learning Outcomes/Course Outcome

Course Outcome	Description
CO1	Understand basic programming concepts
CO2	Use various programming constructs of MATLAB to solve problems
CO3	Plot graphs
CO4	Design interfaces.