National School Curriculum

# INSTRUCTIONAL GUIDE FOR PHYSICS

## CLASSES XI & XII

**Department of Curriculum and Professional Development**
Ministry of Education, Royal Government of Bhutan

“Your parents, relatives, and friends would be very proud of what you have achieved. At your age, to have completed your studies is your personal accomplishment. Your knowledge and capabilities are a great asset for the nation. I congratulate you for your achievements. Finally, your capabilities and predisposition towards hard work will invariably shape the future of Bhutan. You must work with integrity, you must keep learning, keep working hard, and you must have the audacity to dream big.”

*- His Majesty Jigme Khesar Namgyel Wangchuck*

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**Provisional Edition 2021**

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## Foreword

COVID-19 has caused unforgiving disruptions in the public education all over the world, and brought about threats of fragmentation in the society due to disparities in accessibility and connectivity in many systems. In Bhutan too, continuity of education and learning has been severely affected as a result of sporadic nationwide school closures, restrictions and health protocols. The disruptions exposed the limitation of the existing ideologies and practices in education. This has deprived children living in poverty worldwide, who rely on the physical settings of their schools for educational materials and guidance, of the learning and other essential educational services. Cognizant of the global trend to embrace the competency based learning as education for the 21st century, the current priority of the Government is to transform the knowledge and textbook based learning to competency based learning through open source and experiential learning.

In the new normal education, human interaction and well-being is a priority. Technology, particularly digital technology that enables communication, collaboration and learning across distance, is a formidable tool though not a panacea but a source of innovation and expanded potentials. As we embrace this exceptional opportunity to transform the education, it is imperative to reimagine the organization of our educational institutions and learning environments. In the post COVID-19 era, we must prioritize the development of the whole person not just the acquisition of academic knowledge. Inspiration for the change can be drawn from the 1996 Delors report, *Learning the treasure within*. Its four pillars of learning as "learning to know", "learning to do", "learning to be", and "learning to live together" are the current global ethos of teaching and learning. Therefore, curricula must be increasingly perceived as an integrated, theme-based and problem-based orientation that allow learners develop a strong base of knowledge about one's self and about the world, and find purpose of life and be better able to participate in social and political milieu.

The National School Curriculum is, not just a mere response to the pandemic, but also culmination of the curriculum reform work for the last four years by the erstwhile Royal Education Council. It is an attempt to transform education from the teaching of "what" to learning of "how" and "why" towards empowering learners with the transversal competencies and the 21s t century skills, and preparing them to be lifelong learners. In tandem with this initiative, we are optimistic that the paradigm shift in Sceince education orients our education process in empowering young generation with the scientific mind-set and disposition, and skills towards nurturing nationally rooted and globally competent citizens.

With this guide, we are optimistic that our learners and teachers are ushered through a life enriching experiential science education.

Tashi Delek

**(Tashi Namgyal)**
**DIRECTOR**

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## 1. Introduction

The conventional education, which is predominantly knowledge based and examination centred teaching and learning has been the time old practises. Stress of this model is on the learning of textual information perceived by educators important for the grade. On the other hand, with the advancement in ICT, the world is flooded with such information, which is widely read by all at their leisure. What learners cannot acquire from the multiple sources are the skills, values and change of behaviour, which are crucial in facilitating learners realise their potential to be socially responsible and productive individuals, and optimise their contribution in the nation building processes – economic, social, political development. In the contemporary world, textbook based, knowledge-based education compromises the development of psychomotor and affective domains of learning, affecting the holistic development and psychosocial wellbeing of learners.

The pandemic situation also explicated that the old ways of working, teaching and learning, and lifestyle have limitations. Consequently, new ways of how we work and live, teach and learn, stay connected are the contemporary traditions. In this context, an overhaul of how we think and do are imperative, not a choice. The transformation of classroom instruction from the teacher centred to that of learner centred learning however calls for the following adjustment, or even the overhaul of some of the practices.

i. Reduction of learning content to facilitate deep learning as opposed to the width of the teaching and learning through active engagement of learners.
ii. Integration of ICT as tools and ends of the learner's education. The use of multimedia and ICT software are commonly utilised in the teaching and learning as innovation to introduce variation in stimuli, and sustain learner's interest and zeal in learning.
iii. Adoption of theme-based learning content facilitates in broadening the horizon of learning beyond the four walls, and stimulates the transfer of the learnt concepts to the learner's immediate environment. This arrangement makes learners aware of the realities of the social, political, economic and cultural practises and ethos of the society. Being aware of the immediate environment of the scopes and challenges, learners are sensitised to the opportunities and issues.
iv. Consideration to ground the curriculum design and instruction approaches on the epistemological theories is imperative to facilitate deep learning as opposed to factual

learning. The selection and use of them, however, is subject to the nature of the subject. For instance, constructivism is more apt for science, while connectivism may be relevant for languages and ICT curricula to facilitate deep learning and inspire the generation of new knowledge and ideas.

v. Active engagement of learners is imperative for competency-based education and learning. Inevitably, summative assessment has limitations in gauging the progressive development of the learner. This is achieved objectively by the use of the continuous formative assessment (CFA). However, if summative assessment evidence is used to provide feedback to help learners in learning, it can serve as one of the techniques of CFA.

The curriculum is grounded on the wisdom and principles of competency-based learning, built on reality of the immediate environment, and the belief system of the society, promotes the personalised learning; fosters life enriching experiences, which inspires youth to generate new knowledge and create new ideas to innovate as young scientists or enterprising individuals.

Towards this, learning is facilitated through the "Instructional Guide" with learners taking responsibility for their learning. Roles of teachers are facilitation, guide, evaluation in the course of learners' active engagement, and assess the performance for improvement and enhance learner's learning. Therefore, the NSC Physics Instructional Guide (Physics IG) is an attempt to transform education from the teaching of "what" to learning of "how" and "why" towards empowering learners with the transversal competencies and the 21$^{st}$ century skills, and preparing them to be lifelong learners.

## 2. Purposes of the Instructional Guide

In the National School Curriculum, deep learning synonymous to "less is more" is facilitated with the use of Instructional Guide for each subject and specific class. The content of the instruction in the guide for respective subjects are aligned with the subject's curriculum framework. Therefore, the Physics IG is purported to achieve the following objectives towards facilitating uninterrupted teaching and learning:

i. Strengthen competency based learning and experiential learning to foster sensitivity to realities of life and environment.

ii. Strengthen blended learning and flip classroom with multimedia, digital pedagogies and ICT devices and websites as tools and ends of the learning.
iii. Prioritise learning content with emphasis on creating time and space for deep learning and raise sensitivity of the realities of the world around them through active engagement of learners.
iv. Facilitate the use of CFA for learning using diverse appropriate assessment techniques and tools commensurate with individual differences in learning, and gather evidence to guide planning of educational programs and activities for learners.
v. Promote inclusive learning through the blended learning which facilitates learning anywhere, any time with the learner being responsible for the learning.
vi. Inspire teachers to assume the roles of facilitation, guide, motivator and evaluator.
vii. Guide both teachers and parents in facilitating learning of their children.

The experiential and personalised learning practices are widely used around the world and are grounded on different models. One of such models that suits the current situation and expectation of education for the 21st century is the ADDIE model (Analyse, Design, Develop, Implement and Evaluate).

# Class XI

# 1. Newtonian Mechanics

The general study of the relationships between motion, forces, and energy is called mechanics. It is a large field and its study is essential to the understanding of physics, which is why these chapters appear first under Newtonian mechanics. Fundamental concepts of mechanics are critical to any future scientist, innovator, engineer or curious student who wants to figure out the rudiments of the physical world.

Topics in the study of Newtonian Mechanics include dynamics, kinematics, mechanical properties of solids, and work and energy. These topics are designed to completely relate to our day-to-day activities.

**Competencies:**

- Explain scalars and vectors to solve numerical problems and relate its applications to real life situations.
- Carry out an experiment to investigate motion of an object in terms of position, velocity and acceleration with respect to time and apply mathematical relations to solve the problem numerically and graphically.
- Analyse the projectile motion, including the resolution of vertical and horizontal components of acceleration, velocity, and displacement using interactive simulation to relate its applications in games, military, and physical processes in motion.
- Verify Newton's laws of motion to apply their concept in everyday experiences.
- Examine the law of conservation of momentum and circular motion using relevant tools (simulations, apps, or physical tools) to relate its significance in daily life.
- Interpret the concept of elastic properties of materials using Hooke's law to make the right choice of material for the construction of different infrastructures.
- Investigate the transformation of energy experimentally to describe the conservation of mechanical energy.

## 1.1. Motion in a Straight Line

### 1.1.1. Rest and Motion.

*(Scope: rest and motion, position and path length).*

**Objective(s)**:

i. Carry out an experiment to explain rest and motion, position and path length of an object.

**Learning Experiences:**

The teacher may deliver the lesson in the following order of activity to investigate the motion of the body in terms of rest and motion, position and path length of an object. The teacher may provide the interactive simulation link https://ophysics.com/k7.html or relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) on rest and motion, position and path length of an object.

- The learner uses simulation link https://ophysics.com/k7.html or relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.) and video link https://bit.ly/3bJNBMS to explore rest and motion, position and path length
- Based on the information gathered from the simulation and video or relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) the learner presents their findings to the class.

**Questions:**

1. What keeps the object at rest?
2. Are rest and motion absolute or relative?
3. How can we determine whether the object is at rest or not?
4. Are all moving objects considered in motion?

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of rest and motion, position and path length of an object from the explanation using a checklist.

**Working scientifically:** Assess the learner's ability to explore and play the simulation using the observation form while playing the simulation.

**Scientific values and attitudes:** Assess the learner's abilities to relate or connect the concept with real life situations using a checklist.

The teacher may provide necessary intervention if need be.

**Resources:**

- REC repository.
- Fundamentals of Physics Class XI by Wiley (Reprint 2019).

- Science Curriculum Framework 2022 (SCF, 2022)
- Formative Assessment for classes PP - VI, 2020
- https://ophysics.com/k7.html
- https://bit.ly/3bJNBMS

### 1.1.2 Instantaneous Velocity.

(*Scope: instantaneous speed and acceleration using velocity-time graph).*

**Objective(s):**

ii. Interpret instantaneous values of speed and velocity, and acceleration using graph or CAI (Computer Assisted Instruction) tools.

**Learning Experiences:**

The teacher may carry out the instructional practices in the following sequence of 5E model (Engage, Explore, Explain, Elaborate and Evaluate). The teacher may introduce the concept of average velocity, instantaneous speed and velocity, and velocity-time graph from the video links https://bit.ly/3bK4SVZ and https://bit.ly/3cuL0p7 or relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) on instantaneous speed and velocity, and velocity-time graph. The teacher may provide hypothetical data to deliver the lesson as:

- The learner engages in the reflection of what they already know and recognise what they don't yet understand regarding the concept of speed, velocity and acceleration.
- Explores the video links https://bit.ly/3bK4SVZ and https://bit.ly/3cuL0p7 or relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) on instantaneous speed and velocity, and velocity-time graph.
- Plots graphs using graph paper and CAI tools to explain instantaneous speed and velocity.
- Analyses the graphs and explains the understanding of instantaneous speed and velocity, and velocity-time graph.
- Constructs a connection between speed, velocity, acceleration, distance, and displacement with reference to the information gathered.

**Questions:**

1. How do you determine the instantaneous velocity?
2. How do you solve instantaneous velocity problems?
3. How do you find instantaneous velocity from average velocity?

4. How do you find instantaneous velocity without calculus?
5. What is an example of instantaneous velocity?
6. Explain the difference between average velocity and instantaneous velocity.

**Assessment:**

The teacher may use checklist/observation/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's comprehension on the concept of speed, velocity and acceleration from the explanation using a checklist.

**Working scientifically:** Assess the learner's skill to plot graphs and interpret the concept of instantaneous velocity and speed, acceleration using a rubric while they perform the activity.

**Scientific values and attitudes:** Assess a learner's ability to relate speed, velocity and acceleration using observation form.

The teacher may provide necessary intervention if needed.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- Formative Assessment for classes PP - VI, 2020
- https://bit.ly/3bK4SVZ
- https://bit.ly/3cuL0p7

### 1.1.3. Kinematic Equations.

*(Scope: derivation using graphical method, solve numerical problems*).

**Objective(s):**

iii. Derive kinematic equations using graphical methods for uniform motion.

**Learning Experiences:**

The teacher may deliver the lesson on derivation of kinematic equations using a graphical method for uniform motion in the following order of instructional practices. The teacher may provide the link https://bit.ly/2OOGABk or relevant materials (books, internet links, handouts, downloaded

digital content, articles, etc.) on kinematic equations of uniform motion and explain the steps to derive the equations using the graphical method.

- The learner explores the information on kinematic equations for uniformly accelerated motion from the link https://bit.ly/2OOGABk or the relevant sources (handouts, internet links, books, articles, downloaded digital content etc.,) and derives the equations guided by the teacher.
- Interpretes the equations from the graph and solves numerical problems using the kinematic equations.

**Questions:**

1. What are kinematic equations used for in real life?
2. Can kinematic equations be used when acceleration is zero?

   or

   Can equations of kinematics be used when acceleration acceleration varies with time? if not, what form would these equations take?
3. How do you solve kinematic equations questions?
4. What are the variables in kinematic equations?

**Assessment:**

Teacher may use any relevant assessment tool such as marking scheme, checklist, etc., to assess the learner incorporating the following domains:

**Scientific knowledge:** Assess the learner's concept on area and slope while deriving the kinematic equations using a checklist.

**Working scientifically:** Use a marking scheme to assess the learner's competency to derive the kinematic equations and solve the numerical problems.

**Scientific values and attitudes:** Assess a learner's ability to incorporate important procedures and steps while deriving the kinematic equations using a marking scheme.

The teacher may provide necessary intervention if needed.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- New Normal Science Curriculum Framework 2021 (NNSCF, 2021)

- Formative Assessment for classes PP - VI, 2020
- https://bit.ly/2OOGABk

## 1.2 Motion in a Plane

### 1.2.1 Scalars and Vectors.

*(Scope: addition and subtraction of vectors by graphical method, resolution of vectors, phasor).*

**Objective(s)**:

iv. Interpret the differences between scalars and vectors to perform addition and subtraction of vectors using interactive simulation to comprehend the concept of resolution of vectors.

**Learning Experiences:**

The teacher may deliver the lesson on the differences between scalars and vectors and algebraic operations of vectors in the following order of POE (Predict, Observe, Explain). The teacher may provide an interactive simulation link https://bit.ly/3lerwJi or relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.,) on addition and subtraction of vectors.

- The learner explores and differentiate between scalar and vector quantity from relevant sources (books, internet links, handouts, downloaded digital content, articles, etc.)
- The learner predicts the magnitude and the direction of the resultant vector of algebraic operations of vectors, rectangular components of a vector and projection of the rotating vector.
- The learner plays the simulation from the link https://bit.ly/3lerwJi and observes the direction and the magnitude of the resultant vectors, rectangular components of a vector and projection of the rotating vector.
- The learner explains the magnitude and the direction of the resultant vector, rectangular components of a vector and projection of the rotating vector based on the information gathered from the simulation.
- The learner deduces the general rules for vector addition and subtraction.

**Questions:**

1. Why is it important to identify the quantity is scalar or vector?

2. What is the difference between scalar quantities and vector quantities?
3. What does the resultant vector represent?
4. Will the order of drawing the vectors affect the resultant Why or why not?
5. How is resultant different from Equilibrant?
6. Dawa walks 8m north, 4m west, 6m south, 14m east, and then stops to catch his breath. What is the magnitude of his displacement from his original point?
7. Find the x and y components of a 25 m displacement at an angle of 60º?

**Assessment:**

The teacher may use DARTs (directed activities related to text)/observation form/marking scheme/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's comprehension of resultant vectors, rectangular components of a vector and projection of the rotating vector from the explanation using a marking scheme.

**Working scientifically:** Assess the ability of the learner to perform algebraic operation of vectors through the completed DARTs (directed activities related to text) submitted by the learner.

**Scientific values and attitudes:** Assess the learner's logical reasoning and curiosity while carrying out the activity using an observation form.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- National School Science Curriculum Framework 2021 (SCF, 2021)
- Formative Assessment for classes PP - VI, 2020
- https://bit.ly/3lerwJi
- https://bit.ly/3bNkokg

### 1.2.2 Parallelogram Law of Vector addition

*(Scope: derivation, solve numerical problems to find the resultant vectors)*

**Objective(s)**:

v. Derive and verify the parallelogram law of vector addition.

**Learning Experiences:**

The teacher may deliver the lesson on parallelogram law of vector addition in the following order of guided inquiry. The teacher may provide the video link https://www.youtube.com/watch?v=4l-oLyNI-i0 or any other relevant resources (Practical manual class XI and XII, books, articles, downloaded digital content, internet links, etc.,) to guide the derivation of parallelogram law of vector addition and simulation http://www.olabs.edu.in/?sub=1&brch=5&sim=20&cnt=4 to verify the parallelogram law of vector addition.

- The learner explores the relevant resources (practical manual class XI and XII, books, articles, downloaded digital content, internet links, etc.,) and explains the parallelogram law of vector addition.
- Derives the parallelogram law of vector addition using video link https://www.youtube.com/watch?v=4l-oLyNI-i0 or any other relevant resources (practical manual class XI and XII, books, articles, downloaded digital content, internet links, etc.,) guided by a teacher.
- Verifies the parallelogram law of vector addition following the procedures given in practical manual Class XI and XII and using simulation link http://www.olabs.edu.in/?sub=1&brch=5&sim=20&cnt=4
- Solves numerical problems using parallelogram law of vector addition

**Questions:**

1. What is the parallelogram law of vector addition? Give an example.
2. How do you verify the parallelogram law of vector addition?
3. How do you use the parallelogram rule?
4. Can we find subtraction of two vectors using parallelogram law?
5. How do you find the magnitude and direction of a resultant vector using the parallelogram law?

**Assessment:**

The teacher may use a rating scale/observation form/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's ability to state parallelogram law of vector addition from explanation using a checklist.

**Working scientifically:** Assess the learner's skill to draw vector diagrams, verify parallelogram law of vector addition and solve numerical problems using a rating scale.

**Scientific values and attitudes:** Assess the learner's curiosity and perseverance while exploring the simulation to verify the parallelogram law of vector addition using an observation form.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Science Curriculum Framework 2022 (SCF, 2021)
- Practical Manual Class XI and XII
- https://www.youtube.com/watch?v=4l-oLyNI-i0
- http://www.olabs.edu.in/?sub=1&brch=5&sim=20&cnt=4

### 1.2.3 Projectile Motion

*(Scope: derivation, terms related to projectile motion, application in daily life)*

**Objective(s)**:

vi. Examine the projectile motion using mobile apps or interactive simulations and relate its applications in everyday experiences.

**Learning Experiences:**

The teacher may carry out the instructional practices on examining the projectile motion based on the following order of CER (Claim, Evidence and Reasoning) model. The teacher may provide the simulation link https://bit.ly/3czZKD6 of projectile motion and video link https://bit.ly/3vofIZA or PowerPoint Presentation on the terminologies used to describe the projectile motion. The teacher may demonstrate how objects are catapulted using a working model (catapult) and ask the learners to make a prediction and profess maximum horizontal distance coverage of projectile motion.

- The learner explores the projectile motions (components or the terminologies) from the link https://bit.ly/3vofIZA or PowerPoint Presentation and derives the required mathematical expressions with help of the teacher.

- Makes a claim on maximum horizontal range and time of flight of projectile motion.
- Explores the simulation link https://bit.ly/3czZKD6 justifies their claim with the evidence based on projectile path, initial velocity, maximum height, time of flight, acceleration due to gravity, and projected angle.
- Relates and explains its application in real life situations.

**Questions:**

1. How does projectile motion relate to everyday life?
2. How do we solve projectile motion questions?
3. What are the factors that affect projectile motion?
4. What are the two independent components of projectile motion?
5. What force do we ignore when doing calculations involving projectiles?
6. A parcel is dropped from a horizontally flying plane when it is vertically above the target. Will it drop on the target?
7. Why do competitive swimmers jump slightly upward before diving into a race?

**Assessment:**

The teacher may use checklist/apps/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Design a quiz (Hot potatoes, ClassMarker, FlexiQuiz, etc.,) to assess the learner's conceptual understanding on variables affecting the projectile motion.

**Working scientifically:** Assess the ability to identify and explain the variables that determine the maximum projection results while operating the simulation using a checklist.

**Scientific values and attitudes:** Assess a learner's ability to relate the projectile motion with real life experiences using a checklist.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- Formative Assessment for classes PP - VI, 2020

- https://bit.ly/3czZKD6
- https://bit.ly/3vofIZA

## 1.3 Laws of Motion

### 1.3.1 Law of Inertia.

*(Scope: Newton's first, second (F = ma), and third law of motion and its applications in daily life, calculate the impulse due to a force, and impulse-momentum theorem).*

**Objective(s)**:

vii. Design an experiment to verify Newton's laws of motion and demonstrate the applications of Newton's laws and impulse in real life situations.

**Learning Experiences:**

The teacher may deliver the lesson on Newton's laws of motion based on the following order of design thinking (Empathise, Define, Ideate, Prototype, Test). The teacher may deliver the lesson on the law of inertia using daily life applications to brainstorm the concept of Newton's laws of motion. The teacher may divide the class into three groups and assign a law to each group for discussion. The teacher may guide the learners to design, conduct and verify the experiments based on Newton's laws of motion in their respective groups. The teacher may provide relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.,) on inertia and Newton's Laws of motions.

- The learner relates the concept of inertia to daily life experiences by exploring the resources (books, internet links, handouts, downloaded digital content, articles, etc.,) on inertia and Newton's Laws of motions provided by the teacher.
- Involves in the discussion within the group to gain insight and synthesise the information gathered to identify the features and functions of the experimental design to demonstrate Newton's law of motion.
- Discusses alternatives and establishes the best solution to design an experiment to demonstrate Newton's law of motion.
- Constructs the prototype of the experimental design to carry out the experiment.
- Tests the prototype to demonstrate Newton's law of motion.
- Refines the prototype based on the feedback and conducts the experiment to verify Newton's law of motion and in the group and records the findings.

- Relates impulse-momentum theorem with Newton's second Law of motion based on the information gathered from designing a prototype and deduce the mathematical expression of impulse.
- Explains impulse-momentum theorem and calculates the impulse.
- Relate Newton's laws and impulse in real life situations based on the concept learned from the prototyping and calculation.

**Questions:**

1. How do Newton's laws of motion affect your daily life?
2. Do heavier objects fall faster?
3. How does increasing mass affect the force of an object in motion?
4. How does momentum affect impulse?
5. How will you use the principle of impulse and momentum in your daily life?
6. Using Newton's laws explain why heavier objects require more force than lighter objects to move or accelerate them?
7. How can Newton's laws be used to explain how rockets are launched into space?
8. How do Newton's law affect Tug og war?

**Assessment:**

The teacher may use DARTs (directed activities related to texts)/rubrics/observation form/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of Newton's law of motion using completed DARTs (directed activities related to texts) submitted by the learner.

**Working scientifically:** Assess the learner's ability to prototype the identified design to demonstrate Newton's law of motion using a rubric. The teacher may also assess the learner's ability to use the mathematical expression to calculate impulse using a checklist.

**Scientific values and attitudes:** Assess the learner's innovation, creativity and curiosity to design a prototype to verify Newton's law of motion using observation form. The teacher may also assess the learner's ability to relate Newton's laws and impulse in real life situations based on the concept learned from the prototyping and calculation using a checklist.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- Formative Assessment for classes PP - VI, 2020

### 1.3.2. Conservation of Momentum.

*(Scope: elastic and inelastic collision).*

**Objectives(s):**

viii. Conduct an experiment to verify the law of conservation of momentum using simulation or physical tools.

**Learning Experiences:**

The teacher may deliver the lesson on conservation of momentum using an interactive simulation from the link https://ophysics.com/e2.html based on the following order of instructions. The teacher may design an experiment using simulation to measure the speed of two inelastic boxes of an identical mass.

- The learner explores the simulation link https://ophysics.com/e2.html and launches the first box to collide with the stationary box.
- Rrecords the speed of the first cart before the collision and the combined speed of the box after the collision.
- Repeats the experiment a number of times.
- Calculates initial momentum as (mass of first cart x velocity of first cart) and the final momentum as (mass of first cart + mass of second cart) x combined velocity of both the carts. (The learner may use the link https://bit.ly/3tkHYKO to cross check the answer)
- Explains the concept of conservation of momentum from the data analysed.

**Questions:**

1. What conditions must be satisfied for momentum to be conserved?
2. When can conservation of momentum be used?
3. Under what conditions is momentum not conserved?

4. How is conservation of momentum calculated?
5. How is the conservation of momentum used in real life?

**Extended Learning Activity:**

The teacher may extend the experiment to investigate the conservation of momentum for:

a. both carts are moving before collision
b. carts having different masses (one in motion and one in rest)
c. carts having different masses (both in motion)
d. elastic and inelastic collisions.

**Assessment:**

The teacher may use rubric/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of the law of conservation of momentum from explanation using a checklist.

**Working scientifically:** Aassess the learner's ability to verify the law of conservation of momentum through simulation using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to relate the concept of conservation of momentum in rocket technology and everyday life using a checklist.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- Formative Assessment for classes PP - VI, 2020
- https://ophysics.com/e2.html
- https://bit.ly/3tkHYKO

### 1.3.3. Circular Motion.

*(Scope: uniform circular motion, centripetal force, centripetal acceleration, average speed, period and frequency of rotation).*

**Objective(s)**:

ix. Conduct an investigation to exhibit that force varies with mass, velocity and radius to equate centripetal force and weight.

**Learning Experiences:**

The teacher may introduce the lesson on angular displacement, period and frequency of rotation, angular velocity and centripetal acceleration to familiarise the learner with the terminologies and foundational concepts. The teacher may design the activity and instruct the learner to carry out the investigation to exhibit the relation between variables (mass, velocity and radius) and centripetal force (weight) in the following order of POGIL Pprocess-Oriented Guided Inquiry Learning) approach. The teacher may upload the video links https://bit.ly/3bM456W, https://bit.ly/3eCCUNM, and https://bit.ly/3lnSY7x or relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.,) to explore the relationship amongst the variables (mass, velocity and radius) and centripetal force (weight).

- The learner explains the basic concepts, terminologies, and mathematical relations to describe the circular motion by studying the video links https://bit.ly/3bM456W, https://bit.ly/3eCCUNM, and https://bit.ly/3lnSY7x or relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.)
- Uses improvised centripetal force apparatus to determine the linear velocity of the bob moving in circular motion by including mass and radius as variables.
- Repeats the experiment by varying the value of mass and keeping the radius constant and vice versa.
- Uses the gathered information (mass, linear velocity and radius) to calculate the centripetal force using relevant mathematical relations.
- Interprets the effect of variables (mass, radius and angular velocity) on the linear velocity and centripetal force of the circular motion.
- Explores the significance of circular motion in daily life.

**Questions:**

1. What makes an object move in circular motion?
2. How is centripetal force related to circular motion?
3. Can centripetal acceleration change the speed of circular motion?
4. What force causes Earth's centripetal motion?

5. Find the force acting on a stone of mass 10 Kg moving in a circle of radius 5 m at a speed of 8 m/s.

**Assessment:**

The teacher may use rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's understanding of dependent, independent and control variables while investigating using a checklist.

**Working scientifically:** Assess the learner's ability to interpret the effect of variables on the linear velocity of circular motion and centripetal force using a rubric. The teacher may also assess the learner's ability to follow instructions and carry out the experiment to calculate the centripetal force (weight) using a rubric.

**Scientific values and attitudes:** Assess the learner's ingenuity to improvise the centripetal force apparatus to determine the linear velocity of the bob moving in circular motion and appreciation towards the significance of circular motion in our daily life using a checklist.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://bit.ly/3bM456W
- https://bit.ly/3eCCUNM
- https://bit.ly/3lnSY7x

## 1.4. Mechanical Properties of Solids

### 1.4.1. Elastic Behaviour of Solids.

**1.4.2.** *(Scope: elastic behaviour of solids, types of stress and strain, stress and strain curve,calculate stress and strain, Hooke's law, work done by a spring force, Young's modulus and applications of elastic behaviour of materials).*

**Objective(s)**:

x. Carry out an experiment to verify Hooke's law and explore the applications of materials in the engineering field based on their mechanical properties.

**Learning Experiences:**

The teacher may deliver the lesson in the following order of activity to verify Hooke's law and explore the applications of elastic materials in the engineering field. The teacher may provide the relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.,) to familiarise the elastic behaviour of solids, types of stress and strain, stress and strain curve, Hooke's law, and work done by the spring force. The teacher may provide the interactive simulation links https://bit.ly/3rN4xaP, https://rb.gy/4j9kqa and video links https://youtu.be/nQXodRH7F4c, https://youtu.be/5f1n6VAtZmo, and https://youtu.be/tCBlt5e2jwg or relevant materials (handouts, books, internet links, articles, downloaded digital content, etc.,) on Hooke's law.

- The learner explains the elastic behaviour of solids, types of stress and strain, stress and strain curve, Hooke's law, and work done by the spring force based on presentation by the teacher or from the links https://youtu.be/nQXodRH7F4c, and https://youtu.be/tCBlt5e2jwg
- Verifies Hooke's law using the simulation link https://bit.ly/3rN4xaP and explains the variables that affect the work done (Potential Energy).
- Explores the concept of Young's modulus of the materials from the link https://youtu.be/5f1n6VAtZmo and solves the numerical problem provided by the teacher.
- Compares the value of Young's modulus of the wires (Aluminium, Copper, Steel, and Brass) from the simulation link https://rb.gy/4j9kqa and identifies appropriate materials for the particular purposes.

**Questions:**

1. What are the applications of elastic behaviour of solids?

2. What is the elastic behaviour of solids?
3. What is stress and strain?
4. On what factors does the elastic limit of a material depend?
5. What does Young's modulus tell you about a material?
6. Why is steel more elastic than rubber?
7. Mention a situation where the restoring force is not equal and opposite to the applied force.
8. Why does spring balance show wrong readings after they have been used for a long time?

**Assessment:**

The teacher may use rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's ability to classify the materials based on elasticity properties using a checklist.

**Working scientifically:** Assess the learner's ability to follow the instructions and carry out the experiment to verify Hooke's law using a rubric. The teacher may also assess the learner's ability to solve numerical problems using a rubric.

**Scientific values and attitudes:** Assess the learner's appreciation of the significance of mechanical properties of solids in the engineering field using a checklist.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://bit.ly/3rN4xaP
- https://youtu.be/5f1n6VAtZmo.
- https://rb.gy/4j9kqa
- https://youtu.be/nQXodRH7F4c
- https://youtu.be/tCBlt5e2jwg

### 1.4.2 Density of Objects

*(Scope: compare the densities of different materials, least count, zero error)*

**Objective(s):**

xi. Compare the density of a glass slab and a wire using vernier callipers and screw gauge.

**Learning Experiences:**

The teacher may design the experiment to compare the density of a glass slab and a wire using vernier callipers and screw gauge in the following order of activity. The teacher may introduce the apparatus (screw gauge and vernier calliper) and demonstrate the operation of instruments and the calculation of zero error and least count. The teacher may use practical manual XI and XII to explain the steps to calculate. The teacher may provide a video links https://rb.gy/rmygl4 and https://rb.gy/ppfnuy or any other relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.,) to explore on measurement of objects using vernier calliper and screw gauge.

- The learner explains different parts of the instruments (screw gauge and vernier calliper) and the measurement procedures by exploring the links https://rb.gy/rmygl4 and https://rb.gy/ppfnuy and other relevant materials (practical manual XI and XII, books, internet links, handouts, downloaded digital content, articles, etc.)
- Calculates least count and zero error based on the concept taught by the teacher.
- Measures the density of objects (glass and wire) following the steps given in practical manual Class XI and XII.
- Compares the density of glass slab and wire using the data obtained from the experiment.

**Questions:**

1. How do we investigate the density of objects?
2. How do you find the least count of an instrument?
3. What does the density of an object depend on?
4. What is the screw gauge and vernier calliper used for?

**Assessment:**

The teacher may use rating scale/observation form/rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's ability to explain different parts of the instruments (screw gauge and vernier calliper) and the measurement procedures using a checklist.

**Working scientifically:** Assess the learner's skill to handle the instruments (screw gauge and vernier calliper), identify zero error and calculate least count using observation form while performing the experiment. The teacher may also assess the learner's ability to follow instructions and carry out the experiment to measure density using a rubric.

**Scientific values and attitudes:** Assess the learner's accuracy in measurement of density from the practical record submitted by the learner using a rating scale.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Science Curriculum Framework 2022 (SCF, 2022)
- Practical Manual Class XI and XII
- https://rb.gy/rmygl4
- https://rb.gy/ppfnuy

## 1.5 Work and Energy

### 1.5.1. Work. *(Scope:*

*commutative properties of scalar products, graphical explanation of work done, calculate work done using scalar product of vectors, work done by gravitational force).*

**Objective(s):**

xii. Carry out an activity to interpret the force- displacement graph and relate work done in terms of scalar product of vectors to verify work done by gravitational force using simulation.

**Learning Experiences:**

The teacher may deliver the lesson on interpretation of force-displacement graph and work done in terms of the scalar product of vectors based on the order of OMG (Observe, Measure and Grade) approach. The teacher may carry out the demonstrations of work done and help the learner derive the work done equation and interpret the force-displacement graph. The teacher may provide the video link https://cutt.ly/XIilXcP and simulation link https://cutt.ly/sIizwRW or any other relevant

materials (books, internet links, handouts, downloaded digital content, articles, etc.,) to verify the mathematical expression of work done by the gravitational force. The teacher may provide hypothetical data to calculate and interpret the work done.

- The learner writes and displays their understanding of work done on the classroom wall using sticky notes or any other materials based on their previous knowledge.
- Explores the definition of work done by going through the definitions written on the sticky notes or any other materials pasted on the wall (Gallery walk) and consolidates the definition of work done.
- Derives the equation of work done by analysing the demonstrations shown by the teacher.
- Based on the derivation, the learner plots the force-displacement graph using hypothetical data provided by the teacher to calculate and interpret the work done.
- The learner explains the work done by the gravitational force from the link https://cutt.ly/XIilXcP or other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.)
- Verifies the work done by the gravitational force based on the information gathered from the simulation link https://cutt.ly/sIizwRW
- Deduces the mathematical relation of the work done based on the information gathered and solves the numeral problems.

**Questions:**

1. What is the relationship of work to energy?
2. What is a scalar product?
3. Is work done by gravitational force positive or negative?
4. How do you find the work done on a graph?

**Assessment:**

The teacher may use rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's comprehension of the force-displacement graph to relate with work done in terms of the scalar product of vectors during explanation using a checklist.

**Working scientifically:** Assess the learner's ability to plot a graph using the hypothetical data provided by the teacher and calculate work done using a rubric.

**Scientific values and attitudes:** Assess the learner's curiosity and honesty in exploring information to verify the mathematical expression of work done by the gravitational force from simulation using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository.
- Fundamentals of Physics Class XI by Wiley (Reprint 2019).
- Science Curriculum Framework 2022 (SCF, 2022)
- https://cutt.ly/sIizwRW
- https://cutt.ly/XIilXcP

### 1.5.2. Conservation of Mechanical Energy.

*(Scope:kinetic energy (K.E), calculation of K.E for moving bodies using final expression, concept of potential energy (P.E), calculation of P.E near the Earth's surface, law of conservation of mechanical energy using equations of potential energy and kinetic energy, and its calculation from work done).*

**Objective(s):**

xiii. Investigate the transformation of energy experimentally to describe the conservation of mechanical energy.

**Learning Experiences:**

The teacher may deliver the lesson in the following order of activity. The teacher may upload the interactive simulation link https://javalab.org/en/mechanical_energy_en/ or any relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) on conservation of energy.

- The learner explains the kinetic energy, potential energy, and their calculations using the relevant mathematical expression based on information gathered from relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.) .
- Verifies the law of conservation of energy using the values of variables from the link https://javalab.org/en/mechanical_energy_en/ based on the information gathered.

- Calculates K.E for moving bodies using final expression and potential energy near the Earth's surface based on the concept of law of conservation of mechanical energy.
- Deduces the law of conservation of mechanical energy and relates the concept in daily life.

**Questions:**

1. How is mechanical energy conserved?
2. What is the formula for conservation of mechanical energy?
3. What is the difference between conservation of energy and conservation of mechanical energy?
4. What daily activities show conservation of mechanical energy?
5. State the principle of conservation of mechanical energy and illustrate in the case of a freely falling body.

**Assessment:**

The teacher may use rubrics/checklist/observation form/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding on conservation of mechanical energy, kinetic energy, and potential energy during explanation using a checklist.

**Working scientifically:** Assess the learner's ability to calculate K.E for moving bodies using final expression and potential energy near the Earth's surface using a rubric.

**Scientific values and attitudes:** Assess the learner's curiosity and ability to play simulation with different variables using an observation form.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://javalab.org/en/mechanical_energy_en/
- https://www.youtube.com/watch?v=DyaVgHGssos
- https://www.youtube.com/watch?v=BcZfRSlaw7s

**Revision questions:**

1. Can a body be at rest and motion at the same time justify with an example?

2. The position (in metres) of an object moving in a straight line is given by $s(t)=6t^2 + 2t + 10$, where t is measured in seconds. What is the equation of the instantaneous velocity v(t) of the particle at time t?
3. The position of a particle is given by $x(t)=4.0t+0.8t^3$m.
    a. find the instantaneous velocity at t=3.0 s.
    b. Calculate the average velocity between 1.0 s and 5.0 s.
4. An aeroplane accelerates down a runway at 5.0 $m/s^2$ for 45.2 s until it finally lifts off the ground. Determine the distance travelled before takeoff.
5. Pema is driving through town at 30.0 m/s and begins to accelerate at a constant rate of -2.0 $m/s^2$. Eventually Pema comes to a complete stop.
    a. Represent Pema's accelerated motion by sketching a velocity-time graph. Use the velocity-time graph to determine this distance.
    b. Use kinematic equations to calculate the distance that Pema travels while decelerating.
6. A dog runs 10m to chase a ball and then runs back 10m to the person who threw it. If this happens five times to completion, what is the dog's distance travelled?
7. Two vectors having equal magnitude A and make an angle θ with each other. Then find the magnitude and direction of the resultant.
8. A vector A is directed 30º west of north direction and another vector B along 15º south of east. Their resultant cannot be in which direction? Justify your answer. options

    1) North, 2) North East, 3) East, 4) South

9. State parallelogram law of vectors . Derive an expression for the magnitude and direction of the resultant vector.
10. Two forces of 3 N and 4 N are acting at a point such that the angle between them is 60 degrees. Find the resultant force?
11. A car goes 10 km east, 6 km south, 3 km west and 2 km north. Find the resultant displacement.
12. Why does a horizontally-fired bullet hit the ground at the same time as a bullet dropped from the same height?

13. A body is projected with a speed of 40ms $^{-1}$ at an angle of 50º with the vertical. Find the maximum height, time of flight and the horizontal range of the motion. [Take = 10 m/s²]
14. Why should we wear seatbelts? Justify your answer with Newton's Laws of motion.
15. A 30 kg mass is sitting on a frictionless surface. An unknown constant force pushes the mass for 3 seconds until the mass reaches a velocity of 5 m/s.

    a) What is the initial momentum of the mass?

    b) What is the final momentum of the mass?

    c) What was the force acting on the mass?

    d) What was the impulse acting on the mass?

16. In the effort to extinguish fire, a fireman must hold a hose that ejects large amounts of water at a high velocity with great caution. Why would such a task be difficult?
17. A large truck and a car had a head-on collision. Which vehicle experiences the greatest momentum change?
18. A 30 Kg boy jumps (from rest) into a moving trolley of mass 60 Kg and is already moving at a velocity of 6 m/s to the left. What is the speed of the trolley after the boy has jumped in?
19. A bird flies in a circle of 15 m radius and completes 5 revolutions per minute. Find the angular velocity, linear velocity, and acceleration.
20. Give three examples of situations in which centripetal forces arise, detailing precisely which forces contribute to the centripetal force.
21. A wire is suspended from a roof but no weight is attached to the wire. Is the wire under stress?
22. The length of a wire is cut in half. What will be the effect on the increase in its length under a given load?
23. What is the difference between the technique used in determining the density of glass slab and a wire?
24. Find work done by the gravitational force of earth on moving a 20 kg mass from one place to another which is 10 m away on a horizontal road?

25. How do we interpret the work done by a force in one dimension as an area under a force vs position curve?
26. Calculate the work done by the force of gravity when a satellite moves in an orbit of radius 50000 km around the earth?
27. A 5 kg rock falls from a 50 m cliff. What is the kinetic and potential energy when the rock has fallen 25 m?
28. An object starts sliding from a height 20m slide without the initial velocity. If there is no friction force, what is the velocity of the object at the base of the slide?

# 2. Fluid Mechanics and Thermal Physics

Thermal physics ultimately leads to the study of thermodynamics, which is the study of changing thermal systems by using kinetic theory and statistical mechanics. It is critical to understand the mechanism of heat flow and laws governing thermodynamic processes because heat is very important in our daily life for various purposes like, warming the house, cooking, heating the water and drying the washed clothes. The heat also has many usages in the industries such as making and processing the food and manufacturing of the glass, the paper, the textile, etc.

**Competencies:**

- Explain the concept of internal energy and its relation with heat and work using simulations or physical tools to comprehend the concept of conservation of energy.
- Describe the internal energy to comprehend thermodynamic processes and technological implications in daily life.

## 2.1.1 Heat, Internal Energy, and Work.

*(Scope: internal energy and its relation with heat and work, first law of thermodynamics (pressure-volume (PV) diagram), thermodynamic processes, equation and its calculations, internal energy at absolute zero temperature)*

**Objective(s)**:

i. Conduct an experiment to explain work done on the system and work done by the system to comprehend the thermodynamic processes.

ii. Interpret the relation between internal energy and temperature to understand the motion of the gas molecules and plot PV diagram using interactive simulation.

**Learning Experiences:**

The teacher may deliver the lesson on heat, internal energy and work done in the following order of REI (Research, Evidence, and Inference). The teacher may design an experiment to demonstrate work done on the system and by the system (e.g. bottle with the balloon tied). The teacher may provide the simulation link https://bit.ly/3bRk0kM on gas properties and numerical problems related to internal energy and temperature.

- The learner explains the concept of heat, internal energy, and work based on information gathered from any relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.)
- Designs and conducts an experiment to explain work done on the system and by the system using relevant available materials.
- Explains the first law of thermodynamics (PV diagram) based on information gathered from the link https://bit.ly/3bRk0kM or other relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.)
- Constructs an explanation on how internal energy and temperature is related based on the evidence gathered.
- Computes numerical problems related to internal energy and temperature provided by the teacher by using the relevant formula.
- Prepares a presentation to create awareness on the conservation of the environment and improvement of economic value through infrastructure built based on green technology (thermal insulation).
- Evaluates the need of thermal reservoirs for the people living in the cold places.

**Questions:**

1. How do you read a PV diagram?
2. What is the significance of the area of a closed curve on a PV diagram?
3. What is the significance of the first law of thermodynamics?
4. What happens when internal energy increases?

**Assessment:**

The teacher may use rubrics/observation form/marking scheme/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of work done on the system, work done by the system, concept of internal energy, and temperature from explanation using a rubric.

**Working scientifically:** Assess the learner's problem solving skills while solving numerical problems related to internal energy and temperature provided by the teacher using a marking scheme.

**Scientific values and attitudes:** Assess the learner's curiosity, innovation, and creativity while devising an experiment to demonstrate work done on the system and work done by the system using an observation form. The teacher may also assess the learner's appreciation towards the conservation of the environment, and improvement of economic value through infrastructure built based on green technology (thermal insulation) through work submitted by the learner using a rubric.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://bit.ly/3bRk0kM

**Revision questions:**

1. Interprete PV diagram with an illustration?
2. 5000 J of heat is added to a system and 4000 J of work is done by the system. What is the change in internal energy of the system?
3. What happens to the internal energy of the object if the temperature increases?

# 3. Electricity and Magnetism

Electricity and magnetism are two very important topics in physics. Changing magnetic field creates a changing electric field (and vice versa). Therefore, magnetism is very important because we use it to create electrical energy. In fact, most of the energy that we use today comes from rotating magnets. Electricity use has intensely changed our life. We use electricity to do many jobs every day—from lighting, heating, and cooling homes to powering televisions and computers. Electricity and magnetism are manifestations of a single underlying electromagnetic force.

**Competencies:**

- Conduct an experiment to demonstrate Lorentz force and determine the direction of current, magnetic field and force using appropriate rules to apply the concept in construction of electric motors.
- Explain magnetic flux and its density to determine the field strength and its applications.
- Illustrate the pattern of motion of a charged particle in a uniform magnetic field using 3D interactive simulation to comprehend its application in electronics.
- Identify the colour bands of the resistor to specify the actual value of resistance used in the electrical circuits.
- Explain electrical power and electrical energy consumption to calculate the electric bill.
- Investigate the effectiveness of parallel and series connections of resistors to make a professional judgement for household circuiting based on evidence.

## 3.1 Magnetic Fields

### 3.1.1 Magnetic Force and Field.

*(Scope: Lorentz force, magnetic force on a current carrying conductor in a magnetic field, magnetic field pattern due to a long straight current carrying conductor).*

**Objective(s)**:

i. Design an experiment to demonstrate Lorentz force and determine direction of force, current and magnetic field using right hand rule.

**Learning Experiences:**

The teacher may deliver the lesson on Lorentz force based on the following order of design thinking. The teacher may divide the class into groups and guide the learners to design, conduct and verify the experiment in their respective groups. The teacher may provide the interactive simulation link

https://bit.ly/3rS9vmG or video links https://cutt.ly/fIpYfoy https://youtu.be/Ri557hvwhcM, https://cutt.ly/WIpYv1s or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to supplement the concept.

- The learner is involved in the discussion and consultation within the group to gain insight and sympathetic perception on how to demonstrate Lorentz force and determine direction of force, current, and magnetic field by studying the video links https://cutt.ly/fIpYfoy https://youtu.be/Ri557hvwhcM, https://cutt.ly/WIpYv1s or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) provided by the teacher.
- Analyses and synthesises the information gathered to identify the features and functions of the experimental design.
- Discusses alternatives and establishes the best experimental design to demonstrate Lorentz force.
- Constructs the prototype of the design to carry out the experiment.
- Tests the prototype to verify Lorentz force and refines based on the feedback provided.
- Conducts the experiment using the prototype to verify Lorentz force and determines direction of force, current and magnetic field using right hand rule.
- Analyses the direction of the magnetic field from the link https://bit.ly/3rS9vmG.
- Analyses the direction of the force experienced by a conductor when the direction of current is reversed.
- Prepares the presentation in their respective groups and presents it to the class.

**Questions:**

1. How should a current-carrying conductor be placed in a magnetic field, so that the force acting upon the conductor is maximum ?
2. Draw magnetic lines of force around a straight, long current carrying conductor.
3. Derive an expression for the force experienced by a current-carrying straight conductor placed in a uniform magnetic field.
4. Does a magnetic field exert a force on a static charge? Explain.

**Assessment:**

The teacher may use observation form/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of the learner on Lorentz force and direction of force and magnetic field when direction of current is changed using a checklist.

**Working scientifically:** Assess the learner's ability to design the experiment using the prototype to verify Lorentz force using a rubric.

**Scientific values and attitudes:** Assess the learner's curiosity, innovation, communication, creativity while developing a prototype using an observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://cutt.ly/fIpYfoy
- ttps://youtu.be/Ri557hvwhcM
- https://cutt.ly/WIpYv1s
- https://bit.ly/3rS9vmG

### 3.1.2 Magnetic Flux.

(Scope: *magnetic flux, flux density and numerical problems*).

### 3.1.3 Motion of a Charged Particle in a Uniform Magnetic Field.

*(Scope: motion of a charged particle in a uniform magnetic field).*

**Objective(s)** ii. Explain the magnetic flux and its density to determine the magnetic field strength.

iii. Illustrate the motion of a charged particle placed in a uniform magnetic field using 3D interactive simulation.

**Learning experience:**

The teacher may deliver the lesson on magnetic flux in the following order of scientific inquiry. The teacher may provide a 3D interactive simulation link https://ophysics.com/em8.html, video links https://youtu.be/Y2XvIofbwpc, and https://youtu.be/84ZTzeCfswg or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) on the

concept of helical motion of charged particles in a uniform magnetic field. The teacher may design and provide a worksheet to verify the effect on the radius of the circular path by the variables.

- The learner explains magnetic flux through the surface of different orientations based on the information gathered from the video link https://youtu.be/Y2XvIofbwpc or any other relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.,) on the concept of magnetic flux.
- Deduces the mathematical expression for magnetic flux and flux density and use it for the calculation.
- Deduces the concept of helical motion of charged particles in a uniform magnetic field from the video link https://youtu.be/84ZTzeCfswg or any other relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.,) provided by the teacher.
- Verifies the effect on the radius of the circular path and velocity of the charge particle by the variables using the worksheet and the 3D interactive simulation link https://ophysics.com/em8.html provided by the teacher.
- Relates the significance of magnetic flux to the real life applications.

**Questions:**

1. A charged particle moving in a straight line perpendicular to a uniform magnetic field enters the field. What will be its path in the field and why? Will there be any change in its speed?
2. How does the radius of a circular path of a charged particle moving in a uniform magnetic field depend on its momentum and charge?
3. Under what condition is the magnetic flux through a surface in uniform magnetic field maximum?

**Assessment:**

The teacher may use rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's understanding on magnetic flux and motion of a charged particle in a uniform magnetic field using a checklist.

**Working scientifically:** Assess the learner's ability to explore the 3D interactive simulation and deduce the concept of helical motion of charged particles in a uniform magnetic field using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to relate the significance of magnetic flux to the real life applications using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://ophysics.com/em8.html
- https://youtu.be/Y2XvIofbwpc
- https://youtu.be/84ZTzeCfswg

### 3.2 Electric Circuits

#### 3.2.1. Resistivity of Various Materials.

(Scope: resistor colour codes)

#### 3.2.2. Electrical Energy and Power.

*(Scope: calculate electrical energy, power in electric circuits, and electric bill based on the consumption of the electrical energy*).

**Objective(s)**:

iv. Obtain the resistance value of carbon resistor using colour coding and verify the value of resistance using multimeter and mobile application

v. Explain electrical power and electrical energy consumption to calculate the electric bill.

**Learning experience:**

The teacher may deliver the lesson on electric circuits, colour coding of carbon resistor, electrical power consumption based on the following order of OMG (Observe, Measure and Grade). The teacher may provide a multimeter, resistors of different values, colour bands, and an application

link https://rb.gy/6uqei3 or any other relevant resources (books, articles, downloaded digital content, internet links, etc.,) to verify the value of resistance. The teacher may explain and demonstrate the calculation of electrical energy consumption.

- The learner observes the colour codes of resistors and relates the resistance of the resistor with the colour bands provided by the teacher.
- Specifies the resistance value and verifies the values using a multimeter or application link https://rb.gy/6uqei3
- Calculates the monthly bill of electrical energy consumption and compares it with meter reading at an individual's house.
- Infers on the different patterns of energy consumption and suggests ways to reduce energy consumption.

**Questions:**

1. The maximum power rating of a 20 Ω resistor is 2.0 kilowatt. Can you safely use this resistor across a 300 V dc source of negligible internal resistance?
2. A house is fitted with 20 bulbs rated 100W each, 10 fans consuming 0.5A each and an electric kettle of 100 Ω resistance. Electricity is supplied at 220V and at a rate of Nu.0.50 per KW-hr. What will be the expenditure of electricity in the month of September, if all the appliances are used for 6 hours daily?
3. What would be the resistance of a resistor colour coded brown-red-orange?
4. Show graphically how electrical resistance of a semiconductor and conductor varies when its temperature is varied.
5. What highest voltage can you safely put across a 98 Ω-0.5watt resistor?

**Assessment:**

The teacher may use marking scheme/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding on colour bands of carbon resistance from explanation using a checklist.

**Working scientifically:** Assess the learner's ability to calculate the resistance value of a carbon resistor using colour coding while verifying the colour coding using a marking scheme.

**Scientific values and attitudes:** Assess the learner's ability to compare the theoretical energy consumption values with auto generated energy consumption bills and suggest ways to reduce energy consumption while solving numerical problems using a marking scheme .

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- National School Science Curriculum Framework 2021(NSSCF, 2021
- Physics Class Ten by kinley Gyeltshen and Sumitra Subba ( reprint 2017)
- https://rb.gy/6uqei3

### 3.2.3. Internal Resistance of a Cell.

*(Scope: internal resistance, voltage drop).*

**Objective(s)**:

vi. Investigate the voltage drop across the dry cell to determine the efficiency of a dry cell.

**Learning Experiences:**

The teacher may design the experiment to calculate the internal resistance and voltage drop across the dry cell in the following order of activity. The teacher may introduce the electrical apparatus (ammeter, galvanometer, meter bridge, resistance box, key, jockey, battery eliminator, connecting wires, etc.,), circuit connections and demonstrate the calculation of least count of electrical devices. The teacher may provide the video link https://bit.ly/3tpG7bb or any other relevant resources ( practical manual class XI and XII, books, articles, downloaded digital content, internet links, etc.,) to explain the working principle of potentiometer and calculate the internal resistance and voltage drop across the cell.

- The learner checks the zero error and calculates least count based on the concept taught by the teacher.
- Explains the working principle of potentiometer and the measurement procedures by exploring the link https://bit.ly/3tpG7bb and other relevant materials (practical manual XI and XII, books, internet links, handouts, downloaded digital content, articles, etc.)

- Carries out an experiment and records the readings following the procedures in practical manual class XI and XII.
- Calculates internal resistance and voltage drop across the dry cell from data recorded.

**Questions:**

1. Is internal resistance a drawback of the cell? Does it remain the same?
2. What is the internal resistance of a cell? On what factors does it depend?
3. Does the internal resistance of a cell affect the voltage drop of a cell?
4. If the current through the cell is 0.5A, find the voltage drop across the cell.
5. It is easier to start a car engine on a warm day than on a cold day. Why?
6. When a high power heater is connected to electric mains, the bulbs lightening in the house becomes dim, why?

**Assessment:**

The teacher may use observation form/rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's understanding of the working principle of potentiometer and the measurement procedures from explanation using a checklist.

**Working scientifically:** Assess the learner's skill to connect circuits and calculate the least count using observation form while performing the experiment. The teacher may also assess the learner's ability to follow instructions and carry out the experiment to calculate the internal resistance and voltage drop using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to relate internal resistance and voltage drop with the efficiency of battery in real life situations using a checklist.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Science Curriculum Framework 2022 (SCF, 2022)
- Practical Manual Class XI and XIId
- https://bit.ly/3tpG7bb

### 3.2.4. Series and Parallel Circuits.

(*Scope:series and parallel combination of resistors in electrical circuits, calculate the effective resistance and effective conductance of electric circuit, principle of wheatstone bridge)*

**Objective(s)**:

vii. Experiment with the equivalent resistance of resistors in series and parallel combinations to make a professional decision based on investigative evidence for residential circuitry.

**Learning experience:**

The teacher may deliver the lesson on equivalent resistance of resistors in series and parallel combinations in the following order of guided inquiry. The teacher may provide the relevant materials (ammeter, voltmeter, resistors, connecting wires, key, etc.,) to perform the experiment. The teacher may instruct the learner to explore the effective resistance by connecting the resistors in different ways. The teacher may provide the simulation links https://rb.gy/d3hzxf and https://bit.ly/3K5zWyy, video link https://youtu.be/pd3RkGs1Tsg, and resistance calculator link https://bit.ly/3GbI1zz or any other relevant resources (practical Manual Class XI and XII, books, internet links, handouts, downloaded digital content, articles, etc.) to verify the effectiveness of combinations of resistors in a circuit and explain wheatstone bridge principle.

- The learner explores the different possible ways of making an electric circuit connection from the materials provided by the teacher.
- Validates their proposed connections based on the information gathered from the simulation link https://rb.gy/d3hzxf, video link https://youtu.be/pd3RkGs1Tsg, or any other relevant resources (practical Manual Class XI and XII, books, internet links, handouts, downloaded digital content, articles, etc.,)
- Hypothesizes the effective resistance of the resistors connected in different ways.
- Designs and experiments to examine the effective resistance of resistors connected by them.
- Collects and analyses data from the experiment and deduces the mathematical relations to find the effective resistance of different types of connections.
- Validates their experiment results using the simulation link https://rb.gy/d3hzxf and resistance calculator link https://bit.ly/3GbI1zz.

- Deduces the mathematical expressions for the combination of resistors from the video link https://youtu.be/pd3RkGs1Tsg or any other relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.)
- Solves questions provided by the teacher based on the two types of connections.
- Debates on their choice of connection for household circuiting based on data analysed.
- Deduces the concept of wheatstone bridge principle from the simulation link https://bit.ly/3K5zWyy

**Questions:**

1. Draw circuit diagrams to combine three resistors of 1 Ω, 2Ω and 3Ω to obtain equivalent resistances of 6Ω and (6/11)Ω respectively.
2. Explain principle of wheatstone bridge with help of appropriate circuit diagram.
3. Show that the equivalent resistance of resistors in series is equal to the sum of resistance of individual resistors.
4. Derive the relation among the resistances of the arms of a balanced wheatstone's bridge**.**
5. Why current does no flow through the galvanometer of a balanced wheatstone's bridge?

**Assessment:**

The teacher may use rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of effective resistance of resistors connected in series and parallel from the mathematical relation drawn from the experiment using a rubric.

**Working scientifically:** Assess the learner's ability to complete the circuit connection accurately and perform the experiment to validate the effectiveness of the circuit combination using a rubric.

**Scientific values and attitudes:** Assess the learner's attentiveness, collaboration, curiosity, honesty while performing an experiment to validate the effectiveness of the circuit combination using an observation form. The teacher may assess the learner's awareness on the household circuits based on the concept of series and parallel circuits using an observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- Practical Manual Class XI and XII
- https://rb.gy/d3hzxf
- https://bit.ly/3GbI1zz
- https://youtu.be/pd3RkGs1Tsg
- https://bit.ly/3K5zWyy

**Revision Questions:**

1. Suppose you are provided with one electrically charged body and a bar magnet. Will there be any force between these two objects? Justify your answer.
2. The proton and an alpha particle move in a uniform magnetic field with the same velocity. Which particle, proton or alpha particle, experiences the greatest magnetic force? Why?
3. In a certain arrangement, a proton does not get deflected while passing through a magnetic field region. Under what condition is it possible?
4. Imagine that you are sitting in a room filled with a uniform magnetic field pointing vertically downwards. At the centre of the room, two electrons are released horizontally with the same speed but in the opposite directions. Describe their motion.
5. A uniform magnetic field acts at right angles to the direction of motion of electrons. As a result, the electron moves in a circular path of radius of 2cm. If the speed of the electron is doubled, then what will be the new radius of the circular path?
6. A magnetic field has a magnitude of 1 Tesla and is uniform over a circular surface whose radius is 0.10m. The field is inclined at an angle 35$^{o}$ with the surface. What is the magnetic flux through the surface?
7. The resistance of our body is high enough, of order of 10 kilo-Ω. Then, why do we experience a strong shock on touching a “live” wire of, say, 220V supply?

8. Dawa removed a wire from a rod heater and another from a computer. The resistance of both wires were the same at room temperature. When heated the resistance of the heater wire increased and that of the computer decreased. What conclusions can be drawn regarding the nature of the wires? Support your answer with reasons.
9. During the experiment, your physics teacher advised you not to keep jockey in touch with wire for a longer period of time while finding the balance point. What would be the reason behind this?
10. An arc lamp operated at 80V takes 10A current. How much resistance should be connected in series with the lamp to use it at 240V main?
11. When we switch on the lights one after the other, what is the effect on the resistance of the electric circuit of the house? On the current flowing in the main line?

# 4. Waves and Optics

Wave Optics deals with the study of various phenomenal behaviors of light like reflection, refraction, interference, diffraction, polarization, etc. Light often displays properties that are wave-like. The physics of wave motion underlie many important phenomena. The water wave on the sea, the vibration of a guitar string, and the quantum mechanical wave associated with an electron can all be described in a similar way. A basic understanding of the electromagnetic spectrum and its application in modern communication systems is a must for any aspiring physics student.

**Competencies**

- Investigate the properties of waves using simulation to comprehend the significance of waves in daily life.
- Explain the concept of total internal reflection and to describe its application in communication, medical technology and natural phenomena.
- Explain the electromagnetic waves (EM), its modes of propagation, basic terminologies to comprehend the modern communication systems.
- Interpret analogue and digital signals to substantiate the advantages of digital signals in modern communication.
- Describe polarization of EM waves to understand its applications in the plastic industry, movie industry and seismology.

## 4.1 Optics

### 4.1.1 Snell's Law.

*(Scope: reflection, refraction, calculation of refractive index using Snell's law).*

**Objective(s)**:

i. Carry out an experiment to demonstrate Snell's law and examine its application in designing optical instruments.

**Learning Experiences:**

The teacher may carry out an experiment to demonstrate Snell's law in the following order of guided inquiry. The teacher may ask the questions like how is an angle of incidence and refraction related to refractive index (Snell's law). The teacher may provide the materials such as glass slabs, protractor to measure the angles, drawing pins and drawing board to perform the experiment. The

teacher may also provide the link https://rb.gy/7cetej or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.)
to verify the result from the experiment.

- The learner conducts a research on hypothetical questions asked by the teacher from the relevant sources (books, internet links, handouts, downloaded digital content, articles, etc.)
- Carries out an experiment on refraction and reflection of light based on the materials provided by the teacher and records the values of angle of incidence, reflection, and refraction.
- Computes the values of ratio of sine of angle of incidence to the sine of angle of refraction using the data gathered from the experiment.
- Verifies their experimental result using the link https://rb.gy/7cetej.
- Deduces and explains Snell's law and makes scientific judgement to select the appropriate material to design a particular optical instrument for various purposes.
- Solves the numerical questions based on Snell's law.

**Questions:**

1. Why does refraction of light occur when light passes from one medium to another?
2. The refractive index of diamond relative to air is 2.42 and that of glass is 1.51. How much faster does light travel in glass than in diamond?
3. What is refraction of light? State the laws of refraction.
4. Can the refractive index of a medium relative to another medium be less than unity?

**Assessment:**

The teacher may use a rubric/observation form/marking scheme/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding to identify the angle of incidence and refraction and justify the selection of materials to design optical instruments from explanation using a rubric.

**Working scientifically:** Assess the ability to carry out an experiment on refraction and reflection of light based on the materials provided by the teacher and compute the problem based on Snell's law while experimenting using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to make scientific judgement to select appropriate material to design optical instruments based on the concept of reflection and refraction using a checklist.

Provide necessary intervention to the learner based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://rb.gy/7cetej

**4.1.2 Refractive Index.**

*(Scope:, angle of incidence, angle of deviation, angle of refraction, angle of emergence, angle of prism).*

**Objective(s):**

ii. Study how the angle of incidence and angle of minimum deviation determine the refractive index of a given prism

**Learning Experiences:**

The teacher may design an experiment on the refractive index in the following order of activity. The teacher may recapitulate the concept of snell's law and explain the concept of angle of incidence, angle of emergence and angle of deviation using a video links https://bit.ly/3tl86Zw, https://bit.ly/3I082SK or any other relevant resources (practical manual class XI and XII, books, articles, downloaded digital content, internet links, etc.,) to measure angle of incidence, angle of deviation and calculate refractive index of prism from the graph. The teacher may provide a simulation link https://bit.ly/3Gp5gGs to verify its result.

- The learner explains the concept of angle of deviation, angle of emergence and angle of incidence and calculates refractive index of prism using the video links https://bit.ly/3tl86Zw and https://bit.ly/3I082SK or any other relevant resources (practical manual class XI and XII, books, articles, downloaded digital content, internet links, etc.)
- Records the data and uses graph paper or other CA tools to show the relationship between angle of incidence and angle of deviation.

- Analyzes the graph and calculates the minimum angle of deviation from the graph.
- Verifies the refractive index of the prism using the simulation link https://bit.ly/3Gp5gGs

**Questions:**

1. What is the angle of deviation for a prism?
2. How does the angle of deviation vary with the angle of incidence while finding refractive index of the prism?
3. On what factors does the deviation produced by a thin prism depend?
4. Does a prism laterally displace a ray incident upon it?

**Assessment:**

The teacher may use anecdotal record/rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of angle of deviation, angle of emergence and angle of incidence while explaining Snell's law using a checklist.

**Working scientifically:** Assess the learner's ability to follow instructions and carry out the experiment to determine refractive index of prism using rubric. The teacher may also assess the learner's skill to plot a graph showing the relationship between angle of incidence and angle of deviation using rubric.

**Scientific values and attitudes:** Assess the learner's curiosity, interest, and accuracy in determining the refractive index of prism using rating scale or anecdotal record.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Science Curriculum Framework 2022 (SCF, 2022)
- Practical Manual Class XI and XII
- https://bit.ly/3tl86Zw
- https://bit.ly/3I082SK
- https://bit.ly/3Gp5gGs

### 4.1.3 Total Internal Reflection.

*(Scope: formation of rainbow, optical fibres, construction and working of optical fibre: acceptance angle (final expression) and its application in medical technology and communication*).

**Objective(s):**

iii. Explain the concept of total internal reflection and relate its applications in communication and natural phenomena (rainbow).

**Learning Experiences:**

The teacher may deliver the lesson in the following order of instructional practices. The teacher may provide the semi-circular glass prism or right angled glass prism, monochromatic light source and worksheet to perform an experiment on total internal reflection. The teacher may provide the link https://bit.ly/3Gp4UzC or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to explain the working of optical fibre.

- The learner designs an experiment to demonstrate total internal reflection by studying the relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) provided by the teacher.
- Completes the worksheet based on observation from the experiment and explains the concepts of total internal reflection and conditions required for the occurrence of total internal reflection.
- Explains the construction and working of optical fibre based information from the link https://bit.ly/3Gp4UzC.
- Explains the natural occurrence of the rainbow and types of rainbow based on the information gathered on refraction and total internal reflection.
- Verifies the conceptual understanding of formation of the rainbow from the links http://www.ophysics.com/l17.html and https://ophysics.com/l18.html.
- Relates the concepts of total internal reflection in the field of medicine and communication.

**Questions:**

1. What is the critical angle for a material of refractive index $\sqrt{2}$ relative to air?
2. Name the principle on which the working of optical fibres is based.
3. Can total internal reflection occur when light travels from rarer to denser medium? Justify your answer.
4. Describe one example of how ptical fibres are used for medical purposes.

5. Why is optical fibre preferred over other optical devices in telecommunications?

**Assessment:**

The teacher may use rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's concepts, laws and theories of total internal reflection, construction and working of optical fibre from the explanation using a rubric. **Working scientifically:** Assess the ability of the learner to perform the experiment and apply the concept to explain the formation of the rainbow from the explanation using a checklist.

**Scientific values and attitudes:** Assess the learner's scientific curiosity and honesty while performing the experiment using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://bit.ly/3Gp4UzC
- http://www.ophysics.com/l17.html
- https://ophysics.com/l18.html

### *4.1.4* Radius of curvature and focal length of concave mirror .

*(Scope:spherometer, least count, focal length, relation between focal length and radius of curvature)*

**Objective(s):**

iv. Determine the focal length of a concave mirror based on its radius of curvature.

**Learning Experiences:**

The teacher may design the experiment to determine focal length of the concave mirror using a spherometer in the following order of activity. The teacher may provide a video link https://bit.ly/3niYgn1 or any other relevant materials (practical manual XI and XII, books, internet

links, handouts, downloaded digital content, articles, etc.,) to introduce the spherometer and demonstrate the operation of spherometer, calculation of least count and experimental procedures to determine the focal length of concave mirror.

- The learner explains different parts of the spherometer and the measurement procedures by studying the video link https://bit.ly/3niYgn1 and other relevant materials (practical manual XI and XII, books, internet links, handouts, downloaded digital content, articles, etc.)
- Performs the experiment and records the circular scale reading and main scale reading of the spherometer using the format given in practical manual Class XI and XII.
- Calculates the focal length of the concave mirror using the data obtained from the experiment and relates focal length with its radius of curvature.

**Questions:**

1. What do you understand by the least count of the spherometer?
2. What is meant by the radius of curvature of a mirror?
3. How is the focal length of a concave mirror related to its radius of curvature?
4. What is the radius of curvature of a concave mirror, if its focal length is 15 cm?

**Assessment:**

The teacher may use marking scheme/rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge**: Assess the learner's explanation on different parts of the spherometer using a checklist.

**Working scientifically**: Assess the learner's skill in operating the spherometer and follow instructions to carry out the experiment using a rubric. The teacher may also assess the learner's skill to tabulate the data and calculate the focal length of a concave mirror using a marking scheme.

**Scientific values and attitudes**: Assess the learner's ability to relate the manufacturing process of optical instruments and the concept of relationship between radius of curvature and focal length using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Science Curriculum Framework 2022 (SCF, 2022)
- Practical Manual Class XI and XII
- https://bit.ly/3niYgn1

## 4.2 Waves

### 4.2.1. Characteristics of Transverse and Longitudinal Waves.

*(Scope: wave motion and types of waves, calculation of wavelength, frequency, velocity, displacement, amplitude, period and phase, differences between transverse and longitudinal waves along with graphical representations).*

**Objective(s):**

v. Explain the concept of waves and the characteristics of transverse and longitudinal waves using simulations and solve numerical problems related to waves.

**Learning experience:**

The teacher may deliver the lesson on waves and the characteristics of transverse and longitudinal waves based on the following order of PROE (Predict, Reason, Observe, Explain). The teacher may provide an interactive simulation links https://ophysics.com/w6.html and https://rb.gy/ozjsxu, video link https://rb.gy/xsbpz6 or any other relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.,) on transverse and longitudinal waves. The teacher may provide the numerical problems related to waves.

- The learner explains the types of waves (transverse and longitudinal) with graphical representation.
- Predicts the mathematical relationship amongst variables (wavelength, frequency, velocity, displacement, amplitude, period) and justifies with reasons.
- Observes the relationships amongst variables (wavelength, frequency, velocity, displacement, amplitude, period) from the links https://rb.gy/ozjsxu and https://ophysics.com/w6.html.

- Explains the types of waves, deduces the relationships amongst variables (wavelength, frequency, velocity, displacement, amplitude, and, period) based on the observation made from the simulation.
- Solves numerical problems related to waves using the mathematical relationships of waves.

**Questions:**

1. Explain the three main types of waves .
2. Distinguish between two types of mechanical waves.
3. How is the wavelength and frequency of a wave related?
4. What will be the wave velocity if a RADAR gives 54 waves per minute, where wavelength of the given wave is 10m?
5. Differentiate between the waves produced by the electron in motion and the wave produced by the sun.

**Assessment:**

The teacher may use rubrics/observation form/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's understanding of the concept while differentiating the types of waves through graphical representation using a rubric.

**Working scientifically:** Assess the learner's ability to record observations, perform analysis and interpret data while experimenting with simulation of waves using a rubric.

**Scientific values and attitudes:** Assess the learner's attentiveness, collaboration, curiosity, honesty while experimenting with the simulation using an observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://ophysics.com/w6.html
- https://rb.gy/ozjsxu
- https://rb.gy/xsbpz6

## 4.3 Electromagnetic Waves

### 4.3.1. Electromagnetic Waves.

*(Scope: electromagnetic waves, its applications in communication, elements of a communication system* and *basic terminologies used in communication systems*).

**Objective(s).**

vi. Design a model to explain electromagnetic waves and its application in modern communication systems.

**Learning experiences:**

The teacher may deliver the lesson on electromagnetic waves following the order of design thinking to design a model (e.g. Hertz's experiment) that demonstrates the production of electromagnetic waves. The teacher may take the learner for a field trip (telecommunication center or base-station or mobile tower) or provide any relevant electronic gadgets used for electronic communication to gain insight on modern communication systems. The teacher may design a worksheet to be completed during the field trip. The teacher may provide video links https://bit.ly/3fcckud and https://bit.ly/3GpYn7N or relevant resources (book, handout, downloaded digital content, internet links, etc.,) to explore and construct design ideas. The teacher may divide the class into groups to design a model.

- The learner observes, discusses, consults and develops a sympathetic perception on how to demonstrate electromagnetic waves based on information gathered from the links https://bit.ly/3fcckud and https://bit.ly/3GpYn7N
- Identifies the features and functions of the experimental design based on the information gathered from the observation, consultation, and discussion.
- Discusses alternatives and establishes the best experimental design to demonstrate electromagnetic waves.
- Constructs and tests the prototype to demonstrate the electromagnetic waves.
- Refines the prototype based on the feedback provided by the teacher.
- Explains the characteristics of electromagnetic waves and demonstrates the production of electromagnetic waves using the model they developed.
- visits the (telecommunication center or base-station or mobile tower) or uses any relevant electronic gadgets used for electronic communication to gain an insight into the application of electromagnetic waves in modern communication systems (optional).

- Completes the worksheet provided by the teacher based on the information gathered.

**Questions:**

1. Light waves can travel in vacuum but sound waves require a material medium to travel. Why?
2. How are the electric field vector, magnetic field vector and velocity vector oriented in an electromagnetic wave?
3. State at least four characteristics of electromagnetic waves.
4. Explain two modes of communication.
5. The number of devices called amplifier is used in telecommunication systems. Why is this amplifier installed in the communication system?

**Assessment:**

The teacher may use checklist/rubrics/observation form/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of electromagnetic waves and its application in modern communication systems while designing a prototype using a rubric.

**Working scientifically:** Assess the learner's ability to construct, test the prototype to demonstrate the electromagnetic waves and follow safety measures while developing the prototype using a checklist.

**Scientific values and attitudes:** Assess the learner's innovation, curiosity, creativity while designing a model to explain and demonstrate electromagnetic waves using a observation form.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://bit.ly/3fcckud
- https://bit.ly/3GpYn7N

### 4.3.2 Propagation of Electromagnetic Waves.

*(Scope: the propagation of electromagnetic waves and calculation of maximum line-of-sight to get digital signals).*

**Object(s).**

vii. Explain modes of propagation of electromagnetic (EM ) waves to understand the concept of maximum line-of-sight and calculate maximum line-of-sight.

**Learning experiences:**

The teacher may deliver the lesson on propagation of electromagnetic waves in the following order of PEOE (Predict, Explain, Observe, Explain). The teacher may provide the video links https://bit.ly/34JIj2Q and https://bit.ly/33qIb7E or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to explore different modes of propagation of electromagnetic waves and calculation of maximum line-of-sight.

- The learner predicts different modes of electromagnetic waves propagation and explains their prediction based on the previous knowledge.
- Observes how electromagnetic waves propagate through different medium from the links https://bit.ly/34JIj2Q and https://bit.ly/33qIb7E or any other relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.,) provided by the teacher.
- Evaluates and explains the most effective mode of propagation of EM waves (ground, sky, space waves) and calculates the maximum line-of-sight.

**Questions:**

1. Why is ground wave communication not used for high-frequency signal waves and for very long range communication?
2. A TV tower has a height of 15m. What is the population density around the tower if the total population covered is 2000? Radius of earth is 6400km.
3. Explain three modes of propagation of waves.
4. What do you understand about the critical frequency of a layer of atmosphere?
5. Is it necessary for a transmitting antenna to be at the same height as that of the receiving antenna for line-of-sight communication?
6. Why is a satellite used for communication purposes?

**Assessment:**

The teacher may use rubrics/checklist/rating scale/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's understanding of propagation of electromagnetic (EM ) waves and its application in the communication field from explanation using a checklist.

**Working scientifically:** Assess ability to record observation, perform analysis and interpretation on the propagation of waves using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to explain the importance of the location and size of antennas from the concept of types of propagation of waves using a rating scale.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://bit.ly/34JIj2Q
- https://bit.ly/33qIb7E

### *4.3.2.* Analogue Signal and Digital Signal.

*(Scope: differences between analogue and digital signals and sampling of analogue signals to get digital signals, advantages of digital signals in modern communication*).

**Objective(s):**

viii. Examine the advantages of digital signals over analogue signals in modern communication systems through the use of multimedia.

**Learning Experience:**

The teacher may deliver the lesson on advantages of digital signals over analogue signals in modern communication systems following the order of CER (Claim, Evidence, Reasoning). The teacher may provide video links https://bit.ly/31OCdwW, https://bit.ly/3K4c6TZ and https://bit.ly/3K3lVlb or any other relevant resources (downloaded digital content, handout, book, internet links, articles etc.,) to explore the difference between analogue signals and digital signals

and sampling theorem governing sampling and reconstruction of analogue signals. The teacher may provide a forum for an educational debate on advantages and disadvantages of digital and analogue signals in modern communication gadgets following the order of EBA (Evidence Based Argumentation).

- The learner makes a claim concerning the advantages of digital signals over analogue signals in modern communication systems based on their previous knowledge.
- Gathers evidence to support their claim from the video links https://bit.ly/31OCdwW and https://bit.ly/3K4c6TZ or any other relevant resources (downloaded digital content, handout, book, internet links, articles, etc.)
- Explores how sampling theorem governs sampling and reconstruction of analogue signals from the link https://bit.ly/3K3lVlb.
- Provides reasons based on the evidence gathered to support their claim on the advantages of digital signals over analogue signals in modern communication systems and explains the sampling and reconstruction of analogue signals using sampling theorem.
- Debates on advantages and disadvantages of digital and analogue signals in modern communication gadgets within the groups guided by the order of EBA.

**Questions:**

1. Which type of signal is denoted by a sine wave?
2. Which type of signal is represented by discrete values?
3. What are the advantages of digital signals over analog signals?
4. Why are digital signals more reliable in transmitting information than analog signals?
5. Analog circuits are usually more susceptible to noise. What do you understand from this?

**Assessment:**

The teacher may use rating scale/rubrics/observation/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual knowledge on digital signals and analogue signals, sampling of analogue signals from explanation using a rubric.

**Working scientifically:** Assess the scientific skills of data interpretation and analysis on the advantages and disadvantages of digital and analogue signals in a modern communication system while debating using a rating scale.

**Scientific values and attitudes:** Aassess the learner's skill in respecting others' view while debating on the advantages and disadvantages of digital and analogue signals in modern communication gadgets using an observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework 2022 (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://bit.ly/31OCdwW **,**
- https://bit.ly/3K4c6TZ
- https://bit.ly/3K3lVlb

4.3.3. **Polarization of Electromagnetic Waves.**

(*Scope: polarization of electromagnetic waves and its applications in plastic, movie industry and seismology*).

**Objective(s):**

ix. Explain the concept of polarization of EM waves using simulation and multimedia and explore its applications.

**Learning Experience:**

The teacher may deliver the lesson on polarization of EM waves in the following order of scientific inquiry. The teacher may ask questions like what is the difference between polarised and unpolarised waves and how the polariser reduces the intensity of the wave. The teacher may provide the interactive simulation links https://ophysics.com/l3.html , https://bit.ly/3qizvt1 and video link https://youtu.be/SGidJhcEhPQ or any other relevant resources (downloaded digital content, handout, book, internet links, articles, etc.) to explore on concept of polarization of wave.

- The learner answers the questions posed by the teacher by studying the video link https://youtu.be/SGidJhcEhPQ or any other relevant resources (downloaded digital content, handout, book, internet links, articles, etc.,) provided by the teacher.

- Explores and verifies the concept of polarization based on information gathered from the links https://youtu.be/SGidJhcEhPQ, https://ophysics.com/l3.html, and https://bit.ly/3qizvt1 or relevant resources (downloaded digital content, handout, book, internet links, articles, etc.)
- Explains how the polarizer reduces the intensity of the wave and the analyser detects the polarized waves.
- Explains polarization of EM waves and explores its application in sunglasses, plastic industry, movie industry, and seismology.

**Questions:**

1. What is plane-polarised light?
2. Sunlight, Sodium, Headlight of a car- which of these are polarised light?
3. What is the essential difference between polarised light and unpolarized light?
4. Will ultrasonic waves show any polarisation? Give a reason.
5. Can the human eye detect polarized light?
6. Light waves can be polarised while sound waves cannot be. Why?

**Assessment:**

The teacher may use rubrics/rating scale/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual knowledge on how polarizer reduces the intensity of the wave and analyzer detects the polarized waves from explanation using a rubric.

**Working scientifically:** Assess the learner's skill in sketching the unpolarised and polarised wave showing its direction of vibration in a plane using a rating scale. The teacher may also assess the learner's ability to identify the polariser and analyser while exploring the simulation using a checklist.

**Scientific values and attitudes:** Assess the learner's curiosity while exploring the simulation and relate the concept in various applications using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- National School Science Curriculum Framework 2021 (NNSCF, 2021)
- https://youtu.be/SGidJhcEhPQ,
- https://ophysics.com/l3.html,
- https://bit.ly/3qizvt1

**Revision Questions:**

1. Distinguish between absolute refractive index and relative refractive index of a medium.
2. A ray of light which is incident in air on the surface of a glass block is deviated through 15 degrees. The angle of incidence in air is 60 degrees. What is the angle of refraction in glass?
3. A ray of light incident on an equilateral glass prism shows minimum deviation of 30 degrees. Calculate the speed of light through the glass prism.
4. Is the angle of minimum deviation produced by a prism in a light ray different for different colours of light?
5. A ray of light passing through a prism deviates towards the base of the prism. Can you think of a situation when a ray would deviate away from the base?
6. The sun begins to be seen a little before it rises, and continues to be seen for several minutes after it has actually set. Explain.
7. Stars viewed from a spacecraft above the earth's atmosphere do not twinkle but the stars appear twinkling for the observer on earth. Why is it so?
8. Design and carry out the experiment to determine the focal length of a convex mirror using a spherometer.
9. Can we measure the radius of curvature of wrist watch glass by using a spherometer? Give a reason.
10. How can you design a spherometer with greater accuracy?
11. When is the number of waves said to be "in phase" and "out of phase" during its superposition?
12. Why is the whirlpool formation considered as neither transverse nor longitudinal?

13. A truck driver is broadcasting at a frequency of 27MHz with a CB (citizen's band) radio. Determine the wavelength of the electromagnetic wave being transmitted.
14. How do we communicate through mobile phones? Explain with help of basic terminologies used in communication systems.
15. The ozone layer in the atmosphere is crucial for human survival on earth. Why?
16. What will be the consequences if the frequency of the radio wave becomes more than the critical frequency of the layer? Name the mode of propagation in this case?
17. Is conversion between two signals; digital and analog, a reversible or irreversible process? Explain.
18. How will you identify experimentally whether a given beam of light is plane polarised or unpolarised ?
19. Why do we use poloriods in sun glasses instead of coloured glasses?

## 5. Atomic, Nuclear and Space Physics

The fundamental discoveries of atomic structure and their constituents enabled various manifestations of technological momentum such as, semi-conductor electronics, development of key concepts in physical laws, and offered an alternative energy source for fossil fuels in the form of nuclear power.

In the contemporary world, the applications of nuclear science and technology have become ever relevant, well beyond what could be imagined a decade ago; at the same time, challenges of nuclear radiation and safety significantly impedes the future development of nuclear energy around the world.

Nuclear physics has become imperative for space technology: nuclear energy is used to power science experiments, satellites, and space probes. In the future, it may even be used to boost vessels with people on board to other planets. Nuclear physics enables the development of reliable models for the interaction of radiation with matter for accurate risk assessments to transport spacecraft and accomplish space missions.

**Competencies:**

- Describe the atomic masses and composition of nucleus to explain nuclear force using interactive simulation to determine the advantages and disadvantages of the nuclear force.
- Investigate spectral series of hydrogen atom to study the emission spectrum using interactive simulation to show that all materials, when hot, will emit light.
- Investigate the phenomenon of radioactivity using the nuclear equation of decay reaction and discuss the benefits and risks involved.
- Describe the universal law of gravitation to determine the acceleration due to gravity on Earth, escape velocity, and explain centripetal force and gravitational force that keeps celestial bodies in orbit.
- Explore information on satellite technologies to make the best use of their applications in the area of remote sensing.

## 5.1 Atoms

### 5.1.1 Atomic Spectra.

(*Scope: discrete energy level, transition between energy level, atomic spectra and spectral series of a hydrogen atom, Rydberg's formula and its usage in determining wavelength of spectral lines*).

**Objective(s):**

i. Investigate a spectral series of a hydrogen atom using interactive simulations or any apps.

**Learning Experience:**

The teacher may carry out the instructional practices in the following order of 5E (Engage, Explore, Engage, Elaborate, and Explain). The teacher may provide the interactive simulation links https://www.falstad.com/nw/hydrogen.html and https://www.ophysics.com/m1.htm for the learner's to analyse the energy level of the orbit, the wavelength and spectrum of a hydrogen atom when an electron transits from one energy level to the other. The teacher may provide the simulation link https://rb.gy/om72zi to verify the spectrum of the hydrogen atom with other elements. The teacher may provide the worksheet to be completed by the learner based on the information from the simulation to explain the concept of absorption and emission of the spectrum.

- The learner analyses the energy level of the orbit, the wavelength and spectrum of a hydrogen atom when an electron transits from one energy level to the other from the interactive simulation links https://www.falstad.com/nw/hydrogen.html and https://www.ophysics.com/m1.htm.
- Verifies the spectrum of the hydrogen atom and compares it with other elements through the interactive simulation link https://rb.gy/om72zi.
- Completes the worksheet based on information from the simulation and explains the energy level of the orbit, the wavelength and spectrum of a hydrogen atom when an electron transits from one energy level to the other.
- Explains the concept of spectrum absorption and emission during transition through different energy levels.

**Questions:**

1. What do you understand by 'transition'?
2. Explain the meaning of 'excited atom'.

3. State the transition that emits the first line of the Balmer series of spectral lines of hydrogen?
4. Name a series of hydrogen spectra which is obtained in the infrared region. Write the general formula expressing the wavelength of the series.
5. Hydrogen atom has only one electron, but its emission spectrum has many lines. Explain with reason.

**Assessment:**

The teacher may use rubrics/marking scheme/observation form/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual knowledge on the energy level of the orbit, the wavelength and spectrum of a hydrogen atom when an electron transits from one energy level to the other from explanation using a rubric.

**Working scientifically:** Assess the learner's scientific skills of data interpretation and communication while playing simulation using a rubric. The teacher may also assess the learner's accuracy while completing the worksheet based on the information gathered from simulation using a marking scheme.

**Scientific values and attitudes:** Assess the learner's curiosity while exploring the simulation using an observation form.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://rb.gy/om72zi
- https://www.falstad.com/nw/hydrogen.html
- https://www.ophysics.com/m1.htm

## 5.2 Nuclei

### 5.2.1. Radioactivity.

*(Scope: isotope, stability, radioactivity, law of radioactive decay, final expression with decay constant, half-life and calculation, decay curves, nuclear decay equations, applications of radioactivity, safety)*

**Objective(s):**

ii. Explain the concept of half-life decay of radioactive nuclei using water analogy to comprehend radioactivity.

iii. Investigate the phenomenon of radioactivity using the concept of half-life and the nuclear decay equation to assess the benefits and risks involved.

**Learning Experience:**

The teacher may deliver this lesson in the following order of guided inquiry. The teacher may ask the questions like: how can you determine the age of an element or an object? or why is carbon dating important to archeology? The teacher may provide the materials required (burette, beaker) to perform the experiment. The teacher may guide the learner to perform the experiment of half-life decay. The teacher may provide the simulation links https://rb.gy/v1pu7x and https://javalab.org/en/half_life_period_en/ or video links https://cutt.ly/TIas7ic and https://youtu.be/CaYoDxWxww8 or any other relevant resources (practical manual for classes XI-XII, books, internet links, handouts, downloaded digital content, articles, etc.,) to explore the concept of isotopes, stability, radioactive decay, application and safety of nuclear radiation.

- The learner explains isotopes and stability from the simulation link https://rb.gy/v1pu7x and video link https://cutt.ly/TIas7ic to relate the concept with radioactive decay based on the knowledge of atomic structure and its composition.
- Answers the question posed by the teacher by studying the relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.)
- Performs the experiment based on half life decay using a water analogy given in the physics practical book for classes XI- XII.
- Computes the values and plots the graph based on the data gathered from the experiment.
- Deduces the law of radioactive decay based on the information gathered to explain half-life.

- Calculates half life using the final mathematical expression of half life using the final mathematical expressions of radioactive decay with decay constant.
- Consolidates the concepts of half life from the simulation link https://javalab.org/en/half_life_period_en/ or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.)
- Explores the types of nuclear decay and decay equation from the video link https://youtu.be/CaYoDxWxww8 or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.) to explain the applications of nuclear radiations, risk and safety.

**Questions:**

1. Define half-life of a radioactive substance. Establish a relation between half-life T and decay constant .
2. The half life of thorium-X is 3.64 days. After how many days will 0.1 of the mass of a sample of the substance remain undecayed?
3. Arrange alpha, beta and gamma rays in the decreasing order of their penetrating power.
4. Half life of radon is 3.8 days. What does it mean?
5. What do you understand by 'radiation hazard'?

**Assessment:**

The teacher may use checklist/marking scheme/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual knowledge on isotope, stability,radioactivity and law of radioactive decay from explanation using a checklist.

**Working scientifically:** Assess the learner's scientific skill of data interpretation, analysis, and communication while plotting a graph using the data from the experiment and solving numerical problems related to half-life using a marking scheme.

**Scientific values and attitudes:** Assess the learner's ability to explain the risk and safety of nuclear radiations using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- Science Curriculum Framework 2022 (SCF, 2022)
- Physics practical book for classes XI- XII, REC.
- https://rb.gy/v1pu7x
- https://cutt.ly/TIas7ic
- https://javalab.org/en/half_life_period_en/
- https://youtu.be/CaYoDxWxww8

### 5.3 Space Technology

#### 5.3.1. Universal Law of Gravitation.

(Scope: *acceleration due to gravity of the Earth, orbital velocity, centripetal force)*

**Objective(s):**

iv. Describe the effect of gravitational force on centripetal force to comprehend the motion of satellites in the orbit.

**Learning Experience:**

The teacher may deliver the lesson on universal law of gravitation in the following order of instructional practises. The teacher may provide the interactive simulation links https://rb.gy/tpnhc6, https://rb.gy/b13jqg, https://rb.gy/wssnfh, https://rb.gy/ffz8va and video link https://rb.gy/uxxxbu or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to determine the mathematical relationship between mass, distance of separation, gravitational force, Newton's law of gravitation, explain relationship between centripetal force and gravitational force, and the motion of celestial bodies.

- The learner determines the mathematical relationship between mass, distance of separation and gravitational force from the links https://rb.gy/tpnhc6, https://rb.gy/ffz8va, and https://rb.gy/uxxxbu and deduces Newton’s law of gravitation.
- Derives the relation between acceleration due to gravity and gravitational force to infer the relation between distance and acceleration due to gravity based on the information gathered.

- Analyses the relationship between gravitational force and centripetal force that keep the satellite in orbit from the link https://rb.gy/b13jqg
- Explains how the motion of a projectile (cannonball) is fundamentally the same as the orbit of a celestial body from the interactive simulation link https://rb.gy/wssnfh and deduces the expression of orbital velocity.

**Questions:**

1. How does the magnitude of gravitational force between two bodies change with change in mass of the body and distance of separation?
2. What roles does gravitational force and centripetal force play to keep the satellite in orbit?
3. How does a satellite maintain its orbital velocity?

**Assessment:**

The teacher may use rubrics or any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual knowledge on universal law of gravitation, gravitational force and centripetal force from explanation using a rubric.

**Working scientifically:** Assess the learner's ability to determine the mathematical relationship between mass, distance of separation and gravitational force and deduce Newton's law of gravitation and orbital velocity from the simulation using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to relate the concept of gravitational force and centripetal force to keep the satellite in orbit using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class XI by Wiley (Reprint 2019)
- National School Science Curriculum Framework 2021 (NNSCF, 2021)
- https://rb.gy/tpnhc6
- https://rb.gy/ffz8va
- https://rb.gy/uxxxbu
- https://rb.gy/b13jqg

- https://rb.gy/wssnfh

**5.3.2. Satellites.**

*(Scope: Types of satellites based on their orbit and payload).*

**Objective(s):**

v. Describe different types of satellites.

**Learning Experience:**

The teacher may carry out the instructional practices on satellites in the order of Gallery walk. The teacher may deliver the introductory lesson on natural and artificial and types of satellites based on the payloads, orbits and its size. The teacher may divide the class into groups and assign the topics limited to the following:

1. Payload
    a. Payload of Communication satellite.
    b. Payload of Remote sensing satellite.
    c. Payload of Global positioning satellite.
2. Orbits
    a. Geostationary orbit (GEO)
    b. Low Earth orbit (LEO)
    c. Medium Earth orbit (MEO)
    d. Polar orbit and Sun-synchronous orbit (SSO)
3. Size
    a. Nano satellite
    a. Cube satellite
    b. Small satellite
    c. Large satellite

The teacher may provide the video links https://rb.gy/tkgfgy on types of orbit, https://rb.gy/0fwlkz, and https://rb.gy/gfmr84 on types of satellite or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) for the learner to explore on the given topic.

- The learner gathers information in groups on the topic assigned by the teacher from the video links https://rb.gy/tkgfgy on types of orbit, https://rb.gy/0fwlkz, and

https://rb.gy/gfmr84 on types of satellite or any other relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.)

- Prepares to display the content of their topic on the wall based on the information gathered.
- Takes notes on the topics displayed on the wall by going around the work stations.
- Draws conclusions on the types of satellites based on payload, orbit, and size.

**Questions:**

1. What are the advantages of geostationary orbit?
2. Which payloads are used in Earth observation missions?
3. How do payloads and orbit determine the type of satellite for the particular mission?
4. How does the payload condition the size of the nanosatellite?

**Assessment:**

The teacher may use checklist/rubric/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's understanding on the types of satellites based on orbit, size and payload from the display using a checklist.

**Working scientifically:** Assess the learner's collaboration, communication, inquiry skills while doing scientific research on the types of satellites based on orbit, size and payload using a rubric.

**Scientific values and attitudes:** Assess the learner's creativity, curiosity, innovation and communication skills while displaying their work on the wall using a rubric.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Understanding Space: an introduction to astronautics by Sellers et. al (2004)
- New Normal Science Curriculum Framework 2021 (NNSCF, 2021)
- https://rb.gy/0fwlkz
- https://rb.gy/tkgfgy
- https://rb.gy/gfmr84

### 5.3.3. Space Technology Applications.

*(Scope: communications, Earth observation, disaster management, weather forecast, education, health, navigation, agriculture, etc.)*

**Objective(s)**:

vi. Explain the applications of satellite technology for various purposes.

**Learning Experience:**

The teacher may deliver the lesson on application of satellite technology in the following order of REI (Research, Evidence, and Inference). The teacher may provide the video links https://bit.ly/3HYIrtK, https://bit.ly/3HY8voF, https://bit.ly/3K6deq2, https://bit.ly/3r40Q1i , https://bit.ly/3HYJ1rq , and https://bit.ly/3zRsPFn or any other relevant resources (book, handout, downloaded digital content, articles, internet links, etc.,) on the application of satellite technology.

- The learner gathers information and evidence on application of satellite technology from the links https://bit.ly/3HYIrtK, https://bit.ly/3HY8voF, https://bit.ly/3K6deq2, https://bit.ly/3r40Q1i , https://bit.ly/3HYJ1rq , and https://bit.ly/3zRsPFn or any other relevant resources (book, handout, downloaded digital content, articles, internet links, etc.,) provided by the teacher.
- Explains the application of satellites in the field of communications, Earth observation, disaster management, weather forecast, education, health, navigation, agriculture based on the information gathered.
- Creates a short animation using programming language (e.g. scratch, block programming) of their favourite application of satellite and upload in social media or submit to Bhutan Space Week's social media pages (Instagram and Facebook - @bhutanspaceweek) to promote space technology.

**Questions:**

1. How do satellites communicate with stations on Earth?
2. How satellite communication contributes to precision farming?

**Assessment:**

The teacher may use rubrics/rating scale/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding on application of satellite technology from explanation using a rubric.

**Working scientifically:** Assess the learner's scientific skill of data interpretation, inquiry and validation while conducting research using a rating scale. The teacher may also assess the learner's communication skills and programming skills while creating an animation of satellite application using a rubric.

**Scientific values and attitudes:** Assess the learner's creativity, curiosity and innovation while creating an animation of satellite application using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Understanding Space: an introduction to astronautics by Sellers et. al (2004)
- New Normal Science Curriculum Framework 2021 (NNSCF, 2021)
- https://bit.ly/3HYIrtK
- https://bit.ly/3HY8voF
- https://bit.ly/3K6deq2
- https://bit.ly/3r40Q1i
- https://bit.ly/3HYJ1rq
- https://bit.ly/3zRsPFn

### 5.3.4. Satellite Data Analysis.

*(Scope: satellite data analysis, remote sensing).*

**Objective(s)**

vii. Analyse satellite data to study local and global phenomena such as global warming, natural disaster, land use, etc.

**Learning experiences:**

The teacher may carry out the instructional practices in the following order of POGIL. The teacher may design an activity for the learner to analyse the satellite image timelapse and data archived over the period of time showing local or global challenges such as global warming, climate change, natural disaster, land use, etc. The teacher may provide the video links https://youtu.be/sBI3MIbzIBA and https://youtu.be/vzfGMMEEz5w or any relevant resources

(books, internet links, handouts, downloaded digital content, articles, etc.,) to explore on the satellite data analysis and remote sensing.

- The learner explores the concept on remote sensing and types of remote sensing satellite from the video links https://youtu.be/sBI3MIbzIBA and https://youtu.be/vzfGMMEEz5w or any other relevant materials (books, internet links, handouts, downloaded digital content, articles, etc.)
- Explores the satellite image timelapse and gathers information archived over the period of time showing local or global challenges such as global warming, climate change, natural disaster, land use, etc., from the relevant sources.
- Analyses the satellite image timelapse and data archived over the period of time and provides inference based on the analysis.
- Constructs a connection between human activity and global challenges faced at present and develops a sympathetic understanding towards global challenges.
- Prepares a PowerPoint presentation on their findings and presents it to the class.

**Extended Learning Activity**

The teacher may upload the links https://rb.gy/2ztass of Bhutan space week containing data analysis of micro climate shift in Bhutan and https://rb.gy/ubo5og of modeling Asian elephant (Elephas maximus) habitat suitability along the southern Bhutan border with NASA Earth observations so that the learner can relate the data analysis to local phenomenon.

**Questions:**

1. What is remote sensing?
2. What does the remote sensor record: radiance or reflectance?

**Assessment:**

The teacher may use checklist/rating scale/rubric/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding on the remote sensing and types of remote sensing from the presentation using a checklist.

**Working scientifically:** Assess the learner's scientific skills such as investigating using technology, data collection, scientific reasoning, and communication using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to sensitize the local or global challenges with scientific evidence from the presentation using a rating scale.

Provide necessary intervention to the learner based on their achievement.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository.
- Science Curriculum Framework 2022 (SCF, 2022)
- Understanding Space: an introduction to astronautics by Sellers et. al (2004).
- https://youtu.be/sBI3MIbzIBA
- https://youtu.be/vzfGMMEEz5w
- https://rb.gy/2ztass
- https://rb.gy/ubo5og

**Revision Questions:**

1. If hydrogen atoms are excited to the 4th energy level, how many different wavelengths are possible for the emitted radiation?
2. Explain the formation of the Lyman series in the hydrogen spectrum with the help of an energy-level diagram. Write the formula for the frequency of the spectra lines of this series.
3. The ionising power of beta particles is less compared to alpha particles, but their penetrating power is more, why?
4. In a magnetic field the curvature of the path followed by beta particles is more than the curvature of the path of alpha particle. Why?
5. A student from primary school says that, since Earth's gravity is so much stronger than the Moon's gravity, rocks on the moon could be dropped to the Earth. What is wrong with this assumption?
6. First Bhutanese nanosatellite, BHUTAN-1 was launched into orbit aboard the SpaceX CRS-15 mission on 29 June 2018. The satellite operates at a certain altitude and passes over Bhutan for four to five times per day. Write the equation for orbital velocity of BHUTAN-1 orbiting the earth at a height of h from the surface of the earth.

7. Orbiting thousands of miles above earth satellites can run into problems. Need for reconfiguration of purpose can happen. Is it possible to modify the payload of a satellite in orbit?
8. Location is a key requirement when attempting to monitor and map the spread of a disease like Covid-19. In what ways can the satellite communication system help monitor spread of covid-19 globally.
9. Analysis by National Center for Hydrology & Meteorology (NCHM) has identified 2674 glacial lakes, of which 17 are categorised as potentially dangerous in Bhutan. With accelerated melting of the glaciers, dangers for the country's population and infrastructure are increasing. In what ways can satellite remote sensing and data analysis help fight accelerated glacier melting in Bhutan?

# Class XII

# 1. Newtonian Mechanics

Newtonian mechanics is based on the application of Newton's laws of motion, assuming that the concepts of distance, time, and mass are absolute, i.e. motion is in an inertial frame of reference. Newtonian mechanics includes topics usch as oscillating system, simple harmonic motion, amplitude and period of an oscillating system, general equation of simple harmonic motion and acceleration, velocity and how the displacement of an oscillating system changes with time. The oscillations can be very complex like the oscillation of a piano string or the oscillation of the earth during an earthquake or a heartbeat. There are also vibrations that are not very obvious to us, such as the vibrations of air molecules that convey the sensation of sound, the vibrations of atoms in a solid that convey the feeling of temperature or vibrations. motion of electrons in radio and television antennas. generator. We are indeed constantly surrounded by vibrations because oscillations are not limited to physical objects such as musical instruments but visible light, microwaves, radio waves and radiation. Therefore, the study of vibrations is essential for the understanding of various systems, whether mechanical, acoustic, electrical or atomic.

**Competencies:**

- Conduct an experiment to interpret the concept of simple harmonic motion graphically using interactive simulation and study its application in amusement parks, open space gyms, earthquake seismometers etc.
- Explain the concept of resonance through an experiment to create awareness about the effect of seismic waves on infrastructures and design a conceptual model of earthquake resistant infrastructures.

## 1.1. Oscillations

### 1.1.1. Periodic and Oscillatory Motions.

*(Scope: periodic and oscillatory motions, simple harmonic motion, time period and frequency of periodic motion and displacement of periodic motion and its calculation, relation between simple harmonic motion and uniform circular motion).*

### 1.1.2. Velocity and acceleration in simple harmonic motion.

*(Scope: velocity and acceleration in simple harmonic motion.)*

**Objective(s)**:

i. Explain periodic motion, oscillatory motion and motion of simple harmonic systems graphically using interactive simulation.

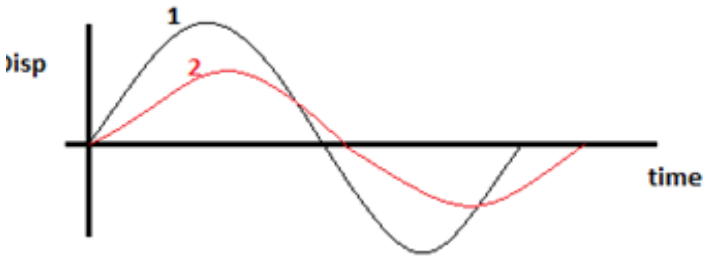
**Learning Experiences:**

The teacher may deliver the lesson on oscillation in the following order of instructional practices. The teacher may provide the links https://bit.ly/3rlxHPr or other relevant resources on periodic motion and oscillatory motion and instruct the students to explore the information from the video. The teacher may provide the interactive simulation link https://ophysics.com/w4.html on position, velocity and acceleration of Simple Harmonic Motion (SHM).

- The learner explores information on periodic motion and oscillatory motion from the link https://bit.ly/3rlxHPr or relevant resources (textbook, internet link, handout, etc.)
- Explains periodic motions, oscillatory motions, and terms related to SHM based on the information gathered.
- Explores the applications of oscillatory motions in everyday life, shares it to the class or submits learners' work to the teacher through CLT (Collaborative Learning Technology).
- Solves numerical problems related to SHM provided by the teacher.
- Uses the interactive simulation from the link https://ophysics.com/w4.html and interprets velocity and acceleration of the SHM graphically. The learner also explains the relation between SHM and circular motion from the simulation.

**Questions**

1. Every simple harmonic motion is periodic motion, but every periodic motion need not be a simple harmonic motion. Give one example to justify your statement.
2. What is the time period of $f(t)= \cos(2\omega t + \varphi)$?
3. Discuss the importance of applications of simple harmonic motion in daily life with TWO examples.
4. The displacement vs time graphs of 2 SHMs are given below. Which parameter is the same for both of them?




5. —---------- motion is the projection of uniform circular motion on a diameter of the circle in which the latter motion takes place.

**Assessment:**

The teacher may use observation/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding and the applications of SHM, periodic motion, and oscillatory motion from the explanation using a rubric.

**Working scientifically:** Assess the ability of the learner to interpret the graphs from the simulation using observation form.

**Scientific values and attitudes:** Assess the ability to relate the concept of oscillatory motions in daily life from the presentation or illustration submitted through CLT using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021).
- https://bit.ly/3rlxHPr
- https://ophysics.com/w4.html

### 1.1.3. Energy in Simple Harmonic Motion.

*(Scope: energy in Simple Harmonic Motion (SHM), Hooke's law, slope and intercept from graph, least count of stopclock)*

**Objective(s)**:

ii. Use algebraic or computational representations to claim that total energy in SHM is conserved.

**Learning Experiences:**

The teacher may deliver the lesson on energy in SHM using the CER model (Claim, Evidence, Reason) in the following order of activity. The teacher may provide the interactive simulation link https://ophysics.com/w1.html or experiment using a mass-spring system to explain the energy change in a mass-spring system.

- The learner derives the equation of SHM with the help of the teacher.
- Claims that total energy in SHM is conserved.
- Use the interactive simulation link https://ophysics.com/w1.html or experiment using a mass-spring system to gather evidence on energy conservation to validate the claim.
- Provides reasons and explanations to support the claim that the energy is conserved in SHM.

**Question**

1. Consider a particle executing simple harmonic motion of amplitude 'A' and angular frequency 'ω'. What is the magnitude of displacement from the mean position when kinetic energy is equal to the magnitude of potential energy?
2. Is total energy conserved in simple harmonic motion?
3. A particle is performing a SHM. calculate its total energy if its mass is doubled keeping the amplitude and force constant the same.

**Assessment:**

The teacher may use checklist/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the understanding of conservation of energy in SHM from learners' claim using rubrics.

**Working scientifically:** Assess the analytical skills to interpret the graph of potential energy, kinetic energy and the total energy using rubrics/checklist. The teacher may also assess skills in playing

simulation using a checklist. The teacher may assess learners' ability to use the mass-spring system to determine the force constant of a spring using observation form.

**Scientific values and attitudes:** Assess the learners' honesty in reporting the data gathered from the experiment using a checklist.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://ophysics.com/w1.html

### 1.1.4. System Executing Simple Harmonic Motion: Simple Pendulum.

*(Scope: simple pendulum, acceleration due to gravity, time period, least count of vernier caliper and stopclock, conceptual relationship between effective length and time period, slope from graph)*

**Objective(s)**:

iii. Determine the value of acceleration due to gravity of a place to provide scientific evidence that a simple pendulum executes SHM.

**Learning Experiences:**

The teacher may deliver the lesson using one or both of the following methods using structured inquiry. The teacher may provide materials such as clamp stand, bob, vernier calliper, thread, ruler and instruct learners to determine the value of acceleration due to the gravity of a place OR the teacher may provide the link https://bit.ly/3rk3gZB and instructs the learner to simulate the experiment online experiment.

The teacher may ask the driving questions: How does the motion of a simple pendulum executes SHM and what factors affect the time period of a simple pendulum?

- The leaner conducts the experiment on simple pendulum to determine the value of acceleration due to the gravity of a place using materials such as clamp stand, bob, vernier calliper, thread, and ruler.

- Obtains and analyses the data obtained from the pendulum experiment and applies it to calculate unknown variables.
- Explains how the length of the pendulum affects the time period based on the experiment.
- Explains the SHM based on the motion of the pendulum.

**Question**

1. A girl is swinging in the sitting position. How will thetime period of the swing change if she stands up?
2. The bob of a vibrating simple pendulum is made of ice. How will the time period of swing change when ice starts melting?
3. Calculate the maximum velocity at which an oscillating pendulum of length one metre will attain if its amplitude is 8 cm. (g=9.8 m/s2)

**Assessment:**

The teacher may use checklist/observation/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of the factors affecting the time period of a simple pendulum using a rubric.

**Working scientifically:** Assess the ability to conduct (curiosity, honesty, collaboration, and communication skills) an experiment using an observation form while performing the experiment.

**Scientific values and attitudes:** Assess the learners ability to work in collaboration and willingness to participate using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- XI-XII physics practical (Edition 2020)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/3rk3gZB

### 1.1.5. Forced Oscillations and Resonance.

*(Scope: free, forced oscillation and resonance, condition for resonance in forced oscillations, frequency of tuning fork, tension of wire, resonance, sonometer)*

**Objective(s):**

iv. Experimentally investigate the concept of resonance using a tuning fork.

**Learning Experiences:**

The teacher may deliver the lesson in the following order of the instructional practices. The teacher may provide the link https://bit.ly/3Fv6a2O or any other relevant resources that explains the concept of resonance. The teacher may provide materials such as a sonometer and tuning fork to experimentally demonstrate the concept of resonance.

- The learner explores information on resonance from the link https://bit.ly/3Fv6a2O or other relevant resources.
- The learner explores and explains the conditions required for the occurrence of resonance in forced oscillations.
- The learner experimentally demonstrates the concept of resonance using a tuning fork .
- The learner analyses and explains the impacts of resonance in daily life.
- The learner designs a model (3-D or illustration or animated video) of earthquake resistant infrastructures based on the concept of resonance to create awareness on the importance of constructing earthquake resistant infrastructures and share their models to the class.

**Question**

1. How can earthquakes cause disaster?
2. Will the forced oscillation depend on their natural frequency? why?
3. What are the advantages and applications of resonance?

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding on forced oscillation, resonance, the consequences of resonance, and the importance of constructing earthquake resistant infrastructures using a rubric.

**Working scientifically:** Assess the learners' ability to observe resonance in sonometer using a checklist or may assess the comprehensiveness of the model using an observation form.

**Scientific values and attitudes:** Assess the learners' accountability and honesty while performing the experiment on resonance using a checklist and also assess the application of the concept of resonance in construction of infrastructure using the checklist.

The teacher may provide intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/3Fv6a2O
- Mobile Apps

**Revision Question**

1. A sewing machine needle moves in a path 4 cm and the frequency of its oscillations is 10 Hz. What are its displacement and acceleration 1/120 s after crossing the centre of its path?
2. A simple pendulum's bob is composed of wood. What effect would it have on the time period if the wooden bob was replaced with an identical iron bob?
3. Why is uniform circular motion not oscillatory?
4. When a pendulum clock is transported to the summit of a mountain, does it lose or gain time?

## 2. Fluid Mechanics and Thermal Physics

The study of fluid behavior (liquids, gases, blood, and plasmas) at rest and in motion is known as fluid mechanics. Fluid mechanics has numerous applications in mechanical and chemical engineering, as well as biological and astrophysical systems. Surface tension and capillary with their applications in daily life, viscosity of fluids and their motion, equation of continuity, and applications of Bernoulii's Principle are all covered in this study topic.

The study of heat is known as thermal physics. The energy of a substance or system expressed in terms of the motion or vibration of its molecules is known as heat energy or thermal energy. The more heat energy a substance has, the faster its molecules travel. The average kinetic energy of the molecules is defined as temperature.

**Competencies:**

- Conduct an experiment on surface tension to comprehend the movement of liquids in capillary tubes and flow of liquids through porous surfaces and apply the concept to clean water.
- Design an experiment to measure the viscosity of the fluids to comprehend behaviour of flow of fluid.
- Validate Bernoulli's equation using interactive simulations or models to explore the various applications in sizing the pipe, flow sensors, ejectors, pitot tube, etc.
- Interpret gas expansion in terms of molecular motion that results in gas pressure due to molecular bombardment to understand the behaviour of gases.

### 2.1 Fluid Mechanics

#### 2.1.1. Surface Tension.

*(Scope: Motion of bodies in a uniform gravitational field with fluid resistance, graphs and only final expressions, molecular theory for surface tension, applications of surface tension, cause and effect of surface tension in liquids, angle of contact, movement of liquids in capillary tubes using ideas of surface tension, travelling microscope, least count of travelling microscope, flow of liquids through porous media using capillary action.)*

**Objective(s)**:

i. Carry out an experiment on surface tension of liquid from capillary rise method to comprehend its importance in everyday phenomena.

**Learning Experiences:**

The teacher may deliver the lesson on surface tension in the following order of instructional practices. The teacher may use the video link https://rb.gy/yzqy8f to explain the motion of bodies in a uniform gravitational field with fluid resistance. The teacher may provide the link https://rb.gy/bfviue or relevant resources (books, internet links, handouts, etc.,) on molecular theory for surface tension, applications of surface tension, cause and effect of surface tension in liquids, angle of contact and capillarity. The teacher may provide the materials (traveling microscope, capillary tube, etc.,) and instruct learners' to explore the relation between surface tension and capillarity through an experiment The teacher may instruct learners to conduct a constructive debate on the topic: Will it be possible for animals and plants to survive without surface tension?

- The learner analyses the motion of bodies in a uniform gravitational field with fluid resistance based on the information gathered from the link https://rb.gy/yzqy8f.
- Prepares notes from the link https://rb.gy/bfviue and presents to the class based on the information gathered or submits their works through CLT.
- The learner carries out an experiment to investigate the relation between surface tension and capillarity using a traveling microscope and capillary tube.
- The learner explores the examples of surface tension, its importance, and its application in everyday life.
- The learner participates in constructive debate on the topic: Will it be possible for animals and plants to survive without surface tension?

**Questions:**

1. Is there a difference between tap water and distilled water in terms of surface tension? Explain your answer.
2. Why does oil spread over the surface of the water?
3. How do detergents remove the oil and wax from the clothes?

4. One leg of a U tube has a radius of 0.5 cm, while the other has a radius of 0.1 cm. The tube is filled with water. Determine the difference in water levels in the two tubes. (Water S.T = 0.070 N/m, g = 9.8m/s2)
5. Why is it not possible to write directly on blotting paper or newspaper with an ink pen?

**Assessment:**

The teacher may use checklist/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of the motion of bodies in a uniform gravitational field with fluid resistance by posing relevant questions using a checklist. The teacher may also assess the comprehension of the concepts on surface tension, angle of contact and capillarity from the notes using a rubric.

**Working scientifically:** Assess the scientific skills, experimentation, creativity, presentation, communication skills and decision making skills while presenting the notes, performing the experiment and debating using a rubric.

**Scientific values and attitudes:** Assess the learners' ability to relate and express the importance of surface tension and capillarity using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/3zVb6gq
- https://bit.ly/3A0FZQr

**2.1.2. Viscosity of Fluids.**

*(Scope: viscosity of fluids, streamline, laminar and turbulent flow, equation of continuity - principle of continuity in any steady state process, Bernoulli's principle and its application).*

**Objective(s)**:

ii. Design an experiment to measure the viscosity of the fluids and explain its applications in our daily life.

iii. Verify Bernoulli's equation using interactive simulations or models.

**Learning Experiences**

The techer may delover the lesson on viscosity of fluids and Bernoulli'seduation in the following order of guided discery learning. The teacher may use video link https://bit.ly/3rfG3I8 to teach the concept.

- The learner explores the concept of viscosity from the link https://bit.ly/3noveCq or any other relevant resources (books, downloaded digital content, internet link, handouts, etc.).
- Designs and experiments to measure the viscosity of different types of fluids based on the information gathered.
- The learner explores the applications of viscosity of fluids and suggests relevant fluids for a particular purpose.
- Explores and explains streamline, laminar, and turbulent flow from any relevant resources (books, downloaded digital content, internet link, handouts, etc.).
- Applies the law of continuity to solve numerical problems provided by the teacher and relates the law to practical applications.
- The learner explains the concept of Bernoulli's equation and relate its applications in veryday life.
- Verifies Bernoulli's equation using the simulation link https://ophysics.com/fl2.html.

**Questions:**

1. How can Reynolds number help to predict the flow pattern in fluid mechanics?
2. Why are liquid molecules move at different speeds in various streamlines?

3. Why is a jet attached to the head of a firefighter's water pipes?
4. Why does a fast-moving train drag anything in and nearby its path?
5. Deep water is practically motionless. What exactly does it clarify?

**Assessment:**

The teacher may use observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept of viscosity and its application, streamline and turbulent flow from the experiment using observation form.

**Working scientifically:** Assess the learner's ability to analyse, apply and evaluate numerical questions related to the equation of continuity using a rubric. The teacher may laso assess the learner's ability to verify Bernoulli's equation from the simulation using rubrics.

**Scientific values and attitudes:** Assess the learners' ability to appreciate applications of Bernoulli's Principle in daily life using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/3noveCq
- https://ophysics.com/fl2.html

## 2.2 Kinetic Theory of Gas

### *2.2.1* Kinetic Theory of Ideal Gas.

*(Scope: real and ideal gas, postulates and consequences of the kinetic theory of gases, pressure of an ideal gas, kinetic interpretation of temperature and final expression of average, rms and most probable speed of gas molecule)*

**Objective(s)**: iv. Differentiate between real and ideal gases using multimedia.

v. Explain kinetic theory of an ideal gas and solve numerical problems.

**Learning Experiences**

The teacher may deliver the lesson in the following order of instructional practices on postulates of kinetic theory of gases. The teacher may provide the link https://bit.ly/33gJtm0 that explains the procedures to derive the kinetic gas equation and assign numerical questions related to it.

- The learner explores the difference between real and ideal gases from the link https://bit.ly/3cA7JA4 or any other relevant resources (books, handouts, internet links, downloaded digital content etc).
- The learner explains the postulates of kinetic theory of ideal gases using relevant resources (books, handouts, internet links, etc.).
- The learner derives the kinetic gas equation based on the information from the link https://bit.ly/33gJtm0 and.
- Solves numerical problems using the kinetic gas equations provided by the teacher.
- The learner explores the applications of speed of molecules using Maxwell's speed distribution curve.

**Questions**

1. How can ideal gas be differentiated from real gas?
2. A gas is at temperature $80^0$C and pressure 5x $10^{-10}$ $Nm^{-2}$. What is the number of molecules per $m^3$ if Boltzmann's constant is 1.38 x $10^{-23}$ $JK^{-1}$.
3. Six particles are moving at the speed 2, 3,3,3,7 and 8 m/s. Calculate rms speed, average speed and most probable speed of particles.
4. Under what circumstances would you expect a gas to behave significantly differently than predicted by the ideal gas law?

**Assessment:**

The teacher may use checklist /rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding on postulates of kinetic theory of gases using a checklist.

**Working scientifically:** Assess the learner's ability to apply the kinetic gas equation to solve the numerical problems using a rubric.

**Scientific values and attitudes:** Assess the learners' appreciation and willingness to explore various applications of ideal gas and Maxwell's speed distribution curve using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF-2021)
- https://bit.ly/33gJtm0

**Revision Question**

1. One of the major impacts of a disaster during a storm is damages caused to the roof. Moreover, tall buildings are affected the most when compared to short buildings. Why are buildings' roofs being blown away by strong winds? What scientific laws can be applied to prevent this disaster?
2. The walls of the container are designed as per the purpose of utility. Explain the design of a container wall through mathematical expression to withstand the pressure exerted by the gas on the walls of the container.
3. Estimate the total number of air molecules in a room of capacity 25 m3 at a temperature of 27°C. How can you use the scientific ideas to accommodate the number of air molecules obtained from the calculation in a room of capacity 25 m3? Will the same design of the container fit to store the gas molecules?

## 3. Electricity and Magnetism

**Introduction**

This theme emphasises on Coulomb's law on force of attraction and repulsion between charges, Faraday's laws of electromagnetic induction, and Kirchhoff's laws of electric circuits using various resources ranging from simulation to video lessons. It includes information on applications of these laws such as a.c. generator and transformer.

The theme also includes electric field, its strength and electric flux; capacitor and how it stores energy in electronic devices; self and mutual inductance, temperature dependence of resistivity of conductors, semiconductors, thermistors, and superconductors for various applications, and electrical resonance.

Basics of electricity and magenetism is studed in lower classes. Under this theme, concepts are designed for much deeper understanding of the phenomenon.

**Competencies:**

- Examine force of attraction and repulsion between charges using any interactive simulations or apps to explain Coulomb's law.
- Interpret electric field, its strength and express electric flux for uniform and non-uniform electric field using simulations or apps to relate its applications in our life.
- Construct a model of capacitor to explain its function as energy storage used in electronic devices.
- Design an experiment to verify Faraday's laws of electromagnetic induction and apply the concept to design a working or conceptual model of a generator.
- Explain the concept of self and mutual inductance and design a model (conceptual or working) to comprehend the working mechanism of a transformer.
- Investigate the temperature dependence of resistivity of conductors, semiconductors, thermistors, and superconductors to identify appropriate materials for various applications.
- Explain the distribution of voltage and current within the circuit and solve circuit network problems using the concept of Kirchhoff's law.
- Explain a.c. circuit using interactive simulation or apps to describe the occurrence of electrical resonance.

## 3.1 Electricity

### 3.1.1 Electric Charge.

(*Scope: basic properties, Coulomb's law, forces due to multiple charges*).

**Objective(s)**:

i. Explain the basic properties of electric charge and verify Coulomb's law using interactive simulations.

**Learning Experiences**

The teacher may deliver the lesson on the properties of charge in the following order of instructional practices. The teacher may explain the basic properties of electric charge and provide the simulation link https://ophysics.com/em1.html or any relevant resources (books, internet links, handouts, downloaded digital content, etc.,) on Coulomb's law. The teacher may provide a worksheet to derive the mathematical expression of Coulomb's law.

- The learner gathers the information on the properties of electric charge from relevant resources (books, internet links, handouts, downloaded digital content, etc.)
- Verifies the electrostatic force between two point charges (Coulomb's law) from the link https://ophysics.com/em1.html.
- The learner completes the worksheet by varying the values of magnitude of charges and the distances between the charges.
- Interprets the data from the worksheet and explains Coulomb's law.
- Solves the numerical problems on electrostatic force by applying the mathematical expression of Coulomb's law.

**Questions:**

1. What conclusion(s) can be drawn from the F Vs r and F Vs q1 graphs?
2. Explain the properties of charges with the help of simulation.
3. How does the direction of the force that acts on each of two charged objects due to the other object change depending on the type of charge? How do you know?
4. 
    a. Two insulated charged copper spheres A and B have their centres separated by a distance of 50 cm. What is the mutual force of electrostatic repulsion if the charge on each is $6.5 \times 10^{-7} C$?

b. What is the repulsion force if each sphere is charged twice as much as t$6.5 \times 10^{-7} C$ and the distance between them is halved?

**Assessment:**

The teacher may use observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of electrostatic force and derivation of Coulomb's law using observation form.

**Working scientifically:** Assess the learner's ability to apply Coulomb's law to solve the numerical problems using a rubric from the questions provided.

**Scientific values and attitudes:** Assess the learner's scientific skills of experimentation while performing the simulation and deriving the law using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/3GxoYzR
- https://ophysics.com/em1.html

### 3.1.2 Electric Field.

*(Scope: electric field and electric field intensity, physical significance of electric field, electric field lines and their properties, electric flux, electric field strength due to a point charge, electric field strength between two charged parallel plates, charged particle moving in a uniform electric field).*

**Objective(s)**:

ii. Relate electric field, and electric flux and determine the strength of the charge of an object using relevant mathematical expressions.

**Learning Experiences:**

The teacher may deliver the lesson on electric field and electric field strength in the following order of instructional practices. The teacher may provide the link https://bit.ly/3cvq4OH that shows the interaction between the two types of charges. The teacher may explain the concept of electric flux and electric field strength due to a point charge by using the link https://bit.ly/38FNqA3 or any other relevant resources (books, handouts, internet links, downloaded digital content, etc.,) and assign numerical questions. The teacher may derive the expression of a charged particle in a uniform electric field and provide the link https://ophysics.com/em6 to study electric field strength between two charged parallel plates and the variables that affect the trajectory of a charged particle in a uniform electric field.

- The learner explains electric field and electric field strength from the lesson delivered by the teacher or other relevant resources (books, handouts, internet links, etc.).
- The learner explores and explains the properties of electric field lines using the link https://bit.ly/3cvq4OH.
- Gathers information on electric flux and electric field strength due to a point charge from the link https://bit.ly/38FNqA3 or any other relevant resources (books, handouts, internet links, downloaded digital content, etc.)
- Applies the equation of electric flux and electric field intensity and solves related numerical problems.
- The learner identifies electric field strength between two charged parallel plates and explains the variables that affect the trajectory of a charged particle in a uniform electric field by using the link https://ophysics.com/em6.
- Prepares a note or a presentation on the information gathered and submits their works.

**Questions:**

1.
    a. Explain a few properties of electric field lines from the simulation link https://bit.ly/3cvq4OH,
    b. What do you think the sensor's role in the simulation is?
2. Describe an electric flux and electric field strength due to a point charge.
3. A circular plane sheet of radius 10cm is placed in a uniform electric field of $5 \times 10^5 \mathrm{N}C^{-1}$, making an angle of $60^0$ with the field. Calculate electric flux through the sheet.

4.

a. How does the change in voltage and distance between two charged parallel plates affect the trajectory of a charged particle in a uniform electric field?
b. Explain how variables such as initial velocity, charge of particle and particle mass affect the trajectory of a charged particle in a uniform electric field.

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept of electric field, electric field lines, electric field intensity, the similarities and the differences between electric field and gravitational field using a checklist while the learner explains.

**Working scientifically:** Assess the learner's ability to solve numerical problems using a rubric.

**Scientific values and attitudes:** Assess the learner's curiosity to play simulation while learning Coulomb's law using an observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/3cvq4OH
- https://bit.ly/38FNqA3
- https://ophysics.com/em6

## 3.2 Capacitors

### 3.2.1 Capacitors and Capacitance.

*(Scope: capacitors and capacitance, unit of capacitance, $q = CV$ and effect of dielectric on capacitance, energy stored in capacitors (analytical and graphical), charging and discharging of capacitor (final expression and graphs)).*

**Objective(s)**:

iii. Construct a simple model of a capacitor to explain the working and its applications in electronic devices.

**Learning Experiences:**

The teacher may deliver the lesson on capacitors in the following order of instructional practices. The teacher may instruct the learner to watch videos from the links https://bit.ly/3lsFl7j and https://bit.ly/3qHrISw and explain the concept of the capacitors.

The teacher may provide the simulation link https://bit.ly/3cuTzAd and instruct the learner to deduce the factors affecting capacitance of a capacitor. The teacher may ask the learner to construct a simple model of capacitor to explain the working and its applications in electronic devices.

- The learner gathers information from relevant resources (books, handouts, internet links, etc.) on energy stored in a capacitor and comprehends analytically and graphically how capacitors charge and discharge.
- The learner gathers information and explains the concept of capacitors from the links https://bit.ly/3lsFl7j and https://bit.ly/3qHrISw provided by the teacher.
- Explains the factors affecting capacitance of a capacitor and stored energy, and comprehends analytically and graphically how capacitors charge and discharge using simulation link https://bit.ly/3cuTzAd or any other relevant resources (books, handouts, internet links, downloaded digital content, etc.)
- Deduces the mathematical expression of the capacitance of a capacitor from the information gathered and solves related numerical problems.
- The learner constructs a simple model of a capacitor to explain its working.
- The learner explores the applications of capacitors in electronic devices from relevant resources (books, handouts, internet links, downloaded digital content, etc.)

**Questions:**

1. Describe the working of capacitor?
2. What factors affect the capacitance of a capacitor? How?
3. A capacitor of 20μF is charged to a potential of 10 kV. Find the charge accumulated on each plate of the capacitor.
4. How would you calculate the net charge of a charged capacitor?

**Assessment:**

The teacher may use checklist/marking scheme/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's understanding of capacitor, capacitance and the factors affecting the capacitance of a capacitor using a rubric from the model and explanation.

**Working scientifically:** Assess the learner's ability to use the simulation to comprehend how capacitors charge and discharge using a checklist. The teacher may also assess learners' ability to design a model of a capacitor using a marking scheme.

**Scientific values and attitudes:** Assess the learner's appreciation towards the importance of capacitors in daily life to store energy using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/3lsFl7j
- https://bit.ly/3qHrISw
- https://bit.ly/3cuTzAd

### 3.2.2 Combination of Capacitors.

*(Scope: series and parallel combinations of capacitors).*

**Objective(s)**:

iv. Explain the concept of combination of capacitors in series and parallel.

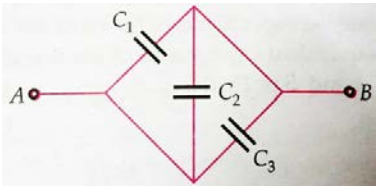
**Learning Experiences:**

The teacher may deliver the lesson on combination of capacitors using PROE (Predict, Reason, Observe, and Explain). The teacher may provide the simulation link https://bit.ly/3lfgyDo to carry out the activity. The teacher may provide the links https://bit.ly/3tkzIdX and https://bit.ly/3cvJcfE on the combination of capacitors and its applications.

- The learner predicts the equivalent capacitance when the capacitors are connected in parallel and series and justify the predictions with scientific reasons.
- The learner conducts simulation from the link https://bit.ly/3lfgyDo and observes the changes in the equivalent capacitance of the capacitor when two or more capacitors are connected in parallel or series.
- The learner explains the changes in capacitance when the capacitors are connected in parallel and series with appropriate scientific principles.
- The learner watches the video from the links https://bit.ly/3tkzIdX and https://bit.ly/3cvJcfE to explain the concepts on combination of capacitors and its applications.
- The learner solves the numerical problems on combinations of capacitors.

**Questions:**

1. What happens to the total capacitance of capacitors when connected in series and in parallel?
2. In the figure given below, $C_1 = 1\mu F$, $C_2 = 2\mu F$ and $C_3 = 3\mu F$. Find the equivalent capacitance between points A and B.




3. Can we give any desired charge to a capacitor? Justify your answer.

**Assessment:**

The teacher may use checklist/observation form/rubrics/marking scheme/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's explanation on the effectiveness of capacitance of capacitors in different combinations (series or parallel) using a rubric.

**Working scientifically:** Assess the learner's ability to conduct simulation using a checklist. The teacher may also assess the ability to solve numerical problems on combinations of capacitors using a marking scheme.

**Scientific values and attitudes:** Assess the learner's attitude towards making informed decisions on which combination of capacitors to use in daily life by using a observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/3cvJcfE
- https://bit.ly/3tkzIdX
- https://bit.ly/3lfgyDo

### 3.3 Electromagnetic Induction

#### 3.3.1. Magnetic Flux.

*(Scope: terms and final expressions of: magnetic circuit, permeability, magnetic field strength, magneto-motive force, reluctance, permeance, and flux in magnetic circuit).*

#### 3.3.2. Magnetic moment of a bar magnet.

*(Scope: magnetic moment, tangent law, deflection magnetometer - Tan A position)*

#### 3.3.3. The Experiments of Faraday and Henry.

*(Scope: experiments of Faraday and Henry, Faraday's laws of electromagnetic induction, Lenz's law, energy conservation, and a.c. generator).*

**Objective(s)**: v. Explain magnetic flux and terms related to it and solve numerical problems.

vi. Define magnetic moment and compare the magnetic moment of two bar magnets to comprehend the magnetic field strength.

vii. Design an experiment to verify Faraday's laws and relate Lenz's law to explain the working of a.c. generator.

**Learning Experiences:**

The teacher may introduce the lesson or provide any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) on magnetic flux and the terminologies (magnetic circuit, permeability, magnetic field strength, magneto-motive force, reluctance, and permeance) related to magnetic circuit. The teacher may provide a magnetometer to experimentally compare the magnetic moment of two bar magnets in Tan-A position to comprehend the magnetic field strength.

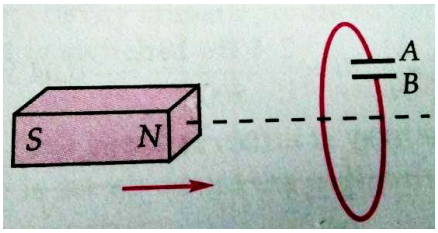
The teacher may use the 5E model (Engage, Explore, Explain, Elaborate, Evaluate) to deliver the lesson on Faraday's laws of electromagnetic induction and Lenz's law. The teacher may provide the link 2OybL3Vhttps://bit.ly/ as an additional resource for the learner to explore the concept of electromagnetic induction. The teacher may use the link https://bit.ly/3eySyKe or other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) that explains the working of an a.c. generator.

- The learner explains magnetic flux and the terminologies used in magnetic circuits based on the information gathered from the relevant resources (books, internet links, handouts, etc.).
- The learner uses a magnetometer and experimentally compares the magnetic moment of two bar magnets in Tan-A position to comprehend the magnetic field strength.
- The learner engages in recapitulating and restating their prior knowledge on electromagnetic induction and Lenz's law using relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- Explores and explains the concept of electromagnetic induction and Lenz's law using the link 2OybL3Vhttps://bit.ly/.
- Designs and carries out an experiment to verify Faraday's law of electromagnetic induction and Lenz's law based on the information gathered.
- Explains their experimental design to verify Faraday's law of electromagnetic induction and Lenz's law.
- The learner elaborates on the working of an a.c. generator using the concept of electromagnetic induction and Lenz's law and uses the link https://bit.ly/3eySyKe to verify their explanation.
- The learner evaluates and reviews understanding of electromagnetic induction by answering the questions assigned by the teacher.
- The learner explains the importance of an a.c generator in everyday life.
- Prepares a note or presentation on the information gathered and submits through CLT.

**Questions:**

1. What is the basic cause of induced emf?
2. How does the change in distance of the magnet from the centre of the magnetometer affect the magnetic moment of the given bar magnet?

3. Predict the polarity of the plate A of the capacitor, when a magnet is moved towards it, as shown in figure below:




4. Why is an a.c. generator so called?
5. How does electromagnetic induction occur?

**Assessment:**

The teacher may use checklist/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of magnetic flux, magnetic circuit, permeability, magnetic field strength, magnetomotive force, reluctance, permeance, Faraday's law of electromagnetic induction, and Lenz's law while explaining using a checklist.

**Working scientifically:** Assess the learner's skills in designing an experiment to verify Faraday's laws of electromagnetic induction and Lenz's law based on relevant resources (books, handouts, internet links, etc.) using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to critically relate the working and significance of an a.c. generator from the notes submitted by the learner using rubrics.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/2OybL3V
- https://bit.ly/3tpgWCh
- https://bit.ly/3rQtX7n
- https://bit.ly/3eySyKe

### 3.3.4. Inductance.

*(Scope: inductance, self induction and mutual induction, coefficient of self induction, coefficient of mutual induction, transformer).*

**Objective(s)**

viii. Comprehend self and mutual induction to explain the concept of a transformer using simulations/multimedia.

**Learning Experiences:**

The teacher may carry out the instructional practices in the following order of activity to deliver the lesson on inductance. The teacher may derive mathematical expressions of coefficient of self induction and coefficient of mutual induction. The teacher may provide the links https://bit.ly/3vrVL4n and https://bit.ly/3qMp3qN on inductance, types and working of a transformer respectively. The teacher may provide numerical problems related to inductance and transformation ratio.

- The learner explains the concept of inductance, self inductance, mutual inductance, and transformer based on the information gathered from the link https://bit.ly/3vrVL4n or other relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- The learner compares self induction and mutual induction based on the equations derived with the help of the teacher and applies the expressions to solve numerical problems.
- Differentiates between a step-up and a step-down transformer based on the data derived from the simulation link https://bit.ly/3qMp3qN.
- The learner designs a model of a transformer to explain its working.
- Applies the transformation ratio of voltages and currents to solve numerical problems.

**Questions:**

1. Describe an experiment to demonstrate the phenomenon of self-induction.
2. What is the main difference between step-up and step-down transformers?
3. Why does a transformer work with only a.c current but not direct current?
4. An emf of 0.5 V is developed in the secondary coil, when current in the primary coil changes from 5.0 A to 2.0 A in 300 millisecond. Calculate the mutual inductance of the two coils.

**Assessment:**

The teacher may use checklist/observation form/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's explanation on inductance, self inductance, mutual inductance, and the working principle of a transformer using a checklist.

**Working scientifically:** Assess the learner's ability to conduct simulation on a transformer using observation form. The teacher may use a checklist to assess the problem solving skills, analytical skills, and logical reasoning skills while solving the numerical questions.

**Scientific values and attitudes:** Assess the learner's curiosity, persistence, and creative thinking to design a model of a transformer using an observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository.
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019).
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/3vrVL4n
- https://bit.ly/3qMp3qN

### 3.4 Electric Circuit

#### 3.4.1 Classification of Substances.

*(Scope: classification of substances into conductors, insulators and semiconductors based on the energy bands, effect of temperature on the resistivity of conductors, semiconductors, thermistor and superconductors, potential applications of Room Temperature Superconductors (RTS)).*

**Objective(s)**:

ix. Classify substances into conductors, insulators and semiconductors and evaluate their dependence on temperature.

**Learning Experiences:**

The teacher may deliver the lesson using flipped classroom. The teacher may provide the links https://bit.ly/30GRpb9, https://rb.gy/qmebmk, https://rb.gy/q9yfyr, and https://rb.gy/bcmxcc or any

other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) few days before the class and instruct the learner to prepare for quiz and discussions.

- The learner gathers information from the links https://bit.ly/30GRpb9, https://rb.gy/qmebmk, https://rb.gy/q9yfyr, and https://rb.gy/bcmxcc or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) provided by the teacher and prepares for the quiz.
- Participates in the quiz and discussions.
- The learner submits their works through CLT or to the teacher.

**Questions:**

1. Differentiate among conductor, semiconductor and insulator on the basis of energy bands.
2. What are the advantages of superconductors?
3. If room temperature superconductors (RTS) could be made, what applications could they have?
4. How does temperature affect the resistivity of conductors, semiconductors and insulators?
5. What is a thermistor? Differentiate between NTC and PTC thermistors.

**Assessment:**

The teacher may use checklist/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concepts on conductors, insulators and semiconductors and dependence on temperature gathered from the resources using a rubric during the quiz.

**Working scientifically:** Assess the learner's information handling skills from the information gathered from the quiz using a checklist.

**Scientific values and attitudes:** Assess the learner's interest, collaboration, honesty and integrity in processing the information from resources provided by the teacher while conducting a quiz using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository

- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF -2021)
- https://bit.ly/30GRpb9
- https://rb.gy/qmebmk
- https://rb.gy/q9yfyr
- https://rb.gy/bcmxcc

### 3.4.2 Semiconductors.

*(Scope: types of semiconductor).*

**Objective(s)**:

x. Explain semiconductors and its importance in designing electronic devices.

**Learning Experiences:**

The teacher may use the 5E Model to introduce the concept of a semiconductor, its types (intrinsic and extrinsic semiconductor) and the differences between the n-type and p-type semiconductor. The teacher may provide the link https://bit.ly/3GqBtgz to explore the information on applications of semiconductors.

- The learner engages in discussion and clarifies doubts on the concept of a semiconductor and its characteristics.
- The learner explores the types of semiconductors (intrinsic and extrinsic) and the differences between the n-type and p-type semiconductor from the relevant (books, handouts, internet links, downloaded digital conten, etc.)
- Explores the applications of semiconductors in manufacturing various kinds of electronic devices and its advantages over other materials from the link https://bit.ly/3GqBtgz.
- The learner explains their understanding of semiconductor, its types, and the formation of n-type and p-type semiconductors based on the information gathered.
- Elaborates on the importance and benefits of semiconductors in designing electronic devices in daily life.
- Evaluates and verifies their understanding on the concept of semiconductors, its characteristics, and types using the information gathered from the simulation link https://rb.gy/jgzgrh
- The learner submits their works through CLT or to the teacher.

**Questions:**

1. Define semiconductors.
2. Differentiate p-type semiconductor from n-type semiconductor.
3. What would our lives be like if the smei-conductor was never invented?
4. What are the advantages of using a semiconductor compared to any other materials in designing electronic devices?

**Assessment:**

The teacher may use checklist/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of semiconductors, its properties, and the applications of semiconductors in electronic devices using a rubric from the explanation.

**Working scientifically:** Assess the learner's ability to argue based on evidence on the importance of semiconductors in electronic devices using a rubric.

**Scientific values and attitudes:** Assess the learner's interest and positive attitude towards the importance of using semiconductors for new developments in science and technology while elaborating information from relevant resources using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF, 2021)
- https://rb.gy/pnuflv
- https://rb.gy/4dfmty
- https://rb.gy/jgzgrh
- https://bit.ly/3GqBtgz

### 3.4.3. DC Circuits.

*(Scope: d.c. circuits, Kirchhoff's laws, applications of potential divider in light sensor, temperature sensor, and audio volume controls).*

**Objective(s)**:

xi. Conduct an experiment to verify Kirchhoff's laws.

xii. Design a model based on the application of potential dividers using interactive simulations.

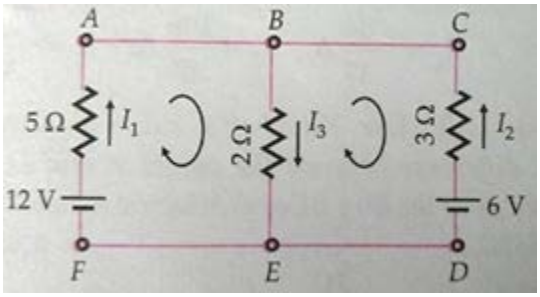
**Learning Experiences:**

The teacher may deliver the lesson on d.c. circuits using activity based learning method/approach. The teacher may explain Kirchhoff's laws and potential divider using presentation or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.). The teacher may use the link https://rb.gy/pifrqf or instruments and instruct the learner to construct any electric circuit to verify Kirchhoff's laws. The teacher may instruct the learner to design a model on the application of a potential divider using the same simulation link .

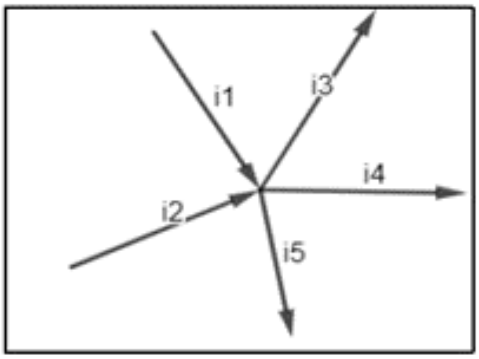
- The learner comprehends Kirchhoff's laws and potential divider from the teacher's presentation or explanations.
- The learner applies the conceptual understanding of Kirchhoff's laws to construct electric circuits and verifies the rules using the circuit construction kit from the link https://rb.gy/pifrqf or instruments.
- Applies the concept of potential divider and designs a model using interactive simulation from the links https://rb.gy/pifrqf, https://bit.ly/3FfBHpj, and https://bit.ly/3GlpYXV
- The learner explores the applications of potential dividers in light sensor, temperature sensor, and audio volume controls.
- Prepares a presentation or a note based on the conceptual understanding of the lesson and submits through CLT or to the teacher.

**Questions:**

1. Using Kirchoff's laws in the electrical network shown below, calculate the values of $I_1$, $I_2$ and $I_3$.




2. What is the significance of a potential divider in an electric circuit?
3. Describe the working of fire alarms?
4. Calculate the current $i_5$ if the current $i_1$ = 10 A, $i_2$ = 7A, $i_3$ = 9 A, and $i_4$ = 4 A. Also state which rule is applied in the figure given below.




**Assessment:**

The teacher may use checklist/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the comprehension of concepts of Kirchhoff's laws and potential divider using a checklist from the presentation.

**Working scientifically:** Assess the learners' ability to construct electric circuits in simulation or from instruments using rubrics. The teacher may also assess the learners' ability to design a model on the concept of potential divider using a rubric from the model.

**Scientific values and attitudes:** Assess the significance of the models developed based on Kirchoff's laws and potential divider using a rubric from the model and presentation.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- https://rb.gy/yixzzn
- https://rb.gy/h3blbs
- https://rb.gy/ztqnhk
- https://rb.gy/pifrqf
- https://rb.gy/mbjuss

### 3.4.4 Electromotive force of a dry cell.

*(Scope: electromotive force (emf) of a dry cell, null point, least count, resistance per unit length, slope from graph).*

**Objective(s):**

xiii. Determine emf of a dry cell by changing the resistance.

**Learning Experiences:**

The teacher may deliver the lesson on the emf of a dry cell using structured inquiry. The teacher may provide the links https://bit.ly/3Gqqnbg, https://bit.ly/3nmPHHQ, https://bit.ly/3fgXMJR or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) to recap on the concept of emf of a dry cell. The teacher may provide instruments (potentiometer, resistance box, ammeter, voltmeter, one-way plug key, connecting wire, d.c. source, jockey, galvanometer, dry cell) and instruct the learner to experimentally determine the emf of the given dry cell by changing the resistance.

- The learner uses the links https://bit.ly/3Gqqnbg, https://bit.ly/3nmPHHQ, https://bit.ly/3fgXMJR or other relevant resources (books, handouts, etc.) to recap on the concept of emf of a dry cell.
- The learner performs an experiment using the instruments (potentiometer, resistance box, ammeter, voltmeter, one-way plug key, connecting wire, d.c. source, jockey, galvanometer, dry cell) to determine the emf of the given dry cell with the help of teachers instruction.

- Collects, analyses and interprets the data gathered from the experiment.
- Presents the result from the experiment and submits their work.

**Questions:**

1. How can the emf of a dry cell be determined by varying the resistance?
2. Explain resistance per unit length.
3. Why use a potentiometer to determine the emf of a dry cell when it can be done easily and quickly using a voltmeter?

**Assessment:**

The teacher may use checklist//rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept of emf of dry cell from the explanation and experiment using a rubric.

**Working scientifically:** Assess the learner's skills to carry out the experiment, gather, analyse and interpret data from the experiment and presentation using a checklist.

**Scientific values and attitudes:** Assess the willingness of the learner to report the result of the experiment even if it is not as expected from the presentation using a rubric while they report.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- Physics Practical Manual (Class XI & XII) by REC
- https://bit.ly/3Gqqnbg
- https://bit.ly/3nmPHHQ
- https://bit.ly/3fgXMJR

### 3.4.5 Specific resistance

*(Scope: principle of wheatstone bridge, specific resistance of resistor, least count).*

**Objective(s):**

xiv. Determine specific resistance of the given wire by changing the resistance of the resistance box.

**Learning Experiences:**

The teacher may deliver the lesson on the specific resistance of the given wire in the following order of activity. The teacher may provide the links https://bit.ly/31ScN1q, https://bit.ly/3nlW2U5 and https://bit.ly/33rJWl1 or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) to gather information on specific resistance of the given wire and principle of wheatstone bridge. The teacher may provide instruments (potentiometer, galvanometer, one-way plug key, connecting wire, d.c. source, jockey, resistance box, screw gauge, given resistor of unknown resistance) and instruct learners to experimentally determine the specific resistance of the given wire.

- The learner uses the links https://bit.ly/31ScN1q, https://bit.ly/3nlW2U5 and https://bit.ly/33rJWl1 or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) to gather information on specific resistance of the given wire and principle of wheatstone bridge.
- The learner writes notes on specific resistance of the given wire and principle of wheatstone bridge.
- The teacher may provide instruments (potentiometer, galvanometer, one-way plug key, connecting wire, d.c. source, jockey, resistance box, screw gauge, given resistor of unknown resistance) and instruct learners to experimentally determine the specific resistance of the given wire.
- The learner presents the result from the experiment and submits their work.

**Questions:**

1. Explain the principle of Wheatstone bridge.
2. How does the specific resistance of the given wire change with change in resistance of the resistance box?
3. A wire of 10 ohm resistance is stretched to thrice its original length. What will be its new resistivity?

**Assessment:**

The teacher may use checklist/o/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept of specific resistance of the given wire and principle of wheatstone bridge from the notes using a rubric.

**Working scientifically:** Assess the learner's skills in handling instruments to determine the specific resistance of the given wire using a checklist.

**Scientific values and attitudes:** Assess the willingness of the learner to report the result of the experiment even if it is not as expected from the presentation using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- Physics Practical Manual (Class XI & XII) by REC
- https://bit.ly/31ScN1q
- https://bit.ly/3nlW2U5
- https://bit.ly/33rJWl1

### 3.4.6 AC Circuits.

*(Scope: a.c. circuit, root mean square (RMS) value of a.c., sinusoidal variation of voltage and current when ac voltage is applied to resistor, inductor and capacitor in an a.c. circuit (final expressions)).*

### 3.4.7 AC Voltage Applied to a Series LCR Circuit.

*(Scope: phasor diagram solution, analytical solution and resonance).*

**Objective(s)**:

xv. Explain the sinusoidal variation of voltage and current in an a.c. circuit using interactive simulation/multimedia.

xvi. Apply graphical and mathematical methods to analyse the maximum current in the LCR circuit.

**Learning Experiences:**

The teacher may use the flipped classroom to deliver the lesson on a.c. circuit. The teacher may provide the links https://rb.gy/0v0fto, https://rb.gy/qmiuut, and https://rb.gy/e1brn8 and ask the driving question: Why do we use the RMS value of voltage and current in an a.c. circuit instead of the peak value? a few days before the actual class. The teacher may deliver the lesson on a.c. voltage applied across a resistor, a capacitor, an inductor, and the circuit containing all the three electrical components (LCR circuit) analytically and graphically.

- The learner observes the change in the current and voltage of an a.c. source by constructing an a.c. circuit using the information from the link https://rb.gy/0v0fto.
- The learner studies the definition and the significance of RMS value from the links https://rb.gy/qmiuut and https://rb.gy/e1brn8 a few days before the class.
- During the class, the learner presents their understanding of a.c. circuit and the sinusoidal variation of voltage and current of an a.c. from the simulation during the class.
- The learner discusses the concept of RMS value, its expression, and answers the driving question raised by the teacher: Why do we use the RMS value of voltage and current in an a.c. circuit instead of peak value?
- Aapplies the equation of RMS voltage and current to solve numerical problems.
- Aapplies the expression of a.c. voltage across a resistor, a capacitor, an inductor and LCR circuit to solve numerical problems (resistance, reactance, impedance, phase angle, etc.) related to the circuits.
- Explains the concept of electrical resonance and interprets the resonance curve from the materials provided by the teacher or other resources (books, handouts, internet links, etc.).

**Questions:**

1. Why do we use the RMS value of voltage and current in an a.c. circuit instead of the peak value?
2. Explain how current and voltage of an a.c. source varies sinosoidally.
3. 220 V a.c. is more dangerous than 220 V d.c. Why?
4. When a series LCR-circuit is brought into resonance, the current in the circuit increases to a large value. Why?

5. Distinguish between resistance, reactance and impedance of an a.c. circuit.

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of an a.c. circuit, RMS value and its significance, and resonance by using a rubric from the explanation.

**Working scientifically:** Assess the learners' ability to interpret the information from the links https://rb.gy/0v0fto, https://rb.gy/qmiuut, https://rb.gy/e1brn8 provided by the teacher using a checklist.

**Scientific values and attitudes:** Assess the learner's critical thinking on how electrical resonance is applied in daily life by using observation form from the explanation.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

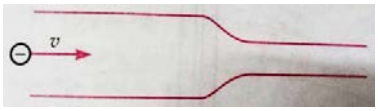
**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- https://rb.gy/qmiuut
- https://rb.gy/0v0fto
- https://rb.gy/e1brn8

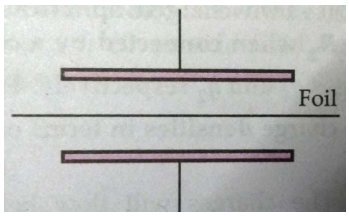
**Revision Questions:**

1. The proton that is the nucleus of the hydrogen atom attracts the electron that orbits it. Relative to this force, does the electron attract the proton with less, more or equal force?
2. Consider three charges $q_1$, $q_2$, $q_3$ each equal to $q$ at the vertices of an equilateral triangle of side $l$. What is the force on a charge Q (with the same sign as $q$) placed at the centroid of the triangle?
3. Measurements show that there is an electric field surrounding Earth. Its magnitude is about 100 N/C at Earth's surface, and it points inward toward Earth's center. From this information, can you state whether Earth is negatively or positively charged?

4. An electron moves along a metal tube with variable cross-section, as shown in the figure below. How will its velocity change when it approaches the neck of the tube?



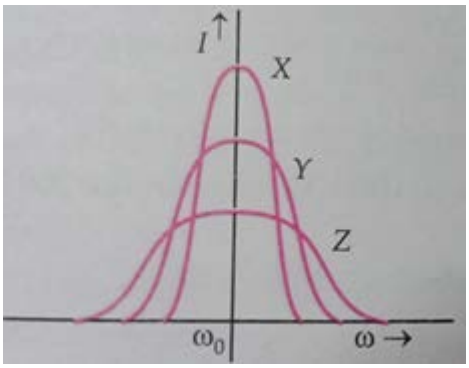

5. Five balls, numbered 1 to 5 are suspended using separate threads. Pairs (1, 2), (2, 4), (4, 1) show electrostatic attraction, while pairs (2, 3) and (4, 5) show repulsion. What is the nature of charge on ball 1?
6. Is there any kind of material which when placed between the plates of a capacitor reduces its capacitance?
7. A sheet of aluminium foil of negligible thickness is placed between the plates of a capacitor as shown in the figure below.




What effect has it on the capacitance if the foil is
(a) electrically insulated, and
(b) connected to the upper plate with a conducting wire?

8. When a capacitor is connected across a battery, why does each plate receive a charge of exactly the same magnitude? Is this true even if the plates are of different sizes?
9. Why is it dangerous to touch the terminals of a high-voltage capacitor even after the charging circuit is turned off?
10. A bar magnet is placed on one side of the compass box at a certain distance. The position of the second bar magnet is adjusted on the other side to nullify the deflection. Will the distances of the two bar magnets be equal from the centre of the magnetic needle? Give reasons.
11. Can a transformer be considered as an electrical lever? What does it multiply?
12. What are the advantages of measuring resistance by the Wheatstone bridge method over other methods?

13. Three students X, Y, Z performed an experiment for studying the variation of alternating currents with angular frequency in a series LCR-circuit and obtained the graphs shown below. They all used a.c. sources of the same rms value and inductances of the same value. What conclusion can be drawn about the capacitance values?



# 4. Waves and Optics

Optics is the branch of physics which deals with the study of optical phenomena. Optics can be divided into two categories, which is Ray optics and Wave optics. Ray optics is the simplest theory of light. Rays travel in optical media according to a set of geometrical rules; hence ray optics is also called geometrical optics. Ray optics is an approximate theory, but accurately describes a variety of phenomena. Ray optics is concerned with the locations and directions of light rays, which carry photons and light energy (They also carry momentum, but the direction of the momentum may be different from the ray direction). It is useful in describing image formation, the guiding of light, and energy transport.

Wave optics deals with the connection of waves and rays of light. It is used when the wave characteristics of light are taken into account. Wave Optics deals with the study of various phenomenal behaviours of light like reflection, refraction, interference, diffraction, polarisation etc. It is otherwise known as Physical Optics.

**Competencies:**

- Conduct an experiment to study the behaviour of light when it strikes on different optical media and use the concept to design optical instruments.
- Investigate and sketch image formation for different optical media using interactive simulation to comprehend the significance of optical media in optical instruments.
- Verify Huygens' principle using appropriate light sources to explain the wave nature of light.
- Illustrate interference and diffraction graphically and use the concept to study the stellar spectra and relate the concept in the field of optical communication.
- Explain the particle nature of light and the photoelectric effect (Einstein's photoelectric equation) using interactive simulations/multimedia to relate its working in solar panel.

## 4.1. Ray Optics

### 4.1.1. Reflection of Light by Spherical Mirrors.

*(Scope:reflection of light by spherical mirrors, cartesian sign convention, magnification, mirror equation (final expressions)).*

**Objective(s)**:

i. Conduct an experiment to comprehend the behaviour of light when it strikes on spherical mirrors using interactive simulation and sketch ray diagrams.

**Learning Experiences:**

The teacher may deliver the lesson on reflection of light by spherical mirrors using POE (Predict, Observe, and Explain). The teacher may explain or provide the link https://rb.gy/pa4pr2 on reflection of light by spherical mirrors. The teacher may use the simulation link https://ophysics.com/l10.html and verify the position and the characteristics of the image formed by the spherical mirrors when the object is placed at a different position in front of the mirror. The teacher may provide the links https://rb.gy/ezwccb and https://bit.ly/3vl71zv and instruct the learner to conduct virtual experiments.

- The learner gathers information on the reflection of light by spherical mirrors from the teacher's explanation or from the link https://rb.gy/pa4pr2.
- The learner predicts the position and the characteristics of the image formed by the spherical mirrors when the object is placed at a different position in front of the mirror.
- Observes the formation of the images by spherical mirrors from the link https://ophysics.com/l10.html.
- The learner carries out an experiment virtually using the links https://rb.gy/ezwccb and https://bit.ly/3vl71zv to calculate the focal length of the spherical mirrors.
- The learner constructs ray diagrams and explains the formation of images by spherical mirrors.
- Explores the practical applications and aberrations of spherical mirrors in daily life.
- Prepares a presentation or note on the information gathered.

**Questions:**

1. A dentist uses a concave mirror to examine a tooth that is 1.00 cm in front of the mirror. The image of the tooth forms 10.0 cm behind the mirror.
    a) What is the mirror's radius of curvature?
    b) What is the magnification of the image?
2. Why is shaving with a concave mirror preferable than shaving with a plane mirror?
3. Two concave mirrors have the same focal length but the aperture of one is larger than that of the other. Which mirror forms the sharper image and why?

4. How will you distinguish between a plane, a concave and a convex mirror without touching its surface?
5. A man stands in front of a unique-shaped mirror. He discovers that his image has a small head, a fat body, and normal-sized legs. What do you think of the three components of the mirror's shapes?

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept of reflection, construction of ray diagrams, and the characteristics of the image formed by the spherical mirrors from the presentation or note using a check list.

**Working scientifically:** Assess the learners' ability to examine theories and concepts through logical reasoning and follow procedures to carry out an experiment through simulation by using a rubric.

**Scientific values and attitudes:** Assess the learner's interest and positive attitude towards the importance of using a mirror for developments in science and technology while elaborating information from relevant resources using a observation form during presentation.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- https://rb.gy/pa4pr2
- https://ophysics.com/l10.html
- https://rb.gy/ezwccb
- https://bit.ly/3vl71zv

4.1.2. **Refraction through Spherical Surfaces.**

*(Scope: Cartesian sign convention, linear (transverse) magnification, refraction by lenses, converging and diverging lenses, derivation and application of lens equation (final expression), focal length of lens using u-v and displacement method (range and least count of optical bench, slope from graph) mathematical expression of magnification, power of a lens, focal length by combination of lenses)*

**Objective(s)**:

ii. Verify the focal length of a given convex lens by u-v and displacement method.

iii. Determine the focal length of concave and convex lenses based on the concept of combination of lenses.

**Learning Experiences:**

The teacher may deliver this lesson in the following order of instructional practices. The teacher may ask the questions like: how can you determine the position and characteristics of the image formed by a convex and a concave lens?

The teacher may provide the simulation link https://bit.ly/3I5hl3U and video link https://bit.ly/3fltPYP or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) to explore concepts on diverging and converging lenses. The teacher may provide the link https://bit.ly/33fS0pj on lenses, its types and the differences between a virtual image and a real image. The teacher may upload the link https://bit.ly/3GuEFHV that illustrates the positions and the characteristics of images formed by a concave and a convex lens.

The teacher may use guided inquiry to guide the learner to perform experiments on verification of the focal length of a given convex lens by u-v and displacement method, determination of focal length of given convex lens by combining it coaxially with another convex lens, and verification of the focal length of a concave lens graphically and analytically.

- The learner gathers information on refraction of light through spherical surfaces from the simulation link https://bit.ly/3I5hl3U and video link https://bit.ly/3fltPYP or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- Explains about lenses, its types (converging or diverging lenses) and the differences between a real image and a virtual image using the link https://bit.ly/33fS0pj.

- Gathers information on the position and the characteristics of images formed by a concave and convex lens using the link https://bit.ly/3GuEFHV.
- The learner researches on questions asked by the teacher from the relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- The learner performs the experiments on verification of the focal length of a given convex lens by u-v and displacement method, determination of focal length of given convex lens by combining it coaxially with another convex lens, and verification of the focal length of a concave lens graphically and analytically.
- Interpretes the data obtained from the experiment and presents it to the class.
- Explains magnification, power of a lens, and combination of lenses in contact from the relevant resources (books, handouts, internet links, etc.)
- The learner explains the applications of concave and convex lenses, and their combination in everyday life.

**Questions:**

1. A convex lens forms a real image of a point object placed on its principal axis. If the upper half of the lens is painted black, the image will not be shifted. Why?
2. A convex lens forms a real image of an object for its two different positions on a screen. If height of the image in both the cases be 8 *cm* and 2 *cm*, what is the height of the object?
3. How focal length of the lens immersed in liquid changes with the following conditions:
    a) If the refractive index of liquid is equal to refractive index of lens,
    b) If the refractive index of liquid is less than refractive index of lens and
    c) If the refractive index of liquid is greater than the refractive index of lens.
4. An object placed 4 cm in front of a converging lens produces a real image 12 cm from the lens. What is the magnification of the image? What is the focal length of the lens? Draw the ray diagram to show the formation of the image based on the above conditions..
5. A convex lens of focal length 0.10 m is used to form a magnified image of an object of height 5 mm placed at a distance of 0.08 m from the lens. Find the position, nature and size of the image.

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concepts on refraction of light through spherical surfaces, focal length, magnification, and power from explanation using a checklist.

**Working scientifically:** Assess the learner's scientific skills of data collection, analysis, interpretation, and results on the experiments performed from the explanation and work submitted to the teacher using a rubric.

**Scientific values and attitudes:** Assess the learner's honesty to report the exact result of the experiments from the work submitted to the teacher, and appreciation of the concept of lenses and their combinations in various day-to-day applications from explanation using observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- Physics Practical Manual (Class XI & XII) by REC
- https://bit.ly/3I5hl3U
- https://bit.ly/3fltPYP
- https://bit.ly/3GuEFHV
- https://bit.ly/33fS0pj

### 4.1.3. Refractive Index

*( Scope: law of refraction, real depth, apparent depth, traveling microscope, least count)*

**Objective(s)**:

iv. Perform an experiment to compare the refractive index of two liquids and verify the law of refraction.

**Learning Experiences:**

The teacher may deliver this lesson using structured inquiry. The teacher may provide the links https://bit.ly/34RdFEP, https://bit.ly/3qr6jAg, https://bit.ly/33vyiFN or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) to understand the concepts on law of refraction, real depth and apparent depth. The teacher may ask questions to check the learner's conceptual understanding from the links https://bit.ly/34RdFEP, https://bit.ly/3qr6jAg, https://bit.ly/33vyiFN. The teacher may describe the parts, least count and the use of a traveling microscope. The teacher may provide materials (traveling microscope, water, oil, pin/nail, saw dust/thermocol, and magnifying lens) and instruct the learner to perform an experiment to compare the refractive index of two liquids.

- The learner gathers information on the concepts law of refraction, real depth and apparent depth from the links https://bit.ly/34RdFEP, https://bit.ly/3qr6jAg, https://bit.ly/33vyiFN or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) and provides answer to the questions asked by the teacher.
- The learner explains the calculation of least count (travelling microscope).
- The learner performs an experiment to compare the refractive index of two liquids.
- Shares the findings to the teacher and classmates.

**Questions:**

1. State the laws of refraction.
2. Why is it important to know about the refractive index of liquid?
3. Calculate the least count of travelling microscope.

**Assessment:**

The teacher may use checklist/observation form/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of the law of refraction, real and apparent depth from the answers to the questions asked by the teacher using a checklist.

**Working scientifically:** Assess the learner's ability to use the traveling microscope to gather data on real and apparent depth, and mathematical computation skills in calculating and comparing refractive index of two liquids from explanation using observation form.

**Scientific values and attitudes:** Assess the learner's open-mindedness, honesty and perseverance in performing the experiment from presentation using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- Physics Practical Manual (Class XI & XII) by REC
- https://bit.ly/34RdFEP
- https://bit.ly/3qr6jAg
- https://bit.ly/33vyiFN

## 4.2.Wave Optics

4.1.1. **Wavefront and Huygens' Principle.**

*(Scope: wavefront, types of wavefronts and Huygens' principle).*

4.1.2. **Refraction and Reflection of Plane Waves using Huygens Principle.***(*

*Scope: derivation)*

**Objective(s)**:

v. Verify Huygens' principle to comprehend refraction and reflection of plane waves using interactive simulations.

**Learning Experiences:**

The teacher may deliver the lesson in the following order of instructional practices. The teacher may explain wavefront, types of wavefronts, and Huygens' principle. The teacher may provide the simulation link https://rb.gy/1ijp59 and instruct the learner to verify the law of reflection and refraction using Huygens' principle.

- The learner gathers the information on wavefront, types of wavefronts, Huygens' principle, refraction, and reflection of plane waves using Huygens principle from the presentation or relevant resources (books, handouts, internet links, etc.).
- Verifies the laws of reflection and refraction of waves using Huygens' principle from the simulation link https://rb.gy/1ijp59.

- Explains wavefront, types of wavefronts, Huygens' principle, refraction, and reflection of plane waves using Huygens principle based on information gathered.
- Prepares a presentation or a note on the concept based on information gathered and submits.

**Questions:**

1. Sketch the shape of wave front emerging from the following sources of light and also mark the rays:
    a) linear source,
    b) point source and
    c) source at infinity.
2. Prove the laws of reflection and refraction of waves using the concept of Huygen's Principle.
3. What is the significance of Huygens principle?
4. Differentiate between a ray and a wave front.
5. Draw the wave front coming out from a convex lens, when a point source of light is placed at its focus.

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding of wavefront, Huygens' principle, reflection, and refraction of plane waves using a rubric from the presentation or notes.

**Working scientifically:** Assess the learners' ability to apply Huygens' principle to explain reflection and refraction of plane waves while conducting the simulation by using a checklist.

**Scientific values and attitudes:** Assess the learner's curiosity, persistence, and creative thinking while conducting simulation using an observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)

- https://rb.gy/iu5hbv
- https://rb.gy/uigqj8
- https://rb.gy/3yhkp3
- https://rb.gy/2at9wl.
- https://rb.gy/1ijp59

### 4.2.3. Superposition of Waves.

*(Scope: superposition of waves, interference, coherence and incoherence, path difference and phase difference).*

### *4.2.4.* Interference and Young's Experiment.

*(Scope: conditions for constructive and destructive interference, locating the fringes and intensity in double-slit interference).*

**Objective(s)**:

vi. Investigate Young's experiment to understand superposition and interference of light waves using interactive simulation.

**Learning Experiences:**

The teacher may introduce the concept of superposition of waves and interference using POGIL (Process-Oriented Guided Inquiry Learning). The teacher may orient the learner on the basic concept of interference and provide the interactive simulation links https://bit.ly/3rdsBoe and https://rb.gy/shshrt that shows the superposition of waves and interference of water, sound, and light waves respectively.

- The learner gathers the information on the concept of interference and the superposition of waves from the link https://bit.ly/3rdsBoe
- Explains coherent sources, incoherent sources, path difference, phase difference, and conditions necessary for sustained interference from relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- The learner observes the interference patterns created by water, sound, and light waves from the link https://rb.gy/shshrt.
- The learner explores and explains the conditions for constructive and destructive interference in terms of path and phase differences of the two sources of light from the relevant resource (books, internet links, handouts, etc.).

- The learner carries out the Young's double slit experiment using the link https://rb.gy/shshrt and varies the parameters (slit width, slit separation, amplitude, and frequency of the light) to observe and analyse the change in the fringe width of the interference pattern.
- Relates their observations and findings on interference patterns and fringe width gathered from relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- Solves the numerical problems related to positions (linear and angular positions) of fringe and fringe width.

**Questions:**

1. State the conditions necessary for the formation of constructive and destructive interference.
2. In Young's experiment, the distance between slit and screen is doubled and separation is halved. Calculate the fringe width formed on the screen.
3. What is the difference between coherent source and monochromatic source of light?
4. A single light beam is split into two sources in Young's double slit experiment. Would the same pattern emerge if two separate sources of light, such as a distant car's headlights, were used? Explain.

**Assessment:**

The teacher may use checklist/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of interference, superposition principle, coherent and incoherent sources, path and phase differences, sustained interference, and the conditions for constructive and destructive interference using a rubric from the explanation.

**Working scientifically:** Assess the ability of the learner to determine the unknown variables, apply appropriate formulae, solve the questions, and analyse the solutions while solving the numerical problems related to linear position, angular position, and fringe width by using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to appreciate the application of waves in daily phenomena while performing the task using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- https://ophysics.com/waves4.html
- https://rb.gy/shshrt
- https://bit.ly/3fla4AK

### *4.2.5.* Diffraction.

*(Scope: diffraction of light, diffraction by single slit: locating minima, use of diffraction in the spectral analysis of the light from the star).*

**Objective(s)**:

vii. Explain the phenomena of diffraction of light and compare its intensity to that of interference.

**Learning Experiences:**

The teacher may carry out the instructional practices in the following order of activity. The teacher may provide the link https://rb.gy/shshrt that shows the diffraction of water, sound and light waves through a single slit opening and the diffraction patterns produced by various wavelengths of light.

- The learner explains the diffraction by a single slit for locating minima from relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- The learner observes the diffraction of light through a single slit opening and the diffraction patterns produced by different colours from the simulation link https://rb.gy/shshrt.
- Gathers information on conditions for the dark fringes in a single slit diffraction and solves numerical problems to locate the minima on the diffraction patterns.
- Differentiates between interference and diffraction based on the intensity patterns observed from the simulations or the information gathered from any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- The learner gathers information on components, construction, and the working of a spectrograph for spectral analysis from relevant resources and shares it to the class.

**Questions:**

1. How will a diffraction pattern change when white light is used instead of a monochromatic light?
2. Differentiate between interference and diffraction.
3. What will be the angular separation of the first order fringe from the central maximum, when a light of wavelength 500 nm is diffracted at a slit of width 0.5 mm?
4. Name some examples that we see around involving diffraction in daily life?

**Assessment:**

The teacher may use checklist/marking scheme/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept of diffraction, diffraction patterns formed by waves using a marking scheme from the presentation.

**Working scientifically:** Assess the learner's ability to apply the expression of the conditions of dark fringes to locate the minima and to explain the working of a spectrograph using a rubric. The teacher may assess the learner's ability to compare interference and diffraction based on intensity patterns from presentation using a rubric.

**Scientific values and attitudes:** Assess the learner's interest and positive attitude towards the use of diffraction in the spectral analysis of the light from the star using a checklist from explanation.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- https://rb.gy/shshrt
- https://rb.gy/eikjnq

## 4.3. Quantum Physics

### 4.3.1. Particle Nature of Light: The photon.

*(Scope: energy of photon and unit conversion in eV, photon model of electromagnetic radiation).*

### 4.3.2. Electron Emission and Photoelectric Effect.

*(Scope: electron emission, experimental study of photoelectric effect, significance of the terms work function, stopping potential and threshold frequency, wave theory of light*).

### *4.3.3.* Einstein's Photoelectric Equation: Energy Quantum of Radiation.

*(Scope: photoelectric equation, numerical problems, and conservation of energy)*

**Objective(s)**:

viii. Discuss the photon model of electromagnetic radiation and calculate energy of photon in eV.

ix. Verify Einstein's photoelectric effect to comprehend the particle nature of light using multimedia/simulation.

**Learning Experiences:**

The teacher may deliver the lesson in the following order of instructional practices. The teacher may prepare a presentation or use the links:

1. Particle nature of light: The photon: https://bit.ly/2OVtJ0k
2. Electron emission: https://bit.ly/38FGbIG Question
3. Photoelectric effect: https://bit.ly/3rQ3OWq or https://bit.ly/3cuRe8x
4. Photoelectric effect and wave theory of light: https://bit.ly/3vqvRxO

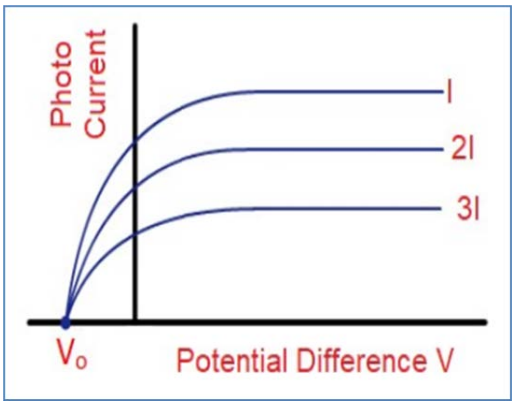
The teacher may provide the simulation link https://rb.gy/lhfk4w and instruct the learner to verify Einstein's photoelectric effect.

- The learner gathers information from the teacher's explanation or videos from the links https://bit.ly/2OVtJ0k, https://bit.ly/38FGbIG, and https://bit.ly/3rQ3OWq, https://bit.ly/3cuRe8xg, and hhttps://bit.ly/3vqvRxO to explain the concepts and phenomena of particle nature of light and photoelectric effect.
- The learner carries out the experiment on photoelectric effect from the link https://rb.gy/lhfk4w to verify and validate the observation made from the video.

- Prepares and presents the concept of photoelectric effect (including all the scopes) using PowerPoint presentation.

**Questions:**

1. What are the properties of photons?
2. A Final year Sherubtse College student was doing a practical examination to calculate the energy of photon of red and violet color. Which photon would be more energetic? Why?
3. The yellow light in a photoelectric effect can only emit electrons. Will green and red light produce photoelectrons in the same way as yellow light does?
4. The graph given illustrates the photoelectric experiment. Study the graph and then answer the questions that follow.




a) When the potential decreases, the photocurrent decreases but does not becomes zero at zero potential. Why?

b) Do the intensities of incident light affect the stopping potential or cutoff potential?

c) What do you conclude from the graph?

**Assessment:**

The teacher may use checklist/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess conceptual understanding of the particle nature of light, electron emission, photoelectric effect, photoelectric effect and wave theory of light, and Einstein's photoelectric equation from their presentation using a rubric.

**Working scientifically:** Assess the learner's ability to investigate, interpret observation, apply the knowledge and understanding in making informed decisions while conducting the simulation using

a rubric. The teacher may assess the learner's ability to recognise the significance of photoelectric effect in producing green energy using a checklist.

**Scientific values and attitudes:** Assess the learner's appreciation on wave theory of light in our daily life using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF-2021)
- https://bit.ly/2OVtJ0k
- https://bit.ly/38FGbIG
- https://bit.ly/3rQ3OWq
- https://bit.ly/3cuRe8xg
- hhttps://bit.ly/3vqvRxO
- https://rb.gy/lhfk4w

### *4.3.4.* Wave Nature of Matter.

*(Scope: de Broglie matter waves, mathematical expressions and numerical problems).*

**Objective(s)**:

x. Explain the wave nature of light through the de Broglie wave equation using multimedia.

**Learning Experiences:**

The teacher may deliver the lesson on wave nature of matter, de Broglie wave equation, Heisenberg's uncertainty principle, de Broglie wavelength of an electron, and electron diffraction or provide the links https://bit.ly/33wuJPv and https://bit.ly/3nmmhK6 or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.) The teacher may use EBA (Evidence Based Argumentation) to conduct a constructive debate on the topic: Is light a particle or a wave?

- The learner gathers information on the wave nature of matter, de Broglie equations, Heisenberg's uncertainty principle, and electron diffraction from the links

https://bit.ly/33wuJPv, https://bit.ly/3nmmhK6 or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.)

- The learner participates in the constructive debate: Is light a particle or a wave? and provides reasons and scientific evidence to support their claim.
- The learner applies the de Broglie wave equation and solves numerical problems assigned by the teacher.
- The learner submits their work through CLT or to the teacher.

**Questions:**

1. Explain what is mean by the dual nature of light?
2. What is the de Broglie wavelength?
3. Why can't we see the wave nature of matter in our everyday lives? Justify your answer with the help of an example.

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept on wave nature of matter, de Broglie hypothesis, Heisenberg's uncertainty principle, and electron diffraction using a checklist from the debate.

**Working scientifically:** Assess the learner's ability to search, organise, present and communicate during debate using an observation form. The teacher may also assess the problem solving skills and analytical reasoning skills of the learner using a rubric through questions provided.

**Scientific values and attitudes:** Assess the learner's open-mindedness and respect for views and opinions of others during debate using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF-2021)
- https://bit.ly/33wuJPv

- https://bit.ly/3nmmhK6

**Revision Question:**

1. An object is placed 20 cm from (a) a converging lens and (b) a diverging lens of focal length 15 cm. Calculate the image position and magnification in each case.
2. In air, a thin converging lens has a focal length 'f'. Explain briefly how the focal length of the lens will change if it is completely immersed in a liquid.
3. What changes in a focal length of a i) concave mirror and ii) convex lens occur when incident violet light on them is replaced with red light?
4. The power of a lens is -8 D. Find the focal length and state the nature of the lens.
5. Will the reflected rays converge at a point when a parallel beam of light is incident on a concave mirror of large aperture?
6. A convex lens is placed in contact with a plane mirror. A point object at a distance of 20 cm on the axis of this combination has its image coinciding with itself. What is the focal length of the lens?
7. A person standing before a concave mirror cannot see his image unless he is beyond the centre of curvature. Why?
8. You read a newspaper, because of the light it reflects. Then why do you not see even a faint image of yourself in the newspaper?
9. An object is placed between the pole and the focus of a concave mirror produces a virtual and enlarged image. Justify using mirror formula.
10. A converging and diverging lens of equal focal lengths are placed coaxially in contact. Find the focal length and power of the combination.
11. Although the surfaces of a goggle lens are curved, it does not have any power. Why?
12. What is the focal length of a convex lens of focal length 30cm in contact with a concave lens of focal length 20cm? Is the system a converging or a diverging lens? Ignore thickness of the lenses.
13. Huygen's principle is important in describing the nature of waves. Explain the application of Huygen's principle to describe the sound and light waves. is it possible to describe the nature of light and sound waves without Huygen's principle.

14. The modern automobile muffler senses the sound propagating down the exhaust pipe and creates a matching sound with opposite phase to reduce the ambient noise. The phenomenon used by this device is called destructive interference. Explain the formation of destructive interference and suggest the possible ways in which there are only a destructives waves.
15. If you are given a diffraction grating and prism in dispersing light for spectral analysis, which one would you choose and why?

## 5. Atomic, Nuclear, and Space Physics

Nuclear physics is the branch of physics that studies matter's constituents (protons and neutrons) and their interactions. Modern nuclear physics includes, in particular, particle physics, which is taught in tandem with nuclear physics.

Atomic physics is the study of atoms as an isolated system of electrons and an atomic nucleus. It is primarily concerned with the arrangement of electrons around the nucleus, as well as the processes that cause these arrangements to change.

Nuclear and atomic physics is important in many aspects of our lives. Nuclear power generation is one of the most well-known applications of nuclear physics. Many of today's most significant advances in medicine, materials, energy, security, climatology, and dozens of other sciences stems from the wellspring of basic nuclear physics research and development.

Space Science, also known as Space Technology, is a branch of science (or engineering) concerned with the study of the universe. Originally, all of these disciplines were considered to be a part of astronomy.

In many respects, space technology is beneficial to the world. It's a space science or aerospace industry technology that aids spaceflight, satellites, and space research. The study of the cosmos is a discipline of engineering.

Space technology has resulted in a slew of new devices and technologies. Space technology is a broad subject that requires a large number of scientists to meet its never-ending requirements. It also helps with the infrastructure of space stations and space warfare.

Above all, space technology alerts humanity to impending disasters, perhaps saving thousands of lives. Space technology provides daily services such as GPS systems, weather forecasting, and climate monitoring.

**Competencies:**

- Examine the interior components of atoms and explain the behaviour and properties of each component to explain the standard model.

- Study the concept of nanotechnology and recognise its significance and influence in our society.
- Study nuclear energy as an alternative source of energy in future to assess the pros and cons of nuclear energy.
- Identify the rocket parameters using interactive simulation to comprehend the process of rocket launch and satellite deployment.
- Examine the methods of satellite disposal and suggest ways to minimize the accumulation of defunct satellites in space.

## 5.1. Particle Physics

### 5.1.1. Standard Model.

*(Scope: elementary particles and four fundamental forces)*

### 5.1.2. Particles and Antiparticles.

*(Scope: particles and antiparticles, annihilation of particles).*

### 5.1.3. Classification of Particles.

*(Scope: classification of particles, quarks and leptons, properties of quarks, conservation laws regulating particles, change of quarks during $\beta^+$ and $\beta^-$ decay).*

**Objective(s)**:

i. Explain the interior components of atoms, its behaviour and properties using interactive simulation or video.

ii. Describe particles and antiparticles to comprehend the concept of annihilation.

**Learning Experiences:**

The teacher may deliver the lesson in the following order of collaborative learning practices. The teacher may divide the learners into different groups and provide a topic for each group and instruct them to prepare a group presentation. The teacher may provide video links https://bit.ly/3fpA79T, https://bit.ly/3rhHZ2T and https://bit.ly/3GmVhBv on standard model, particles and antiparticles, and classification of particles respectively or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.)

- The learner explores information on respective topics in groups and prepares a presentation.
- Presents or explains their group work to the class.

- Shares their presentation or note with the friends after incorporating the feedback provided by the teacher and the peer.

**Questions:**

1. Protons and neutrons are not fundamental particles. Justify.
2. Why Hydrogen is known as strongly interacted particle
3. For proton and antiproton, mention one property which is:
    a) Common.
    b) Opposite
4. Show that the charge of a proton is +1e and the charge of a neutron is zero using the quark model. Predict their baryon number and strangeness by using conservation law?
5. Explain the transformation of quarks when a proton becomes a neutron.

**Assessment:**

The teacher may use observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept of the standard model, particle, antiparticle and classification of particles using a rubric from the presentation.

**Working scientifically:** Assess the learner's ability to explain the concept, search, retrieve, organise, analyse, interpret scientific information, present, and communicate scientific ideas logically, participation, and accept constructive criticism or feedback from presentation using a rubric from presentation.

**Scientific values and attitudes:** Assess learner ability to understand standard model and its real life application by using observation form from presentation

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF-2021)
- https://bit.ly/3fpA79T
- https://bit.ly/3rhHZ2T

- https://bit.ly/3GmVhBv
- https://bit.ly/3npwDZI

### 5.1.4. Nanotechnology.

*(Scope: nanotechnology, applications and future implications).*

**Objective(s)**:

iii. Explain the concept of nanotechnology and its real-world applications.

**Learning Experiences:**

The teacher may deliver the lesson on nanotechnology in the following order of scientific inquiry. The teacher may provide the links https://bit.ly/3rgqhNi, https://bit.ly/3GqqO5C, and https://bit.ly/3zXJV4G, https://bit.ly/3I1ZUkR or other relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) to explore the information on nanotechnology and its applications.

- The learner gathers information on the concept of nanotechnology, real-world applications of nanotechnology (medical, military field, electronics, communication, etc.,), and its future implications in the digital age from the links https://bit.ly/3rgqhNi, https://bit.ly/3GqqO5C, https://bit.ly/3zXJV4G, https://bit.ly/3I1ZUkR or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- The learner explores the future applications of nanoparticles in the digital age.
- The learner prepares a conceptual animated or interactive presentation on nanotechnology, application, and future implications using any programming language or any other tools.
- Shares or uploads their work on social media or to the teacher.

**Reflective Questions:**

1. What is nanotechnology and what are its likely impacts?
2. What are the advantages of nanomaterials over bulk materials?
3. What are Carbon nanotubes? What are their important applications?
4. How can nanotechnology be used for the treatment of foot odour and brain disorder?
5. Nanotechnology is technology to manipulate and control a substance at the nanometer level. Besides numerous applications of the nanotechnologies, it poses threats to mankind. Justify by giving two examples of nanotechnology threats.

**Assessment:**

The teacher may use observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept of nanotechnology and its applications from the presentation using a rubric.

**Working scientifically:** Assess the learner's ability to analyze, interpret and communicate the information on nanotechnology using a rubric from the model.

**Scientific values and attitudes:** Assess the learner's curiosity and appreciation towards the significance of nanotechnology in real life applications from presentation using a observation form. The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF- 2021)
- https://bit.ly/3rgqhNi
- https://bit.ly/3GqqO5C
- https://bit.ly/3zXJV4G
- https://bit.ly/3I1ZUkR

## 5.2. Nuclear Energy

### 5.2.1. Nuclear Energy.

*(Scope: nuclear energy, mass defect, binding energy, nuclear stability, thermal neutrons).*

**Objective(s)**:

iv. Explain mass defect and binding energy per nucleon and solve numerical problems.

v. Interpret the curve of average binding energy per nucleon against nucleon number.

**Learning Experiences:**

The teacher may use the 5E model to deliver the concept of nuclear energy, mass defect, and binding energy. The teacher may provide the link https://bit.ly/3fl83ET or use any other available resources

(books, handouts, internet links, downloaded digital conten, etc.,) on nuclear binding energy and mass defect.

- The learner engages in a class activity to discuss their prior knowledge on atomic number, mass number, and mass defect.
- The learner explores relevant resources to gather information on the concept of nuclear binding energy and mass defect from the link https://bit.ly/3fl83ET.
- The learner uses the information and explains the concept of nuclear energy, mass defect, and binding energy per nucleons.
- The learner elaborates on the mass defect and derives the mathematical expression of mass defect. The learner uses the concept of binding energy per nucleon to interpret and elaborate on the curve of average binding energy per nucleon against mass number.
- The learner evaluates their understanding on nuclear energy, mass defect, and binding energy by answering the questions assigned by the teacher and solving numerical problems based on mass defect and binding energy.
- The learner relates or identify the right atom to be used for the production of energy

**Questions:**

1. Neutrons are regarded suitable particles for nuclear fission reactions when compared to other particles. Why?
2. The binding energy per nucleon of particle is 7.07 MeV. What do you mean by this statement?
3. Large nuclei are unstable. Explain.

**Assessment:**

The teacher may use checklist/marking scheme/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the description on nuclear energy, mass defect, and binding energy from information gathered using a checklist.

**Working scientifically:** Assess the learner's ability to interpret graphs, solve related problems by using appropriate formulae from the question provided and explanation, using a marking scheme and a checklist.

**Scientific values and attitudes:** Assess the learner's determination to solve numerical problems on mass defect and binding energy and relate the applications of nuclear energy in various fields using a checklist.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF-2021)
- https://bit.ly/3fl83ET

### 5.2.2. Nuclear Fission: The basic process.

(*Scope: nuclear fission, nuclear chain reaction-controlled and uncontrolled, nuclear fission reactor, peaceful and destructive applications of nuclear fission).*

**Objective(s)**:

vi. Evaluate the useful and destructive applications of nuclear fission.

**Learning Experiences:**

The teacher may deliver the lesson on nuclear fission in the following order of instructional practices. The teacher may explain thermal neutron, nuclear fission, chain reactions, and reactor and provide the simulation link https://bit.ly/3eJibIe to supplement the information.

- The learner gathers information on the concept of nuclear fission from the teacher's explanation and from the link https://bit.ly/3eJibIe provided by the teacher or from any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- The learner explains nuclear fission from the simulation link https://bit.ly/3eJibIe or from the information gathered.
- Examines the useful and destructive applications of nuclear fission from any relevant resources (books, handouts, internet links, downloaded digital conten, etc.,) and presents to the class and incorporates necessary feedback from the peers and the teacher.
- Recommends the best way to use the nuclear fission reaction for social and economic benefits.

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of nuclear fission using a checklist from the learner's explanation.

**Working scientifically:** Assess the learner's ability to use simulation to interpret observation, and gather evidence on useful and destructive applications of nuclear fission using a rubric from explanation.

**Scientific values and attitudes:** Assess the learner's attitude on adoption of nuclear fission and its usefulness application and recommendation on the best way to use the nuclear fission reaction for social and economic benefits by using observation form from explanation.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF, 2021)
- https://bit.ly/3I8wWzZ
- https://bit.ly/3qzNJ9f
- https://bit.ly/3eJibIe

**5.2.3. Nuclear Fusion: The basic process.**

*(Scope: nuclear fusion, thermonuclear fusion in the Sun and other stars-CNO Cycle and P-P cycle, controlled thermonuclear fusion, advantages of nuclear fusion as a potential energy source over nuclear fission).*

**Objective(s)**:

vii. Compare and contrast nuclear fission and nuclear fusion.

**Learning Experiences**

The teacher may deliver the lesson on nuclear fusion based on the following order of DBGL (Digital Based Game Learning). The teacher may deliver the introductory lesson on the concept of nuclear

fusion from the links https://bit.ly/3qpuw9S and https://bit.ly/3np0EZv or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.) The teacher may explain the concept of Thermonuclear cycle in the sun from the links https://go.nasa.gov/3FsjLry and https://bit.ly/33BjPrK or any other resources (books, handouts, internet links, downloaded digital conten, etc.)

- The learner explains the concept of nuclear fusion and fusion reactions from the links https://bit.ly/3qpuw9S and https://bit.ly/33AZNh5
- The learner explains thermonuclear fusion from the link https://go.nasa.gov/3FsjLry or any other relevant resources (books, handouts, internet links, downloaded digital conten, etc.)
- The learner gathers information on controlled thermonuclear fusion and thermonuclear reactors from any relevant resources (books, handouts, internet links, etc.).
- The learner's explains the thermonuclear fusion in the Sun and other stars-CNO Cycle and P-P cycle from the link https://bit.ly/3rkw8ku
- Compares and contrasts nuclear fission and nuclear fusions based on the information gathered.
- The learner participates in a constructive debate on nuclear fusion as a potential source of energy over nuclear fission.
- Prepares a note or a presentation based on their understanding of the lesson and submit through CLT.

**Questions:**

1. Fusion reaction has more advantages than fission reaction. Do you agree with this statement? Justify your answer
2. What are the two sets of thermonuclear fusion reactions that occur inside the sun and star?

**Assessment:**

The teacher may use checklist/observation form/rubrics/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of nuclear fusion, thermonuclear fusion in the Sun and other stars, controlled thermonuclear fusion, comparison between nuclear fission and fusion and the advantages of nuclear fusion over nuclear fission from the note or presentation submitted by the student using a rubric.

**Working scientifically:** Assess the learner's ability to explore, organise, and compare nuclear fission and fusion using a checklist from the presentation.

**Scientific values and attitudes:** Assess the learner's belief and trust with the usefulness of energy generated from thermonuclear fusion using observation form from the presentation.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Fundamentals of Physics Class 12 by Wiley (Reprint 2019)
- National School Science Curriculum Framework (NSSCF, 2021)
- https://bit.ly/3qpuw9S
- https://go.nasa.gov/3FsjLry
- https://bit.ly/33AZNh5
- https://bit.ly/3rkw8ku

### 5.3. Space Science and Technology: Satellite Development

#### 5.3.1. Processes of Satellite Development.

*(Scope: mission definition review, preliminary design review, critical design review, safety review).*

**Objective(s):**

viii. Explain satellite development processes to develop a model of an artificial satellite.

**Learning Experiences:**

The teacher may deliver the lesson in the following order of scientific inquiry. The teacher may instruct the learner to explore the information on development of satellites from any relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to gather information to develop a model of an artificial satellite.

- The learner defines the mission of the satellite by simulating stakeholder consultation scenarios, needs analysis, literature review, and cost-benefit analysis.
- The learner proposes a preliminary design (conceptual design) depending on the availability of components and system integration feasibility.

- The learner considers factors of the space environment such as launch vibrations or shock, radiations, temperature to foolproof the design (critical design review).
- Based on the type of launch vehicles and their safety requirements, the learner verifies if the satellite is fit to qualify for flight.

**Assessment:**

The teacher may use rating scale/rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of the process of satellite design (*Mission definition review, Preliminary design review, Critical design review, Safety review)* from explanation using a checklist.

**Working scientifically:** Assess the learner's ability to plan and propose the design of a mission, identify the factors of the space environment in the designing of a mission by using a rubric.

**Scientific values and attitudes:** Assess the learner's curiosity, innovativeness, financial awareness of a mission and creativeness to design a mission on launching a rocket and stationing satellite using a rubric/rating scale.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Understanding Space: an introduction to astronautics by Sellers et. al (2004)
- Science Curriculum Framework 2022 (SCF, 2022)

### 5.3.2. Orbital Mechanics and Satellite Launch.

*(Scope: Kepler's laws, rocket technology)*

**Objective(s):**

ix. Explain the concept of rocket launch technology.

**Learning Experiences:**

The teacher may deliver lessons on orbital mechanics and satellite launch in the following order of digital game based learning. The teacher may provide the simulation link https://rb.gy/b13jqg or video links https://bit.ly/3qmAPL1 and https://bit.ly/3A1SdbB or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to explain Kepler's laws. The teacher may provide the video links https://bit.ly/3K8glOA and https://bit.ly/3fllVyO or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to explain rocket launching technology and stationing of the satellite around earth. The teacher may provide the game links https://rb.gy/sc8hn8 and https://iss-sim.spacex.com/ to simulate the rocket launch by incorporating all the factors required for successful launch and docking.

- The learner explains the Kepler's laws from the simulation link https://rb.gy/b13jqg
- The learner gathers information on the concept of rocket technology to launch the satellite from the video links https://bit.ly/3trPM0W and https://bit.ly/3tnG1AI or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.).
- The learner explains the rocket launch and docking from the game links https://rb.gy/sc8hn8 and https://iss-sim.spacex.com/ or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.)
- The learner develops a physical or conceptual model of a spacecraft (satellite or rocket) to explain concepts of satellite or rocket technology and explain to the whole class.

**Questions:**

1. State Kepler's second laws of planetary motion and its application in space exploration.
2. An artificial satellite orbits the planet without consuming any fuel. But why is it that an airplane needs fuel to fly at a given altitude?
3. A remote sensing satellite of earth revolves in an orbit at a height of $0{,}25\times10^6$ m above the surface of earth. Find the orbital speed and the period of revolution of the satellite. Given earth radius, $R_e = 6.38\times10^6\ m$ *and* $g = 9.8\ ms^{-2}$

**Assessment:**

The teacher may use rating scale/rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the conceptual understanding of the Kepler's laws and satellite launch from explanation using a checklist.

**Working scientifically:** Assess the learner's ability to design, develop and produce a physical or conceptual rocket model using rubric.

**Scientific values and attitudes:** Assess the learner's curiosity, creativity, and innovativeness in developing the physical or conceptual rocket model using a rating scale. The teacher may also assess the significance of a rocket in launching a satellite using a rubric. The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository.
- Understanding Space: an introduction to astronautics by Sellers et. al (2004).
- Science Curriculum Framework 2022 (SCF, 2022).
- https://bit.ly/3noEo1M
- https://bit.ly/3I8smlf
- https://bit.ly/3trPM0W
- https://bit.ly/3tnG1AI

**5.3.3. Satellite Subsystems and Satellite Tracking or Operation.**

*(Scope: command and data-handling subsystem (CDHS), electrical power system (EPS), environmental control and life-support subsystem (ECLSS), onboard computer (OBC), structures and mechanics, satellite ground station, satellite tracking, satellite operation).*

**Objective(s)**

x. Explain earth segment subsystems to investigate transmission and reception of signals from satellites and describe space segment subsystems to comprehend how satellites are stationed in a particular orbit.

**Learning Experiences:**

The teacher may carry out the lesson on satellite subsystems and satellite tracking in the following order of instructional practices. The teacher may provide the video link https://youtu.be/p-xUcjGhhmk or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to gather information on the satellite subsystems.

- The learner gathers information from the video link https://youtu.be/p-xUcjGhhmk or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to conceptualize the working of satellite subsystems (CDHS, EPS, ECLSS, OBC) and explains the system using block diagrams.
- The learner explains the structural design and mechanics of a spacecraft that supports the mission based on information gathered from relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.)
- The learner gathers information on satellite ground station, satellite tracking, and satellite operation and creates a block diagram to explain satellite communication.
- Prepares a presentation on satellite communication using any programming language or interactive presentation tools and shares the work in any social media.

**Questions:**

1. Explain communication and data handling subsystem (CDHS).
2. Design the functional and operational requirement of the weather forecasting satellite to transform the mission objective into a designing process.

**Assessment:**

The teacher may use observation form/rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concepts on satellite subsystems, the structures and mechanics of a satellite, satellite ground station, satellite tracking, operations, and satellite communication from explanation using a checklist.

**Working scientifically:** Assess the learner's ability to explore and gather information, communicate ideas, and recognise the significance of satellite subsystems and satellite tracking from explanation using a rubric.

**Scientific values and attitudes:** Assess the learner's curiosity, intellectual drive and appreciation of modern technology through satellite communication from presentation using an observation form.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Understanding Space: an introduction to astronautics by Sellers et. al (2004)
- New Normal Curriculum Framework in Science (NNCFS-2021)
- https://youtu.be/p-xUcjGhhmk

**5.3.4. The Space Environment.**

*(Scope: major hazards of the space environment, living and working in space).*

**5.3.5. Satellite Disposal.**

*(Scope: end of life of a satellite, disposal, space debris management)*

**Objective(s):**

xi. Identify the elements of the space environment to minimize space hazards.

**Learning Experiences:**

The teacher may use REI (Research, Evidence, Inference) to deliver the lesson on the concept of a space environment in the following order of activity. The teacher may provide the article link https://go.nasa.gov/3twxNGF and video link https://bit.ly/3HYrKym or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to explain the concept of space, space environment, major hazards of the space environment, and their effects on spacecrafts.

The teacher may provide the video links https://youtu.be/HVov8o9x0yI and https://youtu.be/w_PWL0oZzOc or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to explain the concept of space disposal and space debris management.

- The learner explores the information on the space environment and spacecraft from the article link https://go.nasa.gov/3twxNGF and video link https://bit.ly/3HYrKym or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.) .
- The learner prepares a presentation and presents their explanations on the major environmental hazards (gravity, atmosphere, radiation, vacuum, micrometeoroids and space junk, and charged particles) that affect the spacecraft in the Earth's orbit.

- The learner explains the end of life of a satellite, satellite disposal, and space debris management using information gathered from the video links https://youtu.be/HVov8o9x0yI and https://youtu.be/w_PWL0oZzOcI or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) and shares it to the class.
- The learner's suggest ways to remove satellite debris in space to reduce hazards of the space environment in line with the GNH philosophy.

**Questions:**

1. What are the major hazards of the space environment?
2. If you get an opportunity to design a space satellite, for what purpose would you design it and why? Suggest one innovative way to remove your satellite from space once it expires.

**Assessment:**

The teacher may use rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the concept of space, space environment, and the major hazards of the space environment from explanation using a checklist.

**Working scientifically:** Assess the learner's ability to explore relevant materials, gather and organise information, and communicate the major hazards of the space environment, their effects on spacecrafts from the presentation delivered by the learner using a rubric.

**Scientific values and attitudes:** Assess the learner's ability to suggest ways to remove satellite debris in space to reduce hazards of the space environment in line with the GNH philosophy from the presentation using rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Understanding Space: an introduction to astronautics by Sellers et. al (2004)
- Science Curriculum Framework 2022 (SCF, 2022)
- https://go.nasa.gov/3twxNGF

- https://bit.ly/3HYrKym
- https://youtu.be/HVov8o9x0yI
- https://youtu.be/w_PWL0oZzOc

### 5.3.6. Space Law and Regulations.

*(Scope: international space treaties, registration convention, frequency regulations, international governing bodies such as international telecommunications union [ITU], united nations office for outer space affairs [UNOOSA]).*

**Objective(s):**

xii. Study the space laws and regulations to create awareness that all nations have equal opportunity and accountability to explore space.

**Learning Experiences**

The teacher may use REI (Research, Evidence and Inference) to carry out lessons on international space treaties, registration convention, frequency regulations and international governing bodies as ITU and UNOOSA in the following order of instructional practices. The teacher may provide the link https://bit.ly/3bPsBnQ and video link https://bit.ly/33mWkmy or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.,) to carry out research or literature review on international space treaties and registration conventions.

- The learner carries out research or literature review on international space treaties and registration conventions from the links https://bit.ly/3bPsBnQ and https://bit.ly/33mWkmy or any other relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.).
- The learner researches on frequency regulations from the link https://bit.ly/30KeXMr
- The learner studies the space treaties, laws and regulations, frequency regulations from the link https://bit.ly/30JePg2 and information on international regulatory bodies (ITU and UNOOSA) from any relevant resources and explores their basic roles.
- The learner discusses in group to share their ideas and infer the basic ideas on the topics researched, prepare the comprehensive write up and share it with the class or submits to the teacher for the assessment.

**Questions:**

1. Explain the space laws and regulations.

**Assessment**

The teacher may use rubrics/checklist/any other relevant assessment tools by incorporating the following components in the three domains:

**Scientific knowledge:** Assess the learner's conceptual understanding on international space treaties, registration convention and frequency regulations from explanation using a rubric.

**Working scientifically:** Assess the learner's scientific skills of research, data interpretation and communication from presentation using rubric.

**Scientific values and attitudes:** Assess the learner's awareness on space laws and regulations to appreciate the impact of space laws and regulations for harmonious and just society from presentation using a rubric.

The teacher may provide necessary intervention based on need.

Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

**Resources:**

- REC repository
- Understanding Space: an introduction to astronautics by Sellers et. al (2004)
- Space Mission Engineering: The New SMAD (Space Technology Library, Vol. 28)
- https://bit.ly/3bPsBnQ
- https://bit.ly/33mWkmy
- https://bit.ly/30JePg2
- https://bit.ly/30KeXMr

**Revision Questions**

1. The work functions of metals A, B, C and D are 5.2 eV, 2.0 eV, 6.3 eV and 3.5 eV respectively. Which metal is the (i) most photosensitive? (ii) least photosensitive?
2. The threshold wavelength for tungsten is 2400 . When tungsten is illuminated with light of wavelength 1600, find

   i) Work function

ii) Maximum kinetic energy of the emitted electrons

iii) Stopping potential.

3. Nuclear reactor is a device where controlled fission reaction produces steady amount of energy. What are the things you need to take into account for a successful operation of nuclear reactor?
4. A satellite A with mass m orbits the earth at a distance of r from its center. Another satellite, B, with a mass of 2m, orbits the earth at a distance of 2r from its center. Calculate the ratio of their time periods.
5. Engineers began designing rocket pieces that could be recovered and reused in the 1980s with NASA's space shuttle. What are some of the advantages of reusing rocket parts?

***Annexure 1***

## Weighting and Time Allocation_class XI

| Theme | Topics | Time in Minutes | Weighting |
|---|---|---|---|
| Newtonian Mechanics | Motion in a Straight Line | 672 | 9 |
| | Motion in a Plane | 676 | 8 |
| | Laws of Motion | 754 | 10 |
| | Mechanical Properties of Solids | 458 | 6 |
| | Work and Energy | 396 | 5 |
| Fluid Mechanics and Thermal Physics | Thermal Physics | 284 | 4 |
| Electricity and Magnetism | Magnetic Fields | 654 | 8 |
| | Electric Circuit | 694 | 10 |
| Waves and Optics | Ray Optics | 476 | 8 |
| | Waves | 396 | 4 |
| | Electromagnetic Waves | 672 | 9 |
| Atomic, Nuclear, and Space Physics | Atoms | 254 | 5 |
| | Radioactive Decay | 314 | 7 |
| | Space Applications | 500 | 7 |
| **Total** | | **7200** | **100** |

***Annexure 2***

## Weighting and Time Allocation_class XII

| Theme | Topics | Time in Minutes | Weighting |
|---|---|---|---|
| Newtonian Mechanics | Oscillations | 864 | 12 |
| Fluid Mechanics and Thermal Physics | Fluid Mechanics | 406 | 7 |
| | Kinetic Theory of Gases | 266 | 3 |
| Electricity and Magnetism | Electricity | 306 | 4 |
| | Capacitors | 306 | 4 |
| | Electromagnetic Induction | 612 | 9 |
| | Electric Circuit | 805 | 12 |
| Waves and Optics | Ray Optics | 649 | 10 |
| | Waves Optics | 725 | 9 |
| | Quantum Physics | 562 | 8 |
| Atomic, Nuclear Space Physics | Particles Physics | 522 | 7 |
| | Nuclear Energy | 459 | 7 |
| | Satellite Development | 718 | 8 |
| **Total** | | **7200** | **100** |