B.Sc. (Hons.) Physics

Learning Outcomes

DISCIPLINE SPECIFIC CORE COURSE

SEMESTER -I

DSC-1: MATHEMATICAL PHYSICS I (2222011101)

Learning Objectives

The emphasis of the course is on applications in solving problems of interest to physicists. The course will teach the students to model a physics problem mathematically and then solve those numerically using computational methods. The course will expose the students to fundamental computational physics skills enabling them to solve a wide range of physics problems. The skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

Learning Outcomes

After completing this course, student will be able to,

- Draw and interpret graphs of various elementary functions and their combinations.
- Understand the vector quantities as entities with Cartesian components which satisfy appropriate rules of transformation under rotation of the axes.
- Use index notation to write the product of vectors in compact form easily applicable in computational work.
- Solve first and second order differential equations and apply these to physics problems.
- Understand the functions of more than one variable and concept of partial derivatives.
- Understand the concept of scalar field, vector field, gradient of scalar field and divergence and curl of vector fields.

- Perform line, surface and volume integration and apply Green's, Stokes' and Gauss's theorems to compute these integrals and apply these to physics problems
- Understand the properties of discrete and continuous distribution functions. In the laboratory course, the students will learn to,
- Prepare algorithms and flowcharts for solving a problem.
- Design, code and test simple programs in Python/C++ to solve various problems.
- Perform various operations of 1-d and 2-d arrays.
- Visualize data and functions graphically using Matplotlib/Gnuplot

DSC-2: MECHANICS (2222011102)

Learning Objectives

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. The students will learn the collisions in the centre of mass frame, rotational motion and central forces. They will be able to apply the concepts learnt to several real world problems. In the laboratory part of the course, the students will learn to use various instruments, estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.

Learning Outcomes

Upon completion of this course, students will be able to,

- Learn the Galilean invariance of Newton's laws of motion.
- Understand translational and rotational dynamics of a system of particles.
- Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
- Understand Einstein's postulates of special relativity.

- Apply Lorentz transformations to describe simultaneity, time dilation and length contraction
- Use various instruments for measurements and perform experiments related to rotational dynamics, elastic properties, fluid dynamics, acceleration due to gravity, collisions, etc.
- Use propagation of errors to estimate uncertainty in the outcome of an experiment and perform the statistical analysis of the random errors in the observations.

DSC-3: WAVES AND OSCILLATIONS (2222011103)

Learning Objectives

This course reviews the concepts of waves and oscillations learnt at school from a more advanced perspective and goes on to build new concepts. It begins with explaining ideas of free oscillations and superposition of harmonic motion leading to physics of damped and forced oscillations. The course will also introduce students to coupled oscillators, normal modes of oscillations and free vibrations of stretched strings. Concurrently, in the laboratory component of the course students will perform experiments that expose them to different aspects of real oscillatory systems.

Learning Outcomes

On successful completion of this course, the students will have the skill and knowledge to,

- Understand simple harmonic motion
- Understand superposition of N collinear harmonic oscillations
- Understand superposition of two perpendicular harmonic oscillations
- Understand free, damped and forced oscillations
- Understand coupled oscillators and normal modes of oscillations
- Understand travelling and standing waves, stretched strings

GE: MECHANICS

Learning Objectives

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. The students will learn the collisions in the centre of mass frame, rotational motion and central forces. They will be able to apply the concepts learnt to several real world problems. In the laboratory part of the course, the students will learn to use various instruments, estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.

Learning Outcomes

Upon completion of this course, students will be able to,

- Learn the Galilean invariance of Newton's laws of motion.
- Understand translational and rotational dynamics of a system of particles.
- Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
- Understand Einstein's postulates of special relativity.
- Apply Lorentz transformations to describe simultaneity, time dilation and length contraction
- Use various instruments for measurements and perform experiments related to rotational dynamics, elastic properties, fluid dynamics, acceleration due to gravity, collisions, etc.
- Use propagation of errors to estimate uncertainty in the outcome of an experiment and perform the statistical analysis of the random errors in the observations.

SEMESTER -II

DSC-4: MATHEMATICAL PHYSICS II (2222011201)

LEARNING OBJECTIVES

The emphasis of course is on applications in solving problems of interest to physicists. The course will also expose students to fundamental computational physics skills enabling them to solve a wide range of physics problems. The skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Use curvilinear coordinates to solve problems with spherical and cylindrical symmetries
- Represent a periodic function by a sum of harmonics using Fourier series
- Obtain power series solution of differential equation of second order with variable coefficient using Frobenius method
- Understand the properties and applications of Legendre polynomials
- Learn about gamma and beta functions and their applications
- In the laboratory course, the students will learn to • Apply appropriate numerical method to solve selected physics problems both using user defined and in-built functions from Scilab/ Python
- Solve non-linear equations
- Perform least square fitting of the data taken in physics lab by user defined functions.
- Interpolate a data by polynomial approximations
- Generate and plot a function by its series representation
- Generate and plot Legendre polynomials and verify their properties.

- Numerically integrate a function and solve first order initial value problems numerically.

DSC-5: ELECTRICITY AND MAGNETISM (2222011202)

LEARNING OBJECTIVES

This course reviews the concepts of electromagnetism learnt at school from a more advanced perspective and goes on to build new concepts. The course covers static and dynamic electric and magnetic fields due to continuous charge and current distributions respectively.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Apply Coulomb's law to line, surface, and volume distribution of charges.
- Apply Gauss's law of electrostatics to distribution of charges
- Solve boundary value problems using method of images
- Understand the concept of electric polarization and bound charges in dielectric materials
- Understand and calculate the vector potential and magnetic field of arbitrary current distribution
- Understand the concept of bound currents and magnetic susceptibility in magnetic materials
- Understand the impact of time-varying magnetic and electric fields in order to comprehend the formulation of Maxwell's equations.

DSC-6: ELECTRICAL CIRCUIT ANALYSIS (2222011203)

LEARNING OBJECTIVES

This course covers the basic circuit concepts in a systematic manner which is suitable for analysis and design. It aims at study and analysis of electric circuits using network theorems and two-port parameters.

LEARNING OUTCOMES

At the end of the course the student will be able to,

- Understand the basic concepts, basic laws and methods of analysis of DC and AC networks and their difference
- Solve complex electric circuits using network theorems.
- Discuss resonance in series and parallel circuits and also the importance of initial conditions and their evaluation.
- Evaluate the performance of two port networks.

SEMESTER -III

DSC-7: MATHEMATICAL PHYSICS-II (2222012301)

LEARNING OBJECTIVES

The emphasis of course is on applications in solving problems of interest to physicists. The course will also expose students to fundamental computational physics skills enabling them to solve a wide range of physics problems. The skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Determine continuity, differentiability and analyticity of a complex function, find the derivative of a function and understand the properties of elementary complex functions.
- Work with multi-valued functions (logarithmic, complex power, inverse trigonometric function) and determine branches of these functions.
- Evaluate a contour integral using parameterization, fundamental theorem of calculus and Cauchy's integral formula.
- Find the Taylor series of a function and determine its radius of convergence.
- Determine the Laurent series expansion of a function in different regions, find the residues and use the residue theory to evaluate a contour integral and real integral.
- Understand the properties of Fourier transforms and use these to solve boundary value problems.
- Solve linear partial differential equations of second order with separation of variable method.
- In the laboratory course, the students will learn to,
- create, visualize and use complex numbers
- use Gauss quadrature methods to numerically integrate proper and improper definite integrals
- Solve the boundary value problems numerically
- Compute the fast Fourier transform of a given function

DSC-8: THERMAL PHYSICS (2222012302)

LEARNING OBJECTIVES

This course deals with the relationship between the macroscopic and microscopic properties of physical systems in equilibrium. It reviews the concepts of thermodynamics learnt at school from a more advanced perspective and how to develop them further to build new concepts. The course gives an understanding about the fundamental laws of thermodynamics and their applications to various systems and processes. It also includes a basic idea about the kinetic theory of gases, transport phenomena involved in ideal gases, phase transitions and behavior of real gases. The students will be able to apply these concepts to several problems on heat. The lab course deals with providing the knowledge of the concepts of Thermodynamics studied in the theory paper with the help of experiments and give the students a hands-on experience on the construction and use of specific measurement instruments and experimental apparatuses used in the Thermal Physics lab, including necessary precautions.

LEARNING OUTCOMES

At the end of this course, students will be able to

- Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics.
- Understand the concept of reversibility, irreversibility and entropy.
- Understand various thermodynamic potentials and their physical significance with respect to different thermodynamic systems and processes.
- Deduce Maxwell‟s Thermodynamical relations and use them for solving various problems in Thermodynamics.
- Understand the concept and behaviour of ideal and real gases.
- Apply the basic concept of kinetic theory of gases in deriving Maxwell-Boltzman distribution law and its applications.
- Understand mean free path and molecular collisions in viscosity, thermal conductivity, diffusion and Brownian motion.
- While doing the practical, the students will have an opportunity to understand and hence use the specific apparatus required to study various concepts of thermodynamics. Hence, the student will be able to comprehend the errors they can encounter while performing the experiment and how to estimate them.

DSC 9: LIGHT AND MATTER (2222012302)

LEARNING OBJECTIVES

The objective of this course reviews the concepts of light and matter, their properties and their dual nature. This course provides an in depth understanding of dual nature of light, interference and diffraction with emphasis on practical applications of both.

LEARNING OUTCOMES

On successfully completing the requirement of this course the student will have the skill and knowledge to,

- Appreciate the dual nature of light which is part of EM spectrum and the dual nature of matter simultaneously.
- Understand the phenomena of interference and diffraction exhibited by light and matter, their nuances and details.
- Delve in to the depth of understanding wave optics with its various kinds of interference and diffraction exhibited by light.
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from aperture, understand Fraunhoffer and Fresnel Diffraction.
- Learn about the application of matter waves in latest technological developments of electron microscope e.g. SEM and TEM used widely for characterization in several fields of physics such as material science, nanotechnology etc.
- In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment. Wavelength of light sources, resolving power and dispersive power of optical equipment can be learnt first-hand.

SEMESTER -IV

DSC 10: MODERN PHYSICS (2222012401)

LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck' s law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation and its applications to step potential and rectangular potential problems. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. This paper covers the in depth knowledge of lasers, its principle and working. It also introduces concepts of nuclear physics and accelerators.

LEARNING OUTCOMES

After getting exposure to this course, the following topics would be learnt.

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering.
- The Schrodinger equation in 1-dimension, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values. Commutator of position and momentum operators.
- Time independent Schrodinger equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels. Reflection and transmission across a step and rectangular potential barrier.
- Modification in Bohr's quantum model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.

- Lasers and their working principle, spontaneous and stimulated emissions and absorption, Einstein's A and B coefficients, Metastable states, components of a laser and lasing action in ruby and He-Ne lasers and free electron laser.
- Basic properties of nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory.
- Types of Accelerators, Van-de Graff generator linear accelerator, cyclotron, synchrotron

DSC 11: SOLID STATE PHYSICS (2222012402)

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon the arrangement of its atomic and molecular constituents. The gained knowledge helps to solve problems in solid state physics using relevant mathematical tools. It also communicates the importance of solid state physics in modern society.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, crystals and symmetry operations
- Understand elementary lattice dynamics and its influence on the properties of materials
- Describe the origin of energy bands, and their influence on electronic behaviour
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids
- Explain the origin of the dielectric properties exhibited by solids and the concept of
- polarizability
- Understand the basics of superconductivity

- In the laboratory students will carry out experiments based on the theory that they have earned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop.
- They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor

DSC 12: ANALOG ELECTRONICS (2222012403)

Learning Objectives

This course introduces the concept of semiconductor devices and their analog applications. It also emphasizes on understanding of amplifiers, oscillators, operational amplifier and their applications.

Learning Outcomes

At the end of this course, the following concepts will be learnt.

- To learn about diodes and its uses in rectification
- To gain an insight into working principle of photodiodes, solar cells, LED and zener diode as voltage regulator
- To gain an understanding of construction and working principle of bipolar junction transistors (BJTs), characteristics of different configurations, biasing and analysis of transistor amplifier
- To be able to design and understand use of different types of oscillators
- To learn the fundamentals of operation amplifiers and understand their operations to compare, add, or subtract two or more signals and to differentiate or integrate signals etc.
- In the laboratory course, the students will be able to study characteristics of various diodes and BJT. They will be able to design amplifiers, and oscillators. Also different applications using Op-Amp will be designed.

SEMESTER -V

Quantum Mechanics and Applications (32221501)

Learning Objectives

After learning the elements of modern physics, in this course students would be exposed to more advanced concepts in quantum physics and their applications to problems of the sub atomic world.

Learning Outcomes

The students will be able to learn the following from this course:

Methods to solve time-dependent and time-independent Schrodinger equation.

- Quantum mechanics of simple harmonic oscillator.
- Non-relativistic hydrogen atom: spectrum and eigenfunctions.
- Angular momentum: Orbital angular momentum and spin angular momentum.
- Bosons and fermions - symmetric and anti-symmetric wave functions.
- Application to atomic systems
- In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical 1D &3D potentials.

Solid State Physics (32221502)

Learning Objectives

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. The gained knowledge helps to solve problems in solid state physics using relevant mathematical tools. It also communicates the importance of solid state physics in modern society.

Learning Outcomes

On successful completion of the module students should be able to

- Elucidate the concept of lattice, crystals and symmetry operations.
- Understand the elementary lattice dynamics and its influence on the properties of materials.
- Describe the main features of the physics of electrons in solids: origin of energy bands, and their influence electronic behaviour.
- Explain the origin of dia, para, and ferro-magnetic properties of solids.
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability.
- Understand the basics of phase transitions and the preliminary concept and experiments related to superconductivity in solid.
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

DSE-Advanced Mathematical Physics (32227502)

Learning Objectives

The course is intended to impart the concept of generalized mathematical constructs in terms of Algebraic Structures (mainly Vector Spaces) and Tensors to have in-depth analysis of our physical system.

Learning Outcomes

At the end of this course, students will be able to

- Understand algebraic structures in n-dimension and basic properties of the linear vector spaces.
- Represent Linear Transformations as matrices and understand basic properties of matrices.
- Apply vector spaces and matrices in the quantum world.
- Learn basic properties of Cartesian and general tensors with physical examples such as moment of inertia tensor, energy momentum tensor, stress tensor, strain tensor etc.
- Learn how to express the mathematical equations for the Laws of Physics in their covariant forms.
- In the laboratory course, the students are expected to solve the problems using the Scilab/C++/Python computer language: Eigenvalues and Eigenvectors of given matrix, determination of wave functions for stationary states as eigenfunctions, eigen energy values of Hermitian differential operators, Lagrangian formulation in classical dynamics etc.

DSE-Nuclear and Particle Physics (32227504)

Learning Objectives

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem based skills to be able to understand the basic properties of nuclei as well as knowledge of experimental determination of the same, the concept of binding energy, its various dependent parameters, N-Z curves and their significance

Learning Outcomes

- To appreciate the formulations and contrasts between different nuclear models such as Liquid drop model, Fermi gas model and Shell Model and evidences in support.
- Knowledge of radioactivity and decay laws. A detailed analysis, comparison and energy kinematics of alpha, beta and gamma decays.
- Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.
- To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter. Through the section on accelerators students will acquire knowledge about Accelerator facilities in India along with a comparative study of a range of detectors and accelerators which are building blocks of modern day science.
- It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub- atomic particles with the different conservation laws, concept of quark model.
- The acquired knowledge can be applied in the areas of nuclear medicine, medical physics, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

SEMESTER -VI

Electromagnetic Theory (32221601)

Learning Objectives

This core course develops further the concepts learnt in the electricity and magnetism course to understand the properties of electromagnetic waves in vacuum and different media.

Learning Outcomes

At the end of this course the student will be able to:

- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
- Understand electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma.
- Understand electromagnetic wave propagation in bounded media: reflection and transmission coefficients at plane interface in bounded media.
- Understand polarization of Electromagnetic Waves: Linear, Circular and Elliptical Polarization. Production as well as detection of waves in laboratory.
- Learn the features of planar optical wave guide.

Statistical Mechanics (32221602)

Learning Objectives

Statistical Mechanics deals with the derivation of the macroscopic parameters (internal energy, pressure, specific heat etc.) of a physical system consisting of large number of particles (solid, liquid or gas) from knowledge of the underlying microscopic behavior of atoms and molecules that comprises it. The main objective of this course work is to introduce the techniques of Statistical Mechanics which has applications in various fields including Astrophysics, Semiconductors, Plasma Physics, Bio-Physics etc. and in many other directions.

Learning Outcomes

By the end of the course, students will be able to:

- Understand the concepts of microstate, macrostate, phase space, thermodynamic probability and partition function.
- Understand the use of Thermodynamic probability and Partition function forcalculation of thermodynamic variables for physical system (Ideal gas, finite level system).

- Difference between the classical and quantumstatistics
- Understand the properties and Laws associated with thermal radiation.
- Apply the Fermi- Dirac distribution to model problems such as electrons in solids and white dwarf stars
- Apply the Bose-Einstein distribution to model problems such as blackbody radiation and Helium gas.
- In the laboratory course, with the exposure in computer programming and computational techniques, the student will be in a position to perform numerical simulations for solving the problems based on Statistical Mechanics.

DSE-Classical Dynamics (32227626)

Learning Objectives

This course on classical dynamics trains the student in problem solving ability and develops understanding of physical problems. The emphasis of this course is to enhance the understanding of Classical Mechanics (Lagrangian and Hamiltonian Approach).

Learning Outcomes

At the end of this course, students will be able to:

- Understand the physical principle behind the derivation of Lagrange and Hamilton equations, and the advantages of these formulations.
- Understand small amplitude oscillations.
- Understand the intricacies of motion of particle in central force field. Critical thinking and problem-solving skills
- Recapitulate and learn the special theory of relativity extending to Four – vectors.
- Learn the basics of fluid dynamics, streamline and turbulent flow, Reynolds's number, coefficient of viscosity and Poiseuille's equation.

DSE-Communication System (32227613)

Learning Objectives

This paper aims to describe the concepts of electronics in communication and communication techniques based on Analog Modulation, Analog and digital Pulse Modulation. Communication and Navigation systems such as GPS and mobile telephony system are also introduced. This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

Learning Outcomes

At the end of this course, students will be able to

- Understand of fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- Gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- Gain an in-depth understanding of different concepts used in a satellite communication system.
- Study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- Understand evolution of mobile communication generations 2G, 3G, and 4G with their characteristics and limitations.
- In the laboratory course, students will apply the theoretical concepts to gain hands on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.