Programme Outcomes, Programme Specific Outcomes and Course Outcomes For PG Programmes

Programme Name: ***M.Sc. in Physics***
(e.g *M.Sc in Physics/ MA in Bengali/MCA etc.)*

Number of Semesters: 4

Name of the Department
University of North Bengal
West Bengal, INDIA

Programme Outcomes

- 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 as 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 thereof.
- Prepare the students to pursue research careers, careers in academics, in industries in physical science and in 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.
- Make them understand that acquiring knowledge and skills appropriate to their professional activities is a never-ending process.
- Inspire them in such a way that they can demonstrate and maintain the highest standard on ethical issues in their professional lives.
- Create an awareness among the students to be persons of integrity, to be responsible and enlightened citizens with a commitment to deliver good to the society within the scope of the bestowed rights and privileges.

Programme Specific Outcomes

- 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 as 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 thereof.
- Prepare the students to pursue research careers, careers in academics, in industries in physical science and in 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.

- Make them understand that acquiring knowledge and skills appropriate to their professional activities is a never-ending process.
- Inspire them in such a way that they can demonstrate and maintain the highest standard on ethical issues in their professional lives.
- Create an awareness among the students to be persons of integrity, to be responsible and enlightened citizens with a commitment to deliver good to the society within the scope of the bestowed rights and privileges.

Course Outcomes

SEMESTER–I

Course Code	Course Name	Course Outcomes
PHY 1101	**Mathematical Methods in Physics**	Knowledge gained • Knowledge gained in areas like (i) Complex analysis, (ii)Integral transforms, and (iii) Differential equations and special functions • Knowledge gained in areas like (i) Linear Vector Space and operator algebra, (ii) matrix diagonalization and series of matrices, (iii) tensor algebra, (iv) introductory group theory, and (iii) Green's functions. Skills gained • The students acquire skills to apply different mathematical techniques to solve problems in the areas of heat flow, potential theory, elasticity, fluid mechanics, electromagnetic theory and quantum mechanics and condensed matter physics. • The students acquire skills to apply different mathematical techniques to a very wide range of natural systems from very simple (like an atom) to very complicated (like an astrophysical object), and try to understand the underlying dynamics of each. Most of these techniques are useful in other scientific and/or technology areas too. Competency developed • Students gain competence which will enable them to solve problems in many areas of science and engineering. • Students are/should be competent enough to solve problems and apply the above-mentioned techniques in areas like Quantum Mechanics, Quantum Field Theory, Astrophysics and Cosmology. They should be able to apply the mathematical techniques even beyond in Chemical, Biological and Geological systems as well as in technology.
PHY 1102	**Classical Mechanics**	Knowledge gained • Lagrange's and Hamilton's formalism: Generalised coordinates, Virtual work, Principle of Least Action, Lagrange's equation of motion, Hamilton's Principle, Noether's Theorem. Two-body central force problem, effective potential technique, study of kepler system, Rigid body Kinematics, Euler angles,rigid rotator and heavy symmetrical top. Hamilton's equation, Routh's Procedure, Canonical transformations, Poisson brackets, Liouville's theorem. Hamilton Jacobi Theory, action-

		angle variables. Small oscillations, normal coordinates, continuous system, Lagrangian and Hamilton formalism of continuous systems and fields, special theory of relativity, four vectors and metric, Lagrangian formulation of relativistic mechanics, Nonlinear dynamics, periodic motions, chaotic trajectories and Liapunov exponents. • In this paper we teach Special theory of Relativity (STR) at an advanced level. Skills gained • The students learn STR and acquire knowledge of four vectors and tensors more vigorously to use it to understand Advanced Quantum Mechanics, Nuclear Physics, Particle Physics and other papers in the next semesters • Students acquire basic knowledge of Mechanics, skills and techniques to solve a mechanical problem, • Students learn rocket launching, satellite parking parameters, MOMS parameters and time of flight and other techniques how to divert the path of an asteroid if it is coming in the direction of the earth. Competency developed • The students develop competency to solve the problems of STR, Advance Quantum Mechanics, Nuclear Physics, Particle Physics and other papers in the next semesters • They develop to short out the classical mechanics problems from other areas. For example a particle moving with very high velocity. Also the topic of continuous systems helps them to obtain the concept of field and the dynamics of the field. • The students learned in Special theory of Relativity how to determine the energy required for a projectile in the laboratory to create a new particle knowing the target nucleus at very high energy. •
PHY 1103	**Electronics I**	Knowledge gained • Knowledge gained in areas like (i) Feedback in amplifiers, (ii) Audio power amplifiers, (iii) Oscillators, (iv) Power supplies and Electronic regulators, (v) Some special application of OP AMP, (vi) Digital electronics and (vii) Networks and lines. Skills gained • The students acquire skills to design different electronic circuits like (i) Feedback amplifiers, (ii) Audio power amplifiers, (iii) Oscillators, (iv) Electronic regulators, (v) Digital circuits and (vii) Filters and transmission lines. Competency developed • Students should be competent enough to design different electronic circuits which are very useful in the application point of view.
PHY 1104	**Computational Methods in Physics I**	Knowledge gained in - • Fortran programming and numerical analysis • Writing programs in Fortran to solve numerical analysis programme

		• Solving algebraic, transcendental, and polynomial equations • Solutions of linear simultaneous equations • Solution of differential equations • Finding values of integrals • Finding eigenvalues and eigenfunctions • Methods of least squares and curve fitting • Generation of random numbers and their applications in finding values of integrals Monte Carlo simulation Skills gained in solving various numerical analysis problems in advanced physics and engineering. Following points may be omitted • Different number systems; representation of integer and real numbers; ASCII codes. • Programming of different solutions stated above in the FORTRAN language. • The students acquire skills to apply different computational techniques to a different field of physics. Competency developed in solving real life problems in classical mechanics, quantum mechanics, electromagnetism, waves and optics and simulation techniques. Following points may be omitted. • Facility in working with mathematical problems that involve polynomial equations. • Facility in handling problems involving polynomial equations • Applying mathematical methods to the real-life problems • Highly developed reasoning ability. • Students should be competent enough to solve the problems of physics computationally.
PHY 1305	**Laboratory Course I**	Knowledge gained: • Knowledge gained in experimental areas like (i)Stabilized power supply, (ii) Passive filters, (iii) Push Pull amplifier, (iv) Clipping and clamping circuits, (v) Astable multivibrator, (vi) Feedback amplifier using OPAMP, (vii) Analog (D/A) converter and (viii) 2's complement Adder-subtractor operations. Skills gained: • Students get a direct hand on experience working with analog and digital circuits and operation. Competency Developed: • Students get proficiency in analog and digital circuits designing and implementation for real life operation.

SEMESTER—II

Course Code	Course Name	Course Outcomes
PHY 2106	**Electrodynamics & Plasma Physics**	Knowledge gained

		• Maxwell's equations; Gauge transformations; Concept of retarded potentials; Electromagnetic radiation from both localized and moving source; Covariant formulation of electrodynamics. • Basics of plasma physics; Various aspects of wave propagation in plasma. Skills gained • An overall knowledge of classical theory of electrodynamics is gained. • Skills are developed to encounter cumbersome analytical calculations. • Basic knowledge of plasma physics is acquired. Competency Developed • Apart from their basic understanding of the subject, the students are efficient enough to solve various unknown problems of electrodynamics, relevant for competitive examinations like NET, GATE, JEST, SET etc.
PHY 2107	**Statistical Mechanics**	Knowledge gained: • Basic postulates of classical statistical mechanics; concepts of microstates, phase-space, partition function and density function; micro-canonical, canonical and grand canonical ensembles; Maxwell-Boltzmann distribution; connection between statistical mechanics and thermodynamics applications to simple systems. • Quantum statistics; density operator, indistinguishable particles; Fermi-Dirac and Bose-Einstein distributions; applications - Degenerate Fermi gas, White dwarf system, Saha's ionization formula, Black-body radiation, Debye's theory of specific heat, Pauli's theory of patramagneticsm, Bose-Einstein condensation. Skills gained: • Introductory knowledge of Statistical Mechanics is acquired. Skills of using the statistical principles and applying the techniques learnt thereof to simple thermodynamic systems under equilibrium are developed. Competency Developed: • Students are/should be competent enough to connect the principles of statistics with the laws of mechanics, and apply their knowledge to more complicated thermodynamic systems in and beyond the domains of physics (like in chemical, biological, geological systems and in technology), as well as to systems that are not in equilibrium.
PHY 2108	**Quantum Mechanics I**	Knowledge gained • General formalism of Quantum Mechanics, mixed states, wave packets, uncertainty relation, representation in quantum mechanics, picture of quantum mechanics, Eigenvalue problem, matrix mechanics, angular momentum, Clebsch-Gordon coefficients, time independent perturbation theory, Zeeman effect, stark effect, Variational method, time dependent perturbation method, interaction picture, Fermi's golden rule, WKB approximation, semiclassical reduction of

		Schrodinger equation, turning points and connection formulae, bound states solution, barrier penetration. Skills gained • Basic knowledge of Quantum Mechanics is acquired. Skills and techniques to use Quantum mechanical principles in simple and complicated systems. • The basic knowledge to solve 1 dimensional and thereafter 3-dimensional potential problems. • The idea of spinor and its matrix representation. • The need for a perturbative technique to solve some physical problems. Competency Developed • The students after the course are competent enough to use the knowledge of Quantum Mechanics to different Quantum Mechanical systems encountered in different areas of Physics. • They learn to solve the non-relativistic quantum mechanical problem and can demarcate the problems which are quantum mechanical.
PHY 2309	**Computational Methods in Physics II**	Knowledge gained • Knowledge acquired in different number systems and variables. • Knowing how to solve algebraic, transcendental, polynomial equations, linear simultaneous equations, ordinary differential equations: • Knowledge acquired in various physics problems like curve fitting, Numerical integration, interpolation, Matrix eigenvalue problem, Data sampling, Monte-Carlo integration, Monte-Carlo Simulations of simple physical systems such as Random walk problem, Nuclear decay phenomena, etc. Skills gained • Skill acquired on FORTRAN Programming to solve: algebraic transcendental, polynomial equations, linear simultaneous equations, Eigenvalue problem, Ordinary differential equations, Numerical integration, Interpolation, Curve fittings, Random number, Monte-Carlo integration and simulation, Data sampling, Planetary orbit problem, Simple and coupled oscillation problem, Nuclear decay problem, Random walk problem, etc. Competency Developed • Competency developed on FORTRAN Programming and its applications in different physical problems as mentioned above.
PHY 2110	**Comprehensive Course I**	Knowledge gained: • This course is designed basically to address a few limitations of the semester system, e.g., to remind a student what she/he has learnt in the previous semester(s). A student learns how to solve critical problems in some of the core areas of Physics.

		Skills gained: • Develop problem solving skills, ability of independent thinking. • Prepare and motivate the students to feel comfortable under challenging conditions. Competency Developed: • Assist students in preparing for different state and national level competitive examinations like NET, SET, JEST, GATE etc.
PHY 2111	**Comprehensive Viva-voce I**	Knowledge gained: • Provide adequate knowledge in some of the core areas of Physics, empowering thereby a student to face interviews and develop communication skills. Skills gained: • Develop presence of mind, develop problem solving skills, ability of independent thinking and develop communication skills. Competency Developed: • Assist students in preparing for interviews and for different state and national level competitive examinations like NET, SET, JEST, GATE etc.

SEMESTER—III

Course Code	Course Name	Course Outcomes
PHY 3112	**Quantum Mechanics II**	Knowledge gained: • Symmetries in quantum mechanical systems; Identical particles and exchange symmetry. • Scattering theory. • Limitations of non-relativistic quantum mechanics; Dirac's theory of spin-1/2 particles; Lorentz transformation of a spinor and the bilinear covariants; Introductory quantum (free) field theory - examples of scalar and spinor field quantization. Skills gained: • Various consequences of the symmetry transformations in quantum mechanical systems are understood. • Scattering theory allows a student to probe the nature of interaction(s) between two elementary particles, and understand thereby the fundamental structure (building blocks) of all material objects. • The techniques applied in relativistic quantum theory and quantum field theory, will enable a student to further investigate and understand the properties of the fundamental particles that our universe is made of and the interactions between them. Competency Developed: • In this course a student for the first time learns the formalisms of modern physics, which she/he will find useful while pursuing a

		research career in fundamental physics research and/or as an academician.
PHY 3113	**Condensed Matter Physics I**	Knowledge gained • On Elementary Crystallography, basis, crystal class and Ewald construction. • Knowledge on lattice vibrations and thermal properties and quantization of lattice vibrations, phonon momentum. • Discussion on free electron Fermi gas with Classical free electron theory and Fermi-Dirac probability distribution function is discussed and hence an comprehensive view on Fermi energy is obtained. • Dielectric Properties of insulators and ferroelectricity. • In Magnetic properties of solids, Diamagnetism, paramagnetic susceptibility and ferromagnetism is discussed and a quantum picture of Heisenberg exchange energy is covered. • Semiconductors and their properties include motion of hole-electron pair-carrier transport equation. • Superconductivity: Properties of superconductors with discussion on Meissner effect. London's equations are covered and discussion on superconducting magnets is carried out. Skills gained • In crystallography, knowledge on symmetry operations and classification of lattices gives an understanding to define the structure of a crystal. Competency Developed • Elements of band theory with tight binding approximation is covered and application to simple cubic lattices is discussed. • This helps in solving a real life electron band structure through computation.
PHY 3114	**Nuclear & Particle Physics I**	Knowledge gained • The students gather advanced knowledge in Nuclear physics. The different nuclear interactions and the corresponding nuclear potentials and its dependence on the couplings are learned. The knowledge helps to choose for an Advance course in Nuclear and particle Physics. Skills gained • The course gives an understanding of the nucleus at low energy. Competency Developed • The students develop basics to solve some of the problems of nuclear physics and their limitations in nature.
PHY 3115	**Atomic & Molecular Physics**	Knowledge gained

		• On one-electron atoms: Fine and hyperfine structure, Interactions of one-electron atoms with static external electric field, magnetic field and electromagnetic radiations, Two and many electron atoms: finding the least energy configurations and the corresponding energies. Molecular physics: Diatomic molecules-rotation, vibration and electronic spectra, configuration of diatomic molecules. Lasers and its applications. Skills gained • The students know how to simplify the Dirac Hamiltonian to recover the fine structure of the hydrogen atom. Can calculate the energy spectrum of fine and hyperfine interactions, Zeeman effect and Stark's effect. Can calculate transition rate in one-electron atom. Can obtain the wave functions and energies for the two and many electron atoms, Developed skills in molecular spectra, particularly in diatomic molecules and lasers. Competency Developed • The students can apply the concepts of quantum mechanics in atomic and molecular physics. Competency developed in solving problems on atomic and molecular (diatomic molecules) physics and lasers.
PHY 3316	**Laboratory Course II**	Knowledge gained: • The students gained knowledge in some apparatus and can undertake the measurements of Zeeman effect, Fabry-Perot interferometer, Ultrasonic interferometer, e/m measurement by various methods, low pressure gauge, etc. Skills gained: • Skill developed in assembling various kinds of apparatus, data taking manually as well as using computer interfaced instruments and data analysis. Skill developed to analyze data and optimized errors in a measurement. Competency Developed: • The students are competent enough to assemble/design a setup for a given measurement. They can use personal computers to analyze the data and to prepare their laboratory reports.

SEMESTER—IV

Course Code	Course Name	Course Outcomes
PHY 4117	**Astrophysics & Cosmology**	Knowledge gained: • The knowledge of representation of very large and small distances and their practical units are introduced. The students gain knowledge of the different techniques to measure distance of a star and formulas for measuring distances. It is taught here that the sun is a controlled thermonuclear reactor with a variety of new physics that emerged out of the study of the light and neutron coming out of it. The sun has two faces one that exists for a few days/months and other that exist for millions of years. The use of quantum mechanics, nuclear physics and statistical mechanics are learned by them here.

		• It is shown here that they need Einstein's General theory of Relativity for describing the phenomena of the universe and in the case of neutron stars and Black holes. They also learn how the universe originated in the past (Big Bang theory) and what are the different phases. The experimental tests upon which the cosmological theories are built up. The different cosmological parameters for understanding the observed universe. Skills gained: • The students learn to solve problems to determine the surface temperature of a star in terms of the surface temperature of the sun if the luminosity of the star is determined. • They determine the age of the universe. • Determines the density of an X-ray Pulsar from the knowledge of its time period of rotation. • Many features of the universe which are not understood by STR and Classical Mechanics. • Life history of a star, Galaxy, clusters and superclusters. Competency Developed: • The students develop competency to solve problems in Astrophysics relevant for NET, SET etc. and other examinations. • The students gather information in Astrophysics and cosmology which are new to them and they are eager to know more. But in one paper it is not possible to address all the interesting features unless some Elective papers are introduced.
PHY 4118 **PHY 4119** **PHY 4120**	**Elective- I**	Knowledge gained: Condensed Matter Physics II • A more elaborate view on lattice dynamics leading to plotting a determining phonon dispersion curves • A Detailed discussion of Band theory of solids leading to finding a real life electron band structure. • Quantum theory of Ferromagnetism and its development • The phenomenon of magnetic resonance is discussed leading to understand the principle of instruments based on these principle • Elaborate Discussion on Superconductivity and superconducting magnets Nuclear and Particle Physics II • The students gather advanced knowledge in models of the nucleus at very high energy, the nucleus looks like a solid core (rigid) at the centre. The nuclear force is a mixture of different types of exchange force. The Compound model of the nucleus and its statistical analysis which was experimentally verified thereafter by Indian Scientist S. N. Ghosal is learned in the paper. • The nuclear force is spin dependent and confirmed from the study of scattering of low energy neutrons from ortho and para hydrogen. The inelastic scattering at very high energy which herald the concert of pion production is also learned. • The Briet-Wigner 1-level formula is introduced here to know that unstable particles with some spin and mass exist. Students came to

		know that in the accelerator/ the Laboratory existence of exotic particles are discovered making use of the formula. Skills gained • Detailed discussion of Band theory helps in solving a real life electron band structure through computation • Instruments based on Superconductivity including Josephson tunnelling; AC and DC effects and SQUID gives an understanding of application of the phenomenon Competency Developed • The phenomenon of magnetic resonance is discussed leading to understand the principle of instruments based on these principle • Superconducting instruments involving Josephson tunneling; AC and DC effects and SQUID gives an understanding of application of the phenomenon.
PHY 4121 **PHY 4122** **PHY 4123**	**Elective- II**	Knowledge gained: Condensed Matter Physics III • Crystallography, band structure of semiconductors, dielectric and optical properties insulators, phase transitions and critical phenomena, nanomaterials and liquid crystals. Nuclear and Particle Physics III: • Electromagnetic field quantization; Propagators of scalar, spinor and electromagnetic fields; Quantum Electrodynamics (QED) and interacting fields, examples of some basic interactions; Gauge theories of QED and Quantum Chromodynamics (QCD); Introduction to Quark-gluon Plasma. Electronics III • Knowledge gained in areas like (i) Electronic communication systems, (ii) Microwave communication, (iii) Satellite communication, (iv) Fiber optic communication, (v) Advanced Digital Circuits and (vi) Microprocessors and Microcontrollers. Skills gained: Condensed Matter Physics III • Students gains skills necessary (i) to determine crystal structures of small organic molecules, (ii) to study transport properties in semiconductors including quantum Hall effect, (iii) to study ferroelectric properties, (iv) to study of propagation of em waves in insulators, (v) to study photonic crystals and electro-optic modulators, (vi) to analyze phase transitions, (vii) to characterize nanomaterials and (viii) to understand the physics and technology of liquid crystals. Nuclear and Particle Physics III • The students learn how to deal with the fundamental particles and their interactions in an analytical and quantitative way. Anyone who wants to

		pursue a research career in the field of fundamental particles, should have this basic skill. Electronics III • The students acquire skills to design various electronic circuits like (i) Electronic communication systems, (ii) Microwave communication systems, (iii) Satellite communication systems, (iv) Fiber optic communication systems and (v) Advanced Digital Circuits Competency Developed: Condensed Matter Physics III • Students gain competency in analyzing various properties of different advanced condensed matter systems. Nuclear and Particle Physics III: • A student not only learns the intricacies of the fundamental building blocks of nature, but she/he becomes mathematically competent to deal with complicated problems in almost any area of science and technology. Electronics III • The students acquire skills to design various electronic circuits like (i) Electronic communication systems, (ii) Microwave communication systems, (iii) Satellite communication systems, (iv) Fiber optic communication systems and (v) Advanced Digital Circuits
PHY 4324	**Laboratory Course III**	• The students perform some experiments by using Geiger-Muller counters, Scintillators and Nuclear emulsion. They acquire a hands on experience of handling these particle detectors, collect and analyze data and verify some results that they learn in theory.
PHY 4125	**Comprehensive Course II**	Knowledge gained: • This course allows a student to brush up the knowledge acquired in the previous semester, and develop problem solving skills. Skills gained: • Develop problem solving skills, develop an ability of independent thinking, and learn how to feel comfortable under challenging conditions. Competency Developed: • Assist students in preparing for different state and national level competitive examinations like NET, SET, JEST, GATE etc.
PHY 4226	**Comprehensive Viva-voce II**	• Assist students in preparing for interviews, develop presence of mind as well as communication skills.