National School Curriculum

INSTRUCTIONAL GUIDE FOR PHYSICS

CLASSES IX & X

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, themes based and problems based orientation that allows 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 Science 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 21st 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).

Therefore, in the process of making the Instructional Guide, study of its strength and weakness and feedback from the field were collated. The invaluable information and expertise from diverse fields informed the selection of its design and deleopment. The evolving global trends in education and the national priorities inspire the implementation of the curriculum. Towards ensuring that the curriculum is relevant and appropriate for all through the time, rigorous assessmenett and evaluation shall inform its efficacy, opportunities and challenges, which in recirpocation guide the future plans.

Class IX

1. Newtonian Mechanics

Newtonian mechanics is a branch of physics that deals with forces and its effects on objects. It includes concepts of basic quantities in which the relationship between the speed, velocity, acceleration and their parameters provide information about the motion of bodies. It also includes concepts such as Newton's laws of motion, and kinematics. Thus, it forms the basis for learner's problem-solving skills, applying forces to infer body motions and good technique in breaking down word problems

Competencies:

- Analyse and communicate the inferences of motion graphs by using mathematics and Computer Assisted Instruction (CAI) tools and apps to comprehend the nature of motion through graphical representation.
- Use natural phenomena and modern technology to construct concepts on effects of forces in opposite directions and relate them to everyday life.
- Investigate the concept of momentum experimentally and solve numerical problems using equations of linear motions related to real life situations.
- Experiment the laws of motion and use the concept to explain the applications of these laws on real-life situations.
- Carry out scientific investigation to substantiate the mathematical relationship among the net force, mass, and acceleration to predict the motion of an object.

1.1. Force and Acceleration

1.1.1. Graphical Representation of distance-time graph and velocity-time graph

(Scope: representation and interpretation of speed, velocity and acceleration from distance time graph and velocity time graph)

Objective(s):

i. Illustrate distance-time graph and velocity-time graph manually and using CAI tools.

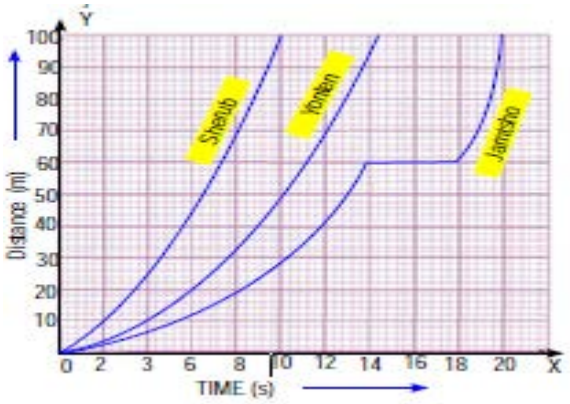
Learning Experiences:

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 speed and velocity, distance-time graph, velocity-time graph, and provide hypothetical data to deliver the lesson as follows:

- The learner may watch videos from the links https://youtu.be/Xo3KBoEMDEo, https://youtu.be/apewLkLAR-U, https://youtu.be/vxFYfumAAlY to engage in reflection on the concept of distance, speed and acceleration. The learner may also reflect on the concept through hands-on activities.
- Explores the distance-time and velocity-time graphs by carrying out practical demonstrations or using hypothetical data provided by the teacher.
- Plots graphs using graph paper and CAI tools to explain distance-time graphs.
- The learner elaborates on the concept of distance-time or velocity-time graph to construct and explain graphs using available data.
- Shares their work for feedback and validation by peers and the teacher to draw generalisation on the concepts.

Questions:

1. Graph below shows how Sherab, Yonten, and Jamtsho ran a 100 metres dash during an Annual School Sports Day.



   a. Who won the race? Explain your answer.
   b. Who stopped for a rest? Explain your answer.
   c. How long was the rest? Explain your answer.
   d. What is the time taken by the runner-up in the race?
   e. Calculate the average speed of Jamtsho.

2. Tshering rides a bike along a straight highway. The following table gives the velocity of his bike at various intervals of time:

Time(s)	0	5	10	15	20	25
Velocity (ms^{-1})	5	10	15	20	25	30

Answer the following questions:

a. Draw a velocity-time graph using CAI or graph paper for the above motion.
b. Calculate the acceleration of the bike.
c. What is the total distance travelled by Tshering at the end of the journey?
d. What is the significance of this epereince to our life?

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 comprehension of the concept of speed, velocity, and acceleration from the explanation using a checklist.

Working scientifically: assess the learner's skills to record data, plot graphs (manually and using CAI tools), interpret the concept of velocity and acceleration from the graph.

Scientific values and attitudes: assess the learner's ability to relate or connect the concept with real life situations using question and answer techniques or online assessment tools.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/Xo3KBoEMDEo
- https://youtu.be/apewLkLAR-U
  https://youtu.be/vxFYfumAAlY

1.1.2 **Balanced and Unbalanced Force**

(Scope: resultant force due to balanced and unbalanced forces to determine the state of a body)

Objective(s):

ii. Describe the effects of balanced and unbalanced force to determine the state of a body.

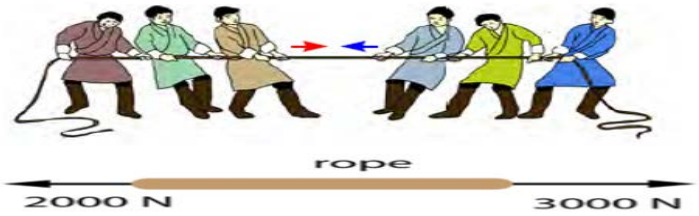
Learning Experiences:

The teacher may deliver the lesson in the following order of activity. The teacher may provide the worksheet to note down the effects of balanced and unbalanced force based on the data collected from the simulation link https://bit.ly/3tnNGvp

- The learner varies the forces to see the effect of balanced and unbalanced force from the simulation link https://bit.ly/3tnNGvp
- Records the forces in use, initial state of a body, the net force, and final state of a body in the worksheet.
- Infers the effects of balanced and unbalanced force based on the information gathered and relates the concept to the real life situations.

Questions:

1. The figure below shows two teams pulling a rope in opposite directions to each other (tug-of-war). The arrows show the magnitude and the direction of the forces. What is the resultant force?



2. A book placed on a table does not move. Identify the forces in action and justify why the book does not move.
3. What type of force should be applied to move the book?

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 the effect of balanced and unbalanced force while sharing inferences using a rubric.

Working scientifically: assess the learner's ability to record data, calculate the resultant force and draw inferences from the simulation using a rubric.

Scientific values and attitudes: assess the learner's ability to relate the concept in their daily life situations while sharing inferences using a rubric.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://bit.ly/3tnNGvp

1.1.3. **Momentum of a Body**

(Scope: explanation, mathematical expression, simple numerical problem, and applications).

Objective(s):

iii. Investigate variables that describe the momentum.

Learning Experiences:

The teacher may carry out the instructional practices on momentum and its variables based on the following order of CER (Claim, Evidence and Reasoning) model. The teacher may set the tone to create a claim by the learner with question(s) or example(s) after conducting a demonstration of momentum using available materials.

- Learners make a claim about variables used to describe momentum based on teacher's demonstration or from the link https://youtu.be/0zxTIn67q3Y
- The learner performs the experiment using available materials to gather the evidence to validate their claim.
- The learner justifies their claim with the evidence based on mass and velocity, and solves related numerical problems.
- The learner relates and explains its applications in real life situations.

Questions:

1. Sonam and Wangchuk are taking part in a long jump event during their school's annual sports day. Sonam ran a few distances before taking the jump while Wangchuk jumped without running. Who will jump furthest? Justify your answer.
2. Tshen Tashi shot a lawn tennis ball and a cricket ball of the same size to a window glass. Which one will have more impact? Justify.

Assessment:

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

Scientific knowledge: assess the comprehension of the learner to identify and explain the variables that describe momentum while giving reasons using a checklist.

Working scientifically: assess the learner's ability to solve related numerical problems using a checklist.

Scientific values and attitudes: assess the learner's ability to relate or connect the concept in their daily life situations using a checklist.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/0zxTIn67q3Y

1.1.4 Equations of Linear Motion

(Scope: linear motion equations and simple numerical problems)

Objective(s):

iv. Apply three equations of linear motion to solve simple numerical problems related to real life experiences.

Learning Experiences:

The teacher may use the Flipped Classroom model to teach the concept related to equations of linear motion. The teacher provides learning resources (books, internet links, handouts, downloaded digital

content, articles, video links https://youtu.be/GX5zToM_Vvg and https://youtu.be/WJN_F3PYp58 etc.) and facilitates discussion and numerical problem solving.

- The learner explores relevant information on linear equation from the resources (books, internet links, handouts, downloaded digital content, articles, video links https://youtu.be/GX5zToM_Vvg and https://youtu.be/WJN_F3PYp58 etc.)
- Takes note of the variables used in equations of linear motion, use of equations of motion, and reflects on the points for clarification and discussion before the learning session.
- Discuss and solve numerical problems during the learning session.
- Solves the questions provided by the teacher and submits for the assessment.

Questions:

1. Complete the table below. *(Provide some situation or context before proving this DART related activity,)*

Quantity	Condition during motion	Magnitude
Initial velocity	Starts from rest	……
Final velocity	……	zero
…….	Moves with uniform velocity	zero

2. The school is 1 km away from a teacher's house. A teacher driving to the school has an acceleration of 20 m/s^2. When starting from rest, what would be the distance travelled in 10 seconds? How much more distance does the teacher have to travel to reach the school?

Assessment:

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

Scientific knowledge: assess the learner's conceptual understanding of variables used in the equation, and use three equations of linear motion to solve numerical problems using a checklist.

Working scientifically: assess the learner's ability to solve numerical problems using a marking scheme.

Scientific values and attitudes: assess their abilities to relate the significance of the equations of linear motion in daily activities using a checklist.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/GX5zToM_Vvg
- https://youtu.be/WJN_F3PYp58

1.1.5 Newton's First Law of Motion

(Scope: inertia of rest and motion, and applications)

Objective(s):

v. Apply the concept of Newton's first law of motion to design a simple model that explains the benefits of wearing a seat belt.

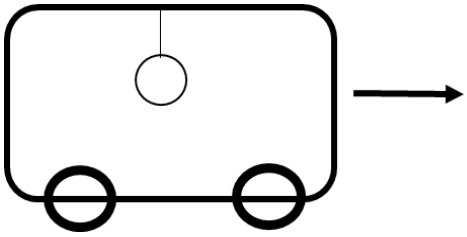
Learning Experiences:

The teacher may introduce the lesson on inertia, types of inertia, and the law of inertia to familiarise the learner with the terminologies and foundational concepts. The teacher may design an activity and instruct the learner to carry out the investigation to exhibit the applications of inertia of rest and motion in the following order of POGIL (process-oriented guided inquiry learning) approach.

- The learner familiarises the basic concepts and terminologies to explain the law of inertia through a group discussion or teacher's interactive powerpoint presentation or using the links https://youtu.be/1XSyyjcEHo0 and https://youtu.be/5oi5j11FkQg.
- The learner uses everyday examples related to rest and motion to explore the applications of the law of inertia.
- The learner gathers information to design a simple model that explains the benefit of wearing a seat belt while travelling in a car.
- The learner shares their generalisation based on the model to the class and relates the significance of the law of inertia in daily life.

Questions:

1. The seat belt was invented in the late 1800s by an English Engineer, George Cayley, to help stop pilots from falling out of their gliders. Then, it was first used in 1885 to prevent ejection from horse-drawn carriages. The restraints were used later on air planes and racing cars. Why are seat belts used in cars?
2. In the figure below, the arrow represents the direction of motion of the car initially at rest. What will happen to the ball hanging from the roof of the car if the moving car suddenly stops?



Assessment:

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

Scientific knowledge: the teacher may assess the concept of inertia, its types and the law of inertia while explaining using a rubric.

Working scientifically: assess the learner's ability to follow instructions, and improvise the model during the learning process using an observation form.

Scientific values and attitudes: The teacher may assess the learner's ability and incorporate feedback during model improvisation and to relate the significance of the law of inertia in daily life using a checklist.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/1XSyyjcEHo0
- https://youtu.be/5oi5j11FkQg

1.1.6 Newton's Second Law of Motion

(Scope: relation among force, mass and acceleration, simple numerical problems)

Objective(s):

vi. Conduct an investigation to support the claim that Newton's second law of motion describes the mathematical relationship among the net force, mass, and acceleration.

Learning Experiences:

The teacher may use a confirmation inquiry model to deliver the lesson on Newton's second law of motion. The teacher may ask the guiding question related to force, mass, and acceleration. The teacher may provide the learner with relevant learning resources (books, internet links, handouts, downloaded digital content, articles, video link https://youtu.be/vaz8J5jBSQQ, simulation link https://bit.ly/3qOM2BB etc.), procedures to carry out the experiment, solve numerical problems, and guide the learner through learning experiences.

- The learner explores the relevant information from the resources (books, internet links, handouts, downloaded digital content, articles, video link https://youtu.be/vaz8J5jBSQQ, etc)
- Carries out the experiment or uses the simulation link https://bit.ly/3qOM2BB to explore the relationship between variables used in Newton's second law.
- Collects and analyses data to draw a relationship between the net force, mass, and acceleration.
- Constructs a mathematical relation and uses it to solve numerical problems.

Questions:

1. Phuntsho after completing his 1500 m race was made to come to a halt gradually by his school sports instructor (SSI). Why was he not exhorted to stop instantly?
2. Prove that Newton's first law is contained in Newton's second law of motion.
3. On one sunday students travelling to work in tractors were affected by the jerks of the tailor. Therefore, the teacher provided an option to use a wooden plank or cotton cushion to sit on. If you are a student, which one would you use? Justify.

Assessment:

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

Scientific knowledge: assess the concept of Newton's second law of motion, and relation among three variables while they solve the problem using a rubric.

Working scientifically: assess the learner's ability to carry out an experiment, draw inferences, solve numerical problems, analyse data from experiment or simulation using a rubric.

Scientific values and attitudes: assess the learner's ability to relate to the applications of law in daily life situations using a rubric.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/vaz8J5jBSQQ
- https://bit.ly/3qOM2BB

1.1.7 Newton's Third Law of Motion

(Scope: qualitative explanation and applications)

Objective(s):

vii. Design a model to demonstrate and relate the concept of Newton's third law of motion to real life situations.

Learning Experiences:

The teacher may use a three phase guided learning cycle (Exploration phase, Concept invention phase and Application phase) to deliver the lesson on the explanations and applications of Newton's third law of motion. The teacher may guide the learner to plan and design a working model to demonstrate Newton's third law of motion (eg. a d.c. motor driven boat).

- The learner explores the information related to Newton's third law of motion from any learning resources (books, internet links, handouts, downloaded digital content, articles, video link https://youtu.be/y61_VPKH2B4 etc.) or daily experiences.
- Plans and designs a working model to demonstrate Newton's third law of motion.
- Demonstrates the working of the model to verify Newton's third law of motion.

- Uses two identical spring balances to verify and validate the existence of equal and opposite forces.
- Explains Newton's third law of motion based on evidence gathered and relates the concept to real life situations.

Questions:

1. "There is a cause-effect relation in Newton's third law" Justify.
2. There are two equal and opposite forces in action to qualify as Newton's third law of motion. Elucidate on the net force of these two forces.
3. Reflection is defined as bouncing back of waves. Is the reflection of sound and light waves an example of Newton's third law? Justify your answer.

Assessment:

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

Scientific knowledge: assess the learner's comprehension of the concept of Newton's third law of motion and its applications during explanation using a checklist.

Working scientifically: assess the scientific skills (observation, questioning, gathering evidence, designing model, drawing inferences) of the learner through observation using an observation form.

Scientific values and attitudes: assess the ability of the learner to relate the significance of the law in daily life using observation form.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/y61_VPKH2B4

Revision Questions:

1. A Biker travels with a constant velocity of 20 m/s for 5 s. The brakes are then applied and the bike is uniformly decelerated until it comes to rest in further 8 s. Hence,

i. Draw a velocity time graph for the motion.

ii. find the distance travelled by bike in the first 5 s.

iii. find the distance travelled after the brakes are applied.

iv. find the total distance covered.

v. find acceleration in first 5 s and deceleration in last 8 s.

2. Unbalanced forces acting on a body may not change the dimension and balanced forces may change the dimension. Justify.
3. A criketball of mass 0.5 kg and a tennis ball of mass 0.75 kg possess equal momentum. What is the velocity of a tennis ball if the baseball is moving at 21 m/s?
4. Students want to measure the height of their school building. So, they dropped a stone from the top. The stone took 1.2 seconds to hit the ground. Calculate the height of the building.
5. Inertia is the property dependent on mass. Justify.
6. A force of 10 N is applied to a mass m_1 and m_2 gives an acceleration of 4 m/s^2 and 12 m/s^2 respectively. Calculate the acceleration if both the masses are tied together.

2. Fluid Mechanics and Thermal Physics

Fluid mechanics is the study of fluid behavior at rest and in motion. Fluid mechanics enables us to understand the behavior of fluids under various forces and atmospheric conditions. Further, it helps us to identify a variety of applications in mechanical and fluid engineering. Among several applications of fluid mechanics, this theme includes the role of fluid-upthrust as elucidated by Archimedes' principle and principle of floatation and in metrology for weather forecasting.

Heat is a type of energy that can be used for a variety of purposes. We cook with heat energy from various sources, such as firewood, LPG, or electricity. Our wet clothes dry as a result of the sun's heat energy. In the winter, we use heat energy from the sun or an electric heater to keep warm because heat energy can be transferred from one body to another, all of these things are possible. Temperature is an important factor in determining heat energy transfer because the temperature difference allows the heat energy to be transferred.

Competencies:

- Experiment and communicate the results of fluid pressure to relate its applications in mechanical and fluid engineering.
- Elucidate phenomena based on the result of an investigation on Archimedes' principle to comprehend the applications of Archimedes' principle and principle of floatation and design any model based on Archimedes' principle and principle of floatation.
- Measure the temperature of the bodies in different scales and convert it from one scale to another scale to understand relationships among various temperature measuring scales.
- Carry out an experiment to investigate the mode of transfer of thermal energy (heat) to apply the concept in designing heat efficient devices.
- Describe and apply the conceptual understanding of thermal expansion of matter in designing devices like thermometers and infrastructures.

2.1. Pressure in Fluid

2.1.1 Pressure inside a Liquid.

(Scope: laws of liquid pressure, derivation of mathematical expression, and applications in daily life).

Objective(s):

i. Carry out an experiment to verify the laws of liquid pressure and derive mathematical expression to relate its application in daily life.

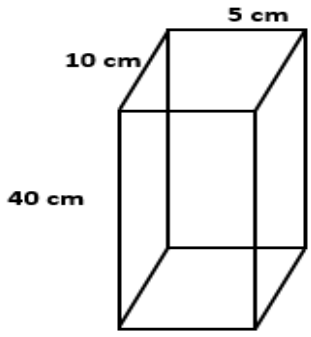
Learning Experiences:

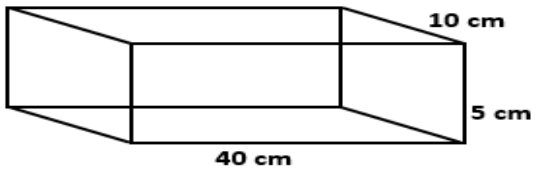
The teacher may use the instructional practises on fluid pressure by introducing the concept related to pressure. The teacher may provide the learner with relevant learning resources (books, handouts, downloaded digital content, articles) or the interactive simulation link https://bit.ly/2Q3ugxM to engage the learner in the learning process through the 5E model as follows.

- The learner uses the relevant learning resources (books, handouts, downloaded digital content, articles) or the interactive simulation link https://bit.ly/2Q3ugxM and engages in the demonstration.
- Explores the methods to investigate pressure inside a liquid, use available materials to carry out the experiment, and conduct the investigation.
- Based on the information gathered from the experiment or simulation, the learner explains the laws of liquid pressure.
- Derives the mathematical expression for fluid pressure, solves related numerical problems, and relates its application in daily life.
- Reflects and incorporates feedback given by the teacher and peers to evaluate their understanding of the concepts and its application.

Questions:

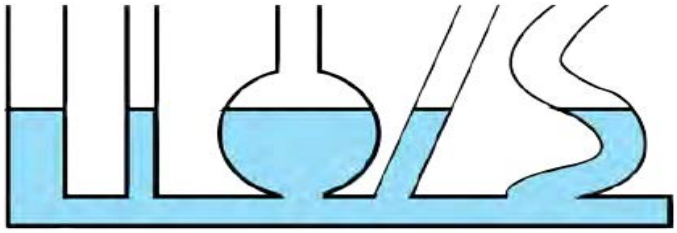
1. Given below is a brick of weight 5 newton placed vertically and horizontally. Which one would exert more pressure on the ground? Justify the answer with reason.





2. The water supply tanks are placed at higher height. Justify.

3. Liquid finds its own level. Irrespective of the shape of the vessel, liquid takes its own level. The level of the water in all tubes of communicating tubes is the same. It is because liquids flow to equalise any pressure differences.



What must be the pressures at the top of each tube and similarly at the bottom of each tube?

Assessment:

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

Scientific knowledge: assess the conceptual understanding of the fluid pressure, laws of liquid pressure, and applications of pressure due to fluid while explaining using a checklist.

Working scientifically: assess the ability of the learner to explore, organise ideas, carry out investigation, derive mathematical expression and solve numerical problems.

Scientific values and attitudes: assess the learner's ability to relate the significance of fluid pressure in daily life using observation form.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://bit.ly/2Q3ugxM

2.1.2 Atmospheric Pressure and Weather Forecasting

(Scope: concept on barometer, types of barometer, and their use in weather forecasting)

Objective(s):

ii Evaluate the variation of atmospheric pressure to forecast weather.

Learning Experiences:

The teacher may use the POE (Predict, Observe, Explain) model to deliver the lesson on atmospheric pressure and its applications in forecasting weather. The teacher may introduce the concept of types of barometers or let the learner gather information on the concept from the relevant resources (books, internet links, handouts, downloaded digital content, articles, video links https://rb.gy/de1vbg and https://rb.gy/fqgnvk).

- The learner gathers information on the concept of atmospheric pressure, instruments to measure atmospheric from relevant resources (books, internet links, handouts, downloaded digital content, articles, video links https://rb.gy/de1vbg and https://rb.gy/fqgnvk).
- Predicts the weather based on pressure variation and provides justification of their prediction.
- Observes the change in barometric reading and forecast weather.
- Explains the applications of pressure variation to forecast weather .

Questions:

1. Moist air is lighter than dry air. When there is more water vapour in the air, atmospheric pressure falls, and vice versa. So, as the temperature rises, the density of the air falls and the atmospheric pressure falls. More water vapour in the atmosphere indicates the possibility of rain. As a result, a barometer is used in weather forecasting. Therefore, how do you predict weather using a barometer?
2. When a balloon is inflated, it bulges equally all around. Explain.
3. Aneroid barometer has two pointers, usually a black and golden colour. The Black hand indicator always points to the current air pressure. The gold or constant hand indicator can be set to match the current pressure. Now, discuss how to use these two pointers to predict the weather. Also discuss how to set the barometric reading to match the actual pressure of your place. Learners may use this link to get help. https://www.youtube.com/watch?v=ieq-kRxdLaw

Assessment:

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

Scientific knowledge: assess the learner's conceptual understanding of the barometer, its types and advantages during explanation using a checklist.

Working scientifically: assess the learner's ability to observe, infer, and communicate information from the barometric readings using observation form.

Scientific values and attitudes: assess the learner's ability to relate the significance of weather forecasting in daily life using observation form.

The teacher may provide necessary intervention if need be.

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

Resources

- REC repository
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://rb.gy/de1vbg
- https://rb.gy/fqgnvk

2.2.Buoyant Force

2.2.1. Upthrust.

(Scope: derivation and calculation of upthrust).

2.2.2. Archimedes' Principle.

(Scope: verification of Archimedes' principle, calculation of relative density and its applications).

Objective(s):

iii. Verify Archimedes' principle to compute buoyant force, relative density and volume of irregular shaped objects through experimentation or simulation.

Learning Experiences:

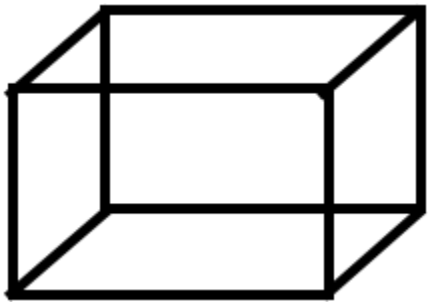
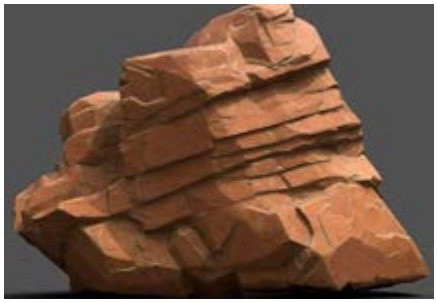
The teacher may deliver the lesson on Archimedes' principle and related concepts using a confirmation inquiry cycle. The teacher may provide the video links https://youtu.be/khc2wUBsFU4, or https://youtu.be/05WkCPORlj4, or https://youtu.be/Nf8js4AYOHM, and simulation link https://bit.ly/3qNX8Xw or experimental procedures to carry out the experiment, and related numerical problems.

- The learner deliberate on the Archimedes' principle and related concepts using video links https://youtu.be/05WkCPORlj4, https://youtu.be/khc2wUBsFU4, https://youtu.be/Nf8js4AYOHM) or from experimental procedures.

- Carries out the experiment or uses the simulation link https://bit.ly/3qNX8Xw to verify the Archimedes' principle.
- Collects and analyses data, and draws a conclusion to verify the principle.
- Applies the concept of Archimedes' principle in the calculation of the upthrust, relative density, and volume of irregular objects.
- Shares the findings physically or though CLT and recognises the significance of the principle in daily experiences.

Questions:

1. You were given a cube and an irregular object as shown in the figure below. How would you find the volume of these two objects?

Cube	Rock
	

2. A boat floating in a tank is carrying passengers. If passengers drink water, what will happen to the water level in the tank?
3. There are two balloons which are filled with Helium gas and carbon dioxide. Explain which one will float more in the air using the concept of Archimedes' principle.
4. Explain how Archimedes' principle can be used to find the purity of substance.

Assessment:

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

Scientific knowledge: assess the learner's conceptual understanding of the Archimedes' principle, buoyant force, relative density, and volume of irregular objects while sharing the concept using a checklist.

Working scientifically: assess the learner's ability to carry out the experiment, record data, draw conclusions to verify the Archimedes' principle and solve numerical problems using observation form.

Scientific values and attitudes: assess the ability of the learner to relate the applications of Archimedes' principle in daily life using observation form.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/khc2wUBsFU4
- https://youtu.be/Nf8js4AYOHM
- https://youtu.be/05WkCPORlj4
- https://bit.ly/3qNX8Xw

2.2.3. Floating Bodies

(Scope: conditions and forces on floating body)

2.2.4. Applications of Principle of Floatation in Everyday Life.

Objective(s):

iv. Design a device to explain the principle of floatation and its application in real life situations.

Learning Experiences:

The teacher may guide the learner through the process of POGIL on the principle of floatation by initiating group discussion on the foundational concepts of floating bodies, principle of floatation, and hydrometer from any learning resources (books, internet links, handouts, downloaded digital content, powerpoint presentation, articles, etc.) or daily experiences.

- The learner discusses the foundational concepts of floating bodies, principle of floatation, and hydrometer in groups using relevant resources (books, internet links, handouts, downloaded digital content, powerpoint presentation, articles, etc.).
- Explores the conditions for floatation based on the information gathered from relevant resources, and draws patterns and relations.
- Designs a model of a suit to float in water based on the conditions necessary for floatation.
- Shares their generalisation on the principle of floatation to the class and relates the applications of floatation in everyday life.

Questions:

1. In the movie Lottery, Mr. Phurba Thinley earns his living by selling milk. However, he was caught adding water to his milk to increase his production. Which hydrometer was used to check the purity of milk. Explain the working of a hydrometer.
2. Flotation of one of the applications of Archimedes' principle. Draw a relationship between Archimedes' principle and principle of floatation.
3. Design a conceptual boat based on the conditions necessary for floatation.

Assessment:

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

Scientific knowledge: assess the learner's conceptual understanding of the conditions for floating bodies, principle of floatation and hydrometer during explanation on the concept using a rubric.

Working scientifically: assess the learner's ability to gather additional information on the application of floatation, and design a suit (physical or conceptual) to float in water using a rubric.

Scientific values and attitudes: assess the ability of the learner to relate the significance of the principle of floatation in daily life using observation form.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.

- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).

2.3. Heat and Temperature

2.3.1 Measurement of Temperature

(Scope: temperature scales; Celsius, Fahrenheit and Kelvin scales, conversion of temperature from one scale to another, absolute zero).

Objective(s):

v. Measure and convert the temperature of bodies from one scale to another scale.

Learning Experiences:

The teacher may deliver the lesson on the different types of temperature scales, absolute zero, and conversion of temperature from one scale to the other in the following order of activities. The teacher may also provide links Interactive Thermometer and https://youtu.be/4cM0ollAhKM to deliver the lesson.

- The learner explores the lower and the upper fix point of the Celsius, Fahrenheit and Kelvin scales using thermometers or the links Interactive Thermometer and https://youtu.be/4cM0ollAhKM
- Deduces the mathematical relation between the two scales (Celsius and Fahrenheit, Celsius and Kelvin).
- Measures the temperature of a material (eg. warm water) using Celsius and Fahrenheit thermometer or use hypothetical data in one of the scales and convert to the other scale.
- Uses temperature conversion scales to solve related numerical problems.
- Figures out impacts of different temperatures (uses and hazards) in daily life.

Questions:

1. The temperature over 100.4 ^{o}F usually means you have a fever caused by infection or illness. How much is the equivalent temperature in ^{o}C. Why don't we measure our body temperature in Kelvin?
2. An Eskimo while working in Alaska found the temperature reading on laboratory thermometer and Fahrenheit thermometer to be equal. What is this temperature in kelvin?
3. Plot a graph taking ^{o}C on the Y-axis and the corresponding ^{o}F along the X-axis. You may take any hypothetical temperature data to plot this graph

Assessment:

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

Scientific knowledge: assess the learner's comprehension to describe different scales to measure temperature and temperature conversion formula using a checklist.

Working scientifically: assess the ability of a learner to solve numerical problems using a marking scheme.

Scientific values and attitudes: assess the learner's ability to figure out the significance of different temperature measuring scales and relate the concept of heat for different purposes using a checklist. The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://www.mathsisfun.com/measure/thermometer.html
- https://youtu.be/4cM0ollAhKM

2.3.2 Thermal Energy

(Scope: explain the term thermal energy, modes of thermal energy transfer, and applications of thermal equilibrium)

Objective(s):

iv. Conduct an experiment to detect the flow of thermal energy and explain the concept of thermal equilibrium.

Learning Experiences: The teacher may carry out the instructional practises on thermal energy based on the following order of POE (Predict, Observe and Explain) model. The teacher may give a powerpoint presentation on thermal energy, types of heat transfer, applications and thermal equilibrium. The teacher may use video links https://rb.gy/0wfuv2 and https://tinyurl.com/54h5pthv to show the concept of heat and types of heat transfer.

- The learner predicts the changes in thermometers of the hot and cold bodies in thermal contact (heat transfer and thermal equilibrium) using the concept learned from teacher's presentation or watching videos from the links https://rb.gy/0wfuv2 and https://tinyurl.com/54h5pthv.
- Performs an experiment to observe the temperature changes as suggested from the video link https://tinyurl.com/2p9bvhz2.
- Provides evidence to justify their prediction based on observation.
- Relates and explains its applications in real life situations.

Questions:

1. Bumthang is a cold place where people usually sit near a fire during winter. They feel warm near the fire due to the transfer of heat from higher temperature to low temperature. Explain how each mode of transfer of heat helps in keeping the people warm.
2. Heat and temperature are related to each other but do not have the same meaning. Heat is the cause and temperature is the effect. In this regard differentiate heat and temperature.
3. During the cold winter, people usually rub their hands with each other to keep warm. Explain.
4. How is thermal equilibrium applied in storing food in the refrigerator?

Assessment:

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

Scientific knowledge: assess the learner's comprehension of thermal energy, types of heat transfer while explaining using a checklist.

Working scientifically: assess the learner's ability to carry out the experiment (observing, questioning, gathering evidence , drawing inferences) using an observation form.

Scientific values and attitudes: assess the learner's ability to relate the applications of heat transfer and thermal equilibrium for different purposes using an observation form.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://tinyurl.com/54h5pthv
- https://rb.gy/0wfuv2.
- https://tinyurl.com/2p9bvhz2.

2.3.3. Thermal Insulation

(Scope: applications of thermal insulation).

Objective(s):

vii. Design a device to minimise the transfer of thermal energy to explain the concept of thermal insulation.

Learning Experiences:

The teacher may use design thinking (Empathise, Define, Ideate, Prototype, Test) to design a device to minimise the transfer of thermal energy.

- The learner deliberate the concept of thermal energy, mode of transfer of thermal energy, thermal equilibrium from relevant materials (books, handouts, downloaded digital content, articles, powerpoint, video lesson, the link https://youtu.be/qcodqXaiczE to supplement the information).
- Empathises with the energy sustainability based on the current pattern of energy use.
- Defines the factors affecting the rate of thermal energy consumption and its dissipation.
- The learner in the group generates an idea to develop a model of thermal energy saving device to sustain the thermal energy.
- Based on the ideas generated, the learner develops a prototype in the group.
- The learner tests the prototype and explains how it would minimise the transfer of thermal energy.
- Shares the generalisation derived from the prototype and relates the application of thermal insulation in daily life.
- Designs awareness programs on the significance of thermal insulation and energy saving devices and presents using any relevant means of communication.

Questions:

1. Consider a Bhutanese house in your locality and complete the following table to explain how each part of a house minimises heat loss through different means.

Parts of House?	**Measures to minimise heat loss**	**Reduces heat loss by**
Windows	Double layer glass and curtains	Conduction
Roof		
Walls		
Floor		
Others		

2. Explain how thermal insulation functions in hot and cold places.
3. Read about the Energy conscious building design for Building (Wall / Roof / Floor) from any relevant sources and design a building that would best insulate heat loss.

Assessment:

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

Scientific knowledge: the teacher may use a rubric to assess the learner's comprehension on thermal insulation during presentation.

Working scientifically: the teacher may use rubric to assess the learner's ability to generate ideas, organise ideas, develop models, and communicate information during the learning process..

Scientific values and attitudes: assess the learners' ability to relate the applications of thermal insulation in daily life using a rubric.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/qcodqXaiczE

2.3.6. Thermal Expansion of Matter.

(Scope: types of thermal expansion and its applications, anomalous expansion of water and its effects).

Objective(s):

viii. Describe thermal expansion and relate its application in the engineering field.

Learning Experiences:

The teacher may carry out the instructional practises on thermal expansion of matter, its types and applications using the Flipped Learning model. The teacher may develop relevant learning materials (PowerPoint presentations. handouts, etc.) and share video links https://rb.gy/bs0xvh and https://rb.gy/aqoyxp to the learner before class. The teacher may initiate and facilitate discussion on the concepts, and share the DARTs (directed activity related to texts) during the class.

- The learner explores information on the concept from the prepared materials (PowerPoint presentation, videos, handouts, etc.) shared by the teacher (before class).
- Engages in the group discussion and deliberates on types of thermal expansion and their applications to further enhance their learning on the concept of thermal expansion (during the class).
- Completes the DARTs on thermal expansion of matters and its applications.
- Explores for more information on the applications of thermal expansion of matter and relates to the engineering practises and natural phenomena (eg. anomalous expansion of water and its effects).

Questions:

1. Lobzang bought a bottled pickle with a metallic lid. However, he was not able to open it. Suggest a way with scientific reason to help her open the lid.

2. Water pipes in cold places like Haa, Paro, Bumthang usually burst in winter when the temperature falls below freezing point. Explain the concept behind this phenomenon and suggest ways to prevent it with explanation.
3. What are the similarities and differences between expansion in liquids and gases?

Assessment:

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

Scientific knowledge: The teacher may use a checklist to assess the learner's conceptual understanding on different types of thermal expansion, anomalous expansion of water, and applications while completing DARTs.

Working scientifically: assess the learner's ability to provide scientific reasoning on the application of thermal expansion during class discussion on thermal expansion using a rubric.

Scientific values and attitudes: assess the learner's ability to relate the application of thermal expansion in various infrastructures and natural phenomena using rubrics.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://rb.gy/bs0xvh
- https://rb.gy/aqoyxp

Revision Questions:

1. A cube of dimension 4cm x 4cm x 4m and mass 64 g is placed on a solid surface. Similarly, a Mercury of density 13.6 g/cm^3 was filled up to 12 cm in a container. Which one would exert the greater pressure on the base?
2. Koptong and his friends are planning to visit Singye Dzong for the pilgrimage. Their pilgrimage site is at very high altitude and experiences frequent weather variations. So, they want to take a

barometer with them to predict the weather and measure altitude. What type of barometer should they use? Why?

3. A spherical marble and wood of the same diameter are held under water. Which one would experience more upthrust? Justify your answer.
4. A body experiences more upthrust on Earth than on the moon. Justify.
5. If we press down the floating body further downward, what will happen to upthrust and weight?
6. If the temperature of bodies differ by 1.8 ^{0}F, what is the difference on Celsius scale?
7. Why are cold blooded animals not found in high altitude?
8. Hotels use plates made up of ceramic material with a lid and people in villages use dapa. Which container would keep the food warmer for a long duration? Explain the answer with reason.
9. Describe an experiment to demonstrate expansion in solid, liquid and gas.

3. Electricity and Magnetism

Every day, we use electricity and magnetism, but how do they work? What's the connection between them? The electricity and magnetism unit discusses electricity from atomic charge particles to current flowing in homes and businesses. Static electricity and electric currents are the two types of electricity. There are two types of current as well: direct (DC) and alternating (AC). Magnetism and electricity are inextricably linked. A magnetic field is created by flowing electrons, while an electric current is created by rotating magnets. The integration of these two essential forces is electromagnetism. Nearly every gadget, appliance, car, and equipment we use is powered by electricity and magnetism.

We would be in the dark if we didn't have electricity. We would be living in a world where everything is powered by physical force and lit by an open flame. Since the late 1800s, electricity has illuminated our homes and streets, powered our appliances, and facilitated the creation of computers, phones, and a variety of other technologies. However, many people take electricity for granted. It's as simple as flipping a switch. Understanding what electricity is and how it is prepared for safe usage allows us to appreciate this source of energy. Meanwhile, we couldn't generate electricity without magnets. Electricity and magnetism, as well as their interaction, are essential to the modern world's functioning.

Competencies:

- Interpret electric current using interactive simulation to generate concepts of electrical variables that affect each other.
- Analyze the graph of alternating current and direct current to recognize the power supplied by different sources.
- Design and construct d.c. motor to appreciate their applications in various electrical devices.

3.1 Electric Charge

3.1.1. Electric Current

(Scope: electric current in terms of the flow of charge carried by free electrons in metals, measurement of electric current, and related numerical problems)

Objective(s):

i. Interpret electric current in terms of flow of charge using interactive simulation to elucidate the understanding of flow of current.

Learning Experiences:

The teacher may use the instructional practices on the electric current using relevant learning resources (books, handouts, downloaded digital content, articles, powerpoint presentation) or using interactive simulation from the link https://bit.ly/30LhfLa to explore electric current as rate of flow of charge in a metal.

- The learner uses the relevant learning resources (books, handouts, downloaded digital content, articles, powerpoint presentation) or use interactive simulation link https://bit.ly/30LhfLa to interpret the electric current as rate of flow of charge and its mathematical representation.
- Interprets the electric current using mathematical representation and solves related numerical problems.

Questions:

1. Describe flow of electric current as flow of charge using an analogy from everyday life.
2. Calculate the number of charges (electrons) flowing through a conductor in 1 second, if the charge on each electron is 1.6×10^{-19} C.
3. Would the electric current increase or decrease, when the number of electrons passing through a cross-section of a conductor increases? Justify.

Assessment:

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

Scientific knowledge: assess the learner's conceptual understanding of electric current and flow of charge during explanation using a rubric.

Working scientifically: assess the ability of the learner to solve numerical problems and interpret the concept of electric current from the simulation using a rubric.

Scientific values and attitudes: assess the learner's ability to use electricity safely for daily activities using a self rating scale.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://bit.ly/30LhfLa

3.2 Magnetic Effect of Current

3.2.1. Alternating Current and Direct Current.

(Scope: a.c. and d.c. with graphical representations).

Objective(s):

ii. Analyse the graph of alternating current and direct current using a simulation or an oscilloscope.

Learning Experiences:

The teacher may use POE (Predict, Observe, and Explain) model to teach the concept of alternating current (a.c) and direct current (d.c) with the graphical representations using oscilloscope or simulation from the link https://bit.ly/30HMhn8. The teacher may provide the video link https://youtu.be/vN9aR2wKv0U to verify the concept of a.c and d.c.

- The learner predicts the direction of flow of charge and the types of graph for the a.c. and d.c. before the experiment or the demonstration with the simulation.
- Observes the graph of a.c. and d.c displayed on the oscilloscope or the simulation link https://bit.ly/30HMhn8 .
- Explains the nature of the graph for a.c. and d.c. to differentiate between two types of current based on visual representation.
- The learner may also use the video link https://youtu.be/vN9aR2wKv0U to support their explanation.
- Analyses the applications of a.c. and d.c. for different purposes.

Questions:

1. Differentiate between alternating and direct current based on the direction of flow using suitable examples.
2. Electrical appliances function based on either a.c or d.c. List down all the electrical appliances at your home and sort them into a.c or d.c functioning appliances.
3. Why is a.c preferred over d.c for longer distance transmission?

Assessment:

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

Scientific knowledge:.The teacher may use a rubric to assess the comprehension of the learner to differentiate between a.c. and d.c. while communicating the inferences.

Working scientifically: The teacher may use a rubric to assess the ability of the learner to operate the oscilloscope or simulation to comprehend the differences between a.c and d.c.

Scientific values and attitudes: assess the ability of the learner to analyse the applications of a.c. and d.c. for different purposes using observation form.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://bit.ly/30HMhn8
- https://youtu.be/vN9aR2wKv0U

3.2.2 Force on a Current Carrying Conductor placed in a Magnetic Field.

(Scope: Lorentz force, construction, working, and applications of d.c. motor)

Objective(s):

iii. Design a simple direct current (d.c.) motor by applying the concept of magnetic effect of current.

Learning Experiences:

The teacher may use DBL (Design Based Learning) to teach the concept of force on a current carrying conductor (Lorentz force) and construct a working model of a d.c motor using the following process. The teacher may provide resources (video links https://youtu.be/5KiyTpmPHIo , https://www.youtube.com/watch?v=6I jk Gj-0 , books, internet

links, handouts, downloaded digital content, articles, etc.) and instruct the learners to gather the necessary materials required to set up an experiment to demonstrate the Lorentz force.

- The learner discusses in groups to set up an experiment to demonstrate the Lorentz force based on information gathered from relevant learning resources (video links https://youtu.be/5KiyTpmPHIo, https://www.youtube.com/watch?v=6I_jk_Gj-0, books, internet links, handouts, downloaded digital content, articles, etc.).
- Designs and executes the experiment to demonstrate Lorentz force using the required materials.
- Gathers information and necessary materials to construct a model of d.c motor. The learner may use the video from the link https://youtu.be/WI0pGk0MMhg as a reference.
- Tests the model and relates the applications of magnetic effect of current in various electrical appliances.

Questions:

1. Reflect on the conditions necessary for voltage to be induced in a conductor?
2. How can the magnitude of induced voltage be varied?
3. Describe the law that explains direction of the induced voltage.
4. Describe the law that explains direction of the force experienced by a current carrying conductor placed in a magnetic field.

Assessment:

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

Scientific knowledge: The teacher may use a rubric to assess the learner's conceptual understanding of the working principle of d.c. motor (Lorentz force) while explaining the working of a d.c. motor.

Working scientifically: assess the ability of the learner to experiment on lorentz force and construct d.c. motor to explain the working of a d.c. motor by using a rubric.

Scientific values and attitudes: assess the ability of the learner to relate application of magnetic effect of current in various electrical appliances by using a rubric.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.

- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/WI0pGk0MMhg
- https://youtu.be/5KiyTpmPHIo
- https://www.youtube.com/watch?v=6I jk Gj-0 .

Revision Questions:

1. Norbu's mobile phone battery is low and he learned that he had left his mobile phone adapter at home. However, he had two thin copper wires with him. Can he use these wires to charge his mobile phone by inserting them into the socket? Why?
2. Figure below shows two conductors A and B with different potentials. State the direction of (i) flow of electrons and (ii) flow of current. Justify your answer.
3. Sonam lights a torch for 10 seconds during power cut and a current of 0.4 A flows through the torch filament. What is the magnitude of charges flowing through the filament?
4. Will current flow more easily through a thick wire or a thin wire of the same material when connected to the same source? Why?

4. Waves and Optics

The study of light has been a paramount part of human lives. Natural phenomena such as reflection, refraction, diffraction and interference have captured the interest of humans thereby studying light aided in discovering numerous uses. Therefore, the field of physics known as optics investigates the components and properties of light, as well as its interactions with matter and thereby leads to development of equipment that use or detect it. Hence in this theme study of properties of light ultimately foster learners to apply concepts of optics such as total internal reflection in our daily lives.

We are surrounded by different types of waves. Sound is a wave that travels through air and vibrates our eardrum enabling us to hear. Photons make up light, which is a unique type of wave. If you throw a rock into a pond, waves will form in the water. A wave is a type of disturbance (oscillation) that travels through space and matter. Energy is transferred from one place to another through wave motions. In this theme, terms related to waves and properties of two types of waves (transverse and longitudinal) will be discussed. Learners will study about waves displaying several basic phenomena such as reflection, refraction etc. Thus waves can be employed for various purposes such as ultrasound, SONAR, RADAR.

Competencies

- Design and use models to describe the laws of refraction through various materials to relate its applications in daily use.
- Design any working or conceptual model of an optical instrument using the concept of total internal reflection to comprehend its application in various fields.
- Differentiate between transverse and longitudinal waves by using simulations or physical tools and construct the relationship between frequency and wavelength to explain the nature of waves.
- Communicate scientific and technical information about the properties of waves (reflection and refraction) and appreciate the applications of waves in communication, medicines, and entertainment.

4.1 Ray optics

4.1.1 Refraction of Light

(Scope: refraction of light through a glass slab, laws of refraction, refractive index)

Objective(s):

i. Carry out an experiment to comprehend the laws of refraction using a ray box or glass slab.

ii. Apply the concept of refraction to construct an optical instrument.

Learning Experiences:

The teacher may deliver the lesson on refraction of light in the following order of guided inquiry. The teacher may ask guiding questions related to the change in path of light while travelling from one medium to another medium. The teacher may provide required materials to conduct the experiment to comprehend the laws of refraction and videos links https://youtu.be/sBb5WUw2_2I and https://youtu.be/4l2thi5_84o. The teacher may also provide the simulation link https://bit.ly/3qGONos to supplement the experimental verification of the laws of refraction.

- The learner researches on questions asked by the teacher from the relevant sources.
- The learner may watch videos from the links https://youtu.be/sBb5WUw2_2I and https://youtu.be/4l2thi5_84o to gather ideas on the concept.
- Designs and experiments on refraction of light through a glass slab.
- Based on the observation, the learner draws conclusions on the laws of refraction and explains the concept of refractive index.
- Verifies their experimental result from the link https://bit.ly/3qGONos .
- Solves numerical problems using the concept of refractive index.
- Uses the concept of refraction to construct an instrument (as an extended learning activity) and submits it to the teacher.

Questions:

1. When compared to glass, is air a rarer or denser medium?
2. What will happen to the velocity of light when it travels from glass to air?
3. Describe the refractive index in your own words.
4. Light enters from air to glass having refractive index 1.5. Calculate the speed of light in the glass when the speed of light in vacuum is $3x10^8$ ms^{-1}

Assessment:

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

Scientific knowledge: assess the learner's conceptual understanding on refraction, laws of refractions, and refractive index during explanation using a rubric.

Working scientifically: assess the ability of the learner to carry out the experiment by using appropriate materials, make scientific judgement from the observations, and solve related numerical problems using a rubric.

Scientific values and attitudes: assess the ability of the learner to relate the concepts in various natural phenomena and to design optical instruments using a rubric.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/sBb5WUw2_2I
- https://youtu.be/4l2thi5_84o
- https://bit.ly/3qGONos

4.1.2.Total Internal Reflection.

(Scope: explanation, natural phenomena and applications).

Objective(s):

iii. Explain the concept of total internal reflection using any simulation and CAI tools to comprehend its application in various purposes.

Learning Experiences:

The teacher may use the instructional practice to teach total internal reflection in the following order of activity. The teacher may provide necessary materials (laser light, water, semi-circular glass, glass slab, etc., or through the video link https://youtu.be/ybvjcjndn_4 ,

https://youtu.be/5VrVqpV7RNA) to demonstrate the critical angle and total internal reflection. The teacher may provide the simulation link https://rb.gy/7cetej.

- The learner explores the information on total internal reflection, critical angle, and conditions for total internal reflection from the relevant sources like video links https://youtu.be/ybvjcjndn_4, https://youtu.be/5VrVqpV7RNA.
- Designs an experiment to demonstrate or use the simulation link https://rb.gy/7cetej and explain the concept of total internal reflection, critical angle, and conditions for total internal reflection.
- Prepares an interactive PowerPoint presentation to demonstrate the conceptual understanding of total internal reflection, critical angle, and conditions for total internal reflection, and the applications of total internal reflection based on the experimental result.

Questions:

1. Kinga passes laser lights from air to glass and is incident on a glass surface at the angle 30^{o}. At what angle will it get refracted inside the glass? Take absolute refractive index of glass as 1.5.
2. What are the prerequisites for total internal reflection ?
3. What is the relationship between diamond gleaming and total internal reflection?
4. Draw a diagram of periscope that is constructed using plane mirrors.

Assessment:

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

Scientific knowledge: assess the learner's conceptual understanding of critical angle, total internal reflection, conditions required for the total internal reflection while explaining on the concept using a rubic.

Working scientifically: assess the ability of the learner to demonstrate the phenomenon of total internal reflection experimentally or from the simulation using a rubric.

Scientific values and attitudes: assess the ability of the learner to relate the concept of total internal reflection to natural phenomena and its application in daily life by using a rubric.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/ybvjcjndn_4
- ttps://youtu.be/5VrVqpV7RNA
- https://rb.gy/7cetej.

4.2.Waves.

4.2.1. Types of Waves.

(Scope: transverse and longitudinal).

4.2.2. Properties of Waves.

(Scope: terms used in waves, reflection and refraction of sound and light waves).

Objective(s):

iv. Describe the properties and terms related to transverse and longitudinal waves using simulations or available materials.

Learning Experiences:

The teacher may deliver the lesson on waves, the characteristics of transverse and longitudinal waves, and properties of waves in the following order of PROE (Predict, Reason, Observe, Explain). The teacher may provide an interactive simulation from the links https://ophysics.com/w6.html and https://cutt.ly/kzL1355 or relevant materials such as slinky or helical springs to demonstrate the nature of transverse and longitudinal waves. The teacher may also provide a video link https://rb.gy/rxrnna to comprehend the concept of reflection and refraction of sound and light waves.

- The learner gathers information on the types of waves (transverse and longitudinal waves) with graphical representation, the properties of waves and identifies the terms used to describe waves from the link https://ophysics.com/w6.html and https://cutt.ly/kzL1355.
- Predicts the mathematical relationship amongst variables (wavelength, frequency, wave velocity, amplitude, and time period) and justifies with reasons.

- Uses slinky or helical springs or explores the simulation from the links https://cutt.ly/kzL1355 and https://ophysics.com/w6.html to observe the relationships amongst variables (wavelength, frequency, wave velocity, amplitude, and time period).
- Explains the types of waves, deduces the relationships amongst variables (wavelength, frequency, wave velocity, amplitude, and time period) based on the observation made from the demonstration or simulation.
- The learner may use a video link https://rb.gy/rxrnna to further substantiate the concept of waves.
- Solves numerical problems related to waves using the mathematical relationships.

Questions:

1. Explain what is meant by compression and rarefaction in the context of a longitudinal wave.
2. List some of the characteristics of longitudinal waves.
3. Dawa plays a guitar and generates a transverse wave of frequency 10 Hz. Find its time period.
4. Light wave of wavelength 500 nm travels through a medium with a frequency $3x10^{14}$ Hz. What is its velocity through that medium?

Assessment:

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

Scientific knowledge: assess the learner's comprehension to differentiate the types of waves through graphical representation and explain the properties of waves using a rubric.

Working scientifically: assess the learner's ability to observe, analyse, interpret waves forms, and solve numerical problems using a rubric.

Scientific values and attitudes: assess the learner's ability to relate the importance of reflection and refraction of waves in daily life using rubrics.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://rb.gy/rxrnna
- https://cutt.ly/kzL1355
- https://ophysics.com/w6.html

4.2.3. Uses of Waves.

(Scope: ultrasound, SONAR, RADAR).

Objective(s):

v. Explore the application of waves in daily application using CAI tools

Learning Experiences:

The teacher may use the 5E model to deliver the lesson on applications of ultrasound, SONAR, and RADAR in the following order of activity. The teacher may provide the links https://youtu.be/I1Bdp2tMFsY , https://youtu.be/ql2Y-3hOfGY or learning resources (books, internet links, handouts, downloaded digital content, powerpoint presentation, articles, etc.) to supplement the concepts.

- The learner engages in understanding the applications of waves from the information provided by the teacher or from the links https://youtu.be/I1Bdp2tMFsY, and https://youtu.be/ql2Y-3hOfGY.
- Explores additional information on applications of waves from any other relevant resources (book, handouts, internet, etc.).
- Explains the application of waves in daily life using the information gathered.
- Elaborates on the application of waves in various fields and solves related numerical problems.
- Incorporates the feedback provided by the teacher and peer and submits it for assessment.

Questions:

1. A toddler hears an echo from a cliff 4 seconds after the sound from a powerful cracker is produced. What is the distance between the toddler and the cliff? (Take velocity of sound in air as 340 ms^{-1})
2. What is the purpose of SONAR and how does it work?

3. What distinguishes the SONAR method from the RADAR method?

Assessment:

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

Scientific knowledge: assess the learner's conceptual understanding on the uses of waves through explanation using a rubric.

Working scientifically: assess the ability of the learner to actively engage in the group activities and solve the numerical problems using a checklist.

Scientific values and attitudes: the teacher may assess the ability of the learner to relate the concepts learnt to the daily applications using observation form.

The teacher may provide necessary intervention if need be.

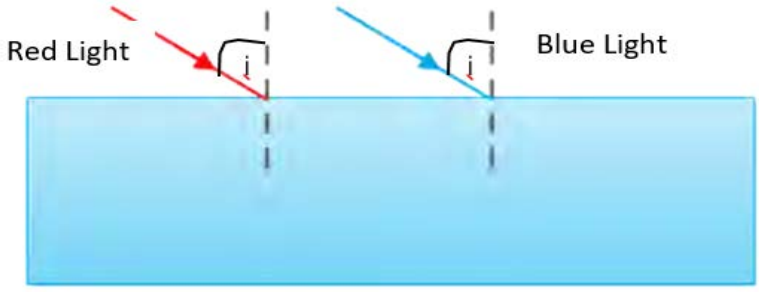
Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/I1Bdp2tMFsY
- https://youtu.be/ql2Y-3hOfGY

Revision Questions:

1. As shown in the Figure given below, a red ray and a blue ray are refracted from a rarer medium to a denser medium at the same angle of incidence. In which of these cases will the refraction angle be greater? Why?



2. The road appears wet at a certain distance ahead on hot summer days during sunny hot days. Why?
3. When sound waves and light waves travel from air to water, they both experience refraction. What distinguishes the refraction of sound waves from the refraction of light waves?
4. Penjore enjoys listening to Bhutan Broadcasting Service (BBS), his favourite radio station. Radio signals with a frequency of 1.07×10^8 Hz are broadcast from the station. Radio signals travel at a speed of 3×10^8 m/s through the air. What is the wavelength of these waves?
5. A submarine sends out a sonar pulse, which takes 1.02 seconds to return from an underwater cliff. How far is the cliff from the surface of water if the speed of sound in salt water is 1531 ms^{-1}?

5. Atomic, Nuclear and Space Physics

What do you get when you cut a piece of paper in half and then keep cutting it smaller and smaller? This is a similar thought experiment to one explored by Greek philosopher Democritus around 400 BC. Democritus came to the conclusion that everything must be composed of small eternal particles if you keep cutting. They were dubbed atomos, which means "indivisibles" by him. This theme will focus on how the atom's nucleus is made up of a densely packed collection of protons and neutrons. The protons have a net positive charge, therefore an atom's nucleus is positively charged overall, while the negatively charged electrons rotate around the core nucleus. Learners will also explore nuclide notation.

Astronomical observations date back to the beginning of time. Primitive man must have studied the daily rotation of the sky, as well as the motions of the sun and moon relative to the stars, in order to keep track of time for agricultural and civic reasons. Here the learners will study that astronomers use telescopes to observe objects that are far away. Curved mirrors collect and concentrate light from the night sky in most telescopes, including all big telescopes.Therefore explore more on types and construction of telescopes.It all started with Sputnik, the first satellite to be launched into orbit by USSR in 1957. Since then, space exploration has progressed, with the Moon serving as a focal point. Learners will explore the advancement of Moon Exploration. Learners will also explore the Physical and Chemical Properties of the Moon and its Environment.

Competencies:

- Design a model or use technological tools to comprehend the structures of atom and nucleus to represent elements using nuclide notation.
- Explore different types of telescopes and components to comprehend its application as an astronomical instrument.
- Gather evidence related to advancement in moon exploration to describe physical and chemical properties of the moon and explore the possibility of settling on the moon in future.
- Design physical or virtual prototype of any one of the items necessary for human survival on the Moon.

5.1 Nuclear Atom

5.1.1 The Nuclear Atom

(Scope: nuclear composition, protons and neutrons, proton number, nucleon number, nuclide notation).

Objective(s):

i. Describe the composition of the nucleus, in terms of protons and neutrons and represent radioactive elements using nuclide notation.

Learning Experiences

The teacher may deliver the lesson on the nuclear atom in the following order of activity. The teacher may use video links https://bit.ly/3cwRZOj, https://www.youtube.com/watch?v=dGNGCAo tNc or relevant resources (downloaded digital content, handout, book, internet, etc.) to show the basic structure of the atom and nucleus. The teacher may provide a worksheet and show the ways of representing radioactive elements using nuclide notation.

- The learner participates in understanding of the composition of atomic structure and nuclide notation using the video links https://bit.ly/3cwRZOj and https://www.youtube.com/watch?v=dGNGCAo tNc or other resources (downloaded digital content, handout, book, internet, etc.).
- Completes a worksheet on composition of nucleus using nuclide notation of radioactive elements based on the teacher's instruction.

Questions:

1. What are the three constituents of an atom?
2. What is found in an atom's nucleus?
3. The outermost shell of an atom of element X contains one electron. If this electron is taken from the outermost shell, what kind and value of charge formed as an ion?
4. Nuclides are written as AXZ, where "A" stands for the total number of protons and neutrons, "Z" stands for the number of protons, and the difference between A and Z stands for the number of constituents of a nucleon.

Assessment

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

Scientific knowledge: assess the learner's conceptual understanding of atomic structure and its representation from a worksheet using a checklist.

Working scientifically: The teacher may use a marking scheme to assess the learner's ability to complete a worksheet.

Scientific values and attitudes: assess the learner's honesty in completing the worksheet using a self rating scale.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://www.youtube.com/watch?v=dGNGCAo tNc
- https://bit.ly/3cwRZOj

5.2 Astronomical Instruments

(Scope: concept, components, types and construction of telescope)

Objective(s):

ii. Explain the components and basic operation of different types of telescopes and design a prototype of a telescope.

Learning Experiences:

The teacher may gather information from relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.) to explore the components and basic operation of astronomical instruments. The teacher may also prepare a presentation or handouts to deliver the lesson and follow the open inquiry cycle to engage the learner.

- The learner goes through the teacher's input and notes the key points.
- The learner frames question(s) on the components and basic operation of astronomical instruments after going through the teacher's lesson.
- The learner explores information on components and operation of telescopes from relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.) to gather evidence.
- The learner answers the question(s) based on the evidence gathered and shares it to the class.

- Based on the concept learned, the learner designs a physical/virtual prototype of a telescope to comprehend its parts or application, and present it to the class.

Questions:

1. Who was the first scientist to employ a telescope for space observation.
2. A telescope that employ two converging lenses is called
    a. reflecting telescope
    b. refracting telescope
    c. simple telescope
    d. compound microscope
3. A telescope can make stars look
    a. bigger
    b. brighter
    c. smaller
    d. all of above

Assessment

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

Scientific knowledge: assess the knowledge of the learner to explain components of a telescope, different types of telescope, and its working using a rubric.

Working scientifically: assess the ability of the learner to retrieve, organise, analyse, and interpret scientific information, design a comprehensive model, present and communicate scientific ideas in a logical manner using an observation form.

Scientific values and attitudes: assess the ability of the learner to accept constructive criticism or feedback from peers and the teacher, and relate the concepts in space exploration using a rubric.

The teacher may provide necessary intervention if need be.

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)

5.3. The Moon

5.3.1. Advancement of Moon Exploration.

(*Scope: history of Moon exploration, current developments, future possibilities).*

Objective(s):

iii. Explore evidence related to advancement in moon exploration.

Learning Experiences:

The teacher may introduce the lesson on the moon exploration by sharing history of the Moon exploration, current developments, and future possibilities using the information gathered from the learning resources (internet, scientific papers, books, etc). The teacher may also let the learner explore additional information on the moon exploration from relevant resources (books, internet links, handouts, downloaded digital content, articles, video, etc.). The teacher may use the CER (Claim, Evidence and Reasoning) model in the following order. The teacher may set the tone to create a claim by the learner with the question based on characteristics of the Moon.

- The learner gathers information from the explanation by the teacher.
- The learner makes a claim on the characteristics of the Moon and its environment.
- The learner explores information from the internet, scientific articles, and books to gather evidence on their claim.
- The learner justifies their claim with the evidence and shares it to the class.

Questions:

1. Is the moon a planet or a satellite? Justify your answer
2. Although astronauts last stepped on the Moon in 1972, robotic spacecraft have continued to explore the Moon on an irregular basis over the years. Describe some recent interesting developments in the field of moon exploration.
3. Describe some of the future status of the moon exploration.

Assessment:

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

Scientific knowledge: assess the learner's comprehension to explain the characteristics of the Moon using a rubric.

Working scientifically: assess the learner's ability to search, retrieve, organise, analyse, interpret scientific information, present and communicate scientific ideas in a logical manner using checklist.

Scientific values and attitudes: assess the learner's curiosity to learn, and ability to relate the effects of the moon to some natural phenomenon on the earth using a observation form.

The teacher may provide necessary intervention if need be.

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).

5.3.2. Physical and Chemical Properties of the Moon and its Environment.

(*Scope: position, size, composition, impact of Moon's environment on human health, and survival on the Moon).*

Objective(s):

iv**.** Describe composition, positions, and sizes of the Moon relative to the Earth.

Learning Experiences:

The teacher may deliver the lesson on physical and chemical properties of the Moon using CAI tools. The teacher may provide the link https://bit.ly/3coAhfK, and guide the learner through required topics to learn the concept of composition, positions, and sizes of the Moon relative to the Earth. The teacher may also provide learning resources (books, internet links, scientific papers, books, downloaded digital content, articles, and the link https://rb.gy/qmqjdi) to the learner to explore additional information on the concept.

- The learner gathers information on the concept based on the information shared by the teacher.

- The learner may also use learning resources (books, internet links, scientific papers, books, downloaded digital content, articles, and the link https://rb.gy/qmqjdi) to explore additional information on the concept.
- The learner may also explore information related to the concept and complete online activities from the link https://bit.ly/3coAhfK.
- Designs a model (illustration, 2D model, 3D model physically or using programming language through CLT) to exhibit the compositions, positions, and size of the Moon relative to the Earth and shares it to the class.

Questions:

1. What are the materials that make up the moon?
2. In relation to the earth, compare the diameter and mass of the moon.
3. Why doesn't the moon have weather?
4. How does the Moon's movement contribute to a more habitable Earth?

Assessment:

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

Scientific knowledge: assess the conceptual understanding of the learner to explain the concept of composition, positions, and sizes of the Moon relative to the Earth using a checklist.

Working scientifically: assess the ability of the learner to use scientific information accurately, and design a model of the moon using an observation form.

Scientific values and attitudes: assess the ability of the learner to collaborate in designing the model using an observation form.

The teacher may provide necessary intervention if need be.

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)
- https://bit.ly/3coAhfK
- https://rb.gy/qmqjdi

5.3.2. Physical and Chemical Properties of the Moon and its Environment

(*Scope: position, size, composition, impact of Moon's environment on human health, and survival on the Moon)*

Objective(s):

v. Explore the requirements for human survival on the Moon.

vi. Design physical or virtual prototype of any one of the items necessary for human survival on the Moon.

Learning Experiences:

The teacher may deliver the lesson on human survival on the Moon using CAI tools or provide relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.). The teacher may provide the link https://tinyurl.com/yckscnex and https://tinyurl.com/2e698yjz to explore how we would live on the Moon and guide the learner through required topics to explore the requirements for human survival on the Moon following the open inquiry cycle.

- The learner gathers information on the concept based on the information shared by the teacher.
- The learner explores information related to the concept from the video link https://tinyurl.com/yckscnex and https://tinyurl.com/2e698yjz or from relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.)
- The learner shares the information gathered physically or through CLT.
- Based on the concept learned, the learner designs a physical or virtual prototype of any one of the items necessary for human survival on the Moon and presents it to the class.

Questions:

1. Which materials are necessary for the survival of human beings on the moon?
2. Compare the composition, size and position of the moon in relation to earth.
3. List the materials or components which are hazardous to human beings on the moon.

Asssement

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

Scientific knowledge: assess the learner's ability to explain requirements for human survival on the Moon using a rubric.

Working scientifically: assess the learner's ability to gather information on requirements for human survival on the Moon and design the model of any one of the items necessary for human survival and present using a rubric.

Scientific values and attitudes: assess the curiosity of learners to explore the scope of moon exploration using self rating scale.

The teacher may provide necessary intervention if need be.

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).
- https://tinyurl.com/2e698yjz
- https://tinyurl.com/yckscnex

Revision questions:

1. An element's atomic number and mass number are 16 and 32, respectively. Calculate the number of protons, electrons, and neutrons there are in it.
2. Protons have a positive charge, whereas electrons have a negative charge. In spite of the fact that an atom has both proton and electron, why is there no charge?
3. What does the focal length of a telescope refer to? Discuss the significance of long and short focal length in relation to observing objects in space.
4. What will be the significance of exploring moon in the scientific world?
5. Imagine that you are designing and building models for NASA's first human settlement on moon. What life support systems would you recommend which are crucial to the successful settlement of humans on Moon?

Class X

1. Newtonian Mechanics

From the marvel of determining the stability of the body and its applications in various fields to comprehending the concept of work, power and energy, the theme "Newtonian Mechanics" has the details. The learner will get to explore the factors affecting stability of a body, types of equilibrium, and apply the concept of principle of moment in solving problems. Establishing the relationship among work, energy, and power to relate the concept with daily applications through examples and numerical problems will stimulate the learner to exhibit their grasp of the concept. Towards the end of the theme, the learner will be engaged in demonstrating their comprehension on the law of conservation of energy, efficient methods of energy consumption, and power generation for a sustainable future.

Competencies:

- Locate the centre of gravity experimentally to determine the stability of the body and relate its significance in everyday experiences.
- Determine the resultant force and moment to comprehend the concepts of equilibrium to apply the effect in principle of moment.
- Construct and present arguments using evidence to support the claim that the force on falling objects changes with velocity.
- Establish relationships among energy, work, and power to relate with daily application and solve related numerical problems.
- Demonstrate the understanding of the law of conservation of energy using various examples and appreciate its applications in real life phenomena.
- Describe the efficient methods of energy consumption and generation to attain energy sustainability and make evidence based decisions for power generation to minimise its negative impact on environment, society, economy and culture in the global and local context.

1.1 Gravitational Force

1.1.1. Centre of Gravity (C.G) and Stability of Bodies

(Scope: location of C.G, relation of position of C.G and area of base of support with stability)

1.1.2. Equilibrium.

(Scope: definition and application of stable, unstable, and neutral equilibrium)

Objective(s):

i. Investigate the location of the center of gravity to relate with stability of bodies.

ii. Demonstrate three types of equilibrium to relate it to the real life application.

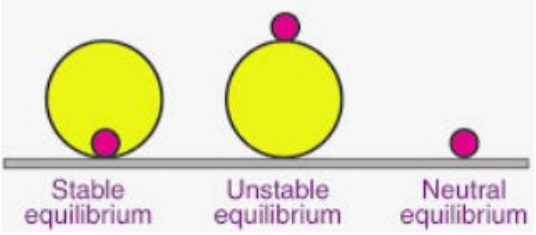
Learning Experiences:

The teacher may use the 5E Model (Engage, Explore, Explain, Elaborate, Evaluate) to introduce the concept and establish the relation of C.G and area of base of support with stability, and demonstrate three types of equilibrium. The teacher may provide relevant resources (books, internet links, handouts, downloaded digital content, articles and links https://bit.ly/3qKYoL2 and https://bit.ly/3bOGJxP to teach the concepts of C.G, area of base of support, and types of equilibrium.

- The learner engages in demonstration on stability of a body using available materials as per the teacher's instruction.
- Explores relationship between C.G and area of base of support using relevant resources (books, internet links, handouts, downloaded digital content, articles, and links https://bit.ly/3qKYoL2 and https://bit.ly/3bOGJxP).
- Explains the concept of different types of equilibrium based on position of C.G and area of base of support.
- Observes things around them and elaborates on the significance of the concept of C.G and area of base of support in everyday experiences.
- Reflects and incorporates feedback given by the teacher and peers to evaluate their understanding of the concepts.

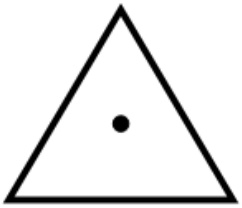
Questions:

1. The stability of the body depends on _____ and _____.
2. The centre of gravity of a body need not necessarily be at the centre and on the body itself. Justify with an example.
3. Observe the diagram carefully and explain three types of equilibrium.

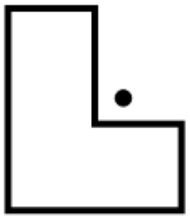


4. Locate the centre of gravity for the figure (a) and (b).

a.



b.



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 of the C.G, area of base of support, and three types of equilibrium from the explanation using a checklist.

Working scientifically: assess the ability of a learner to explore and gather evidence, and communicate the findings while demonstrating the factors affecting stability of a body using an observation form.

Scientific values and attitudes: assess the learner's curiosity, and ability to elaborate on the significance of stability through explanation of 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
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- New normal curriculum framework in science (NNCFS- 2021).
- https://bit.ly/3qKYoL2
- https://bit.ly/3bOGJxP

1.2 **Moment of Force**

1.2.1 Forces and Equilibrium

(*Scope: resultant force and conditions for equilibrium).*

Objective(s):

iii. Examine the effect of resultant force to comprehend the conditions for the equilibrium.

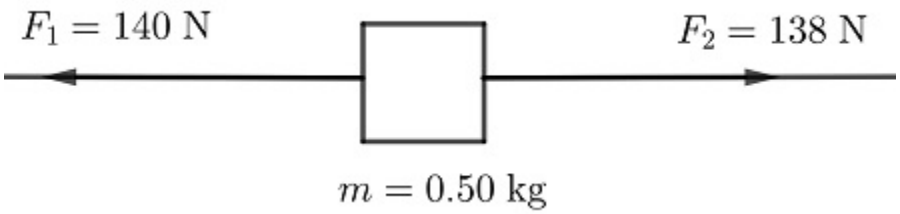
Learning Experiences:

The teacher may use NHT (Numbered Heads Together) to deliver the lesson on effect of resultant force to comprehend the conditions for the equilibrium. The teacher may demonstrate the concept, the effect of resultant force and the conditions for the equilibrium or let the learner gather information using relevant resources (books, internet links, handouts, downloaded digital content, articles, and links https://bit.ly/3zQNObv).

- The learner watches the video from the link https://bit.ly/3zQNObv or uses the relevant resources provided by the teacher to understand the concept of resultant force and the conditions for the equilibrium.
- Notes down the effects of resultant force and conditions for the equilibrium.
- Discusses the effects of resultant force and conditions for the equilibrium.
- Shares the findings and calculates resultant force. .

Questions:

1. Describe two conditions for a body to be in the state of equilibrium.
2. On a body of mass 0.50 kg, Dorji applies a force F1 and Sangay applies force F2 as shown below.



a) What will be the resultant force on the body?
b) Will the body be at equilibrium? Why?
c) In which direction will the body move?

3. What are some of the effects of resultant force?

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 comprehension of the concept of resultant force and the conditions for the equilibrium while gathering information using a checklist.

Working scientifically: assess the learner's skills to illustrate the effects of resultant, the conditions for the equilibrium and calculate resultant force while presenting the findings using a checklist.

Scientific values and attitudes: assess the learner's ability to relate the concept with real life situations while carrying out a learning task using a checklist.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/3zQNObv

1.2 **Moment of Force**

1.2.2 Couple

(Scope: definition, mathematical expression, application, and numerical problems).

1.2.3. Principle of Moments

(Scope: definition, mathematical expression, application and numerical problem).

Objective(s):

iv. Explore the application of couple in various devices.

v. Deduce the mathematical expression for the principle of moments through an interactive simulation or experiment.

Learning Experiences:

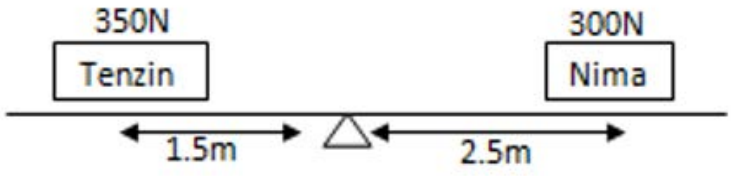
The teacher may carry out the instructional practises in the following order of activities. The teacher may use the link https://tinyurl.com/yr3mhmdz to teach about the couple and related concepts. The teacher may use the video link https://bit.ly/3tc5OIO and simulation link https://bit.ly/3bMyHFt to demonstrate the principle of moment and related concept. The teacher may provide some numerical questions to practice and apply the mathematical relation for torque and principle of moment.

- The learner watches the video from the link https://tinyurl.com/yr3mhmdz to understand the concept of the couple.

- The learner watches the video from the link https://bit.ly/3tc5OIO and plays the simulation from the link https://bit.ly/3bMyHFt provided by the teacher to comprehend the principle of the moment.
- Constructs the definition and mathematical expression for the moment of couple or torque, and principle of moment.
- Solves the mathematical problems assigned by the teacher.
- Relates the concept of torque with the principle of moment and its application in real life.

Questions:

1. Describe applications of a couple in various devices that you have used or seen around.
2. Illustrate the principle of moment using a relevant example.
3. Tenzin and Nima are playing on a seesaw. Tenzin weighs 350 N sits 1.5 m away from the pivot on the left side and Nima, weighs 300N sits 2.5 m away from the pivot on the right side .



i. Calculate the clockwise moment?
ii. Calculate the counter clockwise moment?
iii. On which side (clockwise or anti clockwise) will the seesaw turn?
iv. At what position and direction a body C of 225 N must be placed to balance the seesaw?

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 a couple, mathematical representation of the moment of couple and principle of moment while explaining using a checklist.

Working scientifically: assess the learner's skills to record data, carry out the simulation and solve numerical problems while carrying out the learning task using a checklist and a marking scheme.

Scientific values and attitudes: assess the learner's ability to relate or connect the concept of torque and principle of moment with real life situations from the presentation using a checklist.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/3bMyHFt
- https://bit.ly/3tc5OIO
- https://tinyurl.com/yr3mhmdz

1.3 Falling Objects

1.3.1 Forces on Falling Objects

(Scope: free fall, drag force, terminal velocity)

Objective(s):

vi. Examine the motion of falling objects to explain that force changes with change in velocity.

Learning Experiences:

The teacher may use PEOE (Predict, Explain, Observe, Explain) to carry out the instructional practices. The teacher may use an interactive simulation links https://cutt.ly/9IfFTR1 and https://cutt.ly/uIfFF0I and show the clip related to drag force and terminal velocity using the given link https://bit.ly/3vjEgTL and https://cutt.ly/gIfGyLY. The teacher may also provide learning resources (books, handouts, downloaded digital content, articles, etc.).

- The learner predicts and explains how objects with different density and surface area fall with different velocity.
- Conducts experiments to observe and explain the fall of different objects with different density and surface area.
- Uses the simulation links https://cutt.ly/9IfFTR1 and https://cutt.ly/uIfFF0Ion the free fall and explains how objects fall in vacuum and the change in velocity of the falling object.

- Watches videos from the links https://bit.ly/3vjEgTL and https://cutt.ly/gIfGyLY to supplement the explanation on the concept of free fall, drag force and terminal velocity.

Questions:

1. List down two characteristics of a free falling object.
2. If a sky driver uses a parachute, when does the parachute reach terminal velocity?
3. Drag force on a body increases with the increase in speed of the body. Justify with one example from everyday experiences.
4. When a body is falling freely, will there be a change in its velocity? Justify your answer.

Assessment:

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

Scientific knowledge: assess the learner's understanding of free fall, drag force, terminal velocity, and the factors that affect free falling objects using DARTs (Directed Activities Related to Texts) while explaining.

Working scientifically: use an observation form to assess the learner's ability to carry out the experiment and use simulation to explore the concept of falling objects.

Scientific values and attitudes: use rubrics to assess the learner's ability to relate the phenomena of free fall and explain factors affecting it to daily life while carrying out the learning task.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://cutt.ly/9IfFTR1
- https://cutt.ly/uIfFF0I
- https://bit.ly/3vjEgTL
- https://cutt.ly/gIfGyLY.

1.4 Work and energy

1.4.1 Work and Power

(Scope: work done, work done against gravity, power, and efficiency).

1.4.2 Energy

(Scope; potential energy, kinetic energy, law of conservation of energy).

Objectives:

vi. Examine the concept of work done to calculate power and efficiency of different machines.

vii. Describe transformation of energy between potential and kinetic energy to demonstrate the energy conservation using simulations or a prototype.

Learning Experiences:

The teacher may carry out the instructional practice on work, power and energy using cooperative learning strategy. The teacher may divide learners into a home group of five members and assign topics (work, power, potential energy, kinetic energy, conservation of energy) for discussion to carry out the activity. The teacher instructs the expert group to discuss the assigned topics using relevant resources.

- The learner in an expert group prepares a presentation on the assigned topic after gathering information from the available resources such as text book, the internet, handouts, videos links https://bit.ly/3bO1CsO or https://youtu.be/wj159dDRom0 etc.
- Presents on their respective topic to the home group and incorporates feedback received from peers and the teacher.
- Based on the concept of energy, the learner in the home group develops a prototype (conceptual or physical) to demonstrate the concept of energy transformation and presents it to the class.

Questions:

1. Tashi throws a ball with a force of 50 N to a distance of 23 m. Tshering throws the same ball with the same force, but the ball rolls to a distance of only 32 m. Who does more work?
2. What are the three factors that affect the work done?
3. Four different electric bicycles were driven along the road. The work done by their motors and time taken to do that work is shown in the table given below. Which one of the electric bicycles produces the most power?

	Work done in J	Time taken in S
A	2000	1
B	10,000	20
C	20,000	40
D	40,000	400

4. Lhamo was driving a 2000 kg car at a speed of 40 m/s. When she reached near her house, she slowed down her car to 10 m/s. What was the change in kinetic energy of the car?
5. Explain the law of conservation of energy using a relevant example from everyday life.
6. Why are machines not 100% efficient?

Assessment:

The teacher may use checklist/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, power, potential energy, kinetic energy and conservation of energy using a peer assessment rubric during presentation on the concept.

Working scientifically: use a rubric to assess the learner's collaborative skills during discussion, communication skills during presentation, creativity and innovation in developing a prototype.

Scientific values and attitudes: assess the learner's curiosity and innovation while exploring and developing the prototype 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
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/3bO1CsO
- https://youtu.be/wj159dDRom0

1.4.3 Energy Conservation

(Scope: efficient ways to use energy).

Objective(s):

ix. Analyse the change in use of energy due to changing behaviour of people and new electrical appliances.

x. Design an energy efficient building or house integrating efficient ways to use energy (conceptual or physical).

Learning Experiences:

The teacher may use Design Thinking (Empathise, Define, Ideate, Prototype, Test) and guide the learner through the concepts of change in the pattern of energy use and then design an energy efficient building/house by integrating efficient ways of using energy. The teacher may introduce the key concepts on energy conservation through a presentation and guide the learner through the following learning process.

- The learner empathises on the current trend of energy uses in their household or locality through a group discussion/interview within their house or at least three neighbours and defines the problem.
- Brainstorms and ideates on the efficient use of energy and generates creative solutions from relevant resources/the internet/asking the elders in their community .
- Designs and develops a prototype (conceptual or physical) of an energy efficient house or building and presents it to the class to validate the efficiency of their prototype or submit a brief explanation (video or write-up) to the teacher for the feedback and assessment through CLT.
- Adapts ideas from the top three prototypes and shares it to their household or community on the efficient and sustainable use of energy.

Questions:

1. Describe twin pillars of sustainable energy policy.
2. Why do you think there is a need for economical and sustainable use of energy resources?
3. What are some of the methods to reduce energy loss from our home?
4. Elaborate on the three methods to use energy efficiently by using relevant examples.

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: may use a rubric to assess the learner's knowledge on the concept of energy conservation and change in the pattern of energy use during presentation.

Working scientifically: may use a rubric to assess the ability of the learner to gather evidence on energy efficiency and design a relevant prototype during the learning process.

Scientific values and attitudes: assess the learner's ability to relate the concept of energy efficiency during sensitisation in their household/school/locality using a rubric.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)

1.4.4 Impact of Power Generation on the Environment.

(Scope:hydroelectricity, solar energy, bioenergy, wind energy, nuclear energy and its impact on environment).

Objective(s):

xi. Discuss various methods of power generation to provide evidence-based ideas to generate power with minimum negative impact on the environment, economy and culture.

Learning Experiences:

The teacher may use the CER Model (Claim, Evidence, Reasoning) to deliver the lesson on the methods of power generation and its impact on the environment. The teacher may provide information on the concept of power generations or relevant learning resources (books, internet links, handouts, downloaded digital content, articles, video links https://rb.gy/tium04, https://rb.gy/719tel, https://rb.gy/s8t5il, etc.) on each method of power generation (hydroelectricity, solar energy, bioenergy, wind energy, and nuclear energy) and its impact on the environment.

Based on the information on each method of power generation and its impact on the environment, the learner claims one of the methods of generating energy as the best method with minimum impact on the environment.

- The learner gathers evidence from available resources (books, internet links, handouts, downloaded digital content, articles, video links https://rb.gy/tium04, https://rb.gy/719tel, https://rb.gy/s8t5il, etc.) on advantages and disadvantages of their choice of power generation and tabulates it to support their claim.
- Provides reason based on evidence gathered and presents the generalised finding to the whole class and relates the significance of power generation with minimum impact on the environment.

OR

The teacher may also initiate PBL (Project Based Learning) by taking learners for a field trip to explore the process of power generation and inquire about its impact on the environment if any power generation sources are located near the school or within the reach of the school.

- The learner in groups will generate the driving question for the project.
- Goes on a field trip as planned by the teacher and collects data on the driving question and derives conclusion from the data.
- The learner after reaching back to school will carry out a presentation based on their observations and data collected to the whole school. Or design an appropriate prototype to show the power generation with minimum impact on the environment.

Questions:

1. You are working in a nuclear power plant. Mention at least two precautions from the harmful effects of nuclear radiation.
2. Compare the generation of energy from solar, wind, and hydropower.
3. Bhutan has built a number of small and big hydropower facilities, generating between 1615 and 1623 megawatts of hydroelectricity. Do you believe Bhutan should build more of these kinds of hydropower plants? Support your answer with justifications.

Assessment:

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

Scientific knowledge: may use a marking scheme to assess the learner's comprehension on methods of power generation and its impact on the environment during a quiz.

Working scientifically: assess the skills of the learner to generalise claims, gather evidence, and communicate findings during the learning process using a rubric. Or, the teacher may also assess the ability of the learner to plan, collect data, analyse, and develop a prototype (physical or conceptual) during the PBL learning cycle using a rubric.

Scientific values and attitudes: assess the learner's curiosity to explore reliable energy sources for the future (lesser impact and greater efficiency) and advocate on the clean and renewable source of energy using a rating scale.

The teacher may provide necessary intervention if need be.

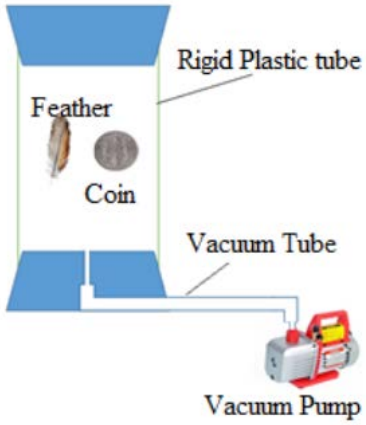
Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://rb.gy/tium04
- https://rb.gy/719tel
- https://rb.gy/s8t5il

Revision Questions:

1. Lowering the centre of gravity (C.G.) and increasing the area of the base of support (B.S.) are two major elements that influence body stability. Explain how the concept of stability is used when a person travels by bus.
2. In an experimental setup below, a coin and a feather of roughly the same surface area are made to fall in a plastic tube. It was observed that the feather falls much more slowly than the coin. Next, air is pumped out of the tube using a vacuum pump. Now it is observed that the feather falls much more rapidly almost as fast as the coin.



Why do you think a feather does not fall in the same manner in the two experiments?

3. The world record for weight lifting is held by Lasha Talakhadze, a Georgian weightlifter. Breaking his own record, in 2019, he lifted 484 kg to a height of 2.3 m in 4 s. Calculate:

   i. The weight lifted by Talakhadze.

   ii. The work done by him, and

   iii. The power developed by him.(take g=10m s^{-2}).

4. Two students are planning for a new sitting arrangement in the physics laboratory. In doing so, they exert a force of 25 N and 8 N respectively to the same cupboard on a frictionless floor as shown below. If the cupboard is displaced by 7 m, what is the work done?

5. There is a tremendous need for energy due to rising population, manufacturing, and consumption. As a result, humanity has begun to experiment with various power producing systems. While some strategies have a favourable environmental impact, others do not. Which electricity producing method is the most efficient? Provide evidence to back up your assertion.

2. Fluid Mechanics and Thermal Physics

The Fluid Mechanics covers everything from pressure due to solids and liquids to pressure transfer inside liquids (Pascal's law). The overall content aids us in comprehending the behaviour of pressure exerted by a solid and a fluid.

Learners will be able to investigate the elements that determine the pressure inside a liquid by creating an experiment, as well as using Pascal's rule, specific heat capacity, and the theory of calorimetry to solve difficulties.

Understanding Pascal's law and the specific heat capacity of various substances in everyday applications through examples, experiments, and numerical puzzles will encourage the learner to demonstrate their grasp of the concept.

Competencies:

- Experiment to deduce mathematical relationship between factors affecting pressure due to solid and fluid to apply its concept in daily life.
- Investigate and design a functional prototype to elucidate the application of Pascal's law in various hydraulic machines.
- Explain the exchange of heat between the system and surrounding to design a calorimeter to verify the principle of calorimetry.
- Analyse and compare the specific heat capacity of substances to make the right choice of materials for specific purposes such as high specific heat capacity material as coolant and low specific heat capacity material as utensils.
- Illustrate the latent heat of fusion and vaporisation through experimentation and be able to relate to the natural phenomena.

2. Fluid mechanics

2.1 Thrust on a Surface Area.

2.1.1 Pressure

(scope: magnitude of pressure due to solid and fluid, mathematical relation, numerical problems and its applications).

Objective(s):

i. Design an experiment to explain the factors affecting the magnitude of pressure due to solid.

ii. Devise an experiment to establish mathematical expression of factors affecting fluid pressure.

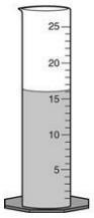
Learning Experiences:

The teacher may guide the learner through the concept and application of pressure due to solid and fluid using the following order of Guided Inquiry (Ask, Plan and investigate, Collect Data, Analyse, and Share). The teacher may provide learning resources (books, internet links, handouts, downloaded digital content, articles, etc.) to help the learner explore information on the concept of pressure due to solid and fluid.

- The learner responds to various questions on pressure due to solid and fluid and gathers information on the concept of pressure due to solid and fluid from relevant learning resources (books, internet links, handouts, downloaded digital content, articles, etc.)
- Frames questions or hypotheses to investigate the factors affecting pressure due to solid and pressure due to fluid.
- Predicts the possible factors to the question they framed and plans the investigation using available materials.
- Carries out the experiment as planned and collects data.
- Analyses the data to construct reasonable explanations or mathematical representations to answer the question.
- Shares their findings with other learners in the class.
- States applications of pressure in real life situations, and solves problems based on pressure due to solid and pressure due to fluid.

Questions:

1. Why does a lady walking in high heels cause little dimples in a floor than walking with flat heels?
2. The pressure exerted by 16 cm of a liquid is 1600 Pa. The acceleration due to gravity g=10 m/s^2. Calculate the density of liquid and identify the type of liquid based on density.



3. What will happen to acceleration due to gravity if we move further away from the centre of earth?
4. Why should you use an iron hammer instead of a wooden hammer?

Assessment:

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

Scientific knowledge: assess the learner's conceptual understanding of pressure due to solid and fluid, and factors affecting solid and fluid pressure from explanation using a rubric.

Working scientifically: assess the ability of the learner to search information, plan investigation, collect data, present findings, and solve numerical problems using an observation form during the learning process.

Scientific values and attitudes: assess the learner's ability to relate the significance of pressure due to solid or pressure due to fluid in daily life using a rubric during the explanation.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)

2.2 Transmission of Pressure in the Liquid

2.2.1 Pascal's Law

(Scope: description, application, and numerical problems)

Objective(s):

iii. Verify Pascal's law through an experiment (simulation or practical) to relate its application in hydraulic machines.

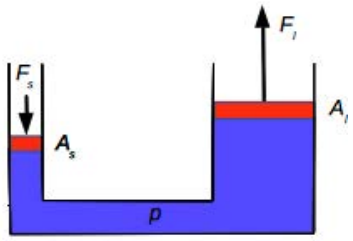
Learning Experiences:

The teacher may provide conceptual information on Pascal's law through presentation or demonstration, and instruct the learner to carry out confirmation inquiry (Ask, Plan and Investigate, Collect data, Analyse data, Share) to verify Pascal's law.

- Based on the question provided by the teacher, the learner brainstorms on the transmission of pressure.
- The learner gathers materials and carries out the experiment or uses simulation links https://tinyurl.com/yckryvav or https://javalab.org/en/pascals_principle_en/ following the procedures. The learner may use the video link https://bit.ly/3eDGU0B as a reference in carrying out the experiment.
- Collects and analyses data, and draws a conclusion to verify the law.
- Shares the findings to the class and recognizes the significance of the law in the working of hydraulic machines.

Questions:

1. What will happen to the pressure on the piston if we double the area of the piston?
2. Support the statement "hydraulic machines act as a force multiplier".
3. A hydraulic lift with piston of area $A_s = 25\ cm^2$ and $A_l = 225\ cm^2$ is shown in the given figure. If the weight of the block $F_l = 1800\ N$, find the minimum force F to lift up the weight F_l.



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: the teacher may use a checklist to assess the learner's conceptual understanding of Pascal's law while using law in experimentation.

Working scientifically: assess the learner's ability to follow the instruction, carry out experiment or simulation to verify the law, and report the finding using a rubric.

Scientific values and attitudes: assess the learner's ability to relate the application of the law in the working of hydraulic machines while the learner shares findings from 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
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/3eDGU0B
- https://tinyurl.com/yckryvav
- https://javalab.org/en/pascals_principle_en/

2.2.2 Application of Pascal's Law

Objective(s):

iv. Develop a structure or model of any hydraulic machine based on the principle of transmission of liquid pressure.

Learning Experiences:

The teacher may use design thinking to develop a prototype of any hydraulic machine incorporating the principle of transmission of liquid pressure. The teacher may provide the link https://bit.ly/3eES0lW or relevant resources (books, power presentation, internet link, etc.) on the principle of hydraulic machines and its applications, and guide students through the design cycle.

- The learner explores the link https://bit.ly/3eES0lW or relevant resources to gather information on the application of the principle of hydraulic machines.
- Discusses how the transmission of liquid pressure acts as a force multiplier to do work.
- Brainstorms and comes up with creative ideas to design a prototype of the structure/model of any hydraulic machine that incorporates the principle of transmission of liquid pressure.
- Develops a prototype based on the design.
- The learner puts the prototype on test and re-develops the prototype if required.
- Based on the test results, the learner explains the ways to multiply force to the rest of the learners in the class, and relates its significance in daily life.

Questions:

1. The principle of Pascal's Law is in action every time you witness a car come to a halt. Support the assertion.
2. The hydraulic jack also uses the principle of lever. Support the statement with a diagram.

3. What are the necessary conditions for Pascal's law to be valid?

Assessment:

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

Scientific knowledge: may use a checklist to assess the learner's conceptual understanding of hydraulic machines and its application from the discussion .

Working scientifically: assess the learner's ability to design a prototype of a hydraulic machine and present its working using a rubric.

Scientific values and attitudes: the teacher may assess the learner's ability to recognize the applications of hydraulic machines in making work easier in daily life during the model presentation using a observation.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/3eES0lW

2.3. Thermal Physics

2.3.1 Specific Heat Capacity

(Scope: concept of heat capacity, compare specific heat capacity of different substances and its application, numerical problems)

Objectives:

v. Conduct an experiment to compare specific heat capacity of different substances to select the substances for specific purposes.

Learning Experiences:

The teacher may carry out the instructional practises on the concept of heat capacity and specific heat capacity through activity based learning. The teacher may provide the link https://tinyurl.com/y6xztz3t and deliver the concept of heat capacity and specific heat capacity to

solve numerical problems. The teacher may also provide the link https://tinyurl.com/3k25h9bb or relevant resources to carry out the experiment on specific heat capacity of different substances.

- The learner comprehends the differences between heat capacity and specific heat capacity from the link https://tinyurl.com/y6xztz3t.
- Carries out the experiment after watching the video from the link https://tinyurl.com/3k25h9bb or uses relevant resources to carry out the experiment.
- Collects and analyses data to draw conclusions on specific heat capacity of different substances.
- Communicates the results and generalises the applications of specific heat capacity of different substances for specific purposes.
- Solves the numerical problems using appropriate formulae and variables.

Questions:

1. The amount of heat absorbed or evolved by a body depends upon its mass, specific heat capacity and
    A. final temperature
    B. change in temperature
    C. initial temperature
    D. average temperature
2. Namgay is undecided about whether water or another liquid should be used as a coolant in automotive radiators. What advice would you give him? Why?
3. A kg of iron and a kilo of lead, both at 1000 degrees Celsius, are kept on ice. It is discovered after some time that the iron has melted more ice than the lead. Why?

Assessment:

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

Scientific knowledge: may use a rubric to assess the conceptual understanding of heat capacity and specific heat capacity from the explanation using a rubric.

Working scientifically: assess the learner's ability to conduct the experiment, record data and communicate findings from the experiment using a rubric and to solve numerical problems using a marking scheme.

Scientific values and attitudes: assess the ability of the learner to be inquisitive, follow instruction, collaborate, and recognize the significance of specific heat capacity of different substances from the conclusion 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.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://tinyurl.com/3k25h9bb
- https://tinyurl.com/y6xztz3t

2.3.2. Calorimeters and Calorimetry

(Scope: calorimeters, principle of calorimetry and its applications, and numerical problems).

Objective(s):

vi. Design calorimeter and carryout experiment to validate the principle of calorimetry.

Learning Experiences:

The teacher may use a scientific inquiry method to carry out the lesson on calorimeter, principle of calorimetry and its applications following the instructional procedure. The teacher may ask questions based on the concept of heat exchange in an open and isolated system to help the learner build hypotheses.

- Based on the guiding questions from the teacher, the learner builds up their hypothesis on the heat, heat flow involving the concept of system and surrounding.
- Conducts an experiment to investigate the loss and gain of heat using calorimetry.
- Collects data and analyses to explain the principle of calorimetry.

- Based on the information input from the teacher, the learner gathers information on the construction and working of a calorimeter and designs a model. The learner may use the video link https://youtu.be/xizMoB6sZ7Y as a reference to develop a calorimeter.
- The learner presents their model to the class.
- The learner may also play with the simulation using the link https://bit.ly/3cuymq8, plots the graph between change in temperature with time and analyses and writes short notes explaining the application of heat exchange.

Questions:

1. Will you feel the water colder than it truly is if you dip your hand in cold water after dipping it in warm water? Give an explanation for your answer.
2. Same amount of heat is added to two substances of the same mass having specific heat capacities C_1 & C_2 such that $C_1 > C_2$. Select the correct statement.

   a) The change in temperature of 1 is greater than the change in temperature of 2

   b) The change in temperature of 1 is less than the change in temperature of 2

   c) Both will have the same change in temperature

   d) Temperature changes can't be related with specific heat capacities

3. The heat required to raise 3kg of copper from 0^0C to 10^0C raises 1 kg of lead from 10^0C to 100^0C. If the specific heat capacity of copper is 0.095 cal/g^0C, find the specific heat capacity of lead.

Assessment:

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

Scientific knowledge: the teacher may use a checklist to assess the learner's comprehension of the principle through explanation.

Working scientifically: the teacher may use a rubric to assess the ability of the learner to carry out an experiment using the given procedures, analyse data, and communicate findings.

Scientific values and attitudes: the teacher may assess the learner's ability to recognize and relate the application of heat flow between the system and the surroundings during explanation using a rubric.

The teacher may provide necessary intervension based on need.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://youtu.be/xizMoB6sZ7Y
- https://bit.ly/3cuymq8

Objective(s):

vii. Interpret the principle of calorimetry and use calorimetric data to calculate heat exchange.

Learning Experiences:

The teacher may carry out the instructional practises to calculate heat gained or lost based on the interpretation of principle of calorimetry. The teacher may provide learning resources (books, internet links, handouts, downloaded digital content, articles etc.) to let the learner gather additional information on calorimetry.

- The learner goes through the given numerical problems to identify the principle or concept used in the problem.
- Lists data, quantities, and variables given in the question.
- Translates the data into an algebraic equation and solves for the missing variable.
- Relates the conclusion from numerical problems to some real life application.

Questions:

1. A solid of mass 50g at 150°C is placed in 100g of water at 11°C, when the final temperature recorded is 20°C ? Find the specific heat capacity of solid.(specific heat capacity of water = $4.2J/g^{-10}C^{-1}$)
2. What relation can you draw between the principle of calorimetry and the law of conservation of energy?

3. 0.1 m^3 of water at 80^0C is mixed with $0.3m^3$ of water at 60^0C. What is the final temperature of the mixture?

Assessment:

The teacher may use checklist/observation form/rubrics/rating scale/marking scheme/anecdotal records 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 principle or concept used in the problem while solving numerical problems using a marking scheme.

Working scientifically: assess the ability of the learner to solve numerical problems based on interpretation of the principle of calorimetry using a marking scheme.

Scientific values and attitudes: assess the ability of the learner to act responsibly to accomplish allocated tasks, and seek feedback and clarification while solving numerical problems using a checklist.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)

2.3.3 Latent Heat

(Scope: latent heat of fusion, explain latent heat of vaporisation and its effects)

Objective(s):

viii. Illustrate the latent heat of fusion and vaporisation through experimentation to relate its application to natural phenomena.

Learning Experiences:

The teacher may use the 5E model to deliver the lesson on the concept of latent heat of fusion of ice and latent heat of vaporisation of water. The teacher may provide a link https://youtu.be/xavFw8TlfAk or other relevant materials to engage the learner in gathering information on the concept of latent heat.

- The learner engages in gathering information related to latent heat of fusion and latent heat of vaporisation, and its effects using relevant resources or the video link https://youtu.be/xavFw8TlfAk.
- Explores the relevant materials required for the experiment and prepares an experimental set up.
- Experiments to observe the process of latent heat of fusion of ice and latent heat of vaporisation of water.
- Explains the concept of latent heat of fusion of ice and vaporisation of water based on the observation using graphical representation.
- Elaborates on the effects of latent heat of fusion of ice and vaporisation of water, and relates it to natural phenomena.
- Reflects and incorporates feedback given by the teacher and peers to evaluate their understanding of the concepts.

Questions:

1. A vessel containing water is kept in an oven. The temperature of water increases as heat is supplied to it from the oven. But the temperature stops rising when the water begins to boil. What is the reason for this? Where does the heat go then?
2. The cubes of ice are found to cool the drinks more effectively than cold water at the same room temperature. Supports this statement.
3. Why steam at 100^0C causes more severe burns than boiling water at the same temperature?

Assessment:

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

Scientific knowledge: assess the learner's knowledge on latent heat of fusion and latent heat of vaporisation while explaining the concept using a checklist.

Working scientifically: assess the learner's ability to explore the information, use scientific skills in conducting the experiment, gather data, draw inferences, and communicate findings during the learning process using a rubric.

Scientific values and attitudes: assess the learner's ability to carry out the experiment with safety measures, collaborate with peers during experiment, and relate the concept of latent heat to the natural consequences while explaining the concept using a rubric.

Teacher may provide necessary intervension based on need.

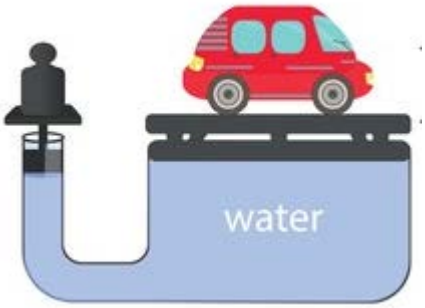
Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

Resources:

- REC repository.
- Physics Class Nine by Kinley Gyeltshen and Sumitra Subba (Reprint 2019).
- https://youtu.be/xavFw8TlfAk

Revision Questions:

1. Design a prototype/model of any hydraulic machine that incorporates the principle of transmission of liquid pressure.
2. A piece of ice at 0 degree celsius is heated at a constant rate and its temperature recorded at regular intervals till steam is formed at 100 degree celsius. Draw a temperature-time graph to represent the change in phase. Label the different parts of your graph.
3. The diagram below shows the set-up to study hydraulic principle by placing different weights on the small piston. The table below shows the result of this experiment.



Weight	4	8	10	18
Load	6	12	15	27

i) What is the relationship between weight and load?

ii) How can you lift a much heavier load by placing a smaller weight on the small piston?

4. Sonam found that the change in temperature of the aluminium container of mass 5kg is from 25^0C to 15^0C. Will there be heat loss or gain? Calculate the amount of heat lost or gained by the container. Take the specific heat capacity of aluminium as 600 $jkg^{-1}{}^0C$.
5. Study the specific heat capacity of substances given in the table and answer the following questions.

Substances	**Specific heat capacity in** cal/g^0C
Copper	0.095
Gold	0.032
Concrete	0.21
Olive oil	0.43
Platinium	0.032

   a. If all the substances given are heated for the same duration of time, which substance will be heated to a maximum temperature?
   b. When 344 calories of heat are supplied to 40 g of a substance, there is a rise in its temperature by 20^0C. Identify the substance.

3. Electricity and Magnetism

Although conceived of as distinct phenomena until the 19th century, electricity and magnetism are now known to be components of the unified field of electromagnetism. Particles with electric charge interact by an electric force, while charged particles in motion produce and respond to magnetic forces as well. Many subatomic particles, including the electrically charged electron and proton and the electrically neutral neutron, behave like elementary magnets. On the other hand, in spite of systematic searches undertaken, no magnetic monopoles, which would be the magnetic analogues of electric charges, have ever been found.

For a long period of time, electricity and magnetism were considered as two entities. Hans Christan Orested, and then later Michael Faraday proved the interdependence between electricity and magnetism.

Thus, electricity and magnetism are two related phenomena produced by the electromagnetic force. Together, they form electromagnetism. A moving electric charge generates a magnetic field. A magnetic field induces electric charge movement, producing an electric current.

In this theme, we shall study more on these two topics, their relationships, and their applications in our daily life.

Competencies:

- Deduce the relation among potential difference, current and resistance to verify Ohm's law and analyse I-V graphs for different types of conductors to relate its uses in electronic gadgets.
- Demonstrate understanding of Faraday's laws of electromagnetic induction through simulation or model and apply the concept to design and explain the working of an a.c generator.
- Explain the concept of heating effect of current and electric power to relate its applications in daily use of electrical appliances.
- Design and experiment on working of step up and step down transformers based on electromagnetic induction to explore its application in power transmission and various electrical appliances.

3.1. **Electric Circuit**

(Scope: flow of electric current, potential difference, resistance and resistors, factors affecting resistance, potential drop)

Objective(s):

i. Explore the concept of electric current, potential difference and resistance using appropriate analogy/CAI tools/simulation/mobile apps.

Learning Experiences:

The teacher may recapitulate the concept of electric current and potential difference based on previous knowledge and use POE (Predict, Observe, Explain) to establish the relationship between electric current and potential difference in the following order of activity.

- The learner recapitulates the concept of electric current and potential difference.
- Predicts the relationship between electric current and potential difference.
- Observes the relationship between electric current (based on amount of charges) and potential difference (reading in the voltmeter) from the simulation links https://bit.ly/2OpfBww or http://ophysics.com/em4.html
- Uses ideas gathered from the observation or uses analogy to explain their understanding of the relationship to the whole class.

Questions:

1. Based on the comprehension of electric current and potential difference, deduce the mathematical relationship between electric current, potential difference, and resistance.
2. Use the following table or generate your own reading from the PhET simulation on electric current and potential difference and answer the following questions.

Voltage (V)	Current (I)
3.0	0.151
6.0	0.310
9.0	0.448
12.0	0.511
15.0	0.750

a) Use the above data to plot the graph using CAI or graph paper labelling the right variables with the axis.

b) Calculate the slope of the graph and explain the slope which represents one of the variables of electricity.

Assessment:

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

Scientific knowledge: Assess the conceptual understanding of the learner to establish a relationship between electric current and potential difference while explaining or sharing analogy using a rubric.

Working scientifically: May use a checklist to assess the learner's ability to use the simulation to deduce information on the relation between potential difference (voltage) and electric current (based on amount of charges).

Scientific values and attitudes: Assess the learner's ability to relate the concept of current drawn and voltage at which the various electrical devices operate in daily life using a checklist.

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

Resources:

- REC repository.
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/2OpfBww
- http://ophysics.com/em4.html

3.2 Ohm's law

(*Scope: law, verification, Ohmic and non-ohmic conductor, calculations)*

Objective(s):

ii. Devise an experiment or use simulation to construct a relationship amongst current, potential difference, and resistance.

iii. Interpret the graph of ohmic and non-ohmic conductors to comprehend its application in various electrical devices.

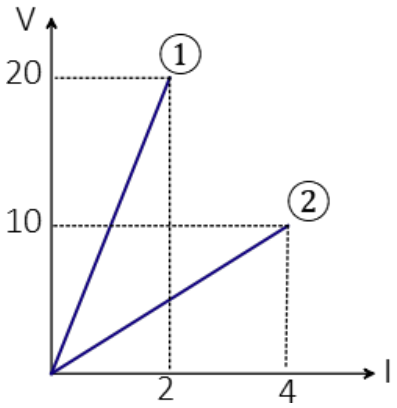
Learning Experiences:

The teacher may provide conceptual information on current, potential difference and resistance through presentation or demonstration, and instruct the learner to carry out confirmation inquiry (Ask, Plan and Investigate, Collect data, Analyse data, Share) to verify the Ohm's law through practical experimentation or verify from the simulation link https://bit.ly/3bKsBFx. The teacher may assign numerical problems based on Ohm's law and provide the video link https://bit.ly/2Nh7uRS to identify ohmic or non ohmic.

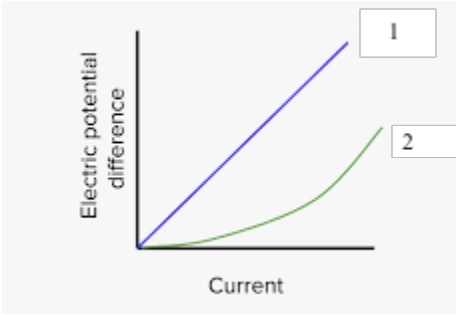
- Based on the information provided by the teacher, the learner brainstorms on the relation between current, voltage and resistance.
- The learner designs and experiments to construct the relation among current, voltage, and resistance physically or using the simulation link https://bit.ly/3bKsBFx.
- Collects and analyses data (current-voltage graph), and draws a conclusion to construct the relation among current, voltage, and resistance.
- Explains Ohm's law based on inferences drawn from the experiment and information from any relevant sources.
- Sets up the similar experiment in groups with different materials (copper wire, tungsten wire, manganese wire, nichrome wire, diode, thermistor, LDR etc.)
- Use one type of material in each group and find out the variation of current with the voltage.
- Plots current-voltage graphs for the experiment using CAI tools and shares their findings to the whole class or share through CLT.
- Explains the graph and identifies ohmic or non-ohmic conductors from the material provided based on graphs plotted for each material.
- Watch the video on ohmic and non-ohmic conductors using the link https://bit.ly/2Nh7uRS.
- Solves the related numerical problems.

Questions.

1. Explain the relationship between current, voltage, and resistance. Make each variable a subject and use mathematics to deduce the relationships.
2. The voltage-current curve for an ohmic conductor is plotted as shown in the figure below. What is the resistance of resistors 1 and 2?



3. A student conducts an experiment and measures the current and voltage across two unknown resistors. Then she/he plots her/his finding in a current-voltage coordinate, as shown in the figure. What can be concliuded about resistors A and B?



4. In a circuit, the potential drop across the 10 kΩ -resistor is 100 V. What is the current through the resistor?

Assessment:

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

Scientific knowledge: Assess the learner's conceptual understanding of the Ohm's law and the relationship among variables from discussion using a checklist.

Working scientifically: Assess the learner's ability to carry out the experiment, gather data, plot graphs and draw conclusions using a rubric.

Scientific values and attitudes: Assess the learner's ability to relate the use of Ohm's law in various appliances while interpreting I-V graphs using a rubric.

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

Resources:

- REC repository.
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/2Nh7uRS
- https://bit.ly/3bKsBFx .

3.3 Heating Effect of Current

(Scope: applications, electric power, and numerical problems

Objective(s):

iv. Describe the heating effect of electric current and its application in a range of devices to calculate its electric power. (5)

Learning Experiences:

The teacher may use guided inquiry to investigate the variation of current with change in resistance in following order. The teacher may ask the question: how is heating effect determined by change in resistance and apply its concept in calculating electric power? The teacher may also provide video links https://rb.gy/jmi1pi, https://rb.gy/p9qogm, https://rb.gy/xlf5ny to supplement on the heating effect of current.

- Based on the information from previous lessons, the learner uses the question to investigate the variation of change in current with change in resistance.
- The learner plans and investigates the variation using required materials.
- Collects and analyses the data to share it to the whole class.
- Analyses the variation of current with variation in resistance and applies its concept in the heating effect of current ($H = I^2$Rt).
- Watch videos from the links https://rb.gy/jmi1pi, https://rb.gy/p9qogm, https://rb.gy/xlf5ny to supplement their analysis.
- Solves the numerical problems on the heating effect of electric current and electric power.
- Analyses the applications of heating effect in daily life and appreciates its positive impact on human life and environment.

Questions:

1. The resistors with high resistance and high melting points are used are used in electrical appliances such as rice cookers, warmers, and curry cookers. What are the advantages of utilizing high-resistance, high-melting-point resistors?
2. The heating effect of a current is as given by $H = I^2Rt$. What will happen to the heat produced if the current increases by two times? Resistances remain constant.
3. Find the heat energy produced in a resistance of 10 Ω when 5 A current flows through it for 5 minutes.
4. The electric current passing through a metallic wire produces heat because of
   (a) collisions of conduction electrons with each other.
   (b) collisions of the atoms of the metal with each other.
   (c) the energy released in the ionization of the atoms of the metal.
   (d) collisions of the conduction electrons with the atoms of the metallic wires.

Assessment:

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

Scientific knowledge: Assess the learner's comprehension on variation of current with resistance and the heating effect of current while explaining using a checklist.

Working scientifically: Assess the learner's ability to carry out the experiment, analyse data, solve numerical problems using a checklist.

Scientific values and attitudes: Assess the learner's ability to carry out the experiments with safety measures, and relate the application of the heating effect of current in daily life while explaining the concept using a rating scale.

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

Resources:

- REC repository.
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://rb.gy/jmi1pi
- https://rb.gy/p9qogm

- https://rb.gy/xlf5ny

3.4 Electromagnetic Induction

(Scope: Faraday's laws, a.c generator, working of a.c generator, factors affecting the magnitude of induced emf, types of transformers, applications, and numerical problems)

Objective(s):

v. Carry out an experiment or use simulation to demonstrate Faraday's laws and explore their applications in real life situations.

vi. Develop a model/simulation/animation to illustrate the working of a.c generator employing relevant programming language/interactive presentation tools.

Learning Experiences:

The teacher may use field trip to teach the concept of electromagnetic induction and its application in the following order of activity. The teacher may plan and arrange a field trip to the nearest hydroelectric power station or substation. The teacher may provide foundational input on the concept of electromagnetic induction and related terminologies, and complete necessary arrangements before the field trip. The teacher may develop a worksheet and questions to be completed during and after the field trip. The teacher may facilitate the learner to develop a mini-hydro power plant (physical or conceptual) and exhibit it to the whole school.

(OR)

The teacher may use predict, observe and explain (POE) to explain the concept of Faraday's law in the following order of instructional sequences. The teacher may bring an experimental set up to demonstrate Faraday's law and ask the learner to predict what will happen if the magnet is moved near the conductor coil, if speed of motion of magnet is increased, if the number of turns of coil is increased, etc. The teacher may also use the simulation from the link https://bit.ly/3qGSpqw to supplement the concept.

- The learner predicts on the concept of electromagnetic induction as per the questions posed by the teacher.

- Observes the experimental demonstration made by the teacher and carries out the practical or plays the simulation from the link https://bit.ly/3qGSpqw as instructed by the teacher to observe an induction of electricity.
- Explains the concept of electromagnetic induction and Faraday's laws from the observation made and states Faraday's law of electromagnetic induction and relates its applications in devices like a.c generator and transformer.

OR

The teacher may use the 5E Model to deliver the lesson on practical application of electromagnetic induction to construct a.c generator or mini hydropower plant. The teacher may use the video from the link https://youtu.be/MW1YUy3Yqpc or handouts on the working of a.c generator.

- The learner engages in gathering information related to Faraday's law and electromagnetic induction based on the information from relevant sources.
- The learner explores the information on working and application of a.c generator from the video https://youtu.be/MW1YUy3Yqpc or any other relevant sources.
- The learner explains the working of the generator and the procedure to construct the model of a.c generator to the class.
- The learner elaborates the concept on working of a.c generator and factors affecting the magnitude of voltage induced through construction of a.c generator in a group or develops an animation or simulation using relevant software to simulate the working of a.c generator under the guidance of the teacher.
- The learner demonstrates and presents their model (physical or conceptual) to the whole school while the teacher assesses their works.

Questions:

1. When a moving charge particle is placed in a magnetic field, it experiences a force. What happens when the current carrying conductor is placed inside the magnetic field?
2. "Whenever there is change in the magnetic field lines passing through the conductor, voltage is induced in it". Using this statement answers the following questions.
   i. Name the law given by the statement.
   ii. How long will the induced current remain in the conductor?.
   iii. What is the relationship between induced voltage and rate of change magnetic field?.

3. Use the a.c generator model and answer the following questions

   i. Explain the parts of a.c generator.

   ii. Name the working principle of a.c generator.

   iii. State the working principle of a.c generator.

Assessment:

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

Scientific knowledge: Assess the comprehension of the learner on Faraday's laws, factors affecting the magnitude of voltage induced while explaining using a rubric.

Working scientifically: May use a rubric to assess the ability of the learner to carry out demonstration on Faraday's laws, organise ideas, and develop a model of a.c generator during the learning process.

Scientific values and attitudes: Assess the learner's ability to relate the application of electromagnetic induction in power generation and transmission while presenting the model of a.c generator using a rubric.

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

Resources:

- REC repository.
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/3qGSpqw
- https://youtu.be/MW1YUy3Yqpc

Objective(s):

vii. Design a conceptual model of transformer with high efficiency, state applications and basic calculations on transformation ratio.

Learning Experiences:

The teacher may use the instructional practises in the following order to guide the learner through the concept of transformer, types, ways to step up or step down the output voltage, use of transformation ratio in designing an efficient transformer. The teacher may use the video link https://bit.ly/38BCXpd to give additional information to the learner.

- The learner gathers information concept, construction and types of transformer, ways to step up or step down the output voltage, use of transformation ratio in designing an efficient transformer from teacher's presentation, video link https://bit.ly/38BCXpd and other relevant sources.
- Studies the variables that are involved in altering the output voltage of the transformer.
- The learner designs a conceptual transformer considering all the factors that affect its efficiency in a group.
- Uses a transformation ratio to calculate the output voltage, current and number of turns for any given input.
- Narrates the application of the transformer designed by them, and presents their group work to the class for peer assessment.

Questions:

1. How is a voltage produced on a transformer's secondary coil?
   (a) The changing magnetic field in the core cuts across the secondary coil, inducing a voltage.
   (b) The current in the primary coil conducts through the iron core and into the secondary coil.
   (c) The secondary coil is attached to an external power supply.
   (d) To change the voltage of an alternating current.
2. A transformer has a primary and secondary coil with 500 and 5000 loops, respectively. If 220 V is the input voltage, what is the voltage of the output?
3. A transformer has 1200 loop primary coil and 1000 loop secondary coil. What is the current in the secondary coil if the primary coil's current is 4 Ampere?
4. Transformers are used in many electrical devices. Name the types of transformer used in mobile charger.

Assessment:

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

Scientific knowledge: Assess the learner's conceptual understanding of the transformer, its types, and factors affecting output of the transformer while designing using a rubric.

Working scientifically: Assess the learner's ability to design a conceptual model using a rubric and to solve numerical problems based on transformation ratio using a marking scheme.

Scientific values and attitudes: Assess the learner's ability to relate the use of transformers in power transmission and in electrical devices while explaining the applications of transformers using a rubric.

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

Resources:

- REC repository.
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/38BCXpd

Revision Questions:

1. Assume you have a wire in a circuit with a current of 10 amps that branches into two other wires. How much current must be flowing in the other wire if one has 7 A?
2. Birds do not electrocute when they sit on high-tension wires, even when the line is bare, but a squirrel that steps from a bare wire to a pole or another wire kills instantaneously. Why?
3. An AC voltage of 5 V is converted to 50 V using a transformer having 10 main turns and 100 secondary turns. Explain why this isn't incompatible with the concept of energy conservation.
4. An electric guitar pickup is made out of a tiny metal coil coiled around a magnet. If the magnetic field near the pickup changes, current is induced in the coil due to Faraday's law. Is it possible to use this type of pickup with nylon or other non-metal strings? Explain.

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, Ray optics and Wave optics. Wave optics deals with the connection of waves and rays of light. Wave Optics deals with the study of various phenomenal behaviours of light like reflection, refraction, interference, diffraction, polarisation etc

Waves are a very significant part of our daily life. Understanding waves is necessary to comprehend a variety of physical phenomena, including light and the wave qualities of matter, such as electrons and atoms.

Waves and optics have a wide range of uses in our daily lives, including communication and medicinal applications.

Competencies:

- Examine the scientific and technical information of electromagnetic waves and their applications to comprehend the applications of waves in communication, medicines and entertainment.
- Gather evidence to comprehend communication using different waves over short and long distances to compare their effectiveness in communication for specific purposes.
- Interpret the ways of transmitting information using digital signals and analogue signals integrating scientific and technical information to claim that digital signals are more reliable and effective than analogue signals.

4.1. Types of Electromagnetic Waves

(Scope: types of electromagnetic waves based on frequency and wavelength, applications, and safety measures)

Objective(s):

i. Describe scientific properties of electromagnetic waves and their application.

Learning Experiences:

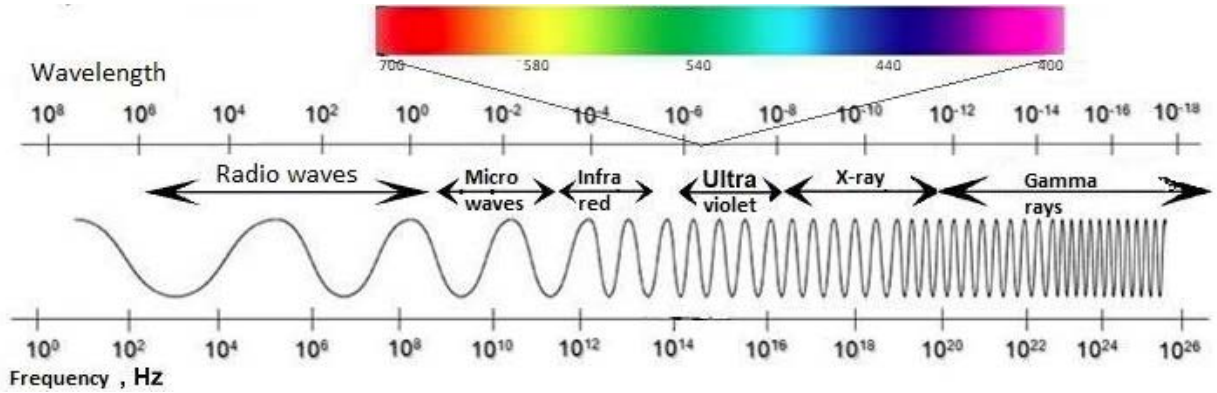
The teacher may divide the learners into groups and assign them with one of the electromagnetic waves to explore its properties, applications, and harmful impacts using REI (Research, Evidence, Inference). The teacher may provide links https://bit.ly/3bKtjmb and

https://bit.ly/2OR00Wc or relevant resources (books, handouts, etc.) to assist the learner to gather evidence. The teacher may also carry out instructional practises to impart the concept on the use of electromagnetic waves for communication over long and short distance.

- The learner explores information on one of the electromagnetic waves from the relevant sources (the internet, text books, handouts, etc.).
- Gathers the evidence on the concept and organises the evidence from the links https://bit.ly/3bKtjmb and https://bit.ly/2OR00Wc.
- Obtains information regarding harmful effects of waves, communicates about the safety measures, and explores more facts on the concept of communication over long and short distance from the relevant resources.
- Prepares a group presentation and shares their inferences on the concept through presentation or through CLT.

Questions:

Use the figure given below to answer the questions.



1. Which of this electromagnetic radiation has lowest and highest energy?
2. What happens to the frequency and wavelength of the waves as it moves towards the right side from the left side?
3. Using the concept of question 2, what will be the relationship between frequency and wavelength. Write its mathematical form.

Assessment:

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

Scientific knowledge: Assess the conceptual understanding of the properties of electromagnetic waves from the presentation using a checklist.

Working scientifically: Assess the ability of the learner to explore relevant sources, gather evidence and make inferences during presentation by using a rubric.

Scientific values and attitudes: May use a rubric to assess the ability of the learner to recognise the applications of electromagnetic spectrum in daily life and communicate safety measures during presentation.

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

Resources:

- REC repository.
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/3bKtjmb
- https://bit.ly/2OR00Wc

4.2 Communication through Waves

(Scope: communication over short and long distances, communication through sound waves, analogue and digital signals).

Objective(s):

ii. Demonstrate understanding of application of electromagnetic waves for communication over long and short distances.

iii. Design a device or use model that is used to communicate over short and long distances using electromagnetic waves.

Learning Experiences:

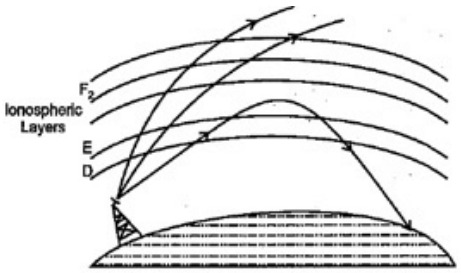
The teacher may use design thinking to facilitate the learner to design a prototype that is used to communicate using electromagnetic waves (eg. homemade radio and a mini radio station in the school) in the following order. Teachers may provide the link https://tinyurl.com/2p8vj25w or provide relevant resources to understand the application of electromagnetic waves.

- The learner watches the video from the link https://tinyurl.com/2p8vj25w or relevant resources to understand the application of electromagnetic waves.

- Engages in discussion to empathise on the need to have daily national and international news and information updates for the students in the school.
- Defines and focuses on the question based on their insight from the empathy stage.
- Explores information on the internet and other relevant resources, brainstorms and comes up with creative ideas to design a prototype.
- Develops a prototype based on the design.
- Puts the prototype on test and re-develops the prototype if required or refines their conceptual model based on comments and feedback.
- Based on the test results, the learner explains the use of electromagnetic waves in communication, and relates its significance in daily life or submits an explanation of the illustration/conceptual model with special emphasis on the application of such models to do real world work through CLT.

Questions:

1. Why are short waves used for long distance radio transmission?



2. What distinctions can you make between the short and long-distance communication based on the figure given?
3. Describe the brief explanation on internet communication.
4. Describe some negative effects of mobile communication.

Assessment:

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

Scientific knowledge: the teacher may use a checklist to assess the conceptual understanding of application of electromagnetic waves during explanation.

Working scientifically: Assess the ability of the learner to gather relevant information, and present the ideas using a rubric while designing a prototype.

Scientific values and attitudes: Assess the learner's ability to emphasize on the use of electromagnetic waves in communication and design solutions using a rubric during the learning.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://tinyurl.com/2p8vj25w

Objective(s):

iv. Perform an experimental verification to show that sound waves obey the laws of reflection.

Learning Experiences:

The teacher may facilitate the learner to comprehend the properties of sound waves and confirm that sound waves obeys the laws of reflection by following the order of confirmation inquiry. The teacher may provide learning resources (books, internet links, handouts, downloaded digital content, articles etc.).

- The learner explores the properties of sound waves and gathers information to frame a question on reflection of sound waves from relevant resources.
- Predicts the possible answers to the question, following the instruction provided to investigate using relevant resources.
- Carries out the experiment and collects data.
- Analyses the data to confirm that sound waves obey the law of reflection.
- Shares their findings to the class.
- States the phenomena and applications of the reflection of sound waves in real life situations.

Questions:

1. What happens if the pipe through which sound is heard is lifted vertically for a short distance in your experiment to verify the laws of reflection sound?
2. Mention the scientific evidence to prove that sound waves undergo reflection?

3. During the process of performing the experiment to verify the reflection of sound, you may not be able to get the expected result. Mention the conditions necessary for you to get the expected result?

Assessment:

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

Scientific knowledge: Assess the comprehension of properties of sound waves during presentation using a checklist.

Working scientifically: Assess the ability of the learner to carry out experiments, record data and draw inferences using a rubric.

Scientific values and attitudes: Assess the ability of the learner to be inquisitive, follow instructions, and recognize the significance of the reflection of sound waves using a rubric during the learning process.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)

Objective(s):

v. Interpret the ways of transmitting information using digital signals and analogue signals.

Learning Experiences:

The teacher may carry out instructional practises on analogue and digital signal through a group discussion by instructing the learner to gather information on the concept, find differences, interpret ways of transmitting information using digital signals and analogue signals, provide reasons on why digital signal is better than analogue signal, and prepare a group presentation.

- The learner gathers information on the analogue and digital signals from any relevant sources (such as https://youtu.be/gGxpUZ_iuYA and https://youtu.be/qSEmEpv5ct8) and finds their differences.

- Discusses ways of transmitting information using digital signals and analogue signals.
- The learner provides reasons to explain advantages of digital signals over analogue signals to transfer information in telecommunication technology.
- The learner prepares a group presentation and shares it with the whole class.

Questions:

1. Using a digital signal instead of an analog transmission has various advantages. What causes it to be so?
2. Which of the following devices stores the data in an analog from?
   (a) CD.
   (b) USB stick.
   (c) Cassette Tape.
   (d) Computer hard drive.
3. There are three types of waves: carrier wave, signal wave, and modulated wave.For a variety of causes, waves are modulated in frequency or amplitude. Draw a diagram that depicts both frequency and amplitude modulation. Give reason for the modulation of frequency or amplitude

Assessment:

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

Scientific knowledge: Assess the learner's conceptual understanding of the analogue signal, digital signal, process of transmitting information, and the advantages of digital signal while presenting using a rubric.

Working scientifically: Assess the learner's ability to gather evidence to prove advantages of digital signal over analogue signal and communicate findings using a rubric.

Scientific values and attitudes: Assess the learner's ability to provide justification to use digital signals in communication systems using a rubric during presentation.

The teacher may provide necessary intervention if need be.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://youtu.be/gGxpUZ_iuYA
- https://youtu.be/qSEmEpv5ct8

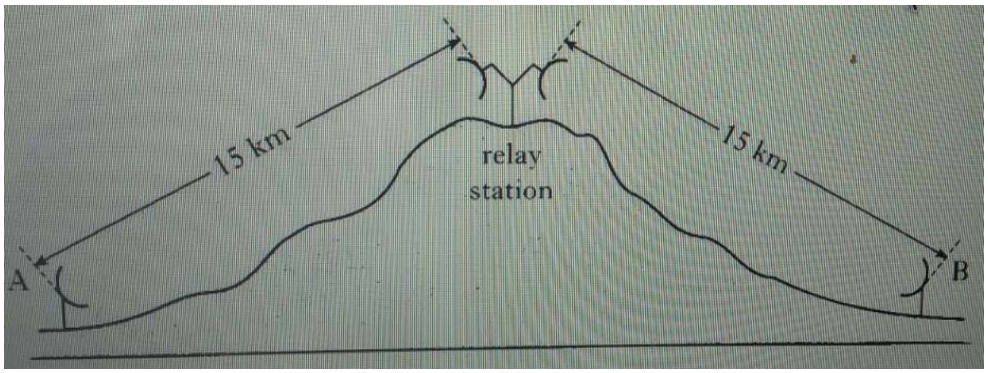
Revision Questions:

1. The diagram given below shows the electromagnetic spectrum in order of increasing frequency from left to right. Use the information to answer the following questions.

Radio waves		Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

a. Name the missing radiation.
b. Name an ionising radiation from the spectrum.
c. Explain ionisation.

2. A Tashi Cell company uses microwaves to transmit information between two positions A and B separated by a range of hills. A relay station on top of hills receives and transmits the signal using curved reflectors.



a. Explain why a curved reflector is used to receive a signal. Use diagram to explain your answer.
b. The microwaves have a wavelength of 15mm and a speed of $3x10^8$m/s in air. Calculate the frequency of the microwaves.

c. The relay station requires an energy source but is too remote to have a mains electricity supply. Suggest a possible alternative energy supply.

3. An on-board computer system linked by optical fiber controls some modern aircraft. A ray of light inside an optical fibre is depicted in the diagram below.

a. Copy and complete the diagram to show the path of the ray of light in the fibre.

b. Name the effect that occurs when the ray bends inside the surface of fibre.

5. Atomic, Nuclear, and Space Physics

Radioactivity is a natural phenomena that happens in a variety of substances. Radioactive decay, also known as nuclear decay or radioactivity, is the process by which the nucleus of an unstable atom loses energy by emitting radiation, including alpha particles, beta particles, gamma rays. The effects of these radiations can be harmful to living cells but, when used in the right way, they have a wide range of beneficial applications, particularly in medicine. The formation of daughter nuclei, related hazards of radiation and safety precautions are discussed in the first part.

Although it is one of the weakest of the four known fundamental forces, it governs the nature of astrophysical objects like stars and galaxies, and the structure and evolution of the whole Universe. Universal law of gravitation proposed by Isaac Newton in the 17th century recognised gravity as a universal force between any two particles of matter. Theories governing evolution of the universe, the scientific findings related to the universe and it's evolution are given due emphasis in this theme. With the advancement in science and technology, mankind is progressing in space exploration to understand the universe better. Flyby, Orbiter, Rover, Human Space Exploration are discussed as space exploration methods. Finding life elsewhere is discussed as one of the main purposes of space exploration.

Competencies:

- Explain the concept of radioactivity with its properties to understand their applications and safety precautions while working with radiations.
- Demonstrate understanding of the universal law of gravitation and its role in the formation of the universe with the help of model or simulation.
- Communicate scientific and technical information about the formation of the universe, stars, solar system, and planets to understand the universe and its evolution.
- Use the information and communication technologies to enhance the conceptual understanding of space exploration, space technology and their purposes.

5.1 Nuclear Atom

5.1.1 Radioactivity *(Scope: detection and properties of α,β,γ radiation, radioactive decay and its applications, safety precautions)*

Objective(s):

i. Explore the characteristics of α, β and γ particles and identify their emission using a s imulation or CAI tools.

ii. Explain applications and safety precautions related to radioactive substances.

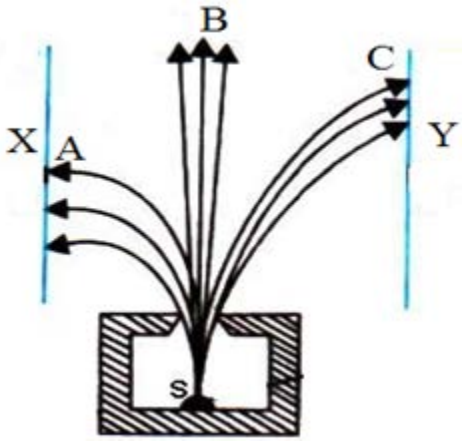
Learning Experiences:

The teacher may use the following instructional practises to teach the concept of detection and properties of α , β, γ radiation, and safety precautions while handling radioactive substances. The teacher may deliver a lesson through a presentation and show the video from the link https:// youtu.be/VTHQYjkCqV0 on emission of alpha, beta and gamma radiations.

- The learner gathers information on the types of emission and the properties of alpha, beta and gamma radiations from the teacher's presentation.
- Explores information on the radioactive disintegration and safety precautions from the video link ttps://youtu.be/VTHQYjkCqV0 or relevant resources (books, internet links, handouts, downloaded digital content, articles, etc.) and presents to the class.
- Develops a simulation (using programming language) or an animation or a model on emission of alpha beta and gamma rays as an extended activity and shares the whole class or through CLT.

Questions:

1. Compare and contrast alpha, beta, and gamma decay.
2. If a radioactive element with 92 protons undergoes alpha decay, how many protons will be there in the new element that forms as the product of the reaction? Name an element formed after the radiation?
3. Study the diagram and answer the following:



i. Name the radiations A, B and C.

ii. Name the plates X and Y as either negative or positive.

Assessment:

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

Scientific knowledge: May use a rating scale to assess the learner's conceptual understanding of detection and the properties of α , β, γ radiation during the presentation.

Working scientifically: The teacher may use a rating scale to assess the learner's ability to design simulation, animation or model on emission of alpha beta and gamma rays.

Scientific values and attitudes: The teacher may use a rating scale to assess the learner's ability to recognize effects and use the safety precautions of radiation in daily life during presentation.

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

Resources:

https://youtu.be/VTHQYjkCqV0

5.2. Space Exploration

5.2.1. The Universe *(Scope:Newton's law of universal gravitation and its role, the origin and evolution of the universe: Solar system, galaxies, stars, planets).*

Objective(s):

iii. Explain the law of universal gravitation using interactive simulation.

Learning Experiences

The teacher may deliver the lesson on gravity as a force that acts throughout the universe, and calculate the value of acceleration due to gravity of a planet. The teacher may share the simulation link https://bit.ly/3rRNfJB to calculate the force of gravity between two bodies and engage the learner through a structured inquiry cycle.

- The learner gathers information on the concept of gravity, acceleration due to gravity and the universal law of gravitation from the teacher's input.
- Records the data from the simulation https://bit.ly/3rRNfJB and draws the relationship between variables to explain the universal law of gravitation.
- Shares the conclusion drawn from the experiment to the class or submit through CLT.
- Solves related numerical problems and relates the significance of the law in the universe.

Questions:

1. State the universal law of gravitation.
2. If the distance between two masses is doubled, what will be the gravitational force between them?
3. Determine the gravitational force if two masses are 200 kg and 500 kg separated by a distance of 8 m. Consider G = 6.67259 x 10 - 11 N m^2/kg^2.

Assessment:

The teacher may use checklist/observation form/rubrics/rating scale/marking scheme/anecdotal records 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 gravitation and acceleration due to gravity while explaining using a checklist.

Working scientifically: Assess the learner's ability to gather data from the simulation and solve numerical problems using a marking scheme.

Scientific values and attitudes: Aassess the learner's ability to relate the significance of the law of gravitation in functioning of the universe 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
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/3rRNfJB

Objective(s):

iv. Communicate scientific and technical information about the evolution of the universe, solar system, planets, and stars.

Learning Experiences:

The teacher may use activity based methods to deliver the lesson on the formation and evolution of the universe, stars, solar system, and planets. The teacher may divide learners into groups and assign a topic each to the group.

- The learner gets into their respective group and discusses and explores the information related to the topic they are assigned. The learner may use learning resources provided by the teacher (books, internet links, handouts, downloaded digital content, articles etc.) or watch the videos from the following links https://bit.ly/2NjJFcj , https://bit.ly/3bK5ACP, https://bit.ly/2Q6RGCn, and https://rb.gy/vfshd8.
- Based on the information gathered, the learner prepares a presentation using relevant presentation tools.
- The learner presents their work to the class, while the teacher supplements and provides feedback and support whenever necessary and assesses their work.

Questions:

1. Cosmologists have postulated the two endings to the universe. What are they?
2. Modern cosmologists supposes that the universe came from a "big bang" event about 13 billion years ago. Justify with some relevant reasons.
3. Describe stages in a life cycle of a star.
4. Explain how cosmological redshift explains the expansion of the universe.

Assessment:

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

Scientific knowledge: Assess the learner's ability to communicate scientific and technical information about the evolution of the universe, solar system, planets, and stars from the presentation using a rubric.

Working scientifically: Assess the presentation skills, comprehensiveness of the presentation, delivery techniques and technical terms used by the learner while presenting using a rubric.

Scientific values and attitudes: Assess the learner's ability to appreciate the scientific knowledge on the evolution of the universe, stars, solar system and planets and relate with different philosophies of the evolution of the universe during presentation using a rubric.

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

Resources:

- REC repository
- Physics Class Ten by Kinley Gyeltshen and Sumitra Subba (Reprint 2017)
- https://bit.ly/2NjJFcj
- https://bit.ly/3bK5ACP
- https://bit.ly/2Q6RGCn
- https://rb.gy/vfshd8.

5.2.2. Space explorer

(Scope: human space exploration, rovers, spacecrafts)

Objective(s):

v. Describe various types of space exploration and spacecraft used to enhance understanding of space exploration.

vi. Design a prototype of spacecrafts to explore the universe.

Learning Experience

The teacher may deliver the lesson on types of space exploration and spacecraft used in the following order of REI (Research, Evidence and Inference) approach. The teacher may explore the internet, academic papers, and books etc. to provide background information on the human space exploration and spacecraft used. The teacher may also explore more about space exploration using mobile apps such as NASA, NASA BE A MARTIAN, Hubble Space Center, Space Museum etc. to supplement the concept. The teacher may prepare a presentation or handouts to deliver the lesson.

- The learner goes through the teacher's input and makes notes of the key points.
- Engages in researching and gathering evidence on the human space exploration and spacecraft used from the internet, academic papers, downloaded digital content, books, etc.
- Draws inferences on human space exploration and presents the findings to the class for feedback and comments.

- Based on the concept learned, the learner designs a physical/virtual prototype of spacecrafts to explore the universe, and presents the model .

Questions:

1. Do you think space exploration is important? Why?
2. Compare and contrast between orbiter and rover space exploration.
3. Which method of space exploration do you think is the best method of space exploration? Give reasons.

Assessment:

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

Scientific knowledge: Assess the learner's conceptual understanding on types of space exploration while sharing the inferences using a rubric.

Working scientifically: Assess the learner's ability to search, retrieve, organise, analyse, interpret scientific information, design a model, present and communicate scientific ideas during the learning process using a rubric.

Scientific values and attitudes: Assess the learner's ability to accept feedback from peers and the teacher, and to relate the significance of space exploration for mankind during presentation using a rubric.The teacher may provide necessary intervention if need be.

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)

5.2.3. Purpose of Space Exploration

(Scope: evidence of life elsewhere - Mars)

Objective(s): vii. Explore the possibility of human survival beyond Earth.

Learning Experiences:

The teacher may carry out the instructional practises using the CER (claim, evidence and reasoning) model on the possibility of human survival beyond Earth. The teacher may provide resources from the internet, scientific papers, books, etc. for exploration. The teacher may set the tone to create a claim by the learner with the question based on characteristics of habitable planets.

- The learner makes a claim(s) on characteristics of habitable planets based on the teacher's question.
- Explores information from the internet, scientific articles, and books to gather evidence on their claim.
- Justifies their claim with the evidence and shares it to the class.

Questions:

1. What are some of the characteristics of habitable planets?
2. Why do you think mankind is exploring space by investing lots of resources?
3. Describe some current trends in the space exploration.

Assessment:

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

Scientific knowledge: Assess the learner's knowledge on the characteristics of habitable planets beyond the Earth during the presentation using a checklist.

Working scientifically: Assess the learner's ability to gather and organise evidence, and draw conclusions from the presentation using a rubric.

Scientific values and attitudes: Assess the learner's curiosity to explore and expand the knowledge on life beyond Earth using a rating scale.

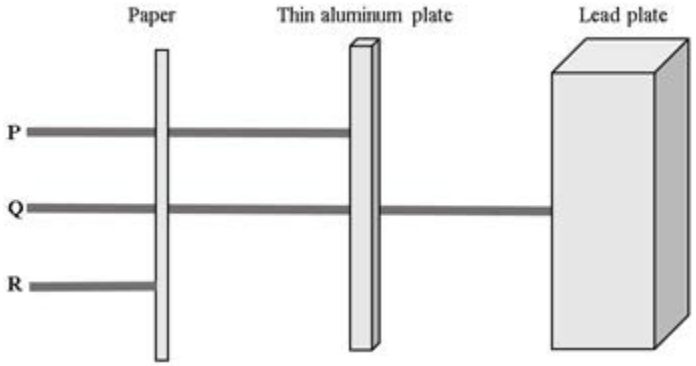
Refer Science Curriculum Framework (SCF, 2022) and Formative Assessment for classes PP - VI, 2020 for recording and reporting.

Resources:

- REC repository.
- Understanding Space: an introduction to astronautics by Sellers et. al (2004)

Revision Questions:

1. The following figure shows the penetrating power of the radiations. Identify the radiations and arrange the radiation in decreasing order of the penetration power.



2. The 'Big Bang' theory is one theory explaining the origin of the Universe. The graphs X, Y and Z show how the size of the Universe that may have changed with time.

Which graph suggests the concept of the 'Big Bang' correctly? Justify your choice.

3. "Space exploration is sending people or machines into space to visit other planets and objects in space. Mankind has dreamt of visiting space for hundreds of years, but it wasn't until 1969 that the first person walked on the Moon." With the advancement in technology, there are various methods of space exploration. Which methods of exploration would you prefer? Why?

Annexure 1

Weighting and Time Allocation for class IX

Theme	Topics	Time in Minutes	Weighting
Newtonian Mechanics	Force and Acceleration	465	13
	Newton's Law of Motion	348	10
Fluid Mechanics and Thermal Physics	Pressure in Fluids	332	10
	Buoyant Force	465	13
	Temperature and Heat	378	8
Electricity and Magnetism	Electric Charge	316	8
	Electromagnetism	348	10
Waves and Optics	Ray Optics	332	8
	Waves	248	8
Atomic, Nuclear, and Space Physics	Nuclear Atom	80	3
	The Moon	288	9
Total		**3600**	**100**

Annexure 2

Weighting and Time Allocation for class X

Theme	Topics	Time in Minutes	Weighting
Newtonian Mechanics	Gravitational Force	288	6
	Moment of Force	232	8
	Falling Objects	244	6
	Work and Energy	376	12
Fluid Mechanics and Thermal Physics	Thrust on a surface area	144	4
	Transmission of Pressure in Fluid	244	6
	Calorimetry	372	12
Electricity and Magnetism	Electric Current	244	6
	Electromagnetic Effects	344	8
Waves and Optics	Types of Electromagnetic Waves	244	8
	Communication Through waves	244	8
Atomic, Nuclear and Space Physics	Nuclear Atom	288	8
	Space Exploration	336	8
Total		**3600**	**100**