M. Sc. PHYSICS SYLLABUS

P. G. DEPARTMENT OF PHYSICS

UDAYANATH AUTONOMOUS COLLEGE OF SCIENCE AND TECHNOLOGY

ADASPUR, CUTTACK-754011

Mark and Credit Distributions		
Semester	**Credit**	**Marks**
First	**28**	**400**
Second	**28**	**400**
Third	**36**	**600**
Fourth	**28**	**400**
Total	**120**	**1800**

P. G. Department of Physics

Choice Based Credit System

FIRST SEMESTER

Theory	**Credit Point**	**Teaching Hours**	**Marks**
PHY101: Classical Mechanics	6	60-65	100
PHY102: Mathematical Methods	6	60-65	100
PHY103: Quantum Mechanics-I	6	60-65	100
Practical			
PHY104: Computational Methods in Physics	10	150-180	100

SECOND SEMESTER

Theory	**Credit Point**	**Teaching Hours**	**Marks**
PHY201: Quantum Mechanics-II	6	60-65	100
PHY202: Basic Electronics	6	60-65	100
PHY203: Basic Solid State Physics	6	60-65	100
Practical			
PHY204: Modern Physics & Optics	10	150-180	100

THIRD SEMESTER

Theory	**Credit Point**	**Teaching Hours**	**Marks**
PHY301: Advanced Quantum Mechanics	6	60-65	100
PHY302: Statistical Mechanics	6	60-65	100
PHY303: Special Paper	6	60-65	100
Advanced Condensed Matter Physics-I			
Practical			
PHY304: Electronics	10	150-180	100
Dissertation			
PHY305: Project	8		200

FOURTH SEMESTER

Theory	**Credit Point**	**Teaching Hours**	**Marks**
PHY401: Basic Nuclear and Particle Physics	6	60-65	100
PHY402: Classical Electrodynamics	6	60-65	100
PHY403: Special Paper	6	60-65	100
Advanced Condensed Matter Physics-II			
Practical			
PHY404: Condensed Matter Physics	10	150-180	100

FIRST SEMESTER

PHY101

Classical Mechanics Full Marks-100

Unit-I-34 Marks

Mechanics of a System of Particles, Lagrangian Formulation, Velocity-Dependent Potentials and Dissipation Function, Symmetry and Conservation Theorems;Homogeneity and Isotropy of Space and Conservation of Linear and Angular Momentum, Homogeneity of Time and Conservation of Energy.

Hamiltonian Formulation:

Calculus of Variations, Hamilton's Principle and Euler-Lagrange's Equation, Extension of Hamilton's Principle to Nonholonomic Systems, Legendre Transformation and the Hamilton's Equations of Motion, Physical Significance of Hamiltonian, Derivation of Hamilton's Equations of Motion from a Variational Principle, Routh's Procedure, Δ-Variation, Principle of Least Action.

Unit-II-32 Marks

Canonical Transformations:

Canonical Transformation, Types of Generating Function, Conditions for Canonical Transformation, Integral Invariance of Poincare, Poisson Bracket, Poisson's Theorem, Lagrange Bracket, Poisson and Lagrange Brackets as Canonical Invariants, Infinitesimal Canonical Transformation and Conservation Theorems, Liouville's Theorem.

Hamilton Jacobi Theory:

Hamilton-Jacobi Equation for Hamilton's Principal Function, Harmonic Oscillator and Kepler Problem by Hamilton-Jacobi Method, Action-Angle Variables for Completely Separable System, Kepler Problem in Action-Angle Variables, Geometrical Optics and Wave Mechanism.

Unit-III-34 Marks

Small Oscillations:

Problem of Small Oscillations, Example of Two Coupled Oscillator, General Theory of Small Oscillations, Normal Coordinates and Normal Modes of Vibration, Free Vibrations of a Linear Triatomic Molecule.

Rigid Body Motion:

The Independent Co-ordinates of a Rigid Body, Orthogonal Transformations, The Euler's Angles. the Cayley-Klein Parameters, Euler's Theorems on the Motion of a Rigid Body, Infinitesimal Rotations, Rate of Change of a Vector, The Coriolis Force.

Rigid Body Dynamics:

Angular Momentum and Kinetic Energy of Motion about a Point. The Inertia Tensor and Moment of Inertia, Eigenvalues of Inertial Tensor and the Principal Axis Transformation. The Euler Equations of Motion, Torque-free Motion of a Rigid Body. The Heavy Symmetrical Top with One Point Fixed. Elementary Idea about Nonlinearity and Chaos.

Text Books:

Classical Mechanics	: H. Goldstein

Reference Books:

Mechanics	: Landau and Liftshitz
Analytical Mechanics	: L. Hand and J. Flinch
Classical Mechanics	: Corben & Stehle
Classical Dynamics	: Marion & Thornton
Classical Mechanics of Particles and Rigid Bodies	: Kiran Gupta

PHY102

Mathematical Methods of Physics Full Marks-100

Unit-I-34 Marks

Complex Variables:

Functions of Complex Variables, Cauchy's Condition of Analyticity, Cauchy's Ingetral Theorem, Cauchy's Integral Formula, Calculus of Residues, Cauchy's Residue Theorem, Evaluation of Definite Integrals.

Tensor Analysis and Differential Geometry:

Cartesian Tensors in Three-Space, Curves in Three Space and Frenet Formula, General Tensor Analysis, Covariant Derivative and Christoffel Symbol (Derivation not Required).

Unit-II-34 Marks

Special Functions:

Solutions of Bessel, Laguerre, Hypergeometric and Confluent Hypergeometric Equa-

tions by Generating Function Method and Their Properties. Green's Function, Properties, Soutions of Partial Differential Equations (Laplace, Wave and Heat Equations in 2D and 3D) by Green's Function Method.

Unit-III-32 Marks

Groups and Group Representations:

Definitions of Groups, Finite Groups, Examples from Solid State Physics, Sub-groups and Classes, Group Representations, Characters, Infinite Groups and Lie Groups, Irreducible Representation of SU(2), SU(3) and O(3).

Text Books:

Mathematical Methods of Physics	: J. Mathews & R. L. Walker
Mathematics for Physicists	: Dennery & Krzywicki
Mathematical Methods of Physics	: Arfken and Weber
Group Theory	: M. Hamermesh
Mathematics of Classical and Quantum Physics	: F. W. Byron and R. Fuller

Reference Books:

Methods of Theoritical Physics	: Morse and Feshbach Vol I, Vol II

PHY103

Quantum Mechanics-I Full Marks-100

Unit-I-32 Marks

General Principles of Q. M.:

Linear Vector Space Formulation : Linear Vector Space (LVS) and its Generality, Vectors - Scalar Product, Metric Space, Basis Vectors, Linear Independence, Linear Superposition of General Quantum States, Orthonormality of Basis Vector, Completeness, Schmidt's Orthonormalisation Procedure, Dual Space, Bra and Ket Vectors.
Operators - Linear, Adjoint, Hermitian, Unitary, Inverse, Antilinear Operators, Noncommutativity and Uncertainty Relation, Complete Set of Compatible Operators.
Simultaneous Measurement, Projection Operator, Eigenvalues and Eigenvectors of Linear, Hermitian, Unitary Operators, Matrix Representation of Vectors and Operators, Matrix Elements, Eigenvalue Equation and Expectation Values, Algebraic Result on Eigenvalues, Transformation of Basis Vectors, Similarity Transformation of Vector and

Operator Representation, Diagonalization.

Vectors of LVS as Wavefunctions in Coordinate, Momentum and Energy Representations.

Quantum Dynamics:

Time Evolution of Quantum States, Time Evolution Operator and its Properties, Schrodinger Picture, Heisenberg Picture, Interaction Picture, Equations of Motion, Symmetry Principles and Conservation Laws, Operator Method Solution of 1D Harmonic Oscillator, Matrix Representation and Time Evolution of Creation and Annihilation Operators, Density Matrix.

Unit-II-34 Marks

Rotation and Orbital Angular Momentum:

Rotation Matrix, Angular Momentum Operators as the Generators of Rotation, $\hat{L}_x$, $\hat{L}_y$, $\hat{L}_z$ and $\hat{L}^2$ and their Commutator Relations, Raising and Lowering Operators ($\hat{L}_+$ and $\hat{L}_-$), $\hat{L}_x, \hat{L}_y, \hat{L}_z$ and $\hat{L}^2$ in Spherical Polar Coordinates, Eigenvalues and Eigenfunctions of $\hat{L}_z, \hat{L}^2$ (Operator Method), Spherical Harmonics, Matrix Representation of $\hat{L}_+, \hat{L}_-$ and $\hat{L}^2$.

Spin Angular Momentum:

Spin 1/2 Particles, Pauli Spin Matrices and their Properties, Eigenvalues and Eigenfunctions, Spinor Transformation under Rotation.

Addition of Angular Momentum:

Total Angular Momentum $\hat{J}$, Eigenvalue Problem of $\hat{J}_z$ and $\hat{J}^2$, Angular Momentum Matrices, Addition of Angular Momenta and C. G. Co-efficients, Angular Momentum States for Composite Systems in the Angular Momenta (1/2, 1/2) and (1, 1/2).

Unit-III-34 Marks

Motion in Spherically Symmetric Field:

Hydrogen Atom, Reduction to Equivalent One Body Problem, Radial Equation, Energy Eigenvalues and Eigenfunctions, Degeneracy, Radial Probability Distribution, Atomic Spectra of One and Many Electron Systems, Free Particle Problem, Incoming and Outgoing Spherical Waves, Expansion of Plane Waves in terms of Spherical Waves, Continuum and Bound States of a 3D Square Well, Particle in a Sphere.

Text Books:

Quantum Physics	: S. Gasiorowicz
Quantum Mechanics	: L. I. Schiff
Modern Quantum Mechanics	: J. J. Sakurai
Quantum Mechanics	: E. Merzbacher
Quantum Mechanics	: A. Messiah, Vol I
Advanced Quantum Mechanics	: P. Roman
Quantum Mechanics	: R. Shankar
Quantum Mechanics	: A. Ghatak and S. Lokanathan
Quantum Mechanics	: S. N. Biswas

Reference Books:

Quantum Mechanics	: A. Das
Elementary Theory of Angular Momentum	: M. E. Rose
Principles of Quantum Mechanics	: P. A. M. Dirac
Quantum Mechanics(Non-relativistic theory)	: L. D. Landau and E. M. Lifshitz
Quantum Mechanics	: James Peebles

PHY104 (Practical Paper)

Computational Methods in Physics Full Marks-100

Preliminaries:

- Basic FORTRAN Statements like Comment, Read, Write, Format, Dimension, If-Then, GoTo, Compilation, Stop, End, Sub-programme etc.
- Arithmetic expressions and operations: Addition, Subtraction, Multiplication, Division; Logarithm and Exponential of a Number; Area of a Triangle; Volume of a Sphere
- Complex numbers: Addition, Subtraction, Multiplication and Division
- Trigonometric functions: Sine, Cosine and Tangent of an Angle
- Largest and Smallest of a Given Set of Numbers; Solution of Quadratic Equation
- Do loop, Nested Do loop: Sum of an AP Series, GP Series, Sine Series and Cosine Series; To Generate and Print First Hundred Prime Numbers; Factorial of a

Number; To Find the Sum of the Digits of a Number

- Matrix manipulation: Matrix Addition and Multiplication; Transpose of a Square Matrix
- Function statement
- Data Files: Open,Close,Read, Write

Numerical Methods:

- Solution of System of Linear Equations:
    1. Gauss Elimination
    2. Gauss – Seidel iteration
    3. Gauss-Jordan elimination
    4. Matrix elimination
- Eigenvalues and Eigenvectors of Matrices
- Lagrange Interpolation
- Richardson Extrapolation
- Integration:
    1. Trapezoidal Rule
    2. Simpson 1/3 Rule
    3. Romberg Method
- Differentiation
- Solution of Differential Equation:
    1. Runge-Kutta 4th Order
    2. Boundary Value Problem
    3. Higher Order Differential Equation
    4. Partial Differential Equation

- Solution of Algebraic Equation
    1. Newton- Raphson Method
    2. Bisection Method
- Mean and Standard Deviation of a Data Set
- Correlation Coefficient Determination for a Data Set
- Data Fitting:
    1. Straight Line Fit
    2. Polynomial Fit

Books:

Fortran 77 and Numerical Methods	: C. Xavier
Programming and Computing with FORTRAN 77/90 (Allied Publishers 1992)	: P. S. Grover
Computer Oriented Numerical Methods	: R. S. Salaria
Fundamentals of Computers (Prentice Hall, India)	: V. Rajaraman
FORTRAN 77 (Jaico Book, 1989)	: R. N. Reddy & C. A. Ziegler
Mathematica Book	: Wolfram
Numerical Analysis	: Johnson and Rees
Numerical Recipes	: Teukolsky and Press

SECOND SEMESTER

PHY201

Quantum Mechanics-II Full Marks-100

Unit-I-34 Marks

Approximation Methods for Stationary States:

Rayleigh Schrodinger Method for Time-Independent Perturbation Theory, First and Second Order Correction, Perturbed Harmonic Oscillator, Anharmonic Oscillator, The Stark Effect, Quadratic Stark Effect and Polarizability of Hydrogen Atom, Degenerate Perturbation Theory, Removal of Degeneracy, Parity Selection Rule, Linear Stark Effect of Hydrogen Atom, Spin-Orbit Coupling, Relativistic Correction, Fine Structure of Hydrogen like Atom, Normal and Anomalous Zeeman Effect, The Strong-Field Zeeman Effect, The Weak-Field Zeeman Effect and Lande's g-factor, Hyperfine Splitting.

Variational Methods:

Ground State of One-Dimensional Harmonic Oscillator and He-Atom, Hydrogen Molecular Ion, Rotational and Vibrational Spectra of Diatomic Molecules, Franck-Condon Principle, Raman Effect, NMR, ESR.

Unit-II-34 Marks

WKB Approximation Method:

General Formalism, Validity of WKB Approximation Method, Correction Formulas, Application to Bound States, Bohr Somerfield Quantization Rule, Application to Harmonic Oscillator, Tunneling through a Potential Barrier, Cold Emission, Alpha Decay and Geiger-Nuttal Relation.

Time Dependent Perturbation Theory:

Transition Probability, Constant and Harmonic Perturbation, Fermi's Golden Rule, Electric Dipole Radiation and Selection Rules. Spontaneous Emission, Einstein's A, B-Co-efficients, Basic Principle of LASER and MASER.

Unit-III-32 Marks

Scattering Theory:

High Energy Scattering : Scattering Amplitude and Cross Section, Born Approximation, Application to Coulomb and Screened Coulomb Potential. Low Energy Scattering :

Partial Wave Analysis for Elastic and Inelastic Scattering, Effective Range and Scattering Length, Optical Theorem, Black Disc Scattering, Hard Sphere Scattering, Resonance Scattering from a Square Well Potential.

Text Books:

Quantum Physics	: S. Gasiorowicz
Quantum Mechanics	: N. Zettili
Quantum Mechanics	: R. Shankar
Quantum Mechanics	: A. K. Ghatak and S. Lokanathan
Quantum Mechanics	: A. Das

Reference Books:

Quantum Mechanics	: E. Merzbacher
Quantum Mechanics	: S. N. Biswas
Quantum Mechanics	: L. I. Schiff
Quantum Mechanics	: A. Messiah, Vol I
Principles of Quantum Mechanics	: P. A. M. Dirac
Quantum Mechanics (Non-relativistic theory)	: Landau and Lifshitz
Modern Quantum Mechanics	: J. J. Sakurai
Advanced Quantum Mechanics	: P. Roman
Elementary Theory of Angular Momentum	: M. E. Rose

PHY202

Basic Electronics Full Marks-100

Unit-I-34 Marks

Review of Semiconductors and Devices:

Amplifiers:

Frequency Response of Linear Amplifier Pass Band, R. C. Frequency Response, Gain Band-width Product, Feedback Amplifiers, Effect of Negative Feedback, Bootstrapping the FET, Multistage Feedback, Stability in Amplifiers, Noise in Amplifiers.

Operational Amplifiers:

The Differential Amplifiers, Rejection of Common Mode Signals. The Operational Amplifier, Input and Output Impedances, Application of Operational Amplifiers, Unit Gain Buffer, Summing, Integrating and Differentiating Amplifiers, Comparators and Log-

arithmic Amplifiers.

Unit-II-34 Marks

Oscillator Circuits:

Feedback Criteria for Oscillation, Phase Shift, Wein Bridge Oscillator, Crystal Controlled Oscillator, Reflex Klystron Oscillator, Principle of Multivibrator.

Digital Circuits:

Logic Fundamentals, Boolean Theorem, Logic Gates - RTL, DTL and TTL Gates for NAND or NOR Circuits, CMOS Switches, RS Flip-flop, JK Flip-flops.

Unit-III-32 Marks

Radio Communication:

Ionosphere Propagation, Antennas of Different Types, Dipole and Hertzian Dipole Antenna, Superheterodyne Receiver (Block Diagram). Various Types of Optical Fibers and Optical Communications.

Test And Measuring Instruments:

Working Principle of CRO, Multimeter and Signal Generators.

Text Books:

Electronics Fundamentals and Application	: J. D. Ryder
Integrated Digital Electronics	: Millman and Halkias
Foundation of Electronics	: Chattopadhyay, Rakshit,
	: Saha and Purkait
Electronics and Solid State Physics	: Puri & Babbar

PHY203

Basic Solid State Physics Full Marks-100

Unit-I-32 Marks

Crystal Symmetry:

Point Groups and Space Groups.

Phonons and Lattice Vibration:

Vibrations of Monoatomic and Diatomic Lattice, Dispersion Relation, Optic and Acoustic Modes, Quantum of Lattice Vibration and Phonon, Phonon Momentum, In-

elastic Scattering of Neutrons and Photons by Phonons.

Thermal Properties of Insulators:

Lattice Heat Capacity, Debye & Einstein Model, Anharmonic Crystal Interactions, Thermal Conductivity and Thermal Expansion.

Unit-II-34 Marks

Free Electron Fermi Gas:

Density of States in One Dimension, Effect of Temperature of Fermi-Dirac Distribution, Free Electron Gas in Three Dimensions, Heat Capacity of Electron Gas, Electrical and Thermal Conductivity of Metals.

Band Theory:

Electrons in Periodic Potential, Bloch's Theorem, Cronig Penny Model, Origin of Band Gap, Effective Mass of Electron.

Unit-III-34 Marks

Semiconductors:

Intrinsic and Impurity Semiconductors, Band Gap, Intrinsic & Extrinsic Carrier Concentration, Law of Mass Action, Mobility in the Intrinsic Region, p-n Junction.

Superconductivity:

Experimental Survey, Meissner Effect, London Equation, Type-I and Type-II Superconductors, Thermodynamics of Superconductors, Energy Gap in Superconductors, Isotope Effect, Basic Concepts of Electron-Phonon Interaction and Cooper Pairing in BCS Theory, Landau Theory of Diamagnetism and Pauli Theory of Paramagnetism.

Text Books:

Introduction to Solid State Physics	: C. Kittel
Solid State Physics	: Ashcroft and Mermin
Principles of Condensed Matter Physics	: P. M. Chaikin and T. C. Lubensky
Quantum Theory of Solids	: C. Kittel

Reference Books:

Solid State Physics	: A. J. Dekker
Quantum Theory of Solid State	: J. Callaway
Solid State Physics	: O. E. Animaler
Theory of Solids	: Ziman

PHY204 (Practical Paper)

Modern Physics and Optics Full Marks-100

- Michelson Interferometer:
    1. Wavelength of Sodium Light
- Rydberg Constant Apparattus:
    1. To Estimate the Value of Rydberg Constant by Finding the Series Limit of Hydrogen
- Babinet's Compensator:
    1. Birefringence of Mica Sheet
- Laser Kit:
    1. Wavelength of Laser
    2. Spot Size of Laser
    3. Divergence of the Laser Beam
    4. Intensity Distribution Curve
    5. Particle Size of Lycopodium Powder
- Photocell:

1. Planck's Constant
2. Characteristics of Photocell

- Millikan's Oil Drop Experiment:
  1. Charge of the Electron
- G. M. Counter:
  1. Plateau Region Determination
  2. Absorption Coefficient of Given Foils
  3. Nuclear Counting Statistics
  4. Inverse Square Law Verification
  5. Short Half Life Determination
- Helmholtz Coil:
  1. Determination of Horizontal Component of Earth's Magnetic Field
- Thomson's Apparatus:
  1. Measurement of e/m of Electron
- Optical Fibre:
  1. Determination of Numerical Aperature of the Fibre
- Zeeman Effect Apparatus:
  1. Determination of Bohr Magneton

THIRD SEMESTER

PHY301

Advanced Quantum Mechanics Full Marks-100

Unit-I-34 Marks

Relativistic Quantum Mechanics:

Klein-Gordon Equation and its Drawbacks, Dirac Equation, Dirac Gamma Matrices and their Properties, Dirac Equation using Gamma Matrices, Non-relativistic Reduction of Dirac Equation, Magnetic Moment Term and g-Value of Electron, Darwin and Spin-Orbit Coupling Term, Free Particle Solutions of Dirac Equation for Zero and Nonzero Momentum and their Physical Interpretation, Energy and Spin Projection Operators.

Unit-II-34 Marks

Lorentz Transformations and Lorentz Group, Poincare Transformations and Poincare Group, Representations of Lorentz and Poincare Group, Lorentz Covariance of Dirac Equation, Space Reflection, Charge Conjugation and Time Reversal Symmetries, Bilinear Covariants, Gordon Decomposition and g-Value of Electron, Transition from Discrete to Continuous Systems, Fields, Lagrangian and Hamiltonian Formulations of Continuous Systems, Noether's Theorem; Symmetry and Conseravation Rules.

Unit-III-32 Marks

Quantization of Free Fields:

Second Quantization, Covariant Quantisation of Real and Complex Scalar Fields; Derivation of Hamiltonian, Momentum for the Systems, Normal Ordering, Fock Space of Number States, Charge of the Particles, Unequal-Time Commutators of Fields, Feynman Propagators Quantization of Dirac Fields: Basic Anticommutators of Creation and Annihilation Operators, Pauli Exclusion Principle, Derivation of Hamiltonian, Momentum and Angular Momentum of the System. Spin of Dirac Particles, Majorana Representation, Unequal-Time Anticommutators of the Fields and Feynman Propagators, Local U(1) Gauge Invariance of Dirac Lagrangian Density and Electromagnetic Interaction, Normal Ordering, Covariant Quantization of Electromagnetic Field, Lagrangian Density, Gauge Condition, Gupta-Bleuler Prescription, Photon Propagators.

Text Books:

Advanced Quantum Mechanics	: J. J. Sakurai
Relativistic Quantum Mechanics	: J. D. Bjorken and S. D. Drell
Relativistic Quantum Fields	: J. D. Bjorken and S. D. Drell
Quantum Field Theory	: F. Mandl and G. Shaw

Reference Books:

Quantum Field Theory	: C. Itzykson and J. Zuber
Quantum Field Theory	: M. E. Peskin and D. V. Schroeder
Quantum Field Theory	: L. H. Ryder
Quantum Field Theory	: S. Weinberg

PHY302

Statistical Physics Full Marks-100

Unit-I-32 Marks

Classical Statistical Mechanics:

Postulate of Classical Statistical Mechanics, Liouville's Theorem, Micro Canonical Ensemble, Derivation of Thermodynamics, Equipartition Theorem, Classical Ideal Gas, Gibb's Paradox.

Canonical Ensemble and Energy Fluctuation, Grand Fluctuation, Grand Canonical Ensemble and Density Fluctuation, Equivalence of Canonical and Grand Canonical Ensemble.

Unit-II-34 Marks

Quantum Statistical Mechanics:

The Density Matrix, Ensembles in Quantum Statistical Mechanics; Ideal Gas in Micro Canonical and Grand Canonical Ensembles; Equation of State for Ideal Fermi Gas, Theory of White Dwarf Stars, Ideal Bose Gas, Photons and Planck's Law, Phonons, Bose-Einstein Condensation.

Unit-III-34 Marks

Phase Transition:

Thermodynamic Description of Phase Transitions, Phase Transitions of Second Kind,

Discontinuity of Specific Heat, Change in Symmetry in a Phase Transition of Second Kind, Order Parameter, Landau Theory of Phase Transition, Ising Model: Definition of Ising Model, 1D Ising Model, Qualitative Ideas on Critical Pheneomena, Critical Indices and Scaling Hypothesis.

Text Books:

Statistical Mechanics	: K. Huang
Statistical Mechanics	: R. K. Pathria

Reference Books:

Elementary Statistical Physics	: C. Kittel
Statistical Mechanics	: F. Mohling
Statistical Mechanics	: Landau and Lifsitz
Physics Transitions & Critical Pheneomena	: H. E. Stanly
Thermal Physics	: C. Kittel
Fundamentals of Statistical & Thermal Physics	: F. Reif

PHY303
Special Paper

Advanced Condensed Matter Physics-I Full Marks-100

Unit-I-32 Marks

Lattice Vibrations:

Born-Oppenheimer Approximation, Hamiltonian for Lattice Vibrations in the Harmonic Approximation, Normal Modes of the System and Quantization of Lattice Vibrations - Phonons.

Energy Bands:

Wave Equation for an Electron in a Periodic Potential, Bloch Functions, Brillouin Zones, $\epsilon - k$ Diagram under Free Electron Approximation, Nearly Free Electron Approximation - Diffraction of Electrons by Lattice Planes and Opening of Gap in $\epsilon - k$ Diagram, Effective Mass of Electrons in Crystals, Holes, Tight Binding Approximation.

Unit-II-34 Marks

Fermi Surface:

Construction of Fermi Surface, Experimental Methods of Study of Fermi Surface, Cy-

clotron Resonance, de Hass van Alphen Effect.

Electron Interaction:

Perturbation Formulation, Dielectric Function of an Interacting Electron Gas (Lindhard's Expression), Static Screening, Screened Impurity, Kohn Effect, Friedel Oscillations and Sum Rule, Dielectric Constant of Semiconductor, Plasma Oscillations.

Unit-III-34 Marks

Transport Properties:

The Boltzmann Equation, Electrical Conductivity, General Transport Coefficients, Thermal Conductivity, Thermoelectric Effect, Hall Effect, Elementary Ideas on Quantum Hall Effect, Magnetoresistance, Elementary Ideas of Giant Magneto-Resistance and Colossal Magneto-Resistance.

Text Books:

Principles of the Theory of Solids	: J. M. Ziman
Introduction to Solid State Physics	: C. Kittel
Advanced Solid State Physics	: Philip Phillips

Reference Books:

Introduction to Modern Solid State Physics	: Yuri M. Galperin
Solid State Physics	: Aschroft, Mermin
Introduction to Solids	: Azaroff
Elementary Solid State Physics	: M. A. Omar
Principles of Condensed Matter Physics	: Chaikin and Lubensky
Solid State Physics, Essential Concepts	: David W. Snoke

PHY304 (Practical Paper)

Electronics Full Marks-100

- Transistor Characteristics:
  1. Germanium: PNP, NPN: CE, CB, CC
  2. Silicon: PNP, NPN: CE, CB, CC
- LCR Circuit:

1. Quality Factor
2. Resonance Curve

- Junction Diode Rectifier and Filter Characteristics:
  1. Half Wave Ripple Factor
  2. Full Wave Center Tap Ripple Factor
  3. Full Wave Bridge Ripple Factor
  4. Voltage Doubler Ripple Factor
  5. Capacitor Filter
  6. Capacitor Filter with Capacitor Value Doubled
  7. Inductor Filter
  8. Capacitor Input L-section Filter
  9. Capacitor Input Π-section Filter
- Hartley and Colpitt Oscillator:
  1. Operation of the Hartley Oscillator
  2. Operation of the Colpitt Oscillator
- Bipolar Junction Transistor Amplifier:
  1. Operation of Single-stage and Multi-stage RC-Coupled Amplifier
  2. To Calculate A_V, A_I, R_o and R_i of CE RC-Coupled Amplifier
  3. Frequency Response of RC-Coupled Amplifier
  4. Effect of Load Resistance and Source Resistance on Operation of an Amplifier
  5. To Calculate Current Gain and Input Impedance of Darlington Pair and β of a Transistor
  6. To Calculate the Voltage Gain of Darlington Pair Using Voltage Divider Biasing
- Applications of Operational Amplifier (OP-AMP):
  1. Inverting Amplifier

2. Non-inverting Amplifier
3. Buffer
4. Comparator
5. Adder
6. Subtractor
7. Square Wave Generator
8. Differentiator and Verify its Working as High Pass Filter
9. Integrator and Verify its Working as Low Pass Filter
10. Logarithmic Amplifier
11. Current Controlled Voltage Source (CCVS)
12. Voltage Controlled Current Source (VCCS)

- Modulation and Demodulation:

1. To Understand the Synchronization and Control Signals on ST2152 Techbook
2. Study the Switching Delay and its Control on ST2152 Techbook with Potentiometer
3. Study the Importance of Frame Synchronization Signal in Receiving the Correct Output at Correct Output Channel
4. Study of Extraction of Synchronization Pulses from the TDM Samples in Operating Mode 3
5. Study the Working of the Phase Lock Loop
6. Study of Complete TDM-PAM System and the Overall Effect of the Individual Parameter/Mode on the Communication System
7. Study the Working of a TDM-PAM Transmitter and Receiver at 3 Channel Communication Mode i.e. Mode 1
8. To Observe the Working of a TDM-PAM Transmitter and Receiver at 2 Link Communication Mode i.e. Mode 2
9. To Observe the Working of a TDM-PAM Transmitter and Receiver at 1 Channel Communication Mode i.e. Mode 3

- Flip-Flops:
    1. Study of R-S Flip-Flop
    2. Study of J-K Flip-Flop
    3. Study of D Flip-Flop
    4. Study of T Flip-Flop
- Universal Gates:
    1. To Design NOT Gate using NAND Gate
    2. To Design AND Gate using NAND Gate
    3. To Design OR Gate using NAND Gate
    4. To Design NOT Gate using NOR Gate
    5. To Design AND Gate using NOR Gate
    6. To Design OR Gate using NOR Gate
- Fabrication of Astable Multivibrator:
    1. To Assemble an Astable Multivibrator by using Two NPN Transistors and Study its Time Period

PHY305

Dissertation Project Full Marks-200

Topics Include:

General Theory of Relativity, Cosmology, Astroparticle Physics, High Energy Physics, Nano Science and Nano Technology, Materials Science, Nuclear Matter, Black Hole Physics, Accelerators Physics, Data Analysis and Computational Simulation.

Dissertation : 100 Marks,

Presentation and Viva : 100 Marks

FOURTH SEMESTER

PHY401

Basic Nuclear and Particle Physics Full Marks-100

Unit-I-32 Marks

Two Nucleon Problem:

Central and Noncentral Forces, Deuteron and its Magnetic Moment and Quadrupole Moment; Force Dependent on Isospin, Exchange Force, Charge Independence and Charge Symmetry of Nuclear Force, Mirror Nuclei.

Nuclear Models:

Gas Model, Liquid Drop Model, Bethe - Weisazcker Semi-Emperical Mass Formula, Fission, Magic Numbers, Shell Model, Shell Model Predictions for Angular Momentum, Magnetic Moments, Electric Quadrupole Moments of Nuclei, Existence of Excited States of Nuclei and Iomeric Nuclei.

Unit-II-34 Marks

Nuclear Reaction:

Energetics of Nuclear Reaction, Compound Nucleus Theory, Resonance Scattering, Breit - Wigner Formula, Alpha Decay, Fermi's Theory of Beta Decay, Selection Rule for Allowed Transition, Parity Violation.

Nuclear Structure:

Form Factor and Charge Distribution of the Nucleus, Hofstader Form Factor.

Unit-III-34 Marks

Particle Physics:

The Standard Model of Particle Physics, Particle Classification, Fermions and Bosons, Lepton Flavors, Quark Flavors, Electromagnetic, Weak and Strong Processes, Spin and Parity Determination of Pions, Isospin, Strangeness, Hypercharge, and Baryon Number, Lepton Number, Gellmann - Nishijima Scheme, Quarks in Hadrons: Meson and Baryon Octet, Elementary Ideas of SU(3) Symmetry, Charmonium, Charmed Mesons and B Mesons, Quark Spin and Colour.

Text Books:

Introduction to Nuclear Theory	: L. R. B. Elton
Nuclear Physics	: B. B. Roy and B. P. Nigam
Nuclear Physics	: K. S. Krane
Subatomic Physics	: Frauenfelder and Henley
Concepts of Particle Physics	: Gottfried and Weisskopf
Elementary Particle Physics	: D. J. Griffiths
Introduction to Nuclear Physics	: P. E. Hodgson & E. Gadioh
Structure Of The Nucleus	: Preston & Bhaduri
Introduction to High Energy Physics	: D. H. Perkins
Leptons and Quarks	: L. B. Okun
Quarks and Leptons	: F. Halzen & A. D. Martin

Reference Books:

Theoritical Nuclear Physics	: Blatt and Weisskopf
Introductory Nuclear Physics	: S. S. Mulong
Particle Physics	: R. Omnes

PHY402

Classical Electrodynamics Full Marks-100

Unit-I-32 Marks

Maxwell's Equations:

Maxwell's Equations in Free Space; Derivation, Magnetic Charge, Maxwell's Equations Inside Matter, Displacement Current, Vector and Scalar Potentials, Wave Equation for Potentials, Lorentz and Coulomb Gauge Conditions, Wave Equation for Electric and Magnetic Fields in Absence of Sources.

Covariant Formulation of Maxwell's Equations:

Lorentz Transformation, Scalars, Vectors and Tensors, Maxwell's Equations and Equations of Continuity in terms of A_μ and J_μ, Electromagnetic Field Tensor and its Dual, Covariant form of Maxwell's Equations, Lagrangian for a Charged Particle in Presence of External Electromagnetic Field and Maxwell's Equation as Euler-Lagrange Equations.

Unit-II-34 Marks

Plane Waves in Non - Conducting Media

Plane Waves in Non - Conducting Media, Velocity of Wave Propagation and Energy Flow, Linear, Circular and Elliptic Polarisation, Reflection and Refraction of Electromagnetic Waves at a Plane Interface between Dielectrics, Normal and Oblique Incidence, Total Internal Reflection and Polarisation by Reflection, Waves in Dispersive Media, Kramer - Kronig Relation.

Plane Waves in Conduction Media:

Plane Waves in Conduction Media, Reflection and Transmission at a Conducting Surface, Cylinderical Cavities and Wave Guides, Modes in Rectangular Wave Guide and Resonant Cavities.

Diffraction:

Kirchoff's Formulation of Diffraction by a Circular Aperature.

Unit-III-34 Marks

Green's Function Solution for Retarded Potential:

Green's Function Solution of Potential Form of Maxwell's Equations, Retarded and Advanced Green's Functions.

Multipole Radiation:

Potential, Fields and Radiation due to an Oscillating Electric Dipole, Radiation due to a Centre - fed Linear Antenna, Angular Distribution of Power Radiated, Rayleigh Scattering, Magnetic Dipole.

Radiation by Point Charge:

Lienard - Weichert Potential, Field due to a Point Charge, Angular Distribution of Radiation and Total Power Radiated by an Accelerated Charge, Larmor's Formula, Thomson's Scattering.

Text Books:

Classical Electrodynamics	: J. D. Jackson
Classical Theory of Fields	: Landau & Lifsitz
Introduction to Electrodynamics	: D. J. Griffiths
Principles of Optics	: M. Born and E. Wolf
Electricity and Magnetism	: Berkeley Physics Course, Vol 2, : E. M. Purcell
Foundations of Electromagnetic Theory	: Reitz, Milford & Christy
Electromagnetism: Principles and Applications	: Lorrain & Corson

PHY403
Special Paper

Advanced Condensed Matter Physics-II Full Marks-100

Unit-I-32 Marks

Magnetism:

Theories of Ferromagnetism, Weiss and Heisenberg Model - Conditions for Ferro- and Antiferro- Magnetic Order, Spin Waves and Magnons, Bloch's $T^{3/2}$ Law, Antiferromagnetic Order, Neel Temperature.

Diluted Magnetic Semiconductors:

Elementary Concepts.

Ferroelectricity:

Ferroelectric Crystals, Classification of Ferroelectric Crystals, Polarization Catastrophe, Soft Optical Phonons, Landau Theory of Phase Transition - Second and First Order Transition.

Multiferroics:

Elementary Concept.

Unit-II-34 Marks

Electronic and Lattice Defects:

Lattice Defects, Frenkel and Schottky Defects, Line Defects, Edge and Screw Dislocations - Burger's Vector, Plannar (Stacking) Faults - Twin Planes and Grain Boundaries, Color Centers - Mechanism of Coloration of a Solid, F - center, Other Color Centers.

Excitons:

Loosely Bound, Tightly Bound, Excitonic Waves, Electron - Hole Droplets.

Solids:

Amorphous Materials, Quasi - Crystals, Nanostructured Materials - Classification based on Spatial Extension (0-D, 1-D and 2-D), 0-D Nanostructures - Quantum Dots, Widening of Band Gap in Quantum Dots, 1-D Nanostructures - Quantum Wires, Tubes, Belts, 2-D Nanostructures - Quantum Wells - Superlattices.

Unit-III-34 Marks

Superconductivity:

Electron - Phonon Interaction, Second Quantization form of Hamiltonian for Electrons and Phonons in Interaction, Electron - Electron Interaction due to Virtual Phonon Exchange, Cooper Pairs and BCS Hamiltonian, Superconducting Ground State and the Gap Equation at T = 0 K.

Josephson Effect:

Macroscopic Quantum Mechanical Effect, DC Josephson Effect, Effect of Electric Field - AC/Inverse AC Josephson Effect, Effect of Magnetic Field, SQUID.

High T_c Superconductors:

Elementary Ideas.

Text Books:

Introduction to Solid State Physics	: C. Kittel
Quantum Theory of Solids	: C. Kittel
Text Book of Nanoscience and Nanotechnology	: B. S. Murty, P. Shankar,
	: B. Raj, B. B. Rath and J. Murday

Reference Books:

Introduction to Modern Solid State Physics	: Yuri M. Galperin
Introduction to Solids	: Azaroff
Elementary Solid State Physics	: Omar
Solid State Physics	: Aschroft & Mermin
Science of Engineering Materials and	: C. M. Srivastava & C. Srinivasan
Carbon Nanotubes	
Solid State Physics	: A. J. Dekkar
Solid State Physics	: R. L. Singhal
Low Dimensional Semiconductor Structures	: K. Bamam and D. Vvedensky
Semiconductor Quantum Dots	: L. Banyal and S. W. Koch
An Introduction to the Physics of	: J. H. Davies
Low Dimensional Semiconductors	
Introduction to Superconductors	: Ketterson
The Physics of Quasicrystals	: Eds. Steinhardt and Ostulond
Principles of Nanoscience and Nanotechnology	: Ed. H. S. Nalwa
(Vol.1-4)	
Solid State Physics	: S. O. Pillai
Introduction to Solid State Physics	: Arun Kumar
Solid State Physics	: Wahab
Solid State Physics and Electronics	: R. K. Puri, V. K. Babbar
Solid State Physics	: H. E. Hall
Fundamentals of Solid State Physics	: Saxena, Gupta, Saxena

PHY404 (Practical Paper)

Solid State Physics Full Marks-100

- Hall Effect Experiment:

1. Hall Coefficient
2. Carrier Density
3. Carrier Mobility

- Gouy's Method:
  1. Measurement of Susceptibility
- Digital Gaussmeter:
  1. Magnetic Field Measurement
- Electron Spin Resonance Spectrometer:
  1. Determination of Spin Gyromagnetic Ratio (g)
- Curie Temperature Kit:
  1. Determination of the Energy Loss in the Ferrite at Room Temperature
  2. Determination of Curie Temperature
- Composite Piezo-Electric Oscillator:
  1. Determination of Young's Modulus
- Lattice Dynamics Kit with Frequency Meter:
  1. Study of the Dispersion Relation for the Mono-atomic Lattice-Comparison with Theory
  2. Determination of the Cut-off Frequency of the Mono-atomic Lattice
  3. Study of the Dispersion Relation for the Di-atomic Lattice – 'Acoustical Mode' and 'Optical Mode' Energy Gap - Comparison with Theory
- Forbidden Energy Gap Kit:
  1. Forbidden Energy Band Gap
- Ultrasonic Interferometer for Solids:
  1. Ultrasonic Velocity in Solids

2. Temperature Variation of Ultrasonic Velocity

- Ultrasonic Interferometer for Liquids:

1. Ultrasonic Velocity in Liquids

- Four Probe Method:

1. Resistivity of semiconductor at different temperatures and determination of the band gap