# SYLLABUS FOR POST GRADUATE COURSE IN PHYSICS

# (Master of Science Examination)

## CHOICE BASED CREDIT SYSTEM (CBCS)

## 2023-2025

| | |
|---|---|
| **First Semester Examination** | **2023-24** |
| **Second Semester Examination** | **2023-24** |
| **Third Semester Examination** | **2024-25** |
| **Fourth Semester Examination** | **2024-25** |

## SCIENCE COLLEGE (AUTONOMOUS) HINJILICUT, GANJAM, ODISHA

## 2023

# Course Curriculum & Syllabi-2022

## POSTGRADUATEDEPARTMENTOFPHYSICS

**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.FacultyMembers:**

1. Dr. BinodBihariPatra, H.O.D
2. Mr. Arun Kumar Khadanga,Reader
3. Dr. Keshab Chandra Shadangi, Reader
4. Mrs. PrativaKumariSahu, Lecturer
5. Mr. JituMuthamajhi, Lecturer,
6. Miss. JhumuriPadhi, Lecturer,

7. Miss. SulekhaMahankuda, Lecturer.

## 2. Syllabus:

# M.SC.PHYSICSSYLLABI

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

| 1 | Course | Course title | Hrsp erWe 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 | | | 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 | BasicSolid-StatePhysics | 4 | 4 | 3 | 20 | 80 | 100 |
| | PHY-C204 | QuantumMechanics-II | 4 | 4 | 3 | 20 | 80 | 100 |
| | PHY-P205 | Optics(Practical) | 12 | 6 | 4 | | | 100 |
| | PHY-VAC206 | Material CharacterizationTechniq ueOR DFTandMaterials Modelling | | | | | | |
| | | Total | **28** | **22** | | | | **500** |

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

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

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **III** | PHY-C301 | RelativisticQuantum Mechanics&FieldTheory | 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 OrNuclearScience-1(N.P.) | 4<br>4 | 4<br>4 | 3<br>3 | 20<br>20 | 80<br>80 | 100<br>100 |
| | PHY-EP304 | ModernPhysics(Practical) | 12 | 6 | 4 | | | 100 |
| | PHY-VAC305 | OpticalFiberSensor OrFiber Optics OrAtomicAndMolecularSpectra | | | | | | |
| | PHY-CT300 | FibreOpticsAnd Optoelectronics | 04 | 04 | 03 | 20 | 80 | 100 |
| | | Total | **28** | **22** | | | | 500 |
| **IV** | PHY-E401A **OR** PHY-E401B | Elementary Particle Physics Or GTR | 4<br>4 | 4<br>4 | 3<br>3 | 20<br>20 | 80<br>80 | 100<br>100 |
| | PHY-C402 | Basic Nuclear Physics | 4 | 4 | 3 | 20 | 80 | 100 |
| | PHY-CE403 | Project And Seminar | 4 | 4 | | | 50<br>50 | 100 |
| | PHY-CE404A **OR** PHY-CE404B | Condensed Matter & Materials Physics II Or Nuclear Science-II | 4<br>12 | 4<br>6 | 3<br>4 | 20<br>20 | 80<br>80 | 100<br>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: Cerdittransfer**

**A student has to register for 14 core papers (including three core labs), 6 elective papers(includingonelab inelective),andoneproject andseminar,twovalueaddedcourses**

## Programme Outcome:

- Instil among the students an attitude of being inquisitive so that they are capableof independentandcritical thinking.
- Trainupthestudentsinsuchawaythattheycanobjectivelycarryoutinvestigations,scientificand/orotherwise,withoutbeingbiasedorwithouthavingany preconceived notions.
- Equip the students with such skills to make them understand the mysteries ofnature atdifferentscalesofspaceandtime, from subnuclearto cosmological.
- Enable the students to analyze problems starting from first principles, evaluateandvalidateexperimentalresults, anddrawlogicalconclusions.
- Prepare the students to pursue research careers, careers in academics, industriesinPhysicalScienceandalliedfields.
- As technology exploits the rules of Physics, students properly trained in Physicscanbe goodresearchers inthe Fieldof technologytoo.
- Imbibe effective scientific and/or technical communication abilities among thestudents.

# FirstSemester

| SubCode: PHY- C101 | MathematicalMethodsinPhysics | |
|---|---|---|
| **Semester:1** | **Credit:4** | **CoreCourse** |
| **Pre-requisites:** Basicunderstandingofrealanalysis,Complexnumbers,Grouptheory | | |
| **Courseoutcome:**<br>✓ Tolearnaboutvarious mathematicaltools employedto study physicsproblems.<br>✓ Togetgoodexperienceinusingandunderstandingareaslike complexvariables,Tensoranalysis, GroupTheory and specialfunctions.<br>✓ Tostrengthenthestudent'sanalyticalabilitiesandhelpthem formulatedifferent relationshipsinmechanicsandphysicscompactly. | | |

**Unit-1** **12hours**

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 indefiniteintegrals by contour integration, Indented semi-circular contour, evaluation of single and multi-valuedfunctions,branchpoints andbranchcuts ,Contourintegrationinvolving branch point.

**Unit-2** **12hours**

Tensors:Introduction,Typesoftensor,Invarianttensor,epsilontensor,Pseudotensor,thealgebra of tensor, Quotient law, Metric Tensor, Covariant derivative of tensor, FundamentalTensor,Cartesian tensor,Christoffel symbol.

**Unit-3** **12 hours**

GroupTheory:Definitionsofgroups,subgroupsandclasses,Isomorphism,Homomorphism, Cayley'stheorem,Grouprepresentations,Orthogonalitytheorem,characters,Orthogonality relation for group character, Character table, Preliminary idea about infinite group, calculation ofgenerator, Calculation of generator associated with S.U. (2) and SO(3) group, HomomorphismbetweenS.U.(2) and $O^+(3)$group.

**Unit-4** **12hours**

SpecialFunctions:LegendrePolynomials,generatingfunctions,Recurrenceformulae,Orthogonali typropertiesofLegendre'spolynomialof1stkind,Besselgeneratingfunction,Recurrence formulae, Orthogonality properties of Bessel's polynomials, Fourier and Laplacetransformation.

**Textbooks:**

1. MathematicalMethods ofPhysics byMathews andWalker (W.A. BenjaminInc.)
2. Matricesand Tensors inphysics by A. W. Joshi (New AgeInternationalPublisher)
3. MathematicalMethodsinthe physicalSciencebyMaryL.Boas (Wiley-India)

**ReferenceBooks:**

1. MathematicalMethodsforPhysicistbyG.ArfkenandH.Weber,AcademicPress(Elsevier)
2. ElementsofGroupTheorybyA.W.Joshi(New AgeInternationalPublisher)
3. MathematicalPhysicsbyH.K.DasandDr.R.Verma(S.Chand&CompanyL.T.D.)
4. MathematicalPhysicsbyP.K.Chattopadhyaya(NewAgeInternational)

| Sub.Code:PHY-C102 | ClassicalMechanics | |
|---|---|---|
| Semester:1 | Credit:4 | CoreCourse |
| **Pre-requisites:**Basicunderstandingofgeneralizedcoordinate,Newtoniandynamics | | |

**Courseoutcomes:**

- ✓ Tounderstanddegrees of freedomanddynamicsof arigid bodymotion.
- ✓ Tounderstandcomplexkind ofgyroscopicmotionas likeheavysymmetrictop.
- ✓ TomakeoutacleardistinctionofLagrangianandHamiltoniandynamics.
- ✓ TounderstandHamiltonian dynamicsandevolutionofquantummechanics.
- ✓ Tounderstandsmalloscillationoccurringinmicroandmacro-systems

**Unit-1** **10hours**

**KINEMATICSOF RIGIDBODYMOTION:**

Independent coordinates of a rigid body, Orthogonal transformations, Eulerian angles, infinitesimalrotations, rate of change of vector, Coriolis force, angular momentum and kinetic energy of motionaboutapoint,inertialtensorandthemomentofinertia,EigenvaluesofInertialtensorandtheprincipal axis transformation, methods of solving rigid body problems and Euler's equations of motion,torquefreemotion of arigid body. Heavy symmetrical top withone pointfixed.

**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,IntegralInvarianceof Poincare, PoissonBracket,Poisson'sTheorem,LagrangeBracket,PoissonandLagrangeBracketsasCanonicalInvariant ,InfinitesimalCanonicaltransformation andConservationTheorems,Liouville'sTheorem HamiltonJacobi Theory:Hamilton-JacobiEquationforHamilton'sPrincipalFunction,HarmonicOscillatorandKeplerproblembyHamilton-JacobiMethod,Action-AngleVariablesforcompletelySeparableSystem,KeplerProbleminAction-AngleVariables

**Unit-4** **10hours**

**SMALL OSCILLATION:** Problem of Small Oscillations, Example of linear triatomic molecule andtwo coupledOscillator,GeneralTheoryofSmallOscillations,NormalCoordinatesandNormalModesof Vibration.

**TestBooks:**

1.ClassicalMechanics-byH.Goldstein(Addison-Wesley)

**Referencebooks:**

1. ClassicalMechanicsby S.N.Biswas,BooksandAlliedPublisherLtd.
2. ClassicalMechanicsbyJ.C.Upadhay, HimalayaPublishingHouse.
3. ClassicalMechanicsby LandauandLiftshitz(ButterWorth)

| SubCode:PHY-C103 | ComputerProgrammingandNumericalAnalysis | |
|---|---|---|
| **Semester:1** | **Credit:4** | **CoreCourse** |
| **Pre-requisites:**BasicknowledgeofComputer,MathematicalPhysics | | |
| **Courseoutcomes:**<br>✓ Tounderstand the importanceofcomputerapplication inScienceandengineering.<br>✓ Tolearnand understandbasic computerlanguageFORTRAN77.<br>✓ Tocomputeand developalgorithmsforsolutionofscienceandengineering problems. | | |

**Unit-1** **10hours**

Data types, expressions, statements, input and output commands, conditional and interactiveconstructs,characteranddatamanagements,arraymanipulations,subprogram,subroutine.

**Unit-2** **12hours**

Numerical integrations by trapezoidal and Simpson method, finding the root of an equation byNewton-Raphsonmethod,findingprimenumbers,Runga-Kuttamethod,interpolationsortingand similarotherproblems .

**Unit-3** **12 hours**

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

**Unit-4** **12hours**

EigenvaluesandeigenvectorsofmatriceS,powerandJacobimethod,FiniteDifferences,InterpolationwithequallySpacedandunevenlyspacedpoints(Newton'sandLagrange'smethod),ForwardandBackwardInterpolation,Extrapolation,NumericalIntegrationbytrapezoidandSimpson'srule,SolutionoffirstandsecondorderdifferentialequationusingRunge-Kutta(RK-4)method.

**Textbooks:**

1. FundamentalsofComputersbyV.Rajaraman,PrenticeHallof IndiaLtdPublishers.
2. Fortran77andNumericalMethodsbyCXavier,NewAge International(P)LtdPublishers.
3. NumericalMethodsinScienceandEngineeringbyS.Rajasekaran,S.chand

**ReferenceBooks:**

1. NumericalMathematicalAnalyses byJ.B. Scarborough,OxfordandI.B.H.PublishingCompany
2. Numericalmethodsforengineeringand scientificcomputationbyM KJain(WileyEastern
3. NumericalMethodsforScientificandEngineering ComputationbyMKJain,SRKIyengarandRJain, New AgeInternational (P) LtdPublishers.

| SubCode:PHY-C104 | QuantumMechanics-1 | |
|---|---|---|
| **Semester:1** | **Credit:4** | **CoreCourse** |
| **Pre-requisites::BasicMathematicalPhysics** | | |

**CourseOutcomes:**

- ✓ To apply quantum mechanics to the dynamics of single particle in one-,,two andthree-dimensionalpotential fields
- ✓ Tostrengthentheanalyticalabilitiesofthestudentandhelpthemtoapplyitin differentbranchesof physics compactly.

**Unit–1** **14 Hours**

**GENERALPRINCIPLESOFQUANTUMMECHANICS:**

Postulates of Quantum Mechanics and meaning of measurement, Operators and their expectationvalues, 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, Diracdelta function, linear operators, Adjoint operators, Unitary Operators, Expectation values ofdynamical variables and physical interpretation of Hermitian operators, Eigen values and eigenvectors, orthonormality of eigen vectors, probability interpretation, Degeneracy, Schmidt methodof orthogonalisation, Expansion theorem, Completeness and closure properties of the basis set,Coordinateandmomentumrepresentations,compatibleanIncompatibleobservables,Commutator algebra, uncertainty relation as a consequence of non- commutability, minimumuncertainty wave packet, Representations of Ket and Bra vectors and operators in matrix form,Unitarytransformation ofbasis vectorsand operators.

**Unit–2** **12 Hours**

**QUANTUMDYNAMICS:**

Time evolution of quantum states, Time evolution operator and its properties, Schrödinger,Heisenberg andInteraction picture, Equations of motion,Operator methodsolution of Harmonicoscillatorproblem,Matrixrepresentationandtime evolution of creationand Annihilationoperators.

**Unit-3** **14Hours**

**ROTATIONANDORBITALANGULARMOMENTUM:**

Orbital angular momentum operators as generators of rotation, Lx, Ly, Lz and $L^2$ and theirCommutationrelations,RaisingandLoweringoperators(L+andL-),Lx,Ly,LzandL$^2$in

Spherical Polar coordinates, Eigen values and Eigen functions of Lz and $L^2$ (operator method),Matrixrepresentation ofLx, Ly, Lzand $L^2$.

**Unit–4** **12 Hours**

**SPINANGULARMOMENTUM:**
Spin ½ particles, Pauli spin matrices and their properties, Eigen values and Eigen functions, Spinand rotations. Total angular momentum: Total angular momentum J, Eigen value problem of Jzand $J^2$ , Angular momentum matrices, Addition of angular momentum and C. G. coefficients forthestates with ( i)$j_1$=½ and $j_2$=½ ( ii ) $j_1$=1 and $j_2$=½.

**Textbooks**:
1."QuantumMechanics:ConceptsandApplications"byNouredineZettileJohnWileyandsons.

**ReferenceBooks:**

1. "QuantumMechanics",L.I.SchiffL.I3rd Ed,McGrawHillBookCo.
2. "QuantumMechanics"E.Merzbacher,2ndEd.,JohnWiley&Sons.
3. ,"QuantumPhysics",S.Gasiorowicz JohnWiley.
4. "ATextBookofQuantumMechanics"byP.M.Mathews.andVenkatesan,TataMcG rawHill.
5. Introductionto Quantum Mechanics, by D.J.Griffiths,2nd edition ,PearsonPublications

| SubCode:PHY- P105 | ComputerProgrammingandNumericalA nalysis (Laboratory work) | |
|---|---|---|
| **Semester:1** | **Credit:4** | **CoreCourse** |
| **Pre-requisites:Basicknowledgeofcomputer** | | |
| **CourseOutcomes:**<br>✓ Tolearnand practicebasiccomputer languageFORTRAN77.<br>✓ ToprogramdifferentmethodsassociatewithPhysicsandEngineering | | |

1. Numericalintegrationbytrapezoidalmethod
2. NumericalintegrationbySimpsonmethod
3. SolutionoffirstandsecondorderdifferentialequationbyRungaKuttaMethod
4. Matrixaddition,subtraction,multiplicationandmanipulation
5. Matrixinversion
6. Findingtherootsofanequation byNewton-Rapsonmethod
7. Leastsquarefittingoflinearparameters
8. Determinationofprimenumbers.
9. Toarrangeasetofnumbers inincreasingordecreasingorder
10. SumofA.P andG.P series,Sine andCosineseries
11. Factorialofanumber
12. Evaluationoflogandexponentialsbysummingofseries
13. Anyother suitableexperiments.

# Second Semester

| SubCode: PHY- C201 | : ClassicalElectrodynamics | |
|---|---|---|
| Semester:2 | Credit:4 | CoreCourse |
| **Pre-requisites:BasicMathematicalPhysics,(ii) ClassicalElectricityandMagnetism.** | | |

**CourseOutcomes:**

- ✓ Toemphasizeelectric andmagneticradiationfieldphenomenaandBremsstrahlungradiationin aCoulomb field and Cherenkovradiation,
- ✓ ElectromagneticScattering.

**Unit –I** **14Hours**

(a) **Covariantformulationofelectrodynamics:**CovariantformofMaxwell'sequation(fourvectorandtensorform),Maxwellfieldtensor,covariantdefinitionofelectromagnetic energy and momentum, transformation of electromagnetic field components,Lagrangianof achargedparticle inan external electromagneticfield.

(b) **TheInhomogeneousWaveequation:**Waveequationsforpotentials,solutionbyFourier analysis, Radiation field, Radiation energy, Hertz potential, Computation of radiationfieldsby Hertzmethod,electricdipoleradiation,multipole-radiation.

**Unit–II** **12 Hours**

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

**(b)** Waveguides, Propagationof electromagneticwaves in rectangularwaveguides**.**

**Unit–III** **14 Hours**

**Radiationfrom AcceleratedCharges:**

Radiation from an accelerated charge, Fields of an accelerated charge radiation at low velocity,Caseofvelocityparalleltoacceleration,radiationfromcircularorbits,Radiationwithnorestrictionsontheaccelerationorvelocity,ClassicalcrosssectionforbremsstrahlunginaCoulombfield, Cherenkov radiation.

**Unit–IV** **14 Hours**

**Radiation,scatteringanddispersion:**

Radiativedampingofachargedharmonicoscillator,forcedvibrations,scatteringbyanindividual 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 scatters,scatteringfromavolumedistribution, Rayleigh scattering,the dispersion relation.

TextBook:

1. "ClassicalElectricityandMagnetism"byWolfgangK.H.PanofskyandMelbaPhilips ,SecondEdition.

Referencebooks:

1"ClassicalElectrodynamics",JaksonJD,JohnWiley.

2. 'IntroductiontoElectrodynamics",GriffithsDJ,PrenticeHall.

| SubCode:PHY-C202 | StatisticalMechanics | |
|---|---|---|
| **Semester:2** | **Credit:4** | **Core Course** |
| **Pre-requisites: Basiclawsofthermodynamics** | | |

**CourseOutcomes:**

- ✓ *To*developaworkingknowledgeofstatistical mechanics.
- ✓ To learn statistical interpretation of various phenomena like ensembles, ideal systems,photon gas, Low temperature physics and their applications, Bose Einstein condensation,phasetransition.
- ✓ Toexploreitsapplicationsinotherbranchesofphysicslikematerialscienceandthe physicsofcondensedmatter.

**Unit-1** **12 Hours**

ClassicalStatisticalMechanics:Postulatesofclassicalstatisticalmechanics,Lowville'stheoremmicro-canonical ensemble, derivation of thermodynamics, equi-partition theorem, Classical ideal gas,Gibb's paradox, .canonical ensemble, energy fluctuation in canonical ensemble, grand canonicalensemble, density fluctuation in grand canonical ensemble, equivalence of canonical and grandcanonicalensemble.

**Unit-2** **12Hours**

Quantum Statistical Mechanics: Postulates of quantum statistical mechanics, density matrix,Liouville's theorem, ensembles in quantum statistical mechanics, third law of thermodynamics, Idealgasesinmicro-canonicalensemble.Particleinabox,M.B.,B.E.andF.D.distributions.TheIdealGasesinGrand Canonical Ensemble, Equation of stateofIdeal BoseGas, FermiGas.

**Unit-3** **12Hours**

Fermi Gas:The Equationof state of an Ideal Fermi gas, High temperature and low Densities,LowtemperatureandHigh Densities,Theory of WhiteDwarfStars, Pauliparmagnetism.

**Unit-4** **12 Hours**

BoseGas:IdealBosegas,Photon,Planck'slaw,Bose-Einsteincondensation.1$^{st}$orderand2$^{nd}$orderphase transitions, Ginzburg landau theory of phase Transition, Ising model (one dimensionalIsingmodel)

**TextBook:**

1.StatisticalMechanics–K.Huang,WileyIndia

**Referencebooks:**

1. Statistical Mechanics – Landau andLifshitz,ButterWorth
2. StatisticalMechanics-R.K.Patheria,P.D.Beale3rdEd,ButterWorth-Heinemann
3. Fundamental statistical and thermal Physics-F. Reif, Tata McGraw-HillEdition
4. Elementarystatistical mechanics,C.Kittel,DoverPublication

| Sub.Code:PHY-C203 | Basic Solid State Physics | |
|---|---|---|
| Semester:2 | Credit: 4 | CoreCourse |
| **Pre-requisites:** Crystalstructure,Bragg'sDiffraction,Reciprocallatticespace | | |

**CourseOutcomes:**

- ✓ 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 handlemodeldescription based on physical laws** | | |
| **CourseOutcomes:** ✓ To learn the properties of molecules and atoms and their constituents—electrons,protons, neutrons, and other moreesoteric particles such as quarksandgluons. | | |

**Unit-1** **12Hours**

**Motionin asphericallysymmetricfield:**

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

**Unit-2** **12Hours**

**Approximatemethods:**

stationary perturbation theory, Rayleigh Schrodinger method for non-degenerate case, first andsecondorderperturbation,anharmonicoscillator, generaltheoryforthedegeneratecase,removalofdegeneracy, linear Stark effect, normal Zeemaneffect**.**

**Unit-3** **12Hours**

**Time-dependentperturbationtheory:**

Transitionprobability,constantandharmonicperturbation,FermiGoldenrule.Variationalmethod:Ground state of Heatom.

W.K.B.method:connectionformulas,Bohr-Sommerfeldquantizationrule,Harmonicoscillatorandcoldemission**.**

**Unit-4** **12Hours**

**Scatteringamplitudeandscatteringcrosssection:**

Bornapproximation,applicationtoCoulombandscreenedCoulombpotentials.

Partialwave analysis forscattering, optical theorem,scatteringfrom ahardsphere, resonantscatteringfromasquarewellpotential.

Identicalparticles,Symmetricandantisymmetric wavefunction,Coulombandexchangeinteractions.

TextBook:

**1.**"QuantumMechanics:ConceptsandApplications"byNouredineZettile JohnWileyandsons.

**ReferenceBooks:**

"Quantum Mechanics",L.I. Schiff 3rd Ed, McGraw Hill Book Co."QuantumMechanics"E.Merzbacher,2ndEd.,JohnWiley&Sons.

"QuantumPhysics",S.GasiorowiczJohnWiley.

"ATextBookofQuantumMechanics"byP.M.Mathews.andVenkatesan,TataMcGrawHill.Introductionto Quantum Mechanics, byD.J.Griffiths ,2nd edition, PearsonPublications

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

1. Experimentswithopticalbench:BiprismStraightedgeandnarrowwire
2. Experimentswithspectrometer:SingleandDoublesplit
3. ExperimentswithMichelsoninterferometer:DeterminationofAandαThicknessofmica 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 theinstruments facilities available at Berhampur University. This will help the students tounderstandthespectroscopictechniquesrequiredforcharacterizationofmaterialssynthesizedin laboratory. | | |

| Chapter/Unit | **Contents** | Hours/Semester |
|---|---|---|
| 1 | **UV-visiblespectroscopy**:Baselinecorrectionwithsuitablesolvent,blankingthe instrument,determinationofsuitable | 10 |
| | concentration, quantitative measurement of sample of differentconcentration. Kinetic measurement of reaction to determine rateconstant,spectralmeasurementofdifferentcompounds,dataexport in different format and plotting in origin. Other tips &things to watch out for when measuring particle size, Band gapmeasurementusing Taucplot. | |
| 2 | **Photoluminescence spectroscopy**: Determination of excitationand emission peak for unknown sample, choosing right filter forcorrectmeasurement,usingsolidsampleaswellassolutionsample, measurement in fluorescence and phosphorescence modefor lanthanide doped sample as well as organic molecules. Lifetimemeasurementandcalculationoflifetimeinsingleanddoubleexponentialplottinginorigin.Dataexportandplottinginorigin.OthertipsinPLmeasurement. | 10 |
| 3 | **X-RayDiffractionStudies**:Basicprinciples,Baselinecorrection,Crystalstructuredetermination,Calculationofcrystallite size from XRD data, Insertion of negative hkl indicesinXRDgraph,Calculationofd-spacing,latticeconstant,crystalline mode, microstrain, dislocation density, Modified W-Hplotforcrystallitesize/microstrain andenergy density. | 10 |

| | | |
|---|---|---|
| 4 | **Magnetic susceptibility Measurement**: Elementary idea aboutmagneticpropertiesofmetalcomplexes,Diamagnetism,Paramagnetism,Magneticsusceptibilityanditsmeasurement,Ferromagnetism,FerrimagnetismandAnti-ferromagnetism. | 10 |
| Total | | 40 |

5. Polarization Experiments Babinet compensator Edsar-Butlerbands Quarter wave plate MallusLawStudy ofelliptical polarizedlight

6. ConstantDeviationSpectrographyCalibrationZeemaneffect

7. BabinetQuartzSpectrography

8. Anyother suitableexperiments

Anyother experimentsthat maybeset upfrom timeto tim

| Sub Code: PHY-VAC206B | DFTandMaterials Modelling | |
|---|---|---|
| **Semester:2** | **Non-Credit:** | **VAC** |
| **Pre-requisites:**QuantumPhysics,MathematicsandComputation | | |

**CourseOutcomes:**

1. Tounderstandasingle atomanditsbehaviourindependently.
2. Tounderstandevolutionofdifferentpropertiesdependentondensityfunctional.
3. To understand different approximations leading to better exchangecorrelation.
4. Tounderstandimplementationof DFTonQuantum Expressoandcodes
5. Toevaluatenumericallydifferentphysicalproperties.

**Unit-I**

Preliminaries:Atomicmodel,Thehydrogenatom,SolutionofSchrodingerEquation,Electron wavefunctionsandenergies,Probabilitydistribution.Multi-electronatoms,Hartree-FockTheory,Freeelectron model(FEM), Nearly freeelectronmodel(NFEM)

**Unit-II**

The Schrodinger Equation, Density FunctionalTheory—From Wave Functions to ElectronDensity, Exchange–Correlation Functional, Localized and Spatially Extended Functions, Wave-Function-Based Methods, Hartree–Fock Method, Beyond Hartree–Fock. DFT Calculations forSimple Solids, Periodic Structures, Supercells, and Lattice Parameters, Face-Centered CubicMaterials,HexagonalClose-PackedMaterials,CrystalStructurePrediction,Phase Transformations,

**Unit-III**

Nuts and Bolts of DFT Calculations: Reciprocal Space and k Points, Plane Waves and theBrillouin Zone, Integrals in k Space, Choosing k Points in the Brillouin Zone, Metals—SpecialCasesinkSpace,SummaryofkSpace,EnergyCutoffs,Pseudopotentials,NumericalOptimization, DFT Total Energies-An Iterative Optimization Problem, Geometry Optimization,InternalDegreesofFreedom,OptimizingSupercellVolumeandShape,ElectronicStructure and,Electronic DensityofStates,LocalDensityof StatesandAtomicCharges,Magnetism

**Unit-IV**

Applications:**QuantumEspresso**,MaterialsCloud,Examples:**Silicon:**Self-consistentField,Writingtheinput,Runningthecode,Readingtheoutput,latticeconstantandbulkmodulusof silicon,Bands,**Graphene:**,Computetheband-structure.

**References:Books**


1. APractical IntroductiontoDensityFunctionalTheoryByL.Rademaker
2. Electronic Density Functional Theory Recent Progress and New Directions by John F.DobsonGiovanni Vignaleand MukundaP. D**as.**

# Third Semester

| SubCode:PHY-C301 | RelativisticQuantumMechanics&Field theory | |
|---|---|---|
| **Semester:3** | **Credit:4** | **CoreCourse** |
| **Pre-requisites: Quantum Mechanics, Special theory of relativity, Mathematical PhysicsandElectrodynamics.** | | |
| **CourseOutcomes:**<br>✓ Tostudytheeffectofrelativityonquantummechanicsandtodevelopthe formulationforRelativisticsystems along with thequantizationprinciple.<br>✓ 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'stheoremandconservationlaws,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:**

- ✓ Tomake thestudent familiarwith basicanaloganddigital electroniccomponents.
- ✓ UnderstandD.C.analysisandA.C.modelsofsemiconductordevices
- ✓ Applyconcepts for thedesign ofAmplifier
- ✓ Understand number representation and conversion between differentrepresentationsin digital electroniccircuits
- ✓ Analyze logic processes and implement logical operations using combinational logiccircuits.

**Unit-1** **10Hours**

**Amplifiers:**Transistors,Two-portnetworkanalysis,theveninstheorem,transconductancemodel, Frequency response of linear amplifiers R.C. and Transformer coupled amplifiers, gainbandwidth product, feedback amplifiers, effects of negative feedback, F.E.T., MOSFET, Boot-strappingtheF.E.T.

**Unit-2** **8 Hours**

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

**Unit-3** **12Hours**

**Operational Amplifiers:** The differential amplifier, D.C. and A.C. signal analysis, integralamplifier, rejection of common mode signals, CMMR, The operational amplifier, input andoutputimpedances,ApplicationofoperationalAmplifiersunitgainbuffer,summing,integratinga mplifier, Comparator, Operationalamplifier as adifferentiator

**Unit-4** **12Hours**

**Digital Circuits:** Logic fundamentals, Booleantheorem, logicgates: AND, OR, NOT, NOR,NANDXOR,andEXNOR.RTL,DTLandTTLlogic,Flip-flop,RS-andJK-Flipflop,A/DandD/AConvertors

**Textbooksandreadingmaterials**

1. ElectronicfundamentalandapplicationbyJ.D. Ryder,PHI,LearningPvtLtd.

2. Electronics:Circuitsand Analysis,D.C.Dubey,AlphaScience

**References**:

1. Foundationofelectronics–Chattopadhyay,Rakshit,SahaandPurkait,NewageInternational publisher
2. Electronicsprinciples-AlbertMalvino,TataMcGraw-HillEdition
3. ModernDigitalElectronics-R.PJain,Tata McGraw-HillEdition

| Sub Code: PHYC303A | CondensedMatterandMaterialPhysics | |
|---|---|---|
| Semester:3 | Credit:4 | CoreCourse |
| **Pre-requisites:** Basic knowledge in solid state physics, Classical mechanics, Quantummechanicsand elementarymathematicstohandlemodeldescriptionbased onphysicallaws | | |
| **CourseOutcomes:**<br>✓ Toprovidean introductiontothephysicsofcondensedMatters<br>✓ To make them acquainted with the areas like quantization of lattice vibrations,electron–electroninteraction,superconductivityandAdvancedSuperconductivity. | | |

**Unit-1** **12Hours**

Quantisationoflatticevibration:Phonons,normalcoordinatetransformation,creationandannihilation operators. Methods of band calculation-Tight binding method, O.P.W. and pseudopotential methods. Fermi Surface, de Haas-vanAlpheneffect. Transport theory-Boltzmannequation,relaxationtimeapproximation,electricalconductivityandthermalconductivity.

**Unit-2** **12Hours**

Electron-electroninteraction:Hartreeapproximation,Hartree-Fockapproximation,Hartree-Fock theory for jellium model. Density functional theory-general formulation, Local DensityApproximation.

**Unit-3** **12Hours**

Superconductivity:Occurrenceofsuperconductivity,Meissnereffects,Type-IandIIsuperconductors,energygap,Isotopeeffect,Theoreticalsurvey:Thermodynamicsofsuperconductingtransition,Londonequations,coherencelength,Qualitativeideasaboutthe B.C.S.theory,Singleparticletunneling,Josephsoneffect.

**Unit-4** **12Hours**

AdvancedSuperconductivity:Electron-phononinteraction,Microscopictheoryofsuperconductivity,Quasielectrons,Cooperpairs,B.C.S.theory,GroundStateofsuperconductingelectrongas, elementaryideas ofhigh Tcsuperconductors

**TextBook:**

1. PhysicsofCondensedMatterByPrasantaK.Misra(AcademicPress,2010)
2. QuantumTheoryofSolidStatebyJ.Callaway(AcademicPress)

**Referencebooks:**

1. Principlesofthetheoryofsolids, J.M.Ziman(Cambridgeand Universitypress)
2. SolidStatePhysics byC.Kittle (JohnWiley andsons, InsSingapore)
3. Introductionto thetheoryof Solid StatePhysicsby J.D. Patterson (Addison-Wesley,1971)

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

**CourseOutcomes:**

- ✓ Tounderstandthe advanceof NuclearPhysics

**Unit-1** **12 Hour**

**RotationamMatrixandTensor:**Rotationalinvarianceinthreedimensions,eigenvaluesaeigenfunc ionsofangularmomentumoperators,explicitrepresentationoftherotationmatriceAdditionofangula momenta,Clebsch-Gordoncoefficients,irreduciblesphericaltensor,matrelementof tensoroperators, Wigner-Eckart theorem

**Unit-2** **12Hours** and

**Opticalmodel:**Opticalmodel,deuteronstrippingandpick-upreaction,ElementaryideasBruecknertheory s,i x

**Unit-3** **12Hours**

**CollectiveModel:**CollectiveVibrationalmodesofasphericalnucleus,collectiveoscillationquadrupedeformation,Expression for moment of inertia. of

**Unit-4** **12Hours**

**RotationalSpectra:**Rotationalspectra ofeven-evennuclei,couplingofaparticleandcollectimotion,electricquadruplemoments, s, magneticdipolemoments

**Textbooks:**

1.NuclearPhysicsbyR.R.RoyandB.P. Nigam,JohnWiley ve

**ReferenceBooks:**

1. PhysicsofthenucleusbyM.A.Preston, AddisonWesley.
2. NuclearPhysicsbyS.S.M.Wong,PrenticeHall.
3. IntroductiontoNuclearPhysicsbyH. A.Enge,AddisonWesley
4. Structureof theNucleusby M.A. Prestonand R KBhaduri, AddisonWesley

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

1. Determinationofe/mby

I) Brauntubemethod

II) MagnetronValvemethod

2. Determination of Planck'sconstant(h)byPhoto-electriceffectmethods

3. MeasurementofvelocityoflightbyLecherwire

4. G.M.counterexperiments:

I) CharacteristicsoftheGeigertube

II) InverseSquare Law.

III) Absorptioncoefficientof theAluminiumfoil.

5. CharacteristicsofDiode andZenerdiode.

6. Studyof logicgatesAND, OR, NOT,NAND, NOR, EXOR.

7. MakingAND,OR,NOT GatesusingNANDGates.

8. VerificationofBooleanAlgebra.

9. VerificationofDualnature.

10. CharacteristicsofF.E.T. (FieldEffectTransistor).

Anyother experimentsthat maybesetupfromtime totime

| SubCode:PHY-E301 | FiberOpticsandOptoelectronics | |
|---|---|---|
| **Semester:4** | **Credit:4** | **ElectiveCourse** |
| **Pre-requisites:**BasicPhysicsatthehighersecondarylevel | | |

**Courseoutcomes:**

- ✓ Theobjective ofthiscourseistofamiliarize studentsthe roleoffiber opticsindaytodayapplications.
- ✓ Toprovidebasicknowledgefordesigningsimple experimentusing L.E.D.,FiberandDetector

**Unit-1** **12 Hours**

**Opticalfiber:**Opticalfiberstructure:StepIndexFiber,GradedIndexFiber,Transmissionoflightthroughcylindricalwaveguidebyusingelectromagnetictheory.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,

CambridgeUniversityPress

ReferenceBooks:

3. G.Keiser,OpticalFibre Communications,Mc-Graw-Hill.

4. J.M.Senior,OpticalFibreCommunicationsPrinciplesandPractice,PHI.

OR

| **SubCode:PHY-VAC305A** | **AtomicandMolecularSpectra** | |
|---|---|---|
| **Semester:4** | **Non-Credit** | **VAC** |
| **Pre-requisites:BasicknowledgeinQuantumMechanics-I,ModernPhysics,Basic NuclearPhysics** | | |
| **Courseoutcomes:**<br>✓ Tounderstanddifferentatomicmodelsandtheirdevelopments<br>✓ Tolearnbehaviorof atomandmoleculesinthepresenceofelectricandmagneticfieldand molecular vibration.<br>✓ Tounderstandatomicandmolecularspectra | | |

**Unit-1** **12Hours**

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

**Unit-2** **12Hours**

Hartrees'centralfield approximation,atomicorbitaland Hund'srule. L.SandJ.J Coupling

**Unit-3** **12Hours**

Normal and AnomalousZeeman effect, Explanations of Zeeman Effect in sometransitions.Paschen-BachEffectStark-Effect:WeakfieldandstrongfieldStarkeffectinhydrogen.Hyperfinestructureandisotopeeffect,Nuclearspinandhyperfinestructure.

**Unit-4** **12Hours**

Typesofmolecularspectra,Electronicspectra,Vibrational-Rotationalspectra,moleculeasaharmonicandnon-harmonicoscillator,PureRotationalSpectra,moleculeasarigidandnon-rigidrotator.TheRamanspectraandmolecularstructure.

**TextBook:**

1. AtomicandMolecularspectra: Laserby RajKumar
2. IntroductiontoatomicspectrabyH. E.White

OR

| **SubCode:PHY-VAC305B** | **ASTRONOMYAND ASTROPHYSICS** | |
|---|---|---|
| **Semester:3** | **Non-Credit:4** | **VAC** |
| **Pre-requisites:BasicknowledgeinQuantumMechanics-I,Modern Physics,BasicNuclear Physics** | | |
| **Courseoutcomes:**<br>1. **Tounderstand ToolsofAstronomyandcelestialmechanics**<br>2. **Tointroducebasicastronomicalprinciplesinthestudyoftheplanets,starsandgalaxies.** | | |

**UNITI:** **15Hours**

**Celestial Mechanics and Astrometry**: The celestial Sphere, Positions of stars, Proper motions of starsandplanets, Distancesofnearby stars.

**ToolsofAstronomy:**Telescopes:BasicOptics,OpticalTelescopes,RadioTelescopes,Infrared,Ultraviolet,X-ray,andGamma-RayAstronomy–detectorsandobservatoriesGravitationalWavesdetectorsandNeutrino detectors All-SkySurveysand Virtual Observatories.

**UNITII:** **15 Hours**

**The Solar System:** The Sun, The Physical Processes in the solar system, The Terrestrial and the GiantPlanets,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 ofstars:Binary stars, Search forExtrasolar Planets

**UNITIII:** **15 Hours**

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

**UNITIV:** **15Hours**

**Our Galaxy And The Interstellar Matter**: The shape and size of our Galaxy,Interstellarextinctionandreddening,Galacticcoordinates,Galactic rotation,Stellarpopulation,Inter StellarMedium,Thegalacticmagneticfield andcosmic

**References**:


1. IntroductiontoStellarAstrophysics,Volume1,Basicstellarobservationsanddata,ByErikaBohm-Vitense, CambridgeUniversity Press
2. AnIntroductiontoModernAstrophysics,SecondEdition,ByCarrollB.W.,OstlieD.A.,Pearson Addison Wesley.
3. "AstrophysicsforPhysicists"byArnabRaiChoudhuri,CambridgeUniversity Press,2010
4. GalacticAstronomy:StructureandKinematicsbyMihalas&Binney,W.H.Freeman&CoLtd; 2nd Revised edition 1981.


**CourseOutcome:**

Learnershould beableto:

1. Haveknowledgeof theexpanseof theuniverseand thenatureof theplanets,stars and galaxies.
2. Understandhowtheastronomicalobservationsaredoneforthesecelestialobjects.
3. Applymathematicaltools andphysicslaws tounderstand thenatureof planets,stars andgalaxies.
4. Useonlineresourcestoanalysethedataobtainedfromvarious astronomicalobservations.
5. EvaluatetheresultsofthisanalysesandinterpretthenatureoftheSolarsystem,varietyofstars and galaxies.
6. Createnewobservationalprogramsordata analysesandinterpretationprojectsin astronomy

| SubCode:PHY-VAC305C | OPTICALFIBRESENSOR | |
| --- | --- | --- |
| Semester:3 | Non-Credit:4 | VAC |
| Pre-requisites:BasicknowledgeinQuantumMechanics-I,Modern Physics,BasicNuclear Physics | | |
| Courseoutcomes:<br>1. Identify different types of optical sensors and their performance characteristics - Analyze agivensensingrequirementanddesignanappropriatesensor-Realizeandimplementanoptimalsensing solutionforagiven requirement | | |

**Courseoutline**

**UNIT-1** **12Hours**

Needforopticalsensors•DifferenttypesofSensors•Opticalreceiverdesign;noiseissues,

**UNIT-II** **12Hours**

Amplitude Modulated sensors • Lock-in detection, Phase modulated sensors • Phase noiseanalysisand mitigation;Sensitivitylimits, Wavelength modulatedsensors•

**UNIT-III** **12Hours**

Interrogatordesign,sensitivitylimits,PolarizationModulatedSensors

**UNIT-IV** **12Hours**

Analysisofcurrentsensor,DistributedFiberSensors•Raman&Brillouinscattering-basedsensors.

Reference:

1. R.P.KHARE,OxfordUniversityPress

## Fourth Semester

| **Sub Code: PHY-E401A** | **ElementaryParticlePhysics** | |
|---|---|---|
| **Semester:4** | **Credit:4** | **ElectiveCourse** |
| **Pre-requisites:**<br>✓ **Basicknowledgein Quantummechanics,**<br>✓ **RelativisticQuantumMechanics** | | |
| **CourseOutcomes:**<br>✓ Themain goalofparticlephysicsis tolearn aboutthe universearoundus.<br>✓ Overthepast half century, particle physicists haveformulated theStandard Model,a beautifulframeworkthatexplainsthevisible universefromthesmallestto thelargestscales. | | |

**Unit-1** **12Hours**

Historical introduction to the Elementary Particles, Classification of elementary particles andtheir interactions: Photons, Leptons, Quarks, Mesons, Baryons. Lepton number, Baryon number,colorquantum number, Strangeness quantumnumber.

**Unit-2** **12Hours**

Chargeindependenceofnuclearforces,Isospin,Testforisospinconservation,AssociatedProduction of Strange particles, Gell-Mann Nishijima scheme, conservation laws in relation toparticlereactions and decays.

**Unit-3** **12Hours**

Unitary Symmetry: S.U. (2), S.U. (3), Concept of I-Spin, U-Spin, V-Spin, SU(3) Quarkmodel,TheEight-fold way,Mesons andBaryons in theOctet representation.TheBaryonDecouplets,Evidenceofcolor,Gell-Mann–Okubomass formula**.**

**Unit-4** **12Hours**

**DiscreteSymmetry:**

Parity (P) : Parity in quantum mechanics and Field theories, Test of Parity. Time reversal (T) :TimereversalinquantummechanicsandFieldtheories,TestofTimereversalChargeconjugation (C) : Additive quantum number, Charge conjugation in field theories, Test of Chargeconjugation. 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:**<br>✓ Tolearnabouttheadvances inGeneralTheoryofRelativity.<br>✓ 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 it's transformationproperties,Contraction,Symmetricandantisymmetrictensors;4-dimensionalvelocityandacceleration;four-momentumandfour-force;Covariantequationsofmotion;Relativistickinematics(decayandelastic scattering); Lagrangian and Hamiltonian ofarelativisticparticle.

**Unit-2** **12hours**

TheEquivalencePrinciple,TheWeakandStrongPrincipleofEquivalence,TheEquationofMotioninpresenceof GravitationalForces,The affineconnection,TheMetricTensor$g_{uv}$ ,RelationbetweenMetricTensorandAffineConnection,ThetransformationofAffineConnection,Covariant derivatives.

**Unit-3** **12hours**

TheNewtonianLimit:Relationbetween$g_{00}$ andtheNewtonianpotential,TimeDilationinaGravitationalField, Redshift of spectrallines, TheSolarRedShift.

**Unit-4** **12hours**

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

**Textbooksandreadingmaterials:**

**1.** Specialtheoryofrelativity,RobertResnick(OxfordUniversity )

**2.** GravitationandCosmologybyStevenWeinberg(JonWileyandSons)Ref
erences:

2. IntroducingEinstein'sRelativitybyRayDInverno(ClarendonPress)

3. AnIntroductiontoGeneralRelativityandCosmologybyTail.Chow,(Springer)

4. PrinciplesofCosmologyandGravitationbyM.Berry(Ca
mbridgeUniversity )

5. Specialtheoryofrelativity,RobertKatzD.Van( NostrondCompany,I.N.C.

| **Sub Code: PHY-C402** | **BasicNuclearPhysics** | |
|---|---|---|
| **Semester:3** | **Credit:4** | **CoreCourse** |
| **Pre-requisites:**Quantummechanics(Iand II),Electrodynamics,MathematicalPhysics | | |
| **CourseOutcomes:**<br>✓ Tounderstandthebasic propertiesofNucleusandNuclearmatter**.**<br>✓ Tolearnandunderstand aboutDeuteron,Scattering,NuclearenergyandNuclearModel.<br>✓ TounderstandtheapplicationofQuantummechanicsinNuclearphysics anditscorrelationwith Atomic and Particle Physics | | |

**Unit-1** **12Hours**

Nuclear properties: Nuclear Radius, Nuclear Mass and Binding Energy, Angular Momentum,Parityand Symmetry, MagneticDipole Momentand ElectricQuadrupleMoment. TwonucleonsBoundstateproblem:Centralandnon-centralforce,thedeuteron,tensorforces,magneticmoment and quadruplemoment of deuteron

**Unit-2** **12Hours**

Nucleonscatteringproblem:n-pscatteringatlowenergy,scatteringcrosssectionandscattering

length,effectiverangetheory.
Nuclearforce:Mesontheoryofnuclearforce,Yukawainteraction

**Unit-3** **12Hours**

Nuclear reaction and resonances, Breit-Wigner formula for s-waves, compound nucleus. Liquiddropmodel, Bohr-Wheeler theory offission, nuclearfusion

**Unit-4** **12Hours**

Single particle modelof nucleus,magic numbers, spin-orbitcoupling, angular moment andparities of nuclear ground states, magnetic moments and Schmidt lines, Collective model of Bohrand Mottelson.

**TextBook:**
**1.** NuclearPhysicsbyR.R.RoyandB.P.Nigam(JohnWiley)
**2.** NuclearPhysicsbyD.GTayal,HimalayaPublishingHouse
**3.** NuclearPhysicsbyS.N.Ghoshal,S.Chand

**Referencebooks:**
**1.** PhysicsofthenucleusbyM.A.Preston (AddisonWesley)
**2.** NuclearPhysicsbyS.S.M.Wong(PrenticeHall)
**3.** IntroductiontoNuclearPhysicsbyH.A.Enge(AddisonWesley)

**Referencebooks:**
**1.**TheFundamentals ofAtomicand MolecularPhysics byL.Robert,Springer

<table>
<tr><td>Sub Code: PHY-E403</td><td colspan="2">ProjectandSeminar</td></tr>
<tr><td>Semester:4</td><td>Credit:4</td><td>PROJECT</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Courseoutcomes:<br>✓ Themainobjectiveofthis courseis towork inaminiproject ,learn abouthowtopreparearesearchreport and present beforeanaudience.</td></tr>
</table>

| Sub Code: PHY-E404A | CondensedMatterandMaterialsPhysics | |
|---|---|---|
| Semester:4 | Credit:4 | Elective |
| Pre-requisites:BasicSolidStatePhysics | | |

**Objectives:**

- ✓ Themainobjective ofthiscourse istolearnaboutopticalandmagnetic propertiesofmaterialsand theirresponseto internaland externalstimuli

**Unit-1** **12Hours**

**Opticalproperties:**Absorption,intrabandandinterbandtransition,Absorptionspectraofmaterials,Luminiscence,Fluorescence,phosphorescence,Colourcentres,Opticalfibres(elementary ideas). Basic principles of Electron Spin Resonance, N.M.R. and Lasers-principles,Inducedabsorption,SpontaneousEmissionandstimulatedEmission,EinsteinAandB Coefficients,Rubylaser,Helium-NeonLaserand SemiconductingLaser.

**Unit-2** **12Hours**

**Magnetism:**LangevinDiamagnetismandVanVleckParamagnetism,Paramagnet:Derivationsof Curie law, Pauli paramagnetic susceptibility, Ferromagnetism: Curie point and the exchangeinteraction,Curie-Weisslaw,Ferrimagneticorder,Curietemperatureandsusceptibilityofferrimagnets,Antiferromagneticorder,susceptibility belowthe Neeltemperature.

**Unit-3** **12Hours**

**Advanced magnetism and materials:** Landau's theory of diamagnetic susceptibility, Spin waves andmagnon specific heat, N.M.R. Knight shift, Diluted magnetic and ferromagnetic semiconductorsSpintronics-giantmagnetoResistance(GMR),Mott'stheoryofspin-dependentscatteringofelectrons

**Unit-4** **12Hours**

**NovelMaterials:**Metallic nano clusters: Nanoscienceand nanoclusters,liquiddrop model,size and surface volume ratio. Graphene: Graphene lattice, tight binding approximation, DiracFermionsElementaryideasaboutpolymers,Charecterisationofmaterials:Experimentaldiffraction methods, Bragg law, Laue conditions, Geometrical Structure factor and Atomic formfactor,Non-crystallinematerials-diffractionpattern,amorphoussemiconductors,lowenergy excitations, heat capacity, thermal conductivity. Basic principles of Raman Effect in crystals andMossbauertechniques

**TextBooks:**
1. PhysicsofCondensedMatter-PrasantaK.Misra(AcademicPress,2010)
2. OpticalPropertiesofSolids,MarkFox,OxfordUniversityPress

**References**:
2. IntroductiontoSolidStatePhysics,C.Kittel,JohnWileyandSons,Inc.Singapore.
3. SolidstatePhysicsbyAschcroftandMermin,HarcourtAsiaPTE.Ltd.(A HarcourtpublishersInternationalcompany)

<table>
<tr><td>Sub Code: PHY-E404B</td><td colspan="2">NuclearScience-2(FieldTheoryandParticlePhysics)</td></tr>
<tr><td>Semester:4</td><td>Credit:4</td><td>Elective</td></tr>
<tr><td colspan="3">Pre-requisites:<br>QuantumFieldtheory,ElementaryParticlePhysicsandMathematicalPhysics.</td></tr>
<tr><td colspan="3">Courseoutcomes:<br>✓ Tolearnthefieldtheoretictechniquesasapplicabletotheinteractingelementaryparticlesandto be conversant withthe currentstatus ofparticlephysics.<br>✓ Tolearnthefundamentalconceptofspontaneousbreakingonthebasisof weakinteractionalong with decay widthcalculation.</td></tr>
</table>

**Unit-1** **12hours**

**FieldTheory:**
Unequal space time commutation and anti-commutation rules for field operators. Propagatorfunctions and their integral representations, Vacuum expectation values, Feynmann propagators,Concept of T-Product and Normal Product, Feynman diagram rules in coordinate and momentumspace,Wick'sTheorem,Propertiesofscatteringmatrix,Briefideaofelectron-photonscattering.

**Unit-2** **12hours**

**ParticlePhysics:**
Brief review of elementary particles and their interactions, S.U. (3) Quark Model, The BaryonandMesonState,Baryon-Mesoncoupling:TheFandDterms,Gell-Mann-OKubomassformula.TheHeavyQuarks:CharmandBeyond,S.U.(6)QuarkModel:wave-functionforMesonsand Baryons, Magneticmoment of Baryons.

**Unit-3** **12hours**

**WeakInteraction:**V-Aformofweakinteraction,,MuonandPiondecaycalculation,elementary notion of leptonic decays of strange particles, the Cabibbo angle, intermediate vectorbosons, Elements of Neutral K-meson theory : Decay of Neutral K-mesons, regeneration of K-mesons,CP violation inneutral K decay.

**Unit-4** **12hours**

Spontaneous symmetry breaking, Higgs Mechanism, Brief idea of Salam-Weinberg Theory ofStandardModel.NeutrinoPhysics:NeutrinoMassandExperimentallimits,NeutrinolessDouble-Betadecay,Neutrino oscillation,Solarneutrino puzzle,Magnetic moment ofneutrino.

**Textbooksandreadingmaterials**

**1.** IntroductiontoElementaryParticlesbyD.Griffiths,JohnWiley&sons.
**2.** Relativistic quantum field theory by J.D.Bjorkenand S.D. Drell, McGraw-Hill BookCompany.
**3.** AnIntroductoryCourseofParticlePhysics,Palas.B.Pal.C.R.C.Press.
**4.** Elementaryparticlephysics byGasiorwicz,Addison-Wesley publishingCompany
**5.** ElementaryParticlePhysicsbyG.Kallen, Addison-WesleypublishingCompany
**6.** QuarksandLeptons:F.Halzenand A.D.Martin,JohnWiley.
7.AModernintroduction toparticlephysics:FayyazuddinandRiazuddin,WorldScientific,Singapore.

| **Sub Code: PHYE405A** | **CONDENSEDMATTER&MATERIALSPHYSICS (Laboratorywork)** | |
|---|---|---|
| **Semester:1** | **Credit:4** | **ElectiveCourse** |
| **Pre-requisites:**BasicknowledgeofCondensed MatterandMaterialsPhysics | | |
| **Courseoutcomes:**<br>✓ Todesignandanalyze principles inCondensed Matterand MaterialsPhysics. | | |

1. Determinationofenergy gapof agivensemiconductorby fourprobemethod
2. DeterminationofHallconstantof asampleanditsidentification
3. Determinationofenergy gap byp-njunctionmethod
4. Studyofdispersion relationofan electricanalog ofmonoatomic linearchain
5. Studyofdispersionrelation ofanelectricanalog ofdiatomiclinearchain

6. Determinationofspecificheatofagivensampleusing athermocouple
7. Determinationofdielectricconstantof agiven sampleby lecherwiremethod
8. DeterminationofB-H curveof agivenFerro-magnet

Anyother experimentsthat maybeset upfrom timeto time.

| **Sub Code: PHYP405B** | **NuclearScience(Laboratorywork)** | |
|---|---|---|
| **Semester:1** | **Credit:4** | **Elective Course** |
| **Pre-requisites:** Basic knowledge of Condensed and MaterialPhysics | | |
| **Courseoutcomes:** ✓ TodesignandanalyzeexperimentsinNuclearScience | | |

1. Determinationofhalf-lifeofunknownsource
2. Determinationoflinearabsorptioncoefficient
3. Verificationofinversesquarelaw
4. Experiment with gamma ray spectrometeri.Energyanalysisofunknownga mmasourceii.Spectrum analysis of 60 Co and 137 Coiii.Activityof Gamma emitter
5. HighresolutionofgammarayspectroscopyEnergyresolutionwithGe(Li)detect orPhoto pick efficiencyfor Ge(Li)detector

Anyother experimentsthat maybeset upfrom timeto time

| **SubCode:-VAC406** | **CulturalHeritageof SouthOdisha** | |
|---|---|---|
| **Semester:1** | **Credit:4** | **VAC** |
| **Pre-requisites:** | | |
| **Courseoutcomes:** ✓ The teaching impacted to P.G students of Science College (Autonomous), Hinjilicut on the variousdimensionsoftheliteraryandculturalheritageof SouthOdishawillhelpthemtoacquirethe valuableunderstanding of thesame. | | |
| ✓ They will be inspired adequately to takethe positivelearnt from the course and usethem in future in their personal literary and cultural pursuits and their by promote theliteratureandcultureof theodishaon aGlobal Scale | | |

| | |
|---|---|
| UnitI | Literarywork ofKabiSamratUpendraBhanja |
| UnitII | OtherLiteratures of South Odisha |
| UnitIII | CulturalHeritageofSouth Odisha |
| UNTIV | FolkandTribalTraditions ofSouthOdisha |