COURSES OF STUDIES

FOR

M.Phil. EXAMINATION

(2019-2020 Session)

PHYSICS

(Semester System)

POST GRADUATE DEPARTMENT OF PHYSICS

NORTH ORISSA UNIVERSITY

SRIRAM CHANDRA VIHAR

TAKATPUR, BARIPADA-757003

DEPARTMENT OF PHYSICS

CURRICULUM STRUCTURE (M. Phil.)

Semester-I

Paper Code	Course Title	Credit	Marks
PHY-601	Research Methodology-I	05	50
PHY-603	Research Methodology-II	05	50
PHY-605	Practical	10	100

Total 20 200

Semester-II

Paper Code	Course Title	Credit	Marks
PHY-602	General Theory	05	50
PHY-604	Elective(A,B.C)	05	50
PHY-606	Dissertation	10	100

Total 20 200

Grand Total 40 400

Elective Courses Offered:

1. Advanced Nuclear Physics
2. Advanced Quantum Theory
3. Advanced Condensed Matter Physics

Programme Outcome:

- The students will gain concrete knowledge and comprehensive understanding of the advanced physical science.
- They will be efficient to take up challenges for National/International competitive physicists/researchers in various areas of theoretical as well as experimental physics.
- They will be capable enough for technical and analytical skill to pursue their further higher studies and build up continuous learning through their professional career.
- They will be trained to appear national level tests like UGC-CSIR NET, JEST, GATE, etc., and professional jobs in various fields successfully.
- They will acquire the sense of academic and social ethics.

Programme Specific outcome:

- The student will understand the core courses forming the advance study of physics namely, Mathematical Physics, Numerical Analysis, Advanced Condensed Matter Physics, Advanced Quantum Theory and Nuclear Physics etc.
- They will learn computational physics to train themselves to use computers as a mean for scientific computation and analysis.
- They will understand the basic concepts of certain sub fields through elective course such as Nuclear Physics, Advanced Condensed Matter Physics, and Advanced Quantum Theory.
- They will be motivated towards research in physics through the dissertation/project work in both theory and experimental streams.
- They will develop creative thinking and problem-solving capabilities encouraged through mentor system.
- They will learn through experimental skills in both the core and elective labs, designed to develop an appreciation for the fundamental concepts and working of devices used in scientific methods of physics.
- They will be capable of taking up higher studies / research of interdisciplinary nature.

SEMESTER-I

Phy-601 Research Methodology-I Marks-50

Course Objectives: To introduce the skill development by: (i) using a scientific programming languages such as FORTRAN 77, (ii) applying these programme techniques to analyse/handle data for their research problems and (iii) writing and editing the text using LATEX.

UNIT – I (10)

Introduction to FORTRAN-77, Flow charts, Algorithms, Integer and Floating point, Arithmetic, Precision, Variable types, Arithmetic statements, Input & output statements, Control statements, Do loops, While structure, Arrays, Subscripted, Subroutines, Sub program, Data files

Unit-II (10)

Matrices and linear system of equation**:** Pivotal condensation, Gauss elimination method, Gauss-Seidel-iteration method, Gauss Jordan elimination method, matrix inversion, Eigen values and Eigen vectors.

Unit-III (10)

Numerical differentiation and integration: trapezoidal rule, Simpson's rule, Gaussian Quadrature formula

Unit-IV (10)

Solving the equations by Newton-Raphson's method**,** Computation of Gamma, Bessel function, Runge-kutta method of solving Schroedinger equation

Unit-V (10)

Computational methods of statistical parameter: classification and tabulation of data, Arithmetic means, Median, Mode, Mean deviation, Standard deviation, Correlation, Least square fitting of linear equations

Writing with LATEX: Basic information, Create and typeset a simple LATEX document, elementary mathematical type setting, Use of Graphics, Advanced mathematical type setting

Course Outcome: After completion of this course student will be able to understand the concept of programming. Then they would able to solve transcend equation, differential equation, integration and some mathematical function numerically which will help them for their theoretical research problems. Besides the students are trained with the basic ideas of statistics, so that they can apply these techniques to analyse data for their research problems. Handling of numerical problems makes the students competent to work as research associates. Also, they would able to write and edit text using LATEX.

Books:

1 Numerical Algorithms- E.V Krishnamurthy, S.K.Sen
2 Computer Application in Physics- Suresh Chandra
3 Fortran 77 and Numerical Methods- C. Xavier
4 Introduction to Numerical methods and Fortran programming- Mc Calla, Thomas R
5 Numerical analysis for Scientists & Engineers- M.K. Jain

Phy-603 Research Methodology-II Marks-50

Course Objectives: The students will gather knowledge to study the molecular structure of materials using Raman spectra and Infra-red spectra. They will also acquire the skill for analysing the data using numerical technique.

Unit-I **(10)**

Newton divided difference interpolation, Lagranges interpolation, Comments for equality spaced points interpolation, Spline interpolation, Linear splines, Quadratic splines, Cubic splines.

Unit-II **(10)**

Special Integrals, Error integral, Sine integral, Cosine integral, Fresnel integrals, Liouville integral, Weber integrals, Heine's integrals, Dawson's integrals, Ajry's integrals.

Unit-III **(10)**

Nature of the Raman spectra, Experimental arrangement for Raman spectra, Classical theory of Raman effect, Quantum theory of Raman effect, Pure rotational Raman spectrum, Raman spectra and molecular structure, Infra-red spectra versus Raman spectra.

Unit-IV **(10)**

Vibrational Raman spectra, Raman activity of vibrations, Rule of mutual exclusion, over tone and combination vibration, rotational fine structure, Polarization of light and the Raman Effect, structure determination from Raman and infrared spectroscopy.

Unit-V **(10)**

Frank-Condon Principle, Quantum Mechanican formulation of Frank-Condon Principle, Explanation of intensity distribution in absorption, Bands from Frank Condon Principle, Explanation of intensity distribution in emission Bands, Condon parabola, Line intensities in a Band, Rotational intensity distribution.

Course Outcomes: After successful completion of this course student will gain knowledge on different interpolation, special integrals which are very useful in further research work. They will also learn the usefulness to study molecular structure of materials using Raman spectra and Infra-red spectra and also explanation of intensity distribution in emission Bands. The skill of analysis of numerical technique helps students to work in the research institutions.

Books:

1. Quantum Mechanics: L.I.Schiff
2. Fundamentals of Molecular Spectroscopy: Colin N. Banwell &Elaine, M. Mccash

Phy-605 **Practical** **Marks-100**

Course Objectives: To introduce the students about various experimental techniques associated with Solid State Physics and Nuclear Physics. They also develop the skill in handling different scientific equipment.

1. Determination of Curie temperature on ferromagnetic and ferroelectric materials.
2. Determination of Debye temperature from specific heat measurement.
3. Determination of Hall Coefficient.
4. Determination of Plank's constant using photoelectric effect method.
5. Study the dispersion relation curve using lattice dynamic kits.
6. To calibrate the energy of the gamma sources.
7. Determination of absorption co-efficient of Aluminum using G.M Counter.
8. X-test and operating point determination using G-N tube
9. To analyze the energy of an unknown Gamma source
10. Estimation of Nuclear efficiency of the G.M. detector for (a) Gamma source and (b) Beta source.
11. To study Beta particle Range and maximum energy (Feather analysis).

Course Outcome: Students will perform some experiments to become familiar with the properties of solids taught in the solid state physics elective and nuclear physics courses. The skill of handling instruments in these two different areas helps students to work in the respective research institutions.

SEMESTER-II

Phy-602 General Theory Marks-50

Course Objective: To provide the introductory knowledge on the General Theory of Relativity, Atomic and Molecular spectra.

Unit-I (General Theory of Relativity) (10)

The General Theory of Relativity: The Principle of Equivalence, Gravitational force, Relation between $g_{\mu\nu}$ and $\Gamma^{\lambda}_{\mu\nu}$, Geodesics, the Newtonian limit, Time Dilation**,** Tensor Analysis**:** The Principle general Covariance, Vector and Tensors, Tensor Algebra, Tensor densities, Transformation of the Affine Connection, Covariant differentiation

Unit-II (General Theory of Relativity) (10)

Riemann Christoffel Curvature tensor, Ricci tensor , Commutation of Covariant Derivatives, Algebra Properties of $R_{\lambda\mu\nu\kappa}$, The Bianchi Identities, Geodesic deviation, Einstein's Field equation,

Unit-III (General Theory of Relativity) (10)

Classical Tests of Einstein's Theory: The General Static Isotropic Metric, The Schwarzschild Solution**,** General Equation of motion, unbound orbits: deflection of light by sun, Bound Orbits: Precession of Perihelia,

Unit-IV (Atomic and Molecular spectra) (10)

Helium Atom and its spectrum: Exchange force, spectrum of Helium, quantum – mechanical explanation of the splitting of terms of He-atom, ground state energy of Helium atom, prohibition of intercombinations Multi-electron atoms: Multi-electron atoms in Schroedinger's theory (central field approximation, Hartree's self consistent field), results of hartree teory, atomic orbitals and the Hund's rule, the periodic table

Unit-V (Atomic and Molecular spectra) (10)

Spectra of Alkaline-Earth elements and Complex spectra: Essential features of spectra of Alkaline-Earth elements, vector model for two valence electron atom (Application to spectra), interaction energy (Triplet separations) in LS and i-j couplings, comparison of terms in L-S and i-j couplings, Regularities in complex spectra, The Breadth of spectral lines: natural breadth, Doppler Effect, external effects

Course Outcomes: After successful completion of this course student will be able to explore general theory of relativity, Atomic and Molecular spectra which will be useful in theoretical research by using different theoretical models.

Books:

1. Gravitation & Cosmology : S. Weinberg
2. General Relativity and Cosmology : S.K. Srivastava

3. General Theory of Relativity :P.A.M. Dirac
4. Atomic and Molecular Spectra: Laser : Raj Kumar

Phy-604 Nuclear Physics (Elective-A) Marks-50

Course Objective: To provide the comprehensive knowledge to explore the same in theoretical research on Nuclear and Particle Physics.

Unit-I **(10)**

Resonance in compound nucleus model, Resonance cross section, Determination of cross sections on the basis of compound Nucleus model, decay or emission rates of the compound nucleus

Unit-II **(10)**

Direct reaction and optical model: plane of theory of direct reactions, theoretical cross section with optical model, optical giant resonances, the optical model parameters.

Unit-III **(10)**

Heavy-ion induced nuclear reactions: General aspect, elastic scattering critical angle, deflection function, rainbow scattering, diffraction in elastic scattering, Fraunhofer diffraction, Fresnel diffraction.

Unit-IV **(10)**

Heavy ion potential Collision, optical potential, strong coulomb interaction, the folding model, the strong absorption model

Unit-V **(10)**

Semi classical (WKB) approximation of heavy ion collision, The phase-shift in the semiclassical approximation, the partial wave function in WKB, evaluation of the scattering amplitude in WKB, fusion of heavy ions

Course Outcomes: After successful completion of this course student will be able to explore Nuclear Physics which will be useful in theoretical research on Nuclear Physics and Particle physics.

Books

1. Theory of Nuclear Reaction- P. Frobrich and R. Lipperheide
2. Semi-Classical Methods in Nucleus-Nucleus Scattering- D. M. Brink
3. Theoretical Nuclear Physics- J.M. Blatt and V.F. Weisskopf
4. .Nuclear Physics-H.S.Hans

Phy-604 Advanced Quantum Theory (Elective-B) Mark-50

Course Objective: To provide a comprehensive knowledge to explore advanced quantum physics in theoretical research by using different theoretical models.

Unit-I **(10)**

The interaction of Electromagnetic Radiation with Atomic Systems: Some Basic Electromagnetic Background, The energy of electromagnetic fields, Quantization of Electromagnetic Modes, Electromagnetic creation and annihilation operators, travelling wave quantization

Unit-II **(10)**

Black body radiation, derivation of average energy per mode, Induced transitions in collision dominated atomic systems.

Unit-III **(10)**

Spontaneous transitions, graphical representation of spontaneous decay of an excited population monitored via the emitted radiation, Quantum mechanical derivation of the spontaneous transition rate A, The spontaneous life time of the 2p→1s transition in atomic hydrogen.

Unit-IV **(10)**

The time evalution of a collision two level atom. Absorption and amplification in atomic systems-collision dominated regime. Diagramatic representation of amplification of a traveling wave in an inverted population medium and attenuation in an absorbing medium.

Unit-V **(10)**

Eletric-polarization, susceptibility and the dielectric constant, significance of electric susceptibility, density matrix derivation of the atomic susceptibility, graphical behaviour of real and imaginary part of susceptibility, significance of real part of susceptibility

Course Outcomes: After successful completion of this course student will be able to explore advanced quantum theory which will be useful in theoretical research by using different theoretical models.

Books:

1. The introduction to theory and application of Quantum Mechanics: Amnon Yariv

Phy-604 Advanced Condensed Matter Physics (Elective-C) Marks-50

Course Objectives: To provide skill for the understanding various aspects of Condensed Matter Physics using standard theoretical principles. Also, to provide a comprehensive knowledge on several measurement to understand the practical aspect of few Condensed Matter Physics problems.

Unit-I **10 Marks**

Superconductivity: Elementary ideas and characteristic properties, B.C.S. pairing theory, Ginzburg-Landau theory, Application of Ginzburg-Landau theory (Temperature dependent order parameter ψ (T), Coherence length ξ, The length ξ and upper critical field Bc2, Ginzburg-Landau Abrikosov (GLA) prediction for Bc2/Bc1).

Unit-II **10 Marks**

Optical properties: Scattering, Refraction, Theory of refraction and absorption, relation between refractive index and electronic polarizability, Reflection and transmission, Reflectivity in-terms of dielectric constant, relation between reflectivity and conductivity, Transmittivity, Atomic theory of optical properties.

Unit-III **10 Marks**

Magnetic measurement: Basic concept, experimental technique (Gouy method, Faraday method, Change in flux method, vibrating sample magnetometer). Formula for data handling (Van-Vleck equation, Curie law, Paramagnetism, data analysis), crystal field theory (the octahedral crystal field, spin orbit coupling in octahedral field, Zeeman Effect) and Exchange coupling (an orbital effect, vector model).

Unit-IV **10 Marks**

Metal-insulator transition: Phenomenology of metal-insulator transition, Metal-insulator transition caused by overlapping bonds, The mean free path, weak localisation, Bergmann's treatment, Conductivity below σmin near the Anderson metal insulator transition, the inelastic diffusion length, scaling theory, Hopping conduction, Pseudogaps and metal-insulator transitions

Unit-V **10 Marks**

Basic ideas about semiconductor, Intrinsic and impurity semiconductors, band gap, law of mass action, intrinsic and extrinsic carrier concentration, mobility in the intrinsic region, P-N junction, rectification. Hall effect in semiconductor.

Course Outcomes: After successful completion of this course student will be able to explore materials properties particularly on electrical, optical and magnetic by using theoretical models. The theoretical knowledge in this sector helps students to work in the research institutions.

Books:

1. Material Science: MS Vijaya, G Rangarajan
2. Solid State Physics: Asscchroff Mermin
3. Introduction to Superconductivity: M. Tinkham
4. Metal-insulator transition N.F. Mott
5. Solid State Chemistry Techniques A. K. Cheetham and P.Day

Phy-606 **Dissertation** **Marks-100**

Course Objectives: To provide hands on training to gather knowledge and implement the same for undertaking methodological research in the topic of their interest. Also, to develop conceptual knowledge on undertaking research career in future.

At the semester end, the student will submit project report in the form of dissertation which will be examined through the process of grand viva by both the external and internal examiner selected by Board of studies.

Course Outcomes: Students will develop their ability to search literature, analyse theoretical or experimental data to perform research through the dissertation work.

It develops skill and helps students in getting employability in semiconductor industry as well as reactor physics