Department of Physics,
Government (Autonomous) College, Rourkela
M.Sc. Physics Course Structure
Effective from 2023 -24 Batch

I Semester

Course No	Course Title	Credit
AECC- I	Entrepreneurship Development	2 CH
PHY – 101	Classical and Relativistic Mechanics	4 CH
PHY – 102	Quantum Mechanics (I)	4 CH
PHY – 103	Mathematical Methods for Physics	4 CH
PHY – 104	Computer Programming	4 CH
PHY – 105	Computer Practical (I)	2 CH
PHY – 106	Optics Practical	2 CH
Total of I Semester		**22 CH**

Students have to enroll for a course on Entrepreneurship Development.

II Semester

Course No	Course Title	Credit
AECC- II	Environmental Studies & Disaster Management	2 CH
PHY – 201	Electrodynamics	4 CH
PHY – 202	Quantum Mechanics (II)	4 CH
PHY – 203	Basic Electronics	4 CH
PHY – 204	Statistical Mechanics	4 CH
PHY – 205	Computer Practical (II)	2 CH
PHY – 206	Electricity and Magnetism Practical	2 CH
Total of II Semester		**22 CH**

The students have to enroll for a course on Environmental Studies & Disaster Management to be offered by the college.

III Semester

Course No	Course Title	Credit
IDC	General concept of Physics	3 CH
PHY – 301	Solid State Physics	4 CH
PHY – 302	X-ray and Laser Spectroscopy	4 CH
PHY – 303	Condensed Matter Physics (I)	4 CH
PHY – 304	Research Methodology	4 CH
PHY – 305	Condensed Matter Physics Practical (I)	2 CH
PHY – 306	Modern Physics Practical (I)	2 CH
	MOOC course	3 CH
Total of III Semester		**26 CH**

The students will enroll for one MOOC course being offered which will be of 3 credits and the credit will be incorporated. Further students also have to enroll for a course on IDC or Open Elective to be offered by other departments of the college.

IV Semester

Course No	Course Title	Credit
PHY – 401	Nuclear Physics	4 CH
PHY – 402	Particle Physics	4 CH
PHY – 403	Condensed Matter Physics (II)	4 CH
PHY – 404	Research Project	4 CH
PHY – 405	Condensed Matter Physics Practical (II)	2 CH
PHY – 406	Modern Physics Practical (II)	2 CH
Total of IV Semester		**20 CH**

The students have to enroll compulsorily for one non-credit course like: Yuvasanskara, NCC/NSS/Sports/Yoga/ SUPW.

Grand Total Semester I to IV – 90 CH

Subject: M.Sc. Physics
Academic Session: 2023-25

I Semester

Course No	Course Title	Credit	Mark Distribution	Maximum Marks
AECC-I	Entrepreneurship Development	2 CH	60+20+20	100
PHY – 101	Classical and Relativistic Mechanics	4 CH	80+20	100
PHY – 102	Quantum Mechanics (I)	4 CH	80+20	100
PHY – 103	Mathematical Methods for Physics	4 CH	80+20	100
PHY – 104	Computer Programming	4 CH	80+20	100
PHY – 105	Computer Practical (I)	2 CH	50	50
PHY – 106	Optics Practical	2 CH	50	50
Total of I Semester		**22 CH**		600

Students have to enroll for a course on Entrepreneurship Development.

II Semester

Course No	Course Title	Credit	Mark Distribution	Maximum Marks
AECC-II	Environmental Studies & Disaster Management	2 CH	60+20+20	100
PHY – 201	Electrodynamics	4 CH	80+20	100
PHY – 202	Quantum Mechanics (II)	4 CH	80+20	100
PHY – 203	Basic Electronics	4 CH	80+20	100
PHY – 204	Statistical Mechanics	4 CH	80+20	100
PHY – 205	Computer Practical (II)	2 CH	50	50
PHY – 206	Electricity and Magnetism Practical	2 CH	50	50
Total of II Semester		**22 CH**		600

The students have to enroll for a course on Environmental Studies & Disaster Management to be offered by the college.

III Semester

Course No	Course Title	Credit	Mark Distribution	Maximum Marks
IDC	Concept of Physics (For non-core students)	3 CH	60+20+20	100
PHY – 301	Solid State Physics	4 CH	80+20	100
PHY – 302	X-ray and Laser Spectroscopy	4 CH	80+20	100
PHY – 303	Condensed Matter Physics (I)	4 CH	80+20	100
PHY – 304	Research Methodology	4 CH	80+20	100
PHY – 305	Condensed Matter Physics Practical (I)	2 CH	50	50
PHY – 306	Modern Physics Practical (I)	2 CH	50	50
	MOOC course	3 CH		
Total of III Semester		**26 CH**		600

A Mohanta 19.07.23   19/07/23   19/07/23   19/07/23   19/07/23   19/07/23   Ranjana 19.07.23

The students will enroll for one MOOC course which will be of 3 credits and the credit will be incorporated. Students have to choose from a list of related courses floated by different online platforms like SWAYAM and NPTEL. Further non-core students also have to enroll for a course on IDC to be offered by different departments of the college other than their respective departments.

IV Semester

Course No	Course Title	Credit	Mark Distribution	Maximum Marks
PHY – 401	Nuclear Physics	4 CH	80+20	100
PHY – 402	Particle Physics	4 CH	80+20	100
PHY – 403	Condensed Matter Physics (II)	4 CH	80+20	100
PHY – 404	Research Project	4 CH	100	100
PHY – 405	Condensed Matter Physics Practical (II)	2 CH	50	50
PHY – 406	Modern Physics Practical (II)	2 CH	50	50
Total of IV Semester		**20 CH**		500

The students have to enroll compulsorily for one non-credit course like:
Yuvasanskara, NCC/NSS/Sports/Yoga/ SUPW

Grand Total Semester I to IV – 90 CH

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

PHY- 101: 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 and Rigid body kinematics and dynamics:** Principal axis transformation, normal co-ordinates & normal modes, vibration of linear symmetric molecules, Generalized 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.
2. **Hamiltonian Formulation and Canonical transformations:** 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, Legendre transformation generating functions and classifications of canonical transformations, Poisson's brackets, Equations of motion in Poisson- bracket form, canonical invariants, Liouville's theorem.
3. **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.
4. **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: The students will be able to remember and derive various formulas of Hamiltonian mechanics, small oscillations, canonical transformations, rigid body dynamics and relativistic mechanics in four vector notation. They will be able to analyse the various concepts and solve problems relating to the knowledge gained. Apply the mechanical formulations learned, to practical physics/science problems in different topics and gain understandings about its limitations and their implication in quantum mechanics.

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

19/07/23 19/07/23 19/07/23 19/07/23 19/07/23 19.07.23 Rajana 19.07.23

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

PHY- 102 : Quantum Mechanics (I)

OBJECTIVE: Course introduces the methods to do the mechanics of atomic and subatomic particles.

1. **Review and Postulates of quantum mechanics:** Inadequacy of classical mechanics, Wave-particle duality, wave-packets, Uncertainty principle, Schrodinger equation, wave function and its significance, 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.
2. **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.
3. **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.
4. **Symmetries and conservation laws, and Theory of angular momentum:** Space and time translation symmetries, generators and the conservation of energy-momentum, symmetries under rotation, generators, 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.

OUTCOME: Familiarizing students with the theoretical framework of non-relativistic quantum mechanics and its applications to simple problems. The students will gain knowledge about general formalism of Quantum Mechanics, wave packets, uncertainty relation, representation in quantum mechanics, picture of quantum mechanics, Eigenvalue problem, matrix mechanics, angular momentum, Clebsch-Gordon coefficients. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. Apply the quantum mechanical techniques and laws learned to practical physics/science problems in different topics including chemistry and biology.

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., 1978.

[3] Quantum Mechanics 2nd Ed; Bransden and Joachain; Pearson; 2000;

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- 103 : Mathematical Methods for Physics

OBJECTIVE: This course will help the students to solve the mathematical problems in Physics.

1. **Function of a complex variable, Linear vector space and Matrices:** Residue theorem, evaluation of integrals by the method of residues, multi-valued function-branch point and branch cut, contour integration involving branch point, Definition, linear independence, basis and dimension, scalar product, dual vector, Cauchy-Schwarz inequality, orthonormal basis, Schmidt orthogonalisation process, Inverse of a matrix, orthogonal matrix, rotation, similarity transformation, Eigenvalues and Eigenvectors, secular equation, Cayley- Hamilton theorem, matrix diagonalisation.
2. **Partial differential equations and Group theory:** 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, 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.
3. **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.
4. **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: The students will be able remember and derive various theorems of complex variables, linear algebra , differential equations with special functions, tensors and group theory and integral transforms. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. Apply the mathematical techniques and laws learned, to practical physics/science problems in different topics.

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** **4CH**

PHY- 104: Computer Programming

OBJECTIVE: To gain basic knowledge on computer programming.

1. **Introduction to Program (General)**: Introduction to programming language, Programming discipline – algorithm and flow charts.
2. **Introduction to computer programming in Fortran 90/95**: Numerical constants and variables, arithmetic expressions; implicit declaration, named constants, input/output; List directed input/output statements, Format specifications.
   Logical expressions; IF structure, Block DO loop While, Do-While, For loops, Arrays and Strings, Functions, I/O with files, functions, subroutines
3. **Root Finding Methods**: Methods for determination of zeroes of linear algebraic equations: Secant Method, Newton-Raphson Method; Convergence of solutions; Solution of simultaneous linear equations.
   Interpolation and Approximation: Introduction to interpolation, Lagrange approximation, Newton polynomials.
4. **Numerical differentiation and Integration**; Numerical differentiation, Quadrature, Simpson's rule, Gauss's quadrature formula
   Differential Equations: Euler's method, Runge Kutta methods, Finite difference method.

OUTCOME: The students will be able write computer programmes in Fortran to solve algebraic transcendental, polynomial equations, linear simultaneous equations, Eigenvalue problem, Ordinary differential equations, Numerical integration, Interpolation, Random number generation. They will be able to analyse and debug programmes for scientific computing and solve problems relating to the expertise gained. Apply the programming skill developed to practical physics/science problems in different topics.

Texts Books:

[1] V. Rajaraman – Computer Programming in Fortran 90 and 95 (PHI Learning, 2013)

[2] Mathews, J.H., Numerical Methods for Mathematics, Science and Engineering, Prentice-Hall, (2000).

References:

[1] William H. Press, , Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Numerical Recipes: The Art of Scientific Computing, Cambridge University Press, (2007)

[2] Salaria, R.S., Programming in Fortran, Khanna Publishing, (2008).

SEMESTER-I **COURSE-V** **2CH**

PHY- 105: Computer Practical (I)

OBJECTIVE: 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 90/95)

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 by Lagrange method.
5. Numerical solution of simple algebraic equation by Newton-Raphson method
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. Plotting data file using GNUPLOT (line and surface plot)

(Any Other Experiments Suggested by Course Teacher)

OUTCOME: The students will learn basic OS commands under Linux and Windows use word processor under Windows and Linux, editor commands under Linux. They will use the editing command to write and execute computer programming in Fortran. They will be able sort numbers, sum various series, matrix inversion and solution to linear and quadratic equations and curve fitting. Apply the programming techniques learned, to practical physics/science problems in different topics.

SEMESTER-I **COURSE-VI** **2CH**

PHY- 106: 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)

OUTCOME: The students will experiment with biprism, single slit, double slit, plain diffraction grating, Babinet compensator, resolving power of telescope, Interferometers etc. They will be able to handle sophisticated equipment and learn its use in diverse field in science and technology. Apply the skill developed to pursue experimental research in advanced topics.

19/07/23 19/07/23 19/07/23 19/07/23 19/07/23 19.07.23 19.07.23

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

PHY-201 : Electrodynamics

OBJECTIVE: The course content covers the propagation of electromagnetic waves in linear media (vacuum, dielectric, and conductor).

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, polarization and dispersion, Radiation and Scattering:** Propagation of plane electromagnetic waves in free space, dielectrics and conductors, Reflection and refraction, polarization, Fresnel's law, 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. 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.

3. **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.

4. **Relativistic Electrodynamics: 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. Covariant formulation of equation of motion of a charge particle under electromagnetic force.

19/07/23 19/07/23 19/07/23 19/07/23 19.07.23 19/07/23 19.07.23

OUTCOME: It familiarizes students with different principles and phenomena when electromagnetic wave propagates in different media. Solve problems relating to 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. Apply the techniques and laws learned to the problems of energy momentum conservation in relativistic collision between two particles, dynamics of a charge particle under electromagnetic force, relativistic generalization of Larmour 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] Electrodynamics; Gupta, Kumar and Sharma; Pragati Prakashan; 2010
[4] David J Griffith: Introduction to Electrodynamics, PHI publishing.
[5] H. Goldstein: Classical Mechanics.
[6] B Podolsky and K S Kunz: Fundamental of Electrodynamics
[7] 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-202 : Quantum Mechanics (II)

OBJECTIVE: To utilize the principles of quantum mechanics to solve different problems at atomic level.

1. **Spin Angular Momentum and Identical Particles:** Expt. Evidence, Pauli theory, spin wave functions, properties of Pauli matrices, System of two spin1/2 particles, Symmetry and anti-symmetry of wave functions as conserved quantities, spin-statistics relation, Pauli exclusion principle, Simple manifestation of Pauli principle, Fermi level.
2. **Approximation Methods:** Time independent perturbation theory, energy levels and eigen functions up to 2nd 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.
3. **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.
4. **Relativistic Quantum Mechanics:** Klein-Gordon equation, drawback, Dirac equation – derivation, Properties of Dirac matrices, plane wave solution of Dirac equation.

OUTCOME: Students will learn about spin angular momentum, identical particles, scattering Theory, differential and total scattering cross-section laws, partial wave analysis and application to simple cases; Integral form of scattering equation, Born approximation validity and simple applications, Approximation Methods, Dirac equation and its solutions. They will be able to analyse the above concepts and solve quantum mechanical like approximation methods and exact solutions of Schrödinger equation problems relating to the knowledge gained. Apply the scattering and approximation methods to solve problems like tunnelling through barriers and use of scattering theory for understanding interaction between elementary particles.

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.

19/07/23 19/07/23 19/07/23 19/07/23 19/07/23 19-07-23 19.07.23

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

PHY-203: 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 and Oscillators:** 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, 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.

3. **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.

4. **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: Knowledge gained in areas like (i) Feedback in amplifiers, (ii) Audio power amplifiers, (iii) Oscillators, (iv) Power supplies and Electronic regulators, (v) Some special application of OP AMP, (vi) Digital electronics and (vii) Networks and lines. Students should be competent enough to design different electronic circuits which are very useful in the application point of view.

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-IV** **4 CH**

PHY-204 : 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 learn basic postulates of classical and quantum statistical mechanics; concepts of microstates, phase-space, partition function and density function; micro-canonical, canonical and grand canonical ensembles; various distribution functions and their application to degenerate Fermi gas, White dwarf system and Bose-Einstein condensation. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. Apply the statistical laws to study any thermodynamic system under equilibrium in solid state physics, nuclear physics and cosmology.

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

19/07/23 19/07/23 19/07/23 19/07/23 19/07/23 19.07.23 19.07.23

SEMESTER-II **COURSE-V** **2 CH**

PHY-205 : 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 90/95)

1. Evaluation of integrals using Trapezoidal method and testing the accuracy of the method
2. Evaluation of integrals using Simpson's method
3. Evaluation of integrals using Gauss quadrature formula
4. Numerical differentiation- calculation of first and second order derivatives at any point in the range of a tabular data
5. Solution of first and second order differential equations using Runge-Kutta method
6. Solution of first and second order differential equations using finite difference method
7. Solution of Eigen value equation – Schrodinger equation for a given potential
8. Generation of random numbers
9. Matrix diagonalization using LAPACK subroutine
10. Plotting spatial shape of p, d-orbitals using Gnuplot

(Any other experiments suggested by the Course Teacher)

Outcome: The students will learn to plot graphs under windows and Linux OS, to design web-pages and the basics of HTML. They will be able to execute numerical integration by various methods, differentiation and solution to differential equation of first and second order. Apply the programming techniques learned, to practical physics/science problems in different topics.

SEMESTER-II **COURSE-VI** **2CH**

PHY-206: 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)

Outcome: The students will experiment to determine characteristic triode, tetrode, pentode and BJT; use of CRO, Power efficiency of solar panels, Rectifiers, etc. They will be able to handle sophisticated equipment and learn its use in diverse field in science and technology. Apply the skill developed to pursue experimental research in advanced topics.

SEMESTER - III **COURSE - I** **4CH**

PHY- 301 : 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, Band Theory of Solids and Semiconductor Physics:** 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. Bloch Theorem, Nearly free electron model (NFEM), Tight binding models, Approximate solution near a Zone boundary, Kronig-Penny model, effective mass. Intrinsic and extrinsic semiconductors, band model, carrier concentration and electrical conductivity, law of mass action, Magnetic field effects.
3. **Magnetism, Dielectric and Optical Properties of solids:** Review of basic formulae, quantum theories of dia, para and ferromagnetism, Elementary idea of antiferromanetism, Ferrimagnetism, Paramagnetic resonance, Nuclear magnetic resonance, Spin waves. Review of basic formulas, The local field, Clausius-Mossotti relation, Sources of polarizability, Dipolar dispersion, Piezoelectricity, Ferroelectricity.
4. **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: The students will gain knowledge about the quantization of lattice vibrations, phonon momentum, thermal properties of solids, dielectric properties solids and its properties, band theory of solids, Semiconductor Physics, Magnetic properties of solids like Diamagnetism, paramagnetic, ferromagnetism, anti-ferromagnetism and ferrimagnetism and Superconductivity. Students will be able to: correlate the X-ray diffraction pattern for a given crystal structure based on the corresponding reciprocal lattice, explain how the predicted electronic properties of solids differ in the classical free electron theory, quantum free electron theory and the nearly free electron model, and explain various magnetic phenomena in solids.

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 4 CH

PHY- 302: X-ray and Laser Spectroscopy

OBJECTIVE: Laser spectroscopy topics covered here deals with the observation and interpretation of radiation absorbed or emitted by atoms or molecules. This information can lead into the knowledge of structure and properties of the atom/ molecule and help students to apply coherent light to solve various problems in areas such as scientific, industrial, healthcare etc.

1. **Atomic Spectra:** Sommerfeld's extension of the Bohr theory, Vector atom model, Quantum states of one electron atoms, Atomic orbitals, Hydrogen spectrum-Pauli's principle. Spin orbit interaction and fine structure in alkali Spectra, intensity rules – Equivalent and non-equivalent electrons. Interaction energy in LS and jj Coupling – Hyperfine structure
   Zeeman effect – Splitting of spectral lines in presence of weak and strong magnetic field, Stark effect, Two electron systems
2. **Molecular spectra:** Molecular spectra, Rotational spectra of diatomic molecules as a rigid rotator using Schrodinger wave equation and nonrigid rotator, intensity of rotational lines, Frank-Condon principle. Vibrational-rotational spectra, vibrational energy of diatomic molecule-Diatomic molecule as a simple harmonic oscillator, Effect of anharmonicity, Energy levels and spectrum-Morse potential, Raman spectroscopy
3. **Laser Fundamentals:** Einstein's quantum theory of radiation; Population inversion, Rate equations, Stability conditions, Three level and four level lasers;
4. **Types of Laser:** Issues in designing a laser; Pumping mechanisms; Stable and unstable resonators, Laser Cavity, Longitudinal and Transverse Modes, Mode Selection, Gain in a Regenerative Laser Cavity; Q-switching, Mode locking, Laser amplification, Ruby laser, He-Ne laser, Semiconductor lasers.

OUTCOME: The course will enable the student to get an idea about atomic and molecular spectra, spin orbit interaction, Zeeman and Stark effects, Raman spectra. Students will also learn fundamental principles of stimulated emission and how to convert it into coherent light emission, applications of various lasers in various fields including scientific research to common use.

Text Books:

[1] Atomic & Molecular Spectra; Raj Kumar, KedarNath Ram Nath, New Delhi, 1997
[2] Physics of Atoms and Molecules: Bransden and Joachain; Pearson; 2006.
[3] Lasers – Theory and Applications, by K. Thyagarajan and A. K. Ghatak; Macmillan.
[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] Introduction to Atomic and Molecular Spectroscopy by Vimal Kumar Jain, Narosa Publishing House.
[2] Lasers and Non-Linear Optics, B. B. Laud; New Age International, New Delhi.

SEMESTER - III **COURSE – III** **4CH**

PHY- 303 : Condensed Matter Physics (I)

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

1. Lattice Dynamics and Energy Band Theory

Harmonic and Anharmonic approximation, Born-Openheimer approximation, Hamiltonian for lattice vibration in the harmonic approximation to normal modes, quantization, phonons. Wave equation of an electron in a periodic potential, Bloch Floquet theorem, Brillouin Zones, Ellective mass of an electron, tight binding approximation.

2. 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.

3. Beyond the Independent Electron Approximation

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

4. 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: A more elaborate view on lattice dynamics leading to plotting determining phonon dispersion curves, detailed discussion of Band theory of solids leading to finding a real life electron band structure, Characteristics and experimental studies of the fermi surfaces, beyond the independent electron approximation used in complex systems and Wannier representation. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. So that it will help to pursue research career in respective fields.

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

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

PHY- 304: RESEARCH METHODOLOGY

Unit - I

Application of statistical concept / procedures, data, diagrammatic, representation of data, probability, Measure of central tendency, Measures of dispersion, Skewness and kurtosis. Normal distribution: Simple correlation, multiple correlation, regression analysis.

Unit - II

Sampling simple random sampling, stratified random sampling, Systematic sampling. Testing of Hypothesis tests. χ (Chi-square), t and F-tests; Analysis of Variance; Covariance; Principal component analysis, Experimental design: Completely randomized block design, Randomized block design, Latin square design.

Unit – III

One-way analysis of variance, two way analysis of variance, Follow up tests; Non parametric procedure; Plotting graph; Preparing paper/report using Latex. Writing of research reports.

Unit - IV

Integration: Trapezoidal, Simpson, Weddle's and Gaussian Quadrature methods; Differentiation: Numerical derivative; 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), Least square fitting of a set of points to a straight line, Quadratic equation.

Texts and References:

1) D.K. Bhattacharyya, Research Methodology, Excel Books, New Delhi, II Edition
2) C.R. Kothari, Research Methodology.
3) S.C. Gupta, and V.K. Kapoor, Fundamental of Mathematical Statistics, S. Chand, New Delhi.
4) P. Richard, Linux: The complete Reference, Mc GrawHill.
5) J.B. Scarborough, Numerical Mathematical Analysis, Oxford and I.B.H.
6) S. S. Sastry: Introductory methods of Numerical Analysis, Prentice-Hall India Pvt. Ltd. Publisher

SEMESTER –III **COURSE - V** **2 CH**

PHY – 305: 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)

OUTCOME: Students will do experiment on measurement of magnetic susceptibility ([illegible]m) of a paramagnetic substance by Quincke's method, determine the velocity of wave in a liquid medium, measurements of di-electric constant of wax using the Lecher wire, determination of heat capacity of a given sample, and experiments with the Lattice dynamics kit to study of dispersion relation of mono and di-atomic linear chain and to determine the band-gap frequency.

SEMISTER – III **COURSE - VI** **2 CH**

PHY- 306: 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.

OUTCOME: The students will do experiment determe the Lande's g-factor using ESR method, resistivity of semiconductor at different temperatures by Four-probe Method, Hall Coefficient by Hall effect apparatus, specific charge of electron by helical method, Planck's constant Planck's constant using pyrometer and photocell and Frank-Hertz experiment. They will be able to handle sophisticated equipment and learn its use in diverse field in science and technology. Apply the skill developed to pursue experimental research in advanced topics.

(Any other experiment suggested by the course teacher)

SEMESTER - IV COURSE - I 4 CH

PHY- 401 : Nuclear Physics

OBJECTIVE: To gain the knowledge of basic concept of nucleus, nuclear force, nuclear structure, nuclear reaction and nuclear transformation.

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

2. **Symmetries, Nuclear Force and Nuclear Structure:** Exchange nature of nuclear force, phenomenological nucleon-nucleon potentials, elementary idea about Meson theory of nuclear force. Binding energy, semi-empirical mass formula, extreme single particle shell model, magic numbers, magnetic moments.

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

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

OUTCOME: The students will learn about elementary nuclear physics, Meson theory of nuclear force, two nucleon system, nuclear structure and reactions and radioactivity. They will be able to analyse the above concepts and solve problems relating to the knowledge gained. Apply basic concepts to advanced topics in nuclear physics and technology.

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

19/07/23 19/07/23 19/07/23 19/07/23 19.07.23 19.07.23

SEMESTER - IV COURSE - II 4 CH

PHY- 402 : Particle Physics

OBJECTIVE: This course is aimed to introduce elementary particle physics from phenomenological and experimental prospective. 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.

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

OUTCOME: The students will gain knowledge about history of discovery of elementary particle and the nature of fundamental forces, baryon number, lepton number, Eightfold way, quark model of baryons and mesons, CP violation, accelerators and detectors. Apply the mind-set developed in the process to look into any issues relating science or society in a fundamental and logical way challenging conventional wisdoms.

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 – 403 : Condensed Matter Physics (II)

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

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.

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

3. **Types of superconductors:** Type-I and Type-II super conductors, Elementary discussion of high temperature superconductors, Heavy Fermions superconductor and Fullerene superconductor.

4. **Nanostructured Materials:** Brief introduction to different nanostructuredmaterials, 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: At the end of the course students will learn Crystallography, band structure of semiconductors, dielectric and optical properties insulators, phase transitions and critical phenomena, nanomaterials and liquid crystals. They will be able to analyse the above concepts and solve problems relating to the knowledge gained for the future endeavour.

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 - IV** **4 CH**

PHY - 404 : Research Project

Every student will have to work under the supervision of a faculty for a project and deliver a seminar talk on the findings.

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

PHY – 405: 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)

OUTCOME: Students perform experiment to measure resistivity of a material using four probe method, carrier concentration of semiconducting material using Hall effect, dielectric constants of solids and Curie temperature of a ferroelectric material.

SEMESTER - IV COURSE - VI 2 CH

PHY – 406 : 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)

OUTCOME: The students will do experiment to measure dielectric constant of a wax using Lecher wire, determine the velocity of ultrasonic wave in a liquid medium, measure the electric charge of a single electron, spectral sensitivity of photo cell and multi-vibrators, determine the Lande's "g" factor using Nuclear Magnetic Resonance technique. Apply the skill developed to pursue experimental research in advanced topics.

SEMESTER-III **3CH**

IDC: Inter Disciplinary Course (PHYSICS)

Inter Disciplinary Course offered by Department of Physics, GACR

Title of the Course: General Concepts of Physics.
Nature of Course: Open elective paper for students of other departments including students from humanities and social science.
Prerequisites: This course will be at popular level with school level mathematical/science knowledge. What is needed is curiosity to learn how physical world works.
Course Credit: 3 CH
Duration: 3 Hrs lecture/week, total 10 to 12 weeks duration in 3rd Semester.
Evaluation: 20 marks assignment, 20 marks mid semester and 60 marks end semester examination.
Course Objectives: Learning about concepts of physics in their scientific, historical and current technological context.

Unit-1 — 6 Hr

History of Modern Physics from Galileo, Newton up to Einstein, Introduction of solar system, galaxy, various astrophysical objects and big bang cosmology, Introduction of molecules, atoms, nucleus, elementary particles and their observation at various laboratories.

Unit-2 — 8 Hr

Nuclear Physics, Binding Energy, Nuclear Fusion and fission, Nuclear reactors, Nuclear Medicines, X-ray, MRI, PET/CT Scan.

Unit-3 — 8 Hr

Solid, Liquid and Gaseous state of matter. Metal, Insulator and semiconductor, Photoelectric Effect and its uses, Superconductivity and novel materials, Light and lasers, Laws of thermodynamics.

Unit-4 — 8 Hr

Basics of electronics, working of microphones, speakers and amplifiers, Power generation and transmission, Basics of Computers.