COURSES OF STUDIES

PHYSICS SYLLABUS FOR M.Sc DEGREE UNDER SEMESTER SYSTEM

SCHOOL OF PHYSICS
GANGADHAR MEHER UNIVERSITY
AMRUTA VIHAR, SAMBALPUR-768004, ODISHA

18 Sep 2020

VISION

To take the leadership in setting the standard of Physics Education in terms of Teaching and Research in the State and in the Country that will have a transformative impact on society through continual innovation in education, research and creativity.

MISSION

M1 - To make quality education accessible to students.
M2- To maintain high academic standards in teaching and research consistent with global scenario.
M2 - To encourage and facilitate faculty, researchers and students to work synergistically.
M3 - To establish collaboration with other academic and research institutes.

PROGRAMME OUTCOMES
(Chosen from the allowed list as set by UGC)

PO-1: Disciplinary Knowledge: Demonstrate comprehensive knowledge and skills of the disciplines that constitute a programme of study.

PO-2: Critical Thinking: Capability to apply analytic thought to a body of knowledge; analyse and evaluate evidence, arguments, claims, beliefs on the basis of empirical evidence; identify relevant assumptions or implications; formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development.

PO-3: Problem solving: Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge; and apply one's learning to real life situations.

PO-4: Research related skills: Demonstrate a sense of inquiry and capability for asking relevant questions; ability to recognize cause-and effect relationships, define problems, formulate and test hypotheses, analyze, interpret and draw conclusions from data; plan, execute and report the results of an investigation.

PO-5: Scientific reasoning: Ability to analyse, interpret and draw conclusions from quantitative/qualitative data; and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective.

PO-6: Digital Literacy: Capacity to use ICT in a variety of learning situations; demonstrate ability to access, evaluate and use variety of relevant information sources; use appropriate software for data analysis

PROGRAMME OBJECTIVES

(Set by School of Physics)

- Apply theoretical and Experimental knowledge in Physics to solve various problems in physical sciences.
- Develop abilities and skills that encourage research and development activities and are useful in everyday life
- Impart quality education in physics to students through well designed courses of fundamental interest and of technological importance.
- Develop the skill to plan, execute and report the result of extended experimental and theoretical Physics.

PROGRAMME SPECIFIC OUTCOMES

(Set by School of Physics)

PSO-1: Demonstrate the in-depth knowledge in various branches of Physics.
PSO-2: Apply theoretical Knowledge of Physics into various practical problems.
PSO-3: Interpret various Mathematical techniques and Mathematical models of physical behavior
PSO-4: Improve the fundamental concepts and advance techniques of Physics and Scientific methodology.
PSO-5: Enhance Intellectual, Computational, Experimental and Analytical skills of Physical Science.
PSO-6: Familiar with contemporary research within various fields of physics and have the background and experience required to model, analyze, and solve advanced problems in physics.

Matching

Matching Percentage	Level Indicator
> 70	3
= 60 %	2
< 50%	1

MISSION TO PLO MAPPING

	PO-1	PO-2	PO-3	PO-4	PO-5	PO6
M1	3	3	3	3	3	3
M2	3	2	3	3	3	2
M3	3	2	2	3	2	2
M4	1	2	1	3	1	1

PSO TO PLO MAPPING

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
PSO1	3	3	2	3	3	3
PSO2	1	3	3	2	3	3
PSO3	3	2	2	2	2	3
PSO4	1	2	3	3	3	2
PSO5	2	3	3	2	3	2
PSO6	1	2	2	3	1	1

A Brief Overview of Syllabus

FIRST SEMESTER			
Course No.	**Name of Course**	**Marks**	**Credit**
PHY-101	Mathematical Methods in Physics	20+80	4
PHY-102	Classical Mechanics	20+80	4
PHY-103	Quantum Mechanics-I	20+80	4
PHY-104	Statistical Mechanics	20+80	4
PHY-105	Computational Methods in Physics Lab	100	6
SECOND SEMESTER			
PHY-201	Classical Electrodynamics	20+80	4
PHY-202	Quantum Mechanics-II	20+80	4
PHY-203	Basic Solid State Physics	20+80	4
PHY-204	Applied Optics	20+80	4
PHY-205	Modern Physics & Optics Lab	100	6
PHY-206	Open Elective (DSE) (Atomic and Molecular Spectroscopy)	20+80	4
THIRD SEMESTER			
PHY-301	Advanced Quantum Mechanics	20+80	4
PHY-302	Basic Electronics	20+80	4
PHY-303	Special Paper-I (Advanced Condensed Matter Physics)	20+80	4
PHY-304	Physics of Metamaterials	20+80	4
PHY-305	Lab:-Electronics and Solid state Physics	100	6
PHY-306	Open Elective (IDSE)(Nano Science and Nano Technology)	20+80	4
FOURTH SEMESTER			
PHY-401	Basic Nuclear Physics	20+80	4
PHY-402	Particle Physics	20+80	4
PHY-403	Special Paper:II (Advanced Condensed Matter Physics)	20+80	4
PHY-404	Energy Harvesting and Storage Materials	100	4
PHY-405	Project/Dissertation	100	6
		Total Marks=2200	**Total Credit=96**

*NB** **Departmental Specific Elective**

1. Atomic and Molecular Spectroscopy (PHY-206)

*NB** **Inter Disciplinary Specific Elective**

1. Nano Science and Nano Technology (PHY-306)

RELEVANCE TO THE LOCAL, NATIONAL, REGIONAL AND GLOBAL DEVELOPMENTAL NEEDS

The contents incorporated in all the courses of the syllabus are relevant to **global developmental needs.**

Mid semester assessment	**End semester Assessment**
20	80

Employability - (red) Entrepreneurship - (green) Skill Development - (blue)

PHY101: Mathematical Methods in Physics

Course Objective: *To apply general idea of Mathematical Methods for understanding the critical aspects of Physical Sciences.*

Prerequisites: *Knowledge of elementary complex number, elementary differential equations and their solutions, different types of Mathematical functions.*

Unit I **12 hrs**

Complex Integrations: Calculus of Residues, Cauchy's residue theorem, Evaluation of definite integrals. Evaluation of Contour integration involving branch points and cuts.

Unit II **08 hrs**

Tensor Analysis: Cartesian tensors, Rank of tensor, Operation of Tensors, Covariant and contravariant vector, covarient derivatives, Christoffel symbol and metric tensor, Riemann & Ricci tensor, Levi-Civita Tensor, Tensor form of gradient, divergence and curl.

Unit III **08 hrs**

Groups and Group Representations: Definition of groups, Sub groups and classes, Finite groups, Group representations, Characters, Infinite groups and Lie groups, Irreducible representations of SU(2), SU(3) and O(3), SO(3,1).

Unit IV **12 hrs**

Special Functions: Legendre Polynomial, Associated Legendre Polynomial, Bessel's Function of first kind and second kind, Hankel's function, Modified Bessel's function, Hypergeometric and Confluent Hypergeometric functions, Fourier and Laplace transformation.

References

Text Books:

1. Mathematical Methods for Physicists: George Arfken Hans, Weber Frank, E. Harris, (2012), 7th Edition, Academic Press.
2. Mathematical Physics: H K Das, Dr. R. Verma, (2012) S. Chand Publications, 1st Edition

Reference Books:

1. Mathematical Physics with Classical Mechanics: Satya Prakash, (2014), Sultan Chand & Sons, 6th Edition
2. Mathematical Physics: P K Chattopadhyay, (2013), New Age International, 2nd Edition.
3. Mathematical Methods for Physics and Engineering: K. F. Riley, M. P. Hobson and S. J. Bence, (2006), Cambridge University Press, 3rd Edition.

COURSE OUTCOME

After completing this course the students should be able to:

CO1: Understand the use of Residue theorem for evaluation of complex contour and definite integrals.
CO2: Use various tensors with their operation mechanism in theoretical Physics.
CO3: Apply group theory to solve some mathematical problems of interest in physics.
CO4: Apply the mathematical formulation of various special functions in theoretical Physics.

CO-PO Mapping (PHY 101)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	1	1	2	1
CO2	3	1	3	2	2	1
CO3	2	3	3	3	2	2
CO4	2	2	3	2	3	2

Programme articulation matrix row for PHY 101

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 101	3	2	3	2	3	2

CO-PSO Mapping (PHY 101)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	3	2	2	2
CO3	3	3	3	3	2	2
CO4	2	3	3	2	3	3

PHY-102: Classical Mechanics

Course Objective: *To learn the Lagrangian and Hamiltonian formalisms for solving dynamics of different classical systems.*

Prerequisites:*Knowledge of Newtonian Mechanics, Knowledge of solving elementary differential equations.*

Unit I **10 hrs**

Mechanics of a System of Particles, Lagrangian Formulation, Velocity-Dependent Potentials and Dissipation Function, Conservation Theorems and Symmetry Properties, Homogeneity and Isotropy of Space and Conservation of Linear and Angular Momentum, Homogeneity of Time and Conservation of Energy. Calculus of Variations and Euler-Lagrange's Equation, Brachistochrone Problem, Hamilton's Principle, Extension of Hamilton's Principle to Nonholonomic Systems,

Unit II **10 hrs**

Hamiltonian Formulation: Legendre Transformation and the Hamilton Equations of Motion, Physical Significance of Hamiltonian, Derivation of Hamilton's Equations of Motion from a Variational Principle, Routh's Procedure, Δ Variation, Principle of Least Action.

Cononical Transformations: Canonical Transformation, Types of Generating Function, Conditions for Canonical Transformation, Integral Invariance of Poincare, Poisson Bracket, Poisson's Theorem, Lagrange Bracket, Poisson and Lagrange Brackets as Canonical Invariant, Infinitesimal Canonical Transformation and Conservation Theorems.

Unit III **10 hrs**

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

Small Oscillation: Problem of Small Oscillations, Example of Two coupled Oscillator, General Theory of Small Oscillations, Normal Coordinates and Normal Modes of Vibration, Free Vibrations of a Linear Triatomic Molecule.

Unit IV **10 hrs**

Rigid Body Motion: The Independent of Co-ordinates of a Rigid Body, Orthogonal Transformations. The Euler's angles. The Cayley-Klein parameters; Euler's Theorems on the Motion of a Rigid body, Infinitesimal Rotations, Rate of Change of a Vector, The Coriolis Force.

Rigid Body Dynamics: Angular Momentum and Kinetic Energy of Motion about a Point. The Inertia Tensor and Moment of Inertia, Eigenvalues of Inertial Tensor and the Principal Axis. Transformation. The Euler Equations of Motion, Torque-free motion of a rigid body. The Heavy Symmetrical Top with One Point Fixed.

References

Text Books:

1. Classical Mechanics, H. Goldstein, C. P. Poole and J. L. Safko, (2011), Addison Wesley, 3rd edition.
2. Mechanics, L.D. Landau and E.M. Lifshitz, (2000), Butterworth-Heinenann.
3. Classical Mechanics, Rana and Joag, (2001), Tata McGraw-Hill Education, 1st edition.

Reference Books:

1. Classical Mechanics, H. C. Corben & P. Stehle, (2013), Dover Publications, 2nd edition.
2. Analytical Mechanics, L. Hand and J. Finch, (2012), Cambridge University Press, 1st edition.
3. Classical Mechanics , J.C. Upadhyaya,(2013), Himalay Publishing House, 1st edition.
4. A Treatise on the Analytical Dynamics of Particles and Rigid Bodies, E.T.Whittaker, (1999), Cambridge University Press, 4th edition.

COURSE OUTCOME

CO1: : Formulate the Lagrangian formalism for solving dynamics of mechanical systems.
CO2: Formulate the Hamiltonian formalism for solving for the dynamics of mechanical systems.
CO3: Apply Hamiltonian formulation to develop Canonical transformation, Bracket formalism and Hamilton-Jacobi theory for solving the dynamics of a mechanical system.
CO4: Apply Lagrangian formulation to obtain the general theory for systems executing small oscillation for solving the equations of coupled oscillator and, and double pendulum related problems.
CO5: Design the equations of rigid body dynamics for demonstrating the examples of non-inertial frames.

CO-PO Mapping (PHY 102)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	3	1	2	2
CO2	2	3	3	2	3	3
CO3	3	3	3	2	2	2
CO4	2	3	3	2	3	2
CO5	3	3	2	1	2	1

Programme articulation matrix row for PHY 102

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 102	3	3	3	2	3	2

CO-PSO Mapping (PHY 102)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	2
CO3	3	3	3	3	2	2
CO4	2	2	3	2	3	3
CO5	3	3	2	3	2	2

PHY-103: Quantum Mechanics - I (Formalism)

Course Objective: *To learn the formalism of Quantum mechanics in harmonic oscillator and hydrogen atom.*

Prerequisites:*Knowledge of Historical development of Quantum Mechanics, Wave-particle duality, Schrodinger equation (time dependent and time independent).*

Unit I **10 hrs**

Linear Vector Space Formulation: Linear Vector Space (LVS) and its generality, Vectors-scalar product, basis vectors, linear independence, linear superposition of general quantum states, completeness, Closure Property, Schmidt's orthonormalisation procedure, Dual space, Bra and Ket vectors.

Operators and Matrix formalism: Eigen value and Eigen vectors of Linear, Adjoint, Hermitian, Unitary, Inverse, Antilinear, Projection, parity operators, Complete set of compatible operators, Noncommutativity and uncertainty relation, Matrix representation of vectors and operators, Eigen value equation and Expectation value, Transformation of basis vectors, Unitary transformation of vectors and operators, infinitesimal and finite unitary transformation, Continuous representation position and Momentum space wave function.

Unit II **10 hrs**

Quantum Dynamics: Time evolution of quantum states, Time evolution operator and its properties, Schrodinger/Heisenberg/ Interaction pictures, Equations of motion.

Operator method solution of 1D Harmonic oscillator: Matrix representation of creation and annihilation operators, Density matrix.

Rotation and Orbital Angular Momentum: Rotation Matrix, Angular momentum operators as the generators of rotation, L_x, L_y, L_z and L^2 and their commutator relations, Raising and lowering operators. (L^+ and L^-). L_x, L_y, L_z and L^2 in spherical polar coordinates, Eigen values and Eigen functions of L_z, L^2 (OP method) spherical harmonics, Matrix representation of L^+, L^- and L^2.

Unit III **10 hrs**

Spin Angular Momentum: Spin particles, pauli spin matrices and their properties Eigen values and Eigen functions, Spinor transformation under rotation.

Addition of angular momentum:

Total angular momentum **J**. Eigen value problem of J_z and J^2, Angular momentum matrices. Addition of angular momenta and C.G. co-efficients, Angular momentum states for composite systems in the angular momenta (1/2, 1/2) and (1, 1/2).

Unit IV **10 hrs**

Motion in Spherically Symmetric Field: Hydrogen atom, Reduction to equivalent one body problem, Radial equation, Energy eigen values and eigen functions, degeneracy, radial probability distribution. Free particle, problem incoming and outgoing spherical waves, expansion of plane waves in terms of spherical waves, Bound states of a 3-D square well, particle in a sphere.

References

Text Books

1. Quantum Mechanics Concepts and Applications - Nouredine Zettili, (2009), Wiley, 2nd Edition.
2. Introduction to Quantum Mechanics- David J. Griffith, (2004), Cambridge University Press, 2nd Edition.

Reference Books

1. Quantum Mechanics - S. Gasiorowicz, (2003), Wiley, 3rd Edition.
2. Quantum Mechanics - J. J. Sakurai, J. Napolitano, (2011), Cambridge University Press, 2nd Edition.
3. Quantum Mechanics (Non Relativistic theory) - L.D. Landau and E. M. Lifshitz, (1997), Pergamon Press, 3rd Edition.
4. Introductory Quantum Mechanics, R. L. Liboff, (2009), Pearson Press, 3rd Edition.

COURSE OUTCOME

After completing this course the students should be able to:

CO1: Identify orthogonal and normalized basis vectors by applying the concept of bra-ket vectors of Hilbert space.
CO2: Apply quantum mechanical operators with their corresponding eigen value and proper interpretation of unitary transformation associated with quantum mechanics.
CO3: Design time evolution of quantum state with its conservation properties.
CO3: Use operator formalism of Quantum Mechanics to solve one dimensional harmonic oscillator problem.
CO4: Predict the orbital, spin as well total angular momentum operator and C.G. coefficients for a composite angular system.
CO5: Determine the eigen value and eigen function for Hydrogen atom in a spherically symmetric potential and for a free particle.

CO-PO Mapping (PHY 103)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	2	1	2	1
CO2	2	3	3	2	2	2
CO3	2	3	3	2	3	3
CO4	2	3	3	2	3	2
CO5	3	2	2	3	3	3

Programme articulation matrix row for PHY 103

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 103	3	3	3	2	3	3

CO-PSO Mapping (PHY 103)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	2
CO3	2	3	3	3	2	2
CO4	2	2	3	2	1	3
CO5	3	3	2	3	2	1

PHY-104: Statistical Mechanics

Course Objective: *To apply the theory of statistical mechanics for understanding thermodynamic parameters for micro and macro systems.*

Prerequisites: *Basic concepts of theory of Thermodynamics and Probabilistic approach of Quantum Mechanics.*

Unit I **10 hrs**

Classical statistical Mechanics : Postulates of classical statistical mechanics , Liouville‘s theorem micro-canonical ensemble , derivation of thermodynamics , equipartition theorem ,Classical ideal gas , Gibb‘s paradox , canonical ensemble , density fluctuation in grand canonical ensemble , equivalence of canonical and grand canonical ensemble .

Unit II **10 hrs**

Quantum Statistical Mechanics: Postulates of quantum statistical mechanics , density matrix , Liouville‘s theorem, ensembles in quantum statistical mechanics , third law of thermodynamics , ideal gases in micro - canonical and grand canonical ensemble , particle in a box , Maxwell-Boltzmann , Boltzmann-Einstein and Fermi-Dirac distributions .

Unit III **10 hrs**

Bose and Fermi gas: Photons, phonons, Debye-specific heat, electronic specific heat, Bose-Einstein Condensation, Fermi energy, Ground state, Low temperature properties, Mean energy of fermions at absolute zero, Theory of White – Dwarfs (without derivation)

Unit IV **10 hrs**

Phase Transition and Ising model: Thermodynamics description of Phase Transitions, Phase Transitions of second kind, Landau theory of phase transition beyond mean field, Definition of the Ising model, one dimensional Ising model.

References

Text Books:

1. Statistical physics, K. Huang, (2014), Willy Student edition , 2nd edition.
2. Fundamental of statistical & thermal physics, F. Reif, (2010), Levant Books, 1st Indian edition.
3. Fundamental of statistical mechanics, B. B. Laud, (2012), New age international Pvt. Ltd, 2nd Edition.

Reference Books:

1. Statistical physics, Landau and Lifsitz, (2013), Pergamon Press, 3rd Edition, 2013
2. Elementary statistical physics, C.Kittel, (2008), John Wiley & Sons, 2nd Edition.
3. Statistical mechanics - A set of lectures, R.P.Feynman, (2008), The Benjamin publishing company, Inc.
4. Introduction to Statistical Physics, Kerson Huang, (2002), Taylor & Francis, 2nd Edition.

COURSE OUTCOME

After completing this course the students should be able to:

CO1: Understand the concept of statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics.

CO2: Interpret the concept of types of ensembles and calculation of general probability statements for variety of situation of physical interest.

CO3: Analyze the problems involving gases at low temperature or high densities and problems encountered in

connection with the indistinguishable particles.
CO4: Apply Fermi-Dirac and Bose-Einstein statistics to different physical systems.
CO5: Apply different model for phase transitions through statistical techniques to simulate the structure of a physical substance.

CO-PO Mapping (PHY 104)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	1	1	1	2	2
CO2	2	3	3	2	3	2
CO3	1	3	3	3	2	2
CO4	1	3	3	2	2	1
CO5	2	3	3	2	2	2

Programme articulation matrix row for PHY 104

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 104	3	3	3	2	3	2

CO-PSO Mapping (PHY 104)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	3
CO3	3	3	3	3	3	3
CO4	3	2	3	2	3	3
CO5	3	2	2	3	2	2

PHY105: Computational Methods in Physics

Laboratory (6 hrs per week)

Course Objective: *To demonstrate various experiments to understand the critical aspects of wave optics like polarization, diffraction and phenomena in modern Physics.*

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

Programming with FORTAN: Programme solving on computers - algorithm and flow charts in FORTAN data types, expressions and statements, input/output commands, sub programme,

Programming with C++: Structure of C++ programme, compilation , Data types, variable and constant, declaration of variables, initializing variables, arithmetic operators, Increment and Decrement operators, I/O statements, arithmetic expressions, functions, Control statements: decision making and looping statements, array.

Exercises for acquaintance:

1. To find the largest or smallest of a given set of numbers

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

Numerical Analysis:

1. Interpolation by Lagrange method
2. Numerical solution of simple algebraic equation by Newton- Raphson method
3. Numerical integration : Trapezoidal method, Simpons method, Romberg integration, Gauss quadrature method
4. Eigenvalues and eigenvectors of a matrix
5. Solution of linear homogeneous equations
6. Matrix multiplication, addition
7. Trace of a matrix
8. Matrix inversion.
9. Solution of ordinary differential equation by Runge-Kutta Method
10. Solution of Radioactive decay, Simple harmonic oscillator, Schroedinger Equation.

References

Text Books:

1. Computer Programming in FORTRAN 90 and 95: V. Rajaraman, (2018), PHI Learning Private Limited, 18th Edition

2. Fundamentals of Computers: V. Rajaraman, (2015), PHI Learning Private Limited, 6th Edition.

3. Computer Oriented Numerical Methods: R.S.Salaria, Khanna Book Publishing co. (P) LTD. 5th Edition.
4. Programming with C++: J. R. Hubbard, (2000), MCGRAW-HILL, 2nd Edition.

Reference Books:

1. Numerical Recipes in C++: The Art of Scientific Computing, W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery (2002), CAMBRIDGE UNIVERSITY PRESS, 2nd Edition.
2. Numerical Recipes in Fortran 90 The Art of Parallel Scientific Computing, W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery (1996), CAMBRIDGE UNIVERSITY PRESS, 2nd Edition.
3. Fortran 77 and Numerical Methods: C. Xavier, New Age International Publishers.

COURSE OUTCOME

CO1: Develop stable algorithms and skills for solving numerical problems in various areas of Physics.
CO2: Apply numerical techniques for solving linear equations, differential equation and integration.
CO3: Apply numerical techniques fitting the curve, interpolation and related problems.

CO-PO Mapping (PHY 105)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	2	1	2	3
CO2	1	3	3	2	2	3
CO3	1	3	3	2	2	3

Programme articulation matrix row for PHY 105

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 105	3	3	3	2	2	3

CO-PSO Mapping (PHY 105)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	2
CO3	3	3	3	2	2	2

PHY-201 Classical Electrodynamics

Course Objective: *To apprise the students regarding the concepts of electrodynamics and Maxwell's equations and apply in various problem of physical sciences.*

Prerequisites:*Basic Knowledge of Laws of Electrostatics and Magnetism.*

Unit I **10 hrs**

Waves in matter: Electromagnetic waves at plane between dielectrics and dielectric- metal. Fresnel equations for normal and oblique incidence, Energy transport, Polarization by Reflection, Total Internal Reflection, Evanescent waves, Waves in a Multilayer.

Waveguides and resonators: TE & TM modes in dielectrc slab, Wave guide, Cylindrical wave-guides and cavity, modes of rectangular waveguides with conducting walls. Dispersion: The frequency dependence of permittivity, Dispersion in conductors and Kramers- Kronig relations

Unit II **10 hrs**

Potential formulation: Vector and scalars potentials, Wave equation for potentials, Gauge Transformation, Coulomb and Lorentz gauge conditions. Greens function solution of potential form of Maxwells equations, Retarded potential, retarded solutions for field, Poynting theorem in dispersive media. Lienard-Wiechert Potentials, Fields and power of an accelerated point charge, Larmours formula.

Unit III **10 hrs**

Radiation: Electric dipole, Magnetic dipole, Electric Quadrupole and any arbitrary radiation, radiation from Linear Centre-Fed Anteena, angular distribution of power radiated, radiation from circular orbits. Classical cross section for radiation, Bremstrahlung in coulomb field, Cherenkov radiation.

Unit IV **10 hrs**

Scattering: Scattering by small dielectric & perfectly conducting sphere and Conducting Cylinder, Radiation damping of a charged harmonic oscillator, scattering by an individual free scattering electron (Thomson Scattering), Scattering by bound electron (Rayleigh Scattering).

References

Text Books:

1. Introduction to Electrodynamics - D.J. Griffiths, (1991), Pearson Education Ltd. 3rd Edition
2. Classical Electrodynamics - J.D. Jackson, (2004), John & Wiley Sons Pvt. Ltd, New York, 3rd Edition
3. Classical Theory of Electrodynamics - L.D. Landau and E.M. Lifshitz, (1971), Addison, Wesley, 3rd Edition,

Reference Books:

1. Introduction to Electrodynamics - A. Z. Capri and P.V.Panat, (2010), Narosa Publishing House, 5th Edition
2. Classical electricity & Magnetism- Panofsky and Phillips, (1989), Addison Wesley, 2nd Edition.
3. Classical Electromagnetic Radiation - J.B. Marion, (1995), Academic Press, New Delhi, 1st Edition
4. Classical Electricity and Magnetism - Wolfgang K. H. Panofsky and Melba Phillips, (2005), Dover Publications, 2nd Edition.

COURSE OUTCOME

After completing this course the students should be able to:

CO1: Design of Maxwell's equation and their applications in electromagnetic potentials and Gauge transformations.

CO2: Explain the various modes of propagation of plane electromagnetic wave in different media.
CO3: Analyze the electromagnetic fields and radiation of a localized oscillating source (antenna).
CO4: Apply the theory of scattering to various electromagnetic operations.

CO-PO Mapping (PHY 201)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	2	3	3	2	3	3
CO2	3	3	2	2	1	2
CO3	2	3	3	2	3	3
CO4	2	3	2	3	1	2

Programme articulation matrix row for PHY 201

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 201	3	3	3	3	2	3

CO-PSO Mapping (PHY 201)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	2	3
CO2	3	2	2	2	2	2
CO3	3	3	2	2	2	1
CO4	2	2	3	2	1	3

PHY202: Quantum Mechanics – II

Course Objective: *To understand the basic techniques & methods for solving general problems in quantum mechanics and apply these methods in various fields of research and development.*

Prerequisites: *Operator formalism of solving one-dimensional harmonic oscillator, Eigen value and Eigen function of hydrogen atom, Addition of angular momenta (C.G. Coefficients).*

Unit I **10 hrs**

Time Independant Perturbation Theory: Rayleigh Schrodinger Method for Time-Independent Non-Degenerate Perturbation Theory, First and Second Order Correction, Perturbed Harmonic Oscillator, Anharmonic Oscillator, The Stark Effect, Quadratic Stark Effect and Polarizability of Hydrogen atom, Degenerate Perturbation Theory, Removal of Degeneracy, Parity, Parity of atomic states, Parity Selection Rule, Linear Stark Effect of Hydrogen atom.

Unit II **10 hrs**

Correction factors: Spin-Orbit Coupling, Relativistic Correction, Fine Structure of Hydrogen like Atom, Normal and Anomalus Zeeman Effect, The Strong-Field Zeeman Effect, The Weak-Field Zeeman Effect and Lande's g-factor.

Variational Methods: Ground State, First Excited State and Second Excited State of One-Dimensional Harmonic Oscillator, Ground State of H-atom and He-atom.

Unit III **10 hrs**

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

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

Unit IV **10 hrs**

Scattering Scattering amplitude and differential cross Section, Relation between Lab and CM cross sections, Born Approximation. Application to Coulomb and Screened Coulomb Potential,.Partial Wave Analysis for Elastic and Inelastic Scattering, Effective Range and Scattering Length, Optical Theorem, Black Disc-Scattering, Hard-Sphere Scattering, Resonance Scattering from a Square Well Potential, Scattering of identical particles.

References

Text Books

3. Quantum Mechanics Concepts and Applications - Nouredine Zettili, (2009), Wiley, 2nd Edition.
4. Introduction to Quantum Mechanics- David J. Griffith, (2004), Cambridge University Press, 2nd Edition.

Reference Books

1. Quantum Mechanics - S. Gasiorowicz, (2003), Wiley, 3rd Edition.
2. Quantum Mechanics - J. J. Sakurai, J. Napolitano, Cambridge University Press, (2011), 2nd Edition.

3. Quantum Mechanics (Non Relativistic theory) - L.D. Landau and E. M. Lifshitz, (1977), Pergamon Press, 3rd Edition.
4. Introductory Quantum Mechanics, R. L. Liboff, (2009), Pearson Press, 3rd Edition.

COURSE OUTCOME

After completing this course the students should be able to:
CO1: Formulate the time independent perturbation theory to find energy eigen values and eigen functions of quantum mechanical problems that are not exactly solvable.
CO2: Apply the time-independent perturbation theory for understanding the stark and Zeeman effect in the atomic states.
CO3: Formulate WKB approximation and variational method for time-independent potentials.
CO4: Apply the time-dependent perturbation theory for solvingthe time-dependent potential to understand the transition from one stationary state to other in LASER and MASER systems.
CO5: Formulate the quantum theory of scattering for evaluation of scattering cross-section by using Born approximation and partial wave analysis.

CO-PO Mapping (PHY 202)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	2	1	1	2
CO2	2	3	2	1	2	2
CO3	2	3	3	2	2	1
CO4	2	3	3	3	3	2
CO5	2	3	3	1	2	2

Programme articulation matrix row for PHY 202

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 202	3	3	3	2	3	2

CO-PSO Mapping (PHY 202)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	3
CO3	2	3	3	3	3	3
CO4	2	2	3	2	3	3
CO5	3	2	2	3	2	3

PHY203: Basic Solid State Physics

Course Objective: *To study some of the basic properties of the condensed phase of matter especially Crystal Structure, Electric, Dielectrc, Magnetic and thermal behaviour of solids.*

Prerequisites:*Basic knowledge on crystal structures and system.*

Unit I **10 hrs**

Crystal binding: Crystal of inert gases, ionic crystals, covalent crystals, Metallic binding, and hydrogen bounded crystals.

Phonons and lattice vibration: Vibrations of monatomic and diatomic lattices, dispersion, relation, optic and acoustic modes, Quantum of lattice vibration and phonon, phonon momentum, inelastic scattering of neutrons and photons by phonons.

Thermal Properties of insulators: Lattice heat capacity, Debye & Einstein model, Anharmonic crystal interactions, thermal conductivity and thermal expansion.

Unit II **10 hrs**

Free Electron Fermi Gas: Density of state in one dimension, effect of temperature on Fermi-Dirac distribution, Free electron gas in three dimensions, Heat capacity of electron gas, The Boltzmann equation, Electrical conductivity, General Transport coefficients, Thermal conductivity, Thermoelectric effect.

Unit III **10 hrs**

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

Band theory: Electrons in periodic potential, Bloch's theorem, Kronig-Penney model, origin of band gap, Wave equation for an electron in a periodic potential, Bloch functions, Brillouin zones, E-K diagram under free electron approximation.

Unit IV **10 hrs**

Magnetism: Brief concept on Diamagnetism and paramagnetism, Weiss theory of ferromagnetism, Curie-Weiss Law for susceptibility, Heisenberg model- Conditions for ferro- and antiferro-magnetic order, Spin waves and magnons, Bloch's T 2 Law, Antiferromagnetic order, Neel Temperature. Diluted Magnetic Semiconductors.

References

Text Books:

1. Introduction to solid state physics- C. Kittel, J(2016), John Wiley & Sons, 8th Edition.
2. Solid State physics -A. Omar, (2014), Pearson, 1st edition.
3. Semiconductor device: Physics and Technology: S. M. Sze, (2009), Wiley India Private Limited; 2nd Edition.
4. Solid State Physics- Ashcroft Mermin, (2011), Cengage Learning, India Edition, 10th Edition

Reference Books:

1. Principles of condensed matter physics- P.M. Chaikin and T.C. Lubensky, (2000), Cambridge University Press, 3rd Edition.
2. Solid state physics- S. O. Pilli, (2006), New Age International, 6th Edition.
3. Solid state physics- Dan Wei, (2008), Cengauge Learning, 1st Edition.
4. Quantum theory of solid State -J.Callaway, (1991), Academic Press, 2nd Edition.
5. Semiconductor Physics and Devices (Basic Principles), Donal A Neamen, (2012), Tata McGraw-Hill, 3rd Edition.

COURSE OUTCOME

CO1: Understand various aspects of materials related to crystallography and lattice vibrations.
CO2: Interpret phonon vibrations in various lattice and their effects in heat capacity of solid.
CO3: Analyze the behavior of semiconductor under different conditions in fundamental research.
CO4: Explain the dielectric and magnetic behaviour of novel materials and their applications.

CO-PO Mapping (PHY 203)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	1	1	2	2
CO2	2	3	3	2	2	2
CO3	1	3	3	3	2	2
CO4	3	3	2	1	2	2

Programme articulation matrix row for PHY 203

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 203	3	3	3	2	2	2

CO-PSO Mapping (PHY 203)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3

PHY-204: Applied Optics

Course Objective: *The main objective of this course is to teach the students the advance concepts of optics like holography, nonlinear optics.*

Prerequisites: *Basic knowledge on Wave optics and Electrodynamics*

Unit I **10 hrs**

Optics of solids: Plane wave in anisotropic media, types of crystal, Double Refraction at a Boundary, Optical Activity, Faraday Rotation in Solids, Magneto-optic and Electro-optic Effects, Introduction to Nonlinear Optics.

Unit II **10 hrs**

Fourier Optics: Basics of Fourier transformation operation, Definition of spatial frequency and transmittance function, Fourier transform by diffraction and by lens, Spatial frequency filtering, types of filters, Abbe-Porter experiments, phase-contrast microscope.

Holography: Principle of holography, On-axis and off-axis hologram recording and reconstruction, Types of hologram and applications.

Unit III **10 hrs**

Laser spectroscopy: Laser-induced breakdown spectroscopy (LIBS), Laser induced fluorescence spectroscopy, Nonlinear spectroscopy: linear and nonlinear absorption, saturation spectroscopy two-photon and multi-photon spectroscopy, Applications of laser spectroscopy: single molecule detection, trace level detection of explosives and hazardous gases, LIDAR.

Unit IV **10 hrs**

Optical fibers: Guided modes of step-index and graded index fibers, Propagation light in optical fibers, Numerical aperture and Applications of optical fibers in Communication and Sensing.

References

Text Books:
1. Optics- Ajay Ghatak (2012), Tata Mc-Graw Hill, 5th Edition
2. Laser Spectroscopy: Basic Concepts and Instrumentation – W. DemtrÖder (2004), Springer,, 3rd Edition.
3. Introduction to Fourier Optics- J. W. Goodman, (2005), Ben Roberts, 3rd Edition
4. Holography: A Practical Approach- G. K. Ackerman and J. Eichler, (2007), Wiley-VCH, 1st Edition

Reference Books:
1. Introduction to Modern Optics- G. R. Fowless, (2012), Dover Publications, 2nd Edition
2. Laser Spectroscopy and its Applications- R. W. Solarz and J. A. Paisner, (1986), Marcel Dekker, 1st Edition
3. Basics of Holography- P. Hariharan, (2002), Cambridge University Press, 1st Edition
4. Principles and Applications of Fourier Optics – R. K. Tyson, (2014), IOP Publishing, 1st Edition

COURSE OUTCOME

After completing this course the students should be able to:
CO1: Understand basic principle of optical properties of solids.
CO2: Apply the basic concepts of Fourier and holography in various optical devices
CO3: Interpret the idea of LASER Spectroscopy for detection of trace level in hazardous gases.
CO4: Analyze the propagation parameters of Optical fibers.

CO-PO Mapping (PHY 204)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	1	1	1	2	2
CO2	2	3	2	3	1	3
CO3	1	3	3	2	3	3
CO4	1	3	3	3	2	3

Programme articulation matrix row for PHY 204

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 204	2	3	3	3	2	3

CO-PSO Mapping (PHY 204)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	2	2	2	2	2	3
CO3	2	2	2	3	3	3
CO4	1	1	3	2	3	3

PHY205: Optics and Modern Physics

Laboratory (6 hrs per week)

Course Objective: *To demonstrate various experiments to understand the critical aspects of wave optics like polarization, diffraction and phenomena in modern Physics.*

Optics:

1. Experiments with optical bench Biprism Straight edge and narrow wire.
2. Experiments with spectrometer: Single and Double split.
3. Experiments with Michelson interferometer : Determination of λ and a Thickness of mica sheet
4. Fabry Perot interferometer
5. Polarization Experiments
   - Babinet compensator
   - Edsar-Butlerbands
   - Quarter wave plate
   - Mallus Law
   - Study of elliptical polarized light
6. Constant Deviation Spectrograph
   - Calibration
   - Zeeman effect
7. Babinet Quartz Spectrography

Modern Physics:

1. e/m measurement by Braun tube
2. e/m measurement by Magnetron Valve Method
3. e/m measurement by Thomson Method
4. Magnetic field measurement by search coil
5. Ferroelectric transmission point by Dielectric Constant Measurement

6. Rectification by junction Diode using various filters
7. Characteristics of a Transistor.
8. Dielectric constant of solid (wax) by Lecher Wire
9. Verification of Richardson's $T^{3/2}$ law
10. Determination of Planck's constant by total Radiation Method
11. Determination of Planck's constant by Reverse Photoelectric effect method
12. Hysteresis loop tracer
13. Determination of "e" by Millikan's oil drop experiment
14. Measurement of attenuation and phase shift of A.C. in L.C.R. net work
15. RF characteristics of coil
16. Study of power supply
17. Calibration of an oscilloscope
18. Stefan's constant measurement
19. Existence of discrete energy level by Frank Hertz experiment.
20. GM counter experiments: Characteristics of the Geiger tube, Inverse Square Law, Absorption coefficient of the aluminium foil.

COURSE OUTCOME

After completing this course the students should be able to:
CO1: Understand the fundamental concepts of interference, diffraction and polarization of light.
CO2: Apply the basic knowledge of Modern Physics to determine resistivity, Band gap and Hall coefficient of a semi conductor.
CO3: Determine the key electric and magnetic properties of materials.

CO-PO Mapping (PHY 205)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	2	1	2	3
CO2	1	3	3	2	2	3
CO3	1	3	3	2	2	3

Programme articulation matrix row for PHY 205

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 205	3	3	3	2	2	3

CO-PSO Mapping (PHY 205)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	2
CO3	3	3	3	2	2	2

PHY-206: Departmental Specific Elective (DSE) Atomic and Molecular Spectroscopy

Course Objective: *To learn various spectroscopic techniques for understanding the behaviour of materials.*

Prerequisites: *Basic knowledge on fundamentals of quantum mechanics and hydrogen atom problems.*

Unit I **10 hrs**

Quantum mechanics of H atom, Atomic Orbital's and Hund's rule, Magnetic dipole moment, Electron spin and vector atom model, Spin Orbit interaction, Hydrogen Fine structure, Lamb Shift, L-S & J-J Coupling: spectroscopic terms, selection rule, Lande Interval rule, Zeeman Effect (normal and Anomalous) and Paschen-Back Effect: Splitting of spectral lines and selection rules, Hyperfine Structure Spectral Lines: Isotope Effect, Nuclear spin and Hyperfine Splitting and selection rules.

Unit II **10 hrs**

Molecular Electronic States: Molecules and Chemical bonds: Molecular Formation, Ionic binding, Covalent Binding, Valence-bond treatment of H2+, The LCAO method for H2+. The Stability of Molecular States Concept of molecular potential, Separation of electronic and nuclear wave functions, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, Approximation methods for the calculation of electronic Wave function.

Unit III **10 hrs**

Rotation and Vibration of Molecules: Solution of nuclear equation; Molecular rotation: Non-rigid rotator, Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential, Symmetries of electronic wave functions, Shapes of molecular orbital and bond, Term symbol for simple molecules.

Unit IV **10 hrs**

Spectra of Diatomic Molecules: Transition matrix elements, Vibration-rotation spectra: Pure vibrational transitions, Pure rotational transitions, Vibration-rotation transitions, Electronic transitions: Structure, Franck-Condon principle, Rotational structure of electronic transitions, Fortrat diagram, Dissociation energy of molecules, Continuous spectra, Raman transitions and Raman spectra.

References

Text Books

1. Physics of Atoms and Molecules - Bransden and Joachain, (2003), Prentice Hall, 2^{nd} Edition.
2. Atomic and Molecular Spectra: Laser, Raj Kumar, (2012), KNRN, India, 6^{th} Edition.
3. Introduction to Atomic and Molecular Spectroscopy - V. K. Jain, (2007), Narosa, 4th Edition.

Reference Books:

1. Fundamentals of Molecular Spectroscopy- C. N. Banwell, (2012), Tata McGraw Hill, 4^{th} Edition.
2. Molecular spectroscopy, J.M. Brown, (1998), Oxford University Press, 1^{st} edition.
3. Molecular spectroscopy, Jeanne, L. McHale, (2017), CRC press, 2^{nd} Edition.
4. Spectra of atoms and molecules, P. F. Bemath, (2016), Oxford University Press, 3^{rd} Edition.
5. Modern spectroscopy, J.M. Holias, (2004), John Wiley and Sons ltd., 4^{th} edition.

COURSE OUTCOME

After completing this course the students should be able to:
CO1: Analyze energy splitting and allowed transitions of atomic spectra under various conditions.
CO2: Explain the molecular formation and their stability.
CO3: Determine internuclear separation, atomic mass, moment of inertia from fundamental aspects of rotational and vibrational spectroscopy.
CO4: Demonstrate the origin of molecular electronic states and their intensities distribution.
CO5: Determine symmetry element of molecules and their allowed modes of vibrations of in rotational and vibrational spectroscopy.

CO-PO Mapping (PHY 206)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	1	3	2	2	3	2
CO2	3	2	1	1	2	1
CO3	2	3	3	2	2	1
CO4	2	3	3	1	3	2
CO5	2	3	3	3	2	2

Programme articulation matrix row for PHY 206

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 206	2	3	3	2	3	2

CO-PSO Mapping (PHY 206)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	1
CO2	3	2	2	2	2	2
CO3	3	2	3	3	2	3
CO4	2	2	3	2	3	3

PHY301: Advanced Quantum Mechanics
(Relativistic Quantum Mechanics)

Course Objective: *To apply theory of relativistic quantum mechanics and field theory to understand critical aspects of high energy physics and advanced condensed matter physics.*

Prerequisites: *Basic knowledge on fundamentals of non-relativistic quantum mechanics, theory of relativity, Formulism on four vector representations.*

Unit I 08 hrs

Klein-Gordon Equation: Need for a relativistic equation, Klein-Gordon equation and its drawbacks, Real and Complex Klein-Gordon fields, Klein-Grdon equation with electromagnetic field.

Unit II 12hrs

Dirac Equation: Dirac equation, Magnetic moment of electron, Spin-Orbit coupling, Darwins term, Non-relativistic reduction of Dirac equation, Properties of Dirac gamma-matrices, Free particle and plane wave solution of Dirac equation with physical interpretation, Normalized Dirac spinors.

Unit III 12 hrs

Covariance of Dirac equation and Hole Theory: Lorentz transformation, Covariance of Dirac equation and bilinear covariant, Projection operator for Energy and spin, Zitterbewegung, Dirac Hole theory.

Unit IV 08 hrs

Symmetry in Dirac equation: Charge conjugation, space reflection, time reversal symmetries of Dirac equation, Continuous systems and fields, Real (Classical) and Dirac fields, Lagrange and Hamiltonian formulation, Noether's theorem, Second Quantization, Gordon decomposition, Normal ordering.

References

Text Books:

1. Lectures on Quantum Field Theory - Ashok Das (2008), World Scientific, 2nd Edition.
2. Advanced Quantum Mechanics- J. J. Sakurai (2002), Pearson Education India, 4th Edition
3. Relativistic Quantum Mechanics- J. D. Bjorken and S. D. Drell (1964), Mc-Graw Hill, 1ST Edition

Reference Books:

4. Relativistic Quantum Mechanics- L. Maiani and O. Benhar (2012) CRC Press, 1st Edition
5. Relativistic Quantum Physics- Tommy Ohlsson (2011) Cambridge University Press, 1st Edition
6. Quantum Field Theory- L. H. Ryder (2017) Cambridge University Press, 2nd Edition
7. Advanced Quantum Mechanics- F. Schwabl (2005), Springer, 3rd Edition

COURSE OUTCOME

After completing this course the students should be able to:

CO1: Understand the concept of Klein-Gordon equation and its drawbacks.

CO2: Interpret the properties of Four vector Dirac gamma matrices as obtained from Dirac equation and its positive and negative energy states.

CO3: Interpret the properties of a Dirac particle through its covariant Lorentz transformation.
CO4: Analyze the various quantum fields associated with a Dirac particle and its charge conjugate and time reversal states.

CO-PO Mapping (PHY 402)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	1	1	1	2	2
CO2	2	3	3	2	2	1
CO3	2	3	3	2	2	1
CO4	1	3	2	3	3	1

Programme articulation matrix row for PHY 402

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 402	2	3	3	2	3	2

CO-PSO Mapping (PHY 402)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	2
CO2	3	3	3	2	2	2
CO3	3	3	3	2	2	1
CO4	3	2	3	2	2	1

PHY302: Basic Electronics

Course Objective: *To provide a comprehensive understanding of analog electronics like OP-AMP, Oscillators and Digital Electronics*

Prerequisites: *Basic knowledge on Semiconductors, transistor, Boolean algebra*

Unit I **10 hrs**

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.

Amplifiers: Frequency response of linear amplifiers through h-parameters, amplifier pass band, RC, LC. and transformer coupled amplifiers and their frequency response, gain band-width product, Millers theorem, Feedback amplifiers, effects of negative feedback, Boot-strapping the FET, Multistage feedback, Cascaded amplifier, stability in amplifiers, noise in amplifiers.

Unit II **10 hrs**

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

Unit III **12 hrs**

Oscillator/ Multivibrator Circuits: Feedback criteria for oscillation, Hartley oscillator, Colpitt's oscillator, phase shift, Wien bridge oscillator, crystal controlled oscillator, klystron oscillator, Principle of multivibrator, Multivibrator circuits (Astable, Monostable, bistable).

Digital Circuits: Logic fundamentals, Boolean theorem, Logic gates - RTL, DTL and TTL gates, CMS switches, RS flip-flop, JK flip-flops

Unit IV **08 hrs**

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

References

Text Books:

1. The art of electronics - Paul Horowitz, Winfield Hill, (1989), Cambridge University Press, 2nd Edition.
2. Electronic Devices and Circuit Theory - Robert L. Boylestad, (1996), Louis Nashelsky, Prentice Hall, 6th Edition.
3. Hand Book of Electronics- Gupta and Kumar (2016), Pragati Prakashan, 43rd edition

Reference Books:

1. Electronic Devices and Circuits - Millman, Halkias and Jit, (1988), Tata McGraw Hill, 1st Edition.
2. Op-amps and linear integrated circuits - R.A.Gayakwad, (2000), Prentice Hall of India, 6th Edition.
3. Principle of Electronics, V.K.Mehta, R. Mehta, (1980), S. Chand, 3rd Editon.
4. Electronic Principles - Malvino and Bates, (2016), McGraw Hill. 8th Edition.

COURSE OUTCOME

CO1: Understand the working of basic cascaded amplifiers with their frequency response through network theory.
CO2: Apply various modes of OP-AMP for mathematical operations.
CO3: Design various types of oscillators and multivibrators in electronic applications.
CO4: Design the sequential logic circuits for various complex logic and switching devices with validation.

CO-PO Mapping (PHY 302)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	2	2	2	3
CO2	2	3	3	3	3	3
CO3	2	3	1	2	2	3
CO4	2	3	1	3	2	3

Programme articulation matrix row for PHY 302

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 302	3	3	2	3	3	3

CO-PSO Mapping (PHY 302)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3

CO2	3	2	2	2	2	3
CO3	3	3	3	3	2	2
CO4	2	2	3	2	3	3

PHY-303: Special paper- I

Advanced Condensed Matter Physics

Course Objective: *The main objective is the erudition on lattice vibration, energy band, Fermi Surface, electron approximation and electron interaction and also to have a proper idea on Lattice Defects, Excitons and Hall effect.*

Prerequisites: *Basic knowledge on basic condensed matter Physics and Quantum Mechanics.*

Unit I **12 hrs**

Lattice Vibrations: Born-Oppenheimer Approximation, Hamiltonian for lattice vibrations in the harmonic approximation,Normal modes of the system and quantization of lattice vibrations-phonons .Electron-phonon interaction, Second quantized form of Hamiltonian for electrons and phonons in interaction.

Energy Bands: Nearly free electron approximation - Diffraction of electrons by lattice planes and opening of gap in E-K diagram. Effective mass of electrons in crystals, Holes, Tight binding approximation, S and P state band, Warnier functions, Equation of motion in the Wannier representation,The equivalent Hamiltonian Impurity levels, Density of states

Unit II **10 hrs**

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

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

Unit III **08 hrs**

Electron Interaction: Perturbation formulation, Dielectric function of an interacting electron gas (Lindhard's expression), Static screening, Screened impurity, Kohn effect, Friedel Oscillations and sum rule, Dielectric constant of semiconductor, Plasma oscillations

Unit IV **10 hrs**

Electronic and Lattice defects: Lattice defects, Frenkel and Schottky defects. Line Defects, edge and screwdislocations-Burger'sVector,planner (stacking) faults-twin planes and grain boundaries Color centers-mechanism of coloration of a solid, F-center, Other color centers.

Excitons: Loosely bound, tightly bound, Excitonic waves, electron-hole droplets.

Hall effect: Elementary ideas on Quantum Hall Effect, Magneto resistance, Elementary ideas on Giant magneto-resistance and Colossal magneto resistance.

References

Text Books:

1. Principles of the Theory of Solids - J.M. Ziman (2013), Cambridge University Press, 2nd Edition.
2. Introduction to Solid State Physics- C. Kittel (2004), Wiley 8th Edition.
3. Advanced Solid State Physics - Philip Phillips (2012), Overseas Press, India Pvt. Ltd, 2nd Edition.

Reference Books:

1. Electronic Devices and Circuits - Millman, Halkias and Jit, (1988), Tata McGraw Hill, 1st Edition.
2. Solid State physics -A. Omar, (2014), Pearson, 1st Edition.
3. Principles of condensed matter physics- P.M. Chaikin and T.C. Lubensky, (2000), Cambridge University Press, 3rd Edition.
4. Introduction to Modern Solid State Physics - Yuri M. Galperin (2014), CreateSpace Independent Publishing Platform, 2nd Edition.
5.Solid State Physics - N. W Aschroff& N D Mermin (1976), Hercourt College Publishers, 1st Edition.
6. Introduction to Solids - L.V. Azaroff (1993), Mc-Graw Hill Publisher, 1st Edition.

COURSE OUTCOME

After completing this course the students should be able to:
CO1: Understand the concept of lattice vibration and energy bands in solid states.
CO2: Interpret the characteristics of Fermi surfaces for electron approximation theory.
CO3: Analyze the dielectric constant of semiconductor through electron interaction theory.
CO4: Compare various types of electronic and lattice defects.
CO5: Apply magneto-resistance property for various sensing applications.

CO-PO Mapping (PHY 303)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	1	1	2	2
CO2	2	3	3	3	3	3
CO3	2	3	3	3	2	3
CO4	2	3	2	3	2	3
CO5	1	3	2	3	2	2

Programme articulation matrix row for PHY 303

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 303	2	3	3	3	3	3

CO-PSO Mapping (PHY 303)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	3
CO3	3	3	3	3	2	2
CO4	2	3	3	1	2	2
CO5	3	2	2	1	1	1

PHY-304: Physics of Metamaterials

Prerequisites: *Basic knowledge on Optics, Classical Electrodynamics, optical properties of materials.*

Unit I **8 hrs**
Metamaterials and Homogenization: Introduction to Metamaterial, Optical Properties of Dielectric and Metallic Materials, Metal-Dielectric Composites and Mixing Rules, Maxwell–Garnett and Bruggeman theory of homogenization.

Unit II **12 hrs**
Metamaterial with Negative Material parameters: Metals and plasmons at optical frequencies, Wire mesh structures as low frequency plasmas, photonic metallic wire materials, Metamaterials with negative magnetic permeability, metallic cylinders, Split-ring resonator media, Pendry's split rings, Swiss Roll media for radio frequencies, Negative refractive index at optical frequencies.

Unit III **12 hrs**
Theory of Media with $\varepsilon < 0$ and $\mu < 0$: Origins of negative refraction, Dispersion relation, Anisotropic media with positive constitutive parameters, Anisotropic media with positive constitutive parameters, Left-handed media, Moving media, Modified Snell's law of refraction. Plasmonics of media with negative material parameters.

Unit IV **8hrs**
Perfect lens, Super lens and Invisibility: Near-field information and diffraction limit, Mathematical demonstration of the perfect lens, "Near-perfect" lens with an asymmetric slab, Elementary idea of Superlens and electromagnetic invisibility.

References

Textbook

1. Physics and Applications of Negative Refractive Index Materials– S. Anantha Ramakrishna and Tomasz M. Grzegorczyk, (2008), SPIE , 1st editions.
2. Optical Metamaterials: Fundamentals and Applications- Wenshan Cai and Vladimir Shalaev (2010), Spinger, 1st editions

Reference book

1. Phenomena of Optical Metamaterials- Tatjana Gric and Ortwin Hess, (2019), Elsevier, 1st editions.
2. Waves in Metamaterials-L. Solymar and E. Shamonina, (2009), Oxford, 1st editions.

COURSE OUTCOME

After completing this course the students should be able to:
CO1: Understand the basic concept of Metamaterials.
CO2: Interpret the properties of Metamaterials with negative material parameters.
CO3: Apply the theory of Metamaterials in Plasmonics.
CO4: Design perfect lens and super lens using metamaterials.

CO-PO Mapping (PHY 304)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	1	1	2	2
CO2	2	3	3	3	3	3
CO3	2	3	3	3	2	3
CO4	2	3	2	3	2	3

Programme articulation matrix row for PHY 304

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 304	2	3	3	3	3	3

CO-PSO Mapping (PHY 304)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	3
CO3	3	3	3	3	2	2
CO4	2	3	3	1	2	2

PHY 305: Electronics and Solid State Physics

Laboratory (6 hrs per week)

1. Characteristics of Diode and Zener diode.
2. Study of different gates
3. Making AND, OR, NOT Gates using NAND Gates.
4. verification of Boolean Algebra.
5. Verification of Dual nature.
6. Characteristics of FET (Field Effect Transistor).
7. Setting of a transistor amplifier and determination of the amplification factor at various frequencies
8. Frequency response of transister amplifier with the without feedback
9. Characterstics of Harteley oscillator
10. Determination of different parameters of transistor
11. Study of multivibrator - Astable
12. Study of multivibrator - Bistable
13. Study of multivibrator - Monostable
14. VSWR in a microwave transmission line
15. Study of squarewave response of R.C. Network
16. Modulation of detection
17. Lock-in-amplifier
18. Design of operational amplifier circuit
19. Design of a field-effect transistor crystal oscillator
20. Resistivity and Band gap measurement by four probe method
21. Dielectric constant of wax by Lecher’s wire

22. Measurement of Hall coefficient of a semiconducting material
23. Study of digital voltmeter and frequency counter.

COURSE OUTCOME

After completing this course the students should be able to:
CO1: Evaluate various parameters associated with semiconductor diodes (Si, Ge, Zener, LED) and transistor amplifiers.
CO2: Apply the fundamentals of logic gates and its use in implementing basic Boolean operations.
CO3: Evaluate various parameters (resistivity, mobility) of a semiconducting material.
CO4: Use of oscillator circuits in electronic instruments.
CO5: Apply OP-AMP in solving mathematical operations.

CO-PO Mapping (PHY 305)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	1	1	2	2
CO2	2	3	3	3	3	3
CO3	2	3	3	3	2	3
CO4	2	3	2	3	2	3
CO5	1	3	2	3	2	2

Programme articulation matrix row for PHY 305

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 303	2	3	3	3	3	3

CO-PSO Mapping (PHY 305)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	3
CO3	3	3	3	3	2	2
CO4	2	3	3	1	2	2
CO5	3	2	2	1	1	1

PHY-306: Inter-disciplinary Elective Course
(Nano-Science and Nanotechnology)

Course Objective: *The main objective of the course is to help the students understand in broad outline of Nanoscience and Nanotechnology.*

Prerequisites: *Basic knowledge on Quantum Mechanics, Properties of matter.*

Unit I 10 hrs

Background to Nanoscience and nanotechnology: Definition of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challenges of nanoscience and nanotechnology, large surface to volume ratio for nano materials, influence of nano over micro/macro, size effects and crystals.

Unit II **10 hrs**

Moore's law, Classification of nanomaterials: 0D, 1D, 2D, 3D; Characteristic feature of nanomaterials, Density of states for various classes of nano materials, quantum confinement effect on nanomaterials, 2D- Quantum well, 1D-Quantum wire, OD-Quantum dot, Surface and physical properties of nanomaterials.

Unit III **10 hrs**

Nanomaterials fabrication: Different approach of synthesis, Bottom-up approach (Coprecipitation, Sol-Gel Process, Hydrothermal/Solvothermal Methods, Thin-Film Deposition Mechanism, Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD)), Top-Down approach (Powder metallurgy, Lithography), characterization of nano materials.

Unit IV **10 hrs**

Basic features of CNT and Graphene, Application of Nanomaterial: Ferroelectric materials, coating, molecular electronics and nanoelectronics, biological and environmental, Nano composites.

References

Text Books

1. Nanoparticles: From theory to applications – G. Schmidt (2004), Wiley Weinheim, 1st Edition.

2. An Introduction to Nanomaterials and Nanoscience- A.K. Das, D. Mahua (2017), CBS Publishers. 1st Edition

Reference Books:

1. Foundations for Nanoscience and Nanotechnology – Nils O Peterson (2017), CRC Press, 1st Edition

2. A Textbook of Nanoscience and Nanotechnology – T. Pradeep (2012), Tata McGraw-Hill, 1st Edition

3. Introduction to Nanoscience and Nanotechnology – K. K. Chattopadhyay and A. N. Banerjee (2009) PHI Learning Pvt Ltd, 1st Edition

4. Essentials in Nanoscience and Nanotechnology – N. Kumar and S. Kumbhat (2016), Wiley, 1st Edition.

COURSE OUTCOME

After completing this course the students should be able to:
CO1: Explain the properties of nanomaterials
CO2: Classify nanomaterials with respect to their different dimensions.
CO3: Apply various methods for synthesis of nanomaterials.
CO4: Apply nanomaterials in various applications.

CO-PO Mapping (PHY 306)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	2	1	2	3
CO2	2	3	1	2	2	3
CO3	1	3	3	2	2	3
CO4	1	3	3	2	3	3

Programme articulation matrix row for PHY 306

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 306	2	3	3	2	3	3

CO-PSO Mapping (PHY 306)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	3
CO3	3	3	3	3	3	3
CO4	3	2	2	2	3	3

PHY-401: Basic Nuclear Physics

Course Objective: *To impart knowledge about basic nuclear physics properties, Nuclear force and nuclear models and also understanding of related reaction dynamics.*

Prerequisites: *Elementary idea of quantum mechanics and nuclear structure*

Unit I **10 hrs**

Brief Discussion of Nuclear Properties: Nuclear Radius, Nuclear Mass, and Binding Energy, Angular Momentum, Parity and Symmetry, Magnetic Dipole Moment and Electric Quadruple Moment.

Two Nucleons Bound State Problem: Central and noncentral forces, deuteron and its magnetic moment and quadrupole moment; Force dependent on isospin, exchange force, charge independence and charge symmetry of nuclear force, mirror nuclei.

Unit II **10 hrs**

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

Nucleon Scattering Problem: n-p scattering at low energy, scattering cross section and scattering length, effective range theory. Nuclear force: Meson theory of nuclear force, Yukawa interaction.

Unit III **10 hrs**

Nuclear Models: Single particle model of nucleus, Liquid drop model, Bohr-Wheeler theory of fission, nuclear fusion, Shell model, analysis of shell model predictions, magic numbers, spin-orbit coupling, angular moment and parities of nuclear ground states, magnetic moments and Schmidt lines, Collective model of Bohr and Mottelson.

Unit IV **10 hrs**

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

References

Text Books:

1. Nuclear Physics- Dr. S. N. Ghosal, (2016), S. Chand, Revised Enlarged edition.
2. Nuclear Physics - R. R. Roy and B. P. Nigam, (1996), New Age International, 2nd Edition.
3. Nuclear Physics- Satya Prakash , (2015), Pragati Prakashan, 4th Edition.

Reference Books:

1. Atomic and Nuclear physics - Shatendra Sharma, (2008), Pearson India, 1st Edition.
2. Theoretical Nuclear Physics - J. M. Blatt and V. F. Weisskopt, (1979), Wiley, New York, 1st Edition
3. Introductory Nuclear Physics- Samuel S. Wong, (1990), Prentice Hall International Inc., 1st Edition

COURSE OUTCOME

After completing this course the students should be able to:

CO1: Understand the basic nuclear properties and nuclear stability.
CO2: Understand nuclear structure and theory associated with nuclear scattering.
CO3: Interpret the nuclear models associated with nuclear structure and stability.
CO4: Differentiate the process of nuclear reactions associated with alpha decay and beta decay.

CO-PO Mapping (PHY 401)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	1	1	1	2	2
CO2	3	2	1	1	2	2
CO3	1	3	3	2	3	1
CO4	2	3	3	2	2	2

Programme articulation matrix row for PHY 401

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 301	3	3	2	2	3	2

CO-PSO Mapping (PHY 401)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	2	3	3	3	2
CO2	2	2	2	3	2	2
CO3	2	2	3	2	2	1
CO4	1	3	3	3	1	1

PHY- 402: Particle Physics

Course Objective: *To impart knowledge about the developments in the area of high energy Physics and introduce the fundamental concepts relevant to interactions and fields in particle Physics, invariance principles and conservation laws and symmetries in particle physics.*

Prerequisites: *Basic knowledge on Quantum Mechanics, Nuclear Physics, Theory of Relativity, Group Theory*

Unit I **10 hrs**

Histrorical introduction to the Elementary Particles, The Standard model of particle physics, Classification of elementary particles and their interactions, fermions and bosons, lepton flavors, quark flavors, electromagnetic, weak and strong processes, Lepton number , Baryon number, color quantum number, Strangeness quantum number.

Unit II **10 hrs**

Two nucleon state vectors, Isospin, Strangeness and Hypercharge, Lepton and Baryon number conservation, Yukawa's theory, Neutrinos, Charge independence of nuclear forces, Isospin, Test for isospin conservation, Associated production of strange particles, Gell-Mann Nishijima scheme, conservation laws in relation to particle reaction particle reactions and decays.

Unit III **10 hrs**

Discrete Symmetry: Parity(P): Parity in quantum mechanics Parity, Parity conservation and non-conservation, Time reversal, Consequences of time reversal invariance, Charge conjugation, G-parity, Statement of CPT theorem and its consequences, Proof of equality of mass and life time for particle and anti particle.

Unit IV **10 hrs**

Relativistic Kinematics:

Lorentz transformations, four vector, Energy and momentum, Collisions, Examples and application.

Unitary symmetry: Unitary Symmetry and the classification of state, Hadrons and SU (3) multiplets, concept of I-Spin ,U-spin ,V-Spin, Su(3) quark model, the Eight fold way, Mesons and Baryons in the octet represent-ation , the baryon Decouplets, Evidence of color, Baryon Meson coupling.

References

Text Books:

1. Introduction to elementary particles: D. Griffiths (2008), Wiley-VCH, 2nd Edition.
2. Elementary particles physics by Stephen Gasiorowicz (1966), Wiley, New York, 1st Edition
3. Introduction to High energy Physics, Donald H Perkins (2000), CAMBRIDGE UNIVERSITY, 4th Edition.

Reference Books:

1. Quarks and leptons by F. Halzen and A.D. Martin (1984), Wiley, 1st Edition.
2. Modern elementary particle physics by G.Kane (2017), Cambridge University, 2nd Edition.

COURSE OUTCOME

After completing this course the students should be able to:

CO1: Understand the fundamental forces in nature

CO2: Classify the types of elementary particles and understand their nature of interaction

CO3: Interpret various conservation laws associated with the symmetry of elementary particles.

CO4: Apply quark model to understand symmetry in strongly interacting particles that led to the realization of SU(2), SU(3) and higher groups.

CO-PO Mapping (PHY 402)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	2	1	1	2	2
CO2	3	2	1	2	3	2
CO3	1	3	3	2	2	1
CO4	3	2	1	1	2	2

Programme articulation matrix row for PHY 402

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 402	3	3	2	2	3	2

CO-PSO Mapping (PHY 402)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	3	3	3	3
CO2	3	2	2	2	2	3
CO3	2	3	3	3	3	3
CO4	2	2	3	2	3	3

PHY-403: Special paper II

Advanced Condensed Matter Physics

Course Objective: *To study the concepts of condensed matter physics such as Lattice vibration, band gap calculation and then sequentially explore the interaction effects of electron-electron/phonon, and finally the superconductivity with its microscopic concept.*

Prerequisites: *Basic knowledge on basic condensed matter Physics and Quantum Mechanics.*

Unit I **10 hrs**

Quantisation of lattice vibration: Phonons normal coordinate transformation creation and annihilation operators methods of band calculation-tight binding method, OPW and pseudo-potential methods For surface de Haas Van Alphen effect Transport theory Boltzmann equation, relaxation Time approximation electrical conductivity and thermal conductivity.

Unit II **10 hrs**

Electron - electron interaction: Introduction, Hartree - Fock approximation, Hartree - Fock theory for helium Density functional theory general formulation. Local Density approximation

Unit III **10 hrs**

Superconductivity: Experimental survey, Meissner effect, Type-I &Type-II superconductors, thermodynamic properties of superconductors, London's theory, Isotopic effect, Flux quantization, BCS Theory

Unit IV **10 hrs**

Advanced Superconductivity: Electron-electron attractive interaction due to virtual phonon exchange, Cooper pairs and BCS Hamiltonian. Superconducting ground state and the gap equation at T = 0 K.Josephson effect: Macroscopic quantum mechanical effect, DC ,AC Josephson effect, Effect of magnetic field. High- Tc superconductors: Basic ideas and applications.

References

Text Books:

1. Physics of Condensed Matter- Prasanta K Misra (2010), Academic Press, 1st Edition
2. Quantum Theory of Solid state- Joseph Callaway (2012), Academic Press, 1st Edition

Reference Books:

1. Principles of the theory of solids – J.M.Ziman, (1979), Cambridge University Press, 1st Edition
2. Ferroics and Multiferroics – Edited by H. S. Virk and W. Kleeman, (2012), Trans Tech Publisher, 1st Edition.
3. Introduction to solid state physics- C. Kittel (2016), John Wiley & Sons, 8th Edition.

COURSE OUTCOME

After completing this course the students should be able to:

CO1: Explain the quantization process associated with lattice vibration.

CO2: Understand various electron-electron interaction theory.

CO3: Interpret the theory of superconductivity for various types of superconductors.

CO4: Analyze the quantum mechanical aspect associated with superconducting materials.

CO-PO Mapping (PHY 403)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	1	1	1	2	2
CO2	3	2	1	1	2	2
CO3	2	3	3	3	2	2
CO4	1	3	3	3	2	2

Programme articulation matrix row for PHY 403

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 403	3	3	2	2	2	2

CO-PSO Mapping (PHY 403)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	2	3	3	2
CO2	3	3	2	2	2	2
CO3	3	3	3	2	2	1
CO4	3	2	3	2	2	2

PHY-404: Energy Harvesting and Storage Materials

Course Objective: *Learn the Physics of working mechanism of energy harvesting and storage materials.*

Prerequisites: *Basic knowledge on semiconductors, thermodynamics, Electro-chemical properties of materials.*

Unit I **10 hrs**

Solar Cell: Solar cell and its system components, different solar cell and fabrication methods, calculating output and dimensioning of solar cell systems, solar cells in concentrated sunlight, Efficiency of solar cell, series connection of solar cells to modules: functions and characteristics.

Unit II **10 hrs**

Fuel Cell: Fuel cell definition, components, principle of working, thermodynamics and efficiency of fuel cells, Butler-Volmer equation, types of fuel cells and its chemistries – AFC, PAFC, PEMFC,MCFC, DMFC and SOFC – merits and demerits, Hydrogen – production and storage methods for fuel cells, Application of SOFC.

Unit III **10 hrs**

Batteries and Super Capacitors: Batteries: Primary, Secondary batteries, Basic concepts of primary and secondary batteries advantages and disadvantages. Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, role of activated carbon and carbon nano-tube (CNT).

Unit IV **10 hrs**

Synthesis of Materials: Top-Down and Bottom-up approach, Physical vapor deposition (PVD), Chemical vapour deposition (CVD), Sol-Gel, Electro deposition, Spray paralysis, Hydrothermal synthesis. **Characterization of Materials:** X-Ray Diffraction. Optical Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy (basic idea only), Band gap measurement by UV-Visible spectrometer.

References

Text Books:

1. Physics of Energy Sources, George C. King (2018), John Wiley and Sons, 1st edition.
2. The Physics of Energy, Robert L. Jafee and W. Taylor (2018), Cambridge University Press, 1st Edition.
3. Fuel Cells: Current Technology Challenges and Future Research Need, N. H. Behling, Elsevier (2013), 1st Edition.

Reference Books:

1. Non-conventional Energy Resources, G. S. Sawney (2012) PHI Private Ltd., 1st Edition, 2012
2. Renewable Energy Sources for Fuels and Electricity, T. B. Johansson, H. Kelly, Amulya K. N. Reddy and R. H. Williams (1992), Island Press, Wasington.
3. Introduction to Bioenergy, V. Nelson and K. Starcher (2016) CRC Press, 1st edition, 2016.
4. Fundamental of Ocean Renewable Energy: Generating Electricity from Sea, Simon P. Neill and M. R. Hashemi (2018) , Academic Press, Elsevier, 1st Edition.
5. Fuel Cell Technology: Hand Book, G. Hoogers (2003) CRC Press, 1st Edition.
6. Introduction to Nano (Basics to Nanoscience and Nanotechnology) – A. Sengupto and C. K. Sarkar, (2015), Springer, 1st Edition.

COURSE OUTCOME

After completing this course the students should be able to:
CO1: Determine the efficiency of a solar cell based on its output and dimensioning.
CO2: Apply fuel cell for hydrogen production and storage.
CO3: Use batteries and super capacitors for different energy storage applications.
CO4: Apply various synthesis and characterization techniques for energy harvesting and storage materials.

CO-PO Mapping (PHY 404)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	3	1	1	1	2	2
CO2	3	2	1	1	2	2
CO3	2	3	3	3	2	2
CO4	1	3	3	3	2	2

Programme articulation matrix row for PHY 404

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 404	3	3	2	2	2	2

CO-PSO Mapping (PHY 404)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	3	3	2	3	3	2
CO2	3	3	2	2	2	2
CO3	3	3	3	2	2	1
CO4	3	2	3	2	2	2

PHY-405: Project/Dissertation

Course Objective: *Create new physical device or models by applying the basic knowledge of Physics.*

Dissertation is allotted to the P. G. students. For each student a faculty member is assigned as Guide by the Head of the Department. A title or objective of the Dissertation must be chosen by the student in consultation with the Guide. Guide is required to assess the advancement by the student in the Dissertation work.

Course outcome

CO1: Apply the knowledge of Physics for predicting various physical phenomena.
CO2: Design tailor made materials for device applications.

CO-PO Mapping (PHY 405)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO1	1	2	2	3	2	3
CO2	1	2	3	3	2	3

Programme articulation matrix row for PHY 405

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
Course PHY 405	1	2	3	3	3	3

CO-PSO Mapping (PHY 405)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6
CO1	2	2	2	3	3	3
CO2	1	2	2	3	3	3

Mark Distribution

Continuous assessment (By supervisor)	End semester assessment (By Project evaluation committee)		
	Research content	Dissertation	Presentation
30	30	20	20