M.Sc. Physics Syllabus

PG Department of Physics

Government Autonomous College, Angul

Choice Based Credit System

First Semester

Theory	Credit Points	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 Lab	6	150-180	100

Total Credit: 24 Marks: 400

Second Semester

Theory	Credit Points	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: Solid State Physics	6	60-65	100
Practical			
PHY204: Computational Methods in Physics	6	150-180	100

Total Credit: 24 Marks: 400

Third Semester

Theory	Credit Points	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:

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

Total Credit: 30 Marks: 600

Fourth Semester

Theory	Credit Points	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
Practical			
PHY404: a/b/c/d (B: Core Elective Papers – Practical)	6	150-180	100

Total Credit: 24 Marks: 400

Grand Total Credit of 4 semesters = 102; Grand Total Marks = 1800

A: Core Compulsory Papers:

First Semester:

PHY101: Classical Mechanics,

PHY102: Mathematical Methods in Physics

PHY103: Quantum Mechanics-I

PHY104: Modern Physics and Optics

Second Semester:

PHY201: Quantum Mechanics-II (Application to Atomic and Molecular Physics)

PHY202: Classical Electrodynamics,

PHY203: Basic Condensed Matter Physics

PHY204: Computational Methods in Physics

Third Semester:

PHY301: Advanced Quantum Mechanics

PHY302: Basic Electronics (Theory)

PHY304: Electronics (Practical)

Fourth Semester:

PHY401: Basic Nuclear and Particle Physics

PHY402: Statistical Mechanics

B: Core Elective Papers:

Sl NO	Course	Credit Point	Teaching Hours	Marks
	THIRD SEMESTER			
1	PHY303a: Advanced Particle Physics and Field Theory-I	6	60-65	100
2	PHY303b: Advanced Condensed Matter Physics- I	6	60-65	100
3	PHY303c: Advanced Nuclear Physics -I	6	60-65	100
4	PHY303d: Electronics & Instrumentation-I	6	60-65	100
	FOURTH SEMESTER			
5	PHY403a: Advanced Particle Physics and Field Theory-II	6	60-65	100
6	PHY403b: Advanced Condensed Matter Physics –II	6	60-65	100
7	(Magnetism and Nanoscience)			
8	PHY403c: Advanced Nuclear Physics -II	6	60-65	100
9	PHY403d: Electronics & Instrumentation -II	6	60-65	100
PRACTICAL (FOURTH SEMESTER)				
10	PHY404a: Particle and Nuclear Physics	6	150-180	100
11	PHY404b: Condensed Matter Physics	6	150-180	100
12	PHY404c: Electronics & Instrumentation	6	150-180	100
13	PHY303b: Advanced Condensed Matter Physics- I	6	60-65	100

C: Allied Elective Papers

Sl	Course	Credit	Teaching	Marks
1	PHY103 Quantum Mechanics-I	6	60-65	100
2	PHY104: Computational Methods in Physics	6	60-65	100
3	PHY203: Basic Condensed Matter Physics	6	60-65	100
4	PHY303a: Advanced Particle Physics and Field Theory-I	6	60-65	100

D: Free Elective Paper

Sl	Course	Credit	Teaching	Marks
1	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 third Semester. They have to choose one theory and one practical paper out of the core elective papers (Special Papers) in “B” during their fourth Semester.

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

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

<u>Mark and Credit Distributions</u>

Semester	**Credit Points**	**Marks**
First Semester	24	400
Second Semester	24	400
Third Semester	30	600
Fourth Semester	24	400
Total	**102**	**1800**

M.Sc. Physics Syllabus

FIRST SEMESTER

PHY101: Classical Mechanics **Full Mark-100**

Unit- I

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 Nonholonomic Systems, Legendre Transformation and the Hamilton 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

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 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 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

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 of Coordinates 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 Inertia 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:

Textbooks: Classical Mechanics – H. Goldstein

References:

1. Mechanics – Landau and Liftshitz
2. Analytical Mechanics, L. Hand and J. Finch
3. Classical Mechanics – Corben & Stehle
4. Classical Dynamics – Marion & Thornton
5. Classical Dynamics – J C Upadhyaya

PHY102: Mathematical Methods in Physics **Full Mark-100**

Unit-I

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

Special Functions:

Solutions of Bessel, Laguerre, Legendre, Hermite, 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

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).**

Textbooks:

1. Mathematical Methods of Physics – J. Mathews & R. L. Walker;
2. Mathematics for Physicists – Dennery & Krzywicki;
3. Mathematical Methods for Physics – Arfken and Weber;
4. Group Theory – M. Hamermesh

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

PHY103: Quantum Mechanics – I **Full Mark-100**

Unit-I

General Principles of Quantum Mechanics

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 Eigen vectors 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 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, Solving Schrodinger equation for simple 1D problems.

Unit-II

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, Eigenvalues and Eigen functions of **L_z, L^2** (OP method) spherical harmonics, Matrix representation of **L_+, L_-** and **L^2**.

Spin Angular Momentum:

Spin 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. coefficients, Angular momentum states for composite systems in the angular momenta (1/2, 1/2) and (1, 1/2)

Unit – III

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

Books:

Textbooks:

1. Quantum Physics – S. Gasiorowicz
2. Quantum Mechanics- L-I Schiff/ J. Sukurai/ E. Merzbacher/ A. Messiah, Vol.I
3. Advanced Quantum Mechanics – P. Roman
4. Quantum Mechanics –R. Shankar
5. Quantum Mechanics –A. Ghatak and S. Lokanathan
6. Quantum Mechanics – S. N. Biswas

References:

1. Quantum Mechanics – A. Das
2. Elementary Theory of Angular Momentum – M. E. Rose
3. Principles of Quantum Mechanics – P. A. M. Dirac
4. Quantum Mechanics (Non-relativistic theory) – L. D. Landau and E. M. Lifshitz

PHY104 (Practical Paper)

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

1. Michelson Interferometer
2. Fabry-Perot Interferometers
3. Measurement of Rydberg constant
4. Babinet's compensator
5. Constant deviation spectroscope
6. e/m measurement by Braun tube
7. e/m measurement by Magnetron Valve Method
8. e/m measurement by Thomson Method
9. Magnetic field measurement by search coil
10. Ferroelectric transmission point by Dielectric Constant Measurement
11. Rectification by junction diode using various filters
12. Characteristics of a Transistor
13. Dielectric constant of solid (wax) by Lecher Wire
14. Verification of Richardson's $T^{3/2}$ law
15. Determination of Planck's constant by total Radiation Method
16. Determination of Planck's constant by Reverse Photoelectric effect method
17. Hysteresis loop tracer
18. Determination of 'e' by Millikan's oil drop experiment
19. Measurement of attenuation and phase shift of A.C. in L.C.R. network

20. RF characteristics of coil
21. Study of power supply
22. Calibration of an oscilloscope
23. Stefan’s constant measurement
24. Existence of discrete energy level by Frank Hertz experiment.
25. M.Sc. Experiments developed by Indian Academy of Sciences

SECOND SEMESTER

PHY201: Quantum Mechanics – II (Application to Atomic and Molecular Physics) Full Mark-100

Unit-I

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 Anomalous 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

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 Dependent 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

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

Books:

Textbooks:

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

References:

1. Introductory Quantum Mechanics - R. Liboff
2. Quantum Mechanics - E. Merzbacher/ S. N. Biswas/ L. I. Schiff
3. Quantum Mechanics Vol I - A. Messiah
4. Principles of Quantum Mechanics - P. A. M. Dirac
5. Quantum Mechanics (Non-relativistic theory) - Landau and Lifshitz
6. Modern Quantum Mechanics - J. J. Sakurai
7. Advanced Quantum Mechanics - P. Roman
8. Elementary Theory of Angular Momentum - M.E. Rose

PHY202: Classical Electrodynamics **Full Marks -100**

Unit-I

Maxwell's Equations:

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

Lorentz transformation, Scalars, vectors and Tensors, Maxwell's equations and equations of continuity in terms of Aμ and Jμ, 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

Plane Waves in Non-Conducting Media:

Plane waves in non-conducting media, velocity of wave propagation and energy flow, linear, circular and elliptic polarizations, Reflection and refraction of electromagnetic waves at a plane interface between dielectrics at normal and oblique incidences, total internal reflection and polarization by reflection, waves in dispersive media, Kramer-Kronig relation.

Plane Waves in Conducting 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

Green's Function Solution for Retarded Potential:

Green's function solution of potential form of Maxwell's equations, Retarded and advanced Green's Functions, Lienard-Wiechert potential.

Multipole Radiation:

Potential, Fields and radiation due to an oscillating electric dipole; radiation due to a center- fed linear antenna, angular distribution of power radiated, Rayleigh scattering. Magnetic dipole and Electric Quadrupole radiation.

Radiation by Point Charge:

Electric and Magnetic Fields due to a point charge, Angular distribution of radiation and total power radiated by an accelerated charge, Larmor's formula, Thomson’s Scattering

Books:

Textbooks: Classical Electrodynamics - J. D. Jackson

References:

1. Classical Theory of Fields - L. Landau & Lifsitz

2. Introduction to Electrodynamics - D. J. Griffiths.

3. Principles of Optics - M. Born and E. Wolf

4. Introduction to Electrodynamics - Capri and Panat

PHY203: Basic Condensed Matter Physics **Full Marks –100**

Unit-I

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, translation symmetry of crystals, symmetry operations in space group, Brillouin zones, 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- type of crystal binding, covalent, molecular and ionic crystals, London theory of van der Waals hydrogen bonding, cohesive and Madelung energy

Unit II

Lattice Dynamics:

Failure of the static lattice model, adiabatic and harmonic approximation, vibrations of linear monoatomic 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:

Periodic potential and Bloch's theorem, Kronig-Penney model, weak potential approximation, density of states of 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

Semiconductors:

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

Superconductivity:

Experimental survey, Meissner effect, Type-I and Type-II superconductors, thermodynamics of superconductors, London's theory, Electron-electron attractive 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 Tc superconductors: Basic ideas and applications

Books:

Textbooks:

1. Introduction to Solid State Physics - C. Kittel
2. Solid State Physics - Ashcroft and Mermin
3. Principles of Condensed Matter Physics - P. M. Chaikin and T. C. Lubensky

References:

1. Solid State Physics- A.J. Dekker
2. Quantum Theory Solid State - J. Callaway
3. Solid State Physics – O.E. Animaler

PHY204 (Practical)

Computational Methods in Physics **Full Marks -100**

Computers:

Introduction to computer hardware and software, introduction to storage in computer memory, stored programme concepts, storage media, computer operating system, compilers, LINUX commands;

Programming with FORTAN:

Programme solving on computers – algorithm and flow charts, Structure of FORTRAN programme, compilation, FORTAN data types, variable and constant, declaration of variables, initializing variables, arithmetic operators, expressions and statements, arithmetic expressions, functions, Control statements: decision making and looping statements, array, input/output commands, sub-programmes,

Exercises for acquaintance:

1. To find the largest or smallest of a given set of numbers
2. To 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. To find the sum of the digits of a number
12. HCD (GCF) and LCM of two numbers

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, Simpsons method, Romberg integration, Gauss quadrature method
5. Eigenvalues and eigenvectors of a matrix
6. Solution of linear homogeneous equations
7. Matrix inversion.
8. Solution of ordinary differential equations by Runge-Kutta Method
9. Solution of Radioactive decay, Simple harmonic oscillator, Schrödinger Equation

Books:

1. Computer Programming in FORTRAN 90 and 95, V. Rajaraman
2. Fundamentals of Computers (Prentice Hall, India), V. Rajaraman
3. Computer Oriented Numerical Methods- R.S. Salaria
4. An Introduction to computational Physics, T. Pang, Cambridge Univ. Press.
5. Numerical Recipe (Cambridge Univ. Press), W.H. Press, S. A. Teukolsky, W.T. Vetterling and B.P. Flannery
6. Elements of Parallel Processing (Prentice Hall, 1990), V. Rajaraman
7. Fortran 77 and Numerical methods – C. Xavier

8. Programming and Computing with FORTRAN 77/90, (Allied Publishers 1992), P.S. Grover

THIRD SEMESTER

PHY301: Advanced Quantum Mechanics **Full Mark-100**

Unit-I

Relativistic Quantum Mechanics:

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

Unit-II

Free particle solution of Dirac equation, Projection operators for energy and spin, Physical interpretation of free particle solution, Zitterbewegung, 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

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.

Books:

Textbooks:

1. Advanced Quantum Mechanics - J.J. Sakurai
2. Relativistic Quantum Mechanics - J.D. Bjorken and S.D. Drell
3. Quantum Field Theory - F. Mandl and G. Shaw

References:

1. Quantum Field Theory - C. Itzykson and J. Zuber
2. Quantum Field Theory - M. E. Peskin and D. V. Schroeder
3. Quantum Field Theory - L. H. Ryder
4. Quantum Field Theory - S. Weinberg

PHY302: Basic Electronics (Theory) **Full Mark – 100**

Unit-I

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, integral amplifier, rejection of common mode signals. The operational amplifier input and output impedances, application of operational amplifiers, unit gala buffer, summing, integrating and differentiating amplifiers, comparators and logarithmic amplifiers.

Unit-II

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, shift registers, Asynchronous counters, Divide by N counter, Decade ripple counter, synchronous counters, application of counters

Unit-III

Radio Communication:

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

Books:

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

PHY303a: Advanced Particle Physics - I **Full mark-100**

Unit- I

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

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

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.

Books:

Textbooks:

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

References:

1. Modern Elementary Particle Physics (Addison Wesley) - G. Kane
2. Concept of Particle Physics - V. Weisskopf G.K. Gottfried
3. Quarks & Leptons - F. Halzen & A.D. Martin
4. Quantum Field Theory - Itzyksen and Zuber
5. Quantum Field Theory – M. E. Peskin and D. V. Shroeder

6. Quantum Field Theory – L. H. Ryder

PHY303b: Advanced Condensed Matter Physics-I **Full mark-100**

Unit-I

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 periodic potential, Bloch functions, Brillouin zones, E- K diagram under 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

Fermi Surface:

Construction of Fermi surface, Experimental methods of study of Fermi surface, Cyclotron 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

Transport Properties:

The Boltzmann equation, Electrical conductivity, General transport coefficient, Thermal conductivity, Thermoelectric effect, Hall Effect, Elementary ideas on Quantum Hall Effect, Magnetoresistance, Elementary ideas on Giant magneto-resistance and colossal magneto resistance.

Books:

Textbooks:

1. Principles of the Theory of Solids – J.M. Ziman
2. Introduction to Solid State Physics – C. Kittel

3. Advanced Solid State Physics – Philip Phillips, Overseas Press, India Pvt. Ltd.

References:

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

PHY303c: Advanced Nuclear Physics-I **Full mark-100**

Unit-I

Nuclear Momentum Theory:

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

Unit-II

Two Nucleon System:

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

Unit-III

Nuclear Models:

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

Books:

1. Nuclear Physics – R.R. Roy and B.P. Nigam (Wiley Eastern)
2. Elementary Theory of Angular Moemtum – M.E. Rose (John Wiley)
3. Introduction to Nuclear Physics- H. Enge (Addison Wesley)

4. Theoretical Nuclear Physics – Blatt J.M. & Weisskopf (Springer Verlag)

PHY303d: Electronics and Instrumentation - I **Full mark-100**

Unit-I

Elemental and Compound Semiconductors:

Elementary idea about lattice mismatched pseudomorphic materials epitexy and epitexial growth, carrier effective mass and band structure, carrier scattering phenomena, 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 contact. Varactor diode, PIN diode, Schottky barrier and backward diode.

Unit-II

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

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 Counter Decade ripple counter Synchronous counter, application of counters.

Books:

Textbooks:

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. Integrated 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

References:

1. Physics of Semiconductor Devices – S.M. Sze, Wiley Easter Limited, 1987
2. Semiconductor Devices & Integrated Electronics – A.G. Milnes, 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 elfrick, Prentice Hall of India, 1989
5. Microwave propagation and techniques – D.C. Sarkar, S. Chand& Co.Ltd.1910

PHY304: Electronics (Practical) **Full Mark – 100**

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. Characteristics of Hartley 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 square wave 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

PHY305a: Dissertation (Project) **Full mark-100**

Dissertation: 50 marks, Presentation and Viva: 50 marks

Topics include:

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

PHY305b: Review of Literature **Full mark-100**

Dissertation: 50 marks, Presentation and Viva: 50 marks

Topics include:

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

FOURTH SEMESTER

PHY401: Basic Nuclear and Particle Physics **Full Marks – 100**

Unit-I

Two Nucleon Problem:

Central and non-central 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

Nuclear reaction:

Energetics of nuclear reaction, compound nucleus theory, resonance scattering, Breit- Wigner formula, Alpha decay, Fermi's theoryof beta decay, Selection rules for allowed transition, parity violation.

Nuclear Structure: Form factor and charge distribution of the nucleus, Hofstadter form factor.

Unit-III

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.

Books:

Textbooks:

1. Introduction to Nuclear Theory - L.R.S Elton
2. Nuclear Physics - B.B. Roy and B.P. Nigam
3. Nuclear Physics – K. S. Krane
4. Subatomic Physics - Frauenfelder and Henley
5. Concepts of Particle Physics - Gottfried and Weisskopf Elementary Particle Physics - D.J. Griffiths
6. Introduction to Nuclear Physics- P.E. Hodgson & E. Gadioli

References:

1. Theoretical Nuclear Physics - Blatt and Weisokoff

2. Introductory Nuclear Physics - S.S. Wong

3. Particle Physics - R. Omnes

PHY402: Statistical Physics **Full Marks – 100**

Unit-I

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 canonical ensemble and density fluctuation, Equivalence of canonical and grand canonical ensemble.

Unit-II

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

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.

Books:

Textbooks:

1. Statistical Mechanics – K. Huang

2. Statistical Mechanics – R. K. Pathria

References:

1. Elementary Statistical Physics – C. Kittel

2. Statistical Mechanics – F. Mohling
3. Statistical Mechanics – Landau and Lifsitz
4. Physics Transitions & Critical Phenomena – H.E. Stanly
5. Thermal Physics – C. Kittel
6. Fundamentals of Statistical & Thermal Physics – F. Reif

PHY403a: Advanced Particle Physics –II **Full mark-100**

Unit-I

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

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

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.

Books:

Textbooks:

1. Quantum Field Theory - F. Mandl and G. Shaw

2. Introduction to High Energy Physics - D. H. Perkins (Cambridge U. Press)
3. Elementary Particles - I.J. Hughes
4. Elementary Particle Physics - D.J. Griffiths
5. Quarks and Leptons – F. Halzen and A.D. Martin

References:

1. Modern Elementary Particle Physics - G. Kane (Addision Wesley)
2. Concept of Particle Physics - V. Weisskopf & K. Gottfried
3. Quantum Field Theory - Itzyksen and Zuber
4. Quantum Field Theory - M. Peskin and Schroeder (Addision Wesley)
5. Lectures on Quantum Field Theory – Ashok Das (World Scientific)

PHY403b: Advanced Condensed Matter Physics-II (Magnetism and Nanoscience) Full mark-100

Unit-I

Magnetism:

Diamagnetism and paramagnetism of atoms with permanent magnetic moment, Pauli paramgnetism of conducting electrons, Weiss theory of ferromagnetism, Curie-Weiss Law for susceptibility, Heisenberg model–Conditions for ferro- and antiferro-magnetic order, Ising Model, Mean field theory, spin waves and magnons, Bloch's $T^{3/2}$ L 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

Defects in Crystals:

Lattice defects, Frenkel and schottky defects, line defect, edge and screw dislocations, Burger's vector planner (stacking), faults –twin plates and grain boundaries, dislocation densities, dislocation multiplication and slip, strength of crystal, color centers, polarons and excitons

Unit-III

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, Inter-band transition - direct and indirect transition; Absorption in insulators; Polaritons; One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect.

Physics of Semiconductors:

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.

Books:

Textbooks:

1. Introduction to Solid State Physics, C. Kittel, John Willey & Sons, New York.
2. Quantum Theory of Solids – C. Kittel
3. Text Book of Nanoscience and Nanotechnology, B.S. Murty, P. Shankar, B. Raj, B.B. Rath and J. Murday.

References:

1. Introduction to Modern Solid State Physics by Yuri M. Galperin
2. Introduction to Solids- Azroff
3. Elementary Solid State Physics- Omar
4. Solid State physics- Aschroff & Mermin
5. Science of Engineering Materials and carbon nanotubes, CM. Srivastava & C. Srinivasan
6. Solid state physics, A.J. Dekkar Macmillan, London
7. Solid state Physics, R.L. Singhal, Kedarnath and Ramnath Co., Meerut.
8. Low Dimensional Semiconductor Structures, K. Bamam and D. Vvedensky (Cambridge University Book) 2001
9. Semiconductor Quantum Dots, L. Banyal and S.W. Koch (World Scientific) 1993
10. An introduction to the physics of low dimensional semiconductors, J.H. Davies (Cambridge Press) 1998.Nalwa

11. Introduction to Superconductors – Ketterson
12. The Physics of quasicrystals, Eds. Steinhardt and Ostulond
13. Principles of Nanoscience and Nanotechnology, M.A. Shah and T. Ahmad Handbook of Nanostructured materials and Nanotechnology (Vol.1-4) Ed. H.S.
14. Solid State Physics, S.O. Pillai, New Age International Publishers, 2010
15. Introduction to Solid State Physics, Arun Kumar
16. Solid State Physics, Wahab M.A
17. Solid State Physics and Electronics, R.K. Puri, V.K. Babbar
18. Solid State Physics, H.E. Hall
19. Fundamentals of Solid State Physics, Saxena, Gupta, Saxena.

PHY403c: Advanced Nuclear Physics-II **Full mark-100**

Unit-I

Collective model:

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

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

Nuclear Detectors:

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

Books:

1. Nuclear Physics-R.R. Roy and B.P. Nigam
2. Elementary theory of Angular Momentum-M.E. Rose (John Wiley)
3. Introduction to Nuclear Physics-H. Enge (Addision Wesley)
4. Theoretical Nuclear Physics-Bleat J.M & Weisskopf (springer Verlag)

PHY403d: Electronics and Instrumentation-II **Full mark-100**

Unit-I

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

Electric Test and measuring Equipment:

Cathode-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

Microprocessors 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.

Books:

Textbooks:

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

5. Digital Computer Electronics- A.P. Malvino, Tata Mc Graw Hill, 1989.

References:

1. Physics of Semiconductor Devices- S.M Sze, Wiley Eastern Limited,1987.
2. Semiconductor Devices and Integrated Electronics- A.G. Milnes, Van Nostrand Reinhold Company, 1980
3. Microprocessor Fundamental- R.L. Tokhein, 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 and Co. Ltd. 1910.

PHY404a: Particle and Nuclear Physics Lab **Full mark-100**

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 point 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.

PHY404b: Condensed Matter Physics Lab **Full mark-100**

1. Study of energy gap of Germanium by four-probe method.
2. Calibration 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's g factor of DPPII by ESR at Microwave frequency.
13. Study of thermoluminescence of F-center in alkali halide crystals.
14. Study of phase transition using feedback amplifier circuit.