Center for Basic Sciences

(CBS)

Learning Outcome

Of

Five year

M.Sc. Integrated (Physics Stream)

UNDER

FACULTY OF SCIENCE

Approved by Board of Studies in Physics

EFFECTIVE FROM JULY 2022

Center for Basic Sciences
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Integrated M.Sc. in Physics
Center for Basic Sciences
Pt. Ravishankar Shukla University, Raipur (C.G.)

OBJECTIVES :

The objective of Integrated M. Sc. in Physics is to create a pool of highly qualified talented and motivated young students with professional competence in physics with ability

- to embark on careers in front line research and development in physics.
- to take research challenges in the interdisciplinary nature of contemporary physics subjects (e. g. biophysics, medical physics, computational physics).
- to recognize and respond to the scientific demands relevant to need of the country.
- to contribute to the society with their skill and knowledge for uplifting the scientific temperament of the society.

Program Educational Objectives :

PE01: Development of scientific reasoning skills

Student should be able to find a way to comprehend and analyze a new physical process (not discussed in class) in real life by applying adequate sequence of reasoning, starting from fundamental principles of physics leading to come up with predictions or inference about the process.

PEO2: Development of organised knowledge of the major branches of Physics

Student should have knowledge of various branches of physics in enough depth and width to be able to recognise properties of real system by making connections/ links between concepts covered in different courses.

PEO3: Development of quantitative understanding of physical theories and problem solving abilities

Student should be well versed with use of appropriate mathematical tools and should be able to connect the different representations viz. Mathematical expressions, verbal descriptions, Graphs, diagrams. Student should be able to understand approximations used to arrive at the result and its implication on the ranges of validity.

PEO4: Development of familiarity with laboratory techniques and computational skills

Student should be able to perform laboratory exercises, document and analyze the observations, understand sources of error, and ultimately should be able to design an experiment in domain of physics. Student should have familiarity with basic programming techniques, numerical methods and statistical techniques.

PEO5: Development of ability of communicating science to peers and to the society

Student should be able to communicate concisely and clearly about a subject through presentation or writing to various audience, including peers and general public.

PEO6: Development of ability to complete a guided research project

Student should have ability to do an effective literature search, apply adequate method to collect. document and process and analyze the data draw inferences and interpret the results obtain. Should have ability to write a research proposal and formal research paper.

Program Learning Outcomes :

- Student should acquire knowledge and problem-solving skills to pass National level CSIR/UGC NET and State level SET/SLET examination in Physical Science Subject during final year of the course .
- Student should have competence to get selected for Ph. D. Programs in reputed national and international research institutes/universities.
- Student should be able to approach eminent scientists and research institutes with a research proposals to carry out short term/ long term projects.
- Students should have conceptual clarity of the learned topics to be a potentially science teacher of high caliber

General Pattern of the Program

The course structure of five year Integrated-M.Sc. Physics is designed to start the journey so as to help the student to perform a journey from introduction of the subject in the first semester to an advanced level of understanding in the final semester and also give him/her glimpses of contemporary research in the stream of specialization and/or other interdisciplinary areas.

- The curriculum for the first two semesters (first year) is common to all students (10+2 PCM and PCB group) and consist of (i) Introductory theory courses in biology, chemistry, mathematics and physics, (ii) Laboratory courses, and (iii) courses in communication skills, computer basics as well as electronics.
- At the beginning of the second year (third semester), a student will opt for specialization in one of the streams (Biology, Chemistry, Mathematics or Physics) according to their choice.
- In the second and third years of study, the students are taught courses not only in the specialised discipline, but often courses from other science disciplines as well, as recommended for an integrated understanding of the subject matter.
- The courses in fourth and fifth years of the integrated M.Sc. Programmer are more advanced in nature and are mainly from the respective disciplines, although there are some interdisciplinary courses.

- The Center focuses on imparting a complete education and prescribes some compulsory courses which belong to humanities, social sciences, technical communication, history of science, environmental and energy sciences, etc.
- In order to expose the young minds to research early in their career, the students are offered projects from 4th year onward. Thus, in 7th semester they are exposed to supervised learning of a research topic, followed by a mini research project in 8th semester. The 9th semester entails a dissertation, where the students need to go outside of the CBS to carry out a full semester external project.
- The students are thus encouraged to take up summer projects and visit reputed national, international laboratories and universities, so as to broaden their vision and widen their horizon.
- Students also get an opportunity to learn from and interact with eminent scientists from India and abroad who are invited to the Center at regular intervals to deliver colloquia and seminars.

PAPER WISE LEARNING OUTCOME :

SEMESTER- I

P101: Introductory Physics-I (For all streams)

This is common paper for 10+2 biology and mathematics background students. A portion of the content significantly overlaps with 10+2 , the approach taken in delivery is meant to be inclined towards developing the thought process that leads to the conclusions that are being familiarized. The course aims to consolidate the knowledge acquired at +2 level by the student and create deep interest to understand laws of nature by means of developing understanding of physics. The scope of content covered includes -

- A relation of physics with other sciences. Review of conservation of energy and characteristics of fundamental forces.
- Development of an understanding of oscillations with particular emphasis on simple harmonic motion.
- Understanding of phenomenon of resonance and able to understand resonance observed in the nature
- A review of Thermodynamics, as a Macroscopic study of complex systems, mostly in the context of ideal gases.
- A review of microscopic analysis of ideal gases using the kinetic theory of gases.

PL101: Physics Laboratory – I

After successfully completing the laboratory exercises

- Student should have working knowledge of Plots (normal, semi-log, log-log).
- Student should have understanding of uncertainty / error in measurements and uncertainty / error analysis.
- Student should have understanding of concepts of standards and calibration.

SEMESTER - II

P201: Introductory Physics-II (For all streams)

The course introduces the students how mathematical, and graphical tools can be used to simplify the problems and make it possible to visualize the physical phenomena for better understanding. After successful completion student will learn

- how to apply Gauss's law in variety of problems for finding value of electrostatics field
- magnatostatics, and plane electromagnetic waves
- Interference of light using wave theory of light
- Basic concepts geometrical optics
- How human eye detect light and perceive colour

PL201: Physics Laboratory – II

This course covers a theoretical understanding of functionality of electronic components in circuitry and also develops the thought process for instrumentation. In this course, students will gain understanding of

- Basic circuit analysis and network theorems
- foundational electronic components like diodes and transistors.
- More complex electronic components and a variety of applications of the same
- Introductory level digital electronics that includes fundamental memory devices
- Introductory instrumentation which includes and understanding of concepts like sensing and transduction.

G201- Electronics & Instrumentation

This course covers a theoretical understanding of functionality of electronic components in circuitry and also develops the thought process for instrumentation. In this course, students will gain understanding of

- The basic electronics principles and abstractions on which the design of electronic systems is based. These include lumped circuit models, digital circuits, and operational amplifiers.
- Using the abstractions to analyze and design simple electronic circuits.
- Employing Boolean algebra to describe the function of logic circuits.
- Designing circuits which represent digital logic expressions. Specifically, design a gate-level digital circuit to implement a given Boolean function.
- Basic principals behind measuring instruments

GL201 Electronics laboratory

Student will do experiments to learn

- Network theorems
- Diode characteristics in forward and reverse biasing mode.
- How capacitors charges and discharges.
- Characteristics of PNP and NPN transistor.
- To find specific resistance using Wheatstone bridge.

SEMESTER - III

P301: Mathematical Physics – I

After successfully completing this course

- The students will be able to understand and apply the mathematical skills to solve
- quantitative problems in the study of physics.
- Will enable students to apply integral transform to solve mathematical problems of
- interest in physics.
- he students will be able to use Fourier transforms as an aid for analyzing experimental data.
- The students should be able to formulate and express a physical law in terms of tensors, and simplify it by use of coordinate transforms.

P302: Classical Mechanics – I

This course would serve as a foundation in ensuring an appropriate level of understanding of the statics and dynamics necessary for other advanced subjects of physics. Student will gain understanding of

- Fundamental concepts of forces, energy, potentials, linear and angular momentum
- A rigorous exercise in Newtonian Mechanics including that of its applications in Rigid bodies
- Frames of reference
- Statics and Dynamics of Einstein's special relativity
- Introduction to four vectors and concept of spacetime

P303: Electromagnetism

After successfully completing this course

- Student should be able to explain and solve advanced problems based on classical electrodynamics using Maxwell's equation.
- The students will be able to analyze s radiation systems in which the electric dipole, magnetic dipole or electric quadruple dominate.
- The students will have an understanding of the covariant formulation of electrodynamics and the concept of retarded time for charges undergoing acceleration.

P304: Waves and Oscillations

After completing this course student should

- be able to recognize and use a mathematical oscillator equation and wave equation, and derive these equations for certain systems, point out the limitations and be able to refer to very different solutions of identical oscillator equations due to different initial and boundary conditions.
- explain several phenomena we can observe in everyday life that can be explained as wave phenomena, and identify basic principles,
- Understand physical characteristics of SHM and obtaining solution of the oscillator using differential equations
- explain how several waves or parts of waves interact, and be able to calculate and analyze diffraction and interference phenomena, and explain the conditions required for such phenomena to appear.
- describe and calculate what happens when waves move from one medium to another, and be able to explain dispersion and group and phase velocity.
- use geometric optics to describe and explain optical instruments, and by simple measurements estimate what strength glasses a person needs
- use both analytical mathematics and numerical methods to explore the subjects mentioned above. In particular you should be able to analyze experimental oscillator or wave phenomena, such as sound, using suitable methods.

H302 : History and Philosophy of Science (All streams)

After successful completion of this course students should learn

- History of World Science up to the Scientific Revolution.
- History of Ancient Indian Science.
- Philosophy of Science and distinction between science and pseudo science.
- Great Scientific Experiments (though group activity)

PL301: Physics Laboratory – III

After successful completion of this course students should have the procedural and conceptual understanding of the following experiments

- Frequency response of R-C circuit (concept of cut-off freq and filter).
- frequency response of LC circuit.
- concepts of phase difference between voltage and current in these circuits.
- phase factor for appliances using AC mains supply.
- R-L-C (series / parallel) resonance.
- transient response in RL- C series circuit.
- study of Newton's rings.
- determination of the charge of an electron by Millikan's oil drop experiment.

GL301: Applied Electronics Laboratory

After completing the laboratory exercises student will learn

- Working of Logic gates
- half and Full Adder circuits
- De-Morgan's Theorem
- Edge triggered D-Flip Flop
- working of rectifier circuits
- working of filter circuits
- regulated power supply

SEMESTER - IV

P401: Mathematical Physics – II

After successful completion of this course students should have understanding about

- Partial differential equations in curvilinear coordinates
- In-homogeneous equations, Green's functions in 1,2 and 3-dimensions
- Tensors calculus
- Various integral equations
- subgroups, normal subgroup, classes and cosets;

P402: Quantum Mechanics – I

After successfully completing the course, student will :

- Understand inadequacy of classical mechanics and need of a new mechanics
- Understand and explain the differences between classical and quantum mechanics.
- Under stand quantization of physical variables, wave function and its interpretation
- Under the postulates of quantum mechanics and apply it to find wave function for simple problems
- Understand 1-D scattering in quantum mechanics
- acquire adequate and essential background knowledge to study Quantum Mechanics -II (P501)

PCB 401: Physical and Chemical Kinetics

Student will gain understanding of

- Basic concepts of chemical kinetics, theories, fundamental terms, complex reactions and derivations.
- Reactions in solutions and their kinetics too.
- Various techniques for kinetic measurements (for fast reactions) are also described (like temperature and pressure jump methods, flash photolysis).
- Catalysis and surface reactions are also discussed.

G401: Statistical Techniques and Applications

After successful completion of this course students will learn

- Purpose of studying Statistics
- Different types of probability distributions
- Monte Carlo techniques
- Deconvolution methods
- Different types of statistical tests

PL401: Physics Laboratory – IV

This course is meant as an exercise in a basic understanding and application of ExpEyes kit for variety of physics and electronics experiments. After successful completion of this course students will be able to setup and perform experiments of

- Tensors calculus
- Electronics: including rectifier circuits, diode characteristics, transistor characteristics
- Electrical circuits: including combination of L,C,R components in series and parallel
- Mechanics: including gravity pendulum, driven pendulum distance measurement by echo
- Sound: including velocity of sound in Air, Sound Beats etc.

GL401: Computational Laboratory and Numerical Methods

After successful completion of this course students will learn

- The nature of computational physics
- Basic tools for numerical analysis in science
- Writing programs for problems of Matrix Algebra
- Writing programs for solving Differential Equations
- Writing programs for solving problem related to Fourier analysis and nonlinear systems

SEMESTER - V

P501: Quantum Mechanics – II

after successful completion of this course

- Student will be able to solve eigen value problems for simple cases like particle in a box, harmonic oscillator
- Student will learn abstract vector space formulation of quantum mechanics
- Student will learn quantum mechanical treatment of particle with central potential
- Student will learn stationary perturbation theory for non – degenerate and degenerate case
- Student will learn variational method in quantum mechanics and its application
- Student will acquire essential knowledge to study Quantum Mechanics -III (P702) course

P502: Classical mechanics – II

This is a second course in Classical mechanics will help students gain an understanding of

- Lagrangian and Hamiltonian approach to dynamics
- Canonical Transformations
- Small oscillations in simple and coupled systems
- Brief understanding of application of this approach to continuous media

P503: Atomic and Molecular Physics

After successful completion of this course

- Student should learn Atomic Physics with problem solving approach towards spectroscopy.
- Student should have an understanding of the static properties of nuclei, nuclear force and nuclear models.
- students should have an understanding of the structure of the nucleus, radioactive

- decay, nuclear reactions and the interaction of nuclear radiation with matter.
- Students will have an understanding of quantum behavior of atoms in external electric and magnetic fields.

PM501: Numerical Analysis

PL501: Physics Laboratory - V

In this course student will go through rigorous customization and python programming-based implementation of Expeyes. And make his own program and experimental arrangement to study :

- students should have an understanding of the structure of the nucleus, radioactive
- decay, nuclear reactions and the interaction of nuclear radiation with matter.
- Variable mass pendulum
- Coupled pendulum
- Study of EMI
- Study of characteristics of solar cell
- Velocity and acceleration measurement

PML501: Numerical Methods Laboratory

SEMESTER - VI

P601: Electrodynamics

In this course students will develop understanding of

- Gauge theory, diff erent types of radiating systems, antenna, solution of scalar wave equation.
- Multipole expansion of electromagnetic fields
- Scattering and diffraction problems
- Covariant formulation of electrodynamics
- Field produced by moving charge

P602: Statistical Mechanics - I

This course introduces the phenomenon of dealing with physical properties of a complex system via a statistical microscopic analysis. Statistical Mechanics has limitless applications in understanding a variety of physical systems. Student will gain understanding of

- Probability distribution and ensemble theory
- Differences and implications of dealing with a variety of systems under classical and quantum mechanical framework

- The natural differences and implications of Bosonic and Fermionic systems.
- Applications of this concept in explaining properties like paramagnetism and specific heat of materials.

P602 Computational Physics - A
(only for SEMESTER-IV students of session 2021-22)

In this course both quantum and classical computational tools will be introduced. The course aims to give the students competence in the methods and techniques of calculations using computers. At the end of the course the student is expected to have

- a hands on experience in modeling.
- understanding of algorithm development.
- understanding of implementation and calculation of physical quantities of relevance in interacting many body problems in physics.

P603: Condensed Matter Physics – I

In this course, which is a primarily a study of ordered crystals, Student will gain understanding of

- Crystallography
- Lattice vibrations and properties of solids
- Free electron model and electronic specific heat
- Understanding semiconductors, magnetic properties and superconductivity

P604: Lasers

After successful completion of this course

- Student should understand operational principles and construction of lasers
- Student should understand technological issues behind laser construction
- Student should understand optical components that can be used to tailor the properties of the laser
- Student should understand be able to relate the laser operation principles to atom and molecular physics, solid state physics, quantum mechanics and physical optics.

H 601 Ethics of Science and IPR

After successful completion of this course student will learn

- Role and importance of ethics in science.
- About what is plagiarism, and softwares for plagiarism detection
- Types of Intellectual property
- Definition of patent, patent able and non patentable inventions
- Evolution of institution like, GATT and WTO and IPR provisions under TRIPS

PL601: Physics Laboratory – VI

After successful completion of this course student should have procedural and conceptual understanding of the following experiments:

- determination of specific charge (e/m) of electron.
- Study of Faraday rotation and determination of Verdit's constant in a glass material.
- Study of quantum mechanics through acoustic analogue (four sessions).
- Fourier analysis / synthesis – use of simulation.
- Study of characteristics of a coaxial cable and determination of speed of electromagnetic waves in the coaxial cable.
- Investigation of chaos in a spring based coupled oscillator system.

SEMESTER - VII

P701- Astronomy and Astrophysics - I

This is an introductory course for astronomy and astrophysics it will develop foundations of basic concepts of students to take more advance course in astronomy and astrophysics. The student will learn

- Concepts of distance scale of the universe, measurement of brightness of the astronomical objects
- Physics behind the observed spectra of the star. Stellar evolution of the stars using H-R diagram
- Working of telescope and requirement of different telescope for observation in different wavelengths
- Basic properties of Sun as a star
- Astronomical coordinate systems
- Database of the astronomical objects and conversion of nomenclature of the stars
- Essential background to study Astronomy and Astrophysics-II (P801)

P702: Quantum Mechanics – III

After successful completion of this course

- Student should able to understand deeper concepts of quantum mechanics and should comprehend advanced topics like The EPR paradox, quantum entanglement and decoherence
- Student should understand Symmetry in quantum mechanics.
- be able to understand development of relativistic quantum mechanics.
- Student should have an understanding of Dirac's equation in external electromagnet field.
- be able to solve relativistic one-body problems for spin 0 and $\frac{1}{2}$ particles.
- student will learn the solutions of Dirac's equation and its interpretation.
- Student will have adequate background knowledge to take a course on Quantum Field Theory

P703: Statistical Mechanics – II

In this course students will develop understanding of

- Transport phenomena and equations governing the transport in the presence and absence of collisions, random walk problem
- Concept of diffusion and equations governing diffusion
- phenomena of phase transition, types of phase transition and Landau theory of second order phase transition
- Critical phenomena, critical exponent, exponent inequalities

P704: Nuclear Physics-I

Understanding the properties of Nucleus is integral to various physical phenomenon. This course develops an understanding of

- The various properties of nucleus
- Nuclear stability and factors affecting binding energy of nucleus
- Nuclear structure under different models
- Nuclear forces and scattering
- Nuclear decay
- Nuclear interactions and fission/fusion process

P704 Computational Physics - B
(only for SEMESTER-VI students of session 2021-22)

In this course both quantum and classical computational tools will be introduced. The course aims to give the students competence in the methods and techniques of calculations using computers. At the end of the course the student is expected to have

- a hands on experience in modeling.
- understanding of algorithm development.
- understanding of implementation and calculation of physical quantities of relevance in interacting many body problems in physics.

PL701: Advanced Physics Laboratory – I

After successful completion of this course student should have procedural and conceptual understanding of the following experiments

- Spectral features of photoelectric absorption and Compton scattering with scintillation detectors
- Growth of metallic thin films by physical vapor deposition techniques
- operation of a closed cycle cryostat, low temperature thermometers
- using of a dual phase lock-in amplifier. Measurement of the superconducting transition temperature of a superconducting thin film using a mutual inductance technique

PPr701: Reading Project

Student learn to carry out supervised leaning of a research topic, write the report on the topic on own words and make a presentation of the learned topic.

SEMESTER - VIII

PS01: Astronomy and Astrophysics

After successful completion of this course student should have understanding of

- Stellar physics: the equations governing the structure of stars
- various models of stellar structure with linear & quadratic density profiles.
- Stellar evolution from birth of stars to its possible end states
- structure of Milkyway and necessity of multiwavelength observations in astronomy
- active galactic nucleus
- introductory cosmology and models of the universe

PS02: Fluid Mechanics

In this course students will develop understanding of

- Stellar physics: the equations governing the structure of stars
- various models of stellar structure with linear & quadratic density profiles.
- Concept of hydrodynamics, and description of hydrodynamical systems, flow fields,
- and basic equations governing conservation of mass, momentum & energy in hydrodynamical systems
- Equation governing viscous flow, concept of shear and bulk flow viscosity, boundary layers, potential flow, , water waves and lubrication theory of flow
- Tensor representation of viral theorem, flow in magnetic fluids, Generalized Ohm's law & Ambipolar diffusion, Magneto-gravity-acoustic modes
- Stability problem in classical hydrodynamic and hydromagnetic specially Rayleigh-Taylor and Kelvin-Helmholtz instabilities. Jeans' gravitational instability; Benard convection. Parker instability and magnetic buoyancy. Thermal instability.
- Concept of accretion flows and accretion disks, shock and blast waves, hydrodynamics in supernova and blood flow in human heart

P803: Nuclear and Particle Physics

In this course students will develop understanding of

- Stellar physics: the equations governing the structure of stars
- Concept of phase shift, partial wave decomposition, cross section, scattering, optical potential
- Derivation of the resonance cross section, description of cross section, barrier penetration, resonance scattering and compound nucleus model
- Direct reaction and application to various method, high energy scattering and evolution of scattering cross section, heavy ion scattering and physics with radioactive ion beams. Single particle shell model, gas models, deformation in nuclear shape, superheavy nuclei, and spectroscopy of drip-line model
- Basic classification of particles, types of fundamental forces, relativistic kinematics of particle reactions, conservation and symmetries, conservation laws for different quantum numbers, symmetry breaking and generating of masses, families of particles, gauge theory, detection of particles (quarks and gluons)

P804: Condensed Matter Physics – II

The objective of this Advanced course in condensed matter physics is to

- Understand the Phenomenon that governs and explains superconductivity
- Look into various approaches that explain different kinds of magnetic phenomenon
- Introduce density functional theory and a view into some peculiar physical phenomenon in solids

PL801: Advanced Physics Laboratory – II

After successful completion of this course student should have learned methodology and conceptual understanding of the following experiments

- Study of orbit of a visual binary star Kruger 60. Construct an orbit diagram in order to verify that this binary system follows Kepler's law of motion
- Determine the rotational velocity of Saturn. Study the differential motion of ring particles to check that ring particles follow the Keplerian orbit, hence determine the mass of Saturn.
- Study of proper motion of 61 Cygni.
- Determine the period of Pulsars from their pulse profile in different radio frequencies. Find the dispersion by measuring delay in arrival time of pulses at two frequency bands and hence determine distances of the Pulsars.
- Study of Quasar 3C273 and determine its red-shift, recessional velocity, distance, apparent magnitude, absolute magnitude and size of the emitting region. Find that it is very compact yet very luminous object.
- Study of Hubble's law and expansion of the Universe using the spectra of different galaxy cluster fields. Determine the Hubble's constant and age of the Universe.

- Perform photoelectric photometry (in B and V filters) of Pleiades star cluster in order to construct HR Diagram and determine the distance using Main Sequence Fit method.
- Study of light curves of Cepheid Variable stars and determine the distance of Small Magellanic Cloud (SMC) using Cepheid Variable's Period Luminosity Relation.

PPr801: Project

Student will learn to carryout in house supervised research project, submit a report and make a formal presentation of the project.

SEMESTER - IX

PPr901: Project

Student will learn to carryout full semester project outside of the institute with external supervisor, submit a thesis dissertation and make formal presentation of research project.

SEMESTER - X

PE - 1: Quantum Field Theory

After successful completion of this course student should have understanding of

- reasons for the failure of relativistic quantum mechanics, such as the causality problem, and the need for quantum field theory
- the origin of particles and forces
- Analysis of the statistical distributions of identical particles and the repulsive/attractive nature of the forces as a function of spins
- Application of the Feynman rules to calculate probabilities for basic processes with particles (decay and scattering)
- Obtaining classical and/or non-relativistic limits of fully quantum and relativistic models, and identify the relativistic origin of effects such as the spin-orbit interaction
- Useing effective field theory techniques to develop models at large scales
- Describing qualitatively effects such as superconductivity, superfluidity, and ferromagnetism using the concepts of gauge invariance, Goldstone and Higgs mechanism, and spontaneous symmetry breaking.

PE - 2: General Relativity and Cosmology

The objective of this course is to make the student develop an understanding of

- The concept of spacetime in the context of Einstein's Relativity
- Gravity as curving of spacetime

- Results like precession of orbits and black holes
- Cosmology and expansion of the universe
- Gravitational and cosmological redshift

PE - 3: Experimental Techniques

After successful completion of this course student should have understanding of

- Vacuum technology
- Optical systems experimental techniques
- Detectors and its properties used for the experiments
- Particle detectors and radioactive Decay
- Basic electronics of the detectors

PE - 4: CCD Imaging and Spectroscopy

After successful completion of this course student should have understanding of

- Importance of CCD, manufacturing and operations
- Characterization of charge-coupled devices
- Method of CCD imaging, Photometry and astrometry.
- Working principle of CCD Spectrograph and astronomical spectroscopy
- CCDs used in space and at short wavelengths

PE - 5: Biophysics

After successful completion of this course student should have understanding of

- Mathematical Methods in Biophysics
- Quantum Mechanics Basic to Biophysical Methods
- Computational Modeling of Receptor–Ligand Binding and Cellular Signaling Processes
- Stochastic Simulation Algorithms used in biophysics
- Fluorescence Spectroscopy: Fundamental Process of Fluorescence
- Electrophysiological Measurements of Membrane Proteins

PE - 6: Particle Physics

After studying this course, student should be able to

- recognise and name the six flavors of lepton and the six flavors of quark.
- understand that all leptons and quarks have corresponding antiparticles
- appreciate that quarks and antiquarks combine to form baryons, antibaryons and mesons.
- write balanced strong interactions, understanding the role of gluons
- write balanced weak interactions, understanding the role of W and Z bosons

PE - 7: Nonlinear Dynamics and Chaos

In this course students will develop understanding of

- Dynamical system and their classification, phase portrait representation of dynamical system.
- 1-D map, eigen value equation and concepts and properties of eigen values.
- Stability analysis of dynamical systems, concept of fixed point, limit cycle, manifold.
- Linearization of fields, classification of fixed point, manifold theorems.
- Concepts of neighborhood, bifurcations, classification of bifurcations, bifurcations diagram
- Introduction of chaos, fractals, Hamiltonian dynamics

PE - 8: Reactor Physics and Radiation Science

After successful completion of this course student should have understanding of

- Fission process
- Interaction of Neutrons with Matter
- Concept of microscopic cross section
- Diffusion of neutrons
- Chain Reaction
- Slowing down process
- Heterogeneous reactors
- Reactor kinetics
- Neutron Poisons
- Reactivity coefficients

PE - 9: Accelerator Physics and Applications

After this course

- student will understand how different particle accelerators are designed (linear accelerators, cyclotrons and synchrotrons), as well as the possibilities and limitations of the different accelerator types
- student will master simple calculations and methods for numerical simulations describing how a particle beam is accelerated, focused and measured
- student will have knowledge of machines for high-energy physics, including studies for future linear and circular colliders
- student will have knowledge about the accelerator science research frontier, including laser- and plasma wakefield acceleration
- student will have knowledge about the most important applications of particle accelerators to particle physics, material science and medical technology
- student will master theory and techniques for numerical simulations of charged particle beams

PE - 10: Computational Physics - C

In this course both quantum and classical computational tools will be introduced. The course aims to give the students competence in the methods and techniques of calculations using computers. At the end of the course the student is expected to have

- a hands on experience in modeling.
- understanding of algorithm development.
- understanding of implementation and calculation of physical quantities of relevance in interacting many body problems in physics.

PE - 11: Glimpses of Contemporary Sciences

After successful completion of this course. Students will have understanding of

- how physics can be used to increase understanding of various life systems in nature
- modeling of thermodynamics and human population, Falling leaves, Smoke ring.
- study done in filed of Astrochemistry and Astrobiology
- process of bringing atoms to rest, and Laser tweez- ers.

PE - 12: Earth Science and Energy & Environmental Sciences

After successful completion of this course student will have exposure of

- Theories of origin of earth
- Structure of different layers of earth, plate tectonics and geodynamics and the role of mantle plumes in sustaining these processes.

- Electrical and magnetic properties of the different layers in the earth
- Geodynamo and the internal magnetic field of the earth.
- Natural calamities, hazards, and effects of human activity.
- Concept of sustainability, individual and social, and local and global actions for a sustainable future.
- Energy Sources - evolution of energy sources with time.
- Nuclear energy power production in India

PE - 13: Circuits and Electronics

This course is designed to develop students concept of basic electronics principles. After successful completion fo the course students will

- Understand the concepts of employing simple models to represent non-linear and active elements-such as the MOSFET-in circuits.
- Build circuits and take measurements of circuit variables using tools such as oscilloscopes, multimeters, and signal generators. Compare the measurements with the behavior predicted by mathematics models and explain the discrepancies.
- Understand the relationship between the mathematical representation of circuit behavior and corresponding real-life effects.
- Appreciate the practical significance of the systems developed in the course.
- Determine in the laboratory the time-domain and frequency-domain behavior of an RLC circuit. Use operational amplifier models in circuits which employ negative feedback.
- Use complex impedances to determine the frequency response of circuits.
- Determine the power dissipation in digital gates and employ CMOS technology to reduce static power losses.
- Predict how a given circuit will affect an audio signal in the laboratory given the frequency response of the circuit.
- Design, build and test an audio playback system which includes both analog and digital components.