Graduate attributes in Physics

Some of the Graduate attributes of a graduate in Physics are

- **Disciplinary knowledge and skills:** Capable of demonstrating good knowledge and understanding of major concepts, theoretical principles and experimental findings in Physics and its different subfields like Astrophysics and Cosmology, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science and other related fields of study, including broader interdisciplinary subfields like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology etc.
  ability to use modern instrumentation and laboratory techniques to design and perform experiments is highly desirable in almost all the fields of Physics listed above .
- **Skilled communicator:** Ability to transmit complex technical information relating all areas in Physics in a clear and concise manner in writing and oral ability to present complex and technical concepts in a simple language for better understanding.
- **Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in all the basic areas of Physics.
- **Sense of inquiry:** Capability for asking relevant/appropriate questions relating to the issues and problems in the field of Physics, and planning, executing and reporting the results of a theoretical or experimental investigation.
- **Team player/worker**: Capable of working effectively in diverse teams in both classroom, laboratory, Physics workshop and in industry and field-based situations.
- **Skilled project manager:** Capable of identifying/mobilizing appropriate resources required for a project, and manage a project through to completion, while observing responsible and ethical scientific conduct; and safety and laboratory hygiene regulations and practices.
- **Digitally Efficient*:*** Capable of using computers for simulation studies in Physics and computation and appropriate software for numerical and statistical analysis of data, and employing modern e-library search tools like Inflibnet, various websites of the renowned Physics labs in countries like the USA, Europe, Japan etc. to locate, retrieve, and evaluate Physics information.
- **Ethical awareness / reasoning*:*** The graduate should be capable of demonstrating ability to think and analyze rationally with modern and scientific outlook and identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.

- **National and international perspective*:*** The graduates should be able to develop a national as well as international perspective for their career in the chosen field of the academic activities. They should prepare themselves during their most formative years for their appropriate role in contributing towards the national development and projecting our national priorities at the international level pertaining to their field of interest and future expertise.
- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling in all areas of Physics.

Program Learning Outcomes (POs) in B.Sc (Honours) Physics

The student graduating with the Degree B.Sc (Honours) Physics should be able to

- Acquire

  (i) a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas and applications in basic Physics like Astrophysics, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science, and its linkages with related disciplinary areas/subjects like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology;

  (ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government/public service;

  (iii) skills in areas related to one's specialization area within the disciplinary/subject area of Physics and current and emerging developments inthe field of Physics.
- Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics.
- Recognize the importance of mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.
- Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories of Physics.
- Demonstrate relevant generic skills and global competencies such as

  (i) problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary-area boundaries;

(ii) investigative skills, including skills of independent investigation of Physics-related issues and problems;

(iii) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;

(iv) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Physics and ability to translate them with popular language when needed;

(v) ICT skills;

(vi) personal skills such as the ability to work both independently and in a group.

- Demonstrate professional behavior such as

  (i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;

  (ii) the ability to identify the potential ethical issues in work-related situations;

  (iii) appreciation of intellectual property, environmental and sustainability issues; and

  (iv) promoting safe learning and working environment.

Core Course for B.Sc Physics (Hons.)

S. No.	POs	CC-1	CC-2	CC-3	CC-4	CC-5	CC-6	CC-7	CC-8	CC-9	CC-10	CC-11	CC-12	CC-13	CC-14
1	Fundamental understanding of the field	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Application of basic Physics concepts	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Linkages with related disciplines	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	Procedural knowledge for professional subjects	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Skills in related field of specialization	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	Ability to use in Physics problem	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	Skills in Mathematical modeling	X	X	X	X	X	_	_	X	_	X	X	X	_	X
8	Skills in performing analysis and interpretation of data	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	Develop investigative Skills	X	X	X	X	X	X	_	X	X	X	X	X	X	X
10	Skills in problem solving in Physics and related discipline	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	Develop Technical Communication skills	X	X	X	X	-	-	X	X	X	X	X	X	X	X
12	Developing analytical skills and popular communication	X	X	X	X	-	-	X	-	_	_	X	X	-	X
13	Developing ICT skills	X	X	X	X	X	X	_	X	X	X	X	X	X	X
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, self reading, etc	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Discipline Specific Electives (DSE) and

Skill Enhancement Course (SEC) for B.Sc. Physics (Hons.)

S. No	POs	DSE A1.2	DSE B1.2	DSE A2.1	DSE B2.1	SEC A1	SEC B1
1	Fundamental understanding of the field	X	X	X	X	-	-
2	Application of basic Physics concepts	X	X	X	X	-	-
3	Linkages with related disciplines	X	X	X	X	X	X
4	Procedural knowledge for professional subjects	-	-	-	-	X	X
5	Skills in related field of specialization	X	X	X	X	X	X
6	Ability to use in Physics problem	X	X	X	X	-	X
7	Skills in Mathematical modeling	-	-	-	-	-	-
8	Skills in performing analysis and interpretation of data	-	-	-	-	-	X
9	Develop investigative Skills	-	-	-	-	-	X
10	Skills in problem solving in Physics and related discipline	X	X	X	X	-	-
11	Develop Technical Communication skills	-	-	-	-	X	X
12	Developing analytical skills and popular communication	-	-	-	-	X	X
13	Developing ICT skills	-	-	-	-	X	X
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, self reading, etc	X	X	X	X	X	X

Course Learning Outcomes (CLO)

Core Courses (CC)

CC1: MATHEMATICAL PHYSICS-I
(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

Students will be able to

- Revise the knowledge of calculus, vectors, vector calculus. These basic mathematical structures are essential in solving problems in various branches of Physics as well as in engineering.
- Learn the curvilinear coordinates which have applications in problems with spherical and cylindrical symmetries.
- Learn differential equations, partial derivatives which have applications in all branches of physics.
- Learn the matrix and its properties, which have applications in various branches of Physics, especially quantum mechanics.
- In the laboratory course, learn the fundamentals of the python programming language and their applications in solving simple physical problems involving sorting, matrix operations, and differential equations as well as finding theroots of equations. They will also learn GNU Plot.

CC2: MECHANICS

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

After going through the course, the student should be able to

- Understand laws of motion and their application to various dynamical situations, notion of inertial frames and concept of Galilean invariance. He / she will learn the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- Write the expression for the moment of inertia about the given axis of symmetry for different uniform mass distributions.
- Understand the dynamics of system of particles and idea about center of mass and laboratory frames and their correlation.
- Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation, central force.
- Understand the analogy between translational and rotational dynamics, and application of both motions simultaneously in analyzing rolling with slipping.
- Understand simple principles of fluid flow and the equations governing fluid dynamics.
- Describe how fictitious forces arise in a non-inertial frame, e.g., why a person sitting in a merry-go-round experiences an outward pull.
- In the laboratory course, the student shall perform experiments related to mechanics (bar pendulum), rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity) and Sextant etc. Know about the basic theory of errors, their analysis, estimation with examples of simple experiments in Physics

CC3: ELECTRCITY AND MAGNETISM

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

After going through the course, the student should be able to

- Idea about Dirac delta function and it's properties.
- Demonstrate Gauss law, Coulomb's law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
- Explain and differentiate the vector (electric fields, Coulomb's law) and scalar (electric potential, electric potential energy) formalisms of electrostatics.
- Apply Gauss's law of electrostatics to solve a variety of problems.
- Understand the dielectric properties of matter.
- Articulate knowledge of image problem and electrostatic energy.
- Describe the basics of magnetostatics, Bio-Savart Law, magnetic potentials etc.
- Explain Faraday-Lenz and Maxwell laws to articulate the relationship between electric and magnetic fields.
- Understand the magnetic properties of materials and the phenomena of electromagnetic induction.
- Apply Kirchhoff's rules to analyze AC circuits consisting of parallel and/or series combinations of voltage sources and resistors, capacitors, inductors and to describe the graphical relationship of resistance, capacitor and inductor.
- In the laboratory course the student will get an opportunity to study the frequency response of CR, LCR circuits.
- Should be able to determine the unknown resistance using Carey-Foster bridge, potentiometer. Determination of horizontal components of earth's magnetic field, study of mutual inductance.

CC4: WAVES AND OPTICS

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

This course will enable the student to

- Recognize and use a mathematical oscillator equation and wave equation, and derive these equations for certain systems.
- Understand the principle of superposition of waves, so thus describe the formation of standing waves.
- Explain several phenomena we can observe in everyday life that can be explained as wave phenomena.
- Understand the nature of light, concept of coherence.
- Use the principles of wave motion and superposition to explain the physics of interference and diffraction.
- Understand the working of selected optical instruments like biprism, interferometer, diffraction grating.
- In the laboratory course, student will gain hands-on experience of using various optical instruments like spectrometer and making finer measurements of wavelength of light using Newton Rings, Fresnel Biprism, grating etc. Will determine Cauchy-constants.
- The study of behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

CC5: MATHEMATICAL PHYSICS-II

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

This course will enable the student to

- Learn the Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
- Learn about the Frobenius method and special functions, such as the Hermite polynomial, the Legendre polynomial and Bessel functions and their differential equations and their applications in various physical problems such as in diffraction, quantummechanics.
- Learn the beta, gamma and the error functions and their applications in doing integrations.
- Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems.
- Acquire basic knowledge of probability distributions.
- Acquire knowledge of methods to solve partial differential equations with the examples of important partial differential equations in Physics.
- In the laboratory course, learn the basics features of scientific python (scipy) and numerical python (numpy),their utility, advantages and disadvantages.
- Import the scipy and numpy for curve fittings, in solving system of linear equations, solving integrations, generating and plotting special functions such as Legendre polynomial and Bessel functions, solving first and second order ordinary and partial differential equations.

CC6: THERMAL PHYSICS

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

This course will enable the student to

- Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations.
- Learn about Maxwell's thermodynamic relations.
- Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzman distribution law, equitation of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
- Learn about the real gas equations, Van der Waal equation of state, the Joule-Thompson effect and basics of heat conduction in solid.
- In the laboratory course, the students are expected to do some basic experiments in thermal Physics, viz., determinations of Stefan's constant, coefficient of thermal conductivity, temperature coefficient of resistance, variation of thermo-emf of a thermocouple with temperature difference at its two junctions and calibration of a thermocouple, determination of coefficient of linear expansion using optical lever, finding the boiling point of unknown liquid using Platinum resistance thermometer etc.

CC7: MODERN PHYSICS

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

This course will enable the student to

- Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
- Understand the theory of quantum measurements and uncertainty principle.
- Understand the central concepts of quantum mechanics: wave functions, momentum and energy operator, the Schrodinger equation, time dependent and time independent cases, probability density and the normalization techniques, skill development on problem solving e.g. one dimensional rigid box, tunneling through potential barrier, step potential, rectangular barrier.
- Understanding 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.
- Ability to calculate the decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.
- Understand fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
- Understand various interactions of electromagnetic radiation with matter. Electron positron pair creation.
- Understand 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.
- In the laboratory course, the students will get opportunity to perform the following experiments : Measurement of Planck's constant by more than one method. Verification of the photoelectric effect, Determination of e/m of electron. Study of I-V characteristics of tunnel diode.

CC8: MATHEMATICAL PHYSICS-III

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

This course will enable the student to

- Learn about the complex numbers and their properties, functions of complex numbers and their properties such as analyticity, poles and residues. The students are expected to learn the residue theorem and its applications in evaluating definite integrals.
- Learn about variational calculus, Lagrangian Mechanics, Hamiltonian formulation, canonical equations of motion and their applications.
- Learn about basics of Relativity, Relativistic Dynamics, Four Vectors, Cartesian Tensors.
- In the laboratory course, the students should apply their python programming language to solve the following problems:

  (i) Solution first-and second order ordinary differential equations with appropriate boundary conditions,
  (ii) Exploring of the Gaussian integrals and delta function,
  (iii) Evaluation of a converging infinite series up to a desired accuracy,
  (iv) Evaluation of the Fourier coefficients of a given periodic function,
  (v) Plotting the Legendre polynomials and the Bessel functions of different orders and interpretations of the results,
  (vi) Solving some basic partial differential equations.

CC9: ANALOG SYSTEMS AND APPLICATIONS

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

At the end of the course the student is expected to assimilate the following and possesses basic knowledge of the following.

- Circuit and Network analysis.
- N- and P- type semiconductors, mobility, drift velocity, fabrication of P-N junctions; forward and reverse biased junctions.
- Application of PN junction for different type of rectifiers and voltage regulators.
- NPN and PNP transistors and basic configurations namely common base, common emitter and common collector, and also about current and voltage gain.
- Biasing and equivalent circuits, coupled amplifiers and feedback in amplifiers and oscillators.
- Operational amplifiers and knowledge about different configurations namely inverting and non-inverting and applications of operational amplifiers.
- JFET and MOSFET and their characteristics.
- Regulated power supply with zener diode and transistor.
- Oscillators and multi-vibrators.
- In laboratory they are expected to characterize Zener diode, transistors. Also construct amplifiers and oscillators using discrete components. Demonstrate inverting and non-inverting amplifiers using op-amps. Construct regulated power supply.

CC10: QUANTUM MECHANICS AND APPLICATIONS
QUANTUM MECHANICS
(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

This course will enable the student to get familiar with quantum mechanics formulation.

- The interpretation of wave function of quantum particle and probabilistic nature of its location and subtle points of quantum phenomena are exposed to the student.
- Knowledge of free particle, 1D wavepacket and its evolution with time.
- Through understanding the behavior of quantum particle encountering a i) barrier, ii) potential, LHO, the student gets exposed to solving non-relativistic hydrogen atom, for its spectrum and eigenfunctions.
- Concept of generalized angular momenta and spin.
- Study of atomic spectra, different coupling scheme, influence of electric and magnetic fields on atoms will help in understanding Stark effect and Zeeman Effect respectively.
- This basic course will form a firm basis to understand quantum many body problems.
- In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve time independent Schrodinger equation and find the energy eigen-values and their corresponding eigen functions, for simple quantum mechanical one-dimensional and three dimensional potentials. Also, the student will be able to plot the time evaluation of the wave packet solving time dependent Schrodinger equation

CC11: ELECTROMAGNETIC THEORY

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

This course will enable the student to

- Achieve an understanding of the Maxwell's equations, role of displacement current, gauge transformations, scalar and vector potentials, Coulomb and Lorentz gauge, boundary conditions at the interface between different media.
- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
- Analyse the phenomena of wave propagation in the unbounded, bounded, vacuum, dielectric, guided and unguided media.
- Understand the laws of reflection and refraction and to calculate the reflection and transmission coefficients at plane interface in bounded media.
- Understand the linear, circular and elliptical polarisations of em waves.
- Understand propagation of em waves in anisotropic media, uni-axial and biaxial crystals phase retardation plates and their uses.
- Understand the concept of optical rotation, theories of optical rotation and their experimental rotation, calculation of angle rotation and specific rotation.
- In the laboratory course, the student gets an opportunity to perform experiments Demonstrating principles of diffraction and polarization.

- Verify the laws of Polarisation for plane polarised light.
- Verify Fresnel's equations.
- Resolving and dispersive power of grating.
- Measurement of specific rotation using polarimeter.

CC12: STATISTICAL MECHANICS
(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

This course will enable the student to

- Understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability and partition function.
- Understand the studies of particles with their distinguishably orindistinguishably nature and conditions which lead to the three different distribution laws e.g. Maxwell-Boltzmann distribution, Bose-Einstein distribution and Fermi-Dirac distribution laws of particles and their derivation.
- Comprehend and articulate the connection as well as dichotomy between classical statistical mechanics and quantum statistical mechanics.
- Learn to apply the classical statistical mechanics to derive the law of equipartition of energy and specific heat.
- Understand the Gibbs paradox, equipartition of energy and concept of negative temperature in two level system.
- Learn to derive classical radiation laws of black body radiation. Wiens law, Rayleigh Jeans law, ultraviolet catastrophe.
- Learn to calculate the macroscopic properties of degenerate photon gas using BE distribution law, understand Bose-Einstein condensation law and liquid Helium. Bose derivation of Plank's law
- Understand the concept of Fermi energy and Fermi level, calculate the macroscopic properties of completely and strongly degenerate Fermi gas, electronic contribution to specific heat of metals.
- Understand the application of F-D statistical distribution law to derive thermodynamic functions of a degenerate Fermi gas, electron gas in metals and their properties.

- In the laboratory course, the students gets an opportunity to do Monte Carlo simulations to simulate different physical problems like nuclear decay, random walk etc. Also learn Monte Carlo integration to solve the integrations using random numbers.

- Use Computer simulations to study:

    i. Specific Heat of Solids by comparing, Dulong-Petit, Einstein's and Debye's Laws and study their temperature dependence.
    ii. Maxwell-Boltzmann distribution
    iii. Bose-Einstein distribution
    iv. Fermi-Dirac distribution

CC13: DIGITAL SYSTEMS AND APPLICATIONS
(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

As the successful completion of the course the student is expected to be conversant with the following.

- Secure first-hand idea of different components including both active and passive components to gain a insight into circuits using discrete components and also to learn about integrated circuits.
- About analog systems and digital systems and their differences, fundamental logic gates, combinational as well as sequential and number systems.
- Synthesis of Boolean functions, simplification and construction of digital circuits by employing Boolean algebra and combinational circuits.
- Sequential systems by choosing Flip Flop as a building bock- construct multivibrators, counters, registers to provide a basic idea about memory including RAM, ROM and also about memory organization.
- In the laboratory the student is expected to construct both combinational circuits and sequential circuits by employing basic gates and universal gates as building blocks and demonstrate Adders, Subtractors, Shift Registers.

CC14: SOLID STATE PHYSICS

(Credits: 06, Theory-04, Practicals-02)

Course learning outcome (COs):

At the end of the course the student is expected to learn and assimilate the following.

- A brief idea about crystalline and amorphous substances, about lattice, unit cell, Miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays by crystalline materials.
- Knowledge of lattice vibrations, phonons and in depth of knowledge of Einstein and Debye theory of specific heat of solids.
- At knowledge of different types of magnetism from diamagnetism to ferromagnetism and hysteresis loops and energy loss.
- Secured an understanding about the dielectric and ferroelectric properties of materials.
- Understanding the band theory of solids and must be able to differentiate insulators, conductors and semiconductors. Theory of classical Hall effect.
- Understand the basic idea about superconductors and their classifications.
- To 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 band gap and the Hall set up to determine the Hall coefficient of a semiconductor.

DSE-A1: LASER AND FIBER OPTICS

(Credits: 06, Theory-05, Tutorial-01)

Course learning outcome (COs):

This course will enable the student to

- Learn Einstein's coefficient and rate equations of transitions. Basic lasing action, 3 and 4-level lasers.
- Know about different properties of lasers and types of optical resonators.
- Learn about transient effects including different mode selection and switching methods.
- Get an idea about some basic and important Gas, Solid and Semi conductor laser systems.
- Learn about line broadening mechanism, laser cooling and trapping.
- Know about basics of fiber optics and their application in communication and sensing.
- Get an idea about the theory and application of holography.
- Get and introductory knowledge about non liner optics.

DSE-B1: NUCLEAR & PARTICLE PHYSICS

(Credits: 06, Theory-05, Tutorials-01)

Course learning outcome (COs):

This course will enable the student to

- Learn the ground state properties of a nucleus – the constituents and their properties, mass number and atomic number, relation between the mass number and the radius and the mass number, average density, range of force, saturation property, stability curve, the concepts of packing fraction and binding energy, binding energy per nucleon vs. mass number graph, explanation of fusion and fission from the nature of the binding energy graph.
- Know about the nuclear models and their roles in explaining the ground state properties of the nucleus –(i) the liquid drop model, its justification so far as the nuclear properties are concerned, the semi-empirical mass formula, (ii) the shell model, evidence of shell structure, magic numbers, predictions of ground state spin and parity, theoretical deduction of the shell structure, consistency of the shell structure with the Pauli exclusion principles.
- Learn about the process of radioactivity, the radioactive decay law, the emission of alpha, beta and gamma rays, the properties of the constituents of these rays and the mechanisms of the emissions of these rays, outlines of Gamow's theory of alpha decay and Pauli's theory of beta decay with the neutrino hypothesis, the electron capture, the fine structure of alpha particle spectrum, the Geiger-Nuttall law, the radioactive series.
- Learn the basic aspects of nuclear reactions, the Q-value of such reaction and its derivation from conservation laws, The reaction cross-sections, the types of nuclear reactions, direct and compound nuclear reactions, Rutherford scattering by Coulomb potential.
- Learn some basic aspects of interaction of nuclear radiation with matter- interaction of gamma ray by photoelectric effect, Compton scattering and pair production, energy loss due to ionization, Cherenkov radiation.

- Learn about the detectors of nuclear radiations- the Geiger-Mueller counter, the scintillation counter, the photo-multiplier tube, the solid state and semiconductor detectors.
- The students are expected to learn about the principles and basic constructions of particle accelerators such as the Van-de-Graff generator, cyclotron, betatron and synchrotron. They should know about the accelerator facilities in India.
- Gain knowledge on the basic aspects of particle Physics – the fundamental interactions, elementary and composite particles, the classifications of particles: leptons, hadrons (baryons and mesons), quarks, gauge bosons. The students should know about the quantum numbers of particles: energy, linear momentum, angular momentum, isospin, electric charge, colour charge, strangeness, lepton numbers, baryon number and the conservation laws associated with them.

DSE-A2: NANO MATERIALS AND APPLICATIONS

(Credits: 06, Theory-05, Tutorial-01)

Course learning outcome (COs):

At the end of the course the student is expected to possess the concept the following.

- In the Nano systems and its implications in modifying the properties of materials at the nanoscale.
- Concept of Quantum confinement, 3D, 2D, 1D and 0D nanostructure with examples.
- Different synthesis techniques included under top down and bottom up approaches.
- Characterization of nanostructured materials using X-ray diffraction, electron microscopy, Atomic Force Microscopy and Scanning Tunneling Microscopy, TEM, SEM etc.
- Optical properties of nanostructured materials, modification of band gap, excitonic confinement.
- Transport properties of nanostructures materials, Coulomb Blockade, Mott Conductivity, Defects etc.
- Applications of nanostructured materials in making devices namely MEMS, NEMS and other heterostructures for solar cell and LEDs.

DSE-B2: COMMUNICATION ELECTRONICS

(Credits: 06, Theory-05, Tutorial-01)

Course learning outcome (COs):

At the end of the course the student is expected to have an idea/concept of the following,

- Electromagnetic spectra and different frequency bands used in different fields of modern science and technology.
- Various Analog Modulation (AM, FM and PM) and De-modulation (Linear and techniques and its comprehensive electronic circuits using various electrical and electronic components. Electronic circuits are used in different communication systems to explain different types of modulation by using transmitters and receivers.
- Various Digital Modulation
- Concept of sampling and its various types (Natural, flat top etc.) has been explained elaborately. Sampling theorem and its detailed mathematical formulation to explain various types multiplexing.
- Digital transmission, encoding and decoding.
- Satellite communication including uplinking and downlinking.
- Mobile communication/telephony and concepts of cell telephony.
- 2G, 3G, 4G and 5G (Quantitative).

SEC-A1: SCIENTIFIC WRITING

(Credits: 02, Theory-01, Project-01)

Course learning outcome (COs):

At the end of the course the student is expected to have an idea/concept of the following,

- Introduction to scientific writing using LATEX and its different packages.
- Different document classes, page layout and list structure.
- Representation of different mathematical functions and equations.
- Usage of different fonts, creating tables, inserting figures.
- Students are expected to complete a project by writing articles, laboratory reports including graphical analysis of data, bio-data etc using LATEX.

SEC-B1: ARDUINO

(Credits: 02, Theory-01, Project-01)

Course learning outcome (COs):

At the end of the course the student is expected to have an idea/concept of the following,

- Introduction to open source electronic prototyping: ARDUINO.
- Basic idea of ARDUINO board and installation of IDE for programming..
- Structure of ARDUINO programming and interfacing with different devices.
- Students are expected to complete a project by performing simple experiments like LED blinking, interfacing of 7 segment display, construction of thermometer, constructing data logger for studying charging and discharging of capacitor