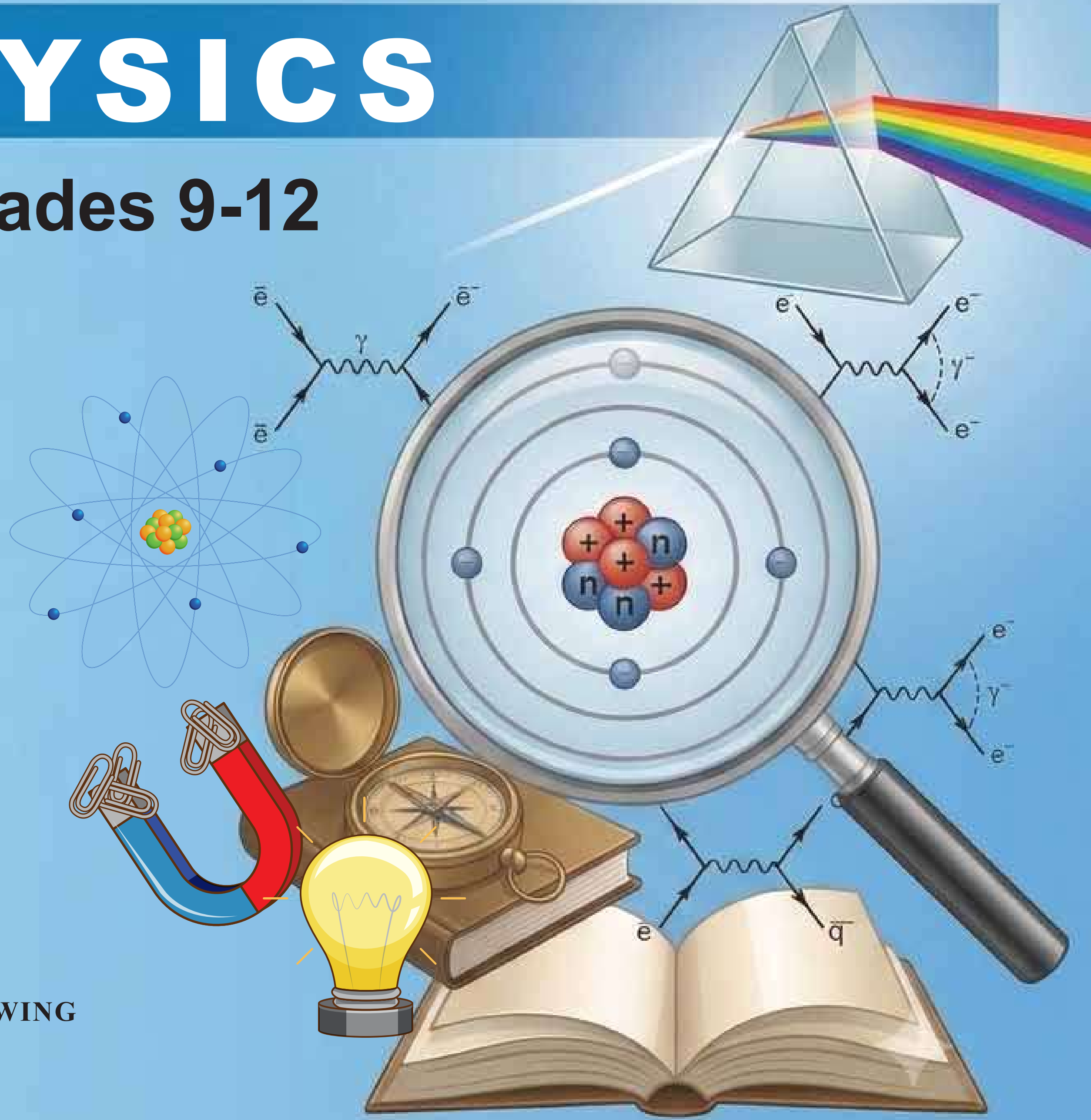
National Curriculum of Pakistan 2026

# PHYSICS

## Grades 9-12




NATIONAL CURRICULUM COUNCIL WING
MINISTRY OF FEDERAL EDUCATION AND
PROFESSIONAL TRAINING, ISLAMABAD
GOVERNMENT OF PAKISTAN

National Curriculum of Pakistan
2026

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# Acknowledgement

It is with great pride that the National Curriculum Council Wing, Ministry of Federal Education and Professional Training, presents the Rationalised National Curriculum 2026 for Physics (Grades IX–XII). Building on the National Curriculum 2022–23, this revision streamlines content to improve coherence, reduce unnecessary overlap, and strengthen conceptual understanding while aligning with national priorities and international standards.

Developed through a consultative, evidence-based process involving subject experts, universities, provincial education departments, textbook boards, assessment bodies, teacher education institutions, and practitioners, the curriculum promotes inquiry-based learning, scientific reasoning, practical application, and meaningful assessment.

The National Curriculum Council Wing sincerely acknowledges the invaluable contributions of all stakeholders whose expertise and commitment have made this rationalisation process possible. Their collective efforts have ensured a curriculum that is relevant, manageable, competency-based, and future-ready for the learners of Pakistan.

**Dr. Tabassum Naz**
Director
National Curriculum Council Wing
Ministry of Federal Education and Professional Training

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# KEY FEATURES OF PHYSICS NCP 2026

The Physics National Curriculum 2026 (NCP 2026) marks a transformative step towards modern, learner-centered science education in Pakistan. Developed through extensive national consultations, it reflects the latest advancements in physics, emerging pedagogical trends, and the collective vision of provinces and stakeholders to nurture scientifically literate, critical thinkers and innovators of tomorrow. Following are the key features of the Physics (NCP 2026):

- **Mutual Consensus:** The development of the Physics curriculum is based on extensive feedback received from provinces and other stakeholders regarding the existing curriculum and course materials. It incorporates the rapid expansion of frontiers in physics knowledge and a paradigm shift in teaching-learning processes towards more interactive, participative, and student-centered approaches that promote active and independent learning.
- **Design:** The curriculum places less emphasis on purely factual material and greater focus on the deep understanding and application of physics concepts and principles.
- **Categorization:** Student Learning Outcomes (SLOs) are organized into cognitive domains and further structured into units and sub-units to facilitate effective learning and to support textbook developers.
- **Sequence:** The curriculum follows a logical sequence of topics with carefully placed concepts appropriate to the cognitive level of students. It eliminates vertical repetition within Physics and horizontal overlapping with other disciplines.
- **Cognitive Level:** Each Student Learning Outcome (SLO) is classified according to the cognitive domains of Bloom's Taxonomy.
- **Curriculum Load:** Special care has been taken to ensure that the curriculum for each grade is manageable while remaining comparable to international standards. Curriculum load has been reduced by removing duplication and overlapping of concepts—both within Physics and with other subjects—thereby creating space for contemporary core topics and emerging areas in the field.
- **Time Allocation:** Grade-wise and unit-wise weightage along with suggested time allocation for each chapter has been provided.

This curriculum framework is designed to foster a deep appreciation of physics, develop critical thinking skills, and prepare students to become scientifically literate citizens equipped to meet the challenges of the 21st century.

# THEORETICAL CONCEPTS PROGRESSION GRID

**Assumption of Prior Knowledge:** It is assumed that students will already have knowledge (and be able to apply it as needed in their current class) of what they learned in their previous grades, so SLOs from previous grades are not repeated in the higher grades. In practice, teachers may want to refresh concepts with their students as appropriate.

| GRADE 9 | GRADE 10 | GRADE 11 | GRADE 12 |
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| **Domain A : PHYSICAL QUANTITIES AND MEASUREMENT**<br>Physics relies on the precise quantification of the natural world. This domain establishes the framework for measuring physical quantities, evaluating experimental uncertainties, validating physical laws through dimensional analysis, and understanding the interdisciplinary scope of physics in solving real-world challenges. | | | |
| **STANDARD:** Students will understand the interdisciplinary nature of physics and master the quantitative language of science by precisely measuring physical quantities, applying scientific notation, and mitigating experimental errors with scientific integrity. Students will apply dimensional analysis to validate mathematical models of physical laws and systematically compound mathematical uncertainties to interpret empirical data from complex systems. | | | |
| **After learning this domain, students can:**<br>**Benchmark I:** Differentiate between science, technology, and engineering; define physics through the relationship between matter and energy; and analyze how its core and interdisciplinary branches (e.g., astrophysics, biophysics) provide solutions to real-world challenges.<br>**Benchmark II:** Distinguish between physical and non-physical quantities; classify quantities as base or derived with their respective SI units; and proficiently manipulate data using scientific notation and metric prefixes.<br>**Benchmark III:** Apply the rules of significant figures in basic arithmetic calculations, distinguish between random and systematic errors, and identify localized strategies to minimize them in school laboratory settings. | | **After learning this domain, students can:**<br>**Benchmark I:** Evaluate and articulate the critical role, impact, and applications of physics across modern scientific frontiers, including space technology, nanotechnology, aerodynamics, medical physics, thermodynamics, and solid-state physics.<br>**Benchmark II:** Differentiate quantifiably between accuracy and precision using empirical datasets; identify systemic, environmental, and human limitations in measurements; and calculate, compound, and express absolute, fractional, and percentage uncertainties across complex mathematical operations (including power factors, averages, and periodic functions) while maintaining appropriate significant figures.<br>**Benchmark III:** Formulate the dimensions of physical quantities using base dimensions (M, L, T); verify the formal structural validity of physical equations using the principle of dimensional homogeneity; and construct plausible physical formulas for single-variant systems. | |

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| **UNIT 1: FUNDAMENTALS OF PHYSICS**<br>(11 Periods)<br>**At the end of this unit, Students will be able to:**<br>**1.1 INTRODUCTION TO PHYSICS**<br>[SLO: P-09-A-01]<br>Know the difference between the terms 'science', 'technology' and 'engineering' with suitable examples from daily life.<br>*(Knowledge)*<br><br>[SLO: P-09-A-02]<br>Understand that Physics is a study of matter, energy and their mutual connections and interactions.<br>*(Understanding)*<br><br>[SLO: P-09-A-03]<br>Explain the role of physics in solving real-world problems (e.g., energy, environment, technology).<br>*(Understanding)*<br><br>[SLO: P-09-A-04]<br>Explain with an example that physics has many sub-fields (like: *Mechanics, Electrostatics, Current Electricity, Electromagnetism, Electronics, Optics, Nuclear Physics, Thermodynamics)* and in today's world involves interdisciplinary fields, (like: *Biophysics, Geophysics, Astrophysics).*<br>*(Understanding)*<br><br>**1.2 PHYSICAL QUANTITIES**<br>[SLO: P-09-A-05] | | **UNIT 1: MEASUREMENT**<br>(07 Periods)<br>**At the end of this unit, Students will be able to:**<br>**1.1 SCOPE OF PHYSICS**<br>[SLO: P-11-A-01]<br>Describe the importance of physics in space technology, nano-technology, aero-dynamics, medical physics, thermodynamics and solid state physics<br>*(Understanding)*<br><br>**1.2 ACCURACY AND PRECISION**<br>[SLO: P-11-A-02]<br>Distinguish between accuracy and precision using some experimental data comparison.<br>*(Understanding)*<br><br>**1.3 UNCERTAINTIES IN MEASUREMENT**<br>[SLO: P-11-A-03]<br>Explain why all measurements contain some uncertainty due to limitations of measuring instruments, experimental methods, and human observation.<br>*(Understanding)*<br><br>[SLO: P-11-A-04]<br>Estimate uncertainties in measurements and express results with appropriate precision.<br>[By using absolute, fractional or percentage uncertainties in formulae involving addition, subtraction, multiplication, division, power factor, average values and time period in their final result while maintaining appropriate significant figures]<br>*(Understanding, Application)* | |

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| Differentiate between physical and non-physical quantities.<br>*(Understanding)*<br><br>[SLO: P-09-A-06]<br>Differentiate physical quantities on the basis of base and derived quantities with their symbols and SI units.<br>*(Understanding)*<br><br>[SLO: P-09-A-07]<br>Express that derived units are always formed as products or quotients of the SI base units<br>*(Understanding, Application)*<br><br>[SLO: P-09-A-08]<br>Express numerical data using scientific notation [In measurements and calculations.]<br>*(Understanding)*<br><br>[SLO: P-09-A-09]<br>Express numerical data using prefixes<br>*(Understanding)*<br><br>[SLO: P-09-A-10]<br>Describe the term Significant Figures and rules to find them.<br>[including how to write final answers correctly after calculations.]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-A-11]<br>Identify the sources of error with examples, and explain how to minimize them [including identifying sources of systematic and random error in measurements]<br>*(Knowledge, Understanding, Application)* | | **1.4 DIMENSIONAL ANALYSIS**<br>[SLO: P-11-A-05]<br>Describe the concept of dimensions using mass, length and time<br>*(Knowledge)*<br><br>[SLO: P-11-A-06]<br>Check the homogeneity of physical equations using dimensional analysis.<br>*(Understanding, Application)*<br><br>[SLO: P-11-A-07]<br>Derive possible formulae in simple cases using dimensional analysis.<br>*(Understanding, Application)* | |

## Domain B : MECHANICS

Mechanics is the study of the motion of mechanical points, bodies, systems, fluids and deformed materials with or without consideration of their associated physical properties and the forces acting on them.

**STANDARD:** Students will master vector algebra and coordinate systems to predict, analyze, and model system behaviors under linear, two-dimensional, rotational, and orbital frameworks. They will apply Newton's laws of motion, universal gravitation, and analyze equilibrium criteria to evaluate the stability and dynamics of mechanical systems. Students will utilize universal conservation laws (momentum and energy) to solve elastic, inelastic, and rotational engineering problems. They will analyze the macro-properties of matter by characterizing fluid statics, fluid dynamics, and the high-strain deformation regimes of solids with mathematical rigor.

**Benchmark I:** Distinguish between scalar and vector quantities; ( identify, represent, and manipulate vectors graphically (head-to-tail) and resolve 2-D vectors into perpendicular components. Differentiate between foundational linear motion terms (distance/displacement, average/instantaneous velocity, and acceleration types). Sketch, interpret, and calculate gradients and areas of distance-time and speed-time graphs to derive and apply the three linear equations of motion to 1-D free-fall problems in non-resistive media.

**Benchmark II:** Distinguish between contact/non-contact forces and map system interactions using free-body diagrams to find net forces. State and apply Newton's three laws of motion to real-world scenarios, identifying mass as a quantitative measure of inertia and analyzing the dynamic effects of a net force on an object's velocity.

**Benchmark III:** Define linear momentum, change in momentum, and impulse. Relate net force to the rate of change of momentum to analyze how collision time influences impact force. State and apply the law of conservation of momentum to calculate outcomes of simple 1-D inelastic collisions.

**Benchmark IV:** Analyze the physical causes, mechanisms, and real-life implications of friction; distinguish qualitatively between rolling and sliding friction, and quantitatively between static ($\mu_s$) and kinetic ($\mu_k$) coefficients. Evaluate the thermal energy dissipation caused by friction and identify industrial/practical methods used to modulate friction.

**Benchmark V:** Illustrate torque, couple, and rotational moments about a pivot; apply the principle of moments to balance rigid systems. Analyze center of mass versus center of gravity. and Explain the concept of equilibrium and the criteria governing stable, unstable,

**Benchmark I:** Formulate and resolve vectors into orthogonal unit coordinate systems (i, j, k). Evaluate scalar (dot) and vector (cross) products along with their geometric/physical properties.

**Benchmark II:** Analyze two-dimensional projectile motion by separating it into independent horizontal and vertical components, and evaluate the qualitative effects of air resistance on the trajectory. Analyze isolated 1-D elastic and inelastic collisions using the simultaneous conservation of linear momentum and kinetic energy.

**Benchmark III:** Evaluate work done from varying force-displacement datasets; distinguish structurally between conservative and non-conservative fields; and prove the path-independence of gravitational fields. Calculate absolute gravitational potential, model field interactions between point masses, and derive escape velocity.

**Benchmark IV:** Formulate angular kinematics relationships $(\theta, \omega, \alpha)$; derive centripetal parameters ($a_c = v^2/r$) across varying force boundaries (tension, friction, gravity); and analyze mass-separation mechanics in centrifuges. Model rigid-body dynamics using the moment of inertia (I), rotational kinetic energy, and the Law of Conservation of Angular Momentum applied to complex mechanical systems.

**Benchmark V:** Derive the analytical relationships matching orbital periods to celestial radii using Newton's Law of Gravitation. Evaluate the physics of apparent weightlessness inside orbiting reference frames, and design artificial gravity environments using centripetal constraints.

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| and neutral equilibrium. ;and determine how base area and mass placement optimize structural stability.<br><br>**Benchmark VI:** Define and calculate work done based on the angle between force and displacement vectors. Formulate and solve conversions between kinetic, gravitational potential, and elastic potential energies via the Law of Conservation of Energy. Calculate mechanical power and system efficiency, justifying why real mechanical systems cannot achieve 100% efficiency.<br><br>**Benchmark VII:** Calculate density and determine it experimentally for regular and irregular solids using fluid displacement methods. Quantify pressure distributions across surface areas, derive the liquid pressure relationship ($P = \rho gh$), and analyze atmospheric pressure variations. State, prove, and apply Pascal's law (to hydraulic systems) and Archimedes' principle of flotation to different objects. Characterize the deformation of solids using stress, strain, and Hooke's Law within elastic limits. | **Benchmark VI:** Model ideal and real fluid behavior using Stokes' Law, the Equation of Continuity, and the Bernoulli field equation to solve transport problems (including the Magnus effect, Venturi meter, and Torricelli theorem).<br><br>**Benchmark VII:** Classify solid and characterize high-strain material behaviors (elastic/plastic regimes, UTS, fracture lines) using elastic moduli and energy calculations derived from force-extension curves. |
| **Unit 2: KINEMATICS**<br>(23 Periods)<br>**At the end of this unit, Students will be able to:**<br>**2.1 SCALARS & VECTORS**<br><br>[SLO: P-09-B-01]<br>Differentiate between scalar and vector quantities<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-02]<br>Represent vectors symbolically and graphically using appropriate notations, scale and direction.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-03]<br>Add vectors graphically using the head-to-tail method and determine the magnitude and direction of the resultant vector.<br>*(Understanding, Application)*<br>[SLO: P-09-B-04] | **Unit 2: VECTORS**<br>(04 Periods)<br>**At the end of this unit, Students will be able to:**<br>**2.1 VECTORS IN DETAIL**<br><br>[SLO: P-11-B-01]<br>Define a unit vector, represent vectors in terms of orthogonal unit vectors **i**, **j**, **k**.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-B-02]<br>Describe the multiplication of vector by a number (scalar).<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-B-03]<br>Describe scalar product of two vectors along with their properties.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-B-04] |

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| Discuss a vector in 2-D as two perpendicular components<br>(Resolution of vectors)<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-05]<br>Determine, by calculation and graphically, the resultant of two vectors at right angles<br>*(Application)*<br><br>[SLO: P-09-B-06]<br>Explain the following vector terms: null vector, negative of a vector, and equal vectors.<br>*(Knowledge, Understanding)*<br><br>**2.2 MOTION AND ITS TYPES (TRANSLATORY, ROTATORY, VIBRATORY)**<br>[SLO: P-09-B-07]<br>Explain using examples how objects can be at rest for an observer and in motion for another observer simultaneously. (relative velocity)<br>*(Understanding, Application)*<br><br>[SLO: P-09-B-08]<br>Discuss different types of motion<br>[i.e.; translatory (linear, random and circular); rotatory and vibratory motions and distinguish among them.]<br>*(Knowledge)*<br><br>**2.3 TERMS ASSOCIATED WITH MOTION**<br>[SLO: P-09-B-09]<br>Differentiate between distance and displacement.<br>*(Knowledge, Understanding)*<br>[SLO: P-09-B-10]<br>Differentiate between speed and velocity. | | Describe vector product of two vectors along with their properties. Also state the method to determine the direction of vector product of two vectors.<br>*(Knowledge, Understanding)*<br><br>**Unit 3: MOTION & FORCE**<br>(05 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>**3.1 ELASTIC COLLISION IN ONE DIMENSION**<br>[SLO: P-11-B-05]<br>Analyze motion for elastic collisions.<br>[This include making use of the fact that for an elastic collision, total kinetic energy is conserved and the relative speed of approach is equal to the relative speed of separation]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-06]<br>Analyze that the momentum of an isolated system is always conserved, some change in kinetic energy may take place.<br>*(Understanding, Application)*<br><br>**2.3 PROJECTILE MOTION**<br>[SLO: P-11-B-07]<br>Explain projectile motion in the absence of air resistance.<br>[This includes followings facts:<br>(i) Horizontal component ($V_H$) of velocity is constant.<br>(ii) Acceleration is in the vertical direction and is the same as that of a vertically free-falling object. | |

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| *(Knowledge, Understanding)*<br><br>[SLO: P-09-B-11]<br>Differentiate between average and instantaneous speed/velocity.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-12]<br>Differentiate between uniform velocity and non-uniform velocity.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-13]<br>Calculate average speed and average velocity using distance, displacement, and time in simple problems.<br>*(Understanding, Application)*<br><br>[SLO: P-09-B-14]<br>Explain the concept of acceleration<br>[This includes knowing that deceleration is negative acceleration]<br>*(Understanding)*<br><br>[SLO: P-09-B-15]<br>Differentiate between uniform acceleration ,non-uniform acceleration and instantaneous acceleration<br>*(Knowledge, Understanding)*<br><br>**2.4 GRAPHICAL UNDERSTANDING OF MOTION**<br>[SLO: P-09-B-16]<br>Sketch and interpret distance–time graphs<br>[This includes determining from the shape of a distance–time graph when an object is:<br>[(a) at rest<br>(b) moving with constant speed<br>(c) accelerating | | (iii) The horizontal motion and vertical motion are independent of each other]<br>*(Understanding, Application)*<br><br>[SLO: P-11-B-08]<br>Determine the following for projectiles:<br>- How high does it go? (height attained)<br>- How far would it go along the level land? (Range)<br>- Where would it be after a given time?<br>- How long will it remain in flight? (time of flight)<br>- launch angle that results in the maximum range.<br>- relation between the launch angles that result in the same range.]<br>*(Application)*<br><br>[SLO: P-11-B-09]<br>Explain how air resistance affects projectile motion.<br>[This includes Understanding of both the horizontal component and vertical component of velocity and hence predicting qualitatively the range of the projectile.]<br>*(Understanding, Application)*<br><br>**Unit 4: WORK, ENERGY & POWER**<br>(09 Periods)<br>**At the end of this unit, Students will be able to:** | |

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| (d) decelerating]<br>*(Understanding, Application)*<br><br>[SLO: P-09-B-17]<br>Discuss how the gradient of a distance-time graph gives the speed.<br>*(Understanding, Application)*<br><br>[SLO: P-09-B-18]<br>Sketch and interpret speed–time graphs<br>[This includes determining from the shape of a speed–time graph when an object is:<br>(a) at rest<br>(b) moving with constant speed<br>(c) moving with constant acceleration<br>(d) moving with changing acceleration]<br>*(Understanding, Application)*<br><br>[SLO: P-09-B-19]<br>Explain that gradient of a speed–time graph gives the acceleration.<br>*(Understanding, Application)*<br><br>[SLO: P-09-B-20]<br>Analyze the distance traveled from speed-time graphs.<br>[By determining the area under the graph for cases of motion with constant speed or constant acceleration]<br>*(Understanding, Application)*<br><br>**2.5 EQUATIONS OF MOTION**<br>[SLO: P-09-B-21]<br>Derive the equations of motion graphically.<br>[For uniform acceleration cases only]<br>*(Understanding, Application)*<br>[SLO: P-09-B-22]<br>Solve problems using the equations of motion.<br>[For the cases of uniformly accelerated motion in a straight line, including the motion of bodies | | **4.1 WORK**<br>[SLO: P-11-B-10]<br>Describe the concept of work as scalar product of force and displacement.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-B-11]<br>Distinguish between positive, negative and zero work done with examples and Deduce the work done from force-displacement graph.<br>*(Understanding)*<br><br>**4.2 WORK DONE IN A CONSERVATIVE FIELD**<br>[SLO: P-11-B-12]<br>Differentiate between conservative and non-conservative forces<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-B-13]<br>Prove that gravitational field is a conservative field.<br>*(Understanding, Application)*<br><br>**4.3 WORK-ENERGY THEOREM**<br>[SLO: P-11-B-14]<br>Deduce the relationship between energy and work<br>a. when friction is not present<br>b. when friction is present<br>*(understanding, Application)*<br><br>**4.4 ABSOLUTE GRAVITATIONAL POTENTIAL**<br>[SLO: P-11-B-15]<br>Define and calculate absolute gravitational potential. | |

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| falling in a uniform gravitational field without air resistance.]<br>*(Application)*<br><br>[SLO: P-09-B-23]<br>Use the approximate value 9.8m/$s^2$ for free fall acceleration near Earth to solve KINEMATICS problems in non-resistive medium.<br>*(Application)*<br><br>**Unit 3: DYNAMICS**<br>(23 Periods)<br>**At the end of this unit, Students will be able to:**<br>**3.1 CONCEPT OF FORCE**<br>[SLO: P-09-B-24]<br>Differentiate between contact and non-contact forces.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-25]<br>Differentiate between mass and weight.<br>(*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-26]<br>Explain that the mass of an object resists changes from its state of rest or motion (inertia) and apply this concept to simple daily life situations.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-27]<br>Represent the forces acting on a body using free body diagrams and discuss net force on an object.<br>*(Understanding, Application)* | | [Use $V_g = -G\frac{M}{r}$ for the gravitational potential in the field due to a point mass]<br>[At a point as the work done per unit mass in bringing a small test mass from infinity to the point]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-16]<br>Analyze how the concept of gravitational potential leads to the gravitational potential energy of two-point masses<br>[Use of $U_g = -G\frac{Mm}{r}$] in problems is expected]<br>*(Knowledge, Understanding, Application)*<br><br>**4.5 ESCAPE VELOCITY**<br>[SLO: P-11-B-17]<br>Define escape velocity and derive its formula using the concepts of gravitational potential energy and kinetic energy. Also calculate the escape velocities for the Moon and the Earth when mass and radius of the bodies are given and use this formula for solving word problems;<br>*(Knowledge, Understanding, Application)*<br><br>**4.6 POWER**<br>[SLO: P-11-B-18]<br>Derive the formula of power in terms of force and velocity and use it in solving word problems<br>*(understanding, Application)* | |

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| **3.2 NEWTON'S LAWS OF MOTION**<br>[SLO: P-09-B-28]<br>State and explain Newton's first law and discuss it as law of inertia.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-29]<br>Identify the effect of force on objects.<br>[It may change the velocity of an object by changing its direction of motion or its speed]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-30]<br>State Newton's second law in terms of acceleration and discuss its applications in daily life situations.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-31]<br>State and explain Newton's Third Law of motion, how action-reaction pairs govern the motion of objects in everyday life.<br>*(Knowledge, Understanding, Application)*<br><br>**3.3 NEWTON'S LAW OF GRAVITATION**<br>[SLO: P-09-B-32]<br>State and apply Newton's law of gravitation to solve problems<br>[ $F = G\frac{m_1 m_2}{r^2}$ for the force between two masses to solve problems]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-33]<br>Define and calculate gravitational field strength.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-34]<br>Calculate mass of Earth using Newton's Law of Gravitation.<br>*(Knowledge, Understanding, Application)* | | **Unit 5: CIRCULAR/ROTATIONAL MOTION**<br>(18 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>**5.1 ANGULAR MOTION**<br>[SLO: P-11-B-19]<br>Define radian; and convert it into/from degree and revolution.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-20]<br>Define and calculate angular displacement, angular velocity and angular acceleration.<br>[This involves derivation and use of $S = r\theta$, $v = r\omega$, $\omega = 2\pi/T$, $a = r\,\alpha$, and $a = v^2/r$ to solve problems]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-21]<br>Use equations of angular motion to solve problems involving angular motions.<br>*(Application)*<br><br>**5.2 CENTRIPETAL ACCELERATION AND CENTRIPETAL FORCE**<br>[SLO: P-11-B-22]<br>Define Centripetal acceleration and derive [$a_c = v^2/r$].<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-23]<br>Define centripetal force and | |

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| [SLO: P-09-B-35]<br>Explain that value of 'g' decreases with altitude from the surface of earth.<br>*(Understanding)*<br><br>**3.4 MOMENTUM**<br>[SLO: P-09-B-36]<br>Explain the concept of momentum and use its formula to calculate momentum of a body.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-37]<br>Explain and analyze how the net force on a body relates to the change in momentum, and how collision time affects the force experienced.<br>*(Understanding, Application)*<br><br>[SLO: P-09-B-38]<br>State and explain law of conservation of momentum and give its examples from daily life.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-B-39]<br>Apply the principle of the law of conservation of momentum to solve simple problems in one dimension.<br>*(Application)*<br><br>[SLO: P-09-B-40]<br>Define and calculate impulse.<br>[Use the equation<br>Impulse = $F\Delta t = m\Delta V$ ]<br>*(Knowledge, Understanding, Application)*<br><br>**3.5 FRICTION**<br>[SLO: P-09-B-41]<br>Explain friction, including the factors responsible for its occurrence. | | deduce the formulae of centripetal force, and solve simple problems.<br>[Use $F = mr\omega^2$, $F = mv^2/r$]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-24]<br>Analyze situations involving circular motion in terms of centripetal force.<br>[e.g. situations in which centripetal acceleration is caused by a tension force, a frictional force, a gravitational force, or a normal force.]<br>*(Understanding)*<br><br>[SLO: P-11-B-25]<br>Analyze how a centrifuge separates materials by applying centripetal force.<br>*(Understanding)*<br><br>**5.3 MOMENT OF INERTIA AND ANGULAR MOMENTUM**<br>[SLO: P-11-B-26]<br>Define moment of inertia and angular momentum, and calculate their values for rigid bodies or simpler physical systems.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-27]<br>Derive and apply the relation between torque, moment of inertia and angular acceleration.<br>*(Understanding, Application)*<br><br>[SLO: P-11-B-28]<br>Explain the law of conservation of angular momentum, and apply it to solve simple problem.<br>*(Knowledge, Understanding, Application)* | |

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| *(Knowledge, Understanding)*<br><br>[SLO: P-09-B-42]<br>Discuss advantages and disadvantages of friction in real life situations.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-43]<br>Analyze the dissipative effects of friction.<br>[This include identifying where dissipation may occur and giving examples such as rubbing hands together produces heat, asteroids that enter the Earth's atmosphere disintegrate due to high temperature generated from air resistance]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-44]<br>Distinguish between the coefficient of *static* friction ($\mu_s$) - maximum force before motion—and the coefficient of *kinetic* friction ($\mu_k$) -force during motion<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-45]<br>Differentiate qualitatively between rolling and sliding friction.<br>[no need for coefficients of friction]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-46]<br>Describe methods to reduce friction.<br>*(Knowledge, Understanding)*<br><br>**Unit 4: TURNING EFFECTS OF FORCE & EQUILIBRIUM**<br>(12 Periods)<br>**At the end of this unit, Students will be able to:**<br>**4.1 MOMENT OF FORCE(TORQUE)**<br>[SLO: P-09-B-47] | | [SLO: P-11-B-29]<br>Analyze real-life applications of the law of conservation of angular momentum, including flywheels, gyroscopes, and the motion of ice skaters, divers and gymnasts.<br>*(Knowledge, Understanding, Application)*<br><br>**5.4 ROTATIONAL KINETIC ENERGY**<br>[SLO: P-11-B-30]<br>Define rotational kinetic energy and derive an expression for rotational kinetic energy and use this expression for solving numerical problems.<br>*(Knowledge, Understanding, Application)*<br><br>**5.5 ORBITAL VELOCITY**<br>[SLO: P-11-B-31]<br>Define and calculate average orbital speed/velocity<br>[from the equation $v = 2\pi r/T$ where r is the average radius of the orbit and T is the orbital period; apply this equation to solve numerical problems<br>*(Knowledge, Understanding)*<br>[SLO: P-11-B-32]<br>Derive the relationship between the orbital period and radius of a circular orbit using Newton's Law of Gravitation.<br>*(Understanding, Application)*<br><br>[SLO: P-11-B-33]<br>Analyze the circular motion of objects in a geostationary orbit.<br>[This includes calculation of orbital radius of geostationary orbit]<br>*(Understanding, Application)* | |

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| Differentiate between like and unlike parallel forces.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-48]<br>Illustrate the concepts of moment of force (torque), moment arm, and line of action of a force using simple examples.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-49]<br>Analyze problems involving turning effects of forces.<br>[Student should know that moment of a force = force × perpendicular distance from the pivot and be able to use this in simple problems and be able to give examples and applications of turning effects in real life]<br>*(Application)*<br><br>[SLO: P-09-B-50]<br>Define couple as a pair of forces tending to produce rotation. Derive its formula and utilize it to calculate couple in numerical problems.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-51]<br>State and explain the principle of moments.<br>*(Knowledge, Understanding)*<br><br>**4.2 EQUILIBRIUM**<br>[SLO: P-09-B-52]<br>Explain the concept of Equilibrium and its types.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-53]<br>Explain the conditions for equilibrium of a body and illustrate them with examples from daily life. | | **5.6 ARTIFICIAL SATELLITES AND WEIGHTLESSNESS**<br>[SLO: P-11-B-34]<br>Define satellite and classify different types of satellites.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-B-35]<br>Explain why the objects in orbiting satellites appear to be weightless.<br>*(Understanding, Application)*<br><br>[SLO: P-11-B-36]<br>Describe how artificial gravity is created to counter weightlessness.<br>*(Understanding, Application)*<br><br>**UNIT 6: FLUID DYNAMICS**<br>(10 Periods)<br>**At the end of this unit, Students will be able to:**<br>**6.1 VISCOUS FLUIDS**<br><br>[SLO: P-11-B-37]<br>Explain why real fluids are viscous fluids.<br>[It includes discussion on viscosity of fluid with respect to density, temperature]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-B-38] | |

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| *(Knowledge, Understanding)*<br><br>[SLO: P-09-B-54]<br>Describe the different states of equilibrium of a body and illustrate them with examples from daily life.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-55]<br>Analyze objects in equilibrium using the principle of moments in simple situations such as weights balanced on meter rod or other similar examples.<br>*(Knowledge, Understanding, Application)*<br><br>**4.3 CENTER OF GRAVITY**<br>[SLO: P-09-B-56]<br>Describe what is meant by center of mass and center of gravity.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-57]<br>Analyze the effect of the position of the center of gravity on the stability of simple objects. [Mathematical description is not required]<br>*(Understanding, Application)*<br>[SLO: P-09-B-58]<br>Suggest how the stability of an object can be improved.<br>[by lowering the center of mass and increasing the base area of the object]<br>*(Understanding, Application)*<br><br>**Unit 5: WORK, ENERGY& POWER**<br>(14 Periods)<br>**At the end of this unit, Students will be able to:**<br>**5.1 WORK**<br>[SLO: P-09-B-59]<br>Define work done and interpret with examples. | | Describe how viscous forces in a fluid cause a retarding force on an object moving through it.<br>*(Knowledge, Understanding)*<br><br>**6.2 TERMINAL VELOCITY**<br>[SLO: P-11-B-39]<br>Analyze the dynamics of an object attaining terminal velocity.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-40]<br>State Stoke’s law and derive an expression for terminal velocity of spherical body falling through viscous fluids by using Stoke’s law.<br>*(Knowledge, Understanding)*<br><br>**6.3 LAMINAR FLOW**<br>[SLO: P-11-B-41]<br>Define and explain steady (laminar) flow, incompressible flow, and non-viscous flow, and apply these principles to analyze the motion of an ideal fluid.<br>*(Knowledge, Understanding, Application)*<br><br>**6.4 EQUATION OF CONTINUITY**<br>[SLO: P-11-B-42]<br>State and prove equation of continuity [use it to solve problems]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-43]<br>Explain that squeezing the end of a rubber/plastic pipe results in increase in flow speed of fluid.<br>*(Understanding, Application)* | |

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| *(Knowledge, Understanding)*<br><br>[SLO: P-09-B-60]<br>Use the equation work done = force × distance moved in the direction of the force W= Fdcos $\theta$ to solve problems.<br>[It also includes types of work on the basis of angle between displacement and force]<br>*(Application)*<br><br>**5.2 ENERGY AND TYPES OF MECHANICAL ENERGY**<br>[SLO: P-09-B-61]<br>Recall energy and its types. [Mechanical, Chemical, Solar, Heat, Wind, Tidal and Sound]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-62]<br>Define mechanical energy and enlist its types.<br>*(Knowledge)*<br><br>[SLO: P-09-B-63]<br>Define kinetic energy and derive its formula and use it to solve simple problems.<br>[using the equations of motion]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-64]<br>Define gravitational potential energy, use its formula to solve simple problems.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-65]<br>Explain the concept of elastic potential energy.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-66] | | **6.5 BERNOULLIE'S EQUATION AND ITS APPLICATION**<br>[SLO: P-11-B-44]<br>State and derive Bernoulli's equation.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-45]<br>Explain and justify how variations in the speed of a fluid lead to differences in pressure, with reference to fluid dynamics concepts. [Bernoulli effect]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-B-46]<br>Analyze the real-world applications of the Bernoulli effect<br>[For example, atomizers in perfume bottles, the swinging trajectory of a spinning cricket ball and the lift of a spinning golf ball (the magnus effect), the use of Venturi ducts in filter pumps and carburetors to adjust the flow of fluid, Torricelli's theorem, etc.]<br>*(Understanding, Application)*<br><br>**UNIT 7: DEFORMATION OF SOLIDS**<br>(07 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>**7.1 CLASSIFICATION OF SOLIDS**<br>[SLO: P-11-B-47]<br>Distinguish between the structures of crystalline, amorphous, and polycrystalline solids. | |

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| State law of conservation of energy and discuss its applications.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-67]<br>Use the formulae for kinetic and gravitational potential energies to solve problems involving simple energy conversions.<br>[make use of the conversion of energy from one form to the other]<br>*(Application)*<br><br>[SLO: P-09-B-68]<br>Enlist renewable and non-renewable energy resources. [especially in Pakistan]<br>*(Knowledge)*<br><br>**5.3 MECHANICAL POWER & EFFICIENCY**<br>[SLO: P-09-B-69]<br>Explain the concept of mechanical power and calculate it.<br>*(Knowledge, Understanding, Application)*<br>[SLO: P-09-B-70]<br>Explain the term efficiency.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-71]<br>Apply the concept of efficiency to solve simple problems involving transfer of energy.<br>*(Application)*<br><br>[SLO: P-09-B-72]<br>Analyze that a system cannot have 100% efficiency.<br>*(Knowledge, Understanding, Application)*<br><br>**Unit 6: DEFORMATION OF SOLIDS & PRESSURE**<br>(16 Periods) | | *(Knowledge, Understanding)*<br><br>**7.2 YOUNG/BULK/SHEAR MODULUS**<br>[SLO: P-11-B-48]<br>Describe deformation of solids in one dimension. [That it is caused by force in one dimension, the deformation can be tensile or compressive.]<br>*(Knowledge)*<br><br>[SLO: P-11-B-49]<br>Explain the terms Young's modulus, Bulk modulus and Shear modulus., use them to solve problems.<br>*(Knowledge, Understanding, Application)*<br><br>**7.3 MECHANICAL PROPERTIES OF SOLID**<br>[SLO: P-11-B-50]<br>Describe the terms elastic deformation, plastic deformation proportional limit, elastic limit, UTS and fracture stress in a tensile test of a wire.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-B-51]<br>Compare brittle and ductile material with the help of their stress-strain curves.<br>*(Understanding, Application)*<br><br>[SLO: P-11-B-52]<br>Analyze and apply the fact that the area under the force–extension graph represents the work done.<br>*(Understanding, Application)*<br><br>[SLO: P-11-B-53] | |

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| **At the end of this unit, Students will be able to:**<br>**6.1 DENSITY**<br>[SLO: P-09-B-73]<br>Explain the concept of density and apply to solve simple problems.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-74]<br>Discuss and explain how to determine the density of a substance [Including for a liquid, regular shaped solid and of an irregularly shaped insoluble solids which sinks in a liquid (find its volume by a displacement method), including appropriate calculations]<br>*(Understanding, Application)*<br><br>**6.2 PRESSURE**<br>[SLO: P-09-B-75]<br>Define and calculate pressure.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-76]<br>Describe how pressure varies with force and area in the context of everyday examples.<br>*(Understanding, Application)*<br><br>**6.3 ATMOSPHERIC PRESSURE**<br>[SLO: P-09-B-77]<br>Justify that the atmosphere exerts pressure.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-78]<br>Describe that atmospheric pressure varies with altitude.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-79] | | Determine the elastic potential energy of a material [That is deformed within the limit of proportionality from the area under the force–extension graph. Also state and use $E_p = \frac{1}{2}Fx = \frac{1}{2}kx^2$ for a material deformed within its limit of proportionality]<br>*(Understanding, Application)* | |

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| Explain that changes in atmospheric pressure in a region may indicate a change in the weather.<br>*(Understanding)*<br><br>**6.4 LIQUID PRESSURE**<br>[SLO: P-09-B-80]<br>Derive a relation ($p=\rho gh$) for pressure beneath a liquid surface and solve problems using this equation.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-81]<br>State and explain Pascal's law.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-82]<br>Apply Pascal's law to hydraulic systems. [with particular reference to the hydraulic press/lift and hydraulic brakes on vehicles.]<br>*(Application)*<br><br>**6.5 PRINCIPLE OF FLOATATION**<br>[SLO: P-09-B-83]<br>State Archimede's principle and prove it.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-09-B-84]<br>State principle of floatation with conditions.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-85]<br>Explain and apply Archimedes' principle of flotation to account for how objects such as ships, submarines, and hydrometers are designed to float or sink in fluids.<br>*(Understanding, Application)*<br><br>**6.6 ELASTICITY**<br>[SLO: P-09-B-86] | | | |

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| Explain the terms stress and strain for elastic materials.<br>[keep it simple for this level]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-87]<br>Explain Hooke's law.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-B-88]<br>Sketch and interpret stress-strain curve for an elastic solid [up to elastic limit].<br>*(Knowledge, Understanding, Application)* | | | |

## Domain C: HEAT AND THERMODYNAMICS

Heat is a form of energy which flows from hot body to cold body through different processes. Thermodynamics deals with the conversion of heat into mechanical energy and vice versa.

**STANDARD:** Students will synthesize the principles of thermal physics, macroscopic thermodynamics, and statistical mechanics to model and analyze energy transformations within physical and environmental systems. They will master the quantitative tracking of temperature scales, caloric heat capacities, phase transitions, and multidimensional thermal expansion across all states of matter, while evaluating the systemic impacts of heat transfer modes on global climate mechanics and macro-geological processes. Furthermore, by applying the kinetic theory of gases alongside the First and Second Laws of Thermodynamics, students will derive microscopic molecular transport parameters, analyze the formal state process changes of ideal systems, and mathematically evaluate the efficiency limits, performance coefficients, and entropy configurations of forward and reversed cyclic power frameworks with absolute scientific rigor.

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| **Benchmark I:** Model the qualitative particulate structures of solids, liquids, gases, and plasma using kinetic-molecular theory. Analyze the relationship between microscopic particle kinetic energy and macroscopic temperature, deduce the physical basis of absolute zero, and calibrate or convert values across standard thermometric scales (Celsius, Fahrenheit, Kelvin) based on varying physical properties, range, sensitivity, and linearity.<br><br>**Benchmark II:** Differentiate between the three primary modes of heat transfer: evaluate conduction in terms of lattice vibrations and delocalized electron transport; explain fluid convection driven by density variations; and characterize electromagnetic radiation independent of a physical medium. Quantify how surface color, texture, surface area, and temperature dictate infrared emission, absorption, and reflection rates. | **Benchmark I:** Formulate the microscopic assumptions of the kinetic theory of gases to bridge the boundary between real and ideal gas approximations. Derive from first principles the pressure relation ($P = 1/3\rho c^2$), root-mean-square velocity ($v_{rms}$), and average translational kinetic energy; and mathematically deduce classic empirical gas laws (Boyle's and Charles's laws) using statistical molecular mechanics.<br><br>**Benchmark II:** Define thermal equilibrium, characterize the internal energy of real versus ideal gases as a function of temperature, and distinguish between work executed *by* versus *on* a thermodynamic system using $W = P\Delta V$. State the First Law of Thermodynamics as an expression of the law of conservation of energy, |

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<td colspan="2">Benchmark III: Apply the principles of fluid convection and radiation to model complex global and local systems, including coastal climates (land/sea breezes), avian/glider thermals, cyclone generation, marine life support systems, and mantle magma flow. Analyze the thermodynamic mechanics of the greenhouse effect, household hot-water frameworks, and insulation, evaluating how global warming amplifies extreme weather events.<br><br>Benchmark IV: Perform quantitative calorimetric calculations utilizing specific heat capacity and latent heats (fusion and vaporization) during isothermal phase changes (melting, boiling, sublimation, deposition). Model linear and volumetric thermal expansion across solids, liquids (real vs. apparent), and gases, and analyze the kinetics of surface evaporation, distinguishing it from boiling while evaluating its application in non-CFC refrigeration.</td>
<td colspan="2">modeling it across four primary thermodynamic processes (isochoric, isobaric, isothermal, and adiabatic) using pressure-volume (P-V) diagram analysis.<br><br>Benchmark III: Differentiate between the molar specific heat capacities of gases at constant volume ($C_v$) and constant pressure ($C_p$), deriving Mayer’s relation (Cp - Cv = R) via thermodynamic work constraints. Evaluate the operational mechanics, structural boundaries, and P-V loop areas of forward and reversed cyclic heat engines, calculating the performance coefficients of refrigerators and verifying the absolute efficiency limits dictated by the Carnot cycle.<br><br>Benchmark IV: Analyze the fundamental directional limits of natural energy transfers using the Second Law of Thermodynamics (Kelvin and Clausius formulations). Characterize entropy as a quantitative metric of systemic microscopic disorder and energy degradation over time, and evaluate the conceptual definition of "negentropy" (negative entropy) as it relates to localized structural order and thermodynamic stabilization.</td>
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<td>Unit 7: THERMAL PROPERTIES OF MATTER (21 Periods)<br>At the end of this unit, Students will be able to:<br><br>7.1 KINETIC MOLECULAR MODEL OF MATTER<br>[SLO: P-09-C-01]<br>Describe qualitatively the particle structure of solids, liquids and gases.<br>[Including their properties to the forces and distances between particles and to the motion of the particles (atoms, molecules, ions and electrons)]<br>(Knowledge, Understanding)<br><br>[SLO: P-09-C-02]<br>Describe plasma as a fourth state of matter.<br>(Knowledge, Understanding)<br><br>7.2 TEMPERATURE<br>[SLO: P-09-C-03]<br>Describe the relationship between the motion of particles and temperature.</td>
<td>Unit 1: HEAT (16 Periods)<br>At the end of this unit, Students will be able to:<br><br>1.1 HEAT CAPACITY<br>[SLO: P-10-C-01]<br>Define specific heat capacity, explain its physical meaning, and calculate it using the relation $Q = mc\Delta T$.<br>(Knowledge, Understanding, Application)<br><br>[SLO: P-10-C-02]<br>Analyze everyday effects due to the large specific heat of water.<br>(Understanding, Application)<br><br>1.2 CHANGE OF STATES<br>[SLO: P-10-C-03]<br>Describe the change of state between solids, liquids and gases.</td>
<td>Unit 8: KINETIC MOLECULAR THEORY & THERMODYNAMICS (23 Periods)<br>At the end of this unit, Students will be able to:<br><br>8.1 KINETIC MOLECULAR THEORY<br>[SLO: P-11-C-01]<br>Describe the basic assumptions of the kinetic theory of gases.<br>(Understanding)<br><br>[SLO: P-11-C-02]<br>Apply the equation of state for an ideal gas [expressed as PV = nRT, and PV = NkT]<br>(Application)<br><br>[SLO: P-11-C-03]<br>Explain how molecular movement causes the pressure exerted by a gas. [Including understanding the temperature, pressure</td>
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| [including the idea that there is a lowest possible temperature (approx. −273°C), known as absolute zero, where the particles have least kinetic energy]<br>*(Understanding)*<br><br>[SLO: P-09-C-04]<br>Explain, with examples, how a physical property which varies with temperature may be used for the measurement of temperature.<br>*(Understanding)*<br><br>**7.3 THERMOMETER**<br>[SLO: P-09-C-05]<br>Convert the temperature from one scale to another (Fahrenheit, Celsius and Kelvin scale)<br>*(Application)*<br><br>[SLO: P-09-C-06]<br>Explain what is meant by the sensitivity, range and linearity of thermometers.<br>*(Understanding)*<br><br>**7.4 CONDUCTION**<br>[SLO: P-09-C-07]<br>Distinguish between good and bad thermal conductors, giving examples of each.<br>*(Understanding)*<br><br>[SLO: P-09-C-08]<br>Explain thermal conduction in all solids [in terms of atomic or molecular lattice vibrations and also in terms of the movement of free (delocalized) electrons in metallic conductors]<br>*(Knowledge, Understanding)*<br><br>**7.5 CONVECTION**<br>[SLO: P-09-C-09] | [including deposition and sublimation]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-C-04]<br>Recall the melting and boiling temperatures for water at standard atmospheric pressure.<br>*(Knowledge)*<br><br>[SLO: P-10-C-05]<br>Explain melting, solidification, boiling and condensation in terms of energy transfer without a change in temperature<br>*(Knowledge)*<br><br>**1.3 THERMAL EXPANSION**<br>[SLO: P-10-C-06]<br>Explain thermal expansion in terms of kinetic theory of matter [For solids, liquids and gases. This includes stating the relative order of magnitudes of the expansion of solids, liquids and gases.]<br>*(Understanding)*<br><br>[SLO: P-10-C-07]<br>Describe qualitatively and quantitively the thermal expansion of solids.<br>[linear and volumetric expansion]<br>*(Understanding, Application)*<br><br>[SLO: P-10-C-08]<br>Explain the thermal expansion of liquid in terms of real and apparent expansion.<br>*(Understanding)*<br><br>[SLO: P-10-C-09] | and density conditions under which an ideal gas is a good approximation of a real gas.]<br>*(Understanding)*<br><br>[SLO: P-11-C-04]<br>Calculate the root-mean-square velocity of an ideal gas.<br>*(Application)*<br><br>[SLO: P-11-C-05]<br>Derive and use the relationship<br>$PV = \frac{1}{3} Nm < c^2 >$<br>[where $< c^2 >$ is the mean-square speed (a simple model considering one-dimensional collisions and then extending to three dimensions using $\frac{1}{3} < c^2 > = < c_x{}^2 >$ is sufficient)]<br>*(Application)*<br><br>[SLO: P-11-C-06]<br>Derive and use the formula for the average translational kinetic energy of a gas.<br>*(Application)*<br><br>[SLO: P-11-C-07]<br>Derive Boyle's and Charles's law with the help of kinetic theory of gases.<br>*(Understanding)*<br><br>**8.2 THERMODYNAMICS**<br>[SLO: P-11-C-08]<br>State that regions of equal temperature are in thermal equilibrium.<br>*(Knowledge)* | |

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| Explain convection in liquids and gases<br>[in terms of density changes]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-C-10]<br>Explain convection in seawater to support marine life.<br>*(Understanding)*<br><br>[SLO: P-09-C-11]<br>Describe the role of land breezes and sea breezes in maintaining moderate coastal climates.<br>*(Understanding)*<br><br>[SLO: P-09-C-12]<br>Explain how birds are able to fly for hours without flapping their wings and gliders are able to rise by riding on thermal currents.<br>*(Understanding)*<br><br>[SLO: P-09-C-13]<br>Use ideas of convection to explain how cyclones are formed.<br>*(Understanding)*<br><br>[SLO: P-09-C-14]<br>Explain magma flow in the Earth's mantle associated with geothermal activity in terms of convection.<br>[Only convection phenomenon should be discussed briefly]<br>*(Understanding)*<br><br>**7.6 RADIATION**<br>[SLO: P-09-C-15]<br>Describe the process of thermal energy transfer by radiation.<br>[and know that it does not require a medium]<br>*(Knowledge, Understanding)* | Analyze the applications and consequences of thermal expansion in real life.<br>*(Application)*<br><br>**1.4 EVAPORATION**<br>[SLO: P-10-C-10]<br>Describe the process of evaporation.<br>[in terms of the escape of more energetic particles from the surface of a liquid]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-C-11]<br>Differentiate between boiling and evaporation.<br>*(Understanding)*<br><br>[SLO: P-10-C-12]<br>Analyze how temperature, humidity, surface area and air movement over a surface affect rate of evaporation.<br>*(Understanding, Application)*<br><br>[SLO: P-10-C-13]<br>Explain how evaporation causes cooling.<br>*(Understanding)*<br><br>[SLO: P-10-C-14]<br>Describe the use of cooling caused by evaporation in the refrigeration process without using harmful CFCs.<br>*(Understanding, Application)* | [SLO: P-11-C-09]<br>Define and explain the term internal energy of a gas (ideal and real), and relate a rise in temperature of an object to an increase in its internal energy.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-C-10]<br>Describe the difference between work done by the system and work done on the system.<br>*(Understanding)*<br><br>[SLO: P-11-C-11]<br>Use $W = P\Delta V$ for the work done when the volume of a gas changes at constant pressure.<br>*(Application)*<br><br>[SLO: P-11-C-12]<br>Explain qualitatively, in terms of particles, the relationship between the pressure, temperature and volume of a gas<br>[Specifically the below case:<br>(a) pressure and temperature at constant volume.<br>(b) volume and temperature at constant pressure<br>(c) pressure and volume at a constant temperature]<br>*(Understanding, Application)*<br><br>[SLO: P-11-C-13]<br>Define and use the first law of thermodynamics. | |

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| [SLO: P-09-C-16]<br>Describe the effect of surface color and texture on the emission, absorption and reflection of infrared radiation<br>*(Understanding, Application)*<br><br>[SLO: P-09-C-17]<br>Discuss how the rate of emission of radiation depends on the surface temperature and surface area of an object.<br>*(Understanding, Application)*<br><br>[SLO: P-09-C-18]<br>Distinguish between good and bad emitters and absorbers of infrared radiation<br>*(Understanding, Application)*<br><br>**7.7 CONSEQUENCES AND EVERYDAY APPLICATION OF HEAT TRANSFER**<br>[SLO: P-09-C-19]<br>Analyze the consequence of heat radiation in the greenhouse effect and its effect in global warming.<br>*(Understanding)*<br><br>[SLO: P-09-C-20]<br>Explain how global warming contributes to extreme weather events.<br>[specifically in the case of hurricanes, heat waves, flooding, rainfall, wildfires, droughts, winter storms]<br>*(Understanding)*<br><br>[SLO: P-09-C-21]<br>Analyze everyday applications of conduction, convection and radiation | **1.5 LATENT HEAT**<br>[SLO: P-10-C-15]<br>Explain the concept of latent heat, including latent heat of fusion and vaporization, and calculate it.<br>[It includes the description of latent heat in terms of particle behavior and the forces between particles.]<br>*(Knowledge, Understanding, Application)* | [It includes that: how the first law of thermodynamics expresses the conservation of energy]<br>*(Understanding, Application)*<br><br>[SLO: P-11-C-14]<br>Discuss first law of thermodynamics for isochoric process, isobaric process, isothermal process and adiabatic process and interpret the processes with PV diagrams.<br>*(Understanding, Understanding)*<br><br>[SLO: P-11-C-15]<br>Differentiate between molar specific heat capacities of a gas at constant volume ($C_v$) and constant pressure ($C_p$).<br>*(Understanding)*<br><br>[SLO: P-11-C-16]<br>Explain why $C_p$ is greater than $C_v$ and derive the Mayer's relation<br>$Cp - Cv = R$<br>*(Understanding)*<br><br>[SLO: P-11-C-17]<br>Describe the working principle of a heat engine.<br>*(Understanding)*<br><br>[SLO: P-11-C-18]<br>State and explain the second law of thermodynamics. | |

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| [Including:<br>(a) heating objects such as kitchen pans<br>(b) heating a room by convection<br>(c) measuring temperature using an infrared thermometer<br>(d) using thermal insulation to maintain the temperature of a liquid and to reduce thermal energy transfer in buildings<br>(e) the mechanism of a household hot-water system]<br>*(Understanding, Application)* | | [including Kelvin statement and Clausius statement with their schematic diagrams]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-C-19]<br>Describe the Carnot engine, explain its working cycle between two heat reservoirs by determining the area enclosed by the cycle on a PV diagram., and discuss its efficiency in terms of temperatures of the hot and cold reservoirs.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-C-20]<br>State that the Carnot cycle sets a limit for the efficiency of a heat engine at the temperatures of its heat reservoirs given by:<br>Efficiency=1-$T_2$(cold reservoir)/$T_1$(hot reservoir)<br>*(Understanding, Application)*<br><br>[SLO: P-11-C-21]<br>Describe that refrigerator is a heat engine operating in reverse as that of an ideal heat engine.<br>[It includes the discussion on its coefficients of performance]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-C-22]<br>Explain that Entropy is a thermodynamic quantity that relates to the degree of disorder of the particles in a system.<br>[It includes the concept that: increase in temperature increases the disorder of the system, increase in entropy means degradation of energy, identifying that | |

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| | | system tends to become less orderly over time.]<br>*(Understanding)*<br><br>[SLO: P-11-C-23]<br>Describe the term "Negentropy"<br>*(Understanding)* | |

## Domain D: OSCILLATIONS AND WAVES

It is the branch of physics in which we study the physical nature of waves and their propagation (with a special look at the cases of sound and light).

**STANDARD:** Students will synthesize the principles of wave mechanics, physical acoustics, and optics to model and analyze oscillatory behavior, energy transport phenomena, and light field propagation. They will master the mathematical derivations, phase-space vectors, and graphical tracking of simple harmonic systems—including mass-spring boundaries, mechanical pendulums, and circular projections—under both conservative and dissipative damping. Furthermore, by applying the universal principles of linear superposition, students will quantify and evaluate frequency quantization in standing waves, model the multi-dimensional transport dynamics of refraction, diffraction, and polarization, and engineer precision optical and sonographic systems with absolute scientific rigor.

**Benchmark I:** Differentiate systematically among periodic, oscillatory, and simple harmonic motions. Define core periodic parameters (x, A, T, f) and prove from first principles the acceleration criteria for SHM ($a \propto -x$). Model restoring forces and vector distributions across mechanical systems (ball-and-bowl and small-amplitude simple pendulums), and execute algebraic calculations using $T = 2\pi\sqrt{l/g}$.

**Benchmark II:** Characterize energy transport across transverse and longitudinal frameworks using spatial wave features, applying the universal wave equation ($v = f\lambda$). Analyze wave interactions across physical boundaries via plane reflection, media refraction, and single-slit diffraction. Quantify acoustic metrics—including intensity, decibel intensity levels, and range velocity dynamics across media phases—while implementing soft material geometries for structural acoustic protection.

**Benchmark III:** Categorize non-audible acoustic spectrums by evaluating the physical boundaries of infrasound (<20 Hz) and ultrasound (>20 kHz) within biological systems. Explain the inverse mechanical-electrical coupling of the piezoelectric effect, and analyze the clinical application of piezoelectric transducers in generating and detecting ultrasonic waves for medical diagnostic sonography.

**Benchmark IV:** Model the refraction of light across material boundaries using refractive index ratios ($n = c/v = \sin i/\sin r$) and Snell's Law ($n_1 \sin i = n_2 \sin r$). Calculate critical angles ($\sin c = 1/n$) governing total internal reflection in optical fibers. Formulate image matrices for thin converging and diverging lenses via geometric ray tracing and thin-lens calculations

**Benchmark I:** Derive and model the kinematic variations of Simple Harmonic Motion (SHM) by evaluating the projection of uniform circular motion on a reference diameter. Calculate instantaneous displacement, velocity, and acceleration vectors alongside their respective phase graphs; apply Hooke's Law to verify mass-spring boundary parameters ($a \propto -x$); and compute total energy conservation boundaries utilizing $E_{total} = \frac{1}{2} m \omega^2 x_0^2$.

**Benchmark II:** Characterize transient system responses by sketching displacement-time profiles across light, critical, and heavy damping regimes. Differentiate between free, forced, and resonant states—evaluating structural, microwave, and telecommunication tuning applications alongside amplitude response sharpness. Quantify wave intensity mechanics ($I = P/A$, $I \propto A^2$) and mathematically derive classical Doppler Effect equations for localized moving frame observers and stationary source coordinates.

**Benchmark III:** Apply the Principle of Linear Superposition to model wave fields from coherent sources, calculating boundary limits for constructive and destructive interference via geometric path differences. Analyze multi-source interference through ripple tanks, phase-canceling headphones, and Young's Double-Slit arrays. Formulate standing wave profiles, calculate beat frequency notes, and derive quantized frequency equations for the harmonics of stretched strings, open organ pipes, and closed organ pipes.

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| (1/f = 1/p + 1/q, M = q/p), evaluate prism dispersion arrays, and engineer corrective lens configurations for short-sighted (myopic) and long-sighted (hyperopic) vision defects. | **Benchmark IV:** Model the angular diffraction of monochromatic and white light vectors through high-density diffraction gratings using d sin$\theta$ = n$\lambda$, to compute target emission wavelengths and spectral line splits. Validate the transverse structural geometry of electromagnetic fields through polarization mechanics, calculate intensity reduction profiles across multi-filter orientations utilizing Malus's Law<br>($I = I_o \cos^2\theta$), and evaluate polaroid configurations in photo-optics and structural stress analysis. |

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| | **UNIT 2: OSCILLATIONS AND WAVES** (16 Periods) | **UNIT 9: SIMPLE HARMONIC MOTION** (13 Periods) | |
| | **At the end of this unit, Students will be able to:**<br><br>**2.1 SIMPLE HARMONIC MOTION**<br>[SLO: P-10-D-01]<br>Differentiate between periodic motion, oscillatory motion, and simple harmonic motion with examples.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-D-02]<br>Define the terms displacement, amplitude, period, frequency, in the context of oscillations<br>*(Knowledge)*<br><br>[SLO: P-10-D-03]<br>Show that the frequency of an oscillation is the reciprocal of its time period.<br>*(Understanding)*<br><br>[SLO: P-10-D-04]<br>Explain that simple harmonic motion occurs when acceleration is proportional to displacement from a fixed point and in the opposite direction<br>*(Understanding)* | **At the end of this unit, Students will be able to:**<br><br>**9.1 CIRCULAR MOTION & SHM**<br>[SLO: P-11-D-01]<br>Describe that when an object moves in a circle, the motion of its projection on the diameter of the circles is SHM.<br>*(Understanding)*<br><br>[SLO: P-11-D-02]<br>Derive and analyze the formulae for instantaneous displacement, instantaneous velocity and instantaneous acceleration of this projection of uniform circular motion (SHO). Use these formulae to solve problems.<br>*(Understanding, Application)*<br><br>[SLO: P-11-D-03]<br>Analyze graphical representations of the variations of displacement, velocity and acceleration for simple harmonic motion<br>*(Understanding, Application)*<br><br>**9.2 MASS SPRING SYSTEM & SHM**<br>[SLO: P-11-D-04]<br>Demonstrate that the motion of a mass attached to a spring is simple harmonic | |

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| | [SLO: P-10-D-05]<br>State the conditions necessary for an object to oscillate with SHM.<br>*(Understanding)*<br><br>[SLO: P-10-D-06]<br>Explain SHM for ball and bowl example.<br>*(Understanding)*<br><br>**2.2 SIMPLE PENDULUM**<br>[SLO: P-10-D-07]<br>Using the motion of a simple pendulum, explain simple harmonic motion by resolving the forces acting on the bob when it is displaced, and show that for small amplitudes the restoring force and acceleration are directly proportional to the displacement from the equilibrium position.<br>*(Understanding, Application)*<br><br>[SLO: P-10-D-08]<br>Describe and explain, using the formula for a simple pendulum, how the time period and frequency depend on the length of the pendulum and gravitational acceleration, and show that they are independent of the mass of the bob for small oscillations.<br>*(Understanding, Application)*<br>[SLO: P-10-D-09]<br>solve problems by using the formula $T = 2\pi\sqrt{l/g}$ for simple pendulum<br>*(Understanding, Application)*<br><br>**2.3 WAVE MOTION**<br>[SLO: P-10-D-10]<br>Describe what is meant by wave motion | by applying Hooke's law and showing that the restoring force and acceleration are proportional to the displacement from equilibrium and directed towards it.<br>*(Understanding)*<br>[SLO: P-11-D-05]<br>Derive and apply expressions for the angular frequency, time period, and frequency of a mass–spring system, and use simple harmonic motion equations to determine instantaneous displacement, velocity, and acceleration<br>*(Understanding, Application)*<br><br>**9.3 ENERGY CONSERVATION IN SHM**<br>[SLO: P-11-D-06]<br>Analyze the interchange between kinetic and potential energy during simple harmonic motion and apply $1/2\ m\omega^2 x_0^2$ for the total energy of a system.<br>*(Understanding, Application)*<br><br>**9.4 DAMPING**<br>[SLO: P-11-D-07]<br>Describe that a resistive force acting on an oscillating system causes damping<br>*(Understanding)*<br><br>[SLO: P-11-D-08]<br>Use the terms light, critical and heavy damping and sketch displacement–time graphs to illustrate light, critical and heavy damping<br>*(Knowledge, Understanding)*<br>[SLO: P-11-D-09]<br>Describe practical examples of damped oscillations [with the importance of critical damping in cases such as a car suspension system.] | |

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| | [as illustrated by vibrations in ropes and springs and by experiments using water waves.]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-D-11]<br>Prove that waves transfer energy without transferring matter<br>*(Understanding)*<br><br>[SLO: P-10-D-12]<br>Illustrate that for a transverse wave, the direction of vibration is at right angles to the direction of the energy transfer<br>[including giving examples such as electromagnetic radiation, waves on the surface of water, and seismic S-waves (secondary)]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-D-13]<br>Illustrate that for a longitudinal wave, the direction of vibration is parallel to the direction of the energy transfer<br>[including give examples such as sound waves and seismic P-waves (primary)]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-D-14]<br>Describe the features of a wave (Transverse and longitudinal waves)<br>[ in terms of wave front, wavelength, frequency, time period, crest (peak), trough, compression, rarefaction, amplitude and wave speed]<br>*(Knowledge)* | *(Understanding, Application)*<br><br>**9.5 FREE & FORCED OSCILLATIONS**<br>[SLO: P-11-D-10]<br>Describe practical examples of free and forced oscillations.<br>*(Knowledge, Understanding)*<br><br>**9.6 RESONANCE**<br>[SLO: P-11-D-11]<br>Explain the fact that resonance involves a maximum amplitude of oscillations and that this occurs when an oscillating system is forced to oscillate at its natural frequency.<br>*(Understanding)*<br><br>[SLO: P-11-D-12]<br>Justify that there are some circumstances in which resonance is useful<br>[such as tuning a radio, microwave oven and other circumstances in which resonance should be avoided such as airplane's wing or a suspension bridge]<br>*(Understanding, Application)*<br><br>[SLO: P-11-D-13]<br>Analyze qualitatively the factors which determine the frequency response and sharpness of the resonance.<br>*(Understanding, Application)* | |

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| | [SLO: P-10-D-15]<br>Analyze and apply the equation wave speed = frequency × wavelength<br>( $v = f \cdot \lambda$ )<br>*(Understanding, Application)*<br><br>**2.4 PROPERTIES OF WAVES**<br>[SLO: P-10-D-16]<br>Describe how waves can undergo reflection at a plane surface, refraction at the boundary between two media and diffraction at a single slit [it includes condition for maximum diffraction] [Teachers may use water waves for explaining these phenomenon]<br>*(Understanding)*<br><br>**UNIT 3: SOUND**<br>(11 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>**3.1 CHARACTERISTICS OF SOUND**<br>[SLO: P-10-D-17]<br>Define the terms pitch, loudness and quality of sound. [Pitch and Loudness have been included for just recall purpose as these SLOs are already discussed in Grade 7]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-D-18]<br>Define intensity of sound and state its SI unit.<br>*(Knowledge)*<br><br>[SLO: P-10-D-19] | **UNIT 10: PROPERTIES OF WAVES**<br>(18 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>**10.1 INTENSITY**<br>[SLO: P-11-D-14]<br>Explain the concept of intensity of waves and Use:<br>(a) intensity = power/area<br>(b) intensity ∝ (amplitude)$^2$<br>for a wave to solve problems.<br>*(Knowledge, Understanding, Application)*<br><br>**10.2 DOPPLER EFFECT AND ITS APPLICATIONS**<br>[SLO: P-11-D-15]<br>Explain and apply the Doppler effect for waves by deriving and using expressions for the apparent frequency when<br>(i) a source moves towards or away from a stationary observer and<br>(ii) an observer moves towards or away from a stationary source, assuming wave speed is constant.<br>*(Understanding, Application)*<br><br>[SLO: P-11-D-16]<br>Apply Doppler's Effect to practical situations, such as radar, medical ultrasound, and astronomical observations.<br>*(Application)* | |

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| | Explain the concept of sound intensity level, derive the formula $\beta = 10 \log_{10}(I / I_0)$, and state its SI unit (decibel, dB). Use the derived formula to solve simple problems involving intensity level.<br>*(Knowledge, Understanding, Application)*<br><br>**3.2 SPEED OF SOUND**<br>[SLO: P-10-D-20]<br>Discuss why sound waves cannot travel in a vacuum<br>[including describing experiments to demonstrate this]<br>*(Understanding, Application)*<br><br>[SLO: P-10-D-21]<br>Illustrate methods involving a measurement of distance and time for determining the speed of sound in air<br>*(Understanding, Application)*<br><br>[SLO: P-10-D-22]<br>State the approximate range of frequencies audible to humans as 20Hz to 20000Hz<br>*(Knowledge)*<br><br>[SLO: P-10-D-23]<br>Describe that, in general, sound travels faster in solids than in liquids and faster in liquids than in gases.<br>*(Knowledge, Understanding)*<br><br>**3.3 ULTRASOUND AND INFRASOUND**<br>[SLO: P-10-D-24]<br>Define ultrasound as sound with a frequency higher than 20kHz | **10.3 INTERFERENCE**<br>[SLO: P-11-D-17]<br>State and explain the principle of superposition for waves from coherent sources.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-D-18]<br>Apply the principle of superposition to explain the working of noise canceling headphones.<br>*(Application)*<br><br>[SLO: P-11-D-19]<br>Analyze the phenomenon of interference of waves using the principle of superposition, including the conditions for constructive and destructive interference expressed in terms of path difference.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-D-20]<br>Explain experiments that demonstrate two-source interference using water waves in a ripple tank, sound and light<br>*(Understanding)*<br><br>[SLO: P-11-D-21]<br>Describe the conditions to observe interference fringes from two coherent sources of light [It includes Young's double slit experiment involving conditions for maxima, minima, distance of $m^{th}$ order bright and dark fringes and | |

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| | and recall the uses of ultrasound in daily life.<br>[It includes how ultrasound can be used to obtain diagnostic information about internal body structures]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-D-25]<br>Explain that piezo-electric effect and its application in medical science [ultrasound waves are generated and detected by a piezoelectric transducer]<br>*(Understanding)*<br><br>[SLO: P-10-D-26]<br>Define infrasound as sound with a frequency less than 20Hz<br>and recall the uses of infrasound.<br>[e.g. by elephants in communication, and in the study of seismic activity]<br>*(Knowledge, Understanding)*<br><br>**3.4 ACOUSTIC PROTECTION**<br><br>[SLO: P-10-D-27]<br>Describe the importance of acoustic protection<br>It includes to explain the use of soft materials to reduce echo sounding<br>[such as in classroom studies, and other public gathering buildings]<br>*(Understanding, Application)*<br><br>**UNIT 4: OPTICS**<br>(22 Periods)<br>**At the end of this unit, Students will be able to:** | fringe width and solve simple problem related to formulae]<br>*(Knowledge, Understanding, Application)*<br>[SLO: P-11-D-22]<br>Explain and illustrate experiments that demonstrate the formation of stationary waves, including the identification of nodes and antinodes.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-11-D-23]<br>Explain the formation of harmonics in stationary waves in case of stretched string. [including the discussion on quantization of frequencies]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-D-24]<br>Explain the formation of harmonics in stationary waves in case of open and closed organ pipes. [including the discussion on quantization of frequencies]<br>(it will be assumed that end corrections are negligible; knowledge of the concept of end corrections is not required)<br>*(Knowledge, Understanding)*<br><br>[SLO: P-11-D-25]<br>Explain beats from two waves of slightly different frequencies, [it includes the calculation of the beat frequency, and its use in tuning instruments, measuring unknown note frequency]<br>*(Knowledge, Understanding, Application)* | |

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| | **4.1 REFRACTION OF LIGHT**<br>[SLO: P-10-D-28]<br>Define the phenomenon of refraction of light and its related terms normal, angle of incidence and angle of refraction.<br>*(Knowledge)*<br><br>[SLO: P-10-D-29]<br>Apply the qualitative principle that a light wave refracts towards the normal when it slows down while entering a medium, and that it refracts away from the normal if it speeds up when it enters a new medium [in the case the angle of incidence is zero, then the waves continue parallel to the normal]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-D-30]<br>Define and use the refractive index from a vacuum to a medium for light as $c/v$<br>*(Knowledge, Application)*<br><br>[SLO: P-10-D-31]<br>Define refractive index $n$ as<br>$n = \frac{sin\ (i)}{sin\ (r)}$<br>where $i$ is the angle of incidence in the vacuum (or air) and $r$ is the angle of refraction in the medium.<br>*(Knowledge)*<br><br>[SLO: P-10- D-32]<br>Apply Snell's law,<br>$n_i\ sin\ (i) = n_r\ sin\ (r)$<br>to solve simple problems.<br>*(Application)* | **10.4 DIFFRACTION**<br>[SLO: P-11-D-26]<br>Describe the diffraction of monochromatic light by a diffraction grating and explain how it can be used to determine the wavelength of light<br>*(Understanding, Application)*<br><br>[SLO: P-11-D-27]<br>Explain why spectral colours are produced when white light passes through the diffraction grating.<br>*(Understanding)*<br><br>[SLO: P-11-D-28]<br>use $d\sin\theta = n\lambda$, for diffraction grating to solve problems<br>*(Application)*<br><br>**10.5 POLARIZATION**<br>[SLO: P-11-D-29]<br>Explain that polarization is a phenomenon associated with transverse waves.<br>*(Understanding)*<br><br>[SLO: P-11-D-30]<br>Define and apply Malus's law [$I=I_0 \cos^2\theta$, to calculate the intensity of a plane-polarized electromagnetic wave after transmission through a polarizing filter or a series of polarizing filters. (calculation of the effect of a polarizing filter on the intensity of an unpolarized wave is not required).]<br>*(Understanding)* | |

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| | **4.2 TOTAL INTERNAL REFLECTION**<br>[SLO: P-10-D-33]<br>Explain the terms critical angle and total internal reflection, and describe the conditions under which total internal reflection occurs in a medium.<br>*(Understanding, Application)*<br><br>[SLO: P-10-D-34]<br>Derive and apply the equation<br>$n = 1/sin\,(c)$<br>to solve simple problems<br>*(Understanding, Application)*<br><br>[SLO: P-10-D-35]<br>Discuss the use of optical fibers [particularly in telecommunications, stating the advantages of their use in the context]<br>*(Understanding, Application)*<br><br>**4.3 INTRODUCTION TO LENS**<br>[SLO: P-10-D-36]<br>Analyze the action of thin converging and thin diverging lenses on a parallel beam of light<br>*(Understanding)*<br><br>[SLO: P-10-D-37]<br>Define and use the terms focal length, principal axis and principal focus (focal point) in context of Converging and diverging lenses.<br>*(Knowledge, Understanding)*<br><br>**4.4 NATURE, SIZE AND LOCATION OF IMAGES FORMED BY LENSES**<br>[SLO: P-10-D-38] | [SLO: P-11-D-31]<br>Explain the use of polaroids in sky photography and stress Understanding of materials<br>*(Understanding, Application)* | |

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| | Differentiate between real and virtual images<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-D-39]<br>Draw ray diagrams to illustrate the formation of images by a converging lens for the object placed at:<br>i) infinity, ii) before 2F iii) at 2F<br>iv) between F and 2F v) at F vi) within focal length of lens.<br>*(Understanding, Application)*<br><br>[SLO: P-10-D-40]<br>Draw ray diagrams to illustrate the formation of images by a diverging lens<br>*(Understanding, Application)*<br><br>[SLO: P-10-D-41]<br>Define and calculate linear magnification of a lens.<br>*(Knowledge, Application)*<br><br>[SLO: P-10-D-42]<br>Introduce and apply the lens formula to determine the relationship between object distance, image distance, and focal length for lenses.<br>[Derivation of lens formula is not included here]<br>*(Knowledge, Application)*<br><br>[SLO: P-10-D-43] | | |

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| | Describe the use of a single lens as a magnifying glass<br>*(Understanding)*<br><br>**4.5 POWER OF LENS/MAGNIFYING AND RESOLVING POWER**<br>[SLO: P-10-D-44]<br>Define power of a lens and its unit and calculate it.<br>*(Knowledge, Application)*<br>[SLO: P-10-D-45]<br>Define the terms resolving power and magnifying power.<br>*(Knowledge)*<br><br>**4.6 DISPERSION OF LIGHT**<br>[SLO: P-10-D-46]<br>Explain the dispersion of light by a prism.<br>*(Understanding)*<br><br>[SLO: P-10-D-47]<br>State the traditional seven colors of the visible spectrum in order of frequency and in order of wavelength<br>*(Knowledge)*<br><br>**4.7 DEFECTS IN VISION**<br>[SLO: P-10-D-48]<br>State and draw ray diagrams to show the formation of images in the normal eye, a short-sighted eye and a long-sighted eye [it includes the causes of short sightedness and long sightedness]<br>*(Understanding, Application)*<br><br>[SLO: P-10-D-49] | | |

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| | Describe the use of converging and diverging lenses to correct long-sightedness and short-sightedness *(Understanding, Application)* | | |

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## Domain E: ELECTRICITY AND MAGNETISM

This is the field that studies the physical properties of electric and magnetic phenomena, along with the nature of electromagnetism.

**STANDARD:** Students will synthesize the principles of classical electrodynamics, field theory, alternating current networks, and solid-state electronics to model, analyze, and manipulate charge and field behaviors across diverse physical mediums. They will master algebraic and calculus-adjacent formulations to quantify electrostatic field intensities, potential gradients, multi-loop circuit matrices, and vector magnetic forces acting on microscopic and macroscopic charge systems. Furthermore, by applying the foundational conservation laws, vector phasor transformations, and quantum-adjacent band structures, students will analyze and engineer practical electromagnetic machinery, safe domestic power distributions, reactive electrical networks, and complex digital semiconductor logic configurations with absolute academic and technical rigor.

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| **Benchmark I:** State charge conservation, duality, and quantization in Coulombs, modeling frictional electron transfer and thermal/moisture discharging pathways in insulators. Apply Coulomb's Law ($F = k\ q_1\ q_2/r^2$) to point charges as a mutual Newtonian third-law interaction. Evaluate electrical conductor polarization via electrostatic induction and ground earthing, and analyze the industrial application of static fields in photocopiers, electrostatic precipitators, and powder-coating systems.<br><br>**Benchmark II:** Characterize magnetic fields as vector force regions acting on individual poles, distinguishing between magnetic and non-magnetic materials. Differentiate the structural configurations of diamagnetic, paramagnetic, and ferromagnetic substances; apply magnetic domain alignment theory to model induction, saturation, and demagnetization pathways (via mechanical impact, thermal agitation, or solenoid field); and analyze the technical deployment of temporary electromagnets and permanent magnets in modern recording and storage media.<br><br>**Benchmark III:** Quantify charge carrier drift kinetics in electrical currents ($I = Q/t$), differentiating between actual electronic and conventional current vectors, and AC versus DC profiles. Apply Ohm's Law ($V = IR$) under constant-temperature bounds, defining | **Benchmark I:** Model localized electric field intensities ($E = F/q = kQ/r^2$) and field configurations for point charges, concentric conductors, and parallel plates, locating null positions ($E_{net} = 0$) for complex charge arrays. Mathematically derive the negative potential gradient ($E = -\Delta V/\Delta r$), absolute single point potentials ($V = kQ/r$), and localized electrostatic system energies ($E = kQq/r$). Model spherical and parallel capacitance configurations, resolve equivalent constraints for series-parallel combinations, and analyze exponential transient curves for charging/discharging cycles using the RC time constant ($\tau = RC$). Explain gas ionization dynamics, Faraday shielding, and the atmospheric mechanics of lightning rods and corona discharges.<br><br>**Benchmark II:** Quantify microscopic carrier drift mechanics within current channels using $I = nqAv$. Model internal cell configurations via terminal equations ($V_t = E - Ir$) across distinct load states. Analyze the temperature coefficient of resistivity ($\alpha$) across metals and intrinsic semiconductors. Map complex multi-loop circuit topologies by applying Kirchhoff's Laws (Charge Conservation $\sum I = 0$ and Energy Conservation $\sum V = 0$), and optimize precision null-balance networks |

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<td colspan="2">resistance (R) and material resistivity ($\rho$ = R A/L). Interpret current-voltage (I-V) performance characteristics for ohmic conductors, filament lamps, and non-ohmic semiconductor diodes, and calculate current, voltage drop, and equivalent resistance across complex series and parallel circuit networks.<br><br>**Benchmark IV:** Evaluate electrical power transfer and thermal Joule heating in resistive systems using derivative energy expressions ($P = VI = I^2R = V^2/R$). Calculate the operational economics of industrial and consumer appliances utilizing kilowatt-hour (kWh). Design and diagnose safe domestic electrical distribution systems by modeling parallel load wiring, three-wire mains profiles (Live, Neutral, Earth), double insulation parameters, and live-to-casing faults managed via current-rated safety fuses and electromagnetic trip switches.<br><br>**Benchmark V:** Model the morphology and directionality of magnetic flux fields around straight conductors and solenoids. Apply Fleming's Left-Hand Rule to determine magnetic force on current-carrying conductors and parallel wires, and analyze the rotational physics of DC motors utilizing split-ring commutators. Evaluate Faraday's and Lenz's laws of electromagnetic induction to calculate time-varying induced EMFs, interpret AC generator voltage outputs, and apply mutual inductance turns ratios (Vp/Vs = Np/Ns) to optimize high-voltage grid transmissions and minimize national grid power losses.</td>
<td colspan="2">by analyzing Wheatstone bridges ($R_1/R_2 = R_3/R_4$) and non-current-drawing Potentiometer systems.<br><br>**Benchmark III:** Evaluate vector magnetic field forces acting on macroscopic currents, $\mathbf{F} = I(\mathbf{L}\mathrm{x}\mathbf{B})$ and unconstrained microscopic charges, $\mathbf{F} = q(\mathrm{v}\mathrm{x}\mathbf{B})$, using these orthogonal relationships to engineer crossed-field velocity selectors. Quantify surface magnetic flux vectors ($\emptyset_B = \mathbf{B.A}$). Derive Faraday's Law of Induction ($V_{induced} = -N\ \Delta\emptyset/\Delta t$) alongside Lenz's Law to verify energy conservation limits in inductive loops, and apply these principles to optimize electromagnetic induction seismometers for geological velocity capturing.<br><br>**Benchmark IV:** Formulate root-mean-square values ($I_{rms} = I_o/\sqrt{2}$, $V_{rms} = V_o/\sqrt{2}$ to evaluate active Joule heating and mean power dissipation in alternating current circuits. Model time-dependent voltage-current phase offsets (leads and lags) across pure resistive, capacitive, and inductive loads. Calculate frequency-dependent reactive constraints (Capacitive Reactance $X_C = 1/2\pi fC$} and Inductive Reactance $X_L = 2\pi fL$), treat high-inductance chokes as current suppressors, and construct vector phasor diagrams to calculate complex total impedance (Z) in series R-C and R-L networks.<br><br>**Benchmark V:** Model electronic band structures by evaluating conduction mechanics via electron-hole pairings across intrinsic and extrinsic (P-type/N-type) semiconductor lattices. Analyze depletion region behaviors under forward and reverse biasing in PN junctions, evaluating their role in single-diode half-wave and four-diode bridge full-wave rectification. Classify NPN and PNP Bipolar Junction Transistor (BJT) topologies (Common-Base, Common-Emitter, Common-Collector), apply current balancing equations ($I_E = I_B + I_C$), and model high-frequency BJT saturation switching alongside an overview of the scale limit advances of quantum computing. Differentiate analog signals from digital bit-byte profiles, construct Boolean logic algebraic statements, and arrange AND, OR, NOT, NAND, and NOR gate matrices to construct security and automation logic control networks.</td>
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<td>**Unit 8: MAGNETISM**<br>(09 Periods)</td>
<td>**UNIT 5: ELECTROSTATICS**<br>(07 Periods)</td>
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<td>**UNIT 1: ELECTROSTATICS**<br>(22 Periods)</td>
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<td>**At the end of this unit, Students will be able to:**<br><br>**8.1 INTRODUCTION TO MAGNETISM**<br>[SLO: P-09-E-01]</td>
<td>**At the end of this unit, Students will be able to:**<br><br>**5.1 ELECTRIC CHARGE**<br>[SLO: P-10-E-01]</td>
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<td>**At the end of this unit, Students will be able to:**<br><br>**1.1 ELECTRIC FIELD**<br>[SLO: P-12-E-01]</td>
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| Describe the forces between magnetic poles and between magnets and magnetic materials<br>[Including the use of the terms north pole (N pole), south pole (S pole), attraction and repulsion, magnetized and unmagnetized]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-E-02]<br>Describe magnetic fields<br>[as a region in which a magnetic pole experiences a force]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-09-E-03]<br>State the difference between magnetic and non-magnetic materials<br>*(Knowledge)*<br><br>**8.2 TYPES OF MAGNETIC MATERIALS**<br>[SLO: P-09-E-04]<br>Describe and distinguish between paramagnetic and diamagnetic materials by their behaviour in the absence of a magnetic field and their response when placed in an external magnetic field.<br>*(Understanding)*<br><br>[SLO: P-09-E-05]<br>Describe the magnetic behaviour of ferromagnetic materials and explain, using magnetic domains, how magnetization and demagnetization occur in an external magnetic field.<br>*(Understanding)*<br><br>[SLO: P-09-E-06] | State that there are positive and negative charges<br>[and charge quantized and is measured in coulombs]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-E-02]<br>State that unlike charges attract and like charges repel<br>*(Knowledge)*<br><br>[SLO: P-10-E-03]<br>Explain that charging of solids by friction involves only a transfer of negative charge (electrons)<br>*(Understanding)*<br><br>[SLO: P-09-E-04]<br>Explain how and why an insulator can be discharged by (a) putting it above a flame, and (b) exposing it to damp conditions<br>*(Understanding, Application)*<br><br>**5.2 COULOMB'S LAW**<br>[SLO: P-10-E-05]<br>State and apply Coulomb's law<br>[$F = k\frac{Q_1 Q_2}{r^2}$ for the force between two point charges in free space, where $k = \frac{1}{4\pi\epsilon_0}$]<br>[including that it follows Newton's 3rd law]<br>*(Knowledge, Understanding, Application)* | | state that an electric field is an example of a field of force<br>*(Knowledge)*<br><br>[SLO: P-12-E-02]<br>Define and calculate electric field strength<br>[It includes discussion on formulas E= F/q and $E = k\, Q/r^2$]<br>*(Knowledge, Understanding, Application)*<br>**1.2 ELECTRIC FIELD LINES OF VARIOUS CHARGE CONFIGURATIONS**<br>[SLO: P-12-E-03]<br>Represent how electric field lines can be drawn around a charge/combination of charges.<br>*(Understanding)*<br><br>[SLO: P-12-E-04]<br>Analyze and illustrate simple electric field patterns<br>[including the direction of the field: (a) around a point charge (b) around a charged conducting sphere (c) between two oppositely charged parallel conducting plates (end effects will not be examined)]<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-05]<br>Determine and justify the position of the null point (where the net electric field is zero) along the line joining two-point charges, for both like and unlike charges.<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-06]<br>Describe the effect of a uniform electric field on the motion of charged particles<br>*(Understanding, Application)* |

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| Explain qualitatively how materials can be magnetized and demagnetized<br>[stroking method, heating, orienting in north-south direction and striking, use of a solenoid]<br>*(Understanding)*<br><br>[SLO: P-09-E-07]<br>Differentiate between temporary and permanent magnets<br>*(Knowledge, Understanding)*<br><br>**8.3 USES OF MAGNETS**<br>[SLO: P-09-E-08]<br>Describe uses of permanent magnets and electromagnets<br>*(Understanding, Application)*<br><br>[SLO: P-09-E-09]<br>Analyze applications of magnets in recording technology<br>*(Understanding, Application)* | **5.3 ELECTROSTATIC INDUCTION AND APPLICATION OF STATIC ELECTRICITY**<br>[SLO: P-10-E-06]<br>Explain how a conductor can be charged by electric induction and then "earthing"<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-07]<br>Suggest how charging and discharging is used in the application of various devices [e.g. photocopier machine, electrostatic precipitator, electrostatic powder painting]<br>*(Understanding, Application)* | | [SLO: P-12-E-07]<br>Explain how a Faraday cage works [by inducing internal electric fields that work to shield the inside from the influence of external electric fields]<br>*(Understanding, Application)*<br>[SLO: P-12-E-08]<br>Explain electrical breakdown [it occurs when a strong electric field passes through a gas and causes its atoms to ionize]<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-09]<br>State that Corona discharge and Lichtenberg figures are visible examples of electrical breakdown.<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-10]<br>Explain how lightning is generated (Including the below steps of formation:<br>- through friction between the water molecules suspended in clouds in the case of thunderstorms, and from between smoke particles in the case of volcanic lightning<br>- lightning streamers are created through the process of electrical breakdown and this provided a path for the electric current from one charged object to the other<br>- in the case of cloud-ground lightning a strong electric field from the clouds induces an opposite net charge in the conducting material present in the ground, and when this field becomes strong enough it generates lightning streams that provide the path for cloud-to-ground and ground-to-cloud discharge) |

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| | | | *(Understanding, Application)*<br><br>[SLO: P-12-E-11]<br>Explain how a lightning rod can protect humans<br>*(Understanding, Application)*<br>**1.3 ELECTRIC POTENTIAL**<br>[SLO: P-12-E-12]<br>Define electric potential and potential difference in electric field<br>*(Knowledge)*<br><br>[SLO: P-12-E-13]<br>Derive and discuss that the electric field at a point is equal to the negative of potential gradient at that point<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-14]<br>Derive the formula for electric potential due to a point charge ($V=1/(4\pi\epsilon_0 r)$)<br>*(Understanding)*<br><br>[SLO: P-12-E-15]<br>State how the concept of electric potential leads to the electric potential energy of two-point charges and use $E_p=Qq/(4\pi\epsilon_0 r)$<br>*(Understanding)*<br><br>[SLO: P-12-E-16]<br>Apply formulae of electric potential, electric potential energy to solve simple problems<br>*(Application)*<br><br>**1.4 CAPACITORS**<br>[SLO: P-12-E-17]<br>Define and calculate capacitance |

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| | | | [as applied to both isolated spherical conductors and to parallel plate capacitors (discuss factors affecting their capacitance)] *(Understanding)*<br><br>[SLO: P-12-E-18]<br>Derive and apply formulae for the combined capacitance of parallel plate capacitors in series and in parallel combinations<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-19]<br>Determine the electric potential energy stored in a capacitor from the area under the potential–charge graph<br>[Use W=1/2 QV=1/2 $CV^2$ to solve physics related problems]<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-20]<br>Analyze graphs of the variation with time of potential difference, charge and current for a capacitor's charging and discharging through a resistor<br>[use $\tau$ = RC, for the time constant for a capacitor charging and discharging through a resistor. Also mention charging and discharging equations for such capacitors]<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-21]<br>List the use of capacitors in various household appliances [such as in flash guns, refrigerators, electric fans, rectification circuits, etc.]<br>*(Knowledge)* |

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| | **UNIT 6: CURRENT ELECTRICITY** (30 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>**6.1 ELECTRIC CURRENT**<br>[SLO: P-10-E-08]<br>Define and calculate electric current<br>[Use the equation electric current = charge/time $I = Q/t$ to solve simple problems]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-10-E-09]<br>Explain electrical conduction<br>[in metals in terms of the movement of free electrons]<br>*(Understanding)*<br><br>[SLO: P-10-E-10]<br>state that current is measured in amps (amperes) and that the amp is given by coulomb per second (C/s)<br>*(Knowledge)*<br><br>[SLO: P-10-E-11]<br>Differentiate between direct current (DC) and alternating current (AC)<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-E-12]<br>Differentiate between conventional and actual(electronic) current<br>*(Knowledge, Understanding)* | | **UNIT 2: CURRENT ELECTRICITY** (14 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>**2.1 BASICS OF CURRENT ELECTRICITY**<br>[SLO: P-12-E-22]<br>Use the relation $I=nqAv$, to calculate the current in a conductor [where n is the number of charge carriers per unit volume.]<br>(detail/introduction of electric current is not required, as it is already discussed in Grad-10)<br>*(Understanding)*<br><br>[SLO: P-12-E-23]<br>Explain the concept of electromotive force (emf), internal resistance, and terminal potential difference of a cell or battery, using standard circuit symbols, and discuss how internal resistance affects energy transfer within the source. (detail/introduction of emf and potential difference is not required, as these terms are discussed in Grad-10)<br>*(Understanding)*<br><br>[SLO: P-12-E-24]<br>Use the relation $V_t = E - Ir$, to analyse the terminal potential difference under different operating conditions, and explain when $V_t < E$, $V_t = E$, or $V_t > E$.<br>[it includes solving simple problems relating to these condition] |

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| | **6.2 EMF and POTENTIAL DIFFERENCE**<br>[SLO: P-10-E-13]<br>Explain and distinguish between electromotive force (EMF) and potential difference (PD),<br>[including their measurement, effect in a circuit and solve simple problems]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-10-E-14]<br>Calculate the total e.m.f. where several sources are arranged in series and in parallel combinations.<br>*(Application)*<br><br>**6.3 OHM'S LAW**<br>[SLO: P-10-E-15]<br>State and apply Ohm's law<br>[Including reference to constant temperature. Use the equation resistance = p.d./current R = V/I to solve simple problems.]<br>*(Knowledge, Understanding, Application)*<br><br>**6.4 RESISTANCE**<br>[SLO: P-10-E-16]<br>Define resistance and its SI unit (Ω).<br>[using a voltmeter and an ammeter and do the appropriate calculations]<br>*(Knowledge, Understanding)* | | *(Application)*<br><br>**2.2 RESISTANCE AND RESISTIVITY**<br>[SLO: P-12-E-25]<br>Discuss the temperature coefficient of resistivity for metals and semiconductors, explaining how their resistivity changes with temperature<br>*(Understanding)*<br><br>[SLO: P-12-E-26]<br>Justify and illustrate the use of color codes for resistors<br>*(Understanding)*<br><br>[SLO: P-12-E-27]<br>Explain how inspectors can easily check the reliability of a concrete bridge with carbon fibers as the fibers conduct electricity<br>*(Application)*<br><br>**2.3 SUPERCONDUCTIVITY**<br>[SLO: P-12-E-28]<br>Describe superconductivity, including that certain materials, when cooled near absolute zero, show zero electrical resistance, and outline its practical uses.<br>*(Understanding)*<br><br>**2.4 THERMISTORS AND LIGHT-DEPENDENT RESISTORS**<br>[SLO: P-12-E-29]<br>Explain the use of thermistors and light-dependent resistors in potential dividers and input sensors [to provide a potential difference that is dependent on temperature and light intensity |

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| | [SLO: P-10-E-17]<br>Discuss factors affecting resistance of a conductor w.r.t. dimensions. Also define resistivity.<br>[It also includes solution of simple problems including length and cross-sectional area of the conductor]<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-10-E-18]<br>Describe the effect of temperature increase on the resistance of a resistor [such as the filament in a filament lamp]<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-19]<br>Interpret current–voltage graphs [including for a resistor of constant resistance, a filament lamp and a diode]<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-20]<br>Identify examples of electrical conductors, insulators and semiconductors<br>[they should be distinguished only on the bases of their ability to conduct or oppose current]<br>*(Understanding)*<br>[SLO: P-10-E-21]<br>Describe and compare the series and parallel combinations of resistors, including their effects on current, potential difference, and total resistance in simple electric circuits.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-10-E-22] | | *(Understanding, Application)*<br><br>**2.5 KIRCHHOFF'S LAWS**<br>[SLO: P-12-E-30]<br>state Kirchhoff's first law and describe that it is a consequence of conservation of charge.<br>*(Understanding)*<br><br>[SLO: P-12-E-31]<br>state Kirchhoff's second law and describe that it is a consequence of conservation of energy.<br>*(Understanding)*<br><br>[SLO: P-12-E-32]<br>use Kirchhoff's laws to solve simple circuit problems (for single and two loops only).<br>*(Application)*<br><br>**2.6 THE POTENTIAL DIVIDER**<br>[SLO: P-12-E-33]<br>Analyze the function of potential dividers in circuits<br>[including using the equation for two resistors used as a potential divider R1/R2= V1/V2]<br>*(Understanding, Application)*<br><br>**2.7 BALANCED POTENTIALS (WHEATSTONE BRIDGE AND POTENTIOMETER)**<br>[SLO: P-12-E-34]<br>Explain and analyze the use of a galvanometer in null methods, including the Wheatstone bridge, to determine unknown resistance with maximum accuracy.<br>*(Understanding, Application)* |

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| | Calculate current, voltage and resistance in parts of a circuit or in the whole circuit.<br>*(Application)*<br><br>**6.5 ELECTRICAL POWER**<br>[SLO: P-10-E-23]<br>Define electric power as the rate of transfer of electrical energy and use the equations<br>$P = IV$, $P = I^2R$, and $P = \frac{V^2}{R}$ to calculate electric power in resistive circuits.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-E-24]<br>How energy is dissipated across the resistors and use the equation energy = current × voltage × time<br>$E = IVt = I^2Rt = V^2t/R$ to solve simple problems<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-10-E-25]<br>Define the kilowatt-hour (kWh) as a unit of electrical energy and relate it to the joule.<br>*(Knowledge, Understanding)*<br>[SLO: P-10-E-26]<br>Calculate the cost of using electrical appliances where the energy unit is the kWh<br>*(Application)*<br><br>[SLO: P-10-E-27]<br>Explain the need to choose components with suitable power ratings.<br>*(Understanding)*<br>**6.6 ELECTRIC HAZARDS**<br>[SLO: P-10-E-28] | | [SLO: P-12-E-35]<br>Describe the function of potentiometer to measure and compare potentials without drawing any current from the circuit.<br>*(Understanding, Application)*<br><br>**Unit 3: ELECTROMAGNETISM AND ELECTROMAGNETIC INDUCTION**<br>(09 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>**3.1 MAGNETIC FORCE ON A CUURENT CARRYING CONDUCTOR/MOVING CHARGE**<br>[SLO: P-12-E-36]<br>Recall that a current-carrying conductor in a magnetic field experiences a force, understand the relation $F=BIL\sin\theta$, to solve simple problems, and define magnetic flux density as force per unit current per unit length for a conductor placed perpendicular to the magnetic field.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-12-E-37]<br>Describe the motion of a charged particle moving in a uniform magnetic field and use $F=qvB\sin(\theta)$ to solve problems.<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-38]<br>Explain how electric and magnetic fields can be used in velocity selectors<br>*(Understanding)* |

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| | State common electric hazards that may be caused from malpractice and lack of maintenance<br>[specifically:<br>(a) damaged insulation<br>(b) overheating cables<br>(c) damp conditions<br>(d) excess current from overloading of plugs, extension leads, single and multiple sockets when using a mains supply]<br>*(Understanding)*<br><br>[SLO: P-10-E-29]<br>Explain the damage that electric shock could do to a human being<br>[in terms of burns, cardio-respiratory failure and seizures]<br>*(Understanding)*<br><br>**6.7 EFFECTIVE USE OF ELECTRICITY**<br>[SLO: P-10-E-30]<br>State common uses of electricity<br>[including heating, lighting, battery charging and powering motors and electronic systems.]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-E-31]<br>Analyze the advantages of connecting lamps in parallel in a lighting circuit<br>*(Understanding)*<br><br>[SLO: P-10-E-32]<br>Explain the use and operation of trip switches and fuses and choose appropriate fuse ratings and trip switch settings | | **3.2 MAGNETIC FLUX**<br>[SLO: P-12-E-39]<br>Understand magnetic flux as [as product of the magnetic flux density and the cross-sectional area perpendicular to the direction of the magnetic flux density]<br>*(Knowledge)*<br><br>[SLO: P-21-E-40]<br>Use $\Phi_B=\mathbf{B}.\mathbf{A}$ to solve numerical problems related to magnetic flux.<br>*(Application)*<br><br>**3.3 ELECTROMAGNETIC INDUCTION**<br>[SLO: P-12-E-41]<br>State and derive the Faraday's law of electromagnetic induction.<br>*(Understanding)*<br><br>[SLO: P-12-E-42]<br>Use Lenz's law to predict the direction of an induced current and relate to the principle of conservation of energy.<br>*(Understanding)*<br><br>[SLO: P-12-E-43]<br>Use Faraday's and Lenz's laws of electromagnetic induction to solve problems<br>*(Application)*<br><br>[SLO: P-12-E-44]<br>Explain how seismometers make use of electromagnetic induction to the earthquake detection<br>[specifically in terms of:<br>(i) any movement or vibration of the rock on which the seismometer rests (buried in a protective case) results in relative motion |

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| | *(Understanding, Application)*<br><br>[SLO: P-10-E-33]<br>Explain what happens when a live wire touches a metal case that is earthed<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-34]<br>Explain why the outer casing of an electrical appliance must be either non-conducting (double-insulated) or earthed<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-35]<br>state that a mains circuit consists of a live wire (line wire), a neutral wire and an earth wire.<br>*(Understanding)*<br>[SLO: P-10-E-36]<br>Explain why fuses and circuit breakers are connected into the live wire for the circuit to be switched off safely.<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-37]<br>Explain why domestic supplies are connected in parallel.<br>*(Understanding, Application)*<br><br>**Unit 7: ELECTROMAGNETISM**<br>(15 Periods)<br>**At the end of this unit, Students will be able to:**<br>**7.1 MAGNETIC FIELD AROUND WIRES** | | between the magnet and the coil (suspended by a spring from the frame.)<br>(ii) the emf induced in the coil is directly proportional to the displacement associated]<br>*(Understanding, Application)*<br><br>**UNIT 4: A.C. CIRCUITS**<br>(07 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>[SLO: P-12-E-45]<br>Apply the relationship that, the mean power in a resistive load is half the maximum power for a sinusoidal alternating current.<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-46]<br>Explain the need for root-mean-square (r.m.s.) values in alternating current as equivalent d.c. values for heating effect, and state and use $I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$ and $V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$ for a sinusoidal waveform.<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-47]<br>Explain the concept of phase of A.C and describe phase lags and leads in A.C Circuits.<br>*(Understanding)*<br><br>[SLO: P-12-E-48]<br>Explain the behavior of alternating current/voltage in resistors, capacitors, and inductors by interpreting voltage–time and current–time graphs, describing phase lead/phase lag using phasor diagrams, and discuss power dissipation in each component.<br>*(Understanding, Application)* |

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| | [SLO: P-10-E-38]<br>Describe the pattern and direction of the magnetic field due to currents in straight wires and in solenoids.<br>[it includes the discussion on effect on the magnetic field of changing the magnitude, direction of the current and effect of ferrous core]<br>*(Knowledge, Understanding)*<br><br>**7.2 FORCE ON A CURRENT CARRYING CONDUCTOR**<br>[SLO: P-10-E-39]<br>Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field [including the effect of reversing:<br>(a) the current<br>(b) the direction of the field]<br>*(Understanding)*<br>[SLO: P-10-E-40]<br>State and use Fleming's left-hand rule to determine the relative directions of the magnetic field, current, and force on a current-carrying conductor.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-E-41]<br>Describe the magnetic field produced by currents in parallel conductors and explain how the fields result in forces of attraction or repulsion between the conductors.<br>*(Understanding, Application)* | | [SLO: P-12-E-49]<br>Identify inductors as important components of A.C circuits termed as chokes<br>[devices which present a high opposition to alternating current]<br>*(Application)*<br><br>[SLO: P-12-E-50]<br>Calculate the reactance of capacitors and inductors.<br>*(Application)*<br><br>[SLO: P-12-E-51]<br>Describe impedance as the phasor (vector) sum of resistance and reactance in RC and RL series AC circuits.<br>*(Understanding, Application)*<br><br>**UNIT 5: ELECTRONICS**<br>(16 Periods)<br>**At the end of this unit, Students will be able to:**<br><br>**5.1 SEMICONDUCTORS**<br>[SLO: P-12-E-52]<br>Distinguish between intrinsic and extrinsic semiconductors, including P-type and N-type materials, and explain how electrons and holes contribute to electrical conduction.<br>*(Understanding)*<br><br>**5.2 DIODE**<br>[SLO: P-12-E-53]<br>Explain the structure and operation of a PN junction diode, including the movement of |

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| | **7.3 TURNING EFFECT ON A CURRENT CARRYING COIL IN A MAGNETIC FIELD**<br>[SLO: P-10-E-42]<br>State that a current-carrying coil in a magnetic field experiences a turning effect and list the factors that increase it. [without considering the effect of the angle between the coil and the magnetic field.]<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-43]<br>Describe the construction and operation of an electric motor, including the action of a split-ring commutator and brushes<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-44]<br>State that it is theorized that the Earth's magnetic field is generated by the rotation of the Earth and its molten iron core that contains charged particles in motion.<br>*(Knowledge, Understanding)*<br><br>**7.4 ELECTROMAGNETIC INDUCTION**<br>[SLO: P-10-E-45]<br>Describe and explain electromagnetic induction, including factors affecting the magnitude of induced e.m.f., such as the rate of change of magnetic field and the number of turns in the coil. | | electrons and holes across the junction under forward and reverse bias<br>*(Understanding, Application)*<br><br>**5.3 RECTIFICATION**<br>[SLO: P-12-E-54]<br>Distinguish graphically between half-wave and full-wave rectification<br>*(Understanding)*<br><br>[SLO: P-12-E-55]<br>explain the use of a single diode for the half-wave rectification of an alternating current<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-56]<br>explain the use of four diodes (bridge rectifier) for the full-wave rectification of an alternating current<br>*(Understanding, Application)*<br><br>**5.4 TRANSISTOR**<br>[SLO: P-12-E-57]<br>Identify the structure and circuit symbols of NPN and PNP bipolar junction transistors.<br>*(Understanding)*<br><br>[SLO: P-12-E-58]<br>Describe the function of emitter, base, and collector in a transistor in a properly biased circuit. |

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| | *(Understanding)*<br><br>**7.5 AC GENERATOR**<br>[SLO: P-10-E-46]<br>Describe how a.c. generators work [(rotating coil or rotating magnet setup) and the use of slip rings and brushes where needed]<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-47]<br>Sketch and interpret graphs of e.m.f. against time for simple a.c. generators<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-E-48]<br>Use the terms period, frequency and peak value as applied to an alternating current or voltage.<br>*(Knowledge, Understanding)*<br><br>**7.6 TRANSFORMER**<br>[SLO: P-10-E-49]<br>Explain the construction and principle of operation of a simple iron-cored transformer<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-E-50]<br>Use the equation $V_p / V_s = N_p / N_s$<br>*(Understanding, Application)*<br><br>[SLO: P-10-E-51]<br>Compare step-up and step-down transformers in terms of turns ratio, voltage, and current. | | [it includes discussion on current equation $I_E = I_B + I_C$ for its common base configuration]<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-59]<br>Recognize the three configurations of a transistor (common emitter, common base, and common collector) in terms of their circuit connections and biasing arrangement. [their input/output characteristics and applications not required]<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-60]<br>Describe the action of a bipolar NPN transistor as a switch and explain why transistors are widely used in digital devices as economical and rapid-response switches. [To enrich this concept students should be given an overview of how with advances in engineering, the number of transistors that can be fit per unit area onto a circuit board has continued to increase dramatically; this has rapidly enhanced computing power. They also be given an overview of how - breakthroughs in quantum physics are causing a new revolution in computing that are enabling computers to make exponentially more logical operations per unit time than with traditional computers]<br>*(Knowledge, Understanding, Application)*<br><br>**5.5 DIGITAL DEVICES**<br>[SLO: P-12-E-61]<br>Compare analogue and digital electronics.<br>*(Knowledge, Understanding)* |

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| | *(Understanding, Application)*<br><br>[SLO: P-10-E-52]<br>Explain how electricity is transmitted at high voltage to reduce power loss and why step-down transformers are used to provide safe, usable voltages to consumers.<br>*(Knowledge, Understanding)* | | [SLO: P-12-E-62]<br>Explain that electronic devices are built from digital logic circuits<br>[that can act as switches that can convert incoming voltage into binary electrical pulses of high and low (or 1 and 0)]<br>*(Knowledge, Understanding)*<br><br>**5.6 LOGIC CIRCUITS**<br>[SLO: P-12-E-63]<br>Explain that Boolean logic is the basis for converting analogue data to digital data<br>[this includes knowing that 'bit' is the smallest unit of data in computing; either 1 or 0. Eight bits make up a byte.]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-12-E-64]<br>State in words and in truth table form, the action of logic gates<br>[specifically of AND, OR, NAND, NOR and NOT]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-12-E-65]<br>Identify the use of logic gates for security purposes [e.g; burglar alarm, fire extinguisher etc.]<br>*(Understanding, Application)*<br><br>[SLO: P-12-E-66]<br>Identify and draw the standard circuit symbols for basic logic gates.<br>*(Application)*<br><br>[SLO: P-12-E-67] |

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| | | | Identify in given problems how Boolean switches can be put into combinations that then allow them to achieve logical operations *(Application)* |

## Domain F: SPACE/MODERN PHYSICS

This domain focuses on new fields of Physics that were developed in the 19th and 20th centuries. These include nuclear physics, relativity and quantum physics.

**STANDARD:** Students will synthesize the principles of nuclear kinetics, quantum mechanics, relativity, and astrophysics to model, quantify, and evaluate the fundamental behavior of matter and radiation across atomic, subatomic, and cosmic scales. They will master non-Newtonian space-time kinematics, apply quantized wave-particle field equations, and utilize conservation laws to evaluate nuclear transformations, including fission, fusion, and exponential decay pathways. Furthermore, by linking microscopic subatomic structures—such as quark-lepton Standard Model matrices—with macroscopic stellar thermodynamics, cosmological expansion models, and advanced nuclear-medical imaging systems, students will analyze, resolve, and engineer solutions to complex physical phenomena with absolute scientific and mathematical rigor.

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| **Benchmark I:** Characterize the planetary model of the atom, defining nuclides and isotopes using standard notation. Evaluate the spatial distribution, mass concentrations, and net charge configurations of the nucleus by analyzing the empirical findings of Rutherford's alpha-particle scattering experiment. Define the spontaneous, random nature of natural radioactive decay, identify the discrete environmental sources of background radiation, explicitly quantifying the impacts of atmospheric radon gas, lithospheric rocks/building materials, dietary intake, and cosmic rays.. Differentiate ionizing behaviors, field deflections, and relative penetrating powers across alpha, beta, and gamma emissions.<br><br>**Benchmark II:** Construct and balance nuclear transmutation equations using nuclide notation for alpha, beta, and gamma decay paths. Differentiate between nuclear fission (heavy splitting, neutron generation, controlled/uncontrolled chain reactions) and nuclear fusion (light nucleus combination). Apply Einstein's mass-energy equivalence equation ($E = mc^2$) to calculate energy yields during isotopic transformations, and model the composition, spectral emission bands, and core fusion engine of the Sun alongside current cosmological hypotheses regarding dark matter.<br><br>**Benchmark III:** Quantify radioactive decay parameters by extracting half-life values ($T_{1/2}$) from data tables and decay curves to calculate remaining sample mass configurations. Apply half-life principles and isotopic decay lines to model archeological carbon-14 dating methods. Evaluate the criteria for matching radiation profiles and half-lives to specialized commercial, medical, and industrial systems (smoke detection, food preservation, cancer therapy). Analyze the physiological hazards of ionizing tracking (cell mutations, oncogenesis) and engineer mitigation protocols focused on exposure time, distance, and shielding geometry. | **Benchmark I:** Differentiate between inertial and non-inertial reference frames, and apply Einstein's postulates to model four-dimensional space-time. Calculate relativistic kinematic deviations—including length contraction, time dilation, and mass increase—alongside mass-energy equivalence. Map the subatomic Standard Model for fundamental particles (quarks, leptons, gauge bosons) and antiparticles, deduce the internal fractional quark configurations of nucleons, and analyze the operational physics of electromagnetic particle accelerators.<br><br>**Benchmark II:** Quantify photon kinematics by calculating localized wave packets for energy ($E=hf$) and radiation force momentum ($p = h/\lambda$). Synthesize the experimental evidence for wave-particle duality by contrasting classical wave failures against the quantum mechanics of the Photoelectric effect, Compton scattering, and nuclear pair production/annihilation. Evaluate particle wave configurations via de Broglie wavelength, and explain how electron diffraction fields are engineered to optimize high-resolution electron microscopy.<br><br>**Benchmark III:** Differentiate the physical characteristics of continuous, line, and band spectra, modeling the discrete electronic transitions of atomic hydrogen during line emission and absorption events ($hf = E_2 - E_1$). Apply Heisenberg's Uncertainty Principle to calculate the fundamental limits of physical measurements. Model the production of continuous and characteristic X-rays via high-voltage target electron bombardment, and evaluate the mathematical reconstructing logic of 3D Computed Tomography (CT) scanning arrays.<br><br>**Benchmark IV:** Evaluate nuclear binding energy per nucleon curves to determine stability parameters governing spontaneous fission and fusion transformations. |

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| | | Calculate real-world energy releases via mass defect calculations. Model the engineering infrastructure of water-moderated nuclear power reactors (enriched fuel cycles, moderators, control rods). Quantify exponential radioactive decay profiles analytically and graphically, translate activity benchmarks using decay constants, and map tissue concentrations via Positron Emission Tomography (PET) dual-gamma coincidence detection.<br><br>**Benchmark V:** Quantify stellar radiation attributes by applying the radiant flux intensity inverse-square law and utilizing Standard Candles for deep-space distance determination. Apply Wien's Displacement Law and the Stefan-Boltzmann Law to calculate the surface temperature and physical radius of stars. Analyze cosmological redshift ratios from astronomical absorption lines, and use Hubble's Law to model the expansion kinetics of the universe and validate the Big Bang paradigm. | |
| | **UNIT 8: NUCLEAR PHYSICS** (21 Periods) | **UNIT 11: MODERN PHYSICS** (15 Periods) | **UNIT 6: QUANTUM PHYSICS** (30 Periods) |
| | **At the end of this unit, Students will be able to:**<br>**8.1 ATOM & ATOMIC NUCLEUS**<br>[SLO: P-10-F-01]<br>Describe the structure of the atom in terms of a small, positively charged nucleus containing protons and neutrons, and electrons arranged in discrete energy levels (shells) around the nucleus.<br>*(shells represent different energies; calculation of energy of orbits is not required at this level).*<br>*(Understanding)*<br><br>[SLO: P-10-F-02]<br>Analyze the findings of the alpha-particle scattering experiments<br>[Specifically that it provides evidence for:<br>(a) a very small nucleus surrounded by mostly empty space<br>(b) a nucleus containing most of the mass of the atom<br>(c) a nucleus that is positively charged] | **At the end of this unit, Students will be able to:**<br>**11.1 RELATIVITY**<br>[SLO: P-11-F-01]<br>Distinguish between inertial and non-inertial frames of reference with example of each.<br>*(Understanding)*<br><br>[SLO: P-11-F-02]<br>Describe the significance of Einstein's postulate that the speed of light in vacuum is constant for all observers.<br>*(Understanding)*<br><br>[SLO: P-11-F-03]<br>Explain that if the speed of light is constant, measurements of space | **At the end of this unit, Students will be able to:**<br>**6.1 PHOTON THEORY**<br>[SLO: P-12-F-01]<br>state the main regions of the electromagnetic spectrum in order of frequency and in order of wavelength<br>*(Knowledge)*<br><br>[SLO: P-12-F-02]<br>state that the speed of all electromagnetic waves in:<br>(a) a vacuum is $3.0 \times 10^8$ m/s<br>(b) air is approximately the same as in a vacuum<br>*(Knowledge)*<br><br>[SLO: P-12-F-03] |

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| | *(Understanding)*<br><br>[SLO: P-10-F-03]<br>Define the terms proton number (atomic number) Z and nucleon number (mass number) A and be able to calculate the number of neutrons in a nucleus<br>*(Knowledge, Application)*<br><br>[SLO: P-10-F-04]<br>Recall the term nuclide and use the nuclide notation $^{A}_{Z}X$.<br>*(Knowledge, Application)*<br><br>[SLO: P-10-F-05]<br>Explain what is meant by an isotope and state that an element may have more than one isotope.<br>*(Understanding)*<br><br>**8.2 BACKGROUND RADIATION**<br>[SLO: P-10-F-06]<br>Explain what is meant by background radiation.<br>*(Understanding)*<br><br>[SLO: P-10-F-07]<br>State the sources that make a significant contribution to background radiation<br>[ including:<br>(a) radon gas (in the air)<br>(b) rocks and buildings<br>(c) food and drink<br>(d) cosmic rays]<br>*(Knowledge)*<br><br>**8.3 NATURAL RADIOACTIVITY** | and time become relative to the observer.<br>*(Understanding)*<br><br>[SLO: P-11-F-04]<br>State the postulates of Special relativity<br>*(Knowledge)*<br><br>[SLO: P-11-F-05]<br>Explain qualitatively and quantitatively the consequences of special relativity<br>[Specifically in the case of:<br>a– the relativity of simultaneity.<br>b– the equivalence between mass and energy.<br>c– length contraction.<br>d– time dilation.<br>e– mass increase]<br>*(Understanding, Application)*<br><br>[SLO: P-11-F-06]<br>Solve simple problems using equation of the consequences of special relativity.<br>*(Application)*<br><br>[SLO: P-11-F-07]<br>State that space-time is a model that treats time as a fourth dimension combined with the three spatial dimensions, and that distortions in space-time can produce observable effects, such as stretching and compression.<br>*(Understanding)*<br>**11.2 PARTICLE PHYSICS**<br>[SLO: P-11-F-08] | State that electromagnetic radiation can behave as particles called photons.<br>*(Knowledge)*<br><br>[SLO: P-12-F-04]<br>Use the photon energy equation E=hf to calculate the energy of a photon. Express energy in joules or electron volts (eV).<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-12-F-05]<br>Explain that a photon has momentum [including that the momentum is given by $p = E/c$ (connect with the idea that light can exert a force) and use this formula to solve problems]<br>*(Knowledge, Understanding, Application)*<br><br>**6.2 PHOTOELECTRIC EFFECT**<br>[SLO: P-12-F-06]<br>Describe that photoelectrons may be emitted from a metal surface when it is illuminated by electromagnetic radiation (introduction to photoelectric effect)<br>*(Knowledge, Understanding)*<br><br>[SLO: P-12-F-07]<br>Describe why classical wave theory cannot explain all observations of the photoelectric effect. (instantaneous emission and independence of KE from intensity).<br>*(Understanding)*<br><br>[SLO: P-12-F-08]<br>Describe and use the terms; threshold frequency and threshold wavelength |

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| | [SLO: P-10-F-08]<br>Describe that some nuclei are unstable and undergo a process called radioactivity, in which they emit radiation spontaneously.<br>*(Understanding)*<br><br>[SLO: P-10-F-09]<br>Describe α-particles, β-particles and γ-radiation are emitted from the unstable nuclei<br>[It includes the description of simple experiment to introduce these radiations and effect of electric and magnetic field on these radiations]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-F-10]<br>Describe the emission of radiation from a nucleus as spontaneous and random<br>*(Understanding)*<br><br>[SLO: P-10-F-11]<br>Analyze qualitatively the order of strength for α-particles, β-particles and γ-radiation in terms of their<br>(a) their relative ionizing effects<br>(b) their relative penetrating powers<br>*(Understanding)*<br><br>[SLO: P-10-F-12]<br>Explain that radioactive decay is a process in which an unstable nucleus changes and, | State that nucleon number and charge are conserved in nuclear processes<br>*(Knowledge)*<br><br>[SLO: P-11-F-09]<br>Describe the composition, mass and charge of α-, β- and γ-radiations<br>[both β– (electrons) and β+ (positrons) are included]<br>*(Knowledge)*<br><br>[SLO: P-11-F-10]<br>Explain that an antiparticle has the same mass but opposite charge to the corresponding particle<br>[Only give the example that a positron is the antiparticle of an electron]<br>*(Knowledge)*<br><br>[SLO: P-11-F-11]<br>Draw and complete a table of the Standard Model showing the three main groups of fundamental particles: quarks, leptons, and force carriers, including the particle name, symbol and charge.<br>*(Knowledge)*<br><br>[SLO: P-11-F-12]<br>Describe quarks and anit-quarks (as a fundamental<br>[including that there are six flavors (types) of quark: up, down, strange, charm, top and | (It includes significance of threshold frequency)<br>*(Understanding, Application)*<br><br>[SLO: P-12-F-09]<br>Explain qualitatively that photoelectric emission occurs when photon energy is equal to or exceeds the work function of the metal.<br>*(Understanding)*<br><br>[SLO: P-12-F-10]<br>Explain photoelectric emission in terms of photon energy and work function energy<br>(It includes derivation of maximum KE of photoelectrons in term of frequency of radiation and application of formula to solve simple problems)<br>*(Understanding, Application)*<br><br>[SLO: P-12-F-11]<br>Explain why the maximum kinetic energy of photoelectrons is independent of intensity, whereas the photoelectric current is proportional to intensity of radiation.<br>*(Understanding)*<br><br>Draw and interpret simple graphs of:<br>a) Maximum kinetic energy vs frequency<br>b) Photoelectric current vs intensity<br>*(Understanding, Application)*<br><br>**6.3 COMPTON EFFECT**<br>[SLO: P-12-F-12]<br>Describe qualitatively the Compton effect: X-rays or gamma rays scatter from electrons, resulting in an increase in wavelength. |

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| | as a result, usually emits α-particles or β-particles and may also emit γ-radiation. *(Understanding)*<br><br>**8.4 NUCLEAR TRANSMUTATION**<br>[SLO: P-10-F-13]<br>Analyze and use nuclear decay equations, written in nuclide notation, to represent the emission of α-particles, β-particles, and γ-radiation from radioactive nuclei.<br>*(Understanding, Application)*<br><br>**8.5 NUCLEAR FISSION/FUSION**<br>[SLO: P-10-F-14]<br>Describe nuclear fission as the splitting of a heavy nucleus into smaller nuclei with the release of energy and neutrons, and explain that the released neutrons may cause further fissions, producing a chain reaction.<br>[It includes only qualitative discussion on fission chain reaction and its types]<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-F-15]<br>Describe nuclear fusion (with example) as the process in which two light nuclei combine to form a heavier nucleus with the release of energy, and recognize nuclear fusion as the main source of energy in stars, including the Sun.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-F-16]<br>Recognize that matter can be converted into energy and energy into matter, so the | bottom] *(Understanding)*<br><br>[SLO: P-11-F-13]<br>Describe protons and neutrons in terms of their quark composition<br>*(Understanding)*<br><br>[SLO: P-11-F-14]<br>Give definitions of<br>(a) hadrons (baryons, mesons)<br>(b) leptons<br>(d) bosons<br>With examples<br>(only definition and examples are required, no extended material)<br>*(Knowledge)*<br><br>[SLO: P-11-F-15]<br>Explain the working principle of particle accelerators and also their uses.<br>*(Understanding, Application)* | *[including conditions for maximum and minimum wavelength shift, and relate Δλ to the Compton wavelength of the electron].*<br>(Derivation of formula is not required)<br>*(Knowledge, Understanding)*<br><br>[SLO: P-12-F-13]<br>*Solve numerical problems using the Compton wavelength shift equation*<br>$\Delta\lambda = \frac{h}{m_e c}(1-\cos\theta)$<br>*(Understanding, Application)*<br><br>**6.4 PAIR PRODUCTION AND PAIR ANNIHILATION**<br>[SLO: P-12-F-14]<br>Explain pair production as the conversion of a high-energy photon into an electron–positron pair in the presence of a nucleus, apply energy–mass equivalence to determine the minimum photon energy required, and explain how conservation of energy and momentum is satisfied.<br>*(Understanding, Application)*<br><br>[SLO: P-12-F-15]<br>Describe pair annihilation as the process in which an electron and a positron destroy each other and produce energy in the form of gamma rays, and explain that energy and momentum are conserved.<br>*(Understanding, Application)*<br>[SLO: P-12-F-16]<br>calculate the energy of the gamma-ray photons emitted during the annihilation of an electron-positron pair<br>*(Understanding, Application)* |

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| | law of conservation of energy still holds, and apply the equation $E = mc^2$ to calculate the energy released in nuclear reactions.<br>*(Understanding, Application)*<br><br>**8.6 HALF LIFE OF A RADIACTIVE ELEMENT**<br>[SLO: P-10-F-17]<br>Explain the meaning of half-life of a radioactive material, and use this concept to calculate the remaining number of nuclei of a sample from the given data, tables, decay curves of number of nuclei versus time.<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-10-F-18]<br>Explain and apply the concept of Carbon dating to estimate age of ancient objects.<br>*(Understanding, Application)*<br><br>**8.7 SAFE USE OF NUCLEAR RADIATIONS**<br>[SLO: P-10-F-19]<br>Explain how the type of radiation and half-life determine which isotopes are used in applications such as: (a) smoke alarms, (b) irradiating food, (c) sterilizing equipment, (d) measuring thickness of materials, (e) diagnosis and treatment of cancer.<br>*(Understanding, Application)*<br><br>**8.8 HAZARDS AND SAFETY FROM NUCLEAR RADIATION**<br>[SLO: P-10-F-20] | | **6.5 WAVE PARTICLE DUALITY**<br>[SLO: P-12-F-17]<br>Analyze the evidence for the wave–particle duality of light.<br>[Explain that the photoelectric effect, Compton's effect etc provides evidence for a particle nature of electromagnetic radiation while phenomena such as interference and diffraction provide evidence for a wave nature]<br>*(Understanding)*<br><br>[SLO: P-12-F-18]<br>Explain qualitatively how electron diffraction provides experimental evidence for the wave nature of particles.<br>*(Understanding)*<br><br>[SLO: P-12-F-19]<br>Explain and apply the de Broglie wavelength to solve problems<br>[use $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$ to solve problems]<br>*(Knowledge, Understanding, Application)*<br><br>**6.6 QUANTUM ENERGY LEVELS**<br>[SLO: P-12-F-20]<br>Understand that there are discrete electron energy levels in isolated atoms (e.g. atomic hydrogen)<br>*(Understanding)* |

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| | State the effects of ionizing nuclear radiations on living things, including cell death, mutations and cancer.<br>*(Knowledge, Understanding)*<br><br>[SLO: P-10-F-21]<br>Explain how radioactive materials are moved, used and stored in a safe way [(with reference to:<br>(a) reducing exposure time<br>(b) increasing distance between source and living tissue<br>(c) use of shielding to absorb radiation]<br>*(Understanding, Application)* | | [SLO: P-12-F-21]<br>Differentiate between continuous, line, and band spectra on the basis of their characteristics and sources.<br>*(Understanding)*<br><br>[SLO: P-12-F-22]<br>Differentiate between absorption spectrum and emission spectrum on the basis of their formation and appearance.<br>*(Understanding)*<br><br>[SLO: P-12-F-23]<br>Explain the appearance and formation of emission and absorption line spectra [discuss for H-atom]<br>*(Understanding)*<br><br>[SLO: P-12-F-24]<br>Use $hf = \Delta E$ to solve problems [It includes calculation of energy levels, frequency, wavelength and energy of radiations]<br>*(Application)*<br><br>[SLO: P-12-F-25]<br>Explain how electron microscopes achieve very high resolution.<br>*(Understanding)*<br><br>**6.7 HEISENBERG'S UNCERTAINTY PRINCIPLE**<br>[SLO: P-12-F-26]<br>Explain Heisenberg's uncertainty principle ($\Delta x \Delta p \geq \hbar$) qualitatively. |

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| | | | *(Understanding)*<br><br>[SLO: P-12-F-27]<br>Use the uncertainty principle to explain why empirical measurements must necessarily have uncertainty in them.<br>*(Understanding)*<br><br>**6.8 X-RAYS**<br>[SLO: P-12-F-28]<br>Explain that X-rays are produced by electron bombardment of a metal target and calculate the minimum wavelength of X-rays produced from the accelerating voltage<br>*(Understanding)*<br><br>[SLO: P-12-F-29]<br>Explain the use of X-rays in imaging internal body structures<br>[including description of the term contrast in X-ray imaging]<br>*(Understanding)*<br><br>[SLO: P-12-F-30]<br>Explain how computed tomography (CT) scanning works<br>[it produces a 3D image of an internal structure by first combining multiple X-ray images taken in the same section from different angles to obtain a 2D image of the section, then repeating this process along an axis and combining 2D images of multiple sections]<br>*(Understanding, Application)*<br><br>**UNIT 7: NUCLEAR PHYSICS**<br>(18 Periods)<br>**At the end of this unit, Students will be able to:** |

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| | | | **7.1 MASS DEFECT & BINDING ENERGY**<br>[SLO: P-12-F-31]<br>Define, explain and use the terms mass defect and binding energy<br>*(Knowledge, Understanding, Application)*<br><br>[SLO: P-12-F-32]<br>Sketch the variation of binding energy per nucleon with nucleon number<br>*(Application)*<br><br>**7.2 NUCLEAR FISSION & FUSION**<br>[SLO: P-12-F-33]<br>Recall what is meant by nuclear fusion and nuclear fission<br>*(Knowledge)*<br><br>[SLO: P-12-F-34]<br>Explain the relevance of binding energy per nucleon to nuclear reactions, including nuclear fusion and nuclear fission<br>*(Understanding)*<br><br>[SLO: P-12-F-35]<br>Compare the amount of energy released in a fission reaction with the (given) energy released in a chemical reaction.<br>*(Understanding)*<br><br>[SLO: P-12-F-36]<br>Explain how the neutrons produced in fission create a chain reaction and that this is controlled in a nuclear reactor<br>[ including the action of coolant, moderators and control rods]<br>*(Understanding)* |

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| | | | [SLO: P-12-F-37]<br>Describe the function of the major components of a water moderated power reactor [core, fuel, rods, moderator, control rods, heat exchange, safety rods and shielding]<br>*(Understanding)*<br><br>[SLO: P-12-F-38]<br>Explain why uranium fuel needs to be enriched before use<br>*(Understanding)*<br><br>[SLO: P-12-F-39]<br>calculate the energy released in nuclear reactions using $E = \Delta m\, c^2$<br>*(Application)*<br><br>**7.3 RADIOACTIVE DECAY**<br>[SLO: P-12-F-40]<br>Explain that fluctuations in count rate provide evidence for the random nature of radioactive decay<br>*(Understanding)*<br><br>[SLO: P-12-F-41]<br>Define activity and decay constant<br>*(Knowledge)*<br><br>[SLO: P-12-F-42]<br>State and use $A = \lambda N$<br>*(Knowledge, Understanding)*<br><br>[SLO: P-12-F-43]<br>Use $\lambda = 0.693/T_{1/2}$ to solve numerical problems<br>*(Application)*<br><br>[SLO: P-12-F-44] |

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| | | | Describe the exponential nature of radioactive decay<br>*(Understanding)*<br><br>[SLO: P-12-F-45]<br>Use the relationship $x = x_0 e^{\lambda t}$<br>[where x could represent activity, number of undecayed nuclei or received count rate) to solve problems analytically and graphically]<br>*(Understanding, Application)*<br><br>**7.4 BENEFITS OF NUCLEAR ENERGY IN MEDICAL FIELD**<br>[SLO: P-12-F-46]<br>Explain what is a medical tracer<br>[ a substance containing radioactive nuclei that can be introduced into the body and is then absorbed by the tissue being studied]<br>*(Understanding)*<br><br>[SLO: P-12-F-47]<br>Illustrate how PET scanning works<br>[positrons emitted by the decay of the tracer annihilate when they interact with electrons in the tissue, producing a pair of gamma-ray photons traveling in opposite directions]<br>*(Understanding)*<br><br>[SLO: P-12-F-48]<br>Explain that the gamma-ray photons from an annihilation event travel outside the body and can be detected<br>[including that an image of the tracer concentration in the tissue can be created by processing the arrival times of the gamma-ray photons] |

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| | | | *(Understanding)* |
| | **8.9 COSMOLOGY**<br>[SLO: P-10-F-23]<br>Explain the nature of the Sun [as a star of medium size it consists mostly of hydrogen and helium, and that it radiates most of its energy in the infrared, visible and ultraviolet regions of the electromagnetic spectrum]<br>[*This topic is provided as additional information. It may be presented briefly in a side box or "for your information" section. Students are not expected to treat it as a main topic or spend significant time on it.*]<br>*(Understanding)*<br><br>[SLO: P-10-F-24]<br>Describe that it is hypothesized that most of the matter in the universe is made up of dark matter<br>[*This topic is provided as additional information. It may be presented briefly in a side box or "for your information" section. Students are not expected to treat it as a main topic or spend significant time on it.*]<br>*(Understanding)* | | **UNIT 8: THERMAL RADIATIONS**<br>(10 Periods)<br>**At the end of this unit, Students will be able to:**<br>**8.1 LUMINOSITY**<br>[SLO: P-12-F-49]<br>Explain the term luminosity<br>[as the total power of radiation emitted by a star]<br>*(Understanding)*<br><br>[SLO: P-12-F-50]<br>Apply the inverse square law for radiant flux intensity<br>[ F in terms of the luminosity L of the source $F = \frac{L}{4\pi d^2}$]<br>*(Application)*<br><br>[SLO: P-12-F-51]<br>Define and apply standard candles<br>[Explain the use of standard candles to determine distances to galaxies]<br>*(Knowledge, Understanding, Application)*<br><br>**8.2 BLACK BODY RADIATIONS**<br>[SLO: P-12-F-52]<br>Explain blackbody radiation<br>*(Understanding)*<br><br>[SLO: P-12-F-53]<br>State and apply Wien's displacement law to solve problems<br>[ $\lambda_{max}T = constant$ to estimate the peak surface temperature of a star]<br>(Knowledge, Application)<br><br>[SLO: P-12-F-54] |

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| | | | State and apply the Stefan–Boltzmann law to solve problems<br>[ $L = 4\pi r^2 \times \sigma T^4$ to solve problems]<br>(Knowledge, Application)<br><br>[SLO: P-12-F-55]<br>Estimate the radius of a star<br>[applying Wien's displacement law and the Stefan–Boltzmann law]<br>*(Application)*<br>[SLO: P-12-F-56]<br>Explain why the emission and absorption lines in spectra from distant astronomical objects are observed at longer wavelengths than their known laboratory values.<br>*(Understanding, Application)*<br><br>**8.3 BIG BANG THEORY**<br>[SLO: P-12-F-57]<br>Explain why redshift leads to the idea that the Universe is expanding<br>[include using $\frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$ for the redshift of electromagnetic radiation from a source moving relative to an observer to solve problems relating to the expanding universe]<br>*(Understanding)*<br><br>[SLO: P-12-F-58]<br>State and explain Hubble's law and how it leads to the Big Bang theory<br>*(Knowledge, Understanding)* |

# EXPERIMENTAL SKILLS

The practical component of physics education plays a central role in developing students' understanding of scientific concepts and processes. The practical examination framework for SSC and HSSC Physics is designed to move beyond routine verification experiments and foster the development of core experimental competencies essential for scientific literacy, higher education, and modern technological careers.

Each experiment included in the curriculum is deliberately aligned with specific experimental skills, ensuring that practical work serves as a structured platform for skill development rather than isolated laboratory activities. These skills include observation, measurement, data handling, graphical Understanding, error estimation, instrumentation handling, experimental design, safety awareness, and scientific reporting.

The selection of experiments emphasizes:

- Development of conceptual understanding through experimentation.
- Training in scientific methods and inquiry-based learning.
- Strengthening of hands-on laboratory competence.
- Application of physics concepts to real-world contexts and technologies.
- Alignment with international best practices in practical science education.

This framework ensures that practical examinations assess not only theoretical knowledge but also students' ability to apply scientific reasoning, use laboratory tools effectively, interpret data logically, and communicate results accurately.

The practical program is therefore structured as a **skill-integrated learning and assessment model**, where each experiment contributes to the progressive development of scientific thinking, experimental discipline, and technological awareness. This approach supports the transition from **content-based learning to skill-based scientific education** in line with the vision of the National Curriculum Council Pakistan for future-ready curricula.

Recognizing the challenges posed by variability in laboratory facilities, teaching practices, and levels of practical innovation, the curriculum specifies a **minimum set of required experiments**. These experiments provide a structured and essential practical foundation to ensure that all students develop the core experimental competencies expected at the secondary and higher secondary levels.

## CONCEPTUAL PREPARATION FOR EXPERIMENTAL WORK

Before conducting any practical experiment, teachers should ensure that students are adequately prepared both conceptually and technically. Practical activities should not be treated as routine procedures; instead, they should be supported by prior understanding of the relevant physics concepts and familiarity with the apparatus involved.

Teachers should first explain the scientific principles related to the experiment, including the relevant laws, definitions, relationships between physical quantities, and the objective of the investigation. For example, before performing an experiment on latent heat using the method of mixtures, students should understand the concepts of heat transfer, specific heat capacity, latent heat of fusion, latent heat of vaporization, and conservation of energy. Similarly, experiments involving electrical circuits should be preceded by instruction on current, potential difference, resistance, and Ohm's law, while optical experiments should build on prior understanding of reflection, refraction, and image formation.

Students should also be introduced to the measuring instruments and apparatus used in the experiment. Teachers should explain the main parts and working principles of each instrument, demonstrate how to determine its least count or scale division, and discuss possible zero error where applicable. Students should learn the correct procedure for taking readings, recording observations accurately, and handling laboratory equipment with care.

Good laboratory practices should be emphasized throughout the preparation and performance of experiments. These include proper experimental setup, safe handling of apparatus, systematic recording of observations, graphical representation of data where required, and identification of possible sources of experimental error such as parallax error, heat loss, friction, or misalignment of apparatus.

Questions related to the concepts, principles, and experimental methods associated with these experiments may appear in practical examinations. Therefore, students should develop a clear and thorough understanding of the physics topics connected with each experiment. They should be able not only to perform the experiment but also to explain the underlying scientific principles, interpret observations, analyze graphs and results, and apply these concepts to solve related problems.

This approach ensures that practical work contributes effectively to the development of experimental skills, conceptual understanding, and scientific reasoning in physics.

## CORE EXPERIMENTAL SKILLS

The practical program develops a set of core experimental skill. Each experiment contributes to the development of one or more of these competencies.

| Skill Code | Experimental Skill | Description |
|---|---|---|
| ES1 | Scientific Observation | Observing physical phenomena carefully and identifying patterns or relationships. |
| ES2 | Measurement and Instrumentation | Using laboratory instruments correctly and recording measurements with appropriate precision. |
| ES3 | Data Recording and Processing | Recording observations systematically and processing experimental data through calculations. |
| ES4 | Graphical Representation | Plotting and interpreting graphs to analyze relationships between variables. |
| ES5 | Experimental Planning and Variables | Identifying independent, dependent, and controlled variables and planning procedures for investigations. |
| ES6 | Error and Uncertainty Understanding | Recognizing measurement errors, estimating uncertainties, and evaluating reliability of results. |
| ES7 | Scientific Communication | Presenting experimental procedures, results, and conclusions clearly and logically. |
| ES8 | Laboratory Safety and Apparatus Handling | Handling laboratory equipment safely and following appropriate laboratory practices. |
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## STANDARD AND BENCHMARKS OF EXPERIMENTAL SKILLS

The practical program is designed to ensure a **progressive development of experimental competencies** across secondary and higher secondary education.

**STANDARD (SSC):** Students perform guided practical investigations to develop measurement, observation, data-recording, graphing, and reporting skills while applying fundamental physics concepts and laboratory safety practices.

**STANDARD (HSSC):** Students conduct and evaluate increasingly sophisticated investigations using advanced apparatus and quantitative methods, analyze data critically, estimate uncertainties, evaluate reliability, and communicate scientific findings using accepted scientific conventions.

| Experimental Skill | Benchmarks SSC Level (Classes 9–10) | Benchmarks HSSC Level (Classes 11–12) |
|---|---|---|
| Scientific Observation | **Benchmark I:** Observe and describe physical phenomena qualitatively. | **Benchmark I:** Analyze observations to explain physical relationships and processes. |
| Measurement and Instrumentation | **Benchmark II:** Use basic laboratory instruments such as meter rules, vernier calipers, screw gauges, mirrors, lenses, thermometers, and stopwatches. | **Benchmark II:** Use advanced instruments such as spherometers, electronic timers, resonance tubes, and potentiometers with greater precision. |
| Data Recording | **Benchmark III:** Record measurements systematically in tables with appropriate units. | **Benchmark III:** Record measurements with appropriate precision and include uncertainty estimates where required. |
| Data Processing and Graphs | **Benchmark IV:** Perform calculations and plot simple graphs to identify relationships between variables. | **Benchmark IV:** Analyze graphs quantitatively to determine gradients, intercepts, and physical constants. |
| Experimental Planning | **Benchmark V:** Identify variables and follow established procedures in laboratory activities. | **Benchmark V:** Design or modify procedures to investigate physical relationships and test hypotheses. |
| Error and Uncertainty Understanding | **Benchmark VI:** Recognize possible sources of experimental error. | **Benchmark VI:** Estimate uncertainties in measured and derived quantities and evaluate reliability of results. |
| Scientific Communication | **Benchmark VII:** Present experimental results using tables, graphs, and simple conclusions. | **Benchmark VII:** Present structured experimental reports including Understanding and evaluation of results. |
| Laboratory Safety and Conduct | **Benchmark VIII:** Follow basic laboratory safety rules and handle apparatus responsibly. | **Benchmark VIII:** Demonstrate responsible and independent laboratory practices while conducting investigations. |

# LIST OF EXPERIMENTS ALIGNED WITH SLOS

The following lists of experiments for SSC and HSSC are prescribed as **minimum required practical activities**. These experiments are designed to support the development of the experimental skills described above while reinforcing the understanding of key physics concepts.

Each experiment contributes to the development of one or more experimental skill domains (ES1–ES8), ensuring that practical work systematically builds students' abilities in scientific inquiry, measurement, data Understanding, experimental reasoning, and communication.

The prescribed practical program ensures that learners develop the experimental competencies necessary for scientific investigation and technological innovation. By engaging in structured laboratory activities, students strengthen their ability to observe phenomena, measure physical quantities accurately, analyze experimental data, evaluate results critically, and communicate scientific findings effectively. This framework promotes the integration of theoretical knowledge with practical inquiry, preparing students for higher education and professional pathways in science, engineering, and technology. Therefore, teachers shall ensure that students are conceptually prepared before performing each experiment and are familiar with the relevant physics topics, principles, experimental objectives, and proper use of laboratory instruments. Practical work should emphasize accurate measurement, systematic data recording, graphical Understanding where appropriate, identification of experimental errors, and interpretation of results. Laboratory activities should be conducted in a manner that promotes scientific inquiry, critical thinking, and responsible laboratory practices.

## SSC

| | Experiments for SSC | Experimental Skills SLOs |
|---|---|---|
| 1. | **Determine the volume of solid cylinder or sphere using vernier caliper.**<br><br>(Domain A: Physical Quantities and Measurements) | **[SLO: SSC-E-01]** Measure linear dimensions of a solid cylinder or sphere accurately using vernier calipers. ES2, ES8<br>**[SLO: SSC- E-02]** Identify and correct for zero error in the vernier calipers before taking measurements. ES2, ES6<br>**[SLO: SSC- E-03]** Determine the least count of the vernier calipers and record all measurements with appropriate precision and significant figures. ES2, ES6<br>**[SLO: SSC- E-04]** Calculate the volume of the solid object using the measured dimensions. ES3, ES4<br>**[SLO: SSC- E-05]** Identify possible sources of error in the measurement process. ES4, ES6<br>**[SLO: SSC- E-06]** Present procedure, observations, calculations, and final results clearly in a structured laboratory report. ES7 |

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|---|---|---|
| 2. | **Determine the thickness of a thin piece of wire using a screw gauge.**<br><br>(Domain A: Physical Quantities and Measurements - Measurements) | **[SLO: SSC-E-07]** Measure the thickness (diameter) of a thin wire accurately using a screw gauge. ES2, ES8<br>**[SLO: SSC-E-08]** Identify and correct for zero error in the screw gauge before taking measurements. ES2, ES6<br>**[SLO: SSC-E-09]** Determine the least count of the screw gauge and record all measurements with appropriate precision and significant figures. ES2, ES6<br>**[SLO: SSC-E-10]** Calculate the average thickness if multiple readings are taken. ES3, ES4<br>**[SLO: SSC-E-11]** Identify possible sources of error in measurements, such as parallax, misalignment, or improper handling. ES4, ES6<br>**[SLO: SSC-E-12]** Present procedure, observations, calculations, and final results clearly in a structured laboratory report. ES7 |
| 3. | **Determine the acceleration of a ball rolling down an inclined angle iron by plotting a graph between $2S$ and $T^2$.**<br><br>(Domain B: Mechanics - Kinematics) | **[SLO: SSC-E-24]** Set up the apparatus correctly to investigate the motion of a ball rolling down an inclined angle iron. ES5, ES8<br>**[SLO: SSC-E-25]** Measure the distance travelled by the ball and the corresponding time taken using appropriate measuring instruments such as a meter scale and stopwatch. ES2, ES3<br>**[SLO: SSC-E-26]** Record observations systematically in a table and calculate the values of $T^2$and $2S$from the measured data. ES3, ES4<br>**[SLO: SSC-E-27]** Plot a graph between $2S$and $T^2$and determine the acceleration of the ball from the slope of the graph. ES4<br>**[SLO: SSC-E-28]** Identify possible sources of error in measuring distance and time during the experiment. ES6<br>**[SLO: SSC-E-29]** Present the experimental procedure, observations, graph, calculations, and conclusion clearly in a structured laboratory report. ES7 |
| 4. | **To find the value of "g" by free fall method using digital timer.**<br><br>(Domain B: Mechanics - Kinematics) | **[SLO: SSC-E-30]** Set up the apparatus correctly to measure the time of free fall using a digital timer. ES5, ES8<br>**[SLO: SSC-E-31]** Measure the vertical distance travelled by a falling object and record the corresponding time of fall. ES2, ES3<br>**[SLO: SSC-E-32]** Use the equation ($S = ½ gt^2$) to calculate the acceleration due to gravity. ES3, ES4<br>**[SLO: SSC-E-33]** Explain that objects falling freely near Earth accelerate due to gravitational force. ES1<br>**[SLO: SSC-E-34]** Identify possible sources of error such as reaction delay or misalignment of the apparatus. ES6 |
| 5. | **To find the weight of an unknown object by using vector addition of forces using Gravesande's Apparatus.**<br><br>(Domain B: Mechanics - Dynamics) | **[SLO: SSC-E-35]** Set up Gravesande's apparatus to study the equilibrium of forces acting at a point. ES5, ES8<br>**[SLO: SSC-E-36]** Measure the magnitudes and directions of forces using known weights. ES2<br>**[SLO: SSC-E-37]** Apply the principle of vector addition of forces to determine the weight of an unknown object. ES1, ES3, ES4<br>**[SLO: SSC-E-38]** Explain that forces acting at a point are in equilibrium when their vector sum is zero. ES1<br>**[SLO: SSC-E-39]** Identify possible errors in aligning pulleys, strings, and weights. ES6 |
| 6. | **Determine the weight of unknown object by principle of moments.**<br><br>(Domain B: Mechanics - Dynamics) | **[SLO: SSC-E-40]** Set up a lever system to investigate the principle of moments. ES5, ES8<br>**[SLO: SSC-E-41]** Measure distances from the pivot and applied weights accurately. ES2, ES3<br>**[SLO: SSC-E-42]** Apply the principle of moments to calculate the weight of an unknown object. ES1, ES4<br>**[SLO: SSC-E-43]** Explain that a body is in equilibrium when clockwise and anticlockwise moments are equal. ES1<br>**[SLO: SSC-E-44]** Identify possible sources of error such as friction at the pivot or inaccurate distance measurement. ES6 |
| 7. | **Determine the volume of irregular shaped soluble stone by displacement method and calculate its density.**<br><br>(Domain B: Mechanics - Density) | **[SLO: SSC-E-45]** Set up a spring apparatus to measure extension produced by different loads. ES5, ES8<br>**[SLO: SSC-E-46]** Measure extension in the spring using a meter scale for different applied loads. ES2, ES3<br>**[SLO: SSC-E-47]** Plot a load–extension graph and interpret the relationship between load and extension. ES4<br>**[SLO: SSC-E-48]** Explain Hooke's law within the elastic limit of the spring. ES1<br>**[SLO: SSC-E-49]** Identify possible sources of error such as parallax in reading extension. ES6 |
| 8. | **To find the density of a body heavier than water by Archimedes principle.**<br><br>Domain B: Mechanics – Principle of | **[SLO: SSC-E-50]** Measure the weight of an object in air and when immersed in water. ES2, ES3<br>**[SLO: SSC-E-51]** Apply Archimedes' principle to determine the buoyant force acting on the object. ES1, ES4<br>**[SLO: SSC-E-52]** Calculate the density of the object using measured values. ES3, ES4<br>**[SLO: SSC-E-53]** Explain that the upthrust on an object is equal to the weight of the displaced liquid. ES1 |

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| | Floatation) | **[SLO: SSC-E-54]** Identify possible experimental errors such as trapped air bubbles. ES6 |
| 9. | **Find relation between load and extension using Load-Extension Graph (Helical Spring).**<br><br>(Domain B: Mechanics - Elasticity) | **[SLO: SSC-E-55]** Measure the mass of the object using a balance. ES2<br>**[SLO: SSC-E-56]** Determine the volume of the object using the displacement method. ES2, ES3<br>**[SLO: SSC-E-57]** Calculate the density using measured mass and volume values. ES3, ES4<br>**[SLO: SSC-E-58]** Explain that density is defined as mass per unit volume. ES1<br>**[SLO: SSC-E-59]** Identify possible errors in reading volume from the measuring cylinder. ES6 |
| 10. | **To trace the magnetic field using a bar magnet.**<br><br>(Domain E: Electricity and Magnetism – Magnetic field of bar magnet) | **[SLO: SSC-E-60]** Trace magnetic field lines around a bar magnet using iron filings or a plotting compass. ES5, ES8<br>**[SLO: SSC-E-61]** Observe and record the pattern and direction of magnetic field lines. ES2, ES3<br>**[SLO: SSC-E-62]** Explain the concept of magnetic field and field lines around a magnet. ES1<br>**[SLO: SSC-E-63]** Describe the regions of strongest magnetic field near the poles. ES1<br>**[SLO: SSC-E-64]** Present observations clearly through labeled diagrams. ES7 |
| 11. | **Plot the temperature vs time graph for heating ice to water and then to steam.**<br><br>(Domain C: Heat and Thermodynamics – Heating a substance before melting point till beyond boiling point) | **[SLO: SSC-E-65]** Measure temperature at regular time intervals during heating. ES2, ES3<br>**[SLO: SSC-E-66]** Record observations and plot a temperature–time graph. ES3, ES4<br>**[SLO: SSC-E-67]** Identify phase changes of ice to water and water to steam from the graph. ES1, ES4<br>**[SLO: SSC-E-68]** Explain that temperature remains constant during phase change. ES1<br>**[SLO: SSC-E-69]** Identify possible sources of error such as heat loss to surroundings. ES6 |
| 12. | **Determine the specific heat capacity of liquid (water) or a metal (lead) by the method of mixtures.**<br><br>(Domain C: Heat and Thermodynamics – Specific Heat Capacity) | **[SLO: SSC-E-70]** Measure mass and temperature of substances before mixing. ES2, ES3<br>**[SLO: SSC-E-71]** Record final equilibrium temperature after mixing. ES3<br>**[SLO: SSC-E-72]** Apply the principle of conservation of energy to calculate specific heat capacity. ES1, ES4<br>**[SLO: SSC-E-73]** Explain that heat lost by the hot body equals heat gained by the cold body. ES1<br>**[SLO: SSC-E-74]** Identify possible experimental errors such as heat loss to the environment. ES6 |
| 13. | **Draw the temperature-time graph for heating ice and water to measure the latent heat of fusion of ice and latent heat of vaporization of water using method of mixtures.**<br><br>(Domain C: Heat and Thermodynamics – Latent Heats of Fusion and Vaporization) | **[SLO: SSC-E-75]** Measure masses and temperatures required for mixture experiments. ES2, ES3<br>**[SLO: SSC-E-76]** Record temperature changes during melting and boiling processes. ES3<br>**[SLO: SSC-E-77]** Use heat equations to calculate latent heat of fusion or vaporization. ES3, ES4<br>**[SLO: SSC-E-78]** Explain the concept of latent heat during phase change. ES1<br>**[SLO: SSC-E-79]** Identify sources of heat loss or measurement errors. ES6 |
| 14. | **Investigate the relationship between length and time period of a simple pendulum, and calculate value of ‘g’.** | **[SLO: SSC-E-80]** Use a stop-watch to measure intervals of time, including the period of an oscillating system by timing an appropriate number of consecutive oscillations. Measure the time period of oscillations of a simple pendulum for different lengths. ES2, ES3<br>**[SLO: SSC-E-81]** Record observations and determine the average time period. ES3<br>**[SLO: SSC-E-82]** Investigate the relationship between length and time period. ES4<br>**[SLO: SSC-E-83]** Calculate the value of acceleration due to gravity using the pendulum formula. ES4 |

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| | (Domain D: Oscillations and Waves – Simple pendulum) | **[SLO: SSC-E-84]** Identify possible sources of error such as large amplitude oscillations. ES6 |
| **15.** | **Study the position of image formed by convex lens (converging lens) when object is placed at (i) 2F (ii) Between F and 2F.**<br><br>(Domain D: Oscillations and Waves – Lenses) | **[SLO: SSC-E-85]** Set up a convex lens apparatus to observe image formation. ES5, ES8<br>**[SLO: SSC-E-86]** Observe the position and nature of images when the object is placed at different distances. ES2, ES3<br>**[SLO: SSC-E-87]** Describe image characteristics when the object is at (2F) and between (F) and (2F). ES1<br>**[SLO: SSC-E-88]** Record observations through ray diagrams. ES7<br>**[SLO: SSC-E-89]** Identify possible errors due to improper alignment of optical components. ES6 |
| **16.** | **Investigate refraction through a glass slab and calculate its refractive index.**<br><br>(Domain D: Oscillations and Waves – Refraction of Light) | **[SLO: SSC-E-90]** Trace the path of a light ray through a glass slab. ES5, ES8<br>**[SLO: SSC-E-91]** Measure angles of incidence and refraction. ES2<br>**[SLO: SSC-E-92]** Use Snell's law to calculate the refractive index. ES3, ES4<br>**[SLO: SSC-E-93]** Explain the phenomenon of refraction. ES1<br>**[SLO: SSC-E-94]** Identify possible errors in drawing or angle measurement. ES6 |
| **17.** | **Determine the critical angle of a glass prism.**<br><br>(Domain D: Oscillations and Waves – Total Internal Reflection) | **[SLO: SSC-E-95]** Trace the path of light through a glass prism. ES5, ES8<br>**[SLO: SSC-E-96]** Measure the angle of incidence at which total internal reflection occurs. ES2<br>**[SLO: SSC-E-97]** Determine the critical angle of the prism material. ES3, ES4<br>**[SLO: SSC-E-98]** Explain the concept of total internal reflection. ES1<br>**[SLO: SSC-E-99]** Identify possible sources of experimental error. ES6 |
| **18.** | **Measure the current and voltage across a resistor and plotting V-I characteristics.**<br><br>(Domain E: Electricity and Magnetism - Ohm's Law, voltage and current) | **[SLO: SSC-E-100]** Set up an electric circuit to measure current and potential difference across a resistor. ES5, ES8<br>**[SLO: SSC-E-101]** Measure current and voltage using an ammeter and voltmeter. ES2, ES3<br>**[SLO: SSC-E-102]** Plot a graph between voltage and current. ES4<br>**[SLO: SSC-E-103]** Explain Ohm's law from the linear relationship in the graph. ES1<br>**[SLO: SSC-E-104]** Identify possible errors such as loose connections or heating of the resistor. ES6 |
| **19.** | **Investigate the relationship between potential difference and length of a wire.**<br><br>(Domain E: Electricity and Magnetism - Ohm's Law, voltage and current) | **[SLO: SSC-E-105]** Set up a circuit to measure potential difference across different lengths of a wire. ES5, ES8<br>**[SLO: SSC-E-106]** Measure potential difference using a voltmeter for different wire lengths. ES2, ES3<br>**[SLO: SSC-E-107]** Plot a graph to analyze the relationship between potential difference and wire length. ES4<br>**[SLO: SSC-E-108]** Explain how resistance varies with length of the conductor. ES1<br>**[SLO: SSC-E-109]** Identify possible sources of experimental error. ES6 |
| **20.** | **Study The Effect of Combining Resistors in Series and Parallel.**<br><br>(Domain E: Electricity and Magnetism - Series and Parallel Combination of Resistors) | **[SLO: SSC-E-110]** Construct circuits with resistors connected in series and parallel. ES5, ES8<br>**[SLO: SSC-E-111]** Measure current and voltage in both configurations. ES2, ES3<br>**[SLO: SSC-E-112]** Calculate equivalent resistance for series and parallel combinations. ES3, ES4<br>**[SLO: SSC-E-113]** Explain how current and voltage behave in series and parallel circuits. ES1<br>**[SLO: SSC-E-114]** Identify possible sources of experimental error in circuit measurements. ES6 |

# HSSC

| | Experiments for HSSC | Experimental Skills SLOs |
|---|---|---|
| 1 | **Measure the volume of a small spherical object using a screw gauge and estimate the uncertainty in the result.**<br>(Domain A: Physical Quantities and Measurements - Measurements) | **[SLO: HSSC-E-01]** Explain the structure, working principle, least count, and zero error of a screw gauge before performing measurements. ES1, ES2<br>**[SLO: HSSC-E-02]** Measure the diameter of a small spherical object using a screw gauge and record readings with appropriate precision. ES2, ES3<br>**[SLO: HSSC-E-03]** Calculate the volume of the sphere using the measured diameter. ES3, ES4<br>**[SLO: HSSC-E-04]** Estimate the uncertainty in the calculated volume based on measurement uncertainty. ES4, ES6<br>**[SLO: HSSC-E-05]** Evaluate possible sources of experimental error and suggest improvements to increase measurement accuracy. ES6 |
| 2 | **Determine the radius of curvature of a convex lens using a spherometer and estimate the uncertainty.**<br>(Domain A: Physical Quantities and Measurements – Measurements & Uncertainty) | **[SLO: HSSC-E-06]** Describe the structure and working principle of a spherometer and determine its least count. ES1, ES2<br>**[SLO: HSSC-E-07]** Measure the height difference using a spherometer to determine the radius of curvature of a convex lens. ES2, ES3<br>**[SLO: HSSC-E-08]** Apply the appropriate formula to calculate the radius of curvature from experimental measurements. ES3, ES4<br>**[SLO: HSSC-E-09]** Estimate uncertainty in the calculated value and analyze its effect on the final result. ES4, ES6<br>**[SLO: HSSC-E-10]** Present the results in a structured laboratory report including calculations and evaluation. ES7 |
| 3 | **Determine the moment of inertia of a flywheel.**<br>(Domain B: Mechanics – Dynamics – Angular Motion) | **[SLO: HSSC-E-11]** Explain the concept of rotational inertia and its role in rotational motion. ES1<br>**[SLO: HSSC-E-12]** Set up the flywheel apparatus and measure relevant quantities such as mass, radius, and number of rotations. ES2, ES5<br>**[SLO: HSSC-E-13]** Record observations systematically and apply the appropriate equations to calculate the moment of inertia. ES3, ES4<br>**[SLO: HSSC-E-14]** Analyze experimental results and evaluate possible sources of energy loss due to friction. ES6<br>**[SLO: HSSC-E-15]** Communicate findings through calculations, tables, and conclusions in a laboratory report. ES7 |
| 4 | **Investigate the fall of spherical steel balls in a viscous medium and determine terminal velocity and coefficient of viscosity.**<br>(Domain B: Mechanics – Dynamics, Terminal velocity of a body and viscosity of a fluid) | **[SLO: HSSC-E-16]** Explain the concepts of viscous drag, terminal velocity, and Stoke's law. ES1<br>**[SLO: HSSC-E-17]** Measure the time taken by steel spheres to travel a fixed distance through a viscous fluid. ES2, ES3<br>**[SLO: HSSC-E-18]** Calculate the terminal velocity of the falling spheres from recorded measurements. ES3, ES4<br>**[SLO: HSSC-E-19]** Determine the coefficient of viscosity of the fluid using Stoke's law. ES4<br>**[SLO: HSSC-E-20]** Evaluate experimental uncertainties and discuss factors affecting the accuracy of the results. ES6 |
| 5 | **Determine the acceleration due to gravity using a mass-spring oscillation system** | **[SLO: HSSC-E-21]** Explain the relationship between restoring force, mass, and oscillation in a mass-spring system. ES1<br>**[SLO: HSSC-E-22]** Measure the oscillation period for different masses attached to the spring. ES2, ES3<br>**[SLO: HSSC-E-23]** Plot an appropriate graph and determine the acceleration due to gravity from the slope. ES4<br>**[SLO: HSSC-E-24]** Analyze the relationship between mass and oscillation period. ES4<br>**[SLO: HSSC-E-25]** Estimate uncertainties and evaluate the reliability of experimental results. ES6 |

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| 6 | **Determine the time period, frequency, and angular frequency of a simple pendulum by varying its length.**<br>(Domain D: Oscillations and Waves – Simple pendulum) | **[SLO: HSSC-E-26]** Explain the theory of simple harmonic motion and the factors affecting the time period of a pendulum. ES1<br>**[SLO: HSSC-E-27]** Measure the time period of oscillations for different lengths of the pendulum. ES2, ES3<br>**[SLO: HSSC-E-28]** Calculate frequency and angular frequency from measured data. ES3, ES4<br>**[SLO: HSSC-E-29]** Plot the relationship between time period and length to analyze the motion quantitatively. ES4<br>**[SLO: HSSC-E-30]** Evaluate experimental uncertainties and suggest improvements. ES6 |
| 7 | **Study stationary waves using Melde's apparatus and determine frequency of ac source.**<br>(Domain D: Oscillations and Waves – Stationary waves) | **[SLO: HSSC-E-31]** Explain the formation of stationary waves and resonance in stretched strings. ES1<br>**[SLO: HSSC-E-32]** Set up Melde's apparatus and adjust tension and frequency to produce standing waves. ES5, ES8<br>**[SLO: HSSC-E-33]** Measure wavelength and tension in the string and record observations accurately. ES2, ES3<br>**[SLO: HSSC-E-34]** Use the wave equation to calculate the frequency of the AC source. ES3, ES4<br>**[SLO: HSSC-E-35]** Discuss possible experimental errors affecting the measurement of wavelength and tension. ES6 |
| 8 | **Determine the wavelength of sound in air using a resonance tube and calculate speed of sound at 0°C.**<br>(Domain D: Oscillations and Waves – Stationary waves) | **[SLO: HSSC-E-36]** Explain the concept of resonance and standing waves in air columns. ES1<br>**[SLO: HSSC-E-37]** Measure the resonance lengths of the air column using a resonance tube apparatus. ES2, ES3<br>**[SLO: HSSC-E-38]** Calculate the wavelength of sound using the measured resonance lengths. ES3, ES4<br>**[SLO: HSSC-E-39]** Determine the speed of sound in air and apply temperature correction to estimate its value at 0°C. ES4<br>**[SLO: HSSC-E-40]** Evaluate uncertainties and sources of experimental error. ES6 |
| 9 | **Sketch magnetic field patterns produced by current in a circular coil and calculating its magnetic field strength at a point.**<br>(Domain E: Electricity and Magnetism – Magnetic field of a current carrying coil) | **[SLO: HSSC-E-41]** Explain how electric current produces a magnetic field and describe the field patterns around a straight conductor, circular coil, and solenoid. ES1<br>**[SLO: HSSC-E-42]** Set up the apparatus to observe magnetic field patterns using a current-carrying conductor and a magnetic compass or iron filings. ES5, ES8<br>**[SLO: HSSC-E-43]** Observe and record magnetic field patterns produced by different current-carrying conductors. ES2, ES3<br>**[SLO: HSSC-E-44]** Interpret the observed patterns and relate them to the direction and magnitude of current. ES4<br>**[SLO: HSSC-E-45]** Present observations through labelled diagrams and evaluate possible experimental errors. ES7, ES6 |
| 10 | **Determine the time constant of an RC circuit by charging and discharging a capacitor.**<br>(Domain E: Electricity and Magnetism - Capacitor) | **[SLO: HSSC-E-46]** Explain the concepts of capacitor charging, discharging, and time constant in an RC circuit. ES1<br>**[SLO: HSSC-E-47]** Set up a resistor-capacitor circuit and measure voltage variation during charging and discharging. ES2, ES5<br>**[SLO: HSSC-E-48]** Record voltage and time measurements with appropriate precision. ES3<br>**[SLO: HSSC-E-49]** Plot the appropriate graph and determine the time constant of the circuit from the data. ES4<br>**[SLO: HSSC-E-50]** Evaluate uncertainties in measured values and discuss possible sources of error. ES6 |
| 11 | **Analyze the variation of resistance of a thermistor with temperature.**<br>(Domain E: Electricity and Magnetism - Thermistor) | **[SLO: HSSC-E-51]** Explain how resistance of a thermistor varies with temperature. ES1<br>**[SLO: HSSC-E-52]** Measure resistance of the thermistor at different temperatures using suitable instruments. ES2<br>**[SLO: HSSC-E-53]** Record observations systematically and plot a resistance-temperature graph. ES3, ES4<br>**[SLO: HSSC-E-54]** Interpret the graph to analyze the temperature dependence of resistance. ES4<br>**[SLO: HSSC-E-55]** Evaluate uncertainties and discuss practical applications of thermistors. ES6 |
| 12 | **Determine the resistance of a wire using a slide wire bridge.** | **[SLO: HSSC-E-56]** Explain the principle of Wheatstone bridge and its application in resistance measurement. ES1<br>**[SLO: HSSC-E-57]** Set up the slide wire bridge apparatus and obtain the balance point. ES5, ES8<br>**[SLO: HSSC-E-58]** Measure the lengths of the bridge wire at the balance point with appropriate precision. ES2, ES3 |

| | | |
|---|---|---|
| | (Domain E: Electricity and Magnetism - Resistance and Wheatstone Bridge) | **[SLO: HSSC-E-59]** Calculate the unknown resistance using the bridge balance condition. ES3, ES4<br>**[SLO: HSSC-E-60]** Evaluate measurement uncertainties and discuss possible experimental errors. ES6 |
| **13** | **Determine the internal resistance of a cell using a potentiometer.**<br>(Domain E: Electricity and Magnetism - Potentiometer) | **[SLO: HSSC-E-61]** Explain the working principle of a potentiometer and its advantages in electrical measurements. ES1<br>**[SLO: HSSC-E-62]** Set up a potentiometer circuit to measure potential difference across a cell. ES5, ES8<br>**[SLO: HSSC-E-63]** Measure balance lengths corresponding to open-circuit and closed-circuit conditions. ES2, ES3<br>**[SLO: HSSC-E-64]** Calculate the internal resistance of the cell using measured values. ES3, ES4<br>**[SLO: HSSC-E-65]** Analyze uncertainties in the measured values and discuss factors affecting accuracy. ES6 |
| **14** | **Determine the EMF of a cell using a potentiometer.**<br>(Domain E: Electricity and Magnetism - Potentiometer) | **[SLO: HSSC-E-66]** Explain the concept of electromotive force (EMF) and the principle of potentiometer measurements. ES1<br>**[SLO: HSSC-E-67]** Set up the potentiometer circuit to obtain the balance point for EMF measurement. ES5, ES8<br>**[SLO: HSSC-E-68]** Measure the balancing length accurately and record observations with appropriate precision. ES2, ES3<br>**[SLO: HSSC-E-69]** Calculate the EMF of the cell using the potentiometer relation. ES3, ES4<br>**[SLO: HSSC-E-70]** Evaluate uncertainties in measurements and assess the reliability of results. ES6 |
| **15** | **Investigate the relationship between current and potential difference for a tungsten filament lamp.**<br>(Domain E: Electricity and Magnetism – Resistance and temperature, Current and Voltage relation) | **[SLO: HSSC-E-71]** Explain why a tungsten filament lamp does not obey Ohm's law at higher temperatures. ES1<br>**[SLO: HSSC-E-72]** Measure current and potential difference across the filament lamp for different applied voltages. ES2, ES3<br>**[SLO: HSSC-E-73]** Plot a current–voltage graph for the filament lamp. ES4<br>**[SLO: HSSC-E-74]** Interpret the non-linear relationship between current and voltage. ES4<br>**[SLO: HSSC-E-75]** Evaluate experimental uncertainties and sources of heating effects. ES6 |
| **16** | **Investigate the relationship between current and capacitance in an ac circuit using parallel capacitors.**<br>(Domain E: Electricity and Magnetism - Capacitors in AC Circuit) | **[SLO: HSSC-E-76]** Explain the concept of capacitive reactance and its dependence on capacitance in AC circuits. ES1<br>**[SLO: HSSC-E-77]** Construct an AC circuit using different capacitors in parallel combinations. ES5, ES8<br>**[SLO: HSSC-E-78]** Measure current for different capacitance values and record observations. ES2, ES3<br>**[SLO: HSSC-E-79]** Analyze the relationship between current and capacitance using graphical or numerical methods. ES4<br>**[SLO: HSSC-E-80]** Evaluate uncertainties and discuss practical implications in AC circuits. ES6 |
| **17** | **Plot the characteristics of a semiconductor diode for forward biasing and reverse biasing.**<br>(Domain E: Electricity and Magnetism - Electronics, Biasing of a diode) | **[SLO: HSSC-E-81]** Explain the working principle of a semiconductor diode and its forward and reverse bias conditions. ES1<br>**[SLO: HSSC-E-82]** Measure current and voltage across the diode in forward and reverse bias. ES2, ES3<br>**[SLO: HSSC-E-83]** Plot the V–I characteristics of the diode. ES4<br>**[SLO: HSSC-E-84]** Calculate forward and reverse resistance from the characteristic curves. ES4<br>**[SLO: HSSC-E-85]** Evaluate measurement uncertainties and discuss diode applications. ES6 |
| **18** | **Study half-wave and full-wave rectification using semiconductor diodes on CRO.**<br>(Domain E: Electricity and Magnetism - Electronics, Rectification) | **[SLO: HSSC-E-86]** Explain the principles of half-wave and full-wave rectification in electronic circuits. ES1<br>**[SLO: HSSC-E-87]** Set up rectifier circuits using diodes and observe output waveforms on a cathode-ray oscilloscope. ES5, ES8<br>**[SLO: HSSC-E-88]** Record and interpret waveform patterns for different rectification circuits. ES3, ES4<br>**[SLO: HSSC-E-89]** Compare the efficiency of half-wave and full-wave rectifiers. ES4<br>**[SLO: HSSC-E-90]** Discuss possible measurement errors in CRO observations. ES6 |
| **19** | **Verify the truth tables of logic gates (AND, OR, NOT, NAND, NOR).**<br>(Domain E: Electricity and Magnetism - Electronics, Logic gates) | **[SLO: HSSC-E-91]** Explain the basic operation of digital logic gates used in electronic circuits. ES1<br>**[SLO: HSSC-E-92]** Construct circuits using logic gates to test their input–output relationships. ES5, ES8<br>**[SLO: HSSC-E-93]** Record input combinations and corresponding outputs systematically. ES3<br>**[SLO: HSSC-E-94]** Verify the truth tables for AND, OR, NOT, NAND, and NOR gates. ES4 |

| | | |
|---|---|---|
| | | **[SLO: HSSC-E-95]** Present results clearly in tabular form and interpret their significance in digital electronics. ES7 |
| **20** | **Study the variation of electric current with intensity of light using a photocell.**<br>(Domain F: Space/Modern Physics – Photoelectric Effect) | **[SLO: HSSC-E-96]** Explain the photoelectric effect and the operation of a photocell. ES1<br>**[SLO: HSSC-E-97]** Set up the photocell apparatus to measure current for different light intensities. ES5, ES8<br>**[SLO: HSSC-E-98]** Measure photocurrent using appropriate electrical instruments and record data systematically. ES2, ES3<br>**[SLO: HSSC-E-99]** Analyze the relationship between light intensity and photocurrent using graphical methods. ES4<br>**[SLO: HSSC-E-100]** Evaluate experimental uncertainties and discuss practical applications of photocells. ES6 |

# GUIDELINES FOR TEXTBOOK AUTHORS

These guidelines are suggested to support textbook authors in developing high-quality, learner-centered textbooks in accordance with the **National Curriculum of Pakistan.** The guidelines reflect national education priorities, constitutional values, and international best practices.

As the textbooks/textual material is an important teaching and learning tool to understand the subjects. Writing textbook is an extremely important, highly technical and delicate task to assist both teachers and students in earning and transmission of the life experiences. It required the translation of curriculum learning outcomes at the proper Cognitive level of learners /students. The concept to be introduced be explained informally before providing the formal definition or statement along with tangible examples from real life situation. The solved examples and the exercises should cover the whole range of variety of questions and their applications in the everyday life. Before writing textbook authors are required to understand the curriculum in letter and spirit. The following key point must be kept in mind:

## 1. ALIGNMENT WITH PAKISTAN NATIONAL CURRICULUM

- Address all prescribed **Student Learning Outcomes (SLOs)** and competencies without omission or distortion.
- Follow the approved scope, sequence, and progression across grades.
- Integrate cross-cutting themes emphasized in the NCF, including:
    - Islamic values and ethics (where applicable)
    - Environmental sustainability (where applicable)
    - Health, safety, and life skills (where applicable)
    - Digital literacy (where applicable)

## 2. IDEOLOGICAL AND CONSTITUTIONAL CONSIDERATIONS

- Ensure content is fully consistent with the **Ideology of Pakistan** and the **Constitution of the Islamic Republic of Pakistan**.
- Promote national cohesion, social harmony, and respect for cultural and religious diversity.
- Avoid content that may undermine national unity or social values.

## 3. LEARNER-CENTERED AND COMPETENCY-BASED APPROACH

- Design content that supports **competency-based learning** as emphasized in the **NCP**.
- Cater to students' cognitive, emotional, and social development at the relevant grade level.
- Encourage inquiry, reasoning, creativity, and problem-solving.
- Minimize rote memorization; emphasize understanding and application.
- Relate concepts to students' real-life experiences, especially local and national contexts.
- Boxed "Tid bits", "interesting information", "do you know", and "point of ponder" may be given to highlight additional information along with the description of concepts particularly related to STEAM connection through inquiry process.
- Each unit must be linked with relevant modern technologies and real-life applications.

- Authors should highlight how physical laws operate in everyday devices and technological systems.

## 4. LANGUAGE, READABILITY, AND MEDIUM OF INSTRUCTION

- Use language that is clear, simple, and age-appropriate.
- Follow the approved **medium of instruction** (Urdu, English, or regional language) as notified.
- Define new or technical terms clearly; include glossaries where required.
- Maintain consistency in terminology and spelling throughout the textbook.

## 5. ORGANIZATION AND CHAPTER STRUCTURE

Each unit or chapter should include:

- Learning objectives expected to be achieved in each chapter/unit should be prominently stated at the beginning of the chapter/unit.
- Each chapter introduction should spark students' curiosity and motivate them to explore and pursue the specific field of physics.
- The contents should be authentic, updated and well organize in sequential order throughout the books.
- Introductory activities or questions activating prior knowledge.
- Developing thematic/concept map may be given at the start of each chapter/unit.
- Concepts, information and examples should match the sequence and content of learning outcomes.
- Well-sequenced content from simple to complex.
- Examples and applications from local environment should be preferred.
- A comprehensive glossary of terms and subjects index, references and authors' profiles may be given at the end of the book.
- The amount of information to be covered by the chapter must match the number of hours of instructional time.
- Coherent and precise summary should be given at the end of each chapter.
- Tables, flow charts/diagrams and concept maps may be given wherever appropriate.
- The contributions of Muslim and Pakistani Scientists may be highlighted appropriately wherever related.
- SI units should be used all over in the text. However, conversion with other units may be added.
- Use headings, subheadings, tables, and visuals to enhance readability.
- Key words, terms and definitions should be highlighted in the text.
- Provide opportunities for self-assessment and formative assessment.
- Some of the thought-provoking questions to deal with problems solving situations in real life may also be given within the chapter/unit.
- Solved numerical examples and end of chapter numerical problems should be based on variety of situations in novel manner and be related to local environment, culture and real-life situations.
- Answers to the numerical problems should be quoted in scientific notation with correct number of significant figures and units, the answers of numerical may be given below the numerical problems.

## 6. PEDAGOGICAL FEATURES AND LEARNING ACTIVITIES

- Include a balanced variety of:
  - Conceptual questions
  - Application-based exercises
  - Activities and projects
  - Inquiry and critical-thinking tasks
- Encourage collaborative learning, discussion, and reflection.
- Support experiential learning.
- Clearly distinguish between core content and enrichment material.

## 7. INCLUSIVITY, GENDER EQUITY, AND SOCIAL SENSITIVITY

- Portray women, men, persons with disabilities, and marginalized groups positively and fairly.
- Avoid stereotypes, bias, or discriminatory language and imagery.
- Reflect Pakistan's regional, linguistic, and cultural diversity.
- Promote values of respect, tolerance, cooperation, and social responsibility.
- The textual material (text, images, illustration, pictures, figure etc.) are equally acceptable by students of either gender and should be from the local /Pakistan environment.

## 8. ILLUSTRATIONS, MAPS, AND VISUAL MATERIAL

- Use visuals that are pedagogically meaningful and culturally appropriate.
- Ensure maps, flags, timelines, and symbols are accurate and officially correct.
- Label all diagrams and figures clearly.
- Maintain consistency in style, scale, and presentation.
- The text should be supported with art i.e. illustrations, diagrams and photographs possibly in colour which should be clear, properly labelled and captioned to make the substance interesting and stimulating.

## 9. INTEGRATION OF SKILLS AND NATIONAL PRIORITIES

- Integrate key skills emphasized in the NCF, including:
  - Critical and analytical thinking
  - Communication skills
  - Numeracy and literacy
  - Ethical and civic responsibility
- Where appropriate, incorporate education for sustainable development, health education, and financial literacy.

- A practical manual for the students should also be written to support practical work.
- Reference of the experiments /practical activities may be made with the related topics in text.

## 10. USE OF DIGITAL AND SUPPLEMENTARY RESOURCES

- Recommend digital resources only if aligned with national policies and approved platforms.
- QR codes or online links (if included) should be relevant, safe, and officially permissible.
- Supplementary materials may include workbooks, teacher guides, or activity manuals.

## 11. ETHICAL, LEGAL, AND COPYRIGHT COMPLIANCE

- Ensure originality and avoid plagiarism.
- Acknowledge all sources and references appropriately.
- Comply with national laws, textbook board regulations, and MoFE&PT guidelines where applicable.

## 12. REVIEW, APPROVAL, AND QUALITY ASSURANCE

- **REVIEWERS:** Feedback from reviewers **must be logical, evidence-based, and unbiased**, clearly linked to curriculum standards and learning outcomes.
- Comments should be **specific, constructive, and actionable**, avoiding vague or generic remarks.
- All observations must be **supported by references** to the National Curriculum, learning benchmarks, or accepted academic standards where applicable.
- Reviewers shall **distinguish between factual errors, pedagogical issues, and stylistic preferences** in their feedback.
- Personal opinions, ideological bias, or preferences unrelated to curriculum objectives **must not influence** the review.
- Feedback should focus on **improving conceptual clarity, accuracy, age appropriateness, and alignment with stated learning outcomes**.
- Any recommended changes must be **clearly justified** and, where possible, include **suggested corrections or alternatives**.
- Reviewers must ensure **consistency in judgment** across chapters, grades, and subject areas.
- Language used in feedback should be **professional, respectful, and objective**, avoiding dismissive or subjective expressions.
- Reviewers are responsible for ensuring that feedback supports **equity, inclusivity, and national education goals** as outlined by NCC Pakistan.
- **PUBLISHERS:** Revised content should be in line with feedback from review committees.
- Ensure compliance with all **Textbook Board and Ministry of Federal Education & Professional Training** requirements before submission.

These guidelines are intended to support the development of high-quality textbooks that meet the educational goals of Pakistan and contribute to meaningful, equitable, and effective learning for all students.

# ASSESSMENT GUIDELINES

Here are the key components of effective physics curriculum assessment guidelines based on current practices:

## Structure of Assessment (Formative vs. Summative)

**Formative Assessment:** Integrated into daily learning to monitor understanding and guide instruction. This includes classroom discussions, quizzes, peer assessments, and, crucially, practical lab work that does not count towards the final exam.

**Summative Assessment:** Evaluates learning at the end of a unit or year. These are high-stakes tests, projects, or final exams.

**Table of Specifications (ToS):** A guide to ensure balanced coverage of content domains and cognitive levels *(Knowledge, Understanding, Application)* in examinations.

## Cognitive Levels in Assessment

Assessment, particularly for higher grades (9-12), should be broken down by cognitive domain:

**Knowledge (K):** Recalling facts, formulas, and definitions.

**Understanding (U):** Explaining phenomena and interpreting data.

**Application (A):** Applying concepts to new situations, solving numerical problems, and using formulas to calculate physical quantities.

## Practical Based Assessments

Given that physics is an experimental science, practical skills are essential.

**Experimental Skills:** Assessment should test the ability to handle equipment safely, collect data, and interpret results.

**Performance Tasks:** Students may be assessed on their ability to design investigations, identify variables, and formulate hypotheses.

**Laboratory Reports/Practical Exams:** These are used to assess practical proficiency, often involving experiments from a prescribed list.

## Core Assessment Areas

**Conceptual Understanding:** Moving beyond calculation to ensure students understand the "why" behind physical phenomena.

**Problem-Solving:** Requiring students to identify knowns/unknowns, select appropriate formulas, and analyze steps in complex problems.

**Data Understanding and Interpretation:** Ability to sketch, plot, and interpret graphs (e.g., speed-time graphs).

**Real-world Application:** Assessing how physical theories apply to everyday technology and environmental issues.

## Best Practices for Design

**Alignment:** Ensure assessment items align directly with defined SLOs.

**Variety:** Use a mix of objective questions, short answers, and long-answer questions to test different skill levels.

**Clear Marking Schemes:** Provide clear rubrics, particularly for practical work and short/extended response questions, to ensure fairness and transparency.

## EXAMPLES OF SOME ASSESSMENT TOOLS

### 1. Conceptual Questions (Non-Quantitative)

These questions test understanding without relying on formulas, ensuring students are not just plugging numbers into equations.

**Best for:** Identifying misconceptions and deep comprehension of principles (e.g., conservation of energy, Newton's laws).

**Examples:** "Why is it not safe to apply brakes only on the front wheel of a bicycle?", or asking to predict what happens to the brightness of bulbs in a circuit if one is removed.

**Methods:** Multiple-choice (with conceptual distracters), true/false with justification, or short-answer questions.

### 2. Constructed Response & Problem-Solving Questions

These require students to formulate their own answers, show their work, and explain their reasoning.

**Best for:** Assessing the ability to analyze a scenario, select appropriate mathematical tools, and calculate results.

**Examples:** "A nail is partially sunk in wood……...or calculate the recoiling velocity".

**Best Practice:** Require students to provide textual evidence for their position or justify their steps.

### 3. Graphing and Diagramming Questions

Physics relies heavily on visual representation.

**Best for:** Assessing interpretation skills (e.g., reading velocity-time graphs) or constructing free-body diagrams.

**Examples:** "Plot the velocity-time graph for the motorcycle".

**Methods:** Drawing, labeling, and interpreting, or matching diagrams to physical situations.

### 4. Two-Tier Diagnostic Questions

These questions are specifically designed to uncover misconceptions.

**Best for:** Pinpointing exactly *why* a student got an answer wrong.

**Structure:** Tier 1 asks for the answer to a problem, and Tier 2 asks for the reasoning behind that answer (e.g., "Choose the best reason for your answer in question 1").

**5. Performance-Based/Practical Tasks**

**Best for:** Assessing laboratory skills, data Understanding, and the ability to apply theory to real-world scenarios.

**Methods:** Laboratory reports, performance-based tests (e.g., using a Vernier caliper), or projects that require designing an experiment.

**Summary of Assessment Alignment**

To ensure a comprehensive assessment, align the question type with the cognitive skills:

| Learning Outcome | Best Question Type |
|---|---|
| **Recall/Recall Facts** | Multiple-choice, Fill-in-the-blank |
| **Understand Concepts** | Conceptual questions, Concept maps, Explanation questions |
| **Apply/Analyze** | Problem sets, Case studies, Graphing, Two-tier questions |
| **Evaluate/Create** | Projects, Peer review, Lab reports |

Using a mix of these types, including both formative (e.g., exit tickets, clicker questions) and summative assessments (e.g., final exams), provides the most accurate picture of student learning.

## Estimated Time Allocation and Weighting for Various Units/Chapters of GRADE IX

| Unit # | Content | Periods (Theory) | Periods (Investigation/ Practical work) |
|---|---|---|---|
| 1. | Fundamentals of Physics (Measurement) | 10 | 6 |
| 2. | Kinematics | 23 | 6 |
| 3. | Dynamics | 22 | 3 |
| 4. | Turning effect of forces and Equilibrium | 12 | 3 |
| 5. | Work, Energy and Power | 14 | 0 |
| 6. | Pressure and Deformation of Solids | 16 | 9 |
| 7. | Thermal Properties of Matter | 21 | 0 |
| 8. | Magnetism | 09 | 3 |
| | | 128 | 30 |
| | | | |

## Estimated Time Allocation and Weighting for Various Units/Chapters of GRADE X

| Unit # | Content | Periods (Theory) | Periods (Investigation/ Practical work) |
|---|---|---|---|
| 1. | Heat | 15 | 9 |
| 2. | Oscillations & Waves | 16 | 3 |
| 3. | Sound | 11 | 0 |
| 4. | Optics | 22 | 9 |
| 5. | Electrostatics | 7 | 0 |
| 6. | Current Electricity | 30 | 9 |
| 7. | Electromagnetism | 15 | 0 |
| 8. | Nuclear Physics | 21 | 0 |
| | | 137 | 30 |

## Estimated Time Allocation and Weighting for Various Units/Chapters of GRADE XI

| Unit # | Content | Periods (Theory) | Periods (Investigation / Practical work) |
|---|---|---|---|
| 1. | Measurement | 7 | 6 |
| 2. | Vectors | 4 | 0 |
| 3. | Motion & Force | 5 | 3 |
| 4. | Work, Energy & Power | 9 | 0 |
| 5. | Circular/Rotational Motion | 18 | 0 |
| 6. | Fluid Dynamics | 10 | 3 |
| 7. | Deformation of Solids | 7 | 0 |
| 8. | KMT & Thermodynamics | 23 | 0 |
| 9. | Simple Harmonic Motion | 13 | 6 |
| 10. | Properties of waves | 18 | 6 |
| 11. | Modern Physics | 15 | 0 |
| | | 129 | 24 |

## Estimated Time Allocation and Weighting for Various Units/Chapters of GRADE XII

| Unit # | Content | Periods (Theory) | Periods (Investigation/ Practical work) |
|---|---|---|---|
| 1. | Electrostatics | 21 | 3 |
| 2. | Current Electricity | 14 | 15 |
| 3. | AC Circuits | 7 | 3 |
| 4. | Electronics | 16 | 9 |
| 5. | Electromagnetism | 9 | 3 |
| 6. | Quantum Physics | 30 | 3 |
| 7. | Nuclear Physics | 18 | 0 |
| 8. | Thermal Radiations | 10 | 0 |
| | | 125 | 36 |

# GUIDELINES FOR TEACHERS

This National Curriculum of Physics 2026 provides a well-structured, competency-based progression from foundational concepts in Grade IX to advanced applications in Grade XII. It emphasizes conceptual understanding, practical skills, reduced content overload, and alignment with 21st-century needs while maintaining international standards. Following are the key highlights for teachers**:**

**Progression & Sequencing:** The curriculum builds logically upon students' prior knowledge, with no repetition of SLOs from previous grades. It progressively develops core concepts such as vector analysis, conservation laws, wave mechanics, and modern physics, effectively preparing students for higher education and STEM careers.

**Cognitive Balance**: SLOs are tagged with Bloom's levels (Knowledge/Remember, Understand, Apply/HOTS). Prioritize 'Application' and practical work for deeper learning.

**Practical Emphasis**: Follow the prescribed minimum experiments (SSC & HSSC lists). Integrate uncertainty analysis, graphing, and error evaluation, especially in HSSC.

**Pedagogy**: Use real-life examples (Pakistan context), inquiry-based activities, free-body diagrams, PV graphs, and technology links. Highlight contributions of Muslim/Pakistani scientists where relevant.

**Assessment**: Blend formative (labs, discussions) and summative assessments.

**Time Management**: Adhere to suggested periods (e.g., Grade IX: 128 theory + 30 practical). Allow flexibility for local contexts.

Teachers should encourage critical thinking, problem-solving, and ethical use of physics (e.g., energy sustainability, safety). This curriculum nurtures scientifically literate, innovative citizens. Regular refresher of prior concepts is recommended.

# List of Internal Review Committee Members

| Sr. No. | Name of Internal Review Committee Member | Designation / Department |
|---|---|---|
| 1. | Dr. Tabbasum Naz | Director, NCC |
| 2. | Mr. Abdul Hanan | DEA, NCC |
| 3. | Dr. Tajammal Hussain Shah, Educationist | --- |
| 4. | Mr. Adnan Rasool | Lecturer, FGEIs |
| 5. | Mr. Naeem Nazeer | SST, IMCB, I-10/I |
| 6. | Engr. Umair Hafeez Khan | Lecturer, Dept of E&T, AIOU |
| 7. | Dr. Ejaz Ahmed | Associate Professor, ICB G-6/3 |
| 8. | Ms. Azka Haider | Lecturer, Fauji Foundation |
| 9. | Mr. Imran Khaliq | Assistant Professor, IMCB G-10/4 |
| 10. | Ms. Afshan Kanwal | Lecturer, FBISE |
| 11. | Mr. Sarfaraz Ahmed | AEA, Secretary Committee, NCC |

# List of Inter Provincial Curriculum Workshop (IPCW) Review Committee Members

| Sr. No. | Name of Committee Members | Designation / Province |
|---|---|---|
| 1. | Mr. Abdul Rauf Zahid | Senior Subject Specialist, Punjab |
| 2. | Dr. Nadeem Anwar | Assistant Professor, South Punjab |
| 3. | Ms. Rozina Channar | Subject Specialist, Sindh |
| 4. | Abdul Rehman Indhar | STBB, Sindh |
| 5. | Dr. Saif Ur Rehman | Subject Specialist, KPK |
| 6. | Ms. Aqeela Nadir Ali | SRO, Balochistan |
| 7. | Mr. Manzoor Ali Khan | DDE, Gilgit Baltistan |
| 8. | Wajid Taj | Subject Specialist, AJ&K |
| 9. | Muhammad Imran Khaliq | Assistant Professor, ICT |
| 10. | Naeem Nazeer | SST, ICT |
| 11. | Mr. Sarfaraz Ahmed | AEA, Secretary Committee, NCC |

**NATIONAL CURRICULUM COUNCIL WING**

MINISTRY OF FEDERAL EDUCATION AND
PROFESSIONAL TRAINING, ISLAMABAD
GOVERNMENT OF PAKISTAN