

Performance Evaluation

1. (a)	Base quantity	Length	Mass	Time	Thermodynamic temperature	Electric current	Luminous intensity	Amount of substance
	S.I. Unit	metre	kilogram	second	kelvin	ampere	candela	mole

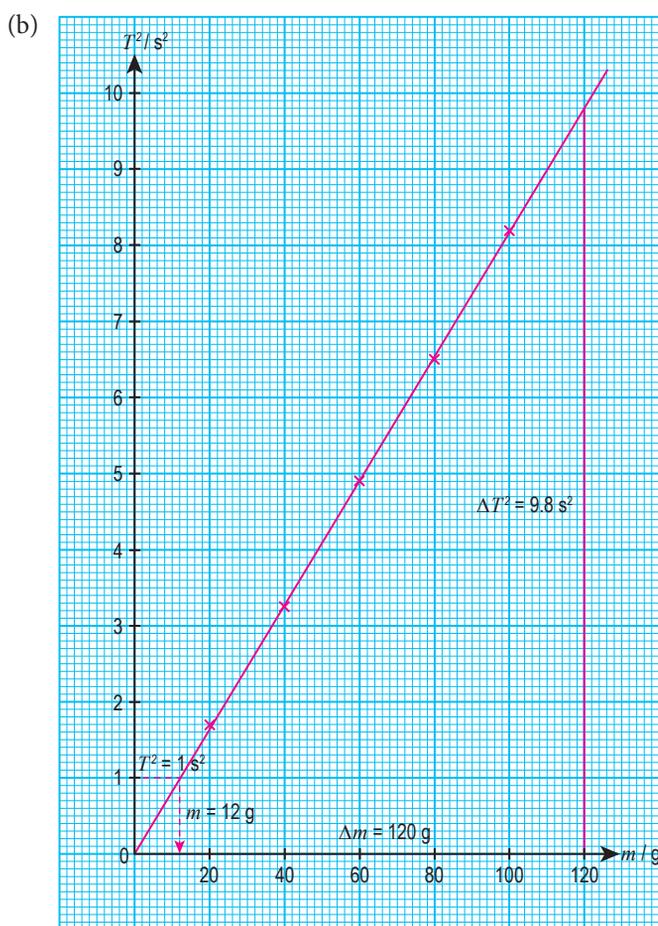
(b) $\text{kg m}^2 \text{s}^{-3}$

2. (a) gradient of graph = 1 m s^{-2}

(b) y-intercept of the graph when $t = 0$ is 15 m s^{-1}

(c) v increases linearly with t

3. (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



(c) $0.0817 \text{ s}^2 \text{ g}^{-1}$

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

(e) From the graph of T^2 against m , use the method of extrapolation to determine the value of m when $T^2 = 1.0 \text{ s}^2$, so T is equal to 1.0 s . Substitute the slotted weights with plasticine of mass m , about 12 g .

4. (a)

Pupil	Time, t / s	Speed, $v / \text{m s}^{-1}$
A	58.79	6.80
B	60.06	6.66
C	57.68	6.93
D	59.87	6.68
E	57.99	6.90

- (b) Use an electronic stopwatch to measure the time of their motion.
(c) Pupil C is the fastest.
(d) Use an electronic sensor to prevent errors in measurement caused by the reaction time of humans when starting and stopping the stopwatch.

5. (a) In the old system, $F = mlt^{-2}$
 $m = Ft^2l^{-1}$

Therefore, in FAT system

$$l = A^{1/2}, \text{ and}$$

$$m = FT^2l^{-1}$$

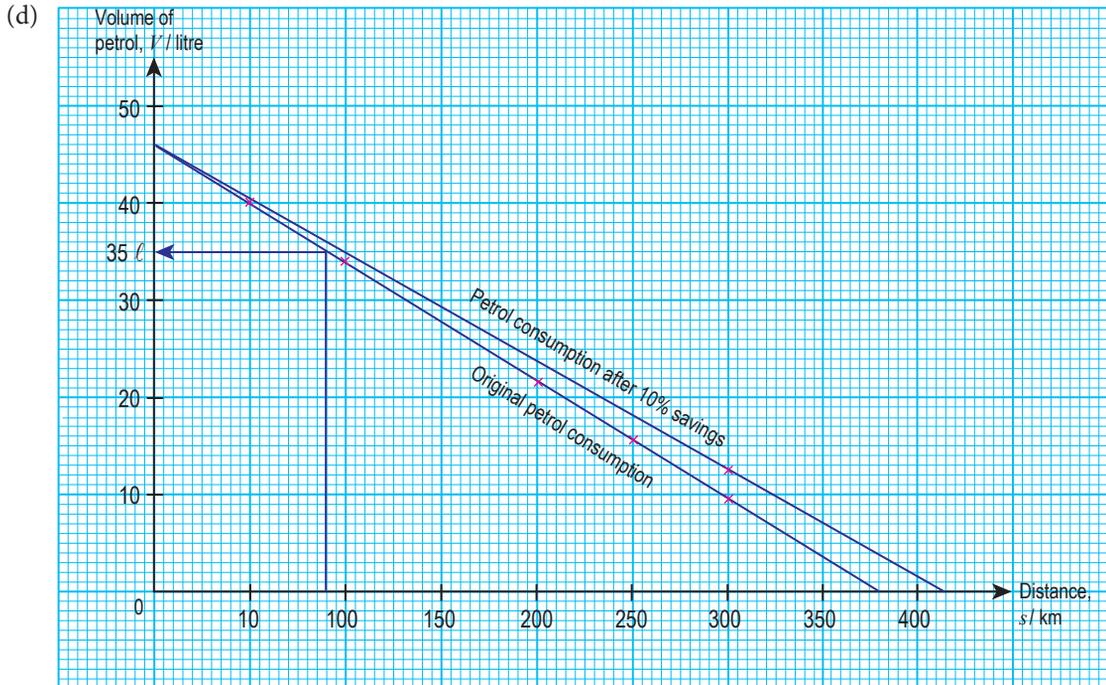
$$= FT^2A^{-1/2}$$

- (b) – 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 very complex and hinder effective communication among physicists.
6. (a) – Straight line that does not pass through the origin and has a negative gradient.
– p decreases linearly with q
- (b) – Curve that does not pass through the origin and has a negative gradient.
– p decreases with q
- (c) – Horizontal straight line with zero gradient.
– p is constant or p does not depend on q
7. (a) (i) $26 - 2 = 24 \text{ s}$
(ii) To obtain the value of one complete oscillation accurately.
(iii) Step 1: Repeat the experiment and obtain the average value of two sets of readings.
Step 2: Use an electronic or digital stopwatch to measure time more accurately.
- (b) (i) Period $T = \frac{24}{20} = 1.2 \text{ s}$
(ii) $l = 10 \div (4 \times \pi^2) \times 1.2^2$
 $= 0.36 \text{ m}$
8. (a) (i) Base quantities – Mass, distance, length
(ii) Derived quantity – Force
(iii) Vector quantity – Force
- (b) S.I. unit for $G = \frac{Fr^2}{Mm}$
 $= \frac{\text{kg m} \times \text{m}^2}{\text{s} \times \text{s} \times \text{kg} \times \text{kg}}$
 $= \text{kg}^{-1} \text{m}^3 \text{s}^{-2}$

Enrichment Corner

9. (a) Draw a graph of V against s and extrapolate the graph to a distance, $s = 0 \text{ km}$, $V = 46 \ell$
(b) – Draw an interpolated line at $s = 80 \text{ km}$, read the value for $V = 35 \ell$
– Consumption of petrol by engine for the first 80 km is $46 \ell - 35 \ell = 11 \ell$

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



Chapter 2 Force and Motion I

Performance Evaluation

1. (a) Use $v = u + at$

$$= 0 + (2.0)(5.0)$$

$$= 10.0 \text{ m s}^{-1}$$
- (b) Use $s = ut + \frac{1}{2}at^2$

$$s_1 = 0 + \frac{1}{2}(2.0)(5.0)^2$$

$$= 25.0 \text{ m}$$
- (c) Fifth second means the time between 4 s and 5 s.
For $t = 4 \text{ s}$

$$s_2 = 0 + \frac{1}{2}(2.0)(4.0)^2$$

$$= 16.0 \text{ m}$$

Therefore, distance travelled in the fifth second

$$s = s_1 - s_2$$

$$= 25.0 - 16.0$$

$$= 9.0 \text{ m}$$

2. Change speed in unit km h^{-1} to m s^{-1} .

$$108 \text{ km h}^{-1} = 30 \text{ m s}^{-1} \text{ and } 72 \text{ km h}^{-1} = 20 \text{ m s}^{-1}$$

- (a) Use $v^2 = u^2 + 2as$

$$\begin{aligned} 2as &= v^2 - u^2 \\ a &= \frac{v^2 - u^2}{2s} \\ &= \frac{20^2 - 30^2}{2 \times 125} \\ &= -2.0 \text{ m s}^{-2} \end{aligned}$$

The car experiences an acceleration of -2.0 m s^{-2} .

- (b) Use $v = u + at$

$$\begin{aligned} t &= \frac{v - u}{a} \\ &= \frac{20 - 30}{-2.0} \\ &= 5 \text{ s} \end{aligned}$$

3. When Swee Lan paddles a boat backwards, a force of action F is applied on the river water and simultaneously a force of reaction of the same magnitude but in the opposite direction to the direction of F acts on the boat. Therefore, the boat moves forward.

4. $F = ma$

$$150 = (1200)a$$

$$a = 0.125 \text{ m s}^{-2}$$

$$v = u + at$$

$$1.5 = 0 + (0.125)t$$

$$t = 12 \text{ s}$$

5. $W_{\text{Moon}} = mg_{\text{Moon}}$

$$2 = m \times \frac{1}{6} g$$

$$W_{\text{Earth}} = mg$$

$$= \frac{12}{g} \times g$$

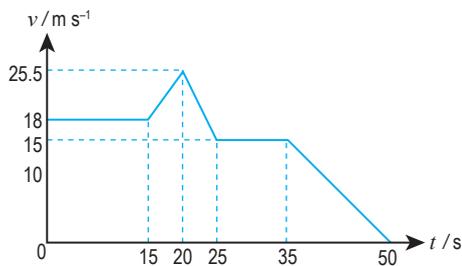
$$= 12 \text{ N}$$

6. $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$$\frac{10}{1\,000} v + 2 \times (-0.5) = 0$$

$$v = 100 \text{ m s}^{-1}$$

- 7.

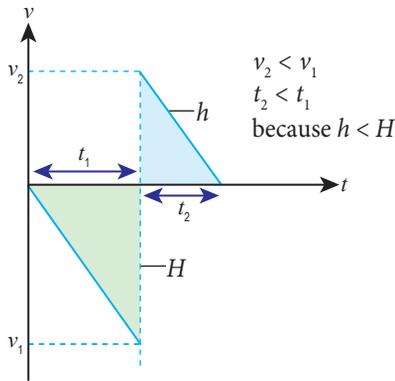


$$\text{Use } v = u + at$$

$$= 18 + (1.5 \times 5)$$

$$= 25.5 \text{ m s}^{-1}$$

8.



9. (a) Acceleration = gradient of graph

$$\begin{aligned} \text{Acceleration of car, } a &= \frac{20}{10} \\ &= 2 \text{ m s}^{-2} \end{aligned}$$

To find the time taken for the car to achieve the speed of the bus = 15 m s^{-1} , use the equation

$$\begin{aligned} v &= u + at \\ 15 &= 0 + 2t \\ t &= 7.5 \text{ s} \end{aligned}$$

(b) Use $s = ut + \frac{1}{2}at^2$

$$\begin{aligned} &= 0 + \frac{1}{2}(2)(7.5)^2 \\ &= 56.25 \text{ m} \end{aligned}$$

(c) To find the distance travelled in time $t = 50 \text{ s} \rightarrow$ Distance = area below the graph

For car,

$$\begin{aligned} x_c &= \text{Area of trapezium} \\ &= \frac{1}{2}(40 + 50)20 \\ &= 900 \text{ m} \end{aligned}$$

For bus,

$$\begin{aligned} x_b &= \text{Area of rectangle} \\ &= 50 \times 15 \\ &= 750 \text{ m} \end{aligned}$$

(d) x_c is longer than x_b , therefore the car is in front of the bus

Distance separating the car from the bus

$$\begin{aligned} x &= x_c - x_b \\ &= 900 - 750 \\ &= 150 \text{ m} \end{aligned}$$

10. (a) Before the launch, the rocket carrying a spacecraft is at rest at the launch pad with zero momentum.

During the launch, a large amount of fast moving hot gases is released through the exhaust. This creates/cause high downward momentum. According to the principle of conservation of momentum, an equally high but opposite momentum is produced. Hence an upthrust gives an acceleration to the rocket.

(b) Acceleration of the rocket can be increased by reducing the mass of the rocket.

11. (a) $F = ma$

$$22\,000 = 25\,000a$$

Initial acceleration of hovercraft, $a = 0.88 \text{ m s}^{-2}$

(b) The layer of air trapped under the hovercraft will reduce friction between the base of the hovercraft and the water surface. As such, the hovercraft can move more quickly.

Enrichment Corner (Suggested answer)

12. – Table tennis ball is not suitable to be used in this experiment.
- Table tennis ball is very light.
 - Motion of table tennis ball is easily influenced by air resistance.
 - Therefore, table tennis ball will not fall under free fall condition.
13. – Sketch based on pupil's creativity.
- Shape of fast train should be streamlined, especially its front part has to be pointed and curved so that it has an aerodynamic shape to reduce air resistance.
 - The body of the train must be made from a material of small density so that its overall mass is light and can produce a high acceleration for the same thrust of the engine.
($F = ma$, for the same F , when m is small, then a is large).
 - An electromagnetic system which produces the same magnetic poles between the platform and the bottom of the fast train to levitate the train above the platform.
 - The train needs to be equipped with safety belts and head rests to avoid or reduce injuries due to accident.
 - Fuel used by the train should be environmentally friendly. For example, electrical energy that is generated from renewable energy.

Chapter 3 Gravitation

Performance Evaluation

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

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

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

- (b) Gravitational force acts as centripetal force

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

Cancel m ,

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

Substitute $v = \frac{2\pi r}{T}$,

$$\frac{GM}{r^2} = \frac{1}{r} \left(\frac{2\pi r}{T} \right)^2$$
$$= \frac{1}{r} \left(\frac{4\pi^2 r^2}{T^2} \right)$$
$$M = \frac{4\pi^2 r^3}{GT^2}$$

- (c) 1 day = 24 hrs, 1 hr = 3600 s

$$T = 687 \text{ days}$$

$$= (687 \times 24 \times 3600) \text{ s}$$

$$M = \frac{4\pi^2 (2.28 \times 10^{11})^3}{(6.67 \times 10^{-11})(687 \times 24 \times 3600)^2}$$
$$= 1.99 \times 10^{30} \text{ kg}$$

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

- (b) Gravitational force between satellite and the Earth $F = \frac{GMm}{r^2}$, where M is the mass of the Earth
Centripetal force = Gravitational force

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

Cancel mass of satellite, m

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

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

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

- (c) Satellites fall freely around the Earth with a central acceleration equal to the acceleration of gravity. The acceleration of gravity does not depend on the mass of the object.
3. Keplers' Second Law states that a line connecting a planet to the Sun sweep out equal areas in equal times. The shorter the distance of a planet from the Sun, the faster the velocity of the planet. From A to B, the speed of planet Uranus increases to a maximum value and then decreases again.
4. (a) Satellite and the Moon as a pair.
The result from the multiplication of the mass of the pair is the smallest. Distance separating the pair is the largest.

(b) $F = \frac{GMm}{r^2}$

$$= \frac{(6.67 \times 10^{-11}) \times (5.97 \times 10^{24}) \times (1.2 \times 10^3)}{(7.87 \times 10^6)^2}$$

$$= 7.71 \times 10^3 \text{ N}$$

5. (a) – Mass of the Earth
– Distance from the centre of the Earth

(b) $g = \frac{GM}{r^2}$

$$= \frac{(6.67 \times 10^{-11}) \times (5.97 \times 10^{24})}{(4.20 \times 10^7)^2}$$

$$= 0.23 \text{ m s}^{-2}$$

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

- (b) Orbital period of the Earth, $T_1 = 365$ days, orbital period of Neptune, $T_2 = 5.98 \times 10^4$ days
Orbital radius of the Earth, $r_1 = 1.50 \times 10^{11}$ m, orbital radius of Neptune = r_2

$$\frac{T_1^2}{T_2^2} = \frac{r_1^3}{r_2^3}$$

$$\frac{365^2}{(5.98 \times 10^4)^2} = \frac{(1.50 \times 10^{11})^3}{r_2^3}$$

$$r_2^3 = \frac{(1.50 \times 10^{11})^3 \times (5.98 \times 10^4)^2}{365^2}$$

$$r_2 = \sqrt[3]{\frac{(1.50 \times 10^{11})^3 \times (5.98 \times 10^4)^2}{365^2}}$$

$$= 4.49 \times 10^{12} \text{ m}$$

7. Orbital period of the Earth, $T_1 = 1.00$ year, orbital period of Saturn = T_2
 Orbital radius of the Earth, $r_1 = 1.50 \times 10^{11}$ m, orbital radius of Saturn, $r_2 = 1.43 \times 10^{12}$ m

$$\frac{T_1^2}{T_2^2} = \frac{r_1^3}{r_2^3}$$

$$\frac{1.00^2}{T_2^2} = \frac{(1.50 \times 10^{11})^3}{(1.43 \times 10^{12})^3}$$

$$T_2^2 = \frac{1.00^2 \times (1.43 \times 10^{12})^3}{(1.50 \times 10^{11})^3}$$

$$T_2 = \sqrt{\frac{1.00^2 \times (1.43 \times 10^{12})^3}{(1.50 \times 10^{11})^3}}$$

$$= 29.44 \text{ years}$$

8. Escape velocity, $v = \sqrt{\frac{2GM}{(R+h)}}$

$$= \sqrt{\frac{2 \times (6.67 \times 10^{-11}) \times (5.97 \times 10^{24})}{(6.37 \times 10^6 + 1\,600 \times 10^3)}}$$

$$= 9\,996 \text{ m s}^{-1}$$

9. (a) Escape velocity of Saturn, $v = \sqrt{\frac{2GM}{R}}$

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

$$= 3.54 \times 10^4 \text{ m s}^{-1}$$

(b) It is impossible for these small particles to escape because the escape velocity of the planet is very high.

10. Between A and B: $F_{AB} = \frac{G \times 100 \times 100}{5^2}$

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

$$P = 400G \dots\dots\dots [1]$$

(i) Between B and C: $F_{BC} = \frac{G \times 100 \times 200}{5^2}$

$$F_{BC} = 800G \dots\dots\dots [2]$$

Compare [1] and [2], $F_{BC} = 2P$

(ii) Between A and C: $F_{AC} = \frac{G \times 100 \times 200}{10^2}$

$$F_{AC} = 200G \dots\dots\dots [3]$$

Compare [1] and [3], $F_{AC} = 0.5P$

11. Gravitational force acts as centripetal force

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

Cancel m , $\frac{GM}{r^2} = \frac{v^2}{r}$

Substitute $v = \frac{2\pi r}{T}$, $\frac{GM}{r^2} = \frac{1}{r} \left(\frac{2\pi r}{T} \right)^2$

$$\frac{GM}{r^2} = \frac{1}{r} \left(\frac{4\pi^2 r^2}{T^2} \right)$$

$$\begin{aligned} \text{Period of orbit of satellite, } T &= \frac{4\pi^2 r^3}{GM} \\ &= \sqrt{\frac{4\pi^2 (R+h)^3}{GM}} \\ \text{Orbit X: } T &= \sqrt{\frac{4\pi^2 [(6.37 \times 10^6) + (6.70 \times 10^3)]^3}{(6.67 \times 10^{-11}) \times (5.97 \times 10^{24})}} \\ &= 5.070 \times 10^3 \text{ s} \\ &= 1.41 \text{ hours} \end{aligned}$$

Satellite P is an imaging satellite with the following features:

- (i) Orbital height is small so that clear photographs can be taken of the surface of the Earth.
- (ii) Orbital period is less than 24 hours so that it can orbit the Earth several times a day. The satellite will be at different locations above the surface of the Earth and can take photographs in many different places.
- (iii) Elliptical shaped orbit so that near and far photographs can be taken.
 - Therefore, satellite P needs to be placed in orbit X.

Satellite Q is a communication satellite with the following features:

- (i) Orbital period of 24 hours so as to rotate together with the Earth and maintain at the same location above the surface of the Earth. This satellite can receive and transmit communication signals to stations on Earth.
- (ii) Round orbit so that its height from the surface of the Earth is constant.
 - Therefore, satellite Q needs to be placed in orbit Y.

12. (a) Gravitational acceleration of a planet is calculated using the formula: $g = \frac{GM}{R^2}$

Escape velocity of a planet is calculated using the formula: $v = \sqrt{\frac{2GM}{R}}$

Orbital period of a planet is calculated using the formula: $T = \sqrt{\frac{4\pi^2 r^3}{GM}}$

The table below shows the gravitational acceleration, escape velocity and orbital period of each planet.

Body	Mass/ kg	Radius of body/ m	Radius of orbit / m	Gravitational acceleration / m s ⁻²	Escape velocity / m s ⁻¹	Orbital period / years
Star	5.90×10^{29}	6.96×10^8	–	–	–	–
Planet A	2.80×10^{22}	1.07×10^6	2.86×10^{10}	1.63	1.87×10^3	0.15
Planet B	6.30×10^{23}	2.30×10^6	9.85×10^{10}	7.94	6.04×10^3	0.98
Planet C	7.40×10^{22}	3.41×10^6	1.15×10^{11}	0.42	1.70×10^3	1.24
Planet D	4.60×10^{25}	1.32×10^7	5.32×10^{11}	17.61	2.16×10^4	12.32
Planet E	1.90×10^{21}	2.42×10^5	2.13×10^{12}	2.16	1.02×10^3	98.73

- (b) – Value of g will determine the body weight of humans. A value of g that is too small or large will cause the blood circulatory system and fluids as well as internal organs in the human body to not function normally.
 - A high enough escape velocity will ensure a planet has an atmosphere that is thick enough for human needs.
 - Orbital period will determine changes in weather and season cycles. A period that is too short causes changes to happen too quickly and is not suitable for plants. On the other hand, too long a period causes each season to last for too long. For example, summers or winters that are too long.

- (c) Gravitational acceleration of Earth, $g = 9.81 \text{ m s}^{-2}$.
 Escape velocity of Earth is $1.12 \times 10^4 \text{ m s}^{-1}$
 Orbital period of Earth around the Sun is 1.00 year.
- Planet *B* has a gravitational acceleration closest to that of Earth.
 - Humans can live comfortably with a few adjustments.
 - Escape velocity of Planet *B* is not too small compared to the escape velocity of Earth.
 - There is a high possibility that the layer of atmosphere of Planet *B* is thick and dense enough for human needs.
 - Orbital period of Planet *B* is about the same as that of Earth.
 - Planet *B* is chosen to be inhabited by humans.

Enrichment Corner

13. – The atmosphere of Mars is about 100 times thinner than the atmosphere of Earth. Satellites can orbit closer to the surface of Mars as compared to Earth and still not experience a large resistance.
- Weather forecasting satellites and imaging satellites need to be in a lower orbit of shorter orbital period than the period of revolution of Mars.
 - Communication satellites need to have the same orbital period as the period of revolution of Mars.

Formula used is:

$$\text{Velocity of satellite: } v = \sqrt{\frac{GM}{(R + h)}}$$

Orbital period around Mars:

$$T = \sqrt{\frac{4\pi^2 r^3}{GM}}$$

$$T = \sqrt{\frac{4\pi^2 (R + h)^3}{GM}}$$

Suggestion for weather forecasting satellite:

Orbital height, $h = 200 \text{ km} = 2.00 \times 10^5 \text{ m}$

$$\begin{aligned} \text{Velocity of satellite, } v &= \sqrt{\frac{(6.67 \times 10^{-11}) \times (6.42 \times 10^{23})}{(3.40 \times 10^6 + 2.00 \times 10^5)}} \\ &= 3.45 \times 10^3 \text{ m s}^{-1} \end{aligned}$$

$$\begin{aligned} \text{Orbital period, } T &= \sqrt{\frac{4\pi^2 (3.40 \times 10^6 + 2.00 \times 10^5)^3}{(6.67 \times 10^{-11}) \times (6.42 \times 10^{23})}} \\ &= 6.558 \times 10^3 \text{ s} \\ &= 1.82 \text{ hours} \end{aligned}$$

Suggestion for imaging satellite:

Orbital height that is slightly more than that of weather forecasting satellite, $h = 250 \text{ km} = 2.50 \times 10^5 \text{ m}$

$$\begin{aligned} \text{Velocity of satellite, } v &= \sqrt{\frac{(6.67 \times 10^{-11}) \times (6.42 \times 10^{23})}{(3.40 \times 10^6 + 2.50 \times 10^5)}} \\ &= 3.43 \times 10^3 \text{ m s}^{-1} \end{aligned}$$

$$\begin{aligned} \text{Orbital period, } T &= \sqrt{\frac{4\pi^2 (3.40 \times 10^6 + 2.50 \times 10^5)^3}{(6.67 \times 10^{-11}) \times (6.42 \times 10^{23})}} \\ &= 6.696 \times 10^3 \text{ s} \\ &= 1.86 \text{ hours} \end{aligned}$$

Suggestion for communications satellite:

Orbital period, $T = 24.6 \text{ hours}$

Direction of motion of orbit is the same as the direction of rotation of Mars.

Orbit above the equator of Mars. Orbital height is calculated using the formula

$$T = \sqrt{\frac{4\pi^2 r^3}{GM}}$$

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

$$r^3 = \frac{GMT^2}{4\pi^2}, \text{ i.e. } T = 24.6 \text{ hours}$$

$$= \frac{(6.67 \times 10^{-11}) \times (6.42 \times 10^{23}) \times (24.6 \times 3600)^2}{4\pi^2}$$

$$= \sqrt[3]{\frac{(6.67 \times 10^{-11}) \times (6.42 \times 10^{23}) \times (24.6 \times 3600)^2}{4\pi^2}}$$

$$r = 2.04 \times 10^7 \text{ m}$$

$$\text{Orbital height, } h = r - R$$

$$= 2.04 \times 10^7 - 3.40 \times 10^6$$

$$= 1.70 \times 10^7 \text{ m}$$

$$\text{Velocity of satellite, } v = \sqrt{\frac{(6.67 \times 10^{-11}) \times (6.42 \times 10^{23})}{(3.40 \times 10^6 + 1.70 \times 10^7)}} = 1.45 \times 10^3 \text{ m s}^{-1}$$

All three satellites are launched from a base close to the equator of Mars so that the distance traveled to the desired orbit is shorter. This saves on fuel consumption. Time of motion in the atmosphere is also shorter.

Chapter 4 Heat

Performance Evaluation

- Heat is absorbed or released during changes of phase without any change in temperature.
 - When steam is condensed into water, latent heat is released to heat up the water.
 - Rapid heating.
– Direct heating of water, that is without wasting heat to heat up the container.
- (c) ✓
- Block A.
 - Block B. The block with a lower specific heat capacity experiences a higher increase in temperature.
- Specific latent heat is the quantity of heat absorbed or released by 1 kg of a substance during a change in its phase without any change in its temperature.
 - $Q = ml$
 $= 0.68 \times 3.34 \times 10^5$
 $= 2.27 \times 10^5 \text{ J}$
- Specific latent heat of vaporisation, l_v of a substance is the quantity of heat absorbed by 1 kg of the substance when boiling or the quantity of heat released by 1 kg of the substance when condensing without any change in its temperature.
 - Mass of water, $m = 480 - 200$
 $= 280 \text{ g}$
 $= 0.28 \text{ kg}$
 - $Q = ml$
 $Pt = ml$
 $1800 \times (710 - 360) = 0.28 \times l$
 $l = 2.25 \times 10^6 \text{ J kg}^{-1}$
- $m = 5.5 \text{ g}$
 $= 5.5 \times 10^{-3} \text{ kg}$
 $Q = mc\theta$
 $= (5.5 \times 10^{-3})(300)(3)$
 $= 4.95 \text{ J}$

7. (a) 2 200 W
 (b) $Q = ml$
 $Pt = ml$
 $2\,200 \times t = 0.5 \times 2.26 \times 10^6$
 $t = 513.6 \text{ s}$
 (c) – All heat supplied by the heating element of the kettle is absorbed by the boiling water.
 – No heat is lost to the surroundings.
8. (a) Gay-Lussac's Law formula: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$$\frac{220}{(27 + 273)} = \frac{P_2}{(87 + 273)}$$

 $P_2 = 264 \text{ kPa}$
 (b) Volume of tyre remains unchanged.
9. (a) Charles' Law formula: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

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

 $V_2 = 3.82 \text{ cm}^3$
 (b) – Mass of the trapped air remains unchanged.
 – Pressure of the trapped air is constant.
 – Trapped air and water are in thermal equilibrium. The temperatures of water and air are the same.
10. (a) Specific latent heat of fusion, l_f of a substance is the quantity of heat absorbed by 1 kg of the substance when melting or the quantity of heat released by 1 kg of the substance when freezing without any change in its temperature.
 (b) Heat absorbed does not increase the average kinetic energy of the molecules. This heat is used to weaken the bonds between the molecules of ice.
 (c) (i) $Q = Pt$
 $= 500 \times 80$
 $= 40\,000 \text{ J}$
 (ii) $Q = ml$
 $40\,000 = m \times 3.34 \times 10^5$
 $m = 0.12 \text{ kg}$
 (d) – All the heat absorbed by the ice is supplied by the immersion heater. No heat is lost to the surroundings.
 – The ice does not absorb heat from the surroundings.
11. (a) (i) $Q = mc\theta$
 $= (0.5)(4200)(100 - 30)$
 $= 147\,000 \text{ J}$
 (ii) $Pt = Q$
 $t = \frac{Q}{P}$
 $= \frac{147\,000}{800}$
 $= 183.75 \text{ s}$
 (b) Plastics have high specific heat capacities and are heat insulators.
 (c) Metals have low specific heat capacities and are good heat conductors.
 (d) Water rises when heated and cold water sinks through convection. So, all the water is heated. Therefore, the heating element of a kettle is fitted at the base of the kettle.

$$\begin{aligned}
 12. (a) \quad c &= \frac{Q}{m\theta} \\
 &= \frac{5\,625}{(0.25)(25)} \\
 &= 900 \text{ J kg}^{-1} \text{ }^\circ\text{C}
 \end{aligned}$$

Referring to Table 4.2, the said substance is aluminium

- (b) Aluminium has a low specific heat capacity and is a good conductor of heat. Therefore, aluminium is suitable for making cooking utensils.

13. Suggested design	Explanation
Steamer made of stainless steel	Will not rust and can be used for a long time
Steamer of larger diameter	More buns can fit in
Cone shaped cover	<ul style="list-style-type: none"> - Traps steam so that steam is not lost to the surroundings - Prevents condensed steam from wetting the buns
Bottom of steamer able to contain larger volume of water	<ul style="list-style-type: none"> - More latent heat is released during condensation of the larger volume of steam when the water boils - Buns are steamed in a short time

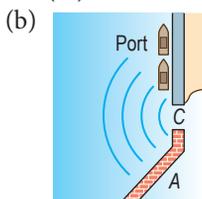
Enrichment Corner

14. (a) Suitability of method A
- Ice around the base of the cup absorbs latent heat from the cup and saucer. Temperature of cup and saucer drops. Heat flows from the hot coffee through the walls of the cup to the melting ice. In this way, the coffee is cooled.
 - This process is slow because it involves flow of heat through the walls of the cup.
 - Water from the melting ice is outside the cup and does not dilute the coffee.
- Suitability of method B
- Ice in the coffee absorbs latent heat directly from the coffee.
 - The coffee loses a large amount of heat and is cooled quickly. Quantity of ice needed is not as much compared to method A.
 - Water from the melting ice will mix with the coffee and change its taste.
- (b) I choose method A.
- Method A can cool the milk coffee without changing its taste.
 - Method B not only cools the milk coffee but also changes its taste.

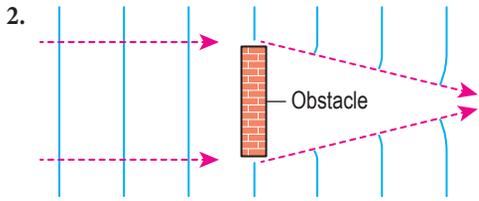
Chapter 5 Waves

Performance Evaluation

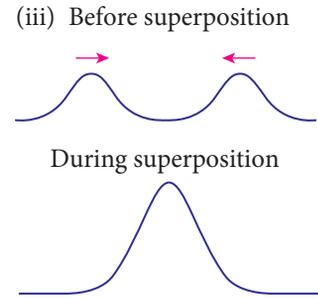
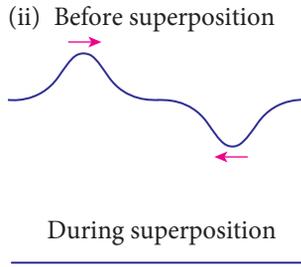
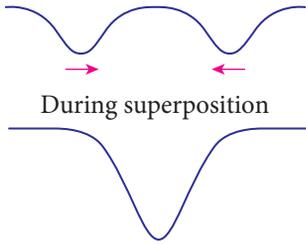
1. (a) (i) Reflection
(ii) Refraction
(iii) Diffraction



- (c) Less diffraction and higher amplitude compare to diffraction through narrow entrance.



3. (a) – Same frequency
 – Constant phase difference
 (b) (i) Q, S
 (ii) P, R
 (c) (i) Before superposition



4. (a) Superposition of waves/Interference
 (b) Bright fringes are formed when waves undergo constructive interference.
 Dark fringes are formed when waves undergo destructive interference.

(c) $\lambda = \frac{ax}{D}$
 $= \frac{0.30 \times 10^{-3} \times 4.0 \times 10^{-3}}{2.70}$
 $= 4.44 \times 10^{-7} \text{ m}$

5. (a) Amplitude = 15 cm, Period = $\frac{1}{f} = \frac{1}{5} = 0.2 \text{ s}$, wavelength = $\frac{1.2}{2} = 0.6 \text{ m}$

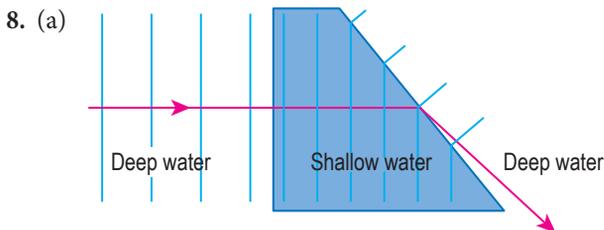
(b) $v = f\lambda$
 $l = \frac{1.2 \text{ m}}{2} = 0.6 \text{ m}, f = 5 \text{ Hz}$
 $v = 5 \times 0.6 = 3.0 \text{ m s}^{-1}$

6. $f = 500 \text{ Hz}, \lambda = 0.67 \text{ m}$
 $v = f\lambda = 500 \times 0.67 = 335 \text{ m s}^{-1}$

7. (a) Amplitude = $\frac{0.5}{2} = 0.25 \text{ cm}$

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

(c) $f = 440 \text{ Hz}$
 $v = f\lambda = 440 \times 75 = 33\,000 \text{ cm s}^{-1}$



$$(b) \frac{v_1}{\lambda_1} = \frac{v_2}{\lambda_2}$$

$$\frac{4}{2} = \frac{9}{\lambda_2}$$

$$\lambda_2 = 4.5 \text{ m}$$

9. (a) Amplitude decreases.
 (b) Damping.
 (c) Air resistance opposes the motion of the pendulum.
 (d) Applying periodic force of the same frequency as the natural frequency of the simple pendulum.

10. Blue – Pattern A
 Green – Pattern C
 Red – Pattern B

$$\lambda = \frac{ax}{D}$$

$$\text{Therefore, } x = \frac{\lambda D}{a}$$

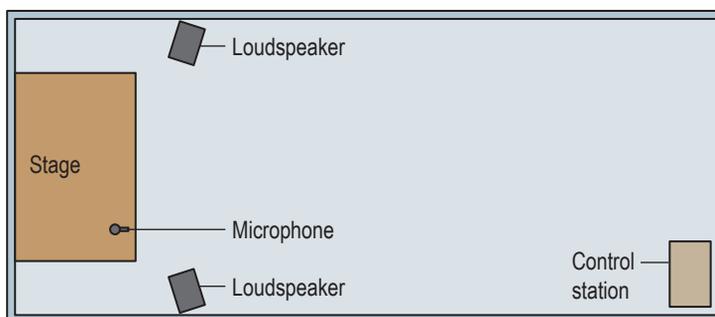
As such, the separation distance between adjacent bright fringes, x is directly proportional to the wavelength, λ . Blue light with the shortest wavelength produces bright fringes that are closest together. Red light with the longest wavelength produces bright fringes that are furthest apart.

11. (a) Microwave is used to carry information.
 Microwave is an electromagnetic wave which moves at the same speed as light and does not need a medium for its propagation.
 (b) Microwave has a much higher frequency than radio wave and can penetrate atmosphere without much loss of energy.
 (c) Launch a communications satellite in geostationary orbit to receive signals from transmitting station and send signals to receiving station.
 The location of the satellite in the geostationary orbit has to be between the transmitting station and receiving station.
 (d) Transmitter and receiver should be located in a high and open space so that waves sent and received do not experience reflection or diffraction due to obstructing objects nearby.

Enrichment Corner

12.	Adjustments	Explanation
	Build an embankment that has a gap at the river estuary	Enables diffraction to occur to reduce the amplitude of water waves which enter the river estuary. This will ensure 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 sea waves of high amplitude from entering the estuary.
	Build a wall of rocks or concrete with holes all along the beach near the river estuary	Diffraction decreases the energy carried by sea waves to reduce erosion of the beach.
	Deepen the river estuary	Produces a large wavelength of low amplitude. Ensures docked ships are stationary and not rolling and pitching.
	Widen the river estuary	Widens the passage for ships.

13.



- Loudspeakers should be installed in a high location and inclined slightly to face the audience. Sound from the loudspeaker will not face any obstruction and can travel to the back portion of the hall.
- The loudspeakers should be far apart, so the distance between 2 adjacent nodes, $x = \frac{\lambda D}{a}$ is small. This reduces soft sound regions cause by destructive interference.
- Microphone should be placed behind the loudspeakers. Sound from the loudspeakers will not propagate directly to the microphone and is not amplified repeatedly to cause noise.
- Control station should be located at the back of the hall. Person in charge can hear the same sounds as the audience. Detailed adjustment can be made to improve the quality of sound. He can also observe everything that happens on stage.

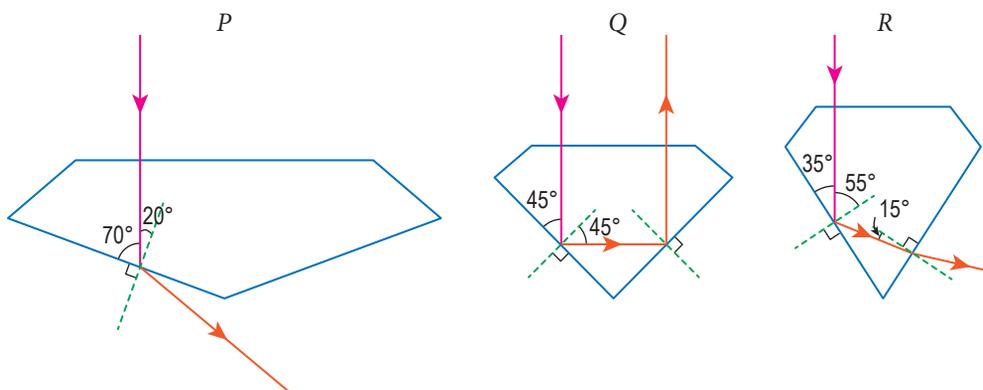
Chapter 6 Light and Optics

Performance Evaluation

- (a) (i) Critical angle is the angle of incidence in an optically denser medium when the angle of refraction is 90° .

- (ii)
$$n = \frac{1}{\sin c} = \frac{1}{\sin 24^\circ} = 2.46$$

(b)

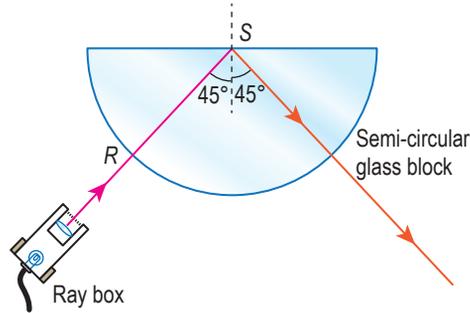


(c) Total internal reflection and refraction of light.

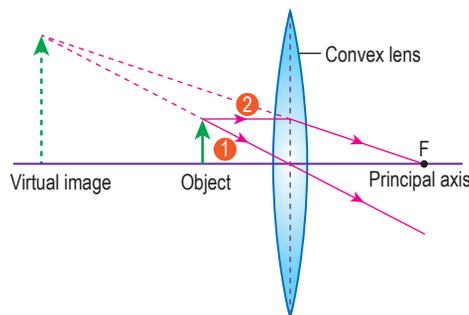
- Distance between object P and its image = $30 - \frac{30}{1.5}$
= 10 cm

- (a) $1.33 = \frac{\sin 55^\circ}{\sin x}$
 $x = 38.02^\circ$

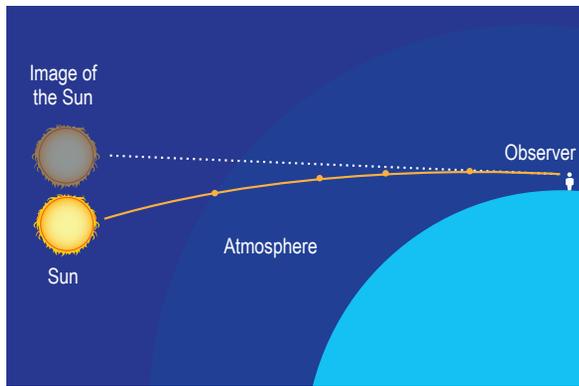
- (b) Speed of light in water = $\frac{3.0 \times 10^8}{1.33}$
 $= 2.26 \times 10^8 \text{ m s}^{-1}$
- (c) Glass has a higher optical density because when light travels from water to glass, the light is refracted towards the normal.
4. (a) RS is the radius of a semi-circle and is the normal to the incident ray at point R , $i = 0$, so $r = 0$.
- (b) $\sin c = \frac{1}{1.52}$
 $c = 41.14^\circ$
- (c)



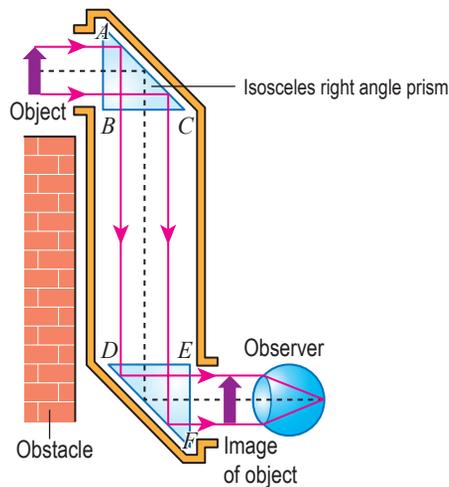
5. (a) (i) $n = \frac{3.0 \times 10^8}{2.9991 \times 10^8} = 1.0003$
- (ii) The value of the refractive index of air is almost equal to 1, that is the speeds of light in air and in vacuum are almost the same.
- (b) The value $\Delta\theta$ on a hot night is different from that on a cold night because the optical density of air depends on temperature.
- (c) Layers of air above the road have different optical density. The layer of air just above the road surface is hotter than the upper layers. The layer of hot air has smaller optical density than cold air. Light which travels from the upper layer to the lower layer is refracted away from the normal repeatedly. When the angle of incidence is larger than the critical angle of air, total internal reflection occurs. Reflected light rays are then refracted towards the normal and reach Rajiv's eyes. Rajiv will see the image of clouds as a puddle of water on the road surface.
6. (a) Upright and magnified
- (b)



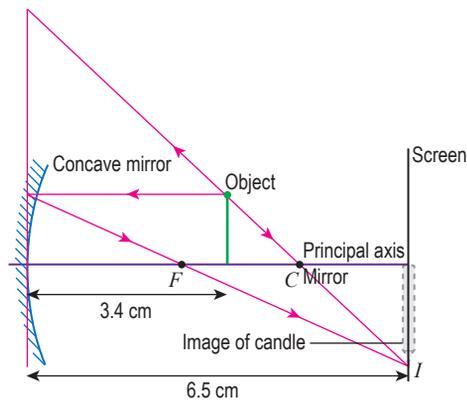
- (c) The image will turn real, inverted, diminished and formed on the opposite side of the lens from the object.
7. (a) The captain's statement is true. The light ray that enters the atmosphere is refracted by the layers of air having different optical densities. Therefore, a virtual image of the Sun is formed above the actual position of the Sun.



- (b) The light rays from the object travel towards the side AB of the upper prism along the normal to AB through an opening in the periscope. The light ray reaches the side AC without refraction. The angle of incidence is 45° and is larger than the critical angle of the prism, 42° . Therefore, total internal reflection happens at the side AC and the light is reflected downwards. The reflected light ray travels towards the side DE of the lower prism along the normal to DE . Once again, the light ray experiences total internal reflection at the side DF . In the end, the light ray emerges from side EF without refraction and enter the eye of the observer. The final image formed is upright and equal in size to the object.

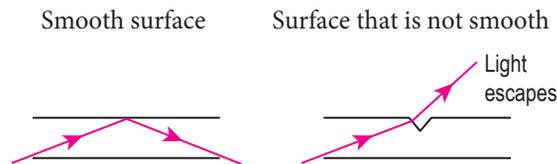


8. (a) (i), (ii)



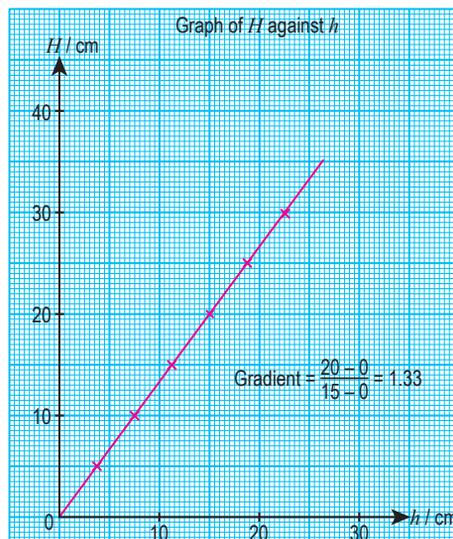
- (b) Move the object closer to the focal point of the mirror with the condition that u is larger than f .

9. (a) Two convex lenses with short focal length are chosen. Objective lens with focal length, f_o and eyepiece lens with focal length, f_e . Focal length f_o is less than focal length f_e . Distance between objective lens and eyepiece lens is larger than $f_o + f_e$. Object distance is between f_o and $2f_o$. Objective lens form the first image, I_1 which is real, inverted and magnified. Image I_1 becomes the object for eyepiece lens. Eyepiece lens functions as a magnifying lens. I_1 is placed between F_o and the optical centre of the eyepiece lens. Eyepiece lens forms the final image, I_2 which is virtual, magnified and still inverted compared with object O .
- (b) The final image is inverted, therefore less suitable to be used to view distant objects on the surface of the Earth.
- (c) Interchange the positions of the objective lens and the eyepiece lens. Then adjust the distance between the objective lens and the eyepiece lens to become $f_o + f_e$.
10. (a) Material I as cladding and material II as core. Refractive index of material I is smaller than refractive index of material II.
- (b) $n_1 = \frac{3.00 \times 10^8}{2.01 \times 10^8} = 1.49$
 $n_2 = \frac{3.00 \times 10^8}{1.96 \times 10^8} = 1.53$
 $n_1 \sin \theta_1 = n_2 \sin \theta_2$
 $1.49 \sin 90^\circ = 1.53 \sin c$
 $c = 76.87^\circ$
- (c) So that all light entering the optical fibre does not escape from places that have depressions (not smooth).

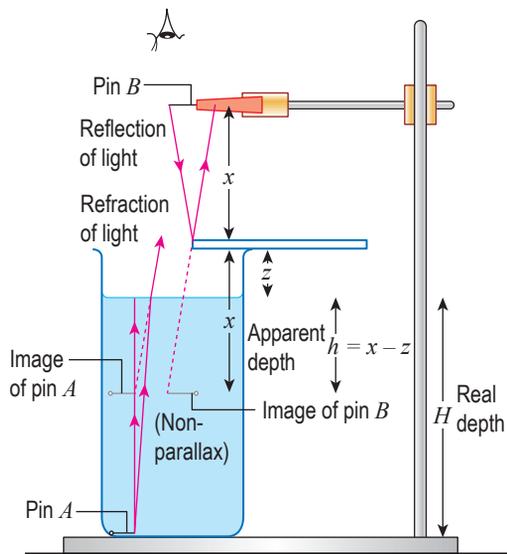


Enrichment Corner

11. (a) Real depth is directly proportional to apparent depth. Gradient of graph is the refractive index of the liquid.



(b)



- (c) Object distance and image distance of a plane mirror are the same, therefore $h + z = x$.
Plane mirror 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.