School of Physics (Autonomous), Sambalpur University
M.Sc. Physics (General Stream) Course Structure
Effective for 2018 -20 Batch

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

OBJECTIVE: To make the students understand the basic concepts of Classical and Relativistic Mechanics and its application in various field of Physics to bring them to a level where they can face the competitive examinations.

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.

OUTCOME: Students will be able to solve many problems in **NET, GATE, JEST** and other competitive Examinations.

Text Books:

[1] Mechanics :L.D. Landau and E.M. Liftshitz ,Pergamon Press
[2] Classical Mechanics : Herbert Goldstein , Pearson
[3] Introduction to classical Mechanics :David Morin, Cambridge University Press.
[4] Classical Mechanics :Tom Kibble, Imperial college press.

References:

[1] Classical Mechanics by J.C. Upadhaya, Himalaya Publishing House.
[2] Classical Mechanics by N. C. Rana and P.S. Joag, Tata McGraw-Hill, New Delhi

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.

Text books:

[1] Quantum Mechanics, Leonard I Schiff, Mc Graw-Hill 1968
[2] A Textbook of quantum mechanics / P. M. Mathews, K. Venkatesan, New York : McGraw-Hill Book Co., c1978.

References:

[1] Quantum Mechanics, Eugen Merzabacher, JOHN WILEY & SONS, INC.
[2] Quantum Mechanics, Franz Schewabl, Springer, Berlin, Heidelberg.
[3] Quantum Mechanics, John L. Powell and Bernd Crasemann, The Amazon Book.
[4] Quantum Mechanics, AjoyGhatak, S. Lokanathan, Springer Netherlands.

SEMESTER-I COURSE-III 4CH

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

Objective: This course will help the students to solve the mathematical problems in 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:** First and second Order Differential Equations, Separation of Variables, Ordinary Differential Equations, Singular Points, Series Solutions – Frobenius' Method, Special functions (Hermite, Bessel, Laguerre and Legendre functions as an assignment), 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.

OUTCOME: Students will be able to solve the problems in **NET, GATE, JEST** and other competitive Examinations.

Text Books:

[1] G.B. Arfken, H.J. Weber and F. Harris: Mathematical Methods for Physicist: A Comprehensive Guide (Elsevier Science and Technology)

[2] T.L. Chow: Mathematical methods for Physicist: A concise introduction (Cambridge University Press)

References:

[1] P. Dennery and A. Krzywicki: Mathematics for Physicists (Harper and Row)

[2] A. W. Joshi: Matrices and Tensors in Physics (Wiley – Eastern)

[3] P. K. Chattopadhyay: Mathematical physics (Wiley- Eastern)

[4] M. C. Potter and J. 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 Books:

[1] Byron Gottfried: Programming with C , Schaum outline series
[2] Byron Gottfried: Programming with FORTRAN 77 , Schaum outline series
[3] Y. Kanetkar: Let Us C , BPB Publications

References:

[1] E. Balaguruswami: Programming in ANSI C , Tata McGraw-Hill

[2] Ian D Chivers and Jane Sleightholme: Interactive Fortran 77: A Hands on approach, Free book at http://www.ebooksdirectory.com/details.php?ebook=2763

[3] 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 Newton's and 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, Quadratic equation.

Texts Books:

[1] J.B. Scarborough: Numerical Mathematical Analysis , Oxford and IBH)
[2] E. Balagurusamy: Numerical Methods , Tata McGraw-Hill
[3] S. S. Sastry: Introductory methods of Numerical Analysis, Prentice-Hall India Pvt. Ltd. Publisher

References:

[1] V. Rajaraman: Computer Oriented Numerical Methods, PHI Learning Pvt. Ltd.
[2] 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, cubic spline, Newton and Starlin Interpolation 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.

Text Books:

[1] J.D.Jackson: Classical Electrodynamics, John Wiley & Sons Publisher.
[2] E.C.Jordan and K.G.Balman: Electromagnetic waves & Radiating Systems
[3] David J Griffith: Introduction to Electrodynamics, PHI publishing.
[4] B Podolsky and K S Kunz: Fundamental of Electrodynamics
[5] Feynman Lectures on Physics, R.P. Feynman, Addison-Wesley publishing.

References:

[1] B.G.Levich: Theoretical Physics, North-Holland Publishing Company.
[2] P. Lorrain and D. Corson: Electromagnetic Fields and Waves, WH Freeman & Co. publisher

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-Sommerfeldquantisation 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.**Semi-classical theory of Radiation.**
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.

Text Books:

[1] Quantum Mechanics, Leonard I Schiff, McGraw-Hill 1968

[2] A Textbook of quantum mechanics / P. M. Mathews, K. Venkatesan, New York : McGraw-Hill Book Co., c1978.

References:

[1] Quantum Mechanics, EugenMerzabacher, JohnWiley& Sons, INC.

[2] Quantum Mechanics, Franz Schewabl, Springer, Berlin, Heidelberg.

[3] Quantum Mechanics, John L. Powell and Bernd Crasemann, The Amazon Book.

[4] Quantum Mechanics, AjoyGhatak, S. Lokanathan, Springer Netherlands.

[5] Relativistic Quantum Mechanics, Bjorken Drell, McGraw-Hill.

SEMESTER-II COURSE-III 4CH

PHY-423 (GS/NS): Statistical Mechanics

OBJECTIVE: To make the students understand the basic concepts of Statistical Mechanics and its application in various field of Physics to bring them to a level where they can face the competitive examinations.

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.

OUTCOME: Students will be able to solve many problems in **NET, GATE, JEST** and other competitive Examinations.

Text Book:

[1] Statiatical Mechanics by K.Huang, Wiley publisher
[2] Statistical Mechanics by S L Gupta, Kumar V, Pragati Pakashan

References:

[1] J.D. Walecka: Fundamentals of Statistical Mechanics (World Scientific)
[2] Pathria: Statiatical Physics, Elsevier India Pvt. Ltd.
[3] Charles Kittel: Elementary Statistical Physics, Dover Publications

SEMESTER-II COURSE-IV 4CH

PHY-424 (GS) Basic Electronics

Objective:

To educate the students with the basics and intricacies of the given subject area and enable them to use the knowledge for meaningful applications.

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,

Outcome:

On successful completion of the curriculum, the students will understand the details of the given course and will be able to apply the knowledge in practical applications.

Text Books:

[1] P C Rakshit and D Chattopadhyay: Foundations of Electronics, New Age.
[2] P C Rakshit and D Chattopadhyay: Fundamentals and Applications, New Age.
[3] John D Ryder: Electronic Fundamentals and Applications , Prentice-Hall Inc.
[4] Robert L Boylestad and Louis Nashelsky: Electronic devices and circuit theory, Pearson
[5] Ramakant A. Gayakwad: Op-Amps and Linear Integrated Circuits , Pearson
[6] David A. Bell: Op-Amps and Linear Integrated Circuits , Prentice-Hall Inc

References:

[1] Jacob Millman and C C. Halkias: Electronic Devices and Circuits , Tata Mc-Hill.
[2] Allen Mottershead: Electronics Devices and Circuits, PHI.
[3] R.P.Jain: Modern Digital Electronics.
[4] S.L. Gupta and V. Kumar: Handbook of Electronics , Pragati Prakashan
[5] D. Roy Choudhary: Networks and Systems, New Age

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. Evaluation of integrals using Trapezoidal method and testing the accuracy of the method
2. Evaluation of integrals using Simpson's 1/3rd method
3. Evaluation of integrals using Weddle's methods
4. Evaluation of integrals using Gauss quadrature formula
5. Numerical differentiation- calculation of first and second order derivatives at any point in the range of a tabular data
6. Solution of first order differential equations using Euler's method and testing the accuracy of the method
7. Solution of first and second order differential equations using Runge-Kutta method
8. Solution of first and second order differential equations using finite difference method
9. Solution of Eigen value equation – Schrodinger equation for a given potential
10. 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

Objective: This course will help the students to understand the concepts of solid state physics and its application.

1. **Lattice Vibration and Thermal properties of solids:** Review of crystal structures and bonding in 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:** Sommerfeld theory of free electron gas, density of states, Fermi-Dirac (FD) distribution function and its temperature dependence, electronic heat capacity, cyclotron resonance and Hall effect, The AC conductivity and optical properties, Thermionic emission.
3. **Band Theory of Solids:** Bloch Theorem, Nearly free electron model (NFEM), Tight binding models, 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, Magnetic field effects.
5. **Magnetism:** Review of basic formulae, quantum theories of dia, para and ferromagnetism, Elementary idea of antiferromanetism, Ferrimagnetism, Paramagnetic resonance, Nuclear magnetic resonance, Spin waves.
6. **Dielectric and Optical Properties of solids:** Review of basic formulas, The local field, Clausius-Mossotti relation, Sources of polarizability, Dipolar dispersion, Piezoelectricity, Ferroelectricity.
7. **Superconductivity:** Experimental study, Meissner effect, Type-I and Type-II superconductors, Critical field, Thermodynamics properties, Isotope effect, The two fluid model, London's equation, Elementary discussion of the BCS theory, Tunneling and the Josephson effect, High T_C superconductors.

OUTCOME: Students will be able to solve the questions in **NET, GATE, JEST** and other competitive Examinations.

Text Books:

[1] M. Ali Omar**:** Elementary Solid State Physics, Pearson Edition

[2] S.O. Pillai: Solid-state Physics, New Age International Pvt. Ltd

[3] R.K. Puri and V.K. Babbar: Solid State Physics , S. Chand and Company Ltd.

References:

[1] A.J. Dekker: Solid-state Physics , Macmillan India Publisher

[2] C. Kittel: Introduction to Solid-state Physics , Wiley Edition

[3] N.W. Ashcroft and N.D. Mermin: Solid-state Physics , Thomson Press (India) Ltd.

[4] C.M. Kachhava: Solid-state Physics, Solid State Devices and Electronics, New Age International Pvt. Ltd

SEMESTER - III COURSE- II 2 CH

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

OBJECTIVE: To make the students understand the basic concepts of X-Ray and Spectroscopy and its application in various field of Physics to bring them to a level where they can face the competitive examinations.

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

2. **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.

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

OUTCOME: Students will be able to solve many problems in **NET, GATE, JEST** and other competitive Examinations.

Text Books:

[1] H. Compton and Samuel K. Allison: X-rays in theory and experiments, D. Van Nostrand Company Inc.
[2] George L. Clark: Applied X-rays, McGraw-Hill Book Company Inc.
[3] W. T. Sproull: X-rays in practice, McGraw-Hill Book Company Inc.
[4] Harvey E. White: Introduction to Atomic spectra, McGraw-Hill Inc.
[5] Gerhard Hertzberg: Spectra of diatomic molecule, Krieger Pub. Company
[6] G. W. King: Spectroscopy and molecular Structure , Holt, Rinehart, New York
[7] S. Bhagavantam: Scattering of light and Raman Effect, Chemical Publishing Company, New York

References:

[1] Atomic and molecular Spectra: Laser by Raj Kumar, Kedar Nath Ram Nath Publisher.
[2] Introduction to Atomic and Molecular Spectroscopy by Vimal Kumar Jain, Narosa Publishing House.

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.

Text Books:

[1] J.D. Jackson: Classical Electrodynamics, John Wiley & Sons
[2] H. Goldstein: Classical Mechanics, Pearson
[3] B.G. Levich: Theoretical Physics, North Holland Publishing Company.

SEMESTER - III COURSE – IV 4CH

PHY- 514 (GS): SPECIAL PAPER – I

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

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] Physics of Semiconductor Devices by Donald A. Naemen, TMH
[2] Solid State Electronic Devices 4th Edition by Ben G. Streetman, PHI
[3] Electronics devices and circuits: Robert L Boylestad and Louis Nashelsky, Pearson

References:

[1] Physics of semiconductor devices: S. M. Sze
[2] Physics of semiconductor devices by D. K. Roy, University press
[3] Electronics devices and circuit theory: Allen Mottershead, PHI.

PHY- 514 (GS): SPECIAL PAPER – I

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 Books:

[1] Nuclear Physics, R. R. Roy and B. P. Nigam, Wiley Eastern Limited.
[2] Introductory Nuclear Theory, L. R. B. Elton, Published by Saunders, Philadelphia.
[3] Introductory Nuclear Physics, Samuel S.M. Wong, Wiley-VCH Verlag GmbH & Co. KGaA.
[4] Introductory Nuclear Physics, Kenneth S. Krane, JOHN WlLEY& SONS.

References:

[1] Nuclear Physics, S. N. Ghoshal, S. Chand Publishing.
[2] Structure of the Nucleus, M. A. Preston and R. K. Bhaduri, CRC Press; 1 edition (December 21, 1993)
.
[3] Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach, K. Heyde, by CRC Press
.
[4] Nuclear Structure, Vol-I & II, Aage Bohr and Ben. R. Mottelson, World Scientific Publishing Co. Pte. Ltd..

[5] NuclearModels: Basic Conceptsin NuclearTheory, Joachim A. Maruhn, Springer London, Limited, 1997.

PHY- 514 (GS): SPECIAL PAPER – I

3) Condensed Matter Physics (I)

OBJECTIVE:

To educate the students with useful applications of Condensed Matter Physics and to enable them to recognize those applications.

UNIT-1. Lattice Dynamics

Harmonic and Anharmonic approximation, Born-Openheimer approximation, Hamiltonian for lattice vibration in the harmonic approximation to normal modes, quantization, phonons.

UNIT-2. Energy Band Theory

Wave equation of an electron in a periodic potential, Bloch Floquet theorem, Brillouin Zones, Ellective mass of an electron, tight binding approximation.

UNIT-3. Fermi Surfaces

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

UNIT-4. Beyond the Independent Electron Approximation

Hartree and Hartree-Fock equation, correlation, Screening, Thomas Fermi Theory of di-electric function.

UNIT-5. Wannier Representation

Wannier function, Equation of motion in the Wannier representation, The equivalent Hamiltonian-Impurity levels, Excitons: Weakly bound excitons and Tight bound excitons

OUTCOME:

Upon completion of the subject, students will be able to understand the Condensed Matter Physics for their different applications.

Text Books:

1. Introduction to Solid State Physics by C. Kittel, Wiley Publication
2. Quantum Theory of Solids by C. Kittel, Wiley Publication
3. Solid State Physics by H. Ibach, H. Luth, Springer Publication
4. Solid State Physics by C. M. Kachhava, TATA McGraw- Hill Publication

References:

1. Solid State Physics by Neil W. Aschroft, N. David Mermin Cengage Learning Pub
2. Principles of Theory of Solids by J. M. Ziman, Cambridge University Press
3. Elementary Solid State Physics by M. Ali Omar, Pearson Publication

PHY- 514 (GS): SPECIAL PAPER – I

4) High-Energy Physics (I)

Objectives and prerequisites of the Course: This course is intended to introduce the basics of quantum field theory (QFT). QFT is essential to understand nature at smallest scales hence it plays important roles in understanding particle physics, advanced nuclear physics, condensed matter physics and cosmology. Application of fundamental concepts QFT to Quantum Electrodynamics(QED) has been rigorously pursued in this course. The prerequisites for the course are Foundation of Quantum Mechanics and Advanced Classical Mechanics. Students should be prepared for lengthy algebraic expressions and calculations involving complex analysis, tensors, Dirac delta functions etc.

1. **Basic Field Theory:** Natural Units, Review of four vectors, tensors and Lorenz Invariance, Motivation for Local field theory, Elementary particles and fields, Lagrangian Density and Euler-Lagrange equations for Scalar, Complex scalar, Dirac and Vector fields.
2. **Symmetries and Conservation Laws:** Noether's theorem, Space-Time translations and the Energy-Momentum Tensor, Lorentz Transformations and Angular Momentum Tensor, Internal Symmetries, Global transformations, U(1) Local transformation and gauge fields. Coupling to Fermions, Coupling to Scalars, The Hamiltonian Formalism.
3. **Free Fields Quantization:** Canonical quantization procedure, Quantization of free hermitain scalar field and Complex Scalar fields. Vacuum, Cosmological Constant, Normal ordering, Relativistic Normalization. Dirac field. Spinors and its Lorentz Transformations, Bi-bilinear Covariants, Quantization of Dirac fields, Commutation and anti-commutation relations and spin statistics theorem, Electromagnetic field quantization, Gupta-Bleuler formalism. Propagators as vacuum expectation values, Green's Functions, time ordering and Wick's Theorem.
4. **Greens' Function and Fields in Interaction:** Propagators as vacuum expectation values, Green's Functions, time ordering and Wick's Theorem. Construction of interaction Lagrangians, Yukawa interaction, φ^4 interaction, The Heisenberg Picture, Interaction picture and S matrix, Dyson's Formula,.
5. **QED and Elementary process**: QED Lagrangian and Perturbative expansion of S Matrix. 1st and 2nd order diagrams. Elementary process and Feynman rules in co-ordinate space, Feynman rules in momentum space. Lowest order calculation of Compton scattering, Klein-Nishina formula. Elementary discussion of mass and charge renormalisation.

Expected Learning Outcome of the course:

- To understand how quantum mechanics and special relativity combine to produce theories of particle creation and annihilation.
- To develop calculational techniques to tree-level Feynman diagrams for quantum electrodynamics and to provide the foundation for more advanced studies in quantum field theory.

Text Books:

1. Quantum Field Theory: C Itzykson and J B Zuber: McGRAW-HILL International Editons 1985
2. Quantum Field Theory : Franz Mandl and Graham Shaw: John Wiley and Sons Ltd, 2010

References:

1. Quantum Field Theory: Lewis H. Ryder : Cambridge University Press: 1996 2nd Edition.
2. Donald H. Perkins: Introduction to High-energy Physics, Cambridge University Press
3. D. C. Cheng and G. K. O'neill: Elementary particle Physics, Addison-Wesley.

SEMESTER - III　　　COURSE - V　　　2 CH

PHY- 515 (GS): Classical Fields

1. Harmonic oscillator in matrix mechanics,

2. Quantization of radiation field: Procedure for second quantization of wave fields (non-relativistic theory), Lagrangian and Hamiltonian formulation of fields, transition from a discrete to continuous system, coordinates of the fields, Lagrangiian formulation for fields,

3. Qunatisation of fields: Field operators, many-particle representation, momentum representation and quantization of Boson and Fermion systems.

4. Covariant treatment of scalar fields: Covariant commutation rules for the fields, quantization, momentum representation and the frequency splitting, creation and annihilation operators, unequal space-time commutators and anti-commutators, propagator functions and their integral representation, vacuum expectation values, Feynman propagator

Text Books:

[1] L.H. Rider : Quantum Field Theory, Cambridge University Press
[2] H. Goldstein: Classical Mechanics, Pearson publisher.

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 Hellical method.
6. Determination of e/m by Magnetron Valve.
7. Determination of Plank's constant by using an optical pyrometer.
8. Determination of Planck's constant by using photo-cell and a ballistic Galvanometer.

(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. 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.

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

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

(suggestion: Experiment in No. 7 may be deleted)

(Any other experiment suggested by the course teacher)

3) Condensed Matter Physics Practical (I)

1. Measurement of magnetic susceptibility (X_m) by Quincke's method

2. Measurement of X_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

(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, 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.

Text Books:

[1] Lewis R. Elton: Introductory Nuclear Physics, publisher, Pitman, 1995
[2] Nuclear Physics, R. R. Roy and B. P. Nigam, Wiley Eastern Limited.
[3] S. N. Ghosal: Nuclear Physics , S. Chand Publisher.

References:

[1] Structure of the Nucleus, M. A. Preston and R. K. Bhaduri, CRC Press; 1 edition
[2] Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach, K. Heyde, by CRC Press

SEMESTER - IV COURSE - II 4 CH

PHY- 522 (GS): Particle Physics

Objectives and prerequisites of the Course: This course is aimed to introduce elementary particle physics from phenomenological and experimental prospectives. The treatment is non-mathematical and it is geared to expose students to the exciting discovery of new particles and the necessity of new ideas for theoretical explanations of observed phenomena. The prerequisites for the course are elements of Lie groups and Quantum Mechanics.

1. **Particle and their classification:** Basic interactions and their characteristics, Classification of elementary particles, their properties and history of their discovery, leptons, baryons, mesons and gauge fields.

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

3. **Elementary discussion of the quark model:** SU(3), Colour and flavour, quark model of hadrons, basic characteristics of weak interaction, parity non-conservation in weak interaction, CP violation.

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. Cherenkov Detectors.

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

Expected Learning Outcome of the course:

At the end the course students should be able to

1. Classify elementary particles and their reactions in terms of quantum numbers and interaction involved.
2. Describe the basic ingredients of the Standard Model of particle physics
3. Explain how experimental results are interpreted in terms of fundamental properties of quarks, leptons and force mediators
4. Master relativistic kinematics for computations of the outcome of various reactions and decay processes.

Text Books:

1. Introduction to Elementary Particles: David Griffiths: WILEY-VCH: 2008
2. Techniques for Nuclear and Particle Physics Experiments: How-to Approach: Leo, William R: Springer-Verlag: 1994

References:

[1] Melvin Leon: Particle physics: an introduction, Academic Press
[2] Donald H. Perkins: Introduction to High-energy physics, Cambridge University Press
[3] David C. Cheng and K. O'neil: Elementary particle physics, Addison Wesley.
[4] M P Khanna: Particle Physics an Introduction , Prentice hall of India Pvt. Ltd.

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

PHY – 523 (GS): Special Paper-II

The student shall choose second part of the 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.

Text Books:

[1] R. L. Boylestad & L. Nashelsky : Electronic Devices and Circuit Theory, Pearson edition

[2] Physics of Semiconductor Devices by Donald A. Naemen, TMH

[3] Solid State Electronic Devices 4th Edition by Ben G. Streetman, PHI

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: George A Kennedy, TMH Publication.

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

PHY- 521 (GS): Nuclear Physics

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.

6. **Nuclear Astro-Physics:Nucleosynthesis in star matter, CNO cycle, elementary idea on s-process and r-process**.

Texts:

[1] Nuclear Physics, R. R. Roy and B. P. Nigam, Wiley Eastern Limited.

[2] Introductory Nuclear Theory, L. R. B. Elton, Published by Saunders, Philadelphia.

[3] Introductory Nuclear Physics, Samuel S.M. Wong, Wiley-VCH Verlag GmbH & Co. KGaA.

[4] Cauldrons in the cosmos: Nuclear Astrophysics, Nuclear Astrophysics,Claus E. Rolfs and William S. Rodney, University of Chicago Press: 1427 E. 60th Street Chicago, IL 60637 USA.

[5] Compact stars : nuclear physics, particle physics, and general relativity, Norman K. Glendenning, New York ; Springer-Verlag.

References:

[1] Nuclear Physics, S. N. Ghoshal, S. Chand Publishing.

[2] Structure of the Nucleus, M. A. Preston and R. K. Bhaduri, CRC Press; 1 edition (December 21, 1993)

[3] Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach, K. Heyde, by CRC Press.

[4] Nuclear Structure, Vol-I & II, Aage Bohr and Ben. R. Mottelson, World Scientific Publishing Co. Pte. Ltd..

[5] Nuclear Models: Basic Concepts in NuclearTheory, Joachim A. Maruhn, Springer London, Limited, 1997.

[6] Theoretical Nuclear Physics, J. M. Blatt and V. F. Weisskof, Springer-Verlag New York.

[7] Theory of Nuclear Structure, M. K. Pal,Published by Scientific and Academic Editions (1983).

[8] Elementary Nuclear Theory, Hans Bethe and Philip Morrison, Dover Publications.

[9] Introductory Nuclear Physics, Kenneth S. Krane, JOHN WlLEY& SONS.

[10] Black Holes, White Dwarfs and Neutron Stars : the physics of compact objects, S. L. Shapiro & S. A. Teukolsky, WILEY-VCH Verlag GmbH & Co. KGaA.

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

3) Condensed Matter Physics (II)

OBJECTIVE:
This paper provides a broad knowledge on Condensed Matter Physics and their use in basic and applied research.

UNIT-1. Magnetism
Dia and Para magnetism, Langevin's equation, diamagnetic and Para magnetic susceptibility, the Curie law, Quantum theory of paramagnetism, Pauli paramagnetism, Landau levels, Ferro, anti-ferro and ferrimagnetism, The nature and origin of the Weiss molecular field: exchange interaction, Temperature dependence, the ferromagnetic phase transition, Spin waves and magnons, Bloch $T^{3/2}$ law, anti ferromagenatic order, Neel temperature, Simple description of magnetic resonances: NMR, ESR and Some applications, the Bloch equation.

UNIT-2. Superconductivity
Fundamental Characterization of Superconductors, Flux exclusion: Meissner effect, London's equation, Instability of the Fermi see and Copper pairs, The BCS theory, BCS Ground state, Comparision with experimental results, super current, the coherence length, Type-I and Type-II super conductors, Elementary discussion of high temperature superconductors, Heavy Fermions superconductor and Fullerene superconductor.

UNIT-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 particles, Quantum mechanical solution and the derivation for the energy spectrum and density of states for Quantum wells, Quantum wires and Quantum dots.

OUTCOME:
To make the students to understand the

- Magnetic properties and applications
- Superconductors and their different applications
- Nan materials and their properties

Text Books:

1. Introduction to Solid State Physics by C. Kittel, Wiley Publication
2. Quantum Theory of Solids by C. Kittel, Wiley Publication
3. Solid State Physics by H. Ibach, H. Luth, Springer Publication
4. Solid State Physics by C. M. Kachhava, TATA McGraw- Hill Publication
5. Solid State Physics by Neil W. Aschroft, N. David Mermin Cengage Learning Pub

References:

1. Nanomaterial synthesis, Properties and Applications Ed. by A.S. Edelstauin and R.C. Cammarata, IOP Publications
2. Physics and Chemistry of finite systems: From clusters to crystals by P. Jena, S.N. Khana and B.K. Rao, Deventer: Kluwer, 1992.
3. Quantum Heterostructures by Vladmir V. Mitin, V.A. Kochelap, Michael A. Stroscio.
4. Principles of Theory of Solids by Ziman, Vikas Publishing House Pvt. Ltd.
5. Elementary Solid State Physics by M. Ali Omar, Pearson Publication

SEMESTER - IV COURSE - III 4 CH

4) High-Energy Physics (II)

Objectives and prerequisites of the Course: This course is aimed to introduce the standard model of particle physics and neutrino physics to advanced undergraduate students. The course is taught from the experimental perspectives; covering details of the underlying theory along with mathematical details.The prerequisites for the course are Quantum field Theory and QED. Students should be prepared for lengthy algebras involving concepts of group theory and matrices.

1. **Symmetries and quarks:** Basic facts about Lie Algebras, SU (2), SU(3), quarks and leptons, strangeness, isospin and color quantum numbers, Eight fold way, Gellman-Nishijima formula, evidence for colour, hadrons as color singlets, Gellman-Okubo mass formula, Charge Conjugation, Parity and Time reversal symmetry.

2. **Gauge Theory and Spontaneous Symmetry Breaking:** Abelian and Non Abelian gauge theory. Geometry of Gauge Invariance, Yang-Mills Lagrangian, Spontaneous Symmetry Breaking in global and local gauge theory, Goldstone Theorem and Higgs Mechanism.

3. **Standard Model:** Helicity, Chirality, V-A structure of weak interaction, $SU(2)_L XU(1)_Y$, Glashow - Salam-Weinberg model and electro weak unification, masses of W and Z bosons, fermion masses and mixing, CP violation, Feynman Rules of Standard Model, production and detection of Higgs.

4. **Neutrino Physics:** neutrino mass, Solar and Atmospheric neutrinos, Detection of neutrinos, Standard Solar Model and neutrino puzzles, neutrino oscillation in vacuum and in matter, MSW resonance, neutrinos in cosmology.

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

Expected Learning Outcome of the course:

At the end the course students should be able to

- Describe the basic ingredients of the Standard Model of particle physics and recent developments in neutrino physics.
- Explain how experimental results are interpreted in terms of fundamental properties of quarks, leptons and force mediators
- Understand and calculate physical process of various extensions of Standard Model and beyond it.

Text Books:

1. An Introduction to Quantum Field Theory: Michael E Peskin and Daniel V Schroeder: Westview Press, 1995, Levant Books 2005.
2. Massive Neutrinos in Physics and Astrophysics:): Rabindra N Mohapatra and Palash B Pal : World Scientific Lecture Notes in Physics: Volume 72, 3rd Edition, 2004
3. Gauge Theories of the Strong, Weak, and Electromagnetic Interactions: Chris Quigg : Princeton University Press: Second Edition 2013.

References:

[1] D. H. Perkins: Introduction to High Energy Physics, Cambridge University Press

[2] T.D. Lee: Particle Physics and Introduction to Field Theory, Harwood Academic Publisher

[3] L.H. Ryder: Quantum Field Theory, Cambridge University Press

[4] M. Leon: Particle Physics: An introduction, Academic Press

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. Experiment with NMR

(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 Curie **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.