Programme Outcome (PO):

The undergraduate (UG) course offered by the Department of Physics, Ramakrishna Mission Vivekananda Centenary College, Rahara, strictly follows the CBCS syllabus prescribed by the UGC. The course is a combination of general and advanced education, simultaneously introducing the concepts of breadth and depth in learning. The fundamental aim of UG course is to impart basic knowledge of the discipline of Physics including phenomenology, theories and techniques, concepts and general principles and links of Physics to other discipline. It is further aimed to provide a firm foundation in every aspect of Physics and to explain a broad spectrum of modern trends in physics and to develop experimental, computational and mathematics skills of students. Department of physics provides a close student-faculty interaction that helps students develop a wide and deep understanding of physics and are well-prepared for pursuing post graduate/research work in physics or related fields. The present curriculum will not only advance their knowledge and understanding of the subject, but will also increase the ability of critical thinking, development of scientific attitude, handling of problems and generating solution, improve practical skills, enhance communication skill, social interaction, increase awareness in environment related issues and recognize the ethical value system.

Programme Specific Outcomes (PSO):

The UG curriculum caters an all-round development of the student, rolling out globally ready individuals into the fast pacing world. The programme specific outcome includes:

- Imparting in students detailed knowledge in diverse premises of physics that includes classical mechanics, thermal physics, acoustics, wave optics, advanced mathematical physics, electricity & magnetism, quantum mechanics, statistical mechanics, electromagnetic theory, electronics, special theory of relativity and atomic physics, modern physics and modern communication electronics.
- Developing proficiency in designing various electronic & electrical devices for domestic, engineering, medical and/or laboratory need.
- Applying conceptual understanding of basic laws & principles of physics to analyze variety of physical phenomena of general real-world problems.
- Developing capabilities of oral and written scientific communication skill and scientific thinking to appreciate advancement of modern physics in diverse areas.
- Knowledge gained through theoretical, computational and lab based experiments will generate technical personnel in various priority areas of research on basic, applied and interdisciplinary science.
- Hands-on course associated with several theoretical papers of the curriculum provides an introduction to computational methods in solving problems in physics and other related areas. It teaches programming tactics, numerical methods and their implementation, together with methods of linear algebra. These computational methods are applied in solving problems of diverse field of science through modeling of classical physical systems

to quantum systems and also to data analysis of linear and nonlinear system of huge size for interpretation of phenomenological events.

Course Outcome (CO)	
Mathematical physics-I	On successful completion of the course, students are expected to understand the following and solve related problems: • Elementary calculus, limits & continuity, plotting functions, Taylor & binomial series. • 1st and 2nd order differential equation, integrating factor, Wronskian & general solution, Uniqueness theorem. • Exhaustive vector calculus and related problem solving ability. • Orthogonal curvilinear coordinate system, probability theory and properties of Dirac delta function.
Mathematical physics-II	On successful completion of the course student are expected to understand the following and solve related problems: • Complex numbers, Euler's formula, De Moivre's theorem, function of complex variables, Cauchy-Rieman conditions, analytic functions, singular functions, Cauchy inequality, Cauchy integral formula, Laurent and Taylor's expansion, residue and residue theorem. • Fourier transforms with examples of trigonometric, Gaussian, finite wave train & other functions. • Addition and Multiplication of Matrices, Null Matrices, Diagonal, Scalar and Unit Matrices, Upper-Triangular and Lower-Triangular Matrices, Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices, Conjugate of a Matrix.Hermitian, Skew- Hermitian Matrices, Singular and Non-Singular matrices, Orthogonal and Unitary Matrices, Trace of a Matrix, Inner Product. • Cayley- Hamiliton Theorem.Diagonalization of Matrices.Solutions of Coupled Linear Ordinary Differential Equations.Functions of a Matrix.
Mechanics	On successful completion of the course, students will 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. • Understand the analogy between translational and rotational dynamics, and application of both motions simultaneously in analyzing rolling with slipping. • Write the expression for the moment of inertia about the given axis of symmetry for different uniform mass distributions. • Understand the phenomena of collisions and idea about center of mass and laboratory frames and their correlation. • Understand the principles of elasticity through the study of Young Modulus and modulus of rigidity. • Understand simple principles of fluid flow and the equations

	governing fluid dynamics. • Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of Gravitation. • Explain the phenomena of simple harmonic motion and the properties of systems executing such motions. • 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. • Describe special relativistic effects and their effects on the mass and energy of a moving object. • Appreciate the nuances of Special Theory of Relativity (STR). • Perform experiments related to the course to acquire better understanding about the course as well as to develop skill.
Classical dynamics	On successful completion of the course, students are expected to understand the following and solve related problems: • Motion of charged particle in electric & magnetic field (for both crossed fields & parallel fields), generalized coordinates & velocities, Lagrangian and Hamiltonian formulation, canonical transformation and Poisson's bracket. • Small amplitude oscillation, point of stable equilibrium, expansion of PE around the minimum, normal modes of oscillation. • Fundamentals of fluid dynamics: continuity equation, Poiseullie's equation, Navier-Stoke's equation, turbulence. • Special theory of relativity: Postulates, Lorentz Transformations, Minkowski space, space-time diagram, Time-dilation, length contraction and twin paradox, four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.
Electricity and Magnetism	On successful completion of the course, students are expected to: • Solve problems involving linear electrical networks using the symmetry concept and/or various network theorems. • Have gained knowledge on various theorems/laws of electrostatics, dielectric properties of matter and solve variety of relevant problems. • Have in-depth knowledge of transient current responses of LR, CR, LCR circuits. • Learn complex reactance & impedance for AC circuits, Series LCR circuit: resonance, power dissipation, Q-factor, band width and solve variety of relevant problems. • Learn Biot-Savart law, Ampere's law, Faraday's law of electromagnetic induction and solve variety of relevant problems. • Perform several experiments related to the course for better understanding and developing skill.
Acoustics and Waves	On successful completion of the course, students will be able to:

optics	• Understand SHM, various types of superposition of SHMs, formation of Lissajous figure and its demonstration by mechanical and electrical methods. • Solve differential equation of free, damped and forced oscillations. • Calculate logarithmic decrement, relaxation factor and quality factor of a harmonic oscillator. • Understand energy relations, velocity and amplitude resonance, sharpness of resonance, power dissipation, band width, Q-factor. • Solve general equation of wave motion, longitudinal waves in fluids, progressive & stationary waves, phase and group velocity, energy propagation. • Know about the acoustical terms like sound intensity, loudness, intensity level, Bel, decibel, phon. • Understand vibration of stretched string: Plucked & Struck. • Gain knowledge on various theories of light. • Use principles of wave motion and superposition to explain interference, diffraction and polarization of light. • Perform experiments related to the course for better understanding.
Thermal Physics	On successful completion of the course, students are expected to: • Become familiar with various laws of thermodynamics, thermodynamic process, conversion of heat into work, Heat engines, concepts of entropy. • Solve problems involving entropy changes in a wide range of processes and determine the reversibility and irreversibility of a process from such calculations. • Realize the importance of thermodynamic potential functions and applications of Maxwell's relations. • Understand the interrelationship between thermodynamic functions and ability to use such relationships to solve practical problems. • Gain knowledge in kinetic theory of gas. • Acquire knowledge on Maxwell-Boltzman law of velocity distribution in ideal gas, collision probability, Transport phenomenon like viscosity, thermal conductivity, diffusion. • Learn behavior of real gases, Joule-Thomson effect. • Perform experiments related to the course for better understanding
Solid State Physics	On successful completion of the course, students will be able to: • Understand the basic concepts of crystal structure: Lattice (direct & reciprocal), basis, unit cell, Miller indices, Brillouin zone, atomic scattering factor & geometrical structure factor. • Understand elementary lattice vibrations (linear monoatomic & diatomic chain) and phonons (acoustical & optical), Dulong-Petit, Einstein & Debye theories of specific heats of solids. • Gain an extended knowledge about dielectric properties of materials. • Understand energy band formation in solids : Kronig-Penny model, band gap, effective mass of electrons and holes, distinction between metal, insulator and semiconductors. • Gain an extended knowledge about semiconducting properties of

	materials, carrier concentration, Fermi level, Hall effect. • Gain qualitative knowledge superconducting properties of materials, Critical magnetic field, Meissner effect. • Understand the basic principles of X-ray diffraction: von Laue equations and Bragg equation. • Gain an extended knowledge about magnetic properties of materials like diamagnetic, paramagnetic and ferromagnetic. • Perform experiments related to the course.
Quantum mechanics and applications.	On successful completion of the course, students will be able to: • Understand Schroedinger equation and dynamical evolution of quantum states, acceptability & interpretation of wave function, operators, eigen values, eigen functions, stationary states, Fourier transform & momentum space wave function, position momentum uncertainty principle. • Gain detailed knowledge on bound states in arbitrary potential. • Understand quantum mechanical simple harmonic oscillator, energy levels, energy eigen functions using Frobenius method. • Understand quantum theory of hydrogen-like atom. • Understand and explain the vector atom model, Orbital & spin angular momentum, concepts of space quantization, Stern-Gerlach Experiment, Larmour's theorem. • Understand spin-orbit coupling (L-S and j-j), spectral notations for atomic states, Hund's rule. • Explain observed dependence of atomic spectral lines on externally applied electric and magnetic field: Zeeman effect (normal & anomalous), Paschen Back & Stark effect. • Perform experiments related to the course.
Statistical mechanics	Successful completion of the course, helps students develop concepts in : • Classical laws of thermodynamics and their application, postulates of statistical mechanics, statistical interpretation of thermodynamics, microcanonical, canonical and grant canonical ensembles; the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac.
Analog systems and application	On successful completion of the course, students are expected to: • Acquire knowledge on working mechanism of various semiconductor devices like diodes, photodiode, LED, solar cell rectifiers, transistors (BJT & FET) etc and their various applications. • Gain knowledge on h-parameters of transistor. • Design of Amplifier of specific gain and troubleshooting. • Employ transistor as a switching device. • Gain detailed knowledge on OP-AMP and its versatile applications. • Understand the mechanism of feedback amplifier and oscillator. • Design of oscillator of specified frequency and troubleshooting
Digital systems and application	After successful completion of the course the student is expected to be conversant with the following: • The need and advantages of Digital Circuits. • The basics of number system and their arithmetic operations.

	• Synthesis of Boolean functions, simplification / minimisation techniques and realization of digital circuits by employing Boolean algebra. • Basic working of an oscilloscope including its different components and to deploy the same to study different wave forms and to measure voltage, current, frequency and phase. • Secure first-hand idea of different components including both active and passive components to gain an insight into circuits using discrete components and also to learn about integrated circuits. • Fundamental logic gates, combinational as well as sequential circuits. • Detailed idea on different types of Flip Flop. Their uses in design of Shift registers, Counters and timers. • Application and use of Counters, Shift Registers and Timers in real world. • Fundamentals of Computer Architecture and Organization. Basic Idea of Control System, Input – Output Devices, Memory mapping and Memory Organization • To design and implement both combinational circuits and sequential circuits by employing NAND as building blocks and demonstrate Adders, Subtractors, Flipflops, Shift Registers and Multivibrators using 555 ICs in the laboratory.
Communication Electronics	After successful completion of the course the student is expected to be conversant with the following: • Electromagnetic spectra and different frequency bands. • Comparison between Analog and Digital Communications Techniques. Benefits and limitations of Digital Communication • Concepts of Modulation and needs, Different types of modulation (Both analog and Digital) and their benefits and limitations, super heterodyne receivers. • Concept of sampling, sampling theorem and time division multiplexing. • Digital transmission, encoding and decoding. • Mobile communication/telephony and concepts of Cellular Network. • Uplink/Downlink, Handover, Cell Selection Techniques and different Subsystems of Cellular Network. • 2G, 3G, 4G and 5G (Qualitative Discussion). Multiple Access Technologies (TDMA / FDMA / CDMA). • Concepts of Satellite Communication. Concepts of transponders, different Sub Systems, positioning and orbits. • Apply the theory that they have learned in the theory class to gain hands on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to study TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.
Modern Physics	On successful completion of the course, students are expected to: • Understand the inadequacies of classical mechanics and appreciate the 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, wave packets and uncertainty principle, 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, tunnelling 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. • Perform the following experiments (i) Measurement of Planck's constant by more than one method. (ii) Verification of the photoelectric effect and determination of the (iii) Determination of the charge of electron and e/m of electron. (iv) Determination of the ionization potential of atoms. (v) Determine the wavelength of the emission lines in the spectrum of Hydrogen atom. (vi) Determine the absorption lines in the rotational spectrum of molecules. (vii) Determine the wavelength of Laser sources by single and Double slit experiments (viii) Determine the wavelength and angular spread of He-Ne Laser using plane diffraction grating. (ix) Verification of the law of the Radioactive decay and determine the mean life time of a Radioactive Source, Study the absorption of the electrons from Beta decay. Study of the electron spectrum in Radioactive Beta decays of nuclei. (x) Plan and Execute 2-3 group projects in the field of Atomic, Molecular and Nuclear Physics in collaboration with other institutions, if, possible where advanced facilities are available work Function of a metal
Computational Physics	On successful completion of the course, students should be able to : • Identify modern programming methods and describe the extent and limitations of computational methods in physics. • Identify and describe the characteristics of various numerical

	methods. • Independently program computers using leading-edge tools. • Formulate and computationally solve a selection of problems in physics. • Apply Monte Carlo simulations. • Numerically solve systems of nonlinear equations. • Numerically calculate eigenvalues and eigenvectors of a matrix. • Numerically calculate multiple integrals. (TRAPIZOIDAL, SIMPSON'S 1/3 METHOD etc.) • Numerically calculate differentiation.(EULAR'S, RK-2 METHOD etc.) • Solve physical problems using modern computational software. (SCILAB, MATLAB etc.) Visualize physical problems and their solutions on a computer. Use PYTHON programming language in a great detail. Plot graphs from the equations with the help of various SOFTWARES as well as directly from writing a program in PYTHON programming language
Electromagnetic theory	After successful completion of the course the student is expected to be conversant with the following: • 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. • Analyze 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 electromagnetic waves. Production as well as detection of waves in laboratory. • Understand propagation of electromagnetic 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. • Understand the features of planar optical wave guide and obtain the Electric field components, Eigen value equations, phase and group velocities in a dielectric wave guide. • Understand the fundamentals of propagation of electromagnetic waves through optical fibres and calculate numerical apertures for step and graded indices and transmission losses. • In the laboratory course, the student gets an opportunity to perform

	experiments to (i) Demonstrate principles of Interference, Refraction and diffraction of light using monochromatic sources of light. Demonstrate interference, Refraction and Diffraction using microwaves. (ii) Determine the refractive index of glass and liquid using total internal reflection of light. (iii) Verify the laws of Polarisation for plane polarised light. (iv) Determine Polarisation of light by Reflection and determine the polarization angle off or air-glass surface (v) Determine the wavelength and velocity of Ultrasonic waves in liquids using diffraction. (vi) Study specific rotation of sugar using Polarimeter. (vii) Analyse experimentally the Elliptically Polarised light using Babinet's Compensator (viii) Study Experimentally the angle dependence of radiation for a simple dipole antenna. (ix) Plan and Execute 2-3 group projects for designing new experiments based on the Syllabi