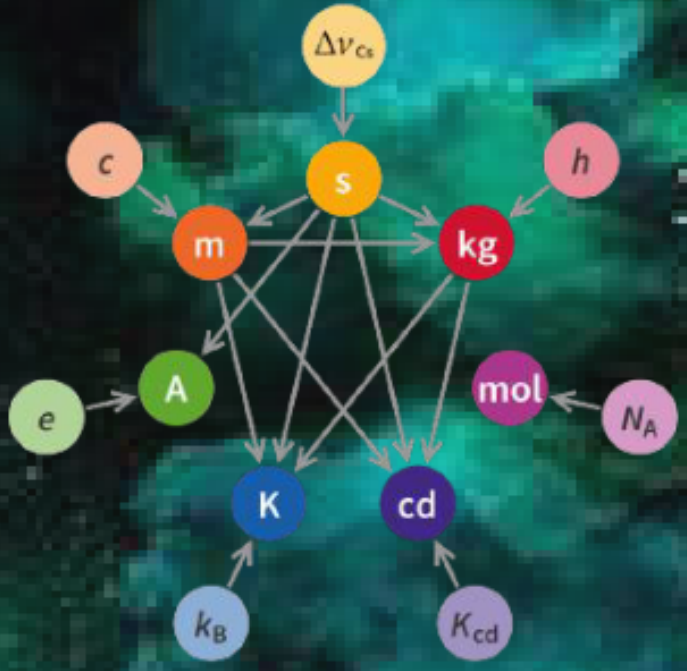
Physics

Teacher's Guide
Grade 9



FEDERAL DEMOCRATIC
REPUBLIC OF ETHIOPIA
MINISTRY OF EDUCATION

Unit 1

Physics and Human Society

Introduction

This unit deals with physics and the human society. In particular, students will learn about definition of physics, different branches of physics, relationship between physics and other fields of study, contribution of prominent scientists in advancing physics, and the way physics knowledge has been evolving and changing in history.

1.1 Lesson 1: Definition and Nature of Physics (1hr)

Learning Strategies

- Engage students in listening, watching and reading different media such as radio, television, newspaper etc. and present to the classroom about their understanding about the nature of physics. .
- Encourage students to identify different media programs and require them to show how physics knowledge is applied. .
- Help the students in describing physics in terms of its objects of study, products, technology it uses, and as a physics community practice.

Teacher Preparation Outline

Before the Lesson

- √ Ask students to give their own conception of physics in their own words

During the Lesson

- √ Ask the students various brainstorming questions to check their understanding of the nature of physics. laws and principles of universe
- √ Discuss the section from the textbook on definition and nature of physics.
- √ Ensure that the students are paying attention to the lesson.
- √ Arrange your students in a group of three or four to facilitate classroom discussion about the definition and nature of physics.
- √ Encourage each student to participate in the discussion
- √ Ask the groups to report a summary of their discussion.

After the Lesson

- √ Get feedback from students about their understanding of the lesson by asking various questions
- √ Suggest reference materials (if there are) that define physics and nature of physics in different ways.

Encourage the students to understand science in general and branches of science in particular. The word “science” is derived from the Latin word 'scientia' meaning knowledge. Science refers to a systematic and organized body of knowledge in any area of inquiry that is acquired using the scientific method. Science can be grouped into two broad categories: natural science and social science. Natural science is the science of naturally occurring objects or phenomena, such as light, objects, matter, earth, celestial bodies, or the human body. Natural sciences can be further classified into physical sciences, earth sciences, life sciences, and others. Physical sciences consist of disciplines such as physics (the science of physical objects), chemistry (the science of matter), and astronomy (the science of celestial objects). Earth sciences consist of disciplines such as geology (the science of the earth). Life sciences include disciplines such as biology (the science

of human bodies) and botany (the science of plants).

Answer to Exercise 1.1
Help students to define physics in their own words. Students can also name various technological devices that have applications of physics knowledge from their locality.

Answer to Activity 1.1
Help students mention the importance of physics other than those discussed in the textbook. They can also list down other physical phenomena that uses physics knowledge in their surroundings. Tell students that a person who study physics is called a "physicist" not a “physician” which is a common mistake.

Assessment

- Ask the students to define what physics is and the nature and application of physics in their day-to-day life
- Ask the students to review literature about how physics knowledge is used to explain natural and physical phenomena such as lightening, the various efforts made by the scientific community to understand natural and physical phenomena, how physics is used in designing technological devices such as mobile phones, computers etc, the various endeavors made by the scientific community to establish physics a discipline, and why, when and how physics was included as a subject in school curricula and how physics became an important discipline of study in the world.

1.2 Lesson 2: Branches of Physics (2hrs)

Learning Strategy

- Encourage the students to describe the different branches of physics and the objects, methods, and latest products from these branch

Teacher Preparation Outline
Before the Lesson

√ Ask the students about how different sorts of knowledge are brought together to make certain things such as building houses, making a car, even cooking a food.

During the Lesson

- √ Give example from real-life that uses knowledges from different disciplines to make things. For instance, mobile phone is the application of physics, chemistry and engineering
- √ Describe the section from the textbook on branches of physics.
- √ Ensure that the students are paying attention to the lesson.
- √ Arrange your students in a group of three or four and ask them to list down the branches of physics and present the summary of their discussion to the classroom. .
- √ Encourage each student to participate in the discussion

After the Lesson

- √ Ask the students various brainstorming questions to check their understanding of branches of physics
- √ Get feedback from students about their understanding of the branches of physics by asking questions. You may give quiz.
- √ Suggest them read some important reference materials that describe about the various branches of physics

Answer to Exercise 1.2

- ► Help students list some physical phenomena in their surroundings. Motivate them to describe in which branch of physics each physical phenomenon can be categorized.

Assessment

- Students are expected to come up with further and further sub-branches of physics and their accurate descriptions and which branch of physics each physical phenomenon can be categorized

1.3 Lesson 3: Related Fields to Physics (2hrs)

Learning Strategies

- Encourage the students search in group for applications of the products of physics from the different branches in today's technology, engineering, or medicine.
- Help the students to describe the relationships between physics and other science subjects by enumerating instants of contributions of physics in the other areas and their contribution to physics.
- Encourage students to discuss the key role of physics in such fields as technology, engineering, medicine, metrology, military, astronomy, etc.

Teacher Preparation Outline

Before the Lesson

√ Ask the students to tell how physics is applied to develop technological devices

During the Lesson

√ Ask the students various brainstorming questions to check their understanding of the applicability of physics in various fields.

√ After getting feedback, introduce the lesson

√ Ensure that the students are paying attention to the lesson.

After the Lesson

√ Get feedback from students about their understanding of the lesson by asking various questions. You can also give class work.

√ Suggest certain reference materials that discuss how physics is related to other fields of studies.

Answer to Activity 1.2

Through group discussion, motivate students to list some other fields or areas of science (other than those discussed in the textbook) where physics is applicable.

Assessment

► Ask students to describe how physics is related to other fields of study and its contribution to the development of certain disciplines and applications.

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1.4 Lesson 4: Historical Issues and Contributors (1hr)

Learning strategies

- Engage students in groups to present one important historical physics issue and at least two prominent physicists/scientists who have developed certain physical laws and principles. Poster presentation with the pictures of the prominent figures might be important. Small group presentation on the past five years Nobel Prize winners in physics (Who they are and what they have done)
- Present pictures and stories about key physics findings, interesting physics tools and set-ups, and prominent scientists;

Teacher Preparation Outline

Before the Lesson

- √ Ask brainstorming questions about some important scientists/physicists they know
- √ Ask them to tell why they became prominent together with what they have discovered.

During the Lesson

- √ Introduce the lesson on historical issues and contributors from the textbook.
- √ Ask the students various brainstorming questions to check their understanding of the historical issues and contributors concerning physics.
- √ Ensure that the students are paying attention to the lesson.

After the Lesson

- √ Get feedback from students about their understanding of the lesson by asking various questions.
- √ Read various reference materials that describe historical issues and contributors to physics

Answer to Exercise 1.3

There are various other well-known historical contributors in physics. For example:

Archimedes is the greatest scientist of ancient times, who pushed mathematics, physics, and engineering to new heights. He created the physical sciences of mechanics and hydrostatics, discovered the laws of levers and pulleys, and discovered one of the most important concepts in physics – the center of gravity. He applied advanced mathematics to the physical world.

Johannes Kepler broke the tradition of thousands of years of astronomy, discovering that the heavenly bodies follow elliptical paths. Kepler's laws of planetary motion were an absolutely crucial breakthrough in our understanding of the

universe.

Ernest Rutherford is the father of nuclear chemistry and nuclear physics. He discovered and named the atomic nucleus, the proton, the alpha particle, the beta particle, and he predicted the existence of the neutron.

There are many other historical contributors in physics which students can come up with by reading various references or online resources.

Assessment

- Students are expected to present the history of prominent scientists that are not mentioned in the textbook at least from classical and modern era of physics with their important contributions.

NB: Assist students to read the online resources provided as clickable contents in the unit. Use the soft copy of the textbook to do so.

Answer to end of unit questions

1. **B**
2. **A**
3. **D**
4. **D**
5. **E**
6. **C**
7. **B**

Unit 2

Physical Quantities

Introduction

This unit imparts knowledge to the students about physical quantities. Particularly, students will learn about scales, standard units, all measurements encountered in their life and surrounding, classification of physical quantities, scientific notations and conversion of units.

2.1 Lesson 1: Scales, Standards and Units (Prefixes)-4hrs

In this section the teacher is expected to use the following learning strategies:

- Encourage students to observe traditional measurement activities in their localities (home, market place etc.) and prepare a report on what they are, where it is practiced, and how people use these measurements to determine the size of somethings.
- Help students to know the abundance of measurement activities and related issues in life;
- Given five quantities (length, mass, time, volume, temperature) identify the traditional and commonly used scales and units of measurement.
- Encourage students to check and the extent to which these measurements are accurately measuring what they intended to measure by comparing with modern measurement tools.
- In a pyramiding method, discuss the need for standards of measurement and identify problems of non-standard measurement practices;

Teacher Preparation Outline

Before the Lesson

- √ Ask the students to list down the different measuring tools used in their locality
- √ Tell them how accuracy is compromised using traditional measuring tools
- √ Tell how people in different parts of the world used different scales to measure
- √ Tell them how ancient people came to understand the importance of common standard scales and units

During the Lesson

- √ Ask the students various brainstorming questions about scales, standard and nonstandard units.
- √ Read the section on scales, standards of length, mass and time, scientific notations, significant figures and prefixes found on the textbook.
- √ Ensure that the students are paying attention to the lesson.
- √ Arrange your students in a groups of three or four to facilitate classroom discussion about scales, standards of length mass, and time, scientific notations significant figures and prefixes
- √ Encourage each student to participate in the discussion
- √ Ask the groups to report summary of their discussion.

After the Lesson

- √ Get feedback from students about their understanding of the lesson by asking important questions
- √ Suggest some important reference materials that could deepen their understanding about the lesson. .

Answer to Activity 2.1

- Guide students to list different examples of nominal scales in their community in relation to taxonomic category in biology (rodent, canine, and primate), religion and so on.

Answer to Exercise 2.1

- Discuss the different examples of ordinal scales such as class rank, horse race, and so on.

Answer to Exercise 2.2

- Grade levels in school, age, income.

Answer to Activity 2.2

- All students tell their weight in kg;
- Yes, scales involving division of two ratio scales are also themselves ratio scales. For example acceleration is the ratio of velocity to time. Velocity itself is the ratio of displacement to time.
- Guide students to observe in groups measurement activities in the surrounding (home, local market and work places) for two days and prepare report on what, where, and how of the measurements observed.
- Guide students to discuss the traditional and commonly used scales and units of measurement for length, mass, time, volume and temperature based on their observation.

Answer to Activity 2.3

- No, the measurements are not standard. For the measurements to be standard, measurements taken by different students in different places must yield the same result.

Answer to Exercise 2.3

- The SI base units of length, mass, and time are meter (m), kilogram (kg) and second (s) respectively.

Answer to Activity 2.4

- We need a standard unit for measurement to make our judgment more reliable and accurate. For proper dealing, measurement should be the same for everybody. Thus there should be uniformity in measurement. For the sake of uniformity we need a common set of units of measurement, which are called standard units.
- Non-standard units can lead to errors in conversion and it doesn't work well across different countries and different places. Also the dimensions of some physical quantity may differ.

Answer to Exercise 2.4

1. 1.26×10^{-6}
2. 2 Significant Figures

Answer to Exercise 2.5

1. 6.371×10^{6} m = 6.371 Mm
2. 7.5×10^{-6} m = 7.5 μm

Assessment
Assessment in this unit should reflect students' ability development in identifying different types of scales, standard units, scientific notations, significant figures, and prefixes.

2.2 Lesson 2: Measurement and Safety (4hrs)

In this section the teacher is expected to use the learning strategy:

- Guide students to observe different measuring instruments help to measure different physical quantities (length, area, volume, time, mass, and so on.)
- Engage students to measure the, length, width and area of the black board.
- Encourage students to determine the masses of different objects

Teacher Preparation Outline
Before the Lesson

- √ Ask students to list down the different measurement tools they ever used in their day-to-day life
- √ Ask students to tell what people in their locality to protect themselves from injury while they are engaged in various activities such as farming, harvesting, cutting, welding, etc.
- √ Introduce the lesson on the measurement and safety from the textbook.

During the Lesson

- √ Introduce the lesson from the textbook
- √ Ask the students various brainstorming questions to check their understanding of measurement with respect to standard and nonstandard units.
- √ Tell students about the various safety measures
- √ Ensure that the students are paying attention to the lesson.

After the Lesson

- √ Get feedback from students about their understanding of the lesson by asking various questions.
- √ Suggest some important reference materials related to measurement.

Answer to Activity 2.5

1. Guide students to observe their local environment and list different instruments used to measure different physical quantities (length, area, volume, time, mass and so on.)
2. Guide students to discuss different measurement activities and related issues in life.

Answer to Activity 2.6

1. Tell students to measure the width and length of their exercise book in meter, centimeter and millimeter. Guide them to compare their results with that of their class mates and discuss the possible source of errors if the measured values are different for the same exercise book.

2. Vernier caliper
3. First he has to measure and graduate the rope using the meter stick and then use the rope.

Answer to Activity 2.7
Materials needed: Tape measure or Carpenter rule
As a teacher you are expected to measure the length, the width and the area of the blackboard carefully before students are involved into this activity.

1. Guide students in groups to measure the length and width of the black board in meter unit.
2. Ask students to calculate the area of the blackboard using the measured value.
3. Make students in each group to compare their result. Finally compare the students' measured values with the exact value that you measured and discuss on sources of errors.
4. Tell students to convert the measured values into cm and mm scale.

Assessment
In this section, assessment should reflect students' ability development in identifying different measuring instruments for different physical quantities and measurement practices (traditional and scientific).

2.3 Lesson 3: Classification of Physical Quantities (4hrs)

Learning strategies:

- Arrange small groups and help them to classify physical quantities as scalars and vectors
- Arrange small groups to help students to measure length, area, volume, density, and speed as derived quantities;
- Encourage students to compute speed and density by measuring distance, time, mass and volume
- Encourage students to use certain instruments such as stop watch, stethoscope and thermometer to measure time, heartbeat and body temperature,

- Encourage students to use smart phones (if available) for measuring time, heartbeat, body temperature, etc.).

Teacher Preparation Outline

Before the Lesson

√ Ask students to tell the class what physical quantities are and how they used to classify them

√ Ask students how they measure some things such as mass of cotton, length of a , area of a plot of land

√ Ask students how people in their locality compute whether something is going fast or slow

√ Ask students how people in their locality measure whether something is denser or lighter

√ Ask students how people in their locality know the size of a certain object

During the Lesson

√ After getting feedback introduce the lesson on classification of physical quantities from the textbook.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

- Ask the students some brainstorming questions to check their understanding on measurement and classification of physical quantities.

√ Suggest some reference materials on classification of physical quantities.

Answer to Exercise 2.6

1. Guide students to discuss the different mechanisms of measuring mass in their local area.
2. Guide students to list mass measuring instruments in their locality. In most cases beam balance, spring balance, triple beam balance and digital balance.

Answer to Activity 2.8

1. Guide students to visit different shops in their local area and observe the measuring procedures carefully. Tell them to write a report on the procedures taken to measure each item and the exactness of the measurement.

Answer to Activity 2.9

Material needed: beam balance

1. Guide students in groups to collect different sample objects as stated in Activity 2.15 of students text book.
2. Guide each group to measure the mass of a) a duster b) an exercise book and c) one stick of chalk and record the value in table.
3. Tell each group to compare its recorded value with that of other groups.

Answer to Activity 2.10

1. Guide students in small groups to discuss and list the names of scientific time measuring devices. Common time measuring devices are watch, stop watch and digital watch.
2. Guide students to record the activities that they did from the sun rise to the sun set. Let the students compare their recorded activities with that of their class mates. Which students used the time properly and wisely? Which students didn't use their time wisely. Finally guide students to discuss the wise use of time in relation to effectiveness.

Answer to Activity 2.11

1. The symbols of physical quantities length, width, and area are l, w and A respectively. The units of length and width are the same and it is meter (m). However, the unit of area is m^2. Length or width are fundamental physical quantities. Area is a derived physical quantity.

Answer to Activity 2.12

1. Fundamental physical quantities are: mass and length. Derived physical quantities are: speed, volume, force and pressure

Answer to Exercise 2.7

1. a) Volume = length × width × height or $V = l \times w \times h$ (length, width and height have the same dimension and are fundamental or basic physical quantities. Its SI unit is m^3.

   b) Density is the ratio of mass to volume. $Density = \frac{mass}{Volume} = \frac{mass}{length \times width \times height}$.

   Density is derived from two fundamental physical quantities mass and length.

   c) Speed is the ratio of distance to time. Speed=$\frac{distance}{time} = \frac{s}{t} = \frac{l}{t}$

   Speed is derived from two fundamental quantities length and time.

2. Guide students to use stopwatch in their mobile (Android) to measure time. Moreover, guide the students to download and install heart rate variability (HRV) analysis software to measure the heart beat and Thermometer APK to measure temperature.

Answer to Activity 2.13

1. Mass, time, area, speed, energy, work, pressure, electric current and temperature are scalar quantities and they are described by their magnitude only. They have no direction. However, velocity, acceleration, force, momentum, current density and displacement are vector quantities. They are described by their magnitude and direction.

Assessment

After the completion of lesson3, the teacher is expected to assess students:

- By writing certain physical quantities on the blackboard, ask students to classify physical quantities as scalar and vector
- Give practical activity or home take assignment to measure time, volume, area, heartbeat and temperature physical quantities and ask them to come up with a written report
- Practical activity on measuring time, heart rate, and temperature using mobile (Android)
- Give quiz

N.B Giving timely feedback for all assessments is very important.

2.4 Lesson 4: Unit Conversion (4hrs)

In this section the teacher is expected to use the learning strategy:

- Engage students in conversion of measured values to fractional units and also from a system of unit to another.
- Engage students in measurement tasks in an accurate manner with commonly available measuring tools (ruler, wristwatch, etc.);
- Engage in accurate estimations of sizes with spans, steps, heartbeats, number of blocks, etc.

Teacher Preparation Outline
Before the Lesson

√ Ask the students various brainstorming questions to check to what extent they are aware of conversion of units

√ Ask students to tell how they used to convert units such as hour in to minutes and minutes in to seconds etc

√ Suggest some reference materials on conversion of units.

During the Lesson

√ After getting feedback introduce the lesson on conversion of units from the textbook. Do practical examples on conversion of units

√ Ensure that the students are paying attention to the lesson.

After the Lesson

√ Give a brief summary of important points

√ Get feedback from what students have done on conversion of units.

Answer to Exercise 2.8
1. B
2. A
3. Vernier Caliper

a) 10 nm = 10×10^{-9} m = 10^{-8} m

b) 10^{-5}mm

c) 0.01 μm

Answer to Exercise 2.9

1. a) 1d = 24 hr,

   b) 1d = 24 × 60 min =1440 min.

   c) 1 d = 1440 × 60 s = 86400 s

2. Guide students to list some traditional ways of measuring time in their community.

3. a) 0.25 h =0.25× 60 min =15 min, 0.25 h = 15 × 60 s =900 s

   b) 3.2 h = 3.2 × 60 min =192 min, 3.2 h = 192 × 60 s = 11520 s

   c) 6.7 h = 6.7 × 60 min = 402 min, 6.7 h = 402 × 60 s = 24120 s

Assessment

In this section, assessment should reflect students' ability on commenting on the inaccuracy of common measurement practices, and attitude and skill development in following standard and accurate measurement procedures. The fluency of students in conversion of units from one system to another must be highly credited

√ Ask students to use measuring instruments such as meter stick, Vernier caliper to determine the sizes of objects and convert the results in to another units such as from cm to m and from cm to nm etc

NB: Assist students to read the online resources provided as clickable contents in the unit. Use the soft copy of the textbook to do so.

N.B Giving timely feedback is very important.

Answer to end of unit questions and problems

Part I

1. B

2. B

3. C

4. B

5. B
6. B
7. A
8. D
9. B
10. B
11. C
12. B
13. B

Part II

1. **False**
2. **False**
3. **True**
4. **False**
5. **True**
6. **False**

Part III

1. Interval scale lacks true zero point. But ratio scale has true zero point. One cannot multiply or divide units in interval scale. However, it is possible to multiply and divide units in ratio scale.
2. 43200 s
3. See student's textbook (it is well defined there)
4. See student's textbook
5. See student's textbook.
6. a) meter b) kilogram c) second
7. Vernier caliper
8. See the safety rules in students' textbook.

9. There are many examples of scalar and vector quantities. Ask students to list at least three scalar and three vector quantities.

Part IV

1. 3.995 kg or 3995 g
2. a) microgram, 10^{-6} g b) milligram, 10^{-3} g
3. 25.5 year= 310.675 month (for 1 y =365.5 d)
4. 840 cm
5. 4320 minute
6. 160 ceramics
7. 0.15 Tm
8. a) 10^{12} km^3, 10^{27} cm^3
9. a) 101 ns b) 10 mg c) 72 Gm

Unit 3

Motion in a Straight Line

Introduction

Motion is a common experience of all students. It can take place in different paths. Among these are rectilinear motion or motion in a straight line, curvilinear motion or motion in a curved path and projectile motion, etc. However, this unit deals with motion in a straight line . In this unit ., students will learn about the concepts of position, distance and displacement; average and instantaneous quantities (such as average speed, average velocity, instantaneous speed and instantaneous velocity), acceleration, uniform motion and graphical representation of motion.

3.1 Lesson 1: Position, Distance and Displacement (4hrs)

Learning Strategies

- Engage students how the location of places are described. ;
- Encourage students in hands-on activity to locate the position of the classroom, the laboratory, library, school gate, etc., first in statements and gradually by drawing.
- Engage students in describing the concepts of reference, reference frame, position vector, etc. .
- Encourage students to use google-map of the school locality and position important places nearby the school and record the position on a paper drawing. The same activity can be repeated expanding the area to the region and/or the country (Ethiopia).

- Encourage students to use google-map to measure distance "Measure distance" facility, determine the distance on road and areal distance between important places. Use the same activity to introduce and distinguish between concepts of "distance and displacement".
- Engage students in graphical vector addition activity with displacement vectors using diagrams drawn to scale. The activity will be used to introduce vector symbols, magnitude, direction, vector diagrams, measurement of angles, and conversion between scales.

Teacher Preparation Outline

Before the Lesson

√ Make the students tell the class about their concept and background experience of motion.

√ Ask students to tell how distance and displacement why it is important to describe the position of something

√ Ask students to compute the path travelled by a certain body when it is moving on a straight line to a certain direction and also when it is going back and forth

√ Ask students what differences they observed

√ Read the section on position, distance and displacement from the textbook.

√ Read various reference materials that explain about position, distance and displacement

During the Lesson

√ After getting feedback from students, introduce the lesson that distance and displacement are distinct characteristically

√ Give examples of distance and displacement

√ Ensure that the students are paying attention to the lesson.

√ Arrange your students in groups of three or four to facilitate classroom discussion the concept of position, distance and displacement.

- √ give an example and solve a problem on distance and displacement in the class
- √ Encourage each student to participate in the discussion

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them homework to come up with the various types of motions they have encountered in their surroundings.

- √ Take the students to a football field and identify two different points in the field. Let th students move from one point to the other point by following different paths. Ask them to tell how many such possible different paths are there and which path is the displacement.
- √ Ask the groups to report summary of their discussion.

Answer to Exercise 3.1

A body is said to be at rest in a frame of reference when its position in that reference frame does not change with time. If the position of a body changes with time in a frame of reference the body is said to be in motion in that frame of reference. The concepts of rest and motion are completely relative; a body at rest in one reference frame may be in motion with respect to another reference frame. Therefore, if your frame of reference is taken to be the horse, your position is not changing with respect to the horse and you are said to be at rest with respect to the horse. However, if your frame of reference is taken to be a point on the ground, obviously your position is changing with respect to the point and you are said to be in motion with respect to it.

Answer to Exercise 3.2

The SI unit of both length and distance is meter. Concerning the dimension of a standard football field, it is expected that the length has to be minimum 100 meters and maximum 110 meter and the width has to be minimum 64 meters and maximum 75 meters for international matches.

Therefore, the minimum distance around a standard football field would be:

$$2 \times 100 + 2 \times 64 = 328 \text{ meters}$$

The maximum distance is:

$$2 \times 110 + 2 \times 75 = 370 \text{ meters}$$

Distance is a positive quantity.

Answer to Activity 3.1

The displacement of the first student is 100 meters to the right of point A.

The displacement of the second student is 100 meters to the left of point A.

The third student returned back to his initial position and has zero displacement.

Answer to Exercise 3.3

If the initial and final positions are the same, the displacement is zero.

Answer to Exercise 3.4

If $x_f > x_i$, the displacement is positive

If $x_f < x_i$, the displacement is negative

If $x_f = x_i$, the initial and final positions are the same and the displacement is zero

Assessment

- Students should demonstrate ability in using reference and reference frames to locate objects in pictures, maps, and google-maps.
- Abilities in calculating distance with appropriate units and using scales and google-maps facilities must be focus of assessment.

3.2 Lesson 2: Average and Instantaneous Speed (2hrs)

Learning strategies

- Encourage students to engage themselves in jogging and running activities to measure their speed in the school sport field.(For about 150m to 200m in total). Use stopwatches (on mobile phones) to accurately measure the time for each 50 meter. Let students in groups record the data for the distance and time taken and in class let groups exchange data to have as many pair of data as possible. Then, use the data and its analysis to introduce the concepts average speed.
- Engage students in collecting data about speed measurement and typical values involved in everyday activities. Then, small group discussions to build up the list and different ways of measuring speed and answer the question what are the maximum and minimum values of speed and units in different life activities (athletics, driving, etc)
- Engage students in solving real-life problems related to instantaneous and average speeds

Teacher Preparation Outline

Before the Lesson

- √ Ask students to describe a certain motion before telling what instantaneous and average speed mean in reality
- √ Ask students to tell why it is important to compute average speed. For instance a runner might be slower somewhere and faster in another place but to judge how fast is the runner we don't need to know at which point he was faster or slower but simply calculating the distance covered by the time taken to arrive at the end line. Therefore, the winner's speed is determined by the average value than what he had done somewhere. (you can give another example)
- √ After doing so just tell the meaning of instantaneous speed and average speed

During the Lesson

- √ Discuss the lesson on average and instantaneous speed from the textbook.
- √ Ask students to tell their own experiences
- √ Ask students some brainstorming questions about the concept of average and instantaneous speed.
- √ Give elaborative examples from the students' day to day activities.
- √ Solve problems on instantaneous and average speed
- √ Ensure that the students are paying attention to the lesson.
- √ If possible, support your lesson with simulated or video record of various bodies moving with various speeds.

After the Lesson

- √ Get feedback from students about their understanding of the lesson by asking various questions. You may deliver a quiz or a class work.
- √ Give class work
- √ Suggest some reference materials that discusses average and instantaneous speed

Answer to Exercise 3.5

Speedometer reads the instantaneous speed of a vehicle.

Answer to Exercise 3.6

Average speed is the speed of a moving body over a given interval of time or it is the overall rate at which the body is moving. However, the instantaneous speed is the speed of the body at any given instant of time. They are both scalar quantities.

Answer to Exercise 3.7

33.33 m/s

Assessment

- Competence in accurately defining average and instantaneous speed
- Students should demonstrate the skill and knowledge of computing average and instantaneous speed

3.3 Lesson 3: Average and Instantaneous Velocity (2hrs)

Learning strategies

- Teacher introduces the ideas of average and instantaneous velocity. It can also be done by giving reading assignment before the teacher's lecture.
- Engage in discussion of the concepts and identifying the difference between average and instantaneous velocity.
- Engage students in jogging and running activities along a given direction in the school sport field. Let them use stopwatches (on mobile phones) to accurately measure the time required to run 100 meter in a given direction. Note that direction is very important here. Let students in groups record the data for the distance covered in a given direction and time taken to calculate the average velocity (average speed in a given direction).Then, introduce the concept average speed.

Teacher Preparation Outline

Before the Lesson

√ Start by asking students to give an example about a certain motion in a given direction.

√ Ask students about their understanding of instantaneous and average speed

- √ Tell them this lesson is the extension of the previous one but remind them that in the previous lesson there was no mention of direction.
- √ Tell them that this lesson considers direction as an important variable in determining its value.

During the Lesson

- √ Tell students the meaning of instantaneous and average velocity by giving examples
- √ Give practical real-life examples in introducing why it is important to compute instantaneous and average velocity.
- √ Read the section on average and instantaneous velocity from the textbook.
- √ Give elaborative examples on average and instantaneous velocity from students' day to day experience.
- √ Give worked examples on instantaneous and average velocity
- √ Ensure that the students are paying attention to the lesson.
- √ If possible, support your lesson with various simulated or video recorded bodies moving with various velocities.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may deliver a quiz or a class work.

- Suggest some reference materials on average and instantaneous velocity.

Answer to Exercise 3.8

No, *average speed* and the magnitude of *average velocity* are not the *same* since speed and velocity are not the *same*. Speed is a scalar while velocity is a vector.

Answer to Exercise 3.9

The distance covered by Tirunesh during the race was 5000 meters and she took 14 min 39.94 sec (or 879.94 sec) to complete this distance. Her average was:

$$v_{av} = \frac{s}{t} = \frac{5000\ \text{m}}{879.94\ \text{s}} = 5.68\text{m/s}$$

Answer to Exercise 3.10

Athlete 1 completes 100m in 55 seconds

The average speed of athlete 1 is

$$v_{av} = \frac{s}{t} = \frac{100\ \text{m}}{55\ \text{s}} = 1.82\text{m/s}$$

Athlete 2 completes the same distance (100 m) in 50 seconds. The average speed of Athlete 2 is:

$$v_{av} = \frac{s}{t} = \frac{100\ m}{50\ s} = 2 m/s$$

Therefore, the average speed of Athlete 2 is greater than that of Athlete 1.

Assessment

- Make sure that students developed competencies in accurately defining average and instantaneous velocity
- Make sure that students have demonstrated competencies in using equations of motion to solve problems on average and instantaneous velocity

3.4 Lesson 4: Acceleration (2hrs)

Learning Strategies

- Engage students in conceptualizing the meaning of acceleration
- Help students to use equations of motion in computing the values of acceleration
- Help students to use the concept of velocity and time to conceptualize acceleration
- Encourage students in computing the value of acceleration given a certain motion in day-to-day life by using equations of motion

Teacher Preparation Outline

Before the Lesson

- √ Give real-life examples of acceleration and ask students to describe it. For instance, you may give a certain motion such as a runner increases his/her speed suddenly to stood first in a race. How can you describe this state of motion? The more the runner increases his/her speed the more he/she accelerates. Tell what this phenomena in reality is.i.e. the more he/she changes his/her speed he/she can arrive the end line with in a short time. Runners' quality in winning the game is determined by their acceleration etc. (give your own example here)
- √ After doing so you can tell the term acceleration
- √ Read the section on acceleration from the textbook.
- √ Read various reference materials that explain about acceleration

During the Lesson

- √ Introduce the meaning of acceleration
- √ Give elaborative examples on acceleration from students' day to day experience.
- √ Give real-life problems and ask students to solve
- √ Ensure that the students are paying attention to the lesson.
- √ If possible, support your lesson with various simulated or video recorded accelerating bodies.
- √ Engage students in practically measuring acceleration using speedometer. Let them observe the initial and final values of the speedometer in a given period of time for a car (or other vehicle) travelling in a given direction. From the data they can calculate the acceleration. For students who do not have access to speedometer, please provide some simulated video links.

After the Lesson

- √ Get feedback from students about their understanding of the lesson by asking various questions. You may deliver a quiz or a class work..

√ Ask students to solve real-life problem using equations of motion

Answer to Exercise 3.11

1. Zero
2. No.

Assessment

- Make sure that students can describe the meaning of acceleration
- Make sure that students are able to solve problems related to acceleration'

3.5 Lesson 5: Uniform Motion (2hrs)

Learning Strategies

- Engage students in describing uniform motions by looking at real-life problem situations
- Encourage students in describing the quantities of uniform motions such as speed and velocity
- Encourage students in distinguishing uniform motions from non-uniform motions
- Engage students in solving real-life problems by using equations of uniform motions

Teacher Preparation Outline
Before the Lesson

√ Give examples of motions i.e. both uniform and non-uniform and ask students what makes then similar and distinct

√ Tell students that a certain motion can either be uniform or non-uniform depending on the pattern of the movement of the object

During the Lesson

- √ Start by asking students about the concept of uniform motion
- √ Introduce the lesson by defining what uniform motion means and giving examples from real-life situation
- √ After getting feedback, introduce the lesson
- √ Ask students to tell the conditions for a certain motion to be uniform and non-uniform
- √ Give elaborative examples of uniform motion from students' day to day experience.
- √ Ensure that the students are paying attention to the lesson.
- √ If possible, support your lesson with various simulated or video recorded bodies undergoing uniform motion

After the Lesson

- √ Ask students some important questions that could help you know their understanding of uniform motion
- √ Make summary of important points

You may deliver a quiz or a class work..

- Suggest some reference materials that explain about uniform motion

Assessment

- Make sure that students could describe the characteristics of uniform motion
- Make sure that students have demonstrated competencies in computing quantities like distance, speed and velocity in a uniform motion.

3.6 Lesson 6: Graphical Representation of Motion (4hrs)

Learning Strategies

- Engage students to plot uniform motion using graphs
- Engage students in drawing s-t, and v-t data and let convert motions using graphs.
- Engage them to determine the slope of s-t graph of a uniform motion by giving its physical meaning.
- Encourage students to compute the distance covered by the body from the v-t graph.
- Give students tabulated s-t, and v-t data and let them convert to graph.
- Engage them to determine the slope of s-t graph of a uniform motion by giving its physical meaning.
- Encourage students to compute the distance covered by the body from the v-t graph.

Teacher Preparation Outline
Before the Lesson

√ Ask students to tell the characteristics of a uniform motion

√ Ask students if they are able to represent numerical values in to x-y coordinate graphs

√ Show how numerical values can be represented in to x-y coordinate

During the Lesson

√ After getting feedback on the students' concept of plotting, introduce the lesson.

√ Introduce the lesson on graphical representation of motion from the textbook.

√ Give elaborative examples of graphical representation of motion (for example, by plotting the s-t or v-t graphs)

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them s-t or v-t data and ask them to represent it graphically.

√ Give classroom exercises to solve problems on uniform motion using graphs

√ Suggest some reference materials that explain about graphical representation of motion

Assessment

- Make sure that students have the competency of representing physical quantities (quantities in motion) and assessing their relationships graphically.
- Make sure that students are able to represent data with graphs and read data from graphs (which is highly valued).
- Make sure that students are expected to draw graphs with correctly labeled axes with units.
- Make sure that students have demonstrated the abilities in using graphs to predict values (say speed) in specific cases (say at a given instant).

Answer to Exercise 3.12

Car B be is moving faster since it has steeper slope.

Answer to Activity 3.2

Encourage the students to draw the graph.

Answer to Activity 3.3

Zero. The graph is horizontal line since the velocity is constant at any time in uniform motion. The slope of horizontal line is zero.

Answer to Activity 3.4

Help students to investigate the types of vehicles that are causing human/animal deaths and property damages in their area? Make them guess the percentage of the accidents caused by violation of speed limit. They should discuss in groups, report to the class and suggest possible solution.

Assessment

- Ability to represent physical quantities (quantities in motion) and their relationships graphically must be assessed.
- The ability to represent data with graphs and reading data from graphs is highly valued. When representing data with graphs students are expected to draw graphs with correctly labeled axes with units. Students should demonstrate abilities in using graphs to predict values (say speed) in specific cases (say at a given instant).

NB:

- Assist students to read the online resources provided as clickable contents in the unit. Use the soft copy of the textbook to do so.

-Using the ICT facility of your school or smart phones, assist students to perform the virtual laboratories by clicking on the provided links at the end of the unit. Use the soft copy of the textbook to do so.

Answer to end of unit questions

Part I

1. In uniform motion, velocity is constant. This means that the average and instantaneous velocity is the same.
2. In uniform motion, the area under velocity against time graph describes the distance covered by the body.
3. The body is at rest
4. The acceleration of a body is positive if it has the same direction as the velocity of the body. If the acceleration and velocity have opposite directions, then the acceleration is said to be negative. Negative acceleration is known as deceleration.
5. b and c
6. The average speed of the athlete is 1.82 m/s.
7. The distance between the two towns A and B is $\frac{60\text{km}}{\text{hr}} \times 2$ hrs = 120 km. For the round trip, the total distance is 2×120 km = 240 km. The average speed for the round trip is given to be 50 km/hr. This means that:

$$50\frac{\text{km}}{\text{hr}} = \frac{240\text{ km}}{\text{t}}$$

where t is the total time taken by the car for the round trip. Therefore,

$$t = 4.8 \text{ hrs}$$

Hence, the time required for the car to travel from town B to A is simply 4.8 hrs – 2 hrs = 2.8 hrs.

Finally, the average speed of the car when travelling from town B to a is

$$v_{av} = \frac{120 \text{ km}}{2.8 \text{ hrs}} = 42.86 \text{ km/hr}$$

8. a 20 m from the origin

   b 2 m/s

9. 22.5 km

10. a Plot the linear graph

    b 10 m/s

    c This is the case of constant velocity.

    d The initial position of the car is at the origin

11. 10 m/s

12. A. 2.5 m/s south

    B. 2.27 m/s north

    C. Zero

    Part II

13. A

14. C

15. B

16. C

17. D

Unit 4

Force, Work and Energy

Introduction

This unit deals with the concepts of force, work and energy. In particular, students will learn about the concept of force, contact and non-contact forces, work and energy. Students will also explore that the scientific definition of work in physics might be different from their traditional belief concerning the concept of work done. They will also learn about work done per unit time, i.e., power.

4.1 Lesson 1: The Concept of Force (2hrs)

Learning strategies

- Encourage the students to use their prior knowledge by deforming various materials to learn the effect of force.
- Engage the students through a variety of force activities (pulling, pushing, stretching or compressing springs etc.)
- Encourage students to use anchor charts to visualize students' learning and connect their prior concept of force to the new one.
- Engage students in using bar magnets or a ball thrown vertically upwards to explain about non-contact forces.

Teacher Preparation Outline
Before the Lesson

- √ Ask students their day-to-day experience such as when they kick a ball, pulling a rope etc and then what makes things to deform/change in shape, slip, move, etc from their day-to-day activities
- √ Ask students what physical quantity is responsible for the effect
- √ Tel students that what makes things to change their shape, move etc is termed as force
- √ Read various reference materials that explain about the concept of force

During the Lesson

- √ Start by asking students about their concept of force
- √ After getting feedback on the students' concept of force, introduce the lesson.
- √ Give elaborative examples by using practical examples that are related to students' day today experience.
- √ Give practical examples on the types of force such as contact and non-contact forces in nature
- √ Give practical examples on the effects of force
- √ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may ask them to mention some practical examples contact, non-contact, action, and reaction forces.

Answer to Activity 4.1

A force does not always cause motion

Answer to Exercise 4.1

Force is a vector quantity and can be represented as $\overrightarrow{F}$ or **F**.

Answer to Activity 4.2

The scales on the roadsides or in the bathroom actually measure your weight. But for convenience they are calibrated to show a reading in mass units, eg kilograms (or pounds).

Assessment

- Make sure that students can define what force is
- Make sure that students can distinguish between contact and non-contact forces and give examples
- Make sure that students could difference between mass and weight and how the gravitational acceleration varies with location.

4.2 Lesson 2: Newton's Laws of Motion (4hrs)

Learning strategies

- Engage students in Implement hands-on force and motion activities
- Engage students in describing the relation between force, and acceleration by applying various forces on a given object (for example, a wooden block)
- Encourage students to describe the relation between mass and acceleration by applying a constant force on various objects of different masses.
- Encourage students to perform various force activities to understand the action and reaction forces
- Encourage students to understand what happens to them while they are moving in a car (or riding a horse) when the car/horse suddenly stops, accelerates or changes direction. This helps them to understand Newton's first law of motion.

Teacher Preparation Outline
Before the Lesson

√ Give examples of a certain motion and ask them to tell what made things to move

√ Before describing newton's laws of motion give an example of an object is stationary, when moving with a constant speed and when accelerating and ask them to tell what made things to behave in such a way

√ Read the section on force and Newton's laws of motion from the textbook.

√ Read various reference materials that explain force and Newton's laws of motion

During the Lesson

- √ Introduce the lesson after eliciting students' experience
- √ Ask students some brainstorming questions about the concept of force and Newton' laws of motion
- √ After getting feedback on the students' concept of force and Newton's laws of motion, introduce the lesson.
- √ Discuss how Newton came to realize the relationship between force and motion
- √ Give elaborative examples by using practical examples that are related to students' day today experiences..
- √ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them a class work, or a quiz.

Answer to Activity 4.3

It is because of the law of inertia. Inertia is a property of matter by which it continues in its existing state of rest or uniform motion in a straight line, unless that state is changed by an external force. In other words, inertia is the tendency of an object to resist any attempt to change its velocity.

Answer to Activity 4.4

In general bodies of higher mass have higher inertia. Mass is a measure of the resistance of an object to change in its velocity. Mass is an inherent property of an object and is independent of the object's surroundings and of the method used to measure it. However, as discussed above, weight is the magnitude of the gravitational force acting on an object.

Answer to Activity 4.5

Encourage the students to do the activity and reach a conclusion.

Answer to Activity 4.6

Encourage the students to do the activity and reach a conclusion.

Assessment

- Make sure that students are able to define Newton's laws of motion

- Make sure that students are able to use Newton's laws of motion to solve real-life problems
- Make sure that students are able to explain the relationship among force, mass and acceleration and proving this relation through practical activities.
- Make sure that students are able to explain action and reaction forces through practical activities.

4.3 Lesson 3: Forces of Friction (1hr)

Learning strategies

- Engage students in activities that friction is the force that slows things down.
- Encourage students to rub their hands together and explain that the heat they feel is because of fractional force between the hands
- Help students to explore friction with wooden spools and sand.
- Encourage students to qualitatively explain the magnitude of friction on various surfaces (smooth and rough)
- Encourage the students to explain the advantages and disadvantages of friction in their locality.

Teacher Preparation Outline
Before the Lesson

√ Ask students about their experiences such as what happens when you travel on a muddy road, a rough surface, what happens when a driver applies a brake to stop a car, etc

√ After brain storming tell them this effect is termed as friction

√ Ask students some brainstorming questions about what force of friction is.

√ Read the section on types of forces of friction from the textbook.

During the Lesson
After getting feedback on the students' concept of friction force, introduce the lesson by telling the meaning of friction and how it inhibits motions

√ Give elaborative examples by using practical examples that are related to students' day today experiences (walking on smooth and rough surfaces etc)

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them a class work, or a quiz

- suggest some reference materials that explain about frictional forces

Answer to Exercise 4.2

Encourage the students to answer this activity by explaining about the advantages of friction.

Assessment

- Make sure that students can describe the characteristics of friction
- Give real-life problems that could help to know their understanding of frictional forces
- Students should explain the advantages and disadvantages of frictional forces through various practical activities.
- Students should relate friction force and normal force through various practical activities.
- Students should explain the difference between static and kinetic frictions.

4.4 Lesson 4: The Concept of Work (2hrs)

Teacher Preparation Outline

In this section the teacher is expected to use the learning strategy:

- Guide students to discuss different types of work such as mental work and physical work;
- Let students explain the scientific meaning of work;
- Discuss on scientific meaning of work with examples;

- Quantitatively describe the scientific meaning of work.

Before the Lesson

√ Ask students to tell their every-day conception of work

√ Read the section on the scientific meaning of work found on the textbook.

During the Lesson

√ Ask the students various brainstorming questions to check their understanding of the scientific meaning of work.

√ Ensure that the students are paying attention to the lesson.

√ Arrange your students in a group of three or four to facilitate classroom discussion about the scientific meaning of work in relation to other types of work.

√ Encourage each student to participate in the discussion

√ Ask the groups to report summary of their discussion.

After the Lesson

√ Get feedback from students about their understanding of the lesson by asking various questions.

√ suggest some reference materials that explain about the scientific work.

Answer to Exercise 4.3

1) The work done said to be zero; (i) When there is no displacement ($S = 0$) and, (ii) When the displacement is normal to the direction of the force ($\theta = 90^o$).

2) Zero

Assessment

In this section, assessment should reflect students' ability development in understanding scientific meaning of work.

4.5 Lesson 5: Kinetic and Potential Energies (2hrs)

Teacher Preparation Outline

In this section the teacher is expected to use the learning strategy:

- Guide students to discuss the definition of energy, forms of energy and transfer of energy to recall what they have learned in grade 7 unit 7 of General Science;
- Discuss the definition and different examples of kinetic energy;
- Discuss the definition and different examples of potential energy;
- Quantitatively describe kinetic and potential energies.
- Guide students to use search engine for online resources and virtual labs.

Before the Lesson

√ Ask your students some brainstorming questions about kinetic and potential energies to explore their background knowledge.

During the Lesson

√ Introduce the concepts of kinetic and potential energies found on the textbook.

√ Ask the students various brainstorming questions to check their understanding of the energy, forms of energy, and transfer of energy.

√ Give them various examples to make sure that they understand the meaning of kinetic and potential energies

√ Ensure that the students are paying attention to the lesson.

√ Arrange your students in a group of three or four to facilitate classroom discussion about the kinetic and potential energies.

√ Encourage each student to participate in the discussion

√ Ask the groups to report summary of their discussion.

After the Lesson

- √ Get feedback from students about their understanding of the lesson by asking various questions. You may give them a class work, or a quiz.
- √ suggest some reference materials that explain about kinetic and potential energies.

Answer to Exercise 4.5

1. In general if the mass is doubled, the kinetic energy is doubled. Since the mass is doubled, $E_k = \frac{1}{2} \times 2m \times v^2 = 2\,(1/2\ mv \wedge 2) = 2 \times 40\ J = 80\ J$

2. In general if the speed is doubled, the kinetic energy is quadrupled. Since the speed is doubled,

$$E_k = \frac{1}{2} \times m \times (2v)^2 = 4\,((1/2\ mv \wedge 2)) = 4 \times 40\ J = 160\ J$$

3. In general if the speed is tripled, the kinetic energy is nine times. Since the speed is tripled

$$E_k = \frac{1}{2} \times m \times (3v)^2 = 9\,((1/2\ mv \wedge 2)) = 9 \times 40\ J = 360\ J$$

Answer to Exercise 4.7

1. Given : $m_A = 2m_B,\ \ h_B = 4\ m,\ \ h_A = 2\ m$
   Required : Compare E_p of object A and B
   Solution:

   Start from the definition

$$E_p = mgh$$

$$E_{pA} = m_A g h_A = 2m_B g\,(2\ m) = \left(4m_B\ g\right)\ m$$

$$E_{pB} = m_B g h_B = m_B g\,(4\ m) = \left(4m_B\ g\right)\ m$$

   Object A and object B have the same potential energy $\left(E_{pA} = E_{pB}\right)$

2. Given : $m_A = 2m_B,\ \ h_B = 3\ m, h_A = 1\ m$
   Required : Compare E_p of object A and B
   Solution:

Start from the definition

$$E_p = mgh$$

$$E_{pA} = m_A g h_A = 2m_B g\,(1\ m) = \left(2m_B\ g\right)\ m$$

$$E_{pB} = m_B g h_B = m_B g\,(3\ m) = \left(3 m_B\ g\right)\ m$$

Potential energy of object B is greater than object A $\left(E_{pB} > E_{pA}\right)$

Assessment..

In this section, assessment should reflect students' ability development in understanding of energy due to the motion and energy due to position of objects.

4.6 Lesson 6: Power (1hr)

Teacher Preparation Outline

In this section the teacher is expected to use the learning strategy:

- Guide students to discuss power, and examples of power in their daily life;
- Discuss the definition and different examples of power;
- Quantitatively describe power and its relationship with work and energy.

Before the Lesson

√ Ask students their conception of power. When do we say certain thing has more power that the other?

√ Powerful means a person's ability to accomplish a job with in a limited time. Here give example.

√ after doing so tell the physical phenomena is termed as power

√ Read various reference materials that explain about power in relation to work and energy.

During the Lesson

√ Introduce the qualitative meaning of power and then its mathematical representation

√ Read the section on concepts of power found on the textbook.

√ Ask the students various brainstorming questions to check their understanding of the power, examples of power, and its relationship with work and energy.

√ Ensure that the students are paying attention to the lesson.

√ Arrange your students in groups of three or four to facilitate classroom discussion about the power.

√ Encourage each student to participate in the discussion

√ Ask the groups to report summary of their discussion.

After the Lesson

√ Get feedback from students about their understanding of the lesson by asking various questions and giving them a class work, or a quiz.

Answer to Exercise 4.8

Given : $m = 100kg, g = 10\frac{m}{s^2}, h = 5m, and\, t = 2s$

Required: P =?

Solution:

$$P = \frac{E_p}{t} = \frac{mgh}{t} = \frac{100\ kg \times 10\frac{m}{s^2} \times 5\ m}{2\ s}$$

$$P = \frac{5000\ kg\frac{m^2}{s^s}}{2\ s} = 2500\frac{J}{s} = 2500\ W$$

Assessment

In this section, assessment should reflect students' ability development in understanding power as the rate of doing work or energy consumption.

NB:

- Assist students to read the online resources provided as clickable contents in the unit. Use the soft copy of the textbook to do so.

-Using the ICT facility of your school or smart phones, assist students to perform the virtual laboratories by clicking on the provided links at the end of the unit. Use the soft copy of the textbook to do so.

Answer to end of unit questions and problems

Part I

1. Mass is a measure of the resistance an object to change in its velocity. Mass is an inherent property of an object and is independent of the object's surroundings and of the method used to measure it. However, as discussed above, weight is the magnitude of the gravitational force acting on an object.

2. **Newton's first law of motion** is sometimes called the law of inertia. It states that a body continues to be in its state of rest or of uniform motion in a straight line unless it is acted on by unbalanced force.

Newton's second law of motion states that the acceleration of a body is directly proportional to the force acting on it and inversely proportional to the mass of the body.
Newton's third law of motion states that every action force has an equal and opposite reaction.

1. If you take the force that your feet exert on the surface as an action force, the reaction force is the force that the surface exerts back on your feet.
2. Yes. This is the case of a uniform motion on a straight line.
3. No. We can only say that the net force on the object is zero.
4. 5 m/s^2
5. 490 N
6. 100 N
7. Friction force is the resistance to the motion of a body when it is in motion on a given rough surface. Forces of friction are very important in our everyday lives. They allow us to walk or run and are necessary for the motion of wheeled vehicles.
8. 400 N

Part II

1. **C**
2. **C**
3. **C**
4. **B**

Part III

1. Given : $m = 2.5\ kg$, $F = 50\ N$, $s = 2\ m$,
   Required : W =?
   Solution:

   Equation of work

$$W = F_{||} s = 50\ N \times 2\ m = 100\ Nm$$

$$W = 100\ J$$

2. i) Given: $m = 50\ kg$, $v = 20\ m/s$
   Required :E_k=?
   Solution:

   Equation of kinetic energy: $E_k = \frac{1}{2} m v^2$

$$E_k = \frac{1}{2} \times 50\ kg \times \left(20\ \frac{m}{s}\right)^2 = 25\ kg \times 400 \frac{m^2}{s^2}$$

$$E_k = 10000\ kg\ \frac{m^2}{s^s} = 10000\ J$$

   ii) Given : $m = 200\ g = 0.2$ kg, $v = 300\ \frac{m}{s}$
   Required:E_k=?
   Solution:

   Equation of kinetic energy: $E_k = \frac{1}{2} m v^2$

$$E_k = \frac{1}{2} \times 0.2\ kg \times \left(300\ \frac{m}{s}\right)^2 = 0.1\ kg \times 90000 \frac{m^2}{s^2}$$

$$E_k = 9000\ kg\ \frac{m^2}{s^s} = 9000\ J$$

   iii) Given: $m = 1000\ kg$, $v = 80\ \frac{m}{s}$
   Required : E_k=?
   Solution;

   Equation of kinetic energy: $E_k = \frac{1}{2} m v^2$

$$E_k = \frac{1}{2} \times 1000\ kg \times \left(80\ \frac{m}{s}\right)^2 = 500\ kg \times 6400 \frac{m^2}{s^2}$$

$$E_k = 3200000\ kg\ \frac{m^2}{s^s} = 3200000\ J = 3.2 \times 10^6\ J = 3.2\ MJ$$

3. (a) Given: $m = 10\ kg$, $h = 10\ m$,$g = 10\frac{m}{s^2}$
Required : E_p =?
Solution:
Equation of potential energy: $E_P = mgh$

$$E_p = 10\ kg \times 10\frac{m}{s^2} \times 10\ m = 1000\ kg\frac{m^2}{s^2}$$

$$E_p = 1000\ J$$

The potential energy of a 10 kg stone at a height of 10 m is 1000 J

(b) Given: $m = 10\ kg$,$g = 10\frac{m}{s^2}$, $E_p = 400\ J$
Required : h =?
Solution:
Equation of potential energy: $E_P = mgh$

$$h = \frac{E_p}{mg} = \frac{400\ J}{10\ kg \times 10\frac{m}{s^2}} = \frac{400 kg\frac{m^2}{s^2}}{100\ kg\frac{m}{s^2}} = 4\ m$$

The 10 kg stone is at a height of 4m from the ground.

4. Given: W= 1.5×10^5 J , $t = 10\ s$
Required:P =?
Solution:
Equation of power: $P = \frac{W}{t}$

$$P = \frac{W}{t} = \frac{1.5 \times 10^5 J}{10\ S} = 1.5 \times 10^4\ \frac{J}{s} = 1.5 \times 10^4\ Watt$$

The rate at which the work is done by the Crane is 1.5×10^4 Watt

Unit 5

Simple Machines

Introduction:

Human beings have been making and using simple machines for a long time. This unit, students explore about simple machines. In particular, students will learn about the purpose of simple machines, types of simple machines, and the mechanical advantage of using simple machines in the society. However, before learning simple machines it is important to introduce you about force and energy.

5.1 Lesson 1 : Simple Machines and their Purpose (3hrs)

In this section the teacher is expected to use the learning strategy:

- Involve students in identifying different purposes of simple machines.
- Tell students to observe the working conditions in their local area and report the application of simple machines.
- Engage them writing a list of simple machines used in their local area from their observations.
- Help students to construct simple machines from locally available materials

Teacher Preparation Outline
Before the Lesson

√ Ask students how people in their locality try to make things simple by using different materials such as pulleys, wedge etc

√ Tell them these are termed as simple machines

1. Read the section on simple machines and their purpose from the textbook.

√ Read various reference materials that are related to simple machine.

During the Lesson

√ Introduce the concept of simple machine by giving examples

√ Start by asking students about the definition of simple machine, purpose of simple machines, and let them list simple machines used in their local area.

√ Let students discuss in groups different simple machines and their purposes.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions.

Summarize important points.

Guide to Activity 5.1

1. Tell students to observe their village in groups for two to three days and write the list of simple machines that are used in day to day activity.

2. Tell each group to write the purpose of each simple machine in the table. Follow up each group and make corrections.

No	Type of simple machine	Purpose of the simple machine
1		
2		
3		
4		

3. Tell the students to write the list of activities that are not supported by simple machine in their village.

4. Tell the students to discuss and suggest some simple machines for the activities that are not supported by simple machine in their village. Summarize the discussion results, correct the wrong proposals, and conclude by suggesting the appropriate simple machines for the activities that are not supported by simple machines.

Answer to Exercise 5.1

1. To change direction.
2. To multiply a force.
3. To multiply a speed.

Assessment
In this section, assessment should reflect students' ability on depth of insight into difficult working practices in the community and the practicalities of proposed solutions by students need to be assessed and credited. Moreover, their ability in relation to the purpose of simple machines should be assessed.

5.2 Lesson 2: Simple Machines at Home (1hr)

In this section the teacher is expected to use the learning strategy:

1. Engage students in developing a list of simple machines at home, collecting drawings and pictures of the simple machines they found at home along brief descriptions of the functions of the machines at home;.

Teacher Preparation Outline
Before the Lesson

- Ask students about their observation and write the list of simple machines that are used by the community in the local area

During the Lesson

√ Start by asking students about the simple machines that are used at home to make work easier.

√ After getting feedback, introduce the lesson.

√ Make students in a small groups to write on different types of simple machines at home and their purposes.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions and comparing it with what you have observed. Moreover, give feedback to students.

Guide to Activity 5.2

1. Guide the students to write a list of simple machines used outside their home and tell them to fill the table given in Activity 5.2 in the students textbook.

2. Tell the students to collect drawings and pictures of the simple machines that they found at their home and guide them to fill the table as indicated in Activity 4.6. Moreover, facilitate the activity by giving right directions.

Answer to Activity 5.3

1. No, it is not possible to increase speed and force at the same time. Because only one quantity can be increased to affect the other quantity. For example, in case of a wheel, if the rim of the wheel is turned then the axle at the center turns with less speed but more force. Thus, the wheel works as a force multiplier. If you turn the axle only then the wheel becomes the speed multiplier. This is because the axle turns a short distance and the outer rim of the wheel turns much further. This is how the wheel moves faster.

Assessment

In this section, assessment in this should reflect students' ability to appreciate the variety and abundance of simple machines in their home.

5.3 Lesson 3: Simple Machines at Work Place (1hr)

In this section the teacher is expected to use the learning strategy:

- In small groups, give students a large list (pictures) of simple machines at different work places, and let them comment on how they are used and how they simplify tasks;

Teacher Preparation Outline

Before the Lesson

- √ Carefully observe the simple machine card (Figure 4.4) and write the name of simple machines, the description of each simple machine, and the purpose of using these simple machines according to the table.

During the Lesson

- √ Make students in small group to observe the figure and fill the table in students textbook.
- √ Make each group to reflect their answer to the class.
- √ Ensure that the students are paying attention to the lesson.

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After the Lesson

Give feedback to each group and finally display the table describing the name of simple machines, the description of each simple machine, and the purpose of each simple machine.

Guide to Exercise 5.2

1. Tell students to observe Figure 5.5 (linked pictures of a simple machine card) showing simple machines at work place. Then guide them to complete the Table given in activity 5.5 on students textbook. Finally check it and give feedback.

Lever, Wheel and axle, lever, pulley, wedge
Screw, wheel and axle, wheel and axle, inclined plane, wedge
Wedge and wheel and axle, inclined plane, lever, lever, wheel and axle
Inclined plane, lever, wheel and axle, wedge, lever

Assessment

In this section, assessment should reflect students' ability to appreciate the variety and abundance of simple machine in their community life should be measured.

5.4 Lesson 4: Classification of Simple Machines (2hrs)

In this section the teacher is expected to use the learning strategy:

- For different group of simple machines, let students identify important variables that can be used in describing and comparing effectiveness in simplifying work; let students use the physics textbook to make sure the variables they identified are the ones used in physics;
- Use the variables in classifying and describing the simple machines

Teacher Preparation Outline

Before the Lesson

√ Ask students to list down simple machines and classify according to the purposes they serve

During the Lesson

√ Start by asking students how to classify simple machines.

√ After getting feedback from the students, introduce that all kinds of simple machines are categorized into six types.

√ Give different examples for six types of simple machines.

√ Already students came across different types of simple machines at home, at work place and from Figure 4.4. Guide students to place each simple machine on its type.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give class activity or quiz related to classifying simple machines.

√ Suggest some reference materials that are related to classification of simple machines. You may give a class activity or a quiz related to classifying simple machines.

Guide to Exercise 5.3

1. Students have listed variety of simple machines at home and work place in the previous activities. Tell students in group to classify them under the type of simple machines. Check it and give feedback.

Assessment

After the completion of lesson 5, the teacher is expected to assess students using:

- Test
- Class work
- Group assignment

N.B Giving timely feedback is very important

5.5 Lesson 5: Mechanical Advantage, Velocity Ratio and Efficiency of Simple Machines (10hrs)

In this section the teacher is expected to use the learning strategy:

- Calculate and use the results for M.A, V.R., and Efficiency to evaluate the performance of machines
- Let students present concerning how to choose a suitable simple machine under a given work requirement.
- Engage students in workout problems.
- Guide students to use search engine for online resources.

Teacher Preparation Outline

Before the Lesson

√ Ask brainstorming question on the advantages of simple machines.

During the Lesson

√ Start by asking students the purpose of six types of simple machines.

√ After getting feedback from the students, introduce the purpose of a specific simple machine, its mechanical advantage (AMA and IMA) and efficiency.

√ Give explanation on the purpose, mechanical advantage (AMA and IMA) and efficiency of each type of simple machine.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give a class activity or quiz related to type of a specific simple machine, its purpose and its mechanical advantage.

√ Suggest some reference materials that are related to characterization of simple machines.

Answer to Exercise 5.4

1. The ratio of output force to input force is called the mechanical advantage of a simple machine. You can also discuss the mechanical advantage of a machine in another way using the definition of work. The input work is the product of the effort force you exert, F_E and distance moved by effort, s_E. Similarly, the output work is the product of the output force, F_L and the distance moved by the load, S_L. The ideal machine transfers all the energy, so the output work is equal to the input work.

$$W_O = W_I \Longrightarrow F_L S_L = F_E S_E \Longrightarrow \frac{F_L}{F_E} = \frac{S_E}{S_L}$$

   For ideal machine the mechanical advantage is the ratio of distance moved by effort to distance moved by the load.

2. The actual mechanical advantage is the ratio of output force to input force, $\left(\frac{F_L}{F_E}\right)$.

3. The ideal mechanical advantage is the ratio of distance moved by effort to distance moved by load, $\left(\frac{S_E}{S_L}\right)$.

Answer to Exercise 5.5

Mechanical advantage of hammer= 15

Exercise 5.6

Load (N)	M.A	Effort (N)
1800	3	600
40	0.25	160
240	0.5	480
900	0.3	3000
2000	4	500

Answer to Exercise 5.7

Distance moved by effort	V.R	Distance moved by the load
0.2	4	0.05
0.8	0.4	2
6	0.6	10
1.8	0.3	6
12	2	6

Answer to Exercise 5.8

1. If $V.R < 1$, the distance moved by the load is greater than the distance moved by the effort. So the simple machine is a distance multiplier or a speed multiplier.

2. If $V.R > 1$, the distance moved by the load is less than the distance moved by the effort. So the simple machine is a force multiplier.

Answer to Activity 5.4

1. No;, it is possible for a machine to increase both the magnitude and distance of a force at the same time. When a machine provides an increase in force, there must always be a decrease in the distance the force moved and vice versa.

Answer to Exercise 5.9

1. $\eta = 75\%$ means, 75% of the work input to the machine is obtained as a useful work output. The remaining 25% of the work input has been lost in overcoming the friction.

Answer to Exercise 5.10

1. $\eta = \frac{M.A}{V.R} = \frac{3}{6} = 0.5$ or $\eta = \frac{M.A}{V.R} \times 100\% = \frac{3}{6} \times 100\% = 50\%$

2. If $M.A = V.R$, then $\eta = 1$ and the machine 100% efficient. That is 100% of the work input to the machine is obtained as a useful work output. There is no lose in energy due to friction.

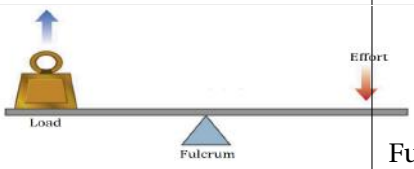
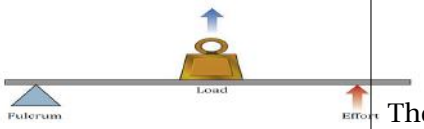
Answer to Exercise 5.11

1. The different parts of lever are load, fulcrum and effort.

2. Guide the students to discuss in group and list some examples of lever that people are using in the local area.

3. Levers can be used as force multipliers or speed multipliers. Levers can be force multipliers, when they increase the force that is put in (the effort). They can be distance or speed multipliers if they make the load move further than the effort. The amount the force or distance is multiplied depends on the distance between the load and the fulcrum and the effort and the fulcrum.

Answer to Activity 5.5

Class	Diagram	Description	Examples
1^{st}		Fulcrum is between the load and effort	1.Scissors 2.See-saw 3.Crow bar 4.Bottle opener
2^{nd}		The load is between the effort and load	1.Wheel barrow 2.Paper cutter 3.Nut crackers
3^{rd}		The effort is between the load and fulcrum	1.Spade 2.Charcoal tongs 3.Tweezers

Answer to Activity 5.6

1. Tell students to observe lever as force multiplier or speed multiplier using different types of levers practically. For force multiplying levers the distance between the effort and fulcrum is greater than the distance between the load and fulcrum. However, for distance or speed multiplying levers the distance between the load and fulcrum is greater than the distance between the effort and fulcrum.

Answer to Activity 5.7

1. Guide students to discuss the purpose of using inclined plane. Finally summarize that the purpose of using inclined plane is to multiply a force.

2. It is easier to push a heavy object up an inclined plane than to lift it to the same height. This is because inclined planes reduce the force necessary to move a load. That is the effort required to move the load is less.

Answer to Exercise 5.12

1. $V.R = \frac{l}{h} = \frac{30\ m}{5\ m} = 6$

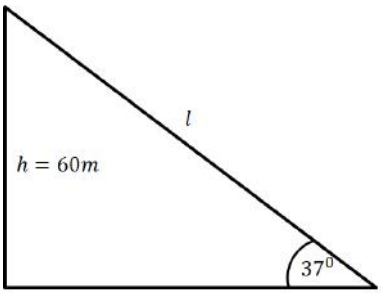
2. 

Figure 5.1

$$\sin 37^\circ = \frac{h}{l} \quad \Longrightarrow l = \frac{h}{\sin 37^\circ} = \frac{60\ m}{0.6}$$

$$37^\circ\, l = 100\ m$$

$$V.R = \frac{l}{h} = \frac{100\ m}{60\ m} = 1.67$$

Given: $l = 40\ m,\ h = 8\ m,\ F_E = 80\ N,\ F_L = 240\ N$

Required: $M.A = ?,\ V.R = ?,\ \eta = ?$

Solution:

$$M.A = \frac{Load}{effort} = \frac{F_L}{F_E} = \frac{240\ N}{80\ N} = 3$$

$$V.R = \frac{l}{h} = \frac{40m}{8\ m} = 5$$

$$\frac{M.A}{V.R} = \frac{3}{5} = 0.6\ \ or 60\%$$

$$F_L = 240\ N$$

Answer to Exercise 5.13

1. Wedges are two inclined planes joined back to back. Wedges are used to split or hold objects together.

2. Let students discuss in groups on the purpose of using wedges in their local area. In most cases they use wedges as force multipliers.

3. Tell students to list examples of wedges used in their village. Some common examples are: knives, axe blade, nails, and spears and so on.

4. An inclined plane stays in one place and something moves up and down the slope. However, the wedge moves to do its work. Inclined planes are used to lift heavy objects to some height, whereas wedges are used to split objects in to two parts.

Answer to Exercise 5.14

1. The purpose of using screw is to multiply force. It is used to raise and lower weights and hold objects together.

Answer to Activity 5.8

1. A wheel and axle involves two circular objects; a larger disc and a smaller cylinder both joined at the center. The larger disc is called a wheel. The smaller cylindrical object or a rod is referred to as the axle.

2. Discuss with students how a wheel and axle can be constructed in their local area. Guide them to construct a wheel and axle from local materials.

Answer to Activity 5.9

1. The distance moved by the effort is greater than the distance moved by the load.

2. See student's textbook.

Answer to Exercise 5.15

1. Given: $d_{wheel} = 20 d_{axel}$
   Required : $M.A$ =?
   Solution:
$$M.A = \frac{R_{wheel}}{r_{axle}} = \frac{d_{wheel}}{d_{axle}} = 20$$

Answer to Exercise 5.16

1. A pulley is a circular body (wheel) with a groove surface and is free to rotate about its center.
2. A fixed pulley, a movable pulley and a compound pulley
3. A fixed pulley is a direction changer, whereas a movable pulley is force multiplier.

Answer to Activity 5.10

1. In a compound pulley the purpose of using fixed pulley is to change the direction of force. However, the purpose of using movable pulley is to multiply force.
2. Figure of pulley systems with $V.R = 2,\ 3,\ 4,\ 5,\ and\ 6$

Assessment
In this section, assessment should reflect students' ability on characterization of simple machines, and associated calculations are where students should demonstrate their competence in.

5.6 Lesson 6: Designing Simple Machine (2hrs)

In this section the teacher is expected to use the learning strategy:

- Group project can be given in which students identify a practical problem from their surrounding that can be solved by introducing a simple machine. After identifying the problem, students should propose and design a simple machine as a solution.

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Teacher Preparation Outline
Before the Lesson

√ Develop an idea helps you to design the best model of a simple machine in your school.

√ Read various reference materials on how to develop simple machines.

During the Lesson

- √ Create four to five groups in each class.
- √ Give a group project in which students identify a practical problem from their surrounding that can be solved by introducing a simple machine.
- √ Discuss the idea of developing a machine by combining two or three types of simple machines.
- √ Guide students to create their own idea in developing the best model of a simple machine.
- √ Guide students to follow the procedure given in the students text book.

After the Lesson

Get feedback from students everyday until they complete their project.

Assessment

In this section, assessment should reflect students' ability on developing the best model of simple machines which is practically applicable in their community.

NB:

- Assist students to read the online resources provided as clickable contents in the unit. Use the soft copy of the textbook to do so.

Answer to end of unit questions

Part I

1. B
2. D
3. A
4. B
5. D

Part II

1. False
2. False
3. False
4. True
5. True

Part III

1. a) Given: $r_{wheel} = 30\ cm,\ r_{axel} = 5\ cm$

   Required: $V.R$ =?,

   Solution:

   $$V.R = \frac{r_{wheel}}{r_{axle}} = \frac{30\ cm}{5\ cm} = 6$$

   b) Given: $F_L = 40\ N$

   Required: F_E =?

   If there is no energy losses, $M.A = VR$

   $$\frac{F_L}{F_E} = 6 \implies F_E = \frac{40\ N}{6} = 6.67\ N$$

   c) $F_E = 20\ N \Longrightarrow M.A = \frac{F_L}{F_E} = \frac{40\ N}{20\ N} = 2\ ? = \frac{M.A}{V.R} = \frac{2}{6} = 0.33 = 33.3\%$

2. a) Given: $F_L = 6000\ N,\ F_E = 300\ N$

   Required: AMA =?

   $$AMA = \frac{F_L}{F_E} = \frac{6000\ N}{300\ N} = 20$$

   No energy losses

   b) If there is no energy losses, $AMA = V.R = 20$

   c) $h = 10\ m\ l$ =? $V.R = \frac{l}{h}] \Longrightarrow 20 = \frac{l}{10\ m} \Longrightarrow l = 200\ m$

3. Given : $l = 12\ cm,\ t = 3\ cm$

   Required:

   a) $V.R$ =?, $V.R = \frac{l}{t} = \frac{12\ cm}{3\ cm} = 4$

   b) What is F_L?, if F_E=20 N.

   If there is no energy loses,

   $M.A = V.R \implies \frac{F_L}{F_E} = 4 \implies F_L = 4F_E = 80\ N$

4. Given: $F_L = 100\ N,\ F_E = 20\ N$

   Required: $M.A$ =?

   $$M.A = \frac{F_L}{F_E} = \frac{100\ N}{20\ N} = 5$$

   5. Given:

   The total load= $140\ N\ \left(Actual\ weight\right) + 5\ N\ (dirt\ on\ pulley) \Longrightarrow F_L = 145\ N$

   $$F_E = 75\ N$$

a) Yes, the load can be moved by a movable pulley because the movable pulley multiplies the applied force twice. That is 150 N is more than enough to move 145 N load

b) No, the fixed pulley changes only the direction and it is impossible to lift 145 N load by applying a 75 N force

1. See student's textbook.
2. See student's textbook.
3. $AMA < IMA$. This is because there are energy losses due to friction in real application of simple machines.
4. See student's textbook.

Unit 6

Mechanical Oscillation and Sound Wave

Introduction

This unit deals with mechanical oscillation and sound wave. In particular, students will learn about oscillation of pendulum and springs, wave propagation in string, propagation of waves and energy transmission, types of waves, production and propagation of sound waves, superposition and musical instruments, and sound standards (loudness).

6.1 Lesson 1: Common Characteristics of Waves (1hr)

Learning strategies

- Brainstorm on the meaning of a Physical wave. Where do you see them? What types are there? Elicit students' responses. List them down.
- Ask students to check their background knowledge on the common characteristics of waves.
- Guide students to use search engine for online resources and virtual labs.

Teacher Preparation Outline
Before the Lesson

√ sk students to check their background knowledge on the common characteristics of waves.

During the Lesson

√ Start by asking students about their concept of common characteristics of waves.

√ After getting feedback, introduce the lesson.

√ Give elaborative examples concerning common characteristics of waves.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions concerning the common characteristics of waves.

√ Suggest some reference materials that explain about common characteristics of waves

Assessment

1. Students' ability of defining and pictorially representing common characteristics of waves such as period, frequency, wavelength and wave speed.

6.2 Lesson 2: String, Pendulum, and Spring (4hrs)

Learning strategies

- Brainstorm on the meaning of a physical wave. Where do you see them? What types are there? Elicit students' responses. List them down.
- Bring necessary materials to the class and demonstrate the vibration of string, pendulum, and spring-mass system and introduce concepts of amplitude, wavelength, period, and frequency;
- In the laboratory, let students in small groups collect data about pendulum and spring oscillations; let students propose and implement ways of accurate measurements of length, mass, and time. In the following class time help students to organize and analyze the data so that they will arrive at the formula for the periods of pendulum and spring oscillation.

- Creative thinking: Design a body-mass measuring device that can be used by astronauts in a space station where there is no significant gravity to measure astronauts' mass as usual.
- Use a spring-mass system to trace the wave form of simple harmonic oscillator. Re-construct the wave form by comparing the trace with sinusoidal wave forms and use it to re-introduce wave characteristics such as frequency, period, wavelength, amplitude, phase, and wave speed.

Teacher Preparation Outline

Before the Lesson

√ Ask students to tell their experiences regarding the motion of strings, pendulum and springs etc before introducing the concept.

During the Lesson

√ Start by asking students about the concept of oscillations of simple pendulum and springs as well as wave propagation in string.

√ After getting feedback on the students' concept of oscillations of simple pendulum and springs as well as wave propagation in string, introduce the lesson.

√ Give elaborative examples by using practical examples that are related to students' day today experience.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may ask them to mention some practical examples and uses of simple pendulum and springs in real life.

√ Suggest some reference materials that explain about oscillations of simple pendulum and spring as well as propagation of wave in string

Answer to Activity 6.1

Let students poke a stick into water contained in a dish. Ask them what they observe. Instead of poking the steak into the water once, let them continuously

move it in and out. Now ask them what they observe. This is an activity demonstrating creation of a single disturbance (wave) and a continuous disturbance (wave).

Answer to Activity 6.2

Encourage the students to perform the activity and measure the value of g in the locality. Let them report in the class. Discuss how the value of g can be improved (the smaller the angle the more accurate the value of g would be).

Answer to Activity 6.3

Encourage the students to bring different springs to the class and perform the activity. To compare the stiffness of the springs, suspend an identical object on all the springs and measure their extended length. The more the extension, the looser the spring is.

Answer to Exercise 6.1

1600 N/m

Assessment

1. Students' ability of identifying societal problems and discussing them in a responsible way is highly credited in this unit. Evidences that they progress in their reasoning using everyday language into use of scientific concepts and ideas must be carefully observed. For this purpose, the various concepts related to sound waves must be precisely defined by students.

2. Students should also be able to use their knowledge of sound in creative ways.

6.3 Lesson 3: Propagation of Waves and Energy Transmission (2hrs)

Learning strategies

- Use a spring-mass system to trace the wave form of simple harmonic oscillator. Re-construct the wave form by comparing the trace with sinusoidal wave forms and use it to re-introduce wave characteristics such as frequency, period, wavelength, amplitude, phase, and wave speed.

- Determine wave speed in different material medium and different temperature.

- Reading assignment: Encourage students to read about such concepts of wave propagation, reflection, and standing wave. Combine and reorganize the reading note in small groups to have short presentations about standing waves to the whole-class.

Teacher Preparation Outline

Before the Lesson

√ Ask students some brainstorming questions about the concept of propagation of waves

√ Read the section on propagation of waves and energy transmission from the textbook.

During the Lesson

√ After getting feedback on the students' concept of propagation of waves and energy transmission, introduce the lesson.

√ Give elaborative examples by using practical examples that are related to students' day today experience (string waves, water waves etc).

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them class work, or quiz.

√ Suggest some reference materials that explain about propagation of waves and energy transmission

Assessment

- Students' ability of identifying societal problems and discussing them in a responsible way is highly credited in this unit. Evidences that they progress in their reasoning using everyday language into use of scientific concepts and ideas must be carefully observed. For this purpose, the various concepts related to sound waves must be precisely defined by students.
- Students should also be able to use their knowledge of sound in creative ways.

6.4 Lesson 4: Sound Wave (5hrs)

Learning strategies

- Make observation at home and in the surrounding to identify bodies producing sound, record brief description of how sound is produced in each case, and whether the sound from these sources is comfortable or disturbing.
- Based on their internet findings let each small group propose solutions to the problems they identified from their observation of the surrounding and poll the whole class to produce a resolution document with specific recommendations to specific agents.
- Group project: Let students (different small groups on different applications) prepare a presentation on the working of the "ultrasound", sonograph, and radar.
- Guide students to use search engine for online resources and virtual labs.

Teacher Preparation Outline

Before the Lesson

√ Read the section on sound wave from the textbook.

During the Lesson

√ Ask students some brainstorming questions about production and propagation of sound wave

√ After getting feedback on the students' concept of production and propagation of sound wave, introduce the lesson.

√ Give elaborative examples by using practical examples that are related to students' day today experience (for example, production of different sounds that students are experienced with throughout the day).

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. Give them a homework to explore the production and propagation of different sounds outside classroom.

√ Suggest some reference materials that explain about sound wave

Answer to Activity 6.4

Encourage the students to perform the activity. Explain and confirm that sounds are produced by vibrating objects. All the sounds you hear are produced by a vibrating object. The air near the vibrating object is set in motion in all directions. The produced sound travels in every direction, in the form of energy and reaches your ear.

Answer to Activity 6.5

When you touch the pith ball with a tuning fork, nothing happens to the pith ball. Now strike the tuning fork by the hammer on the prong by holding on its stem. Then touch the pith ball with the fork; you can see the pith ball flings away. This shows that the energy on the prong is transferred to the pith ball, and the pith ball starts to vibrate.

Answer to Activity 6.6

Encourage students to perform this activity and help them to reach a conclusion based on what they have noticed.

Answer to Exercise 6.2

Light travels much faster than sound.

Answer to Exercise 6.3

Encourage the students to perform the activity and estimate the distance to the thunderstorm. To estimate the distance to the thunderstorm, they should count the number of seconds between seeing the flash of lightning and hearing the thunder using a stopwatch. If you multiply the time measured by the speed of sound at 20℃, it gives the estimated distance to the thunder.

Answer to Exercise 6.4

The sound that you hear back is called an echo.

Answer to Exercise 6.5

During a day, the air near the ground is warmer than the rest of the air. This means that the speed of sound near the ground increases making them bend away from the ground. However, during the night time, the air near the ground is colder than the rest of the air and the speed of sound near the ground decreases. This makes sound waves bend towards the ground enabling us to hear clear sound during the night time.

Assessment

- Students' ability of identifying societal problems and discussing them in a responsible way is highly credited in this unit. Evidences that they progress

in their reasoning using everyday language into use of scientific concepts and ideas must be carefully observed. For this purpose, the various concepts related to sound waves must be precisely defined by students.

- Students should also be able to use their knowledge of sound in creative ways.

6.5 Lesson 5: Superposition of Waves (2hrs)

Learning strategies

- Engage students to observe the image or video of a standing wave on a string.
- Engage students to search from the internet, the library, or from other sources concerning how standing waves are formed and explain it to the class.

Teacher Preparation Outline
Before the Lesson

√ Ask students to tell their experience on what standing waves are and how they are formed.

√ Ask students to tell what they have known when different waves interfere.

√ Ask students some brainstorming questions about superposition of waves and help them connect with their daily life experiences.

During the Lesson

√ After getting feedback on the students' concept of superposition of waves, introduce the lesson.

√ Give elaborative examples by using practical examples that are related to students' day today experience.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. Give them homework to explore the superposition of waves in their locality.

√ Suggest some reference materials that explain about superposition of waves.

Assessment

- Students ability of explaining superposition principle, standing waves and interference of waves.

6.6 Lesson 6: Characteristics of Sound Wave (1hr)

Learning strategy

- Encourage students to tell the loudness of different musical instruments Guide students to use search engine for online resources and virtual labs.

Internet Search: Let students search for local and international standards and safety precautions related to sound pollution.

Teacher Preparation Outline

Before the Lesson

√ Ask students to tell their experiences of listening different things that are sometimes very terrible for their ears such as horns of a car ...

√ Tell students that some sounds are very inconvenient for our ears and others are not even to be heard then tell what this phenomena is

√ Ask students about their experiences concerning how they label different sounds. Elicit their experience.....

√ Give examples of two materials of the same pitch and loudness but made from different materials and then two materials made from the same material and having the same pitch (control one and make the two similar to show how pitch, loudness and tone vary)

√ Before telling what pitch or tone is, it is better to provide examples or ask their experience)

√ Read various reference materials that explain characteristics of sound waves such as loudness, pitch and timber

During the Lesson

√ Introduce the lesson on characteristics of sound waves such as loudness, pitch and timber from the textbook.

√ Ask students some brainstorming questions about characteristics of sound waves such as loudness, pitch and timber

√ After getting feedback on the students' concept of characteristics of sound waves such as loudness, pitch and timber, introduce the lesson.

√ Give elaborative examples by using practical examples that are related to students' day today experience (for example, various sounds from musical instruments and others).

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. Give them a a homework to explore the main causes of sound pollution in their locality (if any).

Suggest some reference materials on the topic

Answer to Exercise 6.6

Two notes of the same pitch and loudness, played from different instruments do not sound the same because of the difference in quality or tone of the sounds.

Answer to Activity 6.7

Encourage the students to investigate the causes of sound pollution in their locality. Let them suggest possible solutions.

Assessment

- Students' ability of identifying societal problems and discussing them in a responsible way is highly credited in this unit. Evidences that they progress in their reasoning using everyday language into use of scientific concepts and ideas must be carefully observed. For this purpose, the various concepts related to sound waves must be precisely defined by students.
- Students should also be able to use their knowledge of sound in creative ways.

NB:

- Assist students to read the online resources provided as clickable contents in the unit. Use the soft copy of the textbook to do so.

-Using the ICT facility of your school or smart phones, assist students to perform the virtual laboratories by clicking on the provided links at the end of the unit. Use the soft copy of the textbook to do so.

Answer to end of unit questions

Part I

1. 3.97 s (Using g = 10m/s^2)
2. 0.314 s
3. (a) The speed of sound in solids > the speed of sound in liquids > the speed of sound in gases.

   (b) The speed of sound in warm air is greater than that in cold air.
4. Longitudinal waves. Examples of longitudinal waves include sound waves and pressure waves, but not limited to these two.
5. 3×10^{16} per second.
6. Refer to the textbook
7. (a) 8 cm (for complete constructive interference)

   (b) 0 (for complete destructive interference)
8. All the sounds you hear are produced by a vibrating object. The air near the vibrating kirar is set in motion in all directions. The produced sound travels in every direction, in the form of energy and reaches your ear even though you cannot see the player.
9. 5000 m/s
10. 348.71 m/s
11. 343 m
12. 0.67 s

    Part II

13. A

14. C

15. B

16. B

17. A

18. C

Unit 7

Temperature and Thermometry

Introduction

This unit deals with temperature and thermometry. Particularly, students will learn about the definition of temperature, temperature and its effects in our life, different thermometric scales, different thermometers and their use, conversion between temperature scales and linear expansion of solid materials.

7.1 Lesson 1: Temperature and our Life (1hr)

By the end of this section you should be able to:
In this section the teacher is expected to use the learning strategy:

- Let students discuss in groups concerning the idea of temperature.
- Introduce the idea of effects of extreme temperatures in different conditions and safety measures that should be taken.
- Guide students to use search engine for online resources and virtual labs.

Teacher Preparation Outline
Before the Lesson

√ Give brainstorming questions about temperature and safety.

√ Start with what students' background knowledge before telling the new concept.

During the Lesson

- √ Ask students some brainstorming questions about the definition of temperature and effects of temperature in human beings life.
- √ After getting feedback on the students' concept of temperature and its effects, let students carry out Activity 7.1, 7.2, and 7.3 to understand the definition of temperature.
- √ Discuss the variation of temperature in relation to living style of people in different regions
- √ Explain severe temperature and safety measures.
- √ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them a class work, or a quiz.

Suggest some reference materials that explain temperature and its effects in our life

Guide and answer to Activity 7.1

- √ Materials needed are: 3 cups, cold water, warm water and hot water. Make students in groups to predict their idea before the experiment, and then tell them to do the experiment and finally reject or accept the idea based on the experiment.
- √ The wood and the metal are in thermal equilibrium with outside air and are thus the same temperature. They feel different because of the difference in the way they conduct heat away from your skin. The metal conducts heat away from your body faster than the wood does. This is just one example demonstrating that the human sense of hot and cold is not determined by temperature alone.
- √ Testing the hotness or coldness of a body by feeling is not reliable.

Answer to Activity 7.2

Encourage the students to observe the motion of water molecules at the given temperatures and compare their average kinetic energy at each temperature using the provided link.

Answer to Activity 7.3

1. Human beings and other living creatures adapt different temperature conditions in our planet Earth. Particularly for human beings this challenge creates room for innovation of temperature related devices.

2. The sun and stars have high temperature in nature. It is also possible to get higher temperature from burning wood, fuel and candle, electric heaters and electric stoves. In contrast to this there are bodies which have lower temperature, water bodies with an ice below0℃.

Answer to Activity 7.4

1. Wear clothing that is appropriate to your environment.

2. Use cooling or heating devices or local materials.

Assessment
Students' ability to identify bodies with very high and very low temperature in their surrounding and in nature in general should be assessed.

7.2 Lesson 2: Extreme Temperature and Safety (1hr)

By the end of this section you should be able to:
In this section the teacher is expected to use the learning strategy:

- Let students discuss the comfortable environmental temperature for human beings.
- Discuss the idea of effects of extreme temperatures and safety measures that should be taken.
- Guide students to use search engine for online resources and virtual labs.

Teacher Preparation Outline
Before the Lesson

√ Start with brainstorming questions before introducing the lesson.

√ Start with what students have known and experienced before telling the new concept

During the Lesson

√ Ask students some brainstorming questions about comfortable temperature to human being and protective measures for extreme temperatures.

√ After getting feedback on the students' concept of extreme temperature and safety, make students discuss about the new lesson and carry out Activity 7.4.

√ Explain severe temperature and safety measures.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them a class work, or a quiz.

√ Suggest some reference materials that explain temperature change and its effects in our life.

Assessment

Students must be able to identify associated hazards (if any) and safety precautions needed involving bodies with extreme temperatures.

7.3 Lesson 3: Temperature Changes and its Effects (2hrs)

In this section the teacher is expected to use the learning strategy:

- Identify conditions in which temperature change brings about observable changes on environment; discuss the effects and extreme cases.
- Guide students to use search engine for online resources and virtual labs.

Teacher Preparation Outline

Before the Lesson

√ Ask students to explain what they observed from media (such as TV) when disasters arising from climate change are happening in different parts of the world.

√ After exploring their response tell them that this is due to temperature change.

During the Lesson

- √ Ask students some brainstorming questions about the global rise in temperature and the causes for the rise in temperature.
- √ After getting feedback on the students' concept of rise in temperature and its causes, start the lesson by elaborating the causes for the rise in temperature from time to time, its effect on different parts of the world, and introduce the controlling mechanisms.
- √ Give elaborative examples of causes for global warming.
- √ Explain about greenhouse gases and their effect in the environment.
- √ Discuss on the impact of indigenous knowledge such as conservation of forest in controlling the rise in temperature.
- √ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them a class work, or a quiz.

Suggest some reference materials that explain temperature change and its effects in our environment.

Answer to Exercise 7.2

1. Greenhouse gases (carbon dioxide, methane, nitrous oxide and fluorinated gases) resulting from human activity are the causes for rising of temperature in our environment.
2. One of the strategy to mitigate this problem is reducing the concentration of greenhouse gases in the environment:
    - Using renewable energy sources such as solar energy, geothermal energy and wind energy and energy from hydropower,
    - Conserving forest, planting trees. Bamboo and other plants can take Carbon dioxide from the air.
    - Reducing emissions from industry.
3. The greenhouse effect is the natural process that warms the Earth's surface.

Answer to Activity 7.5

High temperature has major effects on people environment with respect to:

- Agriculture: the crops that we grow for food need specific conditions to thrive, including the right temperature and enough water,
- Energy: the rise in temperature could make it harder to produce certain types of electricity such as hydropower. This results in power shortage and blackout.
- Health: the rise in temperature affects the environment that provides us with clean air, food, water, and shelter. These threaten human health.
- Water supply: the rise in temperature reduces the amount of water in our local environment.
- Forests provide homes for many kinds of plants and animals. They also protect water quality, offer opportunity for recreation, and provide people with food. However, the rise in temperature results in wildfire that destructs the forest.
- Plants, animals and ecosystem: as the Earth gets warmer, plants and animals that need to live in cold places like mountain might not have a suitable place to live. So they become extinct.

Assessment
Students must be able to identify associated hazards (if any) and safety precautions needed involving bodies with extreme temperatures.

7.4 Lesson 4: Measuring Temperature with Different Thermometric Scales (3hrs)

In this section the teacher is expected to use the learning strategy:

- Engage students in small group discussions and list various conditions in which special techniques of temperature measurement are needed.
- Engage students in reading and compiling a note on the procedure of thermometer making.
- Arrange your students in groups and give an assignment to each group to plan, construct, and test a homemade thermometer. Let them write a report on the functioning and limitations of the developed thermometers.

- Let them make a note describing the history and making of three thermometric scales.
- Let them identify which scale is commonly used locally, discuss in groups by presenting justifications if it is necessary to retain or change the thermometric scale in use.
- Guide students to use search engine for online resources and virtual labs.

Teacher Preparation Outline

Before the Lesson

√ Ask students some brainstorming questions about measuring temperature with different thermometer scales.

√ How does a physician check the body temperature of patients?

√ Explain to your students that body temperature can be measured using Celsius, Fahrenheit, or kelvin. However, measuring by any of the scales is the same except the usage of different scales

During the Lesson

√ After getting feedback on the students' concept of measuring temperature on different thermometer scales, start your lesson by elaborating different temperature scales. Discuss the scientists who contributed in designing different temperature scales.

√ Engage students in small group discussions and list various conditions in which special techniques of temperature measurement are needed.

√ Guide students in groups to design their own temperature scale.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them a class work. Suggest some reference materials that explain measuring with different thermometer.

Answer to Exercise 7.3

Thermometer works: as the substance inside the tube of a thermometer undergoes some changes (expand or contract) when heated or cooled.

Answer to Exercise 7.4

1. Students are expected to mention at least one of the scales from the three scales. (degree Celsius scale, degree Fahrenheit scale or Kelvin scale)
2. Degree Celsius
3. 37 ℃, 98.6 ℉
4. Students are expected to discuss and decide on answer.
5. Make the students discuss and reason out. The answer should be yes.

Answer to Exercise 7.5

1. 0 ℃ or 32 ℉ or 273.15 K
2. 100 ℃ or 212 ℉ or 373.15 K

Guide to Activity 7.6

Materials needed: At least 3 beakers containing cold, warm, and hot water, and a thermometer.

Let the students observe the scale of temperature in thermometer and record the unit of measurement;

Let students measure the temperature in 3 beakers using thermometer and record the values;

Tell students to compare the recorded temperature values.

Guide Exercise 7.6

1. Students in each group are expected to have their designed thermometer and one commercial thermometer. Tell students to observe the temperature of cold and hot (warm) water by both thermometers and record the relation between the two thermometers.
2. Tell students to compare the scale in both thermometers.
3. Tell students convert temperature from degree Celsius scale to their own scale.
4. Engineers use temperature as an indicator of how well a system is operating within its design limit. For example, to keep a building's indoor environment comfortable for people, mechanical engineers continually take temperature measurements of building zones, supply air, outside air, and chilled and hot water supplies. In other applications, such as power

plants, industrial manufacturing facilities, labs, aerospace equipment and medical equipment, temperature measurements are used as well.

5. Tell students to write a paragraph about their experimental activity.

Guide to Activity 7.7

1. The unit of measure on their temperature scale should be $^{\circ}X$, $^{\circ}Y$, $^{\circ}\ Name$ and so on.
2. Guide students to draw the picture of their own temperature scale.
3. Guide students to complete the work sheet of their own temperature scale.

Guide to Exercise 7.7

1. The temperature scales are:

   Celsius temperature scale, Fahrenheit temperature scale, Kelvin scale; the fixed points are:

   - ice point (0℃) and steam point (100℃) for Celsius temperature scale
   - ice point (32 ℉) and steam point (212℉) for Fahrenheit temperature scale
   - ice point (273.15 K) and steam point (373.15K) for Kelvin temperature scale

2. The lower fixed points is the melting point of pure ice at normal atmospheric pressure and the upper fixed point is the boiling point of pure water at normal at normal atmospheric pressure.
3. Different thermometers have different temperature scales. There are:

   - 100 divisions between the lower and upper fixed points of degree Celsius scales;
   - 180 divisions between the lower and upper fixed points of degree Celsius scales;
   - 100 divisions between the lower and upper fixed points of degree kelvin scales

4. The SI unit of temperature is kelvin (K).

5. Tell students to discuss the type of thermometers they came across in their life.

6. Tell students to search types of thermometers and their importance using internet or mobile data.

Assessment

Assessment should focus on students' ability of explaining the making of thermometers and use of different types of them in measuring temperature in different conditions. Give practical assignment for students to measure their classmates body temperature and report to the class

7.5 Lesson 5: Types of Thermometers and their Use (2hrs)

In this section the teacher is expected to use the learning strategy:

- Gather descriptions of different thermometers (alcohol, mercury, gas, electrical, etc.), the associated scales, functioning of the thermometers, and suitability to different conditions.
- Make observation at home and in the surrounding to identify the different types of thermometers used and how/where they are used.
- Guide students to use search engine for online resources and virtual labs.

Teacher Preparation Outline

Before the Lesson

√ Ask students to tell if they know different thermometers

During the Lesson

√ Ask students some brainstorming questions about different types of thermometers and theirs use.

√ After getting feedback on the students' concept of different types of thermometers and their use, start the lesson through discussion about different types of thermometers and their use.

√ Arrange students in groups to discuss and list different types of thermometers and explain their importance.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking various questions. You may give them a class work, or an assignment. Suggest some reference materials that explain different thermometers and their use.

Answer to Exercise 7.8

1. See Section 7.5 in students textbook. Different types of thermometers and their importance are discussed there.

2. The difference between alcohol and mercury thermometers are:

   - Alcohol thermometer is a type of thermometer that uses a bulb filled with alcohol as a temperature sensor whereas a mercury thermometer is a type of thermometer that uses a bulb filled with mercury as a temperature sensor.
   - Mercury thermometer is more durable than alcohol thermometer because mercury does not evaporate easily.
   - Alcohol thermometer is suitable to measure lower temperature; however mercury thermometer is used to measure high temperature.
   - Mercury thermometer has lower value of temperature coefficient of expansion than alcohol thermometer.

3. Different thermometers different ranges of measuring temperature.

   - Alcohol thermometer measures temperature in the range of -115 ℃ to 78.15 ℃.
   - Mercury thermometer measures temperature in the range of -30 ℃ to 300 ℃.
   - Thermocouple measures temperature in the range of -270 ℃ to 2300 ℃.
   - Resistance thermometer measures temperature in the range of -270 ℃ to 700 ℃.
   - Some radiation thermometers measure temperature in the range of 400 ℃ to 1250 ℃.
   - Thermistors measure temperature in the range of 0 ℃ to 100 ℃.

4. We need different thermometers because we have a very broad range of temperature from the lowest possible temperature to a very high temperature, for example temperatures of the sun or star.

Assessment

Assessment should focus on students' ability of identifying different types of thermometers for measuring temperature in different conditions. Suggest some activities that would help teachers to check students understanding of the concepts

7.6 Lesson 6: Conversion Between Temperature Scales (6hrs)

In this section the teacher is expected to use the learning strategy:

- Discuss the relationships between the three thermometric scales (centigrade, Celsius, Fahrenheit, kelvin);
- Through Jigsaw method, let them list important temperature values and express them in terms of the three temperature scales.
- Guide students to use search engine for online resources and virtual labs.

Teacher Preparation Outline
Before the Lesson

√ Ask students some brainstorming questions about the conversion of temperature from one temperature scale to another.

During the Lesson

√ After getting feedback on the students' concept of conversion between temperature scales, start the lesson by deriving equations relating two temperature scales.

√ Discuss the relationships between the three thermometric scales (centigrade, Celsius, Fahrenheit).

√ Engage students in group discussion to list different types of thermometers and explain their importance.

√ Ensure that the students are paying attention to the lesson.

After the Lesson
Get feedback from students about their understanding of the lesson by asking them various questions. You may give them a class work, or a quiz.

√ Suggest some reference materials that explain conversion of temperature scales.

√ Guide students to use search engine for online resources and virtual labs.

Guide to Exercise 7.9

1. Already derived. See the derivation in the students textbook.

2. Already derived. See the derivation in the students textbook.

Answer to Exercise 7.10

1. The division between the lower and upper fixed points of the Celsius temperature scale and the Kelvin temperature scale is 100. The size of one Kelvin is identical to one degree Celsius. That is the change in temperature in Celsius scale is the same as the change in temperature of the Kelvin scale.

2. The same reasoning as 1. $\Delta T_C = \Delta T_K$. Note: $2\,℃ \neq 2K$, however, $(12℃ - 10℃) = 2℃ = (22\ K - 20\ K) = 2\ K$

3. The minimum possible temperature in nature is 0 K or $-273.15\,℃$

Answer to Exercise 7.11

1. $$\frac{T_F - 32}{212 - 32} = \frac{T_K - 273.15}{373.15 - 273.15} \implies \frac{T_F - 32}{180} = \frac{T_K - 273.15}{100}$$
$$T_F - 32 = 1.8\,(T_K - 273.15) \Longrightarrow T_F = 1.8\,(T_K - 273.15) + 32$$
$$\Longrightarrow T_K = \frac{T_F - 32}{1.8} + 273.15$$

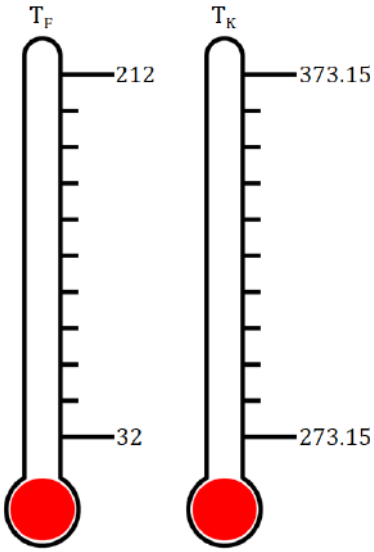

Figure 7.1

2. 300.93 K

3. $$\frac{T_C - 0}{100 - 0} = \frac{T_X - 112}{312 - 112} \implies \frac{T_C}{100} = \frac{T_X - 112}{200}$$
$$T_X = 2T_C + 112 \Longrightarrow T_X = 2\,(28) + 112 = (56 + 112)\,^\circ X$$
$$T_X = 168\,^\circ X$$

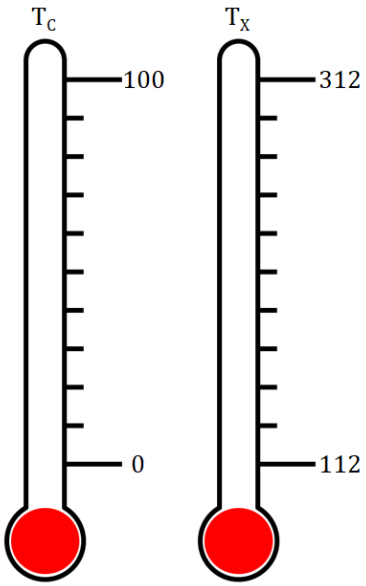

Figure 7.2

Assessment

Students must demonstrate fluency in working with three temperature scales (Celsius, Fahrenheit, Kelvin) and conversion from one to the other scale. Suggest activities that could measure their level of understanding

7.7 Lesson 7: Thermal Expansion of Materials (4hrs)

In this section the teacher is expected to use the learning strategy:

- Engage students in a laboratory experiment with wires of different material and different cross-sectional areas, but with the same length (about 50cm). Fasten them at one end and put on a surface or knife-edge near the other end. Make observation of what will happen when the wires are heated at the same time. Use students' observation and data to introduce the idea of linear thermal expansion, factors determining linear expansion, etc.
- Conduct simple calculations and estimations about linear expansion.
- Guide students to use search engine for online resources and virtual labs.

Teacher Preparation Outline

Before the Lesson

√ Ask students about their background experience concerning the expansion and contraction of materials due to change in temperature.

During the Lesson

√ Ask students some brainstorming questions about the expansion of materials due to increment of temperature.

√ After getting feedback on the students' concept of materials expansion, start the lesson by discussing expansion and contraction of different materials due to change in temperature.

√ Discuss the relationships between: change in length and change in temperature, change in length and the initial length, change in length and the nature of material.

√ Engage students in an experiment with wires of different material and different cross-sectional areas, but with the same length, to observe the change in the length of the wires when there is change in temperature .

√ Make students conduct simple calculations and estimations about linear expansion of materials.

√ Ensure that the students are paying attention to the lesson.

After the Lesson

Get feedback from students about their understanding of the lesson by asking them various questions. You may give them a class work, or a quiz.

√ Suggest relevant reference materials that explain expansion of materials.

Guide to Activity 7.8

1. Tell students to prepare copper, aluminum and steel wires of 2 mm in diameter and 50 cm in length.
2. Guide the students to fasten carefully the three wires at one end and put on a surface or knife-edge near the other end.
3. Tell the students to heat the wires and to observe it carefully.
4. Let students record their observations.
5. Make them to discuss on factors determining the linear expansion of wires.
6. Finally, based on the experiment, tell the students to explain the change in length of each wire.

Answer to Exercise: 7.12

1. When the materials are heated at 100 ℃, the length increases and when they are cooled at −100℃ the length of materials decreases. The change in length of materials is given in the following Table 1. If you double the length of the material, the change in length will be doubled, if you triple the length of the material, its change in length will be tripled and so on. So change in length for materials is not small, and affects in large constructions such as bridges if it is not considered.

Material	Change in length (ΔL) at −100℃	Change in length (ΔL) at 100℃
lead	-0.29	0.29
steel	-0.11	0.11
aluminum	-0.23	0.23
brass	-0.19	0.19
copper	-0.17	0.17
glass	-0.09	0.09
Pyrex^{TM} (glass)	-0.03	0.03

2. All materials expand when they are heated.

3. Different materials react differently when they are heated. The change in length of some materials is very small compared with other materials when they are exposed to same temperature. For example the change in length of a lead is about ten times that of a Pyrex.

4. Lead

5. Pyrex

6. The rate of expansion and contraction are the same. The material that expands the most at high temperature also contracts the most at low temperature. See the table.

7. Pyrex, glass, steel, copper, brass, aluminum, lead

8. Steel

Answer to Exercise 7.13

1. The change in length can also be doubled.

2. Yes, the coefficient of linear expansion depends on the nature of materials. It is different for different materials.

3. When the bimetallic strip is heated, the brass, having the larger value of α, expands more than the steel. Since the two metals are bonded together, the bimetallic strip bends into an arc as in part *b*, with the longer brass piece having a larger radius than the steel piece. When the strip is cooled, the bimetallic strip bends in the opposite direction, as in part *c*

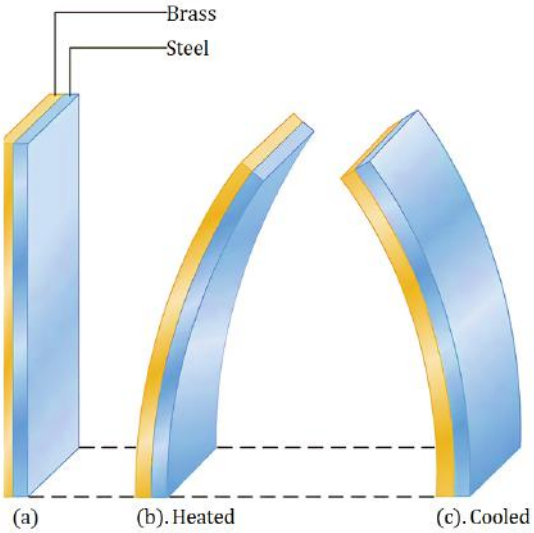

Figure 1: A bimetallic strip and how it behaves when (*b*) heated and (*c*) cooled

Answer to Exercise 7.14

1. A hole in a piece of solid material also expands.

Assessment

Students' understanding and ability to discuss linear expansion and work with calculations with linear expansion must be assessed. Moreover, individual students' group involvement must be credited.

NB:

- Assist students to read the online resources provided as clickable contents in the unit. Use the soft copy of the textbook to do so.

-Using the ICT facility of your school or smart phones, assist students to perform the virtual laboratories by clicking on the provided links at the end of the unit. Use the soft copy of the textbook to do so.

Answer to end of unit questions

Part I

1. D

2. D

3. A

4. C

5. B

6. A

7. A

8. C

Part II

1. Temperature is the degree of hotness or coldness of a body or the measure of the average kinetic energy of the particles in a body
2. Greenhouse gas emissions.
3. An absolute temperature is the possible minimum temperature, 0 K on the Kelvin scale or -273.5 ℃ in Celsius scales.
4. 273.15 K (ice point), 373.15 (steam point)
5. 0 K or -273.15 ℃

Part III

1. -17.78
2. 98.33
3. 87 $^{\circ}X$
4. 0.00047 m empty space should be provided.
5. 0.0051 m