UTKAL UNIVERSITY
NAAC-A+ Accredited

M.Sc. PHYSICS SYLLABUS
UTKAL UNIVERSITY,
VANI VIHAR,
BHUBANESWAR-751004
(CHOICE BASED CREDIT SYSTEM)
2020-21

<u>**M.Sc. Physics Syllabus (Utkal University)**</u>

P.G. Department of Physics
Choice Based Credit System

FIRST SEMESTER

A: Core Compulsory Papers

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

Total credit = 24, Total Mark = 400

SECOND SEMESTER

Theory	**Credit Point**	**Teaching Hours**	**Marks**
PHY201:Quantum Mechanics -II (Application to Atomic and Molecular Physics)	6	60-65	100
PHY202: Classical Electrodynamics	6	60-65	100
PHY203: Basic Condensed Matter Physics	6	60-65	100
Practical			
PHY204: Modern Physics and Optics/ Computational Methods in Physics	6	150-180	100

Total credit = 24, Total Mark = 400

THIRD SEMESTER

	Credit Point	**Teaching Hours**	**Marks**
PHY301: Advanced Quantum Mechanics	6	60-65	100
PHY302: Electronics (D: Free elective)	6	60-65	100
PHY303: a/b/c/d (B: Core Elective Papers-Theory)	6	60-65	100
PHY304: Electronics (Practical)	6	150-180	100
PHY305a: Dissertation/Project	4		100
PHY305b: Review of Literature	2		100

Topics include:

(i) General Theory of Relativity, (ii) Cosmology, (iii) Astroparticle Physics, (iv) High Energy Physics, (v) Nano Science and Nano Technology, (vi) Materials Science, (vii) Nuclear Matter, (viii) Black Hole Physics, (ix) Accelerators Physics, (x) Data Analysis and Computational Simulation.

Total credit = 30, Total Mark = 600

FOURTH SEMESTER

	Credit Point	Teaching Hours	Marks
PHY401: Basic Nuclear and Particle Physics	6	60-65	100
PHY402: Statistical Mechanics	6	60-65	100
PHY403 a/b/c/d (B: Core Elective Papers-Theory)	6	60-65	100
PHY404 a/b/c (B: Core Elective Papers-Practical)	6	150-180	100

Total credit = 24, Total Mark = 400

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Grand Total credit of 4 semesters = 102 ; Grand Total Mark = 1800

A: Core Compulsory Papers

1st Semester:

PHY101: Classical Mechanics;
PHY102: Mathematical Methods in Physics;
PHY103: Quantum Mechanics
PHY104: Modern Physics and Optics/ Computational Methods in Physics

2nd Semester:

PHY201: Quantum Mechanics-II(Application to Atomic and Molecular Physics),
PHY202: Classical Electrodynamics;
PHY203: Basic Condensed Matter Physics;
PHY204: Modern Physics and Optics/Computational Methods in Physics

3rd Semester:

PHY301: Advanced Quantum Mechanics;
PHY302: Electronics
PHY304: Electronics (Practical)

4th Semester:

PHY401: Basic Nuclear and Particle Physics;
PHY402: Statistical Mechanics;

B: Core Elective Papers

Theory	**Credit Point**	**Teaching Hours**	**Marks**
PHY303a: Advanced Particle Physics and Field Theory-I (3rd Sem)	6	60-65	100
PHY303b: Advanced Condensed Matter Physics- I (3rd Sem)	6	60-65	100
PHY303c: Advanced Nuclear Physics -I (3rd Sem)	6	60-65	100
PHY303d: Electronics & Instrumentation-I (3rd Sem)	6	60-65	100
PHY403a: Advanced Particle Physics and Field Theory-II (4th Sem)	6	60-65	100
PHY403b: Advanced Condensed Matter Physics –II (4th Sem)	6	60-65	100
PHY403c: Advanced Nuclear Physics -II (4th Sem)	6	60-65	100
PHY403d: Electronics & Instrumentation -II (4th Sem)	6	60-65	100

Practical

PHY404a: Particle and Nuclear Physics (4th Sem)	6	150-180	100
PHY404b: Condensed Matter Physics (4th Sem)	6	150-180	100
PHY404c: Electronics & Instrumentation (4th Sem)	6	150-180	100

C: Allied Elective Papers

Theory	Credit Point	Teaching Hours	Marks
PHY103 Quantum Mechanics-I	6	60-65	100
PHY104: Computational Methods in Physics	6	60-65	100
PHY203: Basic Condensed Matter Physics	6	60-65	100
PHY303a: Advanced Particle Physics and Field Theory-I	6	60-65	100
PHY303b: Advanced Condensed Matter Physics- I			

D: Free Elective Paper

Theory	Credit Point	Teaching Hours	Marks
PHY302: Electronics	6	60-65	100

* The **Core Compulsory Papers** given in "A" are compulsory for all the M.Sc. (Physics) students.

* M.Sc. (Physics) students have to choose one theory paper out of the core elective papers (Special Papers) in "B" during their 3rd Semester. They have to choose one theory and one practical paper out of the core elective papers (Special Papers) in "B" during their 4th Semester.

* M.Sc. (Physics) students have to choose one dissertation/project topic in 3rd Semester.

* Allied Elective Papers as given in 'C' can be chosen by M.Sc. students of Physics Department as well as allied departments.

* The free elective paper given in "D" can be taken by the M.Sc. Physics students in 4th Semester. Any other department students can also choose this paper.

Mark and Credit Distributions

Semester	*Credit*	*Marks*
1st	24	400
2nd	24	400
3rd	30	600
4th	24	400
Total	**102**	**1800**

M.Sc. Physics Syllabus (Utkal University)

FIRST SEMESTER

PHY101

Classical Mechanics **Full Mark-100**

Course Objectives:
Students will be able to:

- Know the physical concepts and familiar with classical mechanics and also its mathematical form.
- Solving problem of different systems using classical mechanics.
- To demonstrate the knowledge and understanding of the following fundamental concepts in:
  - The dynamics of system of particles,
  - Motion of rigid body,
  - Lagrangian and Hamiltonian formulation of mechanics
  - Transformations and Hamilton Jacobi theory
  - Small oscillation problems
- Develop equations of motion using Lagrangian and Hamiltonian formulation for complicated mechanical systems.

Unit- I- 34 Marks

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

Hamiltonian Formulation:

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

Unit- II- 32 Marks

Cononical 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 Invariant, Infinitesimal Canonical Transformation and Conservation Theorems, Liouville's Theorem.

Hamilton Jacobi Theory:

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

Unit- III- 34 Marks

Small Oscillation:

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 Tri-atomic Molecule.

Rigid Body Motion: The Independent of 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, Eigen values 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.

Books :

Text : Classical Mechanics – H. Goldstein
Ref : Mechanics – Landau and Liftshitz
Analytical Mechanics, L. Hand and J. Finch
Classical Mechanics – Corben & Stehle
Classical Dynamics – Marion & Thornton
Classical Mechanics - J. C. Upadhyaya

Course Outcomes:

- Understand the basic mechanical concepts related to discrete and continuous mechanical systems.
- Describe and understand planar and spatial motion of a rigid body and understand the motion of a mechanical system using Lagrange-Hamilton formalism.
- Demonstrate a working knowledge of classical mechanics and its application to standard problems such as central forces.

PHY102

Mathematical Methods in Physics — Full Mark-100

Course Objective:

- It will provide students with basic skills necessary for the application of mathematical methods in physics.
- Introduction of various existing mathematical methods in order to analyses theories, methods and interpretations.
- Develop understanding among the students how to use methods within his/her field of study of research and in the field of scientific knowledge to work independently.

Unit-I- 34 Marks

Complex Variables:

Cauchy's Integral 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, Riemann & Ricci tensor.

Unit II – 34 Marks

Special Functions:

Solutions of Bessel, Laguerre, Hypergeometric and Confluent Hypergeometric Equations by generating function method and their properties. Solutions of inhomogeneous Partial Differential Equations by Green's function method.

Unit III – 32 Marks

Groups and Group Representations:

Definition 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), SO(3,1).

Books :

Text : Mathematical Methods of Physics – J. Mathews & R. L. Walker;

Mathematics for Physicists – Dennery & Krzywicki;

Mathematical Methods for Physics – Arfken and Weber;

Group Theory – M. Hamermesh

Reference:

Methods of Theoretical Physics, Morse and Feshbach Vol-I, Vol-II.

Course Outcomes:

- Demonstrate the utility and limitations of a variety of powerful calculation techniques and to provide a deeper understanding of the mathematics and useful in theoretical physics.
- Understand elementary ideas in linear algebra, special functions and complex analysis.
- Will be able to apply these to solve problems in classical, statistical and quantum mechanics, electromagnetism as well as solid state physics.

PHY103

Quantum Mechanics-I 100 Marks

Course Objectives:

Students will be able to:

- Study postulates and formalism of quantum mechanics
- Study operator formulation of quantum mechanics
- Study time evolution of a state and operator and apply Schrodinger equation to 1D harmonic oscillator
- Study operator algebra of orbital angular momentum and spin angular momentum operator
- Study motion in spherical symmetric potential and apply Schrodinger equation to solve hydrogen atom

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, anti-linear operators, Noncommutativity and uncertainty relation, complete set of compatible operators, Simultaneous Measurement, Projection operator, Eigen values and eigen vectors of linear, Hermitian, unitary operators, Matrix representation of vectors and operators, matrix elements, eigen value equation and expectation values, algebraic result on eigen values, transformation of basis vectors, similarity transformation of vector and operator representation, diagonalisation.

Vectors of LVS and wave function 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, 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, L_x, L_y, L_z and L^2 and their commutator relations, Raising and lowering operators. (L_+ and L_-). L_x, L_y, L_z and L^2 in spherical polar coordinates, Eigen values and Eigen functions of L_z, L^2 (OP method) spherical harmonics, Matrix representation of L_+, L_- and L^2.

Spin Angular Momentum:

Spin $\frac{1}{2}$ particles, pauli spin matrices and their properties Eigenvalues and Eigen functions, Spinor transformation under rotation.

Addition of angular momentum :

Total angular momentum J. Eigen value problem of J_z and 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 eigen values and eigen functions, degeneracy, radial probability distribution. Free particle problem incoming and outgoing spherical waves, expansion of plane waves in terms of spherical waves, Bound states of a 3-D square well, particle in a sphere.

Text Books :

Quantum Physics – S. Gasiorowicz
Quantum Mechanics- L-I Schiff/ J.Sukurai/ E.Merzbacher/ 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

Ref. 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

Course Outcomes:

- State basic postulates of quantum mechanics
- Understand the Hermitian operators, projection operators, unitary operators etc.
- Solve Schrodinger equation of harmonic oscillator problem completely using operator method
- State addition of angular momentum theorems and spin angular momentum statistics
- Solve for the hydrogen atom using Schrodinger equation

PHY 104/204

Computational Methods in Physics Full Marks -100

(Practical Paper)

Course Objectives:

Students will be able to:

- To learn computer programming using FORTRAN 90 and C,
- To solve physics problems through different numerical techniques
- Use computer programming for simulation and data analysis

Unit-I-50 Marks

Introduction to computational physics, computer architecture overview, tools of computational physics, introduction to storage in computer memory, stored programme concepts, storage media, computer operating system, compilers, LINUX Commands, Machine representation, precision and errors. Introduction to Linux and Computer Programming Language, Introduction to Graphics.

Programming in FORTAN: Introduction to FORTRAN, Structure of a FORTRAN program, Input and output statements, Control statements, Arrays, Sub programs, Data Files, examples of writing FORTRAN-programming of computational methods.

Programming in C: Structure of C program, compilation, constants, variables & data types, initializing variables, arithmetic operators, data input and data output, control structures, decision making and looping statements, arrays, examples of writing C- programming of computational methods.

Numerical Techniques:
Interpolation, solution of algebraic equation, least-square curve fitting, linear algebra and matrix manipulations, inversion, eigenvectors and eigen values, numerical differentiation, numerical integration, Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods, random number generation.

Unit-II-50 Marks

Computer Programming:

A. Exercises for acquaintance:

1. Find the largest or smallest of a given set of numbers
2. Generate and print first hundred prime numbers
3. Sum of an AP series, GP series, Sine series, Cosine series
4. Factorial of a number
5. Transpose a square matrix
6. Matrix multiplication, addition
7. Trace of a matrix
8. Evaluation of log and exponentials
9. Solution of quadratic equation
10. Division of two complex numbers
11. Find the sum of the digits of a number

B. Numerical Analysis:

1. Interpolation by Lagrange method
2. Numerical solution of simple algebraic equation by Newton- Raphson method
3. Least Square fit using rational functions
4. Numerical integration: Trapezoidal method, Simpson's method, Romberg integration,
5. Gauss quadrature method
6. Eigen values and eigenvectors of a matrix
7. Solution of linear homogeneous equations
8. Matrix inversion.
9. Solution of ordinary differential equation by Runge-Kutta Method
10. Solution of Radioactive decay equation, Simple harmonic oscillator, Schrödinger equation

Books:

1. V. Rajaraman, Fundamentals of Computers (Prentice Hall, India).
2. C. Xavier, Fortran 77 and Numerical methods.
3. V. Rajaraman, Computer Programming in FORTRAN 90 and 95.
4. P.S. Grover, Programming and Computing with FORTRAN 77/90, (Allied Publishers)
5. Brain W. Kernighan and Dennis. M. Ritchie, The C Programming Language, New Delhi: Prentice-Hall of India.
6. Byron S. Gottfried. Schaum's outline of Theory and Problems of Programming with C, New Delhi: Tata McGraw-Hill.
7. A. Klein and A. Godunov, Introductory Computational Physics, Cambridge University Press .
8. An Introduction to Computational Physics, T. Pang, Cambridge University Press.

9. Computer Oriented Numerical Methods- R.S.Salaria.
10. Hildebrand, F. B., Introduction to Numerical Analysis, Tata McGraw-Hill.
11. E. Balagurusamy, Numerical Methods, New Delhi: Tata McGraw-Hill.
12. Numerical Recipes: The Art of Scientific Computing, by William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery.

Course Outcomes:

Students will be able to:

- Write computer programs using FORTRAN 90 and C
- Use different numerical methods to solve problems using computer programs.
- Simulate physical systems using Monte Carlo Method.

PHY 104/204

Modern Physics and Optics

Full Mark-100 (Practical Paper)

Course Objectives:

- To analyze various situations or phenomena associated with modern physics and optics physics using basic principles.
- This course will introduce the student to a broad range of physical phenomena involving optics, and modern physics.

Measurement of Rydberg constant
Babinet‟s compensator
Michelson Interferometer
Fabry-Perot Interferometers
onstant deviation spectroscope
e/m measurement by Braun tube
e/m measurement by Magnetron Valve Method
e/m measurement by Thomson Method
Magnetic field measurement by search coil
Ferroelectric transmission point by Dielectric Constant Measurement
Rectification by junction Diode using various filters
Characteristics of a Transistor
Dielectric constant of solid (wax) by Lecher Wire
Verification of Richardson‟s $T^{3/2}$ low
Determination of Planck’s constant by total Radiation Method
Determination of Planck’s constant by Reverse Photoelectric effect method
Hysteresis loop tracer
Determination of ‘e’ by Millikan’s oil drop experiment
Measurement of attenuation and phase shift of A.C. in L.C.R. net work
RF characteristics of coil
Study of power supply
Calibration of an oscilloscope
Stefan’s constant measurement
Existence of discrete energy level by Frank Hertz experiment.
M.Sc. Experiments developed by Indian Academy of Sciences

Course Outcomes:

Students will be able to:

- To verify experimentally some of the laws and principles associated with modern physics and optics.

SECOND SEMESTER

PHY201

Quantum Mechanics – II (Application to Atomic and Molecular Physics)

Full Marks –100

Unit-I- 34 Marks

Course Objectives:

Students will be able to:

- Understand the importance of perturbation theory in quantum mechanics
- Study time independent and time dependent perturbation theory and apply those to various physical problem
- Understand fine structure of hydrogen atom, Stark effect, Zeeman effect,
- Understand interaction of radiation with matter, selection rules
- Understand quantum mechanical description of scattering
- Understand variational principle and its application

Approximation Methods for Stationary States:

Rayleigh Schrodinger Method for Time-Independent Non-Degenerate 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 Anomalus Zeeman Effect, The Strong-Field Zeeman Effect, The Weak-Field Zeeman Effect and Lande"s g-factor.

Variational Methods:

Ground State, First Excited State and Second Excited State of One-Dimensional Harmonic Oscillator, Ground State of H-atom and He-atom, Hydrogen molecule, Hydrogen molecule ion, Rotational and Vibrational Degrees of Freedom.

UNIT II 34 Marks

WKB Approximation Method:

General Formalism, Validity of WKB Approximation Method, Connection Formulas, Bohr Somerfield Quantization Rule, Application to Harmonic Oscillator, Bound States for Potential Wells with One Rigid Wall and Two Rigid Walls, Tunneling Through a Potential Barrier, Cold Emission, Alpha Decay and Geiger-Nuttal relation.

Time Dependant Perturbation Theory:

Transition Probability, Constant and Harmonic Perturbation, Fermi Golden Rule, Interaction of one electron atoms with electromagnetic radiation, Basic Principles of Laser and Maser. Electric Dipole Radiation and Selection rules. Spontaneous Emission Einstein"s A, B-Co-efficients, radiation, Quantum description of spontaneous emission.

UNIT III 32 Marks

Scattering Theory:

Scattering amplitude and differential cross Section, Relation between Lab and CM cross sections, Born Approximation. Application to Coulomb and Screened Coulomb Potential,.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, Scattering of identical particles.

Course Outcomes:

Students will be able to:

- Derive energy and wave function for physical system using time independent perturbation theory
- Derive transition probability under time dependent perturbation theory
- Explain Stark effect, origin of polarizability and dipole moment, fine structure of hydrogen atom and Zeeman effect
- Understand the dipole selections rules in various atomic transitions
- Solve the scattering cross-section for various scattering process such as black sphere scattering, hard sphere scattering and inelastic scattering
- Apply variational principle to find out the ground state energy of the various physical system

Text Books:

Quantum Physics - S. Gasiorowicz.
Quantum Mechanics- N. Zettili
Quantum Mechanics- B.H. Bransden, C.J. Joachain
Quantum Mechanics - R. Shankar
Quantum Mechanics - A. K. Ghatak and S. Lokanathan
Quantum Mechanics- A. Das

Reference Books :

Introductory Quantum Mechanics- R.
Liboff Quantum Mechanics- E.
Merzbacher Quantum Mechanics - S. N.
Biswas Quantum Mechanics - L.I.
Schiff
Quantum Mechanics vol I - A.Messiah
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 Theoryof Angular Momentum - M.E. Rose

PHY 202

## Classical Electrodynamics		Full Marks -100

Course Objectives:

Students will be able to:

- Study the Maxwell's wave equation in different dielectric media and free space
- Understand vector and scalar potential and their importance in electromagnetics
- Study electromagnetic energy transport and Poynting vector
- Understand Lorentz and Coulomb gauge conditions, covariant form of Maxwell's equation.
- Study laws of geometrical optics using Maxwell's equation
- Study Kramer Kronig relation on reflection and absorption of electromagnetic wave
- Study and understand propagation of electromagnetic waves in different types of waveguides.
- Study of retarded potential and solving it by Green's Function techniques for different types of charge distributions
- Study electric, magnetic dipole and quadrupole radiation
- Study electromagnetic radiation due to moving point charge and accelerated charge

Unit. I-32 Marks

Maxwell's Equation: Maxwell‟s equations in free space; Magnetic charge; Maxwell‟s equations inside matter; Displacement current; Vector and scalars 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 Equation:

Lorentz transformation; Scalars, vectors and Tensors; Maxwells 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; Cylindrical cavities and wave guides; Modes in rectangular wave guide and resonant cavities.

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 and Electric Quadrupole radiation.

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.

Course Outcomes:
Students will be able to:

- Demonstrate and analyze Maxwell's wave equation in different media
- Derive scalar and vector potential in presence of different sources
- Derive the Poynting theorem
- Apply Gauge invariance condition to Maxwell's equation
- Derive Maxwell's equation in co-variant form
- Derive covariant form of Maxwell's equations
- Derive relation between reflection coefficient and absorption coefficient
- Calculate different modes of electromagnetic waves in waveguides
- Calculate angular distribution of radiation and power emitted by dipole
- Show that accelerating charge produce electromagnetic radiation

Books:
Text Books:
Classical Electrodynamics - J. D. Jackson
Reference Books:
Classical Theory of Fields - L.Landau & Lifsitz
Introduction to Electrodynamics - D.J.Griffiths.
Principles of Optics-M.Born and E. Wolf
Introduction to Electrodynamics- Capri and Panat

PHY203

Basic Condensed Matter Physics **Full Marks –100**

Course Objectives:
Students will be able to:

- Know the diffraction condition in reciprocal space
- Understand the crystal bonding types in solid
- Understand the specific heat of solid and metals
- Know Kramer Kronig-penny model of electron ion interaction.
- Know the properties of semiconductor materials
- Know the properties of superconductor and high Tc superconductor

Unit-I-32 Marks

Diffraction of electromagnetic waves by crystals: X-rays, Electrons and Neutrons, Symmetry operations and classification of Bravais lattices, common crystal structures, reciprocal lattice, space groups, translational symmetry of crystals, symmetry operations in space groups, Brillouin zone, X-ray diffraction, Bragg's law, Von Laue's formulation, diffraction from non-crystalline systems. Geometrical factors of SC, FCC, BCC and diamond lattices; Basis of quasi crystals.

Crystal Binding: Bond classifications – types of crystal binding, covalent, molecular and ionic crystals, London theory of van der Waals, hydrogen bonding, cohesive and Madelung energy.

Unit II-34 Marks

Lattice Dynamics: Failure of the static lattice model, adiabatic and harmonic approximation, vibrations of linear monatomic lattice, one-dimensional lattice with basis, models of three-dimensional lattices, quantization of lattice vibrations, Einstein and Debye theories of specific heat, Specific heat of metal, phonon density of states, neutron scattering.

Band theory of Solids: Periodic potential and Bloch's theorem, Kronig Penney model, weak potential approximation, density of states in different dimensions, energy gaps, Fermi surface and Brillouin zones. Origin of energy bands and band gaps, effective mass, tight-binding approximation and calculation of simple band-structures. Motion of electrons in lattices, Wave packets of Bloch electrons, semi-classical equations of motion, motion in static electric and magnetic fields, theory of holes, cyclotron resonance.

Unit-III-34 Marks

Semiconductors:

Intrinsic and impurity semiconductors, band gap, law of mass action, intrinsic carrier concentration, mobility in the intrinsic region, p-n junction rectification.

Superconductivity:

Phenomenology, review of basic properties, Meissner effect, Type-I and Type-II superconductors, thermodynamics of superconductors, London's phenomenological theory, flux quantization, Copper instability, BCS theory of superconductivity, Superconducting ground state and gap equation at T= 0K. Josephson effects, Ginzburg- Landau theory, SQUID, High Tc superconductors: Elementary ideas.

Course Outcomes:

- Understand the difference in direct space and Reciprocal lattice space
- Understand the mode of vibrations and Dispersion relation
- Derive Specific heat equation for the metal and insulator
- Derive the Law of mass action relation for the semiconductor material
- Understands the Cooper pair and energy gap in Superconductor

Textbooks:

1. C. Kittel, Introduction to Solid State Physics, Wiley.
2. N. W. Ashcroft and N.D. Mermin, Solid State Physics, Brooks/Cole.
3. J. M. Ziman, Principles of the Theory of Solids, Cambridge University Press.
4. A. J. Dekker, Solid State Physics, Macmillan.
5. Superconductivity by V. L. Ginzburg and E. A. Andryushin (World Scientific, 1994)
6. Introduction to Superconductivity and high-Tc materials by Michel Cyrot and Davor Pavuna, (World Scientific, 1992).
7. Fundamentals of Crystallography, C. Giacovazzo, H. L. Monaco, D. Viterbo, F. scordari, G. Gilli, G. Zanotti, M. Cattl (Oxford University Press).

Reference books:

1. G. Burns, Solid State Physics, Academic Press.

2. M. P . Marder, Condensed Matter Physics, Wiley.
3. P. M. Chaikin and T. C. Lubensky, Principles of Condensed Matter Physics, Cambridge University Press.
4. M. Tinkham, Introduction to Superconductivity, CBS
5. T. Inui, Y. Tanabe and Y. Onodera, Group Theory and Its Applications in Physics (Springer Series in Solid-State Sciences).

PHY 104/204

Modern Physics and Optics **Full Mark-100**

(Practical Paper)

Course Objectives:

- To analyze various situations or phenomena associated with modern physics and optics physics using basic principles.
- This course will introduce the student to a broad range of physical phenomena involving optics, and modern physics.

Measurement of Rydberg constant
Babinet"s compensator
Constant deviation spectroscope
e/m measurement by Braun tube
e/m measurement by Magnetron Valve Method
e/m measurement by Thomson Method
Magnetic field measurement by search coil
Ferroelectric transmission point by Dielectric Constant
Measurement Rectification by junction Diode using various filters
Characteristics of a Transistor
Dielectric constant of solid (wax) by Lecher Wire
Verification of Richardson"s $T^{3/2}$ low
Determination of Planck's constant by total Radiation Method
Determination of Planck's constant by Reverse Photoelectric effect method
Hysteresis loop tracer
Determination of 'e' by Millikan's oil drop experiment
Measurement of attenuation and phase shift of A.C. in L.C.R. net work
RF characteristics of coil
Study of power supply
Calibration of an oscilloscope
Stefan's constant measurement
Existence of discrete energy levels by Frank Hertz experiment.
M.Sc. Experiments developed by Indian Academy of Sciences.

Course Outcomes:

Students will be able to:

- To verify experimentally some of the laws and principles associated with modern physics and optics.

PHY 104/204

Computational Methods in Physics Full Marks -100

(Practical Paper)

Unit-I-50 Marks

Course Objectives:
Students will be able to:

- To learn computer programming using FORTRAN 90 and C,
- To solve physics problems through different numerical techniques
- Use computer programming for simulation and data analysis

Introduction to computational physics, computer architecture overview, tools of computational physics, introduction to storage in computer memory, stored programme concepts, storage media, computer operating system, compilers, LINUX Commands, Machine representation, precision and errors. Introduction to Linux and Computer Programming Language, Introduction to Graphics.

Programming in FORTAN: Introduction to FORTRAN, Structure of a FORTRAN program, Input and output statements, Control statements, Arrays, Sub programs, Data Files, examples of writing FORTRAN-programming of computational methods.

Programming in C: Structure of C program, compilation, constants, variables & data types, initializing variables, arithmetic operators, data input and data output, control structures, decision making and looping statements, arrays, examples of writing C- programming of computational methods.

Numerical Techniques:
Interpolation, solution of algebraic equation, least-square curve fitting, linear algebra and matrix manipulations, inversion, eigenvectors and eigenvalues, numerical differentiation, numerical integration, Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods, random number generation.

Unit-II-50 Marks

Computer Programming:

A. **Exercises for acquaintance:**
   1. Find the largest or smallest of a given set of numbers
   2. Generate and print first hundred prime numbers
   3. Sum of an AP series, GP series, Sine series, Cosine series
   4. Factorial of a number
   5. Transpose a square matrix
   6. Matrix multiplication, addition
   7. Trace of a matrix
   8. Evaluation of log and exponentials
   9. Solution of quadratic equation
   10. Division of two complex numbers
   11. Find the sum of the digits of a number

B. Numerical Analysis:

1. Interpolation by Lagrange method
2. Numerical solution of simple algebraic equation by Newton- Raphson method
3. Least Square fit using rational functions
4. Numerical integration: Trapezoidal method, Simpson's method, Romberg integration,
5. Gauss quadrature method
6. Eigenvalues and eigenvectors of a matrix
7. Solution of linear homogeneous equations
8. Matrix inversion.
9. Solution of ordinary differential equation by Runge-Kutta Method
10. Solution of Radioactive decay equation, Simple harmonic oscillator, Schrödinger equation

Books:

13. V. Rajaraman, Fundamentals of Computers (Prentice Hall, India).
14. C. Xavier, Fortran 77 and Numerical methods.
15. V. Rajaraman, Computer Programming in FORTRAN 90 and 95.
16. P.S. Grover, Programming and Computing with FORTRAN 77/90, (Allied Publishers)
17. Brain W. Kernighan and Dennis. M. Ritchie, The C Programming Language, New Delhi: Prentice-Hall of India.
18. Byron S. Gottfried. Schaum's outline of Theory and Problems of Programming with C, New Delhi: Tata McGraw-Hill.
19. A. Klein and A. Godunov, Introductory Computational Physics, Cambridge University Press .
20. An Introduction to Computational Physics, T. Pang, Cambridge University Press.
21. Computer Oriented Numerical Methods- R.S.Salaria.
22. Hildebrand, F. B., Introduction to Numerical Analysis, Tata McGraw-Hill.
23. E. Balagurusamy, Numerical Methods, New Delhi: Tata McGraw-Hill.
24. Numerical Recipes: The Art of Scientific Computing, by William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery.

Course Outcomes:

Students will be able to:

- Write computer programs using FORTRAN 90 and C
- Use different numerical methods to solve problems using computer programs.
- Simulate physical systems using Monte Carlo Method.

THIRD SEMESTER

PHY 301

Advanced Quantum Mechanics: Full Marks – 100

Course Objectives:

- Understand the importance Covariant form
- Understand Klein-Gordon equation, Dirac equation in relativistic quantum mechanics
- Understand Lagrangian and Hamiltonian Formulations, Noether's theorem
- Understand Quantization of free fields

Unit-I- 34 Mark

Relativistic Quantum Mechanics:

Klein-Gordon equation and its drawbacks, Dirac equation, Properties of Dirac matrices, Non-relativistic reduction of Dirac equation, magnetic moment, Darwins term, Spin-Orbit coupling, Poincare transformation, Lorentz group, Covariant form of Dirac equation, Bilinear covariants, Gordon decomposition.

Unit-II –34 Marks

Free particle solution of Dirac equation, Projection operators for energy and spin, Physical interpretation of free particle solution, Zitter bewegung, Hole theory, Charge conjugation, space reflection and time reversal symmetries of Dirac equation. Continuous systems and fields. Transition from discrete to continuous systems, Lagrangian and Hamiltonian Formulations, Noether's theorem.

Unit-III -32 Marks

Quantization of free fields:

Second quantization, Equal Time Commutators, Normal Ordering, covariant quantization of electromagnetic field, Quantization of scalar, e.m, and Dirac fields, Propagators for scalar, spinor and vector fields.

Textbooks:
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

Course Outcomes:

Students will have achieved the ability to:

- Explain the relativistic quantum mechanical equations, namely, Klein-Gordon equation and Dirac equation.
- Describe second quantization and related concepts.

PHY 302

Electronics — Full Marks – 100

Course Objectives:

- Understand Different type of Amplifiers using Hybrid parameters
- Understand operational principle, model and analysis of various operational amplifiers
- Understand operation model and analysis of various oscillators
- Understand the working, model and analysis of various digital circuits
- Understand model and analysis of radio communication and antenna
- Understand working principles of fiber optics

Unit I: 34 Marks

Amplifiers:
Frequency response of linear amplifiers, amplifier pass band, R.C, L.C. and transformer coupled amplifiers, Frequency response, gain band-width product, Feedback amplifiers, effects of negative feedback, Boot-strapping 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 logarithmic amplifiers.

Unit II: 34 Marks

Oscillator Circuits:
Feedback criteria for oscillation, phase shift, Wien bridge oscillator, crystal controlled oscillator, klystron oscillator, Principle of multivibrator.

Digital Circuits:

Logic fundamentals, Boolean theorem, Logic gates – RTL, DTL and TTL gates, CMS switches, RS flip-flop, JK flip-flops, Master-slave J-K Flip flop, shift- registers, Asynchronous counters, Divide by N Counter Decade ripple counter Synchronous counter, application of counters.

Unit III: 32 Marks

Radio Communication:
Ionospheric propagation, Antennas of different types, super heterodyne, receiver (Block diagram). Various types of optical fibers and optical communications.

Books :

Electronic Fundamental and application – J.D. Ryder Int. Digital Electronics – Heap and Martin
Integrated Electronics – Millman and Halkias
Foundation of Electronics – Chattopadhyay, Rakshit, Saha and Purkalt

Course Outcomes:
- Explain frequency response of linear amplifiers, feedback amplifier
- Explain and design differential amplifier, sum and integrator etc
- Explain feedback criteria for oscillation, crystal-controlled oscillator, Klystron oscillator, principle of multivibrator
- Explain basic logic operations of NOT, AND, OR, NAND, NOR, XOR and flip-flops
- Explain basic principles of radio communications and antennas
- Explain basic principles optical fibers and electromagnetic wave propagation in optical fiber

PHY 303a

Advanced Particle Physics - I Full mark-100

Course Objectives:
- Understand Isospin, Strangeness and Hypercharge, Lepton and Baryon number
- Understand CPT theorem
- Understand Unitary Symmetry and the classification of state, Hadrons and SU (3) multiplets
- Understand the Feynman diagrams in configuration and momentum space
- QED Lagrangian and gauge invariance

Unit- I – 32 Marks

Two nucleon state vectors, Isospin, Strangeness and Hypercharge, Lepton and Baryon number conservation, Yukawa's theory, Neutrinos, Parity, Parity conservation and nonconservation, Time reversal, Consequences of time reversal invariance, Charge conjugation, G-parity, Statement of CPT theorem and its consequences, Proof of equality of mass and life time for particle and anti particle.

Unit- II – 34 Marks

Unitary Symmetry and the classification of state, Hadrons and SU (3) multiplets, properties of representations, Young-Tableux method for direct products of representations, Applications of SU(3) flavour symmetry and of broken SU(3) flavour symmetry, Gell-Mann- Okubo mass formula for Baryons and Mesons, Coleman-Glashow relation, Quarks and Gluons, Colour hypothesis, Evidence of colour, Magnetic moment of baryons, Baryon wave functions.

Unit- III – 34 Marks

Quantum Electrodynamics (QED) :

The S-matrix expansion, Time ordered product, Normal ordered product, Wick's theorem, Feynman diagrams in configuration and momentum space, First order terms in S-matrix, Compton scattering, Electron electron scattering, closed loop, Feynman rules for QED, QED Lagrangian and gauge invariance.

Course Outcomes:

- Understand the meaning and importance of the terms: quark, lepton and boson propagators, Feynman diagrams, quantum numbers, charge, colour, weak charge, flavour, symmetries and conservation laws.
- Demonstrate the Isospin, Strangeness and Hypercharge, Lepton and Baryon number
- Derive the CPT theorem and their applications
- Demonstrate the Unitary Symmetry and the classification of state, Hadrons and SU (3) multiplets
- Derive the Feynman diagrams in configuration and momentum space
- QED Lagrangian and gauge invariance

Text Books :

Introduction of High Energy Physiccs- D.H. Perkins
Elementary Particle Physics- D.J.Griffiths
Elementary Particles- I.J. Hughes
Quantum Field Theory – F. Mandl and G.Shaw

Reference Books:

Modern Elementary particle Pjhysics (Addison Wesley) - G. Kane
Concept of Particle Physics - V. Weisskopf G.K. Gottfried
Quarks & Leptons - F. Halzen & A.D. Martin
Quantum Field Theory - Itzyksen and Zuber
Quantum Field Theory – M. E. Peskin and D. V. Shroeder
Quantum Field Theory – L. H. Ryder

PHY 303b
Advanced Condensed Matter Physics-I Full mark-100

Course Objectives:

- Understand Born Oppenheimer approximation
- Understand the Normal mode of vibrations
- Understand the electron-phonon interaction and second quantization
- Understand Energy gap in solid
- Experimental method for the Fermi surface study
- Understand the electron-electron interaction
- Understand the Transport properties

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.

Electron-phonon interaction, Second quantized form of Hamiltonian for electrons and phonons in interaction.

Energy Bands:

Wave equation for an electron in a periodic potential, Bloch functions, Brillouin zones, E-k diagram under free electron approximation, Nearly free electron approximation - Diffraction of electrons by lattice planes and opening of gap in E-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, Cyclotron Resonance, de Hass van Alphen effect.

Electron Interaction:
Perturbation formulation, Hartree Equation, Hatree-Fock Equation, Dielectric function of an interacting electron gas (Lindhard‟s expression), Static screening, Thomas-Fermi theory of 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 on Giant magneto-resistance and Colossal magnetoresistance.

Course Outcomes:

- Explain the significance and value of condensed matter physics, both scientifically and in the wider community.
- The subject treats materials from an experimental viewpoint, solid state theory and properties.
- Understanding of the interplay between classical – and quantum mechanical phenomena, in condensed matter physics.
- Demonstrate the electron-phonon interaction and second quantization

- Understand electron –ion interaction for energy gap in solid
- Understand the Transport properties

Text Books

1. J. M. Ziman, Principles of the Theory of Solids, Cambridge University Press
2. Advanced Solid State Physics – Philip Phillips, Overseas Press, India Pvt. Ltd.
3. N. W. Ashcroft and N.D. Mermin, Solid State Physics, Brooks/Cole.
4. C. Kittel, Introduction to Solid State Physics, Wiley

Reference Books

Introduction to Modern Solid State Physics - Yuri M. Galperin
Solid State Physics - Aschroft, Mermin
Introduction to Solids - Azaroff
Elementary Solid State Physics - Omar
Principles of Condensed Matter Physics - Chaikin and Lubensky
Solid State Physics, Essential Concepts - David W. Snoke, Pearson Education, 2009

PHY 303c

Advanced Nuclear Physics-I Full mark-100

Course Objectives:

- Introduce students to the fundamental principles and concepts governing nuclear and particle physics
- To impart knowledge about nuclear deformations, properties and nuclear models for understanding of related reaction dynamics.
- Students will be exposed to heavy ion physics.

Unit-I – 34 Marks

Nuclear Momentum Theory : Rotational invariance in three dimensions Eigen values and eigen functions of angular momentum operator, explicit representation of rotation matrices, Addition of angular moments, Clebsch-Gordon, Racah and 3 j coefficients, irreducible spherical tensors, matrix elements of tensor operators, Wigner-Eckart theorem.

Unit-II – 32 Marks

Two Nucleon System:

Ground and excited states of the deuteron, Tensor forces and quadrupole moment of deuteron, Photo disintegration of the deuteron.

Unit-III – 34 Marks

Nuclear Models :

Shell model, analysis of shell predictions, extreme single particle model, configuration mixing individual practice model, L.S. and J.J. coupling schemes.

Course Outcomes:

- Explain the different forms of radioactivity and account for their occurrence
- Master relativistic kinematics for computations of the outcome of various reactions and decay processes.

- Account for the fission and fusion processes.
- Classify elementary particles according to their quantum numbers and draw simple reaction diagrams.

Books :

Nuclear Physics – R.R. Roy and B.P. Nigam (Wiley Eastern)
Elementary Theory of Angular Moemtum – M.E. Rose (John Wiley)
Introduction to Nuclear Physics- H. Enge (Addison Wesley)
Theoretical Nuclear Physics – Blatt J.M. & Weisskopf (Springer Verlag)

PHY 303d

Electronics and Instrumentation Full mark-100

Course Objectives:

- Explain basic concepts and definitions in measurement.
- Describe the bridge configurations and their applications.
- Elaborate discussion about the importance of signal generators and analyzers in Measurement

Unit-I – 32 Marks

Elemental and Compound Semiconductors :

Elementary idea about lattice mismatched pscudomorphic materials epitexy and epitexial growth, carrier effective mass and band structure, carrier scattering phonomena, conduction processes in semiconductors, Bulk and surface recombination, non-radiative and radiative recombinations, Shockley Read Hall theory of recombination, P-N junction theory, Schottky barriers and ohmic contect.

Varactor diode, PIN diode, Schottky barrier and backward diode.

Unit-II – 34 Marks

Gunn effect, Ridly-watkin-Hilsam Mechanism device configuration, Tunnel diodes, Phenomena, theory and device configuration, IMPATT diodes.

LED, Electroluminescent process, LED materials, Device configuration and efficiency, LED structures, Laser operating principles, semiconductor, structures and proper tics, Threshold current, Heterojuction Lasers, Photodetctors, Photoconductors, junction photo diodes, Avalanche photo diodes, solar cells, basic principles, spectral response, Heterojunction and cascaded solar cells, schottky barrier cells, material and design consideration. Thin film solar cells.

Unit- III- 34 Marks

Digital Circuits :

Simplification of digital circuits using Karnaugh maps, characteristics of logic families, Binary adder. Subtracting Flip-flops-RS, JK. Master slave, shift-registers, CMOS dynamic shift-registers, Asynchronous counters, Divide by N Councter Decade ripple counter Synchronous counter, application of counters.

Text Books :

1. Physics of Semiconductor Device – S.M. Sze, Wiley Eastern Limited, 1987
2. Electronic Fundamentals and Applications – J. D. Ryder, Prentice Hall of India
3. Intergrated Electronics – J. Milliman and C. C. Halkies, Mc graw Hill
4. Instrumentation Devices and Systems – C.S. Rangon, G.R. Sarma dn V.S.V. Mani Tata Mc Graw Hill
5. Digital Computer Electronics – A.P Malvino, Tata Mc Graw Hill, 1989

Reference Books :

1. Physics of Semiconductor Devices – S.M. Sze, Wiley Easter Limitted, 1987
2. Semiconductor Devices & Integrated Electronics – A.G. Mllnes, Van Nostrand Reinhold Company, 1980
3. Microprocessor Fundamental – R.L. Tekhenin, Mc Graw Hill, 1986
4. Electronic Instrumentation and Measurement Techniques – W D Cooper and A.D.Helfrick, Prentice Hall of India, 1989
5. Microwave propagation and techniques – D.C. Sarkar, S. Chand& Co.Ltd.1910.

Course Outcomes:

- Identify the various parameters that are measurable in electronic instrumentation.
- Employ appropriate instruments to measure given sets of parameters.
- Practice the construction of testing and measuring set up for electronic systems.
- Understanding about instrumentation concepts which can be applied to Control systems.
- Relate the usage of various instrumentation standards.

PHY 304

Electronics Practical Full Marks – 100

Course Objectives:

- To study basic electronic componenets
- To observe characteristics of electronic devices

1. Setting of a transistor amplifier and determination of the amplification factor at various frequencies
2. Frequency response of transister amplifier with the without feedback
3. Characterstics of Harteley oscillator
4. Determination of different parameters of transistor
5. Study of multivibrator – Astable
6. Study of multivibrator – Bistable
7. Study of multivibrator – Monostable
8. VSWR" in a microwave transmission line
9. Study of squarewave response of R.C. Network
10. Modulation of detection
11. Lock-in-amplifier
12. Design of operational amplifier circuit
13. Design of a field-effect transistor crystal oscillator
14. Study of different gates
15. Study of digital voltmeter and frequency counter.
16. M.Sc. Experiments developed by Indian Academy of Sciences

Course Outcomes:

- Measure voltage,frequency and phase of any waveform using CRO.
- Generate sine, square and triangular waveforms with required frequency and amplitude using function generator.
- Analyze the characteristics of different electronic devices such as diodes, transistors etc., and simple circuits like rectifiers, amplifiers, OPAM etc.,

PHY305a

Dissertation Project **Full mark-100**

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: 50 marks, Presentation and Viva: 50 marks

PHY305b

Review of Literature

Full mark-100

Topics include: Review of Research paper on**:** 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.

Report 50 marks, Presentation and Viva: 50 marks

FOURTH SEMESTER

PHY 401

Basic Nuclear and Particle Physics Full Marks – 100

Unit. I -32 Marks

Course Objectives:

- The students gather advanced knowledge in Nuclear physics.
- The different nuclear interactions and the corresponding nuclear potentials and its dependence on the couplings are learned.
- The knowledge helps to choose for an Advance course in Nuclear and particle Physics.

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:

Liquid drop model, fission, magic numbers, shell model, analysis of shell model predictions

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 rules for allowed transition, parity violation.

Nuclear Structure:

Form factor and charge distribution of the nucleus, Hofstadter 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, Isospin, strangeness, hypercharge, and baryon number, lepton number, Gell-Mann-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.S E

lton 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. Gadioli

Reference Books:

Theoritical Nuclear Physics - Blatt and Weisokoff Introductory Nucelar Physics:S.S.Wong

Particle Physics - R.Omnes

Course Outcomes:

- The course gives an understanding of the nucleus at low energy.
- The students develop basics to solve some of the problems of nuclear physics and their limitations in nature.

PHY402

Statistical Physics Full Marks – 100

Objectives:

- Understand postulates of classical and quantum statistical mechanics
- Study different formalism of statistical physics such as microstate, macrostate and ensembles
- Understand the Boltzmann and Gibb’s interpretation of entropy.
- Study Fermi-Dirac statistics and Bose-Einstein statistics
- Understand phase transitions and Ising model to study ferromagnetism

Unit-I-32 Marks

Classical Statistical Mechanics:

Postulate of classical statistical mechanics, Liouvill’s theorem, micro canonical ensemble, Derivation of thermodynamics, equipartition theorem, classical ideal gas, Gibb’s Paradox.

Canonical ensemble and energy 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 Plank'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. Ising model : Definition of Ising model, One Dimensional Ising model.

Text Book: 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 Phenomena – H.E. Stanly
Thermal Physics – C. Kittel
Fundamentals of Statistical & Thermal Physics – F. Reif

Outcomes:

- State postulates of classical and quantum statistical mechanics
- Differentiate between microstate and macrostate
- Tell the significance Gibb's paradox and indistinguishability in statistical mechanics
- Describe Planck's blackbody radiation relation, electronic specific heat in metals and Bose-Einstein condensation
- Describe thermodynamics of phase transition and formulate the Ising model of phase transitions for ferromagnetism.

PHY403a

Advanced Particle Physics -II   Full mark-100

Course Objectives:

- Introduce students to processes in lowest order
- To impart knowledge about Radiative Corrections
- Students will be exposed to different type of interactions.

Unit-I- 34 marks

QED processes in lowest order

Cross section, spin sums, photon polarization sums, Lepton-pair production in electron-positron collisions, Bhabha scattering, Compton Scattering, Scattering by an external field and Mott Scattering Formula, Bremsstrahlung

Radiative Corrections:

The second order radiative corrections of QED and Feynmann amplitudes involving Photon self energy, Electron self energy, Vertex modification, elementary ideas of charge and mass renormalizations

Unit-II-34 marks

Weak interaction:

Classification of weak interactions, Parity violation and V-A form of weak interaction, Calculations for the decay of Muon and decay of Pion , Elementary notions of leptonic decay of strange particles, The Cabibbo angle and Cabibbo hypothesis, Cabibbo-GIM Mechanism, Intermediate vector Boson, Neutral current.

Unit-III-32 marks

Electroweak Interactions:

Weak isospin and Hypercharge, The basic electroweak interaction, Spontaneous symmetry breaking of discrete symmetry and global gauge symmetry, Spontaneous symmetry breaking of local gauge symmetry and Higgs Mechanism, masses of W and Z bosons, SU(2) X U(1) invariant Standard model (Salam- Weinberg) Lagrangian

Text Books:

Quantum Field Theory - F. Mandl and G. Shaw
Introduction to High Energy Physics - D. H. Perkins (Cambridge U. Press)
Elementary Particles - I.J.Hughes
Elementary Particle Physics - D.J.Griffiths
Quarks and Leptons – F.Halzen and A.D. Martin

Reference Books:

Modern Elementary particle Physics - G.Kane (Addision Wesley)
Concept of Particle Physics - V.Weisskopf & K.Gottfried
Quantum Field Theory - Itzyksen and Zuber
Quantum Field Theory - M.Peskin and Schroeder(Addision Wesley)

Lectures on Quantum Field Theory – Ashok Das (World Scientific)

Outcomes:

- The students develop basics to solve some of the problems of nuclear physics and their limitations in nature.
- Students will be understand in details of different type of interactions

PHY403b

Advanced Condensed Matter Physics-II Full mark-100

Unit I: 32 Marks

Objectives:

- Understand different magnetic material and origin of magnetism
- Study different formalism of spin orientation and their equation at room and temp dependent
- Understand the Ferroelectric materials
- Study the types of defects in the materials
- Understand the optical and semiconductor properties of solid
-

Magnetism:

Diamagnetism, Paramagnetism of atoms with permanent magnetic moment, Pauli paramagnetism of conduction electrons, Weiss theory of ferromagnetism, Curie-Weiss Law for susceptibility, Heisenberg model- Condition for ferro and antiferro-magnetic order, Ising Model, Mean field theory, Spin waves and magnons, magnon contribution to specific heat, Bloch's $T^{3/2}$ Law, Antiferromagnetic order, Neel Temperature, Ferromagnetic domains, Magnetic anisotropy energy, hysteresis.

Ferroelectricity:

Ferroelectric crystals, Classification of ferroelectric crystals, Polarization catastrophe, Soft optical phonons, Landau theory of phase transition-second and first order transition.

Unit II: 34 Marks

Defects in Crystals:

Lattice defects, Frenkel and Schottky defects. Line defects, edge and screw dislocations – Burger‟s Vector, planner (stacking) faults-twin planes and grain boundaries, dislocation densities, dislocation multiplication and slip. strength of crystal, color centers. polarons and excitons.

Unit III:34 Marks

Optical properties of solids

The dielectric function: the dielectric function for a harmonic oscillator, dielectric losses of electrons, Kramers-Kronig relations, Interaction of phonons and electrons with photons, Interband transition - direct and indirect transition; Absorption in insulators; Polaritons; One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect.

Physics of Semiconductor:

Energy Band Structure, Occupation probabilities, Impurities and Imperfection in semiconductors, carrier concentration in thermal equilibrium, Electron Transport Phenomenon, Thermal Effects in Semiconductors, Excess Carrier in semiconductors, recombination, contact phenomenon, Scattering process in Semiconductors: Optical and high frequency effects in semiconductors.

Outcomes:

- State and Derive different mathematical form like the Curie –Weiss law for susceptibility
- Differentiate between magnetic and antiferromagnetic material
- Understant the Landau theory of phase transition
- Describe the Kramers-kronig relation for dielectric materials

Text Books

1. Magnetism in Condensed Matter: Stephen Bludell, Oxford University Press.
2. Magnetism and Magnetic Materials, J. M. D. Coey, *Cambridge University Press.*
3. Introduction to Magnetic Materials: B. D. Cullity, Wiley.

4. C. Kittel, Introduction to Solid State Physics, Wiley.
5. N. W. Ashcroft and N.D. Mermin, Solid State Physics, Brooks/Cole.
6. *J.M. Ziman, Principles of the Theory of Solids, Cambridge University Press*
7. R. A. Smith, *Semiconductors,* Academic Press (1978).
8. K. Seeger, *Semiconductor Physics*: *An introduction*, Springer Verlag (1991).
9. Physics of Semicondutor: S. M. Sze and K. K. Ng.

Reference Books

Introduction to Modern Solid State Physics byYuri M. Galperin
Introduction to Solids- Azroff
Elementary Solid State Physics- Omar
Solid State physics- Aschroff & Mermin
Science of Engineering Materials and carbon nanotubes, CM. Srivastava & C. Srinivasan
Solid state physics, A.J. Dekkar Macmillan, London
Solid state Physics, R.L.Singhal, Kedarnath and Ramnath Co.,Meerut.
Low Dimensional Semiconductor Structures, K. Bamam and D. Vvedensky (Cambridge University Book) 2001
Semiconductor Quantum Dots, L. Banyal and S.W. Koch (World Scientific) 1993
An introduction to the physics of low dimensional semiconductors, J.H. Davies (Cambridge Press) 1998.
Introduction to Superconductors – Ketterson
The Physics of quasicrystals, Eds. Steinhardt and Ostulond
Principles of Nanoscience and Nanotechnology, M.A. Shah and T. Ahmad
Handbook of Nanostructured materials and Nanotechnology (Vol.1-4) Ed. H.S. Nalwa
Solid State Physics: S.O. Pillai, New Age International Publishers, 2010
Introduction to Solid State Physics, Arun Kumar
Solid State Physics: Wahab M.A
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.

PHY403c

Advanced Nuclear Physics-II Full mark-100

Objectives:

- Understand rotational energy spectrum and nuclear wave function for even-even nuclei
- Understand Nuclear reaction
- Study the deuteron stripping and pick up reactions
- Understand the different Nuclear detector

Unit-I- 32 marks

Collective model, rotational energy spectrum and nuclear wave function for even-even nuclei, Energy spectrum and wave function for odd-A nuclei, Nuclear moments , Collective vibration excitation, Rotational Vibration coupling.

Unit-II- 34 marks

Nuclear Reactions:

Compound nucleus, statistical theory of nuclear reactions, evaporation probability and cross section for specific reactions, experimental results, optical model, Kapur-Reierls dispersion formula for potential scattering, Giant resonances, deuteron stripping and pick up reactions

Unit-III- 34 marks

Nuclear Detectors:

Ionisation Chambers, Semiconductor counters, Proportional counters, G.M.Counter, scintillation counter, Wilson expansion Chamber, Bubble Chamber, The nuclear emulsion, Neutron detection; time of flight technique, measurements based on recoil protons, Beta and electron spectrometers, acceleration of charged particles, Van-de-Graff generator, Linear accelerator, Cyclotron, synchrocyclotron

Books:

Nuclear Physics - R. R. Roy and B. P. Nigam
Elementary theory of Angular momentum - M. E. Rose (John Wiley)
Introduction to Nuclear Physics - H. Enge (Addision Welsey)
Theoritical Nuclear Physics-Bleat J.M & Weisskopf (springer Vorlag)

Outcomes:

- State and Derive different Energy spectrum and wave function for odd-A nuclei
- Derive the Kapur-Reierls dispersion formula for potential scattering
- Describe different types of detector and their applications

PHY403d

Electronics and Instrumentation-II Full mark-100

Objectives:

- Understand D/A and A/D Converters
- Understand Cathod-ray Oscilloscope, Digital Voltmeters and Multimeters
- Study the Data Acquisition and Processing
- Understand the Macroprocessors and Microcomputers

Unit-1-32 Marks

D/A and A/D Converters:

Binary weighted resistance DAC, DAC using ladder network, BCD DAC, counter ramp and successive approximation type ADC, single slope, dual slope ADC.

Unit. II – 34 Marks

Electric Test and measuring Equipment:

Cathod-ray Oscilloscope, Digital Voltmeters and Multimeters. Signal Generators. Regulated Power supplies.

Data Acquisition and Processing:

Introduction Transducer (Elementary ideas), Signal conditioning of the inputs, Single channel data acquisition system, Multichannel data acquisition system, Multiplexers and sample Hold circuits.

Unit. III – 34 Marks

Macroprocessors and Microcomputers:

Microcomputers, 8085 Microprocessor architecture, stacks, Resource sharing, Memory access and transfer, interrupts, Microprocessor Softwares, RAM, ROM, EPROM, I/O devices, Operational sequences, Applications.

Outcomes:

- Able to know D/A and A/D converters
- Able to Know the measurement of CRT, Digital voltmeter and Multimeters
- Able to know 8085 Microprceocessor and Microcomputers

Books:

Physics of Semiconductor Devices- S.M. Sze, Wiley Eastern Limitted,1987.
Electronic Fundamentals & Applications-J.D. Ryder, Prentice Hal of India
Integrated Electronics- J. Millman and C.C. Halkias, Mc. Graw Hill
Instrumentation devices and systems- C. Srangan, G.R. Sarma and V.S. Vmani,Tata Mc Graw Hill
Digital Computer Electronics- A.P. Malvino, Tata Mc Graw Hill, 1989.

References

Physics of Semiconductor Devices- S.M Sze,Wiley Eastern Limited,1987. Semiconductor Devices and Integrated Electronics- A.G.Milnes, Van Nostrand Reinhold Company,1980
Microprocessor Fundamental- R.L. Tokhein, Mc Graw Hill,1986.
Electronic Instrumentation and Measurement Techniques- W.D. Cooper and A.D. Helfrick, Prentice Hall of India,1989.
Microwave Propagation and Techniques- D.C. Sarkar, S. Chand and Co. Ltd. 1910.

PHY404a / PHY404c

Particle and Nuclear Physics Lab Full mark-100

Objectives:

- Aim of Particle and Nuclear Physics Lab is to train the students for advanced techniques in particle and nuclear physics so that they can investigate various relevant aspects and be confident to handle sophisticated instruments of particle and nuclear physics.

1. Calibration of the x-ray spectrometer and determination of x-ray energy of unknown sources.
2. Determination of resolving poser of x-ray spectrometers.
3. Study of b spectrum.
4. Determination of absorption co-efficient of Aluminum using G.M Counter.
5. X-test and operating poing determination using G-N tube.
6. Characteristics of G.M. counter.
7. Study of surface barrier detector.
8. Determination of value for DPPH using ESR.
9. Study of counter technique.
10. Study of single channel analyzer.
11. Study of photo detector and photo multiplier.
12. Study of wide-band amplifier.
13. Emulsion photograph studies.

Outcomes:

Students will have understanding of:

- how to operate a GM counter?
- how to find the absorption coefficient of different materials?
- how to handle nuclear materials and nuclear safely management

PHY404b

Condensed Matter Physics lab Full mark- 100

Objectives:

To experimentally realize the structural, optical, magnetic and electric behavior of condensed matters.

1. Study of energy gap of Germanium by four-probe method.
2. Callibration of magnetic field using Hall apparatus.
3. Determination of Hall Voltage and Hall coefficients.
4. Measurement of Hall angle and mobility.
5. Determination of ferroelectric transition point (Curie temperature) of the given sample.
6. Determination of magnetoresistance of bismuth.
7. Study of Laue"s spot of mica sheet using X-ray diffraction technique.
8. Study of the dispersion relation for the monoatomic and lattices using the given electrical transmission line.
9. Find the Young"s modulus for the given metal using composite piezoelectric oscillator technique.
10. Determination of magnetic susceptibility by Guoy-balance.
11. Velocity of ultrasonic waves in a given medium at different temperatures.
12. Measurement of Lande g factor of DPPII by ESR at Microwave frequency.
13. Study of thermoluminescence of F-centre in alkali halide crystals.
14. Study of phase transition using feedback amplifier circuit.

Outcomes:

- How to determine the crystal structure, lattice parameter and crystallite size?
- Measurement and analysis of various types of transport.
- Optical characterization of solid.
- Magnetic and dielectric behavior of solids

PHY404d

Electronics and Instrumentation Lab Full mark-100

Objectives:

To introduce students to entire circuit designs, and to provide in-depth experimental base of Digital Electronics.

1. Study of the various stages of a regulated power supply and find its regulation and ripple factor.
2. Design and assemble of a single stage transistor amplifier and study of its frequency response.
3. Study of phase transition using feed- Back amplifier circuit.
4. Study of multivibrator-Astable.
5. Study of multivibrator-Bistable.
6. Study of multivibrator-Monostable.
7. Design of operational amplifier circuit.
8. Use of operational amplifier for integration and differentiation.
9. Use of operational amplifier for addition and subtraction.
10. Study of various stages of a digital voltmeter.
11. Study of various stages of digital frequency counter.

12. Study of various stages of a CRO and calibrate it for measurement of frequency and amplitude.
13. Determination of Hall voltage and Hall coefficient.
14. Study of different gates.
15. Programming using into 8085 microprocessor.

Outcomes:

- Fundamental designing concepts of different types of Logic Gates, Minimization techniques etc.
  designing of different types of the Digital circuits, and to give the computational details for Digital Circuits.
- characteristics of devices like PNP, and NPN junction diode and truth tables of different logic gates.
- basic elements and to measure their values with multimeter and their characteristic study.

(A) Advanced Course to be introduced as elective/ value added/ Add-on course/ on Computational Dynamics

Topics to cover the following areas:

- Monte Carlo Techniques, data analysis
- Computational Solid State techniques
- Molecular dynamics in many body system calculation
- Non linear dynamics
- Multi scale solid State modelling
- Development of Source code
- Using Public domain code in Fluid dynamics

(B) Add on Course on Materials Characterization and Basic Instrumentation has been started from the academic session 2016-17

Add on Course/value added course under CBCS: 4 credits (40 hours)

(can be taken by Final year Physics, Chemistry, Geology & Biotechnology students)

Basic Materials Characterization and Instrumentation Techniques

Objectives:

- Understand different characterization technique for the material characterization
- Understand Raman and UV- characterization for optical and Raman active materials
- Study the Data Acquisition and Processing different vacuum pumps and theirs applications
- Understand the different Nuclear radiations and detectors

Unit I

General Purpose Characterization Instruments

Commonly used techniques for characterization – X-Ray diffractometer, Electron microscopes, Raman Spectrometer, UV-Visible spectrophotometer, magnetic resonance equipments, electrical conductivity measurement, magnetic susceptibility measurement

Unit II

Vacuum Technology

Units used to describe vacuum, Nature of the Residual Gases in a Vacuum System, Gas flow in a pumping system, Out gassing, Various types of vacuum pumps and their operating range (Rotary pump, Turbomolecular pump, Vapor diffusion pump, Sorption Pumps, Getter Pumps, Cryopump, Ion Pumps)

Measurement of vacuum - Thermal-conductivity Gauges, Ionization Gauges,

Unit III

Nuclear radiations and detectors

Types of radiations (alpha, beta, gamma), Interaction of charge particles and radiations with matter, Different types of detectors- gas detectors, Scintillation detectors, solid state detectors, Pulse shaping techniques, Elementary ideas on cloud and bubble chambers, and Cerenkov detectors.

Outcomes:

- Able to know the characterization technique for structural and morphological analysis of the samples
- Able to Know and handle the different vacuum pumps and their uses
- Able to know and handle the different types of Radiation detector to study the alpha, beta, gamma

References :

1. Elements of X-ray diffraction, B.D.Cullity
2. X-ray diffraction its theory and application, S. S.K. Chatterjee, PHI Learning Pvt. Ltd
3. Spectroscopy: Fundamentals and Data Interpretation, Neeraj Kumar Fuloria, Shivkanya Fuloria, Studium Press India Pvt. Ltd. (2013), ISBN-13: 978-9380012582
4. Vacuum Technology (Third Edition) *A. Roth,* ISBN: 978-0-444-88010-9
5. Introduction to Nuclear and Subnuclear Physics, H. A. Enge