M.Sc. Physics

Semester-based Curriculum Structure under CBCS (w.e.f. Academic Session 2021-2022)

I. **Programme Objectives**:

The Master of Science in Physics is the leading programme of the department. The students are trained to be capable to carry forward learning objectives of this natural science. The students will be able to understand the **Core Courses, Ability Enhancement Compulsory Courses, Skill Enhancement Courses, Generic Elective Courses, Discipline Specific Elective** Courses under the Choice Based Credit System(CBCS).

2. **Programme specific outcome**: On completion of the course, a student acquires advanced theoretical and experimental knowledge of Physics. The students will get an experience to a research field through project/dissertation. They could readily join a research programme in Universities/Institutes/Research Labs, or take up a teaching position.

Course Structure

1st Semester				
Paper Code	paper	Theory/Practical	Credit point	Total Marks
COR101	Mathematical Methods	Theory	4	50
COR102	Classical Mechanics	Theory	**4**	**50**
COR103	Quantum Mechanics	Theory	**4**	**50**
COR104	Electronics	Theory	**4**	**50**
COR105	General Practical I	**Practical**	**4**	**50**
AECC	Instrumentation method	Theory	**2**	**25**
Total			**22**	**275**
2nd Semester				
COR206	Electrodynamics and plasma	Theory	4	50
COR207	Advanced QM	Theory	4	50
COR208	Statistical Mechanics	Theory	**4**	**50**
COR209	General Practical II	Practical	4	50

GEC	**Applied Physics (**CBCS**)**	Theory	4	50
Total			20	250
3rd semester				
COR310	Atomic and molecular spectroscopy	Theory	4	50
COR311	Solid State Physics	Theory	4	50
COR312	Nuclear Physics	Theory	4	50
COR313	Elementary Particle Physics and quantum field theory	Theory	4	50
DSE301	Advanced Practical(I)	Practical	4	50
SEC	Advanced Computer Application	Theory and practical	2	25
Total			22	275
4th semester				
DSE402	Discipline specific Elective 1	Theory	4	50
DSE403	Discipline specific Elective 2	Theory	4	50
DSE404	Discipline specific Elective 3	Theory	4	50
DSE405	Advanced Practical(II):	Practical	4	50
Project	Project/Dissertation		4	50
Total			20	250
Grand Total			84	1050

No of elective papers and practicals are subject to vary time to time as per availability of teachers and infrastructure. Students need to choose CBCS subject from other department. However they may acquire equal CBCS credit from SWAYAM online course subject to necessary permission from the Department.

Abbreviation meaning -- COR: Core Courses, AECC: Ability Enhancement Compulsory Courses, SEC: Skill Enhancement Courses, GEC: Generic Elective Courses, DSE: Discipline Specific Elective.

Semester I

COR101 Mathematical Method

Course Outcome: The students will be able to learn different mathematical tools to deal with the different problems of natural phenomena

Course Content:

Module-1

Calculus of Residues : Residue and evaluation of residue; Cauchys residue theorem; evaluation of definite integrals by the method of contour integration (including integration around branch cuts); evaluation of principal values of improper integrals; summation and inversion of series; partial fraction representation of meromorphic functions; infinite product representation of entire functions (Mittag Leffler Expansion).Analytic Continuation:Definition and some elementary theorems; Schwarz reflection principle; power series method of analytic continuation. Complex Mapping. Conformal Transformation.

Eigenfunction methods for differential equations: Sets of functions. Some useful inequalities Adjoint, self-adjoint and Hermitian operators Properties of Hermitian operator. Reality of the eigenvalues; orthogonality of the eigenfunctions; construction of real eigenfunctions, Sturm–Liouville equations Valid boundary conditions; putting an equation into Sturm–Liouville form.

Module -II

Integral Transforms: Fourier transform, Laplace transforms; Parsevals theorem and convolution theorem; partial differential equation and its classification; Solution of partial and ordinary differential equation by above transformations. Green's Functions:Inhomogeneous differential equation (Poisson equations, wave equation,etc.); Green's Functions, definition and properties (for self adjoint differential operators only)computation of Green's function, direct computation, eigenfunction expansion, integral transform method.

Group Theory: Abstract groups: subgroups, classes, cosets, factor groups, normal, subgroups, direct product of groups; Examples, Homomorphism &isomorphism. Representations:

reducible and irreducible, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations.

Module-III

Introduction to continuous groups: Lie groups, rotation and unitary groups. Representation of SO(3), SU(2), SU(3) and SO(3,1).

Tensors : Coordinate transformation, Jacobian determinant, definition of tensors; contravariant, covariant and mixed tensors; tensor algebra, Riemannian Geometry, signature requirement, metric tensor, invariant volume, associated tensors, parallel transport, covariant differentiation, Christoffel symbols; Geodesics, Ricci identity, Riemann –Christoffel curvature tensors, curved space, Bianchi identity, Ricci tensor, vanishing of the curvature tensor as a condition of flatness. Gradient, divergence, curl and Laplacian in terms of tensors.

Books:

1. Sokolnikoff : Tensor Analysis-Wiley Toppan

2.Lass : Vector and Tensors-McGraw Hill Kogakusha

3.Joshi :Matrices and Tensors-New Age International.

4.A.W. Joshi : Group theory.

5.Riley, Hobson and Bence Mathematical Methods for Physics and Engineering: A Comprehensive Guide.

6. Mathews and Walker: Mathematical Methods of Physics

7.Arfken and Weber: Mathematical methods for Physicists

8.Morse and Feshbach: Methods of Theoretical Physics

9.Pipes and Harvil: Applied Mathematics for Physicists and Engineers –

10.Harper: Introduction to Mathematical Physics

11.Courant and Hilbert: Methods of Mathematical Physics –John Wiley.

12.Smirnov: Course on Higher Mathematics

COR102 Classical Mechanics

Course Outcome: The students will be able to describe a wide variety of physical phenomena (i.e. Small oscillation, rigid body motion, continuous media and non-linear motion etc) by the Lagrangian and the Hamiltonian formalism, non-linear dynamics to generalize the laws of physics in higher dimensions.

Course Content:

Module I

Lagrangian and Hamiltonian formalisms: Study of different systems. Legendre transforms. Hamilton's canonical equations and their applications. Lagrangian and Hamiltonian for relativistic particles, free and forced vibrations problems in Small Oscillations.

Central force: Review of central force problems. Conditions for closed and stable orbits, Bertrand's theorem, Virial Theorem, Laplace-Runge-Lenz Vector.

Module-II

Canonical Transformations : Equations of canonical transformation; generating functions; examples of canonical transformations; integral invariants of Poincare; Lagrange and Poisson brackets as canonical invariants; infinitesimal contact transformations; constants of motion and symmetry principles; generators of infinitesimal symmetry transformations. **Hamilton-Jacobi theory :** Hamilton's principal and characteristic functions; Hamilton Jacobi equations for these two functions; separation of variables in the Hamilton-Jacobi method (e.g. simple harmonic motion, Kepler problem etc.), Hamilton-Jacobi theory, geometrical optics and wave mechanics.

Non linear dynamics: Non-linear Equations, autonomous systems; critical points; stability; Liapunov direct method; periodic solutions; Poincare Bendixon theorem; limit cycles; Lienard theorem

Module-III

Rigid body dynamics: Lagrange's equations of motion for a rigid body; Euler's theorem on the motion of a rigid body; infinitesimal rotations. Euler's equations of motion. Force free motion of a rigid body; heavy symmetrical top with one point fixed; precession and nutation; Larmor precession; gyroscope and asymmetrical top , condition for Fast and sleeping top.

Mechanics of Continuous Media: Transition from discrete to continuous systems; the Lagrangian formulation; stress energy tensor and conservation theorems; Hamiltonian formulation; Poisson brackets and momentum representation; examples.

1. Goldstein, Poole and Safko: Classical Mechanics – Addison Wesley / Narosa.

2. Landau and Lifshitz : Mechanics – Pergamon.

3. Rana and Joag: Classical Mechanics – Tata-McGraw Hill.

4. Whittaker : Analytical Dynamics of Particles and Rigid Bodies – Cambridge.

5. Fetter and Walecka : Theoretical Mechanics of Particles and Continua – McGraw Hill.

6. RaychaudhuriA.K: Classical Mechanics – Oxford.

7. Simmons: Differential Equations – Tata-McGraw Hill.

8. Bhatia: Classical Mechanics – Narosa.

COR103 **Quantum mechanics**

Course Outcome: The objective of this course is to introduce quantum mechanics to the students and its application in Physics in the context of the atomic and sub-atomic world. The students will be able to understand the underlying mechanics through wave mechanics and matrix formulations of quantum mechanics.

Course Content:

Module I

Linear Vector Space formulation: The Linear Vector Space, Dimension and Basis of a Vector Space, concept of state vectors, Time Evolution of the state vectors, basis functions, inner product; dual space; principle of superposition of states, change of basis, Ket vector and its characteristics, Bra vector and its characteristics, orthonormility, completeness condition and closure property.

Hilbert Space and operators: The Hilbert Space, linear Operators, Hermitian Adjoint, Hermitian operator, Time Evolution Operator, Fundamental postulates of Quantum mechanics, eigenvalue equation,, Projection Operators, Commutator Algebra, Parity Operator, Uncertainty Relation between Two Operators, Functions of Operators, Expectation values, Square-Integrable Functions: Wave Functions, Eigenvalues and Eigen vectors of an Operator.

Representations: Representation in Discrete Bases, Representation in Continuous Bases, Matrix Representation of Kets, Bras, and Operators, Position Representation, Momentum Representation, Connecting the Position and Momentum Representations, Schrödinger Equation and Wave Packets, Stationary States: Time-Independent Potentials, the Conservation of Probability.

Module II

Schrödinger, Heisenberg and Interaction pictures: Introduction to the three representations; equation of motion in Schrödinger, Heisenberg and Interaction pictures; time translation operator. Time Evolution of Expectation Values.

Harmonic oscillator with operator algebra: Creation and annihilation operators, Oscillator algebra, Hamiltonian of harmonic oscillator in terms of creation and annihilation operators, Number operator, solution of energy eigenvalues, Selection rule, solution of wave functions, Coherent state, Coherent state as a normalized state, Coherent state is a state of minimum uncertainty product of position and momentum.

Mixed states; density matrix and its properties with examples; use of the density matrix in calculating the average values, Greens function; propagator concept.

Module III

Rotations: Infinitesimal Rotations, Finite Rotations, Properties of the Rotation Operator Euler Rotations, Angular momentum as generator of rotation, Representation of the Rotation Operator Rotation Matrices and the Spherical Harmonics.

Angular Momentum: Introduction to Orbital Angular Momentum, General Formalism of Angular Momentum, Geometrical Representation of Angular Momentum, commutation rules; eigenvalues and eigen functions of angular momentums, Matrix Representation of

Angular Momentum, Spin Angular Momentum, algebra of Pauli spin matrices; spin half particle in a magnetic field and spinors; properties of the spherical harmonics.

Addition of Angular Momenta: Addition of Two Angular Momenta, General Formalism, Calculation of the Clebsch–Gordan Coefficients.

Books Recommended:

1) Introduction to Quantum Mechanics, David J. Griffiths, Third edition, Cambridge University Press
2) Introductory Quantum Mechanics, Fourth edition, Richard L. Liboff, Pearson
3) Quantum Mechanics, Amit Goswami, Waveland Press
4) Quantum Physics" Robert Eisberg and Robert Resnick (John Wiley and sons).
5) Quantum Theory" D. Bohm (Prentice-Hall).
6) Quantum Mechanics Concepts and Applications, 2^{nd} ed , Nouredine Zettili, John Wiley & Sons, Ltd

COR104 **Electronics**

Course Outcome: The students will become familiarized with important electronic devices, circuits and microprocessors.

Course Content:

Module-I

Power Circuits: Regulated power supply; basic concepts; series regulator using BJT and op-amp regulator; SMPS; D.C / D.C converter; Power control by SCR.

Integrated Circuit Fabrication: Monolithic Integrated-circuit technology, Planner process, fabrication of BJT, MOSFET, diodes, Integrated-circuit resistors, capacitors.

Semiconductor Devices: MOSFET, CMOS, Power MOS, UJT, SCR, triac, diac, IGBT.

Operational Amplifiers: Instrumentation amplifiers, Practical integrator and differentiator, Log and anti-log amplifier, Multiplier and Divider, RC active filters-first and second order low pass and high pass filter, band pass and band elimination filter.

Module-II

Network Analysis: Constant k low pass, high pass; band pass and band elimination filters, m derived filters, propagation constants, characteristic impedance for T and Π sections, neper and decibel.

Noise: Different sources of noise; signal to noise ratio; definition and calculation of noise figure.

Amplitude Modulation: basic concepts of modulation, sidebands; double sideband, single sideband and carrier suppressed mode of transmission; power relation; modulation index, typical circuits for generation and detection of amplitude modulated waves; envelope and average detection, generation and detection of suppressed carrier type AM signals. VSB AM and QAM technique in TV broadcasting.

Angle Modulation: Concepts of frequency and phase modulation, Frequency spectrum; bandwidth; reactance tube and p-n junction methods of generation of FM waves; Armstrong system; demodulation by staggered tuned and Foster Seeley discriminator circuits, equivalence between PM and FM.

Module-III

Digital circuits: Encoders, Decoders, tri-state devices, A/D converters-parallel comparator, Successive Approximation, Dual-slope.

Elements of Microprocessors : Review of 8085 μP, functions of ALU, Flags, ALE and different registers; instruction set; Assembly language programming; machine cycle; op-code fetch, memory read, memory write and timing diagram; Memory: FF or Latch as storage elements; array of memory elements; addressing of registers; memory map and address lines, absolute and partial decoding and multiple address ranges.

Transmission Lines, Waveguides and Microwaves oscillators: Parallel wire and coaxial lines; transmission line equation; characteristic impedance; propagation constant; high frequency transmission lines; travelling wave interpretation; VSWR; Coefficient of reflection; principle of stub line matching; directional coupler; Rectangular waveguide; waveguide modes; resonant cavities; reflex klystron; magnetron.

References:

1. Malvino and Leach: Digital Principles and Applications – Tata McGraw Hill
2. Streetman : Solid State Electronic Devices – Prentice Hall India
3. Gaekwad : Op –Amps and Linear Integrated Circuits – Prentice Hall India
4. Taub and Schilling: Digital Integrated Electronics – McGraw Hill Kogakusha
5. Kennedy : Electronic Communication Systems – Tata McGraw Hill
6. D. Roy Chowdhuri and Jain, Linear Integrated Circuits, New Age International (P) Ltd.
7. Milman and Grable, Microelectronics. Tata McGraw-Hill
8. R P Jain, Modern Digital Electronics, Tata McGraw-Hill

9. J D Ryder, Electronic Fundamentals and applications, PHI

10. J D Ryder, Networks, Lines and Fields, PHI

11. Gaonkar: Microprocessor Architecture, Programming and Applications with 8085, PRI

12. Roddy and Coolen, Electronic Communications, Pearson

13. Samuel Y. Liao, Microwave Devices and Circuits, Pearson

14. B. C. Sarkar and S. Sarkar, Analog Electronics, Damodar Prakashani

15. B. C. Sarkar and S. Sarkar, Digital Electronics

16. Ram: Fundamentals of Microprocessors and Microcomputers – D. Rai and Sons

17. Sarkar: Microwave Propagation and Technique – S. Chand

COR105 General Practical I

Course Outcome: This course aims at performing Nuclear, optics, electronics and solid state physics experiments by the students. Hands on experiments in the concerned equipments will give the students the ability of the theoretical understanding.

Course Contents

Nuclear Physics and Advanced Optics (Group A students only)

List of Experiments:

1. a) Determination of the Plateau region of a GM tube. (b) Analysis of statistical fluctuations at low and high count rates.

2. Determination of the half-life of a long lived radioactive sample (40K).

3. Study of gamma absorption in Aluminium and Lead using a GM tube and determination of the mass absorption coefficient.

4. Study of beta absorption in Aluminium using a GM tube and determination of range and energy of beta particles.

5. a) Calibration of a Michelson interferometer using Na-D lines as standard.

b) Measurement of d between Na-D lines.

c) Determination of refractive index/thickness of a thin sheet of a transparent material.

6. Study of spectra of Hydrogen atom using a constant deviation spectrograph/spectrometer, to identify the Rydberg series and to construct its energy level diagram.

7. Study of the molecular spectra of I_2 in absorption and determination of the dissociation energy.

8. Study of emission spectra of Cu and to determine the energy diagram with possible transition.

9. Study of the Zeeman splitting of Na-D lines using a constant deviation spectroscope and Fabry-Perot etalon.

Electronics and Solid State Physics (Group B students only)

List of Experiments:

1. Construction of a power supply with semiconductor devices, zener diodes and using an emitter follower and to study its performance ripple factor, line and load regulations.

2. Construction of a single stage common emitter voltage amplifier, measurement of its gain, input and output impedances and the determination of the gain-bandwidth product using R-C coupling.

3. Experiments on Diac, Triac, SCR and UJT

4. Design and construction of a stable multivibrator and the study of its characteristics and performance.

5. Experiments on Modulation and demodulation.

6. Study of characteristics of FET and MOSFET and use of these as source followers.

7. Study of velocity of sound by ultrasonic interferometer

8. Study of thermal conductivity of nanofluid.

9. Study of viscosity of nanofluid.

10. Study of ferromagnetic Curie temperature of nickel.

References:

1. Laboratory manual

AECC **Instrumentation methods**

Course Outcome: Students will be able to familiarize experimental methods of some sophisticated instruments and interpret the experimental data.

Course content:

Module I

Linear and nonlinear curve fitting, chi-square test.

Particle detectors **:** Principle of Gas filled detector, ionization chamber, scintillation detector and Solid state detectors , Energy Measurements, Signal processing; Multi channel analyzer; Time of flight technique; Coincidence measurements true-to-chance ratio; time resolution. Counting Statistics and Error Prediction: Characterization of Data, Statistical Models, Application of Statistical Models, Error Propagation, Optimization of Counting Experiments, Limits of Detectability.

Module II

Structural and optical properties characterization of materials (XRD, FTIR, UV, PL)

Production and measurement of high vacuum: pumps and gauges

Very High and very low Temperature production and measurement: High temperature furnaces, Cryogenics (brief idea), different thermometers

High magnetic fields production and measurement: superconducting coil magnet, pulse magnetic field, vibrating sample magnetometer, SQUID

Semester II

COR206 **Electrodynamics and plasma**

Course Outcome: The students will learn advanced knowledge of electromagnetic fields and radiation, propagation and scattering of electromagnetic waves. They will learn collective behaviour of charged particles and their dynamics in electromagnetic field which helps to study the basic working model of plasma.

Course Content:

Module I

Electromagnetic Fields : Maxwell's equations & Pointing's theorem (mention only), Conservation of linear and angular momentum - Maxwell's stress tensor, scalar and vector potentials, gauge transformations-Lorentz gauge and Coulomb gauge, the inhomogeneous wave equations - solution of inhomogeneous wave equations by Green's function; retarded and advanced solutions; Multipole expansion of localized charge distributions, Magnetic monopole.

Multipole Radiations: Electric and magnetic dipole field and radiation of a localized oscillating source; Hertz potential and corresponding field equations; Multipole expansion of the electromagnetic field; Electric quadrupole radiations; Sources of multipole radiation-multipole moments.

Module II

Moving Charge: Lienard-Wiechert potentials, the field of a uniformly moving point charge; convection potential and virtual photons.

Radiation from an Accelerated Charge : Fields of an accelerated charge; angular and frequency distributions of the emitted radiation; special cases of acceleration-parallel and perpendicular (circular orbit) to velocity; Larmor's formula and its relativistic generalization; Bremsstrahlung; Cerenkov radiation; radiation reaction; electromagnetic mass.

Module III

Scattering: Radiation damping; scattering by a free electron; scattering and absorption of radiation by a harmonically bound electron; scattering of electromagnetic waves from a system of charges, coherent and incoherent Bragg diffraction. **Magneto-hydrodynamics and Plasma Physics :** Conducting fluid in a magnetic field; freezing in of lines of force; MHD equations; magnetic pressure; magnetic viscosity; pinch effect; Alfven waves; plasma oscillations; screened potential and Debye length.

COR207 Advanced Quantum Mechanics

Course Outcome: The students will be able to understand the underlying mechanics of different phenomena through approximation method, scattering theory, symmetry. They

will be introduced to the basics of quantum computation. They will also learn quantum mechanics for high energy particles in relativistic scale.

Course Content:

Module-I

Approximation methods: Variational method for stationary state problems; Time -independent perturbation theory -non-degenerate and degenerate cases; Time-dependent perturbation theory -transition amplitude; constant and harmonic perturbations; Fermi's golden rule; WKB approximation; Adiabatic and sudden approximations; Applications.

Scattering theory: Scattering amplitude; differential and total cross-sections; Scattering in a spherically symmetric potential partial -wave analysis; phase shift its evaluation; Born approximation; hard sphere scattering.

Symmetries: Symmetry operations as unitary and anti-unitary transformations; conservation laws from invariance principles; Discrete symmetries; reflection, inversion and parity; intrinsic parity; time reversal; Kramers degeneracy.

Module-II

Quantum Computation: Bits and Qubits; Quantum Cryptography; Bloch sphere representation of a Qubit, Multiple Qubits; Quantum Circuits: Single Qubit Gates, Multiple Qubit Gates, Design of Quantum Circuits; Quantum Teleportation; Experimental realization of Quantum Teleportation; Quantum Computation; Logical Operations on Quantum Registers; A real Quantum Computer.

Relativistic Quantum Mechanics: Klein-Gordon Equation: Continuity equation and indefinite norm; free particle solutions; negative energy-momentum solutions and their interpretation, non-relativistic reduction and interpretation of Klein-Gordon equation; the charged Klein-Gordon field; the interaction of a spin-0 particle with an electromagnetic field; spin of the KG particle; invariance properties.

Module-III

Dirac equation: the conjugate Dirac equation; continuity equation; non-relativistic correspondence; spin; helicity and magnetic moment of the Dirac particle. Lorentz covariance for the Dirac particle; gamma matrices, their different representations and properties; bilinear covariant; free particle solutions and their representation; negative energy solutions and hole theory; positron.

References:

1. David Griffiths: Introduction to Quantum Mechanics -Pearson Education
2. L. Schiff: Quantum Mechanics -McGraw Hill Kogakusha
3. E. Merzbacher : Quantum Mechanics -John Wiley
4. J. J. Sakurai : Modern Quantum Mechanics -Addison Wesley
5. Schwabl: Quantum Mechanics -Narosa
6. Bransden and Joachain : Introduction to Quantum Mechanics -Longmans
7. Landau and lifshitz : Quantum Mechanics -Pergamon
8. Davydov : Quantum Mechanics –Pergamon
9. Gasiorowicz: Quantum Physics -John Wiley
10. Baym : Lecture Notes on Quantum Mechanics -Benjamin
11. Schweber : Relativistic Quantum Field Theory -Harper and Row
12. Bjorken and Drell : Relativistic Quantum Mechanics -McGraw Hill
13. Greiner : Relativistic Quantum Mechanics -Springer.
14. Ghatak and Lokanathan : Quantum Mechanics, Theory and Applications –Macmillan
15. Quantum Computation and Quantum Information, M. A. Nielsen & I. Chuang, Cambridge University Press (2000)
16. G. Greenstein and A. G. Zajonc The Quantum Challenge Modern Research on the Foundations of Quantum Mechanics-Narosa Publishing House
17. J.Preskill, Notes on Quantum Computation.
18. Mikio Nakahara and Tetsuo Ohmi,"Quantum Computing", CRC Press (2008).

COR208 Statistical Mechanics

Course Outcome: The students will be able to understand different physical phenomena in the context of statistical definition. In this course, the students will experience the rigorous

approach of Statistical Mechanics to explore interesting phenomenon like Bose-Einstein Condensation, super fluidity etc. They will learn to apply classical and quantum statistical mechanics to explain physical phenomena.

Course content:

Module-I

Review: Random Walk, phase space, phase points, Phase trajectory, Ensemble, Liouville's equation, Gibbs paradox; Free energy, entropy.

Stationary ensembles: Micro canonical, canonical and grand canonical ensembles. Partition function and statistical definition of thermodynamic quantities; computation of partition functions of some standard systems- ideal gas, Harmonic oscillators, rigid rotators, Para magnetism.; relation between density of states and partition function; spin ½ system and negative temperature; grand canonical ensemble and its partition function; chemical potential; dependence of different thermodynamic quantities on the number of particles; energy fluctuations in the canonical ensemble and the equivalence of the canonical and the microcanonical ensembles; density fluctuations in the grand canonical ensemble and its equivalence to the canonical ensemble. Partition function and distribution for perfect gas.

Density Matrix: Quantum mechanical and statistical averaging, quantum Liouville equation, Density matrix for stationary ensembles. Construction of density matrix, Polarization vector, Pure and Mixed states, Application to a free particle in a box, an electron in a magnetic field, beam of spin ½ particles.

Module-II

Quantum Statistics: Fermi and Bose distributions; quantum gas in equilibrium; quantum gases of elementary particles; number density and chemical potential; energy density, equation of state and different thermodynamic quantities; relativistic quantum gas; black body radiation and Planck's law; degenerate Bose gas; lattice specific heat and phonons; Bose condensation and super fluidity; quantum liquid with Bose-type spectrum, example of liquid He; degenerate Fermi gas; degeneracy pressure; specific heat of degenerate Fermi gas; Riemann's $\xi(z)$ and integrals of quantum statistics : relativistic degenerate electron gas; high temperature dense matter; white dwarfs and neutron stars.

Module-III

Real Gas: Free energy; virial equation of state; second virial coefficient and Joule Thomson expansion; inversion temperature, model calculation and van der Waals equation of state.

Ising Model: One dimensional and three dimensional Ising Model, Bragg-William approximation, Bethe-Peierl approximation, Specific heat, high temperature expansion.

Phase Transitions: Liquid-gas, order-disorder, ferroelectric and ferromagnetic transitions; critical points; Ehrenfest's classification; order parameter; continuous and discontinuous transactions; Landau's theory of continuous transitions; continuity of entropy; discontinuity of specific heat; singularities of order parameter and partition function; generalized susceptibility; mean field theory; critical exponents; scaling and fluctuations of order parameter.

References:

1. Landau and Lifshitz: Statistical Mechanics – Pergamon
2. Toda, Kubo and Saito: Statistical Physics – Springer Verlag.
3. Reif: Fundamentals of Statistical and Thermal Physics – McGraw Hill.
4. Pathria: Statistical Mechanics – Pergamon.
5. Ma: Statistical Mechanics – World Scientific.
6. Huang: Statistical Mechanics – John Wiley

COR209 General Practical II

Nuclear Physics and Advanced Optics (Group B students only)

List of Experiments Given in **COR105**

Electronics and Solid State Physics (Group A students only)

List of Experiments Given in **COR105**

GEC Applied Physics (CBCS)

Course outcome: The students of other science subjects will have an overview of the basic Physics .

Course content:

Module-I

Basic Physics: Newtonian mechanics: Vectors; Newton's laws of motion; Force and acceleration; Work, Energy, Power; Newton's laws of Gravitation; Projectiles; Friction; Circular motion; Moment of Inertia.

Ray optics: Reflection and Refraction at a plane boundary; Refractive index; Snell's law; Fermat's principle; Image formation by reflection at a spherical boundary; Concave and Convex mirrors; Lenses.

Wave Optics: Interference, Diffraction, polarization

Elements of electricity and magnetism: Electric field and potential, Gauss law, BiotSavart law, Ampere Circuital law, Maxwell's equation, Electromagnetic wave

Modern physics and relativity: Structure of atoms and nucleus, Radioactivity, Fission, Fusion, Superconductivity, Special theory of relativity.

Module-II

Applied Quantum Mechanics: Basics: Schrödinger equation, Measurements, Expectation values, Stationary states,

Approximation methods: Variational principle, Time independent and Time dependent perturbation theory; WKB approximation.

Some elementary examples: (a) Free electrons in one dimension, π - states in benzene; free electrons in three dimensions. (b) Quantum slabs, wires and dots; quantum wells. (c) The hydrogen atom problem.

Molecules: (a) The Li_2 molecule: LCAO or tight binding states; bonding and anti-bonding State (b) Molecular orbitals; Polar bonds; Non-orthogonal and overlap repulsion. (c) The physics of N_2 , CO and CO_2 ; cohesion; π -bonds; sp hybrids and σ -bonds.

Module - III

Data and error analysis: The presentation of physical quantities with their inaccuracies (measuring errors and uncertainties), Classification and propagation of errors.

Probability distributions: Binomial distribution; Poisson distribution; Gaussian or Normal distribution; Lorentzian distribution; the central limit theorem.

Processing of experimental data: Distribution function of a data series; the average and the mean squared deviation of a data series; estimates for mean and variance; χ^2 Test of a distribution; handling data with unequal weights.

Fitting functions to data: Dependent and independent variables, method of least squares, fitting to a polynomial, minimizing χ^2 for Goodness of Fit, Linear-Correlation Coefficient.

Numerical Methods: Polynomial Interpolation, Numerical Differentiation and Integration, Roots of Nonlinear Equations.

Semester III

COR310 Atomic and Molecular Spectroscopy

Course Outcome: On completion of the course, the student should be able to achieve advanced knowledge about the interactions of electromagnetic radiation and matter and their applications in spectroscopy. They will have the knowledge of basics formalisms of LASER and their properties.

Course content:

Module-I

Atomic Spectroscopy : One electron atom : Hydrogen spectrum; spectral series limit and term values; Ritz combination principle; summary of Bohr-Somerfield model; semi-classical treatments of relativistic corrections and spin-orbit interaction; Thomas correction; non-relativistic limit of Dirac equation; existence of intrinsic spin and anomalous magnetic moment; Dirac – Coulomb problem; relativistic spin-orbit and Darwin terms; correction to Bohr-Somerfield term values; fine structure constant; Lamp-Rutherford splitting; evaluation of integrals $< r^{1/k} >_{nl}$; features of alkali spectrum; double structure; Born Heisenberg approximation; induced dipole field; quantum defects Rydberg and Ritz terms; X-ray spectrum and screening.

Module-II

Many Electron atoms: Schrödinger equation for many electrons system; central field approximation; product function and Hartee equation; Pauli exclusion principle; Slater determinant; Hartree-Fock approximation; exchange integral; Koopmans theorem, Aufbau principle and the periodic table, Electronic configuration; multiplicity of terms; Russel Saunders coupling; Hunds rule; Lande interval rule; j-j coupling; land g factor, Thomas Fermi approximation.

Atoms in External Electric and Magnetic Fields: Zeeman and Paschen Back effects; Stark effect in hydrogen. Electron-Nucleus interaction: Effect of nuclear spin; hyperfine structure of atomic spectrum; ^{133}Cs clock.

Module-III

Molecular structure and Spectra: Adiabatic approximation and separation of electronic and nuclear motions; Hund-Mülliken and exchange integral; covalent bond of homonuclear molecules; hybridization and directed valence bond of carbon.

Electronic terms in molecules: Relation between atomic and molecular terms. Vibrational and rotational structures of singlet terms in diatomic molecules; anharmonicity and rotation vibration coupling; angular part of a singlet wave function for a diatomic molecule; multiplet structures in diatomic molecules and Hund's schemes; symmetry of molecules; Λ doubling.

Rotational and Vibrational Energy Levels: Quantization of rotation of a rigid body; rotational spectrum and bond length measurements; rotation-vibration spectrum; Frank Condon principle; Condon parabola; Fortrat diagram P, Q and R branches; band head; fine structure. Fluorescence and phosphorescence; photo dissociation; Raman spectrum.

LASER: basic principle of laser; interaction of atomic system and radiation-density matrix of two-level systems; atomic susceptibility; line shape; saturation; spontaneous and induced transitions; gain coefficient; homogeneous and inhomogeneous broadening; beam stability; optical resonators and resonance frequency; oscillation condition; threshold inversion; oscillation frequency; power output.

Specific Laser Systems: Semiconductor diode laser; quantum well laser; free electron laser.

References:

1. Bransden and Joachain : Physics of Atoms and molecules – Longmans.
2. Condon and Odabasi : Atomic Structure – Cambridge.
3. Condon and Shortley : Theory of Atomic Spectra – Cambridge.
4. Bethe and Salpeter : Quantum Mechanics of One and two Electron Atoms Springer Verlag.
5. Slater : Quantum theory of Molecules and Atomic Structure, Vols. I and II-McGraw Hill.
6. Slater : Quantum Theory of Molecules and Solids, Vol. I-McGraw Hill.
7. Landau and Lifshitz : Quantum Mechanics Non-relativistic theory – Pergamon.
8. Berestetskii, Lifshitz and Pitaevski : Relativistic Quantum Theory-Pergamon.
9. Davydov : Quantum Mechanics – Pergamon.

COR311 **Solid State Physics**

Course Outcome: This course aims at attaining the knowledge of matter in the condensed phase, their structural, electrical, and magnetic properties. The students will be able to compute parameters related to extent and nature of crystallinity, conductivity, defects etc and the way these affect some basic properties.

Course Contents:

Module I

Crystal symmetry and diffraction: Macroscopic and microscopic symmetry elements, Point groups, Space groups, Equivalent points, Braggs Law; in reciprocal lattice and Brillouin Zones, Laue derivation of amplitude of scattered wave; Equivalence of Bragg's law and Laue's condition, Ewald construction Geometrical structure factor and atomic form factor, Structure factor calculations of some novel metals and compounds with SC, BCC, FCC, HCP, NaCl, ZnS and diamond crystal structures,

Imperfection in solids: Different types of defects and dislocation, point defects and line defects, Frenkel and Schottky defects, defects by non-stoichiometry; electrical conductivity of ionic crystals; classifications of dislocations; role of dislocations in plastic deformation and crystal growth. Luminescence and phosphors, decay mechanisms, thermoluminiscence, thalium activated alkali halides; Colour centers and photoconductivity; electron compounds; Excitons.

Crystal Binding: General considerations about bonding: ionic bonds, covalent bond, van der Walls-Fluctuating dipole forces-or molecular bonding, metallic bonding, hydrogen bonds.

Module II

Transport Properties: Boltzmann transport equation; electrical conductivity of metals and alloys; thermal conductivity of metals and insulators; Wiedemann-Franz law; isothermal Hall effect; quantum Hall effect.

Energy bands in solids: The Bloch theorem; Bloch functions; Review of the Kronig-Penney model; Brillouin zones; Band gap in the nearly free electron model;The tight binding model; Empty lattice band; Number of states in a band; Effective mass of an electron in a band: concept of holes; Classification of metal, semiconductor and insulator; Electronic band structures in solids - Nearly free electron bands; Tight binding method – application to a simple cubic lattice; Band structures in copper, GaAs and silicon; Topology of Fermi-surface; Electron dynamics in an electric field.Cyclotron resonance and determination of Effective mass. Concept of hole.

Module III

Magnetic properties of solids: Semiclassical treatment of paramagnetism for J=1/2, Brillouin function-van Vleck paramagnetism; ground state of an ion and Hund's rules; crystal field splitting and quenching of orbital momentum; Pauli Spin Paramagnetism of Metals; ferromagnetism in insulators; spontaneous magnetization; exchange interactions; antiferromagnetic order; ferrimagnetism; Colossal and Giant magnetoresistance.

Dielectric relaxation: Dielectric solid in static and alternating electric fields; losses; relaxation times; Complex dielectric constant and dielectric losses, relaxation time; Debye equations; Cases of distribution of relaxation time; Cole - Cole distribution parameter; Dielectric modulus; Ferro-electricity; different models and thermodynamic treatment of phase change. Thermo-electricity; electrets.

Phenomenological description of superconductivity: Occurrence of superconductivity; destruction of superconductivity by magnetic field; Thermodynamics of superconductivity; Gibbs free energy; entropy; heat capacity; qualitative description of formation cooper pair and outline of BCS theory and BCS Hamiltonian; energy gap and its experimental evidences; Giaver tunnelling; Flux quantisation; a.c. and d.c. Josephson effect; Vortex state (qualitative discussions); High T_c superconductors (information and qualitative description).

Reference book:

1. Aschroft and Mermin: Solid State Physics – Saunders

2. C. Kittel : Introduction to Solid State Physics – John Wiley

3. Azaroff: Introduction to Solids – Tata McGrawHill.

4. J. Dekker: Solid State Physics- Macmillan.

5. Ali Omar: Elementary Solid State Physics: Principles and Applications – Addison Wesley.

6. D.L. Bhattacharyya: Solid State Physics – Calcutta Book House.

7. Srivastava: Elements of Solid State Physics – Prentice Hall India.

8. Pillai: Solid State Physics – New Age International.

8. Keer:Principlesof Solid State – Wiley Eastern

COR312 Nuclear Physics

Course Outcome: The students will learn an in-depth description of the nucleus and its various properties. They will be able to describe the structure of the nucleus and the nature of the interaction that keeps the nucleus bound.

Course Content:

Module-I

Basic nuclear properties: mass; Change; parity; isospin; binding energy; separation energy.

Nuclear size: Rutherford scattering, electron scattering and form factors, charge density radius and potential radius, Wood-Saxon potential, experimental methods of determination. Static Electric and Magnetic Moments of a Nucleus; magnetic dipole and electric quadrupole moments. experimental determination.

Liquid Drop Model: properties of the model; the semi-empirical mass formula and its application to considerations of nuclear stability, Degenerate Fermi Gas Model applications.

Nuclear Disintegrations: Nuclear Emission: Penetration of potential barrier; nature of barrier for neutrons, protons and alpha particles; Gamow's theory of alpha disintegration and calculation of reduced widths and decay half-lives. Beta Decay**-** Fermi theory; Kurie plot ; log $f\tau$ values, classification and selection rules; Gamma disintegration and selection rule.

Interaction of charged particles with matter: ionization formula, range-energy relationship, charged particle detectors, energy measurement and identification of charged particles.

Module-II

Deuteron: Properties of the deuteron; ground and excited states of deuteron with square-well potential; deuteron radius and probability.

Scattering Problem: **n-p** scattering at low energies; effective range formula and scattering length, shape-independent approximation; modification of effective range for deuteron bound state; scattering by hard sphere and finite square-well potential. **p-p scattering** at low energies; identity of particles, antisymmetrization of wavefunction; comparison with n-p scattering; interference between nuclear and Coulomb forces; effective range. **n-n scattering**; charge-independence and charge symmetry, mirror nuclei, exchange forces and saturation, repulsive core; Relative stability of the n-n, n-p, and p-p systems.

Structure of Complex Nuclei: **Shell Model**: Evidence of shell structure; magic numbers; effective single particle potentials (square-well and harmonic oscillator); extreme single-particle model- its successes and failures in predicting ground state spin, parity and magnetic moments; Nordheim's rules; Schmidt limits, anomalous magnetic moments of nucleons and qualitative discussions about their origin. **Collective Model**: Evidence of collective motion; nature of vibrational and rotational spectra; qualitative discussion in terms of phonons and rigid rotators; quadrupole moments of deformed even-even nucleus.

Module-III

Nuclear Reactions: Classification; conservation principles; kinematics and Q-values; exoergic and endorgic reactions; threshold energy, Experimental setup; cross sections – elastic, inelastic, reaction, total; principle of detailed balance; Partial wave method of calculating cross sections. **Compound Nuclear Reactions:** characteristics; resonance and compound nucleus formation; one level Breit Wigner formula;

Direct Reactions: characteristics; types of direct reactions with examples elastic, inelastic, transfer, stripping, pick-up, knock on and break-up reactions (qualitative discussion with example).

Nuclear Fission: Spontaneous and induced fissions; elementary discussion of Bohr-Wheeler theory; barrier penetration and decay rates in fission; mass distribution of decay products; fission isomers.

Nuclear Fusion and thermo nuclear reaction: Source of energy in stars, Nucleo-synthesis.

References:

1. M. K. Pal: Theory of Nuclear structure (EWA press)
2. Cohen: Concepts of Nuclear Physics (Tata McGraw Hill)
3. Wong: Introductory Nuclear Physics (Prentice Hall)
4. Blatt and Weiskopff : Theoretical Nuclear Physics (Dover)
5. Evans: The Atomic Nucleus (McGraw Hill)
6. Roy and Nigam: Nuclear Physics (New Age International)
7. S. N. Ghoshal: Nuclear Physics (S Chand Publication)

8. Preston and Bhaduri: Structure of the Nucleus (Levant Books)
9. Y.M. Jana: An Introduction to Nuclear Physics (Narosa, New Delhi)
10. Krane: *Introductory Nuclear Physics* (Wiley India, New Delhi).

COR 313 Elementary Particle Physics and quantum field theory

Course Outcome: The students will be able to classify the elementary particles giving the correct quantum number assignments to all quark and lepton flavours. They will able to discuss qualitatively the relationship between symmetries and conservation laws. The student is expected to obtain insight into the most important aspects of quantum field theories after finishing the course.

Course Content:

Module I

Brief history of particle discovery, Relativistic Kinematics and Mandelstam variables. parity; charge conjugation and charge parity; G-parity, time reversal invariance and the principle of detailed balance; CPT theorem (statement only) and its consequences; strangeness; Gell-Mann Nishijima formula,; hypercharge; Properties of Charged Pions and Muons decay modes: measurement of charge, spin, parity, lifetime of pions and muons,

Methods of determination of mass, spin, parity and other quantum numbers of other particles (Principles only). quark structure of baryons and mesons; charm, beauty and truth prediction of Ω; mass formula; baryon and meson resonances , quarkonium; Pauli principle and the colour of quarks. Gluons as mediators in quark quark interaction. Role of Neutrino in parity non-conservation in beta decay; Wu's experiment, Muon Decay and time dilation, Different types of neutrinos.

Module-II

Quantum Mechanics of Fields and Many Particle Systems (Second Quantization) Identical particles: Bosons and Fermions; Symmetric and antisymmetric many body wave functions.

Method of Second Quantization : Lagrangian formalism; Noethers theorem; in-variance under transformations and operator requirements; quantization of a field obeying Schrödinger's equation; quantum conditions for boson and fermion fields; occupation number representation and Fock space; method of writing one and two body operators in the second quantized notation. Quantization of Klein-Gordon Field:Single component free Hermitian scalar field; plane wave and spherical wave decompositions; energy, momentum and displacement operators; symmetry of states; non-hermitian scalar field; charge operator; particles and antiparticles.

Module-III

Quantization of Dirac Field: Plane wave representation; quantum conditions; energy and momentum operators; positivity of energy; current and charge operators symmetrisation.

Quantization of the Electromagnetic Field:Maxwell's equations and the electromagnetic field tensor; quantization in the radiation gauge; transverse photon.

Interacting Fields: Brief discussion; quantized electromagnetic field interacting with a classical source; application to atomic transition probabilities; scattering of radiation (Compton Effect); S matrix and the evolution operator.

Books:

1. Relativistic Quantum Field Theory-Harper and Row.

2. Bjorken and Drell : Relativistic Quantum Mechanics-McGraw Hill.

3. Bjorken and Drell : Relativistic Quantum Fields-McGraw Hill.

4. Greiner : Relativistic Quantum Mechanics-Springer.

5. A.K Das : Lectures on Quanyum Field Theory

6. P.B Pal and Lahiri : Quantum Field Theory

DSE301 Advanced Practical (I)

Course Outcome: This course aims at performing some advanced Nuclear, solid state physics, electronics experiments by the students. Hands on experiments in the concerned equipments will give the students the ability of the theoretical understanding.

Course Contents

(Any six practical should be done taking at least one practical from each section)

A. Solid State Physics

1. To measure the electrical conductivity of a sample by the four probe method and to study the variation of conductivity with temperature.

2. a) to determine the Hall coefficient, electrical conductivity, mobility and carrier concentration in a given material. b) To determine its magnetoresistance.

3. To determine the susceptibility of single crystals by Goe's method.

4. To use ESR for the study of solids.

5. Study of ferroelectric properties of solids by P-E loop tracer.

B. Nuclear Physics

1. Beta spectroscopy with a magnetic spectrometer, obtaining the Fermi-Kurie plot to determine the maximum beta energy and shape factor correction for forbidden beta transitions.

2. Beta spectroscopy with scintillation detectors and measurement of conversion electron fraction.

3. Gamma spectroscopy with scintillation detectors using single-channel and multichannel analyzers: a) Study of resolution at different amplifier gains, (b) Energy calibration for a fixed gain, c) Study of spectrum of 22Na source and determination of the activity from sum peak analysis.

4. Measurement of the thickness of a thin foil from alpha energy loss.

5. Beta-gamma coincidence measurements: study of decay schemes and lifetime of nuclear levels.

6. Gamma-gamma coincidence measurements: angular correlation of the two positron annihilation gammas from 22Na source.

7. Study of angle dependence of Compton shift and scattering cross section and determination of the classical electron radius.

8. Study of alpha scattering from metal targets and verification of the Rutherford formula and identification of the target element.

C. Electronics

1. Study of the characteristics of a solar cell.

2. a) To setup a microwave bench and to measure the guide wavelength for verifying

the relation between λ and λg b) Study of Horn antenna using microwaves.

3. Measurement of attenuation in optical fibres.

4. a) Solving problems by writing programmes in assembly language and to verify these with 8085 µP and 8086 µP kits. (b) **Interfacing of a keyboard, seven segment display, an A/D converter and** a stepper motor with an 8085µP kit.

5. Study of transmission line characteristics.

6. Study of A/D and D/A conversion

SEC Advanced Computer Application

Course Outcome: This advance course aims to acquaint students with computer programming and numerical analysis. Through this course, students will be able to learn the useful computational techniques to find out solutions to the physical problems.

Course content:

1. Plotting of functions and data; fitting etc. using gnuplot/origin etc.
2. Revision of numerical methods for integration, finding roots of equation, solving simultaneous linear differential equations, least squares fitting, interpolation, solving differential equations (Euler method).

3. Use of standard subroutines :

(i) Runge kutta method for solving differential equations (example : anharmonic oscillator).

(ii) Matrix diagonalisation; matrix inversion (eigenvalue problem)

Monte Carlo methods. Applications in

1. Random number generation from different distributions: uniform, Gaussian etc;
2. Numerical integration: Trapezoidal Rule, Simpson 1/3 etc.

Books

1. Tanja van Mourik : Fortran 90/95 Programming Manual

2. A. C. Marshall, J. S. Morgan and J. L. Schonfelder : Fortran 90 Course Notes

3. V. Rajaraman: Computer Oriented Numerical Methods
4. J.M. McCulloch and M.G. Salvadori: Numerical Methods in Fortran
5. R. L. Burden and J. D. Faires : Numerical Methods.
6. Abhijit Kar Gupta : Python

Semester IV

DSE402 **A. Nuclear Physics**

Course Outcome: This course is an advanced course in Nuclear Physics developed in continuation with the Semester-III. After completion of this course, the students will have advanced knowledge on Nuclear Reactions nucleon-nucleon scattering, reactions of nucleons and nuclei with heavy ions at low energies (MeV), different nuclear models.

Contents:

Module-I

Two-nucleon interactions: Scattering: Spin-dependence of the interaction – singlet and triplet scattering lengths; coherent scattering from ortho and para-hydrogen; singlet state of the deuteron; high energy n-p, p-p, n-n scattering; Serber force and Jastrows idea of repulsive core.

Deuteron problem: Electric quadrupole and magnetic moments of the deuteron using intrinsic wave-function; Tensor force and the Rarita-Schwinger equations.

Meson-physics: Yukawa’s hypothesis, OPEP, OBEP, Lippmann Schwinger equation, charged and neutral pion exchange, T-matrix; pseudo-scalar meson field, Derivation of OPEP.

Electro-Magnetic Transitions: Interaction of electromagnetic radiation with matter, E-type and M-type multiple transitions, rate, selection rules, single particle transition, internal conversion, coefficient and rate, internal pair creation, angular correction.

Module-II

Nuclear Shell model: Residual interaction; justification of Nordheim’s rules; configuration mixing; antisymmetrization of wave-functions of two and three nucleons in unfilled shell; Pairing interaction and its effects; Electro-magnetic transition in the Shell model.

Collective Model: Collective modes of vibrational and rotational modes; Hamiltonian of a deformed nucleus and its separation into vibrational and rotational parts; β and γ-vibrations; rotation- vibration coupling; collective spectra of nuclei.

Unified Model: Coupling of collective and individual particle modes; rotation-particle coupling; Nilsson model (qualitative).

Module-III

Nuclear Reactions: Compound Nuclear Reactions; Formation and decay; multilevel Breit-Wigner formula; Weiskopff-Ewing formula; continuum stats; Evaporation model; level density, Erickson's formula; Nuclear temperature; Hauser-Feshbach formalism.

Direct reactions: Formalism: PWBA and DWBA; method of coupled channels; form factors and spectroscopic factors connection with nuclear structure (calculation of a single-nucleon transfer reaction).

Optical Model: Its properties and calculation of its parameters; Phenomenological optical model, Feshbach's formalism.

Heavy ion reactions: Information obtained from these reactions; the applicability of classical approach; Coulomb excitation and scattering; grazing collisions, head-on collisions and their features; WKB method of calculating cross-sections; fusion reactions; exotic model.

References:

1. M. K. Pal : Theory of Nuclear structure (EWA press)
2. Cohen : Concepts of Nuclear Physics (Tata McGraw Hill)
3. Wong : Introductory Nuclear Physics (Prentice Hall)
4. Blatt and Weiskopff : Theoretical Nuclear Physics (Dover)
5. Evans : The Atomic Nucleus (McGraw Hill)
6. Roy and Nigam : Nuclear Physics (New Age International)
7. S. N. Ghoshal : Nuclear Physics (S Chand Publication)
8. Preston and Bhaduri : Structure of the Nucleus (Levant Books)
9. Y.M. Jana : An Introduction to Nuclear Physics (Narosa, New Delhi)
10. Krane : Introductory Nuclear Physics (Wiley India, New Delhi).
11. Preston : Physics of the Nucleus (Addison Wesley)
12. Greiner and Maruhn : Nuclear Models (Springer).
12. Lilley : Nuclear Physics –Principles and Applications, (Wiley India).

DSE402 B. Advanced Electronics-I

Course Outcome**: **The course is intended to introduce to the students the different types of electronics like solar cell, diode , CCD . The students will be able to apply their knowledge of electronics to the various aspects of system design using the electronic circuits and to other branches of physics.

Course Content:

Module-I

Solar Cells and LED: Advantages of using solar energy; principle of operation of a p-n junction solar cell, equivalent circuit, energy-band diagram, I-V characteristics, open-circuit voltage, short-circuit current, fill factor, efficiency, solution of continuity equation, spectral response, limitations of a solar cell and methods of improvement of its performance. Photo-diode. Direct and indirect band gap semiconductors, materials used for the fabrication of light emitting diodes, construction and principle of operation of LED, semiconductor LASER.

MIS Diode and CCD: Energy-band diagrams for ideal metal-insulator-semiconductor diodes in equilibrium and under different applied voltages, accumulation, depletion and inversion cases, space-charge and electric field, differential capacitance, MIS CV curve. Charge coupled devices (CCD): basic operation, CCD structure, two phase CCD, colour CCD

Module-II

Tunnel diode: Effect of high doping, degenerate semiconductors, energy band diagrams of a tunnel diode in equilibrium and under different biasing conditions, current-voltage characteristics, tunnelling current, excess current and thermal current, equivalent circuit and input impedance.

IMPATT Diode: Principle of operation of an IMPATT diode, injection phase delay and transit time effect; small signal analysis; equivalent circuit of the avalanche region; impedances of the avalanche region and the drift regions.

Gunn Diode: Principle of operation of a Gunn diode, simplified band diagram of GaAs, transferred electron mechanism, formation and drift of space-charge domains.

Optoelectronics : Classification and fabrication principles of optical fibres, Step and graded index fibers, Wave propagation in optical fiber media, Losses in fibre, Optical fiber source and detector, Optical joints and Coupler, Fiber characteristics; Basic principles of optical fiber communication, Digital optical fiber communication system.

Module-III

Advanced Analog and Digital Circuits : Buffer, precession rectifier, Comparators; regenerative comparator; function generator (sine, square and triangular), phase locked loop(PLL): Phase detector, Voltage Controlled Oscillator, Block diagram of PLL, operations, Lock-in-Range, Capture Range, Application of PLL; Switched capacitor, MOSFET realization; idea of sequential circuit design; state diagrams, state table and synthesis of clocked sequential circuits, programmable logic devices – PLA, PAL, GAL, Programmable gate arrays.

Books:

1. Sze: Physics of Semiconductor Devices-Wiley Inter-science.

2. Grove: Physics and Technology of Semiconductor Devices-John Wiley.

3. Streetman: Solid State Electronic Devices-Prentice Hall India.

4. Lengyel: Introduction to Laser Physics-Wiley Inter-Science.

5. Gower: Optical Communication Systems-Prentice Hall India.

6. Keiser: Optical Fiber Communications-Tata McGraw Hill.

7. Senior: Optical Fiber Communication-Prentice Hall India.

8. Gandhi: Theory and Practice of Microelectronics-John Wiley.

9. Hovel: Solar Cells (Semiconductors and Semimetals, Vol. II)-Academic Press.

10. Green: Solar Cells-Operating Principles, Technology and System Application-Prentice Hall.

11. D. Roy Chowdhuri and Jain, Linear Integrated Circuits, New Age International (P) Ltd.

12. Gray, Hurst, Lewis and Meyer, Analysis and Design of Analog Integrated Circuits, Wiley

13. R P Jain, Modern Digital Electronics, Tata McGraw-Hill

14. Milman and Grable, Microelectronics. Tata McGraw-Hill

15. Malvino and Leach: Digital Principles and Applications – Tata McGraw Hill.

DSE402 C. Solid State Physics-I

Course Outcome: Students will acquire advanced theoretical knowledge of lattice dynamics, magnetic properties of matter, x-ay scattering and neutron scattering. Integrating these properties, they will be able to figure out solutions for some specific problems, generate ideas for some device fabrication and its utilization in research.

Course Contents:

Module-I

Electron states in Solids: Crystalline Solids: Pseudo potential approach; APW; OPW (qualitative).

Non-crystalline Solids : Electronic density of states; Greens function for single and two impurity states using tight-binding Hamiltonian; idea of Anderson localization; Scattering diagrams; average T-matrix approximation and CPA. Vibration states and low temperature properties of non-crystalline solids.

Lattice Dynamics: Born Oppenheimer approximation and separation of nuclear and electron motions; inter nuclear potentials; lattice Hamiltonian, harmonic approximation, cubic and quadratic terms; force constants and their symmetries. Dynamical matrix, normal coordinates quantization of lattice vibration, Phonons, Grüneisen formula.

Second Quantisation: Notations and Definitions, Interaction Hamiltonian in second quantized form; Applications of Second Quantisation.

Module-II

Diamagnetic properties of metal: Landau diamagnetism; de Hass van Alphen effect; Quantum Hall effect

Magnetic Ordering: Exchange interaction in real systems: Domain wall and Anisotropy energy; double exchange; super exchange; RKKY interaction.

Itinerant ferromagnetism: Exchange interactions between free electrons and exchange hole; Band model of ferromagnetism; Stoner criterion, Temperature behaviour of a ferromagnet in the band model; Exchange enhancement of Pauli susceptibility

Spin wave: Spin waves in ferromagnets; Holstein-Primakoff transformation; Dispersion relation for magnons, magnon heat capacity. Spin waves in antiferromagnets; Ground state energy; Dispersion relation for antiferromagnetic magnons. Magnetic phase diagram; critical points and critical exponents.

Module-III

Magnetic Resonance and Relaxation:

Basic Theory: Quantum mechanical description of spin in a static field; rotating magnetic field; Bloch equation and its solution in weak radio-frequency field. Local field; magnetic dipole broadening and method of moments. Magnetic interaction of nuclei with electrons; quenching orbital motion and chemical shift; Fermi contact interaction; Knight Shift.

Spin-lattice Relaxation: Spin temperature and spin-lattice relaxation time; relaxation of nuclei in metals and Korringa relation.

X-ray Scattering: Debye Waller factor; fundamental and superstructure reflection determination of long range order parameter.

Neutron scattering: Scattering cross-section; scattering from single nucleus, composite target and crystals; elastic and inelastic scattering; incoherent and coherent scattering; magnetic scattering of neutrons; scattering by ions with spin and angular momentum; applications of neutron diffraction technique to identify magnetic ordering.

References:

1. Ashcroft and Mermin: Solid State Physics-Saunders.
2. Ibach and Luth: Solid State Physics – Narosa.
3. White: Quantum Theory of Magnetism – Springer Verlag.
4. Matis: Theory of Magnetism, Vol, I-Springer Verlag.
5.:Charles Kittel: Quantum Theory of Solids, John Wiley & Sons
6. Ziman; Principles of Theory of Solids – Cambridge.
7. Madelung : Solid state Physics – Springer Verlag.
8. Callaway: Quantum Theory of Solids, Vols. I and II-Academic Press.
9. Harrison: Solid State Theory – Tata McGraw Hill.
10. Azaroff : X-ray Crystallography – Academic Press.
11. Squires: Thermal Neutron Scattering – Cambridge.
12. Lovesey : Theory of Neutron Scattering – Cambridge.

DSE403 **A. Particle Physics**

Course Outcome: ***The course emphasizes on how the fundamental particles and their interactions can be realized through the principles based on the special theory of relativity, quantum mechanics, group theory and symmetry principles. After completion of this course, the students will be equipped with the knowledge and techniques to go for the advanced courses as well as to opt for research career in this field.***

Course Content:

Module-I

Group Theory : Lie group, generators, Casimir operators, irreducible representations, U(1), 0(3), SU(2), SU(3) and SU(n), root and weight diagrams, Young tableaux. Proper and improper Lorentz Transformations, SL(2,C) representations, Poincare group.

Hadron Structure and Strong Interactions: Group theoretical construction of hadron states connection with quark model; SU(2) and isospin; SU(3) and hypercharge; properties of hadrons as predicted by group theory; symmetry breaking; Gell-Mann-Nishijima-Okubo mass formula; mixing.

Gauge Field: Gauge invariance in classical electromagnetism and quantum mechanics; global and local gauge transformations; abelian and non-abelian gauges; examples U(1) and SU(3); local gauge invariance; Yang Mills fields; QED.

Module-II

Electromagnetic Interactions: Perturbation Theory: Time ordered and normal ordered products; Wicks theorem; propagators and Greens functions; vacuum expectation values; S matrix; Dysons expansion; Feynman rules; crossing symmetry; cross-section and decay rates.

Applications of perturbation theory: Compton effect and other examples. Radiative Corrections: one loop renormalization; regularization and power counting; renormalization-charge, mass and vertex corrections.

Weak Interactions: Phenomenology: Parity violation and V-A interaction; calculation of typical lifetimes (neutron, pion and muon decays). CVC and PCAC; charged and neutral currents; sum rules; Cabbibo theory; intermediate vector bosons.

Module-III

Vacuum: Goldstone theorem; spontaneous symmetry breaking; massive gauge bosons and Higgs mechanism; electroweak interactions and the Weinberg Salam Glashow model; Lagrangian and Feynman rules for electroweak interactions; weak electromagnetic ,W and Z decays, lifetimes, widths and branching ratios.

Nucleon Structure: Probing a charge distribution with electrons form factors; elastic e-p scattering nucleon from factors, inelastic lepton hadron scattering structure functions; Bjorken scaling and partons; Adler sum rules; hadron production in e+,e-scattering, Drell Yan process.

Quantum chromo dynamics: Non-abelian SU (3) gauge invariance and QCD; QCD Lagrangian and Feynman rules; color; quark-quark interaction; gluons and gluon coupling; jets; confinement and asymptotic freedom. The Standard Model: some tests for the model.

Books:

1.Halzenand Martin: Quarks and Leptons-John Wiley.

2.Bjorken and Drell: Relativistic Quantum Mechanics-McGraw Hill.

3.Bjorken and Drell: Relativistic Quantum Fields-McGraw Hill.

4.Mandl and Shaw: Quantum Field Theory-John Wiley.

5.Itzykson and Zuber: Quantum Field Theory-McGraw Hill.

6.Ryder: Quantum Field Theory-Cambridge.

7.Cheng and Li: Gauge Theories of Elementary Particle Physics-Oxford.

8.Close: An Introduction to Quarks and Partons-Academic Press.

9.Martin and Shaw: Elementary Particles-John Wiley.

10.Perkins: Introduction to high Energy Physics-Addison Wesley/Cambridge.

11.Hughes: Elementary Particles-Cambridge.

12.Griffiths: Introduction to Elementary Particles-John Wiley.

13.Kane: Modern Elementary Particle Physics-Addison Wesley.

14.Muirhead: Physics of Elementary Particles-Pergamon.

DSE403 B. Advance Electronics II

Course Outcome: The course is intended to introduce to the students the different areas of electronics like communication systems, microcontrollers and microprocessor. The students will be able to apply their knowledge of electronics to the various aspects of system design using the electronic circuits and to other branches of physics.

Course Content:

Module-I

Communication Fundamentals : Antennas: Basic Considerations; antenna parameters; current distributions; short electric doublet; half wave dipole; longer antenna; effect of ground; image antenna; Field strength at a point close to the antenna; microwave antenna and other directional antennas.

Propagation of Radio Waves: Types: Ground and surface wave propagation; ionospheres; virtual heights and critical frequencies of layers; propagation of radio waves through ionosphere; loss of energy in the ionosphere; skip distance and MUF; single hop and multi-hop transmission; Chapmans theory (deduction not required); influence of earth's magnetic field; Appleton Hartree formula (deduction not required); Propagation of microwaves through space; environmental effects; radiometer; microwave radiation hazards.

Radar Communication: Duplexer, Radar display, Doppler Radar, CWIF Radar, FMCW Radar, Moving Target Indicator (MTI), Blind Speeds, Radar Applications.

Module-II

Digital Communication: Pulse modulation: PAM, PWM, PPM, Pulse code modulation, coding technique, modulation and demodulation; Digital modulation: ASK, FSK, CPFSK, MSK, PSK, QPSK, DPSK, Principle, modulators and demodulators, carrier recovery circuits, time division multiplexing; digital signal; bit transmission and signalling rate; sampling theory and analysis; error probability and error check; UART and modem; electronic exchange.

Satellite Communication: Principle of satellite communication; satellite frequency allocation and band spectrum, communication satellite link design; digital satellite communication; multiple access techniques; demand assignment control; spread spectrum technique; code division; satellite orbit and inclination; satellite link design, satellite applications, ideas of global communication network.

Module-III

8085 µP: Programming techniques: looping, Counting and Indexing, Data Transfer and 16-bit data operations, Logic operations; Stack and subroutines; Interfacing I/O devices and data converters; 8085 interrupts and interrupts controller; I/O ports; PPI(8255A); Serial I/O and data communication

8086µP: fundamentals; Memory segmentation; Interrupt handling; Idea of the recent advances of microprocessors

Microcontroller: Basic concepts of microcontroller 8051; architecture and programming model.

References:

1. Terman: Electronic and Radio Engineering – McGraw Hill.
2. Kraus: Antenna – McGraw Hill.
3. Reich, Ordnung and Skalnick: Microwave Principles – Affiliated East West Press.
4. Sarkar: Microwave Propagation and Technique – S. Chand.
5. Jordan and Balmain: Radiation and Radiating Systems – Prentice Hall India.
6. Kennedy: Electronic Communication Systems – Tata McGraw Hill.
7. Taub and Schilling: Principles of Communication Systems – Tata McGraw Hill.
8. Carlson: Communication Systems – Tata McGraw Hill.
9. Haykin: Communication Systems – John Wiley.
10. Roddy and Coolen, Electronic Communications, Pearson
11. Gaonkar: Microprocessor Architecture, Programming and Applications with 8085, PRI
12. Malvino: Digial Computer Electronics – Tata McGraw Hill.
13. D. V. Hall: Microprocessor and interfacing – Tata McGraw Hill.

DSE403 C. Solid State Physics II

Course Outcome: *Students will acquire advanced theoretical knowledge of transport, optical, dielectric and superconducting properties of matter. Integrating these properties, they will be able to figure out solutions for some specific problems, generate ideas for some device fabrication and utilize in research application.*

Course Contents:

Module-I

Many Body Physics: Interacting Fermi system; quasi-particles and their energies; Hartree-Fock approximation: exchange energy and quasi-particle energy in HF approximation; Landau Theory of the Fermi Liquid and calculation of equilibrium properties (Specific Heat; compressibility and spin susceptibility); Effective mass and Galilean Invariance.

Transport Properties: First and zero sound. Single particle propagator; spectral representation; Greens function for quasi-particles; retarded response functions; density fluctuation excitations and collective modes.

Electron Transport: Collision term: relaxation time approximation; Kubo-Greenwood formulation of the transport problem; electrical conductivity; thermal conductivity; thermo emf; Peltier coefficient; Thomson coefficient-single and multiple charge carriers.

Module-II

Dielectric and Optical Properties of Solids : General Survey of Optical Properties of Solids; responseof a crystal to electromagnetic fields; dielectric function and long wavelength dielectricresponse of an electron gas to an electric field; plasma oscillation; dispersion relation for electromagnetic wave; Kramers-Kroenig relations; dispersion relations for dielectric function and $\varepsilon(\omega)$.

Inter band transition: Derivation of Sum Rules; Friedel sum rules and oscillations; Inter band transition processes, Semiconductors and separation of conduction electron; Direct and indirect inter band transitions; simple theory of optical absorption due to inter band transition.

Optical properties and band structure: Excitons: Mott-Wannier excitons, Frenkel excitons.

Module-III

Microscopic Description of Superconductivity: Macroscopic Quantum Description of the Supercurrent; The Supercurrent Equation; The London Equations; The Two-Fluid Model; Flux Quantization.

Phenomenological theories of superconductivity: Superconducting order parameter and Ginzburg Landau equations; G-L coherence length and kappa parameter; flux quantization; upper critical field; surface energy; Josephson Effect and applications.

Microscopic Theory of Superconductivity: Froehlich effective electron-electronattraction; Copper pairing; the Bogoliubov-Valatin transformation; BCS theory of the ground state of

Type I superconductors; significance of the energy gap parameter; the transition temperature; elementary excitations in superconductors; density of states.

SQUID magnetometer; Coexistence of superconductivity and magnetism;

References:

1. Pines and Nozieres: Theory of quantum Liquids-Benjamin.
2. Schrieffer: Superconductivity-Pergamon.
3. Ibach and Luth: Solid State Physics-Narosa.
4. Abrikosov, Gorkov and Dzyaloshinski: Methods of Quantum Field Theory in Statistical Physics-Dover.
5. Fetter and Walecka : Quantum Theory of Many Particles Systems-McGraw Hill.
6. Tinkham: Superconductivity-McGraw Hill.
7. Ziman: Principles of the Theory of Solids-Tata McGraw Hill.
8. Kittel: Quantum Theory of Solids-John Wiley.
9. March and Jones: Quantum Theory of Solids, Vols. I and II-Dover.
10. Callaway: Quantum Theory of Solids, Vols. I and II Academic Press.
11. Slichter: Principles of Magnetic Resonance-Springer Verlag.
12. Seeger: semiconductor Physics-Springer Verlag.
13. Kireev: Semiconductor Physics-MIR.

DSE404 A. Applied Nuclear Physics and Nuclear Astrophysics

Course Outcome: The students are expected to learn the physics of nuclear fission and nuclear reactor, nuclear fusion and tokomak, nuclear radiation hazard and radiation dosimetry.

Course Content:

Module-I

Neutron Physics and Reactor Physics : Neutron sources and detectors, interaction of neutrons with matter, moderation of neutron, diffusion equation, Fermi age equation, thermal nuclear reactors, Four factor formula, critical criterion of a thermal reactor, critical size of reactors with different shapes.

Nuclear Fission and Nuclear Fusion : Energy release in fission, Nature of the fission fragments, Energy distribution between the fission fragments, Emission of neutrons in nuclear fission, Energetics of fission process, Bohr Wheeler theory, Cross section of neutron induced fission, Particle induced and photofission, Shell effect and shape isomerism, Nuclear fusion and thermo-nuclear reaction, Cross section of fusion reaction, Lawson Criterion, Different methods of satisfying Lawson criterion, Magnetic confinement, Toroidal confinement; Tokamak.

Module-II

Nuclear Astrophysics: The Hertzsprung-Russell diagram (HRD), Electromagnetic spectra and abundance determinations, Neutrino astronomy, evolution of stellar structure, Spallation reactions; nuclear abundances and steller nuclear reactions;

The Big Bang contribution to primordial nucleosynthesis, Dark matter and Dark energy; The chemical evolution of galaxies;

Energy production in the Sun; solar neutrino problem; non-explosive stellar evolution and concomitant nucleosynthesis;

The hot modes of hydrogen burning, The He to Si explosive burnings, Supernova; the s-process, r-process and the p-process; Heavy-element nucleosynthesis by the s-and r-processes of neutron captures; neutron stars; Nuclear Cosmochronology.

Module-III

Applications: Trace Element Analysis using XRF, PIXE, NAA; Mass Spectrometry with Accelerators, material modification by swift heavy ion radiation, Radioactive Dating, Man-made sources of radiation.

Biological effects of radiation: Physical and chemical damage; dose, dose rate; damage of tissue levels, Radiation shielding and its safety, Diagnostic and therapeutic nuclear Medicine; Projection Imaging, with internal and external radiation, computed Tomography, Magnetic Resource Imaging Principles, Radiation therapy.

References:

1. M. K. Pal : Theory of Nuclear structure (EWA press)
2. Cohen : Concepts of Nuclear Physics (Tata McGraw Hill)
3. Wong : Introductory Nuclear Physics (Prentice Hall)
4. Blatt and Weiskopff : Theoretical Nuclear Physics (Dover)
5. Evans : The Atomic Nucleus (McGraw Hill)
6. Roy and Nigam : Nuclear Physics (New Age International)

7. S. N. Ghoshal : Nuclear Physics (S Chand Publication)
8. Y.M. Jana : An Introduction to Nuclear Physics (Narosa, New Delhi)
9. Krane : Introductory Nuclear Physics (Wiley India, New Delhi).
10. Lilley : Nuclear Physics –Principles and Applications, (Wiley India).

DSE404 B. General theory of Relativity and Cosmology

Course Outcome: The students will be able to learn the basic principles and formalism of classical field theory in general, and in particular the application of these to problems in gravitation and cosmology. The students will have the basic concepts and methods of differential geometry as applied to general relativity after successful completion of the course.

Course Content:

Module-I

General Relativity: Special relativity, Conceptual foundation of GR and curved space-time, Principle of equivalence, Gravity and geometry, Form of the metric and Newtonian limit, Metric tensor and its properties, Concept of curved space-time, Tangent space and four vectors, Tensor algebra and calculus, Covariant differentiation and parallel transport, Riemann curvature tensor, Geodesic and particle trajectories in gravitation field.

Module-II

Einstein's field equations: Einstein's field equation, Definition of the stress tensor, Bianchi identities and conservation of the stress tensor, Einstein's equation for weak gravitational fields and the Newtonian limit.

Sarzschild metric and related topics: Derivation of the metric and its basic properties, $r = 2m$ surface, Effective potential for particle and photon orbits in Schwarzchild metric, Deflection of ultra-relativistic particles, Gravitational red-shift.

Standard Cosmology: The structure of the universe, Cosmological principle, FRW model (closed, open and flat universe), Critical density, Perfect fluid and dynamical equations of cosmology, Hubble's law, Cosmological constant, de Sitter universe, Composition of the energy density of the universe, Dark matter, Dark energy.

Module-III

ΛCDM Cosmology:

Hubble's observation and expanding universe; Friedmann cosmology; Red shift and expansion; Big bang theory; Constituents of the universe; Dark matter and dark energy (as a nonzero cosmological constant); Early universe and decoupling; Neutrino temperature; Radiation and matter-dominated phases; Cosmic microwave background radiation, its isotropy and anisotropy properties; COBE, WMAP and Planck experiments; CMBR anisotropy as a hint to large scale structure formation; Flatness, horizon, and relic abundance problems; Inflation and the slow-roll model.

Books:

1. General Relativity and Cosmology, J. V. Narlikar, Macmillan India

2. General Relativity, I. R. Kenyon, Oxford

3. Classical Theory of Fields, L.D. Landau & E.M. Lifshitz (Volume 2 of A Course of Theoretical Physics) Pergamon Press.

4. Gravitation: Foundations and Frontiers, T. Padmanabhan 1 st ed., Cambridge University Press

5. Theoretical Astrophysics : Galaxies And Cosmology, Vol 3, 1 st ed., T. Padmanabhan, Cambridge University Press

6. First course in general relativity, 2nd ed., B. F. Schutz, Cambridge University Press

7. Introduction to Cosmology, 3rd ed., J. V. Narlikar, Cambridge University Press

DSE404 C. Applied Electronics

Course Outcome: Students will have sound technical skills in electronics and instrumentation which includes doping, Computer Networking, Digital Image processing.

Course Content:

Module-I

Crystal Growth: Growth of single crystals by Czochralski technique, distribution coefficient, rapid-stirring and partial-stirring conditions; zone processes.

Epitaxial Growth of Semiconductors: Epitaxial growth of silicon layer by vapour phase reduction of silicon tetrachloride; kinetics of growth, mass-transfer control and surface-reaction control conditions. Molecular beam epitaxy.

Thin Films: Production of thin films, conductivity and other properties of different types of thin films. Thin film solar cells.

Thermal Oxidation and Doping: Formation of silicon dioxide layer on silicon; kinetics of oxide growth, diffusion-controlled and reaction-controlled cases; expression of oxide layer thickness as a function of time, Doping of impurities, Ion implantation technique.

Module-II

Computer Networking : Principle of computer networks, Circuit switching; Message switching; Packet switching; classification of different type of networks, merits and demerits; LAN, MAN, WAN and their applications, Network topologies; Star, Ring, Tree, Bus topologies; Internet; Network Model, Layered concept, Hierarchy, OSI model, Layers in OSI model, TCP/IP protocol, Addressing.

Cellular Mobile Communication: Frequency reuse, Handoffs, Interference and capacity, Fading, multiple access techniques: FDMA, TDMA, CDMA, major wireless standards.

Module-III

Digital Image processing: Basic concept; image capture; image sampling and quantization; spatial and intensity resolution; basic mathematical tools for image processing; zooming and interpolation; Geometrical transformation; affine transform; outline of image analysis and recording.

Television: Basic concept; TV camera; Display; Scanning; Composite video signal; Receiver block diagram; Color TV system; Concepts of modern TV circuit, Flat TV; Different mode of distribution network.

References:

1. Grove: Physics and Technology of Semiconductor Devices-John Wiley.

2. Holland: Vacuum Deposition of Thin Films-Chapman and Hall.

3. Chopra: Thin Films-McGraw Hill.

4. Gandhi: Theory and Practice of Microelectronics-John Wiley.

5. S.K. Gandhi: VLSI Fabrication Principles: Silicon and Gallium Arsenide- Wiley

7. Chopra and Das: Thin Film Solar Cells-Plenum Press.

8. Tanenbaum: Computer Networks – Prentice Hall.

9. Bertsekas and Gallaghr: Data Network – Prentice Hall.
10. Stallings: Data and Computer Communications – Prentice Hall.
11. B. A. Forouzan: Data Communications and Networking- McGraw Hill
12. Gonzalez and Woods: Digital image processing – Prentice Hall.
13. Jain: Fundamentals of Digital Image Processing – Prentice Hall India.
14. Kennedy: Electronic Communication Systems – Tata McGraw Hill.
15. Gulati – *Monochrome and Color TV,* New Age International Publisher
16. Gibson, Mobile communication Handbook, CRC, IEEE press
17. *William C.Y.Lee*: *Mobile Cellular Telecommunications Analog and Digital Systems*- Tata McGraw Hill.
18. Kennedy: Electronic Communication Systems – McGraw Hill.

DSE404. D. Materials Science

Course Outcome: The students will be able to explain the properties of nanomaterial's, liquid crystals, high temperature superconductor, and nanofluid. They will also understand the theories and mechanisms to explain the exotic properties as observed in these materials.

Course Content:

Module-I

Quantum confined systems: Quantum confinement and its consequences, quantum wells, quantum wires and quantum dots and artificial atoms. Electronic structure from bulk to quantum dot. Electronic structure calculations by abinitio, tight binding, empirical potential and density functional methods. Electron states in direct and indirect gap semiconductors Nano crystals. Confinement in disordered and amorphous systems. Elementary idea about Graphenes, Idea of spin transport in low dimensional systems (Spintronics).

Module-II

Experimental Nano science: Introduction; particle size dependent phenomenon inmaterials; classical nucleation theory and cluster formation; Physical methods; Inert gas consideration; chemical vapour deposition; PLD; mechanical milling.

Chemical methods: Growth of nanostructures, Sol-gel, hydrothermal, Solvo-thermal, metal reduction methods.

Characterization Techniques:X-Ray diffraction; Scanning Electron Microscopy;Transmission Electron Microscopy; UV-visible.

Properties of nanomaterial: Mechanical, electrical, magnetic, optical properties.

Module-III

Liquid crystals: Basic idea; Nematic, Cholestoric and Smectic phases; Discotic and Columner phases; phase sequences and phase diagrams; order parameter.

High Temperature Superconductivity: Introduction and experimental results; Normal state properties. Electronic models: Three-band model; One-band models. Algorithms: Lanczos technique.

Nanofluids: Definition; Different types of nanofluids; Heat transfer investigations using nanofluids; Fabrication, Stability and Thermophysical properties of nanofluids; Molecular dynamics modelling of thermophysical properties; Future work.

Suggested Books

l. Nanostructures-Theory & Modelling by C. Delerueand M. Launoo (Springer, 2004)

2. Nanostructure by V. A. Shchukin, N. N. Le eutsov and D. Birnberg (Springer, 2004)

3. Characterization of Nanophase Materials by Z. L. Wang (Ed.) (Wiley-VCH, 2000)

4. Semiconductor Nanocrystal Quantum Dots by A. L. Rcgach (Ed.) (Springer Wien NY, 2008)

5. Introduction to Nanotechnology by C. P. Poole Jr. & F. J. Owens (Wiley-Interscience, 2003)

6. High-T_c superconductivity and the C_{60} family, Ed. By Sunqi Feng and Hai-Cang Ren, Gordon and Breach Publishers.

7. G. R. Stewart, Rev. Mod. Phys. **56**, 755 (1984)

8. J. G. Bednorz and K. Müller, Z. Phys. B **64,** 189 (1986)

9. P. W. Anderson, Science **235**, 1196 (1987)

10. E. Dagotto, Rev. Mod. Phys. **66**, 763 (1994)

11. Nanofluids: Science and Technology by Sarit K. Das, Stephen U. S. Choi, Wenhua Yu, T. Pradeep - Wiley-Interscience

12. Nanofluids and Their Engineering Applications by K. R. V. Subramanian, Tubati Nageswara Rao, Avinash Balakrishnan – CRC Press

13. N. Ali, J. A. Teixeira, and A. Addali, A Review on Nanofluids: Fabrication, Stability, and Thermophysical Properties, Journal of Nanomaterials, Vol.2018, Page 1 – 33, (2018).

DSE405 Advanced Practical-(II)

(Any six practical should be done taking at least one practical from each section)

A. Solid State Physics

1. To interpret a Debye-Scherer powder X-ray photograph for a sample and to determine the dimensions of the unit cell and the number of atoms in it.

2. To interpret a Laue photograph and to identify the crystal planes.

3. To interpret rotation oscillation photographs and to determine lattice parameters.

4. To handle a goniometer, to study the external symmetry of single crystals and to verify the law of rotational indices.

5. Determination of density of color centers induced in alkali halides.

6. Study of thermoluminiscence.

B. Nuclear Physics

1. Determination of half-life of Indium by thermal neutron activation and study of beta ray absorption.

2. Determination of half-lives of the complex beta source produced by neutron activation of silver.

3. Estimation of percentage of silver in a sample by neutron activation.

4. Study of growth of radioactivity in a sample by neutron activation.

5. Determination of ratio of thermal neutron capture cross sections of 103Rh to 103Rh*

and to 104Rh ground sate, and estimation of the spin cut-off parameter.

C. Electronics

1. Design and construction of an IC regulated and stabilized power supply (constant voltage/constant current) and the study of its characteristics.

2. Design and construction of a multistage amplifier using BJTs and FETs and the study of its gain and bandwidth.

3. Design and construction of a simple pulse generator of variable frequency and width using IC 555 timer.

4. OP AMP based experiments: active filters, Wien bridge oscillator.

5. Construction and application of OP AMP comparator, Schmidt triggers.

6. Experiment based on PLL.

7. Experiment on Pulse Modulation using IC 555 timer.

Project/ dissertation

Course Outcome: The project or dissertation course is offered to motivate a student to take a research problem and pursue theoretical or experimental work under the mentorship of a faculty member. This course is an open invitation to a student for out of box thinking to provide a solution to a physics problem.

Note: The faculty members of the department are usually the supervisors. The faculty members from other academic institutes/colleges also supervise some of the projects/dissertations. The department will notify regarding the selection process and the probable vacancies.