DEPARTMENT OF PHYSICS, KARANJIA AUTONOMOUS COLLEGE

CORE-I: Mathematical Physics-1 (2019-20)

Course Objective

The emphasis of course is to equip students with the mathematical and critical skills required 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.

Course Learning Outcomes

After completing this course, student will be able to

- Draw and interpret graphs of various functions.
- Solve first and second order differential equations and apply these to physics problems.
- Understand the concept of 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.
- Apply curvilinear coordinates to problems with spherical and cylindrical symmetries.

- In the laboratory course, the students will be able to design code and test simple programs in C++ in the process of solving various problems. The aim of this Lab is not just to teach computer programming but toemphasize its role in solving problems in Physics.
- The course will consist of practical sessions and lectures on the related theoretical aspects of the Laboratory. The recommended group size is not more than 16 students.
- Evaluation to be done not only on the programming but also on the basis of formulating the problem.
- Aim at teaching students to construct the computational problem to be solved.
- Students can use any one operating system: Linux or Microsoft Windows.

At least 12 programs must be attempted from the following covering the entire syllabus.

- The list of programs here is only suggestive. Students should be encouraged to do more practice. Emphasis should be given to assess student's ability to formulate a physics problem as mathematical one and solve by computational methods.

CORE-II: Mechanics

Course Objective

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. Students will also appreciate the Collisions in CM Frame, Gravitation, Rotational Motion and Oscillations. The students will be able to apply the concepts learnt to several real world problems.

Course Learning Outcomes

Upon completion of this course, students are expected to

- Understand laws of motion and their application to various dynamical situations.
- Learn the concept of inertial reference frames and Galilean transformations. Also, the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- 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 concept of Geosynchronous orbits
- Explain the phenomenon of simple harmonic motion.
- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.
- In the laboratory course, the student shall perform experiments related to mechanics: compound pendulum, rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity), fluid dynamics, estimation of random errors in the observations etc.

CORE-III: Electricity and Magnetism

Course Objective

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, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. The students will be able to apply the concepts learnt to several real world problems.

Course Learning Outcomes

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

- Demonstrate the application of Coulomb's law for the electric field, and also apply it to systems of point charges as well as line, surface, and volume distributions of charges.
- Demonstrate an understanding of the relation between electric field and potential, exploit the potential to solve a variety of problems, and relate it to the potential energy of a charge distribution.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)
- Understand the concepts of induction and self-induction, to solve problems using Faraday's and Lenz's laws.
- Understand the basics of electrical circuits and analyze circuits using Network Theorems.
- In the laboratory course the student will get an opportunity to verify network theorems and study different circuits such as RC circuit, LCR circuit. Also, different methods to measure low and high resistance, capacitance, self-inductance, mutual inductance, strength of a magnetic field and its variation in space will be learnt.

CORE-IV: Waves and Optics

- **Course Objective**

- This course reviews the concepts of waves and optics learnt at school from a more advancedperspective and goes on to build new concepts. It begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. The course also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

Course Learning Outcomes

On successfully completing the requirements of this course, the students will have the skilland knowledge to:

- Understand Simple harmonic oscillation and superposition principle.
- Understand different types of waves and their velocities: Plane, Spherical, Transverse, and Longitudinal.
- Understand Concept of normal modes in transverse and longitudinal waves: their frequencies and configurations.
- Understand Interference as superposition of waves from coherent sources derived from same parent source.
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from aperture, understand Fraunhoffer and Fresnel Diffraction.
- 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, Fresnel Biprism etc. Resolving power of optical equipment can be learnt first-hand. The motion of coupled oscillators, study of Lissajous figures and behavior of transverse, longitudinal waves can be learnt in this laboratory course.

CORE-V: Mathematical Physics-II

Course Objective

The emphasis of course is to equip students with the mathematical tools required in solving problems interest to physicists and expose them to fundamental computational physics skills thus enabling them to solve a wide range of physics problems. This course will aim at introducing the concepts of Fourier series, special functions, linear partial differential equations by separation of variable method.

Course Learning Outcomes

On successfully completing this course, the students will be able to

- Represent a periodic function by a sum of harmonics using Fourier series and their applications in physical problems such as vibrating strings etc.
- Obtain power series solution of differential equation of second order with variable coefficient using Frobenius method.
- Understand properties and applications of special functions like Legendre polynomials, Bessel functions and their differential equations and apply these to various physical problems such as in quantum mechanics.
- Learn about gamma and beta functions and their applications.
- Solve linear partial differential equations of second order with separation of variable method.
- In the laboratory course, the students will learn the basics of the Scilab software/Python interpreter and apply appropriate numerical method to solve selected physics problems both using user defined and inbuilt functions from Scilab/Python. They will also learn to generate and plot Legendre polynomials and Bessel functions and verify their recurrence relation.

CORE-VI: Thermal Physics

- **Course Objective**

- This course deals with the relationship between the macroscopic properties of physical systems in equilibrium. It reviews the concepts of thermodynamics learnt at school from a more advanced perspective and develops them further. The primary goal is to understand the fundamental laws of thermodynamics and their applications to various systems and processes. In addition, it will also give exposure to students about the Kinetic theory of gases, transport phenomena involved in ideal gases, phase transitions and behavior of real gases.

Course Learning Outcomes

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

- Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics.
- Understand the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations.
- Know about reversible and Irreversible processes.
- Learn about Maxwell's relations and use them for solving many problems in Thermodynamics
- Understand the concept and behavior of ideal and real gases.
- Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzmann distribution law, equitation of energies, and mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
- In the laboratory course, the students are expected to do some basic experiments in thermal Physics, viz., determination of Mechanical Equivalent of Heat (J), coefficientof thermal conductivity of good and bad conductor, temperature coefficient of resistance, variation of thermo-emf of a thermocouple with temperature difference at its two junctions and calibration of a thermocouple.

CC-X: Digital Systems and Applications

Course Objective

This is one of the core papers in physics curriculum which introduces the concept of Boolean algebra and the basic digital electronics. In this course, students will be able to understand the working principle of CRO, Data processing circuits, Arithmetic Circuits, sequential circuits like registers, counters etc. based on flip flops. In addition, students will get an overview of microprocessor architecture and programming.

Course Learning Outcomes

This course lays the foundation for understanding the digital logic circuits and their use in combinational and sequential logic circuit design. It also imparts information about the basic architecture, memory and input/output organization in a microprocessor system. The students also learn the working of CRO.

- Course learning begins with the basic understanding of active and passive components. It then builds the concept of Integrated Chips (IC): its classification and uses.
- Differentiating the Analog and Digital circuits, the concepts of number systems like Binary, BCD, Octal and hexadecimal are developed to elaborate and focus on the digitalsystems.
- Sequential Circuits: Basic memory elements Flips-Flops, shift registers and 4-bits counter leading to the concept of RAM, ROM and memory organization.
- Timer circuits using IC 555 providing clock pulses to sequential circuits and develop multivibrators.
- Introduces to basic architecture of processing in an Intel 8085 microprocessor and to Assembly Language.
- Also impart understanding of working of CRO and its usage in measurements of voltage, current, frequency and phase measurement.
- In the laboratory students will learn to construct both combinational and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Shift Registers, and multivibrators using 555 ICs.

CORE-VIII: Mathematical Physics III

Course Objective

The emphasis of the course is on applications in solving problems of interest to physicists. Students will be examined on the basis of problems, seen and unseen. The course will develop understanding of the basic concepts underlying complex analysis and complex integration and enable student to use Fourier and Laplace Transform to solve real world problems.

Course 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 parametrization, 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 and Laplace transforms and use these to solve boundary value problems.
- In the laboratory course, the students will learn the basics of the Scilab software/Python interpreter and apply appropriate numerical method to solve selected physics problems both using user defined and inbuilt functions from Scilab/Python.

CORE-IX: Elements of Modern Physics

Course Objective

The objective of this course is to teach the physical and mathematical foundations necessary for learning various topics in modern physics which are crucial for understanding atoms, molecules, photons, nuclei and elementary particles. These concepts are also important to understand phenomena in laser physics, condensed matter physics and astrophysics.

Course 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.
- Formulation of Schrodinger equation and the idea of probability interpretation associated with wave-functions.
- The spontaneous and stimulated emission of radiation, optical pumping and population inversion. Three level and four level lasers. Ruby laser and He-Ne laser in details. Basic lasing
- The properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
- Decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrino, its properties and its role in theory of beta decay.
- Fission and fusion: Nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
- In the laboratory course, the students will get opportunity to measure Planck's constant, verify photoelectric effect, and determine e/m of electron, Ionization potential of atoms, study emission and absorption line spectra. They will also find wavelength of Laser sources by single and Double slit experiment, wavelength and angular spread of He-Ne Laser using plane diffraction grating.

CC-VII: Analog Systems and Applications

Course Objective

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

Course Learning Outcomes

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

- Characteristics and working of pn junction.
- Two terminal devices: Rectifier diodes, Zener diode, photodiode etc.
- NPN and PNP transistors: Characteristics of different configurations, biasing, stabilization and their applications.
- CE and two stages RC coupled transistor amplifier using h-parameter model of thetransistor.
- Designing of different types of oscillators and their stabilities.
- Ideal and practical op-amps: Characteristics and applications.
- In the laboratory course, the students will be able to study characteristics of various diodes and BJT. They will be able to design amplifiers, oscillators and DACs. Also different applications using Op-Amp will be designed.

CC-XI: Quantum Mechanics &Applications

Course Objective

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.

Course 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 Eigen functions.
- 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 one-dimensional and three dimensional potentials.

CC-XII: Solid State Physics

Course Objective

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.

Course 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 behavior.
- 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.

CC-XIII: Electromagnetic Theory

Course Objective

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.

Course 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.
- Understand the fundamentals of propagation of electromagnetic waves through optical fibers.
- In the laboratory course, the student get an opportunity to perform experiments with Polarimeter, Babinet Compensator, Ultrasonic grating, simple dipole antenna. Also, to study phenomena of interference, refraction, diffraction and polarization.

CC-XIV: Statistical Mechanics

Course Objective

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.

Course Learning Outcomes

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

- Understand the concepts of microstate, macro state, phase space, thermodynamic probability and partition function.
- Understand the use of Thermodynamic probability and Partition function for calculation of thermodynamic variables for physical system (Ideal gas, finite level system).
- Difference between the classical and quantum statistics
- 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: II Nuclear and Particle Physics

Course Objective

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.

Course Learning Outcomes

- 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
- 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.

DSE-1(CLASSICAL DYNAMICS)

The main outcome of the course is to get idea about the classical dynamics of system of particles ,relativity theory with four vector space.

DSE-3(FORTRAN)

The main outcome is that the students will be able to design code and test simple programs in FORTRAN in the process of solving various problems.The application of FORTRAN is highly seen in solving physics problems .

DSE-IV(PROJECT)

This is a project paper,in which students do a project work based on any experiment and analyse it's data with a theory or take up any theoretical topic and present a report on it under the guidance of a mentor which in a way expose them to the area of new research and innovation.

The content of the course are beneficial for the students in their preparation to persue higher studies as the course is designed in a such a manner that it helps a lot in the preparation of IIT JAM,NET,GATE,BARC ,GRE ,CUCET,CPET and other competitive examination.

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DSE-3(2018)(NANOPARTICLES)

As research areas are developing more focused has shifted towards nano particles.The course gives a detail idea about nano structure and the instruments used in the area of condensed matter physics.

DSE-IV(PROJECT)

This is a project paper,in which students do a project work based on any experiment and analyse it's data with a theory or take up any theoretical topic and present a report on it under the guidance of a mentor which in a way expose them to the area of new research and innovation.

The content of the course are beneficial for the students in their preparation to persue higher studies as the course is designed in a such a manner that it helps a lot in the preparation of IIT JAM,NET,GATE,BARC ,GRE ,CUCET,CPET and other competitive examination.

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