DEPARTMENT OF PHYSICS

PROGRAMME OUTCOMES:

The program outcome of the undergraduate physics courses under the CBCS syllabus at the University of Kalyani would focus on equipping students with a deep understanding of fundamental and advanced physics concepts. Here's how the outcomes can be articulated:

1. **Enhanced Analytical and Problem-Solving Skills:** Students will develop strong analytical skills through rigorous training in mathematical physics, classical mechanics, and quantum mechanics. They will be able to formulate and solve complex physical problems, both analytically and numerically.
2. **Comprehensive Understanding of Fundamental Physics:** Through courses in general properties of matter, thermal physics, optics, and electricity & magnetism, students will gain an in-depth understanding of the core principles that govern the physical world.
3. **Practical Skills and Experimentation:** Hands-on experience in laboratory courses will allow students to connect theory with practice. They will learn to conduct experiments, analyze data, and interpret results, thus building essential skills for scientific research or industry work.
4. **Critical Thinking and Application of Knowledge:** The program will foster critical thinking, enabling students to apply physics concepts to real-world situations and interdisciplinary contexts. They will be prepared to tackle contemporary challenges in physics and related fields.
5. **Communication and Collaboration:** Students will enhance their ability to communicate complex scientific ideas effectively, both in written and oral form. They will also learn to work collaboratively in teams, which is essential in research and professional environments.
6. **Preparation for Advanced Studies and Careers:** The program will prepare students for further studies in physics or related fields, as well as for careers in academia, research, and industry. Graduates will be well-equipped to pursue postgraduate education or professional roles in various sectors.
7. **Ethical and Social Responsibility:** Students will understand the ethical implications of scientific research and technology. They will be aware of their social responsibilities as physicists, contributing to society through scientific knowledge and innovation.

These outcomes ensure that students not only acquire knowledge but also develop the skills necessary to succeed in their future academic and professional endeavors

COURSE OUTCOMES:

PHY-G-CC-T-01: MATHEMATICAL PHYSICS-I

Upon successful completion of this course, students will be able to:

1. **Understand Fundamental Concepts of Calculus**: Demonstrate a solid understanding of the foundational principles of calculus, including limits, continuity, differentiation, and integration, and apply these concepts to solve real-world problems.

2. **Apply Vector Calculus**: Utilize vector algebra and vector calculus, including gradient, divergence, and curl, to analyze and solve problems related to fields, fluid flow, and electromagnetism.
3. **Perform Vector Integration**: Execute line, surface, and volume integrals, and apply the theorems of Green, Gauss, and Stokes to evaluate complex integrals in various coordinate systems.
4. **Analyze Orthogonal Curvilinear Coordinates**: Understand and apply orthogonal curvilinear coordinate systems (such as cylindrical and spherical coordinates) to solve problems involving more complex geometries in physics and engineering.
5. **Utilize the Dirac Delta Function**: Understand the concept of the Dirac delta function, its properties, and its significance in physics and engineering, and apply it in scenarios such as charge distributions and impulse forces.
6. **Integrate Knowledge Across Topics**: Combine the understanding of calculus, vector calculus, vector integration, orthogonal curvilinear coordinates, and the Dirac delta function to solve multi-disciplinary problems in science and engineering.
7. **Develop Analytical and Problem-Solving Skills**: Enhance analytical thinking by solving complex mathematical problems and develop the ability to apply mathematical methods to physical phenomena.

PHY-G-CC-P-01: MATHEMATICAL PHYSICS-I

Upon successful completion of this practical course, students will be able to:

1. **Develop Proficiency in Scientific Computing Tools**: Demonstrate foundational skills in scientific computing, including familiarity with software such as Gnuplot, Origin, and Excel for data visualization and graph plotting.
2. **Understand Errors and Perform Error Analysis**: Comprehend the different types of errors encountered in numerical computations and carry out systematic error analysis to evaluate the accuracy and reliability of numerical results.
3. **Acquire Programming Skills**: Gain introductory programming skills in Python, Fortran, MATLAB, or C, and apply these skills to implement and solve computational problems.
4. **Generate Random Numbers**: Understand and implement algorithms for random number generation, and apply these to various computational simulations and statistical analysis.
5. **Solve Algebraic and Transcendental Equations**: Implement numerical methods such as Bisection, Newton-Raphson, and Secant methods to accurately solve algebraic and transcendental equations.
6. **Perform Interpolation and Error Estimation**: Apply Newton-Gregory forward and backward difference formulas for interpolation, and estimate errors in linear interpolation, enhancing the precision of numerical approximations.
7. **Conduct Numerical Differentiation and Integration**: Utilize numerical differentiation methods (forward and backward difference formulas) and numerical integration techniques (Trapezoidal and Simpson's rules) to solve problems involving differentiation and integration with high accuracy.
8. **Apply the Monte Carlo Method**: Understand and implement the Monte Carlo method for solving problems involving probabilistic and statistical computations.
9. **Integrate Knowledge Across Topics**: Synthesize the computational techniques learned to solve complex numerical problems, ensuring a solid understanding of the practical applications of numerical methods in scientific research.

10. **Develop Computational Thinking and Problem-Solving Skills**: Enhance computational thinking by solving practical numerical problems and develop the ability to apply numerical methods in scientific computing across various disciplines.

PHY-G-CC-T-01: MECHANICS

Upon successful completion of this course, students will be able to:

1. **Understand the Fundamentals of Dynamics**: Grasp the basic principles of dynamics, including Newton's laws of motion, and apply these concepts to analyze the motion of particles and systems under various forces.
2. **Analyze Work and Energy**: Understand the concepts of work, kinetic energy, potential energy, and the work-energy theorem, and apply these to solve problems involving conservative and non-conservative forces.
3. **Understand and Solve Collisions**: Analyze elastic and inelastic collisions using the principles of conservation of momentum and energy, and solve problems involving collisions in one and two dimensions.
4. **Apply Rotational Dynamics**: Understand the dynamics of rotational motion, including torque, angular momentum, and moment of inertia, and apply these concepts to problems involving rotating bodies and systems.
5. **Understand Fluid Motion**: Grasp the principles of fluid dynamics, including the continuity equation, Bernoulli's principle, and viscosity, and apply these to solve problems involving fluid flow and pressure.
6. **Grasp Gravitation and Central Force Motion**: Understand the laws of gravitation, central force motion, and their applications to planetary orbits, satellite motion, and the dynamics of celestial bodies.
7. **Analyze Oscillatory Motion**: Understand simple harmonic motion, damped and forced oscillations, and resonance, and apply these concepts to mechanical and physical systems.
8. **Understand Non-Inertial Systems**: Grasp the dynamics of non-inertial reference frames, including the concepts of fictitious forces like the Coriolis and centrifugal forces, and apply them to solve problems in rotating systems.
9. **Comprehend the Special Theory of Relativity**: Understand the postulates of special relativity, time dilation, length contraction, and the relativistic addition of velocities, and apply these concepts to problems involving high-velocity systems.
10. **Integrate and Apply Concepts**: Synthesize knowledge of dynamics, energy, rotation, fluids, gravitation, oscillations, non-inertial systems, and relativity to solve complex physical problems, enhancing analytical and problem-solving skills across a wide range of physical scenarios.

PHY-G-CC-P-01: MECHANICS

Upon completing this practical course, students will:

1. **Gain Proficiency in Precision Measurement Tools**: Develop skills in using Vernier calipers, screw gauges, and traveling microscopes to make precise measurements of length, diameter, and small distances, essential for conducting accurate experimental physics.
2. **Understand Random Errors in Observations**: Learn to analyze and quantify random errors in experimental data, improving their understanding of measurement uncertainty and data reliability.

3. **Apply Trigonometry in Real-World Problems**: Use a sextant to measure angles and apply trigonometric principles to determine the height of buildings or other tall structures, demonstrating practical applications of theoretical concepts.
4. **Explore Spring Dynamics**: Study the motion of a spring and calculate the spring constant and acceleration due to gravity (g), reinforcing their understanding of oscillatory motion and Hooke's law.
5. **Analyze Rotational Motion**: Determine the moment of inertia of a flywheel or rigid body, deepening their comprehension of rotational dynamics and its applications in various mechanical systems.
6. **Measure Free Fall with Precision**: Use digital timing techniques to determine the acceleration due to gravity and the velocity of a freely falling body, enhancing their skills in precise timing and motion analysis.

This course provides hands-on experience with fundamental physics principles, measurement techniques, and error analysis, fostering a deeper understanding of the physical world and preparing students for advanced experimental work.

PHY-G-CC-T-01: ELECTRICITY AND MAGNETISM

Upon successful completion of this course, students will be able to:

1. **Understand Electric Fields and Potentials**: Comprehend the fundamental concepts of electric fields, electric forces, and electric potential, and apply them to analyze the behavior of charges in various configurations.
2. **Analyze Dielectric Properties of Matter**: Understand the role of dielectric materials in electric fields, including polarization, dielectric constant, and energy storage, and apply this knowledge to solve problems involving capacitors and insulators.
3. **Understand Magnetic Fields and Forces**: Grasp the concepts of magnetic fields and magnetic forces on moving charges and current-carrying conductors, and apply these principles to analyze the behavior of magnets and electromagnets.
4. **Explore Magnetic Properties of Matter**: Study the magnetic properties of materials, including diamagnetism, paramagnetism, and ferromagnetism, and understand their applications in various technologies.
5. **Apply Electromagnetic Induction**: Understand Faraday's law of electromagnetic induction and Lenz's law, and apply these principles to generate and control electric currents in practical applications such as transformers and electric motors.
6. **Analyze Electrical Circuits**: Develop proficiency in analyzing both DC and AC circuits, understanding the behavior of resistors, capacitors, and inductors, and applying Ohm's law, Kirchhoff's laws, and the concept of impedance.
7. **Apply Network Theorems**: Utilize network theorems, such as Thevenin's and Norton's theorems, to simplify and solve complex electrical circuits, enhancing problem-solving skills in circuit analysis.
8. **Understand the Ballistic Galvanometer**: Learn the principles and operation of the ballistic galvanometer, and apply it to measure charge and magnetic flux, deepening their understanding of transient currents and electromagnetic measurement techniques.
9. **Integrate Electromagnetic Concepts**: Synthesize knowledge of electric and magnetic fields, electromagnetic induction, and circuit theory to solve complex problems in electromagnetism, fostering a comprehensive understanding of electromagnetic systems.

10. **Develop Analytical and Practical Skills**: Enhance analytical thinking by solving theoretical and practical problems, preparing students for advanced studies and applications in electrical engineering, electronics, and related fields.

PHY-G-CC-P-01: ELECTRICITY AND MAGNETISM

Upon completing this practical course, students will:

1. **Master the Use of a Multimeter**: Develop proficiency in using a multimeter for measuring resistances, AC and DC voltages, DC current, capacitances, and checking electrical fuses, which are essential skills for troubleshooting and testing electronic circuits.
2. **Analyze RC Circuit Behavior**: Study the characteristics of a series RC circuit, including its response to AC signals, phase relationships, and time constants, deepening their understanding of capacitor and resistor interactions in circuits.
3. **Measure Low Resistances Accurately**: Learn to determine unknown low resistances using both a potentiometer and Carey Foster's bridge, gaining expertise in precision measurement techniques.
4. **Compare Capacitances**: Apply De Sauty's bridge to compare capacitances, understanding the principles behind capacitance measurement and bridge circuits.

This course equips students with hands-on experience in advanced electrical measurement techniques, circuit analysis, and the application of key electrical theorems, preparing them for practical challenges in electronics, electrical engineering, and experimental physics.

PHY-G-CC-T-02: WAVES AND OPTICS

Upon successful completion of this course, students will be able to:

1. **Analyze Superposition of Harmonic Oscillations**: Understand and mathematically describe the superposition of collinear harmonic oscillations and two perpendicular harmonic oscillations, leading to the formation of Lissajous figures and understanding the conditions for constructive and destructive interference.
2. **Understand Wave Motion and Wave Velocity**: Grasp the fundamental principles of wave motion, including transverse and longitudinal waves, and calculate the velocity of waves in different media, applying these concepts to physical systems such as sound waves and water waves.
3. **Study Superposition of Harmonic Waves**: Analyze the superposition of two harmonic waves, understanding concepts like beat frequency, standing waves, and the formation of interference patterns in both one and two dimensions.
4. **Explore Wave Optics**: Comprehend the principles of wave optics, contrasting it with ray optics, and apply it to phenomena such as interference, diffraction, and polarization, providing a deeper understanding of light as a wave.
5. **Understand Interference and Interferometers**: Study the conditions for constructive and destructive interference, apply these concepts to multi-beam interference, and explore the

working principles of interferometers like the Michelson interferometer for precise measurements.

6. **Analyze Diffraction Patterns**: Differentiate between Fraunhofer and Fresnel diffraction, and understand the formation of diffraction patterns from single slits, double slits, and gratings, enabling the application of these concepts to the analysis of optical instruments and systems.
7. **Apply the Principles of Diffraction**: Understand the mathematical treatment of Fraunhofer and Fresnel diffraction, and use these concepts to solve problems involving the resolution of optical systems, such as telescopes and microscopes.
8. **Integrate Knowledge of Wave Phenomena**: Synthesize the principles of wave motion, interference, and diffraction to explain complex optical phenomena, preparing for advanced studies in optics, quantum mechanics, and related fields.
9. **Develop Analytical Skills**: Enhance problem-solving skills by applying mathematical tools to analyze oscillatory and wave phenomena, laying a strong foundation for both theoretical and experimental physics.

PHY-G-CC-P-02: WAVES AND OPTICS

Upon completing this practical course, students will:

1. **Determine Frequency Using Melde's Experiment**: Measure the frequency of an electric tuning fork using Melde’s experiment and verify the X^2-T law, enhancing their understanding of resonance and harmonic motion.
2. **Investigate Coupled Oscillators**: Study the motion of coupled oscillators, including the analysis of normal modes and the effects of coupling on oscillatory systems, deepening their knowledge of complex harmonic systems.
3. **Analyze Lissajous Figures**: Investigate and interpret Lissajous figures produced by the superposition of two perpendicular harmonic oscillations, gaining insights into phase relationships and oscillatory behavior.
4. **Familiarize with Optical Instruments**: Learn to use optical instruments, including Schuster's focusing technique and the determination of the angle of a prism, developing practical skills in optical measurements.

This practical course equips students with hands-on experience in oscillations, wave phenomena, and optical measurements, providing essential skills for analyzing and understanding wave optics and interference patterns

PHY-G-CC-T-02: MATHEMATICAL PHYSICS-II

Upon successful completion of this course, students will be able to:

1. **Analyze Fourier Series**: Understand and apply Fourier series to represent periodic functions as sums of sine and cosine terms, analyze the convergence of Fourier series, and solve problems involving signal processing, heat conduction, and wave motion.
2. **Apply the Frobenius Method**: Use the Frobenius method to find series solutions to linear differential equations with regular singular points, gaining expertise in solving differential equations that arise in physical problems.

3. **Evaluate Special Integrals**: Solve and apply special integrals commonly used in physics and engineering, such as Gamma and Beta functions, to evaluate complex integrals and simplify problems involving special functions.
4. **Understand Theory of Errors**: Analyze and quantify experimental and observational errors using the theory of errors, including error propagation, significant figures, and statistical methods to ensure the reliability and accuracy of scientific measurements.
5. **Solve Partial Differential Equations (PDEs)**: Understand and solve partial differential equations, including the heat equation, wave equation, and Laplace's equation, using various analytical and numerical techniques, and apply these solutions to problems in physics and engineering.
6. **Integrate Mathematical Methods**: Synthesize knowledge of Fourier series, special functions, error theory, and PDEs to approach and solve complex problems in theoretical and applied physics, enhancing analytical and problem-solving skills.

This course provides students with a comprehensive toolkit of advanced mathematical methods, preparing them for complex problem-solving in physics, engineering, and related fields.

PHY-G-CC-T-02: THERMAL PHYSICS

Students taking this course will learn the following:

1. Students will understand the fundamental concepts of thermal equilibrium, internal energy, and the principle of conservation of energy as applied to thermodynamic systems.
2. They will learn about the directionality of natural processes, the concept of entropy, and the importance of irreversibility in thermodynamic systems.
3. Students will explore the quantitative measure of disorder in a system and its implications for the efficiency of thermodynamic processes.
4. They will study different thermodynamic potentials (such as enthalpy, Helmholtz free energy, and Gibbs free energy) and their applications in determining the spontaneity of processes and equilibrium conditions.
5. The course will cover the derivation and application of these relations to solve thermodynamic problems involving changes in state variables.
6. Students will learn about the microscopic description of gases, including the derivation of the ideal gas law, assumptions of kinetic theory, and the concept of temperature from a molecular perspective.
7. They will study the statistical distribution of molecular speeds in a gas, specifically Maxwell-Boltzmann distribution, and its significance in predicting the behavior of gases.
8. The course will cover the dynamics of collisions between gas molecules, mean free path, and transport phenomena such as viscosity, thermal conductivity, and diffusion.
9. Students will learn about deviations from ideal gas behavior, the concept of intermolecular forces, and equations of state such as the van der Waals equation.

Overall, students will gain a deep understanding of the principles governing thermodynamic systems and the behavior of gases, both ideal and real.

PHY-G-CC-P-02: THERMAL PHYSICS

Upon completing this practical course, students will:

1. Measure the mechanical equivalent of heat (J) using Callender and Barne's constant flow method, understanding the relationship between mechanical work and heat energy, and reinforcing the principles of thermodynamics.
2. Determine the coefficient of thermal conductivity of copper using Searle's apparatus, gaining practical knowledge in heat transfer and the thermal properties of materials.
3. Learn to determine the coefficient of thermal conductivity of copper by Angstrom's method, applying alternative techniques to study heat conduction in metals.
4. Use Lee and Charlton's disc method to determine the thermal conductivity of a poor conductor, such as glass or rubber, and understand the differences in thermal properties between good and bad conductors.
5. Measure the temperature coefficient of resistance using a platinum resistance thermometer (PRT), enhancing understanding of how electrical resistance varies with temperature in conductors.
6. Investigate the variation of thermo-electromotive force (Thermo-EMF) in a thermocouple as a function of the temperature difference between its two junctions, and apply this knowledge in temperature measurement and control systems.
7. Calibrate a thermocouple to measure temperatures within a specified range using both the null method and direct measurement with an operational amplifier difference amplifier, learning to determine the neutral temperature and improve accuracy in temperature measurement.
8. Measure the boiling point of a liquid using a platinum resistance thermometer, understanding the practical application of PRTs in determining critical thermal properties of substances.
9. Determine the melting point of a solid using a thermocouple, enhancing the ability to accurately measure phase transitions in materials.

This practical course equips students with hands-on experience in thermal physics, allowing them to measure key thermal properties such as thermal conductivity, mechanical equivalent of heat, and temperature coefficients. These experiments provide a strong foundation for understanding heat transfer, temperature measurement, and the practical applications of thermodynamics in real-world scenarios.

PHY-G-CC-T-02: DIGITAL SYSTEMS AND APPLICATIONS

Upon successful completion of this course, students will be able to:

1. Gain a thorough understanding of integrated circuits, including their design, functionality, and applications in electronic devices, laying a foundation for advanced studies in electronics and digital systems.
2. Learn to operate a Cathode Ray Oscilloscope (CRO) for observing and analyzing electronic signals, mastering techniques for measuring voltage, frequency, phase, and waveform characteristics.
3. Understand the principles of digital circuits, including logic gates, combinational and sequential circuits, and apply Boolean algebra to design and optimize these circuits for various applications.

4. Use Boolean algebra to simplify logic expressions, design efficient digital circuits, and troubleshoot digital systems, ensuring students can approach complex logic problems methodically.
5. Design and analyze data processing circuits such as multiplexers, demultiplexers, encoders, decoders, and arithmetic circuits like adders and subtractors, applying these concepts in digital computing and communication systems.
6. Explore the design and application of sequential circuits, including flip-flops, counters, and registers, with a focus on timing analysis, state diagrams, and practical implementation in digital systems.
7. Study and design circuits using timers like the 555 timer and shift registers, understanding their role in timing, sequencing, and data storage in digital electronics.
8. Gain insights into computer organization, including memory architecture, data paths, and control units, enabling students to understand how hardware and software interact in computing systems.
9. Understand the architecture and instruction set of the Intel 8085 microprocessor, including programming techniques, interfacing, and applications in embedded systems, providing a strong foundation for microprocessor-based design.
10. Synthesize concepts from integrated circuits, digital logic, and microprocessor architecture to design and troubleshoot complex digital systems, preparing for advanced work in electronics, computer engineering, and embedded systems.

This course equips students with a comprehensive understanding of digital electronics, circuit design, and microprocessor architecture, providing essential skills for careers in electronics, computer science, and related fields.

PHY-G-CC-T-03: MATHEMATICAL PHYSICS-III

Upon successful completion of this course, students will be able to:

1. **Apply Complex Analysis**: Understand and apply the principles of complex analysis, including complex functions, contour integration, and residue theorem, to solve problems in physics and engineering, particularly in fields like quantum mechanics and electromagnetic theory.
2. **Utilize Integral Transforms**: Master integral transforms such as Fourier and Laplace transforms, and use them to simplify and solve differential equations, analyze signals, and model systems in various domains of physics and engineering.
3. **Perform Numerical Computations**: Develop proficiency in numerical computation using programming languages such as Python, Matlab, Octave, or Fortran, and apply these skills to solve complex mathematical problems, simulate physical systems, and analyze data.
4. **Solve Differential Equations Using Frobenius Method**: Apply the Frobenius method to find solutions to linear differential equations with regular singular points, enhancing problem-solving abilities in contexts like wave mechanics, heat conduction, and fluid dynamics.
5. **Understand and Apply Special Functions**: Learn and apply special functions (e.g., Bessel functions, Legendre polynomials) that commonly arise in physics, enabling students to solve problems in areas such as quantum mechanics, electrostatics, and fluid dynamics.
6. **Integrate Mathematical Techniques**: Synthesize knowledge of complex analysis, integral transforms, numerical methods, and special functions to tackle advanced problems in theoretical and applied physics, improving analytical and computational skills.

This course equips students with essential mathematical tools and computational techniques, preparing them for research and professional work in physics, engineering, and applied mathematics

PHY-G-CC-T-03: ELEMENTS OF MODERN PHYSICS

1. **Understand Nuclear Structure and Radioactivity**: Explore the structure and stability of atomic nuclei, learn about the liquid drop model, nuclear shell model, and binding energy, and understand the nature of nuclear forces, radioactivity, and the processes of alpha, beta, and gamma decay.
2. **Analyze Nuclear Reactions**: Understand nuclear fission and fusion processes, including mass defect, energy generation, and the operation of nuclear reactors, along with the role of fusion in stellar energy production.
3. **Learn the Principles of Lasers**: Study the principles of laser operation, including Einstein's A and B coefficients, metastable states, optical pumping, population inversion, and the distinction between spontaneous and stimulated emission.

This course equips students with a deep understanding of quantum mechanics, nuclear physics, and laser technology, preparing them for advanced studies and research in modern physics and related fields.

PHY-G-CC-P-03: ELEMENTS OF MODERN PHYSICS

After completing this practical course, students will learn:

1. Measure Planck's constant using black body radiation and photo-detector, and LEDs, gaining hands-on experience with fundamental quantum mechanics concepts.
2. Explore the relationship between photo current and light intensity, and understand how the energy of photo-electrons relates to light frequency, reinforcing the principles of the photoelectric effect.
3. Determine the work function of a material in a vacuum diode, deepening their understanding of electron emission and material properties.
4. Measure the wavelength of the H-alpha emission line of hydrogen, and analyze absorption lines in iodine vapor's rotational spectrum, gaining skills in atomic and molecular spectroscopy.
5. Determine the ionization potential of mercury and the charge-to-mass ratio (e/m) of an electron, reinforcing key concepts in atomic physics.
6. Demonstrate and analyze the quantum tunneling effect using a tunnel diode, linking theoretical concepts to real-world applications.
7. Accurately measure slit widths using single and double slit diffraction, enhancing their skills in optical experimentation and analysis.
8. Set up and use the Millikan oil drop experiment to determine the charge of an electron, solidifying their understanding of one of the most important experiments in physics.

This course provides students with practical experience in quantum mechanics, atomic physics, and optics, helping them connect theoretical principles with experimental observations.

PHY-G-CC-T-03: ANALOG SYSTEMS AND APPLICATIONS

After completing this course, students will learn:

1. **Semiconductor Diodes**: Understand the working principles of semiconductor diodes, including PN junctions, and explore their applications in rectification, signal processing, and voltage regulation.
2. **Two-Terminal Devices**: Gain knowledge of various two-terminal devices such as Zener diodes, LEDs, photodiodes, and their applications in electronics, including voltage stabilization, light emission, and photodetection.
3. **Bipolar Junction Transistors (BJTs)**: Comprehend the structure, operation, and characteristics of BJTs, and apply this knowledge to design and analyze transistor-based circuits like switches and amplifiers.
4. **Amplifiers**: Learn the principles of amplification, including the operation of common-emitter, common-base, and common-collector amplifiers, and understand the importance of biasing and stability in amplifier circuits.
5. **Feedback in Amplifiers**: Explore the concept of feedback in amplifiers, its types, and its impact on gain stability, bandwidth, and distortion, leading to the design of more efficient and stable amplifiers.
6. **Sinusoidal Oscillators**: Understand the theory and design of sinusoidal oscillators, including RC, LC, and crystal oscillators, and their applications in generating stable frequency signals.
7. **Operational Amplifiers (Op-Amps)**: Study the characteristics and applications of operational amplifiers, including ideal and real Op-Amp models, and analyze circuits like inverting, non-inverting, differential, and integrator configurations.
8. **Applications of Op-Amps**: Apply Op-Amps in practical circuits such as filters, comparators, waveform generators, and voltage regulators, enhancing their ability to design versatile and functional electronic systems.

This course equips students with a solid foundation in analog electronics, enabling them to design, analyze, and implement a wide range of electronic circuits and systems.

PHY-G-CC-P-03: ANALOG SYSTEMS AND APPLICATIONS

After completing this practical course, students will learn:

1. Analyze the V-I characteristics of PN junction diodes, LEDs, and Zener diodes, and understand their applications in voltage regulation and light emission.
2. Study the V-I and power curves of solar cells, and learn how to find the maximum power point and efficiency, providing insight into renewable energy technologies.
3. Investigate the characteristics of BJTs in common-emitter configuration and understand their behavior under different biasing configurations, crucial for transistor-based circuit design.
4. Design and build a CE transistor amplifier with a specified gain, explore the frequency response of RC-coupled amplifiers, and evaluate the performance of class A amplifiers.
5. Learn to design and analyze various oscillator circuits, including Wien bridge, phase shift, and Colpitts oscillators, which are fundamental in generating stable signals.
6. Gain practical experience in designing digital-to-analog (DAC) and analog-to-digital converters (ADC), understanding their importance in interfacing digital systems with the analog world.
7. Design inverting and non-inverting amplifiers using Op-Amps, study their frequency response, and apply this knowledge to develop precision analog circuits.

This course provides students with hands-on experience in semiconductor devices, transistor circuits, oscillators, and signal conversion, bridging theoretical knowledge with practical electronics applications.

PHY-G-CC-T-04: QUANTUM MECHANICS AND APPLICATIONS

After completing this course, students will learn:

1. **Fundamentals of Quantum Mechanics**: Understand the time-dependent and time-independent Schrödinger equations and their applications in describing quantum systems.
2. **Hamiltonian Operator**: Analyze the role of the Hamiltonian in quantum mechanics and its connection to energy eigenvalues and eigenstates.
3. **Bound States in Potentials**: Gain insight into the general properties of bound states in arbitrary potentials, crucial for understanding quantum confinement and particle behavior in potential wells.
4. **Quantum Theory of Hydrogen-like Atoms**: Explore the quantum mechanics of hydrogen-like atoms, including the derivation of energy levels, wavefunctions, and their physical significance.
5. **Atoms in Electric and Magnetic Fields**: Learn how external electric and magnetic fields influence atomic energy levels and structure, including the Stark and Zeeman effects.
6. **Many-Electron Atoms**: Understand the complexities of many-electron atoms, including electron-electron interactions, the Pauli exclusion principle, and the configuration of electrons in multi-electron systems.

This course equips students with a deep understanding of quantum mechanics, particularly in the context of atomic systems, preparing them for advanced studies and research in quantum physics and related fields.

PHY-G-CC-T-04: SOLID STATE PHYSICS

After completing this course, students will learn:

1. **Crystal Structure**: Understand the basic concepts of crystal structures, including unit cells, Bravais lattices, and crystal symmetry, essential for analyzing the solid-state properties of materials.
2. **Elementary Lattice Dynamics**: Gain knowledge about lattice vibrations, phonons, and their role in thermal properties, heat capacity, and thermal conductivity of solids.
3. **Magnetic Properties of Matter**: Explore different types of magnetism (diamagnetism, paramagnetism, ferromagnetism), magnetic domains, and how these properties arise from atomic structure and electron configuration.
4. **Dielectric Properties of Materials**: Learn about dielectric constant, polarization mechanisms, and the behavior of materials in an electric field, along with applications in capacitors and insulators.
5. **Ferroelectric Properties of Materials**: Understand ferroelectricity, spontaneous polarization, hysteresis, and applications in memory devices and sensors.
6. **Elementary Band Theory**: Comprehend the basics of electronic band structure, the distinction between conductors, semiconductors, and insulators, and the concept of energy bands in solids.
7. **Superconductivity**: Explore the phenomenon of superconductivity, Meissner effect, critical temperature, and the applications of superconducting materials in technology and research.

This course provides a foundational understanding of the physical properties of materials, preparing students for advanced studies in condensed matter physics and materials science.

PHY-G-CC-P-04: SOLID STATE PHYSICS

After completing the practical course with the mentioned experiments, students will learn:

1. **Magnetic Properties**: Understand and measure the magnetic susceptibility of both paramagnetic solutions and solids, gaining insights into their magnetic behavior.
2. **Piezoelectricity**: Learn how to determine the coupling coefficient of a piezoelectric crystal, exploring the relationship between mechanical and electrical energy in materials.
3. **Dielectric Properties**: Measure the dielectric constant of materials and investigate its frequency dependence, which is crucial for understanding capacitor behavior and material properties in electric fields.
4. **Surface Plasmon Resonance (SPR)**: Determine the complex dielectric constant and plasma frequency of metals using SPR, and measure the refractive index of dielectric layers, which are important for optical applications.
5. **Ferroelectricity**: Study the polarization-electric field (PE) hysteresis loop of a ferroelectric crystal, which is vital for understanding memory storage devices.
6. **Magnetic Hysteresis**: Analyze the BH curve of ferromagnetic materials like iron and calculate energy loss due to hysteresis, providing practical insights into magnetic materials' performance.
7. **Semiconductor Properties**: Measure the resistivity and band gap of semiconductors as a function of temperature, and determine the Hall coefficient, which are key in characterizing and understanding semiconductors.
8. **Mutual Inductance**: Measure the mutual inductance between coaxial coils, which is fundamental to the operation of transformers and inductive coupling systems.

PHY-G-CC-T-04: ELECTROMAGNETIC THEORY

After completing this course, students will learn:

1. **Maxwell's Equations**: Understand the fundamental equations governing electromagnetism, including Gauss's laws for electric and magnetic fields, Faraday's law of induction, and Ampère's law with Maxwell's addition. These equations describe how electric and magnetic fields interact and propagate.
2. **Electromagnetic Wave Propagation in Unbounded Media**: Analyze the behavior of electromagnetic waves traveling through free space or vacuum, including wave speed, wavelength, and frequency, and how these waves can be described using sinusoidal functions.
3. **Electromagnetic Waves in Bounded Media**: Explore how electromagnetic waves propagate through various materials, including dielectrics and conductors. Understand the concepts of wave impedance, reflection, refraction, and attenuation in bounded media.
4. **Polarization of Electromagnetic Waves**: Learn about the different types of polarization (linear, circular, and elliptical) and how electromagnetic waves can be polarized by passing through polarizing materials or reflecting off surfaces.
5. **Rotatory Polarization**: Study the phenomena of optical rotation and the Faraday effect, where the plane of polarization of light is rotated due to interactions with magnetic fields in certain materials.
6. **Wave Guides**: Understand the principles of wave propagation in waveguides, including rectangular and cylindrical waveguides. Learn how waveguides confine and direct

electromagnetic waves and their applications in communication systems and microwave engineering.

This course provides a comprehensive foundation in electromagnetism, focusing on wave phenomena and their applications in various media and technologies.

PHY-G-CC-T-04: STATISTICAL MECHANICS

After completing this course, students will learn:

1. **Classical Statistics**: Understand the basics of classical statistical mechanics, including the Maxwell-Boltzmann distribution, which describes the statistical behavior of particles in a classical system and helps in calculating thermodynamic properties.
2. **Classical Theory of Radiation**: Explore the classical theory of blackbody radiation, including Planck's law and the Rayleigh-Jeans law, and understand phenomena such as blackbody spectra and the ultraviolet catastrophe.
3. **Quantum Theory of Radiation**: Learn about quantum mechanics' approach to radiation, including the quantization of electromagnetic fields, the Planck-Einstein relation, and the quantum description of radiation fields (photons).
4. **Bose-Einstein Statistics**: Study the statistical distribution of indistinguishable bosons, including the Bose-Einstein distribution function, and understand phenomena such as Bose-Einstein condensation and its applications in low-temperature physics.
5. **Fermi-Dirac Statistics**: Understand the statistical distribution of indistinguishable fermions, including the Fermi-Dirac distribution function, and its implications for electron behavior in solids, such as the properties of metals and semiconductors.

This course provides a thorough grounding in statistical mechanics and quantum statistics, bridging classical and quantum theories and their applications in understanding radiation and particle behavior.