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

MSc Physics

2022

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

<table>
<tr><th colspan="2">M.Sc. PHYSICS COURSE STRUCTURE</th></tr>
<tr><td colspan="2">DEGREE
BACHELOR (RESEARCH) OF SCIENCE IN PHYSICS</td></tr>
<tr><td>RT
H
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R</td><td>
<u>SEMESTER VII</u>
• 4 Theory Papers (Compulsory) of 4 Credits each.
• 1 Practical Paper (Compulsory) of 4 Credits.
• 1 Research Project of 4 Credits.
<u>SEMESTER VIII</u>
• 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.
<u>NOTE</u>
* <u>1 Minor Paper</u>, either in Semester VII or VIII, <u>from Other Faculty</u>, of minimum 4 Credits.
* <u>Combined Project Report / Dissertation</u> of Semester VII and VIII will be <u>evaluated together</u> at the <u>end of Fourth Year by the internal and external examiners</u>.
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<tr><td colspan="2">DEGREE
MASTER OF SCIENCE IN PHYSICS</td></tr>
<tr><td>F
T
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<u>SEMESTER IX</u>
• 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.
<u>SEMESTER X</u>
• 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.
<u>NOTE</u>
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	* 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

PH 515C P & PH 525C P
EXPERIMENTAL WORK (Specialization Lab: Renewable Energy 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. Study of V-I variation of solar cell under various illuminations
2. Study of kinetic energy of photoelectrons as a function of frequency of incident radiation
3. Various energy analysis by PVsyst software
4. Effect of temperature on solar energy production
5. Study of solar cell colour sensitivity
6. Solar energy measurement by Pyranometer
7. Solar energy measurement using a pyrheliometer
8. Study of effect of Lload on solar panel output
9. Study of solar collectors
10. Study of solar heating
11. Study of solar charge controllers
12. Study of power conditioning units for solar energy
13. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

PH 523D T
NANOPHYSICS - III

Unit I:

X- ray diffraction(XRD), powder and single crystal diffraction, x ray fluorescence(XRF), x ray photoelectron spectroscopy(XPS), dispersive high pressure XRD and energy dispersive x-ray analysis(EDAX).

Unit II:

Spectrophotometers, UV- Vis Spectrophotometers, IR Spectrophotometers, Fourier transform infrared radiation(FTIR), photoluminescence, electroluminescence and thermoluminiscence spectroscopy,

Unit III:

Scanning electron microscopy (SEM), Transmission Electron Microscopy(TEM), High resolution TEM, Field emission SEM, electron energy spectroscopy, Thermo gravimetric analysis(TGA).

Unit IV:

Absorption, Spontaneous emission and stimulated emission, population inversion, semiconducting lasers, quantum well lasers and quantum dot lasers, Activators and co-activators.

SUGGESTED READINGS:

1. Introduction of Nanotechnology By C.P. Poole Jr.
2. Solid State Physics: A. J. Dekker
3. Handbook of nanotechnology: Bhushan (Ed.), Springer Verlag, New York (2004).

PH 524D T

NANOPHYSICS - IV

Unit I:

Shape memory alloys, principle of one way and two way shape memory alloys, Important parameters in pseudo elastic transformation, shape memories alloys deformation.

Unit II:

Hybrid nano-materials, Magnetic particle ferrites, superhard nanocomposites, assembly of polymer nanoparticles, Functionalization of carbon nanotubes, Nanotube polymer composites.

Unit III:

Application of nano-devices, Resonant tunneling diodes, Single electron transistor, Modulation doped field effect transistor (MODFET), Organic light emitting devices(OLED).

Unit IV:

Nano sensors, Gas sensors, Pollution sensors, Photo sensors, IR detector, Biosensor, nano-materials gas discharge devices, CNT based fluid velocity sensors.

SUGGESTED READINGS:

1. Nanomaterials systems and applications: A.S. Eldestein and R.C. Cammarata.
2. Handbook of nanotechnology: Bhushan (Ed.), Springer Verlag, New York (2004).
3. Nanocomposite science and Technology, Ajayan, Schadler and Braun.

PH 515D P & PH 525D P

EXPERIMENTAL WORK (Specialization Lab: Nanophysics)

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. Growth of nanoparticles by chemical routes
2. Growth of nanophase by sputtering
3. Growth of quantum dots by thermal evaporation
4. Growth of nanoparticles by mechanical milling /attrition
5. Growth of nanoparticles by nanopores templates method
6. Structure characterization of nanomaterials by determination of grain size and its distribution
7. Surface morphological characterization of nanomaterial by AFM
8. Surface morphological characterization of nanomaterial by SEM
9. Surface morphological characterization of nanomaterial by TEM
10. Measurement-R Analysis of sample using FTIR
11. Measurement and analysis of UV/Vis absorption spectrum of nanomaterials
12. Measurement and analysis of photoluminescence spectrum of nanomaterials
13. Measurement and analysis of Raman spectrum of nanomaterials
14. Measurement and analysis of photoluminescence / absorption spectrum of nanomaterials at low temperature
15. Structure characterization of nanomaterials by XRD and determination of average grain size, lattice parameter, etc.
16. Virtual Experiments, related to above experiments, from the Online Virtual Labs of Ministry of Education, Government of India

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

BSc in Physics

2022

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. BHIMRAO AMBEDKAR UNIVERSITY, AGRA

Under Graduate Programmes Ordinance 2021 under New Education Policy for (BA, B.Sc and B.Com)

DEPARTMENT OF HIGHER EDUCATION
U.P. GOVERNMENT, LUCKNOW

National Education Policy-2020
Common Minimum Syllabus for all U.P. State Universities and Colleges
For first three years of Higher Education (UG)

PROPOSED STRUCTURE OF UG PHYSICS SYLLABUS

Name	Designation	Affiliation
Steering Committee		
Mrs. Monika S. Garg, (I.A.S.) Chairperson Steering Committee	Additional Chief Secretary	Dept. of Higher Education U.P., Lucknow
Prof. Poonam Tandan	Professor, Dept. of Physics	Lucknow University, U.P.
Prof. Hare Krishna	Professor, Dept. of Statistics	CCS University Meerut, U.P.
Dr. Dinesh C. Sharma	Associate Professor, Dept. of Zoology	K.M. Govt. Girls P.G. College Badalpur, G.B. Nagar, U.P.
Supervisory Committee-Science Faculty		
Dr. Vijay Kumar Singh	Associate Professor, Dept. of Zoology	Agra College, Agra
Dr. Santosh Singh	Dean, Dept. of Agriculture	Mahatma Gandhi Kashi Vidhyapeeth, Varanasi
Dr. Baby Tabussam	Associate Professor, Dept. of Zoology	Govt. Raza P.G. College Rampur, U.P.
Dr. Sanjay Jain	Associate Professor, Dept. of Statistics	St. John's College, Agra

Syllabus Developed by:

S.No.	Name	Designation	Department	College/University
1.	Dr. Gaurang Misra	Associate Professor	Physics	Agra College, Agra
2.	Dr. Naresh Kumar Chaudhary	Associate Professor	Physics & Electronics	Dr. R. M. L. A. University, Faizabad
3.	Dr. Vikram Singh	Assistant Professor	Physics	St. John's College, Agra

SEMESTER-WISE TITLES OF THE PAPERS IN UG PHYSICS COURSE					
YEAR	**SEMESTER**	**COURSE CODE**	**PAPER TITLE**	**THEORY / PRACTICAL**	**CREDIT**
CERTIFICATE -IN BASIC PHYSICS & SEMICONDUCTOR DEVICES					
FIRST YEAR	**I**	B010101T	Mathematical Physics & Newtonian Mechanics	Theory	4
		B010102P	Mechanical Properties of Matter	Practical	2
	II	B010201T	Thermal Physics & Semiconductor Devices	Theory	4
		B010202P	Thermal Properties of Matter & Electronic Circuits	Practical	2
DIPLOMA - IN APPLIED PHYSICS WITH ELECTRONICS					
SECOND YEAR	**III**	B010301T	Electromagnetic Theory & Modern Optics	Theory	4
		B010302P	Demonstrative Aspects of Electricity & Magnetism	Practical	2
	IV	B010401T	Perspectives of Modern Physics & Basic Electronics	Theory	4
		B010402P	Basic Electronics Instrumentation	Practical	2
DEGREE -IN BACHELOR OF SCIENCE					
THIRD YEAR	**V**	B010501T	Classical & Statistical Mechanics	Theory	4
		B010502T	Quantum Mechanics & Spectroscopy	Theory	4
		B010503P	Demonstrative Aspects of Optics & Lasers	Practical	2
	VI	B010601T	Solid State & Nuclear Physics	Theory	4
		B010602T	Analog & Digital Principles & Applications	Theory	4
		B010603P	Analog & Digital Circuits	Practical	2

SUBJECT PREREQUISITES

To study this subject, a student must have had the subjects **Physics & Mathematics** in class 12^{th}.

PROGRAMME OUTCOMES (POs)

The practical value of science for productivity, for raising the standard of living of the people is surely recognized. Science as a power, which provides tools for effective action for the benefit of mankind or for conquering the forces of Nature or for developing resources, is surely highlighted everywhere. Besides the utilitarian aspect, the value of Science, lies in the fun called intellectual enjoyment. Science teaches the value of rational thought as well as importance of freedom of thought.

Our teaching so far has been aimed more at formal knowledge and understanding instead of training and application oriented. Presently, the emphasis is more on training, application and to some extent on appreciation, the fostering in the pupils of independent thinking and creativity. Surely, teaching has to be more objective based. The process of application based training, whether we call it a thrill or ability, is to be emphasized as much as the content.

Physics is a basic science; it attempts to explain the natural phenomenon in as simple a manner as possible. It is an intellectual activity aimed at interpreting the Multiverse. The starting point of all physics lies in experience. Experiment, whether done outside or in the laboratory, is an important ingredient of learning physics and hence the present programme integrates six experimental physics papers focusing on various aspects of modern technology based equipments. With all the limitations imposed (even the list of experiments as given in the syllabus) if the spirit of discovery by investigation is kept in mind, much of the thrill can be experienced.

1. The main aim of this programme is to help cultivate the love for Nature and its manifestations, to transmit the methods of science (the contents are only the means) to observe things around, to generalize, to do intelligent guessing, to formulate a theory & model, and at the same time, to hold an element of doubt and thereby to hope to modify it in terms of future experience and thus to practice a pragmatic outlook.
2. The programme intends to nurture the proficiency in functional areas of Physics, which is in line with the international standards, aimed at realizing the goals towards skilled India.
3. Keeping the application oriented training in mind; this programme aims to give students the competence in the methods and techniques of theoretical, experimental and computational aspects of Physics so as to achieve an overall understanding of the subject for holistic development. This will cultivate in specific application oriented training leading to their goals of employment.
4. The Bachelor’s Project (Industrial Training / Survey / Dissertation) is intended to give an essence of research work for excellence in explicit areas. It integrates with specific job requirements / opportunities and provides a foundation for Bachelor (Research) Programmes.

PROGRAMME SPECIFIC OUTCOMES (PSOs)	
CERTIFICATE IN BASIC PHYSICS & SEMICONDUCTOR DEVICES	
FIRST YEAR	This programme aims to give students the competence in the methods and techniques of calculations using Newtonian Mechanics and Thermodynamics. At the end of the course the students are expected to have hands on experience in modeling, implementation and calculation of physical quantities of relevance. An introduction to the field of Circuit Fundamentals and Basic Electronics which deals with the physics and technology of semiconductor devices is practically useful and gives the students an insight in handling electrical and electronic instruments. Experimental physics has the most striking impact on the industry wherever the instruments are used. The industries of electronics, telecommunication and instrumentation will specially recognize this course.
DIPLOMA IN APPLIED PHYSICS WITH ELECTRONICS	
SECOND YEAR	This programme aims to introduce the students with Electromagnetic Theory, Modern Optics and Relativistic Mechanics. Electromagnetic Wave Propagation serves as a basis for all communication systems and deals with the physics and technology of semiconductor optoelectronic devices. A deeper insight in Electronics is provided to address the important components in consumer Optoelectronics, IT and Communication devices, and in industrial instrumentation. The need of Optical instruments and Lasers is surely highlighted everywhere and at the end of the course the students are expected to get acquaint with applications of Lasers in technology. Companies and R&D Laboratories working on Electromagnetic properties, Laser Applications, Optoelectronics and Communication Systems are expected to value this course.
DEGREE IN BACHELOR OF SCIENCE	
THIRD YEAR	This programme contains very important aspects of modern day course curriculum, namely, Classical, Quantum and Statistical computational tools required in the calculation of physical quantities of relevance in interacting many body problems in physics. It introduces the branches of Solid State Physics and Nuclear Physics that are going to be of utmost importance at both undergraduate and graduate level. Proficiency in this area will attract demand in research and industrial establishments engaged in activities involving applications of these fields. This course amalgamates the comprehensive knowledge of Analog & Digital Principles and Applications. It presents an integrated approach to analog electronic circuitry and digital electronics. Present course will attract immense recognition in R&D sectors and in the entire cutting edge technology based industry.

SEMESTER-WISE PAPER TITLES WITH DETAILS					
YEAR	SEME-STER	PAPER	PAPER TITLE	PREREQUISITE For Paper	ELECTIVE For Major Subjects
CERTIFICATE IN BASIC PHYSICS & SEMICONDUCTOR DEVICES					
FIRST YEAR	SEMESTER I	Theory Paper-1	Mathematical Physics & Newtonian Mechanics	Physics in 12th / Mathematics in 12th	YES Open to all
FIRST YEAR	SEMESTER I	Practical Paper	Mechanical Properties of Matter	Opted / Passed Sem I, Th Paper-1	YES Bota./Chem./Comp. Sc./ Math./Stat./Zool.
FIRST YEAR	SEMESTER II	Theory Paper-1	Thermal Physics & Semiconductor Devices	Physics in 12th / Chemistry in 12th	YES Open to all
FIRST YEAR	SEMESTER II	Practical Paper	Thermal Properties of Matter & Electronic Circuits	Opted / Passed Sem II, Th Paper-1	YES Bota./Chem./Comp. Sc./ Math./Stat./Zool.
DIPLOMA IN APPLIED PHYSICS WITH ELECTRONICS					
SECOND YEAR	SEMESTER III	Theory Paper-1	Electromagnetic Theory & Modern Optics	Passed Sem I, Th Paper-1	YES Open to all
SECOND YEAR	SEMESTER III	Practical Paper	Demonstrative Aspects of Electricity & Magnetism	Opted / Passed Sem III, Th Paper-1	YES Bota./Chem./Comp. Sc./ Math./Stat./Zool.
SECOND YEAR	SEMESTER IV	Theory Paper-1	Perspectives of Modern Physics & Basic Electronics	Passed Sem I, Th Paper-1	YES Open to all
SECOND YEAR	SEMESTER IV	Practical Paper	Basic Electronics Instrumentation	Opted / Passed Sem IV, Th Paper-1	YES Bota./Chem./Comp. Sc./ Math./Stat./Zool.
DEGREE IN BACHELOR OF SCIENCE					
THIRD YEAR	SEMESTER V	Theory Paper-1	Classical & Statistical Mechanics	Passed Sem I, Th Paper-1	YES Chem./Comp. Sc./Math./Stat.
THIRD YEAR	SEMESTER V	Theory Paper-2	Quantum Mechanics & Spectroscopy	Passed Sem IV, Th Paper-1	YES Chem./Comp. Sc./Math./Stat.
THIRD YEAR	SEMESTER V	Practical Paper	Demonstrative Aspects of Optics & Lasers	Passed Sem III, Th Paper-1	YES Chem./Comp. Sc./Math./Stat.
THIRD YEAR	SEMESTER VI	Theory Paper-1	Solid State & Nuclear Physics	Passed Sem V, Th Paper-2	YES Chem./Comp. Sc./Math./Stat.
THIRD YEAR	SEMESTER VI	Theory Paper-2	Analog & Digital Principles & Applications	Passed Sem IV, Th Paper-1	YES Open to all
THIRD YEAR	SEMESTER VI	Practical Paper	Analog & Digital Circuits	Opted / Passed Sem VI, Th Paper-2	YES Chem./Comp. Sc./Math./Stat.

FIRST YEAR

DETAILED SYLLABUS FOR

CERTIFICATE

IN

BASIC PHYSICS & SEMICONDUCTOR DEVICES

YEAR	SEME- STER	PAPER	PAPER TITLE	UNIT TITLE (Periods Per Semester)
CERTIFICATE IN BASIC PHYSICS & SEMICONDUCTOR DEVICES				
FIRST YEAR	SEMESTER I	Theory Paper-1	**Mathematical Physics & Newtonian Mechanics** Part A: Basic Mathematical Physics Part B: Newtonian Mechanics & Wave Motion	**<u>Part A</u>** I: Vector Algebra (7) II: Vector Calculus (8) III: Coordinate Systems (8) IV: Introduction to Tensors (7) **<u>Part B</u>** V: Dynamics of a System of Particles (8) VI: Dynamics of a Rigid Body (8) VII: Motion of Planets & Satellites (7) VIII: Wave Motion (7)
		Practical Paper	**Mechanical Properties of Matter**	Lab Experiment List Online Virtual Lab Experiment List/Link
	SEMESTER II	Theory Paper-1	**Thermal Physics & Semiconductor Devices** Part A: Thermodynamics & Kinetic Theory of Gases Part B: Circuit Fundamentals & Semiconductor Devices	**<u>Part A</u>** I: 0^{th} & 1^{st} Law of Thermodynamics (8) II: 2^{nd} & 3^{rd} Law of Thermodynamics (8) III: Kinetic Theory of Gases (7) IV: Theory of Radiation (7) **<u>Part B</u>** V: DC & AC Circuits (7) VI: Semiconductors & Diodes (8) VII: Transistors (8) VIII: Electronic Instrumentation (7)
		Practical Paper	**Thermal Properties of Matter & Electronic Circuits**	Lab Experiment List Online Virtual Lab Experiment List/Link

<table>
<tr><td>Programme/Class: Certificate</td><td colspan="2">Year: First</td><td>Semester: First</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course Code: B010101T</td><td colspan="3">Course Title: Mathematical Physics & Newtonian Mechanics</td></tr>
<tr><td colspan="4">Course Outcomes (COs)</td></tr>
<tr><td colspan="4">1. Recognize the difference between scalars, vectors, pseudo-scalars and pseudo-vectors.
2. Understand the physical interpretation of gradient, divergence and curl.
3. Comprehend the difference and connection between Cartesian, spherical and cylindrical coordinate systems.
4. Know the meaning of 4-vectors, Kronecker delta and Epsilon (Levi Civita) tensors.
5. Study the origin of pseudo forces in rotating frame.
6. Study the response of the classical systems to external forces and their elastic deformation.
7. Understand the dynamics of planetary motion and the working of Global Positioning System (GPS).
8. Comprehend the different features of Simple Harmonic Motion (SHM) and wave propagation.</td></tr>
<tr><td colspan="2">Credits: 4</td><td colspan="2">Core Compulsory / Elective</td></tr>
<tr><td colspan="2">Max. Marks: 25+75</td><td colspan="2">Min. Passing Marks:</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0</td></tr>
<tr><td>Unit</td><td colspan="2">Topics</td><td>No. of Lectures</td></tr>
<tr><td colspan="4"><u>PART A</u>
Basic Mathematical Physics</td></tr>
<tr><td>I</td><td colspan="2">Introduction to Indian ancient Physics and contribution of Indian Physicists, in context with the holistic development of modern science and technology, should be included under Continuous Internal Evaluation (CIE).

Vector Algebra
Coordinate rotation, reflection and inversion as the basis for defining scalars, vectors, pseudo-scalars and pseudo-vectors (include physical examples). Component form in 2D and 3D. Geometrical and physical interpretation of addition, subtraction, dot product, wedge product, cross product and triple product of vectors. Position, separation and displacement vectors.</td><td>7</td></tr>
<tr><td>II</td><td colspan="2">Vector Calculus
Geometrical and physical interpretation of vector differentiation, Gradient, Divergence and Curl and their significance. Vector integration, Line, Surface (flux) and Volume integrals of vector fields. Gradient theorem, Gauss-divergence theorem, Stoke-curl theorem, Greens theorem and Helmholtz theorem (statement only). Introduction to Dirac delta function.</td><td>8</td></tr>
<tr><td>III</td><td colspan="2">Coordinate Systems
2D & 3D Cartesian, Spherical and Cylindrical coordinate systems, basis vectors, transformation equations. Expressions for displacement vector, arc length, area element, volume element, gradient, divergence and curl in different coordinate systems. Components of velocity and acceleration in different coordinate systems. Examples of non-inertial coordinate system and pseudo-acceleration.</td><td>8</td></tr>
</table>

IV	**Introduction to Tensors** Principle of invariance of physical laws w.r.t. different coordinate systems as the basis for defining tensors. Coordinate transformations for general spaces of nD, contravariant, covariant & mixed tensors and their ranks, 4-vectors. Index notation and summation convention. Symmetric and skew-symmetric tensors. Invariant tensors, Kronecker delta and Epsilon (Levi Civita) tensors. Examples of tensors in physics.	7
	PART B **Newtonian Mechanics & Wave Motion**	
V	**Dynamics of a System of Particles** Review of historical development of mechanics up to Newton. Background, statement and critical analysis of Newton's axioms of motion. Dynamics of a system of particles, centre of mass motion, and conservation laws & their deductions. Rotating frames of reference, general derivation of origin of pseudo forces (Euler, Coriolis & centrifugal) in rotating frame, and effects of Coriolis force.	8
VI	**Dynamics of a Rigid Body** Angular momentum, Torque, Rotational energy and the inertia tensor. Rotational inertia for simple bodies (ring, disk, rod, solid and hollow sphere, solid and hollow cylinder, rectangular lamina). The combined translational and rotational motion of a rigid body on horizontal and inclined planes. Elasticity, relations between elastic constants, bending of beam and torsion of cylinder.	8
VII	**Motion of Planets & Satellites** Two particle central force problem, reduced mass, relative and centre of mass motion. Newton's law of gravitation, gravitational field and gravitational potential. Kepler's laws of planetary motion and their deductions. Motions of geo-synchronous & geo-stationary satellites and basic idea of Global Positioning System (GPS).	7
VIII	**Wave Motion** Differential equation of simple harmonic motion and its solution, use of complex notation, damped and forced oscillations, Quality factor. Composition of simple harmonic motion, Lissajous figures. Differential equation of wave motion. Plane progressive waves in fluid media, reflection of waves and phase change, pressure and energy distribution. Principle of superposition of waves, stationary waves, phase and group velocity.	7

Suggested Readings

PART A

1. Murray Spiegel, Seymour Lipschutz, Dennis Spellman, "Schaum's Outline Series: Vector Analysis", McGraw Hill, 2017, 2e
2. A.W. Joshi, "Matrices and Tensors in Physics", New Age International Private Limited, 1995, 3e

PART B

1. Charles Kittel, Walter D. Knight, Malvin A. Ruderman, Carl A. Helmholz, Burton J. Moyer, "Mechanics (In SI Units): Berkeley Physics Course Vol 1", McGraw Hill, 2017, 2e
2. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 1", Pearson Education Limited, 2012
3. Hugh D. Young and Roger A. Freedman, "Sears & Zemansky's University Physics with Modern Physics", Pearson Education Limited, 2017, 14e
4. D.S. Mathur, P.S. Hemne, "Mechanics", S. Chand Publishing, 1981, 3e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Programme/Class: **Certificate**	Year: **First**	Semester: **First**
Subject: **Physics**		
Course Code: **B010102P**	Course Title: **Mechanical Properties of Matter**	

Course Outcomes (COs)

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the mechanical properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.

Credits: **2**	Core Compulsory / Elective
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **0-0-4**

Unit	Topics	No. of Lectures
	Lab Experiment List	60

1. Moment of inertia of a flywheel
2. Moment of inertia of an irregular body by inertia table
3. Modulus of rigidity by statistical method (Barton’s apparatus)
4. Modulus of rigidity by dynamical method (sphere / disc / Maxwell’s needle)
5. Young’s modulus by bending of beam
6. Young’s modulus and Poisson’s ratio by Searle’s method
7. Poisson’s ratio of rubber by rubber tubing
8. Surface tension of water by capillary rise method
9. Surface tension of water by Jaeger’s method
10. Coefficient of viscosity of water by Poiseuille’s method
11. Acceleration due to gravity by bar pendulum
12. Frequency of AC mains by Sonometer
13. Height of a building by Sextant
14. Study the wave form of an electrically maintained tuning fork / alternating current source with the help of cathode ray oscilloscope.

Online Virtual Lab Experiment List / Link

Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/?sub=1&brch=74

1. Torque and angular acceleration of a fly wheel
2. Torsional oscillations in different liquids
3. Moment of inertia of flywheel
4. Newton's second law of motion
5. Ballistic pendulum
6. Collision balls
7. Projectile motion
8. Elastic and inelastic collision

Programme/Class: **Certificate**	Year: **First**	Semester: **Second**
Subject: **Physics**		
Course Code: **B010201T**	Course Title: **Thermal Physics & Semiconductor Devices**	

Course Outcomes (COs)

1. Recognize the difference between reversible and irreversible processes.
2. Understand the physical significance of thermodynamical potentials.
3. Comprehend the kinetic model of gases w.r.t. various gas laws.
4. Study the implementations and limitations of fundamental radiation laws.
5. Utility of AC bridges.
6. Recognize the basic components of electronic devices.
7. Design simple electronic circuits.
8. Understand the applications of various electronic instruments.

Credits: **4**	Core Compulsory / Elective
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
	PART A **Thermodynamics & Kinetic Theory of Gases**	
I	**0^{th} & 1^{st} Law of Thermodynamics** State functions and terminology of thermodynamics. Zeroth law and temperature. First law, internal energy, heat and work done. Work done in various thermodynamical processes. Enthalpy, relation between C_P and C_V. Carnot's engine, efficiency and Carnot's theorem. Efficiency of internal combustion engines (Otto and diesel).	8
II	**2^{nd} & 3^{rd} Law of Thermodynamics** Different statements of second law, Clausius inequality, entropy and its physical significance. Entropy changes in various thermodynamical processes. Third law of thermodynamics and unattainability of absolute zero. Thermodynamical potentials, Maxwell's relations, conditions for feasibility of a process and equilibrium of a system. Clausius- Clapeyron equation, Joule-Thompson effect.	8
III	**Kinetic Theory of Gases** Kinetic model and deduction of gas laws. Derivation of Maxwell's law of distribution of velocities and its experimental verification. Degrees of freedom, law of equipartition of energy (no derivation) and its application to specific heat of gases (mono, di and poly atomic).	7
IV	**Theory of Radiation** Blackbody radiation, spectral distribution, concept of energy density and pressure of radiation. Derivation of Planck's law, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law and Wien's displacement law from Planck's law.	7

PART B Circuit Fundamentals & Semiconductor Devices		
V	**DC & AC Circuits** Growth and decay of currents in RL circuit. Charging and discharging of capacitor in RC, LC and RCL circuits. Network Analysis - Superposition, Reciprocity, Thevenin's and Norton's theorems. AC Bridges - measurement of inductance (Maxwell's, Owen's and Anderson's bridges) and measurement of capacitance (Schering's, Wein's and de Sauty's bridges).	7
VI	**Semiconductors & Diodes** P and N type semiconductors, qualitative idea of Fermi level. Formation of depletion layer in PN junction diode, field & potential at the depletion layer. Qualitative idea of current flow mechanism in forward & reverse biased diode. Diode fabrication. PN junction diode and its characteristics, static and dynamic resistance. Principle, structure, characteristics and applications of Zener, Tunnel, Light Emitting, Point Contact and Photo diodes. Half and Full wave rectifiers, calculation of ripple factor, rectification efficiency and voltage regulation. Basic idea about filter circuits and voltage regulated power supply.	8
VII	**Transistors** Bipolar Junction PNP and NPN transistors. Study of CB, CE & CC configurations w.r.t. active, cutoff & saturation regions; characteristics; current, voltage & power gains; transistor currents & relations between them. Idea of base width modulation, base spreading resistance & transition time. DC Load Line analysis and Q-point stabilisation. Voltage Divider Bias circuit for CE amplifier. Qualitative discussion of RC coupled amplifier (frequency response not included).	8
VIII	**Electronic Instrumentation** Multimeter: Principles of measurement of dc voltage, dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, electron gun, electrostatic focusing and acceleration (no mathematical treatment). Front panel controls, special features of dual trace CRO, specifications of a CRO and their significance. Applications of CRO to study the waveform and measurement of voltage, current, frequency & phase difference.	7

Suggested Readings

PART A

1. M.W. Zemansky, R. Dittman, "Heat and Thermodynamics", McGraw Hill, 1997, 7e
2. F.W. Sears, G.L. Salinger, "Thermodynamics, Kinetic theory & Statistical thermodynamics", Narosa Publishing House, 1998
3. Enrico Fermi, "Thermodynamics", Dover Publications, 1956
4. S. Garg, R. Bansal, C. Ghosh, "Thermal Physics", McGraw Hill, 2012, 2e
5. Meghnad Saha, B.N. Srivastava, "A Treatise on Heat", Indian Press, 1973, 5e

PART B

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e
5. A. Sudhakar, S.S. Palli, "Circuits and Networks: Analysis and Synthesis", McGraw Hill, 2015, 5e
6. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Programme/Class: **Certificate**	Year: **First**	Semester: **Second**
Subject: **Physics**		
Course Code: **B010202P**	Course Title: **Thermal Properties of Matter & Electronic Circuits**	

Course Outcomes (COs)

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the thermal and electronic properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.

Credits: **2**	Core Compulsory / Elective
Max. Marks: **25+75**	Min. Passing Marks:
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **0-0-4**	

Unit	**Topics**	**No. of Lectures**
	Lab Experiment List	60

1. Mechanical Equivalent of Heat by Callender and Barne’s method
2. Coefficient of thermal conductivity of copper by Searle’s apparatus
3. Coefficient of thermal conductivity of rubber
4. Coefficient of thermal conductivity of a bad conductor by Lee and Charlton’s disc method
5. Value of Stefan’s constant
6. Verification of Stefan’s law
7. Variation of thermo-emf across two junctions of a thermocouple with temperature
8. Temperature coefficient of resistance by Platinum resistance thermometer
9. Charging and discharging in RC and RCL circuits
10. A.C. Bridges: Various experiments based on measurement of L and C
11. Resonance in series and parallel RCL circuit
12. Characteristics of PN Junction, Zener, Tunnel, Light Emitting and Photo diode
13. Characteristics of a transistor (PNP and NPN) in CE, CB and CC configurations
14. Half wave & full wave rectifiers and Filter circuits
15. Unregulated and Regulated power supply
16. Various measurements with Cathode Ray Oscilloscope (CRO)

Online Virtual Lab Experiment List / Link

Thermal Properties of Matter:
Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/?sub=1&brch=194

1. Heat transfer by radiation
2. Heat transfer by conduction
3. Heat transfer by natural convection
4. The study of phase change
5. Black body radiation: Determination of Stefan's constant
6. Newton's law of cooling
7. Lee's disc apparatus
8. Thermo-couple: Seebeck effects

SECOND YEAR

DETAILED SYLLABUS FOR

DIPLOMA

IN

ADVANCED PHYSICS WITH ELECTRONICS

YEAR	SEME-STER	PAPER	PAPER TITLE	UNIT TITLE (Periods Per Semester)
DIPLOMA IN APPLIED PHYSICS WITH ELECTRONICS				
SECOND YEAR	**SEMESTER III**	Theory Paper-1	**Electromagnetic Theory & Modern Optics** Part A: Electromagnetic Theory Part B: Physical Optics & Lasers	**Part A** I: Electrostatics (8) II: Magnetostatics (8) III: Time Varying Electromagnetic Fields (7) IV: Electromagnetic Waves (7) **Part B** V: Interference (8) VI: Diffraction (8) VII: Polarisation (7) VII: Lasers (7)
		Practical Paper	**Demonstrative Aspects of Electricity & Magnetism**	Lab Experiment List Online Virtual Lab Experiment List/Link
	SEMESTER IV	Theory Paper-1	**Perspectives of Modern Physics & Basic Electronics** Part A: Perspectives of Modern Physics Part B: Basic Electronics & Introduction to Fiber Optics	**Part A** I: Relativity-Experimental Background (7) II: Relativity-Relativistic Kinematics (8) III: Inadequacies of Classical Mechanics (8) IV: Introduction to Quantum Mechanics (7) **Part B** V: Transistor Biasing (7) VI: Amplifiers (7) VII: Feedback & Oscillator Circuits (8) VIII: Introduction to Fiber Optics (8)
		Practical Paper	**Basic Electronics Instrumentation**	Lab Experiment List Online Virtual Lab Experiment List/Link

Programme/Class: **Diploma**	Year: **Second**	Semester: **Third**
Subject: **Physics**		
Course Code: **B010301T**	Course Title: **Electromagnetic Theory & Modern Optics**	

Course Outcomes (COs)

1. Better understanding of electrical and magnetic phenomenon in daily life.
2. To troubleshoot simple problems related to electrical devices.
3. Comprehend the powerful applications of ballistic galvanometer.
4. Study the fundamental physics behind reflection and refraction of light (electromagnetic waves).
5. Study the working and applications of Michelson and Fabry-Perot interferometers.
6. Recognize the difference between Fresnel's and Fraunhofer's class of diffraction.
7. Comprehend the use of polarimeters.
8. Study the characteristics and uses of lasers.

Credits: **4**	Core Compulsory / Elective
Max. Marks: **25+75**	Min. Passing Marks:
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**	

Unit	Topics	No. of Lectures
	PART A **Electromagnetic Theory**	
I	**Electrostatics** Electric charge & charge densities, electric force between two charges. General expression for Electric field in terms of volume charge density (divergence & curl of Electric field), general expression for Electric potential in terms of volume charge density and Gauss law (applications included). Study of electric dipole. Electric fields in matter, polarization, auxiliary field **D** (Electric displacement), electric susceptibility and permittivity.	8
II	**Magnetostatics** Electric current & current densities, magnetic force between two current elements. General expression for Magnetic field in terms of volume current density (divergence and curl of Magnetic field), General expression for Magnetic potential in terms of volume current density and Ampere's circuital law (applications included). Study of magnetic dipole (Gilbert & Ampere model). Magnetic fields in matter, magnetisation, auxiliary field **H**, magnetic susceptibility and permeability.	8
III	**Time Varying Electromagnetic Fields** Faraday's laws of electromagnetic induction and Lenz's law. Displacement current, equation of continuity and Maxwell-Ampere's circuital law. Self and mutual induction (applications included). Derivation and physical significance of Maxwell's equations. Theory and working of moving coil ballistic galvanometer (applications included).	7
IV	**Electromagnetic Waves** Electromagnetic energy density and Poynting vector. Plane electromagnetic waves in linear infinite dielectrics, homogeneous & inhomogeneous plane waves and dispersive & non-dispersive media. Reflection and refraction of homogeneous plane electromagnetic waves, law of reflection, Snell's law, Fresnel's formulae (only for normal incidence & optical frequencies) and Stoke's law.	7

Programme/Class: **Diploma**	Year: **Second**	Semester: **Fourth**
Subject: **Physics**		
Course Code: **B010401T**	Course Title: **Perspectives of Modern Physics & Basic Electronics**	

Course Outcomes (COs)

1. Recognize the difference between the structure of space & time in Newtonian & Relativistic mechanics.
2. Understand the physical significance of consequences of Lorentz transformation equations.
3. Comprehend the wave-particle duality.
4. Develop an understanding of the foundational aspects of Quantum Mechanics.
5. Study the comparison between various biasing techniques.
6. Study the classification of amplifiers.
7. Comprehend the use of feedback and oscillators.
8. Comprehend the theory and working of optical fibers along with its applications.

Credits: **4**	Core Compulsory / Elective
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
	PART A **Perspectives of Modern Physics**	
I	**Relativity-Experimental Background** Structure of space & time in Newtonian mechanics and inertial & non-inertial frames. Galilean transformations. Newtonian relativity. Galilean transformation and Electromagnetism. Attempts to locate the Absolute Frame: Michelson-Morley experiment and significance of the null result. Einstein's postulates of special theory of relativity.	7
II	**Relativity-Relativistic Kinematics** Structure of space & time in Relativistic mechanics and derivation of Lorentz transformation equations (4-vector formulation included). Consequences of Lorentz Transformation Equations (derivations & examples included): Transformation of Simultaneity (Relativity of simultaneity); Transformation of Length (Length contraction); Transformation of Time (Time dilation); Transformation of Velocity (Relativistic velocity addition); Transformation of Acceleration; Transformation of Mass (Variation of mass with velocity). Relation between Energy & Mass (Einstein's mass & energy relation) and Energy & Momentum.	8
III	**Inadequacies of Classical Mechanics** Particle Properties of Waves: Spectrum of Black Body radiation, Photoelectric effect, Compton effect and their explanations based on Max Planck's Quantum hypothesis. Wave Properties of Particles: Louis de Broglie's hypothesis of matter waves and their experimental verification by Davisson-Germer's experiment and Thomson's experiment.	8
IV	**Introduction to Quantum Mechanics** Matter Waves: Mathematical representation, Wavelength, Concept of Wave group, Group (particle) velocity, Phase (wave) velocity and relation between Group & Phase velocities. Wave Function: Functional form, Normalisation of wave function, Orthogonal & Orthonormal wave functions and Probabilistic interpretation of wave function based on Born Rule.	7

PART B Basic Electronics & Introduction to Fiber Optics		
V	**Transistor Biasing** Faithful amplification & need for biasing. Stability Factors and its calculation for transistor biasing circuits for CE configuration: Fixed Bias (Base Resistor Method), Emitter Bias (Fixed Bias with Emitter Resistor), Collector to Base Bias (Base Bias with Collector Feedback) &, Voltage Divider Bias. Discussion of Emitter-Follower configuration.	7
VI	**Amplifiers** Classification of amplifiers based on Mode of operation (Class A, B, AB, C & D), Stages (single & multi stage, cascade & cascode connections), Coupling methods (RC, Transformer, Direct & LC couplings), Nature of amplification (Voltage & Power amplification) and Frequency capabilities (AF, IF, RF & VF). Theory & working of RC coupled voltage amplifier (Uses of various resistors & capacitors, and Frequency response) and Transformer coupled power amplifier (calculation of Power, Effect of temperature, Use of heat sink & Power dissipation). Calculation of Amplifier Efficiency (power efficiency) for Class A Series-Fed, Class A Transformer Coupled, Class B Series-Fed and Class B Transformer Coupled amplifiers.	7
VII	**Feedback & Oscillator Circuits** Feedback Circuits: Effects of positive and negative feedback. Voltage Series, Voltage Shunt, Current Series and Current Shunt feedback connection types and their uses for specific amplifiers. Estimation of Input Impedance, Output Impedance, Gain, Stability, Distortion, Noise and Band Width for Voltage Series negative feedback and their comparison between different negative feedback connection types. Oscillator Circuits: Use of positive feedback for oscillator operation. Barkhausen criterion for self-sustained oscillations. Feedback factor and frequency of oscillation for RC Phase Shift oscillator and Wein Bridge oscillator. Qualitative discussion of Reactive Network feedback oscillators (Tuned oscillator circuits): Hartley & Colpitt oscillators.	8
VIII	**Introduction to Fiber Optics** Basics of Fiber Optics, step index fiber, graded index fiber, light propagation through an optical fiber, acceptance angle & numerical aperture, qualitative discussion of fiber losses and applications of optical fibers.	8

Suggested Readings

PART A

1. A. Beiser, Shobhit Mahajan, "Concepts of Modern Physics: Special Indian Edition", McGraw Hill, 2009, 6e
2. John R. Taylor, Chris D. Zafiratos, Michael A.Dubson, "Modern Physics for Scientists and Engineers", Prentice-Hall of India Private Limited, 2003, 2e
3. R.A. Serway, C.J. Moses, and C.A. Moyer, "Modern Physics", Cengage Learning India Pvt. Ltd, 2004, 3e
4. R. Resnick, "Introduction to Special Relativity", Wiley India Private Limited, 2007
5. R. Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e

THIRD YEAR

DETAILED SYLLABUS FOR

DEGREE

IN

BACHELOR OF SCIENCE

YEAR	SEME-STER	PAPER	PAPER TITLE	UNIT TITLE (Periods Per Semester)
DEGREE IN BACHELOR OF SCIENCE				
THIRD YEAR	**SEMESTER V**	Theory Paper-1	**Classical & Statistical Mechanics** Part A: Introduction to Classical Mechanics Part B: Introduction to Statistical Mechanics	**Part A** I: Constrained Motion (6) II: Lagrangian Formalism (9) III: Hamiltonian Formalism (8) IV: Central Force (7) **Part B** V: Macrostate & Microstate (6) VI: Concept of Ensemble (6) VII: Distribution Laws (10) VIII: Applications of Statistical Distribution Laws (8)
		Theory Paper-2	**Quantum Mechanics & Spectroscopy** Part A: Introduction to Quantum Mechanics Part B: Introduction to Spectroscopy	**Part A** I: Operator Formalism (5) II: Eigen & Expectation Values (6) III: Uncertainty Principle & Schrodinger Equation (7) IV: Applications of Schrodinger Equation (12) **Part B** V: Vector Atomic Model (10) VI: Spectra of Alkali & Alkaline Elements (6) VII: X-Rays & X-Ray Spectra (7) VIII: Molecular Spectra (7)
		Practical Paper	**Demonstrative Aspects of Optics & Lasers**	Lab Experiment List Online Virtual Lab Experiment List/Link
	SEMESTER VI	Theory Paper-1	**Solid State & Nuclear Physics** Part A: Introduction to Solid State Physics Part B: Introduction to Nuclear Physics	**Part A** I: Crystal Structure (7) II: Crystal Diffraction (7) III: Crystal Bindings (7) IV: Lattice Vibrations (9) **Part B** V: Nuclear Forces & Radioactive Decays (9) VI: Nuclear Models & Nuclear Reactions (9) VII: Accelerators & Detectors (6) VIII: Elementary Particles (6)
		Theory Paper-2	**Analog & Digital Principles & Applications** Part A: Analog Electronic Circuits Part B: Digital Electronics	**Part A** I: Semiconductor Junction (9) II: Transistor Modeling (8) III: Field Effect Transistors (8) IV: Other Devices (5) **Part B** V: Number System (6) VI: Binary Arithmetic (5) VII: Logic Gates (9) VIII: Combinational & Sequential Circuits (10)
		Practical Paper	**Analog & Digital Circuits**	Lab Experiment List Online Virtual Lab Experiment List/Link

Programme/Class: **Degree**	Year: **Third**	Semester: **Fifth**
Subject: **Physics**		
Course Code: **B010501T**	Course Title: **Classical & Statistical Mechanics**	
Course Outcomes (COs)		
1. Understand the concepts of generalized coordinates and D'Alembert's principle. 2. Understand the Lagrangian dynamics and the importance of cyclic coordinates. 3. Comprehend the difference between Lagrangian and Hamiltonian dynamics. 4. Study the important features of central force and its application in Kepler's problem. 5. Recognize the difference between macrostate and microstate. 6. Comprehend the concept of ensembles. 7. Understand the classical and quantum statistical distribution laws. 8. Study the applications of statistical distribution laws.		
Credits: **4**	Core Compulsory / Elective	
Max. Marks: **25+75**	Min. Passing Marks:	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**		

Unit	**Topics**	**No. of Lectures**
	PART A **Introduction to Classical Mechanics**	
I	**Constrained Motion** Constraints - Definition, Classification and Examples. Degrees of Freedom and Configuration space. Constrained system, Forces of constraint and Constrained motion. Generalised coordinates, Transformation equations and Generalised notations & relations. Principle of Virtual work and D'Alembert's principle.	6
II	**Lagrangian Formalism** Lagrangian for conservative & non-conservative systems, Lagrange's equation of motion (no derivation), Comparison of Newtonian & Lagrangian formulations, Cyclic coordinates, and Conservation laws (with proofs and properties of kinetic energy function included). Simple examples based on Lagrangian formulation.	9
III	**Hamiltonian Formalism** Phase space, Hamiltonian for conservative & non-conservative systems, Physical significance of Hamiltonian, Hamilton's equation of motion (no derivation), Comparison of Lagrangian & Hamiltonian formulations, Cyclic coordinates, and Construction of Hamiltonian from Lagrangian. Simple examples based on Hamiltonian formulation.	8
IV	**Central Force** Definition and properties (with prove) of central force. Equation of motion and differential equation of orbit. Bound & unbound orbits, stable & non-stable orbits, closed & open orbits and Bertrand's theorem. Motion under inverse square law of force and derivation of Kepler's laws. Laplace-Runge-Lenz vector (Runge-Lenz vector) and its applications.	7

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RAJEEV KUMAR
Digitally Signed By: Registrar

<table>
<tr><th colspan="3"><u>PART B</u>
Introduction to Statistical Mechanics</th></tr>
<tr><td>V</td><td>Macrostate & Microstate
Macrostate, Microstate, Number of accessible microstates and Postulate of equal a priori. Phase space, Phase trajectory, Volume element in phase space, Quantisation of phase space and number of accessible microstates for free particle in 1D, free particle in 3D & harmonic oscillator in 1D.</td><td>6</td></tr>
<tr><td>VI</td><td>Concept of Ensemble
Problem with time average, concept of ensemble, postulate of ensemble average and Liouville's theorem (proof included). Micro Canonical, Canonical & Grand Canonical ensembles. Thermodynamic Probability, Postulate of Equilibrium and Boltzmann Entropy relation.</td><td>6</td></tr>
<tr><td>VII</td><td>Distribution Laws
Statistical Distribution Laws: Expressions for number of accessible microstates, probability & number of particles in ith state at equilibrium for Maxwell-Boltzmann, Bose-Einstein & Fermi-Dirac statistics. Comparison of statistical distribution laws and their physical significance.
Canonical Distribution Law: Boltzmann's Canonical Distribution Law, Boltzmann's Partition Function, Proof of Equipartition Theorem (Law of Equipartition of energy) and relation between Partition function and Thermodynamic potentials.</td><td>10</td></tr>
<tr><td>VIII</td><td>Applications of Statistical Distribution Laws
Application of Bose-Einstein Distribution Law: Photons in a black body cavity and derivation of Planck's Distribution Law.
Application of Fermi-Dirac Distribution Law: Free electrons in a metal, Definition of Fermi energy, Determination of Fermi energy at absolute zero, Kinetic energy of Fermi gas at absolute zero and concept of Density of States (Density of Orbitals).</td><td>8</td></tr>
</table>

Suggested Readings

<u>PART A</u>

1. Herbert Goldstein, Charles P. Poole, John L. Safko, "Classical Mechanics", Pearson Education, India, 2011, 3e
2. N.C. Rana, P.S. Joag, "Classical Mechanics", McGraw Hill, 2017
3. R.G. Takwale, P.S. Puranik, "Introduction to Classical Mechanics", McGraw Hill, 2017

<u>PART B</u>

1. F. Reif, "Statistical Physics (In SI Units): Berkeley Physics Course Vol 5", McGraw Hill, 2017, 1e
2. B.B. Laud, "Fundamentals of Statistical Mechanics", New Age International Private Limited, 2020, 2e
3. B.K. Agarwal, M. Eisner, "Statistical Mechanics", New Age International Private Limited, 2007, 2e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Suggestive Digital Platforms / Web Links

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Course Prerequisites

Passed Semester I, Theory Paper-1 (B010101T)

Programme/Class: **Degree**	Year: **Third**	Semester: **Fifth**
Subject: **Physics**		
Course Code: **B010502T**	Course Title: **Quantum Mechanics & Spectroscopy**	
Course Outcomes (COs)		
1. Understand the significance of operator formalism in Quantum mechanics. 2. Study the eigen and expectation value methods. 3. Understand the basis and interpretation of Uncertainty principle. 4. Develop the technique of solving Schrodinger equation for 1D and 3D problems. 5. Comprehend the success of Vector atomic model in the theory of Atomic spectra. 6. Study the different aspects of spectra of Group I & II elements. 7. Study the production and applications of X-rays. 8. Develop an understanding of the fundamental aspects of Molecular spectra.		

Credits: **4**	Core Compulsory / Elective
Max. Marks: **25+75**	Min. Passing Marks:
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**	

Unit	**Topics**	**No. of Lectures**
	PART A **Introduction to Quantum Mechanics**	
I	**Operator Formalism** Operators: Review of matrix algebra, definition of an operator, special operators, operator algebra and operators corresponding to various physical-dynamical variables. Commutators: Definition, commutator algebra and commutation relations among position, linear momentum & angular momentum and energy & time. Simple problems based on commutation relations.	5
II	**Eigen & Expectation Values** Eigen & Expectation Values: Eigen equation for an operator, eigen state (value) and eigen functions. Linear superposition of eigen functions and Non-degenerate & Degenerate eigen states. Expectation value pertaining to an operator and its physical interpretation. Hermitian Operators: Definition, properties and applications. Prove of the hermitian nature of various physical-dynamical operators.	6
III	**Uncertainty Principle & Schrodinger Equation** Uncertainty Principle: Commutativity & simultaneity (theorems with proofs). Non commutativity of operators as the basis for uncertainty principle and derivation of general form of uncertainty principle through Schwarz inequality. Uncertainty principle for various conjugate pairs of physical-dynamical parameters and its applications. Schrodinger Equation: Derivation of time independent & time dependent forms, Schrodinger equation as an eigen equation, Deviation & interpretation of equation of continuity in Schrodinger representation, and Equation of motion of an operator in Schrodinger representation.	7

IV	**Applications of Schrodinger Equation** Application to 1D Problems: Infinite Square well potential (Particle in 1D box), Finite Square well potential, Potential step, Rectangular potential barrier and 1D Harmonic oscillator. Application to 3D Problems: Infinite Square well potential (Particle in a 3D box) and the Hydrogen atom (radial distribution function and radial probability included). (Direct solutions of Hermite, Associated Legendre and Associated Laguerre differential equations to be substituted).	12
	<u>PART B</u> **Introduction to Spectroscopy**	
V	**Vector Atomic Model** Inadequacies of Bohr and Bohr-Sommerfeld atomic models w.r.t. spectrum of Hydrogen atom (fine structure of H-alpha line). Modification due to finite mass of nucleus and Deuteron spectrum. Vector atomic model (Stern-Gerlach experiment included) and physical & geometrical interpretations of various quantum numbers for single & many valence electron systems. LS & jj couplings, spectroscopic notation for energy states, selection rules for transition of electrons and intensity rules for spectral lines. Fine structure of H-alpha line on the basis of vector atomic model.	10
VI	**Spectra of Alkali & Alkaline Elements** Spectra of alkali elements: Screening constants for s, p, d & f orbitals; sharp, principle, diffuse & fundamental series; doublet structure of spectra and fine structure of Sodium D line. Spectra of alkaline elements: Singlet and triplet structure of spectra.	6
VII	**X-Rays & X-Ray Spectra** Nature & production, Continuous X-ray spectrum & Duane-Hunt's law, Characteristic X-ray spectrum & Mosley's law, Fine structure of Characteristic X-ray spectrum, and X-ray absorption spectrum.	7
VIII	**Molecular Spectra** Discrete set of energies of a molecule, electronic, vibrational and rotational energies. Quantisation of vibrational energies, transition rules and pure vibrational spectra. Quantisation of rotational energies, transition rules, pure rotational spectra and determination of inter nuclear distance. Rotational-Vibrational spectra; transition rules; fundamental band & hot band; O, P, Q, R, S branches.	7

Suggested Readings

<u>PART A</u>

1. D.J. Griffiths, "Introduction to Quantum Mechanics", Pearson Education, India, 2004, 2e
2. E. Wichmann, "Quantum Physics (In SI Units): Berkeley Physics Course Vol 4", McGraw Hill, 2017
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 3", Pearson Education Limited, 2012
4. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e

<u>PART B</u>

1. H.E. White, "Introduction to Atomic Spectra", McGraw Hill, 1934
2. C.N. Banwell, E.M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw Hill, 2017, 4e
3. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e
4. S.L. Gupta, V. Kumar, R.C. Sharma, "Elements of Spectroscopy", Pragati Prakashan, Meerut, 2015, 27e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Programme/Class: **Degree**	Year: **Third**	Semester: **Sixth**
Subject: **Physics**		
Course Code: **B010601T**	Course Title: **Solid State & Nuclear Physics**	

Course Outcomes (COs)

1. Understand the crystal geometry w.r.t. symmetry operations.
2. Comprehend the power of X-ray diffraction and the concept of reciprocal lattice.
3. Study various properties based on crystal bindings.
4. Recognize the importance of Free Electron & Band theories in understanding the crystal properties.
5. Study the salient features of nuclear forces & radioactive decays.
6. Understand the importance of nuclear models & nuclear reactions.
7. Comprehend the working and applications of nuclear accelerators and detectors.
8. Understand the classification and properties of basic building blocks of nature.

Credits: **4**	Core Compulsory / Elective
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
	PART A **Introduction to Solid State Physics**	
I	**Crystal Structure** Lattice, Basis & Crystal structure. Lattice translation vectors, Primitive & non-primitive cells. Symmetry operations, Point group & Space group. 2D & 3D Bravais lattice. Parameters of cubic lattices. Lattice planes and Miller indices. Simple crystal structures - HCP & FCC, Diamond, Cubic Zinc Sulphide, Sodium Chloride, Cesium Chloride and Glasses.	7
II	**Crystal Diffraction** X-ray diffraction and Bragg's law. Experimental diffraction methods - Laue, Rotating crystal and Powder methods. Derivation of scattered wave amplitude. Reciprocal lattice, Reciprocal lattice vectors and relation between Direct & Reciprocal lattice. Diffraction conditions, Ewald's method and Brillouin zones. Reciprocal lattice to SC, BCC & FCC lattices. Atomic Form factor and Crystal Structure factor.	7
III	**Crystal Bindings** Classification of Crystals on the Basis of Bonding - Ionic, Covalent, Metallic, van der Waals (Molecular) and Hydrogen bonded. Crystals of inert gases, Attractive interaction (van der Waals-London) & Repulsive interaction, Equilibrium lattice constant, Cohesive energy and Compressibility & Bulk modulus. Ionic crystals, Cohesive energy, Madelung energy and evaluation of Madelung constant.	7

IV	**Lattice Vibrations** Lattice Vibrations: Lattice vibrations for linear mono & di atomic chains, Dispersion relations and Acoustical & Optical branches (qualitative treatment). Qualitative description of Phonons in solids. Lattice heat capacity, Dulong-Petit's law and Einstein's theory of lattice heat capacity. Free Electron Theory: Fermi energy, Density of states, Heat capacity of conduction electrons, Paramagnetic susceptibility of conduction electrons and Hall effect in metals. Band Theory: Origin of band theory, Qualitative idea of Bloch theorem, Kronig-Penney model, Effectice mass of an electron & Concept of Holes & Classification of solids on the basis of band theory.	9
	PART B **Introduction to Nuclear Physics**	
V	**Nuclear Forces & Radioactive Decays** General Properties of Nucleus: Mass, binding energy, radii, density, angular momentum, magnetic dipole moment vector and electric quadrupole moment tensor. Nuclear Forces: General characteristic of nuclear force and Deuteron ground state properties. Radioactive Decays: Nuclear stability, basic ideas about beta minus decay, beta plus decay, alpha decay, gamma decay & electron capture, fundamental laws of radioactive disintegration and radioactive series.	9
VI	**Nuclear Models & Nuclear Reactions** Nuclear Models: Liquid drop model and Bethe-Weizsacker mass formula. Single particle shell model (the level scheme in the context of reproduction of magic numbers included). Nuclear Reactions: Bethe's notation, types of nuclear reaction, Conservation laws, Cross-section of nuclear reaction, Theory of nuclear fission (qualitative), Nuclear reactors and Nuclear fusion.	9
VII	**Accelerators & Detectors** Accelerators: Theory, working and applications of Van de Graaff accelerator, Cyclotron and Synchrotron. Detectors: Theory, working and applications of GM counter, Semiconductor detector, Scintillation counter and Wilson cloud chamber.	6
VIII	**Elementary Particles** Fundamental interactions & their mediating quanta. Concept of antiparticles. Classification of elementary particles based on intrinsic-spin, mass, interaction & lifetime. Families of Leptons, Mesons, Baryons & Baryon Resonances. Conservation laws for mass-energy, linear momentum, angular momentum, electric charge, baryonic charge, leptonic charge, isospin & strangeness. Concept of Quark model.	6

Suggested Readings

PART A

1. Charles Kittel, "Introduction to Solid State Physics", Wiley India Private Limited, 2012, 8e
2. A.J. Dekker, "Solid State Physics", Macmillan India Limited, 1993
3. R.K. Puri, V.K. Babbar, "Solid State Physics", S. Chand Publishing, 2015

PART B

1. Kenneth S. Krane, "Introductory Nuclear Physics", Wiley India Private Limited, 2008
2. Bernard L. Cohen, "Concepts of Nuclear Physics", McGraw Hill, 2017
3. S.N. Ghoshal, "Nuclear Physics", S. Chand Publishing, 2019

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.

Programme/Class: **Degree**	Year: **Third**	Semester: **Sixth**
Subject: **Physics**		
Course Code: **B010602T**	Course Title: **Analog & Digital Principles & Applications**	

Course Outcomes (COs)

1. Study the drift and diffusion of charge carriers in a semiconductor.
2. Understand the Two-Port model of a transistor.
3. Study the working, properties and uses of FETs.
4. Comprehend the design and operations of SCRs and UJTs.
5. Understand various number systems and binary codes.
6. Familiarize with binary arithmetic.
7. Study the working and properties of various logic gates.
8. Comprehend the design of combinational and sequential circuits.

Credits: **4**	Core Compulsory / Elective
Max. Marks: **25+75**	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**

Unit	Topics	No. of Lectures
	PART A **Analog Electronic Circuits**	
I	**Semiconductor Junction** Expressions for Fermi energy, Electron density in conduction band, Hole density in valence band, Drift of charge carriers (mobility & conductivity), Diffusion of charge carries and Life time of charge carries in a semiconductor. Work function in metals and semiconductors. Expressions for Barrier potential, Barrier width and Junction capacitance (diffusion & transition) for depletion layer in a PN junction. Expressions for Current (diode equation) and Dynamic resistance for PN junction.	9
II	**Transistor Modeling** Transistor as Two-Port Network. Notation for dc & ac components of voltage & current. Quantitative discussion of Z, Y & h parameters and their equivalent two-generator model circuits. h-parameters for CB, CE & CC configurations. Analysis of transistor amplifier using the hybrid equivalent model and estimation of Input Impedance, Output Impedance and Gain (current, voltage & power).	8
III	**Field Effect Transistors** JFET: Construction (N channel & P channel); Configuration (CS, CD & CG); Operation in different regions (Ohmic or Linear, Saturated or Active or Pinch off & Break down); Important Terms (Shorted Gate Drain Current, Pinch Off Voltage & Gate Source Cut-Off Voltage); Expression for Drain Current (Shockley equation); Characteristics (Drain & Transfer); Parameters (Drain Resistance, Mutual Conductance or Transconductance & Amplification Factor); Biasing w.r.t. CS configuration (Self Bias & Voltage Divider Bias); Amplifiers (CS & CD or Source Follower); Comparison (N & P channels and BJTs & JFETs). MOSFET: Construction and Working of DE-MOSFET (N channel & P channel) and E-MOSFET (N channel & P channel); Characteristics (Drain & Transfer) of DE-MOSFET and E-MOSFET; Comparison of JFFET and MOSFET.	8

IV	**Other Devices** SCR: Construction; Equivalent Circuits (Two Diodes, Two Transistors & One Diode-One Transistor); Working (Off state & On state); Characteristics; Applications (Static switch, Phase control system & Battery charger). UJT: Construction; Equivalent Circuit; Working (Cutoff, Negative Resistance & Saturation regions); Characteristics (Peak & Valley points); Applications (Trigger circuits, Relaxation oscillators & Sawtooth generators).	5
	PART B **Digital Electronics**	
V	**Number System** Number Systems: Binary, Octal, Decimal & Hexadecimal number systems and their inter conversion. Binary Codes: BCD, Excess-3 (XS3), Parity, Gray, ASCII & EBCDIC Codes and their advantages & disadvantages. Data representation.	6
VI	**Binary Arithmetic** Binary Addition, Decimal Subtraction using 9's & 10's complement, Binary Subtraction using 1's & 2's compliment, Multiplication and Division.	5
VII	**Logic Gates** Truth Table, Symbolic Representation and Properties of OR, AND, NOT, NOR, NAND, EX-OR & EX-NOR Gates. Implementation of OR, AND & NOT gates (realization using diodes & transistor). De Morgan's theorems. NOR & NAND gates as Universal Gates. Application of EX-OR & EX-NOR gates as pairty checker. Boolean Algebra. Karnaugh Map.	9
VIII	**Combinational & Sequential Circuits** Combinational Circuits: Half Adder, Full Adder, Parallel Adder, Half Substractor, Full Substractor. Data Processing Circuits: Multiplexer, Demultiplexer, Decoders & Encoders. Sequential Circuits: SR, JK & D Flip-Flops, Shift Register (transfer operation of Flip-Flops), and Asynchronous & Synchronous counters.	10

Suggested Readings

PART A

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e
5. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

PART B

1. D. Leach, A. Malvino, Goutam Saha, "Digital Principles and Applications", McGraw Hill, 2010, 7e
2. William H. Gothmann, "Digital Electronics: An Introduction to Theory and Practice", Prentice-Hall of India Private Limited, 1982, 2e
3. R.P. Jain, "Modern Digital Electronics", McGraw Hill, 2009, 4e

Books published in Hindi & Other Reference / Text Books may be suggested / added to this list by individual Universities.