School of Physics (Autonomous), Sambalpur University
M.Sc. Physics (General Stream) Course Structure

I Semester

Course No	Course Title	Credit
PHY - 411	Classical and Relativistic Mechanics	4 CH
PHY - 412	Quantum Mechanics (I)	4 CH
PHY - 413	Mathematical Methods for Physics	4 CH
PHY - 414	Computer Programming	2 CH
PHY - 415	Numerical Methods	2 CH
PHY – 416	Computer Practical (I)	4 CH
PHY – 417	Optics Practical	2 CH
Total of I Semester		**22 CH**

II Semester

Course No	Course Title	Credit
PHY – 421	Electrodynamics	4 CH
PHY – 422	Quantum Mechanics (II)	4 CH
PHY – 423	Statistical Mechanics	4 CH
PHY – 424	Basic Electronics	4 CH
PHY – 425	Computer Practical (II)	4 CH
PHY – 426	Electricity and Magnetism Practical	2 CH
Total of II Semester		**22 CH**

III Semester

Course No	Course Title	Credit
PHY – 511	Solid State Physics	4 CH
PHY – 512	X-ray and Spectroscopy	2 CH
PHY – 513	Relativistic Electrodynamics	2 CH
PHY – 514	Special Paper (I)	4 CH
PHY – 515	Classical Fields	2 CH
PHY – 516	Modern Physics Practical (I)	4 CH
PHY – 517	Special Paper Practical (I)	4 CH
PHY – 518	Seminar	2 CH
Total of III Semester		**24 CH**

IV Semester

Course No	Course Title	Credit
PHY – 521	Nuclear Physics	4 CH
PHY – 522	Particle Physics	4 CH
PHY – 523	Special Paper (II)	4 CH
PHY – 524	Modern Physics Practical (II)	4 CH
PHY – 525	Special Paper Practical (II)	4 CH
PHY – 526	Seminar	2 CH
Total of IV Semester		**22 CH**

Grand Total Semester I to IV – 90 CH

Note:

(1) The courses for I and II semesters will be common to General Stream (GS) and Nuclear Stream (NS). The Nuclear Stream courses will remain suspended till the faculty position improves and the students for the course will read General Stream in III and IV semester.

(2) The student has to submit a write up of his 4th Semester seminar presentation to the Teacher in charge seminar for record.

(3) There are provisions for running 5 special papers listed below out of which the student will choose one. However, the School will run some selective special papers depending on availability of faculty members.

(4) Some new special papers may be introduced in future when the faculty position improves.

List of Special Papers:

1. Nuclear Physics
2. Electronics
3. High Energy Physics
4. Condensed Matter Physics
5. Computer Application in Physics

New Special Papers:

1. Quantum Information and Computation
2. Nano Science
3. Meta Materials

SEMESTER-I COURSE-I 4CH

PHY- 411 (GS/NS): Classical and Relativistic Mechanics

1. **Theory of small oscillations:** Principal axis transformation, normal co-ordinates & normal modes, vibration of linear symmetric molecules.
2. **Rigid body kinematics and dynamics:** Generalised co-ordinates for rotation, rotation as orthogonal transformation, general motion of a rigid body, Euler- angles, angular momentum and kinetic energy of rotation in terms of the Euler-angles, rate of change of a vector, inertia tensor and moments of inertia, Euler's equations of motions, motion of a heavy symmetrical top, motion in a non-inertia frame of reference, coriolis force.
3. **Hamiltonian Formulation:** Derivation of Hamilton's equations from Lagrange's equations, and from the variational principle, Hamiltonian of simple systems and in different co-ordinate systems, solution of equations of motion for Simple Harmonic Oscillator and other simple systems.
4. **Canonical transformations:** Legendre transformation generating functions and classifications of canonical transformations, Poisson's brackets, Equations of motion in Poisson- bracket form, canonical invariants, Liouville's theorem.
5. **Hamilton-Jacobi Theory and Action angle variables:** The Hamilton-Jacobi equation, separation of variables, the Harmonic Oscillator problem, Action angle variables, formulation of periodic systems.
6. **Elements of Relativistic Mechanics:** Interpretation of Lorentz transformations as orthogonal transformation in 4-dimensional Minkowski space, Lorentz scalars, 4-vectors and 4-tensors in Minkowski space, Laws of mechanics in covariant form and the proper time interval, 4-vector position, 4-vector velocity and 4-vector momentum, Generalisation of Newton's force equation to covariant form, energy-momentum relation in relativistic mechanics.

Texts and References:

[1] Landau and Liftshitz: Mechanics (Pergamon)
[2] H.Goldstein: Classical Mechanics (Narosa)

SEMESTER-I COURSE-II 4CH

PHY- 412 (GS/NS): Quantum Mechanics (I)

1. **Review: I**nadequacy of classical mechanics, Wave-particle duality, wave-packets, Uncertainty principle, Schrodinger equation, wave function and its significance.
2. **Postulates of quantum mechanics:** Basic postulates, Representation of states, Representation of dynamical variables, expectation values, observables, Eigenvalue problem, degeneracy, Eigen function, ortho-normality, Dirac-delta function and its properties, completeness, closure property, Application to the momentum space, general derivation of Uncertainty principle, states with minimum uncertainty product, commuting observables and removal of degeneracy, evaluation of system with time and constant of motion.
3. **The central Force Problem:** Separation of the wave equation, theory of orbital angular momentum, eigen values and eigen functions, rigid rotator, the radial equation, spectrum of Hydrogen and Hydrogen-like atoms, three dimensional square well potential, bound states and energy levels, case of infinite depths, the three dimensional isotropic Harmonic oscillator.
4. **Matrix Formulation of Quantum Theory:** Matrix representation of operators, transformation theory-change of basis of representation, Quantum dynamics in schrodinger and Heisenberg pictures, interaction picture, Dirac Bra and Ket notation, harmonic oscillator problem-creation and annihilation operators, energy spectrum and the eigen functions.
5. **Symmetries and conservation laws:** Space and time translation symmetries, generators and the conservation of energy-momentum, symmetries under rotation, generators.
6. **Theory of angular momentum:** Algebra of the generators, diagonalisation, matrix representation of generators J=1/2 and 1 cases, addition of angular momenta, Clebsch- Gorden coefficients, calculation of C.G. coefficients for angular momenta 1/2 and 1/2 and 1/2 and 1 cases.

Texts and References:

[1] Schiff: Quantum Mechanics
[2] Mathews and Venkatesan: A text Book of Quantum Mechanics.
[3] Merzabacher: Quantum Mechanics
[4] Schewabl: Quantum Mechanics
[5] Powel and Crasemann: Quantum Mechanics
[6] Ghatak and Lokanathan: Quantum Mechanics

SEMESTER-I COURSE-III 4CH

PHY- 413 (GS/NS): Mathematical Methods for Physics

1. **Function of a complex variable:** Residue theorem, evaluation of integrals by the method of residues, multi-valued function-branch point and branch cut, contour integration involving branch point.
2. **Linear vector space:** Definition, linear independence, basis and dimension, scalar product, dual vector, Cauchy-Schwarz inequality, orthonormal basis, Schmidt orthogonalisation process.
3. **Matrices:** Inverse of a matrix, orthogonal matrix, rotation, similarity transformation, Eigenvalues and Eigenvectors, secular equation, Cayley-Hamilton theorem, matrix diagonalisation.
4. **Partial differential equations**: of theoretical Physics, 1^{st} Order Differential Equations, Separation of Variable-Ordinary Differential Equations, Singular Points, Series Solutions – Frobenius' Method, A second Solution, Non-homogenous Equation – Green's Function.
5. **Group theory:** Basic concepts of groups, group representation, relevance to quantum mechanics, Lie group and Lie algebra, SU (2) groups and their representation, SO (3) groups and their representation.
6. **Tensors in physics:** Cartesian tensor, covariant, contravariant and mixed tensors, tensor algebra, the Kronecker delta and Levi-Civita symbol, tensors in Minkowski space, tensor calculus, tensors in general relativity, the Reimann-Christoffel symbol, Ricci and Curvature tensor.
7. **Integral Transforms:** Development of Fourier Integral, Fourier Transforms – Inversion Theorem & Derivatives, Convolution Theorem, Momentum Representation, Transfer Functions, Laplace Transform - Derivatives, Properties, Inverse Laplace Transform and applications to solution of differential equations.

Texts and References:

[1] Arfken: Mathematical Physics (Academic)
[2] Dennery and Krzywicki: Mathematics for Physicists (Harper and Row)
[3] Joshi: Matrices and Tensors in Physics (Wiley – Eastern)
[4] Chattopadhyay: Mathematical physics (Wiley- Eastern)
[5] Potter and Goldberg: Methods of Mathematical physics (Prentice Hall)

SEMESTER-I COURSE-IV 2CH

PHY- 414 (GS/NS): Computer Programming

1. **Introduction:** Introduction to programming language, Introduction to using a computer system, Introduction to Program (General).

2. **Programming with FORTRAN:** Programming discipline, statements to write a program, arithmetic, intrinsic functions, standard input and output, Constants, variables and data, IF statements, DO loops, Data Input and Output. Format, arrays and dimension, functions and subroutines, file managements, Common and data statements.

3. **Programmin with C:** Programming discipline, Constants, variables and data types, Operators and expressions, Input and output operations, Decision-making and branching, decision making and looping, array and strings. User defined functions, Structures and Unions, Pointers, Dynamic memory allocation, File managements in C.

Texts and References:

[1] Byron Gottfried: Programming with C (Schaum outline series)
[2] Byron Gottfried: Programming with FORTRAN 77 (Schaum outline series)
[3] E. Balaguruswami: Programming in ANSI C (Tata McGraw-Hill)
[4] Y. Kanetkar: Let Us C (BPB Publications)
[5] Ian D Chivers and Jane Sleightholme: Interactive Fortran 77: A Hands on approach, Free book at http://www.ebooksdirectory.com/details.php?ebook=2763
[6] Internet Resource: http://www.chem.ox.ac.uk/fortran/

SEMESTER-I COURSE-V 2CH

PHY- 415 (GS/NS): Numerical Methods

- Error calculation and handling of error in programing.
- Interpolation: Linear, Quadratic and Cubic and Spline methods. Newton's, Lagrange's, Stirling's and Bessel's interpolation formulae
- Integration: Trapezoidal, Simpson, Weddle's and Gaussian Quadrature methods
- Differentiation: Numerical derivative (1^{st} and 2^{nd} order) based on Stirling's interpolation
- Root Finding: Bisection and Newton-Raphson Method
- Differential Equation: (1^{st} and 2^{nd} order): Euler's method, Runge-Kutta Method (4^{th} order algorithm), Finite difference method.
- Solution of simultaneous linear equation: Matrix inversion method, Gaussian elimination method, LU decomposition method,
- Least square fitting of a set of points to a straight line

Texts and References:

[1] J.B. Scarborough: Numerical Mathematical Analysis (Oxford and IBH)
[2] E. Balgurusamy: Numerical Methods (TMH)
[3] V. Rajaraman: Computer Oriented Numerical Methods
[4] George W. Collins, II: Fundamental Numerical Methods and Data Analysis – Free internet resource available at http://ads.harvard.edu/books/1990fnmd.book

SEMESTER-I COURSE-VI 4CH

PHY- 416 (GS/NS): Computer Practical (I)

Basic: Learning of basic OS commands under Linux and Windows, Learning to use word processor under Windows and Linux, Learning of editor commands under Linux

Programming: (using Fortran and C)

1. Solution of quadratic equation
2. Sorting of a set of numbers in a desired way
3. Series summation like Sin(x), Cos(x), e^x, Log(x) etc.
4. Interpolation – linear, quadratic and cubic spline methods
5. Solution of transcendental equations
6. Matrix multiplication, Transpose of a matrix,
7. Evaluate determinant of a matrix
8. Matrix inversions and solutions of simultaneous linear algebraic equations
9. Solutions of simultaneous linear algebraic equations by Gauss elimination
10. Solutions of simultaneous linear algebraic equations by LU decomposition
11. Least square fitting of a set of points to a straight line

(Any Other Experiments Suggested by Course Teacher)

SEMESTER-I COURSE-VII 2CH

PHY- 417 (GS/NS): Optics Practical

1. Experiment With Biprism.
2. Experiment with Narrow wire.
3. Experiment with Single slit.
4. Experiment with Plane diffraction grating.
5. Experiment with Double slit.
6. Experiment with Babinet compensator.
7. Determination of Resolving Power of Telescope.
8. Determination of the Resolving Power of Grating.
9. Experiment with Constant Deviation Spectrograph.

(Any Other Experiments Suggested by Course Teacher)

SEMESTER-II COURSE-I 4CH

PHY-421 (GS/NS): Electrodynamics

1. **Maxwell's equations, Conservation laws and Electromagnetic potentials:** Maxwell's equations (No derivation), Equation of continuity and conservation of charge, Lorentz force law, Poynting's theorem and conservation of energy, Maxwell's stress tensor and conservation of momentum, Electromagnetic potentials, Gauge transformation, Lorentz and Coulomb gauge, Lorentz force law in the potential formulation, Inhomogeneous wave equation for the potentials and its solution by Green function method, Retarded potentials.
2. **Propagation of plane Electromagnetic waves and polarization:** Propagation of plane electromagnetic waves in free space, dielectrics and conductors, polarization of plane electromagnetic waves, linear, circular, and elliptic polarizations, linear and circular basis.
3. **Dispersion:** The oscillator model and dispersion in dielectrics, conductors and plasma, anomalous dispersion and resonant absorption, casual and non-local connection between D and E, Kramers- Kroning dispersion relations.
4. **Radiation and Scattering:** Retarded potentials, fields and radiation due to an arbitrary system of charges and currents in the electric dipole approximation, Multipole expansion of retarded potentials and fields in the radiation zone, emission of radiation in the electric dipole, magnetic dipole, and electric quadrupole approximations, simple radiating system, Linear centerfed antenna, scattering of plane electromagnetic waves by a bound charge in the electric dipole approximation, resonance scattering, Raleigh scattering and Thomson scattering.
5. **Electromagnetic potentials, fields and Radiation due to a moving point charge:** Leinard-Weichart potentials and fields due to a moving point charge, Radiation by an accelerated point charge, Larmor formula and its generalization to Leinard formula, Angular distribution of emitted radiation, Radiation reaction and damping, Abraham-Lorentz formula.

Texts and References:

[1] J.D.Jackson: Classical Electrodynamics. (Text)
[2] E.C. Jordan and K.G. Balman: Electromagnetic waves & Radiating Systems
[3] B.G.Levich: Theoretical Physics.
[4] D Griffith: Electrodynamics
[5] B Podolsky and K S Kunz: Fundamental of Electrodynamics
[6] Feynman Lectures

SEMESTER-II **COURSE-II** **4CH**

PHY-422 (GS/NS): Quantum Mechanics (II)

1. **Spin Angular Momentum:** Expt. Evidence, Pauli theory, spin wave functions, properties of Pauli matrices, System of two spin1/2 particles.
2. **Identical Particles:** symmetry and anti-symmetry of wave functions as conserved quantities, spin-statistics relation, Pauli exclusion principle, Simple manifestation of Pauli principle, Fermi level.
3. **Approximation Methods:** Time independent perturbation theory, energy levels and eigen functions up to 2^{nd} order, Anharmonic oscillator, non-degenerate and degenerate case-removal of degeneracy, stark effect, He–atom, W.K.B approximation, turning points, applications to bound states and tunneling, Bohr-Sommerfeld quantisation formula, The variational principle, estimation of ground state and excited state energy levels. Time Dependent Perturbation Theory: The Dirac-Picture, transition Probability, density of states, Fermi Golden rule, harmonic perturbation.
4. **Scattering Theory:** The scattering integral equation, scattering amplitude and differential equation, Born approximation, Rutherford scattering, validity of Born approximation, Partial wave analysis, phase shifts, differential and total cross-section for elastic scattering, Optical theorem, low energy scattering (l=0) case, scattering length, effective range.
5. **Relativistic Quantum Mechanics:** Klein-Gordon equation, drawback, Dirac equation – derivation, Properties of Dirac matrices, plane wave solution of Dirac equation.

Texts and References:

[1] Schiff: Quantum Mechanics.
[2] Mathews and Venkatesan: A Text Book of Quantum Mechanics.
[3] Powel and Crassmann: Quantum Mechanics.
[4] Merzbacher: Quantum Mechanics.
[5] Schwabl: Quantum Mechanics.
[6] Ghatak and Lokanathan: Quantum Mechanics.
[7] Bjorken and Drell: Relativistic Quantum Mechanics

SEMESTER-II COURSE-III 4CH

PHY-423 (GS/NS): Statistical Mechanics

1. **Kinetic Theory:** Kinetic theory, binary collisions, Boltzmann transport equation, H-theorem, Maxwell Boltzmann Distribution law, Mean free path.
2. **Classical Statistical Mechanics:** Elements of ensemble theory, phase space, ergodic hypothesis, Liouville's theorem, micro-canonical, canonical and grand canonical ensembles, thermodynamic functions, classical ideal gas, equipartition theorem, Gibb's paradox, energy fluctuations in canonical ensemble, density fluctuations in grand-canonical ensemble.
3. **Quantum Statistical Mechanics:** Density matrix, Quantum Liouville's theorem, ensembles in quantum mechanics, equilibrium average of observables, thermodynamic function, partition function, Ideal mono atomic gas.
4. **Application of Quantum Statistical Mechanics:** Statistics of indistinguishable particles, Derivations of Fermi- Dirac, Bose-Einstein and Maxwell-Boltzmann distribution law, ideal Fermi and Bose gas, theory of white dwarfs and Chandrasekhar limit, Plank's radiation formula, Bose Einstein condensation.

Text Book:

[1] K.Huang: Statiatical Mechanics.

Reference Books:

[1] J.D. Walecka: Fundamentals of Statistical Mechanics (World Scientific)
[2] Pathria: Statiatical Physics.
[3] Kittel: Elementary Statistical Physics.

SEMESTER-II COURSE-IV 4CH

PHY-424 (GS) Basic Electronics

1. **Network Theory:** T and PI network, their inter conversations, Foster's reactance theorem, Thevenin's theorem and Norton's theorem, Reciprocity theorem, superposition and compensation theorem, maximum power transfer theorem.
2. **Amplifiers:** Transistor parameters and equivalent circuit, amplifier characteristics of transistor in CE, CB and CC configurations, small signal low and high frequency transistor circuits and analysis, the Miller effect, gain band width product, effect of cascading, Feedback in amplifiers, effect of negative feedback on gain, distortion, input and output resistances, different feedback circuits.
3. **Oscillators:** Feedback and circuit requirement for oscillators, analysis of Hartley, Colpitt, RC (phase shift) and Wein-bridge oscillator, circuit analysis of astable, monostable and bistable multivibrators.
4. **Operational amplifiers:** Basic OP-AMP-differential amplifier, inverting and non-inverting type, common mode rejection ratio, use of OP-AMP in scale changing, phase shifting, summing, voltage to current (and vice-versa) conversion, multiplying, differentiating and integrating circuits, solution of linear and differential equation using OP-AMP, analog computation.
5. **Digital Electronics:** NAND and NOR as universal gates, Logic functions and their simplifications using K-map, Combinational logic design: multiplexer, half ladder and full ladder, use of adder as substractor, Sequential logic design: Different type of Flip-Flops and their characteristics, advantage of master-slave configuration,

Texts and References:

[1] Ryder: Electronic Fundamentals and Applications (PHI).
[2] Millman and Halkias: Electronic Devices and Circuits (TMH).
[3] Mottershed: Electronics Devices and Circuits (PHI).
[4] Rakshit and Chattopadhyay: Foundations of Electronics.
[5] R.P.Jain: Modern Digital Electronics.
[6] Gupta and Kumar: Handbook of Electronics

SEMESTER-II COURSE-V 4 CH

PHY-425 (GS/NS): Computer Practical (II)

Basic: Learning to plot graphs under windows and Linux OS, Learning to use Internet/E-mail, Learning to design web-pages - Learning the basic of HTML

Programming: (using Fortran and C)

1. Solution of cubic equation

2. Evaluation of integrals using Trapezoidal method and testing the accuracy of the method

3. Evaluation of integrals using Simpson's $1/3^{rd}$ method

4. Evaluation of integrals using Weddle's methods

5. Evaluation of integrals using Gauss quadrature formula

6. Numerical differentiation- calculation of first and second order derivatives at any point in the range of a tabular data

7. Solution of first order differential equations using Euler's method and testing the accuracy of the method

8. Solution of first and second order differential equations using Runge-Kutta method

9. Solution of first and second order differential equations using finite difference method

10. Solution of Eigen value equation – Schrodinger equation for a given potential

11. Generation of random numbers

(Any other experiments suggested by the Course Teacher)

SEMESTER-II COURSE-VI 2CH

PHY-426.: Electricity and Magnetism Practical

1. Static characteristics of a triode, tetrode, and pentode and determination of tube Parameters.
2. Static characteristics of BJT.
3. Determination of the tube constants of a triode by Miller's method.
4. Setting up, calibration and experiments with VTVM.
5. Measurement of current, voltage and frequency with CRO.
6. Setting up and study of unregulated power- supply with various filters and determination of ripple factor.
7. Determination of power factor of a fan.
8. Measurement of the ballistic constant using the Hilbert's magnetic standard.
9. Measurement of ballistic constant by standard solenoid.
10. Measure of a magnetic field by using a search coil and Bismuth spiral.
11. Experiments to obtain B.H. curve.

(Any other experiments suggested by the Course Teacher)

SEMESTER - III COURSE - I 4CH

PHY- 511 (GS): Solid-State Physics

1. **Lattice Vibration and Thermal properties of solids:** Normal modes of mono and diatomic lattice, salient features of dispersions curves, phonon density of states, quantum theory of heat capacity.
2. **Free electron theory of matter:** Sommerfeld theory of free electron gas, density of states, Fermi-Dirac (FD) distribution function and its temperature dependence, electronic heat capacity, Hall effect and cyclotron resonance.
3. **Band Theory:** Bloch Theorem, Nearly free electron model (NFEM), approximate solution near a Zone boundary, Kronig-Penny model, effective mass.
4. **Semiconductor Physics:** Intrinsic and extrinsic semiconductors, band model, carrier concentration and electrical conductivity, law of mass action.
5. **Magnetism:** Review of basic formulae, quantum theories of dia, para and ferromagnatism, elementary idea of antiferromanetism, Ferrimagnetism.
6. **Dielectric Properties:** Definitions, local field, Clausius-Mossotti relation, Polarizability.
7. **Superconductivity:** Experimental study, Meissner effect, Type-I and Type-II superconductors, London's equation, elementary discussion of the BCS theory, High T_C superconductors.

Texts and References:

[1] M. Ali Omar Elementary Solid State Physics, Pearson Edition
[2] A.J. Dekker: Solid-state Physics
[3] C. Kittel: Introduction to Solid-state Physics, Wiley Edition
[4] Ashcroft and Mermin: Solid-state Physics.
[5] Kachhava: Solid-state Physics.
[6] S.O. Pillai: Solid-state Physics.

SEMESTER - III COURSE- II 2 CH

PHY- 512 (GS): X-Rays and Spectroscopy

(i) **X-rays:** Production and properties of X-rays, Augur transitions, Thomson and Compton scattering, X-ray spectra, Mosley diagram, Regular and irregular doublets.

(ii) **Atomic Spectra:** Sommerfeld's extension of the Bohr theory, fine structure of Hydrogen lines, series spectra of alkali metals, Zeeman spectra, Paschenback effect, the Stern-Gerlach Expt., Hyperfine splitting, LS and JJ coupling schemes.

(iii) **Molecular spectra:** Vibrational and rotational spectra, Raman spectra, selection rules, the Frank-Condon principle, elementary theory of lasers, optical pumping and coherence.

Texts and References:

[1] Compton and Allison: X-rays in theory and expts.
[2] Clark: Applied X-rays.
[3] Sproull: X-rays in practice.
[4] White: Atomic spectra.
[5] Hertzberg: Spectra of diatomic molecule.
[6] King: Spectroscopy and molecular spectra.
[7] Bhagawantam: Scattering of light and Raman spectra.

SEMESTER - III COURSE- III 2 CH

PHY- 513 (GS): Relativistic Electrodynamics

1. **The 4-vector covariant formulation:** 4-vector gradient and the D'Alembertian operator, the charge-current 4-vector and covariant formulation of charge conservation law, the 4-vector electromagnetic potential, covariant formulation of the wave equation for the electromagnetic potentials in the Lorentz gauge and the Lorentz condition, Maxwell's electromagnetic field tensor in Minkowski space and transformation equations for the electromagnetic field components, covariant formulation of Maxwell's equations and the Lorentz force law, the four dimensional wave vector and invariance of the phase of plane electromagnetic wave under Lorentz transformation, relativistic Doppler effect, the electromagnetic stress-energy-momentum tensor in the 4-dimensional, Minkowski space and covariant formulation of energy and momentum conservation law for a system of charge particles and electromagnetic fields. Energy momentum conservation in relativistic collision between two particles. Covariant formulation of equation of motion of a charge particle under electromagnetic force, relativistic generalization of Larmor formula.

2. **Dynamics of Relativistic particles and electromagnetic fields:** Lagrangian and Hamiltonian of a charge particle with electromagnetic forces.

Texts and References:

[1] J.D. Jackson: Classical Electrodynamics.
[2] H. Goldstein: Classical Mechanics.
[3] B.G. Levich: Theoretical Physics.

SEMESTER - III COURSE – IV 4CH

PHY- 514 (GS): SPECIAL PAPER – I

(The student shall choose any one of the following special papers)

1) Electronics (I)

1. **Fundamentals:**
   Semiconductors: Formation of energy bands, band gap, elemental and compound semiconductors, E-k diagram, direct and indirect semiconductors, electrons and holes, effective mass, intrinsic semiconductors, extrinsic semiconductors – donor and acceptor levels, Fermi level and Fermi-Dirac distribution function, density of states, thermal equilibrium electron and hole concentrations in C-band and V-band respectively, Intrinsic carrier concentration and Fermi level, extrinsic carrier concentration and Fermi level, degenerate and non-degenerate semiconductors.
   Carrier transport: Drift current density, mobility and conductivity, velocity saturation, diffusion and total current density.
   Excess carriers: Generation and recombination, continuity equation, time dependent diffusion, steady state carrier injection, diffusion length

2. **Junctions:**
   p-n junction: basic structure, contact potential, electric field, space charge width, effect of reverse biasing, junction capacitance, linearly graded junction, hyper abrupt junction and the varactor, forward bias and current flow in p-n junction, carrier injection, minority carrier distribution, ideal current-voltage relation, junction breakdown – Zener and avalanche, transients and switching diodes.
   Metal-semiconductor junction: Ohmic and rectifying contacts, Schottky diode – ideal junction properties, non-ideal effects on barrier height, current-voltage characteristics, comparison with p-n junction.
   Heterojunctions: Materials and band diagram, 2-D electron gas, electric field, potential, space charge, junction capacitance, isotype and anisotype heterojunction, current-voltage relation.

3. **Transistors:**
   BJT: Fundamentals of BJT operation, current gain relations, amplification with BJT, minority carrier distribution, evaluation of terminal currents and current gains and approximations for them, biasing modes and Ebers-Moll model, BJT switching, non-ideal effects – base width modulation, high

injection, emitter band gap narrowing, non-uniform base doping, avalanche breakdown.

JFET: basic operation, pinch off and saturation, ideal dc current voltage relation, transconductance, the MESFET

MOSFET: Properties of the two terminal MOS structure, the MOSFET structure, current-voltage relation, transconductance

HEMT and MODFET: Quantum well structure, Transistor performance, current-voltage relation.

4. **Special Devices:** Basic structure, principle, mechanism of operation, Current voltage relation/characteristics and applications of SCR, UJT, Diac, Triac; photodiode, photo transistor, solar cell, LED, Laser diode, Tunnel diode, Gunn diode and IMPATT diode.

Text Books:

[1] Semiconductor Physics and Devices by Donald A. Neamen (TMH)
[2] Solid State Electronic Devices 4th Edition by Ben G. Streetman (PHI)

Reference books:

[1] Physics of semiconductor devices: S.M. Sze
[2] Physics of semiconductor devices by D.K.Roy, University press
[3] Electronics devices and circuits: Boylested and Nasholsky
[4] Electronics devices and circuit theory: Mottershed

2) Nuclear Physics (I)

1. **Nuclear forces and two nucleon systems:** Spin, parity and iso-spin of two nucleon states, symmetry and nuclear forces.

2. **The Deuteron problem:** Ground state of Deuteron with central force and tensor force, magnetic dipole moment and eletric-quadrupole moment of the deuteron, Low energy Neutron- Proton scattering and phase shift, effective range theory and low energy neutron proton scattering parameters and charge independence of nuclear force.

3. **Meson theory of nuclear force:** scalar and pseudo-scalar meson theory, exchange character of nuclear force, elementary idea about three body and many body forces in nuclei.

4. **Shell Model and Unified Collective Model of the Nucleus:** Motion of nucleon in a mean field of force and extreme single particle shell model, Magic numbers in infinite square-well and harmonic oscillator potential well, spin-orbit interaction and prediction of correct magic numbers, Angular momentum, magnetic dipole moment and electric quadrupole moment of odd-A nuclei, elementary ideas about single particle shell model.

5. **Collective motion in nuclei:** Rotational and Vibrational motions, Rotational spectra of even-even and odd-A nuclei, collective surface vibration of deformed nuclei in the liquid drop model.

Text and References:

.

[1] Roy and Nigam: Nuclear Physics. (TEXT)
[2] Elton: Introductory Nuclear Physics
[3] Ghosal: Nuclear Physics (Chand Publishers).
[4] Preston and Bhaduri: Structure of the Nucleus.
[5] K Heyde, The Nuclear Shell Model, Basic Ideas and Concepts in Nuclear Physics
[6] Bohr and Mottelson, Nuclear Structure Vol-II
[7] Samuel S.M. Wong: Introductory Nuclear Physics
[8] Greiner Marulin: Nuclear Models

3) Condensed Matter Physics (I)

1. **Lattice Dynamics:** Harmonic and Anharmonic approximation, Born-Openheimer approximation, Hamiltonian for lattice vibration in the harmonic approximation to normal modes, quntisation, phonons.

2. **Energy Band Theory:** wave equation of an electron in a periodic potential, Bloch Floquet theorem, Brillouin zones, Effective mass of an electron, tight binding approximation.

3. **Fermi Surfaces:** Characteristics of the fermi surfaces, construction of the fermi surfaces, case of metals, experimental studies of the fermi surfaces, De Hass Van Alphen effect, Cyclotron resonances in metals.

4. **Beyond the Independent Electron Approximation:** Hartree and Hartree-Fock equation, correlation, Screening,Thomas Fermi Theory of di-electric function.

5. **Wannier representation:** Wannier function, Equation of motion in the Wannier representation, The equivalent Hamiltonian-Impurity levels, Excitons.

Texts and references:

1. Kittel: Introduction to solid-state physics.
2. Kittel: Quantum theory of solids.
3. Ibach and Luth: Solid-state physics.
4. Kachhava: Solid state physics.
5. Aschroft and Mermin: Solid-state physics.
6. Ziman: Principles of the theory of solids. (Vikash publishing house pvt. Ltd).
7. M.Ali Omar: Introduction to solid-state physics.

4) High-Energy Physics (I)

1. **Basic Field Theory:** Lagrangian formulation, Euler-Lagrange equations, symmetries of the Lagrangian, Noether's theorem, canonical quantisation procedure, symmetries of quantum fields, quantisation of free hermitain scalar field, Dirac field and electromagnetic field, propagators as vacuum expectation values, time ordering, normal ordering.

2. **Fields in Interaction:** Construction of interaction Lagrangians, Interaction picture and S matrix, Wick's theorem, Feynman diagrams, Lowest order calculation of Compton scattering, the Klein-Nishina formula. Elementary discussion of mass and charge renormalisation in the lowest order.

Texts and References:

[1] Leon: Particle physics: An Introduction (AP)
[2] Perkins: Introduction to High-energy Physics.
[3] Cheng and O'neil: Elementary particle Physics.
[4] S N Ghosal: Atomic and Nuclear Physics
[5] M P Khanna: Particle Physics an Introduction

SEMESTER - III COURSE - V 2 CH

PHY- 515 (GS): Classical Fields

1. **Lagrangian and Hamiltonian formulation of fields:** Transition from a discrete to continuous system, Lagrangian formulation of continuous system and fields, Action principle and Euler-Lagrange equation for fields. Poisson bracket, Hamiltonial formulation.

2. **Symmetry transformation and Noether's theorem, Rotation:** Angular momentum operators, Representation of rotation group, Rotation matrices, Parity, time reversal, Rotation in four-dimensional Minkowski space, angular momentum tensor.

3. **Electromagnetic fields:** Equation of motion of a charge in a field, Gauge invariance, Fourier resolution of the electrostatic field, characteristic vibration of the field, Lagrangian and Hamiltonian of the field.

4. **Quantization of fields:** Field operators, many particle representation, Quantization of Boson and Fermion fields.

Texts and References:

[1] The classical Theory of Fields (vol-2) by Landau and Lifshitz
[2] Quantum mechanics and Field Theory by B.K. Agrawal
[3] Classical mechanics by Goldstein
[4] Quantum mechanics by L.I. Schiff
[5] An introduction to Quantum Field Theory by Palas Das

SEMESTER –III COURSE - VI 4 CH

PHY- 516 (GS): Modern Physics Practical (I)

1. Experiments with the ESR Spectrometer, determination of the Lande's g-factor.
2. Resistivity of semiconductor at different temperatures by Four-probe Method.
3. Determination of Hall Coefficient by Hall effect apparatus.
4. Determination of e/m by Braun tube method.
5. Determination of e/m by helical method.
6. Determination of e/m by Magnetron Valve.
7. Determination of Plank's constant using an optical pyrometer.
8. Determination of Planck's constant using photocell and a ballistic Galvanometer.
9. Verification of Bohr's postulates using Frank-Hertz experiment.

(Any other experiment suggested by the course teacher)

SEMISTER – III **COURSE - VII** **4 CH**

PHY – 517 (GS): Special Paper Practical (I)

The student shall choose the corresponding special paper practical as for Course No. PHY – 514 (GS)

1) Electronics Practical (I)

1. Characteristics of OP-Amp IC741, Inverting and Non-Inverting type, Mathematical Operations using Op-Amp - Adder, Substractor, Differentiator and Integrator.

2. Feedback amplifier using Op-Amp.

3. Relaxation Oscillator using Op-Amp

4. High and low frequency compensation of RC amplifier.

5. Effect of circuit elements on RC amplifier frequency response.

6. Negative feedback effects on RC amplifier.

7. Characteristics of RF amplifier.

8. Characteristics of power amplifier.

9. Hartely oscillator.

10. Colpitt Oscillator

11. Phase shift Oscillator

12. Astable Multivibrator

13. Characteristics of a regulated power supply

14. Characteristics of an FET Amplifier

(Any other experiment suggested by the course teacher)

2) Nuclear Physics Practical (I)

Experiments with GM counter**:**

1. Determination of the operating plateau and its percentage slope.

2. Determination of the dead time of the instrument using Beta source.

3. Determination of the linear mass absorption co-efficient of aluminium for beta source.

4. Determination of the end point energy of beta rays by finding its range in aluminium.

5. Verification of the inverse square law.

6. Determination of half-life of given beta-source.

7. Calibration and determination of resolution of the spectrometer.

8. Spectrum analysis of given Gamma-sources (Cs^{137}, Co^{60}, Co^{57}, N^{22} etc) with the photo peak, back scatter peak, Compton peak etc.

9. Determination of energy and relative intensity of Gamma rays of the supplied source.

10. Determination of the resonance frequencies of different samples using Nuclear Magnetic Resonance technique.

11. Determination of Lande's "g" factor using Nuclear Magnetic Resonance technique.

(Any other experiment suggested by the course teacher)

3) Condensed Matter Physics Practical (I)

1. Measurement of magnetic susceptibility (χ_m) by Quinck's method
2. Measurement of χ_m of solid by magnetic balance.
3. Measurements with the Ultrasonic-interferometer: determination of velocity of ultrasonic waves in the given liquid.
4. Measurements of the di-electric constant of the given liquid by the ultrasonic interferometer.
5. Determination of heat capacity of a given sample.
6. Measurements of di-electric constant of wax (and other materials) using the Lecher wire.
7. To study the hybrid parameters of a junction transistor.
8. Experiments with the Lattice dynamics Kit: (i) Study of dispersion relation of Mono and di-atomic linear chain, (ii) to determine the band-gap frequency.
9. Study of LED, Zener diode and Phototransistor characteristics.
10. Determination of energy gap of a given semiconductor.
11. Determination of transition temperature of the given high T_c material using superconducting kit.
12. Determination of transition temperature of the given high T_c material by plotting resistance versus temperature curve using superconducting kit.
13. Verification of Bohr's postulates using Frank-Hertz experiment.

(Any other experiment suggested by the course teacher)

4) High-Energy Physics Practical (I)

Experiments with GM counter**:**

1. Determination of the operating plateau and its percentage slope.
2. Determination of the dead time for Beta rays.
3. Determination of the linear mass absorption co-efficient of aluminium for beta source.
4. Determination of the end point energy of beta rays by finding its range in aluminium.
5. Verification of the inverse square law.
6. Determination of half-life of given beta-source.
7. Experiments with the Gamma Ray Spectrometer:
8. Calibration and determination of resolution of the spectrometer.
9. Spectrum analysis of given Gamma-sources (Cs^{137}, Co^{60}, Co^{57},N^{22} etc) with the photo peak, back scatter peak, Compton peak etc.
10. Determination of energy and relative intensity of Gamma rays of the supplied source.

(Any other experiment suggested by the course teacher)

SEMISTER - III **COURSE - VIII** **2 CH**

PHY – 518 (GS): Seminar

Every student will deliver a seminar talk on novel ideas in Physics which will be evaluated by the faculty members of the School of Physics

SEMESTER - IV **COURSE - I** **4 CH**

PHY- 521 (GS): Nuclear Physics

1. **Basic facts about Nuclei:** Composition, mass, charge, density, radii, spin parity, I-spin and statistics, Nuclear size: Nuclear and E.M. methods, electron scattering.

2. **The two Nucleon problem and Nuclear Force:** Ground state of deuteron with central force, low energy neutron-proton scattering, concept of scattering length and spin dependence of nuclear force, Elementary idea about proton-proton and neutron-neutron scattering.

3. **Symmetries and Nuclear Force:** Exchange nature of nuclear force, phenomenological nucleon-nucleon potentials, elementary idea about Meson theory of nuclear force.

4. **Nuclear Structure:** Binding energy, semi-empirical mass formula, Fermi Gas Model, extreme single particle shell model, magic numbers, magnetic moments.

5. **Nuclear Reaction:** Elastic and reaction cross-sections, compound nucleus, resonances, Breit-Wigner formula.

6. **Radioactivity:** Laws of radioactivity, Gamow theory of alpha decay, Fermi theory of beta decay, selection rules.

Texts and References:

[1] Elton: Introductory Nuclear Physics.
[2] Roy and Nigam: Nuclear Physics.
[3] Ghosal: Nuclear Physics (Chand Publishers).
[4] Preston and Bhaduri: Structure of the Nucleus.

SEMESTER - IV COURSE - II 4 CH

PHY- 522 (GS): Particle Physics

1. **Particle and their classification:** Basic interactions and their characteristics, leptons, hadrons and gauge fields.

2. **Symmetries and conservation laws:** Energy, momentum, angular momentum, electric charge, lepton and baryon number, parity, charge conjugation and time reversal, so-spin, strangeness and hypercharge quantum numbers, the Gellman Nishijima scheme.

3. **Elementary discussion of the quark model:** Colour and flavour, basic characteristics of weak interaction, parity non-conservation in weak interaction.

4. **Detection of particles and radiation:** Passage of radiation through matter, classical derivation of stopping power (dE/dx) of heavy charged particles, G.M. counter, semi-conductor detectors, bubble chamber and cloud chamber, spark counter.

5. **Accelerators:** The Van-de Graff generator, cyclotron, synchrotron, linear and circular operators.

Texts and References:

[1] Leon: Particle physics: an introduction (AP)
[2] Perkins: Introduction to High-energy physics.
[3] Cheng and O'neil: Elementary particle physics.
[4] S N Ghosal: Atomic and Nuclear Physics
[5] M P Khanna: Particle Physics an Introduction

SEMESTER - IV **COURSE - III** **4 CH**

PHY – 523 (GS): Special Paper-II

The student shall choose second part of the corresponding special paper as in PHY - 514

1) Electronics (II)

1. **Fundamentals:** Transmission through Linear System; Ideal and Practical Filters; Distortion over a channel; Energy and Energy Spectral Density; Power and Power Spectral Density
2. **Analog Modulation:** Principle, Generation, and Detection of DSB, DSB-SC, AM, and SSB, Elementary idea on Superheterodyne AM Receiver; Exponential Modulation, Concept of Instantaneous Frequency, Bandwidth of Angle Modulated Wave, Indirect (Armstrong) and Direct Generation of FM, FM Demodulation, Interference in Angle Modulation.
3. **Digital Modulation:** Sampling approximations, Quantization, PCM, DPCM, Delta Modulation, Adaptive Delta Modulation, ASK, PSK, DPSK, and FSK.
4. **Noise in Communication Systems:** AM receiver SNR, Noise in DSB-SC & SSB using coherent receiver, Noise in AM using envelop detection, Noise in FM system, FM threshold effects, Pre-emphasis and De-emphasis in FM, BW requirements for CW Modulation.
5. **Information Theory and Coding:** Discrete message, Concept of Information amount, Entropy, Information Rate, Coding to increase Average Information per Bit, Shannon's Theorem, Channel capacity, Gaussian Channel Capacity, BW-S/N Tradeoff, Orthogonal Signals for Shannon's Limit, Orthogonal Signal Transmission efficiency.
6. **Ionosphere Communication:** Stratification of ionosphere, propagation of electromagnetic waves through the ionosphere, Effective ϵ and σ of an ionized gas, reflection and refraction of e-m waves by the Ionosphere, Attenuation factor for Ionosphere propagation, Effect of collision and Earth's magnetic field. Skip distance and Maximum usable frequency.

Texts and References:

[1] Principles of Communication Systems: Taub & Scheiling, TMH – 2nd Edition.
[2] Modern Digital and Analog Communication Systems: B. P. Lathi, Oxford University Press, 3rd Edition
[3] Electromagnetic waves & Radiating Systems: E.C. Jordan, K.G. Balman, PHI 2nd edition
[4] Communication Systems: Symon Hykins, New Age International.
[5] Electronic Communication System: Kennedy, TMH Publication.

2) Nuclear Physics (II)

1. **Nuclear Reactions:** Partial wave analysis, Scattering and reaction cross-section, Resonances, The one level Breit- Weigner formula for S-wave neutrons, Kapur-Pierl's many level dispersion formula for S-wave neutrons.

2. **Compound Nuclear Model:** Formation cross-section of compound nucleus and its various modes of decay. The continuum model of nuclear reaction, Statistical theory of nuclear reactions.

3. **The Optical Model:** The complex potential and mean free path of a nucleon in a nucleus, averaging of scattering and reaction cross section Phenomenological optical potentials. General features of direct nuclear reactions, stripping and pick-up reaction cross-sections in **Plane wave Born approximation, Qualitative features of distorted wave Born approximation.**

4. **Nuclear beta decay and weak interaction:** Observed beta decay spectrum, neutrino hypothesis and Fermi theory of beta decay, **Kurie plot**, Fermi and Gamow –Teller transitions, Nuclear transition matrix elements, weak interaction in beta decay and parity violation.

5. **Nuclear fission:** spontaneous and induced fission, fission cross section, mass and energy distribution of fission fragments, description of fission in the liquid drop model, nuclear fission as a barrier penetration phenomena, chain reaction and **elementary idea on construction and working** principle of fission reactors.

Texts and References:

[1] Roy and Nigam: Nuclear Physics.
[2] Preston and Bhaduri: Structure of the Nucleus.
[3] Pal: Theory of Nuclear Structure.
[4] Ghosal: Nuclear Physics (Chand)
[5] Elton: Introductory of Nuclear Physics.
[6] Blatt and Weisskof: Theoretical Nuclear Physics.
[7] Bethe and Morrison: Nuclear Physics.
[8] Samuel S.M. Wong: Introductory Nuclear Physics

3) Condensed Matter Physics (II)

1. **Magnetism:** Dia and Para magnetism, Langevin's equations, diamagnetic and Para magnetic susceptibility, the Curie law, quantum theory of paramagnetism, Pauli paramagnetism, Landau levels, Ferro, anti-ferro and ferrimagnetism, exchange interactions and their characterization, molecular field theory, temperature dependence, the ferromagnetic phase transition, spin waves and magnons, Bloch $T^{3/2}$ law, anti ferromagnetic order, Neel temperature, simple description of magnetic resonances: NMR and ESR, the Bloch equation.

2. **Superconductivity:** Fundamental characterization of superconductors, Meissner effect, London's equation, Instability of the Fermi sea and cooper pairs, BCS ground state and the BCS theory, comparison with experimental results, super current, critical current, the coherence length, type-I and type-II superconductors, elementary discussion of high T_C superconductors, Heavy Fermion superconductor and Fullerene superconductor.

3. **Nanostructured materials:** Brief introduction to different nanostructured materials, Discussion of the size dependent properties related to Mechanical, magnetic and optical properties of these nano particle, Quantum mechanical solution and the derivation for the energy spectrum and density of states for Quantum wells, Quantum wires and Quantum dots.

Texts and references:

[1] Kittel: Introduction to solid-state physics.
[2] Kittel: Quantum theory of solids.
[3] Ibach and Luth: Solid-state physics.
[4] Kachhava: Solid state physics.
[5] Aschroft and Mermin: Solid-state physics.
[6] Ziman: Principles of the theory of solids. (Vikash publishing house pvt. Ltd).
[7] M.Ali Omar: Introduction to solid-state physics.
[8] Nano material synthesis, properties and applications Ed by A.S. Edelsteuin and R.C.Cammarata (IOP publications).
[9] Physics and chemistry of finite systems: From clusters to crystals by P.Jena, S.N.Khana and B.K.Rao (Deventer: Kluwer) (1992).
[10] Quantum Heterostructures by Vladimir V Mitin, V.A.Kochelap, Michael A. Stroscio.

4) High-Energy Physics (II)

1. **Symmetries and quarks:** SU (2), SU(3), quarks and leptons, color and iso-spin quantum number, evidence for colour, hadrons as color singlets, Gellman-Okubo mass formula.

2. **Parton Model:** Deep inelastic scattering, scaling of structure functions, the quark-parton model, Scaling violations, elementary discussion on QCD.

3. **Standard Model:** Weak Interaction, V-A structure, Electro-Weak unification, Salam-Weinberg model, spontaneous symmetry breaking, masses of W and Z bosons, fermion masses and mixing, CP violation

4. **Neutrino Physics:** neutrino mass, neutrino oscillation in vacuum and in matter, Solar and Atmospheric neutrinos, Detection of neutrinos.

Texts and References:

[1] Perkins: Introduction to High Energy Physics
[2] T.D. Lee: Elementary Particle Physics and Field Theory
[3] Ryder: Quantum Field Theory
[4] Quigg: Particle Theory and Unification
[5] R.N. Mohapatra: Neutrino Physics
[6] Leon: Particle Physics

SEMESTER - IV **COURSE - IV** **2 CH**

PHY – 524 (GS): Modern Physics Practical (II)

1. Characteristics of an astable multi vibrator.

2. Experiments with a Lecher wire.

3. Spectral sensitivity of a photocell.

4. Experiments with an Ultrasonic interferometer.

5. Experiments with CD-spectrograph.

6. Magnetic susceptibility of solid by magnetic balance.

7. Determination of e by Millikan's Oil-drop method.

8. Determination of the resonance frequencies of different samples using Nuclear Magnetic Resonance technique.

9. Determination of Lande's "g" factor using Nuclear Magnetic Resonance technique.

(Any other experiment suggested by the course teacher)

SEMESTER - IV **COURSE - V** **4 CH**

PHY – 525 (GS): Special Paper Practical (II)

The student shall choose the corresponding special paper practical as for Course No. PHY – 514 (GS)

1) Electronics Practical (II)

1. Design and study of AM and SSB systems (Generation and Detection).

2. Design and Study of FM systems (Generation and Detection).

3. Design and Study of PCM, PAM and PDM (PWM) systems.

4. Study of truth tables of different logic gates.

5. Study of NAND and NOR gates as Universal building block.

6. Study of various arithmetic circuits, Half adder, full adder, half substractor, full substractor,

7. Study of various Flip-flops.

8. Study of 7-segment display.

9. Study of Multiplexer and Demultiplexer.

10. Design and study of TDM Units.

11. Design and study of FDM Units.

12. Study of ADC and DAC.

13. Measurement of microwave frequency, wavelength, power, and SWR.

14. Study of satellite communication.

(Any other experiment suggested by the course teacher)

2) Nuclear Physics Practical (II)

1. Determination of energy resolution of given Gamma sources.

2. Activity of the Gamma source (Relative Method).

3. Activity of the Gamma source (Absolute Method).

4. Photo-peak efficiency of Na-I crystals.

5. Experiments with the Beta-Ray Spectrometer:

6. Plot of momentum distribution of beta-rays.

7. Calibration by a pulser.

8. Determination of the end point energy of beta rays.

9. The Fermi plot and Kurie plot.

10. Measurement of energy spectrum of emitted beta rays.

11. Experiments with the radiation detection inerfacing instrument: Spectrum analysis of given Gamma-sources (Cs^{137}, Co^{60}, Co^{57}, N^{22} etc) with the photo peak, back scatter peak, Compton peak etc. by obtaining the spectrum on the computer screen with the radiation detection interfacing instrument.

12. Calibration of the gamma spectrum and determination of the energy of unknown source

(Any other experiment suggested by the course teacher)

3) Condensed Matter Physics Practical (II)

1. Measurement of electrical resistivity of germanium crystal by Four-Probe method, at different temperature.
2. Measurement of electrical resistivity of GaAs at different temperature by the Four-Probe method.
3. To set up and study the Hall-effect and measurement of carrier concentration in Ge, Si and GaAs semiconductor.
4. Determination of carrier mobility and Hall coefficient for Ge, Si, and GaAs.
5. Experiment with the electron spin resonance spectrometer.
6. Determination of dielectric constant of a given sample.
7. Determination of longitudinal velocity of Ultrasonic wave.
8. Study of characteristics of transistors (common base and common emitter configurations).
9. Study of characteristics of FET.
10. Determination of band gap in a semiconductor using p-n junction diode.
11. Determination of transistor parameters in CE, CB and CC using BJT. Configurations.
12. Determination of Young's modulus using Piezo electric oscillator.
13. Determination of Curie temperature of a given ferroelectrics sample.
14. Determination of loss factor and natural frequency of a sample.

(Any other experiment suggested by the course teacher)

4) High-Energy Physics Practical (II)

1. Determination of energy resolution of given Gamma sources.
2. Activity of the Gamma source (Relative Method).
3. Activity of the Gamma source (Absolute Method).
4. Photo-peak efficiency of Na-I crystals.
5. Experiments with the Beta-Ray Spectrometer:
6. Plot of momentum distribution of beta-d\rays.
7. Calibration by a pulser.
8. Determination of the end point energy of beta rays.
9. The Fermi-Curie point.
10. Measurement of energy spectrum of emitted beta rays.

(Any other experiment suggested by the course teacher)

SEMESTER - IV **COURSE - VI** **2 CH**

PHY - 526 (GS): Seminar

Every student will deliver a seminar talk on advances in their field of Special Paper and shall submit a write up of the same to the Teacher in charge seminar for record.