Dr. Bhimrao Ambedkar University, Agra

A State University of Uttar Pradesh (Paliwal Park, Agra -282004)

www.dbrau.ac.in

A Documentary Support

for

Matric No. – 1.3.1

Institution integrates cross-cutting issues relevant to **Professional Ethics, Gender, Human Values, Environment & Sustainability and other value framework enshrined in Sustainable Development goals and National Education Policy – 2020** into the Curriculum

under the

Criteria – I

(Curriculum Design and Development)

Key Indicator - 1.3

in

Matric No. – 1.3.1

M. Sc. Physics

PROFESSIONAL ETHICS	ENVIRONMENT & SUSTAINABILITY	NATIONAL EDUCATION POLICY – 2020
HUMAN VALUES	GENDER	

Registrar
Dr. B.R.A. University, Agra

Signature Not Verified
RAJEEV KUMAR
Digitally Signed By: Registrar

DR. BHIM RAO AMBEDKAR UNIVERSITY
AGRA

M.Sc. PHYSICS SYLLABUS

(Effective from 2022)

UNDER

NATIONAL EDUCATION POLICY
2020

M.Sc. PHYSICS COURSE STRUCTURE	
DEGREE **BACHELOR (RESEARCH) OF SCIENCE IN PHYSICS**	
RT H YE A R	**SEMESTER VII** • 4 Theory Papers (Compulsory) of 4 Credits each. • 1 Practical Paper (Compulsory) of 4 Credits. • 1 Research Project of 4 Credits. **SEMESTER VIII** • 3 Theory Papers (Compulsory) of 4 Credits each. • 1 Theory Paper (Optional Paper) of 4 Credits. • 1 Practical Paper (Compulsory) of 4 Credits. • 1 Research Project of 4 Credits. **NOTE** * 1 Minor Paper, either in Semester VII or VIII, from Other Faculty, of minimum 4 Credits. * Combined Project Report / Dissertation of Semester VII and VIII will be evaluated together at the end of Fourth Year by the internal and external examiners.
DEGREE **MASTER OF SCIENCE IN PHYSICS**	
F T H Y E A R	**SEMESTER IX** • One Specialization Branch is to be selected. • There will be 4 Theory Papers known as Specialization Papers (Two in each Semester IX & X) and 2 Practical Papers known as Specialization Labs (One in each Semester IX & X) related with the selected Specialization Branch. • 2 Theory Papers (Compulsory) of 4 Credits each. • 2 Theory Papers (Specialization Paper) of 4 Credits each. • 1 Practical Paper (Specialization Lab) of 4 Credits. • 1 Research Project of 4 Credits. **SEMESTER X** • 2 Theory Papers (Compulsory) of 4 Credits each. • 2 Theory Papers (Specialization Papers) of 4 Credits each. • 1 Practical Paper (Specialization Lab) of 4 Credits. • 1 Research Project of 4 Credits. **NOTE**

	* Combined Project Report / Dissertation of Semester IX and X will be evaluated together at the end of Fifth Year by internal and external examiners.

SEMESTER-WISE TITLES OF THE PAPERS IN
DEGREE BACHELOR (RESEARCH) OF SCIENCE IN PHYSICS

YEAR	SEME-STER	CODE	PAPER TITLE	THEORY / PRACTICAL	CREDIT	MARKS (25+75) #
FOURTH YEAR	VII	PH 411 T	Mathematical Methods In Physics	Theory	4	100
		PH 412 T	Classical Physics	Theory	4	100
		PH 413 T	Atomic Spectra	Theory	4	100
		PH 414 T	Electrodynamics	Theory	4	100
		PH 415 P	Experimental Work	Practical	4	100
		PH 416 R	Research Project - 1	Project Work	4	--
		PH 421 T	Computational Methods In Physics	Theory	4	100

	VIII	PH 422 T	Statistical Physics	Theory	4	100
		PH 423 T	Molecular Spectra	Theory	4	100
		Optional Paper : Select Any One (A / B / C / D / E / F)				
		PH 424A T	Relativity and Cosmology	Theory	4	100
		PH 424B T	Plasma Physics			
		PH 424C T	Laser Physics			
		PH 424D T	Semiconductor Physics			
		PH 424E T	Biophysics			
		PH 424F T	Environmental Physics			
		PH 425 P	Experimental Work	Practical	4	100
		PH 426 R	Research Project - 2	Project Work	4	--
		PH 416 R + PH 426 R	Project Report / Dissertation (Combined Research Projects -1 & 2)		--	100
	TOTAL FOR FOURTH YEAR				**48 + 4***	**1100 + 100***

25 Marks: Internal, based on Continuous Internal Evaluation (CIE) Methods
75 Marks: External, based on End-Semester University Examinations

* 1 Minor Paper, either in Semester VII or VIII, from Other Faculty, of minimum 4 Credits and 100 marks.

SEMESTER-WISE TITLES OF THE PAPERS IN MASTER OF SCIENCE IN PHYSICS						
YEAR	**SEME-STER**	**CODE**	**PAPER TITLE**	**THEORY / PRACTICAL**	**CREDIT**	**MARKS (25+75) #**

FIFTH YEAR	IX	PH 511 T	Quantum Mechanics	Theory	4	100
		PH 512 T	Nuclear Physics	Theory	4	100
		Specialization Paper : Select Any Set (A / B / C/ D)				
		PH 513A T	Electronics - I	Theory	4	100
		PH 513B T	Condensed Matter Physics - I			
		PH 513C T	Renewable Energy Physics - I			
		PH 513D T	Nanophysics - I			
		PH 514A T	Electronics - II	Theory	4	100
		PH 514B T	Condensed Matter Physics - II			
		PH 514C T	Renewable Energy Physics - II			
		PH 514D T	Nanophysics - II			
		PH 515 P	Experimental Work	Practical	4	100
		PH 516 R	Research Project - 3	Project Work	4	--
	X	PH 521 T	Advanced Quantum Mechanics	Theory	4	100
		PH 522 T	Particle Physics	Theory	4	100
		Specialization Paper : As Selected in IX Semester				
		PH 523A T	Electronics - III	Theory	4	100
		PH 523B T	Condensed Matter Physics - III			
		PH 523C T	Renewable Energy Physics - III			
		PH 523D T	Nanophysics - III			

		PH 524A T	Electronics - IV	Theory	4	100
		PH 524B T	Condensed Matter Physics - IV			
		PH 524C T	Renewable Energy Physics - IV			
		PH 524D T	Nanophysics - IV			
		PH 525 P	Experimental Work	Practical	4	100
		PH 526 R	Research Project - 4	Project Work	4	--
		PH 516 R + PH 526 R	Project Report / Dissertation (Combined Research Projects - 3 & 4)		--	100
	TOTAL FOR FIFTH YEAR				**48**	**1100**

25 Marks: Internal, based on Continuous Internal Evaluation (CIE) Methods
75 Marks: External, based on End-Semester University Examinations

PH 411 T
MATHEMATICAL METHODS IN PHYSICS

UNIT I:

Linear vector spaces , basis and dimension. Linear product spaces, orthogonality, Linear independence & orthogonality of vectors, Matrices and special matrices, Inverse ,orthogonal and unitary matrices. Eigenvalues & eigenvectors of matrices and Cayley-Hamilton theorem. Diagonalization of matrices.

UNIT II:

Differential Equations And Special Functions; Solution by series expansion of Hermite, Bessel, Legendre, Associated Legendre, Laguerre and Associated Laguerre differential equations,Basic properties (generating functions, recurrence & orthogonality relations and series expansion) of Hermite, Bessel, Legendre, Associated Legendre, Laguerre and Associated Laguerre functions.

UNIT III:

Laplace Transform: Introduction and properties (linearity, shifting and change of scale). Laplace transform of derivatives and integrals of a function. Differentiation and integration of Laplace transform. Inverse Laplace transforms. Fourier Transform: Introduction and properties (linearity, shifting, change of scale and modulation). Inverse Fourier transforms. Fourier sine & cosine transforms. Fourier integral and Fourier sine & cosine integrals.

UNIT IV:

Functions of a complex variable and analytic functions. Cauchy-Riemann conditions. Integration in the complex plane, Cauchy's integral theorem and Cauchy's integral formula. Taylor and Laurent series ,Ordinary, singular and isolated singular points. Definition and evaluation of residues. Cauchy's residue theorem and Jordan's lemma. Application of Cauchy's residue theorem to the evaluation of definite integrals.

SUGGESTED READINGS:

1. G. Arfken: Mathematical Methods for Physicists
2. J. Mathews and R.L. Walker: Mathematical Methods of Physics
3. G.F. Simmons: Differential Equations with Applications and Historical Notes
4. W.W. Bell: Special Functions for Scientists and Engineers
5. R.V. Churchill and J.W. Brown: Complex variables and Applications

PH 412 T
CLASSICAL PHYSICS

UNIT I:

Preliminaries, Newtonian Mechanics of one and many particle systems, conservation laws, Constraints, their classification, D' Alembert's principle, generalized Co-ordinate & momenta, Lagrange's equations, Hamiltonian and Hamiltonian equations

UNIT II:

Rotating frames, inertial forces, Terrestrial and astronomical applications of Coriolis force, Central force (Definition and Characteristics), Two body problem, closure and stability of circular orbits, general analysis of orbits, Kepler's laws and equation, artificial Satellites; Rutherford scattering

UNIT III:

Principle of least action, derivation of equation of motion: variation and end points, Hamilton's principle and Characteristic functions, Hamilton Jacobi equation

UNIT IV:

Canonical transformation; generating functions Properties; group property; examples; infinitesimal generators, Poisson Brackett, Poisson themes, angular momentum, Poisson Bracket, small oscillations, normal modes and co-ordinates

SUGGESTED READINGS:

1. H. Goldstein: Classical Mechanics
2. N.C. Rana and P.J. Joag: Classical Mechanics
3. D. Strauch: Classical Mechanics-An Introduction

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PH 413 T
ATOMIC SPECTRA

UNIT I:

Review of Bohr's model for single valence electron systems and quantum mechanical treatment of Hydrogen atom, Concept of spin of electron, Pauli's exclusion principle & periodic table, Origin & Significance of various quantum numbers for single valence electron systems, Parity of eigenfunctions, Orbital, spin & total magnetic dipole moments of electron and Lande's g factor. Larmor theorem

UNIT II:

Spectra of alkali elements, Screening constant, Theory of Fine Structure: Spin-orbit interaction energy, corresponding term shift & doublet separation. Relativistic correction energy, Selection rules, allowed transitions & intensity rules, Fine structure of Sodium D line. Fine structure of Hydrogen H-alpha line & Lamb shift, Theory of Hyperfine Structure: Isotopic effect, Energy order of hyperfine structure levels & selection rules.

UNIT III:

Theory of non-penetrating & penetrating orbits, LS Coupling, Spectroscopic terms for non-equivalent & equivalent electrons, Spin-spin , orbit-orbit & spin-orbit interaction energies, Lande's interval rule, JJ Coupling, Spectra of Alkaline Earth Elements: Singlet & triplet structure of spectra.

UNIT IV:

Zeeman Effect: Introduction (normal & anomalous Zeeman effects), Magnetic interaction energy & corresponding term shift. Selection rules, intensity rules & polarisation rules. Anomalous Zeeman effect of fine structure of Sodium D line, Paschan-Back Effect and Stark Effect

SUGGESTED READINGS:

1. H.E. White: Introduction to Atomic Spectra
2. Gerhard Herzberg: Atomic Spectra and Atomic Structure
3. Bransden and Joachain: Physics of Atoms and Molecules

PH 414 T
ELECTRODYNAMICS

UNIT I:

Concept of radiation & power radiated by an accelerated point charge (Larmor's &Lienard's formula), Angular distribution of power radiated by an accelerated point charge, Special case of linear acceleration (Bremsstrahlung radiation) and circular acceleration (synchrotron radiation)

UNIT II:

Electric polarization of a dielectric and polarizability, Clausius-Mossotti relation & Langevin-Debye theory and Debye equation, Dipole-dipole interaction, Laplace equation, boundary conditions and uniqueness theorems, Solution of Laplace equation in spherical coordinates

UNIT III:

Maxwell's equations in terms of electromagnetic potentials, Gauge transformation and invariance of Maxwell's equations under gauge transformation. Maxwell's equations in Coulomb and Lorentz gauge, retarded potentials, electromagnetic potentials (Lienard-Wiechert potentials) and fields due to a moving point charge.

UNIT IV:

Review of Lorentz Transformation (LT) in Minkowski space and 4-vectors, Lorentz invariants (4D scalar product, 4D volume, d' Alembertian and electric charge), Current density 4-vector, LT of current & charge densities, Equation of continuity in terms of current density 4-vector, Potential 4-vector, LT of electromagnetic potentials, Lorentz condition in terms of potential 4vector and its invariance under LT, Maxwell's equations in terms of electromagnetic field tensor and their invariance under LT.

SUGGESTED READINGS:

1. D.J. Griffiths: Introduction to Electrodynamics
2. J.D. Jackson: Classical Electrodynamics
3. Lev Landau: Electrodynamics of continuous media

PH 421 T
COMPUTATIONAL METHODS IN PHYSICS

UNIT I:

Methods for determination of zeros of linear and non linear algebraic equations and transcendental equation, convergence of solutions, solution of simultaneous linear equations, interpolation with equally spaced and unevenly spaced points, curve fitting, polynomial least squares and cubic spline fitting

UNIT II:

Introduction and review of matrix operations, direct methods, Matrix inversion method, Gauss elimination method and Gauss-Jordan method. Iterative Methods, Jacobi method of iteration and Gauss-Seidel iteration method, eigen value and eigen vectors of matrices.

UNIT III:

Numerical Differentiation, derivatives using Newton's forward & backward difference formula, derivatives using Stirling's formula, Numerical Integration, Trapezoidal rule, Simpson's 1/3 rule, Newton-Cotes integration formula

UNIT IV:

Ordinary Differential Equations: Introduction; Power series solution method; Euler's method; Runge Kutta methods, Predictor and corrector method, elementary ideas of solutions of Partial Differential Equations

SUGGESTED READINGS:

1. S.S. Sastry: Introductory Methods of Numerical Analysis
2. R.L. Burden and J.D. Faires: Numerical Analysis
3. E. Isaacson and H.B. Keller: Analysis of Numerical Methods
4. W. Cheney and D. Kincaid: Numerical Methods and Computing

PH 422 T
STATISTICAL PHYSICS

UNIT I:

Specification of states of a system, macroscopic and microscopic states, phase space, trajectories, density of states, Liouville's Theorem, Contact between statistics and thermodynamics, classical ideal gas, entropy of mixing, Gibb's paradox.

UNIT II:

Microcanonical ensemble, system in contact with heat reservoir, canonical ensemble, application of canonical ensembles, system with specified mean energy, calculation of mean values and fluctuation in a canonical ensemble, connection with thermodynamics, Grand Canonical ensemble, physical interpretation of α, chemical potential in the equilibrium state, mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand Partition function.

UNIT III:

Statistics of indistinguishable particles, Quantum distribution of functions (Maxwell-Boltzmann, Fermi Dirac and Bose-Einstein Statistics), Properties of ideal Bose and Fermi gases, Bose-Einstein Condensation, Evaluation of the partition function and its application to the Ising model.

UNIT IV:

Landau theory of phase transition, critical indices, fluctuations and transport phenomena, Brownian motion, Langevin theory, The Fokker-Planck equation, Fluctuation dissipation theorem.

SUGGESTED READINGS:

1. R.K. Pathria and P.D. Beale: Statistical Mechanics
2. C. Kittle: Elementary Statistical Physics
3. K. Huang: Introduction to Statistical Physics
4. F. Reif: Statistical Physics

PH 423 T
MOLECULAR SPECTRA

UNIT I:

Types of molecules; Linear and diatomic molecules, symmetric top, asymmetric top and spherical top molecules, Pure Rotational Spectroscopy: Salient features,Rotational energy levels of diatomic molecules under rigid rotator & non-rigid rotator models, Rotational quantum numbers & selection rules, Isotope effect, Intensity of spectral lines, Energy level diagram & spectral structure.

UNIT II:

Vibrational Spectroscopy, Salient features. Vibrational energy levels of diatomic molecules under harmonic & anharmonic oscillator models, Vibrational quantum numbers & selection rules, Intensity of spectral lines, Energy level diagram & spectral structure, Applications of vibrational spectroscopy.

UNIT III:

Electronic-Vibrational Spectroscopy of Diatomic Molecules: Salient features, Electronic-Vibrational energy levels of diatomic molecules, Selection rules, spectral structure, Intensity of spectral lines, Franck-Condon Principle, predissociation & dissociation energy, dissociation limit

UNIT IV:

Raman Spectroscopy: Salient features,Experimental arrangement, quantum theory of Raman effect, rotational, vibrational & vibrational-rotational Raman Spectra for linear molecules. Stokes & anti Stokes Raman lines. Selection rules. Energy level diagram & spectral structure, Mechanism of Fluorescent and Phosphorescent emission

SUGGESTED READINGS:

1. C.N. Banwell and E. McCash: Fundamentals of Molecular Spectroscopy
2. G. Aruldhes: Molecular Structure and Spectroscopy
3. J.M. Hollas: Molecular Spectroscopy

PH 424A T
RELATIVITY AND COSMOLOGY

UNIT I:

Tensor Algebra: Principle of invariance of physical laws w.r.t. different coordinate systems as the basis for defining tensors. Coordinate transformations, contravariant, covariant & mixed tensors, index notation and summation convention. Spacetime metric (metric tensor), contraction and lowering & raising the indices, Special Relativity In Inertial Frames and Non-Inertial Frames, Distinction between special & general relativity, Euclidean & non-Euclidean geometries, Equivalence Principle and tidal forces.

UNIT II:

Tensor fields and concept of general covariance, Parallel transport, Christoffel symbols and affine connection of spacetime. Covariant derivative of covariant & contravariant vectors, covariant differentiation of a tensor and of metric tensor. Riemannian geometry (manifold) and Christoffel symbols in terms of metric tensor, Locally inertial coordinate systems, Path dependency of parallel transport, Riemann tensor, symmetries of Riemann tensor. Ricci tensor, scalar curvature and Einstein tensor. Bianchi identities and divergence of Einstein tensor. Condition for straightness & shortest distance, geodesic equation and geodesic deviation.

UNIT III:

Curved Newtonian Gravity: Poisson's equation for gravitational field, non-zero components of Ricci tensor and interpretation of gravitation force in curved Newtonian gravity, Energy-Momentum Tensor: Generalization of mass density to energy-momentum tensor, physical interpretation of components energy-momentum tensor and energy-momentum conservation law, Einstein Field Equations (EFE): Poisson's equation for gravitational field to EFE ,Cosmological constant through metric compatibility. Newtonian approximation of EFE and evaluation of proportionality constant for energy-momentum tensor. Trace-reversed form of EFE. Sign conventions for EFE. Qualitative discussion of predictions of EFE.

UNIT IV:

Introduction to Astronomy: Overview of the night sky; Size, mass, density & temperature of astronomical objects; Olbers's paradox; Basic concepts of positional astronomy, Cosmological principles; Weyl postulates; Cosmological parameters; Static, Einstein, expanding, open & closed universe; Cosmological red shift, Hubble's law, Hubble constant, Friedmann models ,Cosmic distance ladder. Qualitative Discussions On: Big bang, Early Universe (thermal history & nucleosynthesis), Various era of evolution of Universe, Cosmic microwave background radiation, Event horizon, Particle horizon.

SUGGESTED READINGS:

1. J. Plebanski and A. Krasinski: An Introduction to General Relativity and Cosmology
2. J.V. Narlikar: An Introduction to Relativity
3. J.V. Narlikar: An Introduction to Cosmology
4. A.K. Raychaudhuri, S. Banerji and A. Banerjee: General Relativity, Astrophysics and Cosmology

PH 424B T
PLASMA PHYSICS

UNIT I:

Motion in electric field constant in space & time, Motion in magnetic field constant in space & time , Motion in electromagnetic field constant in space & time (drift velocity & drift acceleration of guiding centre and electric field drift), Motion in magnetic field constant in time but slowly varying in space through first order orbit theory (Alfven approximation), Magnetic dipole moment & magnetic flux. Magnetic mirror, magnetic mirror effect & magnetic bottle (plasma confinement), Motion in combined electric field constant in space but varying in time and magnetic field constant in space & time, Polarization drift and adiabatic invariants.

UNIT II:

Phase space, distribution function, homogeneous & inhomogeneous plasma and isotropic & anisotropic plasma. Average values and velocity moments of distribution function. Physical interpretations of first, second , third and fourth velocity moments of distribution function,Boltzmann Equation (BE) without & with collision effects, Macroscopic Transport Equations (MTEs) through velocity moments of BE. Derivation & interpretation of first, second & third velocity moments of BE. Solution of MTEs for cold plasma model (Magnetoionic theory) and warm plasma model (Adiabatic approximation).Magneto-Hydrodynamic Equations (MHDEs) from average values of MTEs, Simplified MHDEs, magnetic stress and pinch effect.

UNIT III:

Meaning and definition of Plasma, Quasineutral. Collective behaviour, Debye shielding, Debye length, Debye sphere, plasma parameter (g) and plasma approximation, Criteria for system to be plasma. Plasma oscillations, electron plasma oscillations and electron plasma frequency in cold plasma model.

UNIT IV:

Important terms: Phase & group velocity; dispersion relation; Non-dispersive& dispersive media; Normal & anomalous dispersion; Longitudinal & transverse waves; Cut-offs & resonances. Magnetohydrodynamic Waves: Velocity of Sound (adiabatic sound velocity), Alfven (Alfven velocity) and Magnetosonic (compressional Alfven waves) wave, Electron Waves in Cold Plasma Model: Dispersion relations for parallel & perpendicular components. Cut-offs & resonances for Right-hand Circularly polarized (RCP), Left-hand Circularly polarized (LCP), ordinary and extraordinary waves. CMA diagram. Faraday rotation, Faraday angle & uses of Faraday rotation.

SUGGESTED READINGS:

1. J.A. Bittencourt: Fundamental of Plasma Physics
2. F.F. Chen: Introduction to Plasma Physics and Controlled Fusion

PH 424C T
LASER PHYSICS

UNIT I:

Laser Characteristics, Absorption, spontaneous and stimulated emission, population inversion, properties of laser, metastable state, monochromaticity, coherence, directionality, brightness, absorption coefficient, Einstein's coefficients, threshold condition.

UNIT II:

Three and Four level system and rate equations, pumping mechanics (electron beam impact, optical and current injection type), threshold pump power, relative merits and demerits of three and four level system, g-parameters of laser cavity, line broadening mechanisms, measurements of laser power, energy, wavelength, frequency, line width.

UNIT III:

Principle, construction, energy level diagram and working of Solid State Lasers: Ruby laser, Nd:YAG laser, Semiconductor laser, Gas Lasers: He-Ne laser, Nitrogen laser, CO_2 laser, Excimer laser Liquid Lasers: Dye Laser

UNIT IV:

Industrial Applications: Cutting, melting, welding, drilling, surface hardening, Medical Applications: Skin therapy, laser eye surgery, laser surgery, tumour ablation, Military Applications: Range finders, laser radar, laser gyroscope, Scientific Applications: In spectroscopy, laser deposition, optical fibre communication

SUGGESTED READINGS:

1. K. Thyagarajan and A. Ghatak: Lasers-Fundamentals and Applications
2. B.B. Laud: Lasers and Non-Linear Optics

PH 424D T
SEMICONDUCTOR PHYSICS

UNIT I:

Basic equation for semiconductor device operation, carrier concentrations at thermal equilibrium for intrinsic and doped semiconductors, current density equations, carrier transport phenomena-mobility, resistivity and Hall effect, excess carrier generation and recombination and their lifetime.

UNIT II:
Types of semiconductors, Basic device technology, depletion region and depletion layer capacitance, current-voltage characteristics-ideal case-Shockley equation, generation-recombination process, high injection condition, diffusion capacitance, junction breakdown.

UNIT III:
Formation of transistor, basic current-voltage relationship, mathematical derivations, base transport and recombination factor, static characteristics of CB, CE, CC configurations, power-transistor-general consideration, static and dynamic characteristics of switching transistor (second breakdown), UJT, SCR, junction field effect transistors, their energy band diagram.

UNIT IV:
Energy band relation at metal semiconductor contacts – ideal condition and surface states, depletion layer, Schottky effects. Current transport processes-thermonic emission theory, diffusion theory and thermonic emission-Diffusion theory. General expression for barrier height- Schottky barrier, diode current-voltage measurement, metal-semiconductor IMPATT diode, ideal MIS diode-surface space charge regions and effect of metal work function.

SUGGESTED READINGS:

1. J.D. Ryder: Electronic Fundamentals and Applications
2. S.M. Sze and K.K. Nag: Physics of Semiconductor Devices
3. B.G. Streetman and S.K. Banerjee: Solid State Electronic Devices

PH 424E T
BIOPHYSICS

UNIT I:

Types, size and roles of bio molecules, range of cell sizes and interdivision time scale, range of organisms sizes and life times, scaling laws in biology, complexity of living systems, timeline of life on earth, timescales in biological evolution.

UNIT II:

Dynamical systems, coupled ordinary differential equations, experiments on cellular physiology, phenomena and model of intercellular chemical dynamics, metabolism and gene regulation, cell growth and division.

UNIT III:

The nervous systems, electrical signals of Nerve cells, an overview of the structure and function of neurons, dynamics of a single neuron, neural networks, learning, memories as attractors of neural networks.

UNIT IV:
Growth of bacterial colony, ecological interactions, ecological dynamics, models of ecosystem, probability, entropy and information, application of information theory in genetics.

SUGGESTED READINGS:

1. P. Narayanan: Essentials of Biophysics
2. J.R. Claycomb and Jonathan Quoc P. Tran: Introductory Biohysics-Perspectives on the Living State

PH 424F T
ENVIRONMENTAL PHYSICS

UNIT I:
Structure and thermodynamics of the atmosphere, transport of matter, energy and momentum in nature, stratification and stability of atmosphere, hydrostatic equilibrium, general calculation of the tropics, elements of weather and climates of India.

UNIT II:
Physics of radiation, interaction of light with matter, Rayleigh and Mie scattering, Laws of radiation (Kirchhoff's law, Planck's law, Wein's displacement law etc.Solar and terrestrial spectra, UV radiation, ozone depletion problem,, IR absorption, energy balance of the earth atmosphere system.

UNIT III:
Elementary fluid dynamics, turbulence and turbulent diffusion, factors governing air, water and noise pollution, Heat Island effect, gaseous and particulate matters, wet and dry deposition.

UNIT IV:
Energy source (Renewable and non-renewable) and combustion process, solar energy, wind energy, bioenergy, hydro power, fuel cell, nuclear energy, elements off weather and climate, stability and vertical motion of air, horizontal motion of air and water, pressure gradient, viscous force, inertia force, Reynold's number, Enhanced greenhouse, energy balance, a zero-dimensional greenhouse model, global climate model.

SUGGESTED READINGS:

1. J.L. Monteith and M.H. Unsworth: Principles of Environment Physics
2. E.Boeker:EnvironmentPhysics-SustainableEnergyandClimateChange

PH 415 P & PH 425 P

EXPERIMENTAL WORK (General Lab)

Consolidated list of experiments for both semesters VIIth and VIIth. The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Y of glass plate by Cornu's method
2. Viscosity of a fluid by viscometer method
3. Velocity of ultrasonic waves in a liquid
4. Study of rotatory dispersion of quartz
5. Hall constants of metal
6. LCR at high frequencies
7. Assembly of logic gates and their verification by truth tables
8. Assembly of power supply
9. Ripple factor for different electrical and electronic circuits
10. Verification of principle of digital transformation
11. Study of basic circuits in the construction of computers
12. Study of multivibrator circuits
13. Study of passive filters
14. Study of active filters
15. High resistance by leakage method
16. Ballistic galvanometer
17. Stefan's constant
18. e/m by Thomson method
19. h by photoelectric cell
20. Michelson's interferometer
21. Fabry Perot etalon
22. Edser-Butler
23. Rayleigh Refractometer
24. Jamin's refractometer
25. Babinet Compensator
26. Fresnel's biprism
27. Grating
28. Polarization
29. Verification of Hartmann's formula
30. Verification of Fresnel's law of reflection
31. Spectra calibration by constant deviation spectrometer
32. Study of Zeeman effect
33. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

PH 511 T

QUANTUM MECHANICS

UNIT I:

Properties of linear vector space & Hilbert space, Dirac algebra, Linear operators, operator algebra & special operators; Eigen values & eigen vectors of an operator; Linear superposition of eigen vectors & degeneracy; Commutator algebra & commutation relations; General form of uncertainty relation between two operators, Hermitian operators & properties, Equation of motion, Ehrenfest's theorem, Schwartz inequality, Heisenberg uncertainty relation derived from operator, The schrodinger equation for spherically symmetric potentials, Hydrogen atom, Radial equation, radial probability

UNIT II:

Orbital angular momentum operator for spherically symmetric potentials and commutation relations, Relation between orbital angular momentum operator and rotation operator, Total angular momentum operator, ladder operators, commutation relations, eigen values and explicit form of angular momentum matrices, Intrinsic-spin angular momentum operator and commutation relations and eigen values. Pauli spins operators (matrices) and their properties. Coupling of two angular momenta, Clebsch-Gordan Coefficients and their properties

UNIT III:

Time Independent Perturbation Theory for Non-Degenerate States, first & second order correction to eigen energy & eigen function. Applications– Anharmonic linear oscillator; normal Zeeman effect without electron spin; two electron systems (He atom),Time Independent Perturbation Theory for Degenerate States, first order correction to eigen energy, Applications–Stark effect in Hydrogen atom, Variational method, expectation value of energy, ground state of Helium

UNIT IV:

Heitler-London theory, Application to H_2 molecule, JWKB Approximation: Introduction, conditions for applicability and connection formulae, General expression for scattering problems; transmission & reflection coefficients; application to Gamow's theory of alpha decay, General expression for bound state problems; application to linear harmonic oscillator.

SUGGESTED READINGS:

1. L.I. Schiff: Quantum Mechanics
2. N. Zetilli: Quantum Mechanics-Concepts and Applications
3. D.J. Griffiths: Introduction to Quantum Mechanics
4. A. Ghatak and S. Lokanathan: Quantum Mechanics-Theory and Applications

PH 512 T
NUCLEAR PHYSICS

UNIT I:

Nucleon-Nucleon Interaction, Exchange forces and tensor forces, Meson theory of nuclear forces, nucleon-nucleon Scattering, Effective range theory, Experimental results for nucleon-nucleon scattering, Nuclear Force: Properties of nuclear force, Charge independence & concept of isospin, Yukawa interaction

UNIT II:

Liquid Drop Model, Bohr – wheeler theory of fission, Bethe-Weizsacker mass formula & its applications, Shell Model: Experimental evidence for shell effects, Salient features of Shell model, Single particle states (energy levels), spin-orbit interaction, spectroscopic notation, energy level diagram and reproduction of magic numbers, Applications – Ground state angular momentum & parity; Magnetic dipole moment, Schmidt lines; Electric quadrupole moment, Collective Model of Bohr and Mottelson

UNIT III:

Direct and compound nuclear reaction mechanism, cross sections in terms of partial wave amplitudes, compound nucleus , scattering matrix, Reciprocity theorem, Breit Wigner one level formula, Resonance scattering

UNIT IV:

Beta Decay, Fermi theory of beta decay; Fermi-Kurie plot; Decay constant; Sargent's law; Comparative half-life; Allowed & forbidden transitions; Selection rules (Fermi & Gamow-Teller)
Electron Capture, multipole transitions, selection rules for total angular momentum & parity and probability of emission, total decay constant, conversion coefficient, selection rules and discrete spectrum. Nuclear isomerism, isomeric transitions and probability of transition.

SUGGESTED READINGS:

1. B.L. Cohen: Concepts of Nuclear Physics
1. S.N. Ghoshal: Nuclear Physics
2. M.K. Pal: Theory of Nuclear Structure

PH 513A T

ELECTRONICS - I

UNIT I:

Introduction to operational amplifier, Basic parameters, inverting and non inverting operational amplifier, simple Op-amp circuits, Application of Operational Amplifier in analog computation, operational amplifier as voltage follower.

UNIT II:

Adder, subtractor, integrator, differentiator, log amplifier, Antilog amplifier and Analog multimeter and divider circuits, RMS circuits function fitting and time function generation.

UNIT III:

Active filters, comparator, Astable, Monostable and Bistable multivibrator, Schmitt Trigger, Sample and hold circuit, triangular wave generator and wave shaping circuits

UNIT IV:

Voltage controlled oscillator, phase locked loop, voltage to frequency and frequency to voltage converter, A/D and D/A converter circuit 555 timer, Noise in ICs.

SUGGESTED READINGS:

1. G.B. Clayton: Operational Amplifiers
2. R.A. Gayakward: Op-amps and Linear Integrated Circuit Technology
3. J. Millman and C.C. Halkias: Integrated Electronics Analog and Digital Circuits and Systems

PH 514A T

ELECTRONICS - II

UNIT I:

Number system, codes (Grey code ASCII code and BCD code), Basic circuit logic Gate, digital IC families (DTL, RTL, TTL, and ECL)logic circuits, analysis and system of combinational logic circuit Karnaugh map, pair, quads and octaves.

UNIT II:

Arithmetic logic circuits, half adder full adder, half subtractor and full subtractor, controller,code converters, inverter and adder subtractor circuits. Data processing circuits, multiplexers, demultiplexer, Encoder and Decoder (1 to 16 Decoder BCD Decoder and LED decoders).

UNIT III:

Introduction to flip flop R-S, D-T, J-K and J-K master slave flip flops, synchronous and asynchronous counter, mod counters, ring counter, serial and parallel shift registers

UNIT IV:

Introduction to semiconductor memories, RAM, ROM EPROM and their addressing techniques, Microprocessor (8085) memory and I/O interfacing

SUGGESTED READINGS:

1. D.P. Leach and A.P. Malvino: Digital Principles and Applications 2
2. R.P. Jain: Modern Digital Electronics

PH 513B T

CONDENSED MATTER PHYSICS - I

UNIT I:

Crystalline Solid, unit cells and direct lattice, two or three dimensional bravais lattice, closed packed structure, Interaction of X-Ray with matter absorption of X-Ray, Elastic scattering from a perfect lattice, the reciprocal lattice and its applications, Powder and rotating crystal method, crystal structure factor and intensity of diffraction Maxima.

UNIT II:

Point defects, line defects and planer (stacking) faults. The role of dislocations in plastic deformation and crystal growth. the observation of imperfection in crystals.

UNIT III:

Electrons in a periodic lattice, block theory, band theory, classification of solids, Effective mass, Tight bonding, cellular and pseudo potential methods Fermi surface.

UNIT IV:
De Hass Van Alfen effect, cyclotron resonance, magnetoresistance, Quantum hall effect, Weiss theory of ferromagnetism, spin wave and magnetic curie Weiss law for susceptibility, fermi and antiferromagnetic order domain and block-wall energy.

SUGGESTED READINGS:

1. C. Kittel: Introduction to Solid State Physics
2. H.P. Myers: Introductory Solid State Physics
3. A.J. Dekker: Solid State Physics

PH 514B T
CONDENSED MATTER PHYSICS - II

UNIT I:

Inter atomic forces and lattice dynamics of simple metals, Ionic and covalent crystals, optical phonons and dielectric constants, inelastic neutron scattering, Mossbauer effect, Debye-Waller factor, Anharmonicity, Thermal expansion and thermal conductivity, interaction of electrons and phonons with photons, direct and indirect transitions, absorption in insulators, Polaritons, one phonon absorption, optical properties of metal, skin effect.

UNIT II:

Interaction of electrons with acoustic and optical phonons, polarons, superconductivity, manifestation of energy gap, critical temperature, persistant currents, Meissner effect, Cooper pairing due to phonons, BCS theory of superconductivity, Ginzburg-Landau theory, DC and AC Josephson effect, Vortices in type-II superconductors, high temperature superconductors.

UNIT III:

External Symmetry elements of crystals, concept of point groups, influence of symmetry on physical properties, electrical conductivity, space groups, experimental determination of space groups.

UNIT IV:

Analytical indexing, Ito's method, accurate determination of lattice parameters-least square method, Application of Powder method, oscillation and Burger's precession methods.

SUGGESTED READINGS:

1. C. Kittel: Introduction to Solid State Physics
2. H.P. Myers: Introductory Solid State Physics
3. A.J. Dekker: Solid State Physics

PH 513C T
RENEWABLE ENERGY PHYSICS - I

UNIT I:

Solar Radiation: General Introduction, Solar Spectrum, Solar Constant, Solar Time, Solar Radiation measuring instruments- Pyrheliometer, Pyranometer; Solar Radiation on horizontal and inclined surface, Radiometric properties, Solar spectra.

UNIT II:

Solar Cells: Basic structure of solar cells, Working principle of solar cells, Solar Cell Parameters; Losses and Efficiency limits, Types of solar cells: Crystalline Silicon Solar Cells and Thin Film Solar Cells, PV Modules and arrays, Flat plate collectors, Concentrators.

UNIT III:

Thermodynamics of Solar Energy, Solar Cell Materials, Degradation of Solar Materials, Nanostructure Solar Cells.

UNIT IV:

Solar Energy Application: Solar Water Heating Systems; Solar House; Solar Cooling; Solar Crop Dryers.

SUGGESTED READINGS:

1. A. Severny: Solar Physics
2. Juan Bisquert: The Physics of Solar Cells
3. C.S. Solanki: Solar Voltaics
4. G.N. Tiwari, Arvind Tewari and Shyam: Handbook of Solar Energy

PH 514C T
RENEWABLE ENERGY PHYSICS - II

UNIT I:

Energy Storage; Sensible heat storage; Latent Heat Storage, Chemical energy storage; Phase Transition thermal storage, Hydrogen storage.

UNIT II:

Operation principle of Battery: Basic Concepts, Electrochemical principles and reactions, Factors affecting battery performance, Battery standardization, Battery design.

UNIT III:

Rechargeable Batteries; Electrochemistry of rechargeable batteries, Battery types, Various battery parameters, Batteries in PV Systems.

UNIT IV:

Battery selection criteria, Battery problem areas, Battery maintenance, Battery safety precautions, Battery failures, Charge Controllers.

SUGGESTED READINGS:

1. D. Linden and T.B. Reddy: Handbook of Batteries
2. A. Smets et al: Solar Energy
3. C.J. Chen: The Physics of Solar Energy
4. G.N. Tiwari, Arvind Tewari and Shyam: Handbook of Solar Energy

PH 513D T
NANOPHYSICS – I

Unit – I:

Definition of Nano Science and Nano Technology, Crystal structure, Role of dimension in nano-materials, Size dependence properties & Energy bands. Face centered cubic nanoparticles, particle size determination.

Unit – II:

Synthesis of nano-materials- Physical, Chemical and Biological methods, Synthesis of semiconductor nano-particles by colloidal route, Sol-gel method. Idea for manufacturing of nano wires, nano sheets, nano belts.

Unit – III:

Top-down and bottom up techniques, Formation of nanostructures by mechanical milling and chemical vapour deposition method, Procedures of multilayered thin-films, Nanowires and quantum dots.

Unit – IV:

Carbon nanostructures, carbon clusters, structure and properties of C_{60}, Graphene, Alkali doped C_{60} Carbon nanotubes-fabrication, structure and its properties (Qualitative only), applications of carbon nanotubes.

SUGGESTED READINGS :

1. Introduction of Nanotechnology By C.P. Poole Jr.
2. Nanomaterials Handbook By Y. Gogotsi.
3. Carbon Nanotubes by A. Jorio, G. Dresselhaus.
4. Nanotechnology Applications to Telecommunications and Networking By D. Minoli

PH 514D T
NANOPHYSICS - II

Unit – I:

Single crystalline, Poly crystalline and amorphous structures, Crystal orientation, Unit cells, Preparation of amorphous materials,Imperfection in solids, Imperfection dependent properties of Crystals.

Unit – II:

Nano Composites, Nano polymers, Nano ceramics, Composite materials, Polymer matrix, metal matrix and ceramic matrix composites, Crystal structures.

Unit – III:

Materials and fabrication techniques of photonic band gap crystals, S fabrication of photonic crystal structure,Diffusion in solids,Transformation kinetics.

Unit – IV:

Metal nano particles – Types and their synthesis, Carbon nano tubes and related structures-properties, synthesis and applications, Application of Gold, Silver and Zinc oxide nanoparticles.

SUGGESTED READINGS:

1. Introduction to solid state Physics: C Kittel.
2. Solid State Physics: A. J. Dekker
3. Nanocomposite science and Technology, Ajayan, Schadler and Braun.

PH 521 T
ADVANCED QUANTUM MECHANICS

UNIT I:

Identical Particles: Meaning of identity and consequences, Particle exchange operator, symmetric & anti symmetric wave functions, connection of spin and statistics, collision of identical particles with spin , Exchange degeneracy, Commutator of Hamiltonian & particle exchange operator. Symmetrization of wave functions, Slater determinant and Pauli's exclusion principle.

UNIT II:

Laboratory & centre of mass frames, differential & total scattering cross-section, Formal theory of quantum scattering, scattering amplitude, solution of Schrodinger equation by Green's function and scattering amplitude, Born approximation, condition for validity, scattering amplitude and differential scattering cross-section. Scattering by screened Coulomb potential (Rutherford's formula) and attractive square well potential, Partial wave analysis, phase shifts, scattering amplitude, total scattering cross-section and optical theorem, Evaluation of phase shift, Scattering by a hard sphere and attractive square well potential, Scattering of identical particles.

UNIT III:

Time Dependent Perturbation Theory, first order transition probability for constant perturbation, Fermi's Golden rule, first order harmonic perturbation, Semi-Classical Theory of Radiation Einstein Coefficients, transition rate for spontaneous emission, Introduction to theory of second quantization.

UNIT IV:

Klein-Gordon relativistic time dependent Schrodinger equation, equation of continuity, Dirac Equation(DE), linearization of Hamiltonian by Dirac, Properties of Dirac matrices, Solution of DE for a free particle, DE in electromagnetic field (magnetic moment of electron), DE in central field (intrinsic-spin of electron and spin-orbit coupling energy), solution of DE for Hydrogen atom (energy levels) and negative energy states (Dirac's Hole theory).

SUGGESTED READINGS:

1. L.I. Schiff: Quantum Mechanics
2. N. Zettili: Quantum Mechanics-Concepts and Applications
3. D.J. Griffiths: Introduction to Quantum Mechanics
4. A. Ghatak and S. Lokanathan: Quantum Mechanics-Theory and Applications

PH 522 T
PARTICLE PHYSICS

UNIT I:

Lie Algebra: Definition of lie algebra, Specific Lie Groups: Connection between conservation laws, symmetries & Lie groups. Specific Lie groups – Orthogonal O(n), Special Orthogonal SO(n), Unitary U(n) & Special Unitary SU(n). Structure of SO(2), SO(3), SU(2) & SU(3) Lie groups. Application of Lie groups in Physics.

UNIT II:

Fundamental Interactions, Exchange interaction & properties of mediating quanta, Range & relative strength, Concept of antiparticles (qualitative), Classification of elementary particles based on intrinsic-spin, mass, interaction & lifetime, Families of Leptons, Mesons ,Baryons & Baryon Resonances, Conservation Laws: Conservation law for mass-energy, linear momentum, angular momentum, electric charge, baryonic charge, leptonic charge, isospin (concept of multiplet), strangeness, charge conjugation, parity (space parity & intrinsic parity), time reversal, CP and CPT (CPT theorem), Gell Mann-Nishijima formula and hypercharge.

UNIT III:

Classification of hadrons on the basis of SU(3) group algebra, Quark hypothesis, Properties of quarks (flavours, mass, electric charge, intrinsic-spin, parity, various quantum numbers, strong charge or colour), Quark model of hadrons – Meson ,Baryon octet, Baryaon decuplet (baryon resonances), Elementary idea of – Gluons & glue ball; Quark confinement & asymptotic freedom

UNIT IV:

Detecting instruments; Ionization chamber, solid state detector, GM counter, Scintillation counter, Wilson cloud chamber, Diffusion cloud chamber, Bubble chamber. Particle accelerators; Proton synchrotron (variable field and variable frequency), Electron synchrotron and Betatron

SUGGESTED READINGS:

1. D.J. Griffiths: Introduction to Elementary Particles
2. D.H. Perkins: Introduction to High Energy Physics
3. F. Halzen and A.D. Martin: Quarks and Leptons-An Introductory Course in Modern Particle Physics

PH523A T

ELECTRONICS-III

UNIT I:

Amplitude Modulation, modulation and demodulation techniques, frequency modulation, narrow band and wide band frequency modulation, PLL as frequency demodulator, phase modulation, Equivalance between AM, FM and PM modulation.

UNIT II:

Digital modulation, sampling and quantization, pulse code modulation, ASK FSK PSK and DPSK, frequency division and time division multiplexing.

UNIT III:

Generation of microwave by reflex klystron and semiconductor Gun diode, waveguide and cavity resonator, Microwave antenna, Microwave detector, VSWR power and dielectric measurement Isolator directional coupler, Magic Tee.

UNIT IV:

Satellite Orbit, Satellite frequencies, syncronous satellite, satellite communication, link factor affecting satellite communication, Transponders

SUGGESTED READINGS:

1. G. Kennedy and B. Davis: Electronic Communication Systems
2. J. Millman: Analog and Digital Communication Systems
3. H. Taub, D. Schilling and G. Saha: Principles of Communication Systems

PH 524A T

ELECTRONICS-IV

UNIT I:

Basic radar system, Pulsed radar, Moving largest indicator radar, CW radar cross section, radar display, PPI duplexer, radar antenna, modem radar

UNIT II:

TV system and standard, TV bandwidth and channels, interlaced scanning and video camera tube, TV transmitter and receiver, Colour television.

UNIT III:

Antenna system, short-electric doublets, radiation from one pole and double aerials, Antenna parameters, Antenna array, Folded dipole application, Yagi antenna, Parasitic Antenna, Parabolic reflectors.

UNIT IV:

Wave propagation in isotropic media, Transmission and fibre losses in fibre, Dispersion, Optical waveguide, Optical Fibre source and detector, Coupler, Modern telephone, Optic mux.

SUGGESTED READINGS:

1. G. Kennedy and B. Davis: Electronic Communication Systems
2. J. Millman: Analog and Digital Communication Systems
3. H. Taub, D. Schilling and G. Saha: Principles of Communication Systems
4. R.R. Gulati: Monochrome and Colour Telivision
5. J. Wilson and J. Hawkes: Optoelectronics-An Introduction

PH 515A P & PH 525A P
EXPERIMENTAL WORK (Specialization Lab: Electronics)

Consolidated list of experiments for both semesters IXth and Xth. The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Characteristics of Field Effect Transistor (FET)
2. Characteristics of Silicon Controlled Rectifier (SCR)
3. Characteristics of Uni-Junction Transistor (UJT)
4. h parameters of Bi-Junction Transistor (BJT)
5. Transistor bias techniques
6. Transistor bias stability
7. Study of Common Emitter (CE) RC coupled amplifier
8. Study of FET amplifier
9. Study of feedback amplifier
10. Study of operational amplifier
11. Study of Wien Bridge oscillator
12. Study of multivibrators
13. Study of Hartley oscillator
14. Dielectric constant by Lecher wire
15. Study of voltage power supply with filters
16. Study of current power supply with filters
17. Study of Zener regulated voltage power supply
18. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

PH 523B T

CONDENSED MATTER PHYSICS - III

UNIT I:

Exotic Solids, Structure and symmetries of liquid, Liquid Crystal and amorphous solid, Aperiodic solids and Quasi Crystal, Fibonacci sequence, Penrose lattices and their extension to 3 dimension.

UNIT II:

Special Carbon Solids, Fullerences and tubeless, Electronic properties of tubules, Carbon nanotube based electronic devices, Definition and properties of nanostructured Material, Method and synthesis of nanostructured materials, Quantum size effect and its applications.

UNIT III:

Interacting Electron Gas, Hartree and Hartree Fock approximations, correlations energy, screening, Plasma oscillations, Dielectric function of an electron gas in random phase approximation, limiting case and Friedal oscillations.

UNIT IV:

Electron in Surface States, Strongly interacting Fermi system, Elementary introduction to Landau's Quasi particle theory of Fermi liquid, strongly correlated electron gas, Elementary idea regarding surface state metallic surface and surface reconstructions.

SUGGESTED READINGS:

1. C. Kittel: Introduction to Solid State Physics
2. H.P. Myers: Introductory Solid State Physics
3. A.J. Dekker: Solid State Physics

PH 524B T

CONDENSED MATTER PHYSICS - IV

UNIT I:

Disorder System in Solids, Point defect: Shallow impurity of state in semiconductor, Localized lattice vibrational states of solids, vacancies, interstitial and colour centres in ionic crystal.

UNIT II:

Disorder in Condensed Matter, Substitutional position and topographical disorder, short and long range order, atomic correlation function and structural description of glasses and liquid, Anderson model for random system and electron localization, mobility edges

UNIT III:

Imperfection in Crystals, Mechanism of plastic deformation in solid stress and strain field of screw and edge dislocations, Elastic energy of dislocation, forces between dislocations, stress needed to operate Frank read source, dislocation in fcc hcp and bcc lattices, partial dislocation and stacking solution in close packed structure.

UNIT IV:

Films and Surfaces, Study of surface topography by multiple beam interferometry, conditions for accurate determination of step height and film thickness (Fizeau sringes) electrical conductivity of thin films, difference of behaviour of thin film from bulk Boltzmann transport equation (for diffused scattering) expansion for electrical conductivity for thin film elementary concept of surface crystallography scanning, tunnelling atomic force microscope.

SUGGESTED READINGS:

1. C. Kittel: Introduction to Solid State Physics
2. H.P. Myers: Introductory Solid State Physics
3. A.J. Dekker: Solid State Physics

PH 515B P & PH 525B P

EXPERIMENTAL WORK (Specialization Lab: Condensed Matter Physics)

Consolidated list of experiments for both semesters IXth and Xth. The institution may add / modify the experiments of the same standard, and in addition, can also propose the online Virtual Lab experiments.

1. Measurement of lattice parameters and indexing of powder photographs
2. Interpretation of transmission Laue photographs
3. Determination of orientation of a crystal by back reflection Laue method
4. Rotation /oscillation photographs and their interpretation
5. Modulus of rigidity and internal friction in metals as a function of temperature
6. To measure the cleavage step height of a crystal by multiple Fizeau fringes
7. To obtain multiple beam fringes of equal chromatic order
8. To determine magneto-resistance of a Bismuth crystal as a function of magnetic field
9. To study hysteresis in the electrical polarization of a TGS crystal
10. To measure the dislocation density of a crystal by etching
11. Conductivity of Germanium
12. Four probe method
13. Hall effect
14. Study of fluorescence materials
15. Study of ferromagnetic materials
16. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

PH 523C T
RENEWABLE ENERGY PHYSICS - III

UNIT I:

Solar Energy Conversion Systems, The Solar Resource, Need for Storage, Integration with Power cycle, Site Qualification, Economics and Environmental consideration.

UNIT II:

System Analysis, Design of major components, Overall system, Design of physical principles to the solar system based on application. The process includes idea generation, concepts election and estimation.

UNIT III:

Classification - Central Power Station System, Distributed PV System, Stand alone PV system, Grid Interactive PV System, small system for consumer applications, Hybrid solar PV system, Concentrator solar photovoltaic. System components – PV arrays, inverters, batteries, charge controls, net power meters. PV array installation, operation, costs, reliability.

UNIT IV:

Various PV Systems: Solar Water Heating Systems, Solar Flat-Plate Air Collector, Solar House, Solar Cooling, Solar Crop Dryers, Solar Distillations.

SUGGESTED READINGS:

1. S.W. Director: Solar Cells
2. A. Smets et al: Solar Energy
3. C.J. Chen: The Physics of Solar Energy
4. G.N. Tiwari, Arvind Tewari and Shyam: Handbook of Solar Energy

PH 524C T
RENEWABLE ENERGY PHYSICS - IV

UNIT I:

Introduction to fuel cells, advantages and disadvantages of fuel cells, Fuel Cell Types, Basic Fuel Cell Operation, Fuel Cell Performance, Characterization and Modeling.

UNIT II :

Fuel Cell Thermodynamics, Fuel Cell Reaction Kinetics, Fuel Cell Charge Transport, Fuel Cell Mass Transport.

UNIT III:

Fuel Cell Modeling, Fuel Cell Characterization, Polymer Electrolyte Membrane Fuel Cell and SolidOxide Fuel Cell, PEMFC and SOFC Materials.

UNIT IV:

Fuel Cell Systems, Fuel Processing Subsystem Design, Thermal Management Subsystem Design, Environmental Impact of Fuel Cells.

SUGGESTED READINGS:

1. Fabian Wieghardt: Fuel Cells-Technology for a Clean Energy
2. C.J. Chen: The Physics of Solar Energy
3. S Srinivasan: Fuel Cells from Fundamentals to Applications
4. B. Viswanathan: Fuel Cells Principles and Applications