DEPARTMENT OF APPLIED PHYSICS
INDIAN SCHOOL OF MINES, DHANBAD

COURSE STRUCTURE & SYLLABUS
FOR
2-YEARS M.Sc.
IN
APPLIED PHYSICS

Effective from 2012-2013

2 YEARS M. SC. (APPLIED PHYSICS)
COURSE STRUCTURE

SEMESTER-I

Sl. No.	Course Name	Course No	L	T	P	Credit Hrs
1.	Classical Mechanics	APC 31101	3	1	0	7
2.	Methods of Mathematical Physics	APC 31102	3	1	0	7
3.	Quantum Mechanics-I	APC 31103	3	1	0	7
4.	Electronics	APC 31104	3	1	0	7
5.	Computer programming	AMC 31105	3	0	0	6
6.	Computer programming lab	AMC 31205	0	0	3	3
7.	Experimental Physics-I	APC 31201	0	0	3	3
8.	Experimental Physics-II	APC 31202	0	0	3	3
Total for Semester I			**15**	**4**	**9**	**43**

SEMESTER-II

Sl. No.	Course Name	Course No	L	T	P	Credit Hrs
1.	Quantum Mechanics-II	APC 32101	3	1	0	7
2.	Electrodynamics	APC 32102	3	1	0	7
3.	Atomic and Molecular Spectroscopy	APC 32103	3	1	0	7
4.	Solid State Physics	APC 32104	3	1	0	7
5.	Signal Processing	GPC 98106	3	1	0	7
6.	Experimental Physics-III	APC 32201	0	0	3	3
7.	Experimental Physics-IV	APC 32202	0	0	3	3
8.	Co-Curricular Activity-I	SWC 32701	0	0	0	3
9.	Summer Training (Min. two weeks) (Marks to be added in the next semester)	APC 32901				
Total for Semester II			**15**	**5**	**6**	**44**

SEMESTER-III

Sl. No.	Course Name		Course No	L	T	P	Credit Hrs
1.	Statistical Mechanics		APC 33101	3	1	0	7
2.	Condensed Matter Physics		APC 33102	3	0	0	6
3.	Laser and Holography		APC 33103	3	0	0	6
4.	Nuclear and Particle Physics		APC 33104	3	0	0	6
5.	Elective- I (Any one out of two)	i. Nonlinear Optical Processes & Devices	APE 33101	3	0	0	6
		ii. Science and Technology of Thin film	APE 33102				
6.	Experimental Physics-V		APC 33201	0	0	3	3
7.	Experimental Physics-VI		APC 33202	0	0	3	3
8.	Project		APC 33801	0	0	8	8
9.	Seminar		APC 33401	0	0	0	6
10.	Summer training		APC 33901	0	0	0	5
Total for Semester III				**15**	**1**	**14**	**56**

SEMESTER-IV

Sl. No.	Course Name		Course No	L	T	P	Credit Hrs
1.	Plasma and Space Physics		APC 34101	3	1	0	7
2.	Physics of Nanomaterials		APC 34102	3	1	0	7
3.	Computational Physics		APC 34103	3	1	0	7
4.	Elective-II (Any one out of two)	i. Superfluidity and Applied Superconductivity	APE 34101	3	1	0	7
		ii. Applied Biomedical Physics	APE 34102				
5.	Project & Dissertation		APC 34801	0	0	10	10
6.	Seminar on dissertation		APC 34401	0	0	0	6
7.	Viva-voce on dissertation		APC 34802	0	0	0	4
8.	Comprehensive Viva		APC 34501	0	0	0	4
9.	Co-Curricular Activity-II		SWC 34701	0	0	0	3
Total for Semester IV				**12**	**4**	**10**	**55**

2 YEARS M. SC. (APPLIED PHYSICS)
COURSE CONTENT

SEMESTER-I

APC 31101 CLASSICAL MECHANICS (3–1–0)

Lagrangian Formulation: Mechanics of a system of particles, constraints and generalized Coordinates and momenta, gyroscopic forces, Jacobi integral, Gauge invariance, D'Alembert's principle, Calculus of Variation and Lagrange's equations. Lagrangian formulation of continuous system, variation and end points, Action integrals, Principle of least action
Central force: Equations of motion, orbits: closure and stability of circular orbits, Virial theorem, Kepler problem, Collision and scattering in a central force field
Hamiltonian formulation: Legendre transformations, Hamilton equations, cyclic coordinates and conservation theorems, Canonical transformations, Poisson theorem, Poisson brackets, Angular momentum, Hamilton-Jacobi theory, Generating functions, Properties, group properties
Rigid body kinematics and Dynamics: Orthogonal transformations, Euler angles, coriolis effect, angular momentum and kinetic energy, tensors and dyadic, inertia tensor, Euler equations, applications, heavy symmetrical top.
Small oscillations: Eigenvalue problem, frequencies of free vibrations and normal modes, forced vibrations, two-coupled oscillations, normal modes and co-ordinates, dissipation
Special theory of relativity: Minkowski world and Lorentz transformations, world lines, Relativistic Mechanics of Mass Points, Lorentz covariance of the new conservation laws, Relativistic analytical mechanics, Relativistic force, Lagrangian and Hamiltonian of a relativistic particle.

Reference Books:

1. Classical Mechanics, 3rd Edition.; Goldstein, Safko & Poole; Pearson; 2002
2. Classical Mechanics; Rana & Joag; Tata Mgraw Hill; 1991
3. Classical Mechanics; Gupta, Kumar & Sharma; Pragati Prakashan; 2010
4. Classical Mechanics of Particles and Rigid Bodies; Gupta; John Wiley & Sons; 1988
5. Classical Mechanics: Systems Of Particles And Hamiltonian Dynamics; Greiner; Springer-Verlag; 2004

APC 31102 METHODS OF MATHEMATICAL PHYSICS (3–1–0)

Differential Equations and Special Functions: Second order linear ODEs with variable coefficients; Solution by series expansion; Legendre, Bessel, Hermite and Laguerre equations and their solutions; Physical applications; Generating functions; recurrence relation**;** Green's function and its applications
Review of Complex Variables and Applications to Integrals
Review and Applications of Laplace transform
Fourier transform: Sine, Cosine and Complex transforms with examples, Definition, Properties and Representations of Dirac Delta Function, Properties of Fourier Transforms, Transforms of derivatives, Parseval's Theorem, Convolution Theorem, Momentum representation, Applications to Partial differential equations, Discrete Fourier transform, Introduction to Fast Fourier transform.
Abstract Group Theory
Tensors: Transformation properties, Metric tensor, Raising and lowering of indices, Contraction, Symmetric and anti-symmetric tensors.

Reference Books:

1. Mathematical Methods for Physicists; Arfken & Weber; Academic Press; 2010
2. Essential Mathematical. : Methods For Physicists; Arfken & Weber; Academic Press; 2005
3. Mathematical Methods for Physics and Engineering: Riley, Hobson, Bence; Cambridge University Press; 2002
4. Applied Mathematics For Engineers And Physicists; Pipes; Mcgraw-Hill Book Company; 1970
5. Introduction To Mathematical Physics; Harper; Phi Learning; 2009
6. Mathematical Physics: Advanced Topics; Joglekar; Universities Press; 2006
7. Mathematical Methods for Physics; Wyld; Westview Press; 1999
8. Mathematical Methods in Physical Sciences; Boas; Wiley India Pvt Ltd; 2006
9. Group Theory And Quantum Mechanics; Tinkham; Dover Publications; 2003
10. Elements Of Group Theory For Physicists; Joshi; New Age; 1997

APC 31103 QUANTUM MECHANICS-I (3–1–0)

Short-overview: Why QM? Empirical basis, wave-particle duality, electron diffraction, notion of state vector and its probability interpretation; Operators and observables, significance of eigenfunctions and eigenvalues, commutation relations, uncertainty principle, measurement in quantum theory.

Schrödinger Equation: Time-independent Schrödinger equation, stationary states and their significance, time-dependent Schrödinger equation:

Potential Problems: Potential barrier and tunnelling; simple harmonic oscillator, motion in a central potential: hydrogen atom.

Linear Vector and Representation Theory:

Linear vector space, Dirac notations of Bra - Ket, Matrix representation of Observables and states, Determination of eigenvalues and eigen state for observables using matrix representations for harmonic oscillator, Change of representation and unitary transformations, Coordinate and momentum representations, Equations of motion in Schrödinger and Heisenberg pictures, equivalence

Theory of Angular Momentum:

Symmetry, invariance and conservation laws, relation between rotation and angular momentum, commutation rules, Matrix representations, addition of angular momenta and Clebsch-Gordon coefficients, spin-orbit coupling and fine structure, Pauli spin matrices.

Time-Independent Perturbation theory:

Time-independent Perturbation theory (non-degenerate and degenerate) and applications to fine structure splitting, Zeeman effect (Normal and anomalous), Stark effect, and other simple cases.

Scattering Theory:

Differential and total Scattering cross-sections laws, phase shifts, partial wave analysis and application to simple cases; Integral form of scattering equation, Born approximation validity and simple applications.

Reference Books:

1. Quantum Mechanics; Schiff; Tata Magraw Hill; 2010
2. Introduction of Quantum Mechanics; Griffiths; Pearson Education; 2010
3. Modern Quantum Mechanics; Sakurai; Pearson; 1994
4. Quantum Mechanics; Thankappan; New Age International Pub; 1993
5. Quantum Mechanics 2nd Ed; Bransden & Joachain; Pearson; 2000;
6. Principles of Quantum Mechanics; Dirac; Oxford University Press, Usa; 1982
7. Quantum Mechanics, 3rd Edition; Merzbacher; John Wiley; 2005
8. Quantum Mechanics: Theory And Applications, 1e; Ghatak & Lokanathan; Kluwer Academic Publishers; 2004

APC 31104 ELECTRONICS (3–1–0)

Network theorems: Application to simple circuits; P-N junction devices: Diodes, Transistors and its physics, biasing schemes, Small signal amplifiers, Feed-back theory, Oscillators, Power supply; FET devices and their characteristics; Homo and Heterojunction devices; Frequency dependence and applications; Operational-Amplifiers: Amplifiers, Scalar, Summer, Subtractor, Multiplier, Divider, Differentiator, Integrator, Comparator, Logarithmic amplifier, Wave shapers, Oscillators, Lock-in amplifier; Multivibrators: Astable, Monostable and Bistable; Optoelectronic devices: Solar cells, Photodetectors, and LEDs; High frequency devices: Generators and Detectors.

Number systems; Transistor as a switch; OR, AND, NOT, NOR, NAND, XOR, XNOR gates; De Morgan's laws; Karnaugh map; Arithmetic circuits; RS, JK, JK Master-Slave, T, D Flip-Flops; Registers; Synchronous, Asynchronous and Cascade Counters; Comparators; A/D and D/A conversion; Multiplexer, Demultiplexer; Basics of Microprocessors and Microcontrollers.

Reference Books:

1. Millman's Electronic Devices And Circuits; Millman; Tata Mgraw Hill; 2007
2. Electronic Devices And Circuits (SIE); Cathey; Mcgraw-Hill Education (India) Ltd; 2008
3. Digital Principles and Applications: Leach & Malvino; Tata Mgraw Hill; 2006
4. Electronic Devices and Circuits; Gupta; S. K. Kataria & Sons; 2010
5. Electronic Fundamentals & Applications: Int. & Discrete Systems; Ryder; Phi Learning; 2009
6. Hand Book of Electronics; Gupta & Kumar; Pragati Prakashan; 2010
7. Electronics: Fundamentals & Applications; Chattopadhyay & Rakshit; New Age Int.natl; 2010

AMC 31105 COMPUTER PROGRAMMING (3–0–0)

Introduction, Constants, variables and Data types, Operators and expressions, I/O operations, Control Structures; Arrays, Pointers, The preprocessors, Classes and Objects; Constructors and Destructors, Function overloading; Operator overloading and Type conversions; Inheritance; Polymorphisms, Console oriented I/O operations, File management, Templates; Exception Handling.

AMC 31205 COMPUTER PROGRAMMING LAB (0–0–3)

Laboratory experiments will be set in consonance with the materials covered in AMC31105. It includes programming assignments for practicing and designing on different programming.

APC 31201 EXPERIMENTAL PHYSICS –I (0–0–3)

Physics lab experiments have been designed to perform the optics experiments, such as determination of diameter of a thin wire or human hair, variation of refractive index with wavelength, to find the wavelength of unknown spectral lines using spectrometer, determination of fringe width in Michelson interferometer; experiments on diffraction and interference of light; etc.

APC 31202 EXPERIMENTAL PHYSICS –II (0–0–3)

Physics lab experiments have been designed to perform the experiments on solid state electronics such as study of bridge rectifier; experiments with various ICs like IC555, IC741; experiments using transistors; study of voltage amplification etc.

SEMESTER-II

APC 32101 QUANTUM MECHANICS –II (3–1–0)

Approximation methods
Variational method and applications to helium atom and simple cases; WKB approximation and applications to simple cases. Time- dependent Perturbation theory, Fermi's Golden rule, selection rule, Semi-classical theory of interaction of atoms with radiation.
Identical Particles:
Symmetric and anti-symmetric wave functions, symmetrization postulates, Pauli's exclusion Principle. Spin-statistics connection, self consistent field approximation: Slater determinant, Hartree-Fock method.
Relativistic Quantum Mechanics:
Klein Gordon equation, Dirac equation, negative energy solutions, antiparticles, Dirac hole theory, Gama-matrices and their properties, Covariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Bilinear covariant, Plane wave solution, Two component theory of neutrino, Spin & Helicity, Relativistic Hydrogen atom problem.
Field Quantization:
Equation of motion for field, Symmetries and conservation laws, Noether's theorem, canonical quantization of scalar field, Complex scalar field, electromagnetic field and Dirac field, Problem in quantizing electromagnetic field; Feynman diagrams and rules.

Reference Books:
1. Relativistic Quantum Mechanics: Bjorken and Drell; Mcgraw-Hill; 1998
2. Relativistic Quantum Mechanics: Wave Equations, 3/Ed; Greiner; Springer International; 2006
3. Relativistic Quantum Mechanics And Quantum Fields; Katiyar; Campus Books International; 2009
4. A First Book on Quantum Field Theory: Lahiri; Narosa Book Distributors Pvt Ltd; 2005
5. Quantum Field Theory, Rev.Ed.; Mandl & Shaw; Wiley; 1993
6. An Introduction To Quantum Field Theory; Peskin & Schroeder; Westview Press; 1995
7. Modern Quantum Mechanics; Sakurai; Pearson; 1994
8. Principles Of Quantum Mechaincs; Shankar; Springer; 2006

APC 32102 ELECTRODYNAMICS (3–1–0)

Green's theorem and Green's function-significance and applications.
Plane electromagnetic waves, Maxwell's equations, Gauge Transformation, Lorentz Gauge, Coulomb Gauge, Lorentz force equation and motion of charges, Electric and Magnetic fields due to a Uniformly Moving charge and An Accelerated Charge , Lienard-Weichert potentials, Wave propagation in conductors and dielectrics, Reflection, Refraction, Total internal reflection, Attenuation of waves in metals, Brewster's angle; Lorentz theory of dispersion**.** Wave-guide and resonant cavities, Field at the Surface of and within a Conductor, Cylindrical Cavities and Wave guides, Modes in rectangular wave guide, Power Loses in a cavity, Q of a Cavity. Earth and Ionosphere as a Resonant Cavity. Propagation of electromagnetic wave in ionosphere.
Transmission line;
4-vectors; Transformation properties; 4-dimensional velocity and acceleration, 4-momentum and 4-force; covariant equations of motion.

Reference Books:
1. Classical Electrodynamics; Jackson; John Wiley; 2007
2. Classical Electricity and Magnetism; Panofsky and Phillips; Dover Publications, Inc.; 1990
3. Introduction to Electrodynamics; Griffiths; Phi Learning; 2009

4. Foundations of electromagnetic theory; Reitz, Milford & Christy; Pearson; 2009
5. Electrodynamics; Gupta, Kumar & Sharma; Pragati Prakashan; 2010
6. Classical Electromagnetic Theory; Vanderlinde; John Wiley & Sons; 1993
7. Classical Electrodynamics; Greiner; Springer; 1998

APC 32103 ATOMIC AND MOLECULAR SPECTROSCOPY (3–1–0)

Quantum states of one electron atoms-Atomic orbitals-Hydrogen spectrum-Pauli's principle-Spectra of alkali elements – Spin orbit interaction and fine structure in alkali Spectra – Equivalent and non-equivalent electrons – Normal and anomalous Zeeman effect – Paschen Back effect, Stark effect-Two electron systems, Vector atom model, interaction energy in LS and jj Coupling – Hyperfine structure, – Line broadening mechanisms, Doppler and Lorentz Broadening.
Molecular spectra, Rotational spectra of diatomic molecules as a rigid rotor and non rigid rotor, intensity of rotational lines, Frank-Condon principle. Vibrational-rotational spectra, vibrational energy of diatomic molecule-Diatomic molecule as a simple harmonic oscillator, effect of anharmonicity, Energy levels and spectrum-Morse potential, energy curve-Molecules as vibrating rotor- Vibration spectrum of diatomic molecule. Raman spectroscopy, Rotational Raman spectra of diatomic molecules, Effect of Nuclear spin on intensities of Rotational Raman spectra; Mossbauer spectroscopy.

Reference Books:

1. Physics of Atoms and Molecules: Bransden and Joachain; Pearson; 2006
2. Lasers - Fundamentals and Applications: Thyagrajan & Ghatak; Springer; 2010
3. Introduction to Atomic Spectra; White; Mcgraw-Hill Education; 1934
4. Atomic Spectra And Atomic Structure; Herzberg; Dover; 2008
5. Chemical Applications of Group Theory; Cotton; Wiley India Pvt Ltd; 2009
6. Fundamentals of Molecular Spectroscopy; Banwell; Mcgraw-Hill Education (India) Ltd; 2000
7. Introduction to Molecular Spectroscopy; Barrow; Mcgraw-Hill Education; 1962
8. Modern Spectroscopy; Hollas; Wiley India Pvt Ltd; 2010

APC 32104 SOLID STATE PHYSICS (3–1–0)

Crystallography: Elementary concepts of point and space group and its relevance to crystal structure. Interaction of X-rays with matter, absorption of X-rays. Elastic scattering from a perfect lattice. The reciprocal lattice and its applications to diffraction techniques. The Laue, powder and rotating crystal methods, crystal structure factor and intensity of diffraction maxima Extinctions due to lattice centering.
Defects in Crystals: Point defects, line defects and planer (stacking) faults. Role of defects in crystal growth. The observation of imperfections in crystals, X-ray and electron microscopic techniques.
Lattice Dynamics: Vibration of lattice with two atoms per unit cell, quantisation of lattice vibrations, interaction of electromagnetic waves and particle waves with phonons.
Electronic Properties of Solids: Band theory: Tight-bonding, cellular and pseudopotential methods. Fermi surface, Landau levels, de Hass-van Alphen effect, cyclotron resonance, magnetoresistance, Giant magneto resistance, colossal magneto resistance, Magnetic Resonance,
Magnetism: Spin waves and magnons, Ferri- and antiferro-magnetic order, Ferro and antiferro electric effect. Domains and Bloch-wall energy.
Semi-conductor Physics: Charge carrier density in intrinsic semiconductors, doping of semiconductors, carrier densities in doped semiconductors, conductivity of semiconductors, Hall effect (Classical and Quantum), semiconductor Hetrostructures and Superlattices. Junction capacitance of a PN junction, Luminescence, photo conductivity and optical absorption, Diffusion.

Reference Books:

1. Introduction of Solids; Azaroff; Tata Mgraw Hill; 1984
2. Crystallography Applied to Solid State Physics; Verma & Srivastava; New Age; 1991
3. Principels of Condensed Matter Physics; Chaikin & Lubensky; Cambridge University Press; 2000
4. Solid State Physics-Structure and Properties of Materials; Wahab; Narosa; 2000
5. Solid State Physics; Ashcroft & Mermin; Brooks/Cole; 2003
6. Introduction to Solid State Physics; Kittel; Wiley India Pvt Ltd; 2007

GPC 98106 SIGNAL PROCESSING (3–1–0)

Signals, noise and their classification
Continuous and discrete signals; discretization of continuous signals, sampling theorem, aliasing.
Reconstruction of a signal from its samples-Gibb's phenomenon.
Laplace transform and inverse Laplace transform and its applications.
Review of Complex exponential Fourier series, Fourier integral.
Review of Fourier transform and its properties, energy and phase spectra.
Review of Fourier transforms of some commonly used functions, utility of domain transformation.
Inverse Fourier transforms; use of one and two dimensional Fourier transforms in solving various problems, radial and angular spectra.
Hankel transform and Hilbert transforms their properties, the concept of analytic signal and its uses.
Z transforms: definition and types, Z transforms of causal and non-causal sequences, properties of Z transforms and the region of convergence, application of Z transform & inverse Z transform.
Concepts and application of Poles and Zeroes for Instrumentations.
Introduction to wavelet transforms and its applications.
Digital filters: Basic concepts of Transfer function, Impulse response. Types of filters, ideal filters; design of Martin Graham, Butterworth and Chebyshev filters. Various applications of filters.
Inverse filtering: Wiener filters, deconvolution-predictive and its applications.
Homomorphic filtering, ceptsral analysis and its applications.
Processing of random signals and its applications.

Reference Books:

1. Signals and Circuits; Baskakov; Mir Publishers; 1986
2. Time Series Analysis and Application ; Robinson; D. Reidel; 1981
3. Digital Signal Processing (System Analysis and Design); Dinz, da Silva & Netto; Cambridge University Press
4. Signals and Systems; Rawat; Oxford University Press
5. Digital Signal Processing (Principles, Algorithms and Applications); Proakis & Manolakis; PHI Publication (3rd Edition)

APC 32201 EXPERIMENTAL PHYSICS-III (0–0–3)

This lab is designed to study the electronic materials, modern physics etc.; e.g. the characteristics of Zener diodes; determination of dielectric constant of different materials; determination the diffusion potential and band gap of P-N junction; determination of the Planck's constant; study of Photo-electric effect etc.

APC 32202 EXPERIMENTAL PHYSICS-IV (0–0–3)

Experimental physics lab-IV is designed to study the applications of electronics, spectroscopy; e.g. the frequency and amplitude modulation and demodulation; determination of Fourier components of square and sine waves; study of Zeeman Effect and determination of the e/m ratio; determination of g-factor by ESR spectrometer etc.

SEMESTER-III

APC 33101 STATISTICAL MECHANICS (3–1–0)

Specification of states of a system, contact between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox, phase space, trajectories and density of states, Liouville's theorem; Ensembles: Microcanonical ensemble, canonical and grand canonical ensembles; partition function, calculation of statistical quantities, Energy and density fluctuations.
Density matrix, statistics of ensembles, statistics of indistinguishable particles, Maxwell-Boltzman, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose—Einstein condensation.
Cluster expansion for a classical gas, Virial equation of state.
Ising model, mean-field theories of the ising model in one, two and three dimensions, Exact solutions in one dimension.
Landau theory of phase transition, critical indices, scale transformation and dimensional analysis.
Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem. The Fokker-Planck equation.

Reference Books:

1. Statistical Mechanics: R. K. Pathria; Elsevier; 2002
2. Statistical Mechanics: K Haung; Wiley Eastern; 2003
3. Modern Theory of Critical Phenomena: Shang Keng Ma; Levant Books; 2007
4. Statistical Mechanics: Landau and Lifshitz; Butterworth-Heinemann; 1976
5. Fundamentals of Statistical and Thermal Physics; Reif; McGraw-Hill; 1965
6. Thermodynamics and Statistical Mechanics; Greiner; Springer; 2007

APC 33102 CONDENSED MATTER PHYSICS (3–0–0)

Many electron theory: Interacting Electron Gas: Hartree and Hartree-Fock Methods; Optical Properties: Interactions of Electrons and Phonons with Photons, Direct and Indirect Transitions, Polaritons; Electron Localization in Disordered System: Electron Localization, Density of States, Mott's Localization, Hopping Conductivity.

Superconductivity: Thermodynamics of the superconductive transition, Type I and II superconductors – Vortex state, estimation of H_{c1}, and H_{c2}, London equation, Coherence length, persistent current and Meissner effect. Flux quantisation, duration of persistent currents, Josephson effect, DC and AC Josephson effect.
Electron-Phonon-Electron interaction: Interaction of Electron with Acoustic and Optical Phonons, Long Wavelength Limit of Optical Phonons and Crystal Polarization, Polarons, Cooper Pairing due to Phonon, energy gap, BCS theory of superconductivity,, Ginzburg – Landau theory and its application to Josephson effect. Macroscopic Quantum interference, High temperature superconductors-an elementary idea.

Soft Matter: What is Soft Condensed Matter: forces, energies and time scales. Phase transition in soft matter, Radial distribution function, thermodynamic functions in terms of Radial distribution functions and description of liquids; Colloids, Polymers, Gels, Liquid Crystals; Soft matter in nature.

Reference Books:

1. Principels of Condensed Matter Physics; Chaikin & Lubensky; Cambridge University Press; 2000
2. States of Matter; Goldstein; Dover; 2002
3. Soft Condensed Matter: Jones; Oxford University Press; 2002
4. Soft Matter Physics: Daoud and Williams; Springer; 1999
5. Introduction to Solid State Physics; Kittel; Wiley India Pvt Ltd; 2007
6. Solid State Physics-Structure and Properties of Materials; Wahab; Narosa; 2000
7. Solid State Physics; Ashcroft & Mermin; Brooks/Cole; 2003
8. Introduction to superconductivity; Tinkham; Dover; 2004
9. Many-particle physics; Mahan; Plenum Publishing Corporation; 1990

APC 33103 LASER AND HOLOGRAPHY (3–0–0)

Laser: Gaussian beam and its properties, Laser Rate equations, Stability conditions, focal concentric and unstable resonators, Stable Two – Mirror Optical Resonators, Longitudinal and Transverse Modes of Laser Cavity , Mode Selection , Gain in a Regenerative Laser Cavity, Threshold for 3 and 4 level Laser Systems. Mode Locking, Pulse Shortening – Pico second & femto-second operation, Spectral Narrowing and Stabilization. Gas Lasers, Solid state lasers, Liquid lasers, Semiconductor lasers, Tunable lasers, Excimer Laser and Free electron laser.
Holography: Basics of Holography, Reflection, Rainbow, Colour and Fourier transform holography, theory of in - line and off – axis holography, Holographic interferometry, Non-destructive testing of engineering objects.

Reference Books:

1. Laser Spectroscopy: Basic Concepts And Instrumentation; Demtroder; Springer Publishing Company, Inc; 2004
2. Principles of Lasers; Svelto; Springer; 2009
3. Laser Fundamentals; Silfvast; Cambridge University Press; 2008

APC 33104 NUCLEAR AND PARTICLE PHYSICS (3–0–0)

Nuclear systematics and stability: Masses, sizes, spins, angular momenta, magnetic moments, parity, quadrupole moments, energetics and stability against particle emission, Gamow's theory of Alpha decay, Fermi theory of Beta decay, Gamma decay, Internal conversion, Nuclear isomerism.
Two Nucleon Problem: Nature of nuclear forces, Meson theory of nuclear forces, Deuteron problem, Nucleon-Nucleon scattering, scattering length, coherent and incoherent scattering, Effective range theory.
Nuclear Models: Semi-empirical mass formula and its applications, Liquid drop model, Shell model and its applications, Collective model, Fermi gas model.
Detectors & Accelerators: Gas-Filled Ionization Detectors, Proportional counter, G.M. counter, Semiconductor Detectors, Solid State Scintillation Counters, Synchrotrons, Linear Accelerators, Colliding/Beam Accelerators.
Nuclear Reactions: Conservation laws, Classification, Compound Nucleus theory, Continuum and Statistical theories, Cross-sections, Breit-Wigner formula, Direct Reactions.
Elementary particles: Leptons, Mesons and Baryons, concept of antiparticle, discrete symmetries and conservation laws, Weak interactions (nuclear and particle decays, neutrinos etc.). Isospin and strangeness, Gellmann-Nishijima formula, quark model, colour, resonances, SU(3) classification, flavour of standard model.

Reference Books:

1. Atomic & Nuclear Physics; Vol.2, S N Ghoshal; S. Chand; 1994
2. Structure of the Nucleas; Preston & Bhaduri; Westview Press; 1993
3. Theory of Nuclear Structure; Pal; Affiliated East West Press; 2000
4. Introductory Nuclear Physics; Wong; Phi Learning; 2010
5. Theory of Nuclear Structure; Gupta; Alpha Publication; 2011
6. Nuclear and Particle Physics; Burcham & Jobesl; Longman Publishing Group; 1994
7. Quarks and Leptons: Halzen and Martin; Wiley India Pvt Ltd; 2008
8. Symmetry Principles Particle Physics; Gibson & Pollard; Cambridge University Press; 2010
9. Symmetry Principles in Particle Physics; Emmerson; Oxford University Press; 1972
10. Introduction to High Energy Physics; Perkins; Cambridge University Press; 2010

ELECTIVE-I (Any one out of two)

APE 33101 NONLINEAR OPTICAL PROCESSES AND DEVICES (3–0–0)

Propagation of electromagnetic waves in nonlinear optical media. Nonlinear optical susceptibilities and Symmetry, Three wave mixing: second harmonic generation, phase matching techniques, efficiency, parametric mixing, amplification and oscillation, power considerations. Four wave mixing: Optical phase conjugation. Stimulated Raman Scattering: Quantum mechanical description of Raman Scattering. Electromagnetic theory of Stimulated Raman Scattering, Anti-Stokes scattering. Optical Kerr effect. Nonlinear Spectroscopy. Multiphoton processes. Self-focussing self-induced transparency. Use of density matrix and perturbative approach to nonlinear optical susceptibilities and application to specific interactions. Dyes. Organic Solids. other inorganic solids and special materials. Photorefractive crystals, theory and application to imaging. Electro-Optic effect, Retardation, electro-optic modulators. acousto optics, acousto optic materials and acousto optic modulators. magneto- optic effect. Retardation and modulators. Quantum detectors, limits of detection systems, noise in optical detectors.

Reference Books:

1. Quantum Electronics; Amnon Yariv; John Wiley & Sons; 1989
2. Laser and Non-Linear Optics; Laud; New Age; 1991
3. Essentials of Lasers and Non-Linear Optics; Baruah; Pragati Prakashan; 2000

APE 33102 SCIENCE AND TECHNOLOGY OF THIN FILM (3–0–0)

Growth and structure of films. General features. Nucleation theories Effect of electron bombardment on film structure. Post- nucleation growth Epitaxial films and growth. Structural defects.

Preparation methods: Electrolytic deposition, cathodic and anodic films, thermal evaporation, cathodic sputtering, chemical vapour deposition. Molecular beam epitaxy and laser ablution methods.

Vacuum science and techniques: Vacuum principles; Vacuum generation - Rotary vane pump, Diffusion Pump, Turbomolecular Pump (TMP), Cryo Pump; Vacuum measurement - Thermal conductivity vacuum gauges, Ionization vacuum gauges.

Thickness measurement and monitoring: Electrical, mechanical, optical interference, microbalane, quartz crystal methods.

Analytical techniques of characterization: Small angle X-ray diffraction, electron microscopy, high and low energy electron diffraction, Auger emission spectroscopy.

Mechanical properties of films: Elastic and plastic behavior. Optical properties. Reflectance and transmittance spectra. Absorbing films. Optical constants of film material . Multilayer films.

Anisotropic and gyrotropic films.
Electric properties to films: Conductivity in metal, semiconductor and insulating films. Discontinuous films. Superconducting films. Dielectric properties.
Magnetism of films: Molecular field theory. Spin wave theory. Anisotropy in magnetic films, Domains in films, Applications of magnetic films.
Thin film devices: Fabrication and applications.

Reference Books:

1. Thin Films; Heavens; Dover Publications Inc.; 1991
2. Thin-Film Deposition: Principles and Practice; Smith; McGraw-Hill; 1995
3. Thin Film Fundamentals; Goswami; New Age International Pvt. Ltd; 2007
4. Thin Film Phenomena; Chopra; McGraw-Hill; 1969
5. Handbook of Thin Film Technology; Maissel & Glang; McGraw-Hill; 1970
6. Thin Film Processes I; Vossen & Kern; Elsevier Science & Technology Books; 1978
7. Thin film processes II; Vossen & Kern; Academic Press; 1991

APC 33201 EXPERIMENTAL PHYSICS-V (0–0–3)

This lab has been designed to perform the experiments on fiber optics, photonics; such as determination of the numerical aperture of a given multimode fiber; experiments using fibres; preparation of fiber-end face; determine of the numerical aperture, bending loss and other parameters; experiments using discharge tubes etc.

APC 33202 EXPERIMENTAL PHYSICS-VI (0–0–3)

This lab has experiments on materials characterization like study of ferromagnetic materials in magnetic field; determination of heat capacity of solids; measurement of magneto resistance of semiconductors; study of Curie temperature; determination of lattice parameters; etc.

SEMESTER-IV

APC 34101 PLASMA AND SPACE PHYSICS (3–1–0)

Motion of charged particles in magnetic fields: plasma confinement schemes, Tokomak.
Comprehensive theory of electromagnetic waves in magnetized plasma, Wave propagation in cold and hot plasmas; Wave propagation in inhomogeneous plasma; Wave propagation in the ionosphere and in planetary magnetosphere; Absorption by Landau and cyclotron damping and by transit time magnetic pumping; RF plasma heating.
MHD models: Two-fluid hydrodynamic plasma models: wave propagation in a magnetic field; Simple equilibrium and stability analysis, Linear waves and instabilities in magnetized plasma.
Introduction to kinetic theory; Vlasov plasma model: electron plasma waves and Landau damping; solutions of Vlasov-Maxwell equations in homogeneous and inhomogeneous plasmas.
Coulomb collisions and transport processes; Collisions and discrete particle effects; Conductivity, Diffusion along and across magnetic field; fluctuations in a stable plasma; Fokker-Planck equation and transport phenomena.
Space Physics:
Solar Phenomena: Structure of the Sun, Solar Activity, Prominences, Coronal Heating, Solar Flares.
Solar Wind: Properties, solar wind formations, Interaction of Solar Wind with Magnetized and Unmagnetized Planets.

Magnetophere: Magnetopause, Magnetotail, Magnetic reconnection, Magnetosphere, Plasma flow in the magnetosphere.
Upper Ionosphere: Structure, Ionosphere, Ionospheric Irregularities, Aurora Borealis, Magnetosphere-Ionosphere coupling.

Reference Books:

1. Basic Space Plasma Physics; Baumjohann & Treumann; World Scientific Publishing Co.; 1996
2. Introduction to Space Physics; Kivelson, Kivelson & Russell; Cambridge University Press; 1995
3. Space Plasma Physics: An Introduction; Das; Alpha Science International, Ltd; 2004
4. Plasma Physics and Introductory Courses; Dendy; Cambridge University Press; 1995
5. Introduction of Plasma Physics; Goldston & Rutherford; Taylor & Francis Group; 1995
6. Fundamentals of Plasma Physics; Bittencourt; Springer; 2004
7. Introduction to Plasma Physics and Controlled Fusion, Vol I; Chen; Springer; 2006

APC 34102 PHYSICS OF NANOMATERIALS (3–1–0)

Overview: Band structure, Density of state (DOS) in bands, Variation of DOS with energy, Variation of DOS and band gap with size of crystal; Dimensional dependence of DOS of Fermi gas electrons; Local density of states.
Electron confinement in infinitely deep and finite square well, well with circular cross section, parabolic well potentials.
Quantum size effect: Quantum well, Quantum wire, Quantum dot; Magic Numbers; Conduction electrons and dimensionality, Partial confinement, Properties dependent on DOS.
Electrical transport properties, Single electron tunnelling, Resonance Tunnel Diode, Quantum structural properties in Superconductivity; Excitons, Optical absorption in quantum well, Infrared detectors, Quantum dot lasers, Surface plasmon resonance; Superparamagnetism; Fullerenes and Carbon Nanotubes.
Applications of nanomaterials.
Preparation of nanomaterials: Ball Milling, Chemical bath deposition, Electrodeposition, Sol-gel method, Cluster beam evaporation, Ion beam deposition, RF Plasma Chemical Methods, Thermolysis, Vapour-Liquid-Solid method, Pulsed Laser Methods, Molecular Beam Epitaxy, Biological Methods - Synthesis using micro-organisms and Plant Extract, Nanolithography.
Characterization techniques: Determination of particle size, XRD, Transmission Electron diffraction, Scanning Electron Microscopy, Transmission Electron Microscopy, Scanning Probe Microscopy, Spectro-photometry, Photoluminescence, Infrared and Raman spectroscopy.

Reference Books:

1. Introduction to Nanotechnology; Poole & Owners; Wiley India Pvt Ltd; 2007
2. Quantum Dots; Jacak, Hawrylak & Wojs; Springer; 1998
3. Handbook of Nanostructured Materials and Nanotechnology; Nalva; Academic Press; 1999
4. Carbon Nanotubes Angles Or Demons; Silvana Fiorito; Pan Stanford Publishing; 2008
5. Nanotechnology For Dummies; Booker & Boysen; For Dummies; 2005
6. Nanotechnology: The Fun And Easy Way To Explore The Science Of Matter'S Smallest Particles; Booker & Boysen; Wiley India Pvt Ltd; 2005
7. Nanostructures and Nanomaterials: Synthesis, Properties, and Applications; Cao; World Scientific Publishing Company; 2011
8. Nano Materials; Bandyopadhyay; New Age International Ltd; 2010
9. Introduction to Nanoscience and Nanotechnology; Chattopadhyay & Banerjee; PHI Learning Pvt. Ltd.; 2009
10. Chemistry of Nanomaterials: Synthesis, Properties and Applications; Rao, Muller & Cheetham; Wiley VCH; 2004

APC 34103 COMPUTATIONAL PHYSICS (3–1–0)

Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideas and simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion
Percolation theory and simulation by Hoshen-Kopelman algorithm; Application to simple lattice models in Physics
Elementary ideas of: (a) Time-average and Molecular dynamics: Dynamical equations and physical potentials; Verlet algorithm (b) Ensemble average and Monte Carlo methods; Metropolis algorithm. Introduction to the simulations of: (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: travelling salesman problem (TSP) and satisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique; Chaos.

Reference Books:

1. Understanding Molecular Simulation: From Algorithms To Applications; Frenkel & Smit; Academic Press; 2001
2. Introduction To Percolation Theory; Stauffer & Amnon; CRC Press; 1994
3. Equilibrium Statistical Physics; Plischke & Bergersen; World Scientific Publishing Company; 2006
4. Numerical Recipes in C: The Art of Scientific Computing: W.H. PresB.P. Flannery, S.A. Teukol sky and W.T. Vetterling
5. Monte Carlo Simulations in Statistical Physics; Landau and Binder; Cambridge; 2005

ELECTIVE-II (Any one out of two)

APE 34101 SUPERFLUIDITY AND APPLIED SUPERCONDUCTIVITY (3–1–0)

Weakly interacting Bose gases, Bose-Einstein condensation, ground state and excitations. Liquid ^{4}He and ^{3}He, properties of superfluid ^{4}He, macroscopic wave function, quantized circulation and vortices, excitations, Landau criterion for Superfluidity, two-fluid hydrodynamics, first and second sound, Cryogenics.
Superconducting materials, elemental, alloys, oxides and intermetallic superconductors. Application of superconductivity in production of high magnetic fields, SQUIDs, magnetic levitation, power storage, transmission & distribution and in electronic devices. Discovery of high T_c superconductors, engineering challenges and opportunities in high T_c superconductors.

Reference Books:

1. Introduction to Condensed Matter Physics: Vol. 1; Duan & Guojun; World Scientific Publishing; 2005
2. Superfluidity and Superconductivity; Tilley & Tilley; Overseas Press; 2005
3. Superconductivity: Physics and Applications; Fossheim & Sudbø; Wiley; 2004
4. Introduction to the theory of Superfluidity; Khalatnikov; Perseus Books; 1989
5. Superconductivity, superfluidity, and Condensates; Annett; Oxford University Press; 2004

APE 34102 APPLIED BIOMEDICAL PHYSICS (3–1–0)

Basic interactions which drives structures: Intermolecular and other Interactions, Structure of biomolecules, Structure of nucleic acid and physics of macromolecules.
Experimental techniques used to determine biomolecular structure :X-ray crystallography, Spectroscopic techniques: UV, CD, Fluorescent, NMR; Interaction of laser radiation with tissue, Scattering of light by biological objects, optics of eye, Laser safety, Confocal Microscopy, scanning laser opthalmoscopy, different type of scanners, photo detectors, low coherence and high coherence interferometry, optical coherence tomography and its applications, Different types of noises, Computer aided tomography, Laser surgery.

Reference Books:

1. Biomedical Applications of Introductory Physics; Tuszynski & Dixon; John Wiley & Sons; 2001
2. Optics And Vision; Pedrotti, Pedrotti & Pedrotti; Benjamin-Cummings Publishing Company; 1997
3. Handbook Of Optical Coherence Tomography; Bouma, Tearney & Bouma; Informa Healthcare; 2002
4. Automated Visual Inspection; Hill, Hodgson & Batchelor; IFS/North-Holland; 1985
5. Biomedical Optics: Principles And Imaging; Wang, Wu & Wang; Wiley-Interscience; 2007
6. Magnetic Resonance Imaging: Physical Principles and Applications; Kuperman Academic Press; 2000