Contents

Acknowledgement

This small book is written in hopes that it can help provide a path for those inundated in the impediments of uncertainty towards enlightenment. The motivation behind me spending 2 whole days to write this small book is simply because im pissed at the lack of answers provided by the the form 4 KSSM Physics text book. In doing so, I hope that this not only benefits me but also you, the readers aswell.

Other that that, I would like to acknowledge the fact that at this very moment, I am an SPM student soon to take the examination sometime in March of 2022. In the event that you stumble upon a mistake in my answers, I hope that you can find the time to correct it. For your information, the answers provided in this small book are mostly outsourced from Youtube, Physics Telegram groups and from my Physics teacher. Only a small amount of them are my own answers.

May it serve you well.

CHAPTER 1
MEASUREMENT

Name:	Form:

Formative Practice 1.1)

1. Figure 1.6 shows Encik Fendi taking a measurement of Wei Li.

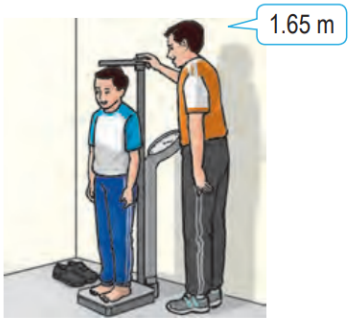


Figure 1.6

(a) State the measured physical quantity.

(b) What is the measured base unit, symbol of the unit, magnitude of the physical quantity and symbol of the physical quantity in the situation shown in Figure 1.6?

Answer:

a) Length

b) Base unit: Length
Symbol of unit: *m*
Magnitude of physical quantity: Scalar quantity
Symbol of physical quantity: ℓ

Formative Practice 1.1)

2. (a) What is the difference between scalar quantity and vector quantity?

(b) Read the following passage.

> Puan Aishah wants to travel to Kota Kinabalu. The distance from her house to Kota Kinabalu is 333 km. She drives her car at a speed of 80 km h^{-1} along a highway. She wants to reach Kota Kinabalu in 3 hours. Therefore, she increases the speed of her car with an acceleration of 1.2 m s^{-2}.

Identify the scalar quantities and vector quantities involved in the situation described above.

Answer:

a) Scalar quantity is a physical quantity with only magnitude while vector quantity has both magnitude and direction.

b) 1 - Velocity (80 km h^{-1}) where it is a vector quantity
2 - Length (333 km) where it is a scalar quantity
3 - Time (3 hours) where it is a scalar quantity
4 - Acceleration (1.2 m s^{-2}) where it is a vector quantity

Formative Practice 1.1)

3. Rina and her friends took part in a Treasure Hunt held in conjunction with Science Day in their school. Each group had to find several objects hidden in the school compound within 30 minutes as listed in Figure 1.7.

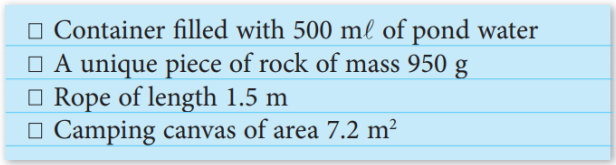


Figure 1.7

Identify the base quantities and derived quantities in the above situation.

Answer:

1 - Time (30 minutes) where it is a base quantity

2 - Mass (950 g) where it is a base quantity

3 - Length (1.5 m) where it is a base quantity

4 - Area (7.2 m^2) where it is a derived quantity

5 - Volume (500 mℓ) where it is a derived quantity

Formative Practice 1.2)

1. Graphs play an important role in scientific investigations.
   (a) What are the uses of graphs?
   (b) Explain the main steps taken in the process of plotting a graph.

Answer:

a) To determine the relationship between two variable from the data collected in a scientific investigation

b) 1. Identify the variable
   2. Determine the variable range
   3. Determine the scale of graph (Must be uniform)
   4. Label both axes with units aswell as title of the graph
   5. Determine the data points and plot them on the graph
   6. Draw the graph

Formative Practice 1.2)

2. Figure 1.13 shows a graph obtained from a study to investigate the relationship between volume, V and temperature, θ of a fixed mass of gas. Based on the graph given in Figure 1.13, answer the following questions.

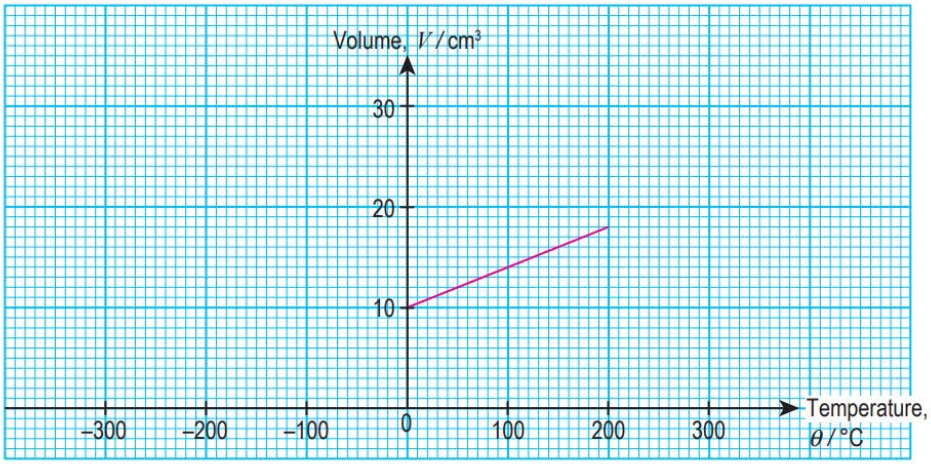


Figure 1.13

(a) What happens to V when θ increases?

(b) Determine the value of θ when the volume is zero. Show on the graph, how you determine the value of θ.

(c) Determine the value of V when $\theta = 300$°C. Show on the graph, how you determine the value of V.

Answer:

a) The value of V will increase linearly with θ.

b) $\theta = -250$°C. The value is determined by extrapolation

c) $V = 22\ cm^3$. The value is determined by intrapolation

Performance Evaluation 1)

1. (a) State seven base quantities and their S.I. units.

(b) Power, P can be defined using the formula, $P = \frac{\text{Force} \times \text{Length}}{\text{Time}}$. Derive the unit for P in terms of S.I. base units.

2. Figure 1 shows a graph of speed, v against time, t obtained from the speed test of a car.

Figure 1

(a) Determine the gradient of the graph v against t.

(b) Determine the y-intercept of the graph when $t = 0$.

(c) State the relationship between speed, v and time, t.

Answer:

1. a)

Base Quantity	S.I. Unit
Length	metre
Mass	kilogram
Time	second
Thermodynamic temperature	kelvin
Electric current	ampere
Luminosity	candela
Substance amount	mole

b) $P = \frac{(ma)\times l}{t}$

$$P = \frac{kg \times (ms^{-2}) \times m}{s}$$

$$P = kgm^2s^{-3}$$

2. a) $m = \frac{40-15}{25} = 1\ ms^{-2}$

b) y-intercept = 15 ms^{-2}

c) speed, v increases linearly with time, t.

Performance Evaluation 1)

3. Hashim carried out an experiment to investigate the relationship between the mass of slotted weights and the period of oscillation, T of a spring as shown in Figure 2.

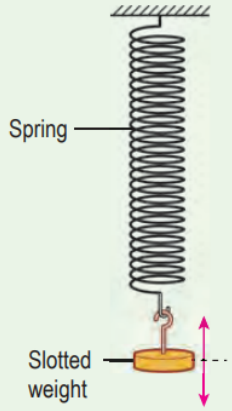


Figure 2

Hashim measured the time, t for 20 complete oscillations for different masses of slotted weights. The data obtained is shown in Table 1.

Table 1

Mass of slotted weights, m /g	20	40	60	80	100
Time for 20 oscillations, t / s	26.0	36.0	44.4	51.0	57.2
Period of oscillation, T					
T^2					

(a) Complete Table 1 by calculating the values of derived data T and T^2. State the appropriate units for both the physical quantities.

(b) Plot a graph of T^2 against m with appropriate scales. Draw the best fit line.

(c) Determine the gradient of the graph. Show clearly how it is done.

(d) If the experiment is done on the Moon, what is likely to happen to the gradient of the graph?

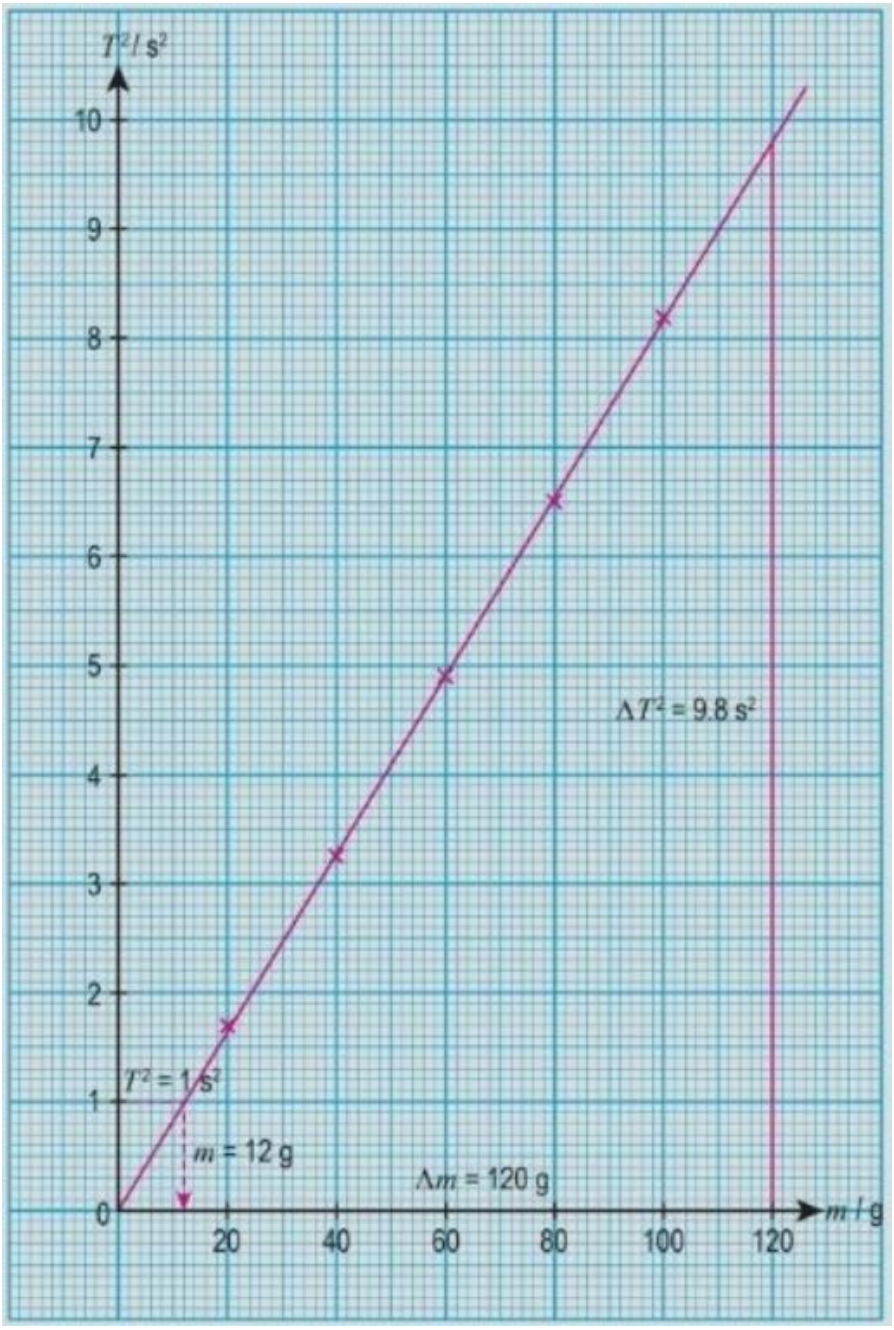
(e) How can an oscillating spring with slotted weights be used as a time measuring device with unit of measurement in seconds? ($T^2 = 4\pi^2\frac{m}{k}$)

Answer:

a)

T/s	1.30	1.80	2.22	2.55	2.86
T^2/s^2	1.69	3.24	4.93	6.50	8.18

b)



c) $\frac{8.18-1.69s^2}{100-20g} = 0.0817s^2g^{-1}$

d) Unchanged because the period of oscillation of a loaded spring does not depend on the value of the gravitational accelaration.

e) The method of extrapolation of the graph of T^2 against m can be used. For example, when T^2 = 1.0s, so T is equal to 1.0s. Substitute the slotted weights with plasticine of mass about 12g

Performance Evaluation 1)

4. Encik Ahmad measured the time taken by five pupils in a 400 m run. Table 2 shows the recorded time.

Table 2

Pupil	Time, t / s	Speed, v / m s^{-1}
A	58.79	
B	60.06	
C	57.68	
D	59.87	
E	57.99	

(a) Complete the table by calculating the speed of the five pupils.

(b) Suggest an appropriate device that Encik Ahmad can use in this situation.

(c) Based on the data in Table 2, which pupil is the fastest runner?

(d) State one way to increase the accuracy of the recorded time.

Answer:

a)

Pupil	**A**	**B**	**C**	**D**	**E**
Speed, v / m s^{-1}	6.80	6.66	6.93	6.68	6.90

b) Encik Ahmad can use an electric stopwatch to measure the time.

c) Pupil C is the fastest.

d) Use an electronic sensor to prevent erros in measurement caused by the reaction time of humans when starting and stopping the stopwatch.

Performance Evaluation 1)

5. Table 3 shows the formula for three physical quantities.

Table 3

Physical quantity	Formula
Force, F	$F = m \times a$
Area, A	$A = l \times l$
Time, T	–

(a) If force, F, area, A and time, T are chosen as new base quantities, then the mass, m and length, l become new derived quantities. State the mass, m and length, l in terms of F, A and T.

(b) What are the constraints faced by physicists if *FAT* is made as a new basic physical quantity?

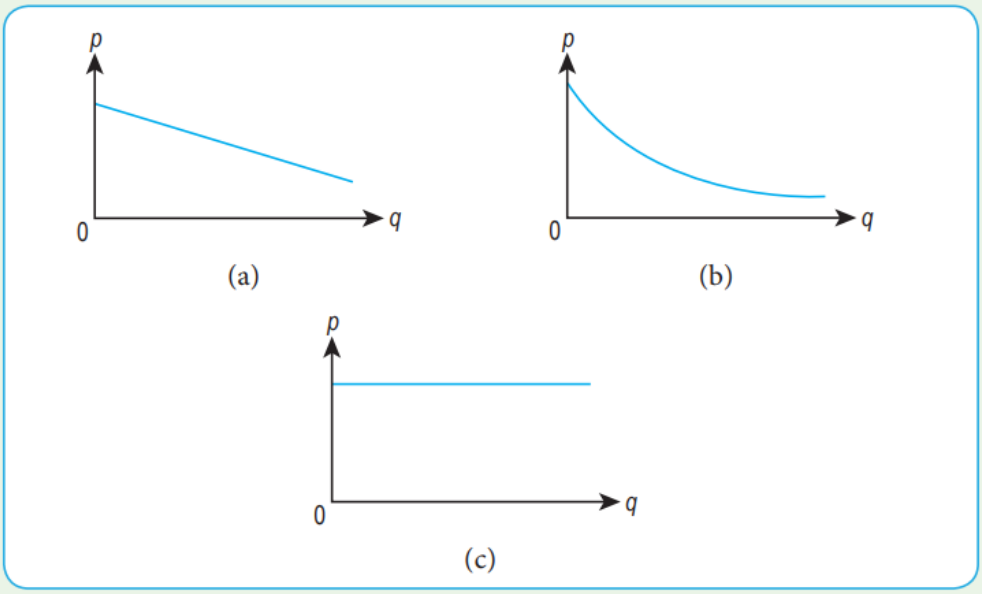
Answer:

a) In the old system, $F = mlt^{-2}$ and $m = Ft^2l^{-1}$
Therefore, in FAT system
$l = \sqrt{A}$ and with $m = FT^2l^{-1}$
Therefore, $m = \frac{FT^2}{\sqrt{A}}$

b) The constraints faced are as follows:
- No measuring instrument can measure force and area accurately.
- No instrument or object is used as standards for force and area.
- Units for derived quantity become complex and disrupt effective communication among physicists.

Performance Evaluation 1)

6. Figure 3 shows graphs obtained from several experiments. Based on the shape of each graph, determine the relationship between the two physical quantities, p and q.



Answer:

a) P decreases linearly with q
b) P decreases with q
c) P is constant with q

Performance Evaluation 1)

7. Figure 4 shows the reading on a mechanical stopwatch at the start and the end of an experiment. The mechanical stopwatch is used to measure the time taken for 20 complete oscillations of a simple pendulum of length, l.

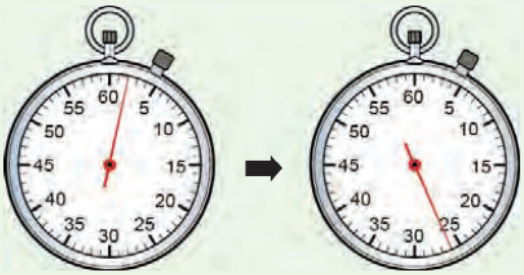


Figure 4

(a) (i) What is the time taken for the pendulum to make 20 complete oscillations?

(ii) Why is it necessary to take the time for 20 complete oscillations?

(iii) Suggest two ways to improve the experiment.

(b) (i) Determine the period of oscillation, T of this pendulum.

(ii) The relationship between length, l and period, T, of a simple pendulum is given by the equation, $l = \left(\frac{g}{4\pi^2}\right)T^2$.

Using the value of T in (b)(i), calculate the length of the pendulum, l.

[g = 10 m s^{-2}]

Answer:

a) i) $26 - 2 = 24s$

ii) To obtain the value of one complete oscillation accurately.

iii) Two ways to improve the experiment are as follows:

1 – Repeat the experiment and obtain the average value of two sets of reading.

2 – Use an electronic or digital stopwatch to measure time more accurately.

b) i) $T = \frac{24}{20} = 1.2s$

ii) $l = (\frac{10}{4\pi^2})(1.2)^2$

$l = 0.37\ m$

Performance Evaluation 1)

8. Newton's Law of Gravitation can be expressed as follows:

$$F = \frac{GMm}{r^2}$$

F is the force
G is the gravitational constant
M and m are the masses
r is the distance between two bodies

(a) Based on the equation, give an example for each of the following:
(i) base quantity (ii) derived quantity (iii) vector quantity

(b) Derive the unit of G in terms of S.I. base units.

Answer:

a) i) Mass, m and distance, r.
ii) Force, F
iii) Force, F

b) $G = \frac{Fr^2}{Mm}$ where $G = \frac{(kgms^{-2})(m)^2}{kg^2}$
$G = kg^{-1}m^3s^{-2}$

Performance Evaluation 1)

9. A driver wants to know the petrol consumption per km of a car in a journey of 300 km at constant speed. He installed a measuring device to record the remaining volume of petrol at every 50 km interval from the starting point. Table 4 shows the readings obtained.

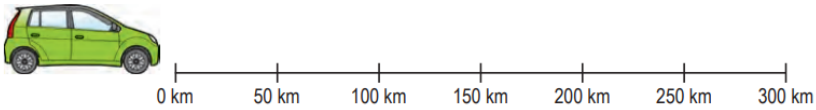


Figure 5

Table 4

Distance, *s* / km	50	100	150	200	250	300
Volume of petrol, *V* / ℓ	40	34	28	23	16	9

(a) The driver forgot to record the volume of petrol at the starting point of the journey. How can the driver estimate the volume of petrol at the start of the journey?

(b) Determine the petrol consumption of the car for the first 80 km. Show how you obtain the answer.

(c) If the petrol consumption of the car for every 50 km travelled can be saved by 10%, show the new values of *V* for every corresponding *s* in a table.

(d) Plot a graph of the new *V* against *s*.

Answer:

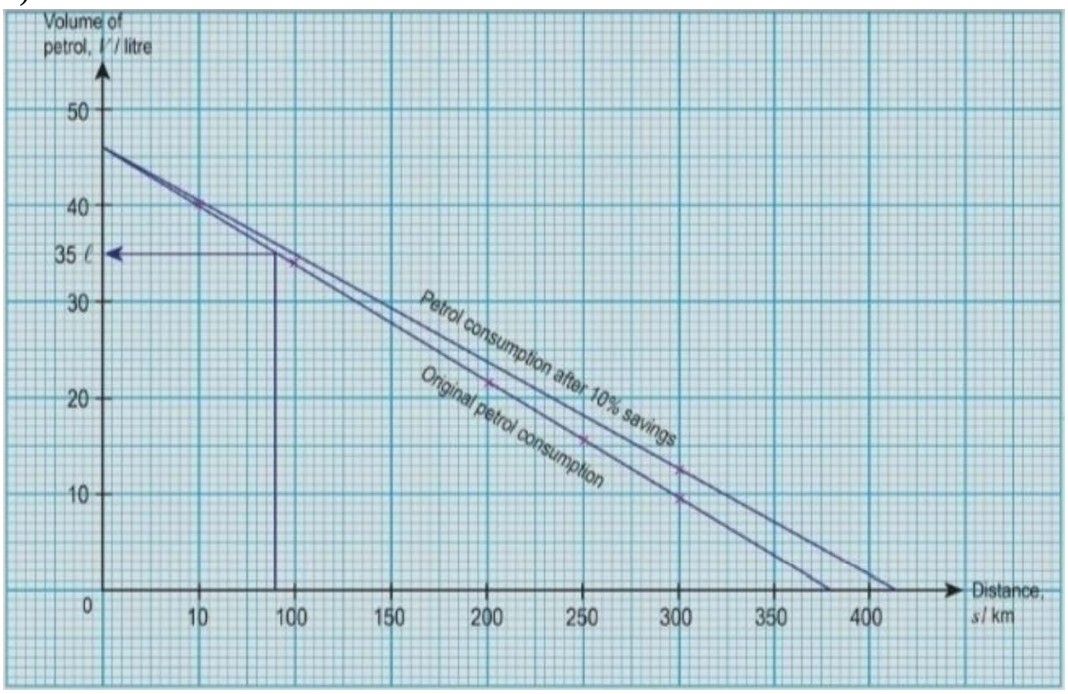
a) Draw a graph of V against s and extrapolate the graph to distance, s = 0 km,V = 46ℓ

b) Consumption of petrol by engine for the first 80km is 46ℓ – 35ℓ =11ℓ

c)

***s*/ km**	50	100	150	200	250	300
***V*/ litre**	40.6	35.2	29.8	25.3	19.0	12.7

d)



CHAPTER 2

FORCE AND MOTION I

Name:	Form:

Formative Practice 2.1)

1. Explain the difference between
   (a) distance and displacement (b) speed and velocity

2. A car moving along a straight road at a velocity of 30 m s^{-1} reduces its velocity at a constant rate until it stops after 5 s. What is the acceleration of the car?

3. Aina rides a smart personal transporter at the Perdana Botanical Gardens. The transporter accelerates uniformly from a velocity of 1 m s^{-1} to a velocity of 5 m s^{-1} in 0.5 minutes. Calculate the displacement of the transporter.

Answer:

1. a) The difference between distance and displacement:

Distance	Displacement
Total length of a route travelled	Shortest distance between two points in a specific direction
Scalar quantity	Vector quantity

b)

Speed	Velocity
Rate of change of distance	Rate of change of displacement
Scalar quantity	Vector quantity

2. u = 30 ms^{-1} v = 0 ms^{-1} t = 5s. Find a.
   $a = \frac{0-30}{5}$ therefore, $a = -6\ ms^{-2}$
   ∴ The car is moving in the opposite direction of the motion of the moving car. The car is decelerating.
3. u = 1 ms^{-1} v = 5 ms^{-1} t = 30s. Find s.
   $s = \frac{5+1}{2} \times 30$ therefore, $s = 90\ m$

Formative Practice 2.2)

1. How do you determine
   (a) velocity from a graph of displacement against time?
   (b) acceleration from a graph of velocity against time?
   (c) displacement from a graph of velocity against time?

2. Based on Figure 2.35, describe the motion of the object from *O* to *D*.

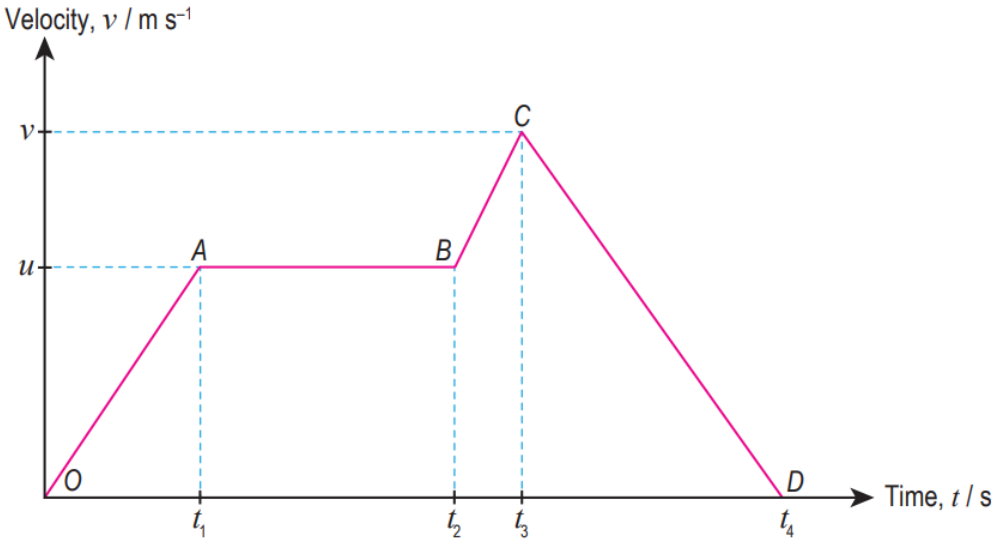


Figure 2.35

Answer:

1. a) Velocity is the gradient of the displacement-time graph.
   b) Acceleration is the gradient of the velocity-time graph.
   c) Displacement is the area under the graph of velocity-time graph.

2.

OA: The object accelerate to the right.	AB: Object move with constant velocity to the right.
BC: The object accelerate to the right.	CD: Object decelerate.

Formative Practice 2.2)

3. Figure 2.36 shows Rokiah taking 3 minutes to walk to the sundry shop located 400 m to the right of her house. After 1 minute, she buys an ice cream and walks to the playground located 300 m from the sundry shop in 2 minutes. She sits and rests on a bench near the playground for 2 minutes. Then, using a shortcut to return to her house, Rokiah reaches her house in 2 minutes.

(a) What is the average velocity of the motion of Rokiah from
  (i) house to the sundry shop?
  (ii) sundry shop to the playground?
  (iii) playground to the house?

(b) Calculate Rokiah's average speed.

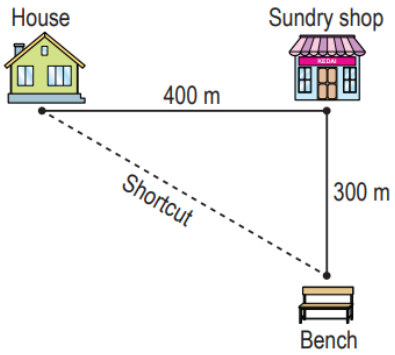


Figure 2.36

4. A car is driven from rest and accelerated at 4 m s^{-2} for 8 s along a straight road. The car is driven at the constant velocity for 20 s and then its brakes are applied. The car reduces its velocity at the rate of 2 m s^{-2} till it stops. Sketch a graph of:

(a) acceleration against time

(b) velocity against time

(c) displacement against time

Answer:

3. a) i) $v = \frac{400}{3(60)} = 2.22\ ms^{-1}$

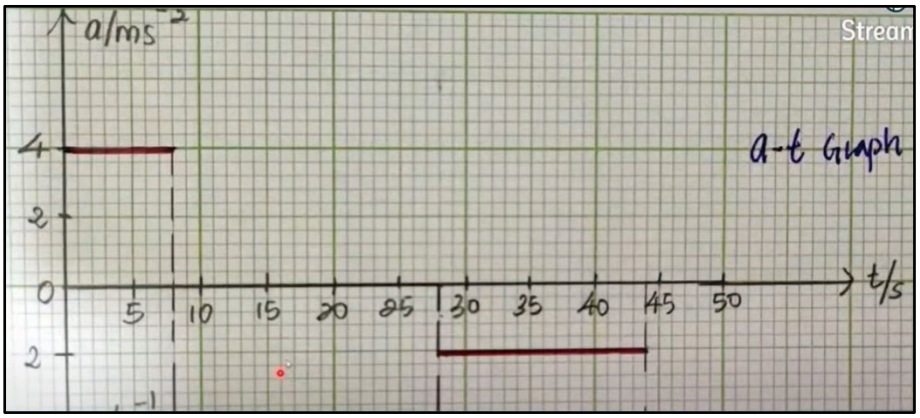
ii) $v = \frac{300}{2(60)} = 2.5\ ms^{-1}$

iii) $s = \sqrt{400^2 + 300^2} = 500\ m$

$v = \frac{500}{2(60)} = 4.17\ ms^{-1}$

b) $v = \frac{400+300+500}{180+60+120+120+120} = 2\ ms^{-1}$

4. a)



T: 0s - 8s

$a = \frac{32}{8} = 4\ ms^{-2}$

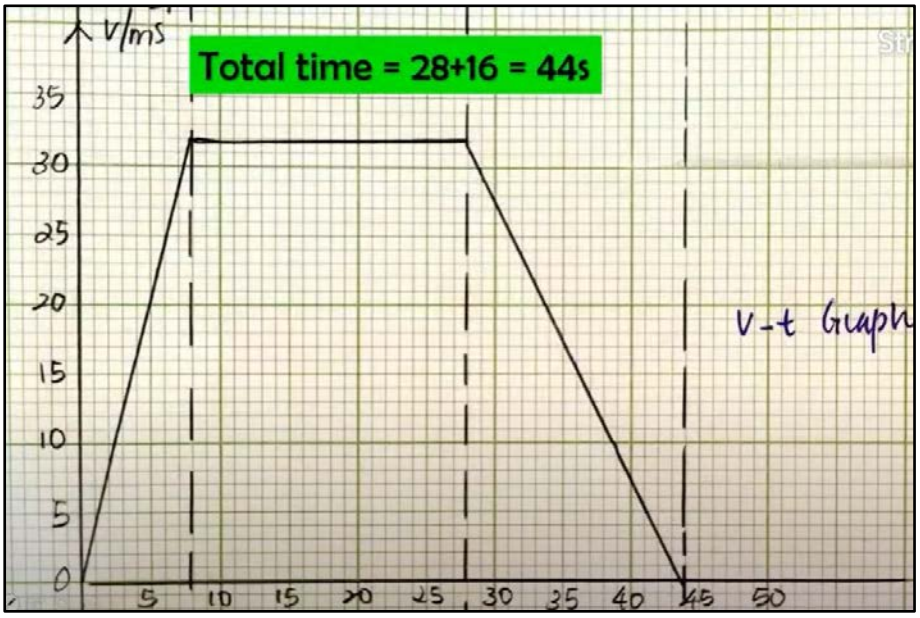
T: 8s - 28s

$a = 0\ ms^{-2}$

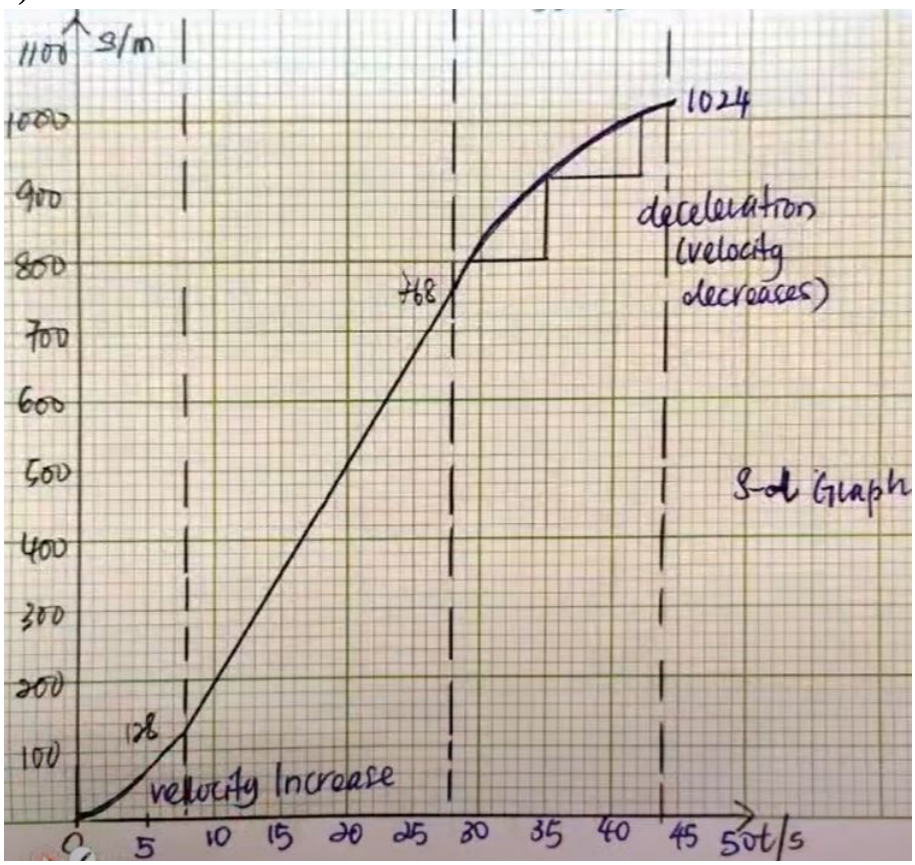
T: 28s - 44s

$a = \frac{-32}{16} = -2\ ms^{-2}$

b)



c)



$\Sigma s = 768 + 256 = 1024\ m$

Formative Practice 2.3)

1. What is meant by free fall?
2. A light hollow plastic ball and a solid steel ball of the same size are released from the cliff of a hill. Will both balls reach the foothill at the same time? Explain your answer.
3. An object thrown vertically upwards reached a maximum height of 5.0 m. Calculate:
   (a) the velocity of the object when thrown
   (b) the time taken for the object to reach its maximum height
   (c) the time required for the object to return to its original level
   Ignore air resistance. [g = 9.81 m s^{-2}]
4. A tennis ball that is released falls vertically from a building of height 50 m. Calculate:
   (a) the time taken for the ball to reach the base of the building
   (b) the velocity of the ball just before hitting the base of the building
   (c) the vertical distance passed at the third second
   Ignore air resistance. [g = 9.81 m s^{-2}]

Answer:

1. Free fall is falling with gravitational acceleration only.
2. No. The steel ball will reach the foot hill first followed by the hollow plastic ball. This is because steel ball is heavier therefore the air resistance acting on it is less.
3. a = -9.81 ms^{-2} v = 0 ms^{-1} s = 5 m
   a) $o^2 = u^2 + 2(-9.81)(5)$
   $u = 9.90\ ms^{-1}$
   b) $0 = 9.90 - 9.81(t)$
   $t = 1.01\ s$
   c) $-5 = \frac{1}{2}(-9.81)t^2$
   $t = 1.01\ s$
   Therefore, the total time required, Σt = 1.01 + 1.01 = 2.02s
4. a = 9.81 ms^{-2} u = 0 ms^{-1} s = 50 m
   a) $50 = \frac{1}{2}(9.81)t^2$
   $t = 3.19\ s$
   b) $v^2 = 0 + 2(9.81)(5)$
   $v = 31.32\ ms^{-1}$
   c) t = 3 s
   $s = \frac{1}{2}(9.81)(3)^2$
   $s = 44.15\ m$

Formative Practice 2.4)

1. Explain the concept of inertia.

2. Brian wishes to pull a table cloth without toppling the things on top of the table cloth. How can Brian do it? Explain your answer.

3. Study the following statements:

> Statement 1: Objects can continue moving only if a force acts on them.
> Statement 2: Rockets in outer space can move without any engine thrust.
> Statement 3: Force is required to change the state of motion of objects.

   (a) Which of the statements can be explained correctly using Newton's First Law of Motion?
   (b) Give reasons of your choice.

Answer:

1. Inertia is the tendency of an object to remain at rest or if it's moving, to continue its motion in a straight line at uniform velocity.
2. 1)Brian must pull the table cloth **quickly**. 2)This is to prevent the objects on the top of the table to **follow the movement of the table cloth**. 3)The object on the table will resist to **maintain its initial state**, that is **stationary**.
3. a) Statement 2.
   b) The rocket will **continue to move** in its trajectory **due to its inertia** and **without any external force** in outer space to act on it.

Formative Practice 2.5)

1. What is meant by momentum and conservation of momentum?
2. A lorry of mass 1 000 kg moves at a velocity of 5.0 m s^{-1}. It collides with a car of mass 800 kg moving at a velocity of 2.0 m s^{-1} in the same direction. If the lorry moves at a velocity of 3.4 m s^{-1} in the same direction after the collision, calculate the velocity of the car.

Answer:

1. **Momentum** is the **product of the mass and velocity** of an object. The principle of **conservation of momentum** is described as the **total momentum before a collision** to be **equal** to the **total momentum after collision** if **no external force acts on the system**.
2. m_1 = 1000 kg, u_1 = 5.0 ms^{-1}, m_2 = 800 kg, u_2 = 2.0 ms^{-1}, v_1 = 3.4 ms^{-1}
   $1000(5) + 800(2) = 1000(3.4) + 800v_2$
   $v_2 = 4ms^{-1}$

Formative Practice 2.6)

1. A force, F acts on a body of mass 5 kg.
   (a) If the body accelerates uniformly from 2 m s^{-1} to 8 m s^{-1}, determine the value of F.
   (b) If F = 10 N, determine the displacement of the body 6 seconds after the body starts to move from rest.
2. A force of 80 N acts on a stationary object for 7 seconds and causes the object to reach a velocity of 35 m s^{-1}. Calculate:
   (a) the mass of the object.
   (b) the displacement of the object.

Answer:

1. a) $F = 5\frac{(8-2)}{2} = 15\text{N}$

   b) $10\text{N} = 5a$

   $a = 2\ ms^{-2}$

   $u = 0\ ms^{-1}$, $t = 6.0\ s$

   $s = 0 + \frac{1}{2}(2(6)^2)$

   $s = 36\ m$

2. $F = 80\text{N}$, $t = 7\ s$, $v = 35\ ms^{-1}$

   a) $m\left(\frac{35-0}{7}\right) = 80\text{N}$

   $m = \frac{80}{5} = 16kg$

   b)

Method 1:

$$s = \frac{1}{2}(v+u)(t)$$

$$s = \frac{1}{2}(35+0)(7)$$

$$s = 122.5\ m$$

Method 2:

$$s = ut + \frac{1}{2}at^2$$

$$s = (0)(7) + \frac{1}{2}(5)(7)^2$$

$$s = 122.5\ m$$

Formative Practice 2.7)

1. In a car collision test, a car of mass 1 500 kg hits the wall with a speed of 15 m s^{-1}. The car bounces back with a speed of 2.6 m s^{-1}. If the collision time is 0.15 s, calculate the:
   (i) impulse in the collision
   (ii) impulsive force acting on the car

2. A football player kicks a ball of mass 450 g with a force of 1 500 N. The contact time of his shoe with the ball is 0.008 s. What is the impulse on the ball? If contact time is increased to 0.013 s, what is the velocity of the ball?

Answer:

1. $m = 1500\ kg$, $u = -15\ ms^{-1}$, $v = 2.6\ ms^{-1}$, $t = 0.15\ s$
   i) $Ft = 1500(2.6 - (-15))$
   $Ft = 26400\ Ns$
   ii) $F = \frac{26400}{0.15}$
   $F = 176000\ N$
2. $m = 0.45\ kg$, $F = 1500\ N$, $t_1 = 0.008\ s$, $t_2 = 0.013\ s$
   If the $t = 0.008\ s$:
   $Impulse = Ft = (1500N)(0.008) = 12\ Ns$

   v if the $t = 0.013\ s$:
   $Impulse = Ft = (1500N)(0.013) = 19.5\ Ns$
   $19.5 = mv$ therefore, $19.5 = (0.45)v$
   $v = 43.33\ ms^{-1}$

Formative Practice 2.8)

1. What is the meaning of gravitational field strength?
2. State the differences between mass and weight.
3. A 10 kg object has a weight of 150 N on a planet.
   (a) What is the gravitational field strength on the planet?
   (b) Is the planet bigger than Earth? Give reasons for your answer.
4. An astronaut of mass 60 kg is assigned to explore the Moon. What is the astronaut's weight on the Moon's surface?

Answer:

1. Gravitational field strength is the force acting per unit mass due to the gravitational pull.
2. The difference between mass and weight:

Mass	Weight
Quantity of matter of an object	Gravitational force acting on an object
Scalar quantity	Vector quantity
S.I. Unit: *kg*	S.I. Unit: N

3. m = 10 *kg*, W = 150 N
   a) $g = \frac{F}{m} = \frac{150}{10} = 15\ \text{N}kg^{-1} / ms^{-2}$
   b) The gravitational field strength of Earth is 9.81 Nkg^{-1} compared to the planet which is 15 Nkg^{-1}. Since the $g_{planet} > g_{Earth}$, the planet is bigger than Earth.
4. m = 60 *kg* given that the moon's **gravitational strength is $\frac{1}{6}$ that of Earth**.

$$W_{moon} = \frac{1}{6}\left(60(9.81)\right) = 98.1\ \text{N}$$

Performance Evaluation 2)

1. A car moves from rest with an acceleration of 2.0 m s^{-2}. Calculate:
   (a) velocity of car after 5.0 s.
   (b) distance travelled in 5.0 s.
   (c) distance travelled in the fifth second.

2. Encik Nizam drives a car at a speed of 108 km h^{-1}. Suddenly he sees a car in front moving very slowly. Therefore, Encik Nizam slows down his car to a speed of 72 km h^{-1}. The displacement made by the car is 125 m. If the acceleration of the car is uniform, calculate
   (a) acceleration of Encik Nizam's car
   (b) time taken for the speed of the car to reduce from 108 km h^{-1} to 72 km h^{-1}.

3. Swee Lan rows a boat forward. She uses an oar to push the water backwards. Why is the boat able to move forward?

Answer:

1. $u = 0\ ms^{-1}$, $a = 2.0\ ms^{-2}$
   a) $v = 0 + (2)(5) = 10\ ms^{-1}$
   b)

   Method 1: $s = \frac{1}{2}(v + u)(t)$

   $s = \frac{1}{2}(10 + 0)(5)$

   $s = 25\ m$

   Method 2: $s = ut + \frac{1}{2}at^2$

   $s = 0(5) + \frac{1}{2}(2)(5)^2$

   $s = 25\ m$

   c) The distance travelled in **the fifth second**:

   $s = s_5 - s_4$

   $s = 25 - \frac{1}{2}(2)(4)^2 = 25 - 16 = 9\ m$

2. $u = 30\ ms^{-1}$, $v = 20\ ms^{-1}$, $s = 125\ m$
   a) $(20)^2 = (30)^2 + 2(125)a$

   $a = -2.0\ ms^{-1}$(The car experiences a deceleration)

   b) Find t,

   $20 = 30 - 2t$

   $t = 5\ s$

3. When Swee Lan paddles a boat backward. An **action force is exerted on the river water** and simultaneously, **a reaction force of the same magnitude** is **exerted in the opposite direction to the direction of the action force**. Therefore, the **boat moves forward**.

Performance Evaluation 2)

4. A car of mass 1 200 kg at rest is moved by a force of 150 N. Determine the acceleration of the car and time taken for the car to reach a velocity of 1.5 m s^{-1}.

5. Gravitational field strength on the Moon is 6 times lower than that on Earth. If a stone weighing 2 N is carried back from the Moon to Earth, calculate the weight of the stone on Earth.

6. A bullet of mass 10 g is fired from a gun of mass 2.0 kg. If the recoil velocity of the gun after firing the shot is 0.5 m s^{-1}, calculate the velocity of the bullet.

Answer:

4. m = 1200 kg, u = 0 ms^{-1}, F = 150 N, v = 1.5 ms^{-1}
   $F = 150 = 1200a$
   $a = 0.125\ ms^{-2}$

   $1.5 = 0 + (0.125)t$
   $t = 12\ s$
5. W_{moon} = 2 N
   $W_{moon} = \frac{1}{6}W_{earth}$
   $W_{earth} = \frac{1}{6}(2\ N) = 12\ N$
6. The collision reaction involved is an explosion.
   $2(-0.5) = 0.01v$
   $v = -100\ ms^{-1}$ or $v = 100\ ms^{-1}$

Performance Evaluation 2)

7. Photograph 1 shows a car moving along a road. Initially, the car moves at a uniform velocity of 18 m s^{-1} for 15 s. Then, the car accelerates at 1.5 m s^{-2} for 5 s. Subsequently, the car starts to decelerate to 15 m s^{-1} in 5 s. The car continues to move at this speed for 10 s and finally decelerates again and stops at time, t = 50 s.

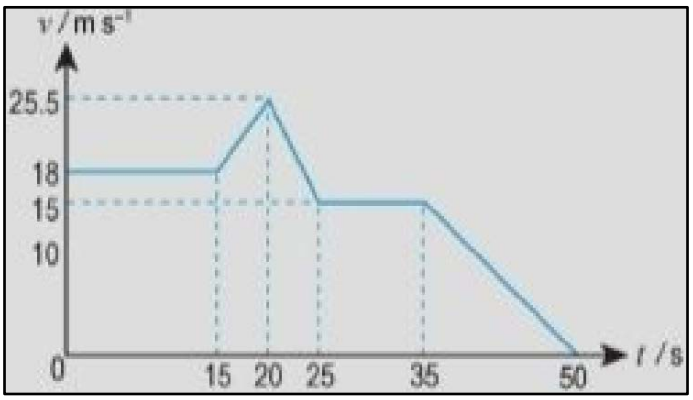
Photograph 1

Based on the given information, sketch the velocity-time graph for the motion of the car. Show the values of velocity and time in your sketch.

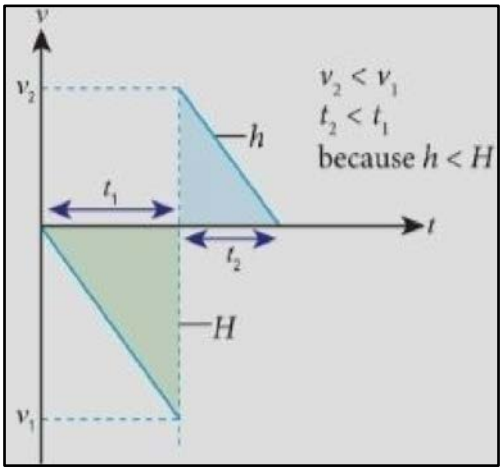
8. A rubber ball is released from a height, H. The ball drops vertically downwards and upon hitting the floor, bounces back a height, h ($h < H$). If the velocity of downward motion is negative, sketch the velocity-time graph for the motion of the rubber ball.

Answer:

7.



8.



Performance Evaluation 2)

9. A car at rest starts to move when a bus moves at a uniform velocity of 15 m s^{-1} passes by its side. The car reaches a velocity of 20 m s^{-1} in 10 seconds and continues to move at a constant velocity in the same direction with the bus. The graph in Figure 1 shows the motion of the car and the bus along a straight road.

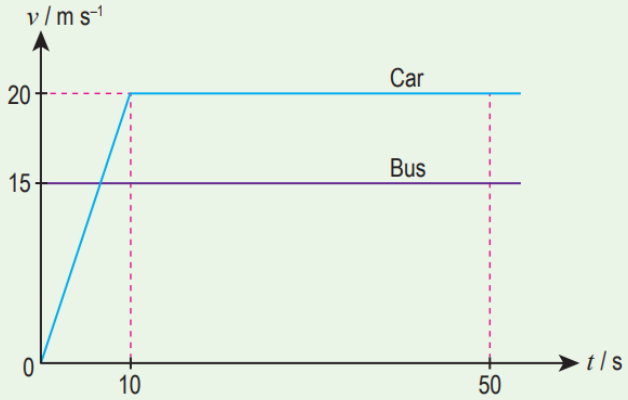


Figure 1

(a) Calculate the time taken for the car to reach the same speed as the bus.

(b) What is the displacement of the car when it reaches the speed of the bus?

(c) Calculate the distance travelled by the car and bus at time, t = 50 s.

(d) At time, t = 50 s, is the car in front of the bus?

Answer:

a) Acceleration of car, $a = \frac{20-0}{10} = 2\ ms^{-2}$

The time taken for the car to reach the same speed as the bus :

$15 = 0 + 2t$

$t = 7.5\ s$

b) $s = 0 + \frac{1}{2}(2)(7.5)^2$

$s = 56.25\ m$

c) The distance travelled by car at t = 50 s:

$s_{car} = Area\ of\ trapezium = \frac{1}{2}(40 + 50)(20)$

$s_{car} = 900\ m$

The distance travelled by bus at t = 50 s:

$s_{bus} = Area\ of\ rectangle = 50 \times 15$

$s_{bus} = 750\ m$

d) Since s_{car} is more than s_{bus}, therefore the car is in front of the bus. Where the distance separating the car from the bus:

$900 - 750 = 150\ m$

Performance Evaluation 2)

10. Photograph 2 shows the launching of a spacecraft using a rocket at a launch pad.

Photograph 2

(a) Explain how the release of hot gases through the rocket's exhaust enables the rocket to accelerate upwards.

(b) How can the acceleration of this rocket be increased?

Answer:

a) Before the launch, the rocket is at rest at the launch pad with zero momentum. During the launch, a large amount of fast moving hot gases is shot out of the exhaust. This creates a high downward momentum. According to the principle of conservation of momentum, an opposite momentum that is of equal magnitude will be produced. Therefore, an upthrust force is produced to accelerate the rocket.

b) $F = ma$ where $m \propto \frac{1}{a}$. The acceleration, a can be increased by reducing the mass, m of the rocket.

Performance Evaluation 2)

11. Photograph 3 shows a hovercraft which can move on land or on the surface of water swiftly because of the support from a layer of air trapped under the hovercraft. The hovercraft of mass of 25 000 kg starts from rest and its engine produces a thrust, *F* of 22 000 N.

(a) Determine the initial acceleration of the hovercraft if there is no friction at that instant.

(b) What is the function of the layer of air trapped under the hovercraft?

Photograph 3

Answer:

m = 25000 kg, u = 0 ms^{-1}, F = 22000 N

a) $F = 22000 = 25000a$

$a = 0.88\, ms^{-2}$

b) The layer of air trapped under the hovercraft will reduce friction between the base of the hovercraft and the water surface. Therefore, the hovercraft will experience less water resistance and move faster.

Performance Evaluation 2)

12. Kok Chew and Zulkefli wish to determine Earth's gravitational acceleration. They plan to release a table tennis ball from the third level of their school building. Discuss the suitability of the table tennis ball in this experiment.

Answer:

The table tennis is not suitable to be used in this experiment.

- The table tennis ball is very light.
- The motion of table tennis ball is easily influenced by air resistance.
- Therefore, table tennis ball will not full under free fall condition.
- The value of the Earth's gravitational acceleration cannot be determined accurately.

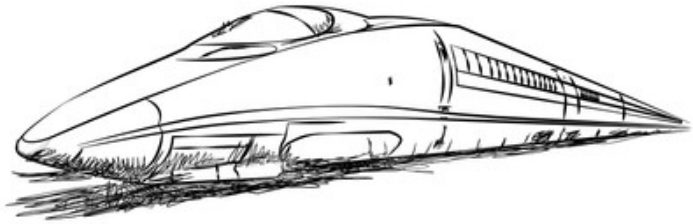
Performance Evaluation 2)

12. Kok Chew and Zulkefli wish to determine Earth's gravitational acceleration. They plan to release a table tennis ball from the third level of their school building. Discuss the suitability of the table tennis ball in this experiment.

13. Assume that you are an engineer who is assigned to invent a model of fast train in Malaysia. This train is required to travel at high speeds using levitation above the railway. Draw your model of the fast train and list its properties by taking into consideration its shape, materials, mechanism and safety aspects.

Answer:

12. The table tennis is not suitable to be used in this experiment.
    - The table tennis ball is very light.
    - The motion of table tennis ball is easily influenced by air resistance.
    - Therefore, table tennis ball will not full under free fall condition.
    - The value of the Earth's gravitational acceleration cannot be determined accurately.
13. The modifications for a fast train are as follows:



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Characteristic	Explanation
Shape: Streamline and aerodynamic	Reduce air resistance for maximum velocity
Materials: Strong and light	Can produce high acceleration
Mechanism: Use an electromagnetic system (Maglev) to move	Eliminate resistance from train tracks to maximise acceleration
Safety aspects: Equipped with safety belts and head rests	Avoid injuries due to accident
Type of fuel used: Solar energy	Environmentally friendly

CHAPTER 3

GRAVITATION

Name:	Form:

Formative Practice 3.1)

1. State Newton's Universal Law of Gravitation.

2. State two factors which influence the magnitude of the gravitational force between two bodies.

3. A piece of space junk of mass 24 kg is at a distance of 7.00×10^6 m from the centre of the Earth. What is the gravitational force between the space junk and the Earth?
[$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}, mass of the Earth = 5.97×10^{24} kg]

4. A weather satellite orbits the Earth at a height of 560 km. What is the value of gravitational acceleration at the position of the satellite?
[$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}, mass of the Earth = 5.97×10^{24} kg, radius of the Earth = 6.37×10^6 m]

5. A man-made satellite of mass 400 kg orbits the Earth with a radius of 8.2×10^6 m. Linear speed of the satellite is 6.96×10^3 m s^{-1}. What is the centripetal force acting on the satellite?

6. Figure 3.23 shows Mercury orbiting the Sun with a radius of 5.79×10^{10} m and a period of revolution of 7.57×10^6 s. Calculate the mass of the Sun.

Answer:

1. Newton's Universal Law of Gravitation states that the gravitational force between 2 bodies is directly proportional to the product of the masses of both bodies aswell as inversely proportional to the square of the distances between the centre of both bodies.

$$F = G\frac{m_1 m_2}{r^2}, \qquad G = 6.67 \times 10^{-11} Nm^2 kg^{-2}$$

2. 1- Mass of the two bodies
   2- Distance between the centre of two bodies

3. $m = 24\ kg, r = 7.00 \times 10^6\ m$

$$F = (6.67 \times 10^{-11})\frac{(24)(5.97 \times 10^{24})}{(7.00 \times 10^6)^2}$$

$$F = 195.04\ N$$

4. $h = 560\ km = 560 \times 10^3\ m$

$$g = (6.67 \times 10^{-11})\frac{(5.97 \times 10^{24})}{((6.37 \times 10^6) + (560 \times 10^3))^2}$$

$$g = 8.29\ ms^{-2}$$

5. $m = 400\ kg, r = 8.2 \times 10^6\ m, v = 6.96 \times 10^3\ ms^{-1}$

$$F = \frac{(400)(6.96 \times 10^3)^2}{8.2 \times 10^6}$$

$$F = 2363\ N$$

6. $r = 5.79 \times 10^{10}\ m, T = 7.57 \times 10^6\ s$

$$M = \frac{4\pi^2(5.79 \times 10^{10})^3}{(6.67 \times 10^{-11})(7.57 \times 10^6)^2}$$

$$M = 2 \times 10^{30} kg$$

Formative Practice 3.2)

1. State Kepler's first law.

2. (a) State Kepler's second law.
   (b) Figure 3.32 shows the orbit of a planet around the Sun. Compare the linear speed of the planet at positions *X*, *Y* and *Z*.

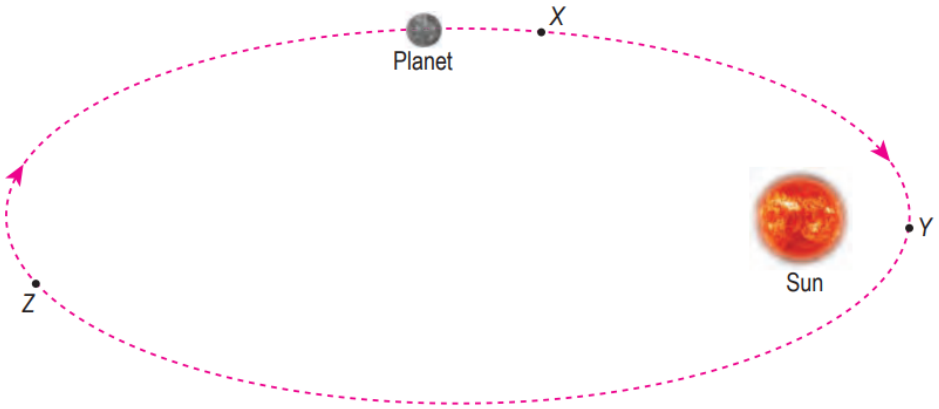


Figure 3.32

3. (a) State Kepler's third law.
   (b) At what height should a satellite be if the satellite is required to orbit the Earth in a period of 24 hours?
   [Orbital period of the Moon = 27.3 days, radius of orbit of the Moon = 3.83×10^8 m]

Answer:

1. Kepler's first law states that all planets move in elliptical orbits with the sun at one focus.
2. a) Kepler's second law states that a line that connects a planet to the sun sweeps out equal areas in equal times.
   b) $v_y > v_x > v_z$
3. a) Kepler's third law states that the square of the orbital period of any planet is directly proportional to the cube of the radius of its orbit. $T^2 \propto r^3$.
   b) $T_{Earth} = 24\ hours = 1\ day$

$$\frac{1^2}{(27.3)^2} = \frac{(6.37 \times 10^6 + h)^3}{(3.83 \times 10^8)^3}$$

$$6.37 \times 10^6 + h = \sqrt[3]{\frac{(3.83 \times 10^8)^3}{(27.3)^2}}$$

$$6.37 \times 10^6 + h = 4.22 \times 10^7\ m$$

$$h = 3.59 \times 10^7\ m$$

Formative Practice 3.3)

1. Compare and contrast geostationary and non-geostationary satellites.
2. What factors determine the linear speed of satellites orbiting the Earth?
3. State two factors which influence the value of escape velocity from a planet.
4. Discuss whether escape velocity from the Earth for spacecraft X of mass 1 500 kg is different from spacecraft Y of mass 2 000 kg.
5. Proba-1 satellite orbits the Earth at a height of 700 km. What is the linear speed of this satellite?

   [$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}, mass of the Earth = 5.97×10^{24} kg, radius of the Earth = 6.37×10^6 m]

Answer:

1.

Geostationary Satellite	Non-Geostationary Satellite
Difference	
Direction of motion is the same as the direction of Earth's rotation	Direction of motion need not be the same as the direction of Earth's rotation
Period of orbit is 24 hours	Period of orbit is less than or more than 24 hours
Remains above the same location	Moves to different locations
Similarity	
Orbits the Earth	

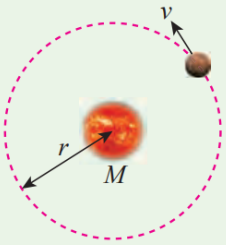
2. 1- Mass of the Earth
   2- Radius of orbit
3. 1- Mass of the Earth
   2- Distance from the centre of the Earth
4. They are the same. This is because the escape velocity, *v* of a planetary body does not depend on the mass of the object attempting to escape the gravitational pull of the planetary body.
5. $h = 700\ km = 700 \times 10^3\ m$

   $$v = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.37 \times 10^6) + (700 \times 10^3)}}$$

   $$v = 7504.82\ ms^{-1}$$

Performance Evaluation 3)

1. Figure 1 shows planet Mars orbits the Sun in a circular motion with orbital period, T.



m = mass of Mars
M = mass of the Sun
r = radius of orbit of Mars
v = linear speed of Mars

Figure 1

(a) For planet Mars, write the formula for:
  (i) gravitational force in terms of m, M and r
  (ii) centripetal force in terms of m, v and r
  (iii) linear speed in terms of r and T

(b) Derive an expression for the mass of the Sun in terms of r and T by using the three formulae in (a).

(c) Radius of orbit of Mars is $r = 2.28 \times 10^{11}$ m and its orbital period is $T = 687$ days. Calculate the mass of the Sun.

Answer:

a) i) $F = \frac{GMm}{r^2}$

ii) $F = \frac{mv^2}{r}$

iii) $v = \frac{2\pi r}{T}$

b) $F_G = F_{Centripetal}$

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$\frac{GM}{r^2} = \frac{v^2}{r}$$

$$M = \frac{v^2 r^2}{Gr}$$

Insert $v = \frac{2\pi r}{T}$ into the equation :

$$M = \frac{(\frac{2\pi r}{T})^2 r}{G}$$

$$M = \frac{\frac{4\pi^2 r^3}{T^2}}{G} = \frac{4\pi^2 r^3}{GT^2}$$

c) $r = 2.28 \times 10^{11}\ m,\ T = 687\ days$

$$M = \frac{4\pi^2 (2.28 \times 10^{11})^3}{(6.67 \times 10^{-11})(687 \times 86400)^2}$$

$$M = 1.99 \times 10^{30}\ kg$$

Performance Evaluation 3)

2. A satellite orbits the Earth with radius, r and orbital period, T.

(a) Write down the linear speed of the satellite in terms of r and T.

(b) Use other suitable formulae to establish the formula for linear speed of the satellite in terms of r and M. M is the mass of the Earth.

(c) Why does the linear speed of a satellite orbiting the Earth not depend on the mass of the satellite?

3. Figure 2 shows the orbit of planet Uranus.

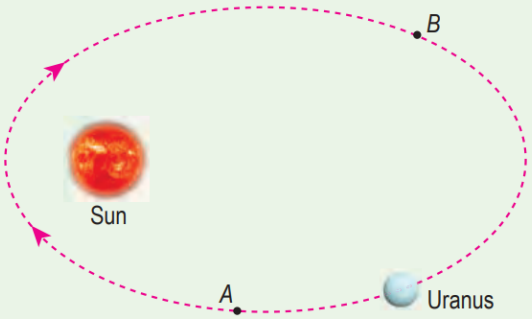


Figure 2

Describe the change in linear speed of planet Uranus when it moves from point A to point B.

Answer:

2. a) $v = \frac{2\pi r}{T}$

b) $F_G = F_{Centripetal}$

$$\frac{GM}{r^2} = \frac{v^2}{r}$$

$$\frac{GM}{r} = v^2$$

$$v = \sqrt{\frac{GM}{r}}$$

c) The satellite falls freely around the Earth with its centripetal accelaration equal to the gravitational accelaration (at its height). Since, the gravitational acceleration does not depend on the mass of object, therefore the linear speed does not depend on the mass of object.

3. Kepler's second law states that a line connecting a planet to the sun sweeps out equal areas in equal times. In this case, the shorter the distance of Uranus from the sun, the faster the speed of Uranus. Therefore from A to B, the speed of Uranus increases to a maximum value to a maximum value and then decrease as it passes by the sun.

Performance Evaluation 3)

4. Figure 3 shows the Earth, the Moon and a satellite.

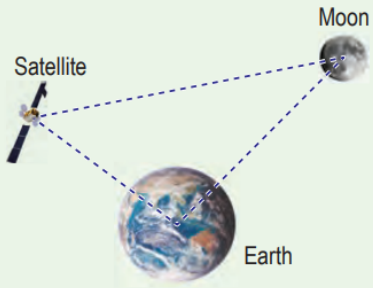


Figure 3

(a) Which pair of bodies experience the smallest gravitational force?
Give a reason for your answer.

(b) Calculate the gravitational force between the Earth and the satellite.
[Mass of the Earth = 5.97×10^{24} kg, mass of satellite = 1.2×10^{3} kg, distance between centre of the Earth and centre of the satellite = 7.87×10^{6} m]

5. (a) What are the factors that determine the value of the gravitational acceleration?

(b) A satellite is at a distance of 4.20×10^{7} m from the centre of the Earth.
What is the value of the gravitational acceleration at this position?
[Mass of the Earth = 5.97×10^{24} kg]

Answer:

4. a) The satellite and the moon as a pair of body experience the smallest gravitational force.
   - According to $F = \frac{Gm_1m_2}{r^2}$, the gravitational force is directly proportional to the product of the masses of two bodies as well as inversely proportional to square of distance between two bodies.
   - The product of the mass of the moon and the satellite is the smallest and the distance between the moon and the satellite is the shortest.
   - Therefore, the moon and the satellite experience the smallest gravitational force.

   b) $F = \frac{(6.67\times10^{-11})(5.97\times10^{24})(1.2\times10^{3})}{(7.87\times10^{6})^2}$

   $F = 7714.93\ N$

5. a) Mass of the Earth and the distance from the centre of the Earth.

   b) $R = 4.2 \times 10^{7}\ m$

   $g = \frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(4.2 \times 10^{7})^2}$

   $g = 0.23\ ms^{-2}$

Performance Evaluation 3)

6. Figure 4 shows the Earth and planet Neptune.

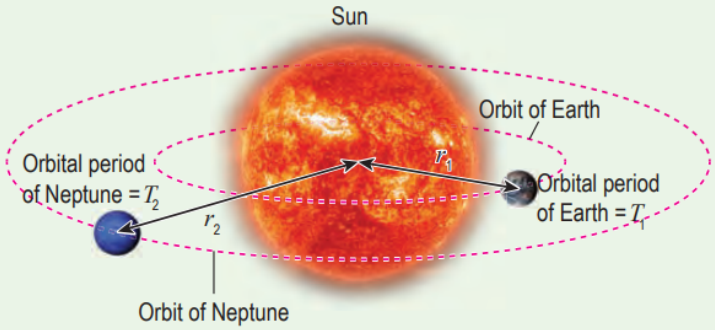


Figure 4

(a) Write down the relationship between orbital period and radius of orbit for the Earth and Neptune.

(b) Orbital period of the Earth is 365 days and radius of orbit of the Earth is 1.50×10^{11} m. Calculate the radius of orbit of Neptune if its orbital period is 5.98×10^4 days.

7. The Earth orbits the Sun with radius of orbit of 1.50×10^{11} m and orbital period of 1 year. Radius of orbit of planet Saturn is 1.43×10^{12} m. What is the orbital period of Saturn?

8. A spacecraft orbits the Earth at a height of 1 600 km. Calculate the escape velocity for the spacecraft.
[$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}, mass of the Earth = 5.97×10^{24} kg, radius of the Earth = 6.37×10^6 m]

Answer:

6. a) $\frac{{T_1}^2}{{T_2}^2} = \frac{{r_1}^3}{{r_2}^3}$

b) $\frac{(5.98\times10^4)^2}{(365)^2} = \frac{{r_{Neptune}}^3}{(1.5\times10^{11})^3}$

$T_{Earth} = 365\ days, r_{Earth} = 1.5 \times 10^{11}\ m,$
$T_{Neptune} = 5.98 \times 10^4\ days$

$$r_{Neptune} = \sqrt[3]{\frac{(5.98 \times 10^4)^2}{(365)^2}}$$

$$r_{Neptune} = 4.49 \times 10^{12}\ m$$

7. $\frac{{T_{Saturn}}^2}{(1)^2} = \frac{(1.43\times10^{12})^3}{(1.5\times10^{11})^3}$

$T_{Earth} = 1\ year, r_{Earth} = 1.5 \times 10^{11}\ m,$
$r_{Saturn} = 1.43 \times 10^{12}\ m$

$$T_{Saturn} = \sqrt{\frac{(1.43 \times 10^{12})^3}{(1.5 \times 10^{11})^3}}$$

$$T_{Saturn} = 29.44\ years$$

8. $$v = \sqrt{\frac{2(6.67\times10^{-11})(5.97\times10^{24})}{(6.37\times10^6)+(1600\times10^3)}}$$

$h = 1600\ km = 1600 \times 10^3\ m$

$$v = 9996.22\ ms^{-1}$$

Performance Evaluation 3)

9. Figure 5 shows planet Saturn with rings made up of small particles around it. Planet Saturn has a mass of 5.68×10^{26} kg and radius of 6.03×10^{7} m.

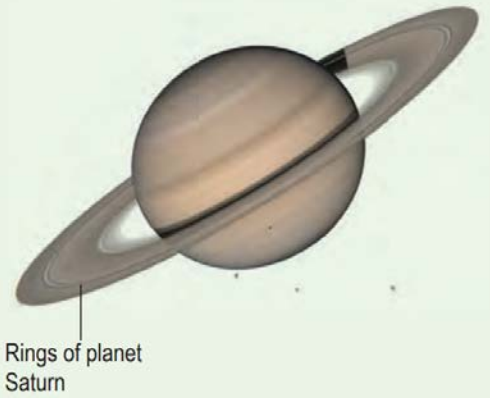


Figure 5

(a) Calculate the escape velocity of planet Saturn.

(b) Discuss the possibility of the small particles in the rings of planet Saturn escaping into the outer space.

Answer:

a) $m = 5.68 \times 10^{26}\ kg, r = 6.03 \times 10^{7}\ m$

$$v = \sqrt{\frac{2(6.67 \times 10^{-11})(5.68 \times 10^{26})}{(6.03 \times 10^{7})}}$$

$v = 35448.14\ ms^{-1}$

b) The possibility of the small particles in the ring of Saturn to escape into outer space is very unlikely. The escape velocity of Saturn is very high, the small particles are unlikely to move as fast as the escape velocity.

Performance Evaluation 3)

10. Figure 6 shows three bodies A, B and C. It is given that the gravitational force between A and B is P.

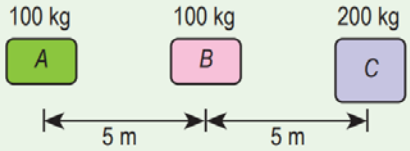


Figure 6

State in terms of P, the gravitational force between

(i) B and C

(ii) A and C

Answer:

$$F_{AB} = P = \frac{G(100)(100)}{5^2}$$

$$P = \frac{G(100)(100)}{5^2}$$

$$\frac{P}{400} = G : 1$$

i. $F_{BC} = \frac{G(100)(200)}{5^2}$

$F_{BC} = \frac{20000G}{25}$

$F_{BC} = 800G : 2$

Insert Equation 1: into Equation 2:

$F_{BC} = 800(\frac{P}{400})$

$F_{BC} = 2P$

ii. $F_{AC} = \frac{G(100)(200)}{10^2}$

$F_{AC} = \frac{20000G}{100}$

$F_{BC} = 200G : 3$

Insert Equation 1: into Equation 3:

$F_{BC} = 200(\frac{P}{400})$

$F_{BC} = \frac{1}{2}P$

Performance Evaluation 3)

11. Table 1 shows information on three types of orbits X, Y and Z for a satellite orbiting the Earth.

Table 1

Orbit	Shape of orbit	Height of orbit / m	Orbital period / hours
X	Ellipse	6.70×10^3	1.41
Y	Circle	3.59×10^7	24.04
Z	Circle	5.43×10^7	41.33

A space agency wishes to launch two satellites, P and Q to orbit the Earth. Satellite P is an Earth imaging satellite that can capture images of various locations on the surface of the Earth while satellite Q is a communication satellite.

Using the information in Table 1, determine which orbit is suitable for satellite P and satellite Q. Explain your choice.

Answer:
Satellite P: Imaging satellite (Non-Geostationary satellite)
Satellite Q: Communication satellite (Geostationary satellite)

Satellite	Characteristic	Explanation
Satellite P	**Shape of orbit**: Ellipse	Near and far photographs can be taken.
	Height of orbit: Low	Clear photographs can be taken of the surface of Earth.
	Orbital period: less than 24 Hours	Can orbit the Earth several times in one day.
Satellite Q	**Shape of orbit**: Circle	The height of the satellite from the surface of Earth is constant.
	Height of orbit: High	Rotate together with the Earth.
	Orbital period: Exactly 24 Hours	Stays above the same location to receive and transmit signals.

Performance Evaluation 3)

12. Assume you are a scientist. Your group has found a new system of bodies. This system is made up of a star at the centre and five planets in a circular orbit around the star. Table 2 shows information on this system of bodies.

Table 2

Body	Mass / kg	Radius of body / m	Radius of orbit / m
Star	5.90×10^{29}	6.96×10^{8}	–
Planet *A*	2.80×10^{22}	1.07×10^{6}	2.86×10^{10}
Planet *B*	6.30×10^{23}	2.30×10^{6}	9.85×10^{10}
Planet *C*	7.40×10^{22}	3.41×10^{6}	1.15×10^{11}
Planet *D*	4.60×10^{25}	1.32×10^{7}	5.32×10^{11}
Planet *E*	1.90×10^{21}	2.42×10^{5}	2.13×10^{12}

(a) Calculate the gravitational acceleration, escape velocity and orbital period of each planet.

(b) How do the values of gravitational acceleration, escape velocity and orbital period influence the suitability of a new planet to be inhabited by humans?

(c) Choose the most suitable planet to be inhabited by humans. Give a reason for your choice.

Answer:

a)

Body	Gravitational acceleration, g / ms^{-2}	Escape velocity, v / ms^{-1}	Orbital period, T / years
Planet A	1.63	1.87×10^{3}	0.15
Planet B	7.94	6.04×10^{3}	0.98
Planet C	0.42	1.70×10^{3}	1.24
Planet D	17.61	2.16×10^{4}	12.32
Planet E	2.16	1.02×10^{3}	98.73

b)

Characteristic of Planet	Suitability	Effect
Gravitational acceleration, g / ms^{-2}	Similar to that of Earth	Value of g that is too small or large will cause the blood circulatory system and internal organs in the human body to not function normally.
Escape velocity, v / ms^{-1}	High enough	Ensure that the planet has an atmosphere that is thick enough for human needs.
Orbital period, T / years	Not too long and not too short	Orbital period determines the change in weather and season cycles of a planet. A perfect balance will ensure plants can grow for human use.

c) The most suitable planet is planet B. This is because:

Characteristic	Suitability
Planet B has a gravitational acceleration that is most similar to that of Earth.	Humans can live comfortably.
The escape velocity of planet B is not too small compared to the escape velocity of Earth.	The layer of atmosphere might be thick and dense enough for human needs
Orbital period of planet B is similar to that of Earth.	The seasonal and weather cycle of the planet might be suitable for plant life and human life.
Therefore, planet B is chosen to be inhabitated by humans.	

Performance Evaluation 3)

13. Assuming humans have successfully inhabited planet Mars. You and a group of scientists are required to invent a system of man-made satellites around Mars. These man-made satellites consist of weather satellites, planet surface mapping satellites and communication satellites. Table 3 shows information on planet Mars.

Table 3

Mass / kg	6.42×10^{23}
Radius of planet / m	3.40×10^{6}
Period of revolution / hours	24.6

Based on the information in Table 3, propose the characteristics of the satellite orbit in terms of orbital height, orbital period, linear speed of satellite, launch base as well as other suitable factors.

Answer:

- The atmosphere of Mars is 100 times thinner than the atmosphere of Earth. Hence, satellites can orbit closer to the surface of Mars compared to Earth and still not experience a large resistance.
- **Weather forecasting and imaging satellites** are **non-geostationary satellite** while **communication satellites** are **geostationary satellite**.

Suggestion	Calculation
Weather forecasting satellite Orbital height, h = 200 km	Linear speed of satellite, v $v = \sqrt{\frac{(6.67 \times 10^{-11})(6.42 \times 10^{23})}{(3.4 \times 10^{6}) + (200 \times 10^{3})}}$ $v = 3448.89\ ms^{-1}$ Orbital period, T $T = \sqrt{\frac{4\pi^2((3.4 \times 10^{6}) + (200 \times 10^{3}))^3}{(6.67 \times 10^{-11})(6.42 \times 10^{23})}}$ $T = 6.558 \times 10^{3}\ s = 1.82\ hours$
Imaging satellite Orbital height, h = 250 km	Linear speed of satellite, v $v = \sqrt{\frac{(6.67 \times 10^{-11})(6.42 \times 10^{23})}{(3.4 \times 10^{6}) + (250 \times 10^{3})}}$ $v = 3425.18\ ms^{-1}$ Orbital period, T $T = \sqrt{\frac{4\pi^2((3.4 \times 10^{6}) + (250 \times 10^{3}))^3}{(6.67 \times 10^{-11})(6.42 \times 10^{23})}}$ $T = 6.696 \times 10^{3}\ s = 1.86\ hours$

Communication satellite	Orbital height, h **With** $\boldsymbol{M = \frac{4\pi^2 r^3}{GT^2}}$, $\boldsymbol{r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}}$ $\boldsymbol{r = \sqrt[3]{\frac{(6.67 \times 10^{-11})(6.42 \times 10^{23})(24.6 \times 3600)^2}{4\pi^2}}}$ $\boldsymbol{r} = 2.04 \times 10^7$ m $h = 2.04 \times 10^7 - 3.4 \times 10^6$ $h = 1.7 \times 10^7\ m$ Linear speed of satellite, v $v = \sqrt{\frac{(6.67 \times 10^{-11})(6.42 \times 10^{23})}{(3.4 \times 10^6) + (1.7 \times 10^7)}}$ $v = 1448.82\ ms^{-1}$ Orbital period, T $T = 24.6\ hours$
Launch Site	The satellites are launched from a base the is close to the equator of Mars. This is done so because the distance to the desired orbit is shorter. Fuel consumption is saved and the time of motion in the atmosphere is also shorter.

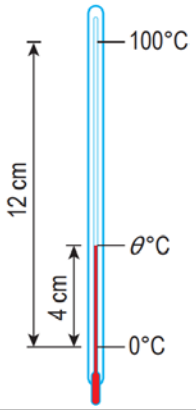
CHAPTER 4

HEAT

Name:	Form:

Formative Practice 4.1)

1. State what happens to two objects in thermal equilibrium.
2. Is our body in thermal equilibrium with the environment? Explain your answer.
3. Aisyah uses an uncalibrated laboratory thermometer to determine the temperature of a liquid, θ°C. She finds that the length of the liquid column when the thermometer is put into the liquid is as shown in Figure 4.6. Calculate the temperature of the liquid, θ°C.



Answer:

1. When two objects are in thermal equilibrium.
   - The temperature of both object are the same.
   - The net heat transfer between the two objects is zero.
2. No.
   - The human body is not in thermal equilibrium with the environment.
   - The human body undergo homeostasis process that maintains the temperature of the human body at 37°C.
3. $L_\theta = 4\ cm, L_{100} = 12\ cm$

   $\theta = \frac{L_\theta}{L_{100}} \times 100°C$

   $\theta = \frac{4}{12} \times 100°C = 33.33°C$

Formative Practice 4.2)

1. What is the difference between heat capacity and specific heat capacity?
2. How much heat energy is needed to increase the temperature of a 0.2 kg mass of gold by 10°C?
   [Given the value of specific heat capacity of gold is 300 J kg^{-1} $°C^{-1}$]
3. A container contains 200 g of water at initial temperature of 30°C. An iron nail of mass 200 g at temperature of 50°C is immersed in the water. What is the final water temperature? State the assumptions you need to make in your calculations.
   [Given the value of specific heat capacity of water is 4 200 J kg^{-1} $°C^{-1}$ and that of iron is 450 J kg^{-1} $°C^{-1}$]

Answer:

1. Difference between heat capacity and specific heat capacity are as follows:

Heat Capacity	Specific Heat Capacity
Quantity of heat needed to raise the temperature of an object by 1°C.	Quantity of heat needed to raise the temperature of 1 *kg* mass of an object by 1°C.
Unit: $J°C^{-1}$	Unit: $Jkg^{-1}°C^{-1}$

2. $m = 0.2\ kg, \theta = 10°C$
   $Q = (0.2)(300)(10) = 600J$
3. $m_{water} = 0.2\ kg, \theta_{water} = 30°C, m_{nail} = 0.2\ kg, \theta_{nail} = 50°C$
   $Q_{nail} = Q_{water}$

   With, $\theta_{nail} > \theta_{final} > \theta_{water}$:
   $(0.2)(4200)(\theta_{final} - 30) = (0.2)(450)(50 - \theta_{final})$
   $(\theta_{final} - 30) = \frac{450}{4200}(50 - \theta_{final})$
   $\theta_{final} - 30 = \frac{75}{14} - \frac{3}{28}\theta_{final}$
   $\frac{31}{28}\theta_{final} = \frac{495}{14}$
   $\theta_{final} = 31.94°C$

   Assumption: No heat loss to the environment.

Formative Practice 4.3)

1. Figure 4.23 shows an electric steamer. Explain how the fish is heated.

2. What is the amount of heat released when 0.8 kg of water at 25°C cools until it becomes ice at –6°C? State the assumptions you make in your calculations.
[Specific heat capacity of water, $c_{water} = 4.2 \times 10^3$ J kg^{-1} °C^{-1}, specific heat capacity of ice, $c_{ice} = 2.0 \times 10^3$ J kg^{-1} °C^{-1} and specific latent heat of fusion of ice, $l_f = 3.34 \times 10^5$ J kg^{-1}]

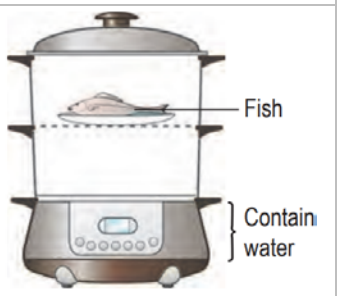


Figure 4.23

Answer:

1. The steam contains a high specific latent heat of vaporisation. The heat from the steam transfers to the fish through condensation process. The fish will absorb the heat and is cooked because a high amount of heat is transferred from the steam to the fish.
2. $m_{water} = 0.8\ kg, \theta_{water} = 25°C, \theta_{ice} = -6°C$

   Water changes from liquid to solid at 0°C
   $\Sigma Q = Q_{25-0} + Q_{Condesation} + Q_{-6-0}$
   $\Sigma Q = (0.8)((4200)(25) + (334000) + (6))$
   $\Sigma Q = (0.8)[(4200)(25) + (334000) + (2000)(6)]$
   $\Sigma Q = 360800\ J$

   Assumption: All the heat released is only from the water and ice.

Formative Practice 4.4)

1. State the physical quantities that are constant in Boyle's Law, Charles' Law and Gay-Lussac's Law.

2. A syringe contains 50 cm^3 of air at a pressure of 110 kPa. The end of the syringe is closed and its piston slowly pushed until the volume of air becomes 20 cm^3. What is the pressure of the compressed air?

3. An air bubble trapped under a leaf in a lake has a volume of 1.60 cm^3 at a temperature of 38°C. Calculate the volume of the bubble if the temperature of the water in the lake drops to 26°C.

Answer:

1. The constant physical quantities in each gas laws are as follows:

Gas Law	Constant Physical Quantity
Boyle's Law	Temperature, T
Charle's Law	Pressure, P
Gay-Lussac's Law	Volume, V

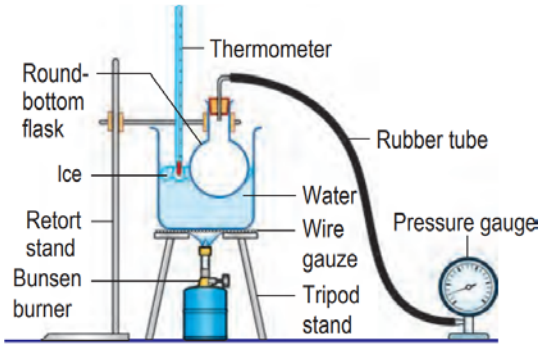
2. $V_1 = 50\ cm^3, P_1 = 110\ kPa, V_2 = 20\ cm^3$
   $(50)(110000) = 20P_2$
   $P_2 = 275000\ Pa = 275\ kPa$
3. $V_1 = 1.60\ cm^3, \theta_1 = 38℃, \theta_2 = 26℃$
   $T_1 = 273 + 38 = 311\ K$
   $T_2 = 273 + 26 = 299\ K$

   $\frac{1.6}{311} = \frac{V_2}{299}$
   $V_2 = 1.54\ cm^3$

Formative Practice 4.4)

4. Pressure in a gas cylinder is 175 kPa at a temperature of 27°C. Heat from a nearby furnace causes the gas pressure to increase to 300 kPa. What is the temperature of the gas inside the cylinder?

5. Figure 4.35 shows an apparatus set up to study the relationship between pressure and temperature for air inside a round-bottom flask.
   (a) Identify four aspects in the apparatus set up that can jeopardise the accuracy of the results of the experiment.
   (b) Suggest modifications to improve the set up.



Answer:

4. $\theta_1 = 27°C, P_1 = 175\ kPa, P_2 = 300\ kPa$
   $T_1 = 273 + 27 = 300\ K$
   $\frac{175000}{300} = \frac{300000}{T_2}$
   $T_2 = 514.29\ K$
   $\theta_2 = 514.29 - 273 = 241.29°C$
5. Experiment to study Gay-Lussac's Law.

a) **Aspect**	b) **Modification**
Thermometer placement: Too high	The bulb of the thermometer should be lowered into the water so that the temperature recorded is more accurate.
Stirrer: No stirrer (No glass rod)	A stirrer (glass rod) should be added so that the water can be stirred and be heated more uniformly.
Round bottom flask placement: Too high	The round bottom flask should be lowered into the water so that the gas can be heated more uniformly
Rubber tube length: Too long	The rubber tube should be shorter so that heat loss from the gas can be minimised.

Performance Evaluation 4)

1. Photograph 1 shows a steam injector machine which can inject steam into water in a container.
   (a) What is the meaning of latent heat?
   (b) Explain how water in the container is heated by steam injected into it.
   (c) What is the advantage of heating water using the injection of steam?

Photograph 1

2. Tick (✓) for situations that show thermal equilibrium.

Situation	Tick (✓)
(a) A hot object and a cold object placed side by side.	
(b) An object is heated by a nearby source of fire.	
(c) Two objects at the same temperature and in contact so that heat can be transferred between them but without net heat transfer.	
(d) Two objects at the same temperature but separated by a heat barrier.	

Answer:

1. a) Latent heat is the quantity of heat needed to change the state of matter of an object without any change in temperature.
   b) Steam is condensed into water, the latent heat released heats up the water in the container.
   c) - Rapid heating.
   - Direct heating of water, that is without wasting heat to heat up the container.
2. c) ✓

Performance Evaluation 4)

3. Block *A* has a high specific heat capacity and block *B* has a low specific heat capacity. If both blocks have the same mass,
   (a) which block needs more energy to raise its temperature by 10°C?
   (b) which block heats up more quickly if supplied with the same amount of heat? Explain your answer.

4. (a) Define specific latent heat.
   (b) The mass of a melting ice cube reduces by 0.68 kg. What is the amount of heat absorbed from the surrounding by the ice cube?
   [Specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}]

Answer:

3. $c_A > c_B$. $m_A = m_B$
   a) Block A
   b) Block B. Block B has a lower specific heat capacity. Therefore, it needs less energy to raise its temperature by 1℃ compared to block A and will heat up more quickly.
4.
   a) Specific latent heat is the quantity of heat needed to change the state of matter of 1 kg of a substance without any change in temperature.
   b) $m = 0.68\ kg$
   $Q = (0.68)(3.34 \times 10^5)$
   $Q = 227120\ J$

Performance Evaluation 4)

5. (a) What is meant by specific latent heat of vaporisation?

(b) Figure 1 shows the graph of mass of water, m against time, t when water in a beaker is heated by a 1 800 W electric heater. At time t = 360 s, the water starts to boil.

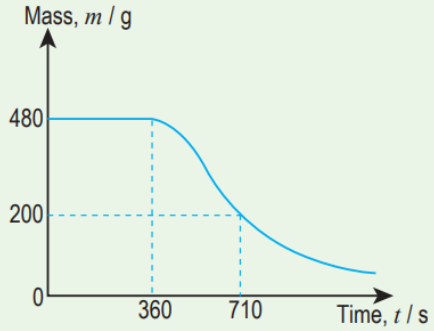


Figure 1

Calculate:

(i) mass of water that becomes steam from t = 360 s until t = 710 s.

(ii) specific latent heat of vaporisation of water.

6. A gold ring of mass 5.5 g experiences a rise in temperature from 36°C to 39°C. How much heat energy is absorbed by the ring?
[Specific heat capacity of gold = 300 J kg^{-1} $°C^{-1}$]

Answer:

5.

a) Specific latent heat of vaporisation is the quantity of heat needed to change a 1 kg substance from liquid to gas without any change in temperature.

b) $P = 1800\ W, t = 360\ s\ (boil)$

a) $\Delta m = (0.48\ kg - 0.2\ kg) = 0.28\ kg$

b) $\Delta t = 710 - 360 = 350\ s$

$Q = Pt = (1800)(35) = 0.28(l)$

$l = 225000\ Jkg^{-1}$

6. $m = 0.0055\ kg, \theta = 39 - 36 = 3°C$

$Q = (0.0055)(300)(3)$

$Q = 4.95\ J$

Performance Evaluation 4)

7. Photograph 2 shows the power rating label of an electric kettle.

Photograph 2

(a) What is the maximum power of this electric kettle?

(b) Calculate the time taken by this kettle to change 0.5 kg of boiling water at 100°C into steam at 100°C when the kettle operates at maximum power.
[Specific latent heat of vaporisation of water $= 2.26 \times 10^6$ J kg^{-1}]

(c) What assumptions are made in your calculations in 7(b)?

8. Air in the tyre of a car has a pressure of 220 kPa at initial temperature of 27°C. After a race, the temperature of the air increases to 87°C.

(a) Calculate the air pressure in the tyre after the race.

(b) What assumptions did you make in **8**(a)?

9. An air bubble is trapped under a leaf floating on the water surface of a lake. The volume of the air bubble is 3.6 cm^3 when the temperature is 20°C.

(a) What is the volume of the air bubble when the water temperature rises to 38°C?

(b) State three assumptions that need to be made in your calculations in **9**(a).

Answer:

7. a) $P = 2200\ W$

b) $m = 0.5\ kg$

$2200t = (0.5)(2.26 \times 10^6)$

$t = 513.64\ s$

c) - All the heat supplied is absorbed.

- No heat is lost to the surrounding.

8. $P_1 = 220\ kPa, \theta_1 = 27°C, \theta_2 = 87°C,$

a) $\frac{220000}{(273+27)} = \frac{P_2}{(273+87)}$

$P_2 = 264000\ Pa$

b) Volume of the tyre remains constant.

9. $V_1 = 3.6\ cm^3, \theta_1 = 20°C$

a) $\frac{3.6}{(273+20)} = \frac{V_2}{(273+38)}$

$V_2 = 3.82\ cm^3$

b) - Mass of the trapped air remains constant.

- Pressure of the trapped air remains constant.

- Trapped air and water are in thermal equilibrium.

Performance Evaluation 4)

10. Figure 2 shows ice cubes being heated by a 500 W immersion heater for 80 seconds. The melted ice cubes are collected in a beaker.
[Specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}]

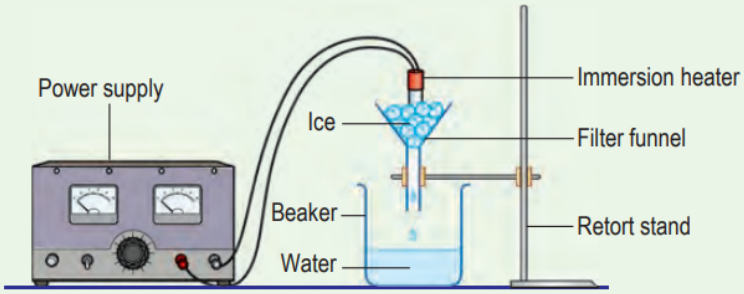


Figure 2

(a) What is meant by specific latent heat of fusion?

(b) Why does the temperature remain unchanged when the ice cubes are changing into liquid?

(c) Calculate:
(i) energy absorbed by the ice cubes.
(ii) mass of melted ice cubes.

(d) What assumptions are made in your calculations in **10**(c)?

Answer:

$P = 500\ W, t = 80\ s$

a) Specific latent heat of fusion is the quantity of heat needed to change a 1 kg substance from solid to liquid without any change in temperature.

b) The heat absorbed is used to weaken the intermolecular bonds of ice and not to increase the average kinetic energy of the molecules.

c) i) $Q = Pt$

$Q = (500)(80) = 40000\ J$

ii) $40000 = m(3.34 \times 10^5)$

$m = 0.12\ kg$

d) - All the heat supplied from the immersion heater is absorbed by the ice.
- No heat is lost to the surrounding.
- The ice does not absorb heat from the surrounding.

Performance Evaluation 4)

11. An electric kettle is filled with 500 g of water at 30°C. The power of the heating element of the kettle is 0.8 kW. Assume that all heat from the heating element is transferred to the water.
[Specific heat capacity of water = 4 200 J kg^{-1} $°C^{-1}$]

(a) Calculate:
  (i) heat energy needed to increase the temperature of the water to 100°C.
  (ii) time taken by the kettle to heat water to a temperature of 100°C.

(b) Why is the handle of the kettle made of plastic?

(c) Why is the heating element of the kettle made of metal?

(d) The heating element of the kettle is located at the base of the kettle. Explain why.

12. A substance has a mass of 250 g. The substance loses 5 625 J of heat when cooled. There is a 25°C drop in temperature.

(a) Calculate the specific heat capacity of the substance. Identify the substance based on Table 4.2 on page 128.

(b) Explain the use of the substance based on its specific heat capacity.

Answer:

11. $m = 0.5\ kg, \theta = 30°C, P = 800\ kW$

a) i) $Q = (0.5)(4200)(100 - 30)$
$Q = 147000\ J$
ii) $0.8t = 147000$
$t = 183.75\ s \approx 184\ s$

b) Plastic has a high specific heat capacity making it a very good heat insulator.

c) Metal has a low specific heat capcity making it a very good heat conductor.

d) Convection occurs where heated water at the base rises to the top and cold water sinks to the base. The interchanging motion of water of different temperatures goes on continuously. Therefore, the heating element is located at the base of the kettle.

12. $m = 250\ g, Q_{loss} = 5625\ J, \theta = 25°C$

a) $c = \frac{5625}{(0.25)(25)}$
$c = 900\ Jkg^{-1}°C^{-1}$
The substance is aluminium.

b) Aluminium is a metal and has a low specific heat capacity making it a very good heat conductor. Therefore, aluminium is best suited to be used as cooking utensils and cooking pans.

Performance Evaluation 4)

13. Photograph 3 shows a bamboo steamer. Amin receives an order from a supermarket to supply 400 steamed buns per day. Suggest and explain the design of the steamer needed. The steamer should be durable, and able to prepare a large quantity of steamed buns in a short time.

Answer:

13.The design of the steamer is as follows:

Characteristic of Design	Explanation
Steamer is made of stainless steal.	Will not rust and can be used for a long time.
Steamer with a large diameter.	More buns can fit in.
Cone shaped cover.	Traps steam so that steam is not lost to the surrounding.
Steamer base with a large volume of water.	More latent heat is released during condensation of steam.

Performance Evaluation 4)

14. Khairi orders a cup of coffee in a restaurant. He finds that the coffee is too hot. Photograph 4 shows two suggested ways to cool the coffee.

Method *A* Method *B*

Photograph 4

(a) Discuss the suitability of methods *A* and *B* to cool the coffee in the cup.

(b) State your choice. Give reasons for your choice.

Answer:

14. a) Suitability of method A and method B are as follows:

Method A	Method B
Ice around the base of the cup absorbs latent heat from the cup and saucer.	Ice in the coffee absorbs latent heat directly from the coffee.
The process is slow because it involes flow of heat through the walls of the cup.	The process is fast because the coffee loses a large amount of heat quickly as the ice is in the coffee.
Water from the melting ice is separated and will not dilute the coffee.	Water from the melting ice will mix with the coffee and dilute it. The taste will be different.

b) Method A is chosen. Method A can cool the coffee without changing its taste meanwhile method B cools the coffee too but changes its taste.

CHAPTER 5
WAVES

Name:	Form:

Formative Practice 5.1)

1. Figure 5.20 shows a graph of displacement against time for a wave.

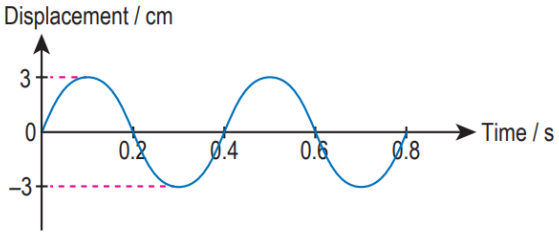


Figure 5.20

(a) What is meant by amplitude?

(b) Determine the period of oscillation, T. Then, calculate the frequency of oscillation.

2. Compare and contrast progressive wave and stationary wave.

3. Figure 5.21 shows a slinky spring being moved forward and backward at one of its ends.

(a) What type of wave is produced by a slinky spring?

(b) Mark "X" at the rarefaction part of the wave in Figure 5.21.

(c) What is the wavelength, λ of the wave?

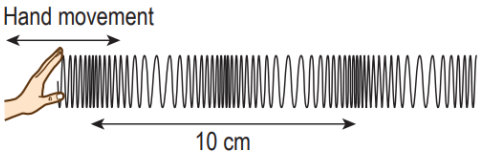


Figure 5.21

Answer:

1. a) Amplitude is the maximum displacement from equilibrium position.

   b) $T = 0.4\ s$

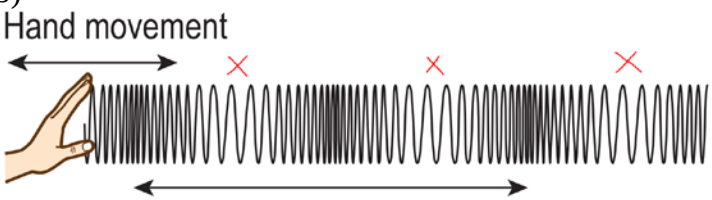
   $$f = \frac{1}{0.4} = 2.5\ Hz$$

2. Comparison of progressive wave and stationary wave are as follows:

Progressive Wave	Stationary Wave
Propagates with time	Does not propagate with time

3. a) Longitudinal waves

   b)



   c) $10 = 2\lambda$

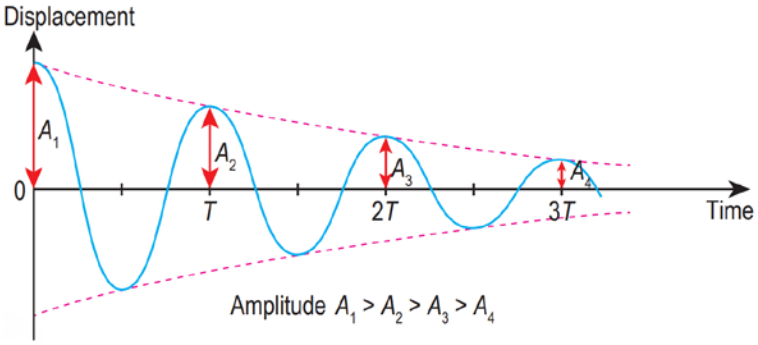
   $\lambda = 5\ cm$

Formative Practice 5.2)

1. What is the meaning of damping?
2. Sketch a graph of displacement against time for a system experiencing damping.
3. State three examples of the effects of resonance in our daily lives.
4. How can resonance overcome damping of an oscillating system?

Answer:

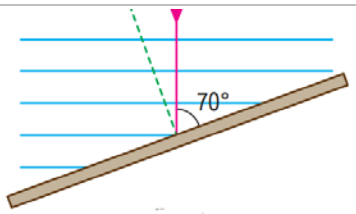
1. Damping is where the amplitude decreases in an oscillating system due to loss of energy.
2. The graph drawn is Displacement-Time:



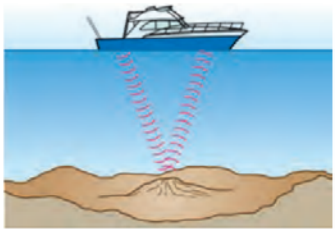
3. - A playground swing
   - Vibration of the guitar strings
   - Pendulum
4. Resonance can overcome damping by applying a force that is of equal frequency to that of the natural frequency of the oscillating system. This way, the damping oscillating system will be made to oscillate with maximum amplitude. Therefore, the damping effect is curbed.

Formative Practice 5.3)

1. Copy Figure 5.32 and draw the wavefront and the direction of the reflected water waves.

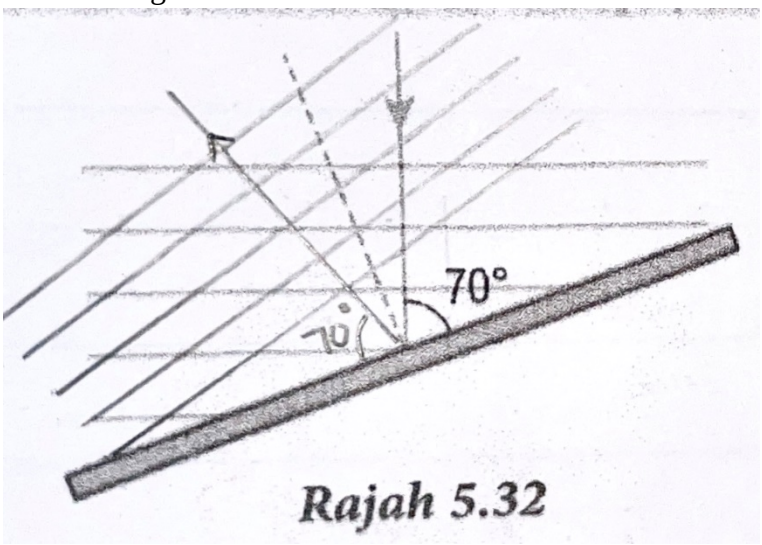


2. Figure 5.33 shows the use of ultrasonic waves by a ship to determine the depth of the sea. The interval time between transmission and receiving of echo of the ultrasonic sound is 0.06 seconds. Speed of the ultrasonic wave in the water is 1 500 m s^{-1}. Determine the depth of the sea.



Answer:

1. The drawing of the reflected wavefront is as follows:



Rajah 5.32

2. $t = 0.06\,s, v = 1500\,ms^{-1}$

$$d = \frac{(1500)(0.06)}{2}$$

$$d = 45\,m$$

Formative Practice 5.4)

1. What phenomenon of waves happens when sea waves are approaching the beach? Explain your answer with the help of a diagram.

2. Figure 5.44 shows plane water waves of frequency 10.0 Hz propagating from deep region to the boundary of shallow region *PQ*. Speed of the water wave in the deep region is 30 cm s^{-1}.

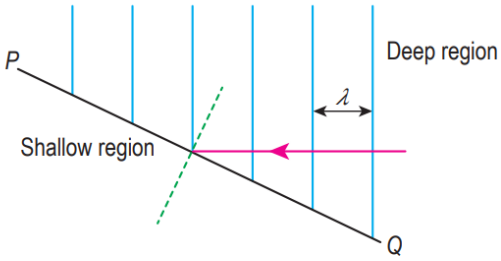
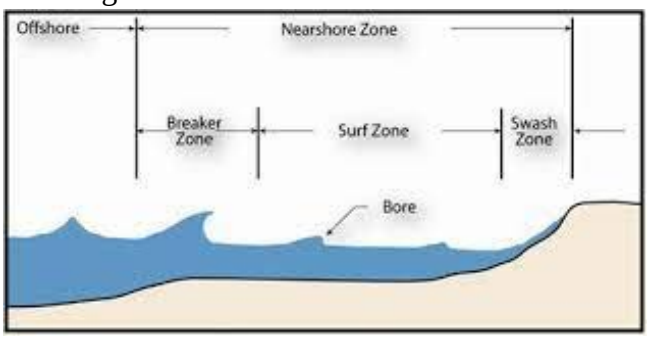


Figure 5.44

   (a) Calculate the wavelength, λ.
   (b) Calculate the speed of the water wave in the shallow region if the wavelength in this region is 1.5 cm.
   (c) Using arrows, draw the direction of propagation of the wave in the shallow region and then sketch the wavefronts of water waves refracted in this region.
   (d) Compare frequency, wavelength and speed in the deep and shallow regions.

Answer:

1. The diagram:



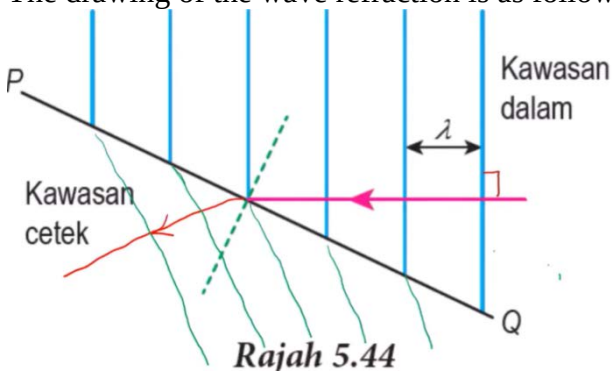
The phenomenon of wave refraction. As the sea waves approach the beach, the sea waves propagate from a deep region to a shallow region. This causes the sea waves to refract towards the normal line. The wave speed and wavelength decreases, whereas the frequency remains constant.

2. $f = 10\ Hz, v_{deep} = 30\ cms^{-1}$

   a) $30 = (10)\lambda$
   $\lambda = 3\ cm$

   b) $\lambda_{shallow} = 1.5\ cm$
   $v = (10)(1.5)$
   $v = 15\ cms^{-1}$

   c) The drawing of the wave refraction is as follows:



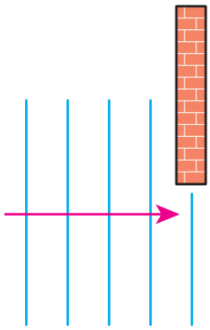
Rajah 5.44

   d) $f_{deep} = f_{shallow}$
   $\lambda_{deep} > \lambda_{shallow}$
   $v_{deep} > v_{shallow}$

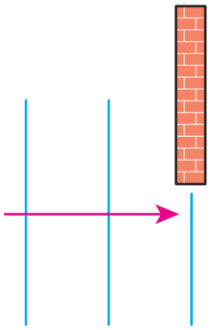
Formative Practice 5.5)

1. Complete the following diagrams by drawing the patterns of diffracted waves.

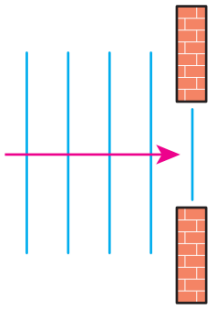
(a)



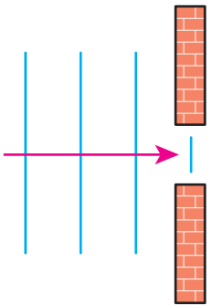
(b)



(c)



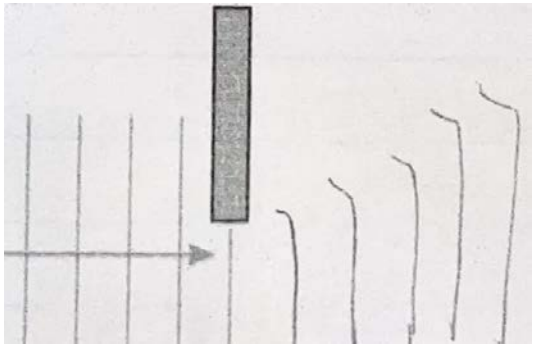
(d)



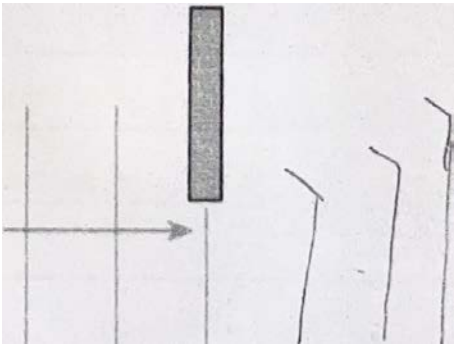
Answer:

1. The drawing of the diffraction waves are as follows:

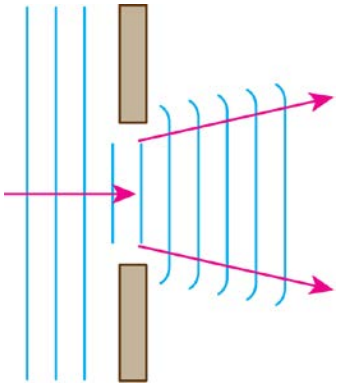
a)



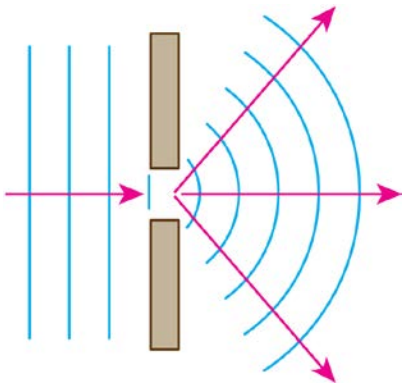
b)



c)



d)



Formative Practice 5.5)

2. Figure 5.54 shows a plan of the living room and bedroom. A child lying on the bed cannot see the television in the living room but can still hear the sound from the television.

(a) By drawing wavefronts, explain how the phenomenon of diffraction enables the child to hear sound from the television.

(b) State another phenomenon which causes sound to propagate from the television to the child.

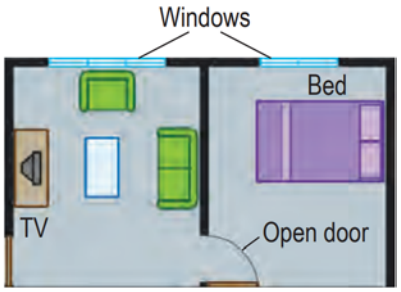
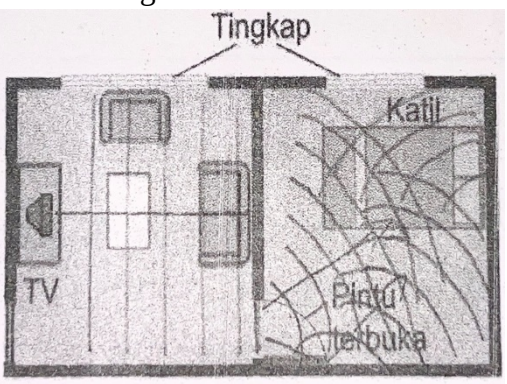


Figure 5.54

Answer:

2. a) The drawing of the diffraction waves are as follows:



The TV produces sound waves. The sound waves propagate across the room and encounters an obstacle. With the door open, the sound waves refract through the door. The sound waves spread out and reflects on the walls of the room. Therefore, the sound from the TV is heard.

b) The phenomenon of wave reflection.

Formative Practice 5.6)

1. Figure 5.67 shows Young's double-slit experiment.

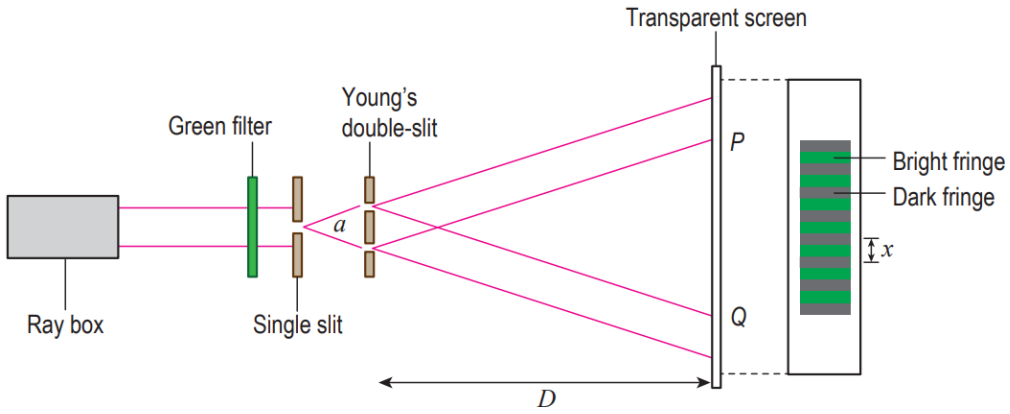


Figure 5.67

(a) State the phenomenon that occurs when light passes through the single slit.

(b) What will happen to the two light rays in the area PQ on the screen?

(c) Describe the formation of bright fringes and dark fringes.

(d) In the apparatus set up of this experiment, a = 0.30 mm, D = 2.5 m and x = 4.6 mm. Calculate the wavelength, λ of the green light.

Answer:

a) Diffraction of light phenomenon.

b) The two light rays will superposition.

c) Two light waves will superposition.

- When a crest meets a crest, constructive interference occurs where a tall crest is formed. The tall crest is seen as a bright fringe.
- When a crest meets a trough, destructive interference occurs where a zero resultant displacement is formed. This is seen as a dark fringe.

d) $a = 0.30\ mm, D = 2.5\ m, x = 4.6\ mm$

$$\lambda = \frac{(0.3 \times 10^{-3})(4.6 \times 10^{-3})}{2.5}$$

$$\lambda = 5.52 \times 10^{-7}\ m = 552\ nm$$

Formative Practice 5.7)

1. Figure 5.71 shows an electromagnetic spectrum.

A	X-ray	*B*	Visible light	Infrared ray	*C*	Radio wave

Figure 5.71

What are waves *A*, *B* and *C*?

2. Arrange the electromagnetic waves below according to the order of increasing frequency.

Infrared ray	X-ray	Microwave	Gamma ray	Radio wave

3. In the air, blue light with a wavelength of 420 nm moves at a speed of 3.00×10^8 m s^{-1}. The speed of the blue light reduces to 2.25×10^8 m s^{-1} when passing through a liquid. What is the wavelength of the blue light in the liquid?

Answer:

1. Wave A: Gamma ray
   Wave B: Ultraviolet ray
   Wave C: Microwave
2. Arrangement of electromagnetic waves according to its frequency are as follows:

→ **Increasing Frequency** →				
Radio wave	Microwave	Infrared ray	X-ray	Gamma ray

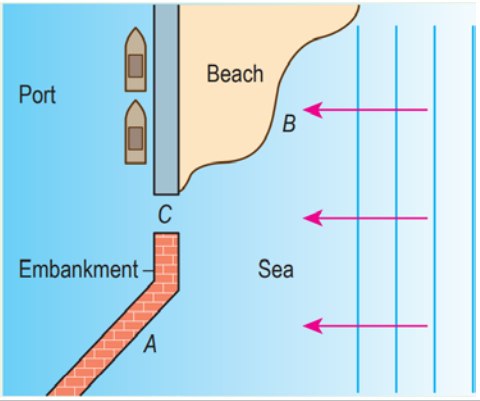
3. $\lambda_{Blue} = 420\ nm, v_{Blue} = 3.00 \times 10^8\ ms^{-1}, v_{Blue\,2} = 2.25 \times 10^8\ ms^{-1}$

$$\frac{420 \times 10^{-9}}{3.00 \times 10^8\ ms^{-1}} = \frac{\lambda_{Blue\,2}}{2.25 \times 10^8\ ms^{-1}}$$

$$\lambda_{Blue\,2} = 3.15 \times 10^{-7} m = 315\ nm$$

Performance Evaluation 5)

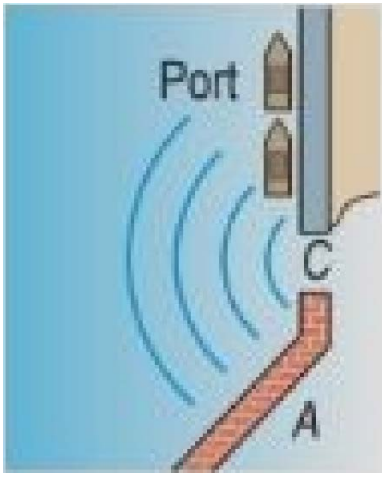
1. Figure 1 shows a port and the area around it.
   (a) State the wave phenomena that occur when sea waves
      (i) collide with the embankment of the port at *A*,
      (ii) move towards the beach at *B*, and
      (iii) pass through the entrance of the port at *C*.
   (b) Draw the wavefronts after the waves pass *C*.
   (c) What is the effect on the waves if the entrance of the port is widened?



Answer:

a) i) Reflection
   ii) Refraction
   iii) Diffraction

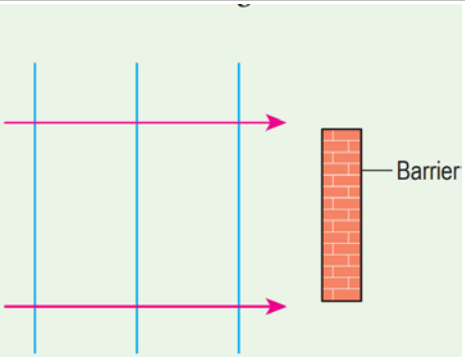
b) The wavefront drawn is as follows:



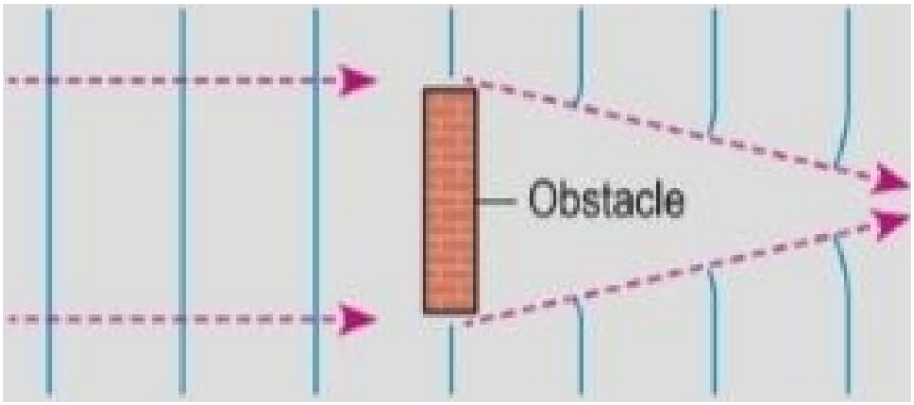
c) The water waves will undergo less diffraction (Less spread out) and will have higher amplitude.

Performance Evaluation 5)

2. Figure 2 shows the wavefront of water waves approaching a barrier. Complete Figure 2 by sketching the wavefront after passing around the barrier.

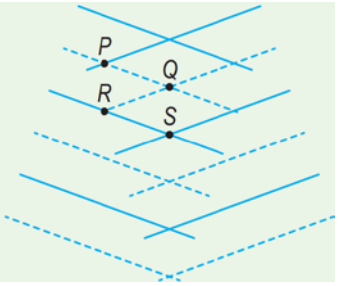


Answer:



Performance Evaluation 5)

3. Figure 3 shows superposition of two coherent plane waves.



(a) What is a coherent wave?

(b) State the points where the following occur

(i) constructive interference,

(ii) destructive interference.

(c) Explain with suitable diagrams, interference at point

(i) *Q*,

(ii) *R*, and

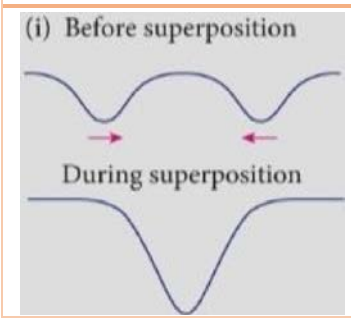
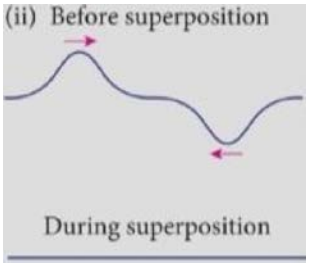
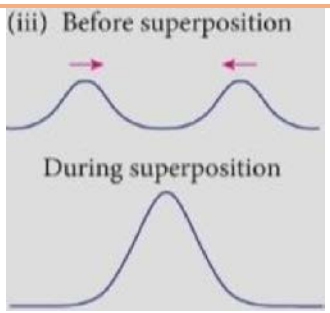
(iii) *S*.

Answer:

a) A coherent wave is a wave with the same frequency and same phase where the phase difference is constant.

b) i) Q and S
ii) P and R

c) Interference diagrams:

i)	ii)	iii)
		

Performance Evaluation 5)

4. Figure 4 shows the apparatus set up of Young's double-slit experiment.

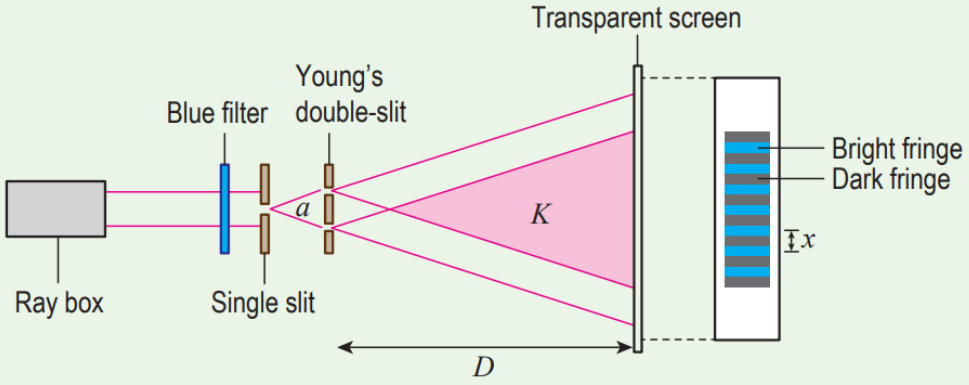


Figure 4

(a) What happens to the light rays at area *K*?

(b) Explain the formation of bright fringes and dark fringes on the screen.

(c) You are given the following information:

- Distance between double slits, a = 0.30 mm
- Distance between double-slits and screen, D = 2.70 m
- Separation distance between two adjacent bright fringes, x = 4.0 mm

Calculate the wavelength, λ of blue light in this experiment.

Answer:

a) The light rays undergo superposition at area K.

b) Two light waves will superposition.

- When a crest meets a crest, constructive interference occurs where a tall crest is formed. The tall crest is seen as a bright fringe.
- When a crest meets a trough, destructive interference occurs where a zero resultant displacement is formed. This is seen as a dark fringe.

c) $a = 0.3\ mm, D = 2.7\ m, x = 4\ mm$

$$\lambda = \frac{(0.3 \times 10^{-3})(4 \times 10^{-3})}{2.7}$$

$$\lambda = 4.44 \times 10^{-7}\ m = 444\ nm$$

Performance Evaluation 5)

5. A student moves a slinky spring repeatedly at a frequency of 5 Hz so that a transverse wave is produced as shown in Figure 5.

(a) Determine the amplitude, period and wavelength of the wave.

(b) Calculate the wave speed along the slinky spring.

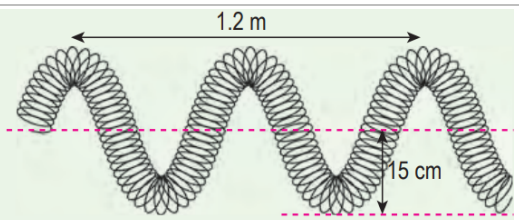


Figure 5

6. A judge blew a whistle which produced a sound of frequency 500 Hz and a wavelength of 0.67 m in the air. What is the wave speed of the sound?

Answer:

5. $f = 5\ Hz$

a) Amplitude, $A = 15\ cm$

Period, $T = \frac{1}{5} = 0.2\ s$

Wavelength, $\lambda = \frac{1.2}{2} = 0.6\ m$

b) $v = f\lambda = (5)(0.6)$

$v = 3\ ms^{-1}$

6. $f = 500\ Hz,\ \lambda = 0.67\ m$

$v = f\lambda = (500)(0.67)$

$v = 335\ ms^{-1}$

Performance Evaluation 5)

7. Figure 6 shows a tuning fork vibrating and producing sound waves.

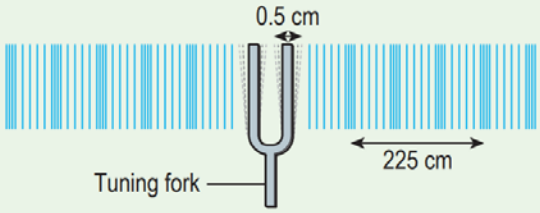


Figure 6

Based on Figure 6, determine the
(a) amplitude of the sound waves,
(b) wavelength of the sound waves,
(c) speed of the sound waves produced when the tuning fork vibrates with a frequency of 440 Hz.

Answer:

a) $Amplitude, A = \frac{0.5}{2} = 0.25\ cm$

b) $\lambda = \frac{225}{3} = 75\ cm$

c) $f = 440\ Hz$
$v = 440(75) = 33000\ cms^{-1}$

Performance Evaluation 5)

8. Figure 7 shows an image of water waves moving from a deep water region to a shallow water region.

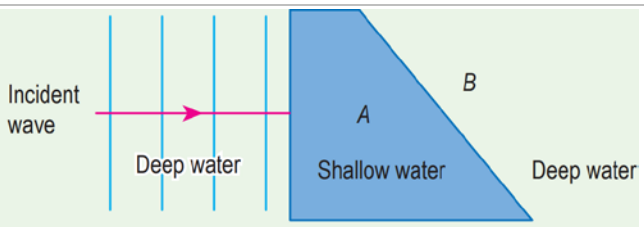


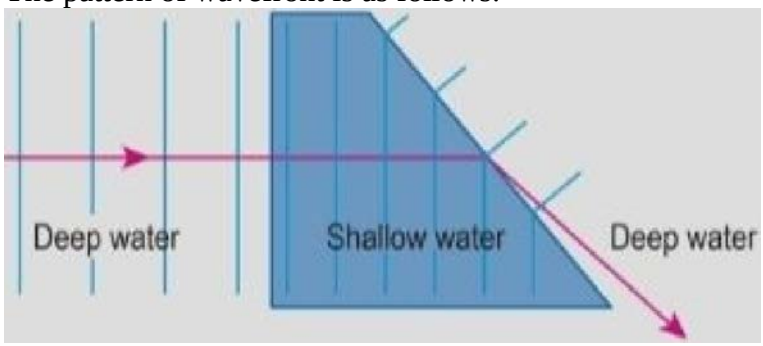
Figure 7

(a) In Figure 7, draw the pattern of wavefront in region *A* and region *B*.

(b) Given that the speed of water waves in the shallow water region and deep water region are 4.0 m s^{-1} and 9.0 m s^{-1} respectively. Wavelength of water waves in the shallow water region is 2 m. Calculate the wavelength of water waves in the deep water region.

Answer:

a) The pattern of wavefront is as follows:



b) $v_{Deep} = 9.0\ ms^{-1}, v_{Shallow} = 4.0\ ms^{-1}, \lambda_{Shallow} = 2\ m$

$$\frac{9}{\lambda_{Deep}} = \frac{4}{2}$$

$$\lambda_{Deep} = 4.5\ m$$

Performance Evaluation 5)

9. Figure 8 shows the graph of displacement against time which represents the oscillation of a pendulum.

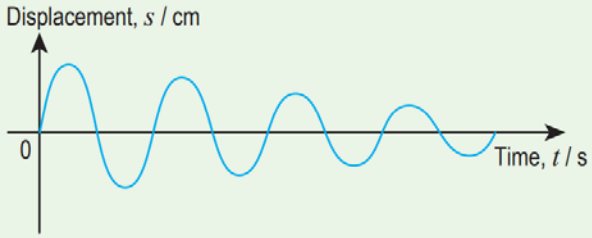


Figure 8

Based on the graph, answer the following questions:

(a) What happens to the amplitude of the oscillating pendulum?

(b) What phenomenon is experienced by the oscillating pendulum?

(c) What is the main reason for the phenomenon?

(d) How is the pendulum able to keep oscillating?

Answer:

a) The amplitude of the oscillating pendulum decreases over time.

b) Damping.

c) External forces such as air resistance oppose the motion of oscillating pendulum.

d) The pendulum should be resonated. A periodic force with a frequency that is equal to that of the natural frequency of the pendulum should be applied.

Performance Evaluation 5)

10. Figure 9 shows the pattern of interference produced by three coloured lights in an experiment.

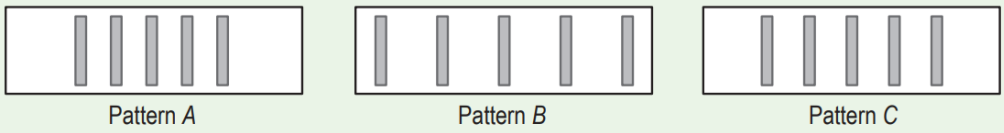


Figure 9

Table 1 shows the coloured lights used in this experiment and the values of wavelength. Complete Table 1 by matching the coloured lights with patterns *A*, *B* and *C*.

Table 1

Colour	Wavelength / nm	Pattern of interference
Blue	400	
Green	550	
Red	700	

Justify your answer.

Answer:

Colour	Wavelength / *nm*	Pattern of Interference
Blue	400	Pattern A
Green	550	Pattern C
Red	700	Pattern B

According to the formula $\lambda = \frac{ax}{D}$, where $\lambda \propto x$.

- The distance between two bright fringes, x is directly proportional to the wavelength, λ.
- Therefore, blue light with the shortest wavelength will produce bright fringes that are closest together.
- While red light with the longest wavelength will produce bright fringes that are the furthest apart.
- Green light has a wavelength that is in between red light and blue light, so it produces a moderately distant and close bright fringes.

Performance Evaluation 5)

11. Figure 10 shows a system of communication which involves direct transmission of electromagnetic wave signals from a transmitting station to a receiving station. The distance between the two distant stations and the shape of the Earth cause the receiving station to be unable to receive clear signals directly from the transmitter. You are required to give several proposals to improve the quality of transmission of signal.

Figure 10

Explain your proposal based on the following aspects:

(a) type of wave broadcasted
(b) frequency of wave
(c) method which enables the wave to propagate through a further distance
(d) locations of transmitter and receiver

Answer:

Modifications made toward a system of communication are as follows:

Characteristic	Explanation
Type of wave broadcasted: Microwave	Microwave is an EM wave that moves at the speed of light and does not need a medium to propagate.
Frequency of wave: High frequency	Allows for the wave to penetrate the atmosphere without much loss of energy / information.
Method which enables the wave to propagate through a further distance: Launch a communication satellite in geostationary orbit	Receive signals from transmitter and send the said signal to the receiver.
Locations of transmitter and receiver: Transmitter and receiver is located in a high and open space	Waves transmitted and received does not experience reflection or diffraction due to obstructing objects nearby.

Performance Evaluation 5)

12. Kompleks Pendaratan Ikan LKIM is a place where fishermen anchor their ship and bring ashore their catch. The river estuary becomes the entrance for ships to dock at the complex. Photograph 1 shows an example of a river estuary.

Photograph 1

(***Source**: Image ©2019 TerraMetrics, Image ©2019 Maxar Technologies*)

Assume you are an engineer who is an expert in reflection, refraction and diffraction of waves. You are required to propose characteristics of the design of the building structure to ensure the fishermen's ships can pass through the river estuary safely based on the following aspects:

(a) building structure that can reduce the height of waves

(b) characteristics of the building structure that can reduce the effects of erosion

(c) depth of the river estuary to enable ships to pass through the estuary safely

Answer:

Modifications made to a river estuary are as follows:

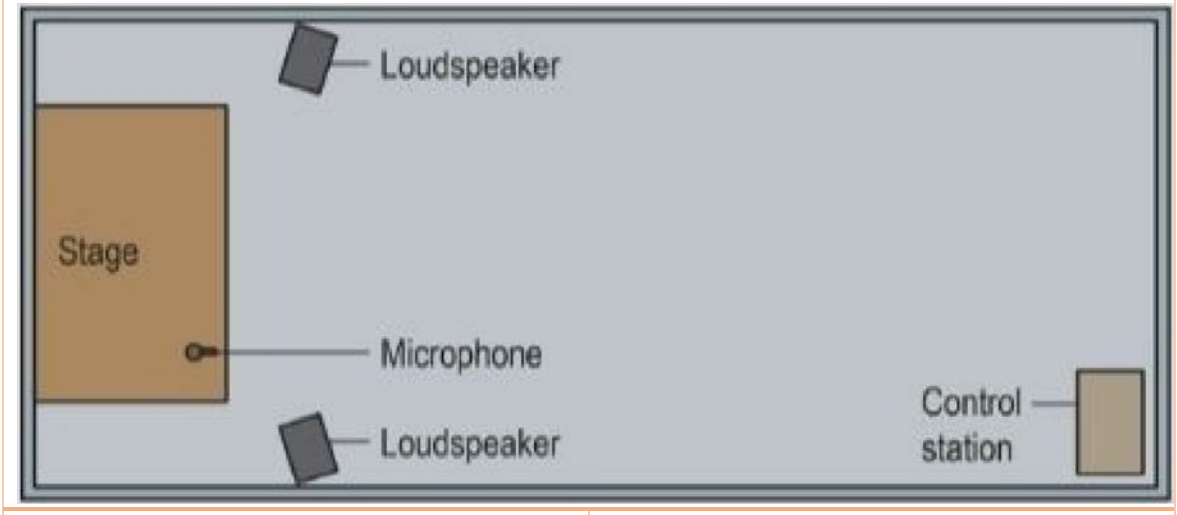
Characteristic	Explanation
Build an embarkment that has a gap at the river estuary	Ensures that the water in the region of the river estuary is calmer for ships to dock.
Build a high wall at the river estuary	Prevents high amplitude sea waves from entering the estuary.
Build a wall of rock all along the beach near the river estuary	Decreases the erosion effect of the beach caused by the sea waves' energy.
Deepen the river estuary	Docked ships are kept stationary and are not rolling and pitching.
Widen the river estuary	The passage for ships is widened.

Performance Evaluation 5)

13. Your new school hall is supplied with a Public Address (PA) system which consists of two loudspeakers, a microphone and a control station made up of an amplifier equipped with USB and DVD slots. You are required to propose the installation of the PA system so that the sound can be heard clearly by the audience. Sketch the layout of the hall and explain your proposal based on the following aspects:

(a) location of loudspeakers
(b) distance between loudspeakers
(c) location of microphone
(d) location of control station

Answer:
Modifications made to a hall PA system are as follows:



Characteristic	Explanation
Location of loudspeakers: High location and inclined slightly to face the audience	Sound from the loudspeaker will not face any obstruction.
Distance between loudspeakers: The loudspeaker should be far apart	Reduces soft sound regions caused by destructive interference.
Location of microphone: Placed behind the loudspeakers	Sound from the loudspeakers will not propagate directly to the microphone and is not amplified repeatedly to cause noise.
Location of control station: Located at the back of the hall	Person in charge can hear the same sounds as the audience and make detailed adjustments when needed.

CHAPTER 6

LIGHT

Name:	Form:

Formative Practice 6.1)

1. Figure 6.16 shows the path of light which travels from medium 1 to medium 2.

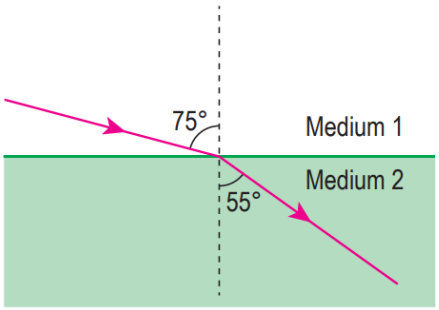


Figure 6.16

(a) Write an equation to relate the light that travels through the mediums.

(b) Determine the refractive index for medium 2 if the speed of light in medium 1 is 3.0×10^8 m s^{-1}.

(c) What is the speed of light in medium 2?

Answer:

a) The equation relating the light that travels through the mediums is:

$$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$$

b) $With\ v_1 = c,\ then\ n_1 = 1$

$$n_2 = \frac{\sin 75}{\sin 55}$$

$$n_2 = 1.18$$

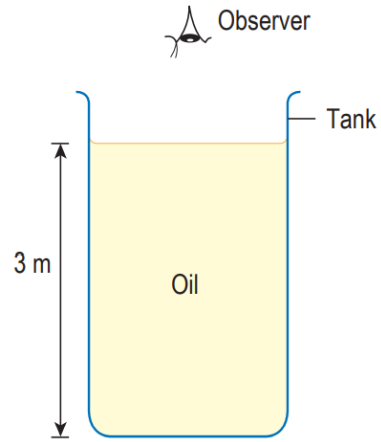
c) Speed of light in medium 2:

$$1.18 = \frac{3 \times 10^8}{v}$$

$$v = 2.54 \times 10^8\ ms^{-1}$$

Formative Practice 6.1)

2. Figure 6.17 shows a tank filled with oil to a height of 3 m. The oil has a refractive index of 1.38. What is the apparent depth of the tank as seen by the observer from above the tank?



Answer:

$H = 3\,m, n = 1.38$

$1.38 = \frac{3}{h}$

$h = 2.17\,m$

Formative Practice 6.2)

1. Figure 6.28 shows the path of light which travels from air to a prism.

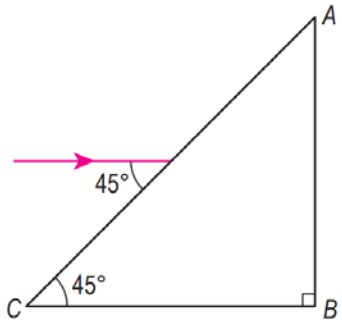


Figure 6.28

(a) Determine the angle of refraction of light ray in the prism. The refractive index of the prism is 1.50.

(b) Will the light ray experience total internal reflection at the side *AB* of the prism? Explain your answer.

Answer:

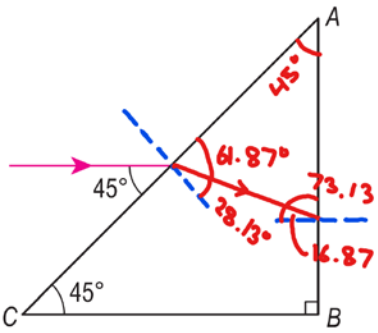
a) $n = 1.5, r = 45°$

$$1.5 = \frac{\sin 45}{\sin r}$$

$$r = \sin^{-1}\left(\frac{\sin 45}{1.5}\right)$$

$$r = 28.13°$$

b) Calculations done:



$\Delta CAB = 180 - 45 - 90 = 45°$

$r' = 90 - 28.13 = 61.87°$

$i'_{AB} = 180 - 61.87 - 45 = 73.13°$

$i_{AB} = 90 - 73.13 = 16.87°$

$$1.5 = \frac{1}{\sin c}$$

$$c = 41.81°$$

Since $c > i_{AB}$, total internal reflection does not occur because the incident angle, i is smaller than the critical angle, c.

Formative Practice 6.2)

2. Figure 6.29 shows a fine optical fibre made up of inner core which has a high refractive index surrounded by cladding material of a low refractive index.

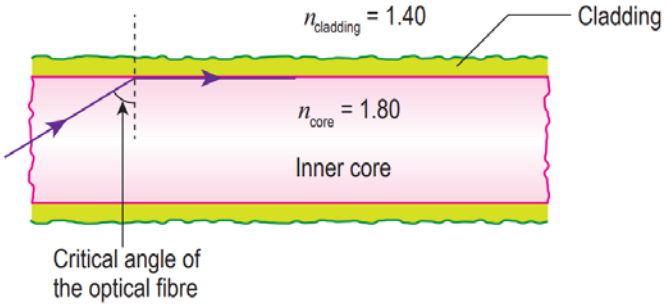


Figure 6.29

(a) Determine the critical angle of the optical fibre.

(b) What is the advantage of fine optical fibre?

Answer:

a) $n = 1.8$

$$1.8 = \frac{1}{\sin c}$$

$$c = 33.75°$$

b) The advantages of fine opticle fibre are:

- High number of signals can be sent at a time.
- Fine optical fibre is thinner and lighter.
- Does not lose a lot of energy when transferred over great distances.
- The signals sent are safe and free from electrical interference.
- Can fit and bend around in small spaces.
- And so on (Anything related is acceptable)

Formative Practice 6.3)

Figure 6.35 shows an image seen through a convex lens with focal length of 10 cm.

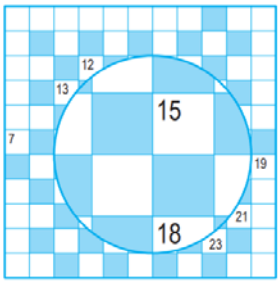
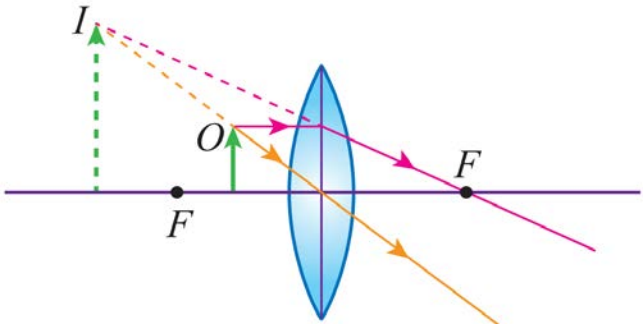


Figure 6.35

1. What are the characteristics of the image?
2. Draw a ray diagram to show how the image in the figure is formed.
3. Suggest a suitable position to place the object to produce an inverted image.

Answer:

1. The characteristics of the image formed is virtual, upright and magnified (VUM).
2. The ray diagram drawn is for a magnifying glass ($u < f$)



3. The object can be placed:
   - between point *F* and 2*F*
   - on point *2F*
   - beyond 2*F*

Formative Practice 6.4)

1. A concave lens with a focal length of 25 cm forms a virtual image of an ant at a distance of 20 cm from the optical centre of the lens.
   (a) What is the original position of the ant?
   (b) Draw a ray diagram to show the formation of a virtual image of the ant.
2. A small bulb is at a distance of 1.6 m from the screen and a thin convex lens with a focal length of 30 cm is placed between the bulb and the screen. Determine two positions of the convex lens that can produce a sharp image on the screen.

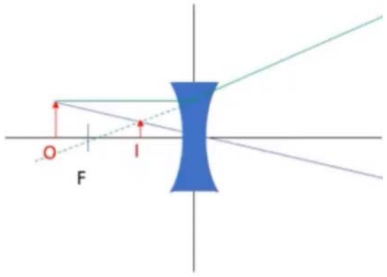
Answer:

1. Concave lens with $f = 25\ cm, v = 20\ cm$
   a) Find u

$$-\frac{1}{25} = \frac{1}{u} - \frac{1}{20}$$
$$\frac{1}{u} = -\frac{1}{100}$$
$$u = -100\ cm$$

   ∴ The original position of the ant is 100 cm from the optical centre of the lens.

   b) The ray diagram of the lenses:



2. $v + u = 1.6\ m, f = 30\ cm\ or\ 0.3\ m. Find\ u$

$$v = 1.6 - u : 1$$
$$\frac{1}{0.3} = \frac{1}{v} + \frac{1}{u} : 2$$

Insert equation 1 into equation 2:

$$\frac{1}{0.3} = \frac{1}{1.6 - u} + \frac{1}{u}$$

$$\frac{u}{0.3} = \frac{u}{1.6 - u} + 1$$
$$\frac{1.6u - u^2}{0.3} = u + 1.6 - u$$
$$1.6u - u^2 = (0.3)(1.6)$$
$$u^2 + 1.6u - 4.8 = 0$$
$$(5u - 6)(5u - 2) = 0$$
$$\therefore u = 1.2\ m, u = 0.4\ m$$

Formative Practice 6.5)

A pupil is supplied with an eyepiece lens which has focal length, f_e = 7 cm and four pieces of objective lenses *A*, *B*, *C* and *D* as shown in Table 6.11.

Table 6.11

Lens	Focal length of objective lens, f_o / cm	Magnification of telescope, *M*	Diameter of objective lens / cm
A	14		5.0
B	14		10.0
C	70		5.0
D	70		10.0

1. Complete Table 6.11.
2. State two lenses which can produce the largest image.
3. State two lenses which can produce the brightest image.
4. Based on your answers in **2** and **3**, state the most suitable lens to be used as the objective lens of a telescope. Explain your answer.

Answer:

1. Magnification of Telescope:

Lens	Magnification of Telescope, M
A	$\frac{14}{7} = 2$
B	$\frac{14}{7} = 2$
C	$\frac{70}{7} = 10$
D	$\frac{70}{7} = 10$

2. Lens C and D (Highest magnification)
3. Lens B and D (Largest diameter)
4. Lens D. It has a long focal length, *f* and a large diameter.

Formative Practice 6.6)

1. Figure 6.47 shows a pupil looking in the direction of a plane mirror and a convex mirror of the same size.
   (a) Complete the path of light for both types of mirrors.
   (b) Which type of mirror can produce a wider field of vision?

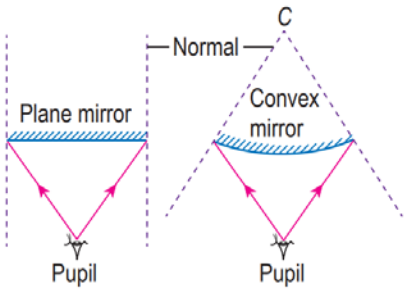
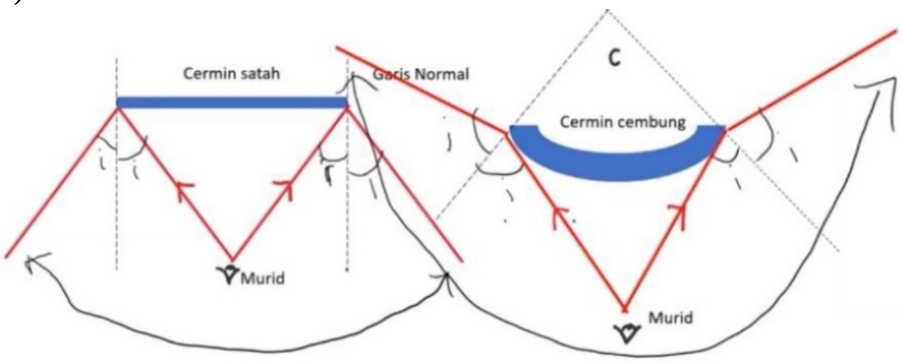


Figure 6.47

2. Adelia holds a shiny steel spoon with its back (convex surface) facing her eyes at a distance of approximately 30 cm. She sees an upright image of herself. However, when the spoon is changed so that the front (concave surface) of the spoon is facing her eyes, an inverted image is observed.
   (a) Explain this situation.
   (b) Why is an upright image not seen on the front surface of the spoon at that distance?

Answer:

1. a)



   b) Convex mirror.

2. $u = 30\ cm$
   a) The shiny surface of the steel spoon can reflect light similar to a mirror.
      - The convex surface of the steel spoon reflects light in a similar manner to a convex mirror.
      - The image produced is upright.
      - While, the concave surface of the steel spoon reflects light in a similar manner to a concave mirror.
      - The image formed is inverted.
   b) The image formed is inverted because his eyes (object) are a bit further than the focal point, f of the concave mirror ($u > f$).

Performance Evaluation 6)

1. Diamond is a precious stone that always appears shiny. Critical angle of diamond in air is 24°.

(a) (i) What is the meaning of critical angle?

(ii) Determine the value of refractive index of diamond.

(b) Figure 1 shows three diamonds of different shapes. A ray enters each diamond as shown in Figure 1. Complete the path of light rays until the ray emerges again into air in Figure 1.

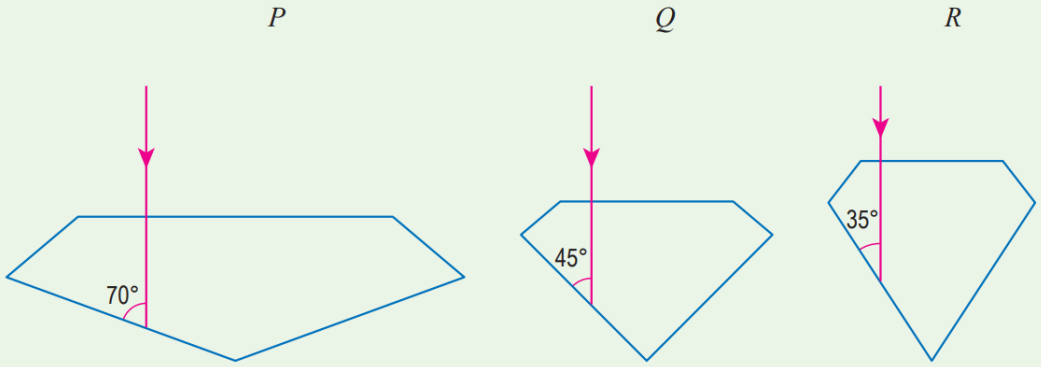


Figure 1

(c) State the physics concepts involved in this phenomenon.

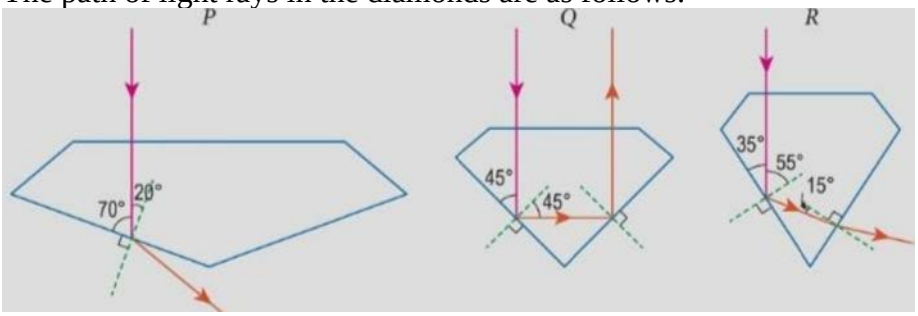
Answer:

a) $c = 24°$

i. The critical angle is the angle of incidence in a high optical density medium when the angle of refraction is 90°.

ii. $n = \frac{1}{\sin 24} = 2.46$

b) The path of light rays in the diamonds are as follows:



c) Total internal reflection and refraction of light.

Performance Evaluation 6)

2. Figure 2 shows a glass block with a refractive index of 1.50 placed between the eyes of the observer, E and the object P. If the thickness of the glass is 30.0 cm, what is the distance between object P and its image?

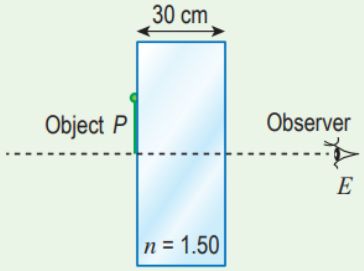


Figure 2

3. Figure 3 shows a light ray travelling from air to water and then entering a glass block. The refractive index of water is 1.33.

(a) Determine angle x.

(b) If speed of light in air is 3.0×10^8 m s^{-1}, what is the speed of light in water?

(c) Between water and glass, which medium has a higher optical density? Explain your answer based on Figure 3.

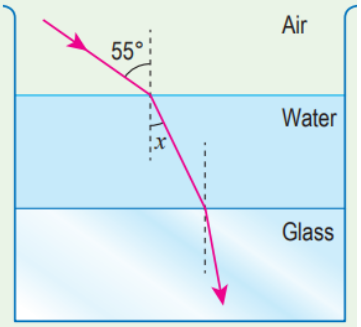


Figure 3

Answer:

2. $n = 1.50,\ Thickness = 30\ cm$

$Distance\ between\ P\ and\ P_{image} = 30 - \frac{30}{1.5} = 10\ cm$

3. $n = 1.33,\ i = 30°$

a) $1.33 = \frac{\sin 55}{\sin x}$

$x = 38.02°$

b) $1.33 = \frac{(3\times10^8)}{v}$

$v = 2.26 \times 10^8\ ms^{-1}$

c) Glass has a higher optical density becacuse when light travels from water to glass, the light is bent towards the normal.

Performance Evaluation 6)

4. Mariam carried out an experiment with a semi-circular glass block and a ray box. Figure 4 shows the path of light ray entering the glass block at point *R* and travelling towards the centre of the semi-circular glass block, point *S*.

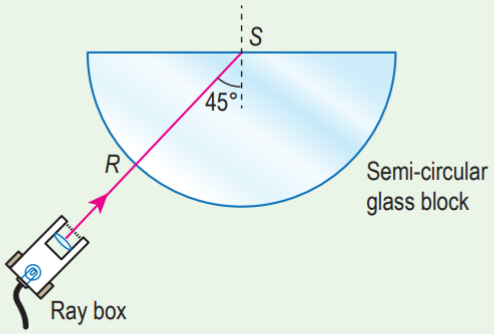


Figure 4

(a) Why does the light ray not change direction at point *R*?

(b) If the refractive index of the glass block is 1.52, determine the critical angle in this medium.

(c) Draw the path of light ray after point *S* and mark the value of the angle of the light ray with the normal at point *S*.

Answer:

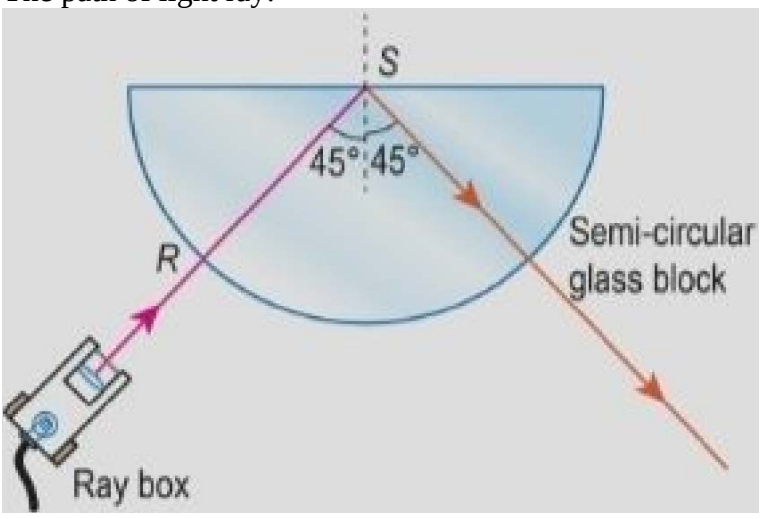
a) Point R is the normal to the incident ray RS. Therefore, $i = 0°, r = 0°$.

b) $n = 1.52$

$$1.52 = \frac{1}{\sin c}$$

$$c = 41.14°$$

c) The path of light ray:



Performance Evaluation 6)

5. When light from a star travels into the Earth's atmosphere, its direction of travel will change. This situation is shown in Figure 5. The change of direction is represented by the angle $\Delta\theta = i - r$.

(a) Speed of light in air is 299 910 km s^{-1} and speed of light in vacuum is 3.00×10^8 m s^{-1}.

(i) Calculate the refractive index of air.

(ii) Explain the value of refractive index obtained.

(b) Value of $\Delta\theta$ on a hot night is different from that on a cold night. State a logical reason for the difference.

(c) Rajiv returns from school in a school van on a hot and bright day. Rajiv can see a puddle of water on the surface of the road ahead. When the van reaches the location of the puddle of water, Rajiv discovers that the puddle of water does not actually exist. Explain this phenomenon.

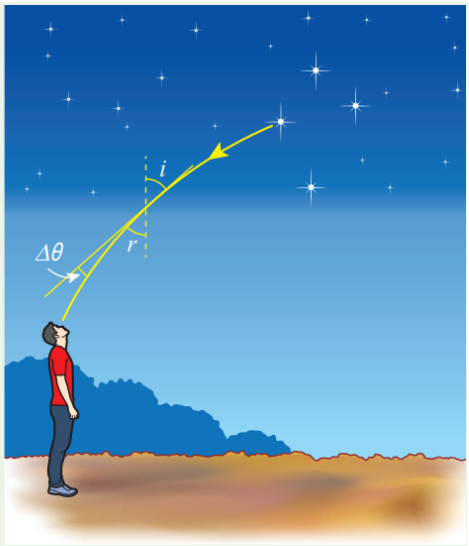


Figure 5

Answer:

a) $c = 3 \times 10^8\ ms^{-1}, v = 2.9991 \times 10^8\ ms^{-1}$

i. Find n

$$n = \frac{3 \times 10^8}{2.9991 \times 10^8} = 1.0003$$

ii. The value of the refractive index of air is almost equal to 1, that is the speed of light in air and in vacuum are identical.

b) The value of $\Delta\theta$ on a hot night is different from that on a cold night because the optical density of air is dependant on temperature. The higher the temperature, the lower the optical density of air.

c) This phenomenon is known as a mirage.

- Layers of air above the road has a smaller optical density due to the high temperature compared to the more upper layers of air.
- Light travelling from the upper layer is refracted away from the normal repeatedly.
- Until the point its angle of incidence is larger than the critical angle of air, total internal reflection will take place.
- The reflected light rays are then refracted towards the normal and reach Rajiv's eyes.
- Rajiv will see an image of the clouds as a puddle of water on the road.

Performance Evaluation 6)

6. Figure 6 shows an object and its virtual image formed by a convex lens.

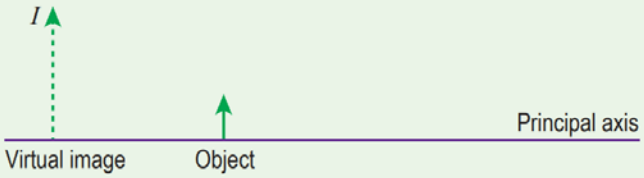


Figure 6

(a) One of the characteristics of image *I* in Figure 6 is that it is virtual. State the other characteristics of image *I*.

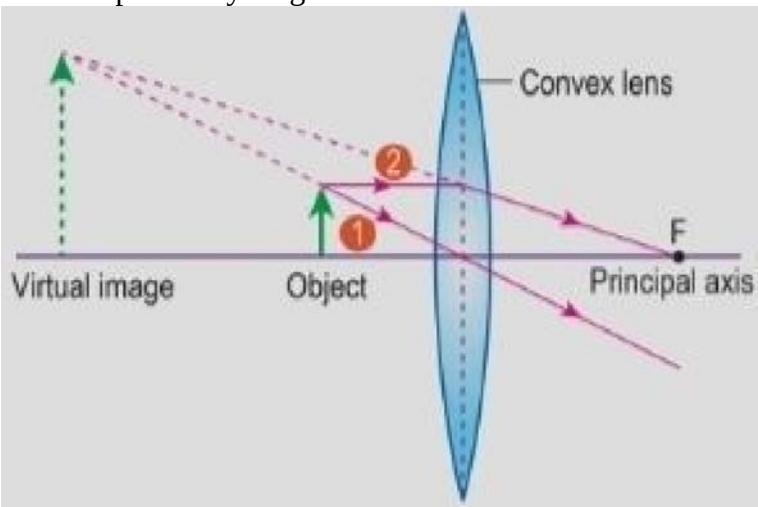
(b) Complete the ray diagram in Figure 6 and determine the position of the lens and focal point of the lens. Mark the position of the focal point of the lens with, *F*.

(c) If the object is slowly moved away from the lens, state two changes that might happen to the image without drawing a ray diagram.

Answer:

a) The other characteristics of image I is upright and magnified.

b) The completed ray diagram:



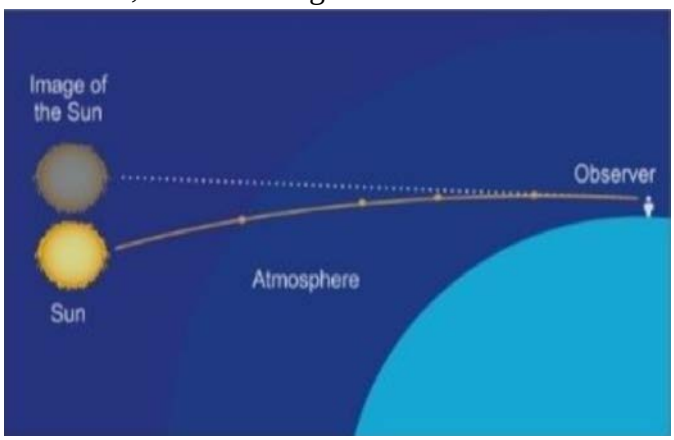
c) The image will change in a way that:
- The image becomes real, inverted and diminished.
- The image forms on the opposite side of the lens from the object.

Performance Evaluation 6)

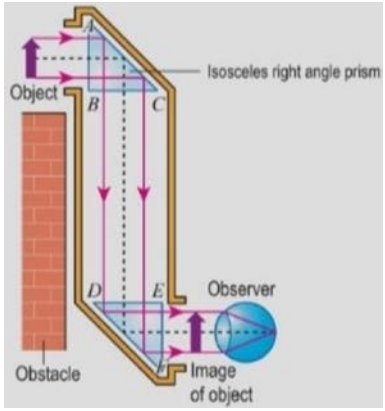
7. A sailor in the navy is looking at the situation on the surface of the sea through a submarine periscope. He found that the Sun is setting. The captain of the submarine told the sailor that the Sun had in fact already set.
   (a) Is the statement of the captain of the submarine true? Explain your answer.
   (b) Explain the formation of image in a prism periscope for object with obstruction in front with the help of suitable ray diagrams.

Answer:

a) The captain's statement is true.
- The light ray that eneters the atmosphere is refracted by the layers of air having different optical densities.
- Therefore, a virtual image of the sun is formed above the actual position of the sun.



b) The prism periscope is used to view an object behind an obstruction:



The light rays from the object travel towards the opening of the periscope at AB.
- Total internal reflection of the light rays occur at AC and the light is reflected downwards.
- The light rays travel toward DE and undergoes total internal reflection again at DF. The light is reflected towards EF.
- The light rays enter the eyes of the observer.
- The final image formed is upright and same size.

Performance Evaluation 6)

8. A lighted candle is placed in front of a concave mirror with a focal length of 2.4 cm. A white screen is moved behind the candle to catch a sharp image as shown in Figure 7.

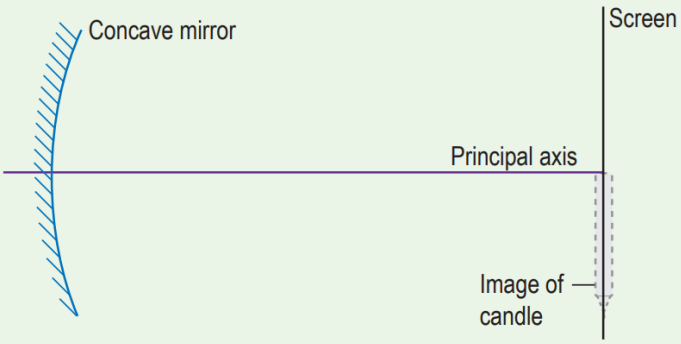


Figure 7

(a) On Figure 7,

(i) mark the focal point of the mirror with F and centre of curvature with C.

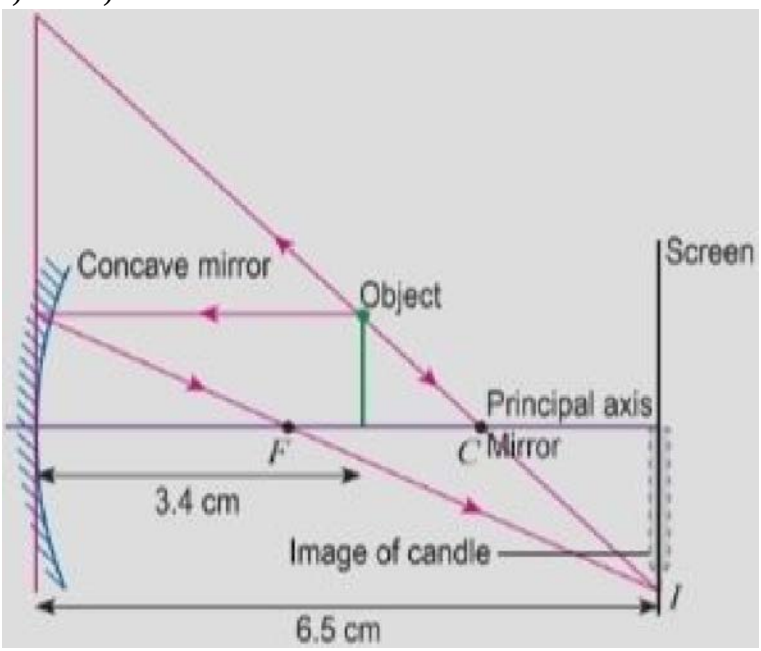
(ii) draw a complete ray diagram to determine the position of the object.

(b) How can the magnification of the image be increased?

Answer:

a) $f = 2.4\ cm$

i) and ii)



b) Move the object so that it is closer to the focal point of the mirror with the condition that u is larger than f.

Performance Evaluation 6)

9. (a) Explain the way to construct a compound microscope using two lenses. In your answer, state the type of lens that you chose, estimate the focal length of the lenses and characteristics of the image formed by each lens.

(b) Why is an astronomical telescope not suitable to be used to see distant objects on the surface of the Earth?

(c) How can you modify a compound microscope to become an astronomical telescope?

Answer:

a) Construction of a Compound Microscope:

Aspect	Explanation
Type of lens: Two convex lens	Objective lens with focal length f_o is placed in front of the eyepiece lens with focal length f_e.
Focal length of lens: $f_o < f_e$	Distance between the objective lens and eyepiece lens must be larger than $f_o + f_e$ in order to form an image.
Characteristics of the image formed by each lens: Each lens forms its own image	Objective lens: - The object is placed in between $2F_o$ and F_o - The first image, I_1 is formed where it is real, inverted and magnified. - It also acts as the object for eyepiece lens. Eyepiece lens: - The object (I_1) is placed between F_e and the optical centre of the eyepiece lens. - Functions as a magnifying lens. - Forms the final image, I_2 from I_1 which is virtual, inverted and magnified.

b) The final image formed is inverted, therefore it is less suitable to be used to view distant object on the surface of Earth.

c) Modifications made to compound microscope so that it functions as an astronomical telescope:
- Interchange the positions of the objective lens and the eyepiece lens.
- Adjust the distance between the objective lens and the eyepiece lens so that it becomes $f_o + f_e$.

Performance Evaluation 6)

10. Table 1 shows the speed of light in vacuum and two materials for making optical fibre.

Table 1

Medium	Speed of light / m s^{-1}
Vacuum	3.00×10^8
Material I	2.01×10^8
Material II	1.96×10^8

(a) Identify suitable mediums to be used as core and cladding of optical fibre. Explain your answer.

(b) Determine the critical angle of the optical fibre.

(c) Why must the surface of optical fibre be very smooth?

Answer:

a) Material I is used as the cladding while material II is used as the core.
- The refractive index of the cladding must be smaller than the refractive index of core.
- Therefore, the refractive index of material I is smaller than the refractive index of material II.

b) $c = 3 \times 10^8\ ms^{-1}, v_1 = 2.01 \times 10^8\ ms^{-1}, v_2 = 1.96 \times 10^8\ ms^{-1}$

$$n_1 = \frac{3 \times 10^8}{2.01 \times 10^8} = 1.49$$

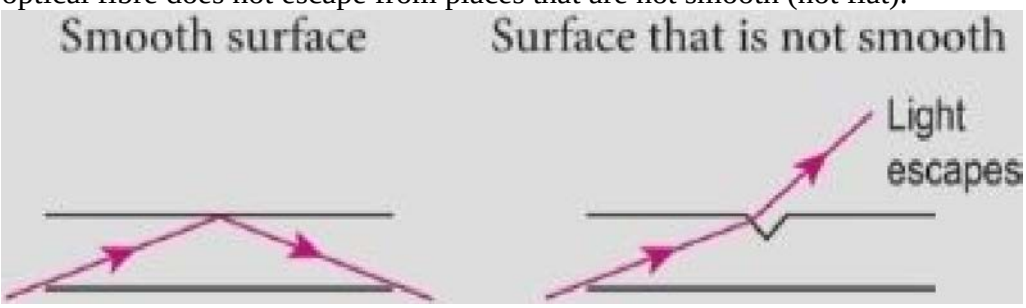
$$n_2 = \frac{3 \times 10^8}{1.96 \times 10^8} = 1.53$$

$$\frac{1.53}{1.49} = \frac{\sin 90}{\sin c}$$

$$c = \sin^{-1}\left(\frac{1.49}{1.53}\right)$$

$$c = 76.87°$$

c) The surface of the optical fibre is very smooth so that all the light that enters the optical fibre does not escape from places that are not smooth (not flat).



Performance Evaluation 6)

11. Amin carries out an experiment to investigate the relationship between real depth, H and apparent depth, h for an object in a liquid. The apparatus set up is shown in Figure 8. Pin A is placed at the base of a tall beaker. Liquid is poured into the beaker until pin A is at a depth of 5.0 cm. The real depth, H for pin A is the distance of the pin from the surface of the liquid.

Another pin, pin B is adjusted until the image of pin B in the plane mirror is in line with the image of pin A when observed from above as shown in Figure 9.

Apparent depth, h for pin A is the same as the distance between the image of pin B and the surface of the liquid. Distance x, can be determined by measuring the distance between pin B and the plane mirror. The distance from the surface of the liquid to the plane mirror, z is also measured.

This procedure is repeated for real depth of liquid, H = 10.0 cm, 15.0 cm, 20.0 cm, 25.0 cm and 30.0 cm. All readings are recorded in Table 2.

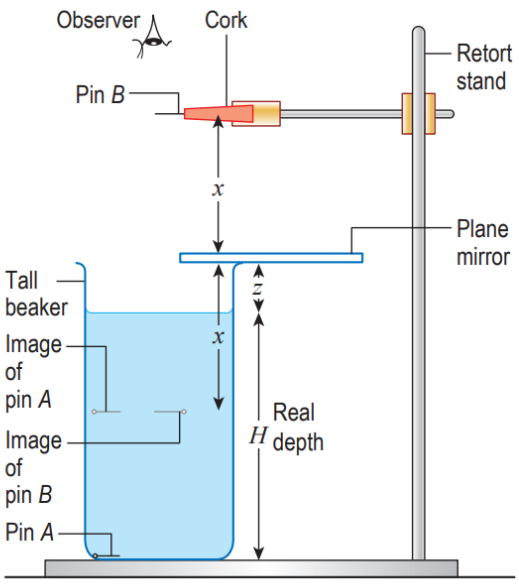


Figure 8

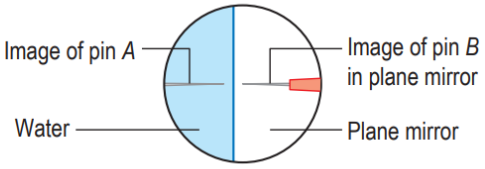


Figure 9

Table 2

H / cm	x / cm	z / cm	h / cm
5.0	30.8	27.0	
10.0	29.5	22.0	
15.0	28.3	17.0	
20.0	27.0	12.0	
25.0	25.8	7.0	
30.0	24.6	2.0	

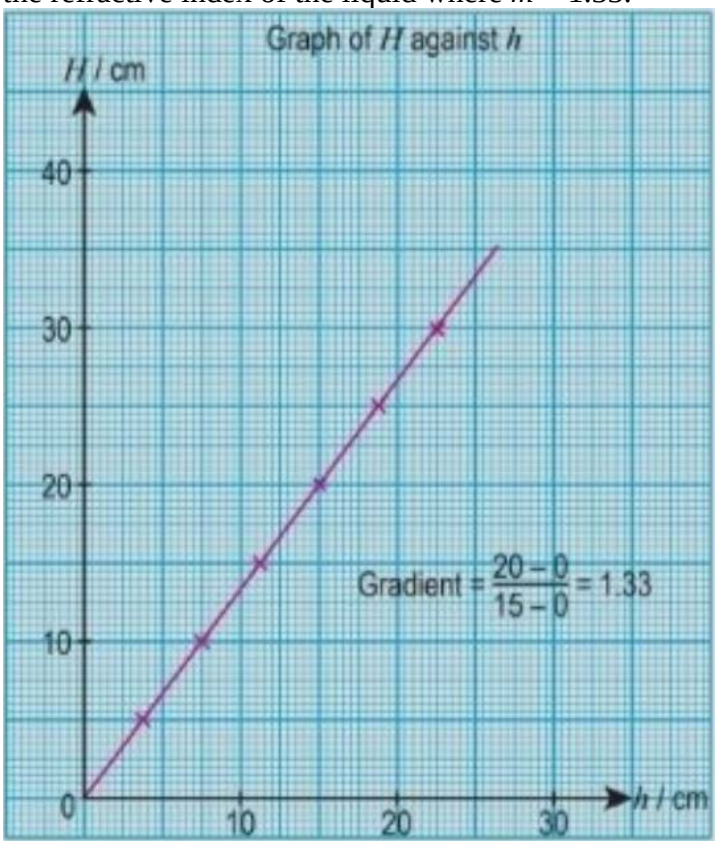
(a) Based on the results of this experiment, determine the relationship between h and H and then deduce the value of the refractive index of the liquid.

(b) Draw suitable ray diagrams regarding the formation of images that can be seen by Amin.

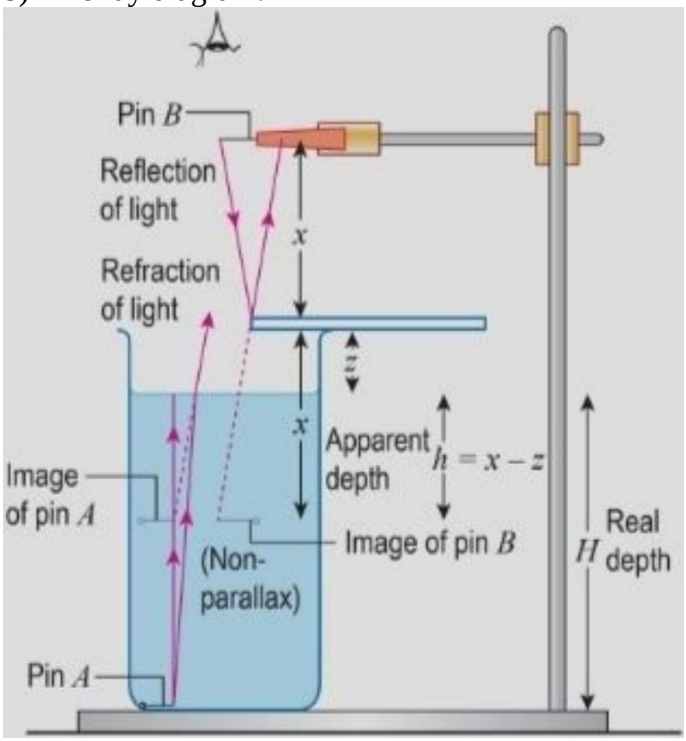
(c) Discuss the importance of plane mirror and non-parallax method in this experiment.

Answer:

a) Real depth, H is directly proportional to apparent depth, h. Gradient of the graph is the refractive index of the liquid where m = 1.33.



b) The ray diagram:



c) Importance of plane mirror and non-parallax method:

- Object distance and the image distance of a plane mirror are the same, therefore $h + z = x$.
- Plane mirror that is placed above the tall beaker facilitates the adjustment of pin B so that its image in the liquid is in a non-parallax condition with the image of pin A.

END

THANK YOU