Department of Physics, CUH
Session : 2016-2018
Syllabus scheme for M.Sc. (Physics) under Choice Based Credit System (CBCS)

Course Type

- Core Course (CC)
- Generic Elective Course (GEC)
- Discipline Centric Elective Course (DCEC)
- Skill Enhancement Elective Course (SEEC)

Total Credits : 102

Semester wise distribution of credits : 24 + 28 + 26 + 24

Semester I

Course	Course Code	Credits	Course Type
Mathematical Methods in Physics	SPMS PHY 01 101 CC 3104	4	CC
Classical Mechanics	SPMS PHY 01 102 CC 3104	4	CC
Quantum Mechanics	SPMS PHY 01 103 CC 3104	4	CC
Laboratory I	SPMS PHY 01 104 CC 00126	6	CC
Numerical Methods and Programming	SPMS PHY 01 101 GEC 3104	4	GEC*
Modern Optics	SPMS PHY 01 102 GEC 3104	4	GEC*
Introduction to Experimental Physics	SPMS PHY 01 103 GEC 3104	4	GEC*
Seminar Presentation I	SPMS PHY 01 101 DCEC 0202	2	DCEC

Semester II

Course	Course Code	Credits	Course Type
Statistical Mechanics	SPMS PHY 01 201 CC 3104	4	CC
Classical Electrodynamics	SPMS PHY 01 202 CC 3104	4	CC
Electronics	SPMS PHY 01 203 CC 3104	4	CC
Laboratory II	SPMS PHY 01 204 CC 00126	6	CC
Latex for Science & Mathematics	SPMS PHY 01 201 GEC 3104	4	GEC*
Environmental Physics	SPMS PHY 01 202 GEC 3104	4	GEC*
Computational Physics	SPMS PHY 01 201 DCEC 3104	4	DCEC
Advanced Quantum Mechanics I	SPMS PHY 01 202 DCEC 3104	4	DCEC

Course	Course Code	Credits	Course Type
Seminar Presentation II	SPMS PHY 01 203 DCEC 0202	2	DCEC

This GEC* course can only be taken by the students of other departments. The department may offer more than one elective courses depending on specialisation and strength of faculty members, and the student has to opt one of them.

Semester III

Course	Course Code	Credits	Course Type
Atomic, Molecular Physics and Laser	SPMS PHY 01 301 CC 3104	4	CC
Nuclear & Particle Physics	SPMS PHY 01 302 CC 3104	4	CC
Solid State Physics	SPMS PHY 01 303 CC 3104	4	CC
Laboratory III	SPMS PHY 01 301 CC 00126	6	CC
Physics of Electronic Material and Devices	SPMS PHY 01 302 DCEC 3104	4	DCEC
Electronic Communication	SPMS PHY 01 303 DCEC 3104	4	DCEC
Thin Film and Integrated Devices	SPMS PHY 01 304 DCEC 3104	4	DCEC
Laser & Spectroscopy	SPMS PHY 01 305 DCEC 3104	4	DCEC
Microprocessor and Microcontroller	SPMS PHY 01 306 DCEC 3104	4	DCEC
Physics of Nanomaterials	SPMS PHY 01 307 DCEC 3104	4	DCEC
Nuclear Physics: Interaction and Model	SPMS PHY 01 308 DCEC 3104	4	DCEC
Advanced Quantum Mechanics II	SPMS PHY 01 309 DCEC 3104	4	DCEC
Advanced Statistical Mechanics	SPMS PHY 01 310 DCEC 3104	4	DCEC

Semester IV

Course	Course Code	Credits	Course Type
Project/Dissertation	SPMS PHY 01 401 PROJ 00024	24	PROJECT
Nonlinear Dynamics	SPMS PHY 01 402 SEEC 3100	—	SEEC
Astrophysics, Gravitation and Cosmology	SPMS PHY 01 403 SEEC 3100	—	SEEC

Mathematical Methods in Physics

Course Code: SPMS PHY 01 101 CC 3104

Matrices, Group Theory and Tensors:
Linear vector spaces, matrix spaces, linear operators, eigenvectors and eigenvalues, matrix diagonalization, special matrices.
Symmetries and groups, multiplication table and representations, permutation group, translation and rotation groups, O(N) and U(N) groups.
Tensors: Coordinate transformations, scalars, contravariant and covariant vectors, mixed and covariant tensor of second rank, addition, subtraction and contraction of tensors, quotient rule. Christoffel symbols, transformation of Christoffel symbols, covariant differentiation, Ricci's theorem, divergence, Curl and Laplacian tensor form, Stress and strain tensors, Hook's law in tensor form.

Second Order Differential Equations and Special functions:
Separation of variables-ordinary differential equations, singular points, series solutions leading to Legendre, Bessel, Hermite, Laguerre functions as solutions. Orthogonal properties and recurrence relations of these functions. Spherical harmonics and associated Legendre polynomials. Sturm-Liouville systems and orthogonal polynomials. Wronskian linear independence and linear dependence.

Complex Variables:
Functions of complex variable, Limits and continuity, differentiation, Analytical functions, Cauchy-Riemannn conditions, Cauchy Integral theorem, Cauchy integral formula, Derivatives of analytical functions, Liouville's theorem. Power series Taylor's theorem, Laurent's theorem. Calculus of residues–poles, essential singularities and branch points, residue theorem, Jordan's lemma, singularities on contours of integration, evaluation of definite integrals.

Integral Transforms:
Fourier Transforms: Development of the Fourier integral from the Fourier Series, Fourier and inverse Fourier transform, Simple Applications: Finite wave train, Wave train with Gaussian amplitude, solution of wave equation as an application. Convolution theorem. Intensity in terms of spectral density for quasi monochromic EM Waves, Momentum representation. Laplace transforms and their properties. Convolution theorem. Application of Laplace transform in solving linear, differential equations with constant coefficient, with variable coefficient and linear partial differential equation.

References:

1. **George Arfken**, Mathematical Methods for Physicists, Academic Press.
2. **L. A. Pipe**, Applied Mathematics for Engineers and Physicists, McGraw Hill.
3. **Merle C. Potter and Jack Goldberg**, Mathematical Methods, Prentice Hall of India.
4. **Fredrick W. Byron and Robert W. Fuller**, Mathematics of Classical and Quantum Physics, Dover Publications.
5. **E.Kreyszig**, Advanced Engineering Mathematics, John Wiley & Sons.
6. **K.F.Riley, M.P. Hobson, and S.J.Bence**, Mathematical methods for Physicists and Engineers Cambridge University Press.

Classical Mechanics

Course Code: SPMS PHY 01 102 CC 3104

Lagrangian Equation of Motion & Central Force Problem:
Newtonian mechanics of one and many particle systems, Virtual work, Constraints: holonomic and non-holonomic, D'Alembert's Principle and Euler-Lagrange Equation of motion, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Conservation theorems and Symmetry Properties, Noether's theorem.
Two body central force problem: Reduction to equivalent one body problem, equation of motion and first integrals, Equivalent one-dimension problem and classification of orbits. Inertial and Non-inertial frame of references, Coriolis force.

Hamilton's Equations of Motion:
Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical equation from Hamilton's variational principle. The principle of least action.

Canonical Transformation and Hamilton-Jacobi Theory:
Canonical transformation, integral invariant of Poincare, Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouville's theorem. Hamilton-Jacobi equation and its application. Action angle variable: adiabatic invariance of action variable,the Kepler problem in action angle variables.

Small Oscillations &Rigid Body Motion:
Stable and unstable equilibrium; Theory of small oscillations in Lagrangian formulation, normal coordinates and its applications, Free vibration of linear harmonic oscillator. Orthogonal transformation, Euler's theorem, Eigenvalues of the inertia tensor, Euler equations, force free motion of a rigid body.

References:

1. **Herbert Goldstein, Charles Poole, John Safko,** Classical Mechanics, Pearson Education.
2. **L.D. Landau and E.M. Lifshitz,** Mechanics, Butterworth-Heinemann.
3. **N.C. Rana and P.S. Joag,** Classical Mechanics, McGraw Hill.
4. **Ronald L. Greene,** Classical Mechanics with Maple, Springer.
5. **A.Sommerfeld,** Mechanics, Academic Press.
6. **I. Percival and D. Richards**, Introduction to Dynamics, Cambridge University Press.

Quantum Mechanics

Course Code: SPMS PHY 01 103 CC 3104

Origin of Quantum Physics:
Review of chronological developments of quantum mechanics; Particle aspects of wave: Black Body Radiation, Photoelectric Effect, Compton Effect, Pair Production; Wave aspects of particle: de Broglie hypothesis, Davisson & Germer's experiment; Wave--Particle Duality.Stren-Gerlach experiment for spin 1/2 system.

Structure of Quantum Mechanics (QM)
Linear spaces and Operators:Vector spaces, Linear independence, Bases, Dimensionality. Linear Transformations, Similarity Transformations; Eigen values and Eigen vectors. Inner product, Orthogonality and Completeness; Gramm Schmidt Orthogonalization Procedure.
Structure of Quantum Mechanics**:** Postulates of QM, Hilbert space; Hermitian and Unitary Operators; Orthonormality, Completeness and Closure. Dirac's bra and ket notation. Matrix Representation and Change of Basis. Operators and Observables, Significance of eigenvector and eigenvalues, Commutation relation; Uncertainty principle for two arbitrary Operators.

Quantum Dynamics:
Problem inone dimension (1D) with different types of potential functions such as particle in box, barrier potential, harmonic oscillator: analytical and algebraic methods. 3 D problems: Hydrogen Atom.

Angular Momenta &Approximate Analysis:
Orbitalangular momentum, angular momentum algebra, raising and lowering operators; Matrix representation for j = 1/2 and j = 1; Spinangular momentum; Addition of two angular momentum, Clebsch-Gordan (CG)Coefficients.
Perturbation Theory: Time-independent non-degenerate and degenerate cases, Time-dependent perturbation theory; variational methods, and WKB method.

References:

1. **Ashok Das and A.C. Melissinos,** Quantum Mechanics, Gordon and Breach Science Publishers.
2. **P.A.M. Dirac,** Lectures on Quantum Mechanics, Dover Publications.
3. **R.Shankar,** Principles of Quantum Mechanics, Springer.
4. **Albert Messiah,** Quantum Mechanics, Dover Publications.
5. **L.I. Schiff,** Quantum Mechanics, McGraw Publications.
6. **Claude Cohen,** Quantum Mechanics, Wiley.
7. **J.J. Sakurai,** Modern Quantum Mechanics, Pearson Education.
8. **E. Merzbecher,** Quantum Mechanics, John Wiley.

Laboratory I

Course Code: SPMS PHY 01 104 CC 00126

1. Ionization potential of Lithium
2. Zeeman Effect
3. Dissociation Energy of I2 molecule
4. Hall Effect
5. Four Probe Method
6. Electron Spin Resonance
7. Telexometer
8. Faraday Effect
9. Frank-Hertz experiment
10. Compton Effect
11. Atomic Spectra of two-Electron Systems
12. Iodine Spectra
13. H-alpha Spectra
14. Coupled Oscillations

Students assigned the general laboratory work will perform at least eight (08) experiments of the above mentioned list. Experiments of equal standard may be added. Workshop soldering and designing of experiments should be included.

Reference:

Worsnop and Flint, Experimental Physics.

A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press.

Numerical Methods and Programming

Course Code: SPMS PHY 01 101 GEC 3104

C/C++:
Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

Numerical Methods of Analysis:
Solution of algebraic and transcendental equations: Iterative, Bisection and Newton-Raphson methods; Solution of simultaneous linear equations: Matrix inversion method; Interpolation: Newton and Lagrange formulas; Numerical differentiation, Numerical Integration: Trapezoidal, Simpson and Gaussian quadrature methods; Least-square curve fitting: Straight line and polynomial fits; Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods.

Simulations:
Generation of uniformly distributed random numbers, Statistical tests of randomness, Monte-Carlo evaluation of integrals and error analysis, Non-uniform probability distributions, Importance sampling, Rejection method, Metropolis algorithm, Molecular diffusion and Brownian motion as random walk problems and their Monte-Carlo simulation.

Short introduction to Programming using C and Psi Lab, class projects may be implemented in any language.

References:

1. **S. S. M. Wong,**Computational Methods in Physics and Engineering, World Scientific.
2. **V. Rajaraman,**Computer Oriented Numerical Methods, Prentice Hall of India.
3. **V. Rajaraman,**Computer Programming in FORTRAN 90/95.
4. **C. F.Gerald,**Applied Numerical Analysis, Pearson/Addison Wesley.
5. **Landau and Binder,**A Guide to Monte Carlo Simulations in Statistical Physics, Cambridge University Press.
6. **Teukolsky, Vetterling and Flannery,**Numerical Recipes 3rd Edition: The Art of Scientific Computing, Cambridge University Press.

Modern Optics

Course Code: SPMS PHY 01 102 GEC 3104

An overview of Geometrical and Wave Optics: Laws of Reflection, Refraction, Total Internal Reflection; Ideas of Interference, Diffraction, Polarisation, Dispersion.

Fresnel Relations: Conductors, Thin Films: Reflection Model, Matrix Formalism, Coating Design, Fourier Optics: Wave Propagation, Fraunhofer Diffraction, Fresnel Diffraction, Spatial Filtering, Holography.

Coherence, Interference and Visibility, Laser Physics: Overview, Gain Saturation, Light-Atom Interactions, Optical Gain and Pumping Schemes, Output Characteristics.

Light Shifts and Optical Forces, Atom-Photon interactions.

Fibre Optics: Mode Analysis, Loss and Dispersion, Photonics Band-gap Crystals. Introduction/Basic idea of LED.

References:

1. **Pedrotti,** Introduction to Optics, Pearson.
2. **A. Ghatak,** Optics, Tata McGraw-Hill.
3. **G. R. Fowles,** Introduction to Modern Optics, Dover Publication.
4. **B. E. A. Saleh and M. C. Teich,** Fundamentals of Photonics, Wiley.
5. **E. Hecht,** Optics, Addison Wesley.
6. **J. T. Verdeyen,** Laser Electronics, Prentice-Hall.
7. **A. E. Siegman,** Lasers, University Science Book.

Introduction to Experimental Physics

Course Code: SPMS PHY 01 103 GEC 3104

Science of Experimental Physics: Background, Objectives, Error Analysis, Graphical Analysis, Writing about Experiments, Design of Experiments.

Probability and Statistics in Experimental Physics: Basic Concepts, Specific Discrete Distributions, Normal Distribution and other Continuous Distributions, Monte-Carlo Method, Inverse Probability: Confidence Limit.

Curve-Fitting Methods: Methods for Estimating Parameters, Regression Analysis, The Regularization Method, Interpolating Functions and Unfolding Problems, Fitting Data with Correlations and Constraints.

Some Fundamental Experiments in Physics: Frequency of Oscillations in Simple Pendulum, Single, Double and N slits Diffraction Experiments, Relation between Refractive Index and Wavelength: Hartmann Formulae, Hall Effect, Ionization Potential of Mercury, Oscillations in Compound Pendulum, more experiments of similar nature may also be discussed.

References:

1. **D.W. Preston and E.R. Dietz,** The Art of Experimental Physics, Academic Press.
2. **C. Cooke,** An Introduction to Experimental Physics, University College London.
3. **B.P. Roe,** Probability and Statistics in Experimental Physics, Springer.

Seminar Presentation I

Course Code: SPMS PHY 01 101 DCEC 0202

This may include subject/research oriented topics.

Statistical Mechanics

Course Code: SPMS PHY 01 201 CC 3104

Elementary Probability Theory:
Preliminary Concepts:mean values, standard deviation, various moments; Random walk problem, Binomial distribution, Poisson distribution, Gaussian distributions, Central Limit Theorem.

Review of Thermodynamics:
Extensive and intensive variables, laws of thermodynamics, Legendre transformations and thermodynamic potentials, Maxwell relations, applications of thermodynamics to (a) ideal gas, (b) magnetic material, and (c) dielectric material.

Classical Statistical Mechanics:
Micro-canonical ensembles and their equivalence, Canonical and grand canonical ensembles, partition function, thermodynamic variables in terms of partition function, ideal gas, Gibbs paradox, validity of classical approximation, equipartition theorem. Maxwell-Boltzmann gas velocity and speed distribution. Chemical potential, Free energy and connection with thermodynamic variables, First and Second order phase transitions; phase equilibrium.

Quantum Statistical Mechanics:
Density Matrix, ensembles in quantum statistical mechanics, simple applications of density matrix. Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics.
Bose system: Ideal Bose gas, Debye theory of specific heat, properties of black-body radiation, Bose- Einstein condensation, experiments on atomic BEC, BEC in a harmonic potential.
Fermi System: Ideal Fermi gas, properties of simple metals, Pauli paramagnetism, electronic specific heat, white dwarf stars.

References:

1. **F. Reif,** Fundamentals of Statistical and Thermal Physics, McGraw Hill.
2. **K. Huang,** Statistical Mechanics, John Wiley & Sons.
3. **R. K. Pathria,** Statistical Mechanics, Pergamon Press.
4. **B. B. Laud,** Fundamentals of Statistical Mechanics, New Age.
5. **Mark W. Zemansky and Richard H. Dittman,** Heat and Thermodynamics, McGraw Hill.
6. **L. D. Landau and E. M. Lifshitz,** Statistical Physics, Butterworth-Heinemann.
7. **Richard P. Feynman,** Statistical Mechanics, Westview Press.
8. **J. P. Sethna,** Statistical Mechanics: Entropy, Order Parameter and Complexity, Oxford University Press.

Classical Electrodynamics

Course Code: SPMS PHY 01 202 CC 3104

Electrostatics&Magnetostatics:
Differential equation for electric field, Poisson and Laplace equations, formal solution for potential with Green's functions, boundary value problems, examples of image method and Green's function method, solutions of Laplace equation in cylindrical and spherical coordinates by orthogonal functions, dielectrics, polarization of a medium, electrostatic energy.
Biot-Savart law, differential equation for static magnetic field, vector potential, magnetic field from localized current distributions, examples of magnetostatic problems, Faraday's law of induction, magnetic energy of steady current distributions.

Maxwell's Equations&Electromagnetic Waves:
Displacement current, Maxwell's equations, vector and scalar potentials, Gauge symmetry, Coulomb and Lorentz gauges, electromagnetic energy and momentum, conservation laws, inhomogeneous wave equation and Green's function solution.
Plane waves in a dielectric medium, reflection and refraction at dielectric interfaces, frequency dispersion in dielectrics and metals, dielectric constant and anomalous dispersion, wave propagation in one dimension, group velocity, metallic wave guides, boundary conditions at metallic surfaces, propagation modes in wave guides, resonant modes in cavities.

Radiation:
Field of a localized oscillating source, fields and radiation in dipole and quadrupole approximations, antenna, radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.

Relativistic Electrodynamics:
Four-vectors relevant to electrodynamics, electromagnetic field tensor and Maxwell's equations, transformation of fields, fields of uniformly moving particles.

References:

1. **J.D. Jackson,** Classical Electrodynamics, Wiley.
2. **David J. Griffiths,** Introduction to Electrodynamics, Benjamin Cummings.
3. **L.D. Landau and E.M. Lifshitz,** Classical Theory of Electrodynamics, Addison-Wesley.
4. **L.D. Landau and E.M. Lifshitz,** Electrodynamics of Continuous Media, Addison Wesley.
5. **Wolfgang K. H. Panofsky and Melba Phillips,** Classical Electricity and Magnetism, Dover Publications.

Electronics

Course Code: SPMS PHY 01 203 CC 3104

Introduction to Network:
Network analysis: Kirchhoff's Laws and Star-Delta networks. Network theorems: Superposition, Thevenin, Norton, & Maximum Power Transfer. Two port networks: z, y, h, and t parameters.

Electronic Devices:
Review of p-n junction, Schottky diode, metal-semiconductor and metal-oxide semiconductor junctions, BJT, JFET, MESFET & MOSFET.
Basic differential amplifier circuit, operational amplifier characteristics and applications: Addition, Subtraction, Integrator, Differentiator; 555 Timer, astable and monostable multivibrator; zero crossing detector. Amplifiers at low and high frequencies.

Digital Electronics:
Overview of Gates, combinational and sequential digital systems, flip-flops: (RS, JK, Master Slave), counters: synchronous/asynchronous and decade.

Electronic Instruments:
Regulated Power supplies, phase shift and Wien bridge oscillators, digital oscilloscopes.

References:

1. **P. Horowitz and W. Hill,** The Art of Electronics, Cambridge University Press.
2. **J. Millman and A. Grabel,** Microelectronics, McGraw Hill.
3. **J.J. Cathey,** Schaum's Outline of Electronic Devices and Circuits, McGraw Hill.
4. **M. Forrest,** Electronic Sensor Circuits and Projects, Master Publishing.
5. **W. Kleitz,** Digital Electronics: A Practical Approach, Pearson.
6. **J.H. Moore, C.C. Davis and M.A. Coplan,** Building Scientific Apparatus, Addison Wesley.

Laboratory II

Course Code: SPMS PHY 01 204 CC 00126

1. Addition, Subtraction and Binary to BCD conversion
2. JK, Master Slave Flip-Flop, up-down counter, 4 bit counter
3. Multivibrator
4. Differential Amplifier using Op Amp
5. Op-amps and its application: Inverting and Non-inverting of given gain; Integrator and Differentiator
6. IC 555 Timer: Astable and Monostable Multivibrator
7. Design of CE Amplifier
8. Design of Regulated Power Supply
9. Arithmetic Logic Unit
10. Digital to Analog Converter (maximum 4-bit)
11. Experiments on MUX, DEMUX, Decoder and shift register
12. I-V characteristics of Photodiode/Solar Cells
13. Voltage regulation of Zener diodes
14. Designing decade counter
15. Characteristics of MOSFET

Computational experiments using computer programming

1. Finite and infinite series
2. Root finding: (bisection, Secant and Newton-Raphson methods)
3. Solving first and second order ordinary differential equations including simultaneous equations (Euler and Runge-Kutta methods)
4. Numerical integration (trapezoidal, Simpson, Gauss quadrature,methods)
5. Matrices (arrays of variable sizes, addition, multiplication, eigenvalues, eigenvectors, inversion, solutions of simultaneous equations)

Students assigned the general laboratory work will perform at least twelve (12) experiments from the above mentioned. More experiments of similar nature may be added.

References:

W. Kleitz, Digital Electronics: A Practical Approach, Pearson.
J.H. Moore, C.C. Davis and M.A. Coplan, Building Scientific Apparatus, Addison Wesley.
V. Rajaraman,Computer Oriented Numerical Methods, Prentice Hall of India.
V. Rajaraman,Computer Programming in FORTRAN 90/95.

Latex for Science & Mathematics

Course Code: SPMS PHY 01 201 GEC 3104

Software installation, Markup Languages, LATEX typesetting basics, LATEX math typesetting, Tables and matrices, Graphics, Packages, Userdefinable, Document classes, text bibTEX, beamer, flash cards / CV, Creating your own package, Project.

References:

1. **Helmut Kopka,**Guide to LATEX.
2. Resources from websites.

Environmental Physics

Course Code: SPMS PHY 01 202 GEC 3104

Introduction to Energy:
Importance of energy in science and society. Types of energy (mechanical, heat, chemical, nuclear, electrical). Law of conservation of energy. Energy transformations. Mechanical energy: force, work, kinetic and potential energy, PE diagrams, conservation of mechanical energy, bound systems. Electricity Basics.

Heat Energy and Kinetic Theory:
Heat and Temperature. Internal Energy, Specific Heat. Ideal gas equation. Kinetic theory interpretation of pressure and temperature. Work, heat, and the first law of thermodynamics. Adiabatic lapse rate. Radiant energy. Blackbody radiation

Energy and Climate Change:
Energy balance of the Earth. Greenhouse effect. Climate feedbacks (water, clouds, ice albedo). Global Climate Models. Evidence for climate change. Paleo-climate. Climate change impacts. Climate change mitigation. Target CO_2 levels.

Energy Source:
Chemical energy. Energy in biology, photosynthesis, respiration. Energy use in the human body, energy content of food. Fossil fuels and their origin (coal, oil, natural gas). Problems with fossil fuels, greenhouse pollution, peak oil. Alternatives to fossil fuels. Alternative energy resource: Wind energy, energy from water on land, ocean energy. Biomass and other sources.

Thermal Aspect of Energy Conservation:
Heat engines and the second law of thermodynamics. The Carnot cycle. Applications of the second law to various energy transformation processes: heat pumps and refrigerators; different engine cycles. Entropy and disorder.

References:

R. A. Hinrichs and M. Kleinbach, Energy, Its Use and the Environment, Brooks Cole.
C. W. Rose,An Introduction to the Environmental Physics of Soil, Water and Watersheds, Cambridge University Press.
P. Hughes, N. J. Mason, Introduction to Physics: Planet Earth, Life and Climate, Taylor & Francis.
J. Monteith, M. Unsworth, Principles of Environmental Physics: Plants, Animals and the Atmosphere, Elsevier.
Egbert Boeker & Rienk Van Groundelle, Environmental Physics (John Wiley).
J.T.Hougtyion, The Physics of Atmosphere (Cambridge University Press, 1977).
J.T. Widell and J. Weir, Renewable Energy Resources (Elbs, 1988).
Sol Wieder, An Introduction of Solar Energy for scientists and Engineers (John Wiley 1982).
R.N. Keshavamurthy and M. Shankar Rao, The Physics of Monsoons (Allied Publishers 1992).
K.L.Kumar, Engineering Fluid Mechanics (S.Chand, 1994).
Landau &Lifshitz, Fluid Mechanics, Pergamon Press (2000).

Computational Physics

Course Code: SPMS PHY 01 201 DCEC 3104

Stochastic Processes:
Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideasand simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion.

Percolation theory:
Percolation theory and simulation by Hoshen-Kopelman algorithm; Application to simple lattice models in Physics.

Simulations of physical models:
Elementary ideas ofMolecular dynamics; Dynamical equations and physical potentials; Verlet algorithm.Time-average and Ensemble average; Monte Carlo methods; Metropolis algorithm. Introduction to the simulations: (a) Ising model in magnetism (b) Bak-Tang-Wiesenfeld model in studies of Self Organized Criticality.

Combinatorial optimization problems:
Classification of problems; examples of optimization problems: traveling salesman problem (TSP) and satisfiability (k-SAT)problem; heuristic methods of solutions and simulated annealing technique.

References

1. **D. Frenkel& B. Smit,**Understanding Molecular Simulation, Academic Press.
2. **D. Stauffer,**Introduction to Percolation Theory, Taylor-Francis.
3. **M. Plischke& B. Bergersen,**Equilibrium Statistical Physics, World Scientific.
4. **W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling,**Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press.

Advanced Quantum Mechanics I

Course Code: SPMS PHY 01 202 DCEC 3104

Symmetry in Quantum mechanics:
Symmetry Operations and Unitary Transformations, conservation principles, space and time translation, rotation, space inversion and time reversal, symmetry and degeneracy.

Identical particles:
Meaning of identity and consequences; Symmetric and anti-symmetric wave-function; incorporation of spin, symmetric and antisymmetric spin wave functions of two identical particles, slater determinant, Pauli exclusion principle.

Time-dependent Perturbation Theory& Scattering Theory:
Interaction Picture; Constant and harmonic perturbations; Fermi Golden rule; Sudden and adiabatic approximations. Beta decay as an example.
Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering.

Relativistic Quantum Mechanics:
Klein Gordon equation, Dirac equation, negative energy solutions, antiparticles, Dirac hole theory, Feynman interpretation of antiparticles, Gamma matrices and their properties, Covariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Spin & Helicity.

References:

1. **S. Flugge,** Quantum Mechanics, Springer.
2. **C. Cohen-Tannoudji, Bernard Diu and FrankLaloe,** Quantum Mechanics, Wiley.
3. **Albert Messiah,** Quantum Mechanics, Dover Publications.
4. **R.Shankar,** Principles of Quantum Mechanics, Springer.
5. **L.I. Schiff,** Quantum Mechanics, McGraw Hill.
6. **J.J. Sakurai,** Modern Quantum Mechanics, Pearson Education.
7. **E. Merzbecher,** Quantum Mechanics, John Wiley.

Seminar Presentation II

Course Code: SPMS PHY 01 203DCEC 0202

This may include subject/research oriented topics.

Atomic, Molecular Physics and Laser

Course Code: SPMS PHY 01 301 CC 3104

Atomic Structure and Atomic Spectra:
Review of Atomic Models: Rutherford's Model, Bohr's model, Sommerfeld's model, Stern-Gerlach experiment for electron spin. Revision of quantum numbers, exclusion principle, electronic configuration. Relativistic correction to energy levels of an atom, atom in a weak uniform external electric field – first and second order Stark effect;The polarizability of the ground state of hydrogen atom and of an isotropic harmonic oscillator; Linear Stark effect for hydrogen atom levels. Spin-orbit interaction, LS coupling, origin of spectral lines, selection rules; X-ray spectra, fine spectra, hyperfine structure, Zeeman effect, Lamb shift.

Molecular Structure:
The nature of chemical bonds, valence bond approach and molecular orbital approach for molecular bonding (for H2 molecule). Bonding and anti-bonding orbitals, pi- bonds, sigma -bonds, different kinds of bonding mechanism, Madelung constant, hybridization, bonding in hydrocarbons.

Molecular spectra:
Rotational levels in diatomic and polyatomic molecules, vibrational levels in diatomic and polyatomic molecules, diatomic vibrating rotator, Born-Oppenheimer approximation, symmetry of the molecules and vibrational levels, experimental aspects of vibrational and rotational spectroscopy of molecules, polarization of light and Raman effect, Raman Spectroscopy.

Lasers:
Requisites for producing laser light, Role of Plane and Confocal cavity resonators, Longitudinal and transverse cavity modes, Mode selection, Q-switching and Mode locking, Generation of Ultra short Pulse.

References:

1. **B. H.Bransden and C. J Joachain,**Physics of Atoms and Molecules, Prentice Hall.
2. **K. Thyagarajan and A.K. Ghatak,**Lasers - Theory and Applications, Plenum Press.
3. **H.E. White,**Introduction to Atomic Spectra, McGraw Hill.
4. **H. G. Kuhn,**Introduction to Atomic Spectra, McGraw Hill.
5. **R. Eisberg and R. Resnick,** Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley.
6. **Arthur Beiser,** Perspectives of Modern Physics, McGraw Hill.
7. **Gerhard Herzberg,** Molecular Spectra and Molecular Structure, Krieger Pub Co.
8. **C. N. Banwell,** Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.

Nuclear & Particle Physics

Course Code: SPMS PHY 01 302 CC 3104

Introductory Concept of Nuclei:
Nuclear angular momentum, Nuclear magnetic dipole moment and Electric quadruple moment, Parity quantum number, Statistics of nuclear particles, Isobaric spin concept, Systematic of stable nuclei.
Nuclear Disintegration: Simple theories of decay, Properties of neutrino, Non conservation of parity and Wu's experiment in beta decay, Electron capture, Internal conversion.

Inter Nucleon Forces:
Properties and simple theory of the deuteron ground state, Spin dependence and tensor component of nuclear forces, Nucleon-nucleon scattering at low energy, Charge-independence of nuclear forces, Many–nucleon systems and saturation of nuclear forces, Exchange forces, Elements of meson theory.

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

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

References:

1. **Roy & Nigam,**Nuclear Physics, Wiley.
2. **H. Enge,**Introduction to nuclear Physics, Addison Wesley.
3. **J.M. Blatt and V.F. Weisskopf,**Theoretical Nuclear Physics, Springer.
4. **J.D. Walecka,**Theoretical Nuclear and Subnuclear Physics, World Scientific.
5. **M.Leon,**Particle Physics:An introduction, Academic Press.
6. **F.I. Stancu,**Group Theory in Subnuclear Physics, Clarendon Press.
7. **B. R. Martin and G. Shaw,**Particle Physics, Wiley.

Solid State Physics

Course Code: SPMS PHY 01 303 CC 3104

Crystal structure:

Crystal structures and lattices with basis, Miller indices, Common crystal structures, Reciprocal lattice, Brillouin zones, X-ray diffraction by a crystal and their equivalence, Laue equations, Ewald construction, Brillouin interpretation, Crystal and atomic structure factors, Structure factor; Experimental methods of structure analysis: Types of probe beam, the Laue, rotating crystal and powder methods.

Lattice dynamics and thermal properties:

Classical theory of lattice dynamics: Vibrations of crystals with monatomic basis and Two atomic basis, Dispersion relation, Group velocity, Acoustical and optical modes; Phonons: Quantization of lattice vibration, Phonon momentum, Inelastic scattering of neutrons by phonons; Thermal properties: heat capacity, Density of states, Normal modes, Debye and Einstein models

Electronic properties of solids:

Free electron gas model: Electrical conductivity and Ohm's law, Density of states, Heat capacity, Fermi energy, Effect of temperature, effective mass, Limitations of the free electron gas model, Band theory of solids: Periodic potential, Bloch's theorem, Kronig-Penney model, Approximate solution near a zone boundary, Periodic, extended and reduced zone schemes of energy band representation, Classification into metals, semiconductors and insulators; Tight binding method and its application to SC and BCC structures.

Superconductivity:

Introduction to Superconductivity, effect of magnetic field, Meissner effect, Type I and type II superconductors, Entropy, Free energy, Heat capacity, Energy gap, Microwave and infrared properties, Isotope effect; Thermodynamics of the superconducting transition, London equation, Coherence length, BCS theory of superconductivity, Flux quantization in a superconducting ring; DC and AC Josephson effects; Macroscopic long-range quantum interference; High Tc superconductors

References:

1. **Charles Kittel,**Introduction to Solid State Physics, Wiley.
2. **Neil W. Ashcroft and N. David Mermin,**Solid State Physics, Holt, Rinehart and Winston.
3. **Rajnikant,**Applied Solid State Physics, Wiley.
4. **H. Ibach and H. Luth,** Solid State Physics: An Introduction to Theory and Experiment, Springer.
5. **J. M. Ziman,**Principles of the Theory of Solids, Cambridge University Press.
6. **M. A. Wahab**, Solid State Physics: Structure and Properties of Materials, 2nd Edition, Narosa Book Distributors.

7. **J. P. Srivastava**, Elements of Solid State Physics, Prentice-Hall of India.

Laboratory III

Course Code: SPMS PHY 01 301 CC 00<u>12</u>6

Each student is required to perform at least five experiments from Section A and at least three experiments from any one of the optional subtopics of Section B: (i) Electronics (ii) Thin Film and Nano-Material (iii) Numerical Techniques; depending upon the courses opted under discipline centric elective course.

Section A

1. Kerr Effect
2. Curie Temperature
3. B-H curve
4. Solid State Nuclear Track Detector (SSNTD)
5. G.M. Counters: characteristics, deadtime and counting statistics
6. Scintillation detector-energy calibration, resolution and determination of gamma ray energy
7. Prism Spectrometer
8. Grating Spectrometer
9. Interferometric method for thin film thickness and strain measurement
10. Ultra-Voilet Visible
11. Surface Plasmon Resonance (SPR)
12. Laser Diffraction
13. Gas Hydrogen Spectra
14. Fourier Transform Infrared Spectroscopy (FTIR)
15. Alpha Spectroscopy with Surface Barrier Detector
16. X-Ray Diffraction
17. Verification of Hartmann formula for prism spectrogram
18. Measurement of optical spectrum of an alkali atom
19. Emitter of electric discharge through air in an evacuated tube
20. Measurement of optical spectrum of alkaline earth atoms
21. Measurement of Band positions and determination of vibrational constants of AlO molecule
22. Measurement of Band positions and determination of vibrational constants of N_2 molecule
23. Measurement of Band positions and determination of vibrational constants of CN molecule
24. Determination of characteristic parameters of an optical fibre
25. Measurement of Raman spectrum of CCl_4

Section B

(i) Electronics

1. PCM/delta modulation and demodulation
2. Fiber optic communication
3. D/A converter interfacing and frequency/temperature measurement with microprocessor 8085/8086
4. A/D converter interfacing and AC/DC voltage/current measurement using microprocessor 8085/8086
5. PPI 8251 interfacing with microprocessor for serial communication

(ii) Thin Film and Nano-Material

1. Chemical Vapour Deposition

2. Vacuum, Thermal Evaporation and DC sputtering
3. Spin Coater
4. Surface morphological characterisation of thin film by AFM/SEM
5. Ball milling

(iii) Numerical Techniques

1. Solution of Linear algebraic equation: Gauss Jordon elimination, Singular Value Decomposition, Sparse linear system.
2. Evaluation of Functions: special functions, evaluation of functions by path integration, incomplete gamma, beta function.
3. Random Numbers: Uniform random numbers generators, statistical distributions and their properties, Rejection Methods, transformation method, simple Monte Carlo integration, Adaptive and recursive Monte Carlo methods, Test of randomness.
4. Signal Processing: FFT, IFFT, Filtering with FFT, convolution and correlation functions, application to real time series data.
5. Eigen systems: Solving eigenvalues and finding eigen functions of Schrodinger equation for analytically unsolvable potentials using variational principle.

Reference:

W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling,Numerical Recipes in C/C++: The Art of Scientific Computing, Cambridge University Press.

J. P. Sethna, Statistical Mechanics: Entropy, Order Parameters, andComplexity, Oxford University Press.

A. C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press.

Physics of Electronic Material and Devices

Course Code: SPMS PHY 01 302 DCEC 3104

Physical Mechanisms:
Crystal structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy Band consideration in solids in relation to semiconductors, Direct and Indirect bands in semiconductor, Electron/Hole concentration and Fermi energy in intrinsic/Extrinsic semiconductor continuity equation, Carrier mobility in semiconductors, Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors(IonizationEnergies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generation in semiconductors, ShockleyRead theory of recombination, Switching in Electronic Devices.

Devices:
Metal/Semiconductor Junction or (Abrupt P-N Junction), Current-voltage characteristics, C-V measurements, Estimation of Barrier Height and carrier concentration from C-V characteristics, Surface/Interface States, Role of interface States in Junction Diodes. Field Effect devices, C-V characteristic of MIS diodes (Frequency dependence), Estimation of Interface Trapped charges by capacitance conductance, method CCD (Charge Coupled Devices), MESFET, MOSFET.

Microwave Devices: Tunnel Diode, MIS Tunnel Diode, Degenerate and Non-degenerate semiconductor, MIS Switch Diode, MIM Tunnel diode. IMPATT Diode. Characteristics, breakdown Voltage, Avalanche Region and Drift Region, Transferred Electron devices.
Photonics Devices: LED and LASER, Photo detectors, Solar-cells.

References:

1. **S.M. Sze,**Physics of Semiconductor Devices, Wiley.
2. **Jasprit Singh,**Semiconductor Devices Basic Principles, Wiley.
3. **A.S. Grove,**Physics and Technology of Semiconductor Devices, Wiley.
4. **B.L. Sharma,**Metal/Semiconductor Schottky Barrier Junction and their Applications, Plenum Press.
5. **E. H.Rhoderick,**Metal/Semiconductor Contacts, Clarendon Press.

Electronic Communication

Course Code: SPMS PHY 01 303 DCEC 3104

Need for communication: AM, FM, modulation index.

Digital communication:

Pulse – Modulation systems, sampling theorem – Low – Pass and Band – Pass signals, PAM, Channel BW for a PAM signal. Natural sampling. Flat – top sampling. Signal recovery through Holding, Quantization of signals, Quantization error, Differential PCM, Delta Modulation, Adaptive Delta Modulation, CVSD.Digital Modulation Techniques: BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK.

Mathematical representation of Noise:

Sources of noise. Frequency domain representation of noise, effect of filtering on the probability density of Gaussian noise, spectral component of noise, effect of a filter on the power spectral density of noise. Superposition of noises. Mixing involving noise. Linear filtering. Noise Bandwidth, Quadrature components of noise, Power spectral density of nc(t), ns(t) and their time derivatives.

Data Transmission:

Baseband signal receiver, probability of error. Optimum filter. White noise. Matched filter and probability of error.Coherent reception. Correlation, PSK, FSK, Non-coherent detection of FSK. Differential PSK, QPSK, calculation of error probability for BPSK, BFSK, and QPSK.

Noise in pulse–code and Delta–modulation system: PCM Transmission, Calculation of Quantization noise, Output – signal power, Effect of thermal noise in D M, Output signal–to–noise ratio in PCM, DM, Quantization noise in DM, Effect of thermal noise in Delta modulation, Output signal to noise ratio in DM.

Computer Communication Systems:

Types of networks, Design features of a communication network, examples: TYMNET, ARPANET, ISDN, LAN.

Mobile Radio and Satellites: Time division multiple Access (TDMA), Frequency Division Multiple Access (FDMA), ALOHA, Slotted ALOHA, Carrier Sense Multiple Access (CSMA) Poisson distribution, Protocols, Cellular communications, Mobile communication via Satellites, Bandwidth consideration in INTERNET.

References:

1. **Taub and Schilling,**Principles of Communication Systems, McGraw Hill.
2. **Simon Haykin,**Communication Systems, Wiley.

Thin Film and Integrated Devices

Course Code: SPMS PHY 01 304 DCEC 3104

Materials for Integrated Circuits:
Classification of IC, CMOS Process Overview, Electronic grade silicon, Crystal growth, Czeehralski and float zone crystal growing methods, Silicon shaping lapping, Polishing and wafer preparation, Hot Processes-I: Oxidation and Diffusion, Oxidation of silicon, oxide deposition by thermal dry oxidation and wet oxidation method Diffusion Process, Diffusion Coefficient, Fick's 1st and 2nd Laws of Diffusion, Vacancy –Impurity interactions, Dopants and Dopant Sources, Doping by Diffusion, ion implantation, Diffusion Process Control, Diffusion Systems, Implantation Technology, Selective Implantation, Junction depth, Channeling, Lattice Damage, Annealing, Dopant Diffusion and Related Operations: Equipment for Diffusion and Related Operations.

Thin Films: Metals and Nonmetals
Vacuum Science and Technology, Evaporation theory and electron beam evaporation, evaporation system, idea of DC and R.F. sputtering system, Physical vapour deposition methods, Design construction of vacuum coating units, Chemicals Vapour Deposition, Reactors for Chemical Vapour Deposition, CVD Applications, Epitaxy methods for thin film deposition, Vapour-Phase Epitaxy, Photolithography, Photoresist Processing and Etching.

Wafer Cleaning methods, Wafer Preparation method: Vapour HMDS Treatment for adhesion improvement of photoresist, photoresist coating methods, soft backing of photo resist, post exposure backing of photo resist, Negative photoresist, Positive photoresist, Contrast and sensitivity of photoresist, Chemical Modulus Transfer Function (CMTF) of Photoresist, Resist Exposure (single, bi-layer and multi-level photoresist exposure) and Resist Development, Hard Baking and Resist curing, Photolithographic Process Control. Photolithography: An Overview, lithography, Raleigh criterion for resolution, Photo lithography source, Resolution and numerical aperture, Photolithographic methods: Contact, proximity and projection and their resolution limit, Photo mask and mask Alignment, Limitations of optical lithography, Concept of phase-shift mask, Idea of electron beam lithography, Electron optics, Idea of an X-ray lithography and x-ray mask, Wet chemical dry etching for material removal, Reactive plasma etching, Ion milling,

Interconnections and Contacts and Packaging and Yield
Ohmic Contact Formation, Contact Resistance, Electro-migration, Diffused Interconnections, Poly-silicon Interconnections, Buried Contacts, Butted Contacts, Silicides, Multilayer Contacts, Liftoff Process, Multilevel Metallization. Testing, Die Separation, Die Attachment, Wire Bonding, Packages, Flip-Chip Process, Tape-Automated-Bonding Process, Yield, Uniform and Nonuniform Defect Densities.

References:

1. **Millman and Taub,**Integrated Electronics, McGraw Hill.
2. **Millman and Gros,**Microelectronics, McGraw Hill.
3. **K.L. Chopra,**Thin Film Phenomena, McGraw Hill.
4. **L. I.Marshel and R. Glang,**Hand Book of Thin Film, McGraw Hill.
5. **S.M. Sze,**VLSI Technology, McGraw Hill.

Spectroscopy

Course Code: SPMS PHY 01 305 DCEC 3104

Pure rotational spectra of diatomic molecules, Polyatomic molecules, Study of linear molecules and symmetric top molecules, Hyperfine structure and quadruple moment of linear molecules, Experimental techniques, Molecular structure determination, Stark effect, inversion spectrum of ammonia, Applications to chemical analysis.

Vibrational spectroscopy of diatomic and simple polyatomic molecules, Harmonic Oscillator, Anharmonic Oscillator - Rotational vibrators - Normal modes of vibration of Polyatomic molecules, Experimental techniques, Applications of infrared spectroscopy, H_2O and N_2O molecules, Reflectance spectroscopy.

Classical theory of Raman Scattering - Raman effect and molecular structure, Raman effect and crystal structure, Raman effect in relation to inorganic, organic and physical chemistry, Experimental techniques, Coherent anti-Stokes Raman Spectroscopy, Applications of infrared and Raman spectroscopy in molecular structural confirmation of water and CO_2 molecules, Laser Raman Spectroscopy.

Theory of NMR, Bloch equations, Steady state solution of Bloch equations, Theory of chemical shifts, Experimental methods, Single Coil and double coil methods, Pulse Method, High resolution method, Applications of NMR to quantitative measurements. Quadruple Hamiltonian of NQR, Nuclear quadruple energy levels for axial and non-axial symmetry - Experimental techniques and applications.

Quantum mechanical treatment of ESR - Nuclear interaction and hyperfine structure, Relaxation effects, Basic principles of spectrographs, Applications of ESR method, Mossbauer Effect,Recoilless emission and absorption - Mossbauer spectrum - Experimental methods - Mossbauer spectrometer, Hyperfine interactions, Chemical Isomer shift, Magnetic hyperfine interactions, Electric quadruple interactions, Simple biological applications

References:

1. **C.N. Banwell and E.M. Mc Cash,** Fundamentals of Molecular Spectroscopy, Tata McGraw-Hill.
2. **G. Aruldas,** Molecular Structure and Spectroscopy, Prentice Hall of India.
3. **D.N. Satyanarayana,** Vibrational Spectroscopy and Applications, New Age.
4. **Raymond Chang,** Basic Principles of Spectroscopy, McGraw Hill.

Microprocessor and Microcontroller

Course Code: SPMS PHY 01 306 DCEC 3104

8085 Architecture - Programmer's model - ALU - Registers and Flags - Stacks - Complete instruction set of Intel 8085 - State transition and timing diagrams - T States - Machine cycles - Instruction cycles - Addressing modes - Assembly language programs – Timing diagram for memory read and memory write cycles - time delay subroutines and delay calculations – maskable and Non-maskable Interrupts.

Interfacing memory and devices – I/O and Memory mapped I/O – Simple polled I/O and Handshaking operations - Programmable keyboard/display interface 8279 - Programmable peripheral device 8255A - 8253 Timer Interface - Wave form generation (Square, triangular and ramp wave) - Programmable communication interface 8251 (USART).

Introduction – 8 and 16 bit Microcontroller families –Flash series – Embedded RISC Processor – 8051 Microcontroller Hardware – Internal registers – Addressing modes – Assembly Language Programming – Arithmetic, Logic and Sorting operations.

Interfacing I/O Ports, External memory, counters and Timers - Serial data input/output, Interrupts – Interfacing 8051 with ADC, DAC, LED display, Keyboard, Sensors and Stepper motor.

Embedded microcontroller system – types of embedded operating system – Micro chip PIC 16C6X /7X family – features – Architecture – Memory Organization – Register file map – I/O ports – Data and flash program memory – asynchronous serial port – Applications in communication and industrial controls.

References:

1. **R.S.Gaonkar,** Microprocessor Architecture, programming and Application with the 8085.
2. **V.Vijayendran,** Fundamentals of Microprocessor 8085 - Architecture, programming and interfacing.
3. **Kenneth J. Ayala,** The 8051 Micro Controller Architecture, Programming andApplications.
4. **John B. Peatman,** Design with PIC Microcontrollers.
5. **R.S. Gaonkar,** Microprocessor Architecture, programming and Application with the 8085.

Physics of Nanomaterials

Course Code: SPMS PHY 01 307 DCEC 3104

Introduction to Nanostructure Materials:
Nanoscience & nanotechnology, Size dependence of properties, Moor's law, Surface energy and Melting point (quasi melting) of nanoparticles.
Band structure of solids: Free electron theory (qualitative idea) and its features, Idea of band structure, insulators, semiconductors and conductors, Energy band gaps of semiconductors, Effective masses and Fermi surfaces, Localized particles, Donors, Acceptors and Deep traps, Mobility, Excitons, Density of states, Variation of density of states with energy and Size of crystal.

Quantum Size Effect:
Quantum confinement, Nanomaterials structures, Two dimensional quantum system, Quantum well, Quantum wire and Quantum dot, Fabrication techniques.

Synthesis of Nanomaterials:
Key issue in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches, Cluster beam evaporation, Ball Milling, Chemical bath deposition with capping agent, Carbon nanotubes (CNT)- Synthesis, Properties and Applications.

Characterization techniques of Nanomaterials:
Determination of particle size, XRD (Scherrer's formula), Increase in width of XRD peaks of nanoparticles, Shift in absorption spectra peak of nanoparticles, Shift in photoluminescence peaks, Electron Microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy(TEM), Scanning Probe Microscopy (SPM), Scanning Tunnelling Electron Microscopy(STEM), and Atomic Force Microscopy (AFM).

References:

1. **Guozhong Cao,**Nanostructures & Nanomaterials, Synthesis, Properties & Applications, Imperial College Press.
2. **Charles P. Poole, Jr. Frank J. Owens,**Introduction to Nanotechnology, John Wiley & Sons.
3. **Paul Harrison,**Quantum Wells, Wires and Dots, John Wiley & Sons.
4. **D. Bimberg, M. Grundmann, N.N. Ledenstov,**Quantum Dot Hetrostructures, John Wiley & Sons.
5. **Hornyak G.L., Tibbals H.F., Dutta J.,Moore J.J.,**Introduction to Nanoscience and Nanotechnology, CRC Press.
6. **Liming Dai,**Carbon Nanotechnology, Elsevier.
7. **Michael J. O'Connell,**Carbon Nanotubes: Properties and Applications, CRC Press.
8. **T. Pradeep**, Nano-The Essentials, McGraw Hill Companies.

Nuclear Physics: Interaction and Model

Course Code: SPMS PHY 01 308 DCEC 3104

N-N interaction:
Phenomenological N-N Potentials (Soft core & hard core) and meson theoretical potentials, Polarization in N-Nscattering.Probing charge distribution with electrons, Form factors, Proton form factors, Qualitative ideas on deep inelastic electron-proton scattering, Bjorken scaling and the patron model, Quark structure of the nucleon.

Nuclear Models:
Single particle model of the nucleus, Angular momenta and parities of nuclear ground states, Qualitative discussion and estimates of transition rates, Magnetic moments and Schmidt lines. Classification of shells, Seniority, Configuration mixing, Pairing Force theory, Simple description of Two particle shell model spectroscopy.Deformable liquid drop and nuclear fission, Collective vibrations and excited states, Permanent deformation and collective rotations: Energy levels and electromagnetic properties of even-even and odd-odd formed nuclei, Nilsson model and equilibrium deformation, Coulomb Excitation Studies, Behaviour of Nuclei at high spin, Back-bending.

High Energy Physics: Particle Physics, Higgs Boson, LHC.

References:

1. **S. N. Ghoshal,**Nuclear Physics, S. Chand Limited.
2. **M. A.Preston and R. K. Bhaduri,**Nuclear Structure, Perseus Books Group.
3. **Brown and Jackson,**Nucleon-nucleon Interaction.
4. **S.S.M. Wong,**Introductory Nuclear Physics, Prentice Hall.
5. **M.K.Pal,**Nuclear Structure.

Advanced Quantum Mechanics II

Course Code: SPMS PHY 01 309 DCEC 3104

Relativistic Quantum Mechanics:
Klein Gordon equation, Dirac equation, negative energy solutions, antiparticles, Dirac hole theory, Feynman interpretation of antiparticles, Gamma matrices and their properties, Covariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Bilinear covariants, Plane wave solution, Two component theory of neutrino, Spin & Helicity, Relativistic Hydrogen atom problem.

Classical Field Theory:
Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem.

Second Quantization:
First Quantization: Many Body Quantum Mechanics; Slater Determinant & Permanent.Second Quantization: Creation & Annihilation Operators, Number Operator; Non-Interacting Bose & Fermi Gas; Hamiltonian for the interacting system; Adding Spin.

FreeField&Quantum Electrodynamics (QED):
Canonical quantization of scalar field, Complex scalar field, and Dirac field.The Feynman Propagator, Feynman diagrams.
Maxwell's Equations: Gauge Symmetry; The Quantization of the Electromagnetic Field: Coulomb Gauge&Lorentz Gauge; Feynman rules; Scattering in QED: The Coulomb Potential.

References:

1. **J.D. Bjorken and S.D. Drell,**Relativistic Quantum Mechanics, McGraw Hill.
2. **J.D. Bjorken and S.D. Drell,**Relativistic Quantum Fields, McGraw Hill.
3. **Amitabha Lahiri and P.B. Pal,**A First Book on Quantum Field Theory, CRC Press.
4. **F. Mandl and G. Shaw,**Introduction to QFT, Wiley.
5. **J.J. Sakurai,**Modern Quantum Mechanics, Pearson.

Advanced Statistical Mechanics

Course Code: SPMS PHY 01 310 DCEC 3104

Phase Transitions and Critical Phenomena
Thermodynamics of phase transitions, metastable states, Van der Waals' equation of state, coexistence of phases, Landau theory, critical phenomena at second-order phase transitions, spatial and temporal fluctuations, scaling hypothesis, critical exponents, universality classes.

Ising Model
Ising model, mean-field theory, exact solution in one dimension, renormalization in one dimension.

Nonequilibrium Systems
Systems out of equilibrium, kinetic theory of a gas, approach to equilibrium and the H theorem, Boltzmann equation and its application to transport problems, master equation and irreversibility, simple examples, ergodic theorem. Brownian motion, Langevin equation, fluctuation-dissipation theorem, Einstein relation, Fokker-Planck equation.

Correlation Functions
Time correlation functions, linear response theory, Kubo formula, Onsager relations.

Coarse-grained Models
Hydrodynamics, Navier-Stokes equation for fluids, simple solutions for fluid flow, conservation laws and diffusion.

References:

1. **K. Huang,** Statistical Mechanics, Wiley.
2. **R.K. Pathria,** Statistical Mechanics, Elsevier.
3. **E.M. Lifshitz and L.P. Pitaevskii,** Physical Kinetics. Elsevier.
4. **D.A. McQuarrie,** Statistical Mechanics, University Science Books.
5. **L.P. Kadanoff,** Statistical Physics: Statistics, Dynamics and Renormalization, Academic.
6. **P.M. Chaikin and T.C. Lubensky,** Principles of Condensed Matter Physics, Cambridge University Press.

Project/Dissertation

Course Code: SPMS PHY 01 401 PROJ 00024

The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics according to the skill and merit of the students.

Nonlinear Dynamics

Course Code: SPMS PHY 01 402 SEEC 3100

Introduction to Dynamical Systems
Physics of nonlinear systems, dynamical equations and constants of motion, phase space, fixed points, stability analysis, bifurcations and their classification, Poincaré section and iterative maps.

Dissipative Systems
One-dimensional noninvertible maps, simple and strange attractors, iterative maps, period doubling and universality, intermittency, invariant measure, Lyapunov exponents, higher dimensional systems, Hénon map, Lorenz equations, fractal geometry, generalized dimensions, examples of fractals.

Hamiltonian Systems
Integrability, Liouville's theorem, action-angle variables, introduction to perturbation techniques, KAM theorem, area-preserving maps, concepts of chaos and stochasticity.

Advanced Topics
Selections from quantum chaos, cellular automata and coupled map lattices, pattern formation, solitons and completely integrable systems, turbulence.

References:

1. **E. Ott,** Chaos in Dynamical Systems, Cambridge University Press.
2. **E.A. Jackson,** Perspectives of Nonlinear Dynamics (Volumes 1 and 2), Cambridge University Press.
3. **A.J. Lichtenberg and M.A. Lieberman,** Regular and Stochastic Motion, Springer.
4. **A.M. Ozorio de Almeida,** Hamiltonian Systems: Chaos and Quantization, Cambridge University Press.
5. **M. Tabor,** Chaos and Integrability in Nonlinear Dynamics, Wiley.
6. **M. Lakshmanan and S. Rajasekar,** Nonlinear Dynamics: Integrability, Chaos andPatterns, Springer.

Astrophysics, Gravitation and Cosmology

Course Code: SPMS PHY 01 403 SEEC 3100

Physics of the Universe:
Astronomical observations and instruments, stellar spectra and structure, stellar evolution, nucleosynthesis and formation of elements, evolution and origin of galaxies, quasars, pulsars, expansion of the universe, big-bang model, CMBR, anisotropy.

General Relativity:
Review of special theory of relativity, four-vector formulation of Lorentz transformation, covariant formulation of physical laws, introduction to general relativity, principle of equivalence, tensor analysis and Riemannian geometry, curvature and stress-energy tensors, gravitational field equations, geodesics and particle trajectories, Schwarz-child solution, Kerr-solution, gravitational waves, relativistic stellar structure, TOV equation, basic cosmology.

References:

1. **K.D. Abhyankar,** Astrophysics: Stars and Galaxies, University Press.
2. **J.V. Narlikar,** An Introduction to Cosmology, Cambridge University Press.
3. **C.W. Misner, K. S. Thorne, J.A. Wheeler,** Gravitation, Freeman.
4. **R. Adler, M. Bazin and M. Schiffer,** Introduction to General Relativity, Pergamon Press.
5. **T. Padmanabhan,** Cosmology and Astrophysics through Problems, Cambridge University Press.