Department of Physics

Course Name: Core Course - 01
Course Code: PHSACOR01T & PHSACOR01P
Topic Name: Mathematical Physics - I

Course Outcome: Upon successful completion of this course

- students will gain a better understanding of calculus of a real variable and subsequently the calculus of more than one variable.
- students will learn to solve first order differential equations.
- students will learn vector calculus and related fundamental theorems.

In the practical component

- Python language is introduced to the students.
- students will learn to write basic python codes and to draw simple graphs using Qtiplot.
- students will learn the implement logical and loop structure in programming.
- students will learn how to define functions in python.
- students will learn to solve algebraic and transcendental equations by bisection and Newton - Raphson method.
- students will learn to handle quadratic equations with complex roots.

Course Name: Core Course - 02
Course Code: PHSACOR02T & PHSACOR02P
Topic Name: Mechanics

Course Outcome: Upon successful completion of this course

- students will learn about gravitation and its impact on the dynamic universe.
- students will understand about elastic properties of matter and its applications by measuring different elastic moduli.
- students will learn about fluid motion, oscillations etc.
- students will acquire basic knowledge about special theory of relativity.
- students will understand different techniques like (i) flexure method (ii) Searle's method (iii) Poiseuille's method etc. to measure Young's modulus, viscosity.
- students will learn how to handle different apparatus like (i) torsional Pendulum (ii) sextant (iii) bar pendulum (iv) Kater's pendulum.
- students will know how to make systematic experimental observation, data collection, recording of data and other basic laboratory practices in this course.
- students will know the technique to plot graphs and determine the different parameters from the graph.
- students will be able to estimate errors in experimental data.

Course Name: Core Course - 03
Course Code: PHSACOR03T & PHSACOR03P
Topic Name: Electricity & Magnetism

Course Outcome: Upon successful completion of this course

- students will learn how to find the electric and magnetic field under certain special conditions.
- students will have an understanding of electrostatic potential and vector potential being important mathematical construct in computing corresponding fields.
- students will learn electromagnetic induction along with the theory of simple electrical circuits.
- students will be able to know about various electrical components, power supply, multimeter and various other measuring instruments like (I) potentiometer (ii) Carey Foster's Bridge (iii) Anderson's bridge (iv) galvanometer etc.
- students will be able to perform experiments on various topics of electricity and magnetism associated with the course.
- students will know about precautions to be taken during performing an experiment and will be able to identify different sources of error.

Course Name: Core Course - 04
Course Code: PHSACOR04T & PHSACOR04P
Topic Name: Waves & Optics

Course Outcome: Upon successful completion of this course

- students will understand the fundamental principles of wave motion.
- students will be able to understand Huygen's wave theory.
- students will be able to understand various optical phenomena, for example interference, diffraction etc.
- students will be able to analyze and solve problems involving wave propagation.
- students will know about different instruments/parts like (i) spectrometer (ii) prism (iii) sodium source, mercury vapour lamp (iv) diffraction grating (v) wedge-shaped film etc.
- students will be able to determine the frequency of an electric tuning fork by Melde's experiment.
- students will understand about different experimental set up like (i) Fresnel biprism (ii) Newton's rings (iii) Michelson's interferometer etc.

Course Name: Core Course - 05
Course Code: PHSACOR05T & PHSACOR05P
Topic Name: Mathematical Physics - II

Course Outcome: Upon successful completion of this course

- students will learn the expansion of a function in Fourier series.
- students will learn a special class of second order differential equation yielding special functions.
- students will learn calculus of variation and subsequently classical mechanics.
- students will get a first exposure to some physically important partial differential equations using separation of variables.

In the practical component (implemented in python language)

- students will learn how to use numpy to simplify program code.
- students will learn matplotlib, a very useful module to draw graphs and plots in two and three dimensions.
- students will learn certain sorting algorithm and how to calculate different statistic out of a data set.
- students will learn numerical method for interpolation, differentiation and integration and the solution of first order differential equation using Euler method.

Course Name: Core Course - 06
Course Code: PHSACOR06T & PHSACOR06P
Topic Name: Thermal Physics

Course Outcome: Upon successful completion of this course

- students will understand the fundamental principles of thermodynamics and laws of thermodynamics.
- students will understand the concepts of entropy, various thermodynamic potentials and their applications in various systems.
- students will be able to understand the microscopic behavior of the systems to explain pressure, transport phenomena, viscosity, diffusion etc.
- students will get the idea of measuring various physical parameters related to the thermal properties of matter.
- students will be able to verify Stefan's law.
- students will learn to determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
- students will be able to determine the temperature coefficient of resistance by platinum resistance thermometer using constant current source.

Course Name: Core Course - 07
Course Code: PHSACOR07T & PHSACOR07P
Topic Name: Digital Systems & Applications

Course Outcome: Upon successful completion of this course

- students will learn the use CRO and basic measuring instruments.
- students will understand the electronic components and IC types.
- students will be able to convert and work with number systems.
- students will learn how to apply Boolean algebra to logic circuits.
- students will learn how to build basic arithmetic circuits (adders/subtractors).
- students will understand multiplexers, decoders, and encoders.
- students will be able to analyse flip-flops and sequential circuits.
- students will learn the use of IC 555 in timer applications.
- students will understand and use shift registers.
- students will be able to design and analyse basic counters.
- students will learn the basics of computer memory and I/O.

Course Name: Core Course - 08
Course Code: PHSACOR08T & PHSACOR08P
Topic Name: Mathematical Physics - III

Course Outcome: Upon successful completion of this course

- students will learn the theory of functions of a single complex variable. This approach turns out to be of importance in studying advanced subjects like quantum field theory, two-dimensional conformal field theory etc.
- students will learn one type of integral transform, viz., the Fourier transform which is essential to study quantum mechanics. It is used to determine Green function of some differential operators having profound physical significance, viz., Laplacian etc.
- students will learn to tackle boundary value problems occurring in electrostatic, wave mechanics, theory of heat conduction etc.
- students will have a clear understanding of how to deal with various matrices representing abstract linear operators.

In the practical component (implemented in python language)

- students will learn matrix manipulation viz. diagonalization, triangulation, computation of determinant, inverse etc. by elementary row operations.
- students will learn different numerical techniques, viz., Gauss elimination method, Gauss-Jordan method and Gauss-Seidal iterative method for approximate solutions of a system of linear equations.
- students will learn to solve heat equation, Laplace equation, Poisson equation and wave equation as boundary value problems by discretizing derivatives.

Course Name: Core Course - 09
Course Code: PHSACOR09T & PHSACOR09P
Topic Name: Elements of Modern Physics

Course Outcome: Upon successful completion of this course

- students will get the idea of relativistic dynamics and its mathematical formulation through 4-vectors and their applications.
- students will know how the quantum theory emerged. They will get the essence how ultraviolet catastrophe was elegantly removed by the famous hypothesis of Planck, the wave - particle duality, an inherent nature of atomic and sub-atomic particles.
- students will have idea of LASER and its applications.
- students will also be able to get the basic knowledge in nuclear and particle physics. This is important to understand the fundamental forces existing in nature and also the properties of atomic nucleus and the existing particles in the universe.
- students will learn about nuclear structure and various models.
- students will learn about the nuclear radiation and nuclear reaction and reactors.
- students will be acquainted with different instruments like (i) spectrometer, (ii) photo detector etc.
- students will understand about different experimental set up like (i) Millikan oil drop apparatus, (ii) how to measure wavelength of LASER source using diffraction of single slit etc.

Course Name: Core Course - 10
Course Code: PHSACOR10T & PHSACOR10P
Topic Name: Analog Systems & Applications

Course Outcome: Upon successful completion of this course

- students will understand basics of electronics and semiconductors.
- they will learn diode types and their applications (rectifiers, LEDs, etc.).
- students will analyse BJT and FET characteristics and operations.
- students will study transistor amplifiers and their parameters.
- students will be able to understand multistage and feedback amplifiers.
- students will learn about oscillators and their working principles.
- students will use Op-Amps and their linear/non-linear applications.
- students will understand A/D conversion techniques.

Course Name: Core Course - 11
Course Code: PHSACOR11T & PHSACOR11P
Topic Name: Quantum Mechanics & Applications

Course Outcome: Upon successful completion of this course

- students will get acquainted with the axiomatic structure of quantum mechanics.
- students will learn how to compute discrete energy levels for certain quantum mechanical systems admitting bound state solutions and the associated normalized eigenfunctions.
- students will learn how to compute the reflection and transmission coefficients in the theory of scattering by certain potentials. As an important application of this, they learn the quantum origin of radioactive disintegration.
- students will learn how to tackle systems in higher (two and three) dimensions with the introduction of angular momentum operator and thereby study the exact solution of hydrogen atom problem.
- students will learn how to apply the quantum theory to atomic and molecular physics, nano-physics etc. to predict the behaviour of a wide variety of systems.

In the practical component (implemented in python language)

- students will learn to solve graphically transcendental equations while determining the bound state energy levels of a finite potential well.
- students will learn a numerical technique to discretize derivatives and thereby solve Schroedinger equation (which is a differential equation) after converting it to a system of algebraic equations. This is known as finite difference method.
- students will learn another popular numerical technique to solve Schroedinger equation in an iterative way, known as the ‘shooting method’.
- students will learn how to numerically estimate the energy levels and the s-wave solution of the hydrogen atom.
- students will learn how to numerically estimate the ground state of the Yukawa potential, an harmonic oscillator and the Morse potential (used to model the vibrational modes of a diatomic molecule).

Course Name: Core Course - 12
Course Code: PHSACOR12T & PHSACOR12P
Topic Name: - Solid State Physics

Course Outcome: Upon successful completion of this course

- students will understand crystal structures and X-ray diffraction.
- they will study lattice vibrations and phonon concepts.
- students will learn magnetic properties and their quantum theories.
- students will understand dielectric behaviour and related equations.
- students will be able to explore ferroelectric, piezoelectric, and pyroelectric effects.
- students will be able to apply Drude's theory to electron transport in metals.
- students will be able to understand band theory and properties of semiconductors.
- students will learn the basic concepts and types of superconductors.

Course Name: Core Course - 13
Course Code: PHSACOR13T & PHSACOR13P
Topic Name: Electromagnetic Theory

Course Outcome: Upon successful completion of this course

- students will learn about Maxwell's equations, gauge transformations, Poynting theorem, momentum density & field energy density.
- Students will understand about the electromagnetic wave propagation in bounded & unbounded media.
- students will learn about the polarization of electromagnetic waves.
- students will know about wave guides & optical fibers - concepts and applications.
- students will understand about optical communication and wave propagation along with transmission theory.
- students will be able to verify the law of Malus for plane polarized light.
- students will understand about different experimental set up like (i) polarimeter, (ii) Babinet's compensator (iii) dipole antenna etc.

Course Name: Core Course - 14
Course Code: PHSACOR14T & PHSACOR14P
Topic Name: Statistical Mechanics

Course Outcome: Upon successful completion of this course

- students will be able to understand statistical properties of matter and connections with thermodynamics.

- students will understand the behaviour of a thermodynamic system in the quantum regime occurring at low temperature and high density.

- students will understand the fundamental principles of statistical mechanics, viz., microstates, macrostates and the concept of entropy.

- students will have the knowledge of two different statistics found in 3+1 dimensions, viz., Fermi-Dirac & Bose-Einstein statistics and Maxwell-Boltzmann distribution as their classical limit.

In the practical component (implemented in Python language)

- students will learn how to compute the partition function and the grand partition function for a thermodynamic system. Computation of them is central in all of statistical mechanics.
- students will learn how to generate the plot showing the temperature variation of specific heat predicted by different models.

Course Name: Discipline Specific Elective - 1
Course Code: PHSADSE01T & PHSADSE01P
Topic Name: Advanced Mathematical Physics-I

Course Outcome: Upon successful completion of this course

- students will have their first exposure to abstract algebra in the form of linear vector space, the knowledge of which is essential to learn quantum mechanics.
- students will learn a very useful integral transform, viz. The Laplace transform needed to solve a wider class of partial differential equations.
- students will learn the basics of tensor formulation and its omnipresence in physical theories.

In the practical component (implemented in python language)

- students will learn how to estimate quantum mechanical ground state of a quartic potential, the corresponding Schrodinger equation of which is not amenable to exact treatment, with the help of a numerical method, viz., the variational principle.
- students will learn how to graphically estimate energy levels by numerically operating the Hamiltonian on its stationary states.
- students will learn how to draw phase space trajectories
- students will have an understanding of special functions as the eigenfunctions of a class of Hermitian operators known as the Sturm-Liouville operators.

Course Name: Discipline Specific Elective - 2
Course Code: PHSADSE02T
Topic Name: Advanced Dynamics

Course Outcome: Upon the completion of course

- students will learn Lagrangian and Hamiltonian dynamics together with the idea idea of canonical transformation.
- students will learn rigid body mechanics, moment & product of inertia and Euler equation.
- students will learn small oscillations and normal modes.
- students will have a fair idea about dynamical system.
- students will learn fluid dynamics, Euler equation and Navier-Stokes equation etc.

Course Name: Discipline Specific Elective-3
Course Code: PHSADSE03T
Topic Name: Nuclear & Particle Physics

Course Outcome: Upon the completion of course

- students will understand the fundamentals of nuclear physics : (i) Nuclear structure and properties (viz., binding energy, spin, parity etc.) (ii) Nuclear reactions.
- students will understand fundamental of particle physics: (i) Elementary particles and their interactions.
- students will learn about the Nuclear models viz., liquid drop model, Fermi gas model, shell model).
- students will learn about Particle Accelerators viz., linear accelerator, cyclotron, synchrotrons).
- students will learn how to apply nuclear and particle physics to the sustainable development of nation.

Course Name: Discipline Specific Elective - 4
Course Code: PHSADSE04T
Topic Name: Advanced Mathematical Physics-II

Course Outcome: Upon successful completion of this course

- students will learn group theory, a major stepping stone to learn recent developments in theoretical physics.
- students will understand the systematic classification of partial differential equations governing the physical world.
- students will learn a fair amount of basic probability concept required for physics and other interdisciplinary subjects.

Course Name: Discipline Specific Elective - 5
Course Code: PHSADSE05T
Topic Name: Astronomy & Astrophysics

Course Outcome: Upon successful completion of this course

- students will have their exposure to astronomical scales.
- students will understand the astronomical techniques.
- students will learn about the milky way, galaxies, large scale structure and expanding universe.

Course Name: Discipline Specific Elective - 6
Course Code: PHSADSE06T & PHSADSE06P
Topic Name: Communication Electronics

Course Outcome: Upon successful completion of this course

- students will understand communication systems and modulation need.
- they will learn analog modulation (AM, FM, PM) and demodulation.
- students will study pulse modulation techniques (PAM, PWM, PPM).
- students will understand digital modulation (PCM, ASK, FSK, PSK, BPSK).
- students will learn the basics of satellite communication systems.
- students will be able to understand mobile telephony and network concepts (GSM, CDMA, 2G–4G).
- students will be able to grasp the GPS and navigation system basics.

Course Name: Generic Elective Papers
Course Code: PHSHGEC01T & PHSHGEC01P
Topic Name: Mechanics

Course Outcome: Upon successful completion of this course

- students will learn vector operations, basic laws of mechanics i.e., Newton's laws of mechanics, rotational motion, related differential equations to solve these problems together with the conservation principles regarding momentum and energy.
- students will learn the law of gravitation for earth, sun and other terrestrial bodies.
- students will learn the theory of oscillations and its classifications.
- students will learn the concept of frame of reference and constancy of the speed of light in vacuum in the context of special theory of relativity.

In the practical component

- students will learn how to handle of slide calipers and screw gauge to measure length of a bar or cylinder, diameter of a wire etc.
- students will learn how to handle stop watch to measure time period, travelling microscope while calculating Young's modulus etc.
- students will be able to determine the moment of inertia of a regular body with the help of another auxiliary body and a cradle suspended by a metallic wire.
- students will learn how to determine the modulus of rigidity of a wire by a torsional pendulum.

Course Name: Generic Elective Papers
Course Code: PHSHGEC02T & PHSHGEC02P
Topic Name: Electricity & Magnetism

Course Outcome: Upon successful completion of this course

- students will learn basic vector calculus, understand the electrostatic field, electric flux, Gauss's law and its applications in electrostatics, electric potential due to an electric dipole, capacitance of conductors with different geometry, concept of polarization etc.

- students will understand the Biot-Savart's law, its applications, Ampere's circuital law, magnetic properties of materials etc.
- students will understand Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, energy stored in magnetic field etc.
- students will understand theorems by Thevenin and Norton, theorems related to maximum power transfer and superposition together with the basics of Anderson's bridge.
- students will learn Maxwell's equations, concept of Poynting vector, electromagnetic wave propagation through vacuum, its transverse nature, polarization etc.

In the practical component

- students will learn how to measure the resistance, capacitance, current and voltages by using a multimeter, to set up series and parallel connections of ammeter and voltmeter to measure currents and voltages.
- students will learn how to determine an unknown low resistance using Carey Foster's bridge.
- students will be able to verify the Thevenin, Norton, superposition and maximum power transfer theorems.
- students will learn how to study the characteristics of a series RC circuit.
- students will learn how to draw the response curve of a series LCR circuit and determine its resonant frequency, impedance at resonance, quality factor Q and band width.

Course Name: Generic Elective Papers
Course Code: PHSHGEC03T & PHSHGEC03P
Topic Name: Thermal Physics & Statistical Mechanics

Course Outcome: Upon successful completion of this course

- students will learn about different thermodynamical processes, the application of first and second law of thermodynamics, entropy of a system, Carnot cycle.
- students will learn the Maxwell's formula of speed distribution and its application to find out the average, r.m.s. and most probable speed of gas molecules, various transport phenomena like viscosity, conduction and diffusion.
- students will learn Planck's law for black body radiation, Wien's distribution and displacement law, Rayleigh- Jeans law, Stefan-Boltzmann law etc.
- students will have a basic understanding of statistical mechanics: phase space, macro state & micro state, statistical entropy and thermodynamic probability. Moreover they will learn basics of Fermi-Dirac & Bose-Einstein statistics.

In the practical component

- students will use travelling microscope to determine the width of a disc to measure the coefficient of thermal conductivity.
- students will be able to verify Stefan's law by using a torch bulb.
- students will be able to determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method. In this experiment, they will study Newton's law of cooling.
- students will be able to observe the variation of thermo-emf produced in a thermocouple having difference of temperature at its two junctions.

Course Name: Generic Elective Papers
Course Code: PHSHGEC04T & PHSHGEC04P
Topic Name: Waves & Optics

Course Outcome: Upon successful completion of this course

- students will understand the superposition of two harmonic oscillations, Lissajous figures and their uses, transverse waves on a string.
- students will know certain important properties of fluid like surface tension and viscosity.
- students will learn sound waves and their Fourier analysis.
- students will learn about the wave nature of light, its properties like interference, diffraction and polarization.

In the practical component

- students will learn the basics of Michelson's interferometer to determine the wavelength of sodium source.
- students will understand the basics of spectrometer and microscope and how to apply them for optical measurement.
- students will know how to accomplish Schuster's focusing for the measurement of the angle of prism.
- students will understand how to determine the dispersive power and resolving power of a plane diffraction grating.
- students will be able to determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 - T law.
- students will be able to see the formation of Newton's rings.

Course Name: Skill Enhancement Course - 1
Course Code: PHSSSEC01M
Topic Name: Basic Instrumentation Skills

Course Outcome: Upon successful completion of this course

- students will get hands-on skill in different instruments.
- students will understand the basics of cathode ray oscilloscope (CRO), construction of CRT, electron gun, electrostatic focusing and acceleration, screen phosphor, visual persistence & chemical composition, time base operation, synchronization etc.
- students will be able to use CRO for the measurement of voltage (dc & ac), frequency, time period, special features of dual trace, digital oscilloscope, probes etc.
- students will learn the principle and working of digital meters, comparison of analog and digital instruments, working principles of digital voltmeter.
- students will be able to use this knowledge in their future careers.

Course Name: Skill Enhancement Course - 2
Course Code: PHSSSEC02M
Topic Name: Computational Physics

Course Outcome: Upon successful completion of this course

- students will understand applications of some fundamental Linux commands.
- students will be acclimatized to LaTeX word processor, its basics, document class, how to prepare an input file, compile LaTeX file, use LaTeX tags to create different environments, define LaTeX commands, change the type style, equation representation: (formulae and equations), draw figures, generate table of contents, bibliography and citation, use different fonts, colors etc.
- students will learn graphical analysis and its limitations, importance of visualization of computational data, basic GNU plot commands: simple plots, plotting data from a file, saving and exporting etc.
- students will understand basic of FORTRAN 90/95 or C++ programming.