

SCIENCE COLLEGE
(AUTONOMOUS), HINJILICUT



Syllabus

For

Two Years M.Sc. Program

2023-25

P.G. Department of Physics

Science College

(Autonomous), Hinjilicut Ganja

m-761102 (Odisha)

Course Curriculum & Syllabi-2022
POSTGRADUATE DEPARTMENT OF PHYSICS
SCIENCE COLLEGE (AUTONOMOUS),
HINJILICUT, GANJAM, ODISHA, INDIA

1. About the Department:

The Department of Physics was opened in the year 1963, since the inception of the college with Intermediate class. In the year 1965 B.Sc Physics in General Subjects was opened after obtaining affiliation from Utkal University. But in the year 1976 B.Sc in Honours subject with 16 seats was opened after getting affiliation from Berhampur University. The Department started with a Vision to spread Science at Higher Education level; particularly to the rural based students and bring them to the National Mainstream. At present the Department offers three years Bachelor's Degree Course in Physics in Honours having 56 seats and Generic Elective for students of Physical Science Departments. The Department curricula have been designed congruent with the CBCS curriculum of U.G.C.

The Department made an outstanding contribution in bringing up the students for Higher Studies as well as for jobs when they go out successfully from this department.

The Department organizes Induction Meeting, Teacher's day Celebration, Seminars, Field Studies, Observation of National Science Day, Extension Activities and Farewell Meeting. Every year, students of this department are selected for taking admission in Central Universities and Other reputed institutions for their higher studies. Many alumni of this department are working in higher positions of State and Central Government organisations. Some of our students are also faculty members in leading national-level institutions and laboratories. This Department is a vibrant place for academics.

The Post Graduate Courses in Physics started in the Department from the current session 2023-24.

2. A. Faculty Members:

1. Dr. Binod Bihari Patra, H.O.D
2. Mr. Arun Kumar Khadanga, Reader
3. Dr. Keshab Chandra Shadangi, Reader
4. Mrs. Prativa Kumari Sahu, Lecturer
5. Mr. Jitu Muthamajhi, Lecturer,
6. Miss. Jhumuri Padhi, Lecturer,
7. Miss. Sulekha Mahankuda, Lecturer.

2. Syllabus:

M.SC.PHYSICSSYLLABI

SCIENCE COLLEGE (AUTONOMOUS),
HINJILICUT, GANJAM, ODISHA-761102, INDIA

1	Course	Course title	Hr sp er We ek	Cre dit	Exam Hrs	Marks		Total
						Mid Sem	End sem	
I	PHY-C101	Mathematical Methods in Physics	4	4	3	20	80	100
	PHY-C102	Classical Mechanics	4	4	3	20	80	100
	PHY-C103	Computer Programming And Numerical Analysis	4	4	3	20	80	100
	PHY-C104	Quantum Mechanics-I	4	4	3	20	80	100
	PHY-P105	Computer Programming In Physics(Practical)	12	6	6	20	80	100
		Total	28	22				500
II	PHY-C201	Classical Electrodynamics	4	4	3	20	80	100
	PHY-C202	Statistical Mechanics	4	4	3	20	80	100
	PHY-C203	Basic Solid-State Physics	4	4	3	20	80	100
	PHY-C204	Quantum Mechanics-II	4	4	3	20	80	100
	PHY-P205	Optics(Practical)	12	4	4	20	80	100
	PHY-VAC206	Material Characterization Technique OR DFT and Materials Modelling						
		Total	28	22				500

Note: C: Core paper, P: Practical, E: Elective, S: Seminar, VAC: Value added course, CT: Credit transfer

A student has to register for 14 core papers (including three core labs), 6 elective papers (including one lab in elective) and one project and seminar, two value added courses

III	PHY-C301	Relativistic Quantum Mechanics & Field Theory	4	4	3	20	80	100
	PHY-C302	Electronics	4	4	3	20	80	100
	PHY- E303 AOR PHY-E303B	Condensed Matter & Materials Physics-I Or Nuclear Science-1(N.P.)	4	4	3	20	80	100
			4	4	3	20	80	100
	PHY-EP304	Modern Physics (Practical)	12	6	4	20	80	100
	PHY-VAC305	Optical Fiber Sensor Or Fiber Optics Or Atomic And Molecular Spectra						
	PHY-CT300	Fibre Optics And Optoelectronics	04	04	03	20	80	100
		Total	28	22				500
IV	PHY-E401A OR PHY-E401B	Elementary Particle Physics Or GTR	4	4	3	20	80	100
			4	4	3	20	80	100
	PHY-C402	Basic Nuclear Physics	4	4	3	20	80	100
	PHY-CE403	Project And Seminar	4	4			50 50	100
	PHY-CE404A OR PHY-CE404B	Condensed Matter & Materials Physics II Or Nuclear Science-II	4	4	3	20	80	100
			12	6	4	20	80	100
	PHY-CE405AOR PHY-CE405B	Condensed Matter & Materials Physics (Practical) Or Nuclear Science (Practical)	12	6	4	20	80	100
PHY-AC406	Cultural Heritage Of South Odisha.							
		Total	28	22				500
		Grand total	112	88				2000

Note: C: Core paper, P: Practical, E: Elective, S: Seminar, VAC: Value added course, CT: Credit transfer

A student has to register for 14 core papers (including three core labs), 6 elective papers (including one lab in elective), and one project and seminar, two value added courses

Programme Outcome:

- Instil among the students an attitude of being inquisitive so that they are capable of independent and critical thinking.
- Train up the students in such a way that they can objectively carry out investigations, scientific and/or otherwise, without being biased or without having any preconceived notions.
- Equip the students with such skills to make them understand the mysteries of nature at different scales of space and time, from subnuclear to cosmological.
- Enable the students to analyze problems starting from first principles, evaluate and validate experimental results, and draw logical conclusions.
- Prepare the students to pursue research careers, careers in academics, industries in Physical Science and allied fields.
- As technology exploits the rules of Physics, students properly trained in Physics can be good researchers in the field of technology too.
- Imbibe effective scientific and/or technical communication abilities among the students.

First Semester

SubCode: PHY- C101	Mathematical Methods in Physics	
Semester:1	Credit:4	Core Course
Pre-requisites: Basic understanding of real analysis, Complex numbers, Group theory		
Course outcome:		
<ul style="list-style-type: none"> ✓ To learn about various mathematical tools employed to study physics problems. ✓ To get good experience in using and understanding areas like complex variables, Tensor analysis, Group Theory and special functions. ✓ To strengthen the student's analytical abilities and help them formulate different relationships in mechanics and physics compactly. 		

Unit-1

12 hours

Complex Variables: Analytic functions, Contour integrals, Cauchy's integral theorem, Laurent's series, singular points, residues and the Residue Theorem, Evaluation of real definite and indefinite integrals by contour integration, Indented semi-circular contour, evaluation of single and multi-valued functions, branch points and branch cuts, Contour integration involving branch point.

Unit-2

12 hours

Tensors: Introduction, Types of tensor, Invariant tensor, epsilon tensor, Pseudotensor, the algebra of tensor, Quotient law, Metric Tensor, Covariant derivative of tensor, Fundamental Tensor, Cartesian tensor, Christoffel symbol.

Unit-3

12 hours

Group Theory: Definitions of groups, subgroups and classes, Isomorphism, Homomorphism, Cayley's theorem, Group representations, Orthogonality theorem, characters, Orthogonality relation for group character, Character table, Preliminary idea about infinite group, calculation of generator, Calculation of generator associated with S.U. (2) and SO(3) group, Homomorphism between S.U.(2) and O⁺(3) group.

Unit-4

12 hours

Special Functions: Legendre Polynomials, generating functions, Recurrence formulae, Orthogonality properties of Legendre's polynomial of 1st kind, Bessel generating function, Recurrence formulae, Orthogonality properties of Bessel's polynomials, Fourier and Laplace transformation.

Textbooks:

1. Mathematical Methods of Physics by Mathews and Walker (W.A. Benjamin Inc.)
2. Matrices and Tensors in physics by A. W. Joshi (New Age International Publisher)
3. Mathematical Methods in the physical Science by Mary L. Boas (Wiley-India)

Reference Books:

1. Mathematical Methods for Physicist by G. Arfken and H. Weber, Academic Press (Elsevier)
2. Elements of Group Theory by A. W. Joshi (New Age International Publisher)
3. Mathematical Physics by H. K. Das and Dr. R. Verma (S. Chand & Company L. T. D.)
4. Mathematical Physics by P. K. Chattopadhyaya (New Age International)

Sub.Code:PHY-C102		ClassicalMechanics
Semester:1	Credit:4	CoreCourse
Pre-requisites: Basicunderstandingofgeneralizedcoordinate,Newtoniandynamics		
Courseoutcomes:		
<ul style="list-style-type: none"> ✓ Tounderstanddegrees of freedomanddynamicsof arigid bodymotion. ✓ Tounderstandcomplexkind ofgyroscopicmotionas likeheavysymmetrictop. ✓ TomakeoutcleardistinctionofLagrangianandHamiltoniandynamics. ✓ TounderstandHamiltonian dynamicsandevolutionofquantummechanics. ✓ Tounderstandsmalloscillationoccurringinmicroandmacro-systems 		

Unit-1

10hours

KINEMATICSOFRIGIDBODYMOTION:

Independent coordinates of a rigid body, Orthogonal transformations, Eulerian angles, infinitesimal rotations, rate of change of vector, Coriolis force, angular momentum and kinetic energy of motion about a point, inertial tensor and the moment of inertia, Eigenvalues of Inertial tensor and the principal axis transformation, methods of solving rigid body problems and Euler's equations of motion, torque free motion of a rigid body. Heavy symmetrical top with one point fixed.

Unit-2

10hours

HAMILTONIANFORMULATION:CalculusofVariationsandEuler-

Lagrange'sEquation,BrachistochroneProblem,Hamilton'sPrinciple,ExtensionofHamilton'sPrincipleto NonholonomicSystems, Legendre Transformation and the Hamilton Equations of Motion, Physical Significance

ofHamiltonian,DerivationofHamilton'sEquationsofMotionfromaVariationalPrinciple,Routh's Procedure,PrincipleofLeastAction

Unit-3

10hours

CANONICAL TRANSFORMATIONS: Canonical Transformation, Types of Generating Function, conditions for canonical transformation, Integral Invariance of Poincare, Poisson Bracket, Poisson's Theorem, Lagrange Bracket, Poisson and Lagrange Brackets as Canonical Invariant, Infinitesimal Canonical transformation and Conservation Theorems, Liouville's Theorem Hamilton Jacobi Theory: Hamilton-

Jacobi Equation for Hamilton's Principal Function, Harmonic Oscillator and Kepler problem by Hamilton-Jacobi Method, Action-Angle Variables for completely Separable System, Kepler Problem in Action-Angle Variables

Unit-4

10hours

SMALL OSCILLATION: Problem of Small Oscillations, Example of linear triatomic molecule and two

coupled Oscillator, General Theory of Small Oscillations, Normal Coordinates and Normal Modes of Vibration.

TestBooks:

1. Classical Mechanics - by H. Goldstein (Addison-Wesley)

Referencebooks:

1. Classical Mechanics by S.N. Biswas, Books and Allied Publisher Ltd.
2. Classical Mechanics by J.C. Upadhyay, Himalaya Publishing House.
3. Classical Mechanics by Landau and Lifshitz (Butterworth)

SubCode:PHY-C103	Computer Programming and Numerical Analysis	
Semester:1	Credit:4	Core Course
Pre-requisites: BasicknowledgeofComputer,MathematicalPhysics		
Courseoutcomes:		
<ul style="list-style-type: none"> ✓ Tounderstand the importanceofcomputerapplication inScienceandengineering. ✓ Tolearnand understandbasic computerlanguageFORTRAN77. ✓ Tocomputeand developalgorithmsforsolutionofscienceandengineering problems. 		

Unit-1

10hours

Data types, expressions, statements, input and output commands, conditional and interactive constructs, character and data managements, array manipulations, subprogram, subroutine.

Unit-2

12hours

Numerical integrations by trapezoidal and Simpson method, finding the root of an equation by Newton-Raphson method, finding prime numbers, Runge-Kutta method, interpolations and similar other problems .

Unit-3

12 hours

Solution of simultaneous linear equations, Gaussian elimination, Pivoting, Iterative Method, Matrix Inversion, Root of a transcendental equation by Newton-Raphson Method, Least square fitting.

Unit-4

12hours

Eigenvalues and eigenvectors of matrices, power and Jacobian method, Finite Differences, Interpolation with equally spaced and unequally spaced points (Newton's and Lagrange's method), Forward and Backward Interpolation, Extrapolation, Numerical Integration by trapezoid and Simpson's rule, Solution of first and second order differential equation using Runge-Kutta (RK-4) method.

Textbooks:

1. Fundamentals of Computers by V. Rajaraman, Prentice Hall of India Ltd Publishers.
2. Fortran 77 and Numerical Methods by C Xavier, New Age International (P) Ltd Publishers.
3. Numerical Methods in Science and Engineering by S. Rajasekaran, S. Chand

Reference Books:

1. Numerical Mathematical Analyses by J.B. Scarborough, Oxford and I.B.H. Publishing Company
2. Numerical methods for engineering and scientific computation by M K Jain (Wiley Eastern)
3. Numerical Methods for Scientific and Engineering Computation by M K Jain, S R K Iyengar and R Jain, New Age International (P) Ltd Publishers.

SubCode:PHY-C104	QuantumMechanics-1	
Semester:1	Credit:4	CoreCourse
Pre-requisites::BasicMathematicalPhysics		
CourseOutcomes: <ul style="list-style-type: none"> ✓ To apply quantum mechanics to the dynamics of single particle in one-,two andthree-dimensionalpotential fields ✓ Tostrengthentheanalyticalabilitiesofthestudentandhelphemtoapplyitin differentbranchesof physics compactly. 		

Unit-1

14 Hours

GENERALPRINCIPLESOFQUANTUMMECHANICS:

Postulates of Quantum Mechanics and meaning of measurement, Operators and their expectation values, Schrodinger equation, Particle in a box, Orthogonality of eigenfunctions. Dirac Notations, Linear vector space, Ket and Bra vectors, Scalar product of vectors and their properties, Dirac delta function, linear operators, Adjoint operators, Unitary Operators, Expectation values of dynamical variables and physical interpretation of Hermitian operators, Eigen values and eigenvectors, orthonormality of eigen vectors, probability interpretation, Degeneracy, Schmidt method of orthogonalisation, Expansion theorem, Completeness and closure properties of the basis set, Coordinate and momentum representations, compatible and incompatible observables, Commutator algebra, uncertainty relation as a consequence of non-commutability, minimum uncertainty wave packet, Representations of Ket and Bra vectors and operators in matrix form, Unitary transformation of basis vectors and operators.

Unit-2

12 Hours

QUANTUMDYNAMICS:

Time evolution of quantum states, Time evolution operator and its properties, Schrödinger, Heisenberg and Interaction picture, Equations of motion, Operator method solution of Harmonic oscillator problem, Matrix representation and time evolution of creation and Annihilation operators.

Unit-3

14 Hours

ROTATION AND ORBITAL ANGULAR MOMENTUM:

Orbital angular momentum operators as generators of rotation, L_x , L_y , L_z and L^2 and their Commutation 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 and L^2 (operator method), Matrix representation of L_x , L_y , L_z and L^2 .

Unit-4

12 Hours

SPIN ANGULAR MOMENTUM:

Spin $\frac{1}{2}$ particles, Pauli spin matrices and their properties, Eigen values and Eigen functions, Spin and rotations. Total angular momentum: Total angular momentum J , Eigen value problem of J^2 and J_z , Angular momentum matrices, Addition of angular momentum and C. G. coefficients for the states with (i) $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$ (ii) $j_1 = 1$ and $j_2 = \frac{1}{2}$.

Textbooks:

1. "Quantum Mechanics: Concepts and Applications" by Nouredine Zettilé John Wiley and Sons.

Reference Books:

1. "Quantum Mechanics", L.I. Schiff L. 3rd Ed, McGraw Hill Book Co.
2. "Quantum Mechanics" E. Merzbacher, 2nd Ed., John Wiley & Sons.
3. "Quantum Physics", S. Gasiorowicz John Wiley.
4. "A Text Book of Quantum Mechanics" by P.M. Mathews and Venkatesan, Tata McGraw Hill.
5. Introduction to Quantum Mechanics, by D.J. Griffiths, 2nd edition, Pearson Publications

SubCode:PHY- P105	Computer Programming and Numerical Analysis (Laboratory work)	
Semester:1	Credit:4	Core Course
Pre-requisites: Basic knowledge of computer		
Course Outcomes:		
<ul style="list-style-type: none"> ✓ To learn and practice basic computer language FORTRAN 77. ✓ To program different methods associated with Physics and Engineering 		

1. Numerical integration by trapezoidal method
2. Numerical integration by Simpson method
3. Solution of first and second order differential equation by Runge Kutta Method
4. Matrix addition, subtraction, multiplication and manipulation
5. Matrix inversion
6. Finding the roots of an equation by Newton-Rapson method
7. Least square fitting of linear parameters
8. Determination of prime numbers.
9. To arrange a set of numbers in increasing or decreasing order
10. Sum of A.P and G.P series, Sine and Cosine series
11. Factorial of a number
12. Evaluation of log and exponentials by summing of series
13. Any other suitable experiments.

Second Semester

SubCode: PHY- C201	: Classical Electrodynamics	
Semester:2	Credit:4	CoreCourse
Pre-requisites: Basic Mathematical Physics, (ii) Classical Electricity and Magnetism.		
Course Outcomes: <ul style="list-style-type: none"> ✓ To emphasize electric and magnetic radiation field phenomena and Bremsstrahlung radiation in a Coulomb field and Cherenkov radiation, ✓ Electromagnetic Scattering. 		

Unit –I

14 Hours

(a) **Covariant formulation of electrodynamics:** Covariant form of Maxwell's equation (four vector and tensor form), Maxwell field tensor, covariant definition of electromagnetic energy and momentum, transformation of electromagnetic field components, Lagrangian of a charged particle in an external electromagnetic field.

(b) **The Inhomogeneous Wave equation:** Wave equations for potentials, solution by Fourier analysis, Radiation field, Radiation energy, Hertz potential, Computation of radiation fields by Hertz method, electric dipole radiation, multipole-radiation.

Unit–II

12 Hours

a) **Lienard-Wiechart potential and Field of a uniformly moving electron:** Lienard-Wiechart potential, Fields of a charge in uniform motion, Direct solution of the wave equation, Convection potential, Virtual photon concept.

(b) Waveguides, Propagation of electromagnetic waves in rectangular waveguides.

Unit–III

14 Hours

Radiation from Accelerated Charges:

Radiation from an accelerated charge, Fields of an accelerated charge radiation at low velocity, Case of velocity parallel to acceleration, radiation from circular orbits, Radiation with no restriction on the acceleration or velocity, Classical cross section for bremsstrahlung in a Coulomb field, Cherenkov radiation.

Unit–IV

14 Hours

Radiation, scattering and dispersion:

Radiative damping of a charged harmonic oscillator, forced vibrations, scattering by an individual free electron, scattering by a bound electron, absorption of radiation by an oscillator, equilibrium between an oscillator and a radiation field, effect of a volume distribution of scatterers, scattering from a volume distribution, Rayleigh scattering, the dispersion relation.

Text Book:

1. "Classical Electricity and Magnetism" by Wolfgang K.H. Panofsky and Melba Philips, Second Edition.

Reference books:

1. "Classical Electrodynamics", Jackson JD, John Wiley.
2. "Introduction to Electrodynamics", Griffiths DJ, Prentice Hall.

SubCode:PHY-C202	StatisticalMechanics	
Semester:2	Credit:4	Core Course
Pre-requisites: Basiclawsofthermodynamic s		
CourseOutcomes:		
<ul style="list-style-type: none"> ✓ To develop a working knowledge of statistical mechanics. ✓ To learn statistical interpretation of various phenomena like ensembles, ideal systems, photon gas, Low temperature physics and their applications, Bose Einstein condensation, phase transition. ✓ To explore its applications in other branches of physics like materials science and the physics of condensed matter. 		

Unit-1

12 Hours

Classical Statistical Mechanics: Postulates of classical statistical mechanics, Lowville's theorem, micro-canonical ensemble, derivation of thermodynamics, equi-partition theorem, Classical ideal gas, Gibb's paradox, .canonical ensemble, energy fluctuation in canonical ensemble, grand canonical ensemble, density fluctuation in grand canonical ensemble, equivalence of canonical and grand canonical ensemble.

Unit-2

12 Hours

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 ensemble. Particle in a box, M.B., B.E. and F.D. distributions. The Ideal Gases in Grand Canonical Ensemble, Equation of state of Ideal Bose Gas, Fermi Gas.

Unit-3

12 Hours

Fermi Gas: The Equation of state of an Ideal Fermi gas, High temperature and low Densities, Low temperature and High Densities, Theory of White Dwarf Stars, Pauli paramagnetism.

Unit-4

12 Hours

Bose Gas: Ideal Bose gas, Photon, Planck's law, Bose-Einstein condensation. 1st order and 2nd order phase transitions, Ginzburg Landau theory of phase Transition, Ising model (one dimensional Ising model)

Text Book:

1. Statistical Mechanics – K. Huang, Wiley India

Reference books:

1. Statistical Mechanics – Landau and Lifshitz, ButterWorth
2. Statistical Mechanics - R.K. Patheria, P.D. Beale 3rd Ed, ButterWorth-Heinemann
3. Fundamental statistical and thermal Physics - F. Reif, Tata McGraw-Hill Edition
4. Elementary statistical mechanics, C. Kittel, Dover Publication

Sub.Code:PHY-C203	BasicSolidStatePhysics	
Semester:2	Credit: 4	CoreCourse
Pre-requisites: Crystalstructure,Bragg'sDiffraction,Reciprocallatticespace		
CourseOutcomes:		
<ul style="list-style-type: none"> ✓ Tounderstanddifferentbondmechanism. ✓ Tounderstandevolutionofphononanditsimportanceinelectricaland thermalproperties ✓ TounderstandF.E.M.andNFEM. ✓ Tounderstanddifferentclassofsolids. 		

Unit-1

10hours

CRYSTAL BINDING: Crystals of inert gases, Ionic crystals, covalent crystals, Metals
LatticeDynamics-

Vibrationsofamonoatomiclinearchain,Vibrationofadiatomiclinearchain,Dispersionrelations,
Acousticand Optic modes, Long-wavelength limits.

Unit-2

10hours

SPECIFIC HEAT OF INSULATORS:Phonon heat Capacity, Debye model for density ofstates,DebyeT³law,Einstein'stheoryofthespecificheatFreeElectronFermigas-Energylevelsinone-dimension, Effect of temperature on the Fermi-Dirac distribution function, Free electron gasin three dimension, Heat Capacity of the electron gas, Electrical conductivity and Ohm's law, Motionin magnetic fields, Static magneto-conductivity tensor, Hall effect, Thermal conductivity ofmetals,Wied man-FranzLaw.

Unit-3

Energybands :Nearly freeelectronmodel, originof theenergygap, Bloch functions, Kronig-

Penney model, Wave equation of electron in a periodic potential, restatement of Bloch theorem,solution of the central equation, approximate solution near a zone boundary, number of orbitalsina band, metals and insulators.

Unit-4

SEMICONDUCTORCRYSTALS:Bandgap,Holes,effectivemass,intrinsiccarrierconcentration, intrinsic mobility, impurity conductivity, donor states, acceptor states, thermalionizationofdonors andacceptors.

DEFECTS AND DIELECTRICS: Classification of defects, Point defects- Schottky and Frenkeldefects, Diffusion and ionic conductivity. Dielectrics-local electric field at an atom, Lorentzfield, field of dipoles inside cavity, dielectric constant and polarisability-Claussius-Mossottirelation,Mechanisms of electronicionic and orientation polarizability

ReferenceBooks:

1. IntroductiontothetheoryofSolidStatePhysicsbyJ.D.Patterson(Addison-Wesley,1971)
 2. SolidStatePhysicsby N.W.Ashcroft andN.D.Mermin ,(HarcourtAsiaP.T.E.Ltd.)
- PhysicsofCondensedMatterbyPrasantaK.Misra(AcademicPress,2010)

QUANTUMMECHANICS-II		
Semester:204	Credit:4	CoreCourse
Pre-requisites: Basic knowledge in Quantum mechanics-1 and Mathematics to handle model description based on physical laws		
Course Outcomes: ✓ To learn the properties of molecules and atoms and their constituents— electrons, protons, neutrons, and other more esoteric particles such as quarks and gluons.		

Unit-1

12Hours

Motion in a spherically symmetric field:

The hydrogen atom, Reduction to equivalent one body problem, radial equation, Energy eigenvalues and eigen functions, Degeneracy, Radial probability distribution, free-particle problem, Expression of plane waves in terms of spherical waves .

Unit-2

12Hours

Approximate methods:

stationary perturbation theory, Rayleigh Schrodinger method for non-degenerate case, first and second order perturbation, anharmonic oscillator, general theory for the degenerate case, removal of degeneracy, linear Stark effect, normal Zeeman effect.

Unit-3

12Hours

Time-dependent perturbation theory:

Transition probability, constant and harmonic perturbation, Fermi Golden rule. Variational method: Ground state of He atom.

W.K.B. method: connection formulas, Bohr-

Sommerfeld quantization rule, Harmonic oscillator and cold emission.

Unit-4

12Hours

Scattering amplitude and scattering cross section:

Born approximation, application to Coulomb and screened Coulomb potentials.

Partial wave analysis for scattering, optical theorem, scattering from a hard sphere, resonant scattering from a square well potential.

Identical particles, Symmetric and antisymmetric wavefunction, Coulomb and exchange interactions.

Text Book:

1. "Quantum Mechanics: Concepts and Applications" by Nouredine Zettilé John Wiley and sons.

Reference Books:

"Quantum Mechanics", L.I. Schiff 3rd Ed, McGraw Hill Book

Co. "Quantum Mechanics" E. Merzbacher, 2nd Ed., John Wiley & Sons.

"Quantum Physics", S. Gasiorowicz John Wiley.

"A Text Book of Quantum Mechanics" by P.M. Mathews and Venkatesan, Tata McGraw Hill. Introduction to Quantum Mechanics, by D.J. Griffiths, 2nd edition,

Pearson Publications

SubCode:PHY- P205	Optics(Laboratorywork)	
Semester:1	Credit	CoreCourse
Pre-requisites:BasicknowledgeofOptics		
CourseOutcomes:Toapplytheprincipleofopticsinexperiments.		

1. Experimentswithopticalbench: Biprism Straightedgeandnarrowwire
2. Experimentswithspectrometer: SingleandDoublesplit
3. ExperimentswithMichelsoninterferometer: DeterminationofAand α Thicknessofmica sheet
4. FabryPerotinterferometer

CourseNo.PHY-VAC206A	CourseName:Materials Characterization	
Semester: II	Non-Credit	VAC
Pre-requisites:		
Course Outcome: The course aims to give the theory and hands-on-training of the instruments facilities available at Berhampur University. This will help the students to understand the spectroscopic techniques required for characterization of materials synthesized in laboratory.		
Chapter/Unit	Contents	Hours/Semester
1	UV- visible spectroscopy: Baseline correction with suitable solvent, blanking the instrument, determination of suitable concentration, quantitative measurement of sample of different concentration. Kinetic measurement of reaction to determine rate constant, spectral measurement of different compounds, data export in different format and plotting in origin. Other tips & things to watch out for when measuring particle size, Band gap measurement using Tauc plot.	10
2	Photoluminescence spectroscopy: Determination of excitation and emission peak for unknown sample, choosing right filter for correct measurement, using solid sample as well as solution sample, measurement in fluorescence and phosphorescence mode for lanthanide doped sample as well as organic molecules. Lifetime measurement and calculation of lifetime in single and double exponential plotting in origin. Data export and plotting in origin. Other tips in PL measurement.	10
3	X-Ray Diffraction Studies: Basic principles, Baseline correction, Crystal structure determination, Calculation of crystallite size from XRD data, Insertion of negative hkl indices in XRD graph, Calculation of d-spacing, lattice constant, crystalline mode, microstrain, dislocation density, Modified W-H plot for crystallite size/microstrain and energy density.	10

4	Magnetic susceptibility Measurement: Elementary idea about magnetic properties of metal complexes, Diamagnetism, Paramagnetism, Magnetic susceptibility and its measurement, Ferromagnetism, Ferrimagnetism and Anti-ferromagnetism.	10
Total		40

5. Polarization Experiments Babinet compensator Edsar-Butler bands Quarter wave plate
Mallus Law Study of elliptical polarized light

6. Constant Deviation Spectrography Calibration Zeeman effect

7. Babinet Quartz Spectrography

8. Any other suitable experiments

Any other experiments that may be set up from time to time

Sub Code: PHY-VAC206B	DFT and Materials Modelling	
Semester:2	Non-Credit:	VAC
Pre-requisites: Quantum Physics, Mathematics and Computation		
<p>Course Outcomes:</p> <ol style="list-style-type: none"> 1. To understand a single atom and its behaviour independently. 2. To understand evolution of different properties dependent on density functional. 3. To understand different approximations leading to better exchange correlation. 4. To understand implementation of DFT on Quantum Espresso and codes 5. To evaluate numerically different physical properties. 		

Unit-I

Preliminaries: Atomic model, The hydrogen atom, Solution of Schrodinger Equation, Electron wave functions and energies, Probability distribution. Multi-electron atoms, Hartree-Fock Theory, Free electron model (FEM), Nearly free electron model (NFEM)

Unit-II

The Schrodinger Equation, Density Functional Theory—From Wave Functions to Electron Density, Exchange–Correlation Functional, Localized and Spatially Extended Functions, Wave-Function-Based Methods, Hartree–Fock Method, Beyond Hartree–Fock. DFT Calculations for Simple Solids, Periodic Structures, Supercells, and Lattice Parameters, Face-Centered Cubic Materials, Hexagonal Close-Packed Materials, Crystal Structure Prediction, Phase Transformations,

Unit-III

Nuts and Bolts of DFT Calculations: Reciprocal Space and k Points, Plane Waves and the Brillouin Zone, Integrals in k Space, Choosing k Points in the Brillouin Zone, Metals—Special Cases in k Space, Summary of k Space, Energy Cutoffs, Pseudopotentials, Numerical Optimization, DFT Total Energies—An Iterative Optimization Problem, Geometry Optimization, Internal Degrees of Freedom, Optimizing Supercell Volume and Shape, Electronic Structure and, Electronic Density of States, Local Density of States and Atomic Charges, Magnetism

Unit-IV

Applications: **Quantum Espresso**, Materials Cloud, Examples: **Silicon**: Self-consistent Field, Writing the input, Running the code, Reading the output, lattice constant and bulk modulus of silicon, Bands, **Graphene**: Compute the band-structure.

References: Books

1. A Practical Introduction to Density Functional Theory By L. Rademaker
2. Electronic Density Functional Theory Recent Progress and New Directions by John F. Dobson, Giovanni Vignale and Mukunda P. Das.

Third Semester

SubCode:PHY-C301	RelativisticQuantumMechanics&Field theory	
Semester:3	Credit:4	CoreCourse
Pre-requisites: Quantum Mechanics, Special theory of relativity, Mathematical PhysicsandElectrodynamics.		
CourseOutcomes: <ul style="list-style-type: none"> ✓ Tostudytheeffectofrelativityonquantummechanicsandtodevelopthe formulationforRelativisticsystems along with thequantizationprinciple. ✓ TointroducebasicconceptofQuantumfieldtheorytounderstandthedynamicsof relativisticsystemsthroughcreationandannihilationoperators 		

Unit-1

12Hours

BriefintroductiontoRelativisticquantummechanics,Klein-Gordonequationanditsdrawbacks, Charge and current densities, Positive and negative energy states, Dirac's Hole theory,Free particle Dirac equation, Properties of the Dirac matrices, Continuity Equation, Spin of theelectron.

Unit-2

12hours

Plain wave solutions of Dirac Equation, Normalization of the wave functions, Dirac equationinanelectromagneticfield,itsnon-relativisticcorrespondence,magneticmoment,Diracequationforacentralpotential,spin-orbitcoupling,CovariantformoftheDiracequation,

ProofofitsLorentzcovariance,Propertiesofthe gamma-matrices.Bilinearcovariants.

Unit-3

10hours

Conceptoffields,Classicalfieldequation,Noether'stheorem andconservationlaws,Gaugeinvariance and chargeconservation, Creation,Annihilation andnumber operators.

Unit-4

14 hours

FieldQuantization:(a)neutralscalarmesonfield(b)chargedscalarmeson field(c)Dirac field.

Textbooksandreadingmaterials:

1. RelativisticquantumfieldtheorybyJ.D.BjorkenandS.D.Drell(McGraw-HillPublisher).
2. LecturesonQuantumFieldTheory,AshokDas,(WorldScientificPublishingCo.)
3. LahiriA,PalP.B.,AFirstBookofQuantumFieldTheory(NarosaPublishingHouse)
4. QuantumMechanics andFieldTheorybyB.K. Agarwal(AsiaPublishingHouse)

Sub Code: PHYC302	Electronics	
Semester:1	Credit:4	CoreCourse
Pre-requisites: P.N. Junction. Network Analysis (KirchhoffLaws)		
CourseOutcomes:		
<ul style="list-style-type: none"> ✓ To make the student familiar with basic analog and digital electronic components. ✓ Understand D.C. analysis and A.C. models of semiconductor devices ✓ Apply concepts for the design of Amplifier ✓ Understand number representation and conversion between different representations in digital electronic circuits ✓ Analyze logic processes and implement logical operations using combinational logic circuits. 		

Unit-1

10Hours

Amplifiers: Transistors, Two-port network analysis, thevenin theorem, transconductance model, Frequency response of linear amplifiers R.C. and Transformer coupled amplifiers, gain bandwidth product, feedback amplifiers, effects of negative feedback, F.E.T., MOSFET, Boot-strapping the F.E.T.

Unit-2

8 Hours

Oscillator circuits: Feedback criteria for oscillation, Nyquist criterion, Phase shift, Wien-Bridge oscillator, Crystal controlled oscillator

Unit-3

12Hours

Operational Amplifiers: The differential amplifier, D.C. and A.C. signal analysis, integral amplifier, rejection of common mode signals, CMMR, The operational amplifier, input and output impedances, Application of operational Amplifiers unit gain buffer, summing, integrating amplifier, Comparator, Operational amplifier as a differentiator

Unit-4

12Hours

Digital Circuits: Logic fundamentals, Boolean theorem, logic gates: AND, OR, NOT, NOR, NAND, XOR, and EXNOR. RTL, DTL and TTL logic, Flip-flop, RS- and JK-Flipflop, A/D and D/A Converters

Textbooks and reading materials

1. Electronic fundamental and application by J.D. Ryder, PHI, Learning Pvt Ltd.
2. Electronics: Circuits and Analysis, D.C. Dubey, Alpha Science

References:

1. Foundation of electronics – Chattopadhyay, Rakshit, Saha and Purkait, Newage International publisher
2. Electronics principles – Albert Malvino, Tata McGraw-Hill Edition
3. Modern Digital Electronics – R.P. Jain, Tata McGraw-Hill Edition

Sub Code: PHYC303A	Condensed Matter and Material Physics	
Semester:3	Credit:4	Core Course
Pre-requisites: Basic knowledge in solid state physics, Classical mechanics, Quantum mechanics and elementary mathematics to handle model description based on physical laws		
Course Outcomes:		
<ul style="list-style-type: none"> ✓ To provide an introduction to the physics of condensed matters ✓ To make them acquainted with the areas like quantization of lattice vibrations, electron-electron interaction, superconductivity and Advanced Superconductivity. 		

Unit-1

12Hours

Quantisation of lattice vibration: Phonons, normal coordinate transformation, creation and annihilation operators. Methods of band calculation-Tight binding method, O.P.W. and pseudopotential methods. Fermi Surface, de Haas-van Alphen effect. Transport theory-Boltzmann equation, relaxation time approximation, electrical conductivity and thermal conductivity.

Unit-2

12Hours

Electron-electron interaction: Hartree approximation, Hartree-Fock approximation, Hartree-Fock theory for jellium model. Density functional theory-general formulation, Local Density Approximation.

Unit-3

12Hours

Superconductivity: Occurrence of superconductivity, Meissner effects, Type-I and II superconductors, energy gap, Isotope effect, Theoretical survey: Thermodynamics of superconducting transition, London equations, coherence length, Qualitative ideas about the B.C.S. theory, Single particle tunneling, Josephson effect.

Unit-4

12Hours

Advanced Superconductivity: Electron-phonon interaction, Microscopic theory of superconductivity, Quasielectrons, Cooper pairs, B.C.S. theory, Ground State of superconducting electron gas, elementary ideas of high T_c superconductors

Text Book:

1. Physics of Condensed Matter By Prasanta K. Misra (Academic Press, 2010)
2. Quantum Theory of Solid State by J. Callaway (Academic Press)

Reference books:

1. Principles of the theory of solids, J.M. Ziman (Cambridge and University press)
2. Solid State Physics by C. Kittel (John Wiley and sons, Ins Singapore)
3. Introduction to the theory of Solid State Physics by J.D. Patterson (Addison-Wesley, 1971)

SubCode:PHY-E303B	NuclearScience-I	
Semester:1	Credit:4	Electivecourse
Pre-requisites:BasicNuclearScience		

CourseOutcomes:

- ✓ To understand the advance of Nuclear Physics

Unit-1 **12 Hour**

Rotation Matrix and Tensor: Rotational invariance in three dimensions, eigenvalues and eigenfunctions of angular momentum operators, explicit representation of the rotation matrix, addition of angular momenta, Clebsch-Gordan coefficients, irreducible spherical tensor, matrix element of tensor operators, Wigner-Eckart theorem

Unit-2 **12 Hours**

Optical model: Optical model, deuteron stripping and pickup reaction, Elementary ideas Brueckner theory

Unit-3 **12 Hours**

Collective Model: Collective Vibrational modes of a spherical nucleus, collective oscillation quadrupole deformation, Expression for moment of inertia.

Unit-4 **12 Hours**

Rotational Spectra: Rotational spectra of even-even nuclei, coupling of a particle and collective motion, electric quadrupole moments, magnetic dipole moments

Textbooks:

1. Nuclear Physics by R.R. Roy and B.P. Nigam, John Wiley

Reference Books:

1. Physics of the nucleus by M.A. Preston, Addison Wesley.
2. Nuclear Physics by S.S.M. Wong, Prentice Hall.
3. Introduction to Nuclear Physics by H. A. Enge, Addison Wesley
4. Structure of the Nucleus by M.A. Preston and R K Bhaduri, Addison Wesley

SubCode:PHY- P306	Modern Physics(Laboratorywork)	
Semester:1	Credit:4	CoreCourse
Pre-requisites:BasicknowledgeofModernPhysics		
Courseoutcomes:		
✓ TodesignandanalyzeexperimentsinModernPhysics		

1. Determination of e/m by
 - I) Brauntube method
 - II) Magnetron Valve method
 2. Determination of Planck's constant (h) by Photo-electric effect methods
 3. Measurement of velocity of light by Lecher wire
 4. G.M. counter experiments:
 - I) Characteristics of the Geiger tube
 - II) Inverse Square Law.
 - III) Absorption coefficient of the Aluminium foil.
 5. Characteristics of Diode and Zener diode.
 6. Study of logic gates AND, OR, NOT, NAND, NOR, EXOR.
 7. Making AND, OR, NOT Gates using NAND Gates.
 8. Verification of Boolean Algebra.
 9. Verification of Dual nature.
 10. Characteristics of F.E.T. (Field Effect Transistor).
- Any other experiments that may be set up from time to time

SubCode:PHY-E301	FiberOpticsandOptoelectronics	
Semester:4	Credit:4	ElectiveCourse
Pre-requisites:BasicPhysicsatthehighersecondarylevel		
Courseoutcomes:		
<ul style="list-style-type: none"> ✓ Theobjective ofthiscourseistofamiliarize studentsthe roleoffiber opticsindaytodayapplications. ✓ Toprovidebasicknowledgefordesigningsimple experimentusing L.E.D.,FiberandDetector 		

Unit-1

12 Hours

Opticalfiber:Opticalfiberstructure:StepIndexFiber,GradedIndexFiber,Transmissionoflightthrough cylindricalwaveguidebyusingelectromagnetictheory.Singlemodeandmultimode fibers, modal concept, modes in step index and graded index fiber,V-number, powerflow in Step Index fiber. Different types of fiber, Elementary idea on Fiber Materials, Fabricationmethod: Double Crucible Method, fiber optic Cables, Photonic crystal fiber and Fiber BraggGrating

UNIT-2

10Hours

Signal degradation in Optical Fiber: Attenuation, Absorption, bending Loss, Scattering Loss,CoreCladdinglosses,dispersionlosses,Materialdispersion,waveguidedispersion,Modaldispersion, Signal distortion in single mode fibers, Design of optimization of single mode fibers.Dispersionshifted and Dispersion flattened fiber.

Unit-3

08Hours

Connector, Couplers and Splices:Connector and splice, losses during coupling between sourcefibers, fiber to fiber, Lensing scheme for coupling improvement, Joint losses, multimode fiberjoints, single mode fiberjoint, Fusion splice, Mechanical Splices, Multimode splices, connectorandcoupler

Unit-4

12Hours

Optical Source and Photodetector: Principle of optical sources, Source material, Choice ofmaterials,IntegralandexternalquantumefficiencyofL.E.D.,Structures,TypesofL.E.D.:Surface emitting L.E.D., Edge emitting L.E.D., Modulation capability, emission pattern, powerbandwidth product, laser Diode Modes, Threshold condition, resonant frequency, Laser DiodeStructure,Briefdescriptionofprincipleofopticaldetectors,PhotomultipliersP.N.,P.I.N.and A.P.D.configuration,Photodetectornoise,Noise sources,SNR,Detectorresponsetime

Textbooks:

1. R.P.Khare,FiberOpticsandOptoelectronics,OxfordUniversityPress
2. AjoyGhatakandK.Thyagarajan,AnIntroductiontoFiberOptics,

Cambridge University Press

Reference Books:

3. G. Keiser, Optical Fibre Communications, Mc-Graw-Hill.
4. J.M. Senior, Optical Fibre Communications Principles and Practice, PHI.

OR

SubCode:PHY-VAC305A	Atomic and Molecular Spectra	
Semester:4	Non-Credit	VAC
Pre-requisites: Basic knowledge in Quantum Mechanics-I, Modern Physics, Basic Nuclear Physics		
Course outcomes: <ul style="list-style-type: none">✓ To understand different atomic models and their developments✓ To learn behavior of atom and molecules in the presence of electric and magnetic field and molecular vibration.✓ To understand atomic and molecular spectra		

Unit-1

12Hours

Revision of Hydrogen atom; Bohr-Sommerfeld Theory, quantum theory of hydrogen atom, wave functions, orbital and spin angular momentum, magnetic dipole moment, spin orbit interaction, fine structure, spectroscopic term and notation. Hydrogen fine structure. Spectrum of Helium.

Unit-2

12Hours

Hartree's central field approximation, atomic orbital and Hund's rule. L.S and J.J Coupling

Unit-3

12Hours

Normal and Anomalous Zeeman effect, Explanations of Zeeman Effect in some transitions. Paschen-Bach Effect Stark-Effect: Weak field and strong field Stark effect in hydrogen. Hyperfine structure and isotope effect, Nuclear spin and hyperfine structure.

Unit-4**12Hours**

Types of molecular spectra, Electronic spectra, Vibrational-Rotational spectra, molecule as a harmonic and non-harmonic oscillator, Pure Rotational Spectra, molecule as a rigid and non-rigid rotator. The Raman spectra and molecular structure.

Text Book:

1. Atomic and Molecular Spectra: Laser by Raj Kumar
2. Introduction to atomic spectra by H. E. White

OR

SubCode:PHY-VAC305B	ASTRONOMY AND ASTROPHYSICS	
Semester:3	Non-Credit:4	VAC
Pre-requisites: Basic knowledge in Quantum Mechanics-I, Modern Physics, Basic Nuclear Physics		
Course outcomes:		
<ol style="list-style-type: none"> 1. To understand Tools of Astronomy and celestial mechanics 2. To introduce basic astronomical principles in the study of the planets, stars and galaxies. 		

UNIT I:**15Hours**

Celestial Mechanics and Astrometry: The celestial Sphere, Positions of stars, Proper motions of stars and planets, Distances of nearby stars.

Tools of Astronomy: Telescopes: Basic Optics, Optical Telescopes, Radio Telescopes, Infrared, Ultraviolet, X-ray, and Gamma-Ray Astronomy – detectors and observatories Gravitational Waves detectors and Neutrino detectors All-Sky Surveys and Virtual Observatories.

UNIT II:**15 Hours**

The Solar System: The Sun, The Physical Processes in the solar system, The Terrestrial and the Giant Planets, Formation of Planetary Systems.

Basic Stellar Parameters: The brightness of the stars, Color-magnitude diagrams (The HR diagrams), The luminosities of the stars, Angular radii of stars, Effective temperatures of stars, Masses and radii of stars: Binary stars, Search for Extrasolar Planets

UNIT III:

15 Hours

The Nature of Stars: Spectral classification, Understanding stellar spectra, Population II stars, Stellar rotation, Stellar magnetic fields, Stars with peculiar spectra, Pulsating stars, Explosive stars, Interstellar absorption

UNIT IV:

15 Hours

Our Galaxy And The Interstellar Matter: The shape and size of our Galaxy, Interstellar extinction and reddening, Galactic coordinates, Galactic rotation, Stellar population, Inter Stellar Medium, The galactic magnetic field and cosmic

References:

1. Introduction to Stellar Astrophysics, Volume 1, Basic stellar observations and data, By Erika Bohm-Vitense, Cambridge University Press
2. An Introduction to Modern Astrophysics, Second Edition, By Carroll B. W., Ostlie D. A., Pearson Addison Wesley.
3. "Astrophysics for Physicists" by Arnab Rai Choudhuri, Cambridge University Press, 2010
4. Galactic Astronomy: Structure and Kinematics by Mihalas & Binney, W. H. Freeman & Co Ltd; 2nd Revised edition 1981.

Course Outcome:

Learners should be able to:

1. Have knowledge of the expanse of the universe and the nature of the planets, stars and galaxies.
2. Understand how the astronomical observations are done for these celestial objects.
3. Apply mathematical tools and physics laws to understand the nature of planets, stars and galaxies.
4. Use online resources to analyse the data obtained from various astronomical observations.
5. Evaluate the results of this analysis and interpret the nature of the Solar system, variety of stars and galaxies.
6. Create new observational programs or data analyses and interpretation projects in astronomy

SubCode:PHY-VAC305C	OPTICAL FIBRE SENSOR	
Semester:3	Non-Credit:4	VAC
Pre-requisites:BasicknowledgeinQuantumMechanics-I,Modern Physics,BasicNuclear Physics		
Courseoutcomes:		
<ol style="list-style-type: none"> 1. Identify different types of optical sensors and their performance characteristics - Analyze a given sensing requirement and design an appropriate sensor- Realize and implement an optimal sensing solution for a given requirement 		

Course outline

UNIT-1 **12Hours**

Need for optical sensors • Different types of Sensors • Optical receiver design; noise issues,

UNIT-II **12Hours**

Amplitude Modulated sensors • Lock-in detection, Phase modulated sensors • Phase noise analysis and mitigation; Sensitivity limits, Wavelength modulated sensors •

UNIT-III **12Hours**

Interrogator design, sensitivity limits, Polarization Modulated Sensors

UNIT-IV **12Hours**

Analysis of current sensor, Distributed Fiber Sensors • Raman & Brillouin scattering-based sensors.

Reference:

1. R.P.KHARE, Oxford University Press

Fourth Semester

Sub Code: PHY- E401A	Elementary Particle Physics	
Semester:4	Credit:4	Elective Course
Pre-requisites: ✓ Basic knowledge in Quantum mechanics, ✓ Relativistic Quantum Mechanics		
Course Outcomes: ✓ The main goal of particle physics is to learn about the universe around us. ✓ Over the past half century, particle physicists have formulated the Standard Model, a beautiful framework that explains the visible universe from the smallest to the largest scales.		

Unit-1

12Hours

Historical introduction to the Elementary Particles, Classification of elementary particles and their interactions: Photons, Leptons, Quarks, Mesons, Baryons. Lepton number, Baryon number, color quantum number, Strangeness quantum number.

Unit-2

12Hours

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 reactions and decays.

Unit-3

12Hours

Unitary Symmetry: S.U. (2), S.U. (3), Concept of I-Spin, U-Spin, V-Spin, SU(3) Quark model, The Eight-fold way, Mesons and Baryons in the Octet representation. The Baryon Decuplets, Evidence of color, Gell-Mann–Okubo mass formula.

Unit-4

12Hours

Discrete Symmetry:

Parity (P) : Parity in quantum mechanics and Field theories, Test of Parity. Time reversal (T) : Time reversal in quantum mechanics and Field theories, Test of Time reversal Charge conjugation (C) : Additive quantum number, Charge conjugation in field theories, Test of Charge conjugation. C.P.T. theorem and its consequences

TextBook:

1. "IntroductionofElementaryParticles",D.Griffith,JohnWiley
2. "QuarksandLeptons"Halzen,F.andMartin,A.D.,JohnWiley
3. "GaugetheoryofElementaryParticle,T.-P. ChengandL.-F.Li,Physics'OxfordUniversityPress
4. SGasiorowicz".Elementaryparticlephysics"by.JohnWiley&Sons.
5. ModernElementaryParticlePhysicsbyG.Kane,Addison-WesleyPublishingCompany
6. MarkThomson"ModernParticlePhysics"CambridgeUniversityPress.

OR

Sub Code: PHY-E401 B	GeneralTheoryofRelativity(G.T.R.)	
Semester:4	Credit:4	Elective
Pre-requisites:: Tensoralgebra,QuantumMechanics		
Courseoutcomes:		
<ul style="list-style-type: none"> ✓ Tolearnabouttheadvances inGeneralTheoryofRelativity. ✓ It will give the basic knowledge of Gravity as a geometry of space-time, gravitationalwavesand theformationof astrophysicalobjects. 		

Unit-1**12hours**

Special theory of relativity: Lorentz transformations; 4-vectors, Tensors and its transformation properties, Contraction, Symmetric and antisymmetric tensors; 4-dimensional velocity and acceleration; four-momentum and four-force; Covariant equations of motion; Relativistic kinematics (decay and elastic scattering); Lagrangian and Hamiltonian of a relativistic particle.

Unit-2**12hours**

The Equivalence Principle, The Weak and Strong Principle of Equivalence, The Equation of Motion in presence of Gravitational Forces, The affine connection, The Metric Tensor g_{uv} , Relation between Metric Tensor and Affine Connection, The transformation of Affine Connection, Covariant derivatives.

Unit-3**12hours**

The Newtonian Limit: Relation between g_{00} and the Newtonian potential, Time Dilation in a Gravitational Field, Redshift of spectral lines, The Solar Red Shift.

Unit-4**12hours**

Definition of Curvature tensor, Algebraic Properties of the curvature Tensor, Ricci Tensor and Curvature Scalar, Bianchi identities. Einstein's field Equations, Energy, Momentum and Angular momentum of gravitation.

Textbooks and reading materials:

1. Special theory of relativity, Robert Resnick (Oxford University)
2. Gravitation and Cosmology by Steven Weinberg (Jon Wiley and Sons) References:
2. Introducing Einstein's Relativity by Ray D Inverno (Clarendon Press)
3. An Introduction to General Relativity and Cosmology by Tail. Chow, (Springer)
4. Principles of Cosmology and Gravitation by M. Berry (Cambridge University)
5. Special theory of relativity, Robert Katz D. Van (Nostrond Company, I.N.C.)

Sub Code: PHY-C402	Basic Nuclear Physics	
Semester:3	Credit:4	Core Course
Pre-requisites: Quantum mechanics (I and II), Electrodynamics, Mathematical Physics		
Course Outcomes:		
<ul style="list-style-type: none"> ✓ To understand the basic properties of Nucleus and Nuclear matter. ✓ To learn and understand about Deuteron, Scattering, Nuclear energy and Nuclear Model. ✓ To understand the application of Quantum mechanics in Nuclear physics and its correlation with Atomic and Particle Physics 		

Unit-1**12Hours**

Nuclear properties: Nuclear Radius, Nuclear Mass and Binding Energy, Angular Momentum, Parity and Symmetry, Magnetic Dipole Moment and Electric Quadrupole Moment. Two nucleons Bound state problem: Central and non-central force, the deuteron, tensor forces, magnetic moment and quadrupole moment of deuteron

Unit-2**12Hours**

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-3

12Hours

Nuclear reaction and resonances, Breit-Wigner formula for s-waves, compound nucleus. Liquid drop model, Bohr-Wheeler theory of fission, nuclear fusion

Unit-4

12Hours

Single particle model of nucleus, magic numbers, spin-orbit coupling, angular momentum and parities of nuclear ground states, magnetic moments and Schmidt lines, Collective model of Bohr and Mottelson.

Text Book:

1. Nuclear Physics by R.R. Roy and B.P. Nigam (John Wiley)
2. Nuclear Physics by D.G. Tayal, Himalaya Publishing House
3. Nuclear Physics by S.N. Ghoshal, S. Chand

Reference books:

1. Physics of the nucleus by M.A. Preston (Addison Wesley)
2. Nuclear Physics by S.S.M. Wong (Prentice Hall)
3. Introduction to Nuclear Physics by H.A. Enge (Addison Wesley)

Reference books:

1. The Fundamentals of Atomic and Molecular Physics by L. Robert, Springer

Sub Code: PHY-E403	Project and Seminar	
Semester:4	Credit:4	PROJECT
Course outcomes:		
✓ The main objective of this course is to work in a mini project, learn about how to prepare a research report and present before an audience.		

Sub Code: PHY-E404A	Condensed Matter and Materials Physics	
Semester:4	Credit:4	Elective
Pre-requisites: Basic Solid State Physics		
Objectives:		
<ul style="list-style-type: none"> ✓ The main objective of this course is to learn about optical and magnetic properties of materials and their response to internal and external stimuli 		

Unit-1

12Hours

Optical properties: Absorption, intraband and interband transition, Absorption spectra of materials, Luminescence, Fluorescence, phosphorescence, Colour centres, Optical fibres (elementary ideas). Basic principles of Electron Spin Resonance, N.M.R. and Lasers- principles, Induced absorption, Spontaneous Emission and Stimulated Emission, Einstein A and B Coefficients, Ruby laser, Helium-Neon Laser and Semiconducting Laser.

Unit-2

12Hours

Magnetism: Langevin Diamagnetism and Van Vleck Paramagnetism, Paramagnet: Derivations of Curie law, Pauli paramagnetic susceptibility, Ferromagnetism: Curie point and the exchange interaction, Curie-Weiss law, Ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, Antiferromagnetic order, susceptibility below the Neel temperature.

Unit-3

12Hours

Advanced magnetism and materials: Landau's theory of diamagnetic susceptibility, Spin waves and magnon specific heat, N.M.R. Knight shift, Diluted magnetic and ferromagnetic semiconductors Spintronics-giant magnetoresistance (GMR), Mott's theory of spin-dependent scattering of electrons

Unit-4

12Hours

Novel Materials: Metallic nano clusters: Nanoscience and nanoclusters, liquid drop model, size and surface volume ratio. Graphene: Graphene lattice, tight binding approximation, Dirac Fermions Elementary ideas about polymers, Characterisation of materials: Experimental diffraction methods, Bragg law, Laue conditions, Geometrical Structure factor and Atomic form factor, Non-crystalline materials-diffraction pattern, amorphous semiconductors, low energy

excitations, heat capacity, thermal conductivity. Basic principles of Raman Effect in crystals and Mossbauer techniques

Text Books:

1. Physics of Condensed Matter-Prasanta K. Misra (Academic Press, 2010)
2. Optical Properties of Solids, Mark Fox, Oxford University Press

References:

2. Introduction to Solid State Physics, C. Kittel, John Wiley and Sons, Inc. Singapore.
3. Solid State Physics by Ashcroft and Mermin, Harcourt Asia PTE. Ltd. (A Harcourt publishers International company)

Sub Code: PHY-E404B	Nuclear Science-2 (Field Theory and Particle Physics)	
Semester: 4	Credit: 4	Elective
<p>Pre-requisites: Quantum Field theory, Elementary Particle Physics and Mathematical Physics.</p>		
<p>Course outcomes:</p> <ul style="list-style-type: none"> ✓ To learn the field theoretic techniques as applicable to the interacting elementary particles and to be conversant with the current status of particle physics. ✓ To learn the fundamental concept of spontaneous breaking on the basis of weak interaction along with decay width calculation. 		

Unit-1

12 hours

Field Theory:

Unequal space time commutation and anti-commutation rules for field operators. Propagator functions and their integral representations, Vacuum expectation values, Feynman propagators, Concept of T-Product and Normal Product, Feynman diagram rules in coordinate and momentum space, Wick's Theorem, Properties of scattering matrix, Brief idea of electron-photon scattering.

Unit-2

12 hours

Particle Physics:

Brief review of elementary particles and their interactions, S.U. (3) Quark Model, The Baryon and Meson State, Baryon-Meson coupling: The F and D terms, Gell-Mann-OKubomass formula. The Heavy Quarks: Charm and Beyond, S.U. (6) Quark Model: wave-function for Mesons and Baryons, Magnetic moment of Baryons.

Unit-3**12hours**

Weak Interaction: V-A form of weak interaction, Muon and Pion decay calculation, elementary notion of leptonic decays of strange particles, the Cabibbo angle, intermediate vector bosons, Elements of Neutral K-meson theory : Decay of Neutral K-mesons, regeneration of K-mesons, CP violation in neutral K decay.

Unit-4**12hours**

Spontaneous symmetry breaking, Higgs Mechanism, Brief idea of Salam-Weinberg Theory of Standard Model. Neutrino Physics: Neutrino Mass and Experimental limits, Neutrinoless Double-Beta decay, Neutrino oscillation, Solar neutrino puzzle, Magnetic moment of neutrino.

Textbooks and reading materials

1. Introduction to Elementary Particles by D. Griffiths, John Wiley & sons.
2. Relativistic quantum field theory by J.D. Bjorken and S.D. Drell, McGraw-Hill Book Company.
3. An Introductory Course of Particle Physics, Palas. B. Pal. C.R.C. Press.
4. Elementary particle physics by Gasiorwicz, Addison-Wesley publishing Company
5. Elementary Particle Physics by G. Kallen, Addison-Wesley publishing Company
6. Quarks and Leptons: F. Halzen and A.D. Martin, John Wiley.
7. A Modern introduction to particle physics: Fayyazuddin and Riazuddin, World Scientific, Singapore.

Sub Code: PHYE405A	CONDENSED MATTER & MATERIALS PHYSICS (Laboratory work)
Semester: 1	Credit: 4 Elective Course
Pre-requisites: Basic knowledge of Condensed Matter and Materials Physics	
Course outcomes: ✓ To design and analyze principles in Condensed Matter and Materials Physics.	

1. Determination of energy gap of a given semiconductor by four probe method
2. Determination of Hall constant of a sample and its identification
3. Determination of energy gap by p-n junction method
4. Study of dispersion relation of an electrical analog of monoatomic linear chain
5. Study of dispersion relation of an electrical analog of diatomic linear chain

6. Determination of specific heat of a given sample using a thermocouple
 7. Determination of dielectric constant of a given sample by Lecher wire method
 8. Determination of B-H curve of a given Ferro-magnet
- Any other experiments that may be set up from time to time.

Sub Code: PHYP405B	Nuclear Science (Laboratory work)	
Semester:1	Credit:4	Elective Course
Pre-requisites: Basic knowledge of Condensed and Material Physics		
Course outcomes:		
✓ To design and analyze experiments in Nuclear Science		

1. Determination of half-life of a known source
 2. Determination of linear absorption coefficient
 3. Verification of inverse square law
 4. Experiment with gamma ray spectrometer.
 - i. Energy analysis of a known gamma source
 - ii. Spectrum analysis of ^{60}Co and ^{137}Cs
 - iii. Activity of Gamma emitter
 5. High resolution gamma ray spectroscopy
 - i. Energy resolution with Ge(Li) detector
 - ii. Photo peak efficiency for Ge(Li) detector
- Any other experiments that may be set up from time to time

Sub Code:-VAC406	Cultural Heritage of South Odisha	
Semester:1	Credit:4	VAC
Pre-requisites:		
Course outcomes:		
✓ The teaching imparted to P.G students of Science College (Autonomous), Hinjilicut on the various dimensions of the literary and cultural heritage of South Odisha will help them to acquire the valuable understanding of the same.		
✓ They will be inspired adequately to take the positive learnt from the course and use them in future in their personal literary and cultural pursuits and their by promote the literature and culture of the Odisha on a Global Scale		

Unit I	Literary work of Kabi Samrat Upendra Bhanja
Unit II	Other Literatures of South Odisha
Unit III	Cultural Heritage of South Odisha
Unit IV	Folk and Tribal Traditions of South Odisha

