

Content

Physical quantities and units; measurement techniques

Measurements MCQ.....	3-5
Measurements structured questions.....	6-11

Describing motion

Motion MCQ.....	14-16
Motion structured questions.....	17-21

Forces and motion

Dynamics MCQ.....	22-24
Dynamics structured questions.....	25-31
Scalars and vectors MCQ.....	32-34
Scalars and vectors structured questions.....	35-39
Momentum MCQ.....	40-41
Momentum structured questions.....	42-48

Turning effect on forces

Turning effect – equilibrium and moments MCQ.....	49-51
Turning effect – equilibrium and moments structured questions.....	52-57

Forces and matter

Density MCQ.....	59-61
Density structured questions.....	62-65
Pressure MCQ.....	66-70
Pressure structured questions.....	71-76
Deformations MCQ.....	77-80
Deformations questions.....	81-86

Work, energy and power

Work, energy and power MCQ.....	89-92
Work, energy and power structured questions.....	93-97
Energy resources MCQ.....	98-99
Energy resources structured questions.....	100-106

Thermal Physics

Kinematic model of matter MCQ.....	108-110
Kinetic model of matter structured questions.....	111-115
Specific heat capacity, changing state MCQ.....	116-119
Specific heat capacity, changing states structured questions.....	120-125
Conduction, convection, radiation and temp. measurement MCQ.....	126-129
Conduction, convection, radiation and temp. measurement structured question....	130-136

Waves

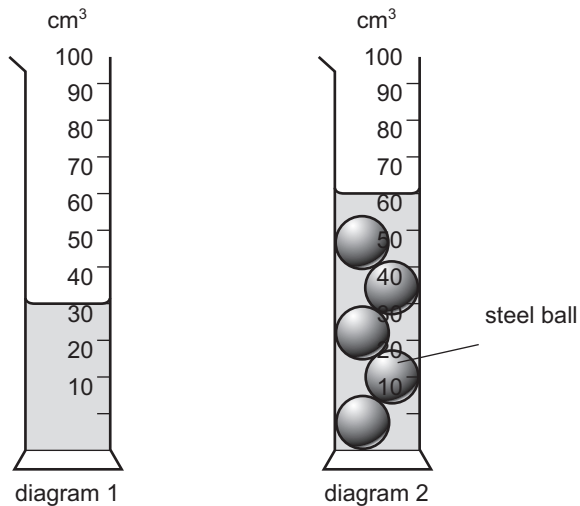
Waves – basic and reflection, refraction and diffraction MCQ.....	139-142
Waves – basic and reflection, refraction and diffraction structured questions.....	143-149
Sound waves MCQ.....	150-152
Sound waves structured questions.....	153-158
Reflection of light MCQ.....	159-161
Reflection of light structured questions.....	162-167
Refraction and dispersion of light MCQ.....	168-170
Refraction and dispersion of light questions.....	171-177
Lenses MCQ.....	178-181
Lenses structured questions.....	182-187
Electromagnetic spectrum MCQ.....	188-190
Electromagnetic spectrum structured questions.....	191-195

Tricky MCQ

Motion.....	196-199
Dynamics.....	200-202
Turning effect.....	203-205
Forces and Matter.....	205-207
Work Energy & Power.....	207-208
Thermal physics.....	209-210
Lenses.....	211-212

Measurements MCQ

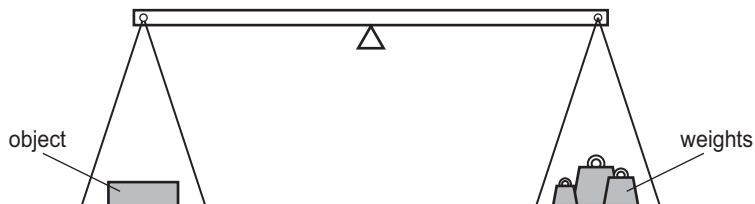
- 1 Diagram 1 shows a measuring cylinder containing water. Five identical steel bars are now lowering the measuring cylinder. Diagram 2 shows the new water level in the cylinder.



What is the volume of each steel ball?

- A 6 cm³ B 14 cm³
C 30 cm³ D 70 cm³

- 2 The weight of an object is found using the balance shown in the diagram. The object is put in the left-hand pan and various weights are put in the right-hand pan.



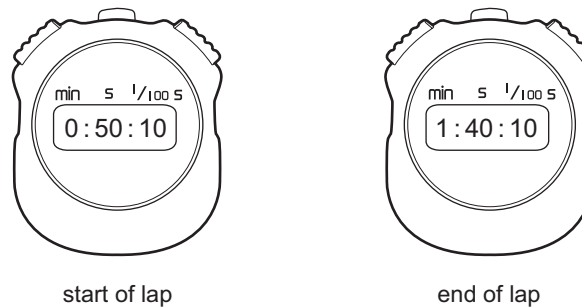
These are the results.

weights in the right-hand pan	effect
0.1 N, 0.1 N, 0.05 N, 0.02 N	balance tips down slightly on the left-hand side
0.2 N, 0.1 N, 0.01 N	balance tips down slightly on the right-hand side

What is the best estimate of the weight of the object?

- A 0.27 N B 0.29 N C 0.31 N D 0.58 N

- 3 A stopwatch is used to time a runner in a race. The diagrams show the stopwatch at the start and at the end of a lap of the race.



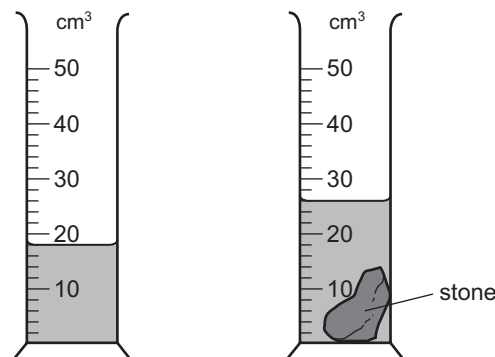
How long did the runner take to finish the lap of the race?

- A 50.00 seconds B 50.10 seconds
C 90.00 seconds D 100.10 seconds

- 4 Which option contains **only** apparatus that could be used to determine the volume of a small block of unknown material?

- A measuring cylinder, metre rule
B measuring cylinder, stopwatch
C metre rule, balance
D metre rule, stopwatch

- 5 The diagram shows a measuring cylinder used to measure the volume of a small stone.



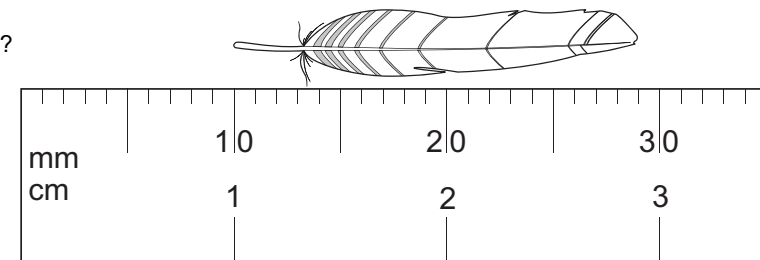
What is the volume of the stone?

- A 8 cm³ B 9 cm³
C 14 cm³ D 26 cm³

- 6 A student uses a measuring cylinder to measure the volume of a quantity of water. Which action would make her result **less** accurate?

- A making sure her eye is level with the water surface
B making sure the cylinder is vertical
C reading the bottom of the meniscus
D using the largest measuring cylinder possible

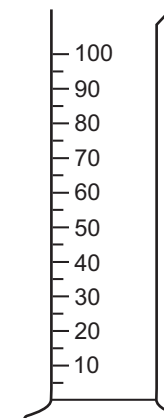
- 7 The diagram shows an enlarged drawing of the end of a metre rule. It is being used to measure the length of a small feather.



What is the length of the feather?

- A 19 mm B 29 mm
C 19 cm D 29 cm

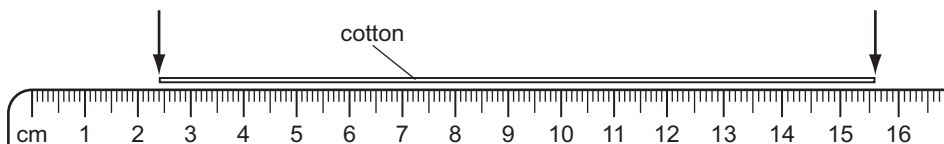
- 8 The diagram shows a measuring cylinder.



Which unit would be most suitable for its scale?

- A mm² B mm³
C cm² D cm³

- 9 A piece of cotton is measured between two points on a ruler.



When the length of cotton is wound closely around a pen, it goes round six times.

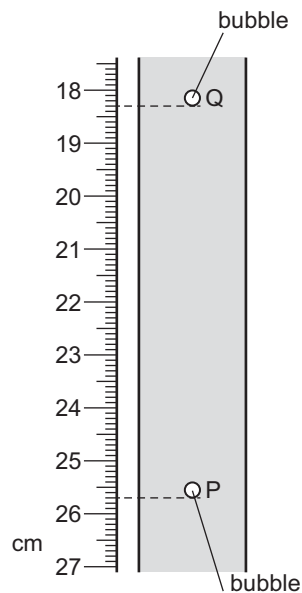


What is the distance once round the pen?

- A 2.2 cm B 2.6 cm C 13.2 cm D 15.6 cm
- 10 What is the most accurate and precise method to measure the thickness of a coin?

- A Use a micrometer screw gauge.
 B Use a ruler and look at the scale perpendicularly.
 C Use a top pan balance.
 D Use the displacement method with water in a measuring cylinder.

- 11 A student determines the average speed of a bubble rising through a liquid at constant speed. When the student starts the stopwatch the bubble is at position P. After 2.0 s the bubble is at position Q.



What is the speed of the bubble between P and Q?

- A 3.2 cm/s B 3.7 cm/s
 C 6.4 cm/s D 7.4 cm/s

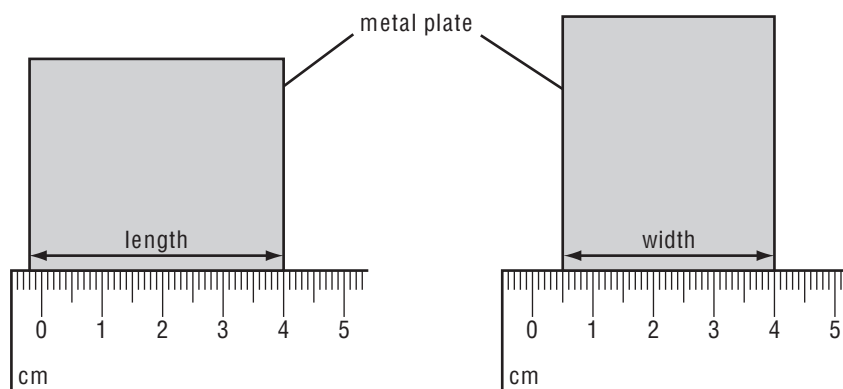
- 12 A pendulum is swinging. Five students each measure the time it takes to swing through ten complete swings.

Three students measure the time as 17.2 s. Another student measures it as 16.9 s, and the fifth student measures it as 17.0 s.

What is the average period of the pendulum?

- A 1.69 s B 1.70 s
 C 1.71 s D 1.72 s

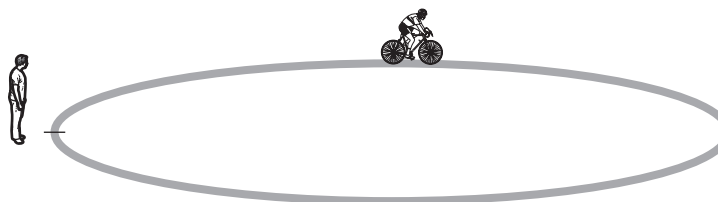
- 13 A student uses a ruler to measure the length and the width of a small rectangular metal plate.



What is the area of the plate?

- A 14.0 cm² B 14.7 cm² C 16.0 cm² D 16.8 cm²

- 14 A cyclist rides round a track three times.



Her friend uses a stopwatch to record the time at the start of the ride, after one circuit, and at the end of the three circuits. The readings from the stopwatch are shown.



at the start



after one circuit

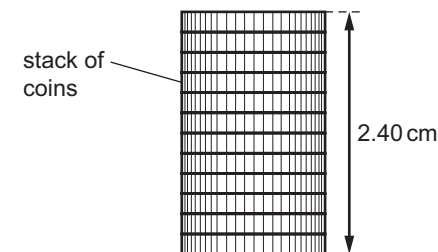


at the end of three circuits

What is the average time for one circuit of the track?

- A 174 s B 180 s
 C 198 s D 200 s

- 15 The diagram shows the height of a stack of identical coins.



What is the thickness of one coin?

- A 0.20 mm B 2.0 mm
 C 0.24 cm D 2.0 cm

- 16 Five athletes P, Q, R, S and T compete in a race.
The table shows the finishing times for the athletes.

athlete	P	Q	R	S	T
finishing time / s	22.50	24.40	25.20	26.50	23.20

Which statement is correct?

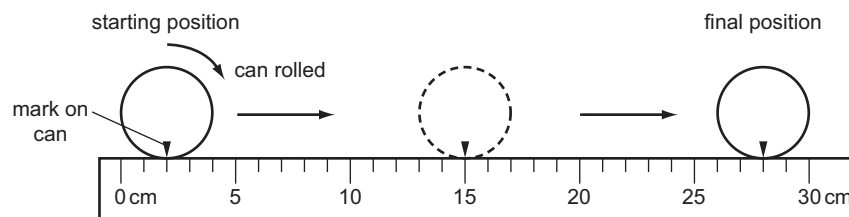
Which statement is correct?

- A** Athlete P won the race and was 0.70s ahead of the athlete in second place.
- B** Athlete P won the race and was 1.90s ahead of the athlete in second place.
- C** Athlete S won the race and was 1.30s ahead of the athlete in second place.
- D** Athlete S won the race and was 2.10s ahead of the athlete in second place.

- 17 Which instrument is used to measure accurately the diameter of a thin metal wire?

- A** 30 cm ruler
- B** measuring tape
- C** metre rule
- D** micrometer screw gauge

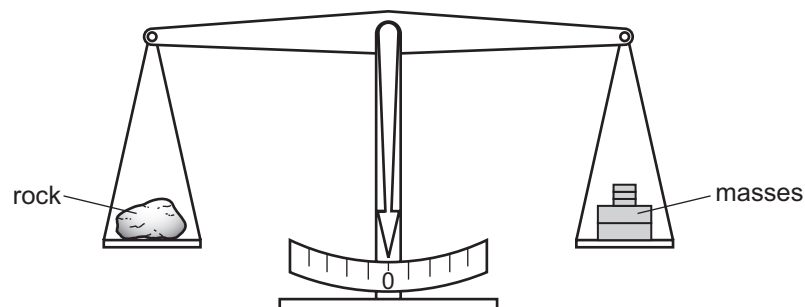
- 18 A cylindrical can is rolled along the ruler shown in the diagram.



The can rolls over twice.

What is the circumference (distance all round) of the can?

- A** 13 cm **B** 14 cm **C** 26 cm **D** 28 cm
- 19 A geologist places a small rock on the left-hand pan of a balance. The two pans are level as shown when masses with a total weight of 23 N are placed on the right-hand pan. Take the weight of 1.0 kg to be 10 N.



What is the mass of the small rock?

- A** 0.023 kg **B** 2.3 kg **C** 23 kg **D** 230 kg
- 20 Which pair contains **only** physical quantities that vary with temperature and so could be used in making a thermometer?
- A** activity of a radioactive source, volume of a gas
- B** mass of a liquid, volume of a liquid
- C** activity of a radioactive source, mass of a solid
- D** volume of a gas, volume of a liquid

Measurements

- 1 A student has a stack of 20 identical coins.

Fig. 1.1 shows the student measuring the height of the stack using a ruler.

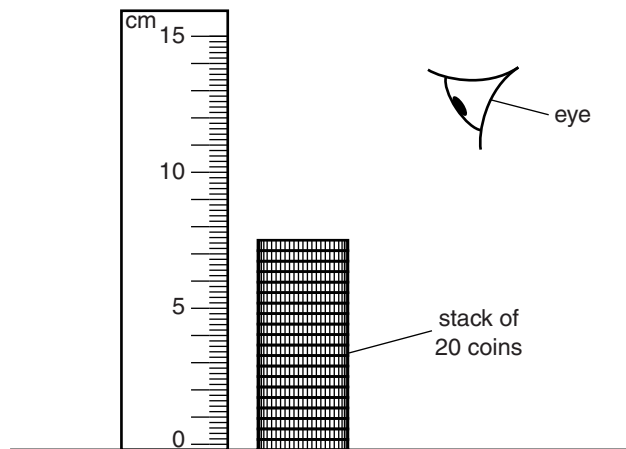


Fig. 1.1

- (a) With his eye at the position shown, the student's measurement of the height of the stack is 6.8 cm.

Suggest two reasons why the student's measurement is inaccurate.

1.
2.

[2]

- (b) Another student correctly determines the height of the stack as 7.7 cm.

Calculate the average thickness of one coin.

thickness = cm [2]

- (c) The mass of a single coin is 12 g.

State this mass in kg.

mass = kg [1]

[Total: 5]

2 In the past, burning candles were used as timers.

A boy carries out an experiment to make his own timer using a burning candle.

Fig. 2.1 shows the length of the candle, and the clock he used, at the start of the experiment and at the end of the experiment.

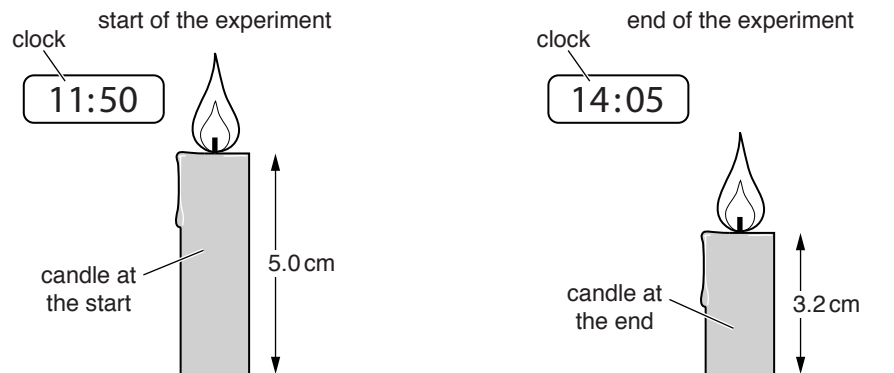


Fig. 2.1 (not to scale)

(a) The candle has a cross-sectional area of 1.6 cm^2 .

Calculate the volume of candle at the start of the experiment.

volume = cm^3 [2]

(b) Use Fig. 2.1 to complete the table.

time at start of the experiment	
time at end of the experiment	
time for which the candle was burning	 hoursminutes = hours

[2]

(c) The difference in the length of the candle from the start to the end of the experiment was 1.8 cm.

Calculate the rate, in cm/hour, at which the candle burns.

rate = cm/hour [2]

(d) The boy estimates that he would need a candle about 24 cm long, of the same material and diameter, to make a candle timer that would last at least one day.

State whether the boy's estimate is correct. Give a reason for your answer.

.....

 [2]

[Total: 8]

3 The period of the vertical oscillations of a mass hanging from a spring is known to be constant.

(a) A student times single oscillations with a stopwatch. In 10 separate measurements, the stopwatch readings were:

1.8s, 1.9s, 1.7s, 1.9s, 1.8s, 1.8s, 1.9s, 1.7s, 1.8s, 1.8s.

What is the best value obtainable from these readings for the time of one oscillation?
Explain how you arrive at your answer.

best value =

explanation

..... [1]

(b) Describe how, using the same stopwatch, the student can find the period of oscillation more accurately.

.....
.....
.....
.....
.....
.....
.....
.....
..... [4]

[Total: 5]

4 Fig 4.1 shows part of a measuring instrument.

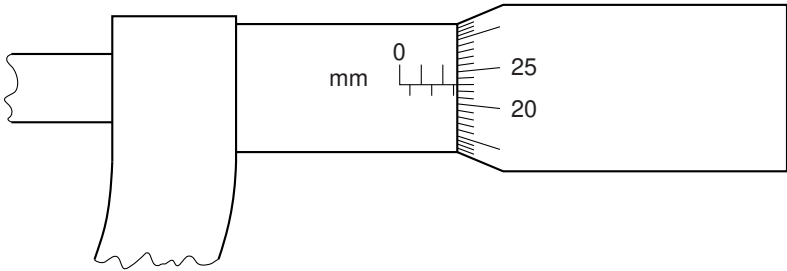


Fig. 4.1

(a) State the name of this instrument.
..... [1]

(b) Record the reading shown in Fig. 4.1.
..... [1]

(c) Describe how you would find the thickness of a sheet of paper used in a magazine.
.....
.....
.....
.....
.....
..... [3]

[Total: 5]

5 An engineering machine has a piston which is going up and down approximately 75 times per minute.

Describe carefully how a stopwatch may be used to find accurately the time for one up-and-down cycle of the piston.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 4]

6 A scientist needs to find the density of a sample of rock whilst down a mine. He has only a spring balance, a measuring cylinder, some water and some thread.

(a) In the space below, draw two labelled diagrams, one to show the spring balance being used and the other to show the measuring cylinder being used with a suitable rock sample. [2]

- (b) The spring balance is calibrated in newtons. State how the mass of the rock sample may be found from the reading of the spring balance.
-[1]
- (c) State the readings that would be taken from the measuring cylinder.
-
-[1]
- (d) State how the volume of the rock would be found from the readings.
-[1]
- (e) State in words the formula that would be used to find the density of the sample.

density = [1]

7 An aluminium rod is cut into a longer section and a shorter section, as shown in Fig. 7.1.



Fig. 7.1

(a) The shorter section of the rod is placed into a measuring cylinder containing water.

Fig. 7.2 shows the appearance of the measuring cylinder before and after this is done.

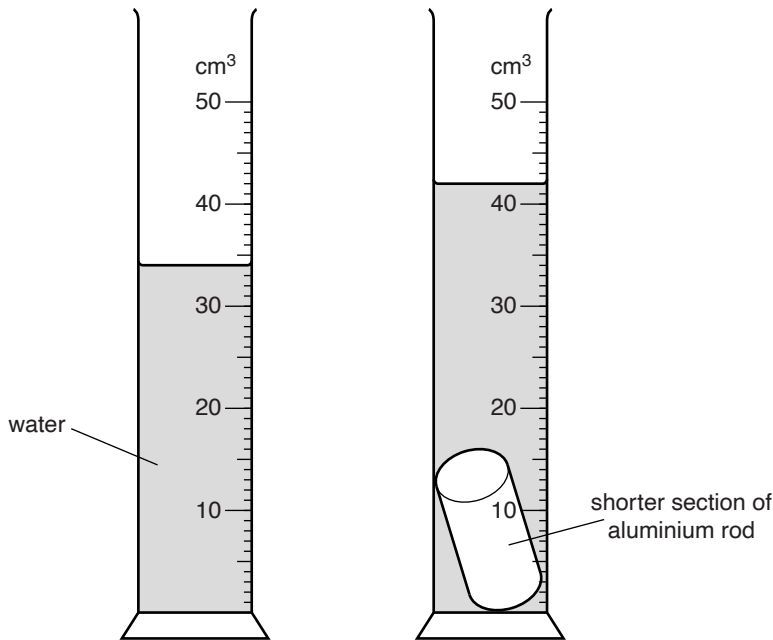


Fig. 7.2 (not full size)

(i) Calculate the volume of the shorter section of aluminium rod.

volume = cm³ [3]

(ii) The mass of this shorter section is measured as 21.2g.

1. Name a laboratory instrument that might have been used to measure this mass.

..... [1]

2. Calculate the density of aluminium.

density = [4]

(b) (i) Name an instrument that could be used to measure the length of the longer section of aluminium rod.

..... [1]

(ii) Suggest a method, different from that in Fig. 7.2, that could be used to determine the volume of this longer section.

.....
.....
.....
..... [2]

[Total: 11]

8 A wind turbine can be seen through the window of the IGCSE Physics class laboratory, as shown in Fig. 8.1.

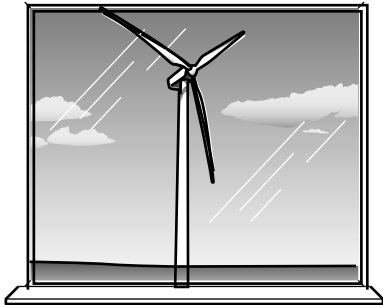


Fig. 8.1

The blades on the wind turbine are turning slowly, so a student uses a laboratory stopclock to time 40 rotations of the blades.

Fig. 8.2 shows the stopclock after 40 rotations of the blades.

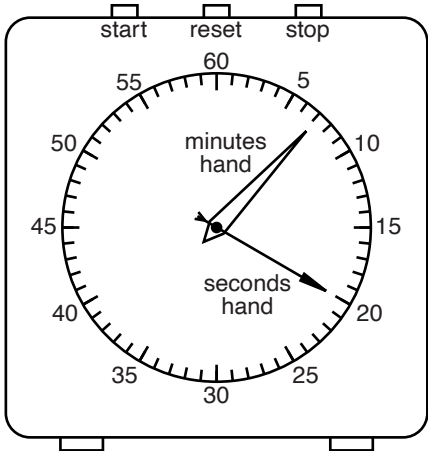


Fig. 8.2

(a) (i) State the reading on the stopclock.

reading = minutes seconds [1]

(ii) Calculate the time, in seconds, for one rotation of the blades.

time for one rotation = s [3]

(b) Later in the day, the blades of the wind turbine are found to take 15 s to rotate once.

The tip of the blade travels in a circle of circumference 75 m.

Calculate the average speed of the tip of the blade.

average speed = m/s [3]

[Total: 7]

Describing Motion; Forces and Motion.

Turning Effect of Forces

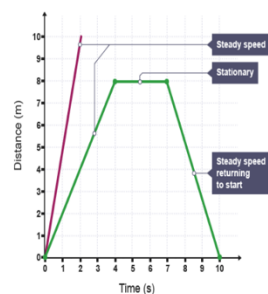
Summary Notes

Movement and position

- Speed is defined as the **distance travelled per unit time**. If the speed of something is changing, it is **accelerating**. The acceleration of free fall near to the Earth is constant.
- $\text{average speed} = \frac{\text{total distance}}{\text{total time}}$
- Velocity is the **speed in a given direction**.
- Acceleration is the **change in velocity per unit time**.
- $\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}} \quad a = \frac{v-u}{t}$
- $(\text{final speed})^2 = (\text{initial speed})^2 + (2 \times \text{acceleration} \times \text{distance}) \quad v^2 = u^2 + 2as$
- Distance is measured in metres (m), time in seconds (s), speed and velocity in metres per second (m/s), and acceleration in metres per second squared (m/s²).

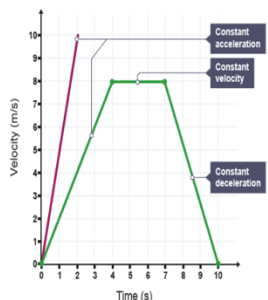
In a distance-time graph:

- The **gradient** is **velocity**
 - Negative gradient is returning back to the starting point
- A horizontal line means it is stationary
- If the distance is zero, it is back at the starting point
- A curved line means that the velocity is changing, and it is accelerating.



In a velocity-time graph:

- The **gradient** is **acceleration**
 - Negative gradient (i.e. negative acceleration) is deceleration
- If the speed is zero, it is at rest
- A horizontal line means constant speed
- The **area** under the line is the **distance** travelled
- A curved line means that the acceleration is changing.



Forces, movement, shape and momentum

Vectors & scalars:

- A **vector** has **magnitude and direction**
- A **scalar** has just a **magnitude**

Examples:

Scalars	Vectors
Distance	Displacement
Speed	Velocity
Time	Acceleration
Energy	Force

Effects of forces:

Forces can change the **speed, shape** or **direction** of a body and they are measured in Newtons (N). There are various different types of forces (e.g. gravitational, electrostatic).

Friction is a force between two surfaces which **impedes motion** and results in **heating**. Air resistance is a form of friction.

To find the resultant of two or more forces acting along the same line, they should be **added** together if in the **same direction** and **subtracted** if in the **opposite direction**.

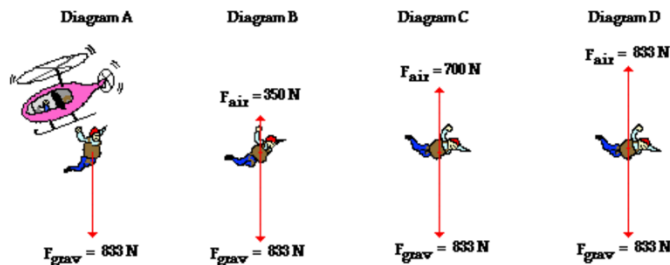
- Newton's first law states that an object has a constant velocity unless acted on by a **resultant force**.
- Newton's second law states that $\text{force} = \text{mass} \times \text{acceleration} \quad F = ma$
- Newton's third law states that **every action force has an equal and opposite reaction force**. For example, the force of the Earth's gravity on an object is equal and opposite to the force of the object's gravity on the Earth.

Mass is a measure of how much matter is in an object, measured in kilograms (kg). **Weight** is a **gravitational force** (the effect of a gravitational field on a mass).

- $\text{weight} = \text{mass} \times \text{gravitational field strength} \quad W = mg$
- The gravitational field strength on Earth is 10N/kg.
- The **weight of an object acts through its centre of gravity**.

For example, motion of a body falling in a uniform gravitational field:

- Initially, there is **no air resistance** and the only force acting on it is **weight**
- As it falls, it **accelerates** which **increases** its speed and hence **air resistance**
- This causes the **resultant force** downwards to **decrease**
- Therefore, the **acceleration decreases**, so it is not speeding up as quickly
- Eventually they are equal and opposite and **balance** so there is **no resultant force**
- So, there is **no acceleration** and the **terminal velocity** is reached



The moment of a force is a measure of its turning effect, measured in Newton metres (Nm).

- $\text{moment} = \text{force} \times \text{perpendicular distance from the pivot}$ $\text{moment} = Fd$
- An object is in equilibrium when the **sum of clockwise moments equals the sum of anticlockwise moments (the principle of moments)** and there is **no resultant force**.
- For a horizontal beam supported at its ends, the upwards forces at the supports change with the position of a heavy object placed on the beam. The nearer the heavy object to a given support, the greater the force at that support.

Source: physicsandmathstutor.com

When a driver notices a hazard:

- The **distance** travelled in the time between the driving **realising he needs to brake** and actually **pressing the brakes** is called the **thinking distance**. Factors which increase the thinking distance include:
 - Greater **speed**
 - Slower reaction time due to **alcohol, tiredness or distractions**. Reaction time can also be increased by **caffeine**, which reduces the thinking distance.
- The distance travelled in the time between **pressing the brakes** and the vehicle **coming to a stop** is called the **braking distance**. Factors which increase the stopping distance include:
 - Greater **speed** or **mass**
 - Poor **road conditions** (icy, wet) or **car conditions** (worn tires, worn brake pads)
- The **stopping distance** is the sum of the thinking distance and braking distance.

The **momentum** of an object is the **product of its mass and velocity**:

- $\text{momentum} = \text{mass} \times \text{velocity}$ $p = mv$
- It is measured in kilogram metres per second (kgm/s).

The **force** exerted on an object is equal to its change in momentum over time:

- $\text{force} = \frac{\text{change in momentum}}{\text{time taken}}$ $F = \frac{mv - mu}{t}$
- Safety features in cars work by **increasing the time taken** for the people in the car **to come to rest** (i.e. there is the **same change in momentum** in a **longer time**, so the **force is reduced**). For example, a **seatbelt** achieves this by **stretching**.

In a collision, the **total momentum before** is **equal to the total momentum afterwards**, known as the **principle of the conservation of momentum**.

For example: a 10kg stationary gun is loaded with a 0.01kg bullet. It is fired, with the bullet travelling at 100m/s. What is the recoil speed of the gun?

$$\text{total momentum before} = 0$$

$$\text{total momentum before} = \text{total momentum afterwards}$$

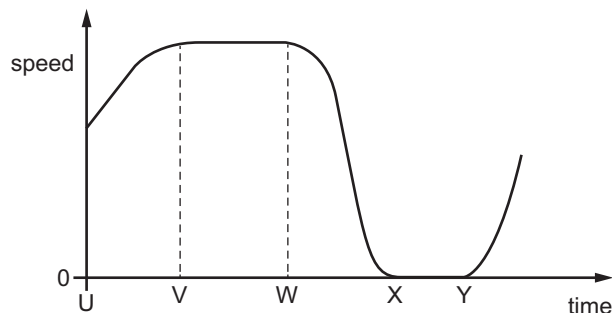
$$0 = 0.01 \times 100 + 10v$$

$$v = -0.1 \text{ m/s}$$

So, the recoil speed is 0.1m/s (-0.1m/s is the velocity which is a vector, so we take the magnitude of it as we are finding the speed).

Motion MCQ

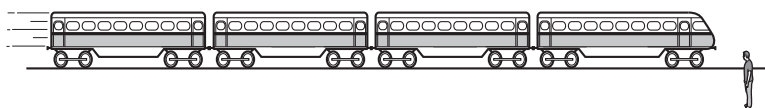
- 1 The graph shows how the speed of a car changes with time.



Between which two times is the car stationary?

- A** U and V **B** V and W
C W and X **D** X and Y

- 2 A man stands by a railway track.

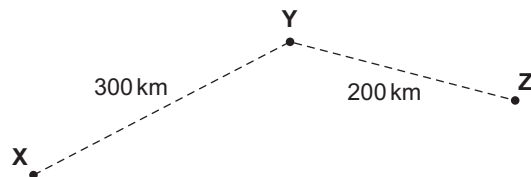


A train travelling at 40 m/s takes 2.0 s to pass the man.

What is the length of the train?

- A** 20 m **B** 38 m
C 40 m **D** 80 m

- 3 An aeroplane flies from town X to town Z, stopping for 1 hour at town Y to pick up more passengers. The distances between the towns are shown in the diagram.

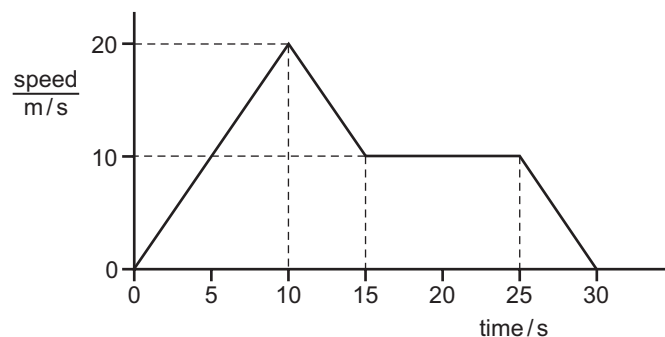


The total time taken between leaving X and arriving at Z is 3 hours.

What is the average speed of the aeroplane **in the air**?

- A** $\frac{500}{4}$ km/h **B** $\frac{500}{3}$ km/h
C $\frac{500}{2}$ km/h **D** $\frac{500}{1}$ km/h

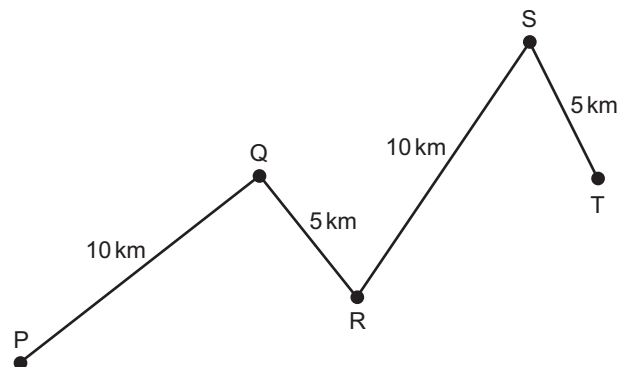
- 4 The graph represents the motion of a car.



What is the distance travelled by the car while it is moving at a constant speed?

- A** 100 m **B** 150 m **C** 250 m **D** 300 m

- 5 A car travels along the route PQRST in 30 minutes.



What is the average speed of the car?

- A** 10 km/hour **B** 20 km/hour
C 30 km/hour **D** 60 km/hour

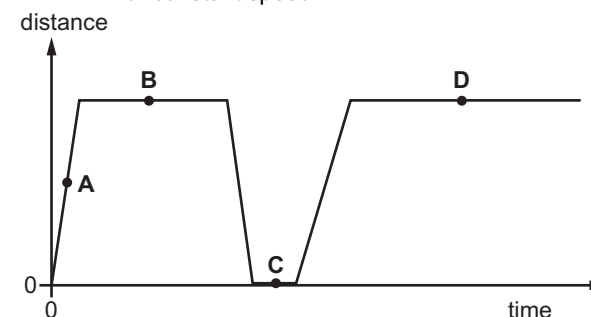
- 6 The table shows the readings on a car speedometer at 5 second intervals.

time/s	speed km/h
0	0
5	30
10	50
15	60
20	65

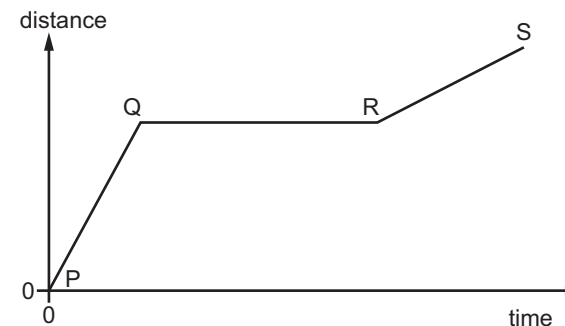
Which row describes the speed and the acceleration of the car?

	speed	acceleration
A	decreasing	zero
B	decreasing	not zero
C	increasing	zero
D	increasing	not zero

- 7 The diagram shows the distance-time graph for a car. At which labelled point is the car moving with constant speed?



- 8 The graph shows how the distance travelled by a vehicle changes with time.

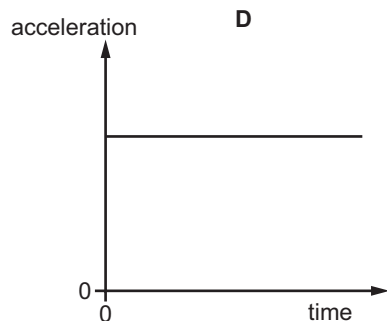
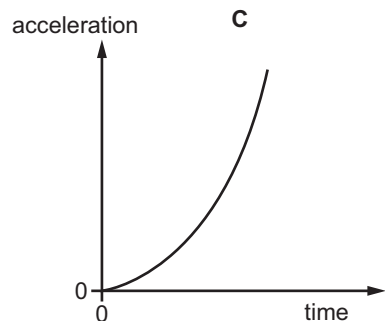
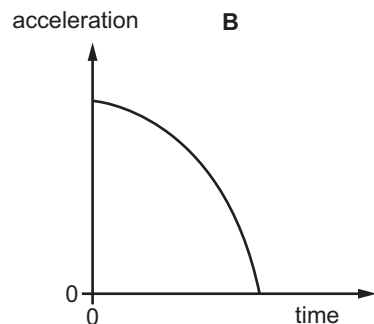
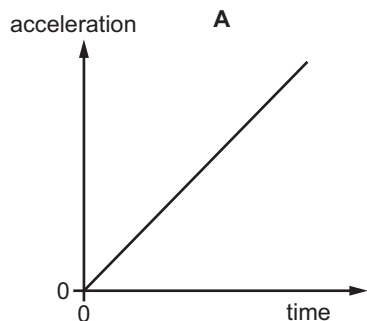


Which row describes the speed of the vehicle in each section of the graph?

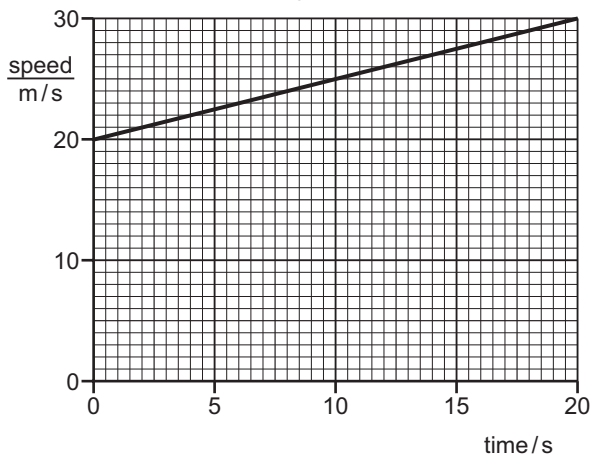
	P to Q	Q to R	R to S
A	constant	zero	constant
B	constant	zero	decreasing
C	increasing	constant	decreasing
D	increasing	zero	constant

- 9 A stone falls freely from the top of a cliff.
Air resistance may be ignored.

Which graph shows how the acceleration of the stone varies with time as it falls?



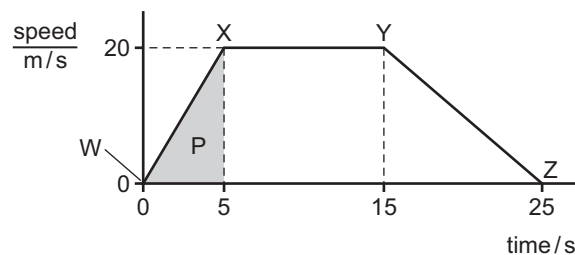
- 10 A car travels along a horizontal road in a straight line.
The driver presses the accelerator to increase the speed of the car.
The speed-time graph for the car is shown



What is the acceleration of the car?

- A** 0.50 m/s^2 **B** 1.00 m/s^2 **C** 1.50 m/s^2 **D** 2.00 m/s^2

- 11 The speed-time graph for an object is shown.



Below are four statements about the acceleration of the object.

Which statement is correct?

- A** The acceleration in the first 5 s is given by area P.
B The acceleration increases between W and X.
C The acceleration is negative between Y and Z.
D The deceleration between Y and Z is $(20 \div 25) \text{ m/s}^2$.

- 12 A ball is dropped onto a floor.

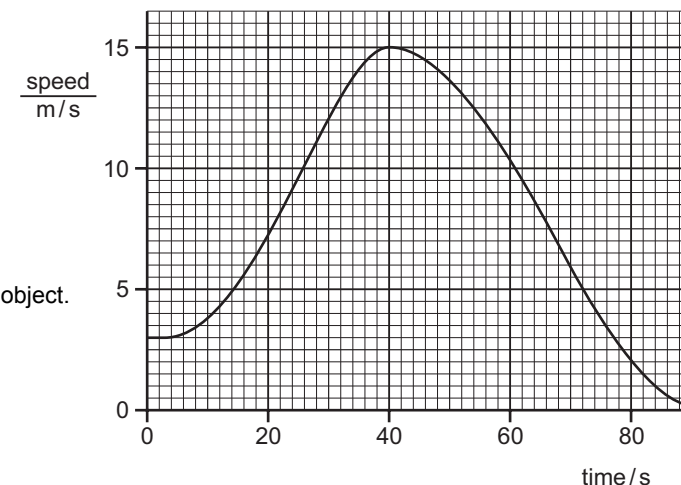
Its speed just before hitting the floor is 3.0 m/s .

Which change would result in a speed of 6.0 m/s just before hitting the floor?

Ignore any effects due to air resistance.

- A** Drop the ball from double the height above the floor.
B Drop the ball from four times the height above the floor.
C Use a ball with double the mass.
D Use a ball with four times the mass.

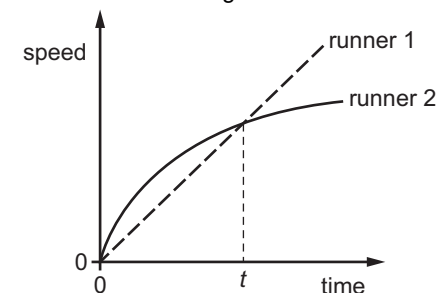
- 13 The speed-time graph shown is for a car moving in a straight line.



What is the acceleration of the car when the time is 40 s?

- A** 0 m/s^2 **B** $\frac{15-3}{40} \text{ m/s}^2$
C $\frac{15}{40} \text{ m/s}^2$ **D** $(15-3) \text{ m/s}^2$

- 14 Two runners take part in a race.
The graph shows how the speed of each runner changes with time.



What does the graph show about the runners at time t ?

- A** Both runners are moving at the same speed.
B Runner 1 has zero acceleration.
C Runner 1 is overtaking runner 2.
D Runner 2 is slowing down.

-
- The figure contains four separate distance-time graphs, each with 'distance' on the vertical axis and 'time' on the horizontal axis. The origin is marked with '0'.
- Graph A:** The line starts at a positive value on the distance axis, remains horizontal for a period of time, and then increases linearly with a positive slope.
 - Graph B:** The line starts at the origin (0,0), increases linearly with a positive slope for a period of time, and then becomes horizontal, indicating constant distance.
 - Graph C:** The line starts at the origin (0,0) and increases with a positive slope that itself is increasing (concave up).
 - Graph D:** The line starts at the origin (0,0) and increases with a positive slope that itself is increasing (concave up), appearing steeper than Graph C.

-
- A diagram showing a ball at the top of a vertical scale. The scale is marked from 0 m at the top to 2.0 m at the bottom, with intermediate marks at 0.5 m, 1.0 m, and 1.5 m. A dashed horizontal line connects the 0 m mark to the ball. A solid vertical line with an arrow pointing downwards represents the path of the ball. A label 'ball' points to the circle representing the ball.

A 5.0m/s^2 **B** 10m/s^2
C 15m/s^2 **D** 20m/s^2

-
- A speed-time graph for a car. The vertical axis is labeled 'speed / m/s' and ranges from 0 to 4.0 with major ticks every 1.0 unit. The horizontal axis is labeled 'time / s' and ranges from 0 to 5.0 with major ticks every 1.0 unit. The graph consists of two straight line segments: one from (0, 0) to (2.0, 4.0) and another from (2.0, 4.0) to (5.0, 0). Dashed lines indicate the peak speed of 4.0 m/s at 2.0 s.

What is the acceleration of the car during the first two seconds and what is the total distance that it travels?

	<u>acceleration</u> m/s ²	total distance / m
A	0.50	10
B	0.50	20
C	2.0	10
D	2.0	20

Motion

- 1 A coconut falls from position X to position Y, as shown in Fig. 1.1.

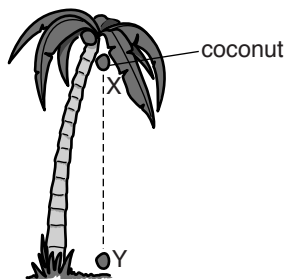


Fig. 1.1

- (a) State what causes the coconut to accelerate.

.....[1]

- (b) Compare the acceleration at positions X and Y. Tick one box.

☐

much greater at X than at Y

☐

much greater at Y than at X

☐

about the same at X as at Y

[1]

- (c) Using the axes in Fig. 1.2, sketch the graph showing how the speed of the coconut changes as it falls from X to Y. [2]



Fig. 1.2

- (d) State how the distance XY is determined from your graph in (c).

.....[1]

[Total: 5]

- 2 A driving instructor gives a student a sudden order to stop the car in the shortest possible time.

Fig. 2.1 shows the speed-time graph of the motion of the car from the moment the order is given.

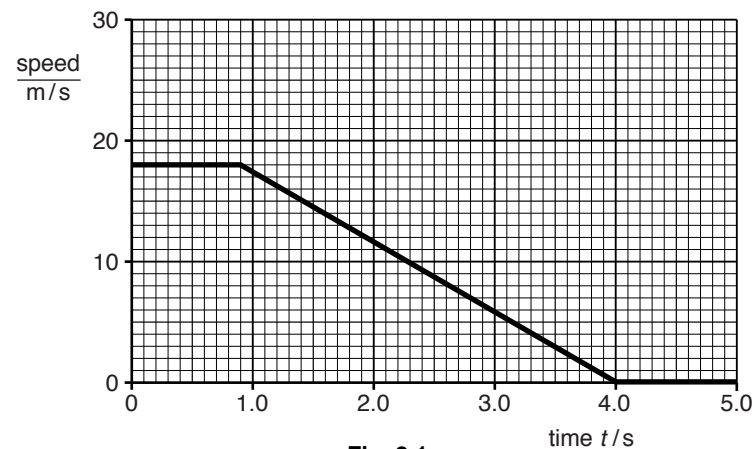


Fig. 2.1

- (a) The order to stop is given at time $t = 0$ s.

- (i) State the speed of the car at $t = 0$ s.

speed =[1]

- (ii) Suggest why the car continues to travel at this speed for 0.9 s.

.....

.....[1]

- (b) Calculate

- (i) the deceleration of the car between $t = 0.9$ s and $t = 4.0$ s,

deceleration =[2]

- (ii) the total distance travelled by the car from $t = 0$ s.

distance =[3]

- (c) Describe and explain a danger to a driver of not wearing a safety belt during a sudden stop.

.....

.....

.....

.....[2]

[Total: 9]

- 3 (a) A car is travelling at a constant speed of 80 km / h.

Calculate the distance travelled by the car in half an hour.

distance = km [1]

- (b) The car in Fig. 3.1 is travelling along a road on which there is a speed detector.

The speed detector consists of two parallel strips attached to the road and connected to a timer.

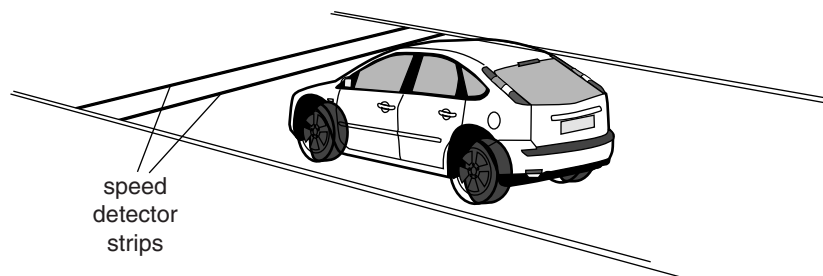


Fig. 3.1

The speed detector strips are 0.50m apart. The time interval between the car hitting the first strip and the second strip is 0.040 s.

Calculate the average speed of the car between the strips.

speed =m/s [3]

- (c) (i) A car is travelling at a speed of 15 m/s. The driver applies the brakes and brings the car to a stop.

Fig. 3.2 represents the last part of the journey.

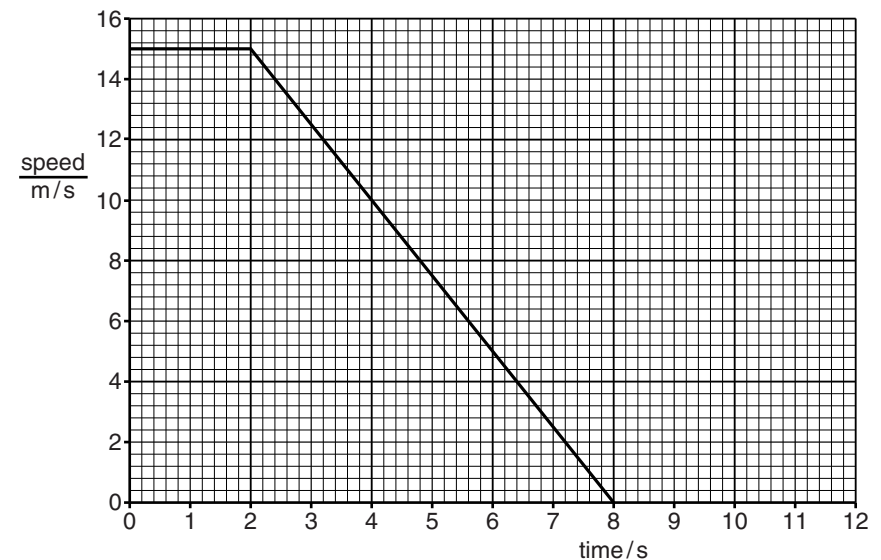


Fig. 3.2

Calculate the distance travelled by the car as it slows down.

distance = m [2]

- (ii) On another occasion, the car is travelling at the same speed of 15m/s when the driver sees a hazard ahead. She uses emergency braking to stop the car in 2.0 seconds.

On Fig. 3.2, draw the speed-time graph for the emergency stop.

[1]

[Total: 7]

4 Fig. 4.1 shows a distance-time graph for a falling object.

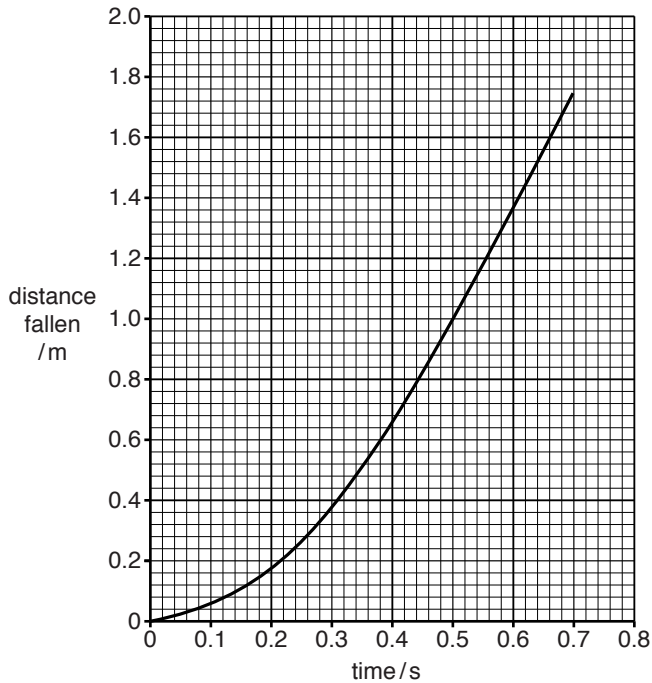


Fig. 4.1

(a) Use this graph to find the time it takes the object to fall from 0.60 m to 1.60 m.

time = s [2]

(b) State and explain what the graph shows about the motion of the falling object.

.....

[2]

[Total: 4]

5 A girl cycles to meet a friend. The distance-time graph for her journey from start to finish is shown in Fig. 5.1.

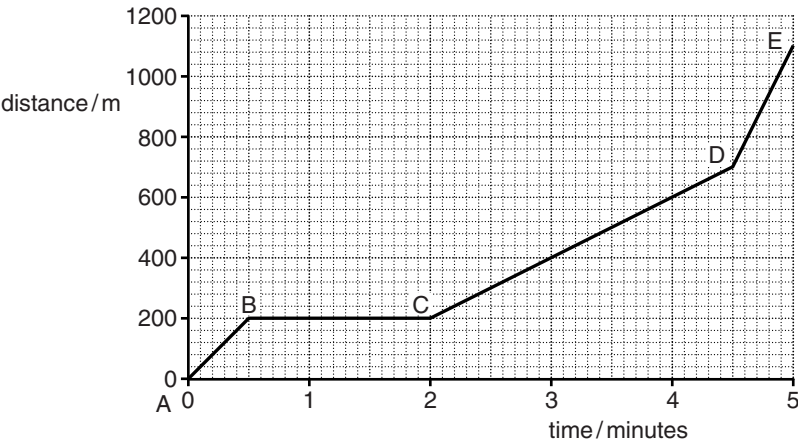


Fig. 5.1

(a) How far does the girl travel from start to finish?

distance =[1]

(b) Describe the motion of the girl between points B and C.

.....[1]

(c) Which section of the graph shows

(i) the part of the girl's journey that involves cycling up a hill 500 m long,

between and [1]

(ii) the girl travelling at the fastest speed?

between and [1]

(d) Calculate her average speed, in m/s, for the whole journey.

average speed = m/s [3]

[Total: 7]

6 An experiment is carried out to find the acceleration of free fall.

A strip of paper is attached to a heavy object. The object is dropped and falls to the ground, pulling the paper strip through a timer. The timer marks dots on the paper strip at intervals of 0.020 s.

Fig. 6.1 shows a section of the paper strip with the first three dots marked. The first dot on the paper strip, labelled A, is marked at the instant the object is dropped.

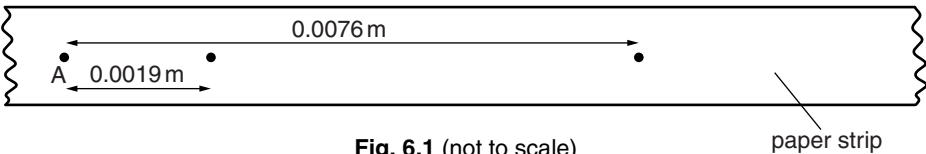


Fig. 6.1 (not to scale)

(a) State how the dots on the paper strip show that the object is accelerating.

.....
[1]

(b) Calculate the average speed of the object

(i) in the first 0.020 s after the object is dropped,

average speed =

(ii) in the second 0.020 s after the object is dropped.

average speed =
 [3]

(c) Use the results from (b) to calculate the acceleration of the falling object.

acceleration =[3]

[Total: 7]

7 At a sports event, a champion runner and a car take part in a race.

(a) The runner runs at a constant speed of 10 m/s from the start of the race. During the first 5.0 s of the race, the car's speed increases from 0 m/s to 25 m/s at a uniform rate.

On Fig. 7.1, draw

- (i) a graph to show the motion of the runner, [1]
- (ii) a graph to show the motion of the car.

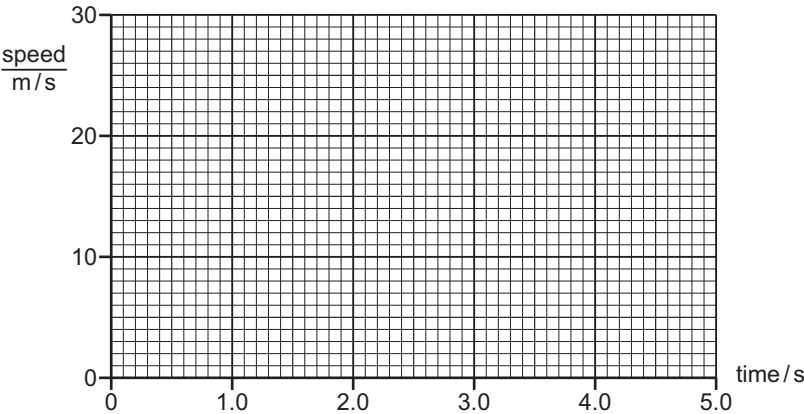


Fig. 7.1

(b) Use your graphs to determine

(i) the distance travelled by the runner in the 5.0 s,

distance =[1]

(ii) the distance travelled by the car in the 5.0 s,

distance =[2]

(iii) the time at which the car overtakes the runner.

time =[2]

[Total: 7]

- 8 A comet, travelling in space, enters the atmosphere of a planet.

Fig. 8.1 is the speed-time graph for the comet from time $t = 0$ s.

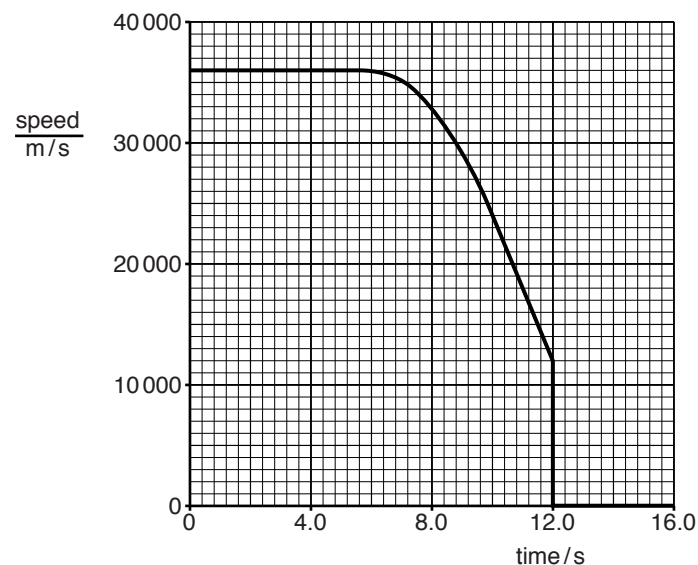


Fig. 8.1

- (b) Explain what the graph shows about the motion of the comet during the period $t = 6.0$ s to $t = 10.0$ s.

.....

[2]

- (c) Determine the acceleration of the comet at $t = 11.0$ s.

acceleration =[2]

- (d) Suggest what happens to the comet at $t = 12.0$ s.

.....
[1]

[Total: 8]

- (a) (i) During the period $t = 0$ s to $t = 6.0$ s, both the speed of the comet and the velocity of the comet remain constant.

State what this suggests about the motion of the comet.

.....
[1]

- (ii) Determine the distance travelled during the period $t = 0$ s to $t = 6.0$ s.

distance =[2]

Dynamics MCQ

- 1 The mass of an astronaut is 70 kg on the Moon.

What is the mass of the astronaut on the Earth?

- A 7 kg B 70 kg
C 80 kg D 700 kg

- 2 In which situation is **no** resultant force needed?

- A a car changing direction at a steady speed
B a car moving in a straight line at a steady speed
C a car slowing down
D a car speeding up

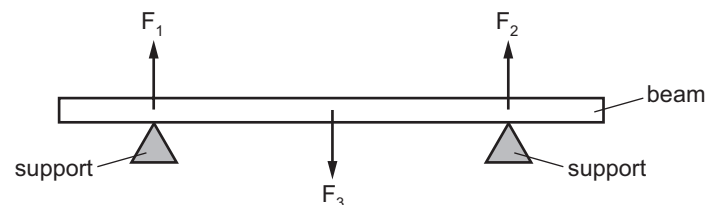
- 3 Which properties of a body can be changed by applying a force to the body?

- A mass, motion and shape
B mass and motion, but not shape
C mass and shape, but not motion
D motion and shape, but not mass

- 4 The mass of an object is measured on Earth. The mass is 5.0 kg. The object is taken to the Moon. The mass of the object is measured on the Moon. What is the mass of the object on the Moon?

- A 0 kg
B more than 0 kg, but less than 5.0 kg
C 5.0 kg
D more than 5.0 kg

- 5 A heavy beam rests on two supports. The diagram shows the only three forces F_1 , F_2 and F_3 acting on the beam.



The beam is in equilibrium.

Which statement is correct?

- A All the forces are equal in size.
B The resultant force on the beam is in the opposite direction to the resultant turning effect.
C The resultant force on the beam is zero and the resultant turning effect on the beam is zero.
D The total upward force is twice the total downward force.

- 6 Which list contains only properties of an object that can be changed by a force?

- A direction of motion, mass, shape
B direction of motion, mass, speed
C direction of motion, shape, speed
D mass, shape, speed

- 7 Which statement about mass or weight is correct?

- A Mass is a force.
B Mass is measured in newtons.
C Weight is a force.
D Weight is measured in kilograms.

- 8 A spaceship approaches the Earth from deep space. Near the Earth, a force on the spaceship causes it to have weight. This causes it to change its speed and direction.

Which type of force causes the spaceship's weight, and which property of the spaceship resists its change in speed and direction?

	force that causes weight	property that resists change in speed and direction
A	gravitational	mass
B	gravitational	volume
C	magnetic	mass
D	magnetic	volume

- 9 An object tends to keep moving with the same speed and in the same direction due to a certain property.

The object also has weight due to the action of a field.

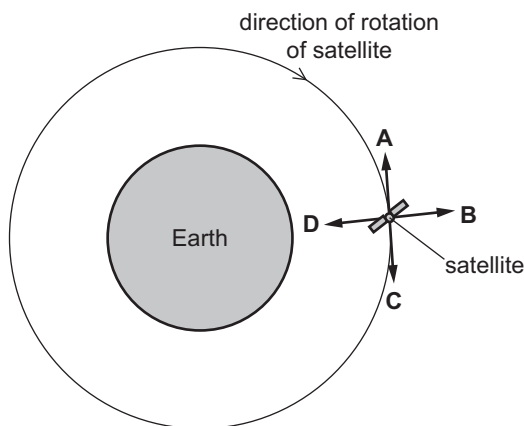
What is the name of the property, and what is the name of the field?

	property	field
A	mass	electric
B	mass	gravitational
C	volume	electric
D	volume	gravitational

- 10 A satellite orbits the Earth above the atmosphere at a constant speed.

The diagram shows the satellite at one point in its circular orbit around the Earth.

Which labelled arrow shows the direction of the resultant force on the satellite at the position shown?



- 11 A cup contains hot liquid. Some of the liquid evaporates.

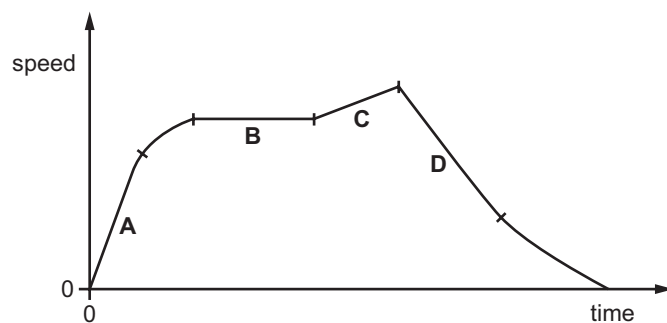
What happens to the mass and what happens to the weight of the liquid in the cup?

	mass	weight
A	decreases	decreases
B	decreases	stays the same
C	stays the same	decreases
D	stays the same	stays the same

- 12 A car travels along a straight road.

The speed-time graph for this journey is shown.

During which labelled part of the journey is the resultant force on the car zero?



- 13 A large stone is dropped from a bridge into a river. Air resistance can be ignored.

Which row describes the acceleration and the speed of the stone as it falls?

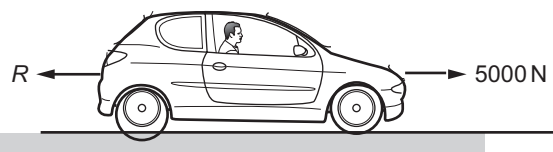
	acceleration of the stone	speed of the stone
A	constant	constant
B	constant	increasing
C	increasing	constant
D	increasing	increasing

- 14 Below are four statements about acceleration.

Which statement is **not** correct?

- A Acceleration always involves changing speed.
- B Changing direction always involves acceleration.
- C Changing speed always involves acceleration.
- D Circular motion always involves acceleration.

- 15 The engine of a car produces a driving force of 5000 N on the car. Resistive forces R also act on the car, as shown.



The car has a mass of 800 kg and an acceleration of 1.0 m/s^2 .

What is the value of R ?

- A 800 N
 - B 4200 N
 - C 5800 N
 - D 8000 N
- 16 A heavy object is released near the surface of the Earth and falls freely. Air resistance can be ignored.
- Which statement about the acceleration of the object due to gravity is correct?
- A The acceleration depends on the mass of the object.
 - B The acceleration depends on the volume of the object.
 - C The acceleration is constant.
 - D The acceleration is initially zero and increases as the object falls.

- 17 An object moves in a circle at constant speed.

Which statement about the force needed on the object is correct?

- A A force away from the centre of the circle keeps the object moving in the circle.
- B A force in the direction of motion of the object keeps it moving in the circle.
- C A force towards the centre of the circle keeps the object moving in the circle.
- D No force is needed to keep the object moving at constant speed in the circle.

- 18 A skydiver reaches terminal velocity. Then he opens his parachute. What happens to the skydiver as the parachute opens?

- A There is a decrease in weight.
- B There is acceleration upwards.
- C There is an increase in speed.
- D There is movement upwards.

- 19 A piece of steel is taken from the Earth to the Moon for an experiment. The gravitational field strength on the Moon is smaller than on the Earth. Which statement about the piece of steel is correct?

- A It has less mass on the Moon than on the Earth.
- B It has more mass on the Moon than on the Earth.
- C It weighs less on the Moon than on the Earth.
- D It weighs more on the Moon than on the Earth.

- 20 A boat is travelling at a steady speed in a straight line across the surface of a lake.

Which statement about the boat is correct?

- A The resultant force on the boat is in the direction of motion.
- B The resultant force on the boat is in the opposite direction to its motion.
- C The resultant force on the boat is vertically downwards.
- D The resultant force on the boat is zero.

- 21 In which pair are both quantities measured in newtons?

A force and pressure
B force and weight
C mass and pressure
D mass and weight

- 22 A car travels forwards along a straight horizontal road. Only the horizontal forces acting on it are shown.



The length of each arrow represents the size of each force.

How do these forces affect the motion of the car?

- A The car moves at constant speed.
B The car moves backwards.
C The car slows down.
D The car's forward speed increases.
- 23 A small steel ball is dropped from a low balcony.

Ignoring air resistance, which statement describes its motion?

- A It falls with constant acceleration.
B It falls with constant speed.
C It falls with decreasing speed.
D It falls with increasing acceleration.

- 24 Which is the unit for force and which is the unit for weight?

	force	weight
A	kg	kg
B	kg	N
C	N	kg
D	N	N

- 25 A force acting on an object causes some properties of the object to change.

Which list contains **only** properties that can be changed by the action of the force?

A mass, motion and shape
B mass, motion and size
C mass, shape and size
D motion, shape and size

- 26 Which statement about the masses and weights of objects on the Earth is correct?

A A balance can only be used to compare weights, not masses.
B Heavy objects always have more mass than light ones.
C Large objects always have more mass than small ones.
D Mass is a force but weight is not.

- 27 An object in a space probe above the Earth weighs 3.5 N. The gravitational field strength at the height of the space probe is 7.0 N/kg.

The gravitational field strength on the Earth's surface is 10 N/kg.

What are the mass and the weight of the object on the Earth's surface?

	mass / kg	weight / N
A	0.50	3.5
B	0.50	5.0
C	2.0	3.5
D	2.0	20

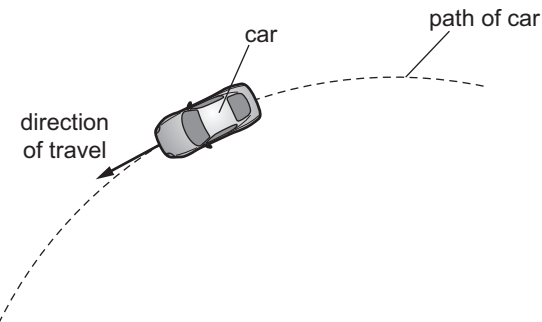
- 28 A skydiver jumps from a stationary helicopter and reaches a steady vertical speed. She then opens her parachute.

Which statement about the falling skydiver is correct?

A As her parachute opens, her acceleration is upwards.
B As she falls at a steady speed with her parachute open, her weight is zero.
C When she accelerates, the resultant force on her is zero.
D When she falls at a steady speed, air resistance is zero.

- 29 A car moves in a circular path as it turns a corner on a horizontal road.

The car moves at constant speed.



Which description of the forces acting on the car is correct?

- A All the forces are balanced as the car is moving at constant speed
B The forces are unbalanced and the resultant force acts away from the centre of the circle
C The forces are unbalanced and the resultant force acts towards the centre of the circle
D The forces are unbalanced and the resultant force is in the direction of travel of the car

- 30 A parachutist is falling through the air at terminal velocity.

Which statement about the parachutist is correct?

- A Every force acting on the parachutist is equal to zero and his acceleration is equal to zero.
B Every force acting on the parachutist is equal to zero and his velocity is equal to zero.
C The resultant force acting on the parachutist is equal to zero and his acceleration is equal to zero.
D The resultant force acting on the parachutist is equal to zero and his velocity is equal to zero.

Dynamics

- 1 (a) Fig. 1.1 shows the axes used to plot distance-time graphs.



Fig. 1.1

On Fig. 1.1, draw graphs for an object that is

- (i) moving with constant speed, labelling the graph A,
- (ii) moving with decreasing speed, labelling the graph B.

[2]

- (b) Fig. 1.2 shows the axes used to plot speed-time graphs.



Fig. 1.2

On Fig. 1.2, draw graphs for an object that is

- (i) moving with constant acceleration, labelling the graph S,
- (ii) moving with increasing acceleration, labelling the graph T.

[2]

- (c) A plane is at rest on an airport runway. The brakes of the plane are released and the engine of the plane provides a constant accelerating force.

Using the following data, calculate the take-off speed of the plane. Ignore any resistive forces.

constant forward force = 56 000 N
mass of plane = 16 000 kg
time of travel along runway = 16 s

speed =[4]

[Total: 8]

- 3 (a)** State why force is a *vector* quantity.

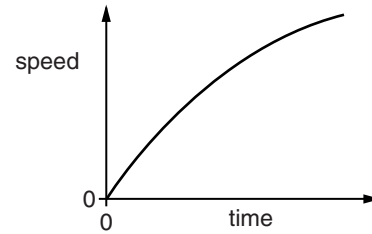


Fig. 2.2

- (b)** A 20 N force and a 15 N force act at the same time on an object of mass 14 kg.

Calculate

- (i) the maximum possible force on the object due to these two forces,

force = [1]

- (ii) the acceleration caused by a resultant force equal to this maximum force.

acceleration = [2]

- (b)** On a day with no wind, a large object is dropped from a tall building. The object experiences air resistance during its fall to the ground.

State and explain, in terms of the forces acting, how the acceleration of the object varies during its fall.

. [4]

[Total: 7]

- (c) Fig.3.1 shows a river in which the velocity of the flowing water is 0.85m/s parallel to the river banks.

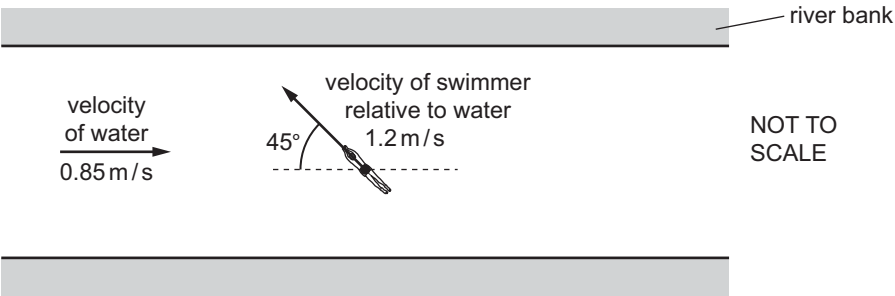


Fig. 3.1

A swimmer sets off from one bank. The velocity of the swimmer relative to the water is 1.2 m/s at 45° to the river banks, as shown in Fig. 3.1.

In the space below, draw a scale diagram to determine the resultant velocity of the swimmer relative to the river banks. This velocity is the resultant of the two velocities shown on Fig. 3.1. Label this resultant on your diagram.

resultant velocity = [3]

[Total: 7]

- 4 At a party, three balloons are filled with a gas less dense than air. The balloons are tied to an empty drink can. The can floats, without moving, in the air above a table, as shown in Fig. 4.1.

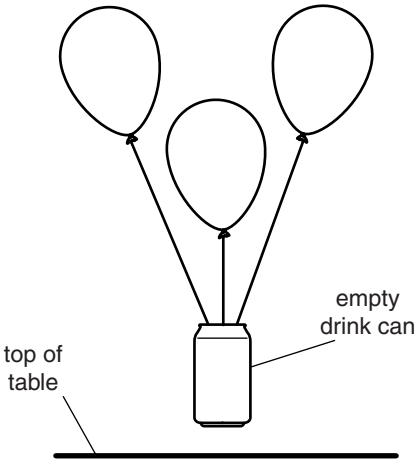


Fig. 4.1

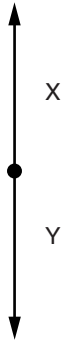


Fig. 4.2

- (a) Fig. 4.2 represents the vertical forces acting on the can as it floats in the air.

State the name given to the downward force labelled Y.

.....[1]

- (b) In terms of the vertical forces acting on the can, explain why the can does not rise or fall.

.....

.....[2]

- (c) A window is opened, causing a draught of air into the room. The window is to the left of the balloons and can, and at the same height.

On Fig. 4.1, draw an arrow indicating the direction of the resultant force on the can. [1]

- (d) One of the balloons suddenly bursts.

State and explain what happens to the can.

.....

.....

.....[1]

[Total: 5]

- 5 (a) (i) Mass is a scalar quantity.

State another scalar quantity.

.....

- (ii) Force is a vector quantity.

State another vector quantity.

.....

[2]

- (b) A boat is floating on still water.

The mass of the boat is 290 000 kg. A resultant force of 50 kN acts on the boat.

Calculate the acceleration of the boat.

acceleration =[3]

- (c) Fig. 5.1, not to scale, shows the view from above of the boat, now on a fast-flowing river. The boat accelerates.

Two forces are shown acting on the boat. The resultant of these forces is at right angles to the river banks.

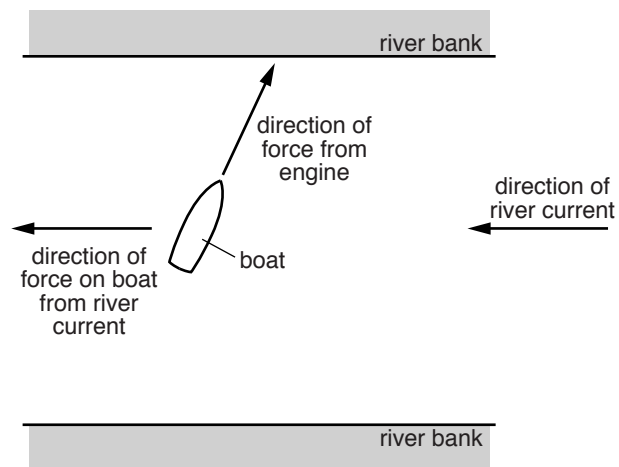


Fig. 5.1 (not to scale)

Fig. 5.2 is an incomplete vector diagram of the forces acting on the boat.

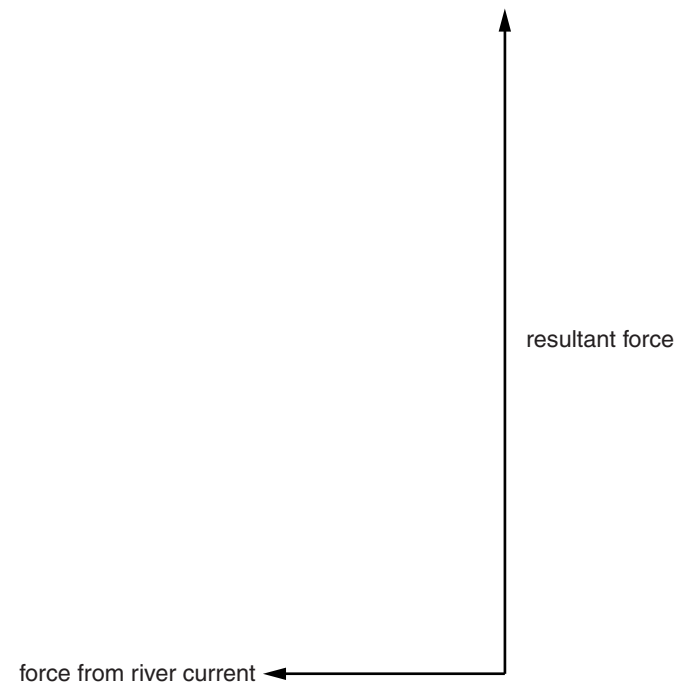


Fig. 5.2

The force from the river current is 80 kN.

- (i) Determine the scale that has been used in the vector diagram.

scale is

- (ii) On Fig. 5.2, complete the vector diagram to determine the magnitude and direction of the force from the engine. Measure the angle between the direction of the current and the force from the engine.

magnitude of force from engine =

angle =

[4]

[Total: 9]

6 Fig. 6.1 is the speed-time graph for an ice skater.

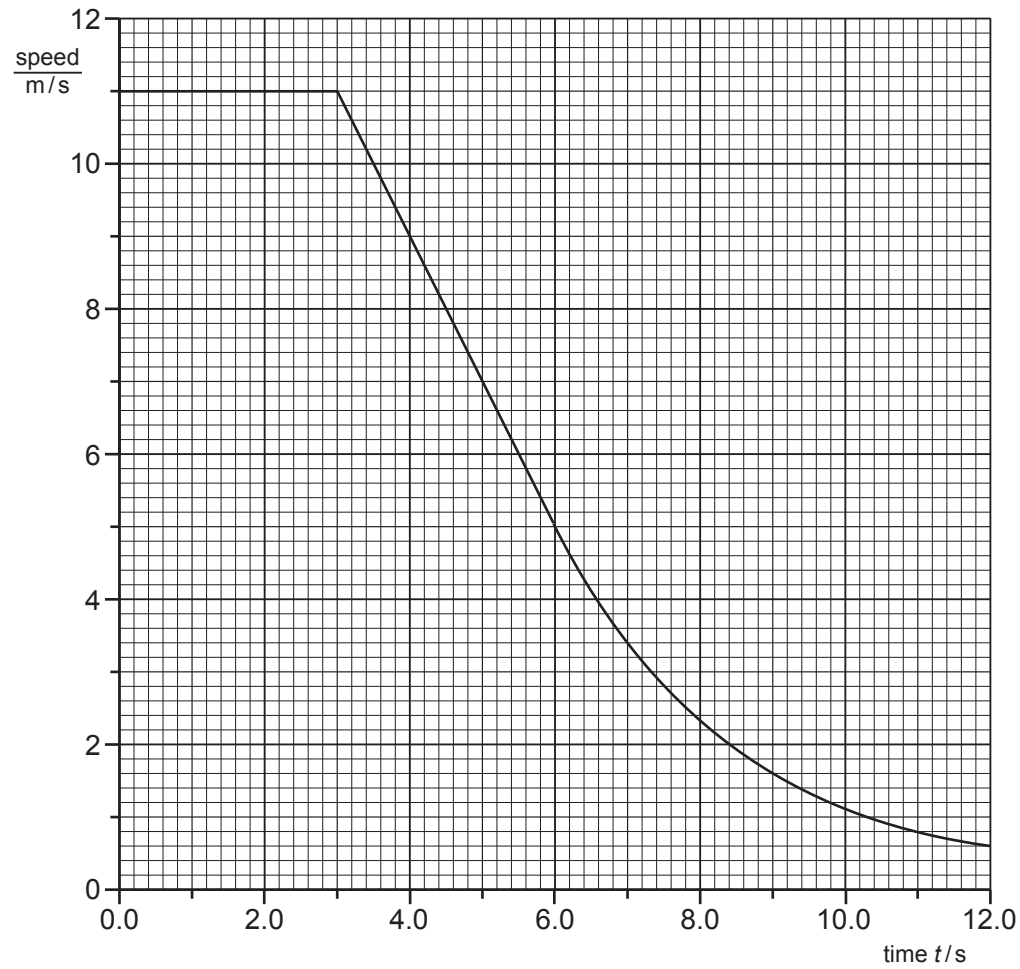


Fig. 6.1

- (a) Explain what is meant by *deceleration*.
.....[1]
- (b) Use Fig. 6.1 to determine
- (i) the distance travelled between times $t = 3.0$ s and $t = 6.0$ s,

(ii) the deceleration between times $t = 3.0$ s and $t = 6.0$ s.

deceleration =[2]

- (c) (i) State what happens to the size of the deceleration after time $t = 6.0$ s.
.....
.....[1]
- (ii) State what happens to the resultant force on the skater after time $t = 6.0$ s.
.....
.....[1]

[Total: 7]

7 (a) (i) Speed is a scalar quantity and velocity is a vector quantity.

State how a *scalar* quantity differs from a *vector* quantity.

.....
.....[1]

(ii) Underline the **two** scalar quantities in the list below.

energy **force** **impulse** **momentum** **temperature** [1]

(c) The boat in (b) is moving due west at a speed of 6.5 m/s relative to the water. The water is moving due south at 3.5 m/s.

In the space below, draw a scale diagram to determine the size and direction of the resultant of these two velocities. State the scale used.

(b) A boat is moving at constant speed.

On Fig. 7.1, sketch a distance-time graph for the boat.

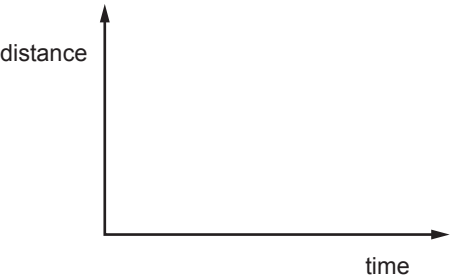


Fig. 7.1

[1]

scale
size of resultant velocity =
direction of resultant
[4]

[Total: 7]

- 8 In a laboratory, an experiment is carried out to measure the acceleration of a trolley on a horizontal table, when pulled by a horizontal force.

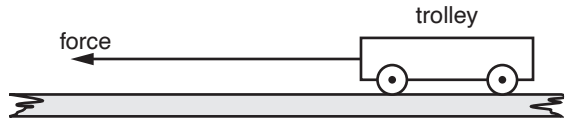


Fig. 8.1

The measurements are repeated for a series of different forces, with the results shown in the table below.

force / N	4.0	6.0	10.0	14.0
acceleration m/s ²	0.50	0.85	1.55	2.25

- (a) On Fig. 8.2, plot these points and draw the best straight line for your points.

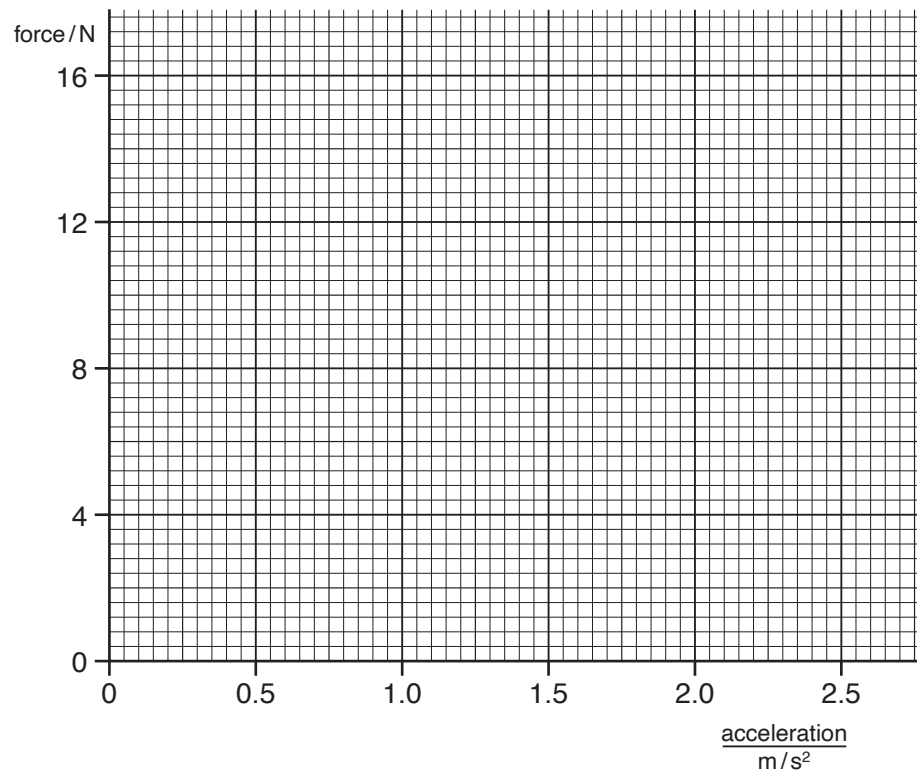


Fig . 8.2

- (b) The graph shows that below a certain force there is no acceleration.
- (i) Find the value of this force.[1]
- (ii) A force smaller than that in (b)(i) is applied to the stationary trolley. Suggest what happens to the trolley, if anything.
.....[1]

- (c) Show that the gradient of your graph is about 5.7.

gradient =[1]

[2]

- (d) (i) State the equation that links resultant force F , mass m and acceleration a .
.....[1]
- (ii) Use your gradient from (c) to find the mass of the trolley.

mass =[2]

- (e) On Fig. 8.3, sketch a speed / time graph for a trolley with constant acceleration.

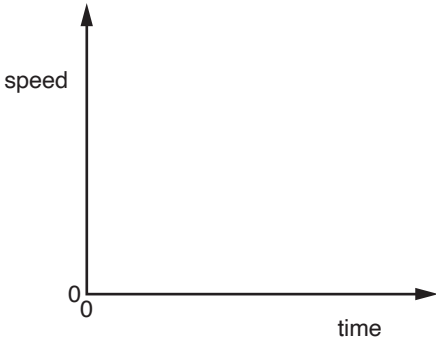


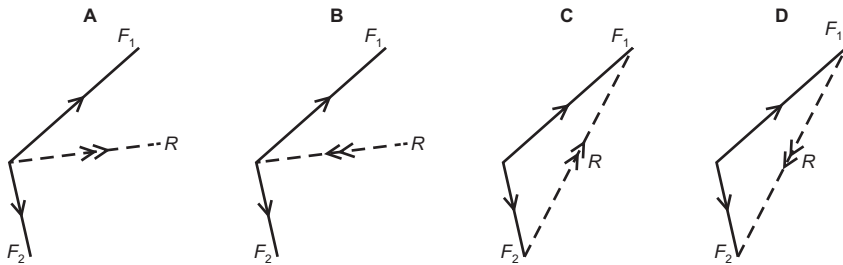
Fig. 8.3

[1]

[Total: 9]

Scalars and vectors MCQ

- 1 Which diagram shows the magnitude and direction of the resultant R of the two forces F_1 and F_2 ?



- 2 Which list contains only vector quantities?

- A acceleration, energy, force, mass
- B acceleration, force, momentum, velocity
- C distance, energy, mass, speed
- D distance, momentum, power, speed

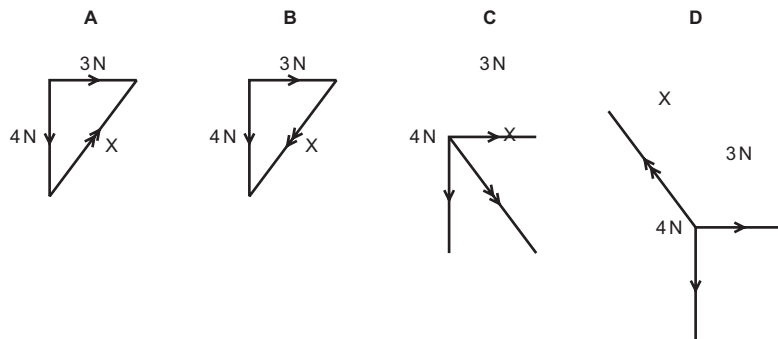
- 3 A scalar quantity has

- A magnitude and direction.
- B no magnitude and no direction.
- C magnitude but no direction.
- D direction but no magnitude.

- 4 An object is acted upon by a 3 N force and by a 4 N force.

Each diagram shows the two forces.

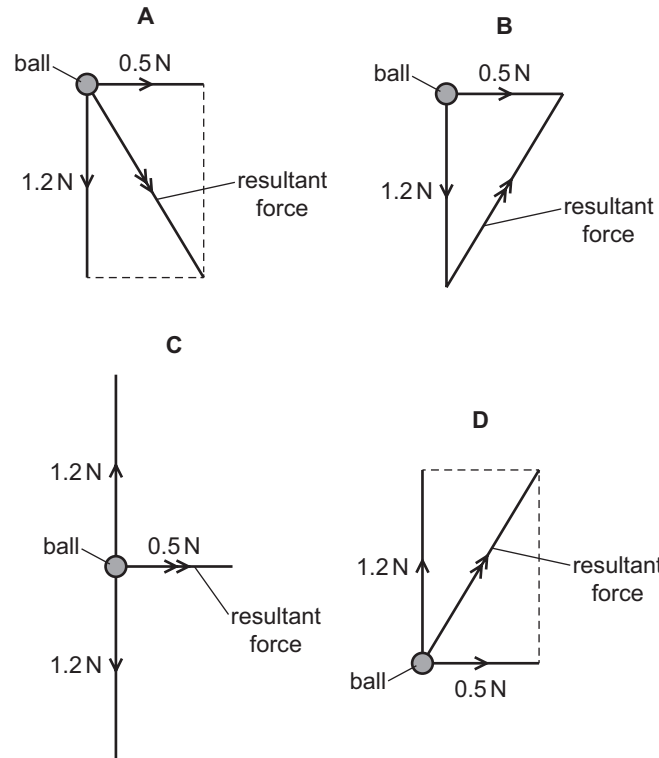
Which diagram also shows the resultant X of these two forces?



- 5 Which list contains only vector quantities?

- A energy, force, velocity
- B speed, acceleration, force
- C velocity, energy, acceleration
- D velocity, force, acceleration .

- 6 A ball of weight 1.2 N drops through the air at terminal velocity. A sudden gust of wind exerts a horizontal force of 0.5 N on the ball from the left. Which diagram shows the resultant force on the ball while the wind is blowing?



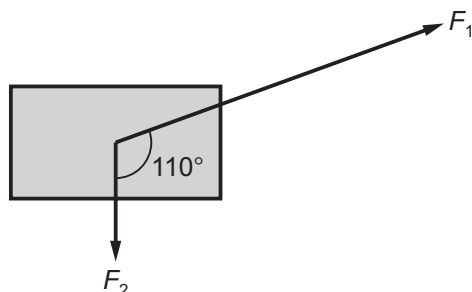
- 7 The diagram shows an object being acted upon by two forces.



What is the size of the resultant force on the object?

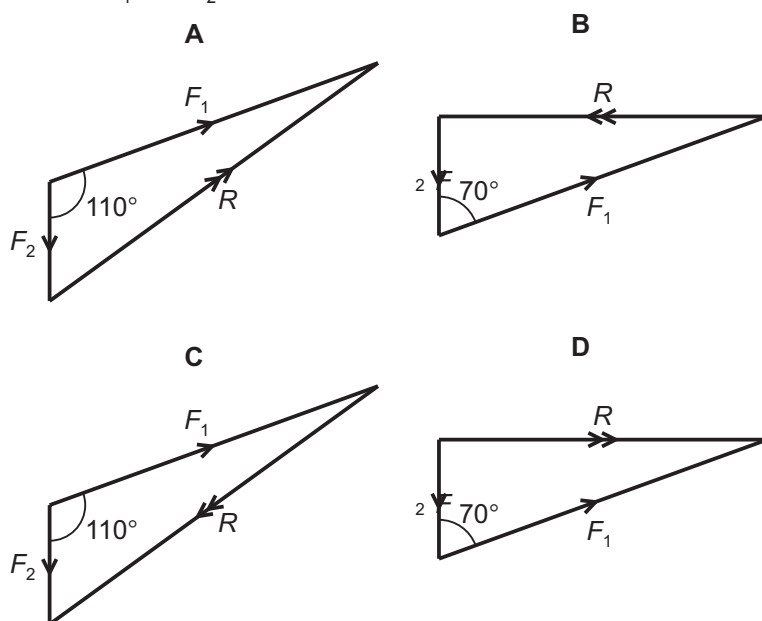
- A 2.0 N
- B 3.0 N
- C 9.0 N
- D 18 N

- 8 The diagram shows the only two forces F_1 and F_2 acting on an object. The magnitude of each force is represented by the length of each arrow.

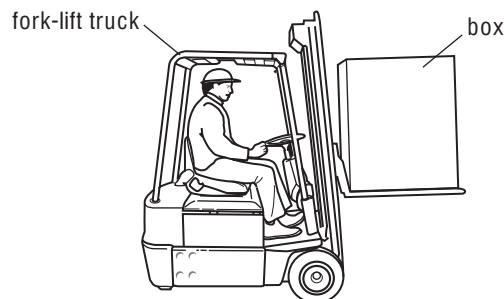


The resultant force acting on the object is R .

Which vector diagram shows how forces F_1 and F_2 add to produce R ?



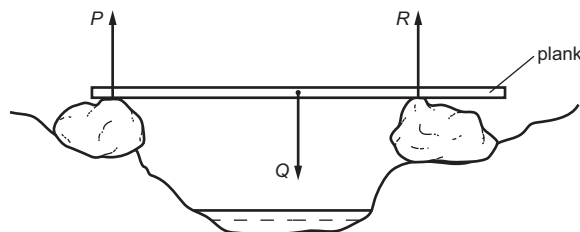
- 9 A box is being moved by a fork-lift truck. The total weight of the box is 3000 N.



The force exerted by the fork-lift truck on the box is 3500 N upwards.

What is the resultant force on the box?

- A 500 N downwards
 B 500 N upwards
 C 6500 N downwards
 D 6500 N upwards
- 10 A wooden plank rests in equilibrium on two rocks on opposite sides of a narrow stream. Three forces P , Q and R act on the plank.



How are the sizes of the forces related?

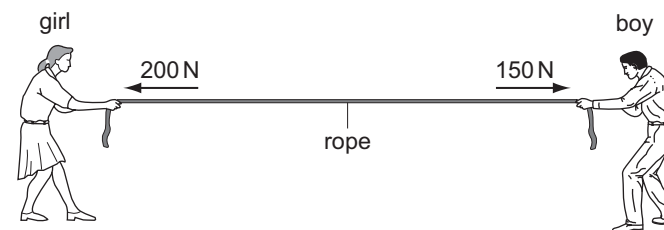
- A $P + Q = R$
 B $P + R = Q$
 C $P = Q = R$
 D $P = Q + R$

- 11 A force acts on a moving rubber ball. How many of the following changes could happen to the ball because of the force

- a change in direction
- a change in shape
- a change in mass
- a change in speed

- A 1 B 2
 C 3 D 4

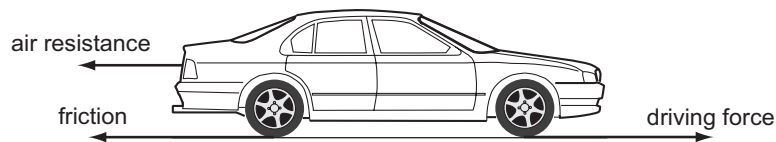
- 12 A girl and a boy are pulling in opposite directions on a rope. The forces acting on the rope are shown in the diagram.



Which single force has the same effect as the two forces shown?

- A 50 N acting towards the girl
 B 350 N acting towards the girl
 C 50 N acting towards the boy
 D 350 N acting towards the boy

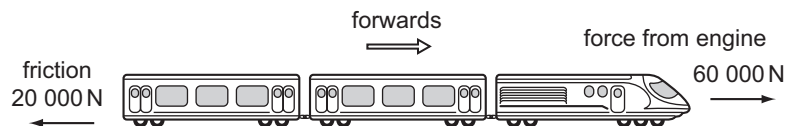
- 13 Three horizontal forces act on a car that is moving along a straight, level road.



Which combination of forces would result in the car moving at constant speed?

	air resistance	friction	driving force
A	200 N	1000 N	800 N
B	800 N	1000 N	200 N
C	800 N	200 N	1000 N
D	1000 N	200 N	800 N

- 14 A train is travelling along a horizontal track at constant speed. Two of the forces acting on the train are shown in the diagram.

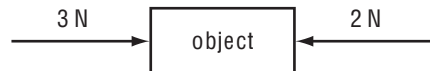


A force of air resistance is also acting on the train to give it a resultant force of zero.

What is this air resistance force?

- A 40 000 N backwards
B 80 000 N backwards
C 40 000 N forwards
D 80 000 N forwards

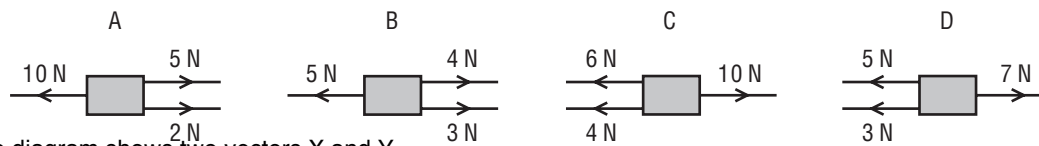
- 15 The object in the diagram is acted upon by the two forces shown.



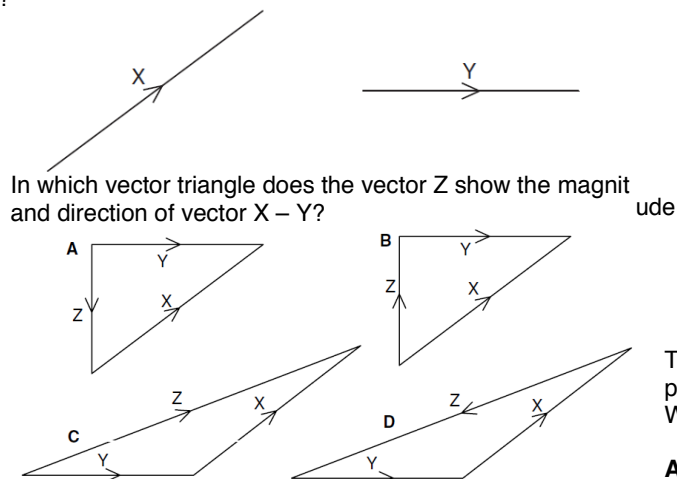
What is the effect of these forces?

- A The object moves to the left with constant speed.
B The object moves to the left with constant acceleration.
C The object moves to the right with constant speed.
D The object moves to the right with constant acceleration.

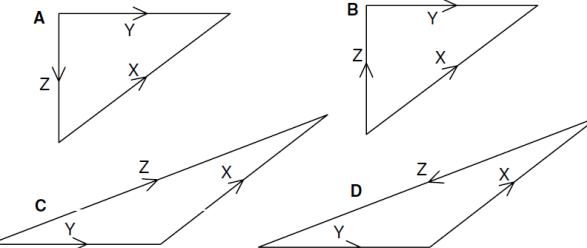
- 16 Which combination of forces produces a resultant force acting towards the right?



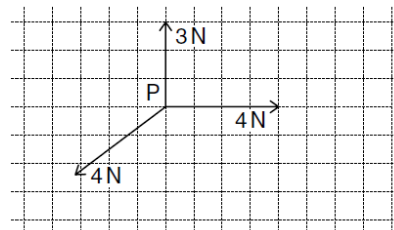
- 17 The diagram shows two vectors X and Y.



In which vector triangle does the vector Z show the magnitude and direction of vector $X - Y$?



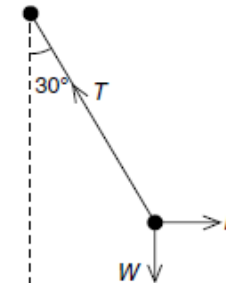
- 18 The vector diagram shows three coplanar forces acting on an object at P.



The magnitude of the resultant of these three forces is 1 N. What is the direction of this resultant?

- A ↓ B ↘ C ↙ D ↗

- 19 A pendulum bob is held stationary by a horizontal force H . The three forces acting on the bob are shown in the diagram.

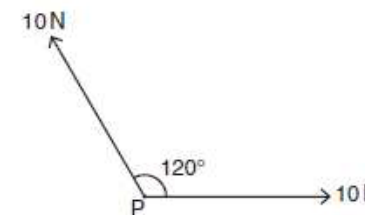


The tension in the string of the pendulum is T . The weight of the pendulum bob is W . Which statement is correct?

- A $H = T \cos 30^\circ$ B $T = H \sin 30^\circ$ C $W = T \cos 30^\circ$ D $W = T \sin 30^\circ$

- 20 Two forces, each of 10 N, act at a point P as shown in the diagram.

The angle between the directions of the forces is 120° .



What is the magnitude of the resultant force?

- A 5 N B 10 N
C 17 N D 20 N

Scalars and vectors

- 1 An object of weight W is suspended by two ropes from a beam, as shown in Fig. 1.1.

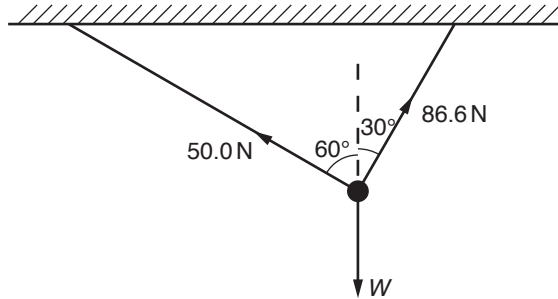


Fig. 1.1

The tensions in the ropes are 50.0 N and 86.6 N , as shown.

- (a) In the space below, draw a scale diagram to find the resultant of the two tensions.

Use a scale of $1.0\text{ cm} = 10\text{ N}$.

Clearly label the resultant.

- (b) From your diagram, find the value of the resultant.

resultant = [1]

- (c) State the direction in which the resultant is acting.

..... [1]

- (d) State the value of W .

$W =$ [1]

[Total: 6]

[3]

- 2 (a) State the factors which completely describe a vector quantity.

.....
 [1]

- (b) An aeroplane is flying towards the east in still air at 92 m/s. A wind starts to blow at 24 m/s towards the north.

Draw a vector diagram to find the resultant velocity of the aeroplane. Use a scale of 1.0 cm = 10 m/s.

resultant speed =

angle between resultant and easterly direction = [5]

[Total: 6]

- 3 (a) (i) State the difference between a scalar quantity and a vector quantity.

.....

- (ii) State one example of a vector quantity.

..... [2]

- (b) Fig. 3.1 shows the top of a flagpole.

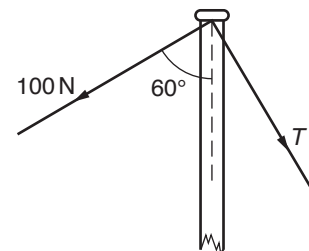


Fig. 3.1

The flagpole is held vertical by two ropes. The first of these ropes has a tension in it of 100 N and is at an angle of 60° to the flagpole. The other rope has a tension T , as shown.

The resultant force is down the pole and of magnitude 200 N.

In the space below, using a scale of 1 cm = 20 N, draw a scale drawing to find the value of the tension T . Clearly label 100 N, 200 N and T on your drawing.

tension T = [3]

[Total: 5]

4 Fig. 4.1 shows a heavy ball B of weight W suspended from a fixed beam by two ropes P and Q.

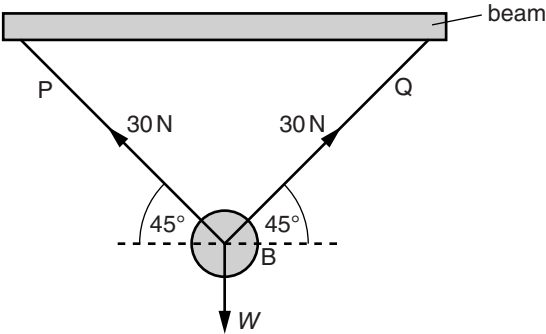


Fig. 4.1

P and Q are both at an angle of 45° to the horizontal. The tensions in P and Q are each 30 N.

- (a) In the space below, draw a scale diagram to find the resultant of the tensions in P and Q. Use a scale of 1.0 cm to represent 5.0 N. Label the forces and show their directions with arrows.

5 Fig. 5.1 is a head-on view of an airliner flying at constant speed in a circular horizontal path. The centre of the circle is to the left of the diagram.

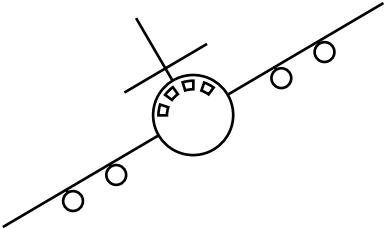


Fig. 5.1

- (a) On Fig. 5.1, draw the resultant force acting on the airliner. Explain your answer.

.....

 [3]

- (b) The weight of the airliner is 1.20×10^6 N and there is an aerodynamic lift force of 1.39×10^6 N acting at 30° to the left of the vertical.

By drawing a scale vector diagram, or otherwise, show that the resultant of these two forces is in the same direction as the resultant force you drew in (a).

- resultant = [4]
- (b) State the direction of the resultant. [1]
- (c) State the magnitude of W . magnitude of W = [1]

[Total: 6]

[3]

- (c) The speed is constant as the airliner flies in this circular path.

State and explain what is happening to the velocity.

.....

.....

.....

..... [2]

[Total: 8]

- 6 (a) In an accident, a truck goes off the road and into a ditch. Two breakdown vehicles A and B are used to pull the truck out of the ditch, as shown in Fig. 6.1.

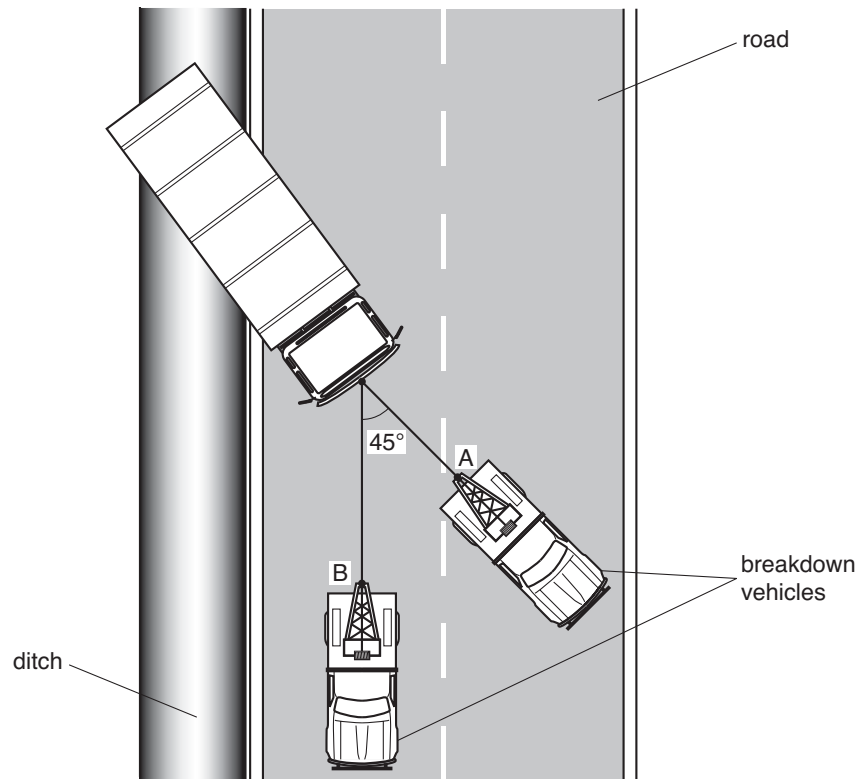


Fig. 6.1

At one point in the rescue operation, breakdown vehicle A is exerting a force of 4000 N and breakdown vehicle B is exerting a force of 2000 N.

- (i) Using a scale of 1 cm = 500 N, make a scale drawing to show the resultant force on the truck.

[4]

- (ii) Use your diagram to find the magnitude and direction of the resultant force on the truck.

magnitude of resultant force =

direction of resultant force = to direction of road [2]

- (b) (i) State why the resultant force is an example of a vector quantity.

..... [1]

- (ii) Give an example of a vector quantity that is not a force.

..... [1]

[Total: 8]

- 7 A student sets up the apparatus shown in Fig. 7.1 in order to find the resultant of the two tensions T_1 and T_2 acting at P. When the tensions T_1 , T_2 and T_3 are balanced, the angles between T_1 and the vertical and T_2 and the vertical are as marked on Fig. 7.1

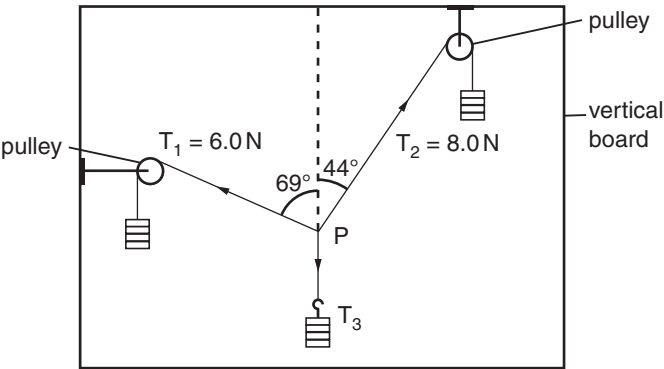


Fig. 7.1

In the space below, draw a scale diagram of the forces T_1 and T_2 . Use the diagram to find the resultant of the two forces.

State

- (a) the scale used,

scale =
- (b) the value of the resultant,

value =
- (c) the direction of the resultant.

direction =

[6]

- 8 (a) (i) State one similarity and one difference between vector and scalar quantities.

similarity

difference [2]

- (ii) Give an example of each quantity.

vector quantity

scalar quantity [2]

- (b) Fig. 8.1 is an overhead view of two tractors pulling a tree trunk.

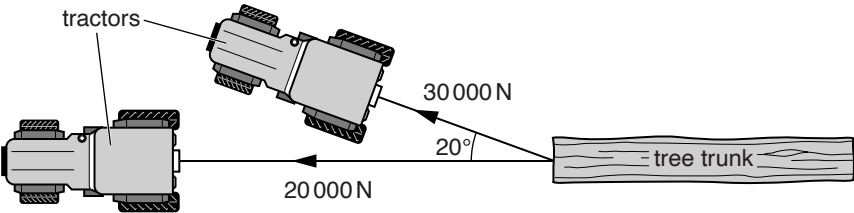


Fig. 8.1

The force exerted by each tractor is indicated in the diagram.

In the space below, carefully draw a scale diagram to determine the resultant force on the tree trunk. State the scale you use.
Write down the magnitude of the resultant force **and** the angle between the resultant force and one of the original forces.

magnitude of resultant force =

direction of resultant force = [4]

[Total: 8]

Momentum MCQ

- 1 An object travels in a circular path at constant speed.

Which statement about the object is correct?

- A It has changing kinetic energy.
- B It has changing momentum.
- C It has constant velocity.
- D It is not accelerating.

- 2 A girl of mass 50 kg runs at 6.0 m/s.

What is her momentum?

- A 300 J B 300 kg m/s
- C 900 J D 900 kg m/s

- 3 An object of mass 50 kg accelerates from a velocity of 2.0 m/s to a velocity of 10 m/s in the same direction.

What is the impulse provided to cause this acceleration?

- A 250 N s B 400 N s
- C 850 N s D 2500 N s

- 4 A bullet of mass 0.10 kg travels horizontally at a speed of 600 m/s. It strikes a stationary wooden block of mass 1.90 kg resting on a frictionless, horizontal surface. The bullet stays in the block.

What is the speed of the bullet and the block immediately after the impact?

- A 30 m/s B 32 m/s
- C 60 m/s D 134 m/s

- 5 A ball of mass 2.0 kg is travelling at a speed of 12 m/s. It moves towards an object of mass 3.0 kg which is at rest.



The ball hits the object and sticks to it. Which row gives the total momentum, and the speed of both objects immediately after the collision?

	<u>total momentum</u> kg m/s	<u>speed</u> m/s
A	0	4.8
B	0	8.0
C	24	4.8
D	24	8.0

- 6 A moving body undergoes a change of momentum.

What is a unit for change of momentum?

- A N m B N/m
- C N s D N/s

- 7 A stone of mass 0.12 kg is fired from a catapult.

The velocity of the stone changes from 0 to 5 m/s in 0.60 s.

What is the average resultant force acting on a stone while it is being fired?

- A 1.0 N B 2.5 N
- C 3.6 N D 8.3 N

- 8 A ball of mass 0.16 kg is moving forwards at a speed of 0.50 m/s. A second ball of mass 0.10 kg is stationary.

The first ball strikes the second ball.

The second ball moves forwards at a speed of 0.50 m/s.

What is the speed of the first ball after the collision?

- A 0.0 m/s B 0.19 m/s
- C 0.31 m/s D 0.50 m/s

- 9 A student cycles along a level road at a speed of 5.0 m/s.

The total mass of the student and bicycle is 120 kg.

The student applies the brakes and stops. The braking distance is 10 m.

What is the average braking force?

- A 150 N B 300 N
- C 15 000 N D 30 000 N

- 10 A body, initially at rest, explodes into two masses M_1 and M_2 that move apart with speeds v_1 and v_2 respectively.

What is the ratio v_1/v_2 ?

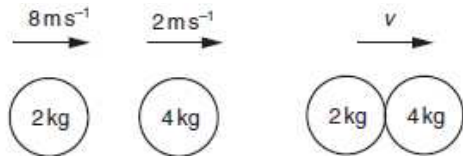
- A $\frac{M_1}{M_2}$ B $\frac{M_2}{M_1}$ C $\left(\frac{M_1}{M_2}\right)^{\frac{1}{2}}$ D $\left(\frac{M_2}{M_1}\right)^{\frac{1}{2}}$

- 11 Two equal masses travel towards each other on a frictionless air track at speeds of 60 cm s^{-1} and 30 cm s^{-1} . They stick together on impact.

What is the speed of the masses after impact?

- A 15 cm s^{-1} B 20 cm s^{-1} C 30 cm s^{-1} D 45 cm s^{-1}

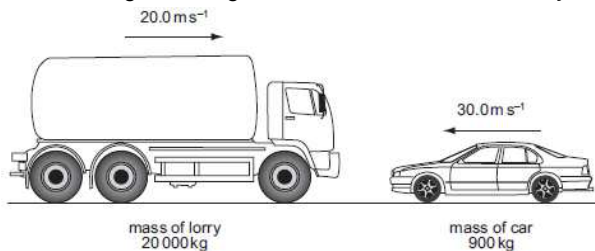
- 12 A ball of mass 2 kg travelling at 8 m s^{-1} strikes a ball of mass 4 kg travelling at 2 m s^{-1} . Both balls are moving along the same straight line as shown.



After collision, both balls move at the same velocity v . What is the magnitude of the velocity v ?

- A 4 m s^{-1} B 5 m s^{-1} C 6 m s^{-1} D 8 m s^{-1}

- 13 The diagram shows a situation just before a head-on collision. A lorry of mass 20 000 kg is travelling at 20.0 m s^{-1} towards a car of mass 900 kg travelling at 30.0 m s^{-1} towards the lorry.



What is the magnitude of the total momentum?

- A 373 kN s B 427 kN s C 3600 kN s D 4410 kN s

- 14 Two equal masses travel towards each other on a frictionless air track at speeds of 60 cm s^{-1} and 40 cm s^{-1} . They stick together on impact.



What is the speed of the masses after impact?

- A 10 cm s^{-1} B 20 cm s^{-1} C 40 cm s^{-1} D 50 cm s^{-1}

- 15 Two railway trucks of masses m and $3m$ move towards each other in opposite directions with speeds $2v$ and v respectively. These trucks collide and stick together. What is the speed of the trucks after the collision?

- A $\frac{v}{4}$ B $\frac{v}{2}$ C v D $\frac{5v}{4}$

- 16 The diagram shows a cannon ball fired from cannon.



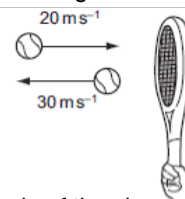
The mass of the cannon is 1000 kg and the mass of the cannon ball is 10 kg. The recoil velocity of the cannon is 5 m s^{-1} horizontally. What is the horizontal velocity of the cannon ball?

- A 200 m s^{-1} B 500 m s^{-1} C 2000 m s^{-1} D 5000 m s^{-1}

- 17 Which is a statement of the principle of conservation of momentum?

- A Momentum is the product of mass and velocity.
B Momentum is conserved only in elastic collisions.
C Momentum is conserved by all bodies in a collision.
D Momentum is conserved providing no external forces act.

- 18 A tennis ball of mass 100 g is struck by a tennis racket. The velocity of the ball is changed as shown.



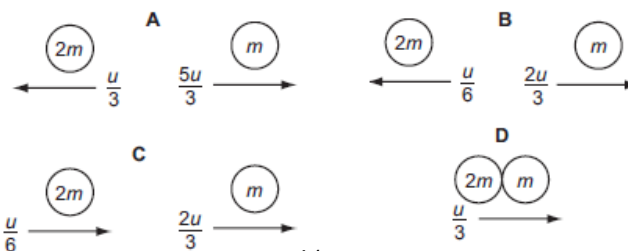
What is the magnitude of the change in momentum of the ball?

- A 1 kg m s^{-1} B 5 kg m s^{-1} C 1000 kg m s^{-1} D 5000 kg m s^{-1}

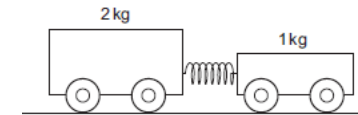
- 19 The diagram shows two spherical masses approaching each other head-on at an equal speed u . One has mass $2m$ and the other has mass m .



Which diagram, showing the situation after the collision, shows the result of an elastic collision?



20. Two trolleys are placed together on a horizontal runway with a compressed spring between them.



When they are released, the 2 kg trolley moves to the left at 2 m s^{-1} .

How much energy was stored in the spring?

- A 4J B 6J
C 8J D 12 J

Momentum

- 1 (a) Explain why momentum is a vector quantity.

.....[1]

- (b) The crumple zone at the front of a car is designed to collapse during a collision.

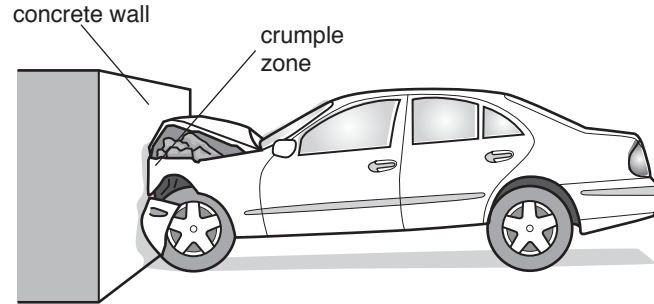


Fig. 1.1

In a laboratory test, a car of mass 1200 kg is driven into a concrete wall, as shown in Fig. 1.1.

A video recording of the test shows that the car is brought to rest in 0.36 s when it collides with the wall. The speed of the car before the collision is 7.5 m/s.

Calculate

- (i) the change of momentum of the car,

change of momentum =[2]

- (ii) the average force acting on the car.

average force =[2]

- (c) A different car has a mass of 1500 kg. It collides with the same wall and all of the energy transferred during the collision is absorbed by the crumple zone.

- (i) The energy absorbed by the crumple zone is 4.3×10^5 J. Show that the speed of the car before the collision is 24 m/s.

[2]

- (ii) Suggest what would happen to the car if it is travelling faster than 24 m/s when it hits the wall.

.....

.....[1]

[Total: 8]

2 Fig. 2.1 shows a hammer being used to drive a nail into a piece of wood.

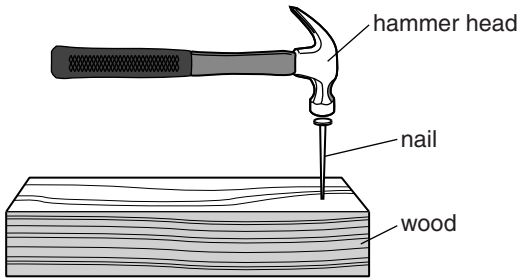


Fig. 2.1

The mass of the hammer head is 0.15 kg.
 The speed of the hammer head when it hits the nail is 8.0 m/s.
 The time for which the hammer head is in contact with the nail is 0.0015 s.

The hammer head stops after hitting the nail.

(a) Calculate the change in momentum of the hammer head.

change in momentum =[2]

(b) State the impulse given to the nail.

impulse =[1]

(c) Calculate the average force between the hammer and the nail.

average force =[2]

[Total: 5]

3 Fig. 3.1 shows a model fire engine. Its brakes are applied.

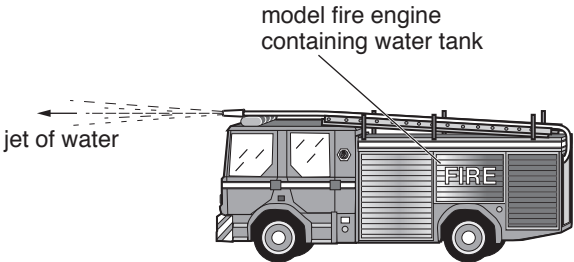


Fig. 3.1

0.80 kg of water is emitted in the jet every 6.0 s at a velocity of 0.72 m/s relative to the model.

(a) Calculate the change in momentum of the water that is ejected in 6.0 s.

momentum = [2]

(b) Calculate the magnitude of the force acting on the model because of the jet of water.

force = [2]

(c) The brakes of the model are released.

State and explain the direction of the acceleration of the model.

Statement

Explanation

.....

(d) In (c) the model contains a water tank, which is initially full. [2]

State and explain any change in the magnitude of the initial acceleration if the brakes are first released when the tank is nearly empty.

Statement

Explanation

.....

.....

[3]

[Total: 9]

4 Fig. 4.1 shows a dummy of mass 70kg used in a crash test to investigate the safety of a new car.

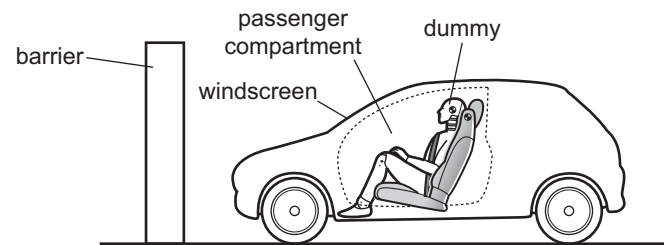


Fig. 4.1

The car approaches a solid barrier at 20 m/s. It crashes into the barrier and stops suddenly.

- (a) (i) Calculate the momentum of the dummy immediately before the crash.

momentum = [2]

- (ii) Determine the impulse that must be applied to the dummy to bring it to rest.

impulse = [1]

- (b) In the crash test, the passenger compartment comes to rest in 0.20 s.

Calculate the deceleration of the passenger compartment.

deceleration = [2]

- (c) The seat belt and air bag bring the dummy to rest so that it does not hit the windscreen. The dummy has an average deceleration of 80 m/s².

Calculate the average resultant force applied to the dummy, of mass 70 kg.

force = [2]

- (d) The deceleration of the dummy is less than the deceleration of the passenger compartment.

Explain why this is of benefit for the safety of a passenger.

.....

 [2]

5 Fig. 5.1 shows two railway trucks on a track.



Fig. 5.1

Truck A of mass 6000 kg is moving at 5.0 m/s. It is approaching truck B of mass 5000 kg, which is stationary.

(a) Calculate the momentum of truck A.

momentum = [2]

(b) The trucks collide, their buffers compress and then they bounce off each other, remaining undamaged.

After the collision, truck B has a momentum of 27 000 kg m/s.

(i) Determine the impulse applied to truck B.

impulse = [2]

(ii) The trucks are in contact for 0.60 s.

Calculate the average force on truck B.

force = [2]

(iii) Calculate the final speed of truck A.

speed = [3]

[Total: 9]

6 Fig. 6.1 shows two cars, A and B, before they collide.

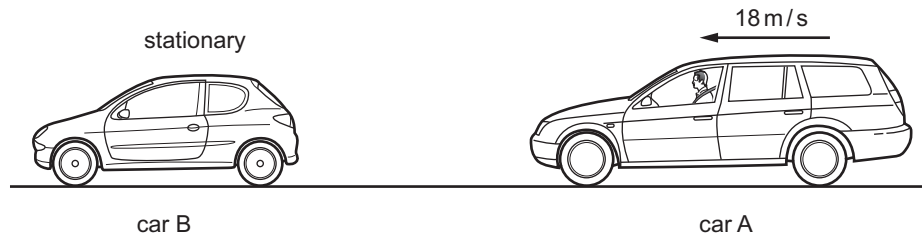


Fig. 6.1

Car B, of mass 1200 kg, is stationary. Car A, of mass 2000 kg, is travelling towards car B at 18 m/s.

(a) Calculate the momentum of car A.

momentum = [2]

(b) The cars collide and car B experiences an impulse. Car A continues to move in the same direction, with a momentum of 21 000 kg m/s.

(i) Calculate the momentum of car B immediately after the collision.

momentum = [1]

(ii) Determine the average impulse experienced by car B during the collision.

impulse = [1]

(iii) The cars are in contact for 0.20 s.

Calculate the average resultant force experienced by car B during the collision.

force = [2]

(c) A modern car is designed so that, during a collision, the front section of the car is crushed and the time of contact increases.

Explain the benefit of increasing the time of contact for the people in the car.

.....

 [2]

[Total: 8]

7 (a) Underline the pair of quantities which must be multiplied together to calculate *impulse*.

- | | | |
|-------------------|---------------------|----------------|
| force and mass | force and velocity | mass and time |
| time and velocity | weight and velocity | force and time |

(b) Fig. 7.1 shows a collision between two blocks A and B on a smooth, horizontal surface.

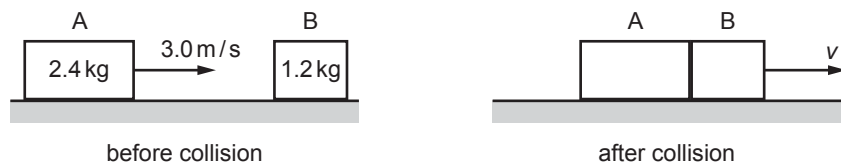


Fig. 7.1

Before the collision, block A, of mass 2.4 kg, is moving at 3.0 m/s. Block B, of mass 1.2 kg, is at rest.

After the collision, blocks A and B stick together and move with velocity v .

(i) Calculate

1. the momentum of block A before the collision,

momentum =[2]

2. the velocity v ,

velocity =[2]

3. the impulse experienced by block B during the collision.

impulse =[2]

(ii) Suggest why the total kinetic energy of blocks A and B after the collision is less than the kinetic energy of block A before the collision.

.....

.....[1]

[Total: 8]

8 (a) State the word equation that defines *momentum*.

.....[1]

[1] (b) A metal block A, travelling in a straight line at 4.0 m/s on a smooth surface, collides with a second metal block B which is at rest. Fig. 8.1 shows the two metal blocks A and B before and after the collision.

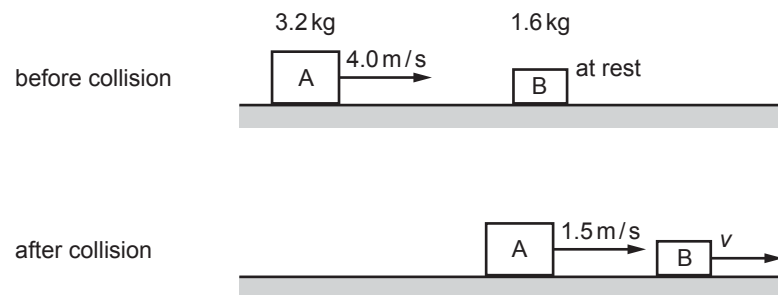


Fig. 8.1

The mass of A is 3.2 kg. The mass of B is 1.6 kg. After the collision, the velocity of A is 1.5 m/s.

Calculate

(i) the momentum of A before the collision,

momentum =[2]

(ii) the velocity v of B after the collision.

v =[3]

(c) In the collision that occurred in (b), block A and block B are in contact for 0.050 s.

Calculate the average force that is exerted on B during the collision.

average force =[2]

(d) After the collision in (b), the total kinetic energy of the two blocks is less than the kinetic energy of block A before the collision.

Suggest **one** reason for this.

.....
.....[1]

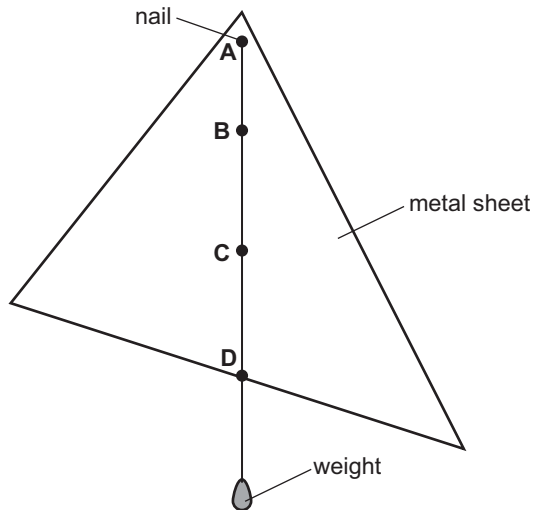
[Total: 9]

Turning effect-equilibrium and moments MCQ

- 1 The diagram shows a uniform, flat metal sheet hanging freely from a nail at point **A**. A weight also hangs freely on a string tied to **A**.

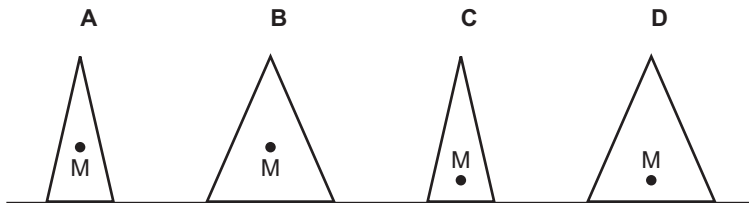
One of the labelled points is at the centre of mass of the metal sheet.

Which point is at the centre of mass?



- 2 The diagrams show four solid cones. The centre of mass of each cone is marked by a point labelled **M**.

Which cone is the most stable?

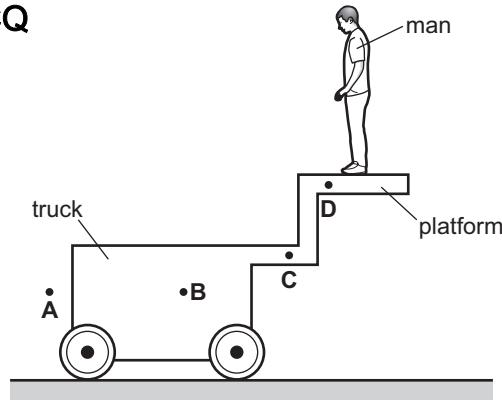


- 3 A heavy truck on wheels has a platform attached to it.

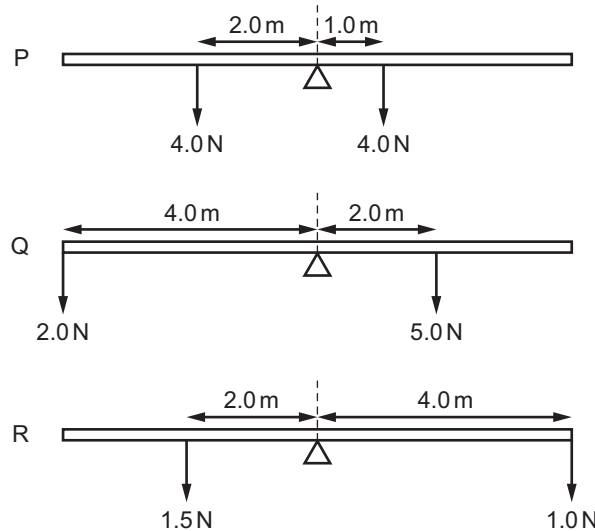
A man stands on the platform.

The truck does not fall over.

Which position **A**, **B**, **C** or **D** could be the centre of mass of the whole system (truck, platform and man)?



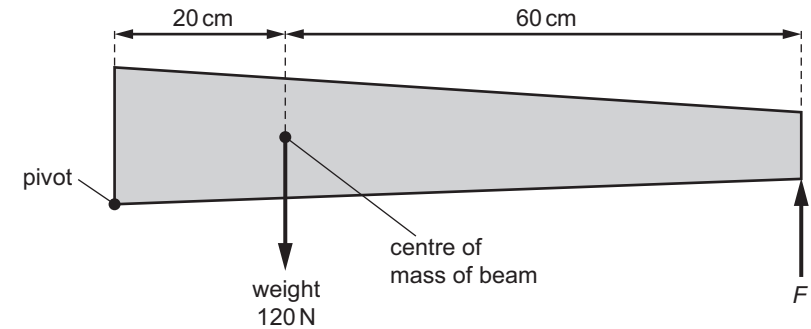
- 4 The diagrams show three uniform beams **P**, **Q** and **R**, each pivoted at its centre. The two forces acting on each beam are also shown.



Which beams rotate clockwise?

- A** P and Q only
B P and R only
C Q and R only
D P, Q and R

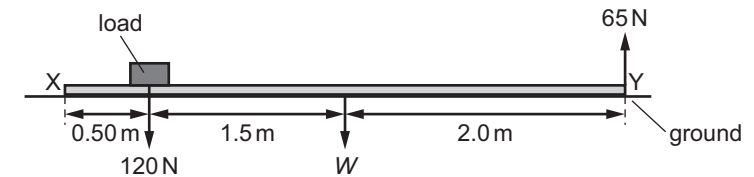
- 5 The diagram shows a non-uniform beam of weight 120 N, pivoted at one end. The beam is kept in equilibrium by force **F**.



What is the value of force **F**?

- A** 30 N **B** 40 N
C 360 N **D** 480 N

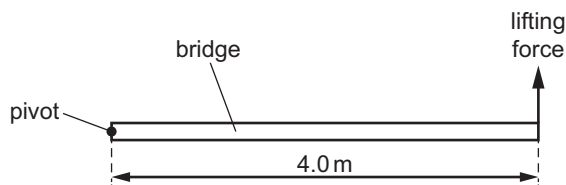
- 6 A long plank **XY** lies on the ground. A load of 120 N is placed on it, at a distance of 0.50 m from end **X**, as shown. End **Y** is lifted off the ground. The upward force needed to do it is 65 N.



In the diagram, **W** is the weight of the plank, acting at its mid-point. What is the value of **W**?

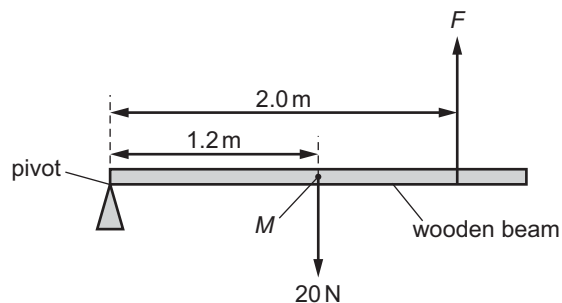
- A** 35 N **B** 47 N
C 100 N **D** 133 N

- 7 The diagram shows a uniform bridge, 4.0 m long and weighing 10 000 N. The bridge is pivoted at one end. A force at the other end gradually increases until the bridge begins to lift.



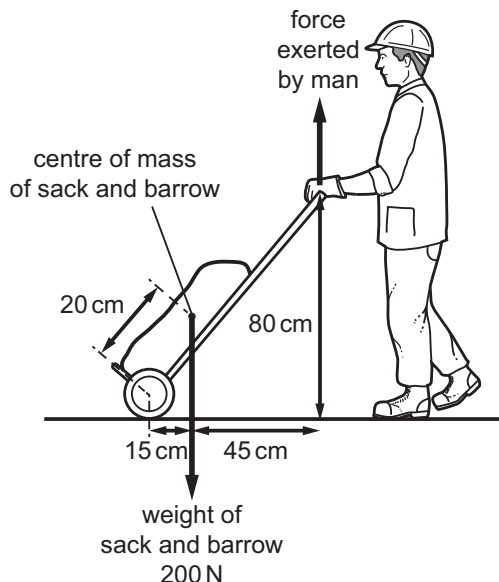
What is the lifting force as the bridge starts to move upwards?

- A 2500 N B 5000 N
C 10 000 N D 20 000 N
- 8 The diagram shows a wooden beam of weight 20 N. The centre of mass of the beam is labelled M. There is a pivot at one end of the beam. The beam is kept horizontal by an upward force F.



What is the magnitude of F?

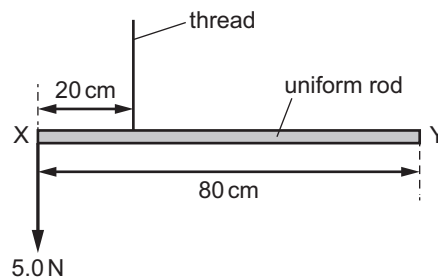
- A 12 N B 20 N
C 30 N D 33 N
- 9 The diagram shows a man holding a sack and barrow stationary. He applies a vertical force to the handle. The centre of mass and the weight of the sack and barrow are shown. The wheel acts as a pivot.



What is the magnitude of the vertical force exerted by the man?

- A 38 N B 50 N
C 67 N D 200 N

- 10 A uniform rod XY of weight 2.0 N has a length of 80 cm. The rod is suspended by a thread 20 cm from end X. A weight of 5.0 N is suspended from end X.

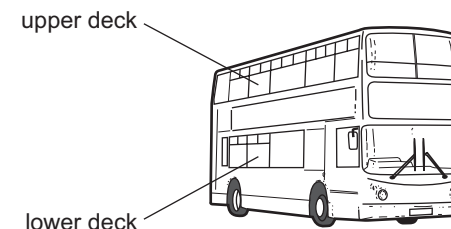


A student hangs a 6.0 N weight on the rod so that it is in equilibrium.

What is the distance of the 6.0 N weight from end X?

- A 6 cm B 10 cm
C 26 cm D 30 cm

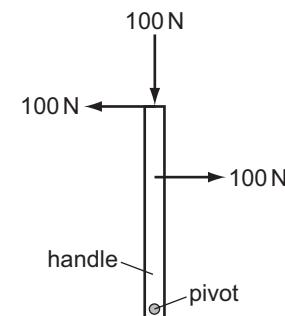
- 11 Passengers are **not** allowed to stand on the upper deck of double-decker buses.



Why is this?

- A They would cause the bus to become less stable.
B They would cause the bus to slow down.
C They would increase the kinetic energy of the bus.
D They would lower the centre of mass of the bus.

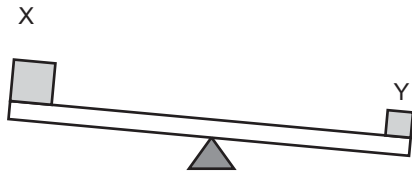
- 12 The diagram shows a handle with three forces, each 100 N, applied to it. The handle is free to move.



What is the effect of the forces on the handle?

- A The handle will move downwards.
B The handle will not move.
C The handle will turn anticlockwise (to the left).
D The handle will turn clockwise (to the right).

- 13 Two objects X and Y are placed on a balance. The balance tilts as shown.

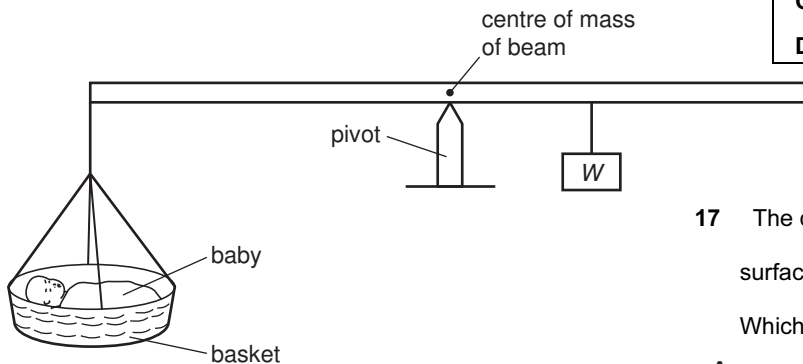


What does this show about the masses and weights of objects X and Y?

	masses	weights
A	X has less mass than Y	X has less weight than Y
B	X has less mass than Y	X has more weight than Y
C	X has the same mass as Y	X has less weight than Y
D	X has the same mass as Y	X has more weight than Y

- 14 The diagram shows a balance being used to find the weight of a baby. The weight of the basket can be ignored.

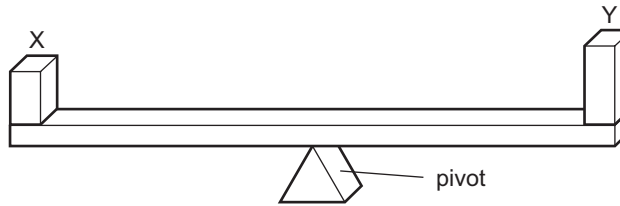
At equilibrium, the pivot is nearer to the weight W than to the baby.



What is the weight of the baby?

- A less than W
- B more than W
- C W
- D impossible to tell

- 15 When two blocks X and Y are placed on a uniform beam, the beam balances on a pivot at its centre as shown.



What does this show about X and Y?

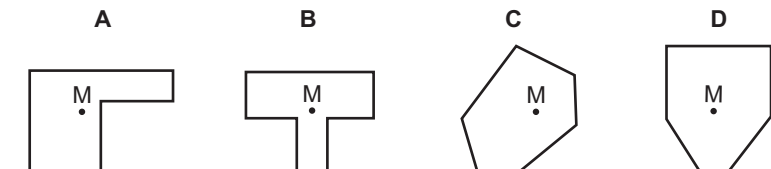
- A They have the same mass and the same density.
- B They have the same mass and the same weight.
- C They have the same volume and the same density.
- D They have the same volume and the same weight.

- 16 What are the conditions for equilibrium?

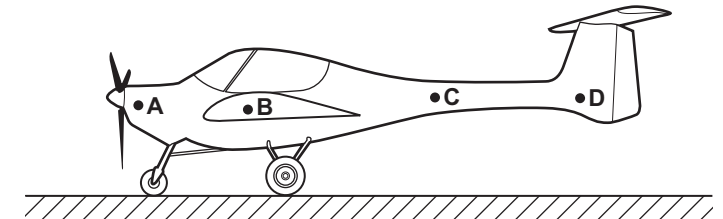
	resultant force acting	resultant turning effect acting
A	yes	yes
B	yes	no
C	no	yes
D	no	no

- 17 The diagram shows four objects standing on a flat surface. The centre of mass of each object is marked M.

Which object will fall over?



- 18 A light aircraft stands at rest on the ground. It stands on three wheels, one at the front and two further back. Which point could be its centre of mass?

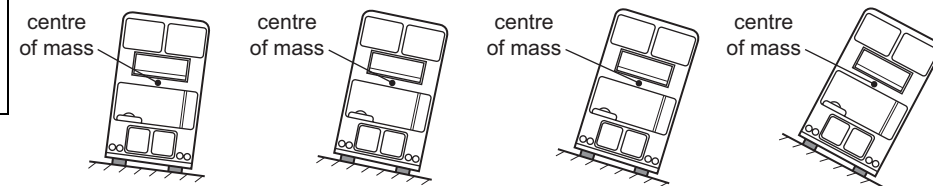


- 19 Two forces act on an object.

In which situation is it **impossible** for the object to be in equilibrium?

- A The two forces act in the same direction.
- B The two forces act through the same point.
- C The two forces are of the same type.
- D The two forces are the same size.

- 20 The diagram shows four models of buses placed on different ramps.



How many of these models will fall over?

- A 1
- B 2
- C 3
- D 4

Turning effect - equilibrium and moments

- 1 (a) A stationary object is acted upon by a number of forces.

State the conditions which **must** be true if the object

- (i) does not accelerate,

.....[1]

- (ii) does not rotate.

.....[1]

- (b) Fig. 1.1 shows a boat that has been lifted out of a river. The boat is suspended by two ropes. It is stationary.

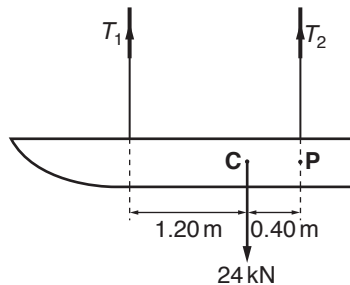


Fig. 1.1 (not to scale)

The weight of the boat, acting at the centre of mass, is 24 kN. The tensions in the ropes are T_1 and T_2 .

Determine

- (i) the moment of the weight of the boat about the point P,

moment =[1]

- (ii) the tension T_1 ,

$T_1 =$ [3]

- (iii) the tension T_2 .

$T_2 =$ [2]

- 2 A student is sitting on a chair as shown in Fig. 2.1.

[Total: 8]

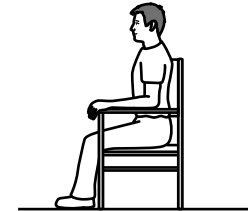


Fig. 2.1

- (a) (i) Estimate the mass of the student.[1]
 (ii) Which statement is correct for the mass of the chair on the Moon and the mass of the chair on the Earth?

Tick the box next to the correct statement.

☐

The mass of the chair is greater on the Moon.

☐

The mass of the chair is less on the Moon but not zero.

☐

The mass of the chair is the same on the Moon.

☐

The mass of the chair is zero on the Moon.

[1]

- (b) The student tips his chair back to the position shown in Fig. 2.2.

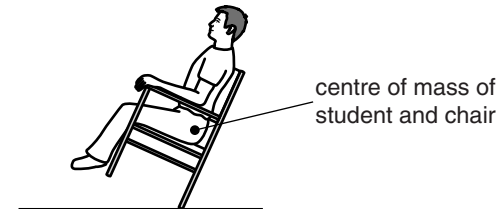


Fig. 2.2

- (i) State and explain how the pressure exerted by the chair on the floor in Fig. 2.2 compares with the pressure exerted by the chair in Fig. 2.1.

statement

explanation

.....[3]

(ii) Explain why the chair will topple over backwards. You may draw on Fig. 2.2 as part of your answer.

.....

.....

..... [2]

[Total: 7]

3 Fig. 3.1 shows an irregularly shaped piece of card.

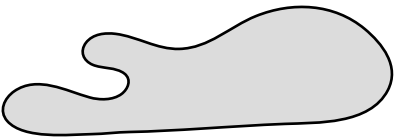


Fig. 3.1

A student is asked to find the centre of mass of the card. The student is provided with a clamp and stand, a small mass attached to a thin string and a long pin.

(a) Describe the procedure for finding the centre of mass of the card. You may draw a diagram.

.....

.....

.....

.....

.....[3]

(b) What simple test can be carried out to confirm that the centre of mass has been found?

.....

.....[1]

[Total: 4]

4 (a) Fig. 4.1 shows a top view of a tourist vehicle in a game park and two elephants pushing against the vehicle. The two forces indicated are at right angles to each other.

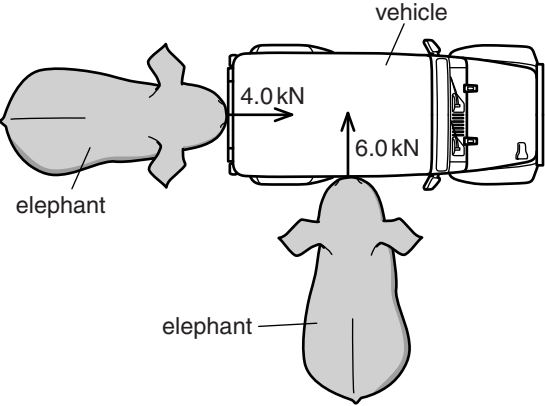


Fig. 4.1

In the space below, draw a scale vector diagram to determine the magnitude of the resultant force. Label the two forces applied and the resultant, and clearly state the scale you use.

magnitude of resultant force =[3]

(b) Fig. 4.2 shows another elephant pushing horizontally against a vehicle with a force of 11 kN at a distance 1.8 m above the ground. Point M is the centre of mass of the vehicle.

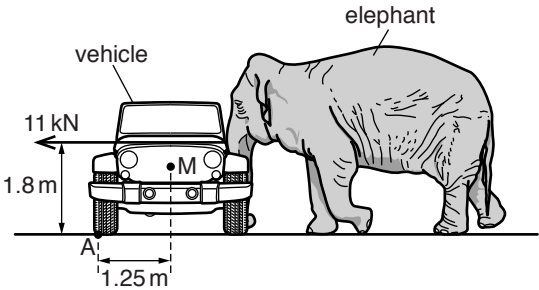


Fig. 4.2

(i) Calculate the moment about point A of the force exerted by the elephant.

moment =[2]

(ii) The mass of the vehicle is 1900 kg, and it does not slide when pushed by the elephant. Determine whether the elephant tips the vehicle over. Show your working.

calculation

conclusion[2]

[Total: 7]

5 A metre rule balances when the 50 cm mark is directly above a pivot.

(a) State where in the rule its centre of mass is located.

.....
..... [1]

(b) Fig. 5.1 shows an apple and a 0.40 N weight placed on the rule so that the rule remains balanced at the 50 cm mark.

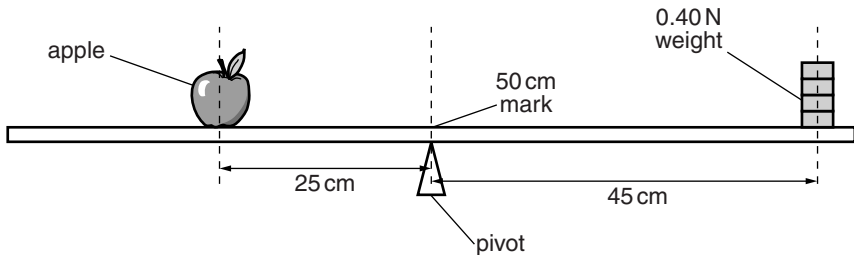


Fig. 5.1 (not to scale)

The centre of mass of the apple is 25 cm from the pivot and the centre of mass of the weight is 45 cm from the pivot.

Calculate

(i) the weight of the apple,

weight = [2]

(ii) the mass of the apple.

mass = [1]

(c) The apple is not moved. The weight is removed from the rule and the pivot is moved to the left until the rule balances as shown in Fig. 5.2.

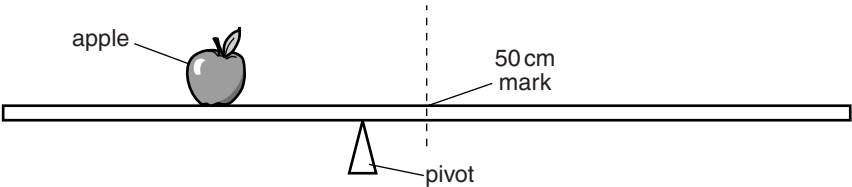


Fig. 5.2 (not to scale)

(i) Explain why the arrangement in Fig. 5.2 balances.

.....
.....
..... [2]

(ii) The pivot in Fig. 5.2 is closer to the 50 cm mark than to the centre of mass of the apple.

Compare the weight of the rule to the weight of the apple.

.....
..... [1]

[Total: 7]

6 Fig. 6.1 shows a mobile bird sculpture that has been created by an artist.

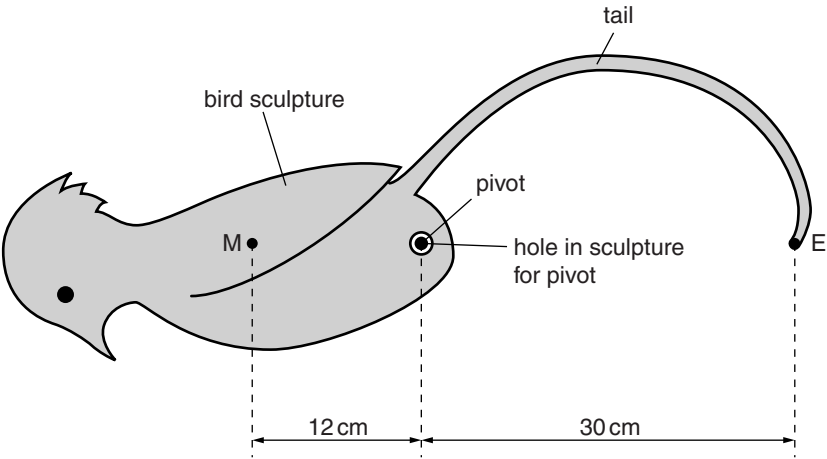


Fig. 6.1

M is the centre of mass of the bird sculpture, including its tail (but not including the counter-weight that will be added later). The mass of the bird and tail is 1.5 kg.

The bird sculpture is placed on a pivot.

The artist adds the counter-weight at the end E of the tail so that the bird remains stationary in the position shown.

(a) Calculate the mass of the counter-weight.

mass = [2]

(b) The centre of mass of the sculpture with counter-weight is at the pivot.

Calculate the upward force acting at the pivot.

force = [1]

(c) The sculpture is rotated clockwise to the position shown in Fig. 6.2. It is held still, then carefully released.

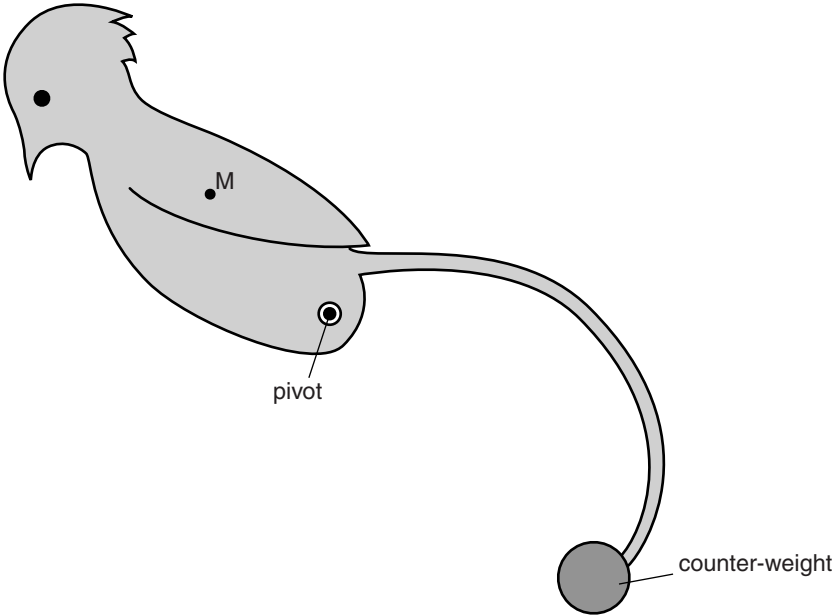


Fig. 6.2

(i) State whether the sculpture will stay in that position, rotate further clockwise or rotate back anticlockwise.

.....

(ii) Explain your answer to (i).

.....

[3]

[Total: 6]

7 (a) Complete the following statement:

The moment of a force about a point is
 multiplied by[1]

(b) Fig. 7.1 shows a uniform iron bar B of weight 30 N and length 1.40 m. The bar is being used to lift one edge of a concrete slab S. A stone, placed 0.20 m from one end of B, acts as a pivot. A force of 40 N pushing down at the other end of B is just enough to lift the slab and hold it as shown.

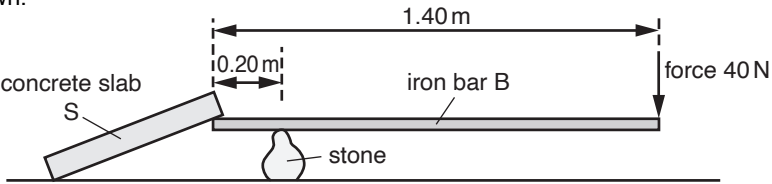


Fig. 7.1

- (i) On Fig. 7.1, draw an arrow to show the weight of bar B acting from its centre of mass. [1]
- (ii) State the distance d of the centre of mass of bar B from the pivot.
 $d =$ [1]
- (iii) Calculate the total clockwise moment, about the pivot, of the forces acting on bar B.

total clockwise moment =[3]

(iv) Calculate the downward force which the slab S exerts on the end of bar B.

force =[2]

(v) Suggest a change to the arrangement in Fig. 7.1 that would reduce the force required to lift the slab.

.....
[1]

[Total: 9]

- 8 (a) State the two conditions required for the equilibrium of a body acted upon by a number of forces.
 1.

 2.
[2]

(b) Fig. 8.1 shows a diagram of an arm with the hand holding a weight of 120 N.

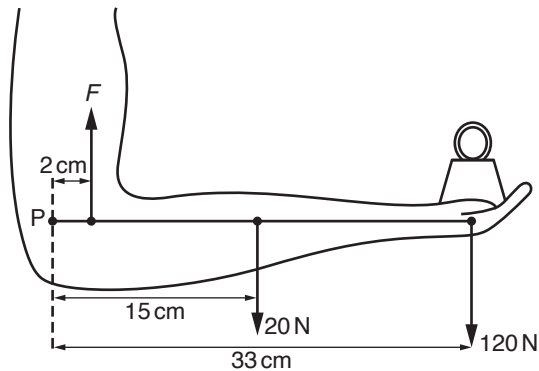


Fig. 8.1

The 20 N force is the weight of the forearm, acting at its centre of mass. F is the force in the muscle of the upper arm. P is the point in the elbow about which the arm pivots. The distances of the forces from point P are shown.

(i) By taking moments about point P, calculate the force F .

force $F =$ [3]

(ii) A force acts on the forearm at point P. Calculate this force and state its direction.

force =[2]

direction =[2]

[Total: 7]

Forces and Matter

Summary Notes

Density and pressure

The **density** of a substance is defined as the **mass per unit volume** and is measured in **kilograms per metre cubed (kg/m³)**.

$$\text{density} = \frac{\text{mass}}{\text{volume}} \quad \rho = \frac{m}{V}$$

To find the density of a liquid:

- Find the mass of the measuring cylinder by placing it on a balance, then fill it with the liquid and measure the new mass. The difference in masses is the mass of the liquid minus the cylinder (alternatively, we can press tare on the balance so it's zeroed). This avoids **zero error**.
- The volume can be read from the cylinder. It must be read straight-on to avoid **parallax error**.
- Find the density using the equation.

To find the density of solid:

- Measure the mass of the solid by placing it on a balance.
- If the solid is:
 - regularly shaped, measure its dimensions using a ruler or other measuring tool and then use a mathematical formula to find the volume.
 - irregularly shaped, immerse it in water and measure the volume of the water displaced. This is the volume of the solid.
- Find the density using the equation.

Pressure is defined as the force per unit area and is measured in **Pascals (Pa)**.

$$\text{pressure} = \frac{\text{force}}{\text{area}} \quad p = \frac{F}{A}$$

For example, lying down on a bed of nails compared to a single nail:

- The **force** applied is the weight of your body
- The total **area** is either a single pin point or many points spread out over a larger area
 - Therefore, on a bed of nails, the pressure is lower as the area is greater.

The **pressure** at a point in a gas or liquid at rest acts **equally** in **all directions** and causes a force at right angles to any surface. Pressure in a fluid (gas or liquid) is created from the movement of particles (as they collide with a surface).

The pressure beneath a liquid surface increases with **depth**, the **density** of the liquid and the **gravitational field strength**.

- It is given by $p = \rho gh$
 - Deeper in the fluid the more particles above the point, hence the greater their weight.
 - Fluids with higher density have more particles per unit of volume, hence greater weight.
 - Weight depends upon gravitational field strength.

A force may produce a change in size and shape of a body. This is called deformation:

- Elastic** deformation is when the object **returns to its original shape** when the load has been removed, an example being a spring being stretched under normal usage.

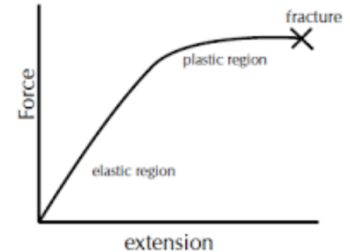
Hooke's law states that for a spring, $F = kx$ where F is the force applied to the spring, k is the spring constant, and x is the extension.

Linear (straight line) force-extension graph:

- Elastic deformation following Hooke's law
 - The point it stops being linear is called the **limit of proportionality**. From then on, it does not obey Hooke's law.
- Gradient is the spring constant, k

Non-linear (curved line) force-extension graph:

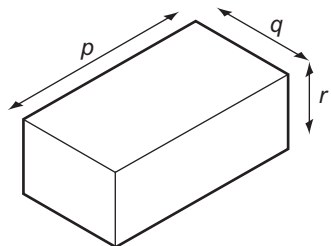
- Deformation not following Hooke's law
- After this region, it will fracture



Source: physicsandmathstutor.com

Density MCQ

- 1 The diagram shows the dimensions of a rectangular block of metal of mass m .



Which expression is used to calculate the density of the metal?

- A $m \times p \times q$ B $m \times p \times q \times r$
 C $\frac{m}{(p \times q)}$ D $\frac{m}{(p \times q \times r)}$

- 2 Diagram 1 shows an empty measuring cylinder on a balance.
 Diagram 2 shows the same measuring cylinder on the balance, but it now contains a liquid

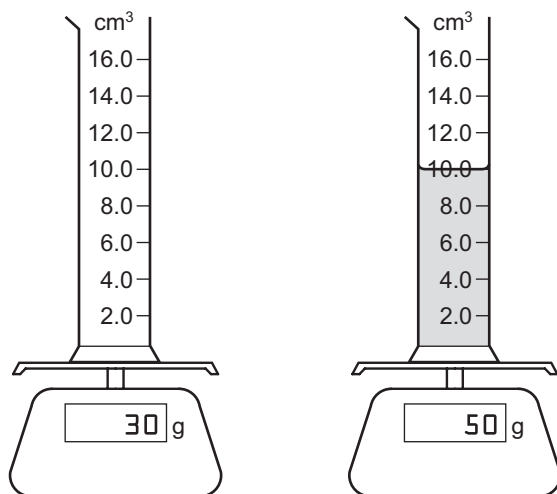


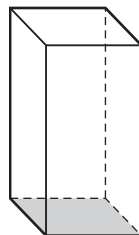
diagram 1

diagram 2

What is the density of the liquid?

- A 0.2 g/cm^3 B 0.5 g/cm^3
 C 2.0 g/cm^3 D 5.0 g/cm^3

- 3 A student wishes to determine the density of the solid block shown.



Which quantities must be known?

- A the area of the shaded face and the volume of the block
 B the area of the shaded face and the weight of the block
 C the mass of the block and the height of the block
 D the mass of the block and the volume of the block

- 4 Two cylinders are made of the same metal.
 Both cylinders have the same cross-sectional area but one is longer than the other.



cylinder 1

cylinder 2

Which quantity is the same for both cylinders?

- A density
 B mass
 C resistance
 D volume

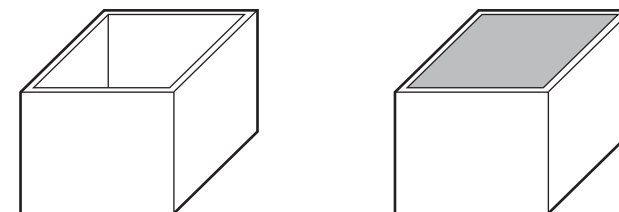
- 5 The mass of a piece of metal is 1200 g.
 A measuring cylinder contains 150 cm^3 of water.

The piece of metal is put into the measuring cylinder.
 The water level rises to 250 cm^3 and covers the metal.

What is the density of the metal?

- A 3.0 g/cm^3 B 4.8 g/cm^3
 C 8.0 g/cm^3 D 12.0 g/cm^3

- 6 The diagrams show an empty rectangular box, and the same box filled with liquid.
 The box has a mass of 60 g when empty.
 When filled with liquid, the total mass of the box and the liquid is 300 g.



empty box
60 g

box filled with liquid
300 g

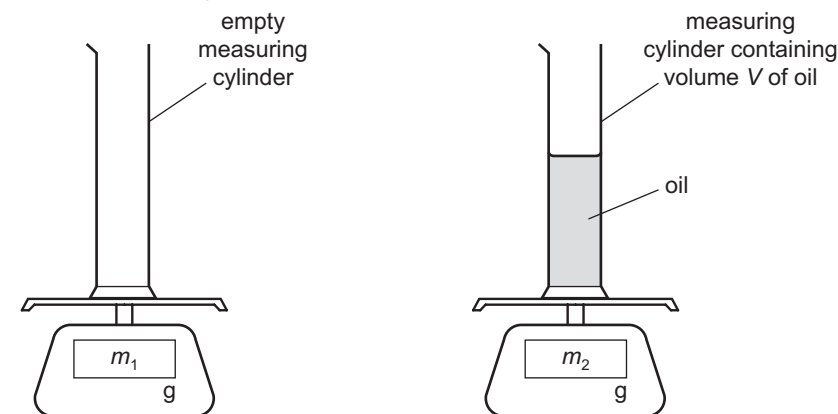
The density of the liquid is 1.2 g/cm^3 .

What is the volume of the liquid in the box?

- A 50 cm^3 B 200 cm^3
 C 250 cm^3 D 300 cm^3

- 7 A student uses a measuring cylinder and a balance to find the density of oil.

The diagram shows the arrangement used.



Which calculation gives the density of the oil?

- A $\frac{V}{m_2}$ B $\frac{V}{(m_2 - m_1)}$
 C $\frac{m_2}{V}$ D $\frac{(m_2 - m_1)}{V}$

- 8 The equation used to find the pressure caused by a liquid can be written as

$$p = h \times Y \times Z$$

where p is the pressure and h is the depth of the liquid.

Which row gives the quantities Y and Z ?

	Y	Z
A	cross-sectional area	gravitational field strength
B	cross-sectional area	volume
C	density	cross-sectional area
D	density	gravitational field strength

- 9 The diagrams show an empty container, and the same container filled with liquid.

The empty container has a mass of 120 g. When filled with the liquid, the total mass of the container and the liquid is 600 g.



empty container
120 g

container filled with liquid
600 g

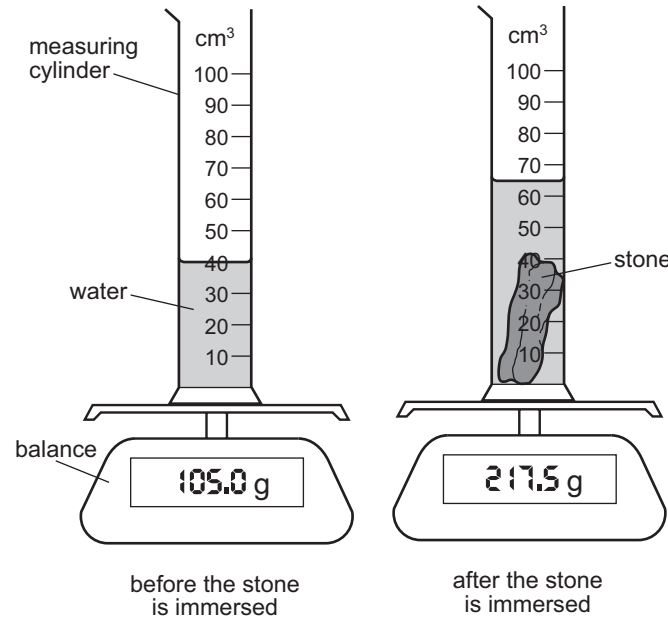
The volume of liquid in the container is 600 cm^3 .

What is the density of the liquid?

- A 0.020 g/cm^3 B 0.80 g/cm^3
C 1.0 g/cm^3 D 1.2 g/cm^3

- 10 A measuring cylinder containing only water is placed on an electronic balance. A small, irregularly shaped stone is now completely immersed in the water.

The diagrams show the equipment before and after the stone is immersed.



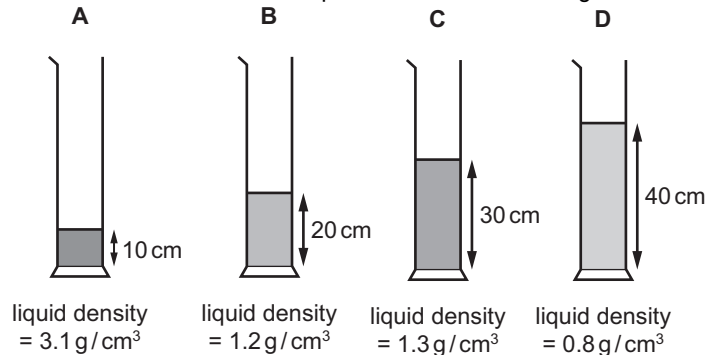
What is the density of the material of the stone?

- A 1.7 g/cm^3 B 3.3 g/cm^3
C 4.5 g/cm^3 D 8.7 g/cm^3

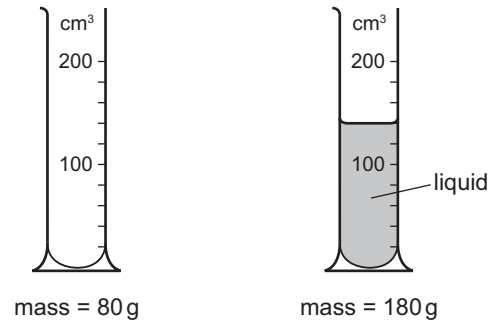
- 11 Four different liquids are poured into four containers.

The diagrams show the depth and the density of liquid in each container.

In which container is the pressure on its base the greatest?



- 12 The masses of a measuring cylinder before and after pouring some liquid into it are shown in the diagram.



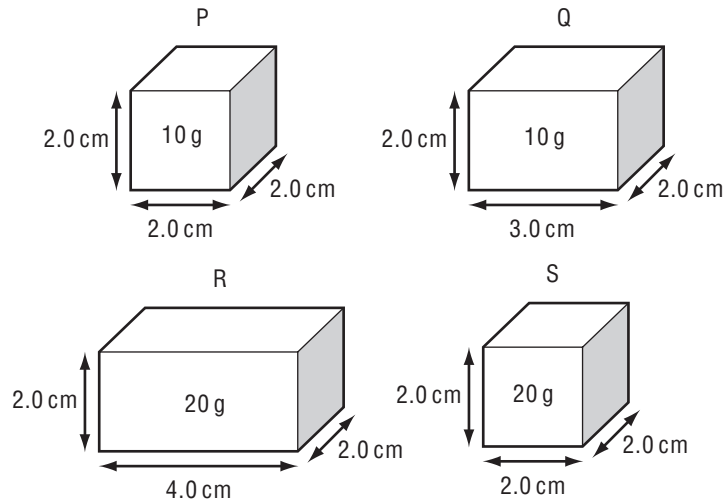
What is the density of the liquid?

- A $\frac{100}{120} \text{ g/cm}^3$ B $\frac{100}{140} \text{ g/cm}^3$
C $\frac{180}{120} \text{ g/cm}^3$ D $\frac{180}{140} \text{ g/cm}^3$

- 13 A steel ball bearing has a mass of 24 g and a density of 8.0 g/cm^3 . It is lowered into a measuring cylinder containing 12 cm^3 of water. What is the new water level in the cylinder?

- A 3.0 cm^3 B 4.0 cm^3
C 15 cm^3 D 16 cm^3

- 14 Four rectangular blocks, P, Q, R and S are shown. Each block is labelled with its size and its mass.

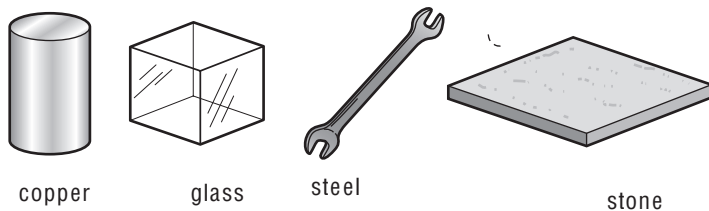


Which two blocks have the same density?

- A P and Q B P and R
C Q and R D R and S
- 15 A student is given four different objects and a metre rule.

Each object has a known mass. She is asked to determine the densities of the material from which the four objects are made.

The objects are a copper cylinder, a glass cube, a steel spanner and a stone tile.



Using only the meter rule, she is able to find the densities of only three of the four materials

Which three materials are these?

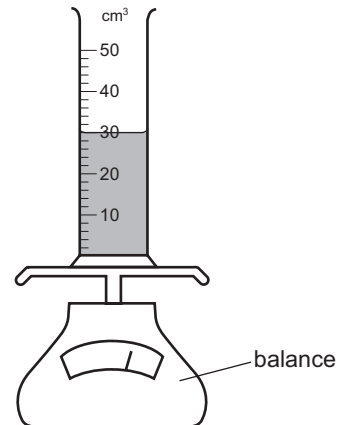
- A copper, glass and steel
B copper, glass and stone
C copper, steel and stone
D glass, steel and stone

- 16 A column of liquid has height h , mass m and density ρ . The gravitational field strength is g .

Which expression gives the pressure due to the column of liquid?

- A $h\rho$ B $m\rho$
C mgh D ρgh

- 17 A measuring cylinder contains 30 cm^3 of a liquid.



Some more of the liquid is added until the liquid level reaches to 50 cm^3 mark.

The reading on the balance increases by 30 g.

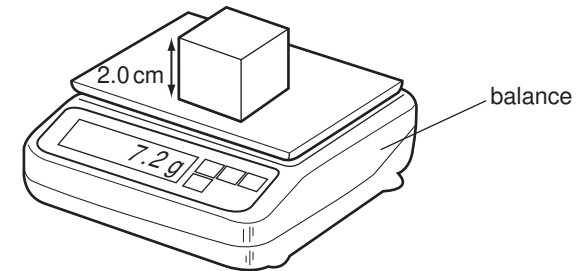
What is the density of the liquid?

- A 0.60 g/cm^3 B 0.67 g/cm^3
C 1.5 g/cm^3 D 1.7 g/cm^3

- 18 A stone has a volume of 0.50 cm^3 and a mass of 2.0 g. What is the density of the stone?

- A 0.25 g/cm^3
B 1.5 g/cm^3
C 2.5 g/cm^3
D 4.0 g/cm^3

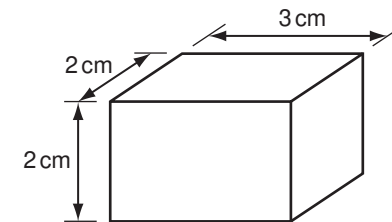
- 19 A cube of side 2.0 cm is placed on a balance.



What is the density of the cube?

- A 0.90 g/cm^3 B 1.2 g/cm^3
C 1.8 g/cm^3 D 3.6 g/cm^3

- 20 The diagram shows a rectangular block of density 2 g/cm^3 .



What is the mass of the block?

- A 2 g B 6 g
C 14 g D 24 g

Density

- 1 A student wishes to find the volume of a piece of wood of irregular shape. Her experiment requires the use of a small brass object of mass 200 g.

- (a)** Calculate the volume of the brass object. The density of brass is 8.4 g/cm^3 .

volume =[2]

- (b)** To find the volume of the piece of wood, the student has a measuring cylinder, a supply of water and the brass object in **(a)**. The piece of wood and the brass object are small enough to be placed in the measuring cylinder.

- (i) The piece of wood does not sink in water.

Suggest why.

.....[1]

- (ii) Describe what the student does to find the volume of the piece of wood, stating the measurements that she makes and any calculations required.

.....[4]

[Total: 7]

- 2 (a)** A student is asked to find the density of a small block of metal, as shown in Fig. 2.1.

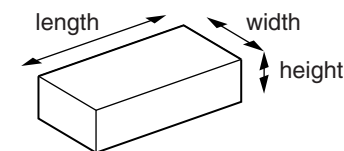


Fig. 2.1

Use words from the list below to complete the following sentences.

balance beaker measuring cylinder protractor rule thermometer

- (i) The student should use a to measure the length, width and height of the metal block.

- (ii) The student should use a to find the mass of the metal block.

[2]

- (b)** A jeweller has a small block of metal. The block has a mass of 15.2 g and a volume of 1.36 cm³.

- (i) Calculate the density of the metal.

density = g/cm³ [3]

- (ii) The jeweller looks up the values for the density of various metals and produces a table, part of which is shown below.

metal	$\frac{\text{density}}{\text{g/cm}^3}$
gold	19.3
lead	11.3
platinum	21.5
silver	10.5

Using your answer to **(b)(i)** and the information in the table, state which metal the block is most likely to be made from.

.....[1]

[Total: 6]

3 A student has 500 identical, rectangular sheets of paper. The mass of 1.0 m^2 of the paper is 0.080 kg .

(a) Using a metre rule, she measures the length of one sheet of paper and its width. The length is 0.300 m and the width is 0.210 m .

(i) Calculate the mass of one sheet of paper.

mass =[1]

(ii) The student makes a single pile of the 500 sheets of paper.

With a metre rule, she measures the height of the pile. The height of the pile is 0.048 m .

Calculate the density of the paper.

density =[3]

(b) A second student has only 5 sheets of the same type of paper.

Suggest how this student determines the density of the paper to a similar accuracy. Additional apparatus may be used.

.....

[2]

[Total: 6]

4 Fig. 4.1 shows remote sensing equipment on the surface of a distant planet.

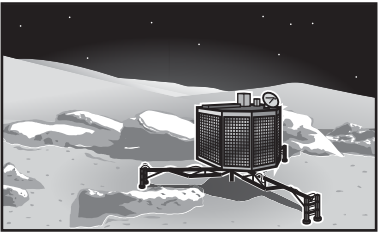


Fig. 4.1

(a) The mass of the equipment is 350 kg . The acceleration of free fall on the surface of this planet is 7.5 m/s^2 .

(i) State what is meant by the term *weight*.

.....
[1]

(ii) Calculate the weight of the equipment on the planet.

weight =[2]

(b) The equipment releases a balloon from a point that is a small distance above the surface of the planet. The atmosphere at the surface of this planet has a density of 0.35 kg/m^3 . The inflated balloon has a mass of 80 g and a volume of 0.30 m^3 .

Make an appropriate calculation and then predict and explain the direction of any motion of the balloon. Show your working.

prediction
 explanation

[4]

[Total: 7]

5 A block of wood has a volume of 210 cm^3 and a mass of 180 g .

(a) Calculate the density of the block of wood.

density =[2]

(b) The block is held just above the surface of a liquid of density 0.88 g/cm^3 .

Predict and explain what happens when the block is released.

.....

[2]

[Total: 4]

6 Fig. 6.1 shows a hollow metal cylinder containing air, floating in the sea.

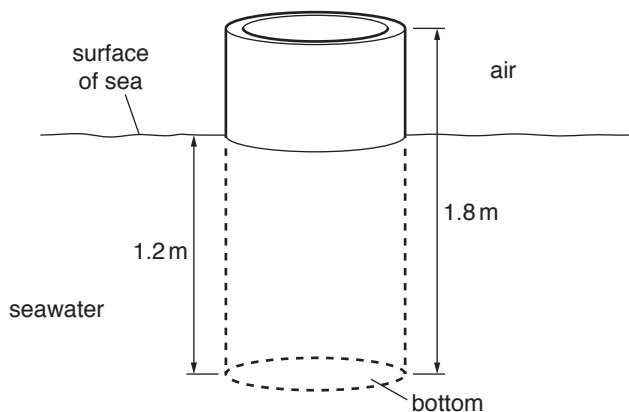


Fig . 6.1

(a) The density of the metal used to make the cylinder is greater than the density of seawater.

Explain why the cylinder floats.

.....
[1]

(b) The cylinder has a length of 1.8 m . It floats with 1.2 m submerged in the sea. The bottom of the cylinder has an area of cross-section of 0.80 m^2 .

The density of seawater is 1020 kg/m^3 . Calculate the force exerted on the bottom of the cylinder due to the depth of the seawater.

force =[4]

(c) Deduce the weight of the cylinder. Explain your answer.

weight =

explanation

[2]

[Total: 7]

7 A student has a large number of coins of different diameters, all made of the same metal. She wishes to find the density of the metal by a method involving placing the coins in water.

(a) State the formula needed to calculate the density.

..... [1]

(b) Describe how the measurements of the required quantities are carried out.

..... [5]

(c) State **one** precaution taken when carrying out the measurements in (b) to ensure that the result is as accurate as possible.

..... [1]

[Total: 7]

8 A student wishes to determine the density of a small, irregularly shaped stone.

(a) With the aid of a labelled diagram, describe an experiment to determine the volume of the stone.

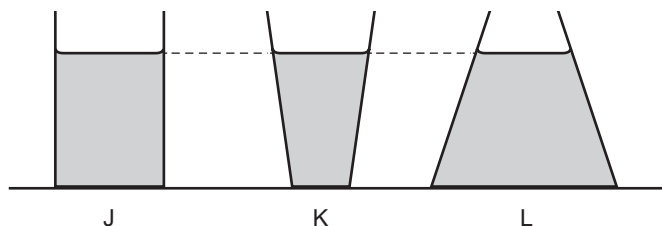
[2]

[Total: 8]

Pressure MCQ

- 1 The diagram shows three different containers J, K and L.

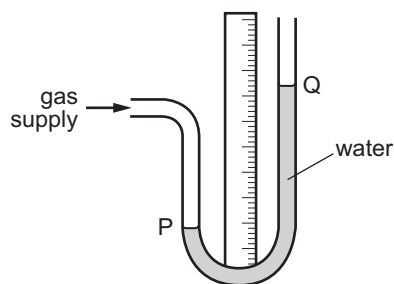
Each container contains water of the same depth



Which statement about the pressure of the water on the base of each container is correct?

- A The water pressure is greatest in container J.
- B The water pressure is greatest in container K.
- C The water pressure is greatest in container L.
- D The water pressure is the same for all three containers.

- 2 A water manometer is connected to a gas supply



There is a gas leak and the pressure of the gas supply falls.

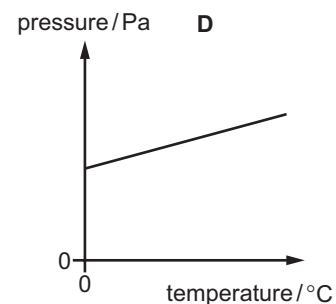
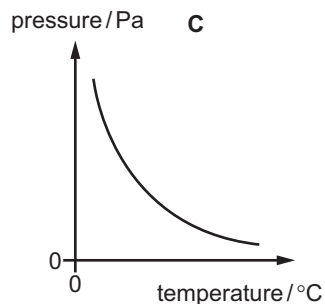
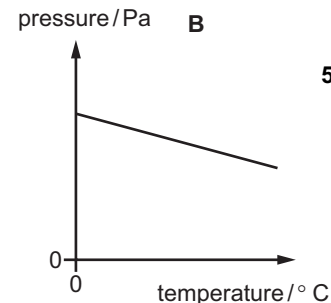
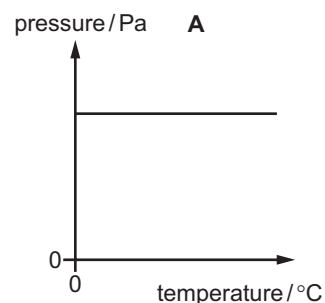
What happens to the water level at P and what happens to the water level at Q?

	water level at P	water level at Q
A	falls	falls
B	falls	rises
C	rises	falls
D	rises	rises

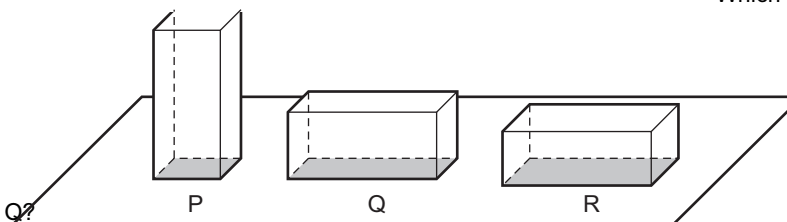
- 3 Some gas is trapped in a container of fixed volume.

The temperature of the gas increases.

Which graph shows how the pressure of the gas changes with temperature?



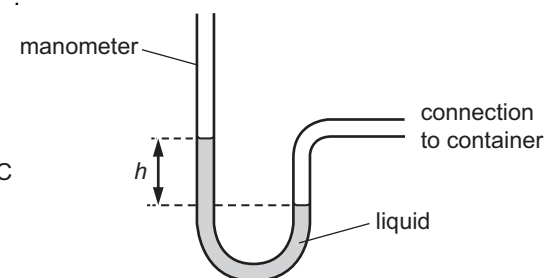
- 4 The scale diagram shows three identical blocks, P, Q and R. The blocks have different areas of contact with the ground.



Which block exerts the greatest pressure on the ground?

- A block P
- B block Q
- C block R
- D they all exert the same pressure

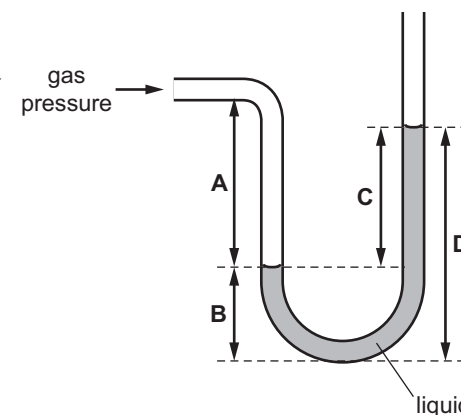
- 5 A manometer is used to measure the pressure of the air in a container



Which change would give a bigger value of height h ?

- A using a less dense liquid
- B using a more dense liquid
- C using a narrower tube
- D using a wider tube

- 6 The diagram shows a manometer containing a liquid. The manometer is used to find the difference between the pressure of a gas and atmospheric pressure. Which distance represents this pressure difference?



- 7 Four physics teachers investigate pressure. They wear identical clothes and lie on different beds of nails.

The table gives the weight of each teacher and the total area of contact between the teacher and the nails.

Which teacher experiences the least pressure from the nails?

	weight of teacher / N	total area of contact / cm ²
A	700	13
B	800	20
C	900	14
D	1000	21

- 8 The table gives four forces and the surface area on which each force acts.

Which row gives the largest pressure on the surface?

	force / N	area / m ²
A	20	2
B	40	2
C	20	4
D	40	4

- 9 What does a barometer measure?

- A** the current in a circuit
- B** the density of a liquid
- C** the pressure of air
- D** the temperature of an object

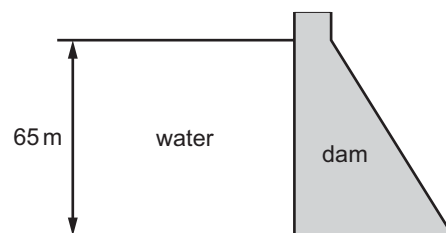
- 10 A man is in contact with the floor. In which of these situations does he produce the least pressure on the floor?

- A** kneeling
- B** lying flat on his back
- C** standing on both feet
- D** standing on one foot

- 11 The water in a lake is at 5°C. A diver measures the pressure of the water at two different depths in the lake. He repeats the measurements on a different day when the water is at 15°C. The density of water decreases when its temperature increases. Which combination of depth and temperature produces the greatest water pressure?

	depth / m	temperature / °C
A	10	5
B	10	15
C	20	5
D	20	15

- 12 The diagram shows a dam holding back water.



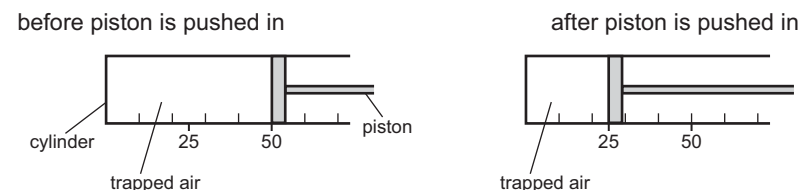
The depth of the water is 65 m.

The density of the water is 1000 kg/m³. The gravitational field strength g is 10 N/kg.

What is the pressure exerted at the base of the dam due to the water?

- A** 15.4 Pa **B** 154 Pa
- C** 65 000 Pa **D** 650 000 Pa

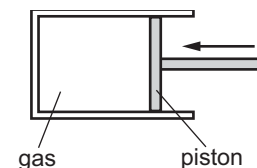
- 13 Air is trapped in a cylinder by a piston. The original volume of the trapped air is V and the original pressure of the trapped air is P . The piston is pushed to the left. The temperature of the gas does not change.



What is the new volume and what is the new pressure of the trapped air?

	new volume	new pressure
A	$2V$	$\frac{P}{2}$
B	$2V$	$2P$
C	$\frac{V}{2}$	$\frac{P}{2}$
D	$\frac{V}{2}$	$2P$

- 14 The diagram shows a gas that is trapped in a cylinder by a piston. The volume of the gas is 120 cm³ and the pressure of the gas is P .



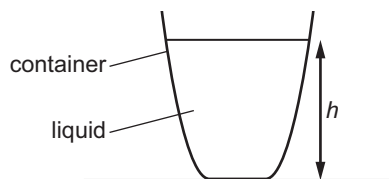
The piston is moved slowly to the left so that the volume of the gas reduced to 30 cm³.

The temperature of the gas does not change.

What is the new pressure of the trapped gas?

- A** $\frac{P}{4}$ **B** $\frac{P}{2}$
- C** P **D** $4P$

- 15 A container is filled with liquid to a certain depth h .



The pressure of the liquid at the bottom of the container depends on several factors.

Which is one factor on which the pressure does **not** depend?

- A the strength of the Earth's gravitational field
B the density of the liquid
C the depth of the liquid
D the strength of the Earth's magnetic field
- 16 The volume of a gas is measured at different pressures.

The pressure p and the volume V of the gas are found to be related by the equation:

$$pV = \text{constant}.$$

Which quantities are kept constant and which quantities change?

	density of gas	mass of gas	temperature of gas
A	✓	✓	✗
B	✓	✗	✓
C	✗	✓	✓
D	✗	✗	✓

key ✓ = constant ✗ = changed

- 17 A diver under water uses breathing apparatus at a depth where the pressure is $1.25 \times 10^5 \text{ Pa}$.



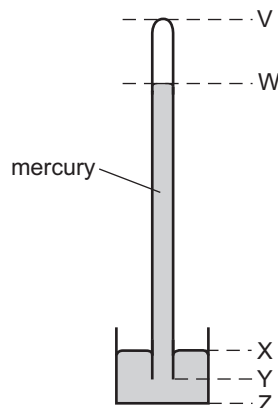
A bubble of gas breathed out by the diver has a volume of 20 cm^3 when it is released. The bubble moves upwards to the surface of the water. At the surface of the water, the atmospheric pressure is $1.00 \times 10^5 \text{ Pa}$.

The temperature of the water is the same at all depths.

What is the volume of this bubble when it reaches the surface?

- A 15 cm^3 B 16 cm^3 C 20 cm^3 D 25 cm^3

- 18 The diagram shows a simple mercury barometer.



The atmospheric pressure increases.

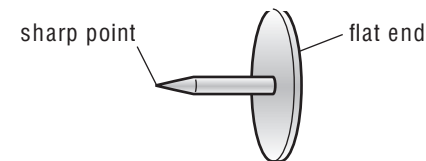
Which distance increases?

- A VW B WY
C XY D XZ

- 19 Gas molecules striking a container wall cause a pressure to be exerted on the wall. Which statement explains this?

- A When a molecule rebounds there must be a change in its energy.
B When a molecule rebounds there must be a change in its momentum.
C When a molecule rebounds there must be a change in its speed.
D When a molecule rebounds there must be a change in its temperature.

- 20 A drawing pin (thumb tack) has a sharp point and a flat end.



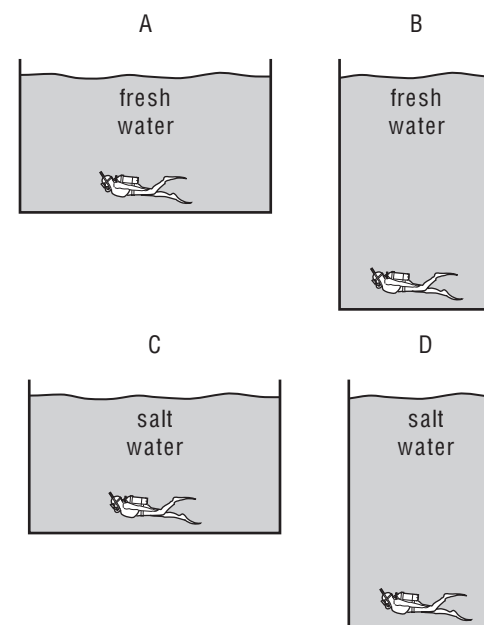
The pin is pushed into a wooden board. How do the pressure and the force at the sharp point compare with the pressure and the force at the flat end.

	force at the sharp point	pressure at the sharp point
A	greater than at the flat end	greater than at the flat end
B	greater than at the flat end	less than at the flat end
C	the same as at the flat end	greater than at the flat end
D	the same as at the flat end	less than at the flat end

- 21 The diagrams show four divers at the bottom of four different swimming pools.

Two swimming pools contain fresh water and two contain salt water. Fresh water is less dense than salt water.

Which diver feels the least pressure from the water?

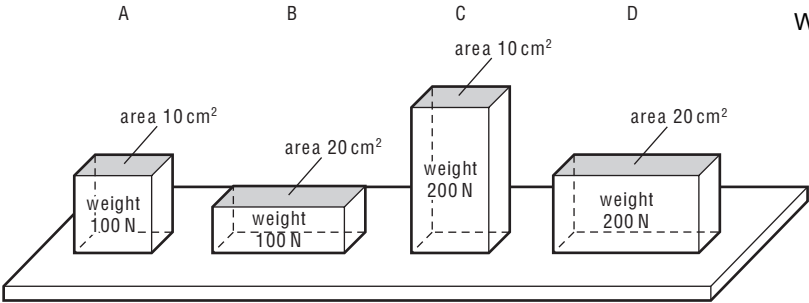


22 It is dangerous for submarines to dive to very great depths.

Why is it dangerous?

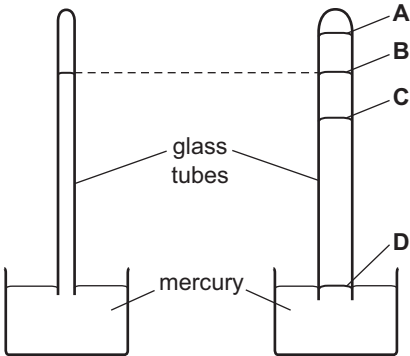
- A The density of water is less at greater depths.
- B The pressure of water is greater at greater depths.
- C The temperature of water is higher at greater depths.
- D The weight of the submarine is greater at greater depths.

23 Which block exerts the greatest pressure on the surface below it?

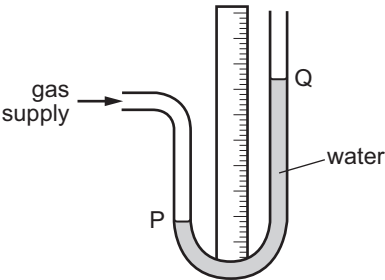


24 The diagrams show two mercury barometers. The right-hand diagram shows a tube of larger diameter. There is a vacuum above the mercury in both tubes.

Which labelled position on the right-hand tube shows the mercury level in the right-hand tube?



25 A water manometer is connected to a gas supply



There is a gas leak and the pressure of the gas supply falls.

What happens to the water level at P and what happens to the water level at Q?

	water level at P	water level at Q
A	falls	falls
B	falls	rises
C	rises	falls
D	rises	rises

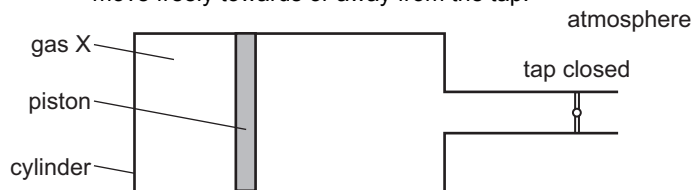
26 A submarine is 20 m below the surface of the sea. The pressure due to the water at this depth is P .

On another day, the submarine is 26 m below the surface of fresh water. The density of sea water is 1.3 times the density of fresh water.

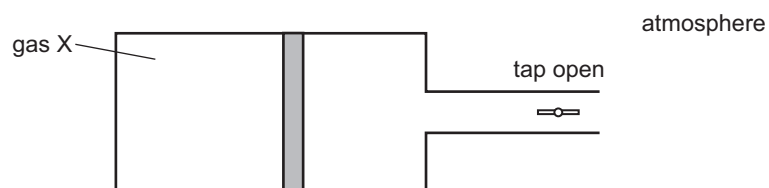
What is the pressure due to the fresh water at a depth of 26 m?

- A $\frac{P}{1.3}$
- B P
- C $1.3 P$
- D $1.7 P$

- 27 A cylinder with a tap contains a fixed mass of gas X. The gas is contained by a piston which can move freely towards or away from the tap.



When the tap is opened, the piston moves slightly to the right, towards the tap.



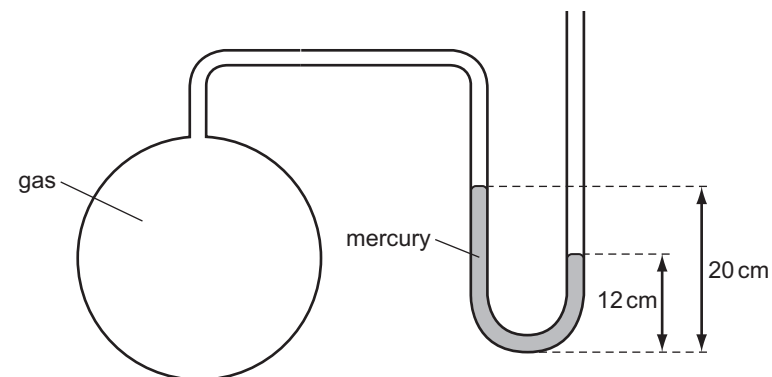
What can be deduced about the pressure of gas X?

	before opening tap	after opening tap
A	less than atmospheric pressure	more than atmospheric pressure
B	same as atmospheric pressure	more than atmospheric pressure
C	more than atmospheric pressure	less than atmospheric pressure
D	more than atmospheric pressure	same as atmospheric pressure

- 28 Which statement is explained by reference to pressure?

- A Objects with greater mass have greater weight.
- B One kilogram of water occupies more volume than one kilogram of lead.
- C Spikes on running-shoes sink into the ground.
- D Water cooled to a low enough temperature turns to ice.

- 29 The diagram shows a mercury manometer used to measure the pressure of gas in a container. Atmospheric pressure is 76 cm of mercury.



What is the pressure of the gas?

- A 56 cm of mercury
- B 68 cm of mercury
- C 84 cm of mercury
- D 96 cm of mercury

- 30 In which position would a boy exert the **most** pressure on the ground?

- A lying on his back
- B sitting down
- C standing on one foot
- D standing on two feet

Pressure

- 1 (a) A student carries out an experiment to find the relationship between the pressure p and the volume V of a fixed mass of gas. The table contains four of her sets of measurements.

p/kPa	250	500	750	1000
V/cm^3	30.0	15.2	9.8	7.6

- (i) Use the data in the table to suggest the relationship between the pressure and the volume in this experiment. Explain how you reach your conclusion.

.....

[2]

- (ii) State the property of the gas, apart from the mass, that remains constant during the experiment.

.....[1]

- (b) A lake is 5.0 m deep. The density of the water is 1000 kg/m^3 .

- (i) Calculate the pressure at the bottom of the lake due to this depth of water.

pressure =[2]

- (ii) A bubble of gas escapes from the mud at the bottom of the lake and rises to the surface.

Place one tick in each row of the table to indicate what happens to the volume, the mass and the density of the gas in the bubble. Assume that no gas or water vapour enters or leaves the bubble.

	increases	stays the same	decreases
volume of bubble			
mass of gas in bubble			
density of gas in bubble			

[2]

[Total: 7]

- 2 A round-bottomed flask is connected to a mercury manometer. The air inside the flask is warm. The arrangement is shown in Fig. 2.1.

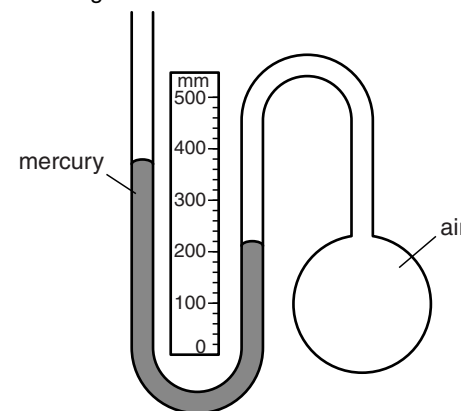


Fig. 2.1

- (a) (i) State the scale reading for the left-hand column.

left-hand column = mm

State the scale reading for the right-hand column.

right-hand column = mm
[1]

- (ii) Atmospheric pressure is equal to 760 mm of mercury.

Calculate the pressure of the air inside the flask.

pressure = mm of mercury [3]

- (b) The air inside the flask cools.

- (i) State what happens to the pressure of the air inside the flask as the air cools.

..... [1]

- (ii) In terms of the air molecules, state **two** ways in which the air changes as it cools.

.....

 [2]

[Total: 7]

3 Fig. 3.1 shows a car and a snow tractor.

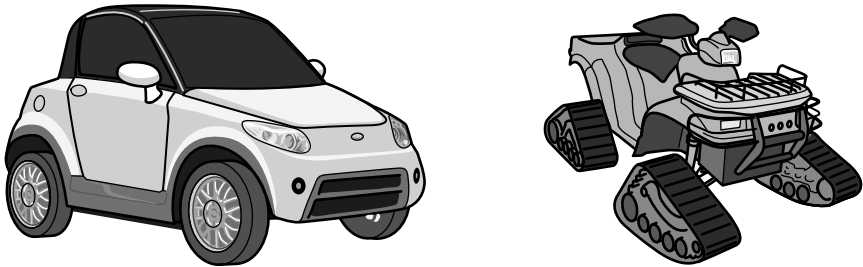


Fig. 3.1

The car and the snow tractor have the same weight.

(a) Explain why the snow tractor can travel across soft snow without sinking, but the car cannot.

.....

[3]

(b) The car driver checks his tyre pressure in a warm garage. The pressure of the air inside the tyre when it is warm is 24.0N/cm².

The car is driven outside and left in the snow.

(i) Suggest a value for the pressure of the air inside the tyre when it is cold.

pressure = N/cm² [1]

(ii) In terms of the air molecules inside the tyre, explain the change in the pressure of the air.

.....

[2]

[Total: 6]

4 A large stone block is to be part of a harbour wall. The block is supported beneath the surface of the sea by a cable from a crane. Fig. 4.1 shows the block with its top face a distance *h* beneath the surface of the sea.

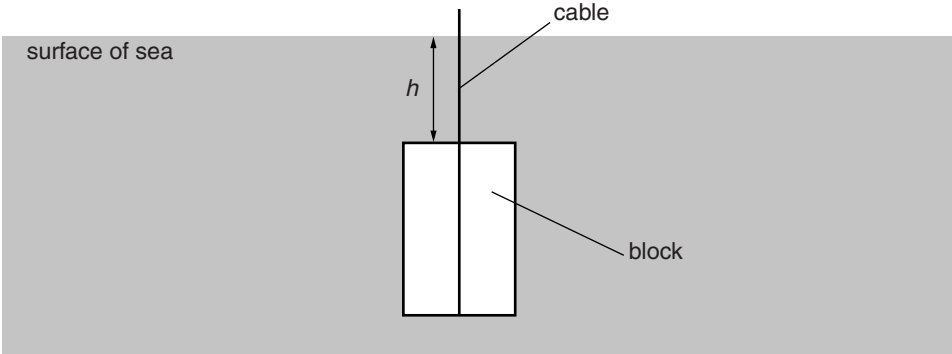


Fig. 4.1

The force acting downwards on the top face of the block, due to the atmosphere and the depth *h* of water, is 3.5 × 10⁴ N.

(a) The top face of the block has an area of 0.25 m².

(i) Calculate the pressure on the top face of the block.

pressure = [2]

The atmospheric pressure is 1.0 × 10⁵ Pa.

(ii) Calculate the pressure on the top face of the block due to the depth *h* of water.

pressure = [1]

The density of sea water is 1020 kg/m³.

(iii) Calculate the depth *h*.

h = [2]

(b) Suggest two reasons why the tension force in the cable is not $3.5 \times 10^4 \text{ N}$.

1.

2.

[2]

(c) The block is lowered so that it rests on the sea-bed.

State what happens to the tension force in the cable.

.....

[1]

[Total: 8]

5 Fig. 5.1 shows a cylinder containing gas compressed by the movement of a piston.

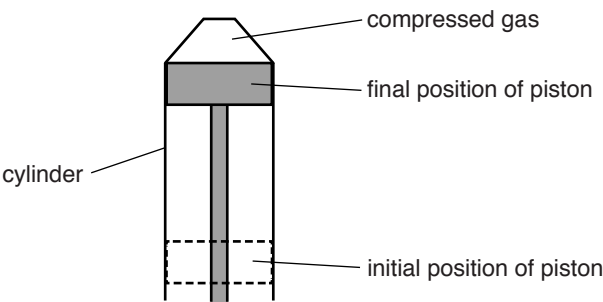


Fig. 5.1

Initially the volume of the gas was 470 cm^3 . The piston moves up and compresses the gas to a volume of 60 cm^3 . The whole arrangement is left for some time until the gas cools to its original temperature. The pressure of the gas is now 800 kPa .

(a) Calculate the initial pressure of the gas.

pressure =[3]

(b) Explain, in terms of molecules, the effect on the pressure of the gas if it was not given time to cool to its original temperature.

.....

.....

.....

.....[3]

(c) The area of the piston is $5.5 \times 10^{-3} \text{ m}^2$ (0.0055 m^2).

Calculate the force exerted by the gas on the piston when the pressure is 800 kPa .

force =[2]

[Total: 8]

6 Fig. 6.1 shows an oil tank that has a rectangular base of dimensions 2.4m by 1.5m.

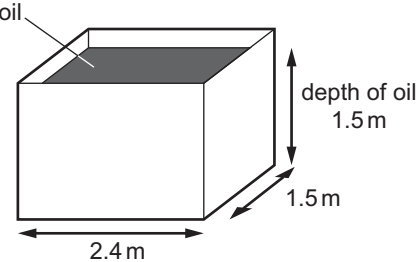


Fig. 6.1

The tank is filled with oil of density 850 kg/m^3 to a depth of 1.5 m.

(a) Calculate

(i) the pressure exerted by the oil on the base of the tank,

pressure = [2]

(ii) the force exerted by the oil on the base of the tank.

force = [2]

(b) The force calculated in (a)(ii) is the weight of the oil.

Calculate the mass of oil in the tank.

mass = [1]

(c) When he is checking the level of oil in the tank, a man drops a brass key into the oil and it sinks to the bottom of the oil.

(i) State what this shows about the density of brass.

..... [1]

(ii) Explain how attaching the key to a piece of wood could prevent the key from sinking.

.....

 [1]

[Total: 7]

- 7 a) State what happens to the molecules of a gas in a sealed container when the temperature of the gas is increased.

..... [1]

- (b) A quantity of gas is contained in a sealed container of fixed volume. The temperature of the gas is increased.

State, in terms of molecules, **two** reasons why the pressure of the gas increases.

1.

2.

[2]

- (c) A helium-filled weather balloon is held at ground level. The volume of the balloon is 4800 m^3 . The pressure of the helium is 98 kPa .

The balloon is released and rises to a height where the volume of the balloon is 7200 m^3 .

- (i) Calculate the new pressure of the helium. Assume that the temperature stays constant.

pressure = [2]

- (ii) Suggest why it may be necessary to release helium from the balloon as it rises even higher.

.....

..... [1]

[Total: 6]

- 8 An archaeologist is investigating a shipwreck and discovers a wooden box on the seabed.

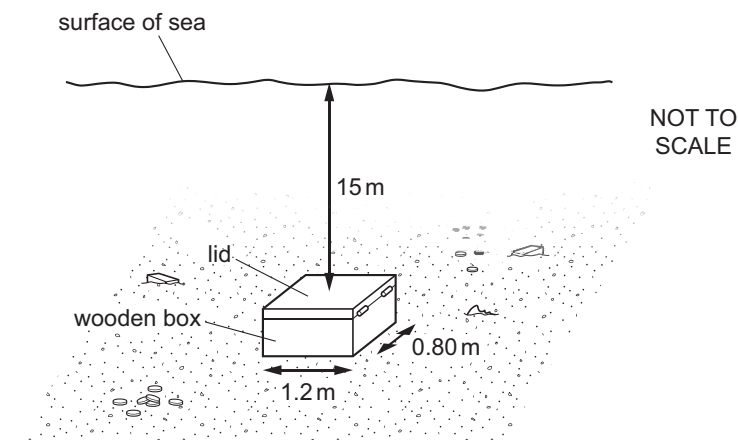


Fig. 8.1

The dimensions of the lid of the box are 1.2 m by 0.80 m and the pressure of the atmosphere is $1.0 \times 10^5 \text{ Pa}$. The lid is 15 m below the surface of the sea.

- (a) The density of sea-water is 1020 kg/m^3 .

Calculate

- (i) the pressure on the lid of the box due to the sea-water,

pressure = [2]

- (ii) the total pressure on the lid,

pressure = [1]

(iii) the downward force that the total pressure produces on the lid.

force = [2]

(b) The force needed to open the lid is **not** equal to the value calculated in (a)(iii).

Suggest **two** reasons for this.

1.

.....

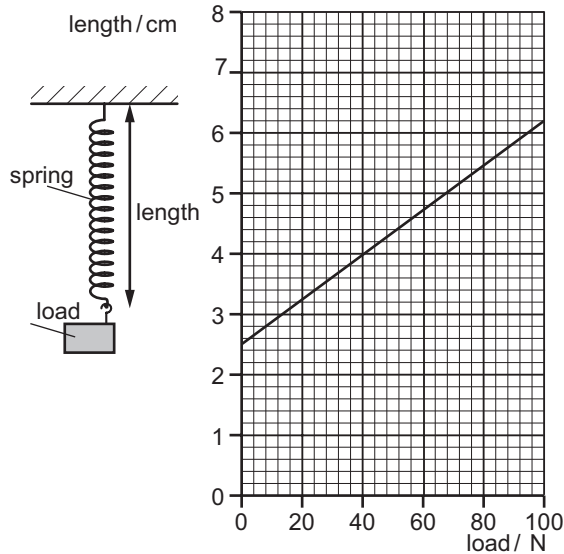
2.

..... [2]

[Total: 7]

Deformations MCQ

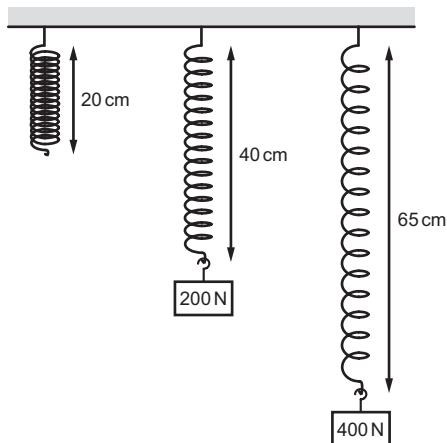
- 1 The diagrams show a spring and a graph of the length of the spring against the load applied to it.



What is the extension of the spring when a load of 40 N is applied to it?

- A 1.5 cm B 2.5 cm C 4.0 cm D 6.5 cm

- 2 Different loads are hung on a spring. The diagram shows the length of the spring with and without the loads attached



What is the extension of the spring when the load is 400 N?

- A 5 cm B 25 cm C 40 cm D 45 cm

- 3 A spring which obeys Hooke's Law has an unstretched length of 10 cm.

A load of 20 N is hung from the spring.

The new length of the spring is 36 cm.

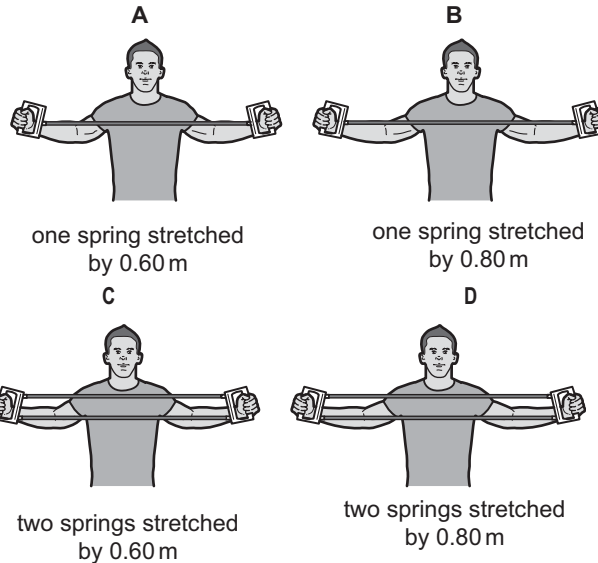
What is the spring constant k of the spring?

- A 0.56 N/cm B 0.77 N/cm
C 1.3 N/cm D 1.8 N/cm

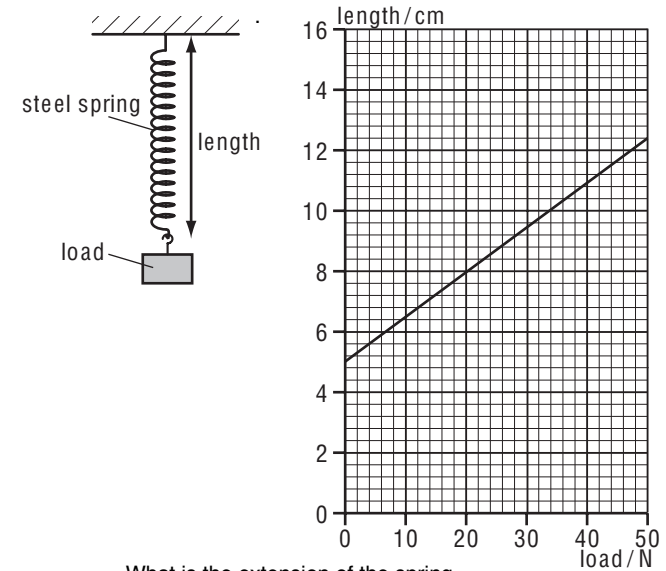
- 4 The diagrams show athletes training by stretching springs.

Each spring has the same stiffness.

Which athlete does the most work?



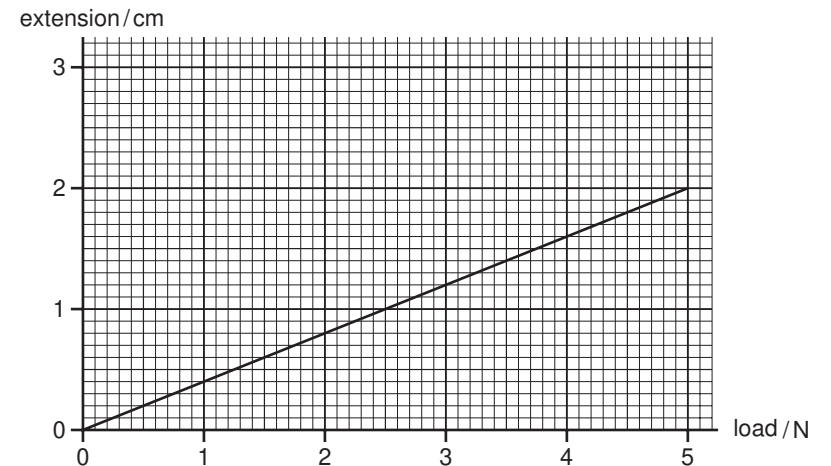
- 5 The diagrams show a steel spring and a graph of its length against the load applied to it



What is the extension of the spring when a load of 20 N is applied to it?

- A 3.0 cm B 4.5 cm
C 5.0 cm D 8.0 cm

- 6 The extension/load graph for a spring is shown. The unloaded length of the spring is 15.0 cm.



When an object of unknown weight is hung on the spring, the length of the spring is 16.4 cm.

What is the weight of the object?

- A 0.55 N B 0.67 N C 3.5 N D 4.1 N

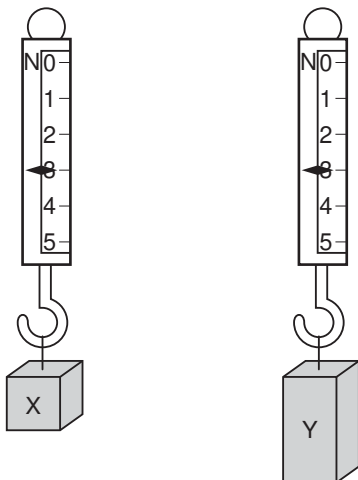
- 7 An experiment is carried out to measure the extension of a rubber band for different loads. The results are shown below.

load / N	0	1	2	3
length / cm	15.2	16.2		18.6
extension / cm	0	1.0	2.1	3.4

Which figure is missing from the table?

- A 17.2 B 17.3
C 17.4 D 17.6

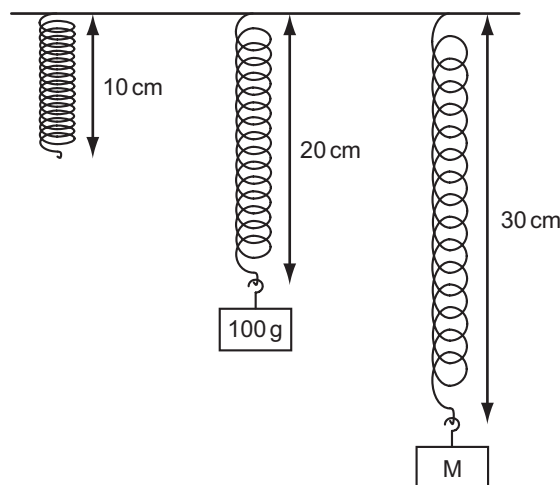
- 8 Two blocks of metal X and Y hang from spring balances as shown in the diagram



What does the diagram show about X and Y?

- A They have the same mass and the same volume but different weights.
B They have the same mass and the same weight but different volumes.
C They have the same mass, the same volume and the same weight.
D They have the same weight and the same volume but different masses.

- 9 Objects with different masses are hung on a 10 cm spring. The diagram shows how much the spring stretches.



The extension of the spring is directly proportional to the mass hung on it.

What is the mass of object M?

- A 110 g B 150 g
C 200 g D 300 g

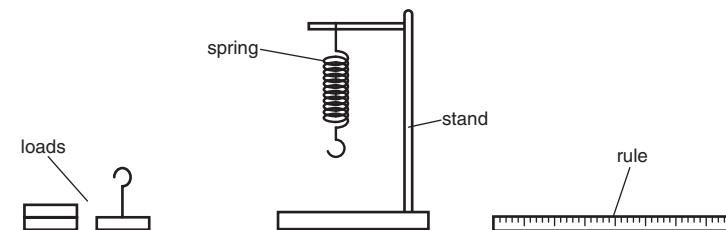
- 10 An experiment is carried out to measure the extension of a rubber band for different loads. The results are shown below.

load / N	0	1	2	3
length / cm	15.2	16.2		18.6
extension / cm	0	1.0	2.1	3.4

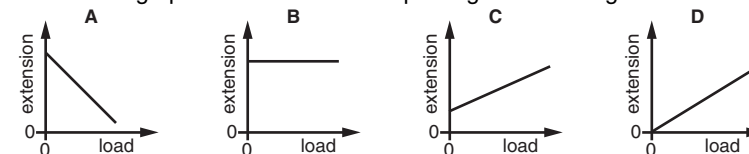
Which figure is missing from the table?

- A 16.5 B 17.3
C 17.4 D 18.3

- 11 A spring is suspended from a stand. Loads are added and the extensions are measured.



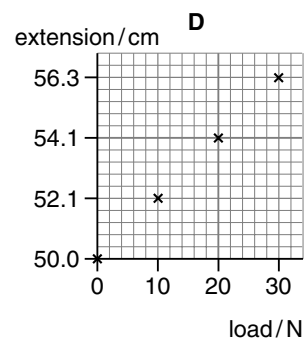
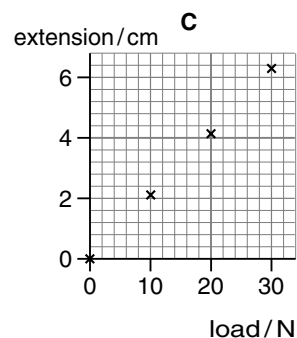
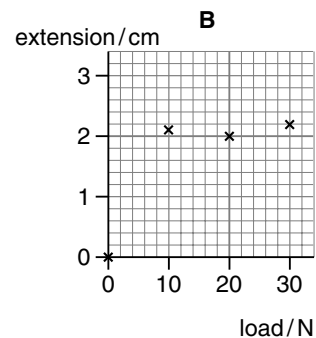
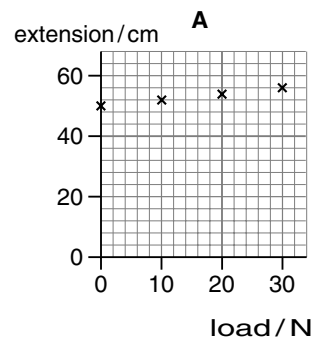
Which graph shows the result of plotting extension against load?



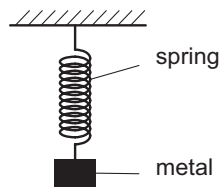
- 12 The table below shows the length of a wire as the load on it is increased.

load / N	0	10	20	30
length / cm	50.0	52.1	54.1	56.3

Which graph correctly shows the extension of the wire plotted against load?



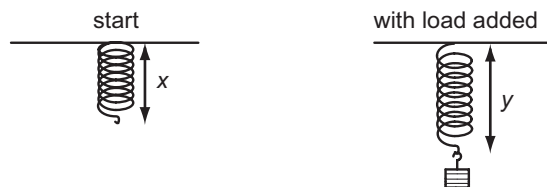
- 13 A spring is stretched by hanging a piece of metal from it.



What is the name given to the force that stretches the spring?

- A friction
B mass
C pressure
D weight

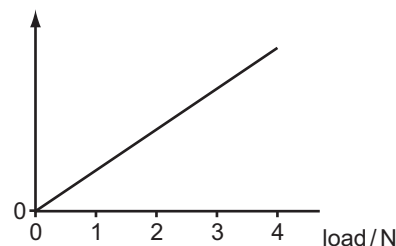
- 14 A student carries out an experiment to plot an extension / load graph for a spring. The diagrams show the apparatus at the start of the experiment and with a load added.



What is the extension caused by the load?

- A x B y
C $y + x$ D $y - x$

- 15 A student adds loads to an elastic cord. He measures the length of the cord for each load. He then plots a graph from the results.

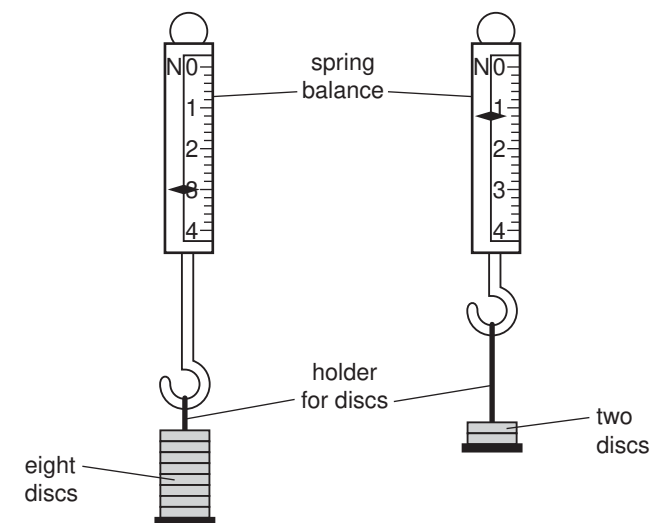


Which length is plotted on the vertical axis?

- A measured length
B original length
C (measured length – original length)
D (measured length + original length)

- 16 The reading on a spring balance with a holder and eight identical discs is 3.0 N.

Six discs are removed and the reading becomes 1.2 N.



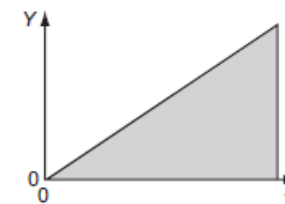
What is the weight of one disc?

- A 0.2 N B 0.3 N
C 0.5 N D 0.6 N

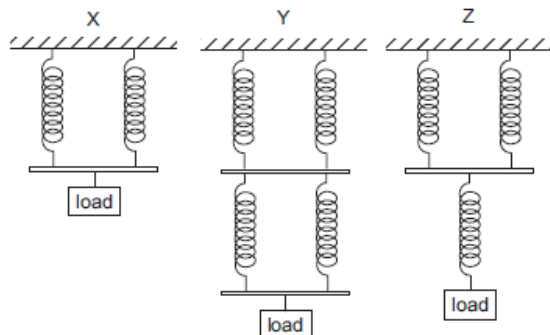
- 17 The graph shown was plotted in an experiment on a metal wire.

The shaded area represents the total strain energy stored in stretching the wire. How should the axes be labelled?

	Y	X
A	force	extension
B	mass	extension
C	strain	energy
D	stress	strain



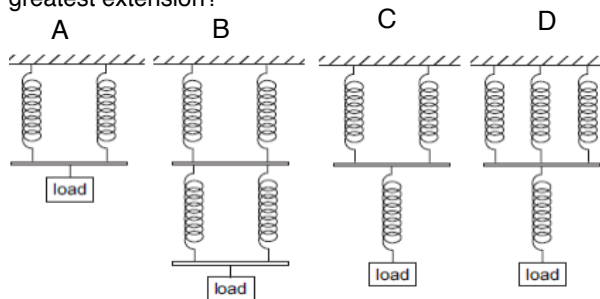
18 A number of similar springs, each having the same spring constant, are joined in three arrangements X, Y and Z. The same load is applied to each.



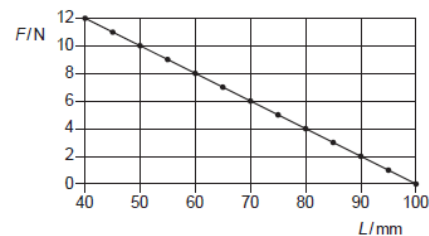
What is the order of increasing extension for these arrangements?

	smallest	→	largest
A	X		Y
B	Z		Y
C	Z		X
D	Y		Z

19 A number of similar springs, each having the same spring constant, are joined in four arrangements. The same load is applied to each. Which arrangement gives the greatest extension?



20 A spring is compressed by a force. The graph shows the compressing force F plotted against the length L of the spring.



What is the spring constant of this spring?

- A** 0.2 N m^{-1} **B** 5 N m^{-1} **C** 100 N m^{-1} **D** 200 N m^{-1}

Deformations

- 1 Fig. 1.1 shows part of the extension-load graph for a spring.

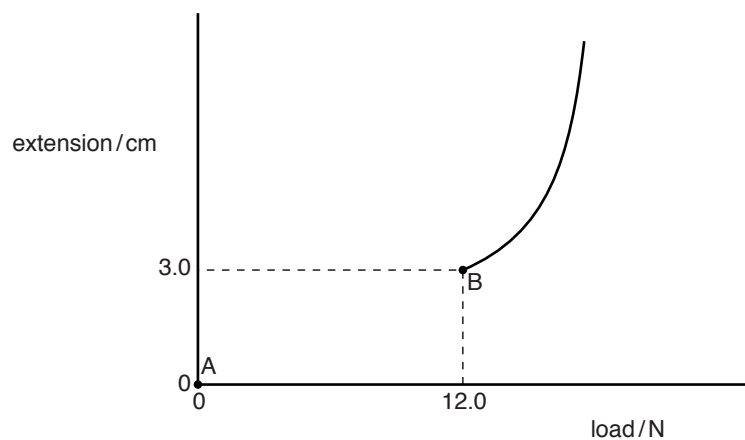


Fig. 1.1

The spring obeys Hooke's law between points A and B.

- (a) (i) On Fig. 1.1, complete the graph between A and B.

[1]

- (ii) State the name of point B.

.....[1]

- (b) The average value of the load between A and B is 6.0 N.

Calculate the work done in extending the spring from A to B.

work done =[2]

- (c) The spring has an unstretched length of 4.0 cm.

An object is hung on the spring and the spring length increases from 4.0 cm to 6.0 cm.

- (i) Calculate the mass of the object.

mass =[3]

- (ii) The object is immersed in a liquid but remains suspended from the spring.

The liquid exerts an upward force on the object and the length of the spring decreases to 5.0 cm.

Calculate the upward force exerted on the object by the liquid.

upward force =[2]

[Total: 9]

2 Fig. 2.1 shows a spring before and after it is stretched by a small load.

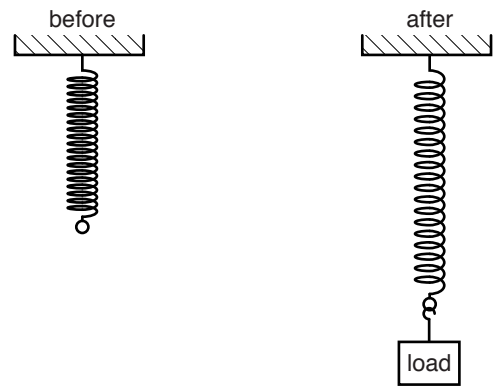


Fig. 2.1

- (a) On Fig. 2.1,
- (i) mark the extension caused by the load,
 - (ii) draw the apparatus needed to determine the extension.
- (b) Fig. 2.2 shows a sketch graph of the length of the spring, plotted against the weight of the load.

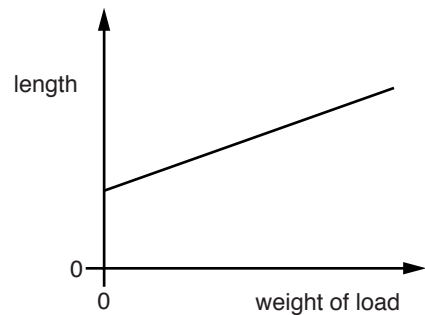


Fig. 2.2

- On Fig. 2.2, mark clearly the unstretched length of the spring.
- (c) State the unit in which the weight of the load is measured.
-[1]

[Total: 4]

3 An athlete of mass 64 kg is bouncing up and down on a trampoline.

At one moment, the athlete is stationary on the stretched surface of the trampoline. Fig. 3.1 shows the athlete at this moment.

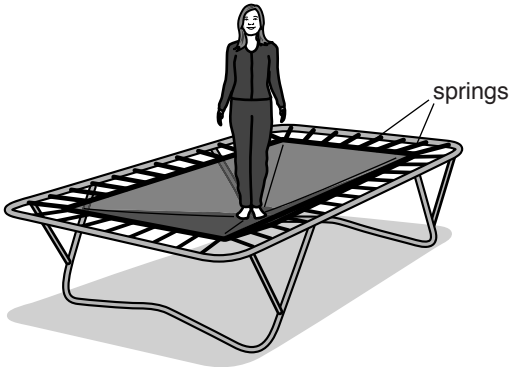


Fig. 3.1

- (a) State the form of energy stored due to the stretching of the surface of the trampoline.
-[1]
- (b) The stretched surface of the trampoline begins to contract. The athlete is pushed vertically upwards and she accelerates. At time t , when her upwards velocity is 6.0 m/s, she loses contact with the surface.
- (i) Calculate her kinetic energy at time t .

kinetic energy =[2]

- (ii) Calculate the maximum possible distance she can travel upwards after time t .

maximum distance =[3]

- (iii) In practice, she travels upwards through a slightly smaller distance than the distance calculated in (ii).

Suggest why this is so.

.....
[1]

- (c) The trampoline springs are tested. An extension-load graph is plotted for one spring. Fig. 3.2 is the graph.

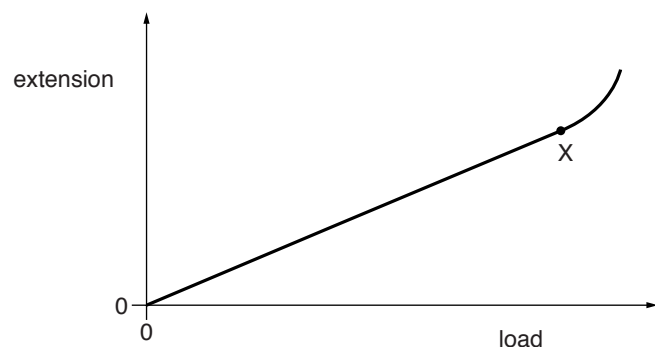


Fig. 3.2

- (i) State the name of the point X.
[1]
- (ii) State the name of the law that the spring obeys between the origin of the graph and point X.
[1]

[Total: 9]

- 4 (a) (i) On Fig. 4.1, draw a graph of extension against load for a spring which obeys Hooke's law. [1]

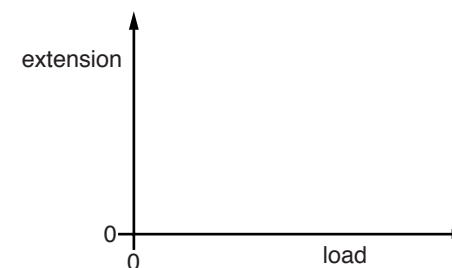


Fig. 4.1

- (ii) State the word used to describe the energy stored in a spring that has been stretched or compressed.
[1]

- (b) Fig. 4.2 shows a model train, travelling at speed v , approaching a buffer.

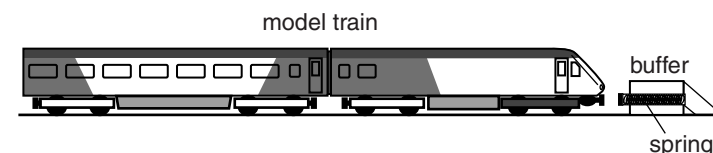


Fig. 4.2

The train, of mass 2.5 kg, is stopped by compressing a spring in the buffer. After the train has stopped, the energy stored in the spring is 0.48 J.

Calculate the initial speed v of the train.

$v =$ [4]

[Total: 6]

5 Fig. 5.1 shows the extension-load graph for a spring.

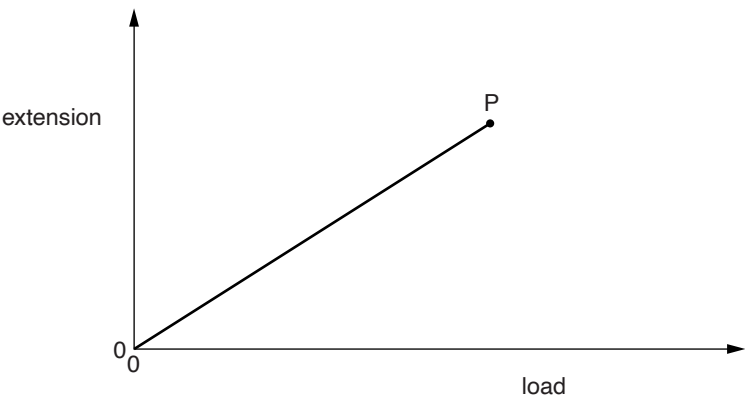


Fig. 5.1

Point P is the limit of proportionality.

- (a) (i) Name the law obeyed by the spring from the origin to P.

.....[1]
- (ii) Describe two features **of the graph** which show that the law is obeyed.

1.

2.[2]
- (b) On Fig. 5.1, sketch a possible continuation of the graph when the spring is loaded beyond the limit of proportionality.

[1]
- [Total: 4]

6 A student investigated the stretching of a spring by hanging various weights from it and measuring the corresponding extensions. The results are shown below.

weight / N	0	1	2	3	4	5
extension / mm	0	21	40	51	82	103

(a) On Fig. 6.1, plot the points from these results. Do not draw a line through the points yet. [2]

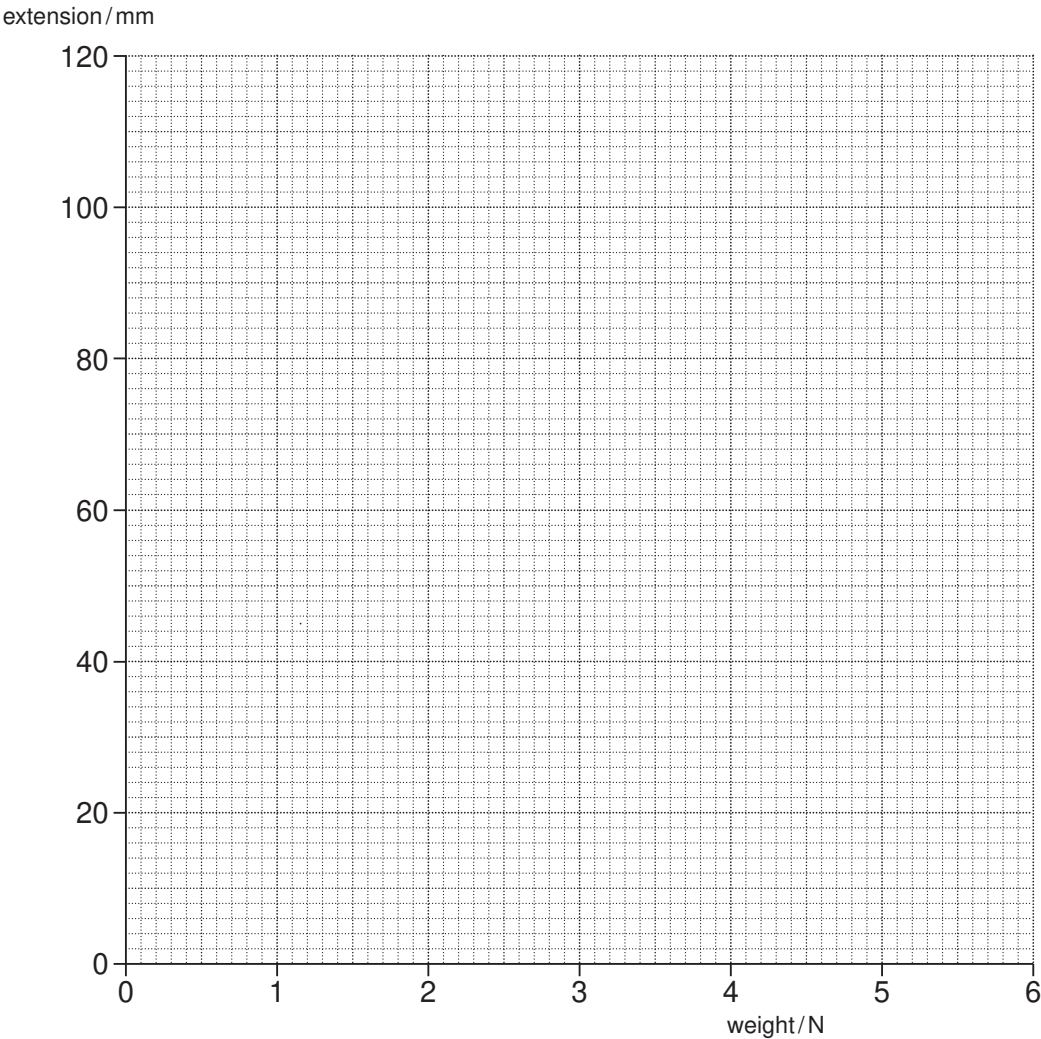


Fig. 6.1

- (b) The student appears to have made an error in recording one of the results.

Which result is this?

..... [1]

- (c) Ignoring the incorrect result, draw the best straight line through the remaining points. [1]

- (d) State and explain whether this spring is obeying Hooke's Law.

.....

 [2]

- (e) Describe how the graph might be shaped if the student continued to add several more weights to the spring.

.....

 [1]

- (f) The student estimates that if he hangs a 45N load on the spring, the extension will be 920 mm.

Explain why this estimate may be unrealistic.

.....

 [1]

[Total: 8]

- 7 Four students, A, B, C and D, each have a spring. They measure the lengths of their springs when the springs are stretched by different loads.

Their results are shown in Fig. 7.1.

	student A	student B	student C	student D
load / N	spring length / cm	spring length / cm	spring length / cm	spring length / cm
0.5	6.7	9.2	9.1	10.0
1.0	7.7	10.0	9.9	11.1
1.5	8.7	10.8	10.7	12.2
2.0	9.7	11.6	11.5	13.3
2.5	10.7	12.6	12.3	14.4
3.0	11.7	13.8	13.1	15.5
3.5	12.7	15.2	13.9	16.6
4.0	13.7	16.8	14.7	17.7

Fig. 7.1

- (a) (i) State which student had loaded the spring beyond the limit of proportionality.

..... [1]

- (ii) Explain how you obtained your answer to (a)(i).

.....

 [2]

- (b) For the spring used by student A, calculate

- (i) the extra extension caused by each additional 0.5 N,

extra extension = [1]

- (ii) the unloaded length of the spring.

unloaded length = [1]

- (c) Student A obtains a second spring that is identical to his first spring. He hangs the two springs side by side, as shown in Fig. 7.2.

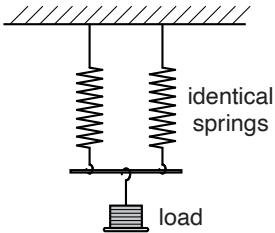


Fig. 7.2

Use the table to calculate the length of each of the springs when a load of 2.5 N is hung as shown in Fig. 7.2. Show your working.

length = [2]
[Total: 7]

- 8 In an experiment, forces are applied to a spring as shown in Fig. 8.1a. The results of this experiment are shown in Fig. 8.1b.

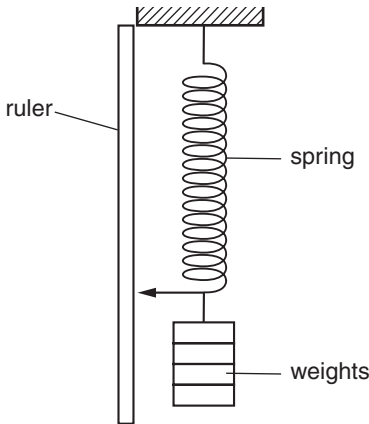


Fig. 8.1a

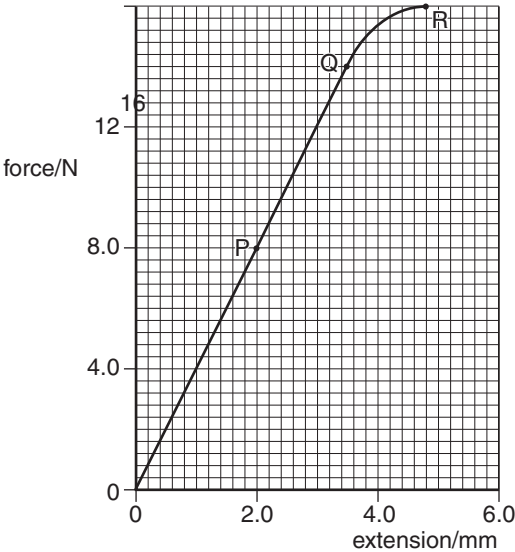


Fig. 8.1b

- (a) What is the name given to the point marked Q on Fig. 2.1b?
.....[1]
- (b) For the part OP of the graph, the spring obeys Hooke's Law.
State what this means.
.....[1]
.....[1]
- (c) The spring is stretched until the force and extension are shown by the point R on the graph. Compare how the spring stretches, as shown by the part of the graph OQ, with that shown by QR.
.....[1]
.....[1]
- (d) The part OP of the graph shows the spring stretching according to the expression
 $F = kx$.
Use values from the graph to calculate the value of k .

$k = \dots\dots\dots$ [2]

Work, Energy and Power

Summary Notes

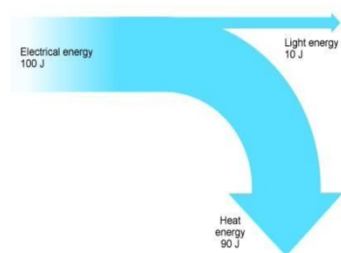
Energy transfers

Energy can be transferred between different stores including **chemical, kinetic, gravitational, elastic, thermal, magnetic, electrostatic** and **nuclear** as a result of an event or process.

Energy can be transferred in various ways including:

- **Mechanically** e.g. when gravity accelerates an object and gives it kinetic energy.
- **Electrically** e.g. when a current passes through a lamp and it emits light and heat.
- **By heating** e.g. when a fire is used to heat up an object.
- **By radiation** e.g. when vibrations cause waves to travel through the air as sound, or an object emits electromagnetic radiation.

Energy is always **conserved**. The total energy before is equal to the total energy after.



The **efficiency** is the **ratio** of the **useful energy output** to the **total energy supplied**, often expressed as a percentage.

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100\%$$

Sankey diagrams can be used to represent the **transfer** of input energy into useful energy and wasted energy. For example, the diagram on the left shows the Sankey diagram for a lamp.

Conduction:

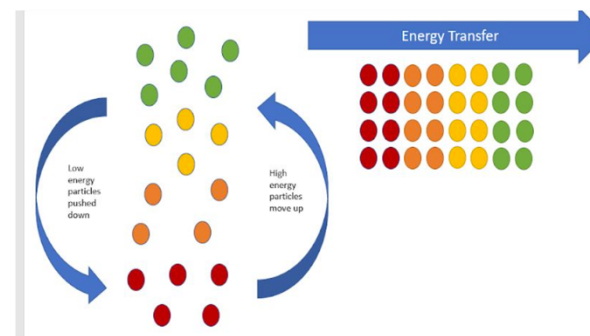
- Thermal energy in **solids** and **liquids** can be transferred by the vibration of particles - this is known as **conduction**.
- Non-metals are usually poor conductors known as **thermal insulators**. As a substance is heated up, the molecules **vibrate more** hitting and cause adjacent molecules to vibrate more too, **transferring heat energy** from hot parts to cooler parts.

Because insulators transfer heat much more slowly, they are used to **reduce unwanted energy transfer** such as in homes.

- Metals are usually good conductors. The electrons can leave the atoms and move freely among positively charged ions. As the metal is heated, the ions and electrons **vibrate more**. The **free electrons collide with ions** throughout the metal and **transfer heat energy** from hot parts to cooler parts.

Convection:

- Thermal energy in **fluids** (liquids and gases) can be transferred by **convection**.
- Convection occurs when molecules in a fluid (which are not fixed together by forces between molecules like in a solid) move from an area of high to low thermal energy. Preventing the circulation of the fluid can help reduce unwanted energy transfer by convection.
- When part of a fluid is heated, it expands - the particles move further apart - and becomes **less dense**. It therefore **rises** up to less dense areas in the fluid. Denser, colder fluid falls down to take its place.
- Examples of convection include in **water boilers** and **hot air balloons**.



Radiation

- Thermal energy is also transferred by **infrared radiation** which does **not require a medium**. Infrared radiation is part of the **electromagnetic spectrum**.
- **Black** bodies with a **dull** texture are the **best absorbers and emitters** of radiation. **White** bodies with a **shiny** texture are the **best reflectors** of radiation. Shiny surfaces can be used to **reduce unwanted energy transfer** such as on the surface of a vacuum flask.
- The **higher the temperature** and the **greater the surface area** of a body the **more infrared radiation** emitted.

Work and power

Work is done when a **force** moves something through a **distance** (whenever energy changes forms). The work done is **equal** to the energy transferred.

$$\text{work done} = \text{force} \times \text{distance} \quad W = Fd$$

The conservation of energy produces a link between gravitational potential energy, kinetic energy and work. For example, when a ball is dropped, gravity does **work** on it and its **gravitational potential energy** becomes **kinetic energy** as it accelerates downwards:

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$$

$$E_k = \frac{1}{2}mv^2$$

$$\text{gravitational potential energy} = \text{mass} \times \text{gravitational field strength} \times \text{height}$$

$$E_p = mgh$$

Power is the **rate at which energy is transferred** or the **rate at which work is done**. For example, a lamp with a greater power will be brighter because it transfers more energy from electrical energy to light and heat energy in a given time.

$$\text{power} = \frac{\text{work done}}{\text{time taken}} \quad P = \frac{W}{t}$$

Energy resources and electricity generation

- **Renewable** energy is energy which can be **replenished** as quickly as it is used.

Examples include:

- Wind
- Water (hydroelectricity, waves, tides)
- Geothermal
- Solar (heating systems and cells)

All have a **potentially infinite** energy supply, but they are usually **more costly** (e.g. the manufacture and implementation of solar panels is very expensive) and **less reliable** (e.g. the wind is intermittent and solar energy relies on good weather).

- **Non-renewable** energy is used more for large-scale energy supplies due to the **large energy output** but will eventually **run out**. Examples include:
 - Fossil fuels (coal, oil, gas)
 - **Cheaper** than most renewable sources but harmful for the environment because they release **greenhouse gases** which cause **global warming**.
 - Nuclear power
 - A **small amount** of radioactive material produces a **lot of energy**, but they produce **highly toxic nuclear** waste which needs to be safely stored underground for many years.

Energy transfers take place in the generation of electricity. For example:

- In burning fossil fuels: **chemical energy** in chemical bonds
- In nuclear reactors: **nuclear energy** in atomic nuclei
- In a solar cell, **light energy** from the sun
- In geothermal energy: heat energy from the Earth's core
- In wind energy: **kinetic energy** from the moving wind
- In HEP: **kinetic energy** of the moving waves or **GPE** of water stored high up

... is transferred into **kinetic energy** in a turning turbine, then into **electrical energy**.

Source: *physicsandmathstutor.com*

Energy, work and power MCQ

1 Which movement will require the greatest amount of work to be done?

- A a force of 10 N moving an object a distance of 3.0 m
- B a force of 10 N moving an object a distance of 5.0 m
- C a force of 15 N moving an object a distance of 3.0 m
- D a force of 15 N moving an object a distance of 5.0 m

2 When a bicycle lamp is switched on, what is the useful energy change **within the battery**?

- A chemical energy to electrical energy
- B electrical energy to chemical energy
- C electrical energy to light energy
- D light energy to chemical energy

3 A student does some work by pulling a suitcase along a corridor. She now pulls a second suitcase along the corridor.

Which row indicates that the student is now doing twice as much work?

	the force used to pull suitcase	the distance the suitcase is pulled
A	is doubled	is doubled
B	is doubled	is halved
C	stays the same	is doubled
D	stays the same	is halved

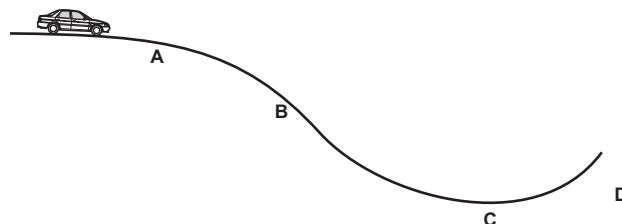
4 What needs to be known to calculate the work done by a force acting on an object?

	the size of the force	the distance the force moves the object	the time for which the force acts
A	✓	✓	✓
B	✓	✓	✗
C	✓	✗	✓
D	✓	✗	✗

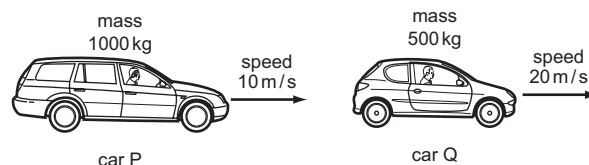
key ✓ = needed ✗ = not needed

5 A car is stationary at the top of a hill with the engine switched off. The brakes are released and the car rolls down the hill.

At which labelled point does the car have the greatest kinetic energy? Ignore friction.



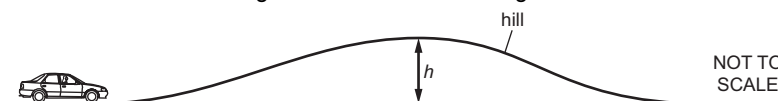
6 Two cars, P and Q, have different masses and different speeds as shown.



Which row correctly compares the momentum and the kinetic energy of P with the momentum and the kinetic energy of Q?

	momentum	kinetic energy
A	P greater than Q	P equal to Q
B	P equal to Q	P equal to Q
C	P equal to Q	P less than Q
D	P less than Q	P greater than Q

7 A car of mass 800 kg travels over a hill of height h .



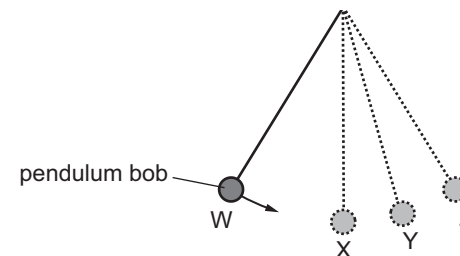
By travelling to the top of the hill, the car gains 40 000 J of gravitational potential energy.

The gravitational field strength g is 10 N/kg.

What is the height h of the hill?

- A 5.0 m
- B 20 m
- C 50 m
- D 500 m

8 A pendulum bob swings along the path WXYZ and back again. Resistive forces can be ignored.



Which statement describes the total energy of the bob?

- A It has a maximum value at X.
- B It has a maximum value at Y.
- C It has a maximum value at Z.
- D It has the same value at W, X, Y and Z.

9 A lorry of mass 4000 kg is travelling at a speed of 4.0 m/s.

A car has a mass of 1000 kg. The kinetic energy of the car is equal to the kinetic energy of the lorry.

What is the speed of the car?

- A 2.0 m/s
- B 4.0 m/s
- C 8.0 m/s
- D 16.0 m/s

- 10 A force acts on an object and causes the object to move a certain distance, in the same direction as the force.

Which row represents a situation in which the largest amount of work is done on the object by the force?

	force / N	distance moved / m
A	2.0	40.0
B	10.0	2.0
C	20.0	6.0
D	100.0	1.0

- 11 A stone of mass m is held at rest in water. The stone is released and falls vertically a distance h . The stone reaches a speed v .

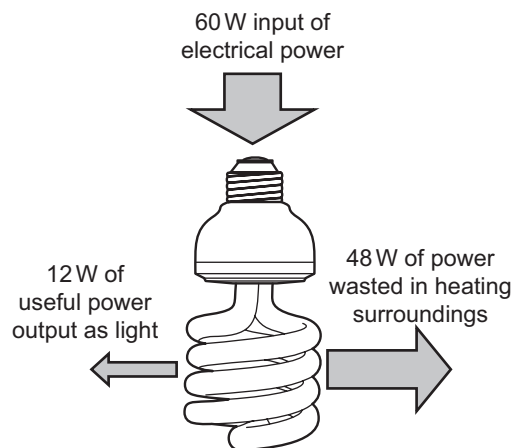
Some of the original energy of the stone is transferred to the water.

As it falls, resistive forces cause the temperature of the water and stone to increase.

Which expression gives the work done against the resistive forces?

- A $\frac{1}{2}mv^2$ B $mgh - \frac{1}{2}mv^2$
 C mgh D $mgh + \frac{1}{2}mv^2$

- 12 The diagram shows the energy used by a modern lamp.

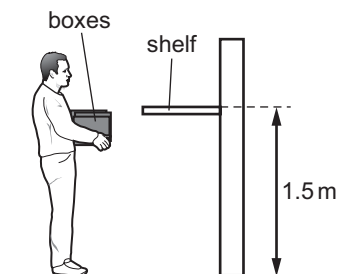


Which expression gives the efficiency of the lamp?

- A $\frac{12}{60} \times 100\%$ B $\frac{12}{48} \times 100\%$
 C $\frac{48}{60} \times 100\%$ D $\frac{48}{12} \times 100\%$

- 13 Three boxes each weigh 100 N. A man lifts all the boxes together from the ground on to a shelf that is 1.5 m above the ground.

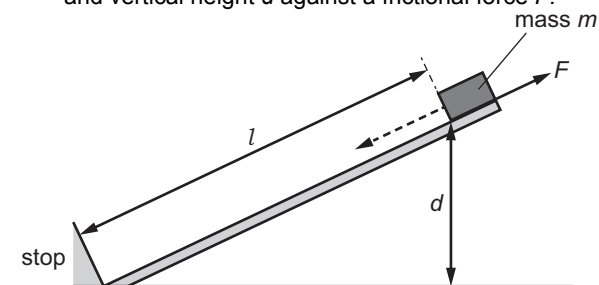
The man takes 2.0 s to do this.



How much useful power does the man produce to lift the boxes?

- A 75 W B 225 W
 C 300 W D 900 W

- 14 A box of mass m slides down a slope of length l and vertical height d against a frictional force F .

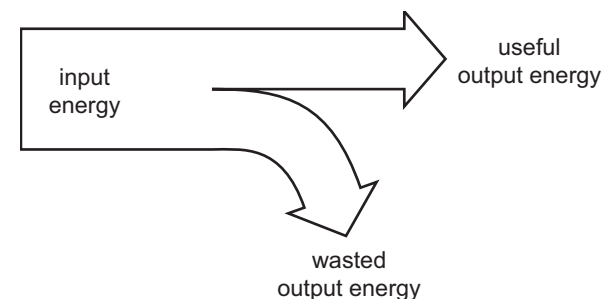


As the box slides down, it loses gravitational potential energy and does the work against friction.

Which row gives the loss in gravitational potential energy and the work done against friction?

	loss in gravitational potential energy	work done against friction
A	mgd	Fl
B	mgd	Fd
C	mgd	Fl
D	mgd	Fd

- 15 The diagram represents the energy transfers for a device.



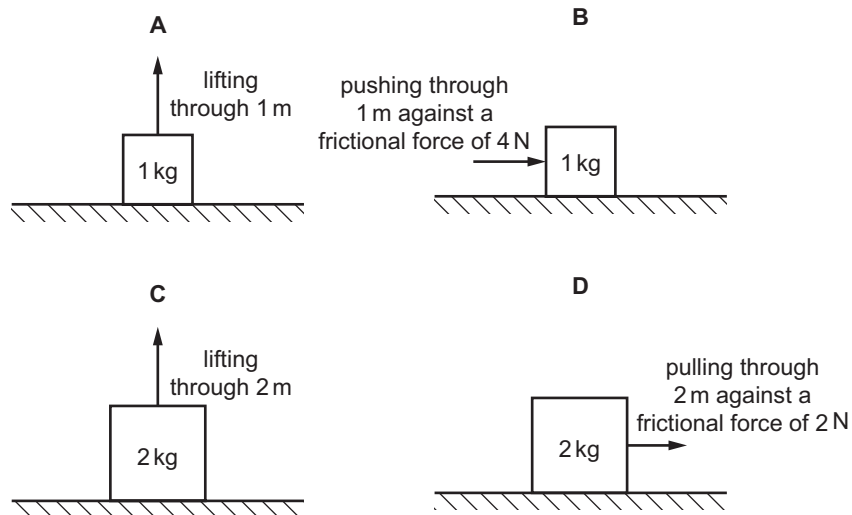
The device is 50% efficient.

Which equation is correct?

- A input energy = useful output energy $\div$ 2
 B useful output energy = wasted output energy $\div$ 2
 C wasted output energy = useful output energy
 D wasted output energy = useful output energy $\div$ 2

16 A student carries out some simple exercises.

In which exercise is the most work done?



17 An object falls from a height of 5.0 m.

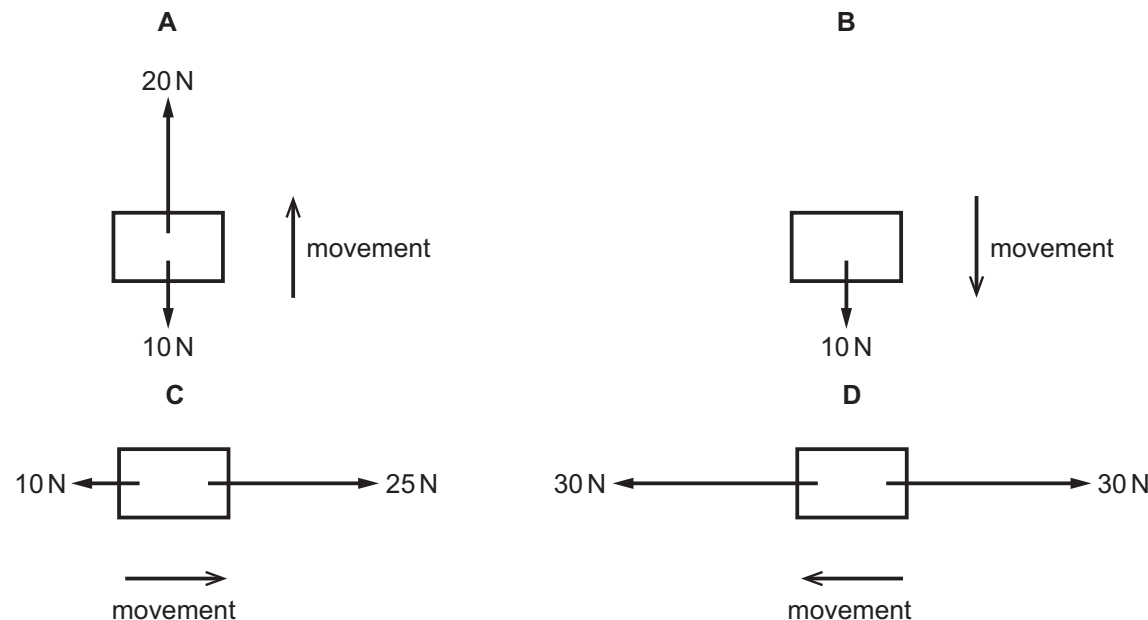
Air resistance can be ignored.

As it hits the ground the object has 750 J of kinetic energy.

What is its mass?

- A 15 kg B 50 kg
C 75 kg D 150 kg

18 The diagrams show four bodies moving in the directions shown. The only forces acting on the bodies are shown in each diagram. Which body gains the most kinetic energy when moving a distance of 1.0 m?



19 A steel ball is fired vertically upwards with a velocity v . The ball reaches a height h . The same ball is now fired vertically upwards from the same position with a velocity $2v$.

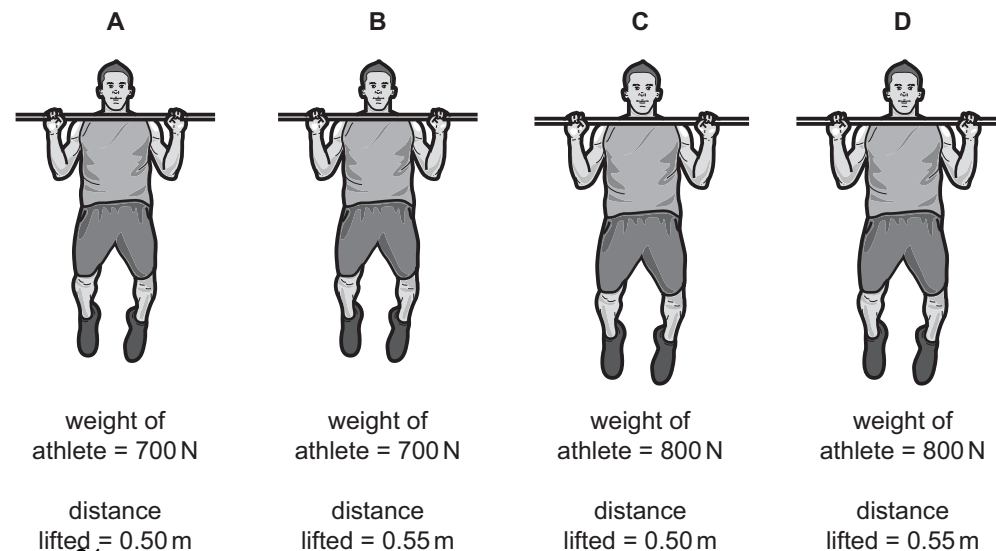
Air resistance can be ignored.

What is the new height reached by the ball?

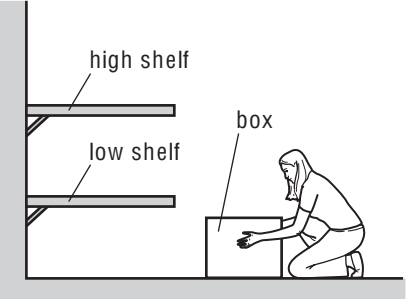
- A h B $2h$ C $4h$ D $8h$

20 The diagrams show four different athletes training by doing pull-ups.

Which athlete does the most work?



21 A woman in a factory has to lift a box on to a shelf.



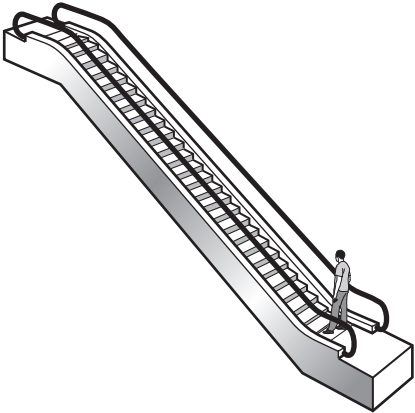
Which action involves the woman in doing the **least** amount of work?

- A lifting the box quickly to the high shelf
- B lifting the box slowly to the high shelf
- C lifting the box to the low shelf first then lifting it to the high shelf
- D lifting the box to the low shelf instead of to the high shelf

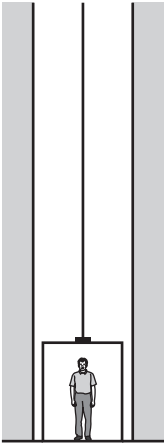
22 An aeroplane is landing. As it descends towards the runway, its speed reduces.
What are the energy changes that take place during the descent?

- A kinetic + gravitational → thermal (heat)
- B kinetic → gravitational + thermal (heat)
- C kinetic + thermal (heat) → gravitational
- D thermal (heat) → kinetic + gravitational

23 A man can either take an escalator or a lift to travel up between two floors in a hotel.



escalator



lift

The escalator takes 20 seconds to carry the man between the two floors. The useful work done against gravity is W . The useful power developed is P .

The lift takes 30 seconds to carry the same man between the same two floors.

How much useful work against gravity is done by the lift, and how much useful power is developed by the lift?

	useful work done against gravity by lift	useful power developed by lift
A	more than W	less than P
B	more than W	P
C	W	less than P
D	W	P

24 A 40W lamp wastes 34J of energy every second by heating its surroundings.

What is the efficiency of the lamp?

- A 0.15%
- B 15%
- C 18%
- D 85%

25 A ball is at rest at the top of a hill. It rolls down the hill.
At the bottom of the hill the ball hits a wall and stops.

Which energy changes occur?

- A gravitational potential energy → internal energy → kinetic energy
- B gravitational potential energy → kinetic energy → internal energy
- C kinetic energy → gravitational potential energy → internal energy
- D kinetic energy → internal energy → gravitational potential energy

Energy, work and power

- 1 A footballer kicks a football and it bounces to another player.

Fig. 1.1 shows part of the path taken by the ball.

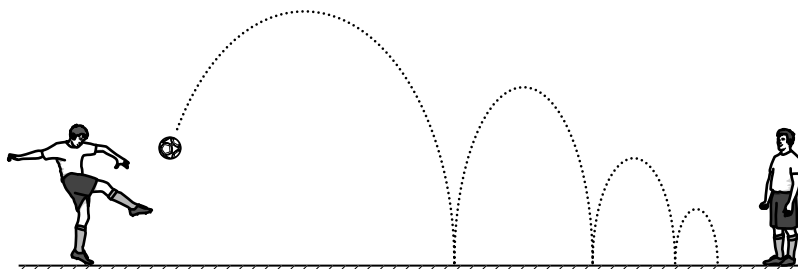


Fig. 1.1

- (a) Use words from the box to complete the sentences below. Each word may be used once, more than once, or not at all.

direction	downwards	forwards	mass	shape	slower	upwards
-----------	-----------	----------	------	-------	--------	---------

- (i) Each time the football moves, it gains gravitational potential energy. [1]
- (ii) Each time the football hits the ground, it changes, and this results in energy stored as strain energy (elastic potential energy). [1]
- (b) Each time the football hits the ground, energy is transferred away from the ball.

- (i) State how you can tell this from the diagram.

.....
[1]

- (ii) State what happens to the energy that is transferred away from the ball.

.....[1]

[Total: 4]

- 2 An electric train is initially at rest at a railway station. The motor causes a constant force of 360 000 N to act on the train and the train begins to move.

- (a) State the form of energy gained by the train as it begins to move.

.....[1]

- (b) The train travels a distance of 4.0 km along a straight, horizontal track.

- (i) Calculate the work done on the train during this part of the journey.

work done =[2]

- (ii) The mass of the train is 450 000 kg.

Calculate the maximum possible speed of the train at the end of the first 4.0 km of the journey.

maximum possible speed =[3]

- (iii) In practice, the speed of the train is much less than the value calculated in (ii).

Suggest **one** reason why this is the case.

.....
[1]

- (c) After travelling 4.0 km, the train reaches its maximum speed. It continues at this constant speed on the next section of the track where the track follows a curve which is part of a circle.

State the direction of the resultant force on the train as it follows the curved path.

.....[1]

[Total: 8]

3 Fig. 3.1 shows an early water-powered device used to raise a heavy load. The heavy load rests on piston B.

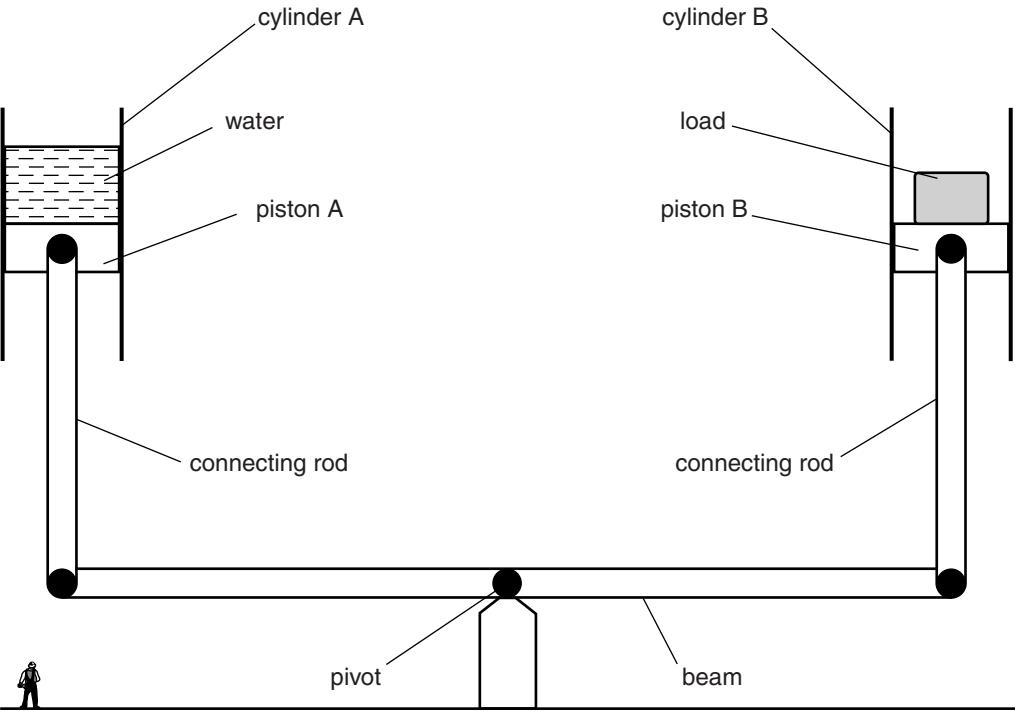


Fig. 3.1 (not to scale)

Initially, a large weight of water in cylinder A pushes piston A down. This causes the left-hand end of the beam to move down and the right-hand end of the beam to move up. Piston B rises, lifting the heavy load.

(a) The weight of water in cylinder A is 80 kN.

Calculate the mass of water in cylinder A.

mass = [2]

(b) The density of water is 1000 kg/m³.

Calculate the volume of water in cylinder A.

volume = [2]

(c) Piston A moves down a distance of 4.0 m.

Calculate the gravitational potential energy lost by the water.

loss of gravitational potential energy = [2]

(d) The heavy load lifted by piston B gains 96 kJ of gravitational potential energy.

Calculate the efficiency of the device.

efficiency = [2]

[Total: 8]

4 Fig. 4.1 shows a cabin used to transport passengers up a hillside.

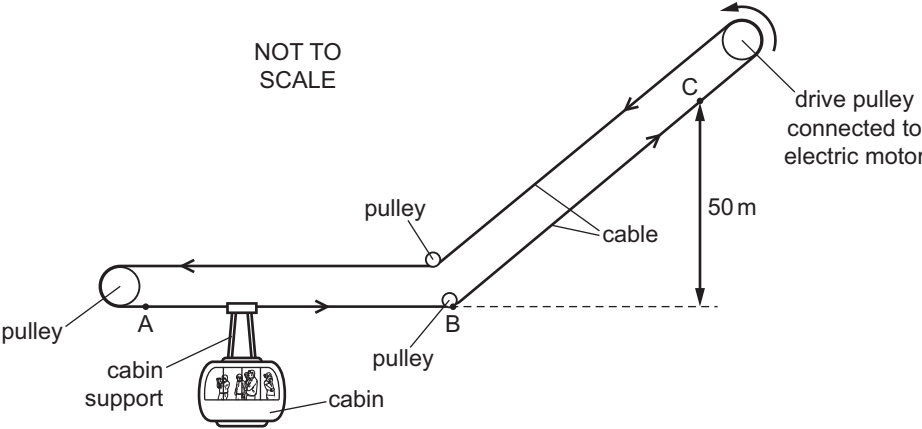


Fig. 4.1

- (c) The cabin then descends back from C to B.
- The weight of the cabin pulls the cable, which rotates the motor. The electric motor acts as a generator when rotated in this way.

Explain the environmental and economic benefits of this arrangement.

.....

.....

.....

.....

.....

.....

[3]

[Total: 7]

The cabin is attached to a cable which moves horizontally from A to B, then up the hill from B to C.

- (a) There is an electrical input of energy to the motor which moves the cable.

Place **two** ticks against types of energy that increase as the cabin moves **horizontally** at **constant speed** from A to B.

- ☐ kinetic energy of the cabin
- ☐ gravitational potential energy of the cabin
- ☐ gravitational potential energy of the cable
- ☐ internal energy of the surroundings
- ☐ internal energy of the wires of the motor

- (b) The cabin and passengers have a total mass of 800 kg. The vertical distance between B and C is 50 m. [2]

Calculate the increase of gravitational potential energy of the cabin and passengers when they move from B to C.

energy = [2]

5 Fig. 5.1 shows a skier taking part in a downhill race.

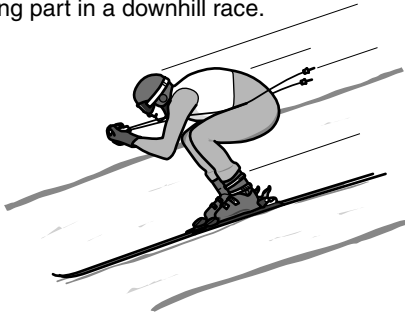


Fig. 5.1

- (a) The mass of the skier, including his equipment, is 75 kg. In the ski race, the total vertical change in height is 880 m.

Calculate the decrease in the gravitational potential energy (g.p.e.) of the skier.

decrease in g.p.e. =[2]

- (b) The skier starts from rest. The total distance travelled by the skier during the descent is 2800 m. The average resistive force on the skier is 220 N.

Calculate

- (i) the work done against the resistive force,

work done =[2]

- (ii) the kinetic energy of the skier as he crosses the finishing line at the end of the race.

kinetic energy =[2]

- (c) Suggest why the skier bends his body as shown in Fig. 5.1.

.....[1]

- 6 (a) (i) Define *power*.

.....[1]

- (ii) In the following list, tick the **two** boxes next to the two quantities needed to calculate the work done on an object.

☐

mass of the object

☐

force acting on the object

☐

speed of the object

☐

acceleration of the object

☐

distance moved by the object

[1]

- (b) A lift (elevator) in a high building transports 12 passengers, each of mass 65 kg, through a vertical height of 150 m in a time of 64 s.

- (i) Calculate the power needed to transport the passengers through this height.

power =[4]

- (ii) The lift (elevator) is driven by an electric motor.

State a reason, other than friction, why the power supplied by the motor is greater than the power needed to transport the passengers.

.....

.....[1]

[Total: 7]

7 A soft rubber ball of mass 0.15 kg is dropped, in a vacuum, from a height of 2.0 m on to a hard surface. The ball then bounces.

(a) State the main energy changes taking place when

(i) the ball is falling,

.....

(ii) the ball hits the surface and is changing shape,

.....

(iii) the ball is regaining its shape and is rising from the surface.

.....

[3]

(b) Calculate the speed with which the ball hits the surface.

speed = [4]

(c) After rebounding from the surface, the ball rises to a height of 1.9 m.

Suggest why the height to which the ball rises is less than the height from which the ball falls.

.....

.....[1]

[Total: 8]

8 A footballer kicks a ball vertically upwards. Initially, the ball is stationary.

(a) His boot is in contact with the ball for 0.050 s. The average resultant force on the ball during this time is 180 N. The ball leaves his foot at 20 m/s.

Calculate

(i) the impulse of the force acting on the ball,

impulse =[2]

(ii) the mass of the ball,

mass =[2]

(iii) the height to which the ball rises. Ignore air resistance.

height =[3]

(b) While the boot is in contact with the ball, the ball is no longer spherical.

State the word used to describe the energy stored in the ball.

.....[1]

[Total: 8]

Energy resources MCQ

- 1 The list contains three energy resources P, Q and R.

P geothermal energy from hot rocks
Q nuclear fission in reactors
R sunlight on solar panels

Which of these resources are renewable?

- A P and Q only B P and R only
C Q and R only D P, Q and R

- 2 Electrical energy may be obtained from nuclear fission.

In which order is the energy transferred in this process?

- A nuclear fuel → generator → reactor and boiler → turbines
B nuclear fuel → generator → turbines → reactor and boiler
C nuclear fuel → reactor and boiler → generator → turbines
D nuclear fuel → reactor and boiler → turbines → generator

- 3 Which row gives the energy change in a battery and the energy change in a solar cell?

	battery	solar cell
A	chemical to electrical	electrical to light
B	chemical to electrical	light to electrical
C	electrical to chemical	electrical to light
D	electrical to chemical	light to electrical

- 4 The box contains the names of eight different energy resources

natural gas	geothermal	solar	waves
hydroelectric	oil	wind	coal

How many of these energy resources are renewable?

- A 3 B 4 C 5 D 6

- 5 Electricity can be generated using different energy resources.

Which energy resource is used to generate electricity without needing any moving parts?

- A geothermal
B hydroelectric
C solar
D water waves

- 6 Which list contains only energy resources that derive their energy from the Sun?

- A geothermal, nuclear, tidal
B hydroelectric, water waves, wind
C geothermal, hydroelectric, solar
D nuclear, solar, water waves

- 7 Energy is released in some nuclear reactions.

Which nuclear reaction takes place in a nuclear power station, and which nuclear reaction takes place in the Sun?

	nuclear power station	the Sun
A	fission	fission
B	fission	fusion
C	fusion	fission
D	fusion	fusion

- 8 Which energy resource does **not** derive its energy from the Sun?

- A geothermal
B hydroelectric
C oil
D waves

- 9 Some processes are more efficient than others.

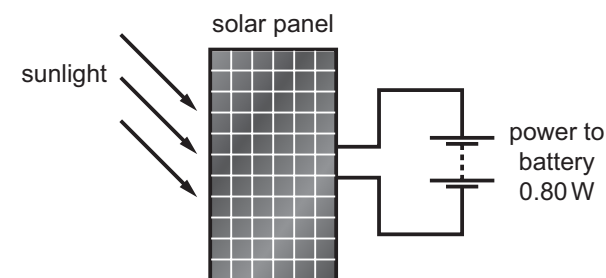
Which expression gives the efficiency of a process?

- A $\frac{\text{total energy output}}{\text{total energy input}} \times 100\%$
B $\frac{\text{useful energy output}}{\text{total energy input}} \times 100\%$
C $\frac{\text{wasted energy output}}{\text{total energy input}} \times 100\%$
D $\frac{\text{wasted energy output}}{\text{useful energy output}} \times 100\%$

- 10 Which energy resource does **not** derive its energy from the Sun?

- A hydroelectric
B nuclear fission
C waves
D wind

- 11 A solar panel is used to recharge a battery. The solar panel produces 0.80 W of electrical power. The panel is 20% efficient.



What is the power input of the sunlight onto the solar panel?

- A 0.16 W B 4.0 W C 8.0 W D 16 W

- 12 Some energy sources are reliably available at all times, and some are not. Which row shows three sources all in their correct columns?

	available at all times	not available at all times
A	geothermal	nuclear fission, solar
B	geothermal, nuclear fission	solar
C	solar, nuclear fission	geothermal
D	solar	nuclear fission, geothermal

- 13 Energy from uranium is transferred to electrical energy in a nuclear power station.

What is the correct order of the stages of this process?

- A boiler → generator → reactor → turbine
- B generator → boiler → turbine → reactor
- C reactor → boiler → turbine → generator
- D reactor → turbine → boiler → generator

- 14 In which pair of energy sources are both sources renewable?

- A oil and coal
- B oil and tidal
- C tidal and geothermal
- D tidal and nuclear fission

- 15 Electricity can be obtained from different energy resources.

Which energy resource is used to obtain electricity without producing heat to boil water?

- A coal
- B gas
- C hydroelectric
- D nuclear

- 16 Which row gives an example of the stated form of energy?

	form of energy	example
A	gravitational	the energy due to the movement of a train along a level track
B	internal	the energy due to the flow of cathode rays in a cathode-ray tube
C	kinetic	the energy due to the position of a swimmer standing on a high diving board
D	strain	the energy due to the compression of springs in a car seat

- 17 Energy is stored in a battery and in a box of matches.

Which type of energy is stored in each of them?

	a battery	a box of matches
A	chemical	chemical
B	chemical	internal (thermal)
C	electrical	chemical
D	electrical	internal (thermal)

- 18 Which form of energy is used to generate electrical energy in a tidal power station?

- A chemical energy
- B gravitational energy
- C internal energy (thermal energy)
- D nuclear energy

- 19 Which line in the table gives an example of the stated form of energy?

	form of energy	example
A	gravitational	the energy due to the movement of a train
B	internal	the energy due to the flow of cathode rays in a cathode ray tube
C	kinetic	the energy due to the position of a swimmer standing on a high diving board
D	strain	the energy due to the compression of springs in a car seat

- 20 Which form of energy do we receive directly from the Sun?

- A chemical
- B light
- C nuclear
- D sound

Energy resources

1 (a) A microphone is a device designed to convert an input of sound energy into an output of electrical energy.

Complete the table below. In each case, give the name of a device that is designed to give the stated energy output with the stated energy input.

energy input	useful energy output	device
sound	electrical	microphone
electrical	sound	
chemical	electrical	
electrical	thermal	
electrical	kinetic	

(b) The electrical energy output from the microphone is less than the sound energy input.

(i) State the principle of conservation of energy.

[1]

(ii) Explain how this principle applies to the microphone.

[2]

[Total: 7]

2 Fig. 2.1 shows a battery-operated alarm clock.

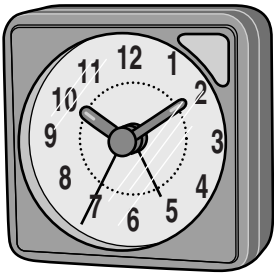


Fig. 2.1

Use words from the box to complete the sentences.

chemical
 electrical
 kinetic
 light
 sound
 thermal

The battery stores energy. When the battery is first connected, electrical energy is transferred to energy of the clock's hands. Some of the electrical energy is transferred to the surroundings as energy. When the alarm bell rings, electrical energy is transferred to energy.

[4]

[Total: 4]

3 Fig. 3.1 shows a hydroelectric power station.

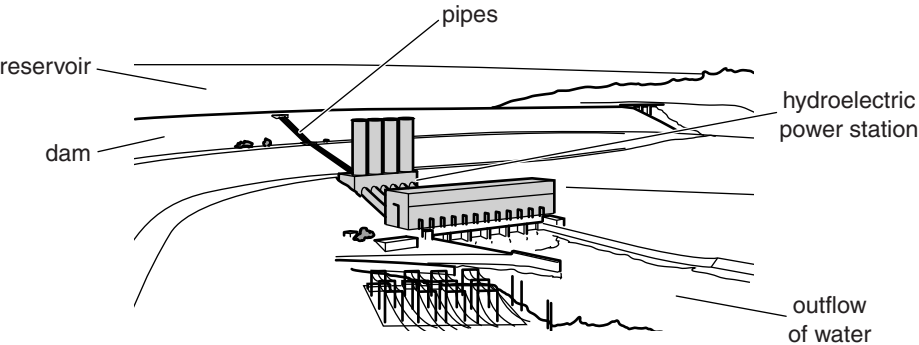


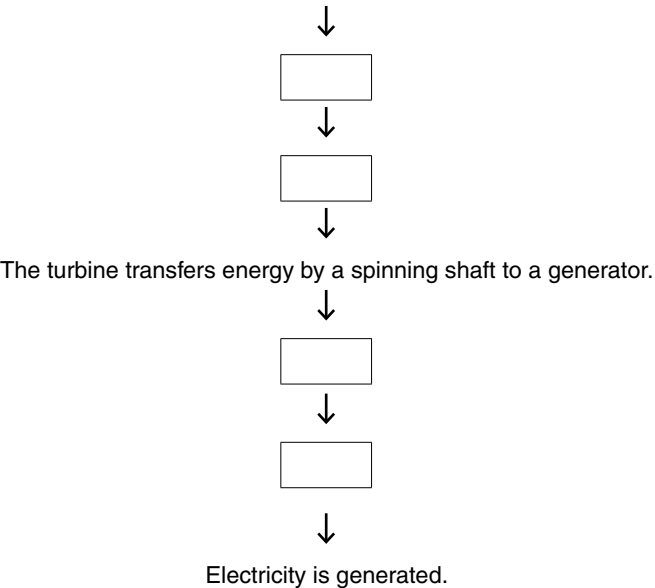
Fig. 3.1

(a) These are some of the stages explaining how the power station works. They are not in the correct order.

- A The electromagnets turn inside a large coil.
- B Water flows down pipes from the reservoir to the turbine.
- C Inside the generator, the spinning shaft turns electromagnets.
- D The falling water keeps the turbine spinning.

Use the letters A, B, C and D to complete the flow chart to explain how the power station works.

Rainwater flows off the hills into the reservoir behind the dam.



(b) Hydroelectric power is described as a renewable source of energy.

Explain what is meant by the term *renewable*.

.....[1]

(c) Using a renewable source of energy is one advantage of hydroelectric power compared with other energy sources.

(i) State two other advantages of hydroelectric power.

- 1.
- 2.[2]

(ii) State one disadvantage of hydroelectric power.

.....[1]

[Total: 7]

4 Different types of power station use different sources of energy.

(a) Draw one straight line from each energy source to the type of power station that uses it.

energy source	type of power station
fossil fuel	hydroelectric
hot rocks underground	nuclear
uranium fuel rods	geothermal
	coal-fired
	wind farm

[3]

(b) Fig. 4.1 shows part of a solar power station.

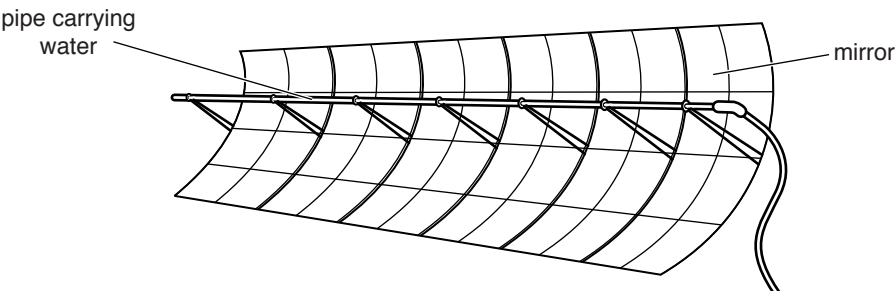
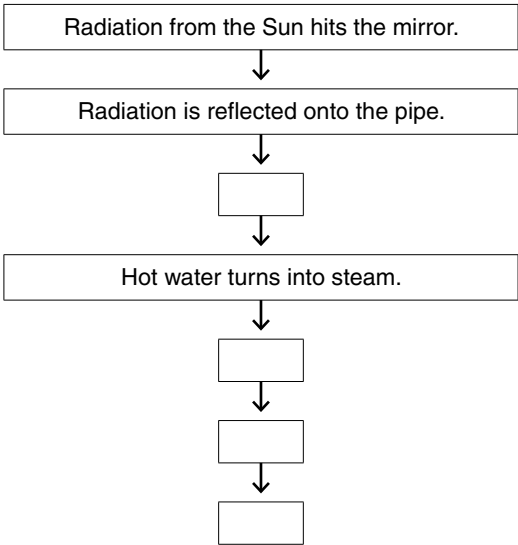


Fig. 4.1

These are some of the stages explaining how the power station works. They are not in the correct order.

- A Electricity is generated.
- B The turbine turns the generator.
- C Steam drives the turbine.
- D Water in the pipe absorbs energy.

Use the letters A, B, C and D to complete the flow chart to explain how the power station works.



[3]

[Total: 6]

5 (a) The boxes on the left contain the names of some sources of energy. The boxes on the right contain properties of some sources of energy.

Draw **two** straight lines **from each box** on the left to the two boxes on the right which describe that source of energy.

solar energy

natural gas

renewable

not renewable

polluting

not polluting

[2]

(b) Coal-fired power stations are polluting.

State an advantage of using coal as a source of energy.

.....

.....[1]

(c) A coal-fired power station generates electricity at night when it is not needed.

Some of this energy is stored by pumping water up to a mountain lake. When there is high demand for electricity, the water is allowed to flow back through turbines to generate electricity.

On one occasion, 2.05×10^8 kg of water is pumped up through a vertical height of 500 m.

(i) Calculate the weight of the water.

weight =[1]

(ii) Calculate the gravitational potential energy gained by the water.

energy gained =[2]

(iii) The electrical energy used to pump the water up to the mountain lake is 1.2×10^{12} J. Only 6.2×10^{11} J of electrical energy is generated when the water is released.

Calculate the efficiency of this energy storage scheme.

efficiency =[2]

[Total: 8]

- 6 Fig. 6.1 shows a water turbine that is generating electricity in a small tidal energy scheme.

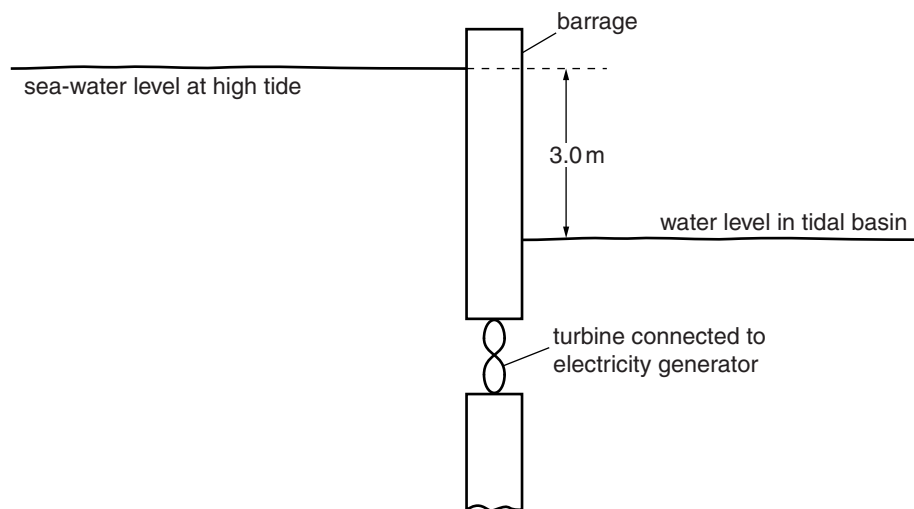


Fig. 6.1

At high tide, 1.0 m^3 of sea-water of density 1030 kg/m^3 flows through the turbine every second.

- (a) Calculate the loss of gravitational potential energy when 1.0 m^3 of sea-water falls through a vertical distance of 3.0 m .

loss of gravitational potential energy = [3]

- (b) Assume that your answer to (a) is the energy lost per second by the sea-water passing through the turbine at high tide. The generator delivers a current of 26 A at 400 V .

Calculate the efficiency of the scheme.

efficiency =% [3]

- (c) At low tide, the sea-water level is lower than the water level in the tidal basin.

- (i) State the direction of the flow of water through the turbine at low tide.

.....

- (ii) Suggest an essential feature of the turbine and generator for electricity to be generated at low tide.

.....

.....

.....

[2]

[Total: 8]

7 Fig. 7.1 shows a small wind-turbine used to generate electricity.

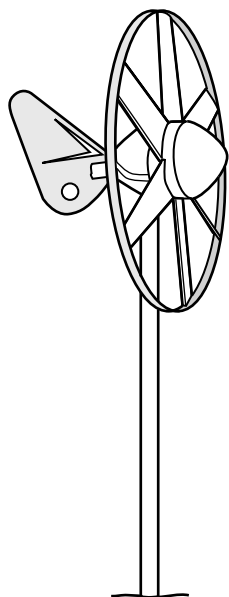


Fig. 7.1

The wind-turbine drives an electric generator.

The wind blows with a velocity of 7.0 m/s at right angles to the plane of the turbine. The mass of air passing per second through the turbine is 6.7 kg .

(a) (i) Calculate the kinetic energy of the air blown through the turbine per second.

kinetic energy = [2]

(ii) Only 8% of this energy is converted to electrical energy.

Calculate the power output of the electric generator.

power output = [2]

(b) The volume of air passing through the turbine each second is 5.6 m^3 (flow rate is $5.6 \text{ m}^3/\text{s}$).

Calculate the density of the air.

density of air = [2]

(c) The turbine turns a generator.

Describe the essential action within the generator that produces electricity.

.....

 [2]

[Total: 8]

- 8 (a) Name the process by which energy is released in the core of the Sun.

..... [1]

- (b) Describe how energy from the Sun becomes stored energy in water behind a dam.

.....
.....
.....
..... [3]

- (c) Data for two small power stations is given in Table 8.1.

	input to power station	output of power station
gas-fired	100 MW	25 MW
hydroelectric	90 MW	30 MW

Table 8.1

- (i) State what is meant by the *efficiency* of a power station.

.....
.....
.....
..... [1]

- (ii) Use the data in Table 8.1 to explain that the hydroelectric station is more efficient than the gas-fired power station.

.....
.....
..... [1]

[Total: 6]

Thermal Physics

Summary Notes

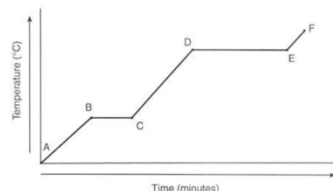
Change of state

Heating a system **increases** its **internal energy** and causes either an **increase** in **temperature** or a **change of state**.

- When the **temperature** of a body **rises**, the energy goes towards making the molecules **vibrate more** and **increases** their **kinetic energy**.
- When a body **changes state**, energy goes towards making the molecules **freer** from each other rather than increasing their kinetic energy – the temperature stays **constant**.
 - Melting** occurs when molecules in a solid vibrate enough to move away from their fixed positions, turning into a liquid.
 - Boiling** occurs when molecules in a liquid gain enough energy to break their bonds and become separate molecules, turning into a gas.

Graph showing the temperature of ice with time when energy is put in at a constant rate:

- From A to B the ice is rising in temperature
- From B to C it is melting into water
- From C to D the water is rising in temperature
- From D to E the water is boiling into steam
- From E to F the steam is rising in temperature



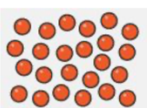
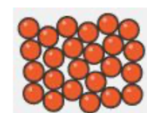
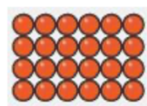
There is **no change in temperature while the substance is changing state** (the line is horizontal) because energy supplied is used to separate the particles (breaking the forces between the molecules).

Evaporation is the escape of molecules with **higher energy** from the **surfaces** of liquids. After they escape, the remaining molecules have a **lower average kinetic energy** which means the temperature is lower (i.e. evaporation **cools** the liquid). This is useful for cooling things down such as sweating from the body.

- To increase the rate of evaporation, increase temperature, increase surface area, or provide a draught.

Evaporation is different to boiling because it can happen at **any temperature** and only occurs at the **surface** of the liquid (boiling occurs throughout a liquid and only at the boiling point).

- Solids**
 - Molecules **close** together in **regular** pattern
 - Strong** intermolecular forces of attraction
 - Molecules **vibrate** but can't move about
- Liquids**
 - Molecules **close** together in **random** arrangement
 - Weaker** intermolecular forces of attraction than solids
 - Molecules **move around each other**
- Gases**
 - Molecules **far** apart in **random** arrangement
 - Negligible/very weak intermolecular forces
 - Molecules move quickly in all directions



The **specific heat capacity** is the **amount of energy** required to raise the temperature of **1kg** of a substance by **1°C** and is measured in **Joules per kilogram degree Celsius (J/kg°C)**.

$$\text{change in thermal energy} = \text{mass} \times \text{specific heat capacity} \times \text{temperature change}$$

$$\Delta Q = mc\Delta T$$

Ideal gas molecules

Gas molecules move **rapidly** and **randomly** due to **collisions** with other gas molecules.

Gases exert **pressure** on a container due to **collisions** between gas molecules and the wall. When the molecules rebound off the walls, they **change direction** so their velocity and therefore **momentum changes**. This means they exert a **force** because force is equal to the change in momentum over time.

- At a constant volume, if the **temperature increases**, the **pressure increases** because the molecules move faster so they collide **harder** and **more frequently** with the walls.
 - The temperature at which the **pressure is zero** is called **absolute zero** (-273°C). The **Kelvin** scale of temperature defines absolute zero to be 0K with an increment of one Kelvin equal to an increment of one degree Celsius. This means that:
 - $\text{temperature in kelvin} = \text{temperature in degrees celsius} + 273$
 - For a gas at fixed mass and volume, where the temperature is measured in Kelvin:

$$\frac{p_1}{T_1} = \frac{p_2}{T_2} \quad \text{or} \quad \frac{p}{T} = \text{constant}$$
- At a constant temperature, if the **volume increases**, the **pressure decreases** because the molecules collide **less frequently** with the walls and over a **greater area**.
 - For a gas at fixed mass and temperature:

$$p_1 V_1 = p_2 V_2 \quad \text{or} \quad pV = \text{constant}$$

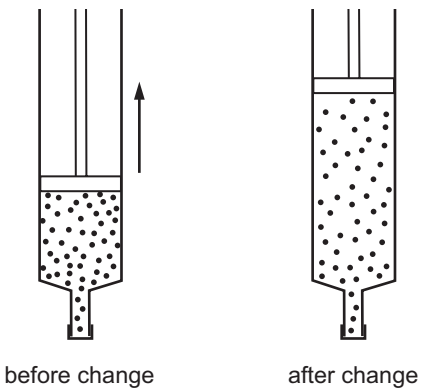
This is known as **Boyle's Law**

The **temperature in Kelvin** of a gas is proportional to the **average kinetic energy** of the molecules. The higher the temperature, the greater the average kinetic energy and so the faster the **average speed** of the molecules.

Source: physicsandmathstutor.com

Kinetic model of matter MCQ

1 The volume of a gas in a sealed syringe is increased. The temperature of the gas does not change.



After this change is made, what has happened to the gas molecules in the syringe?

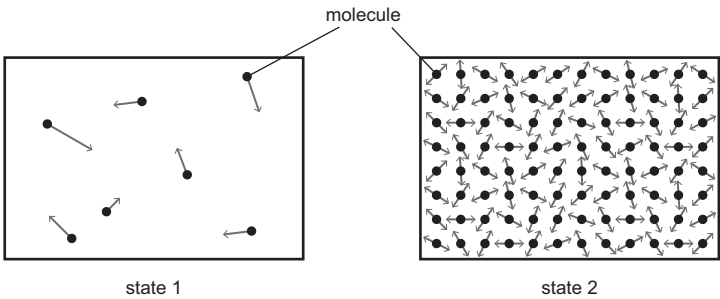
- A They move more quickly.
- B They move more slowly.
- C They hit the syringe walls less often.
- D They hit the syringe walls more often.

2 A cylinder of constant volume contains a fixed mass of gas. The gas is cooled.

What happens to the pressure of the gas and what happens to the kinetic energy of the gas molecules?

	pressure of gas	kinetic energy of molecules
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

3 The diagrams represent the molecules in two different states of matter. The arrows show the motion of the molecules.



What is state 1, and what is state 2?

	state 1	state 2
A	gas	liquid
B	gas	solid
C	liquid	gas
D	liquid	solid

4 A car tyre has a constant volume.

Why does the pressure of the air in the tyre increase when its temperature increases?

- A The air molecules hit each other less often.
- B The air molecules hit the inside of the tyre less often.
- C The average speed of the air molecules in the tyre is greater.
- D There are more air molecules in the tyre.

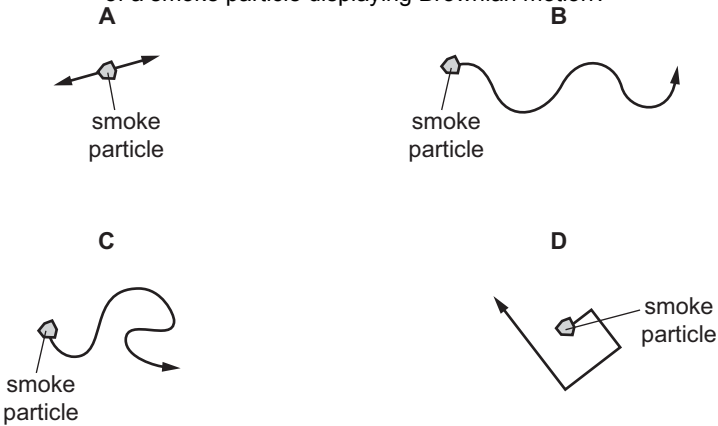
5 A gas at a constant temperature is in a container of fixed volume. The gas exerts a pressure on the walls of the container.

The pressure is caused by the gas molecules striking the walls.

Which statement about the gas molecules when they strike the walls is correct?

- A The average kinetic energy of the gas molecules changes.
- B The average momentum of the gas molecules changes.
- C The average speed of the gas molecules changes.
- D The chemical energy of the gas molecules changes.

6 Which diagram best represents the movement of a smoke particle displaying Brownian motion?

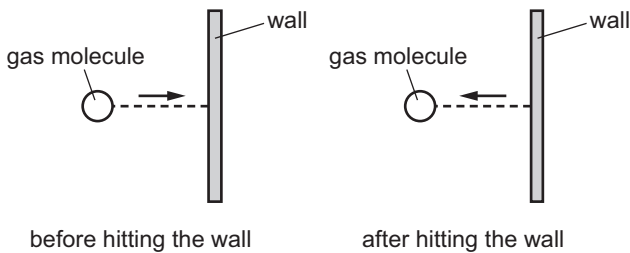


7 Smoke particles, illuminated by a bright light, are seen through a microscope. They move about randomly.

What causes this motion?

- A attraction between the smoke particles and the molecules of the air
- B collisions between the smoke particles and the molecules of the air
- C evaporation of the faster-moving smoke particles
- D warming of the smoke particles by the lamp

8 A gas molecule strikes the wall of a container. The molecule rebounds with the same speed.



What happens to the kinetic energy and what happens to the momentum of the molecule?

	kinetic energy	momentum
A	changes	changes
B	changes	stays the same
C	stays the same	changes
D	stays the same	stays the same

- 9 A sealed bottle of constant volume contains air.

The air in the bottle is heated by the Sun.

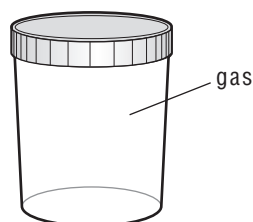
What is the effect on the average speed of the air molecules in the bottle, and the average distance between them?

	average speed of air molecules	average distance between air molecules
A	decreases	decreases
B	decreases	stays the same
C	increases	increases
D	increases	stays the same

- 10 Brownian motion is observed when using a microscope to look at smoke particles in air. What causes the smoke particles to move at random?

- A Smoke particles are hit by air molecules.
- B Smoke particles are moved by convection currents in the air.
- C Smoke particles have different weights and fall at different speeds.
- D Smoke particles hit the walls of the container.

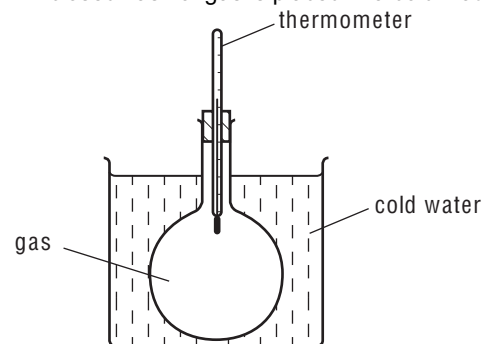
- 11 The diagram shows a sealed jar containing a gas.



Which statement about the gas in the jar is correct?

- A The gas molecules collide with the inside of the jar more often as the temperature increases.
- B The gas molecules move more slowly as the temperature increases.
- C The pressure of the gas decreases as the temperature increases.
- D The pressure of the gas is higher at the top of the jar than at the bottom of the jar.

- 12 A closed flask of gas is placed in a cold-water bath.

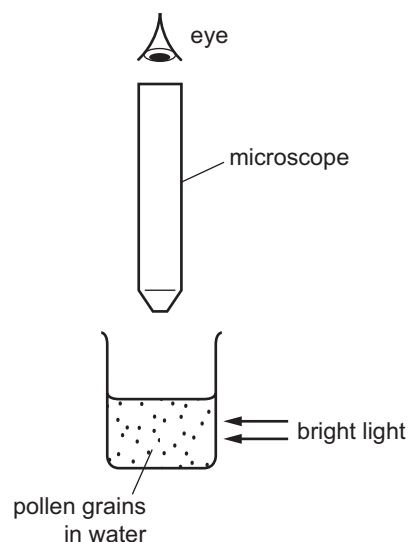


As the flask cools, the temperature of the gas decreases.

What happens to the molecules of the gas?

- A They contract.
- B They expand.
- C They move more quickly.
- D They move more slowly.

- 13 Very small pollen grains are suspended in water. A bright light shines from the side. When looked at through a microscope, small specks of light are seen to be moving in a random, jerky manner.



What are the moving specks of light?

- A pollen grains being hit by other pollen grains
- B pollen grains being hit by water molecules
- C water molecules being hit by other water molecules
- D water molecules being hit by pollen grains

- 14 At -39°C , liquid mercury solidifies without a change of temperature. Which row shows whether the mercury absorbs or releases energy and what happens to the bonds between the mercury atoms?

	energy	bonds between atoms
A	absorbed	stronger
B	absorbed	weaker
C	released	stronger
D	released	weaker

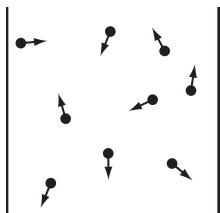
- 15 Brownian motion is observed when looking at smoke particles in air using a microscope. What causes the smoke particles to move at random?

- A Smoke particles are hit by air molecules.
- B Smoke particles are moved by convection currents in the air.
- C Smoke particles have different weights and fall at different speeds.
- D Smoke particles hit the walls of the container.

- 16 The molecules of a substance become more closely packed and move more quickly. What is happening to the substance?

- A A gas is being heated and compressed.
- B A gas is being heated and is expanding.
- C A liquid is boiling.
- D A liquid is evaporating at room temperature.

- 17 The diagram represents the molecules of a gas in a closed container of constant volume.



What happens to the molecules when the gas is heated?

- A They expand.
 B They hit the walls less often.
 C They move further apart.
 D They move more quickly.
- 18 A liquid is left in an open dish. After several days there is less liquid in the dish. Which statement explains this?
- A The least energetic molecules leave the surface and escape into the air.
 B The least energetic molecules leave the surface and return.
 C The most energetic molecules leave the surface and escape into the air.
 D The most energetic molecules leave the surface and return.

- 19 Which line in the table describes the properties of solids and of liquids at a fixed temperature?

	solids	liquids
A	definite volume and definite shape	no definite volume but definite shape
B	no definite volume but definite shape	definite volume and definite shape
C	definite volume and definite shape	definite volume but no definite shape
D	no definite volume but definite shape	no definite volume and no definite shape

- 20 Air is pumped slowly into a car tyre to increase the pressure. The temperature of the air does not change.

Which line in the table is correct?

	number of molecules hitting 1 cm ² of the tyre each second	average speed at which molecules hit the tyre
A	increases	increases
B	increases	unchanged
C	unchanged	increases
D	unchanged	unchanged

Kinetic model of matter

- 1 (a) When materials are heated, they usually expand.

Describe one example where

- (i) the expansion is useful,

.....
.....
.....[2]

- (ii) the expansion causes problems that need to be allowed for.

.....
.....
.....[2]

- (b) State two things that happen to the molecules of a solid when it is cooled.

1.
2.
[2]

- (c) Fig. 1.1 shows some balloons that have been filled with gas and tied to a heavy box.

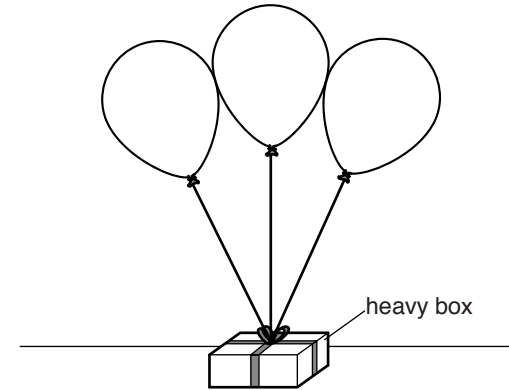


Fig. 1.1

- (i) In the sunlight, the gas in the balloons gets warmer.

State what is seen to happen to the balloons.

.....[1]

- (ii) In terms of molecules, explain your answer to (c)(i).

.....
.....
.....[3]

[Total: 10]

2 Fig. 2.1 shows a Galilean thermometer. This thermometer is used to measure the approximate temperature of the surrounding air.

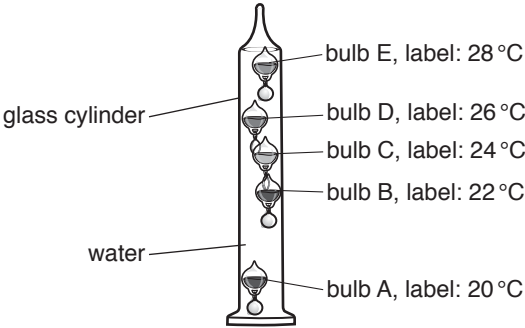


Fig. 2.1

The glass cylinder contains water. When the temperature of the water changes, so does its density

Each bulb has a label printed with a temperature, as shown in Fig. 2.1. The bulbs have different densities. At 21 °C, only bulb A is at the bottom of the cylinder.

(a) Explain, in terms of density, why bulb A is at the bottom of the cylinder and the other bulbs are floating.

.....

.....

.....

.....[2]

(b) The temperature of the surrounding air increases to a temperature above 23 °C.

(i) Suggest **one** reason why there is a delay before the temperature of the water increases to 23 °C.

.....[1]

(ii) Explain why, after this delay, bulb B sinks. Assume the bulbs do not expand.

.....

.....

.....

.....[3]

(c) Bulbs A, B and C are now at the bottom of the cylinder. Bulbs D and E are floating.

State the possible temperature range of the water in the cylinder.

.....[1]

[Total: 7]

3 (a) In the space below, draw a simple labelled diagram of the apparatus used to demonstrate Brownian motion.

(b) State what is observed.

.....

.....

.....[2]

(c) Explain what is observed in terms of molecules.

.....

.....

.....[2]

[Total: 6]

- 4 (a) Explain, in terms of molecules, why it is possible to compress a gas, but not a liquid.

.....

.....

.....

..... [2]

- (b) Two containers made of insulating material contain the same volume of water at room temperature. The containers do not have lids. The volume of liquid in each container gradually decreases.

- (i) After a certain time, the temperature of the water has decreased to below room temperature.

Explain, in terms of molecules, why the temperature has decreased.

.....

.....

.....

..... [2]

- (ii) One of the containers is wide and shallow. The other container is narrow and deep.

Predict which container has the greater rate of cooling. Explain your answer.

.....

.....

..... [2]

[Total: 6]

- 5 (a) Describe the movement of the molecules in

- (i) a solid,

.....

..... [1]

- (ii) a gas.

.....

..... [2]

- (b) A closed box contains gas molecules.

Explain, in terms of momentum, how the molecules exert a pressure on the walls of the box.

.....

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.....

.....

..... [4]

[Total: 7]

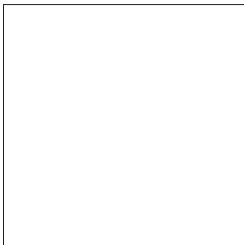
6 (a) Fig. 6.1 represents an atom.



Fig. 6.1

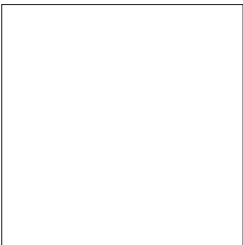
Representing atoms by circles approximately the same size as in Fig. 6.1, sketch

- (i) on Fig. 6.2, the arrangement of atoms in a crystalline solid, [1]
- (ii) on Fig. 6.3, the arrangement of atoms in a gas.



solid

Fig. 6.2



gas

Fig. 6.3

(b) (i) Describe the motion of the atoms in a solid.

.....[1]

(ii) A sculptor makes a statue from a block of crystalline rock using a cutting tool. Explain why he must apply a large force to the tool to remove a small piece of rock.

.....[2]

(c) A helium-filled balloon in the room of a house suddenly bursts.

State and explain, in terms of atoms, what happens to the helium from the balloon after the balloon has burst.

.....[2]

[Total: 7]

7 (a) A microscope that produces a very high magnification is used to observe the Brownian motion of smoke particles in air.

Fig. 7.1(a) shows the apparatus used with the microscope. Fig. 7.1(b) represents the view through the microscope and shows one of the smoke particles being observed.

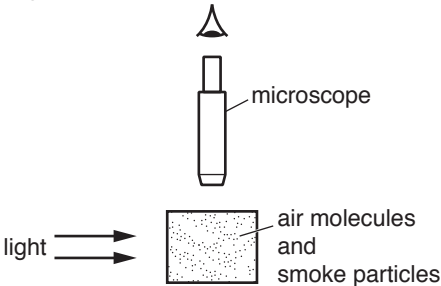


Fig. 7.1(a)

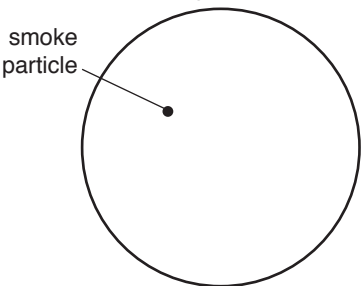


Fig. 7.1(b)

(i) On Fig. 7.1(b), draw a possible path for the smoke particle.

[2]

(ii) Describe how air molecules cause the smoke particle to follow the observed path.

.....[2]

(b) Fig. 7.2 shows a volume of gas in a cylinder.

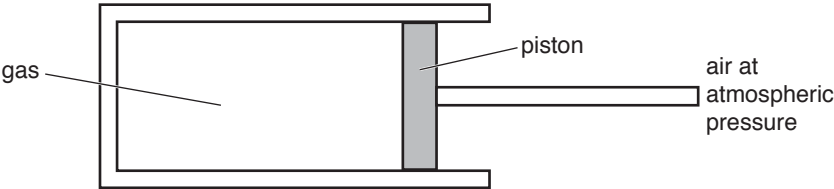


Fig. 7.2

The piston in the cylinder is free to move. The piston moves to the left when the temperature of the gas is decreased.

Explain, in terms of the molecules of the gas, why this happens.

.....[4]

[Total: 8]

8 The whole of a sealed, empty, dusty room is kept at a constant temperature of 15 °C. Light shines into the room through a small outside window.

An observer points a TV camera with a magnifying lens into the room through a second small window, set in an inside wall at right angles to the outside wall.

Dust particles in the room show up on the TV monitor screen as tiny specks of light.

(a) In the space below draw a diagram to show the motion of one of the specks of light over a short period of time.

[1]

(b) After a period of one hour the specks are still observed, showing that the dust particles have not fallen to the floor.

Explain why the dust particles have not fallen to the floor. You may draw a labelled diagram to help your explanation.

.....
.....
.....
..... [2]

(c) On another day, the temperature of the room is only 5 °C. All other conditions are the same and the specks of light are again observed.

Suggest any differences that you would expect in the movement of the specks when the temperature is 5 °C, compared to before.

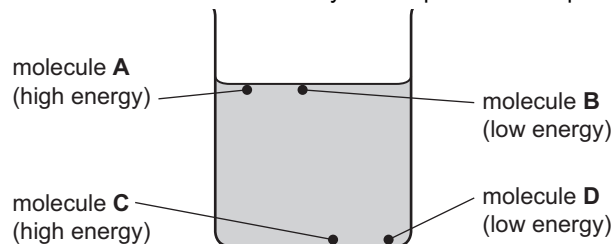
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..... [1]

[Total: 4]

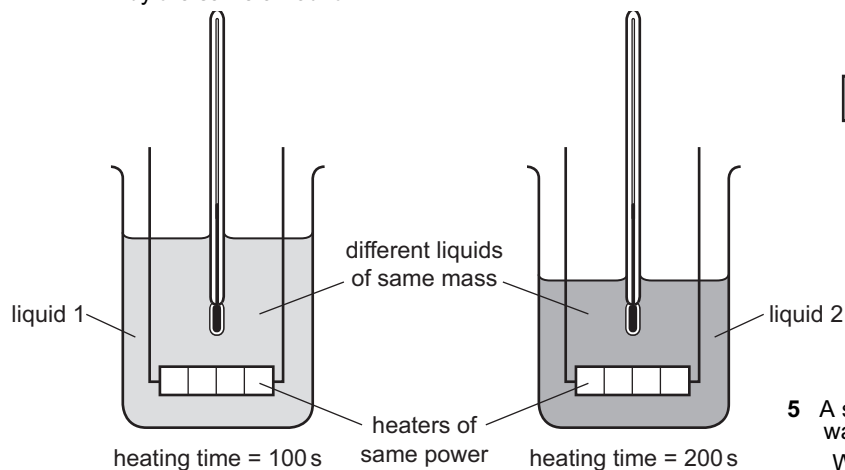
Specific heat capacity, changing states MCQ

- 1 The diagram shows a beaker of water. Four molecules are labelled. The relative amount of energy of each molecule is shown.

Which molecule is most likely to escape from the liquid?



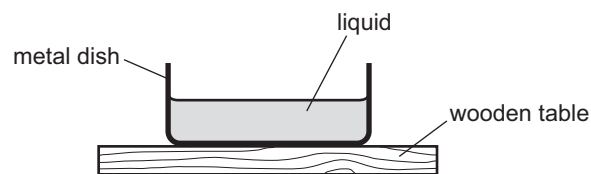
- 2 Equal masses of two different liquids are put into identical beakers. Liquid 1 is heated for 100 s and liquid 2 is heated for 200 s by heaters of the same power. The temperature of both liquids increases by the same amount.



Which statement is correct?

- A Both liquids receive the same amount of energy.
- B Liquid 1 receives more energy than liquid 2.
- C Both liquids have equal thermal capacity.
- D The thermal capacity of liquid 1 is less than the thermal capacity of liquid 2.

- 3 Some liquid is poured into a metal dish on a wooden table. The dish, the liquid, the table and the air around the dish are all at the same temperature.

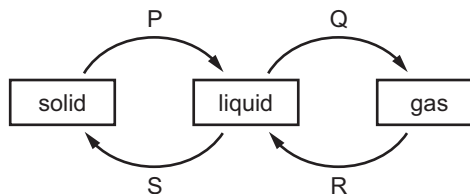


The temperature of the liquid now starts to decrease.

What could cause this temperature decrease?

- A convection currents in the liquid
- B conduction of heat through the metal dish
- C evaporation of the liquid
- D heat radiation from the liquid

- 4 The diagram shows four labelled changes of state between solid, liquid and gas.



Which changes need an energy input?

- A P and Q
- B Q and R
- C R and S
- D S and P

- 5 A swimmer feels cold after leaving warm water on a warm, windy day. Why does she feel cold even though the air is warm?

- A The less energetic water molecules on her skin escape quickly.
- B The more energetic water molecules on her skin do not escape quickly.
- C The water on her skin does not evaporate quickly enough to keep her warm.
- D The water on her skin evaporates quickly and cools her skin.

- 6 A circular metal disc is heated.

Which quantity decreases?

- A its density
- B its diameter
- C its thickness
- D its volume

- 7 The same quantity of thermal (heat) energy is given to two objects X and Y.

The temperature rise of object X is less than the temperature rise of object Y.

What accounts for this difference?

- A X has a larger thermal capacity than Y.
- B X is a better thermal conductor than Y.
- C Y has a larger thermal capacity than X.
- D Y is a better thermal conductor than X.

- 8 A block of copper and a block of lead are heated. The internal energy of each block increases by the same amount.

The block of copper has a lower thermal capacity than the block of lead.

Which conclusion can be made from this information?

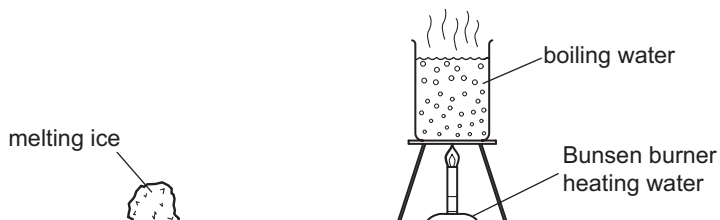
- A The temperature increase of the copper is greater than the temperature increase of the lead.
- B The temperature increase of the copper is the same as the temperature increase of the lead
- C The temperature increase of the copper is less than the temperature increase of the lead
- D The melting point of copper is lower than the melting point of lead.

- 9 When a liquid evaporates, some of its molecules escape from the surface and the temperature of the liquid changes.

Which row describes the escaping molecules and the change in temperature of the liquid ?

	escaping molecules	temperature of the liquid
A	less energetic	goes down
B	less energetic	goes up
C	more energetic	goes down
D	more energetic	goes up

- 10 A piece of melting ice at 0 °C and a beaker of boiling water are both in a laboratory. The laboratory is at 20 °C.

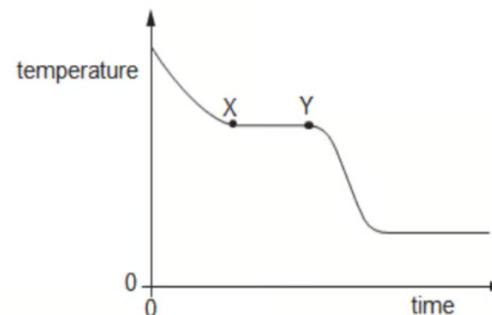


What is happening to the temperature of the melting ice and what is happening to the temperature of the boiling water?

	temperature of melting ice	temperature of boiling water
A	constant	constant
B	constant	increasing
C	increasing	constant
D	increasing	increasing

- 11 A substance is cooled. The graph below shows how its temperature changes over time.

What is happening in the portion of the graph labelled XY?



- A The gas is cooling.
 B The liquid is freezing.
 C The gas is condensing.
 D The liquid is cooling.

- 12 A copper container of mass 0.20 kg contains 0.10 kg of water.

The specific heat capacity of copper is 385 J/(kg °C) and the specific heat capacity of water is 4200 J/(kg °C).

How much energy, in joules, is needed to raise the temperature of the copper container and the water by 10 °C?

- A $(0.20 \times 385 \times 10) - (0.10 \times 4200 \times 10)$
 B $(0.20 \times 385 \times 10) + (0.10 \times 4200 \times 10)$
 C $(0.10 + 0.20) \times \left(\frac{4200 + 385}{2} \right) \times 10$
 D $(0.10 + 0.20) \times (4200 + 385) \times 10$

- 13 A puddle of water is formed after a rain shower on a windy day.

Which statement explains the effect of the wind on the rate of evaporation of the water in the puddle?

- A The wind gives molecules in the water extra kinetic energy and so increases the rate of evaporation.
 B The wind removes evaporated water from near the surface and so decreases the rate of evaporation.
 C The wind removes evaporated water from near the surface and so increases the rate of evaporation.
 D The wind takes energy from molecules near the surface and so decreases the rate of evaporation.

14 Which statement about evaporation is correct?

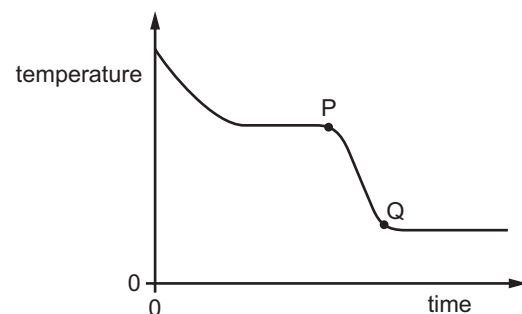
- A Evaporation causes the temperature of the remaining liquid to decrease.
- B Evaporation does not occur from a cold liquid near its freezing point.
- C Evaporation does not occur from a dense liquid, such as mercury.
- D Evaporation occurs from all parts of a liquid.

15 A beaker contains 0.500 kg of water at a temperature of 3.0 °C. The beaker is heated, and the internal energy of the water increases by 21.0 kJ. The specific heat capacity of water is 4200 J / (kg °C).

What is the temperature of the water after it has been heated?

- A 5.5 °C
- B 10.0 °C
- C 13.0 °C
- D 31.5 °C

16 A substance loses thermal energy (heat) to the surroundings at a steady rate. The graph shows how the temperature of the substance changes with time.



What could the portion PQ of the graph represent?

- A gas condensing
- B gas cooling
- C liquid cooling
- D liquid solidifying

17 Which statement describes what happens as ice at 0 °C starts to melt to become water?

- A Energy is absorbed and the temperature remains constant.
- B Energy is absorbed and the temperature rises.
- C Energy is released and the temperature remains constant.
- D Energy is released and the temperature rises.

18 A liquid is at a temperature below its boiling point.

The liquid is then heated so that it becomes a gas at a temperature above its boiling point.

Which row correctly compares the liquid with the gas?

	average distance between the particles	average speed of the particles
A	greater in the liquid	greater in the liquid
B	greater in the liquid	smaller in the liquid
C	smaller in the liquid	greater in the liquid
D	smaller in the liquid	smaller in the liquid

19 A beaker of liquid is left on a laboratory bench. There is an electric fan in the laboratory causing a draught over the liquid.

The liquid evaporates.

Which row shows two changes that will **both** cause the liquid to evaporate more quickly?

	change to surface area of the liquid	change to speed of fan
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

20 A pan, containing 0.750 kg of water which is initially at 13 °C is heated by an electric hob. 35 kJ of thermal energy is put into the water and its temperature rises.

You can assume that all the energy supplied by the hob goes into raising the temperature of the water.

The specific heat capacity of water is 4200 J / kg °C.

To the nearest °C, what is the final temperature of the water?

- A 24 °C
- B 13 °C
- C 19 °C
- D 11 °C

21 In an experiment to measure specific heat capacity, a block of aluminium is heated and its rise in temperature is measured.

The amount of energy gained by the block is E . The mass of the block is m . The rise in temperature of the block is ΔT .

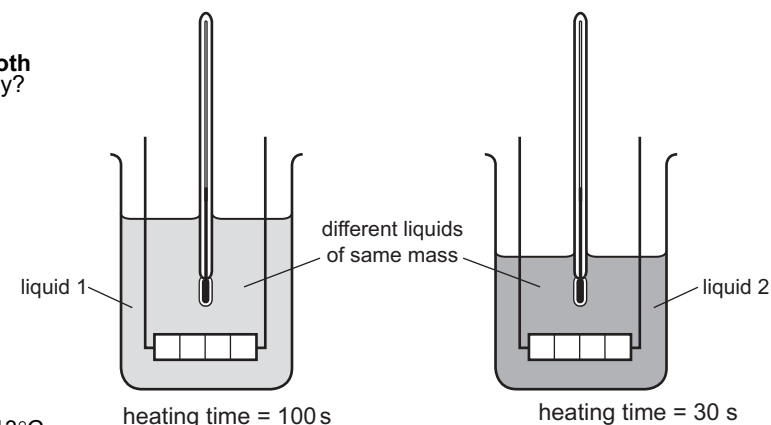
Which expression gives the specific heat capacity of aluminium?

- A $\frac{m}{E \Delta T}$
- B $\frac{m \Delta T}{E}$
- C $\frac{E}{m \Delta T}$
- D $\frac{E \Delta T}{m}$

22 Equal masses of two different liquids are put into identical beakers.

Liquid 1 is heated for 100 s and liquid 2 is heated for 30 s by heaters of the **same power**.

Each liquid has the same rise in temperature



C Which statement is correct?

- A Each beaker of liquid has the same thermal capacity.
- B Each beaker of liquid receives the same energy.
- C The thermal capacity of liquid 2 is less than the thermal capacity of liquid 1.
- D The thermal capacity of liquid 1 is less than the thermal capacity of liquid 2.

23 Which of the following statements defines the specific heat capacity of a substance?

- A** The energy required to raise the temperature of 1kg of a substance by 1°C.
- B** The energy per °C required to raise the temperature of a substance.
- C** The increase in length of 1kg of a substance when its temperature is increased by 1°C.
- D** The energy required to change 1kg of a substance from a liquid to a gas.

24 Liquid evaporates from a beaker.

What happens to the temperature of the remaining liquid and how does this temperature change affect the rate of evaporation?

	temperature	rate of evaporation
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

25 Which quantity does **not** change when there is an increase in temperature?

- A** the density of a steel block
- B** the diameter of the hole in a metal nut
- C** the length of an iron rod
- D** the mass of a metal coin

26 A thermocouple is used to measure temperature. Which is an advantage of using a thermocouple instead of a liquid-in-glass thermometer?

- A** It can measure temperature in the range -10°C to 110°C .
- B** It can measure temperature that changes rapidly.
- C** It has a linear scale.
- D** It is more sensitive.

27 A block of copper has a mass of 2.0 kg.

The block of copper absorbs 12000 J thermal energy.

The specific heat capacity of copper is $385 \text{ J}/(\text{kg } ^{\circ}\text{C})$.

What is the temperature rise of the copper?

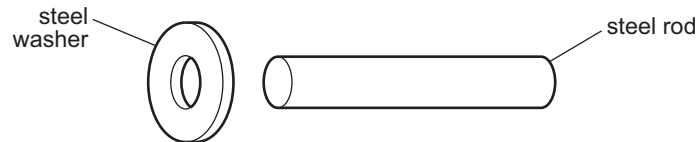
- A** 15.6°C
- B** 31.2°C
- C** 46.8°C
- D** 62.4°C

28 A heater supplies 80 J of energy to a block of metal. The temperature of the block rises by 20°C .

What happens to the block of metal when its temperature falls by 10°C ?

- A** Its internal energy decreases by 40 J.
- B** Its internal energy decreases by 160 J.
- C** Its internal energy increases by 40 J.
- D** Its internal energy increases by 160 J.

29 An engineer wants to fix a steel washer on to a steel rod. The rod is just too big to fit into the hole of the washer.



How can the engineer fit the washer on to the rod?

- A** Cool the washer and put it over the rod.
- B** Cool the washer and rod to the same temperature and push them together.
- C** Heat the rod and then place it in the hole.
- D** Heat the washer and then place it over the rod.

30 A metal block is heated until it is completely melted. It is then allowed to solidify. What happens to the mass of the metal during the changes of state?

	mass during melting	mass during solidification
A	decreases	increases
B	increases	decreases
C	increases	stays constant
D	stays constant	stays constant

Specific heat capacity, changing states

- 1 (a) The source of solar energy is the Sun.

Tick the box next to those resources for which the Sun is also the source of energy.

- | | |
|--------------------------|---------------|
| ☐ | coal |
| ☐ | geothermal |
| ☐ | hydroelectric |
| ☐ | nuclear |
| ☐ | wind |

- (b) Fig. 1.1 shows a solar water-heating panel on the roof of a house .

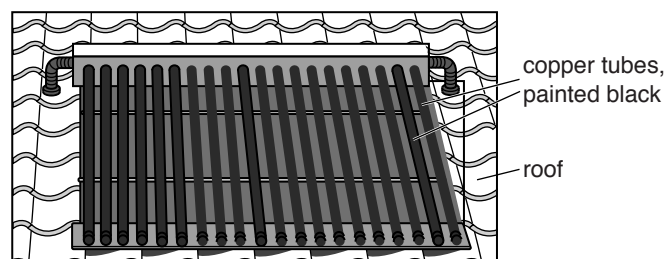


Fig. 1.1

Cold water flows into the copper tubes, which are heated by solar radiation. Hot water flows out of the tubes and is stored in a tank.

- (i) Explain why the tubes are made of copper and are painted black.

.....

[2]

- (ii) In 5.0 s, 0.019 kg of water flows through the tubes. The temperature of the water increases from 20°C to 72°C. The specific heat capacity of water is 4200 J/(kg °C).

Calculate the thermal energy gained by the water in 5.0 s.

[2]

thermal energy =[3]

- (iii) The efficiency of the solar panel is 70%.

Calculate the power of the solar radiation incident on the panel.

power =[2]

[Total: 9]

- 2 (a) (i) State **two** ways in which *evaporation* is different from *boiling*.
- 1
- 2
- [2]

(ii) Give **one** example of a change of state which does not involve boiling or evaporation.

.....[1]

(b) The graph in Fig. 2.1 shows the variation of temperature with time for a substance that is initially liquid.

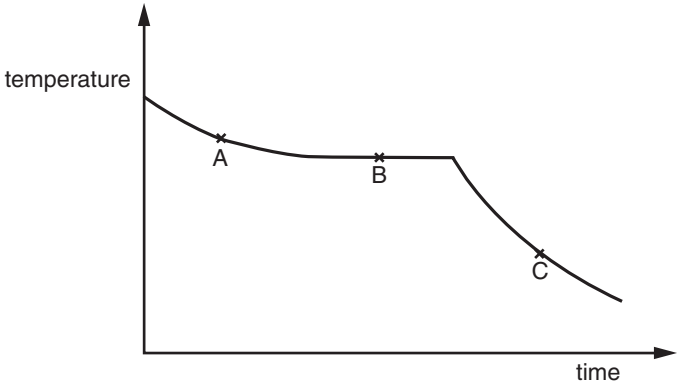


Fig. 2.1

- (i) State what is taking place at points A, B and C. You should say what changes of state, if any, are taking place.
- point A
- point B
- point C
- [3]
- (ii) Suggest why the graph is steeper at point C than at point A.
-
-[1]

3 (a) The arrows on Fig. 3.1 represent four changes of state.

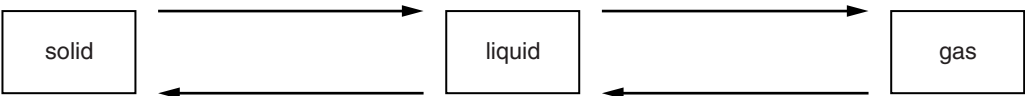


Fig. 3.1

On each arrow, write the name for the change of state. [3]

(b) The statements below are about particles in a gas.

Tick **three** boxes to show which statements are correct.

- ☐ The particles move randomly.
- ☐ The particles are in a regular repeating pattern.
- ☐ The particles are much further apart than they are in a solid.
- ☐ The particles vibrate about fixed positions.
- ☐ The particles expand when they are heated.
- ☐ The particles move faster when they are heated.

[3]

(c) A student spills a small amount of nail varnish remover on one of her hands. Nail varnish remover is a liquid with a low boiling point.

Explain why this hand feels colder than her other hand.

.....

.....

.....

.....[3]

[Total: 9]

4 During both boiling and evaporation, liquid water is converted into water vapour.

The rate at which the mass of **boiling** water decreases depends only on the rate at which the water is gaining thermal energy.

(a) The specific latent heat of vaporisation of water is $2.3 \times 10^6 \text{ J/kg}$. Thermal energy is supplied to boiling water in a kettle at a rate of 460 W.

Calculate the mass of water that is boiled away in 180 s.

mass = [2]

(b) The rate at which the mass of **evaporating** water decreases depends on other factors.

(i) State two of these factors.

- 1.
 - 2.
- [2]

(ii) State two other ways in which evaporation is different from boiling.

- 1.
 - 2.
- [2]

[Total: 6]

5 (a) State what is meant by the *specific heat capacity* of a substance.

.....

.....

..... [2]

(b) A student carries out an experiment to find the specific heat capacity of aluminium. He uses an electric heater and a thermometer, inserted into separate holes in an aluminium block.

The following data are obtained.

mass of aluminium block = 2.0 kg
power of heating element = 420 W
time of heating = 95 s
initial temperature of block = 19.5 °C
final temperature of block = 40.5 °C

Calculate the value of the specific heat capacity of aluminium given by this experiment.

specific heat capacity = [4]

(c) In the experiment in (b), no attempt is made to prevent loss of thermal energy from the surfaces of the block.

Suggest two actions the student could take to reduce the loss of thermal energy from the surfaces of the block.

- 1.
 - 2.
- [2]

[Total: 8]

(a) Suggest

- (i) an example of a change of state resulting from the removal of thermal energy from a quantity of material,

..... [1]

- (ii) the effect of this change of state on the temperature of the material.

..... [1]

(b) Define the *thermal capacity* of a body.

.....

.....

..... [2]

- (c) A polystyrene cup holds 250g of water at 20 °C. In order to cool the water to make a cold drink, small pieces of ice at 0 °C are added until the water reaches 0 °C and no unmelted ice is present.

[specific heat capacity of water = 4.2 J/(g °C), specific latent heat of fusion of ice = 330 J/g]

Assume no thermal energy is lost or gained by the cup.

- (i) Calculate the thermal energy lost by the water in cooling to 0 °C.

thermal energy lost = [2]

- (ii) State the thermal energy gained by the ice in melting.

thermal energy gained = [1]

- (iii) Calculate the mass of ice added.

mass of ice = [2]

[Total: 9]

7 (a) State the energy changes that take place when

(i) a cyclist rides down a hill without pedalling,

.....
.....

(ii) a cyclist pedals up a hill at a constant speed.

.....
.....

[3]

(b) A car of mass 940 kg is travelling at 16 m/s.

(i) Calculate the kinetic energy of the car.

kinetic energy = [2]

(ii) The car is brought to rest by applying the brakes.

The total mass of the brakes is 4.5 kg. The average specific heat capacity of the brake material is 520 J/(kg °C).

Calculate the rise in temperature of the brakes. Assume there is no loss of thermal energy from the brakes.

rise in temperature = [3]

[Total: 8]

8

Fig. 3.1 shows a long, plastic tube, sealed at both ends. The tube contains 0.15 kg of small metal spheres.



Fig. 3.1

A physics teacher turns the tube upside down very quickly and the small metal spheres then fall through 1.8 m and hit the bottom of the tube.

(a) Calculate

(i) the decrease in gravitational potential energy as the spheres fall 1.8 m,

decrease in gravitational potential energy = [2]

(ii) the speed of the spheres as they hit the bottom of the tube.

speed = [3]

(b) The gravitational potential energy of the spheres is eventually transformed to thermal energy in the metal spheres. The physics teacher explains that this procedure can be used to determine the specific heat capacity of the metal.

(i) State one other measurement that must be made in order for the specific heat capacity of the metal to be determined.

.....
.....[1]

(ii) Suggest a source of inaccuracy in determining the specific heat capacity using this experiment.

.....
.....[1]

(iii) The teacher turns the tube upside down and lets the spheres fall to the bottom 100 times within a short period of time.

Explain why turning the tube upside down 100 times, instead of just once, produces a more accurate value of the specific heat capacity.

.....
.....
.....[2]

[Total: 9]

Conduction, convection, radiation and temperature measurements MCQ

1 Which of the following statements about thermal radiation is correct?

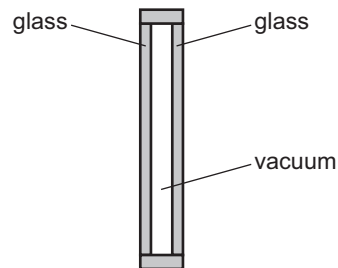
- A It is electromagnetic radiation.
- B It can only happen in vacuum.
- C It involves movement of molecules due to changes in density.
- D It involves transfer of electrons through a material.

2 The metal surface of a kettle is hot.

What happens to the cool air outside the kettle when it comes into contact with the hot kettle?

- A The density of the air decreases and the air falls.
- B The density of the air decreases and the air rises.
- C The density of the air increases and the air falls.
- D The density of the air increases and the air rises.

3 One type of double glazing consists of two panes of glass separated by a vacuum.



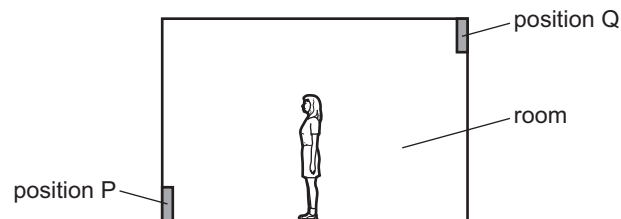
Which method or methods of energy transfer are prevented by the vacuum?

- A conduction and convection
- B conduction and radiation
- C convection and radiation
- D radiation only

4 Two methods by which thermal energy can be transferred are conduction and radiation. Which statement is correct?

- A Conduction involves density changes in fluids.
- B Conduction only occurs in solids.
- C Radiation cannot occur in a vacuum.
- D Radiation involves electromagnetic waves.

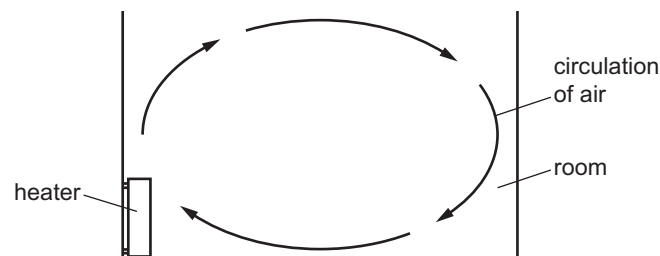
5 A heater is to be fitted in a room to warm the air throughout the room. The diagram shows two possible positions to fit the heater, P and Q.



Which position is better and why?

	position	why?
A	P	warmer air is less dense and rises
B	P	warmer air is more dense and rises
C	Q	warmer air is less dense and falls
D	Q	warmer air is more dense and falls

6 The air in a room is heated by a heater. The diagram shows the circulation of the air in the room.



Which statement about the air that is heated is correct?

- A The air contracts and becomes less dense.
- B The air contracts and becomes more dense.
- C The air expands and becomes less dense.
- D The air expands and becomes more dense.

7 Four rods are made from different metals P, Q, R and S. The rods have equal lengths and equal diameters. The rods are heated at one end, in the same way.

The table shows the time taken for the temperature at the other end of each rod to rise by 1.0°C .

Which metal is the best conductor of thermal energy (heat)?

metal	time taken / s
P	35
Q	30
R	45
S	40

- A metal P
- B metal Q
- C metal R
- D metal S

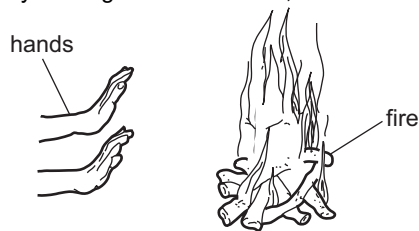
8 In a refrigerator, the cooling unit can be fitted either at the top or at the bottom.

In an oven, the heater can be fitted either at the top or at the bottom.

Which row shows the best position for the cooling unit and the best position for the heater?

	cooling unit	heater
A	bottom	bottom
B	bottom	top
C	top	bottom
D	top	top

- 9 A girl is outdoors. She warms her hands by holding them near a fire, as shown.



How does the heat from the fire reach her hands?

- A conduction only
- B convection and conduction
- C convection and radiation
- D radiation only

- 10 When a family wants to embark on a picnic, they tend to want to take food which is best served chilled, like sandwiches and lemonade.

In order to achieve this, ice packs are packed with the picnic food in a hamper. Two are recommended.

Where does physics dictate both ice packs should be placed in order to keep the food as cool as possible?

- A both at the top of the hamper
- B one at the top of the hamper and one at the bottom
- C both at the bottom of the hamper
- D on either side of the hamper

- 11 A heating engineer fits a heater to the ceiling of an office so that workers in the office are kept warm.

How does thermal energy reach the workers below the heater?

- A conduction and convection
- B convection and radiation
- C convection only
- D radiation only

- 12 Which row shows how heating changes the density of air, and the name of the method of energy transfer caused by this density change?

	density	method of energy transfer
A	decreases	conduction
B	decreases	convection
C	increases	conduction
D	increases	convection

- 13 The thermal transfer of energy through a copper rod involves electrons. A second process is also involved.

What is this method of thermal energy transfer, and what is the second process?

	method	second process
A	conduction	density change
B	conduction	lattice vibration
C	convection	density change
D	convection	lattice vibration

- 14 The diagrams show four spherical objects at the same temperature. Two of the objects are small and two are large.

Two of the objects are white and two are black.

Which object emits infra-red radiation at the greatest rate?



- 15 On a very cold day, a boy puts one hand on the metal handlebars of his bicycle. He puts the other hand on the rubber hand grip.

The metal feels colder than the rubber hand grip, although they are both at the same temperature.

Why is this?

- A The metal has a higher melting point than the rubber.
- B The metal has a lower thermal capacity than the rubber.
- C The metal is a better thermal conductor than the rubber.
- D The metal radiates more infra-red radiation than the rubber.

- 16 A student suggests some uses for the knowledge that black and white objects emit and absorb different amounts of infrared radiation.

Which of her suggestions is correct?

- A Coffee mugs should be black to keep coffee hot.
- B Houses in hot countries should be painted white to keep the occupants cool.
- C White clothing will help you cool down much faster.
- D Solar heating panels should be white to heat the water more quickly.

- 17 The diagrams show four spherical objects of the same size. Two of the objects are white and two are black.

Two of the objects are at the same high temperature and two are at the same low temperature.

Which object emits infra-red radiation at the greatest rate?



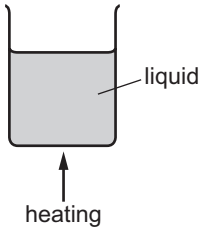
18 An astronaut aboard the International Space Station (ISS) lights a match. Using ideas about convection, what does the flame look like?

- A** It burns upwards, like a normal flame.
- B** It burns like a normal flame, but is directed downwards, towards the Earth.
- C** It burns like a normal flame, but is directed sideways, in the opposite direction to the direction the ISS is travelling.
- D** It burns in a sphere for a short time, before going out.

19 Two otherwise identical cars, one black and one white, are at the same initial temperature .
The cars are left in bright sunshine and their temperatures increase .
During the night their temperatures decrease.
Which car shows the greater rate of temperature increase and which car shows the greater rate of temperature decrease?

	greater rate of temperature increase	greater rate of temperature decrease
A	black	black
B	black	white
C	white	black
D	white	white

20 A liquid is heated in a beaker.



The density of the liquid changes as as its temperature increases.
This causes energy to be transferred throughout the liquid.

How does the density change and what is this energy transfer process?

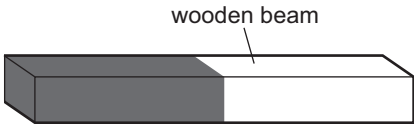
	density	energy transfer process
A	decreases	conduction
B	decreases	convection
C	increases	conduction
D	increases	convection

21 Which processes occur in a metal to cause thermal conduction?

	electron transfer	proton transfer	lattice vibration
A	✓	✓	✓
B	✓	✓	x
C	✓	x	✓
D	x	✓	✓

key ✓ = process occurs x = process does not occur

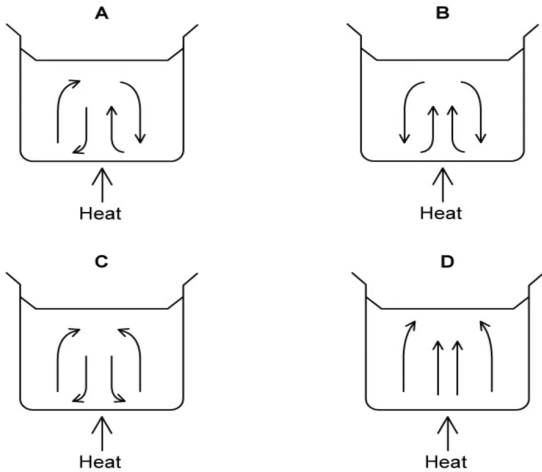
22 A wooden beam is painted part black and part white. The beam absorbs infra-red radiation from the Sun during the day, and loses infra-red radiation to the surroundings at night.



Which part of the beam heats up more quickly during a day, and which part cools down more quickly at night?

	part heating up more quickly	part cooling down more quickly
A	black	black
B	black	white
C	white	black
D	white	white

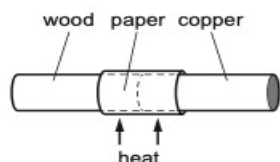
23 Which diagram correctly shows the motion of the particles in a beaker filled with liquid heated from the base?



- 24 A student suggests some uses for containers made from good thermal conductors and for containers made from poor thermal conductors. In which row are both suggested uses correct?

	good thermal conductor	poor thermal conductor
A	keeping a cold liquid at a low temperature	transferring thermal energy quickly from a hot liquid
B	keeping a hot liquid at a high temperature	keeping a cold liquid at a low temperature
C	transferring thermal energy quickly from a hot liquid	transferring thermal energy quickly to a cold liquid
D	transferring thermal energy quickly to a cold liquid	keeping a hot liquid at a high temperature

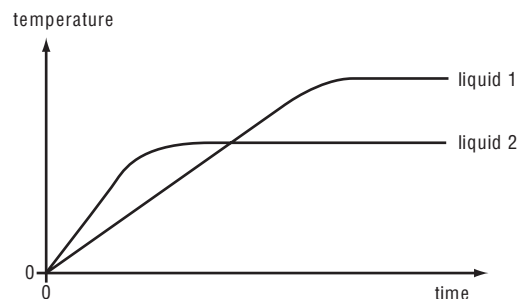
- 25 A copper bar and a wooden bar are joined. A piece of paper is wrapped tightly around the join. The bar is heated strongly at the centre for a short time, and the paper goes brown on one side only.



Which side goes brown, and what does this show about wood and copper?

	brown side	wood	copper
A	copper	conductor	insulator
B	copper	insulator	conductor
C	wood	conductor	insulator
D	wood	insulator	conductor

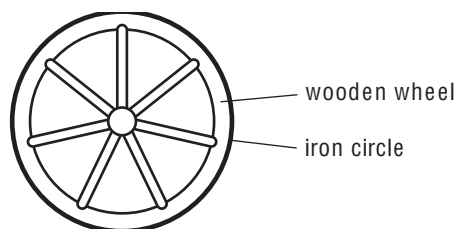
- 26 Equal masses of two different liquids are heated using the same heater. The graph shows how the temperature of each liquid changes with time.



What does the graph tell us about the liquids?

- A Liquid 1 has a higher melting point than liquid 2.
 B Liquid 1 has a higher boiling point than liquid 2.
 C Liquid 1 starts to melt sooner than liquid 2.
 D Liquid 1 starts to boil sooner than liquid 2.

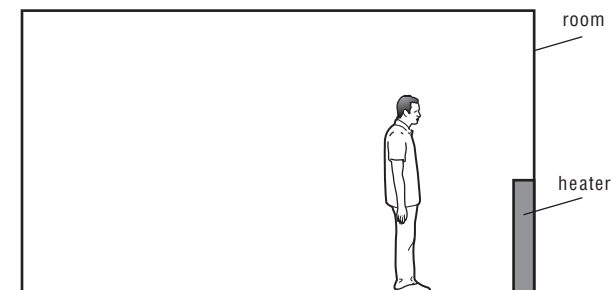
- 27 A wooden wheel can be strengthened by putting a tight circle of iron around it.



Which action would make it easier to fit the circle over the wood?

- A cooling the iron circle
 B heating the iron circle
 C heating the wooden wheel and cooling the iron circle
 D heating the wooden wheel but not heating or cooling the iron circle

- 28 A man goes into a cold room and switches on a heater. The man then stands one metre away from the heater. He feels warmer almost immediately.

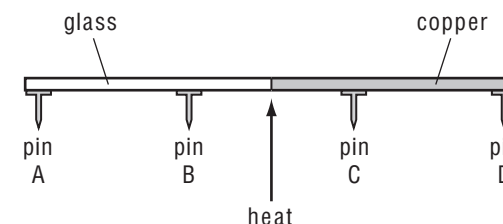


How is thermal energy transferred from the heater to the man so quickly?

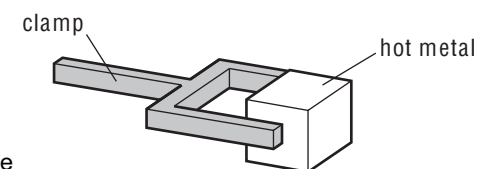
- A by conduction, convection and radiation
 B by conduction only
 C by convection only
 D by radiation only

- 29 A rod is made half of glass and half of copper. Four pins, A, B, C and D are attached to the rod by wax. The rod is heated in the centre as shown.

Which pin falls off first?



- 30 A piece of hot metal is held by a clamp in a cold room. The air next to the metal becomes hot. The density of the air changes and the air moves.



Which row shows the density change of the air and the direction in which the air moves?

	density of air	movement of air
A	decreases	downwards
B	decreases	upwards
C	increases	downwards
D	increases	upwards

Conduction, convection, radiation and temperature measurement

1 Fig. 1.1 shows apparatus that is used to demonstrate some effects of the transfer of energy by radiation.

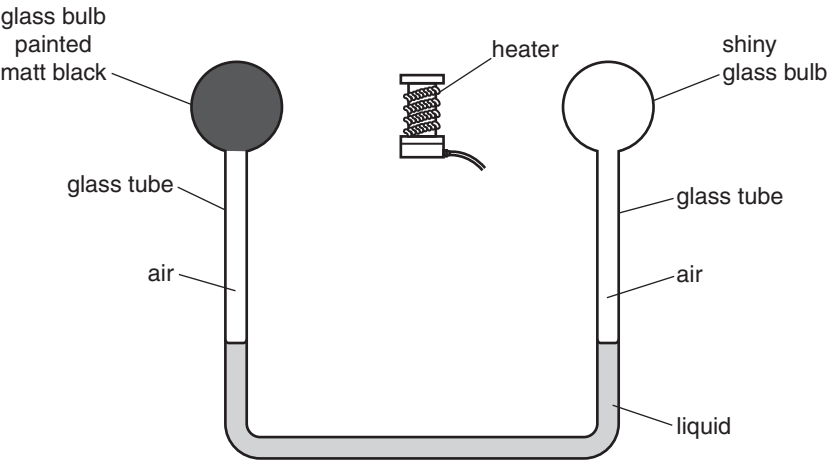


Fig. 1.1

The glass bulb painted matt black, the shiny glass bulb and the spaces above the liquid in the tube all contain air.

The heater glows red when switched on. The heater is the same distance from each bulb.

(a) State the **two** types of radiation that are emitted by the heater.

- 1
- 2

[1]

(b) Before the heater is switched on, the liquid levels in the glass tube are the same.

State and explain any changes in the liquid levels that take place when the heater is switched on.

-
-
-
-
-
-
-
-
-
-

[4]

[Total: 5]

2 Fig. 2.1 shows a domestic hot water system.

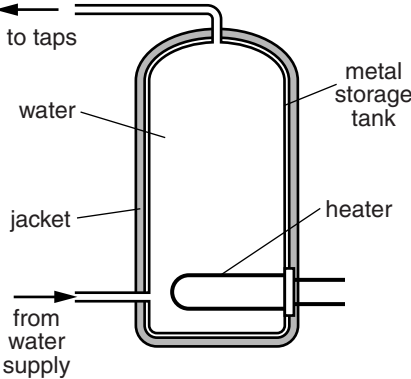


Fig. 2.1

(a) The heater is placed at the bottom of the storage tank.

(i) Name the process by which water in contact with the heater becomes hot.

..... [1]

(ii) 1. Explain how the water at the top of the storage tank becomes hot. Include the word *density* in your answer.

-
-
-
-
-
-
-
-
-
-

[3]

2. State the name given to this process.

..... [1]

(b) Hot water storage tanks are often covered in a material such as polystyrene or a 'jacket' made from a woollen material.

(i) State the purpose of this covering.

..... [1]

(ii) Suggest **two** reasons why the use of such a material is important.

- 1.
- 2.

[2]

[Total: 8]

3 A student has a beaker of liquid as shown in Fig. 3.1.

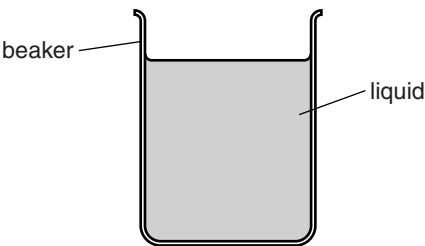


Fig. 3.1

(a) The student makes some measurements. His results are shown in the table.

mass of beaker and liquid	280 g
mass of empty beaker	120 g
volume of liquid	200 cm ³

(i) Calculate the mass of the liquid in the beaker.

mass of liquid = g [1]

(ii) Calculate the density of the liquid.

density = g/cm³ [3]

(b) The student warms the beaker and liquid on an electric heater as shown in Fig. 3.2.

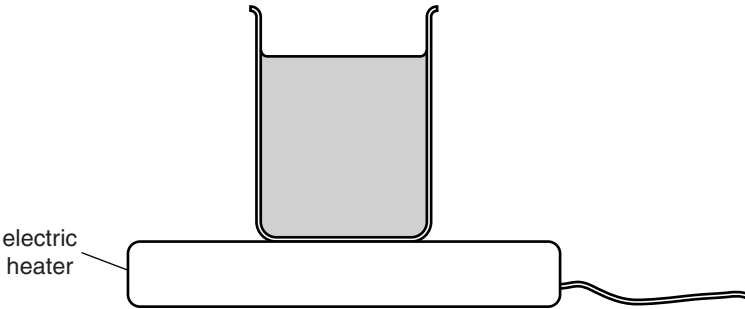


Fig. 3.2

(i) State the name of the process by which thermal energy is transferred through the glass of the beaker.

.....[1]

(ii) Explain how thermal energy is transferred throughout the liquid by convection.

.....

[3]

(c) After heating for 20 minutes, the student re-weighs the beaker and liquid. He finds that the mass of the beaker and liquid has decreased to 260 g.

(i) State the name of the process that causes this decrease in mass.

.....[1]

(ii) In terms of molecules, explain how this process occurs.

.....

[2]

[Total: 11]

4 Fig. 4. shows a cross-section of a double-walled glass vacuum flask, containing a hot liquid. The surfaces of the two glass walls of the flask have shiny silvered coatings.

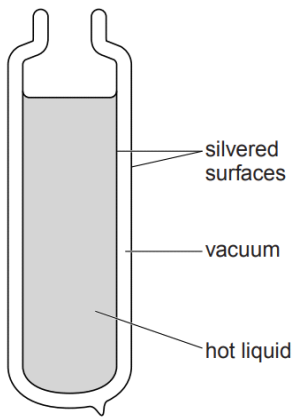


Fig. 4.1

(a) Explain

(i) why the rate of loss of thermal energy through the walls of the flask **by conduction** is very low,

.....

.....

.....

.....

(ii) why the rate of loss of thermal energy through the walls of the flask **by radiation** is very low.

.....

.....

.....

.....

[3]

(b) Suggest, with reasons, what must be added to the flask shown in Fig. 4.1 in order to keep the liquid hot.

.....

.....

.....

.....

.....[3]

[Total: 6]

5 An archaeologist digging at an ancient site discovers a spoon. The spoon is made from an unidentified material.

- (a) The archaeologist suspects that the spoon is made of metal. She places it above a flame, as shown in Fig. 1.1.

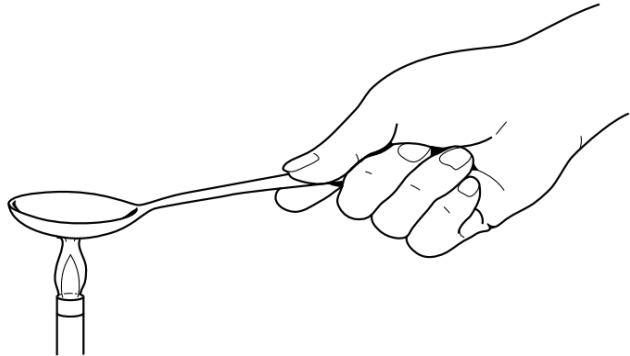


Fig. 1.1

- (i) She notices that the handle of the spoon quickly becomes very hot.

State why this observation supports the suggestion that the spoon is made of metal.

.....
..... [1]

- (ii) Describe, in terms of its atoms, how thermal energy is transferred through a metal.

.....
.....
.....
.....
..... [3]

- (b) The archaeologist hopes that, by determining its density, she will be able to identify the metal.

Describe a method for determining the density of the metal from which the spoon is made.

.....
.....
.....
.....
.....
.....
..... [4]

[Total: 8]

6 Fig. 5.1 shows some apparatus which is used to be used to compare the emission of infra-red radiation from four different painted surfaces.

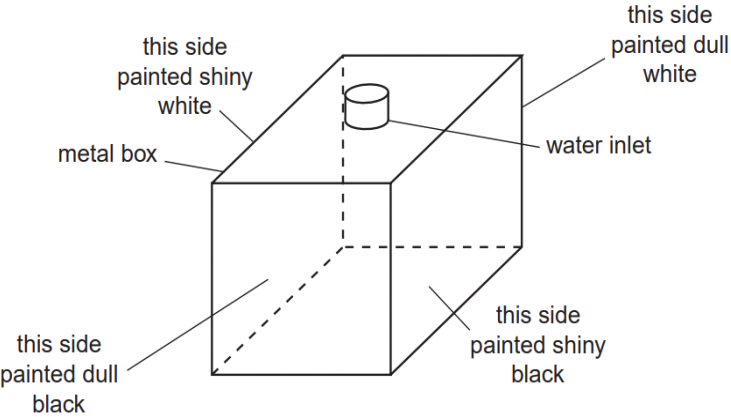


Fig. 5.1

Near the centre of each side is an infra-red detector. The four detectors are identical.

A supply of very hot water is available.

(a) Describe how you would use this apparatus to compare the infra-red radiation from the four surfaces.

.....

 [3]

(b) Suggest which surface will be the best emitter and which will be the worst emitter.

best emitter
 worst emitter [1]

[Total: 4]

7 (a) A 240 V, 60 W lamp is connected to a 240 V supply. The lamp has a constant temperature.
 State

(i) the rate at which the lamp transfers energy to the surroundings,

rate =[1]

(ii) the names of the thermal processes by which the lamp transfers energy to the surroundings.

.....
 [1]

(b) Fig. 7.1 shows a thick copper block that has been heated to 400 °C. One side of the block is dull black. The other side of the block is polished and shiny.

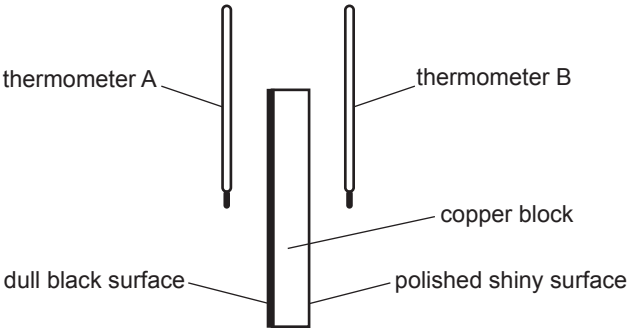


Fig. 7.1

(i) In Experiment 1, the thermometer bulbs are both painted black. They are placed at equal distances from the surfaces of the block. The maximum temperature shown by each thermometer is recorded.

Explain any difference between the maximum temperature shown by the two thermometers.

.....

 [3]

- (ii) In Experiment 2, the thermometer bulbs are both shiny silver-coloured. They are placed at the same distances from the surfaces of the block as in Experiment 1.

State and explain any differences that are observed in the maximum temperatures shown by the thermometers in Experiments 1 and 2.

.....

.....

.....

.....

.....[2]

- (c) Fig. 7.2 shows a firefighter wearing shiny silver-coloured clothing.



Fig. 7.2

State the benefit to a firefighter of wearing shiny silver-coloured clothing.

.....

.....[1]

[Total: 8]

- 8 (a) (i) An electric kettle contains 600 g of water at 20 °C. The heater in the kettle operates at 240 V. The specific heat capacity of water is 4200 J/(kg °C).

The current in the heater is 12 A.

Calculate the time taken for the temperature of the water to rise to 100 °C.

time =[4]

- (ii) State **one** assumption you made in your calculation in (a)(i).

.....[1]

- (b) Using the apparatus shown in Fig. 8.1, describe an experiment to demonstrate good and bad emitters of thermal radiation. Include the expected results and the conclusion.

You may use a diagram.

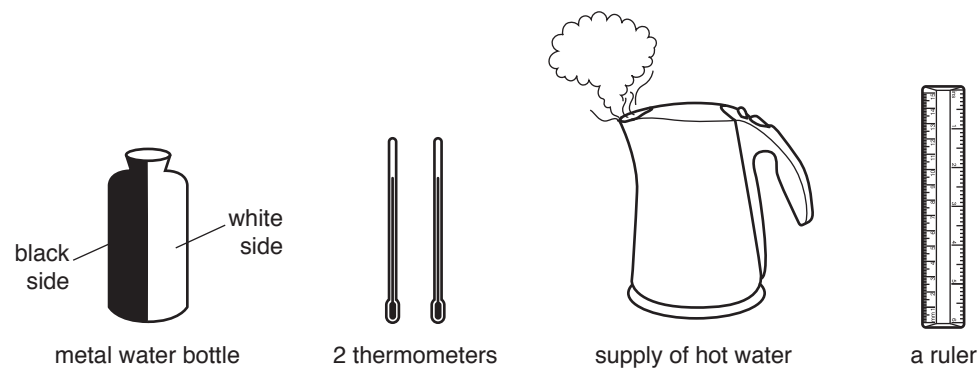


Fig. 8.1

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.....

.....[4]

[Total: 9]

Waves

Summary Notes

General wave properties

Waves **transfer energy and information without transferring matter**; the particles oscillate about a fixed point.

- **Transverse waves**
 - Have **peaks** and **troughs**
 - Vibrations are at **right angles** to the direction of travel
 - An example is light
- **Longitudinal waves**
 - Consists of compressions (particles pushed together) and rarefactions (particles moved apart)
 - Vibrations are in the **same direction** as the direction of travel
 - An example is sound

Amplitude – the **distance** from the **equilibrium** position to the **maximum displacement**
 Wavefront – a line joining points on a wave at the same point in their wave cycle at a given time
 Frequency – the **number of waves** that pass a single point **per second**
 Wavelength – the **distance** between a **point** on one wave and the **same point** on the next wave
 Time period – the **time taken** for **one complete wave** to pass a fixed point

The **speed** of a wave is equal to the product of the frequency and wavelength:

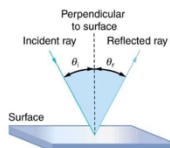
- $speed = frequency \times wavelength \quad v = f\lambda$

The frequency of a wave is equal to the reciprocal of the time period, measured in **Hertz (Hz)**:

- $frequency = \frac{1}{time\ period} \quad f = \frac{1}{T}$

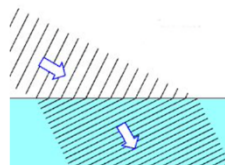
Reflection:

- All waves can be **reflected** when they travel from a medium of low **optical density** (such as air) to one of much higher optical density (such as glass)
- The law of reflection states that:
 - Angle of incidence = angle of reflection
- Frequency, wavelength, and speed are all **unchanged**



Refraction:

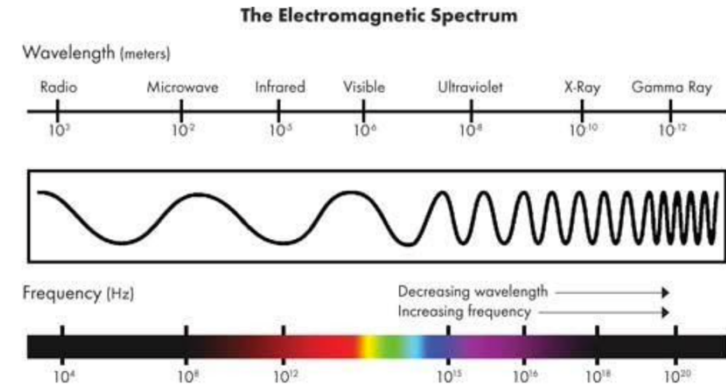
- All waves can be refracted, which is when the **speed** of a wave **changes** when it enters a new medium
- If the wave enters a **denser** medium, its speed **decreases** and it bends **towards** the normal
- If the wave enters a **less dense** medium, its speed **increases** and it bends **away from** the normal



- In all cases, the **frequency** stays the **same** but the **wavelength changes**. As a result, the velocity must change.

Electromagnetic spectrum

You need to learn the **main groups** of the electromagnetic spectrum in order of **decreasing wavelength** and **increasing frequency** including the **colours** of the visible spectrum (ROYGBIV).



All electromagnetic waves travel with the **same high speed** in a vacuum and **approximately the same** speed in air.

Uses of electromagnetic waves:

- **Radio waves** are used for **radio and television communications**. They have a long wavelength and are reflected by a layer of the atmosphere called the **ionosphere**.
- **Microwaves** are used for **satellite transmissions** and in **cooking**. As they have a greater frequency (shorter wavelength) they are more penetrating so can pass through the ionosphere and penetrate deep into food.
- **Infrared radiation** is used in **heaters** and **night vision equipment**.
- **Visible light** is used in **fibre optics** and **photography**.
- **Ultraviolet** light is used in **fluorescent lamps**.
- **X-rays** are used in **medical imaging** and in **security** as (because they have a very short wavelength and high frequency) they can penetrate material easily.
- **Gamma radiation** is used in **sterilising food and medical equipment** due to its high energy.

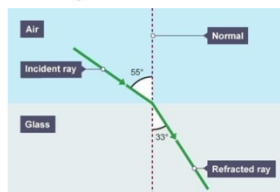
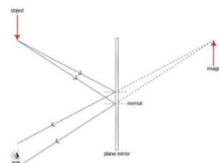
Hazards:

- Microwaves can cause **internal heating** of body tissues.
- Infrared radiation can cause **skin burns**.
- Ultraviolet light exposure increases the risk of **skin cancer** and **blindness**.
 - **Sun cream** and **sun glasses** prevent over-exposure in summer.
- X-rays and Gamma rays are **ionising** radiation that can cause **mutations** leading to **cancer**.
 - **Exposure** to these kinds of radiation should be **minimised** (for example, by using protective shielding made of very dense materials such as lead).

Light and sound

Light waves are **transverse** waves and can be **reflected** and **refracted**.

- **Reflection** of light can be shown when light reflects at a plane mirror and forms an image.
 - This can be represented by a **ray diagram** like the first one shown on the right.
- **Refraction** of light can be shown when light is passed through a glass slab at an angle to its normal.
 - When light enters a more optically dense medium, the **angle of incidence** (the angle between the incident ray and the normal) is **greater** than the **angle of refraction** (the angle between the refracted ray and the normal). This can be represented by a ray diagram like the second one shown on the right.
 - The **opposite** is true when light enters a less optically dense medium.

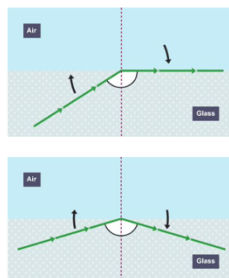


Snell's law relates the angle of incidence and the angle of refraction to the refractive index of a medium by $n_1 \sin i = n_2 \sin r$ where n is the optical density & i is the angle of incidence and r is the angle of refraction.

Total internal reflection:

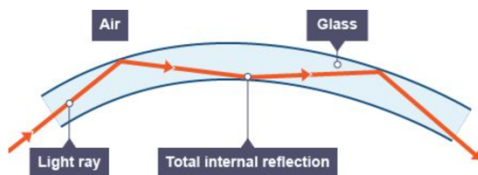
- At a certain angle of incidence called the **critical angle**, the light will travel along the boundary between the two media.
- **Total internal reflection** occurs when the angle of incidence is **greater** than the critical angle and the light **reflects** back into the medium.
- For total internal reflection to occur, the light must also be travelling from a **more optically dense medium** into a **less optically dense medium** (most common example is glass to air).
- The critical angle c can be related to the refractive index by:

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



Optical fibres:

- An **optical fibre** is a long thin rod of **glass** surrounded by cladding which uses total internal reflection to transfer information by light, even when bent.



- They are used extensively in **medicine** (endoscopes, inside-body flexible cameras) and **communications** (high speed data transfer).

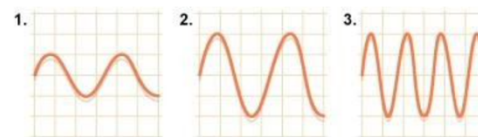
Sound waves are **longitudinal** waves and can be **reflected** and **refracted**.

The range of audible frequencies for a healthy human ear is 20 Hz to 20000 Hz.

To measure the **speed of sound** in air, you can make a noise at a known, large **distance** from a solid wall and record the **time** for the **echo** (reflected sound) to be heard, then use $\text{speed} = \text{distance}/\text{time}$, where distance is 2 x length - taking into account the fact that the sound had to go there and back.

An **oscilloscope** connected to a **microphone** can be used to display a sound wave and find its frequency and amplitude.

- The **greater the amplitude** of a sound wave, the **louder** it is.
- The **greater the frequency** of a sound wave, the **higher its pitch**.

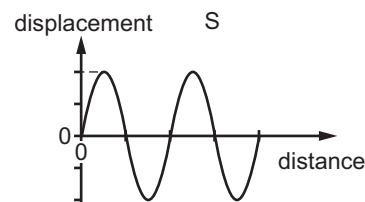
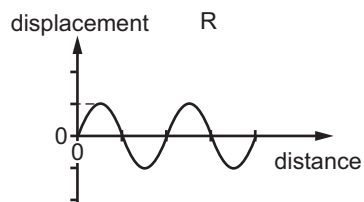
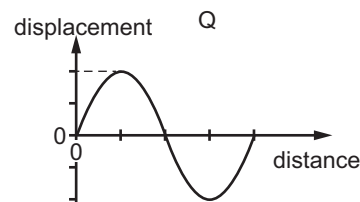
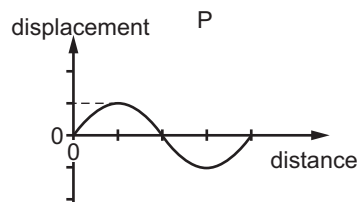


- The first sound wave shown is **quiet** and **low pitched**.
- The second sound wave shown is **loud** and **low pitched**.
- The third sound wave shown is **loud** and **high pitched**.

Source: physicsandmathstutor.com

Waves - basic and reflection, refraction and diffraction MCQ

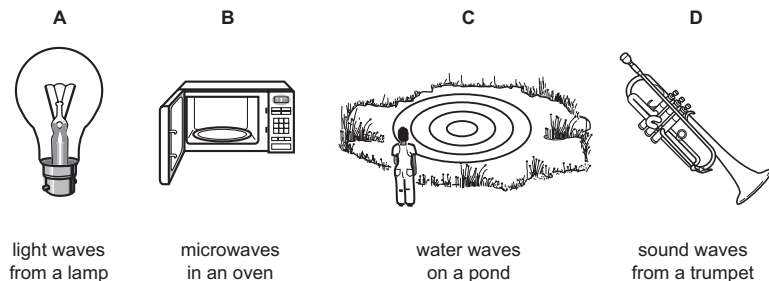
1 The diagram shows four waves drawn to the same scale.



Which statement is correct?

- A The amplitude of wave P is the same as the amplitude of wave R.
- B The amplitude of wave S is double the amplitude of wave Q.
- C The wavelength of wave Q is double the wavelength of wave P.
- D The wavelength of wave S is the same as the wavelength of wave Q.

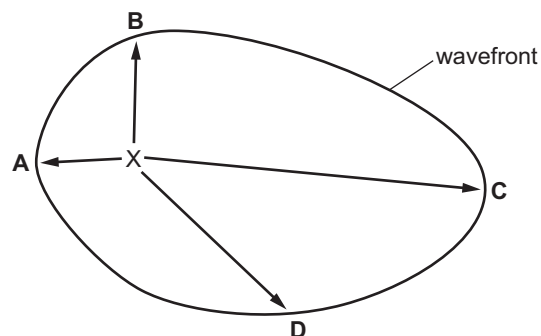
2 Which waves are longitudinal?



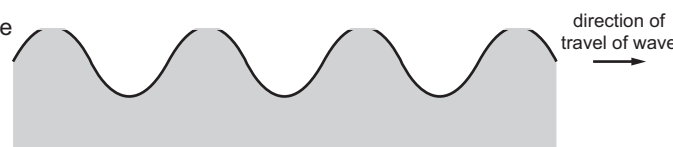
3 Waves travel more quickly on the surface of water when the water is deep.

A stone is dropped at point X into a pool of varying depth. The diagram shows the first wavefront on the surface of the pool.

The region between X and which labelled point is likely to be the deepest?



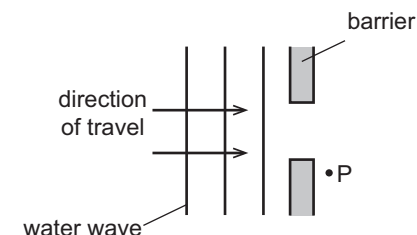
4 The diagram shows a side view of a water wave at a particular time. The diagram is drawn full size.



Which statement about the wave is correct?

- A The wave is longitudinal and the frequency can be measured from the diagram.
- B The wave is longitudinal and the wavelength can be measured from the diagram.
- C The wave is transverse and the frequency can be measured from the diagram.
- D The wave is transverse and the wavelength can be measured from the diagram.

5 The diagram shows a water wave approaching a barrier with a gap.

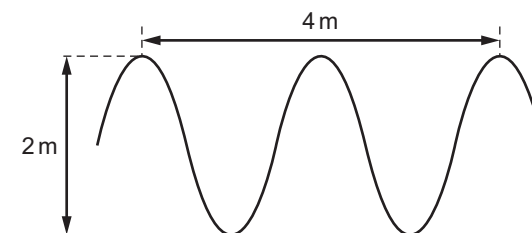


The wave reaches point P.

What is the name of the effect that causes the wave to reach point P?

- A diffraction
- B dispersion
- C reflection
- D refraction

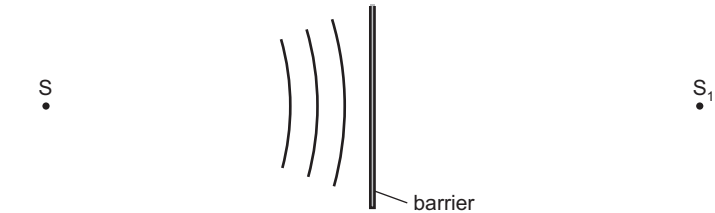
6 The diagram represents a water wave.



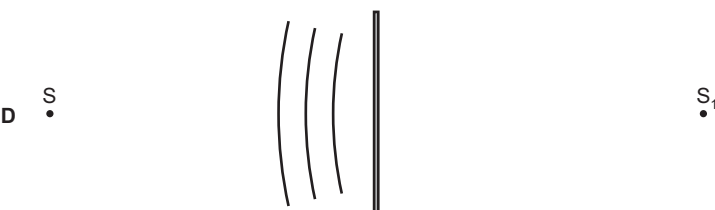
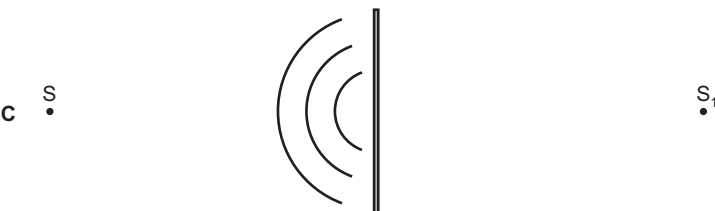
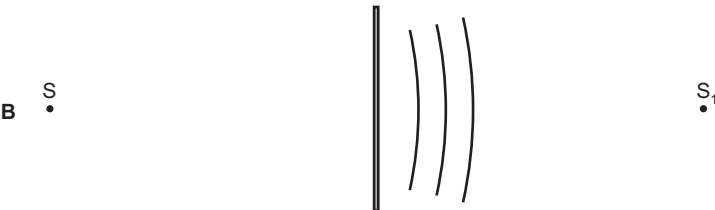
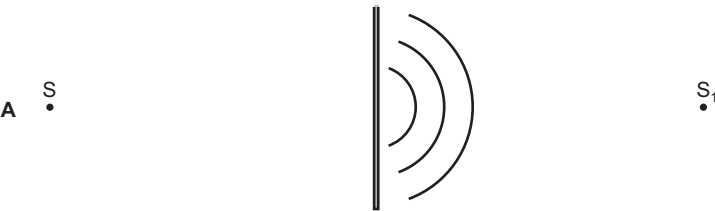
Which row shows the amplitude and the wavelength of the wave?

	amplitude / m	wavelength / m
A	1	2
B	1	4
C	2	2
D	2	4

7 The diagram represents circular wavefronts coming from point S. The wavefronts strike a barrier and are reflected so that they appear to come from point S₁



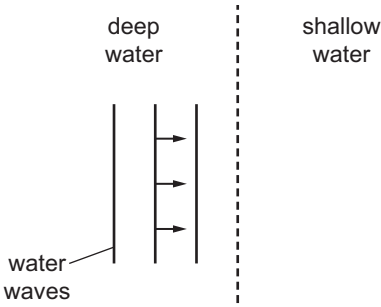
Which diagram shows the reflected wavefronts?



8 Which row correctly defines a type of wave and gives a correct example?

	wave type	direction of vibrations	example
A	longitudinal	parallel to direction of wave travel	radio waves
B	longitudinal	perpendicular to direction of wave travel	light waves
C	transverse	parallel to direction of wave travel	light waves
D	transverse	perpendicular to direction of wave travel	radio waves

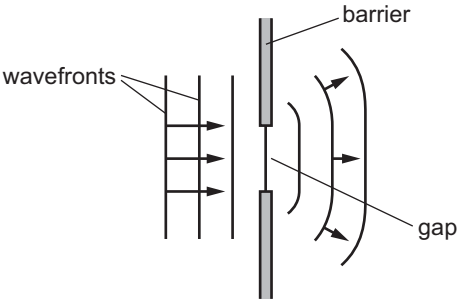
9 A water wave moves quickly in deep water.



The wave now enters shallow water and its speed decreases. Which row shows what happens to the frequency of the wave, and what happens to the wavelength of the wave?

	frequency	wavelength
A	decreases	decreases
B	decreases	does not change
C	does not change	decreases
D	does not change	does not change

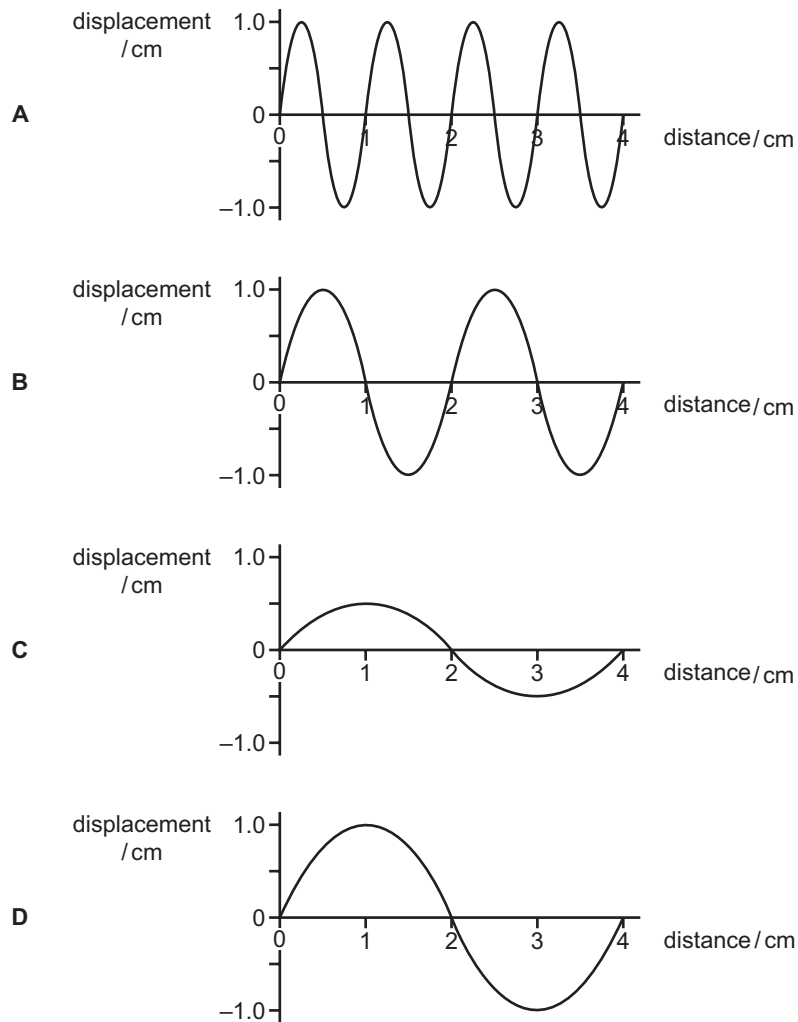
10 The diagram represents plane wavefronts being diffracted by passing through a gap in a barrier.



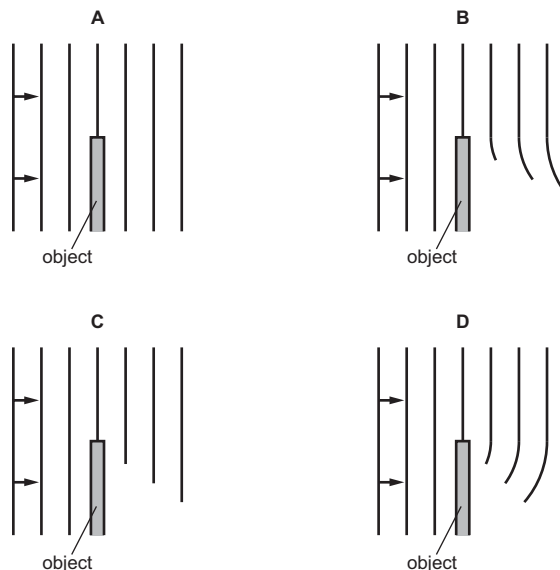
Which pair of changes **must** increase the amount of diffraction that occurs?

- A decrease the wavelength and decrease the size of the gap
- B decrease the wavelength and increase the size of the gap
- C increase the wavelength and decrease the size of the gap
- D increase the wavelength and increase the size of the gap

11 Which wave has an amplitude equal to half its wavelength?



12 Which diagram shows what happens when plane waves pass the edge of the object shown?



13 Sound waves of frequency 2.0 kHz travel through a substance at a speed of 800 m/s . What is the wavelength of the waves?

- A** 0.40 m **B** 2.5 m
C 400 m **D** 1600 m

14 The frequency of a wave is doubled. The speed of the wave does not change. What happens to the wavelength of the wave?

- A** It becomes four times as large.
B It does not change.
C It doubles.
D It halves.

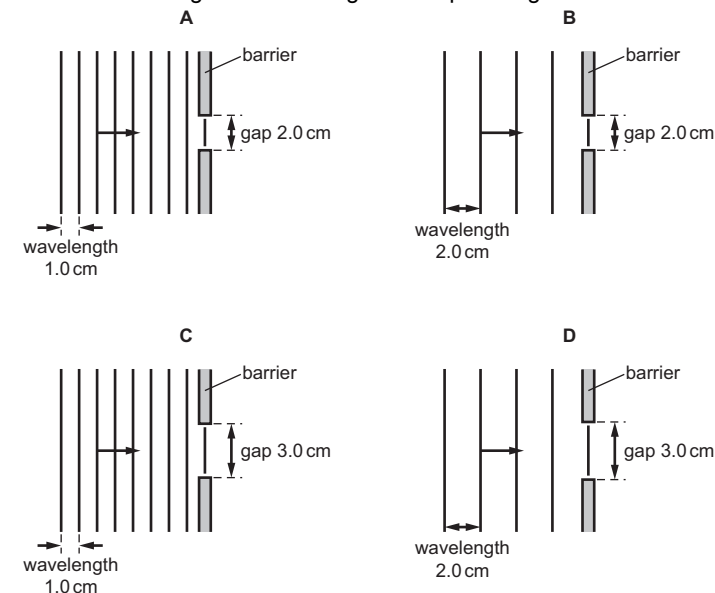
15 A water wave passes into a region where the wave travels more slowly. As it passes into the slow region, what happens to the frequency and what happens to the wavelength of the wave?

	frequency	wavelength
A	decreases	remains the same
B	increases	remains the same
C	remains the same	decreases
D	remains the same	increases

16 Different waves hit barriers with different sized gaps.

The waves will diffract.

In which diagram does the greatest spreading occur?



17 Which row shows an example of a transverse wave and an example of a longitudinal wave?

	transverse	longitudinal
A	light	radio
B	radio	sound
C	sound	water
D	water	light

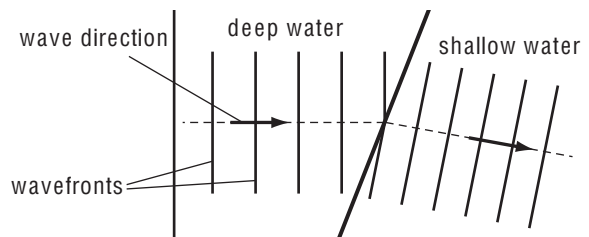
- 18 A boy throws a small stone into a pond. Waves spread out from where the stone hits the water and travel to the side of the pond.

The boy notices that eight waves reach the side of the pond in a time of 5.0 s.

What is the frequency of the waves?

- A 0.20 Hz B 0.63 Hz
C 1.6 Hz D 40 Hz

- 19 Water waves may be used to demonstrate refraction by making them pass into water of a different depth.



Why does the water change direction as it passes into the shallow water?

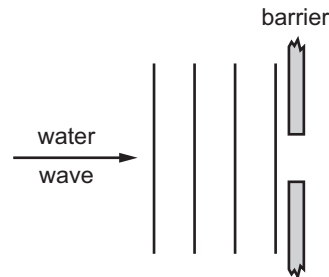
- A The frequency of the wave decreases.
B The frequency of the wave increases.
C The speed of the wave decreases.
D The speed of the wave increases.

- 20 A person uses a surfboard to ride every 30th wave crest towards the beach. The wave crest travels at a speed of 1.6 m/s and the distance between each wave crest is 24 m.

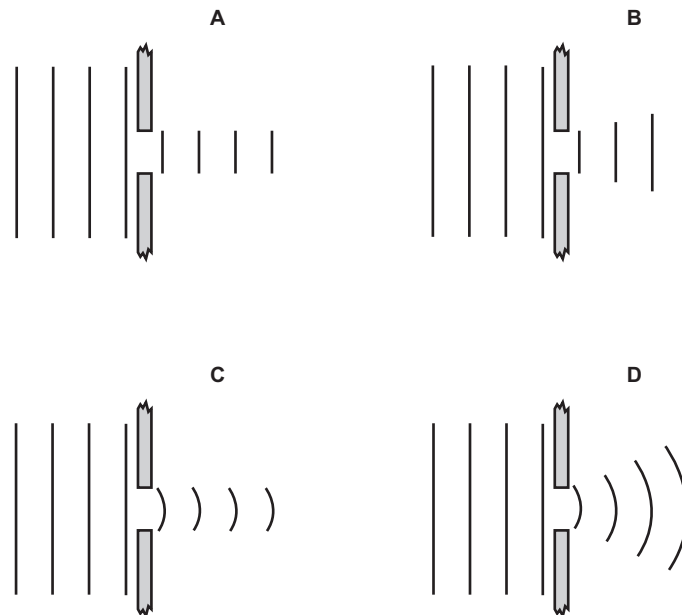
How many wave crests does the person surf in one hour?

- A 1 B 2
C 8 D 450

- 21 In a shallow tank, a water wave moves towards a barrier with a narrow gap



Which diagram shows the wave beyond the barrier?

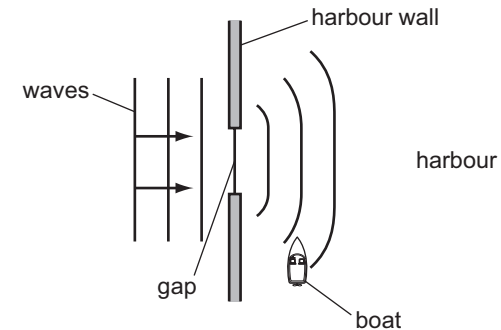


- 22 A wave passes through a gap and diffraction causes the wave to spread out.

Which wave spreads out the most?

- A large wavelength through a gap slightly larger than the wavelength
B large wavelength through a gap much smaller than the wavelength
C small wavelength through a gap much larger than the wavelength
D small wavelength through a gap much smaller than the wavelength

- 23 The diagram shows water waves passing through a gap in a harbour wall. The waves curve round the wall and reach a small boat in the harbour.



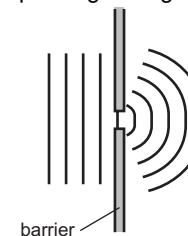
What is the name of this curving effect, and how can the gap be changed so that the waves are less likely to reach the boat?

	name of effect	change to the gap
A	diffraction	make the gap slightly bigger
B	diffraction	make the gap slightly smaller
C	refraction	make the gap slightly bigger
D	refraction	make the gap slightly smaller

- 24 Which row shows the nature of light waves, sound waves and X-rays?

	light waves	sound waves	X-rays
A	longitudinal	longitudinal	transverse
B	longitudinal	transverse	longitudinal
C	transverse	longitudinal	transverse
D	transverse	transverse	longitudinal

- 25 The diagram shows plane water waves passing through a narrow gap in a barrier.



The waves spread out on the far side of the barrier. Which property of waves does this illustrate?

- A diffraction B reflection C refraction D vibration

Waves - basics and reflection, refraction and diffraction

1 (a) Fig. 1.1 represents the waveform of a sound wave. The wave is travelling at constant speed.

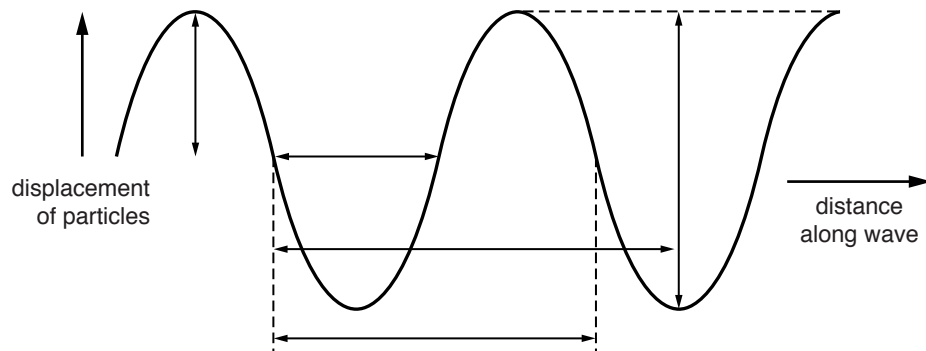


Fig. 1.1

(i) On Fig. 1.1,

1. label with the letter X the marked distance corresponding to the amplitude of the wave, [1]
2. label with the letter Y the marked distance corresponding to the wavelength of the wave. [1]

(ii) State what happens to the amplitude and the wavelength of the wave if

1. the loudness of the sound is increased at constant pitch,

amplitude

wavelength [1]

2. the pitch of the sound is increased at constant loudness.

amplitude

wavelength [1]

(b) A ship uses pulses of sound to measure the depth of the sea beneath the ship. A sound pulse is transmitted into the sea and the echo from the sea-bed is received after 54 ms. The speed of sound in seawater is 1500 m/s. Calculate the depth of the sea beneath the ship.

depth =[3]

- 2 A water wave in a tank travels from a region where the speed of the wave is faster into a region where it is slower.

Fig. 2.1 is a one-quarter scale diagram that shows the wavefronts in the region where the speed is faster.

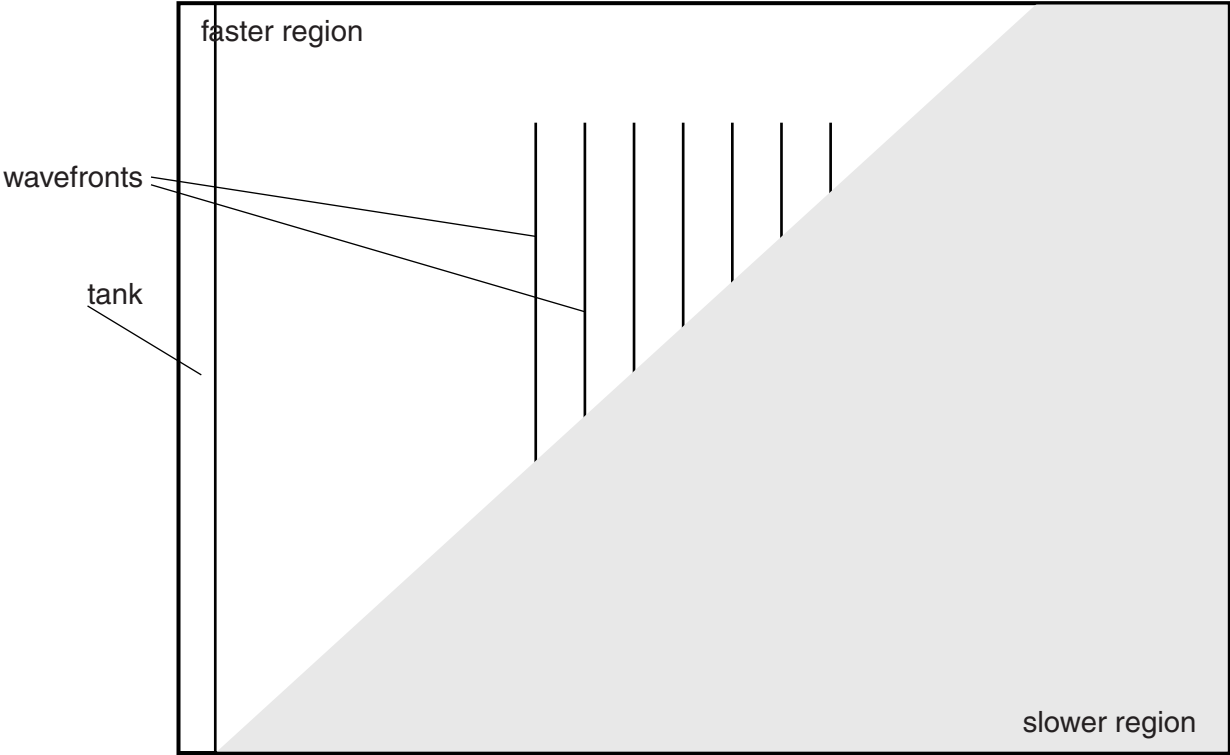


Fig. 2.1 (scale: 1.0 cm represents 4.0 cm)

- (a) (i) Take measurements from the scale diagram in Fig. 2.1 to determine the wavelength of the water wave as it travels in the faster region.

wavelength = [2]

- (ii) The speed of the wave in the faster region is 0.39 m/s.
Calculate the frequency of the wave.

frequency = [2]

- (b) On Fig. 2.1, draw lines that indicate the positions of the wavefronts of the water wave in the slower region. [2]

- (c) State what happens to the frequency of the water wave as it passes into the slower region.
.....
..... [1]

[Total: 7]

- 3 (a) The graph in Fig. 3.1 represents a wave on a rope.

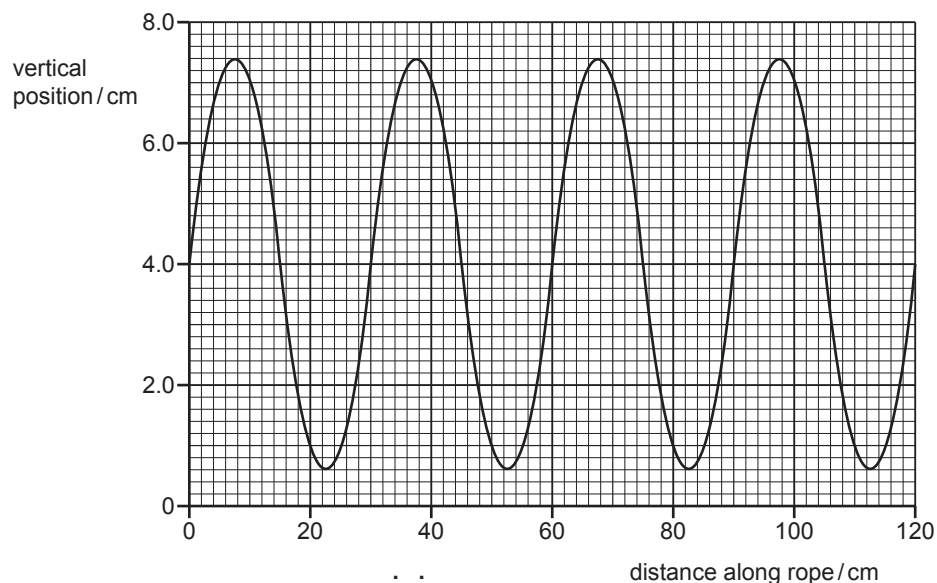


Fig 3 1

Using Fig. 3.1, determine

- (i) the amplitude of the wave,

amplitude =[1]

- (ii) the wavelength of the wave.

wavelength =[1]

- (b) A wave travelling on the surface of water has a wavelength of 2.5 cm and a speed of 8.0 cm/s.

Calculate the frequency of the wave.

frequency =[2]

- (c) The wave in (b) approaches a barrier that has a large gap in its centre.

Fig. 3.2 shows the crests of the wave viewed from above.

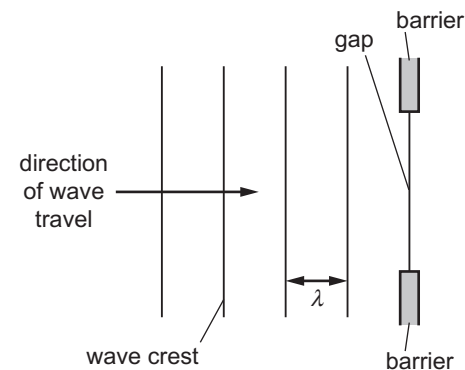


Fig. 3.2

The gap in the barrier is larger than the wavelength λ .

- (i) On Fig. 3.2, draw the pattern formed by three crests after the wave passes through the gap in the barrier. [2]

- (ii) Water is added to the tank and the speed of a wave in the deeper water is greater than that in the shallower water. The frequency of the wave remains constant but its wavelength is different.

1. State and explain how the wavelength in the deeper water has changed.

.....
[1]

2. Apart from the change in wavelength, describe **one** other difference in the pattern formed by the crests after the wave passes through the gap.

.....
[1]

4 Fig. 4.1 shows a view from above of waves on the surface of water in a water tank.

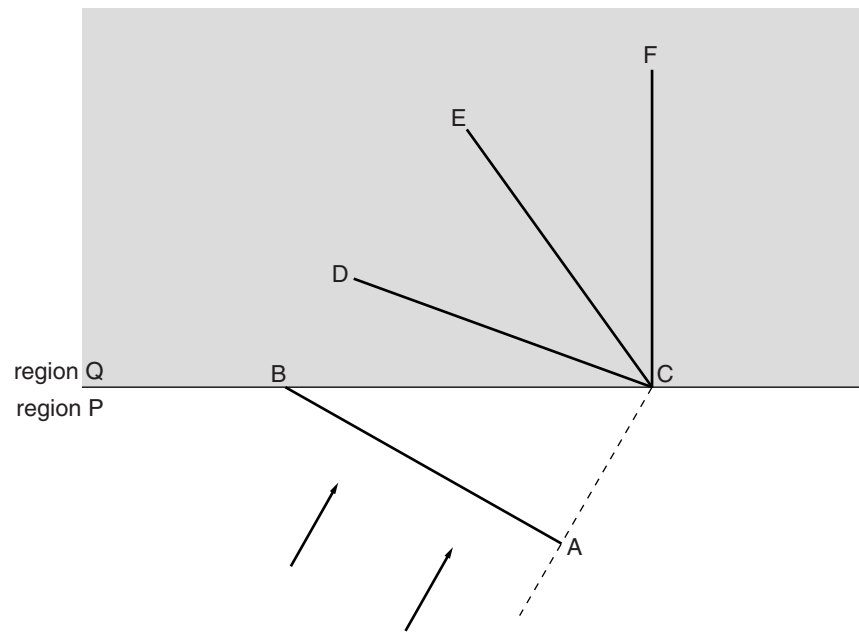


Fig. 4.1

The wavefront AB is travelling in region P towards region Q, where the water is shallower and the waves travel more slowly.

(a) Some time later, the wavefront has moved into region Q.

CD, CE and CF are suggested positions of the new wavefront.

(i) State which is the correct position of the new wavefront.

.....

(ii) Explain your answer to (i).

.....

[4]

(b) Fig. 4.2 shows the waves after a change is made to the way the tank is set up, and the experiment is repeated.

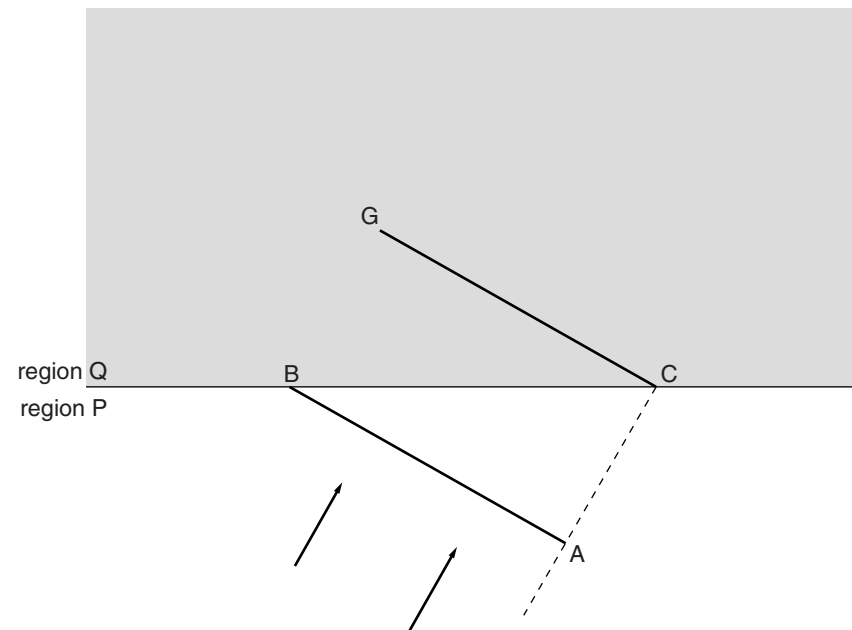


Fig. 4.2

The wave from position AB in region P now moves to position CG in region Q.

State the change that has been made and explain your reasoning.

change

explanation

.....

..... [2]

[Total: 6]

- 5 (a) Fig. 5.1 shows an aerial view of wavefronts passing from the open sea into an outer harbour.

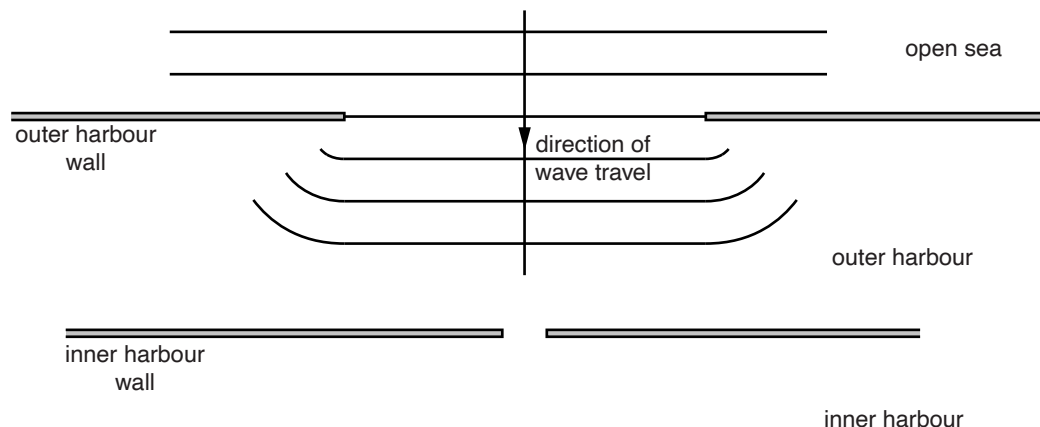


Fig. 5.1

- (i) The wavefronts in the outer harbour are curving at their ends.
Name the process that is occurring at the entrance to the harbour.
..... [1]
- (ii) On Fig. 5.1, carefully complete the wave pattern as the wavefronts progress through the outer harbour and into the inner harbour. Show the rest of the wave pattern in the outer harbour and three wavefronts in the inner harbour. [3]

- (b) Fig. 5.2 shows an aerial view of wavefronts in deep water approaching a region of shallow water where they travel more slowly.

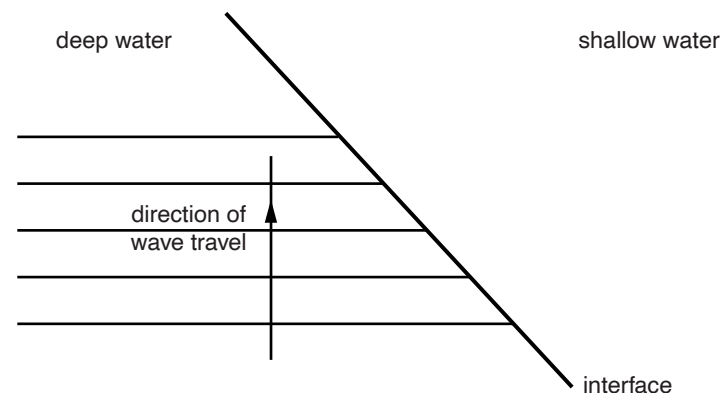


Fig. 5.2

- (i) Name the process that occurs as the wavefronts pass from deep to shallow water.
..... [1]
- (ii) Complete Fig. 5.2 to show possible positions of the five wavefronts in the shallow water. [2]

[Total: 7]

- 6 (a) Fig. 6.1 shows wavefronts approaching a gap in a barrier.

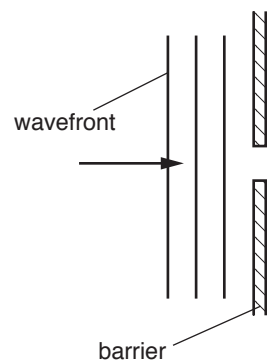


Fig. 6.1

- (i) On Fig. 6.1, draw **three** wavefronts to the right of the barrier.

[2]

- (ii) Fig. 6.2 shows the gap in the barrier increased to five times the gap in Fig. 6.1.

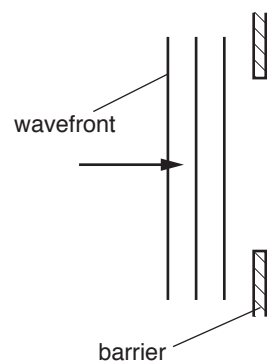


Fig. 6.2

On Fig. 6.2, draw **three** wavefronts to the right of the barrier.

[2]

- (b) Describe, with a labelled diagram, an experiment using water waves that shows the reflection of wavefronts that occur at a straight barrier.

.....

.....

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.....

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.....

.....

[4]

[Total: 8]

7 (a) A wave passes along the surface of the water in a ripple tank. Describe the motion of a molecule on the surface as the wave passes.

.....
 [1]

(b) Fig. 7.1 shows a view from above of water waves approaching a narrow gap in a barrier. The water on both sides of the barrier has the same depth.

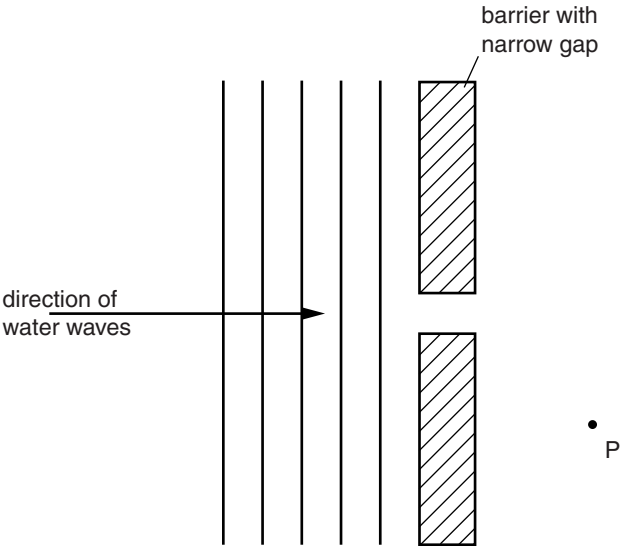


Fig. 7.1

- (i) On Fig. 7.1, sketch the pattern of waves in the region to the right of the barrier. [2]
- (ii) State the process by which waves arrive at point P to the right of the barrier.

..... [1]

(c) The waves approaching the barrier in Fig. 7.1 have a wavelength of 1.4 cm and travel at a speed of 12 cm/s.

Calculate the frequency of the waves.

frequency = [2]

8 (a) (i) A long rope, fixed at one end, is being used by a student to demonstrate transverse waves.

State what the student does to the rope to produce the transverse wave.

.....
 [1]

(ii) Fig. 8.1 shows a section of the rope when the transverse wave is present.

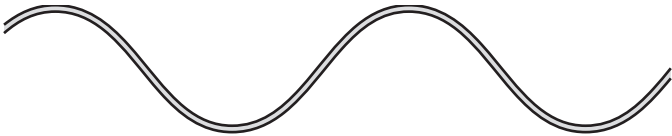


Fig. 8.1

On Fig. 8.1, show

- 1. a distance, labelled λ , corresponding to the wavelength of the wave,
- 2. a distance, labelled A, corresponding to the amplitude of the wave. [2]

Suggest what the student could do to reduce the wavelength of the wave.

(iii)
 [1]

(b) The diagram in Fig. 8.2 represents waves on the surface of water in a ripple tank. The waves are travelling from deep water across a boundary into shallow water.

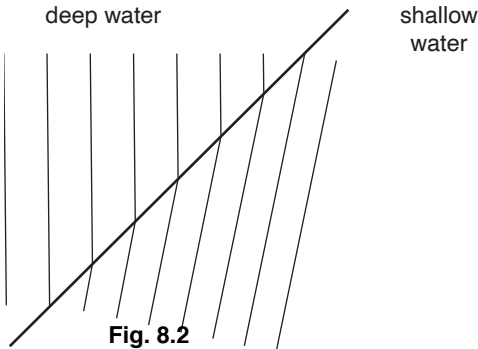


Fig. 8.2

Explain how the diagram shows that water waves travel more slowly in shallow water than in deep water.

.....

..... [3]
 [Total: 7]

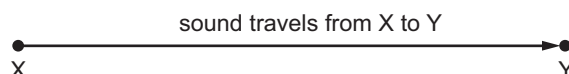
Sound waves MCQ

- 1 A fire alarm is not loud enough and the pitch is too low. An engineer adjusts the alarm so that it produces a louder note of a higher pitch.

What effect does this have on the amplitude and on the frequency of the sound waves that the alarm produces?

	amplitude	frequency
A	larger	larger
B	larger	smaller
C	smaller	larger
D	smaller	smaller

- 2 In an experiment to measure the speed of sound, a student uses a stopwatch to find the time taken for a sound wave to travel from X to Y. She does this six times.



The table shows her results.

measurement	time / s
first	0.5
second	0.7
third	0.6
fourth	0.4
fifth	0.9
sixth	0.5

Which value for the time should be used to calculate the speed of sound?

- A 0.4 s B 0.5 s C 0.6 s D 0.9 s

- 3 Three vibrating objects P, Q and R produce waves in the air of different frequencies as shown.

object	frequency / Hz
P	25
Q	1000
R	15 000

Which of these waves can be heard by a human ear?

- A P, Q and R
B P and Q only
C P and R only
D Q and R only

- 4 Which row states whether light waves and whether sound waves can travel in a vacuum?

	sound waves	light waves
A	no	no
B	no	yes
C	yes	no
D	yes	yes

- 5 Sounds are produced by vibrating objects. A certain object vibrates but a person nearby cannot hear any sound.

Which statement could explain why nothing is heard?

- A The amplitude of the sound waves is too large.
B The frequency of the vibration is too high.
C The sound waves are transverse.
D The speed of the sound waves is too high.

- 6 Two sounds X and Y are produced by loudspeakers.

The amplitude and frequency of each sound wave is given in the table.

	amplitude / mm	frequency / Hz
X	1.3	475
Y	2.0	235

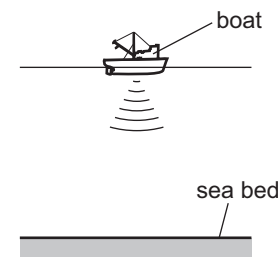
How does sound Y compare with sound X?

- A Y is louder and has a higher pitch.
B Y is louder and has a lower pitch.
C Y is quieter and has a higher pitch.
D Y is quieter and has a lower pitch.

- 7 A pulse of sound is produced at the bottom of a boat. The sound travels through the water and is reflected from the sea bed.

The sound reaches the boat again after 1.2 s.

The speed of sound in the water is 1500 m/s.



How far below the bottom of the boat is the sea bed?

- A 450 m B 900 m C 1800 m D 3600 m

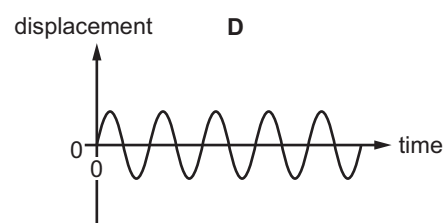
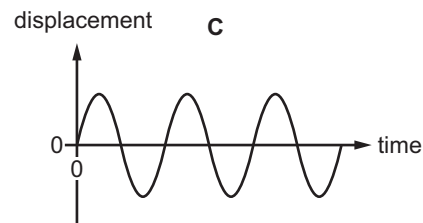
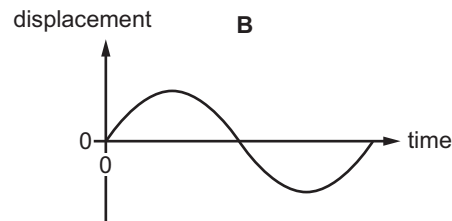
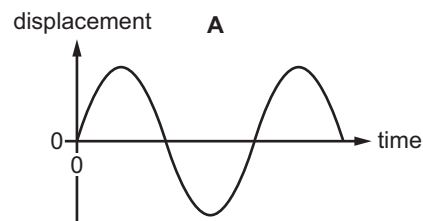
- 8 A girl notices that, when she shouts into a cave, she hears an echo.

Which wave property causes the echo?

- A diffraction
B dispersion
C reflection
D refraction

- 9 The diagrams represent the displacement in four different sound waves. All the diagrams are drawn to the same scale.

Which diagram represents the sound with the highest pitch?



- 10 Which property of a sound wave affects the loudness of the sound?

- A amplitude
- B frequency
- C speed
- D wavelength

- 11 A man is talking at the side of a house. He can be heard by a woman at the front of the house even though she cannot see him.



What is the explanation for this?

- A Sound waves are longitudinal and light waves are transverse.
- B Sound waves are transverse and light waves are longitudinal.
- C The sound waves have a long wavelength and the light waves have short wavelength.
- D The sound waves have a short wavelength and the light waves have long wavelength.

- 12 A man stands 110 m from a high wall. He makes a short, sharp sound and then hears an echo from the wall. The speed of sound in air is 330 m/s.

How long after making the sound does the man hear the echo?

- A 0.33 s
- B 0.67 s
- C 1.5 s
- D 3.0 s

- 13 A sound wave travels through air as a series of compressions and rarefactions.

Which row correctly compares the air pressure in a compression and the air pressure in a rarefaction to the air pressure nearby where there is no sound wave?

	air pressure in a compression	air pressure in a rarefaction
A	higher	higher
B	higher	lower
C	lower	higher
D	lower	lower

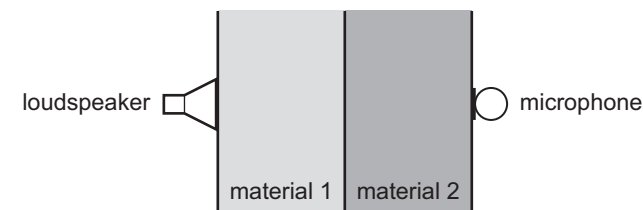
- 14 A sound wave has a certain amplitude and a certain frequency.

A second sound wave is quieter and lower in pitch than the first sound wave.

The second wave has

- A a larger amplitude and a greater frequency.
- B a larger amplitude and a smaller frequency.
- C a smaller amplitude and a greater frequency.
- D a smaller amplitude and a smaller frequency

- 15 The sound from a loudspeaker must pass through two materials to reach a microphone.



Which combination of materials gives the shortest time for the sound to reach the microphone?

	material 1	material 2
A	air	hydrogen
B	air	water
C	copper	aluminium
D	water	oil

- 16 Which range of wave frequencies includes only sounds that can be heard by a human with normal hearing?

- A 3.0 Hz to 300 Hz
- B 30 Hz to 3000 Hz
- C 300 Hz to 30 000 Hz
- D 3000 Hz to 300 000 Hz

- 17 A fire alarm is not loud enough and the pitch is too low.

An engineer adjusts the alarm so that it produces a louder note of a higher pitch.

What effect does this have on the amplitude and on the frequency of the sound?

	amplitude	frequency
A	larger	greater
B	larger	smaller
C	smaller	greater
D	smaller	smaller

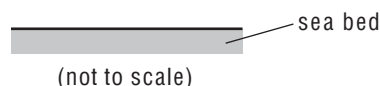
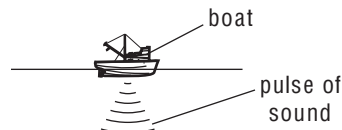
- 18 When the volcano Krakatoa erupted in 1883, it was heard 5000 km away.

Which statement about the sound from the volcano is **not** correct?

- A If such a loud sound were to be made today, an astronaut orbiting in space (a vacuum) at a height of 400 km could hear it.
- B People further from the volcano heard the sound later than people nearer to the volcano.
- C The amplitude of the sound waves would have been smaller further from the volcano.
- D The sound was very loud because a lot of energy was transferred to vibrations of the air.

- 19 A loudspeaker on a boat produces a pulse of sound in the sea.

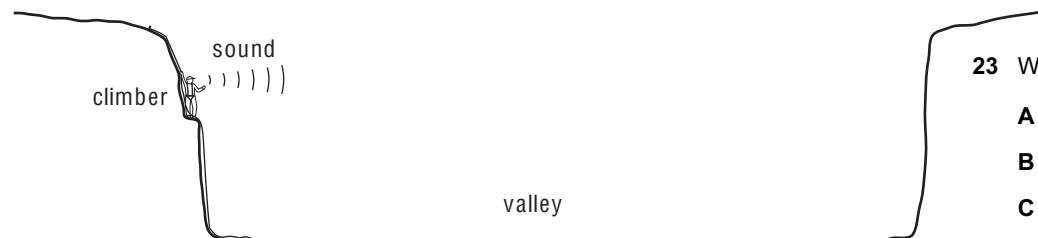
The echo of the pulse is received back at the boat after 3.0 s.
The depth of the sea under the boat is 2250 m.



From this information, what is the speed of sound in the sea water?

- A 330 m/s B 750 m/s
- C 1500 m/s D 6750 m/s

- 20 To estimate the width of a valley, a climber starts a stopwatch as he shouts. He hears an echo from the opposite side of the valley after 1.0 s.



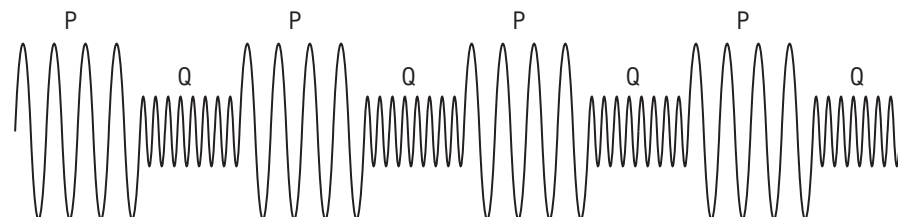
The sound travels at 330 m/s.

What is the width of the valley?

- A 82.5 m B 165 m C 330 m D 660 m

- 21 A police car sounds its siren when travelling to an emergency. The siren produces two different sounds P and Q, which are emitted alternately.

The diagram represents the sound waves emitted by the siren.



Which of the two sounds P and Q is the louder and which has the higher pitch?

	louder sound	sound of higher pitch
A	P	P
B	P	Q
C	Q	P
D	Q	Q

- 22 Which statement about sound waves is correct?

- A They are able to travel through a vacuum.
- B They are able to travel through solids.
- C They are transverse waves.
- D They travel at the same speed in all substances.

- 23 Which statement about ultrasound is correct?

- A It is produced by a rapidly vibrating source.
- B It is uncomfortable to human ears.
- C Its frequency must be greater than 300 kHz.
- D It travels the fastest in a vacuum.

- 24 Both the amplitude and the frequency of a sound wave decrease.
What happens to the sound heard?

- A The sound is louder and has a higher pitch.
- B The sound is louder and has a lower pitch.
- C The sound is quieter and has a higher pitch.
- D The sound is quieter and has a lower pitch.

- 25 A sound wave is travelling through water.

What is a possible speed for the wave?

- A 150 m/s B 300 m/s
- C 1500 m/s D 5000 m/s

Sound waves

- 1 Two students A and B are carrying out an experiment to determine the speed of sound.

They are standing side by side at a distance of 480 m from the school wall, as shown in Fig. 1.1.

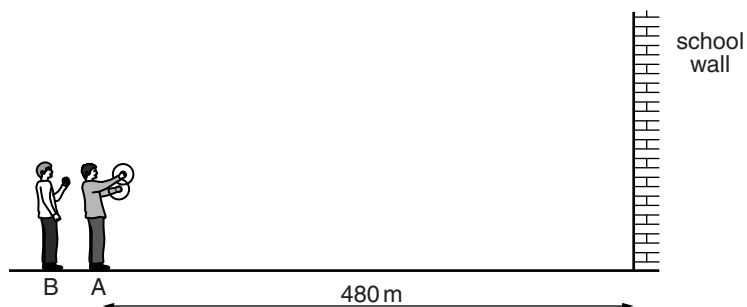


Fig. 1.1 (not to scale)

Student A makes a loud sound by banging two pan lids together once. A short time later, both students hear the sound again.

- (a) State what causes this second sound.

.....[1]

- (b) Underline the phrases that correctly complete the sentences below.

The second sound is $\left\{ \begin{array}{l} \text{louder than} \\ \text{equally as loud as} \\ \text{quieter than} \end{array} \right\}$ the original sound.

This is because the $\left\{ \begin{array}{l} \text{amplitude} \\ \text{frequency} \\ \text{speed} \\ \text{wavelength} \end{array} \right\}$ of the sound has $\left\{ \begin{array}{l} \text{changed.} \\ \text{not changed.} \end{array} \right\}$

[2]

- (c) The time between the two sounds, as measured by student B, is 3.0 s.

- (i) Suggest the instrument that student B used to measure the time.

.....[1]

- (ii) Use the measurements to calculate the speed of sound.

speed = m/s [3]

[Total: 7]

- 3 (a) A sound wave in air consists of alternate compressions and rarefactions along its path.
(i) Explain how a compression differs from a rarefaction.

Fig. 2.1

7

The two traces that have the same amplitude are and [1]

Describe an experiment that they can carry out to determine the speed of sound in air.

..... [5]

[Total: 7]

- 3 (a) A sound wave in air consists of alternate compressions and rarefactions along its path.
(i) Explain how a compression differs from a rarefaction.

1. the wavelength of the sound,

2. the frequency of the sound.

- (b)** At night, bats emit pulses of sound to detect obstacles and prey. The speed of sound in air is 340 m/s .

- (i) A bat emits a pulse of sound of wavelength 0.0085 m.

Calculate the frequency of the sound.

frequency =[2]

- (ii) State why this sound cannot be heard by human beings.

- (iii) The pulse of sound hits a stationary object and is reflected back to the bat. The pulse is received by the bat 0.12 s after it was emitted.

Calculate the distance travelled by the pulse of sound during this time.

distance =[2]

[Total: 8]

- 4 (a) Two students are measuring the speed of sound.

The students are provided with a starting pistol, a stopwatch and a long measuring tape. The starting pistol, when fired, produces a loud sound and a puff of smoke at the same instant.

Describe how the students use the apparatus and how they calculate the speed. You may draw a diagram.

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[4]

- (b) A device at the bottom of the sea emits a sound wave of frequency 200 Hz.

- (i) The speed of sound in sea-water is 1500 m/s.

Calculate the wavelength of the sound in sea-water.

wavelength = [2]

- (ii) The sound wave passes from the sea-water into the air.

State what happens, if anything, to

- the frequency of the sound,
- the speed of the sound.

[2]

[Total: 8]

5 (a) Radio waves, ultrasound and visible light are all waves.

(i) State what is meant by *ultrasound* and suggest a value for the minimum possible frequency of ultrasound waves.

.....
.....
.....

[2]

(ii) State which of these waves are

- electromagnetic,
.....
- longitudinal.
.....

(b) Ultrasound passes through both human flesh and bone.

Fig. 5.1 shows an ultrasound source sending an ultrasound wave into human flesh.

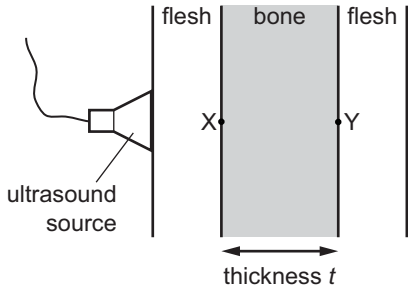


Fig. 5.1

The ultrasound wave travels through the flesh to point X and then through the thickness of the bone to point Y. At Y, some ultrasound is reflected and returns to X.

[2] The total time taken for ultrasound to travel in the bone from X to Y and back to X is 9.0×10^{-6} s. The speed of ultrasound in bone is 4100 m/s.

Calculate the thickness t of the bone.

thickness t = [3]

[Total: 7]

- 6 (a) Fig. 6.1 shows a metal strip, held in a clamp.

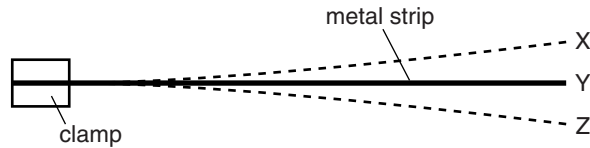


Fig. 6.1

The end of the strip is pulled down and released, so that the strip vibrates. X and Z are the extreme positions of the end of the strip during this vibration. Y is the mid-position.

Explain what is meant by

- (i) the *frequency* of vibration of the strip,

.....

- (ii) the *amplitude* of vibration of the end of the strip.

.....

[2]

- (b) Fig. 6.2 shows two tall buildings, A and B, that are 99 m apart

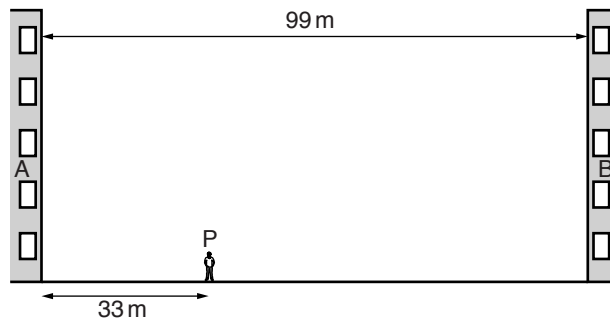


Fig. 6.2 (not to scale)

A student stands at P so that his distance from building A is 33 m. After clapping his hands once, he hears several echoes. The speed of sound in air is 330 m/s.

Calculate the time interval between clapping his hands and hearing

- (i) the first echo,

time =[2]

- (ii) the **third** echo.

time =[1]

- (c) Write down an approximate value for the speed of sound

- (i) in water,

speed =

- (ii) in steel.

speed =

[2]

- (d) Fig. 6.3 shows a dolphin in water emitting a sound wave of frequency 95 kHz



Fig. 6.3 (not to scale)

Using your value from (c)(i), calculate the wavelength of this sound wave.

wavelength =[2]

[Total: 9]

7 A sound wave, travelling in air, approaches a solid barrier with a gap in the middle. Fig. 7.1 represents the compressions and rarefactions of the sound wave. The compressions are labelled A, B and C.

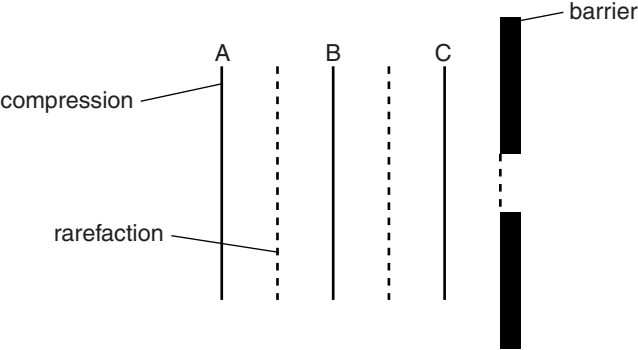


Fig. 7.1

(a) State how a *compression* differs from a *rarefaction*.

.....[1]

(b) The speed of sound in air is 340 m/s. The frequency of the sound is 850 Hz.

For this wave, determine

(i) the wavelength,

wavelength =[2]

(ii) the time that elapses before compression A reaches the barrier.

time =[2]

(c) On Fig. 7.1, draw the shape and positions of compressions B and C as compression A reaches the barrier.

[2]

(d) Sound waves can also travel in water.

State how the speed of sound in water compares with the speed of sound in air.

.....[1]

[Total: 8]

8 Sound from a loudspeaker is travelling in air towards a solid wall.

Fig. 8.1 shows compressions of the incident sound wave and the direction of travel of the wave.

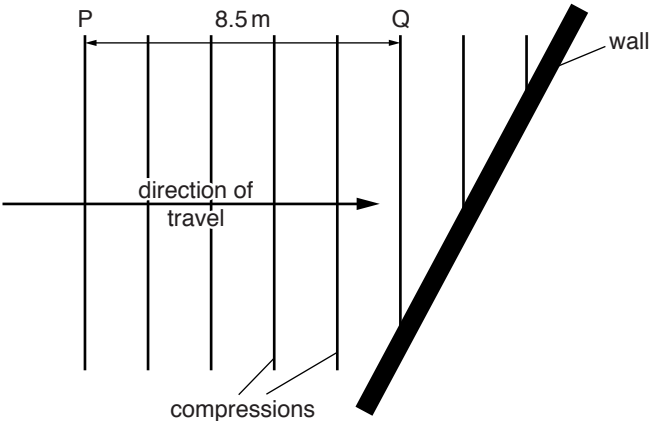


Fig. 8.1

(a) State what is meant by a *compression*.

.....[1]

(b) The distance from point P to point Q is 8.5 m. It takes 25 ms for the compression at P to reach Q.

For this sound wave, determine

(i) the wavelength,

wavelength =[1]

(ii) the frequency.

frequency =[2]

(c) As it strikes the wall, the sound reflects.

Complete Fig. 8.1 to show the positions of three compressions of the reflected sound wave. [2]

(d) The loudspeaker is immersed in water, where it continues to produce sound of the same frequency.

State and explain how the wavelength of the sound wave in water compares with the wavelength determined in (b)(i).

.....

.....[2]
[Total: 8]

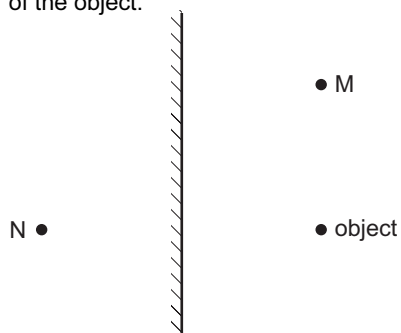
Reflection of light MCQ

- 1 A plane mirror is fitted to a wall.

Which statement about the image formed by the mirror is correct?

- A The image is real.
- B The image is left to right (laterally inverted).
- C The image is smaller than the object.
- D The image is upside down.

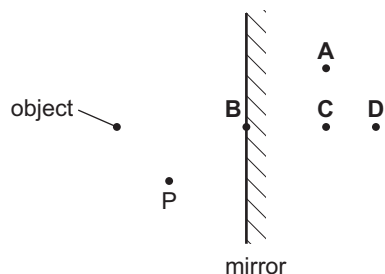
- 2 The diagram shows an object in front of a plane mirror. The mirror forms an image of the object.



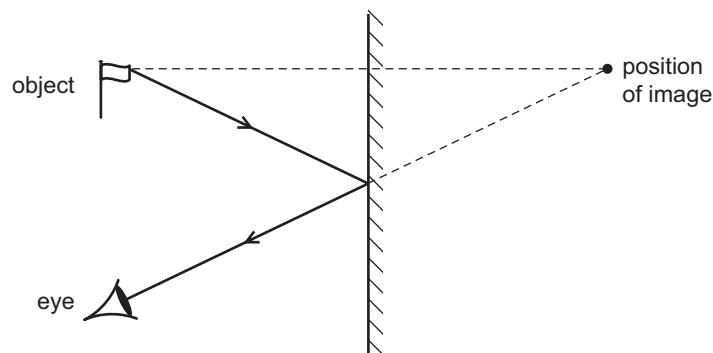
At which labelled point is the image formed, and which type of image is formed?

	where the image is formed	type of image
A	at M	real
B	at M	virtual
C	at N	real
D	at N	virtual

- 3 An object is placed before a plane mirror as shown.
A student views the image of the object in the mirror from point P.
Where does she see the image?



- 4 The image formed by a plane mirror is upright.

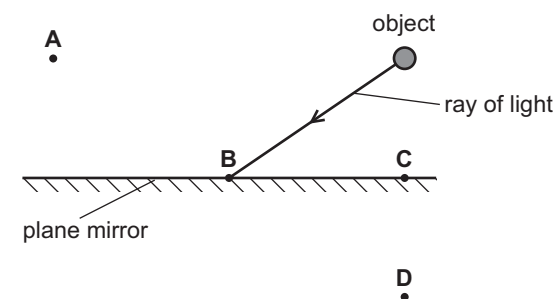


What are the other characteristics of the image?

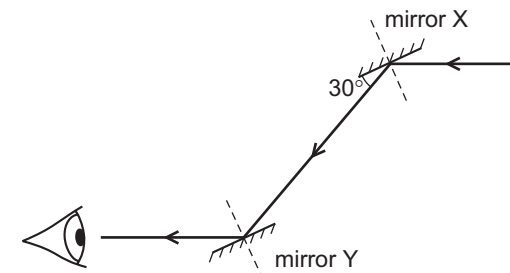
	laterally inverted (left to right)	magnified (larger than the object)	virtual
A	no	yes	yes
B	yes	no	no
C	yes	no	yes
D	yes	yes	no

- 5 A plane mirror is used to form an image of an object

At which labelled point is the image formed?



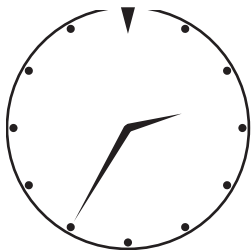
- 6 A ray of light is reflected by two parallel plane mirrors X and Y.



Which statement is correct?

- A The angle of incidence at mirror X is 30° .
- B The angle of incidence at mirror Y is 60° .
- C The angle of reflection at mirror X is 120° .
- D The angle of reflection at mirror Y is 0° .

- 7 The diagram shows the image of a clock in a plane mirror.



What time is shown?

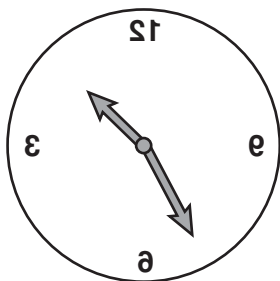
- A 02:25 B 02:35 C 09:25 D 09:35

- 8 A plane mirror is on a wall.

Which is a correct description of the image formed by the mirror?

- A the right way up and smaller than the object
B the right way up and the same size as the object
C upside down and smaller than the object
D upside down and the same size as the object

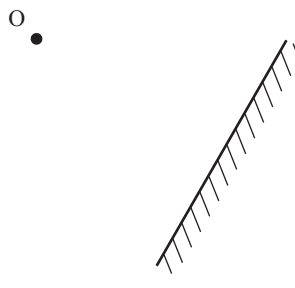
- 9 The image of a clock face as seen in a plane mirror is shown.



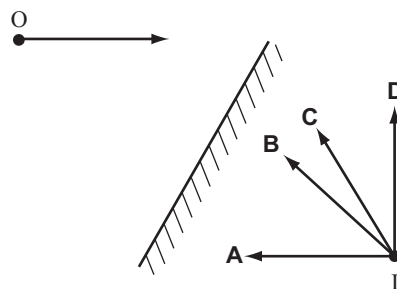
What is the actual time on the clock?

- A 1.25 B 1.35 C 10.25 D 10.35

- 10 An object placed in front of a plane mirror at O produces an image at I.



If the object moves towards the mirror in the direction shown by the arrow, in which direction does the image move?



- 11 A girl writes the word **LEFT** on a piece of card



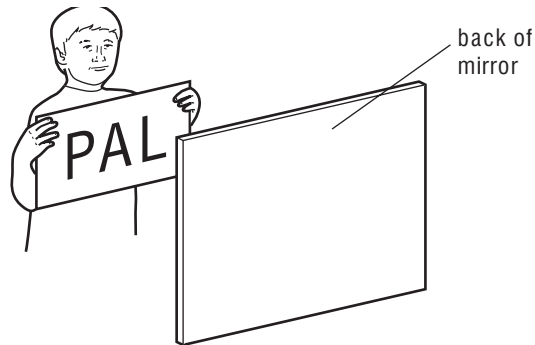
She looks at the image of this card, made by reflection by a plane mirror.

What does she see?

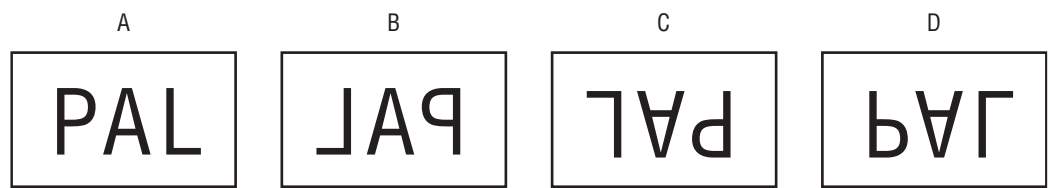
- A **1E EF** B **T73J** C **1J37** D **TFEL**

12 A piece of paper has 'PAL' written on it.

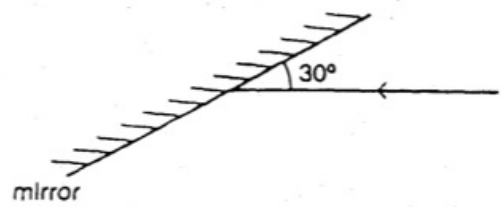
A student holds the paper in front of a plane mirror.



What does the student see?



13 A ray of light strikes a plane mirror.



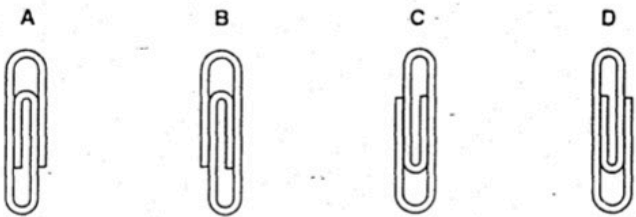
What is the angle of reflection of the ray?

- A 150° B 90° C 60° D 30°

14 A paper-clip is placed in front of a plane mirror.

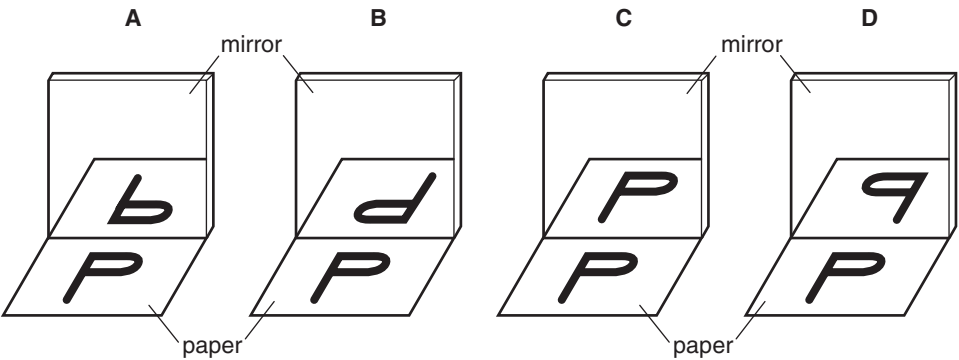


Which diagram shows the image formed behind the mirror?



15 A student looks at the letter P on a piece of paper, and at its reflection in a mirror.

What does he see?



Reflection of light

- 1 A student looks into a vertical mirror to see the reflection of a burning candle.

Fig. 1.1 shows one ray of light being reflected by the mirror.

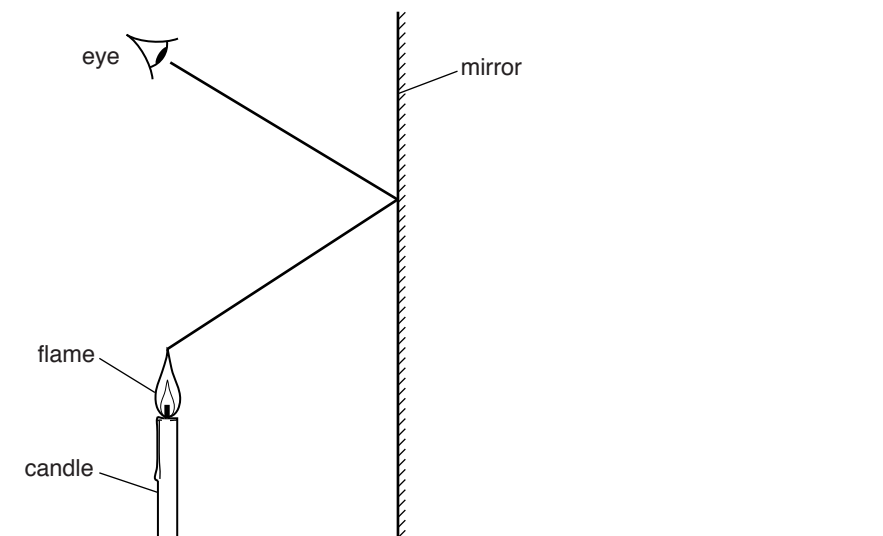


Fig. 1.1

- (a) On the ray in Fig. 1.1, mark arrows to indicate the direction of travel of the light. [1]

- (b) On Fig. 1.1, carefully mark the position of the image of the candle flame. [2]

- (c) The candle is moved further from the mirror.

State what, if anything, happens to

- (i) the position of the image

.....

- (ii) the size of the image.

.....

[2]

[Total: 5]

- 2 A lamp in a large room is suspended below a horizontal mirror that is fixed to the ceiling. Fig. 2.1 is a scale diagram of the lamp and mirror.

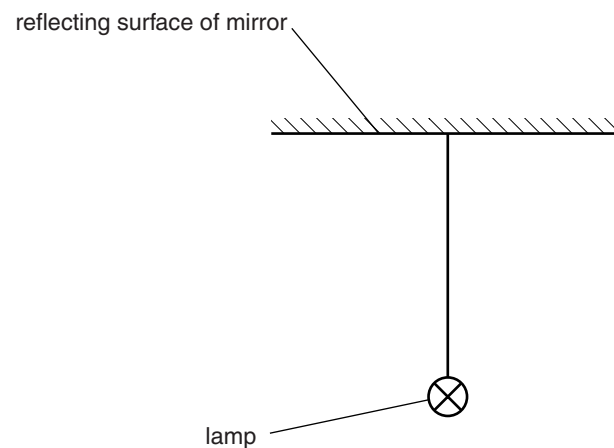


Fig. 2.1

An image of the lamp is formed by the mirror.

- (a) (i) On Fig. 2.1, draw two rays from the centre of the lamp that strike the mirror. Use these rays to locate the image. Label the image I. [3]

- (ii) State **two** characteristics of this image.

1.

2.

[2]

- (b) Suggest an advantage of positioning a mirror above the lamp.

.....

..... [1]

[Total: 6]

3 (a) A police car siren emits sound waves that vary in pitch.

Tick **two** boxes that apply to the sound waves emitted by the siren.

- ☐ electromagnetic
- ☐ longitudinal
- ☐ transverse
- ☐ visible
- ☐ frequency 0.1–10 Hz
- ☐ frequency 100–10 000 Hz
- ☐ frequency 100 000–1 000 000 Hz

[2]

(b) Fig. 3.1 is a top view of one wavefront of a water wave before it strikes a hard boundary .

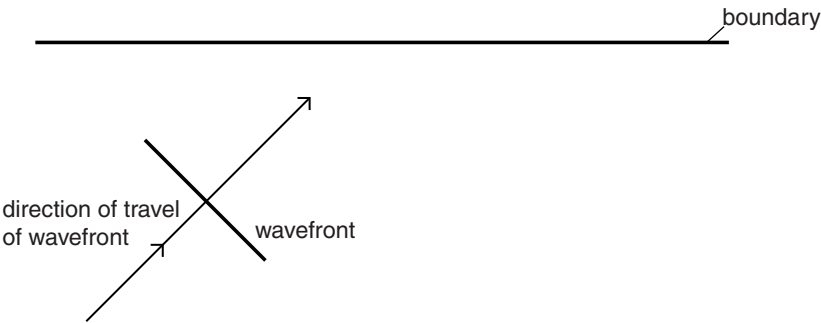


Fig. 3.1

(i) Name the process that occurs as the wavefront strikes the boundary.

..... [1]

(ii) Explain, in terms of wave theory, what occurs as the wavefront strikes the boundary.

.....

.....

.....

..... [2]

(iii) State whether there is an increase, a decrease or no change in the wavelength of the wave after it strikes the boundary.

..... [1]

(iv) The speed of the wave is 3.0 m/s and its wavelength 7.0 cm.

Calculate the frequency of the wave.

frequency = [2]

[Total: 8]

- 4 Fig. 4.1 shows part of the path of a ray of light PQ travelling in an optical fibre.

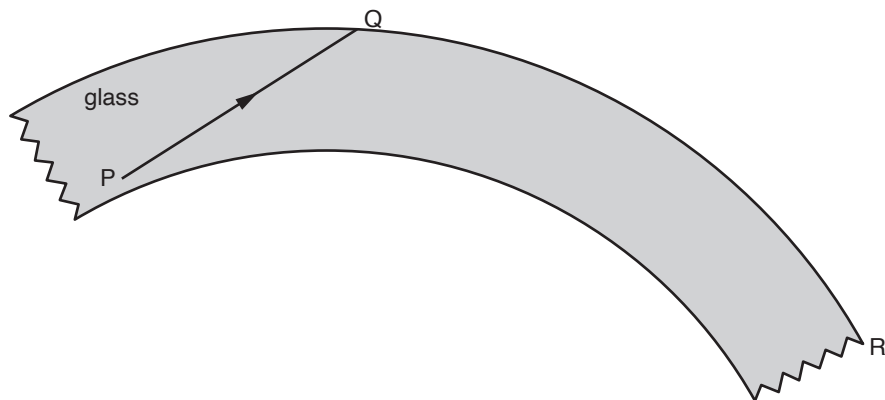


Fig. 4.1

PQ undergoes total internal reflection at Q.

- (a) Explain what is meant by *total internal reflection*, and state the conditions under which it occurs.

.....

.....

.....

.....

..... [3]

- (b) Carefully complete the path of the ray of light, until it reaches the end R of the optical fibre. [2]

[Total: 5]

- 5 (a) A small object S is dipped repeatedly into water near a flat reflecting surface.

Fig. 5.1 gives an instantaneous view from above of the position of part of the waves produced.

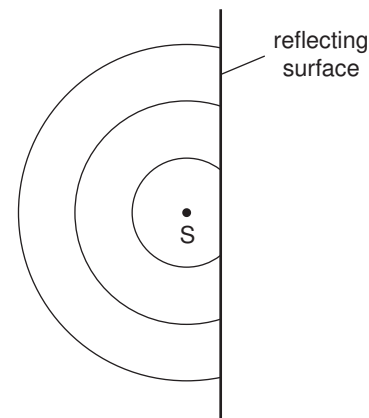


Fig. 5.1

On Fig. 5.1,

- (i) put a clear dot at the point from which the reflected waves appear to come (label the dot R),
- (ii) draw the reflected portion of each of the three waves shown . [3]

- (b) Fig. 5.2 shows a small object P in front of a plane mirror M.

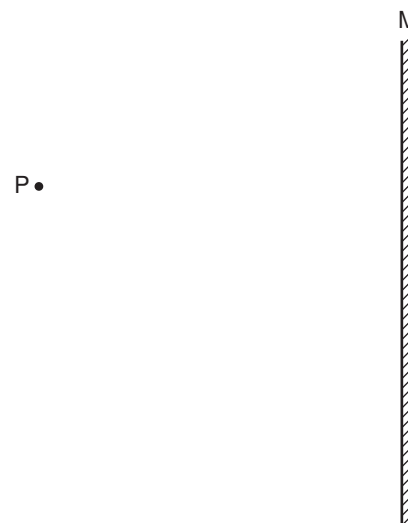


Fig. 5.2

On Fig. 5.2, carefully draw two rays that show how the mirror forms the image of object P. Label the image I. [3]

[Total: 6]

- 6 (a) Fig. 6.1 shows an object O placed in front of a plane mirror M. Two rays from the object to the mirror are shown.

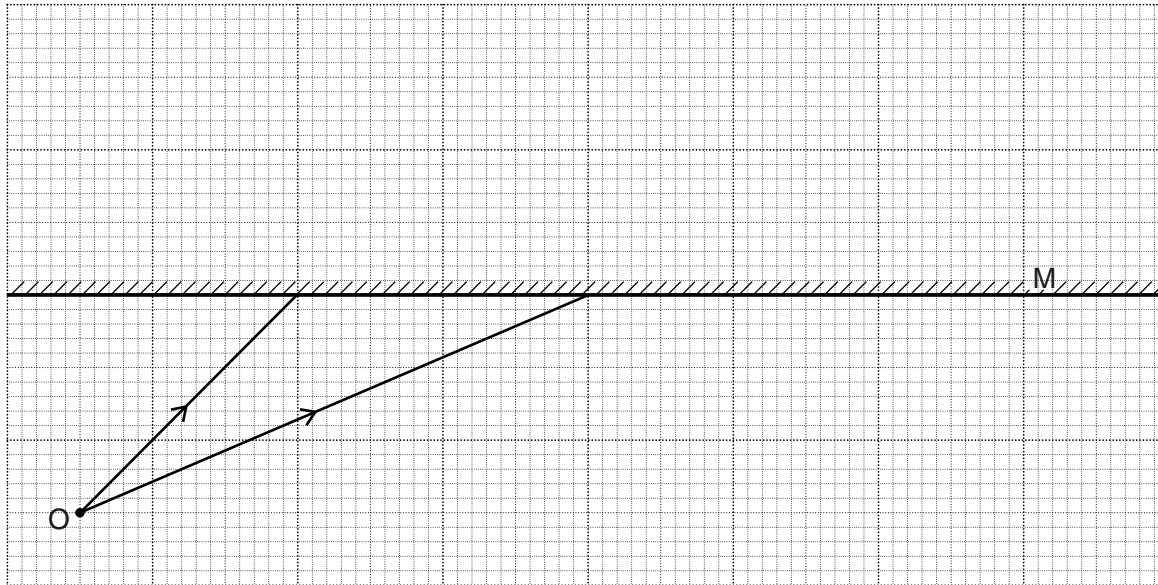


Fig. 6.1

- (i) On Fig. 6.1, for **one** of the rays shown,
1. draw the normal to the mirror,
 2. mark the angle of incidence. Label this angle X.
- (ii) On Fig. 6.1, draw
1. the reflected rays for both incident rays,
 2. construction lines to locate the image of O. Label this image I.

[2]

[2]

- (b) In Fig. 6.2, circular wavefronts from a point source in a tank of water strike a straight barrier.

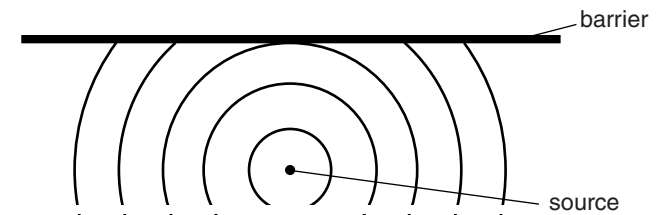


Fig. 6.2

- (i) The reflected wavefronts seem to come from a single point.

On Fig. 6.2, mark a dot to show the position of this point. Label this point C. [1]

- (ii) Draw, as accurately as you can, the reflected circular wavefronts. [2]

[Total: 7]

7 Fig. 7.1 shows the path of a sound wave from a source X.

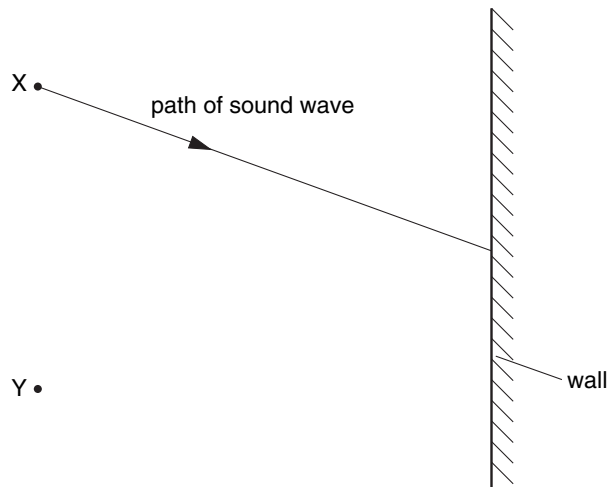


Fig. 7.1

(a) State why a person standing at point Y hears an echo.

..... [1]

(b) The frequency of the sound wave leaving X is 400 Hz. State the frequency of the sound wave reaching Y.

frequency = [1]

(c) The speed of the sound wave leaving X is 330 m/s. Calculate the wavelength of these sound waves.

wavelength = [2]

(d) Sound waves are longitudinal waves.

State what is meant by the term *longitudinal*.

.....

..... [1]

(e) Fig. 7.2 shows two rays of light from a point O on an object. These rays are incident on a plane mirror.

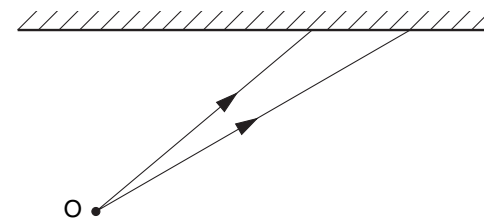


Fig. 7.2

(i) On Fig. 7.2, continue the paths of the two rays after they reach the mirror. Hence locate the image of the object O. Label the image I. [2]

(ii) Describe the nature of the image I.

.....

..... [2]

- 8 Fig. 8.1 shows an arrangement where a plane mirror is used in a shop to watch a display counter. The arrangement is drawn to a scale of 1 cm : 1 m.

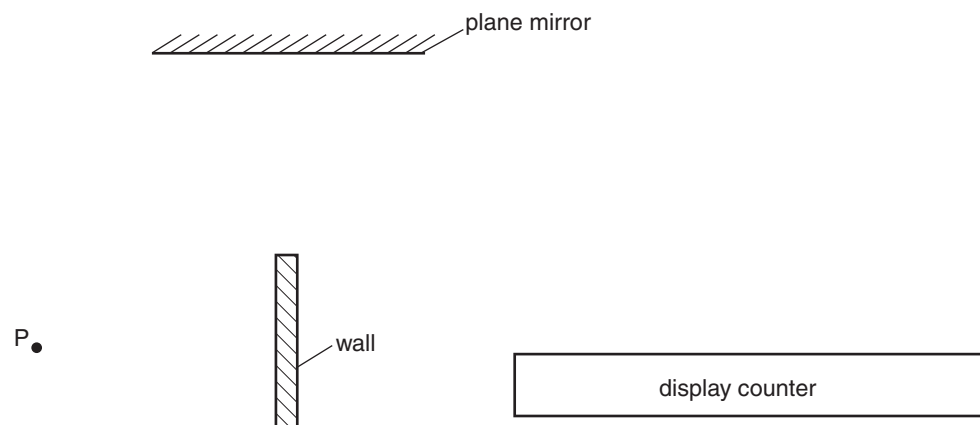


Fig. 8.1

- (a) (i) State the law of reflection.

.....

- (ii) On Fig. 8.1, draw rays to show how much of the display cannot be seen from P. Indicate this by shading in the part that cannot be seen.

[3]

- (b) By construction on Fig. 8.1 and by using the scale, calculate how far the mirror must be moved so that all of the display counter can be seen from P.

distance moved = [2]

- (c) State the characteristics of an image seen in a plane mirror.

.....

.....

..... [2]

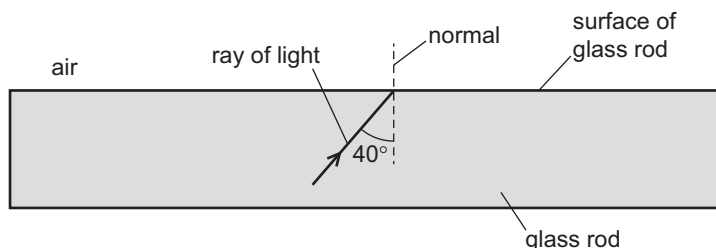
Refraction and dispersion of light MCQ

- 1 Light waves pass from air into glass and are refracted.

What always remains constant when this happens?

- A direction
- B frequency
- C speed
- D wavelength

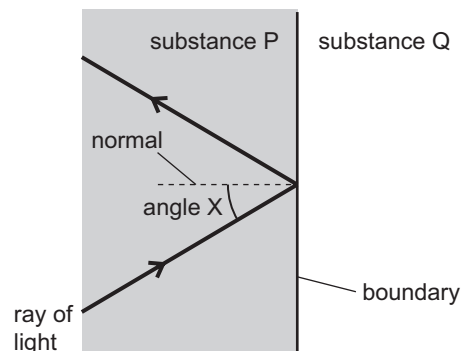
- 2 The diagram shows a ray of light inside a glass rod .
The critical angle for the light in the glass is 42° .



Which row shows what happens to the light when it reaches the surface of the glass rod?

	any light reflected?	any light refracted?
A	no	no
B	no	yes
C	yes	no
D	yes	yes

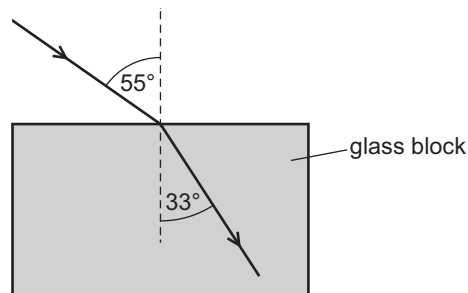
- 3 The diagram shows a ray of light travelling in a substance P.
The ray reaches a boundary with a substance Q.
Total internal reflection occurs at the boundary.



Which row contains correct statements about angle X and about the optical density of substance Q?

	angle X	substance Q
A	smaller than the critical angle	less dense than substance P
B	smaller than the critical angle	more dense than substance P
C	greater than the critical angle	less dense than substance P
D	greater than the critical angle	more dense than substance P

- 4 Light travelling at a speed of 3.0×10^8 m/s strikes the surface of a glass block and undergoes refraction as it enters the block.

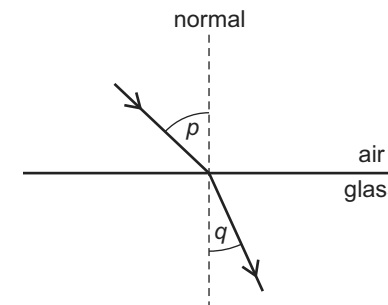


The diagram shows a ray of this light before and after it enters the block.

What is the speed of light in the glass?

- A 1.8×10^8 m/s
- B 2.0×10^8 m/s
- C 4.5×10^8 m/s
- D 5.0×10^8 m/s

- 5 The diagram shows light passing from air into glass. Two angles p and q are marked.



Which pair of equations can both be used to calculate the refractive index n of the glass?

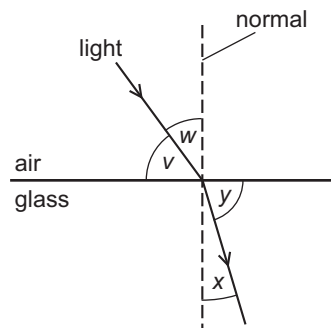
- A $n = \frac{\text{speed of light in air}}{\text{speed of light in glass}}$, $n = \frac{\sin p}{\sin q}$
- B $n = \frac{\text{speed of light in glass}}{\text{speed of light in air}}$, $n = \frac{\sin p}{\sin q}$
- C $n = \frac{\text{speed of light in air}}{\text{speed of light in glass}}$, $n = \frac{\sin q}{\sin p}$
- D $n = \frac{\text{speed of light in glass}}{\text{speed of light in air}}$, $n = \frac{\sin q}{\sin p}$

- 6 The speed of light in air is 3.0×10^8 m/s.

The critical angle for light in a transparent plastic material placed in air is 37° .
What is the speed of light in the plastic material?

- A 1.8×10^8 m/s
- B 2.4×10^8 m/s
- C 3.8×10^8 m/s
- D 5.0×10^8 m/s

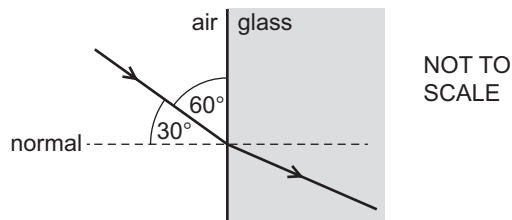
- 7 The diagram shows light travelling from air into glass. Four angles v , w , x and y are shown.



Which formula is used to calculate the refractive index n of the glass?

- A $n = \frac{\sin v}{\sin y}$ B $n = \frac{\sin v}{\sin x}$
 C $n = \frac{\sin w}{\sin y}$ D $n = \frac{\sin w}{\sin x}$

- 8 The diagram shows light passing from air into glass.



The glass has a refractive index of 1.5.

What is the angle of refraction in the glass?

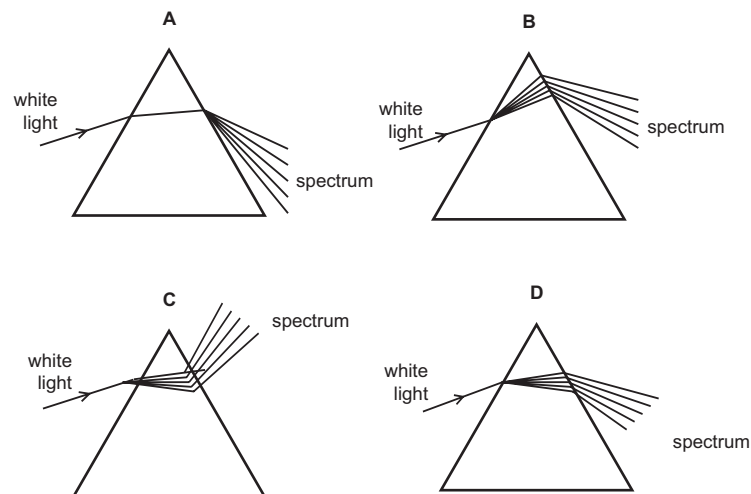
- A 19° B 22°
 C 35° D 49°

- 9 Light enters a glass block at an angle of incidence of 46° . The light refracts at an angle of refraction of 26° .

What is the refractive index of the glass?

- A 0.57 B 0.61
 C 1.64 D 1.77

- 10 Which diagram shows what happens when a ray of white light passes through a prism?

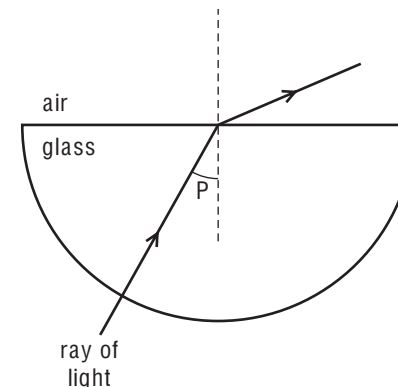


- 11 Light travels in a vacuum and then enters a glass block. The speed of the light in the glass block is 2.0×10^8 m/s.

Which statement about the speed of light is correct?

- A The speed in a vacuum is 1.5 times the speed in the glass.
 B The speed in the glass is the same as the speed in a vacuum.
 C The speed in the glass is 1.5 times the speed in a vacuum.
 D The speed in the glass is 1.0×10^8 times the speed in a vacuum.

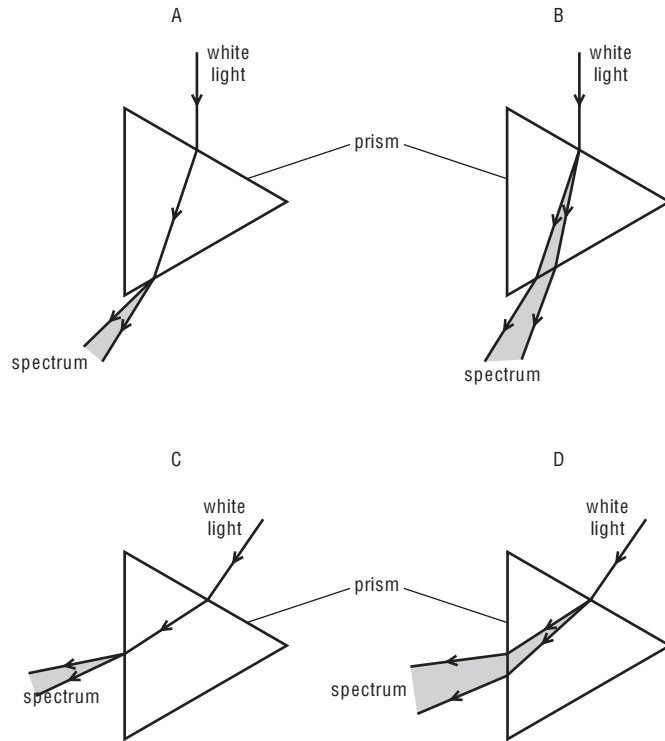
- 12 The diagram shows a ray of light passing through a semicircular glass block into air.



Which row gives correct name for angle P and states how angle P compares with the critical angle?

	name of angle P	angle P compared with the critical angle
A	angle of incidence	larger than the critical angle
B	angle of incidence	smaller than the critical angle
C	angle of refraction	larger than the critical angle
D	angle of refraction	smaller than the critical angle

- 13 A teacher demonstrates the dispersion of white light using a triangular glass prism.
Which diagram shows how this dispersion happens?



- 14 Light passes along an optical fibre.
What happens to the light within the fibre?

- A diffraction
- B dispersion
- C refraction
- D total internal reflection

- 15 Light has a speed of 1.24×10^8 m/s in diamond.
What is the refractive index of diamond?

- A 0.41
- B 1.54
- C 2.42
- D 3.72

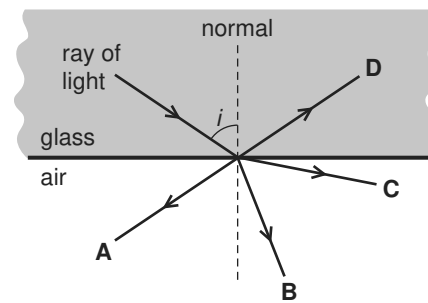
- 16 Which statement describes monochromatic light?

- A light that does not diffract
- B light that has a single frequency
- C light that spreads out when shone through a glass prism
- D light that travels at the same speed in all materials

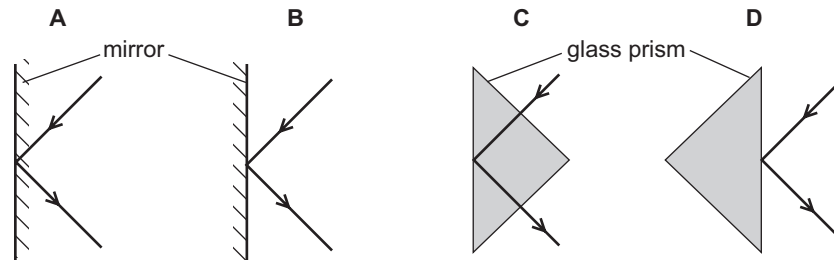
- 17 The diagram shows a ray of light incident on the edge of a piece of glass.

The angle i is bigger than the critical angle.

Which arrow correctly shows the direction of the ray after it leaves the edge of the glass?

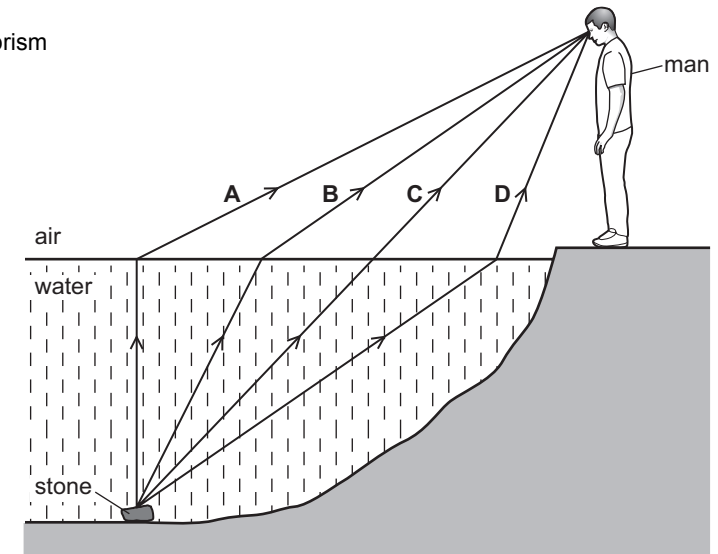


- 18 Which diagram shows total internal reflection of light?



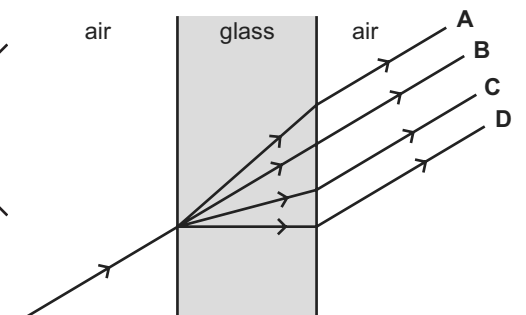
- 19 A man sees a stone at the bottom of a pool of water.

Which path could be taken by light from the stone to the man?



- 20 A ray of light passes through a window.

Which path does it take?



Refraction and dispersion of light

- 1 (a) A ray of light in glass meets a boundary with air.

In Fig. 1.1, the three diagrams X, Y and Z each show a different angle of incidence for the ray.

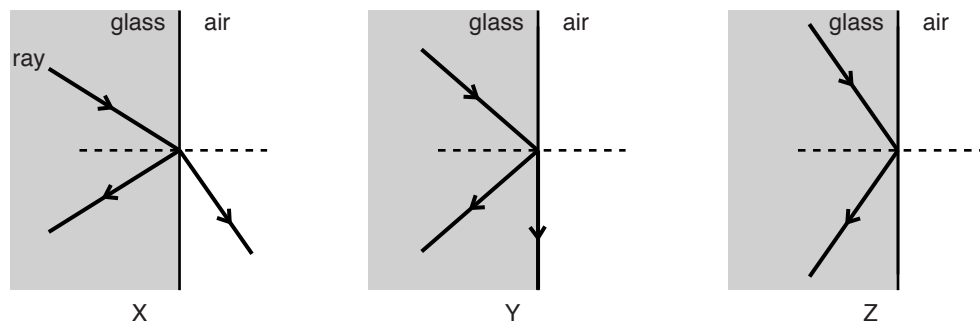


Fig. 1.1

- (i) Write down the letter of any diagram, X, Y or Z, in which the ray undergoes

1. refraction,
2. total internal reflection.

[2]

- (ii) On Fig. 1.1, use the letter C to mark the critical angle for light at the glass-air boundary

[1]

- (b) Water waves move more slowly in shallow water than in deep water.

Fig. 1.2 shows wavefronts of a wave in deep water meeting the boundary with some shallow water.

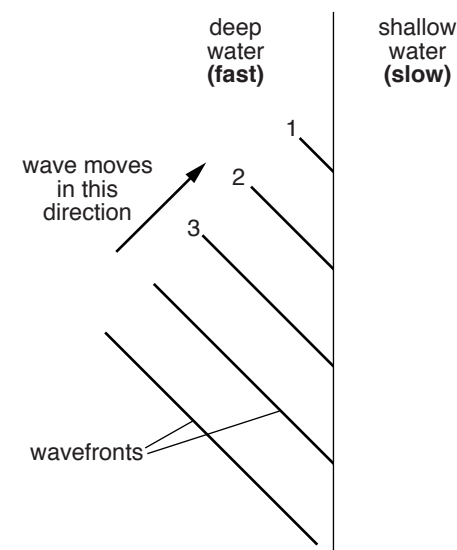


Fig. 1.2

- (i) Using your ruler, carefully complete the wavefronts 1, 2 and 3, showing their possible positions in the shallow water where they move more slowly. [3]

- (ii) Tick the **one** box that describes what is happening at the boundary.

- | | |
|--------------------------|---------------------------|
| ☐ | diffraction |
| ☐ | echo |
| ☐ | refraction |
| ☐ | total internal reflection |

[1]

[Total: 7]

2 (a) Explain what is meant by

(i) *total internal reflection*,

.....
[1]

(ii) *critical angle*.

.....
[1]

(b) Fig. 2.1 shows a ray of light, travelling in air, incident on a glass prism.

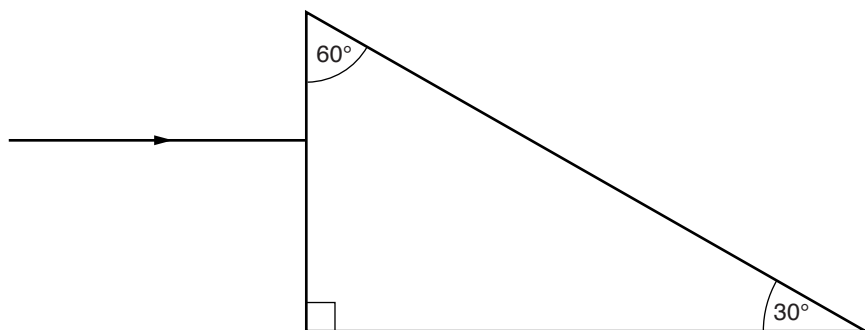


Fig. 2.1

(i) The speed of light in air is 3.0×10^8 m/s. Its speed in the glass is 2.0×10^8 m/s.

Calculate the refractive index of the glass.

refractive index =[2]

(ii) Show that the critical angle for the glass-air boundary is 42° .

[1]

(iii) On Fig. 2.1, draw carefully, without calculation, the continuation of the ray through the prism and into the air.

[3]

[Total: 8]

- 3 (a) A ray of red light passes through a glass block, as shown in Fig. 3.1.

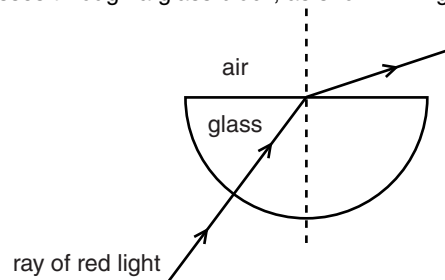


Fig. 3.1

- (i) On Fig. 3.1, clearly label the angle of refraction.
(ii) State the name given to the dashed line drawn at 90° to the boundary.

..... [1]

- (b) A roadside reflector is made of plastic. It reflects the light from car headlamps.

Fig. 3.2 shows part of the path of a ray of light through the reflector.

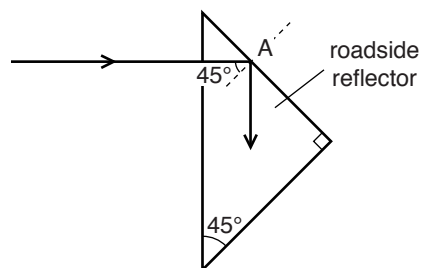


Fig. 3.2

The critical angle for the plastic is less than 45° .

- (i) On Fig. 3.2, complete the path of the ray of light.
(ii) State the term used to describe this type of reflection.

..... [1]

- (iii) Explain why the ray turns through 90° at A.

.....
..... [1]

- 4 (a) Fig. 4.1 represents a wave in a water tank. Five distances are shown, labelled A, B, C, D and E.

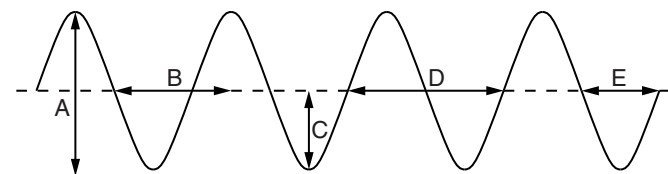


Fig. 4.1

- (i) 1. Which property of the wave is represented by distance C?

[1]

2. Which of the labelled distances represents the wavelength of the wave?

..... [1]

- (ii) Water waves are transverse waves.

State another example of a transverse wave.

..... [1]

- (iii) The speed of the wavefronts is 7.5 cm/s .

Calculate the distance moved by a wavefront in 4.0 s .

distance = cm [2]

[Total: 5]

(b) Fig. 4.2 shows, from above, a wave travelling on water .

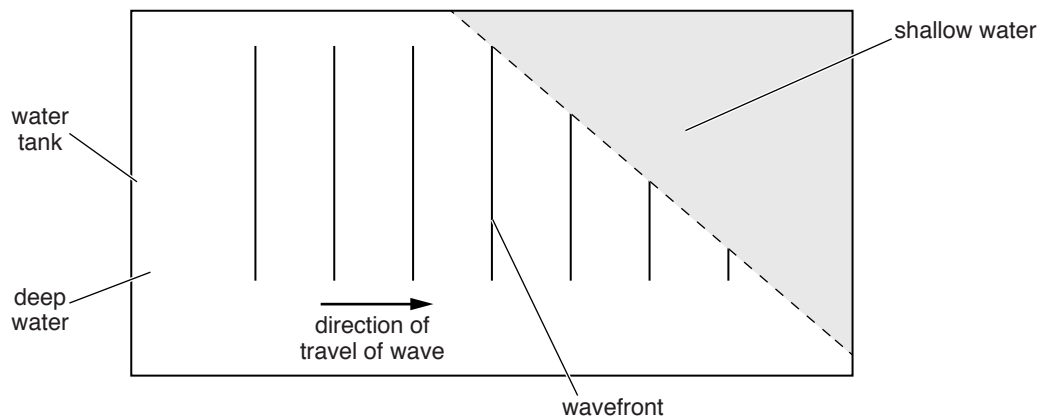


Fig. 4.2

The wave has reached an area of shallow water, where it travels more slowly.

(i) Complete the diagram to show the wavefronts in the shallow water. [3]

(ii) State the term used to describe what happens to the wave as it enters the shallow water.

.....[1]

[Total: 9]

5 (a) (i) A ray of light passes through a length of curved optical fibre.

Draw a diagram showing the fibre and the path of the ray of light.

[1]

(ii) Describe one use of optical fibres in medicine. You may draw a diagram.

.....

.....

.....

.....

.....

.....

.....

[3]

(b) Draw a straight line from each wave on the left to the most appropriate speed.

light in air	90 m/s (9×10^1)
	6000 m/s (6×10^3)
microwaves in a vacuum	100 000 m/s (1×10^5)
	1 000 000 m/s (1×10^6)
sound in steel	300 000 000 m/s (3×10^8)
	60 000 000 000 m/s (6×10^{10})

[3]

(c) The refractive index of a block of glass is 1.5.

Use your value for the speed of light from (b) to calculate the speed of light in this block.

speed = [2]

[Total: 9]

6 (a) Fig. 6.1 shows a protractor superimposed on the path of a ray of light. The light is travelling in glass towards the boundary with air.

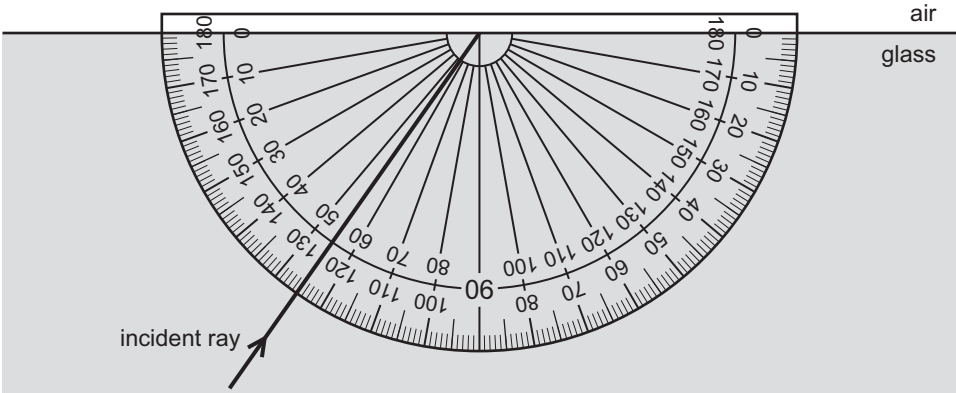


Fig. 6.1

(i) Use the protractor to measure the angle of incidence of the ray of light at the boundary with the air.

angle of incidence = [1]

(ii) The refractive index of the glass is 1.56.

Calculate the angle of refraction in the air.

angle of refraction = [3]

(b) (i) State what is meant by *critical angle*.

.....
 [1]

(ii) Calculate the critical angle of light in glass of refractive index 1.56.

critical angle = [2]

(c) Fig. 6.2 shows a water wave crossing a boundary from shallow water to deep water.

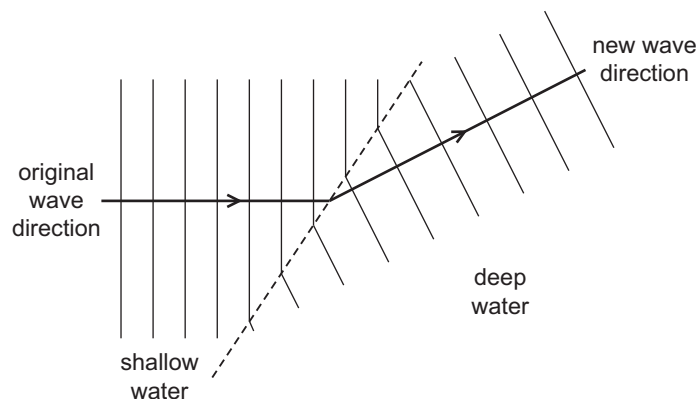


Fig. 6.2

(i) Name the process that takes place at the boundary between the shallow water and the deep water.

..... [1]

(ii) Tick **one** box corresponding to the property of the wave that is the same in the shallow water as in the deep water.

- ☐ amplitude
- ☐ frequency
- ☐ speed
- ☐ wavelength

[1]

[Total: 9]

7 The refractive index n of glass in air is 1.5.

(a) (i) State the equation that relates the speed of light in air v_a , the speed of light in glass v_g and n .

.....[1]

(ii) The speed of light in air is 3.0×10^8 m/s.

Calculate the speed of light in glass.

speed =[1]

(b) Light travelling in glass strikes the edge of the glass. Fig. 7.1 shows a ray of light at an angle of 41° to the normal.

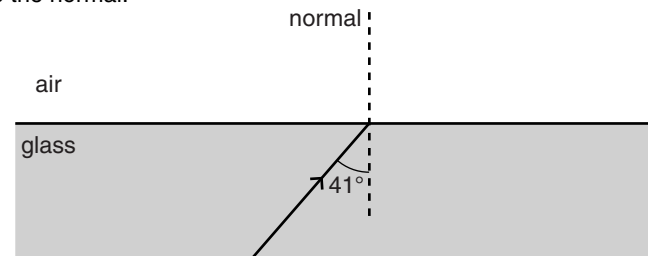


Fig. 7.1

(i) The light passes from the glass into the air.

Calculate the angle that the ray makes with the normal in the air.

angle =[2]

(ii) State what happens to light that strikes the edge of the glass at an angle to the normal much larger than 41° .

.....[1]

(c) Describe one example of how optical fibres are used in medicine.

.....

.....

.....

.....[2]

[Total: 7]

8 (a) A block is made from a particular type of glass.
 Fig. 8.1 shows light passing from air into the glass block

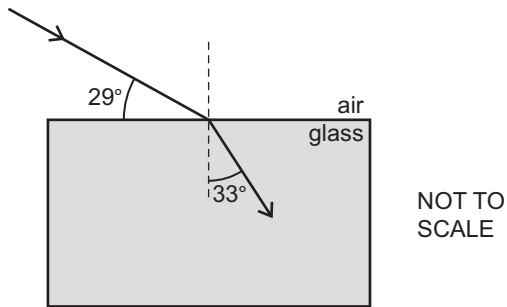


Fig. 8.1

Using information from Fig. 8.1, calculate

(i) the refractive index of light in this type of glass,

.....

.....

..... [3]

[Total: 8]

refractive index = [3]

(ii) the critical angle for light travelling in this type of glass.

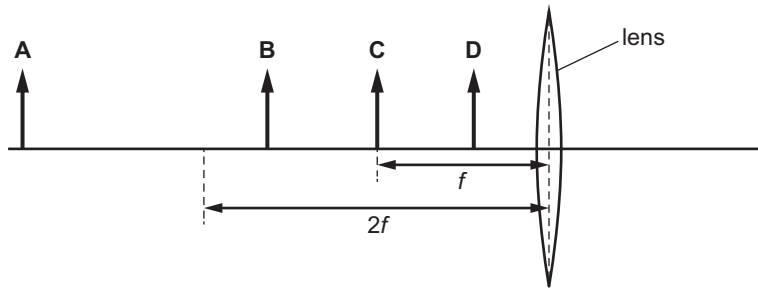
critical angle = [2]

Lenses MCQ

- 1 An object is placed in front of a converging lens. The lens has a focal length f .

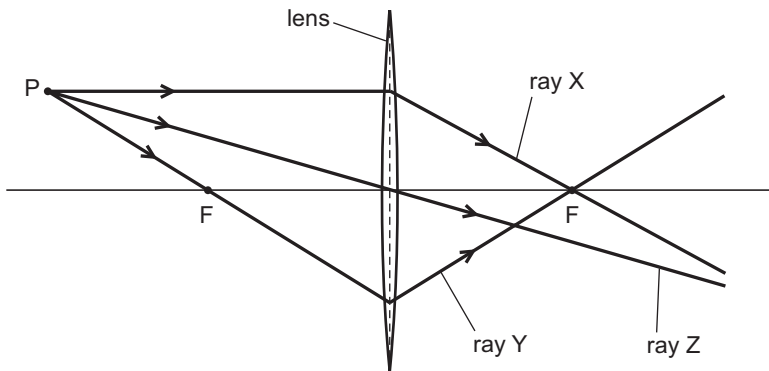
The lens produces a real, enlarged image of the object.

In which labelled position is the object placed?



- 2 A student draws a diagram representing three rays of light from point P passing through a converging lens.

Each point labelled F is a principal focus of the lens.



Which of the rays has the student drawn correctly?

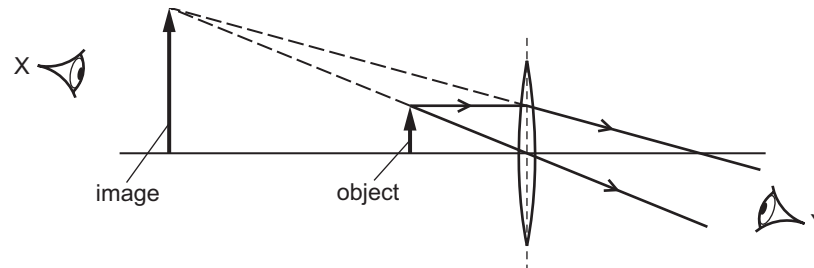
- A ray X and ray Y
- B ray X and ray Z
- C ray Y only
- D ray Z only

- 3 An image is formed by a plane mirror. A second image is formed by a lens used as a magnifying glass.

Which row states the nature of each of these images?

	plane mirror	magnifying glass
A	real	real
B	real	virtual
C	virtual	real
D	virtual	virtual

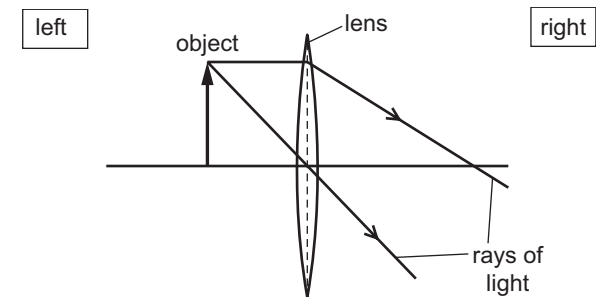
- 4 The diagram shows a converging lens forming an image of an object.



Which statement about the image is correct?

- A It is real and can be seen by an eye at X.
- B It is real and can be seen by an eye at Y.
- C It is virtual and can be seen by an eye at X.
- D It is virtual and can be seen by an eye at Y.

- 6 The incomplete ray diagram shows two rays of light that have passed from one point on an object through a thin converging lens.



Which type of image is formed, and on which side of the lens is it formed?

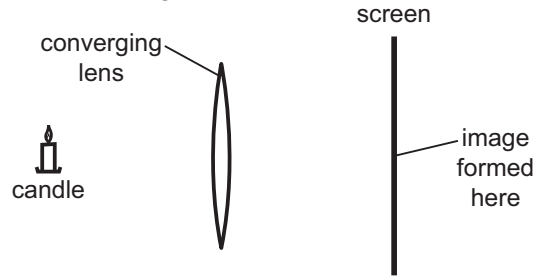
	type of image	which side of lens
A	real	on the left
B	real	on the right
C	virtual	on the left
D	virtual	on the right

- 5 A converging lens is used as a magnifying glass to view an object.

Which statement is correct?

- A The image is inverted.
- B The image is nearer the lens than the object.
- C The image is the same size.
- D The image is virtual.

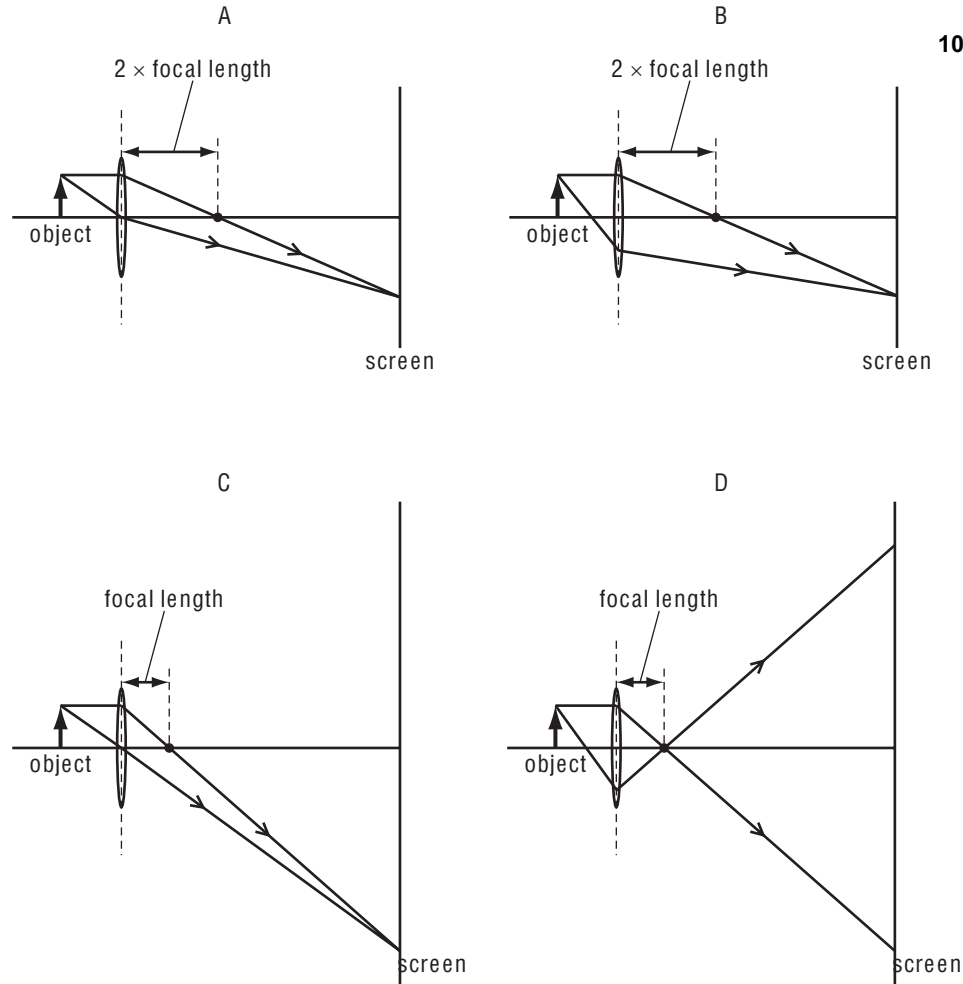
- 7 A converging lens is used to make an image on a screen.



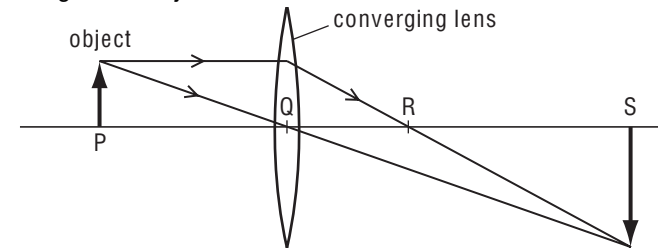
What type of image is formed on the screen?

- A real and inverted
- B real and upright
- C virtual and inverted
- D virtual and upright

- 8 Which diagram shows how an image of an object is formed on a screen by a converging lens?



- 9 The diagram represents a converging lens forming an image of an object.

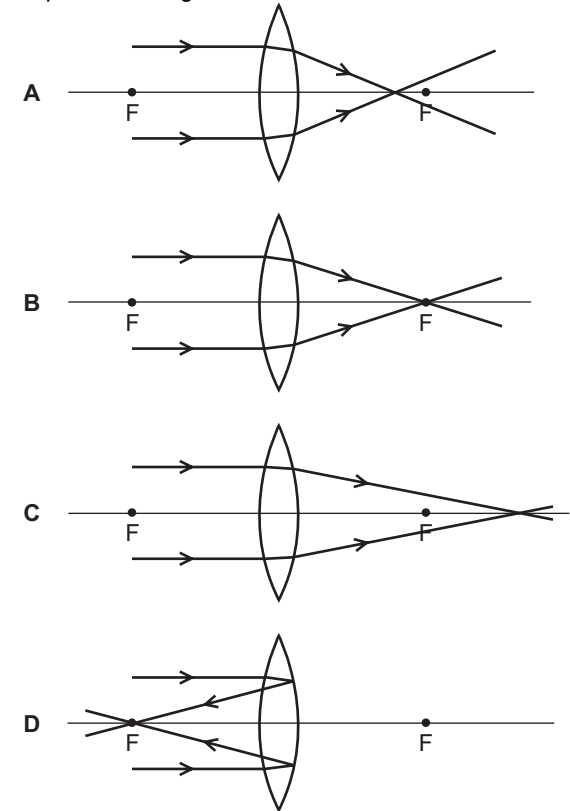


Which distance is the focal length of the lens?

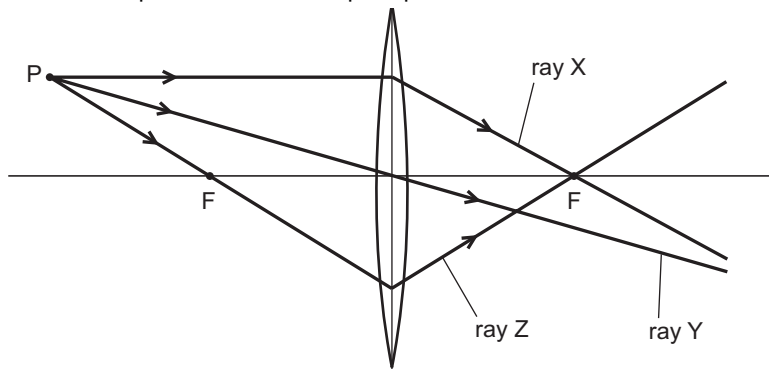
- A PQ
- B PR
- C QR
- D QS

- 10 The points labelled F are the principal foci of a lens. A beam of parallel light is incident on the lens.

Which diagram shows the path of the light after it passes through the lens?



- 11 A student draws three rays of light from point P through a converging lens. Each point labelled F is a principal focus of the lens.

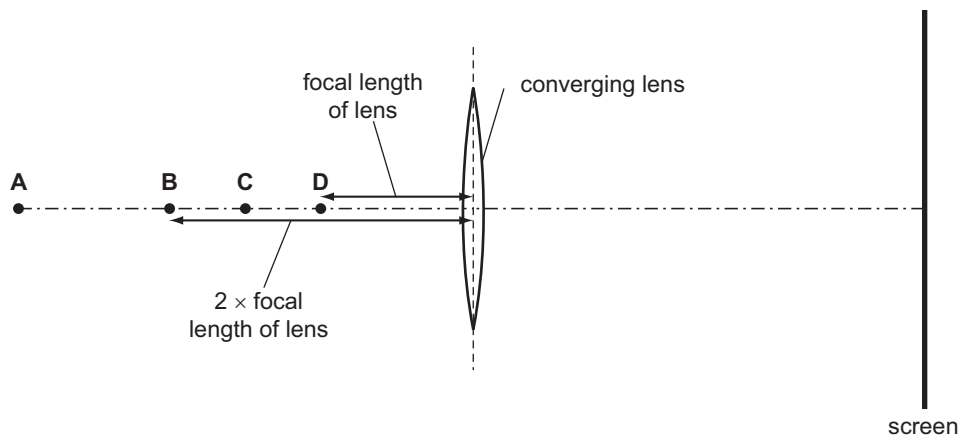


Which of the rays are drawn correctly?

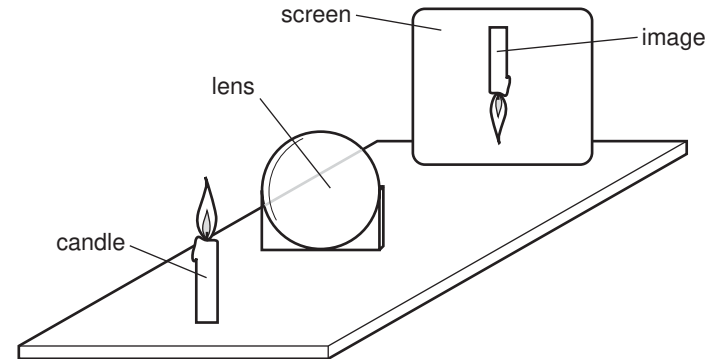
- A ray Y only
- B ray Z only
- C ray X and ray Y
- D ray X and ray Z

- 12 A converging lens in a projector is used to make an **enlarged** image of a small piece of film on a screen.

At which labelled point could the piece of film be placed so that the lens produces this image?



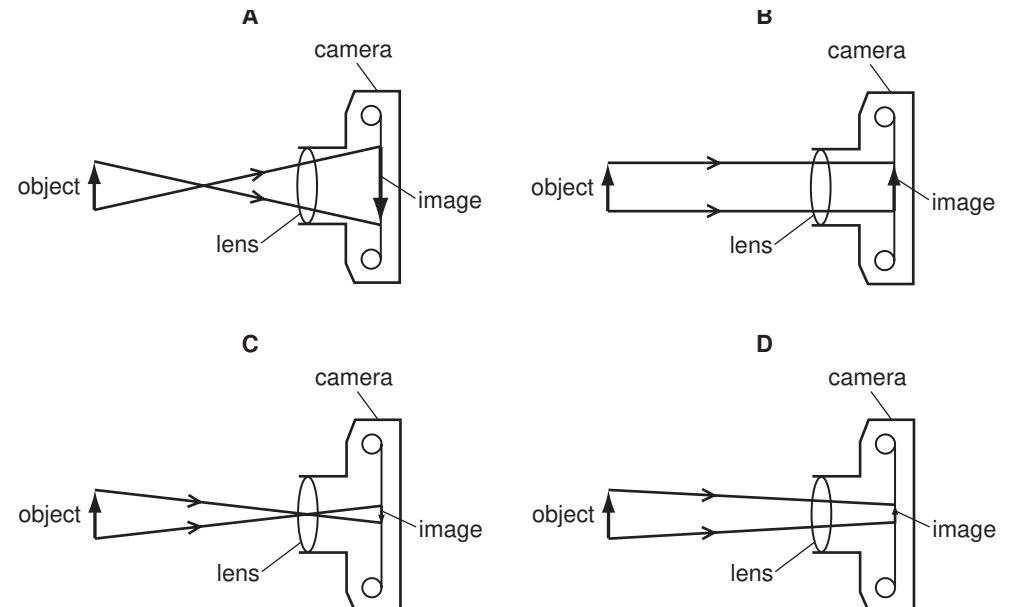
- 13 A thin converging lens is used to produce, on a screen, a focused image of a candle.



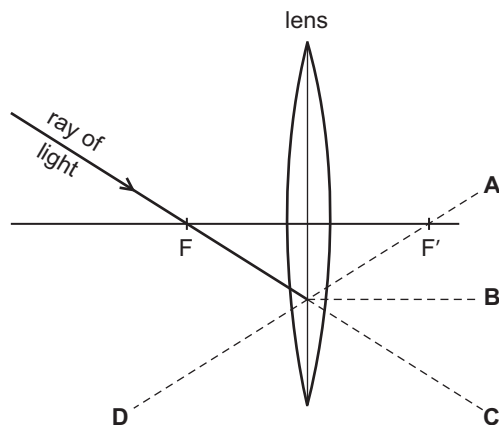
Various focused images are produced on the screen by moving the lens and the screen backwards and forwards. Which statement is **always** correct?

- A The image is at the principal focus (focal point) of the lens.
- B The image is bigger than the object.
- C The image is closer to the lens than the object is.
- D The image is inverted.

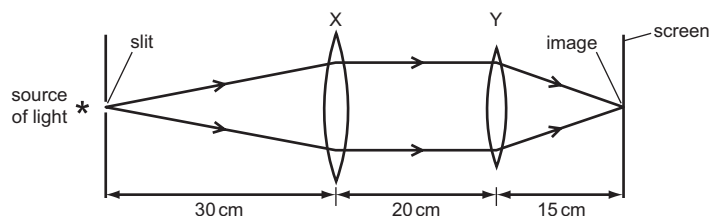
- 14 Which diagram correctly shows rays of light passing through a converging lens in a camera?



- 15 The diagram shows the path of a ray of light passing through a principal focus F of a lens. Which broken line shows the direction of the ray after it leaves the lens?



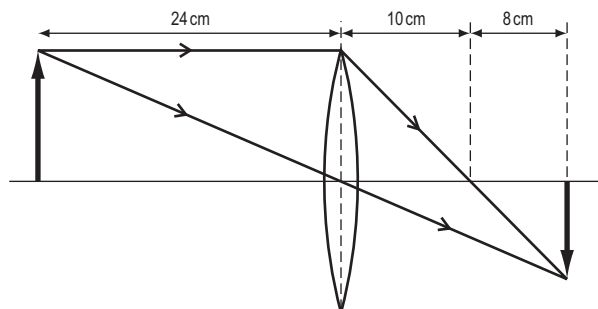
- 16 Two thin converging lenses X and Y are used as shown to give a focused image of an illuminated slit. The rays shown are parallel between X and Y.



What are the correct values for the focal lengths of X and of Y?

	focal length of X / cm	focal length of Y / cm
A	50	35
B	30	20
C	30	15
D	20	20

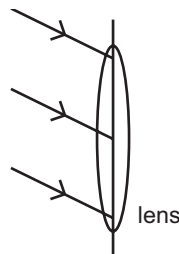
- 17 The ray diagram shows how an image is formed by a converging lens.



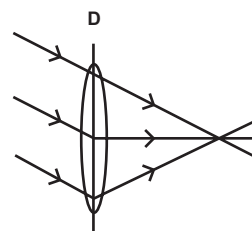
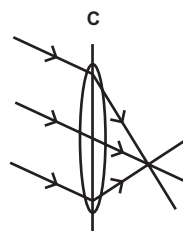
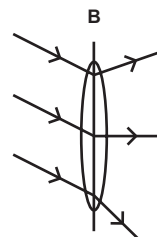
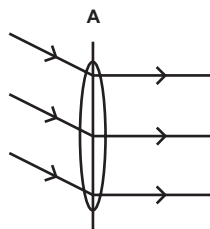
What is the focal length of this lens?

- A 8 cm B 10 cm C 18 cm D 24 cm

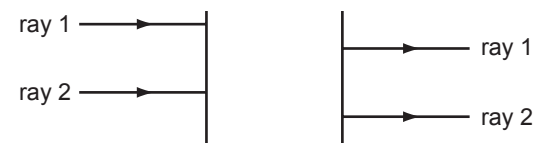
- 18 Three rays of light fall on a converging lens as shown



Which diagram shows the path of the rays after passing through the lens?



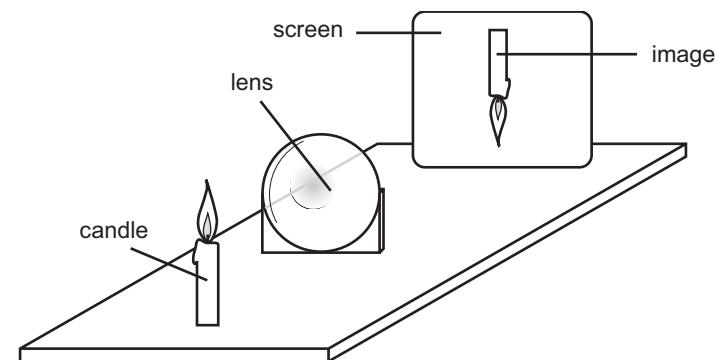
- 19 Rays of light enter and leave a box.



What could be inside the box to make the rays behave as shown?

- A a converging lens
B a parallel-sided glass block
C a plane mirror
D a triangular prism

- 20 A thin converging lens is used to produce, on a screen, a focused image of a candle.



The screen and the lens are moved back and forth and various focused images are produced on the screen.

Which statement is **always** true?

- A The image is at the principal focus (focal point) of the lens.
B The image is bigger than the object.
C The image is closer to the lens than the object is.
D The image is inverted.

Lenses

- 1 Fig. 1.1 is a ray diagram representing two rays passing through a converging lens.

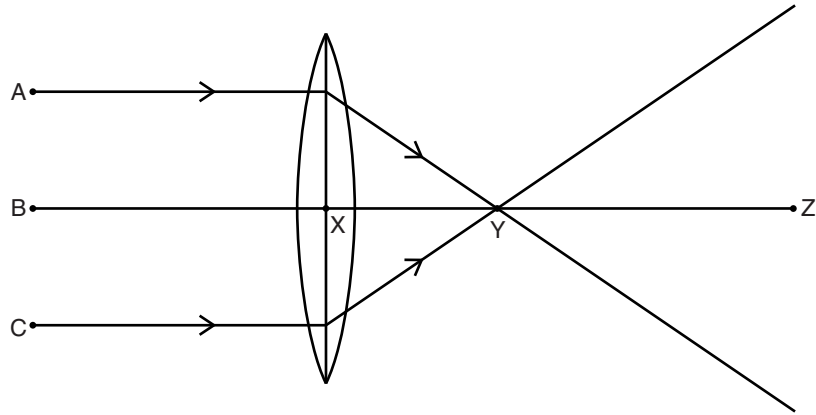


Fig. 1.1

- (a) State which of the labelled points is a principal focus of the lens. [1]
- (b) State which of the distances BX, XY, YZ or XZ is the focal length of the lens. [1]
- (c) On Fig. 1.1, draw another ray from point A to locate the image of point A. Label this image I. [3]
- (d) On the ray diagram in Fig. 1.1, the refraction is shown occurring at the centre line of the lens.
State where the refraction actually occurs.
.....
.....[1]

[Total: 6]

- 2 Fig. 2.1 shows an object and its image formed by a converging lens. One ray from the tip of the object to the tip of the image is shown.

Fig. 2.1 is drawn full size.

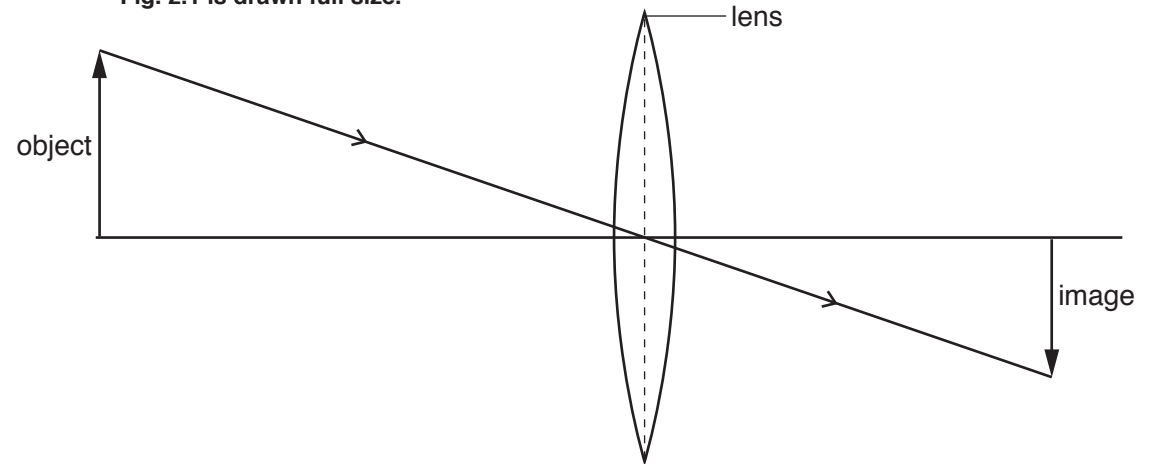


Fig. 2.1

- (a) Place a tick (✓) in **all** boxes that correctly describe the image.

☐	diminished
☐	enlarged
☐	inverted
☐	upright
☐	real
☐	virtual

[2]

- (b) On Fig. 2.1, draw a ray, passing through a principal focus of the lens, from the tip of the object to the tip of the image. Label the principal focus F. [1]
- (c) Use the ray you have drawn in (b) to determine the focal length of the lens.

focal length =[1]

- (d) Draw another ray, **not** passing through a principal focus of the lens, that passes from the tip of the object to the tip of the image. [1]

[Total: 5]

3 (a) Fig. 3.1 represents an object O placed in front of a converging lens.

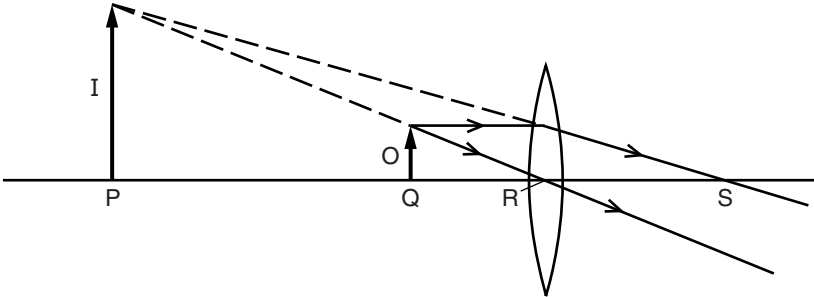


Fig. 3.1

- (i) State a full description of the image I.
..... [2]
- (ii) Using the letters on Fig. 3.1, identify the focal length of the lens.
..... [1]
- (iii) On Fig. 3.1, draw an eye suitably placed to view the image I. [1]

(b) Fig. 3.2 shows an object O placed to the left of a converging lens. A principal focus of the lens is at the position marked F.

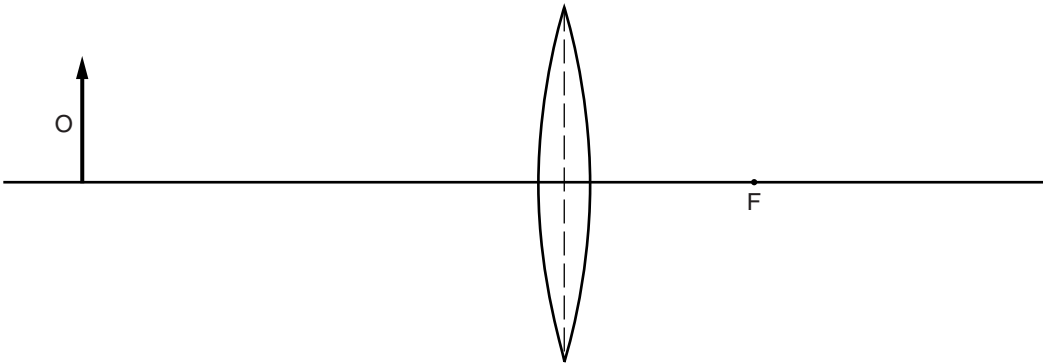


Fig. 3.2

- (i) On Fig. 3.2, draw two rays to locate the image of object O. Draw the image
- (ii) On Fig. 3.2, draw one other ray from the upper tip of O to the image.

[4]

[Total: 8]

4 (a) Fig. 4.1 shows a convex lens being used to produce an image of an object.

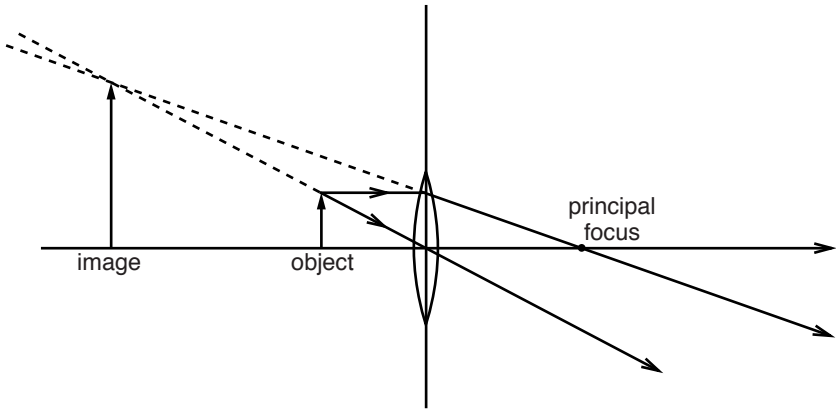


Fig. 4.1

- (i) Place **three** ticks in the table that describe this image.

can only be formed on a screen	
diminished	
enlarged	
inverted	
real	
same size	
upright	
virtual	

[3]

- (ii) On Fig. 4.1, mark a letter E to indicate a possible position for an eye to be placed to observe this image. [1]

- (iii) State an application in which a convex lens is used in this way.

.....[1]

- (b) In the space below, draw a ray diagram to locate the image of an object of height 1.0 cm placed 5.0 cm from a convex lens of focal length 2.0 cm. Draw your diagram full size. You are advised to locate the lens roughly in the centre of the space. Label the image.

- 5 (a) A ray of light in air is incident on a glass block. The light changes direction.
State

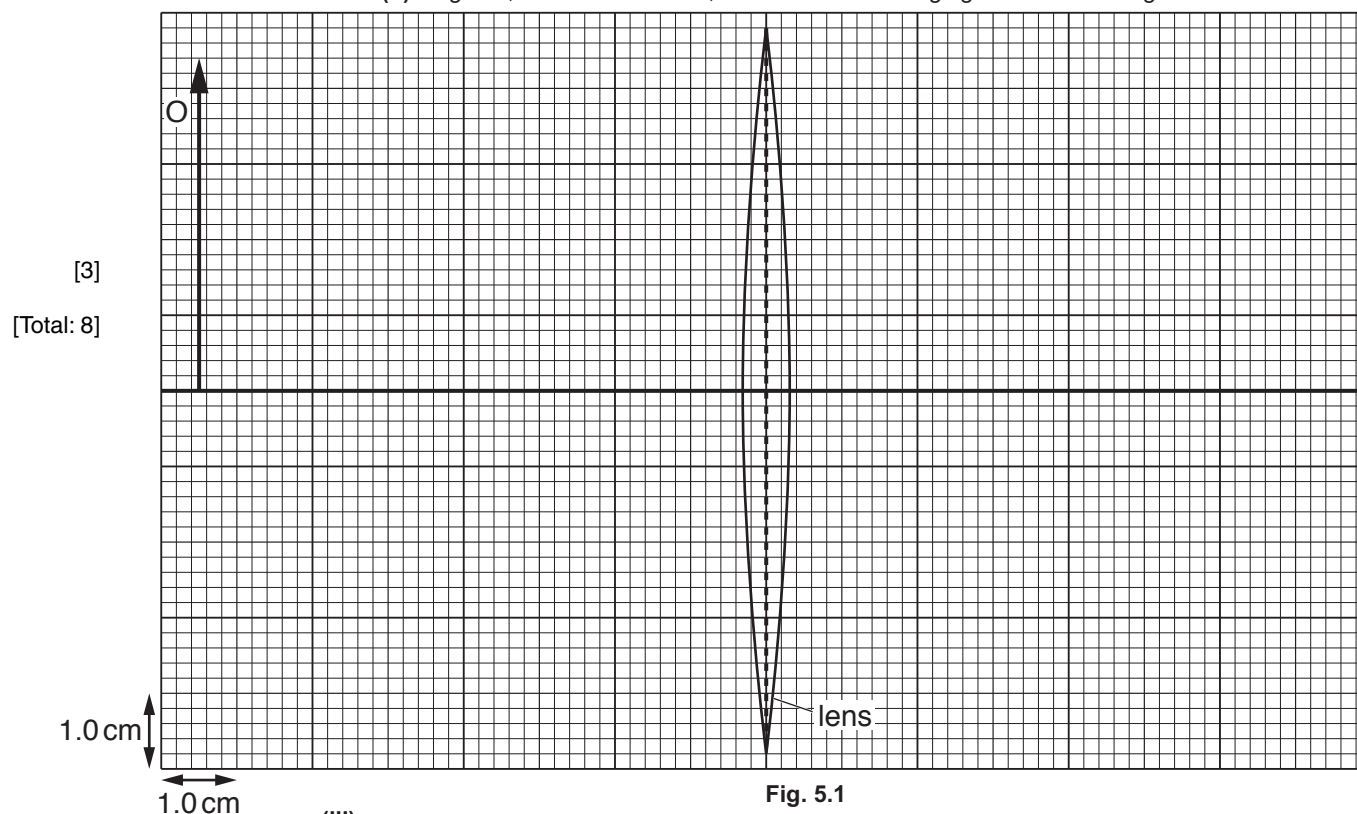
- (i) the name of this effect,

.....[1]

- (ii) the cause of this effect.

.....[1]

- (b) Fig. 5.1, drawn to full scale, shows a thin converging lens of focal length 3.5 cm.



- (i) On Fig. 5.1, mark each of the two principal focuses and label each with the letter F. [1]

- (ii) An object O of height 4.4 cm is placed a distance of 7.5 cm from the lens.

On Fig. 5.1, draw rays from the tip of the object O to locate the image. Draw and label the image. [3]

- (iii) Determine the height of the image.

height of the image =[1]

- (iv) State and explain whether the image is real or virtual.

.....

.....[1]

6 A glass, converging lens is used as a magnifying glass to observe a red ant.

(a) Fig. 6.1 shows the lens, the principal axis, and the two principal focuses F_1 and F_2 .

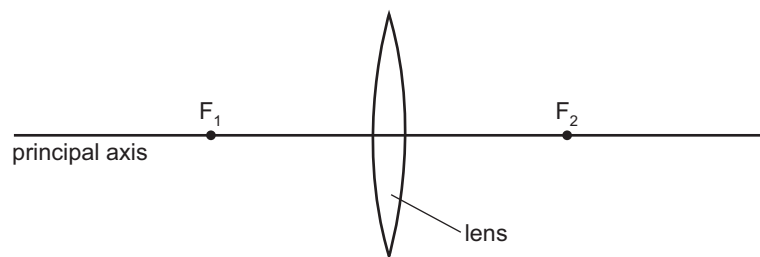


Fig. 6.1

- (i) 1. On Fig. 6.1, mark a point on the principal axis, labelled A, to indicate a suitable position for the ant.
2. On Fig. 6.1, mark a point on the principal axis, labelled E, to indicate a suitable position for the observer's eye.

[1]

(ii) Tick **one** of the boxes to indicate where, on the principal axis, the image of the ant is located.

- ☐ to the left of F_1
- ☐ between F_1 and the lens
- ☐ within the lens
- ☐ between the lens and F_2
- ☐ to the right of F_2

[1]

(iii) Underline **two** words in the list that describe the image produced by the magnifying glass.

diminished inverted real upright virtual

[2]

(b) (i) The red light from the ant passes into the lens.

As the light enters the lens, state what happens to

1. its wavelength,

.....[1]

2. its frequency.

.....[1]

(ii) State how the wavelength of violet light in air differs from the wavelength of red light in air.

.....[1]

[Total: 7]

7 (a) Fig. 7.1 shows a ray of light in water that is incident on a submerged, transparent plastic block.

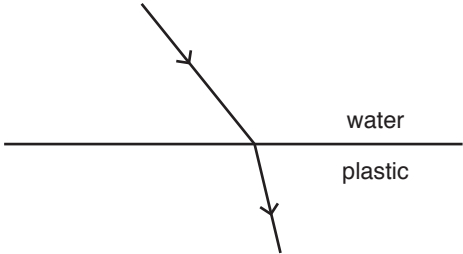


Fig. 7.1

State what happens to the speed of light as it enters the plastic block. Explain your answer.

.....

[2]

(b) Fig. 7.2 shows the two principal focuses F_1 and F_2 of a thin converging lens.

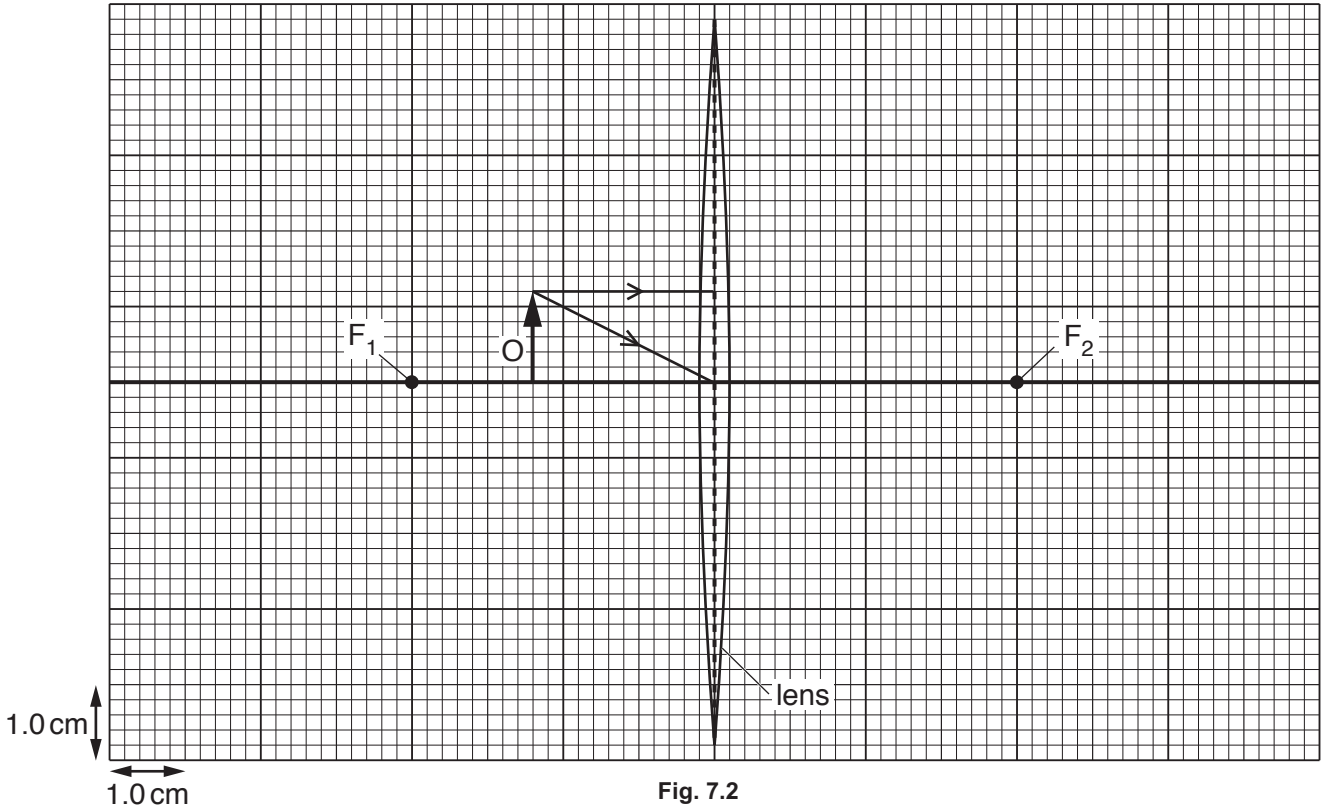


Fig. 7.2

Fig. 7.2 also shows an object O of height 1.2 cm placed close to the lens. Two rays from the tip of the object O are incident on the lens.

(i) On Fig. 7.2, continue the paths of these two rays for a further distance of at least 5 cm. [2]

(ii) Using your answer to (b)(i), find and mark on Fig. 7.2 the image I of object O and label this image. [2]

(iii) Determine the height of image I .

height =[1]

(iv) State and explain whether I is a real image or a virtual image.

.....
[1]

[Total: 8]

- 8 (a) Fig. 8.1 is a ray diagram of a convex lens being used as a magnifying glass to produce a virtual image.

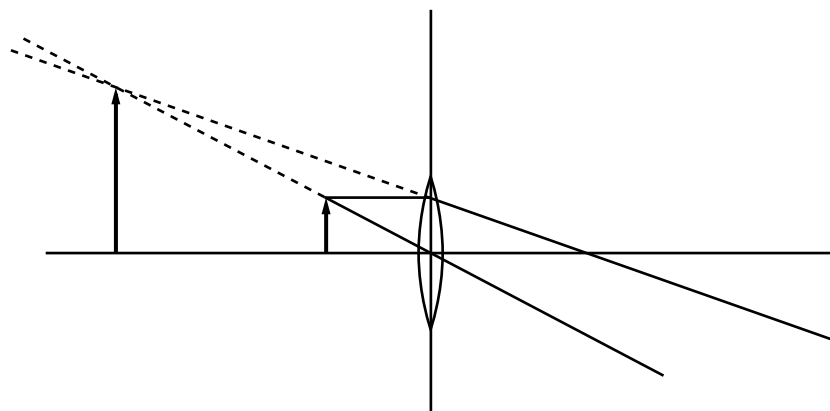


Fig. 8.1

On Fig. 8.1,

- (i) label the object O,
- (ii) label the image I,
- (iii) label a principal focus F,
- (iv) put arrows on the two rays to indicate their directions.

[4]

- (b) Fig. 8.2 shows a ray of light in air incident on an interface with glass. The refractive index of glass is 1.5.

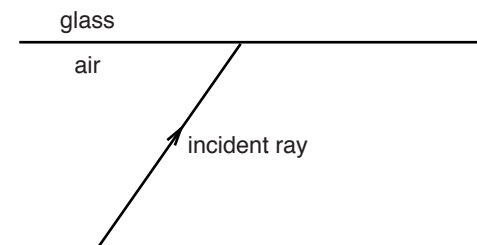


Fig. 8.2

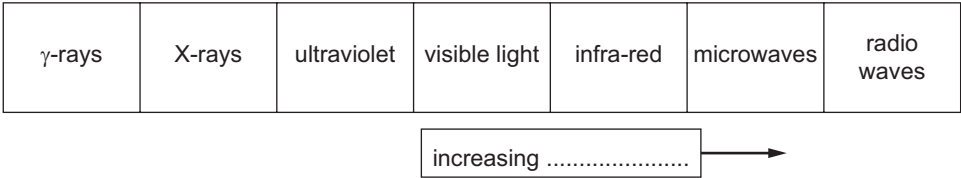
On Fig. 8.2, accurately draw the ray as it travels in the glass. You will need to take a measurement from Fig. 8.2 and carry out an appropriate calculation. Show your working.

[3]

[Total: 7]

Electromagnetic spectrum MCQ

5 The diagram shows the electromagnetic spectrum.



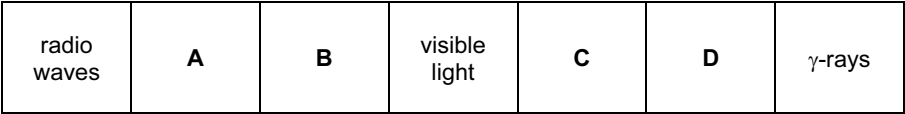
1 Which type of electromagnetic wave is used in airport security scanners?

- A infra-red
- B microwaves
- C radio waves
- D X-rays

2 An intruder alarm sensor detects that a human is warmer than his surroundings. Which type of electromagnetic wave does the sensor detect?

- A infra-red
- B radio
- C ultraviolet
- D visible light

3 The diagram represents the electromagnetic spectrum. Some regions have been labelled, and some labels are missing. Which region should be labelled as infra-red waves?



4 Which group contains only electromagnetic waves?

- A light waves, radio waves, γ -rays
- B light waves, radio waves, sound waves
- C light waves, sound waves, γ -rays
- D radio waves, sound waves, γ -rays

A word is missing from the label below the spectrum. Which word is missing?

- A amplitude
- B frequency
- C speed
- D wavelength

6 Radiation from which part of the electromagnetic spectrum is used in the remote controller for a television?

- A infra-red waves
- B microwaves
- C radio waves
- D ultraviolet waves

7 Which part of the electromagnetic spectrum is used to send television signals from a satellite to Earth?

- A infra-red
- B microwaves
- C ultraviolet
- D visible light

8 Which description applies to infra-red radiation?

- A longitudinal and electromagnetic
- B longitudinal but not electromagnetic
- C transverse and electromagnetic
- D transverse but not electromagnetic

9 Which row shows the natures of light waves, sound waves and X-rays?

	light waves	sound waves	X-rays
A	longitudinal	longitudinal	transverse
B	longitudinal	transverse	longitudinal
C	transverse	longitudinal	transverse
D	transverse	transverse	longitudinal

10 Visible light has a frequency of approximately 5.0×10^{14} Hz.

M and N are two other types of electromagnetic radiation.

The frequency of M is 5.0×10^6 Hz.

The frequency of N is 5.0×10^{15} Hz.

Which types of radiation are M and N?

	M	N
A	radio waves	infra-red
B	radio waves	ultraviolet
C	ultraviolet	X-rays
D	X-rays	infra-red

- 11 The table gives common uses for three types of electromagnetic wave.
Which row correctly identifies the waves?

	satellite television	terrestrial television (not satellite)	television remote controllers
A	infra-red waves	microwaves	radio waves
B	microwaves	radio waves	infra-red waves
C	radio waves	infra-red waves	microwaves
D	radio waves	microwaves	infra-red waves

- 12 Infra-red waves, microwaves, radio waves and sound waves are all used for communications.
Which waves travel at the same high speed in a vacuum?

- A infra-red waves, microwaves and radio waves
- B infra-red waves, microwaves and sound waves
- C infra-red waves, radio waves and sound waves
- D microwaves, radio waves and sound waves

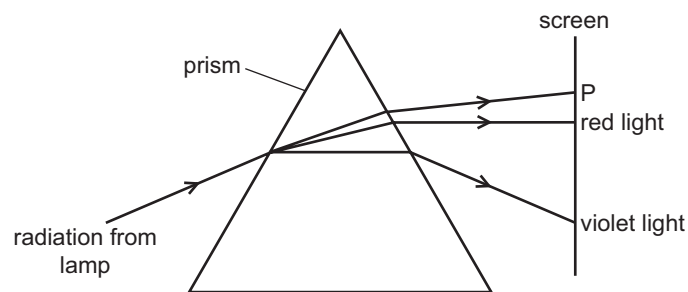
- 13 What is the unit of wavelength?

- A hertz
- B metre
- C metre per second
- D second

- 14 Which row correctly describes light waves and radio waves?

	light waves	radio waves
A	longitudinal	longitudinal
B	longitudinal	transverse
C	transverse	longitudinal
D	transverse	transverse

- 15 The diagram shows radiation from a lamp passing through a prism.



Which type of radiation is found at P?

- A γ -rays
- B infra-red
- C ultraviolet
- D X-rays

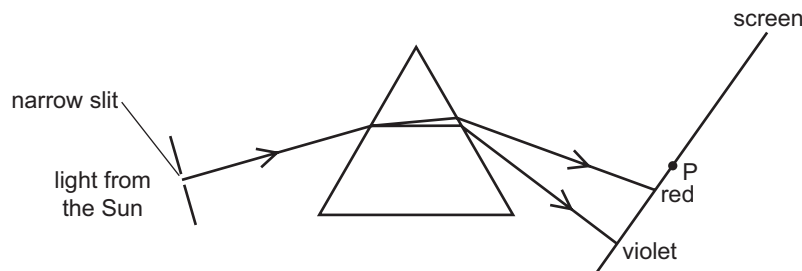
- 17 Which type of wave **cannot** travel through a vacuum?

- A infra-red radiation
- B microwaves
- C sound waves
- D X-rays

- 18 Which statement is correct about the speed of electromagnetic waves in a vacuum?

- A Ultra-violet waves have the greatest speed.
- B Visible light waves have the greatest speed.
- C Infra-red waves have the greatest speed.
- D All electromagnetic waves have the same speed.

- 16 Light from the Sun passes through a prism and a spectrum is produced on a screen.

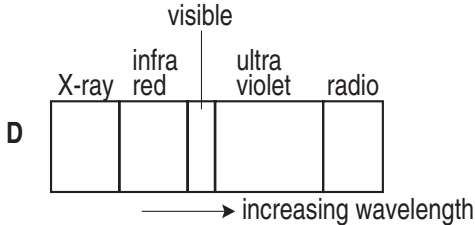
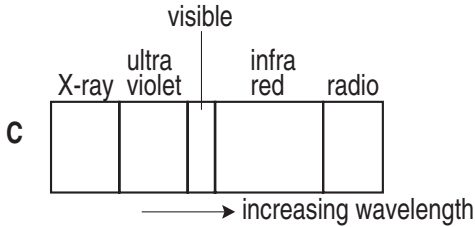
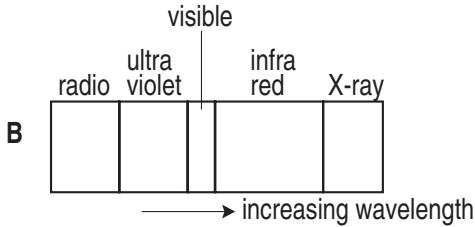
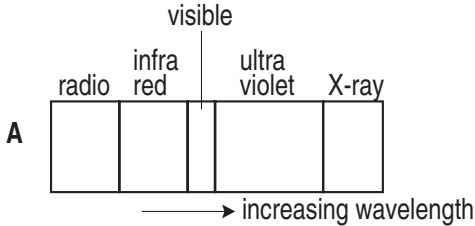


A thermometer placed at P shows a large temperature rise.

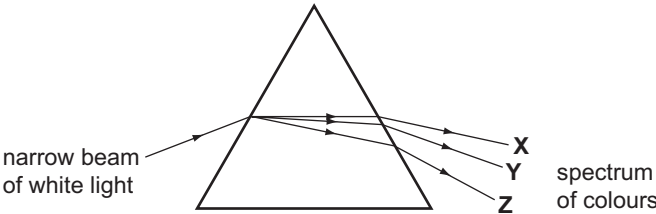
Which type of radiation causes this?

- A infra-red
- B microwave
- C ultra-violet
- D visible light

19 Which diagram shows the correct order of the waves in the electromagnetic spectrum?



20 A student shines a narrow beam of white light into a prism as shown in the diagram. He sees a spectrum of colours emerging from the prism.



Which three colours does he see at **X**, at **Y** and at **Z**?

	X	Y	Z
A	blue	yellow	red
B	red	blue	yellow
C	red	yellow	blue
D	yellow	red	blue

Electromagnetic spectrum

1 Fig. 1.1 represents the electromagnetic spectrum.

γ -rays	X-rays	ultra-violet	visible light			radio waves
----------------	--------	--------------	---------------	--	--	-------------

Fig. 1.1

(a) Identify one feature that is the same for all radiations that form the electromagnetic spectrum.

.....
 [1]

(b) Fill in the blank spaces between visible light and radio waves by adding the names of the radiations. [2]

(c) State the radiation that has the shortest wavelength.

..... [1]

(d) (i) Describe a common use of X-rays.

.....
 [1]

(ii) State a precaution taken by those who work with X-rays.

.....
 [1]

[Total: 6]

2 (a) A student arranges two 45° prisms as shown in Fig. 2.1. He aims a ray of red light to hit the surface of one of the prisms at 90° .

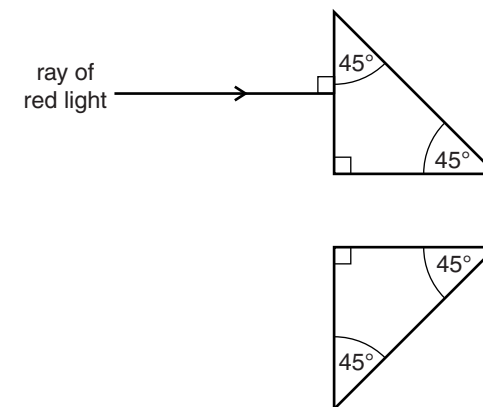


Fig. 2.1

The critical angle for the glass is 42° .

On Fig. 2.1, draw the path of the light through the prisms. [4]

(b) Visible light is one region of the electromagnetic spectrum, as represented in Fig. 2.2.

radio waves	microwaves	infra-red waves	visible light	ultraviolet waves		
-------------	------------	-----------------	---------------	-------------------	--	--

long wavelength

short wavelength

Fig. 2.2

(i) Two regions of the electromagnetic spectrum are missing from Fig. 2.2.

State the name of the missing region with the longer wavelength.

.....[1]

(ii) An infra-red sensor is fitted into a room as part of an intruder alarm system.

Explain how the sensor detects a person in the room.

.....
 [2]

(iii) State two properties that are the same for all electromagnetic waves.

1.
 2. [2]

[Total: 9]

3 (a) Describe the use of X-rays in a security application. Include a diagram.

.....

.....

.....

.....

.....

(b) Draw a straight line from each wave to the most appropriate speed.

radio waves
in air

ultrasound
in air

X-rays in
a vacuum

300 m/s
(3 × 10²)

6000 m/s
(6 × 10³)

1 000 000 m/s
(1 × 10⁶)

300 000 000 m/s
(3 × 10⁸)

60 000 000 000 m/s
(6 × 10¹⁰)

1 000 000 000 000 m/s
(1 × 10¹²)

[3]

[3]

[Total: 6]

4 (a) The following list contains the names of types of energy transfer by means of waves.

γ-rays, infra-red, radio/TV/microwaves, sound, visible light, X-rays

(i) Which one of these is **not** a type of electromagnetic wave?

..... [1]

(ii) State the nature of the wave you have named in (a)(i).

..... [1]

(iii) The remaining names in the list are all regions of the electromagnetic spectrum, but one region is missing.

Name the missing region.

..... [1]

(b) A television station emits waves with a frequency of $2.5 \times 10^8 \text{ Hz}$. Electromagnetic waves travel at a speed of $3.0 \times 10^8 \text{ m/s}$.

Calculate the wavelength of the waves emitted by this television station. State the equation you use.

wavelength = [3]

[Total: 6]

5 In alphabetical order, some major regions of the electromagnetic spectrum are

gamma,
infra-red,
radio,
ultra-violet,
visible,
X-rays.

(a) List these regions in order of decreasing wavelength. The first one has been filled in for you.

longest wavelength **radio**

.....

.....

.....

.....

shortest wavelength [2]

(b) Where in this list would you insert microwaves?

..... [1]

(c) A microwave oven is one device that makes use of microwaves.

Explain why the design of microwave ovens must include effective screening, so that microwaves do not escape.

.....

.....

..... [1]

(d) Suggest one other use for microwaves.

..... [1]

[Total: 5]

- 6 (a) Circle **two** of the following that apply to an ultrasound wave travelling in air.

frequency 3.5 Hz frequency 350 Hz frequency 35 000 Hz longitudinal
transverse speed 1.5 m/s speed 1.5×10^3 m/s speed 1.5×10^6 m/s

[2]

- (b) Calculate the wavelength in a vacuum of X-rays of frequency 1.3×10^{17} Hz.

wavelength =[3]

- (c) A dentist takes an X-ray photograph of a patient's teeth. Explain why it is safe for the patient to be close to the source of X-rays, but the dentist must stand away from the source.

.....
.....
.....
.....[2]

- (d) State, with a reason, why microwave ovens are designed only to work with the door closed.

.....
.....
.....[2]

[Total: 9]

- 7 Fig. 7.1 shows the parts of the electromagnetic spectrum.

γ -rays and X-rays	ultra-violet	visible	infra-red	radio waves
---------------------------	--------------	---------	-----------	-------------

Fig. 7.1

- (a) Name one type of radiation that has

- (i) a higher frequency than ultra-violet,

..... [1]

- (ii) a longer wavelength than visible light.

..... [1]

- (b) Some γ -rays emitted from a radioactive source have a speed in air of 3.0×10^8 m/s and a wavelength of 1.0×10^{-12} m.

Calculate the frequency of the γ -rays.

frequency = [2]

- (c) State the approximate speed of infra-red waves in air.

..... [1]

- 8 Fig. 8.1 shows the regions of the electromagnetic spectrum. Two regions have not been named, and there is an enlargement of the visible region.

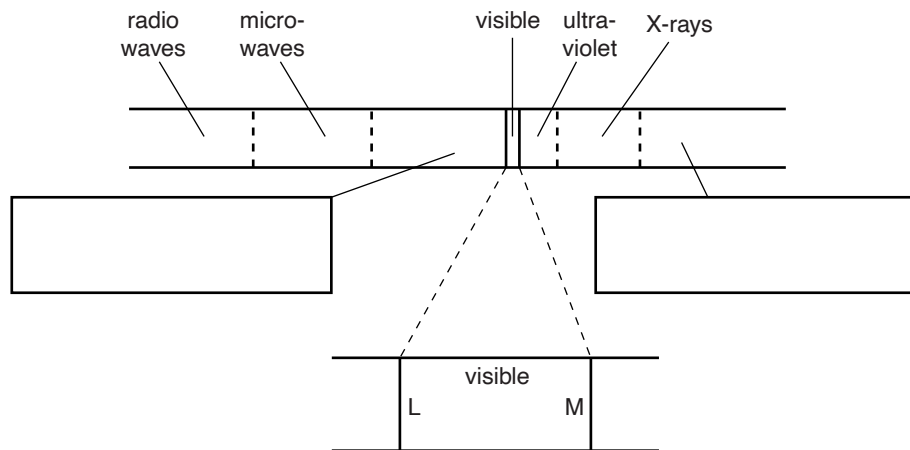


Fig. 8.1

- (a) In the two boxes on Fig. 8.1, write the names of the regions they are indicating. [2]

- (b) State the name of the colour of the light that is found

(i) at the end L of the visible spectrum,

(ii) at the end M of the visible spectrum.

[2]

- (c) (i) A man stands in the beam of light from a spot-lamp and finds that it makes him feel warm.

Which radiation, other than visible, does this observation show that the spotlight is emitting?

.....

- (ii) Suggest one use to which X-rays are put.

.....

[2]

- (d) State one property, apart from their electromagnetic nature, that is the same for the radiations in all the regions of the electromagnetic spectrum.

.....[1]

[Total: 7]

Kinematics

61. A 10-g penny is dropped from a building that is 125 m high. The penny is initially at rest. Approximately how long does it take the penny to hit the ground?

- (A) 3.2 s
- (B) 4.5 s
- (C) 10 s
- (D) 15 s
- (E) 20 s

62. A car in a drag race started from rest and accelerated constantly to a velocity of 50 m/s when it reached the end of a 500-m road. What was the car's rate of acceleration?

- (A) -5.0 m/s^2
- (B) -2.5 m/s^2
- (C) 0.5 m/s^2
- (D) 2.5 m/s^2
- (E) 5.0 m/s^2

63. An airplane is flying horizontally at a velocity of 50.0 m/s at an altitude of 125 m. It drops a package to observers on the ground below. Approximately how far will the package travel in the horizontal direction from the point that it was dropped?

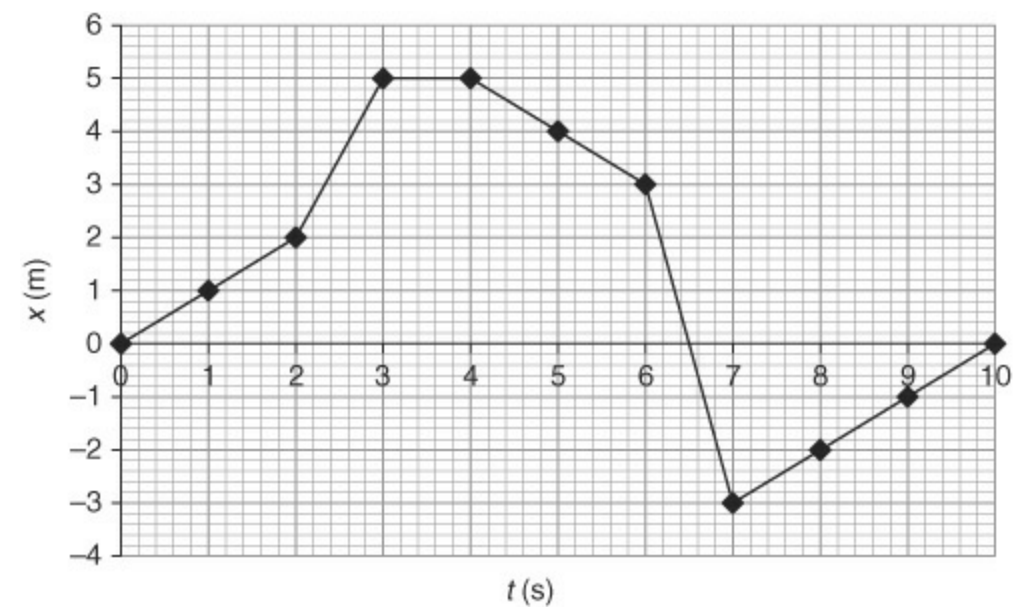
- (A) 100 m
- (B) 159 m
- (C) 250 m

- (D) 1,020 m
- (E) 1,590 m

64. A place kicker kicks a football at a velocity of 10.0 m/s from a tee on the ground at an angle of 30° from the horizontal. Approximately how long will the ball stay in the air?

- (A) 0.0 s
- (B) 0.6 s
- (C) 0.8 s
- (D) 1.0 s
- (E) 1.8 s

65. This graph depicts the motion of an object. During which time interval is the object at rest?



- (A) 0–2 s
- (B) 2–3 s
- (C) 3–4 s
- (D) 4–7 s

(E) 7–10 s

66. A car is traveling at an unknown velocity. It accelerates constantly over 5.0 s at a rate of 3.0 m/s^2 to reach a velocity of 30 m/s. What was the original velocity of the car?

(A) 1.0 m/s

(B) 5.0 m/s

(C) 10 m/s

(D) 15 m/s

(E) 20 m/s

67. A plane takes off from rest and accelerates constantly at a rate of 1.0 m/s for 5 min. How far does the plane travel in this time?

(A) 15 km

(B) 30 km

(C) 45 km

(D) 90 km

(E) 150 km

68. You drop a stone down a well and hear the echo 8.9 s later. If it takes 0.9 s for the echo to travel up the well, approximately how deep is the well?

(A) 40 m

(B) 320 m

(C) 405 m

(D) 640 m

(E) 810 m

69. If you throw a ball straight up into the air, which of the following expressions represents the time at which the ball reaches its maximum

height?

(A) $t = v_f/v_0$

(B) $t = \Delta y/a$

(C) $t = a/(-v_0)$

(D) $t = a/\Delta y$

(E) $t = (-v_0)/a$

70. [For Physics C Students Only] The position of an object can be described by the function, $x(t) = 4t^2 + 6t + 2$. The units of t are in s and the units of x are in m. At 4 s, what is the direction and speed of the object?

(A) 90 m/s in the original direction of motion

(B) 38 m/s in the original direction of motion

(C) 0 m/s

(D) 38 m/s opposite the original direction of motion

(E) 90 m/s opposite the original direction of motion

71. On an airless planet, an astronaut drops a hammer from a height of 15 m. The hammer hits the ground in 1 s. What is the acceleration due to the gravity on this planet?

(A) 10 m/s^2

(B) 15 m/s^2

(C) 20 m/s^2

(D) 25 m/s^2

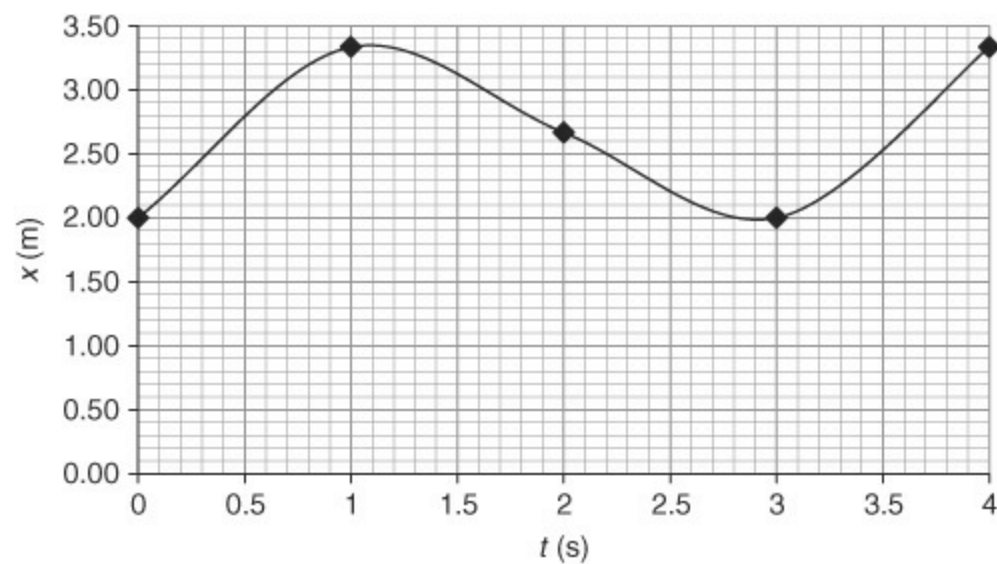
(E) 30 m/s^2

72. A car uniformly accelerates from rest at 3.0 m/s^2 down a 15-m track. What is the car's final velocity?

(A) 30 m/s

- (B) 90 m/s
- (C) 150 m/s
- (D) 450 m/s
- (E) 900 m/s

73. [For Physics C Students Only] An object's position with time is depicted in this graph. Based on that graph, at which time points will the object's velocity be zero?



- (A) 0 s and 2 s
- (B) 0 s and 4 s
- (C) 1 s and 2 s
- (D) 1 s and 3 s
- (E) 2 s and 4 s

74. At what time point does a projectile that is launched at an angle from the ground reach its maximum height?

- (A) One-fifth of the total time in the air
- (B) One-fourth of the total time in the air
- (C) One-half of the total time in the air

- (D) Three-fifths of the total time in the air
- (E) Three-fourths of the total time in the air

75. A boy drops a stone from a cliff and counts the seconds until the stone hits the base. He counts 3 s. About how high is the cliff?

- (A) 3 m
- (B) 10 m
- (C) 15 m
- (D) 45 m
- (E) 90 m

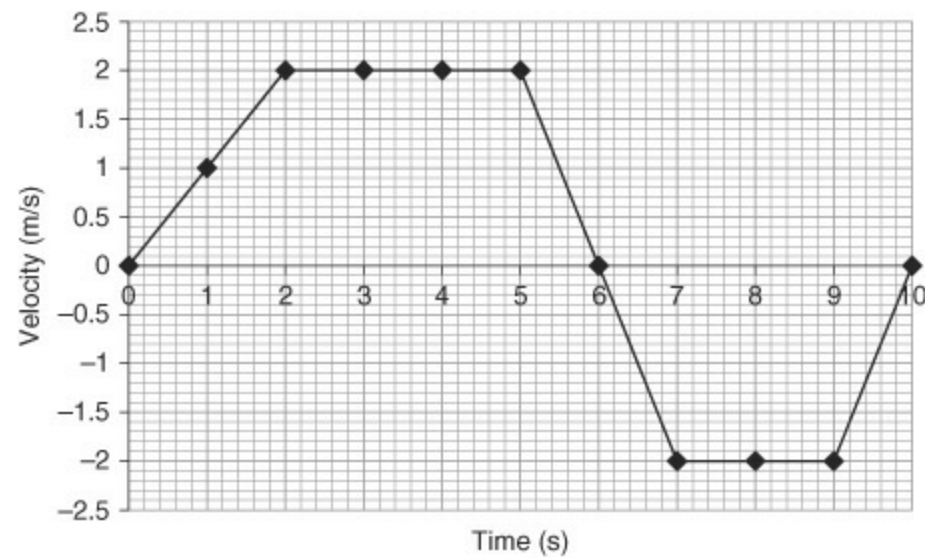
76. A boy is riding a bicycle at a velocity of 5.0 m/s. He applies the brakes and uniformly decelerates to a stop at a rate of 2.5 m/s^2 . How long does it take for the bicycle to stop?

- (A) 0.5 s
- (B) 1.0 s
- (C) 1.5 s
- (D) 2.0 s
- (E) 2.5 s

77. A police officer finds 60 m of skid marks at the scene of a car crash. Assuming a uniform deceleration of 7.5 m/s^2 to a stop, at what was the initial velocity that the car was traveling when it started skidding?

- (A) 20 m/s
- (B) 30 m/s
- (C) 45 m/s
- (D) 60 m/s
- (E) 90 m/s

78. The velocity–time graph of an object’s motion is shown in this graph. At 10 s, what is the object’s displacement relative to the initial time?



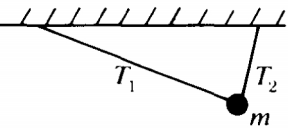
- (A) 3 m
(B) 6 m
(C) 9 m
(D) -6 m
(E) -3 m
79. A projectile is launched with an unknown velocity at an angle of 30° from the horizontal of level ground. Which of the following statements is true?
- (A) The horizontal component of velocity is less than the vertical component of velocity.
(B) The horizontal component of velocity is greater than the vertical component of velocity.
(C) Both the horizontal and vertical components of velocity are equal.
(D) The horizontal component of velocity is used to calculate the time that the projectile is in the air.
(E) The vertical component of velocity is used to calculate the range of the projectile.

80. From rest, a ball is dropped from the top of a building. It takes 4 s to hit the ground. Approximately how tall is the building?

- (A) 40 m
(B) 90 m
(C) 100 m
(D) 160 m
(E) 200 m

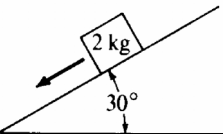
2. Tricky MCQ for Dynamics

SECTION A – Linear Dynamics



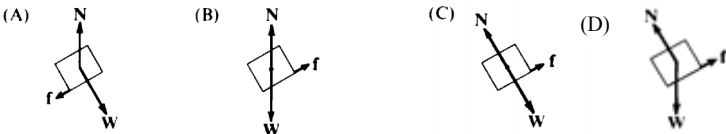
1. A ball of mass m is suspended from two strings of unequal length as shown above. The magnitudes of the tensions T_1 and T_2 in the strings must satisfy which of the following relations?
(A) $T_1 = T_2$ (B) $T_1 > T_2$ (C) $T_1 < T_2$ (D) $T_1 + T_2 = mg$

Questions 2 – 3

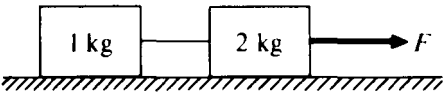


A 2-kg block slides down a 30° incline as shown above with an acceleration of 2 m/s^2 .

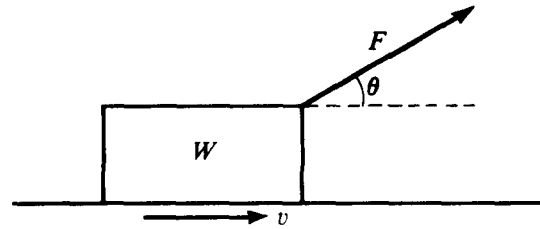
2. Which of the following diagrams best represents the gravitational force W , the frictional force f , and the normal force N that act on the block?



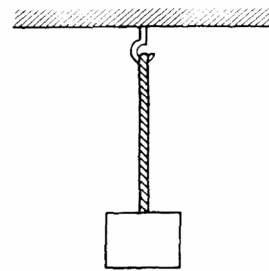
3. Which of the following correctly indicates the magnitudes of the forces acting up and down the incline?
(A) 20 N down the plane, 16 N up the plane
(B) 4 N down the plane, 4 N up the plane
(C) 0 N down the plane, 4 N up the plane
(D) 10 N down the plane, 6 N up the plane



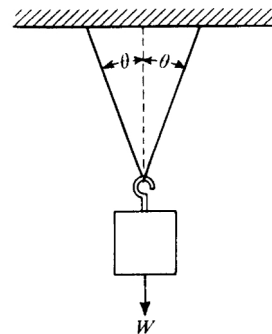
4. When the frictionless system shown above is accelerated by an applied force of magnitude the tension in the string between the blocks is (A) F (B) $\frac{2}{3}F$ (C) $\frac{1}{2}F$ (D) $\frac{1}{3}F$
5. A ball falls straight down through the air under the influence of gravity. There is a retarding force F on the ball with magnitude given by $F = bv$, where v is the speed of the ball and b is a positive constant. The ball reaches a terminal velocity after a time t . The magnitude of the acceleration at time $t/2$ is
(A) Increasing
(B) Decreasing
(C) 10 m/s^2
(D) Zero



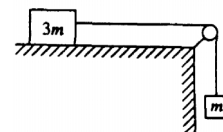
6. A block of weight W is pulled along a horizontal surface at constant speed v by a force F , which acts at an angle of θ with the horizontal, as shown above. The normal force exerted on the block by the surface has magnitude
- (A) greater than W
 (B) greater than zero but less than W
 (C) equal to W
 (D) zero



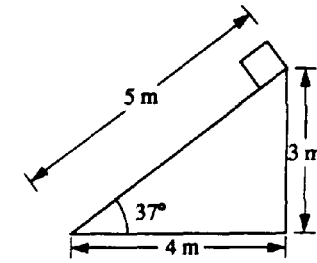
7. A uniform rope of weight 50 N hangs from a hook as shown above. A box of weight 100 N hangs from the rope. What is the tension in the rope?
- (A) 75 N throughout the rope (B) 100 N throughout the rope
 (C) 150 N throughout the rope (D) It varies from 100 N at the bottom of the rope to 150 N at the top.



8. When an object of weight W is suspended from the center of a massless string as shown above, the tension at any point in the string is
- (A) $2W\cos\theta$ (B) $\frac{1}{2}W\cos\theta$ (D) $W/(2\cos\theta)$ (E) $W/(\cos\theta)$



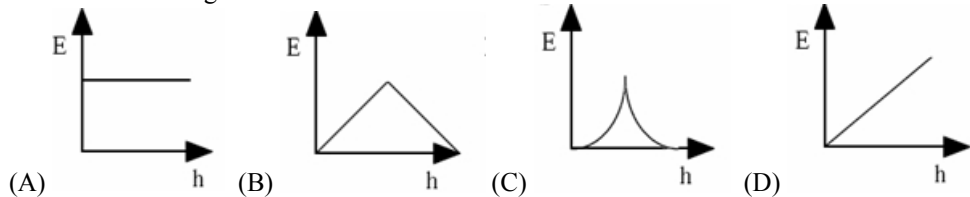
9. A block of mass $3m$ can move without friction on a horizontal table. This block is attached to another block of mass m by a cord that passes over a frictionless pulley, as shown above. If the masses of the cord and the pulley are negligible, what is the magnitude of the acceleration of the descending block?
- (A) $g/4$ (B) $g/3$ (C) $2g/3$ (D) g



A plane 5 meters in length is inclined at an angle of 37° , as shown above. A block of weight 20 N is placed at the top of the plane and allowed to slide down.

10. The magnitude of the normal force exerted on the block by the plane is
- (A) greater than 20 N
 (B) greater than zero but less than 20 N
 (C) equal to 20 N
 (D) zero

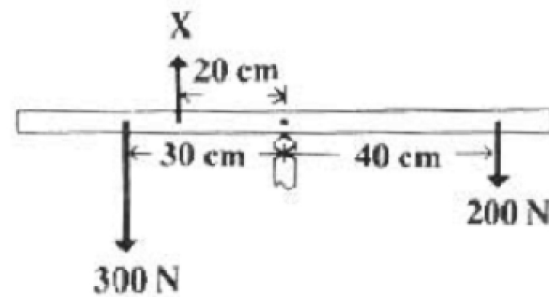
Momentum and Impulse

- A car of mass m , traveling at speed v , stops in time t when maximum braking force is applied. Assuming the braking force is independent of mass, what time would be required to stop a car of mass $2m$ traveling at speed v ?
(A) $\frac{1}{2}t$ (B) t (C) $\sqrt{2}t$ (D) $2t$
- A block of mass M is initially at rest on a frictionless floor. The block, attached to a massless spring with spring constant k , is initially at its equilibrium position. An arrow with mass m and velocity v is shot into the block. The arrow sticks in the block. What is the maximum compression of the spring?
(A) $v\sqrt{\frac{m}{k}}$ (B) $v\sqrt{\frac{m+M}{k}}$ (C) $\frac{(m+M)v}{\sqrt{mk}}$ (D) $\frac{mv}{\sqrt{(m+M)k}}$
- Two objects, P and Q, have the same momentum. Q can have more kinetic energy than P if it has:
(A) More mass than P (B) The same mass as P (C) More speed than P (D) The same speed as P
- A spring is compressed between two objects with unequal masses, m and M , and held together. The objects are initially at rest on a horizontal frictionless surface. When released, which of the following is true?
(A) The total final kinetic energy is zero.
(B) The two objects have equal kinetic energy.
(C) The speed of one object is equal to the speed of the other.
(D) The total final momentum of the two objects is zero.
- Two football players with mass 75 kg and 100 kg run directly toward each other with speeds of 6 m/s and 8 m/s respectively. If they grab each other as they collide, the combined speed of the two players just after the collision would be:
(A) 2 m/s (B) 3.4 m/s (C) 4.6 m/s (D) 7.1 m/s
- A 5000 kg freight car moving at 4 km/hr collides and couples with an 8000 kg freight car which is initially at rest. The approximate common final speed of these two cars is
(A) 1 km/h (B) 1.3 km/h (C) 1.5 km/h (D) 2.5 km/h
- A rubber ball is held motionless a height h_0 above a hard floor and released. Assuming that the collision with the floor is elastic, which one of the following graphs best shows the relationship between the total energy E of the ball and its height h above the surface.

- Two carts are held together. Cart 1 is more massive than Cart 2. As they are forced apart by a compressed spring between them, which of the following will have the same magnitude for both carts.
(A) change of velocity (B) force (C) speed (D) velocity
- A ball with a mass of 0.50 kg and a speed of 6 m/s collides perpendicularly with a wall and bounces off with a speed of 4 m/s in the opposite direction. What is the magnitude of the impulse acting on the ball?
(A) 1 Ns (B) 5 Ns (C) 2 m/s (D) 10 m/s
- A cart with mass $2m$ has a velocity v before it strikes another cart of mass $3m$ at rest. The two carts couple and move off together with a velocity of
(A) $v/5$ (B) $2v/5$ (C) $2v/3$ (D) $(2/5)^{1/2}v$

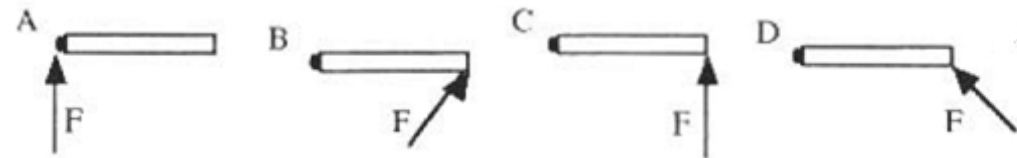
3. Tricky MCQ for Turning effect

Torque

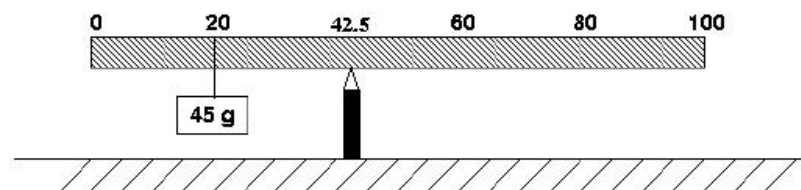
1. A uniform meterstick of mass 0.20 kg is pivoted at the 40 cm mark. Where should one hang a mass of 0.50 kg to balance the stick?
(A) 16 cm (B) 36 cm (C) 44 cm (D) 46 cm
2. A uniform meterstick is balanced at its midpoint with several forces applied as shown below. If the stick is in equilibrium, the magnitude of the force X in newtons (N) is
(A) 50 N (B) 100 N (C) 200 N (D) 300 N



3. A door (seen from above in the figures below) has hinges on the left hand side. Which force produces the largest torque? The magnitudes of all forces are equal.

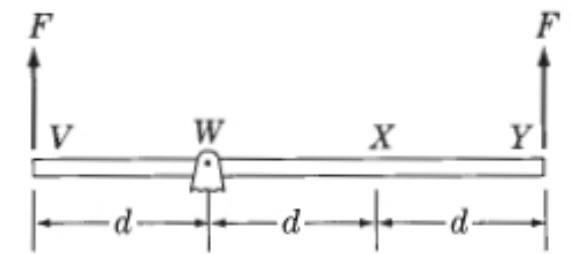


4. A meterstick is supported at each side by a spring scale. A heavy mass is then hung on the meterstick so that the spring scale on the left hand side reads four times the value of the spring scale on the right hand side. If the mass of the meterstick is negligible compared to the hanging mass, how far from the right hand side is the large mass hanging.
(A) 25 cm (B) 67 cm (C) 75 cm (D) 80 cm
5. A uniform meter stick has a 45.0 g mass placed at the 20 cm mark as shown in the figure. If a pivot is placed at the 42.5 cm mark and the meter stick remains horizontal in static equilibrium, what is the mass of the meter stick?



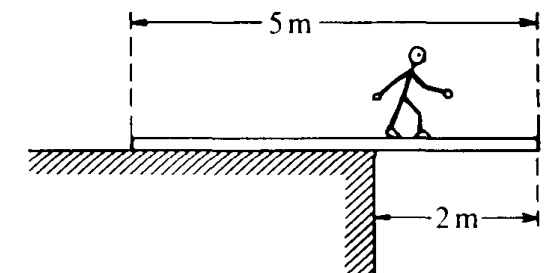
- (A) 45.0 g (B) 72.0 g (C) 120.0 g (D) 135.0 g

6. A massless rigid rod of length $3d$ is pivoted at a fixed point W , and two forces each of magnitude F are applied vertically upward as shown. A third vertical force of magnitude F may be applied, either upward or downward, at one of the labeled points. With the proper choice of direction at each point, the rod can be in equilibrium if the third force of magnitude F is applied at point



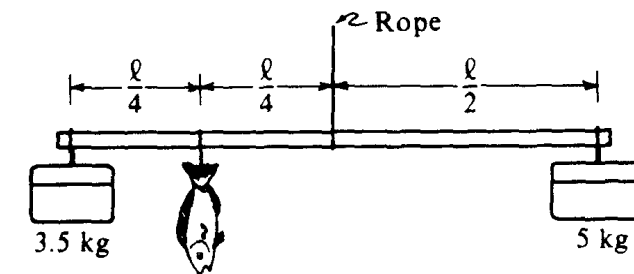
- (A) Y only (B) V or X only (C) V or Y only (D) V, W, or X

7. A 5-meter uniform plank of mass 100 kilograms rests on the top of a building with 2 meters extended over the edge as shown. How far can a 50-kilogram person venture past the edge of the building on the plank before the plank just begins to tip?



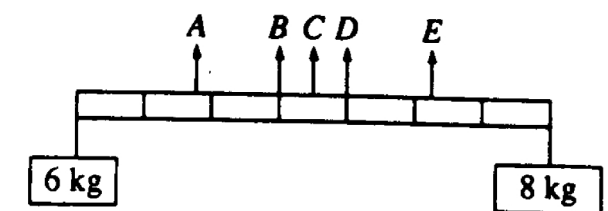
- (A) 0.5 m (B) 1 m (C) 1.5 m (D) 2 m

8. To weigh a fish, a person hangs a tackle box of mass 3.5 kilograms and a cooler of mass 5 kilograms from the ends of a uniform rigid pole that is suspended by a rope attached to its center. The system balances when the fish hangs at a point $1/4$ of the rod's length from the tackle box. What is the mass of the fish?



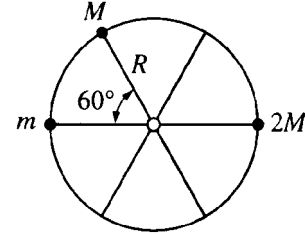
- (A) 1.5 kg (B) 2 kg (C) 3 kg (D) 6 kg

9. Two objects, of masses 6 and 8 kilograms, are hung from the ends of a stick that is 70 cm long and has marks every 10 cm, as shown. If the mass of the stick is negligible, at which of the points indicated should a cord be attached if the stick is to remain horizontal when suspended from the cord?



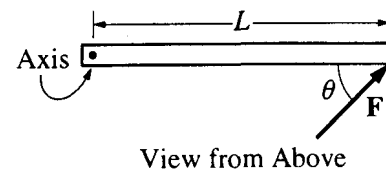
- (A) A (B) B (C) C (D) D

10. A wheel of radius R and negligible mass is mounted on a horizontal frictionless axle so that the wheel is in a vertical plane. Three small objects having masses m , M , and $2M$, respectively, are mounted on the rim of the wheel, as shown. If the system is in static equilibrium, what is the value of m in terms of M ?

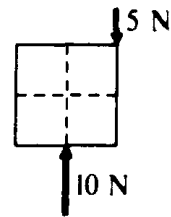


- (A) $M/2$ (B) M (C) $3M/2$ (D) $5M/2$

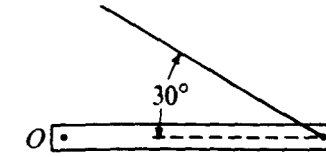
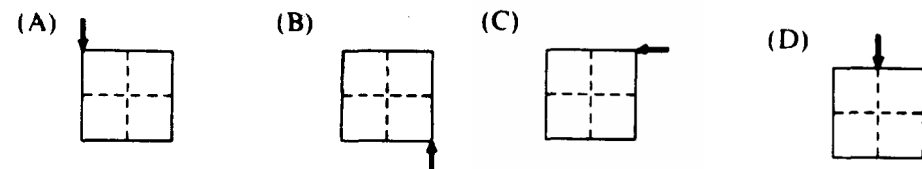
11. A rod on a horizontal tabletop is pivoted at one end and is free to rotate without friction about a vertical axis, as shown. A force F is applied at the other end, at an angle θ to the rod. If F were to be applied perpendicular to the rod, at what distance from the axis should it be applied in order to produce the same torque?



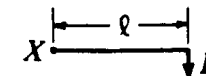
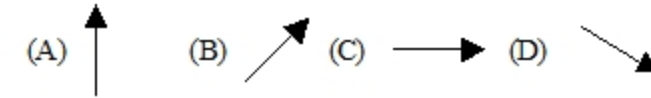
- (A) $L \sin \theta$ (B) $L \cos \theta$ (C) L (D) $L \tan \theta$



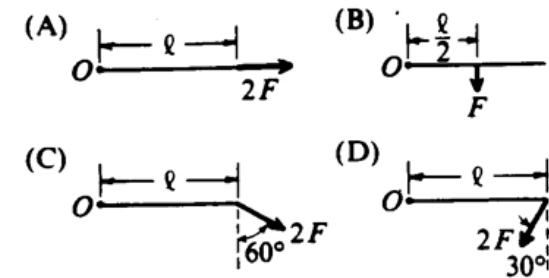
12. A square piece of plywood on a horizontal tabletop is subjected to the two horizontal forces shown. Where should a third force of magnitude 5 newtons be applied to put the piece of plywood into equilibrium?



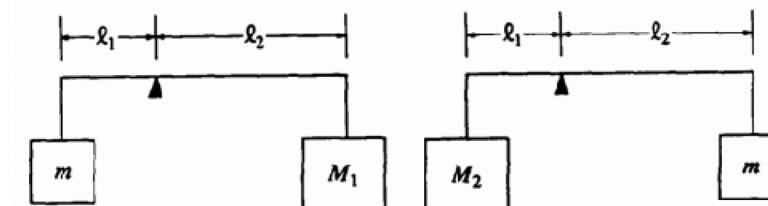
13. A uniform rigid bar of weight W is supported in a horizontal orientation as shown by a rope that makes a 30° angle with the horizontal. The force exerted on the bar at point O , where it is pivoted, is best represented by a vector whose direction is which of the following?



14. In which of the following diagrams is the torque about point O equal in magnitude to the torque about point X in the diagram? (All forces lie in the plane of the paper.)



15. A rod of length L and of negligible mass is pivoted at a point that is off-center with lengths shown in the figure below. The figures show two cases in which masses are suspended from the ends of the rod. In each case the unknown mass m is balanced by a known mass, M_1 or M_2 , so that the rod remains horizontal. What is the value of m in terms of the known masses?

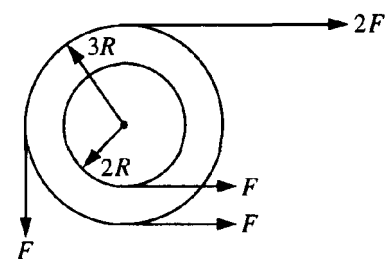


- (A) $\sqrt{M_1 M_2}$ (B) $\frac{1}{2}(M_1 + M_2)$ (C) $M_1 M_2$ (D) $\frac{1}{2}M_1 M_2$

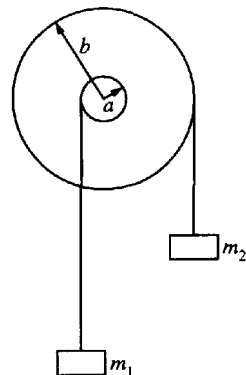
4. Tricky MCQ for Forces & Matter

– Fluid Mechanics

16. A system of two wheels fixed to each other is free to rotate about a frictionless axis through the common center of the wheels and perpendicular to the page. Four forces are exerted tangentially to the rims of the wheels, as shown. The magnitude of the net torque on the system about the axis is
(A) zero (B) $2FR$ (C) $5FR$ (D) $14FR$

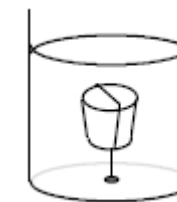


17. For the wheel-and-axle system shown, which of the following expresses the condition required for the system to be in static equilibrium?
(A) $m_1 = m_2$
(B) $am_1 = bm_2$
(C) $am_2 = bm_1$
(D) $a^2m_1 = b^2m_2$



18. A meterstick of negligible mass is placed on a fulcrum at the 0.60 m mark, with a 2.0 kg mass hung at the 0 m mark and a 1.0 kg mass hung at the 1.0 m mark. The meterstick is released from rest in a horizontal position. Immediately after release, the magnitude of the net torque on the meterstick about the fulcrum is most nearly
(A) $2.0 \text{ N}\cdot\text{m}$ (B) $8.0 \text{ N}\cdot\text{m}$ (C) $10 \text{ N}\cdot\text{m}$ (D) $16 \text{ N}\cdot\text{m}$

1. A cork has weight mg and density 25% of water's density. A string is tied around the cork and attached to the bottom of a water-filled container. The cork is totally immersed. Express the tension in the string in terms of the cork weight mg .



- A) 0
B) mg
C) $2mg$
D) $3mg$

2. Three objects all float on top of water. They have the following relationships:

- A and B have the same mass and same density but different shapes
- B and C have the same volume and same shape
- mass & density of C < mass & density of B

Three identical weights are tied to each object, and each is pulled completely beneath the water. Which object will displace the greatest amount of water?

- A) A
B) B
C) C
D) All displace the same amount of water.

3. As a rock sinks deeper and deeper into water of constant density, what happens to the buoyant force on it?

- A) It increases.
B) It remains constant.
C) It decreases.
D) It may increase or decrease, depending on the shape of the rock.

4. A piece of wood with a volume of 50 cm^3 is floating on water, and a piece of iron with a volume of 50 cm^3 is totally submerged. Which has the greater buoyant force on it?

- A) The wood.
B) The iron.
C) Both have the same buoyant force.
D) Cannot be determined without knowing their densities.

5. Salt water is more dense than fresh water. A ship floats in both fresh water and salt water. Compared to the fresh water, the amount of water displaced by the ship when it is in the salt water is

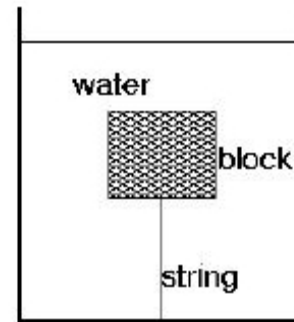
- A) more.
B) less.
C) the same.
D) Cannot be determined from the information given.

6. Water flows through a horizontal pipe. The diameter of the pipe at point B is larger than at point A. Where is the water pressure greater?

- A) Point A
B) Point B
C) Same at both A and B
D) Cannot be determined from the information given.

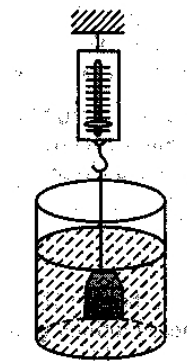
- 7 Two objects labeled K and L have equal mass but densities $0.95D_o$ and D_o , respectively. Each of these objects floats after being thrown into a deep swimming pool. Which is true about the buoyant forces acting on these objects?
- (A) The buoyant force is greater on Object K since it has a lower density and displaces more water.
 (B) The buoyant force is greater on Object K since it has lower density and lower density objects always float “higher” in the fluid.
 (C) The buoyant force is greater on Object L since it is denser than K and therefore “heavier.”
 (D) The buoyant forces are equal on the objects since they have equal mass.

- 8 A block is connected to a light string attached to the bottom of a large container of water. The tension in the string is 3.0 N. The gravitational force from the earth on the block is 5.0 N. What is the block’s volume?
- (A) $2.0 \times 10^{-4} \text{ m}^3$
 (B) $3.0 \times 10^{-4} \text{ m}^3$
 (C) $5.0 \times 10^{-4} \text{ m}^3$
 (D) $8.0 \times 10^{-4} \text{ m}^3$



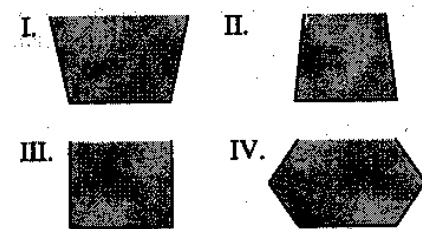
- 9 The figure shows an object of mass 0.4 kg that is suspended from a scale and submerged in a liquid. If the reading on the scale is 3 N, then the buoyant force that the fluid exerts on the object is most nearly

- (A) 1.3 N
 (B) 1.0 N
 (C) 0.75 N
 (D) 0.33 N

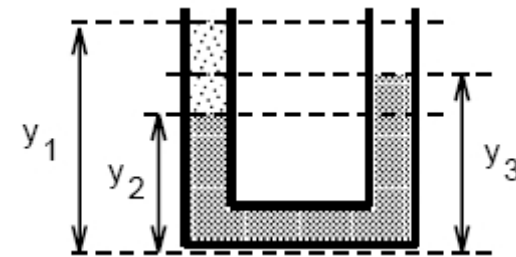


- 10 Each of the beakers shown is filled to the same depth h with liquid of density ρ . The area A of the flat bottom is the same for each beaker. Which of the following ranks the beakers according to the net downward force exerted by the liquid on the flat bottom, from greatest to least force?

- (A) I, III, II, IV
 (B) I, IV, III, II
 (C) II, III, IV, I
 (D) None of the above, the force on each is the same.



- 11 **Multiple Correct:** In the open manometer shown, water occupies a part of the left arm, from a height of y_1 to a height of y_2 . The remainder of the left arm, the bottom of the tube, and the right arm to a height of y_3 are filled with mercury.



Which of the following is correct? (Select two answers.)

- (A) the pressure at a height y_3 is the same in both arms.
 (B) the pressure at a height y_2 is the same in both arms.
 (C) the pressure at the bottom of the right arm is the same as at the bottom of the left arm.
 (D) the pressure at a height y_3 is less in the left arm than in the right arm.

- 12 A vertical force of 30 N is applied uniformly to a flat button with a radius of 1 cm that is lying on a table. Which of the following is the best order of magnitude estimate for the pressure applied to the button?

- (A) 10^2 Pa
 (B) 10^3 Pa
 (C) 10^4 Pa
 (D) 10^5 Pa

Hooke's law

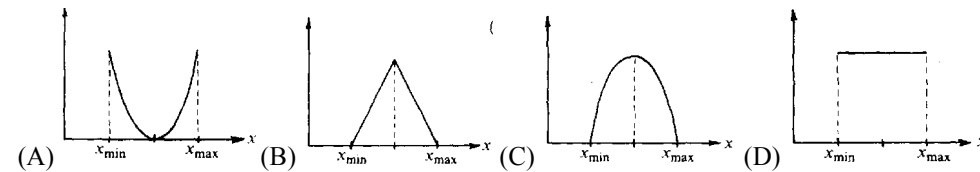
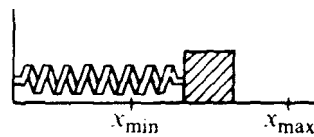
6. The stress at which extension of a material takes place more quickly as compared to the increase in load is called _____

- a) Elastic point
 b) Plastic point
 c) Breaking point
 d) Yielding point

7. Which of these is a non-hookean material?

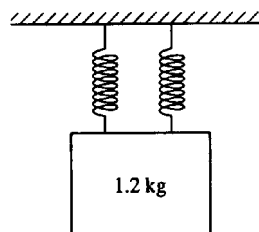
- a) Steel
 b) Rubber
 c) Aluminium
 d) Copper

Questions 16-17: A block oscillates without friction on the end of a spring as shown. The minimum and maximum lengths of the spring as it oscillates are, respectively, $x_{\min}$ and $x_{\max}$. The graphs below can represent quantities associated with the oscillation as functions of the length x of the spring.



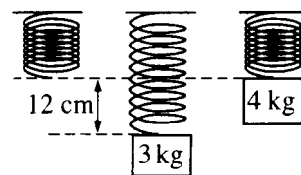
16. Which graph can represent the total mechanical energy of the block-spring system as a function of x ?
 (A) A (B) B (C) C (D) D

17. Which graph can represent the kinetic energy of the block as a function of x ?
 (A) A (B) B (C) C (D) D



20. Two massless springs, of spring constants k_1 and k_2 , are hung from a horizontal support. A block of weight 12 N is suspended from the pair of springs, as shown above. When the block is in equilibrium, each spring is stretched an additional 24 cm. Thus, the equivalent spring constant of the two-spring system is $12 \text{ N} / 24 \text{ cm} = 0.5 \text{ N/cm}$. Which of the following statements is correct about k_1 and k_2 ?
 (A) $k_1 = k_2 = 0.25 \text{ N/cm}$
 (B) $1/k_1 + 1/k_2 = 1/(0.5 \text{ N/cm})$
 (C) $k_1 - k_2 = 0.5 \text{ N/cm}$
 (D) $k_1 + k_2 = 0.5 \text{ N/cm}$

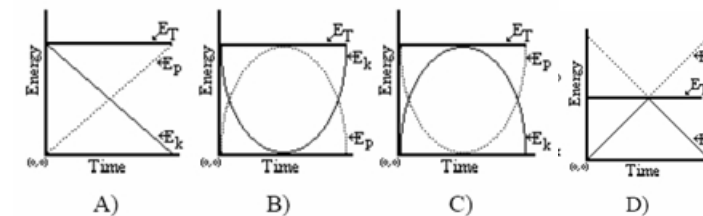
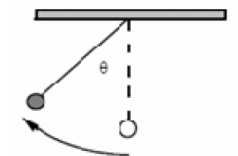
23. A block of mass 3.0 kg is hung from a spring, causing it to stretch 12 cm at equilibrium, as shown. The 3.0 kg block is then replaced by a 4.0 kg block, and the new block is released from the position shown, at which the spring is unstretched. How far will the 4.0 kg block fall before its direction is reversed?
 (A) 18 cm (B) 24 cm
 (C) 32 cm (D) 48 cm



5. Tricky MCQ for Work Energy & Power

Work-Energy

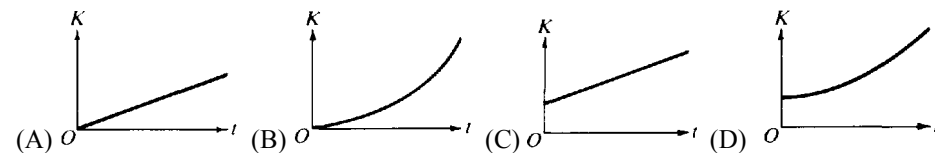
- A force F at an angle θ above the horizontal is used to pull a heavy suitcase of weight mg a distance d along a level floor at constant velocity. The coefficient of friction between the floor and the suitcase is μ . The work done by the frictional force is:
 (A) $-Fd \cos \theta$ (B) $-\mu Fd \cos \theta$ (C) $-\mu mgd$ (D) $-\mu mgd \cos \theta$
- A 2 kg ball is attached to a 0.80 m string and whirled in a horizontal circle at a constant speed of 6 m/s. The work done on the ball during each revolution is:
 (A) 90 J (B) 72 J (C) 16 J (D) zero
- A pendulum bob of mass m on a cord of length L is pulled sideways until the cord makes an angle θ with the vertical as shown in the figure to the right. The change in potential energy of the bob during the displacement is:
 (A) $mgL(1 - \cos \theta)$ (B) $mgL(1 - \sin \theta)$ (C) $mgL \sin \theta$ (D) $mgL \cos \theta$
- A softball player catches a ball of mass m , which is moving towards her with horizontal speed V . While bringing the ball to rest, her hand moved back a distance d . Assuming constant deceleration, the horizontal force exerted on the ball by the hand is
 (A) $mV^2/(2d)$ (B) mV^2/d (C) $2mV/d$ (D) mV/d
- A pendulum is pulled to one side and released. It swings freely to the opposite side and stops. Which of the following might best represent graphs of kinetic energy (E_k), potential energy (E_p) and total mechanical energy (E_T)



Questions 7-8: A car of mass m slides across a patch of ice at a speed v with its brakes locked. It hits dry pavement and skids to a stop in a distance d . The coefficient of kinetic friction between the tires and the dry road is μ .

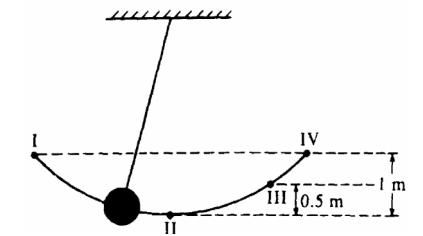
- If the car has a mass of $2m$, it would have skidded a distance of
 (A) $0.5d$ (B) d (C) $1.41d$ (D) $2d$
- If the car has a speed of $2v$, it would have skidded a distance of
 (A) d (B) $1.41d$ (C) $2d$ (D) $4d$
- A ball is thrown vertically upwards with a velocity v and an initial kinetic energy E_k . When half way to the top of its flight, it has a velocity and kinetic energy respectively of
 (A) $\frac{v}{2}, \frac{E_k}{2}$ (B) $\frac{v}{\sqrt{2}}, \frac{E_k}{2}$ (C) $\frac{v}{4}, \frac{E_k}{2}$ (D) $\frac{v}{2}, \frac{E_k}{\sqrt{2}}$

10. A football is kicked off the ground a distance of 50 yards downfield. Neglecting air resistance, which of the following statements would be INCORRECT when the football reaches the highest point?
- (A) all of the ball's original kinetic energy has been changed into potential energy
 (B) the ball's horizontal velocity is the same as when it left the kicker's foot
 (C) the ball will have been in the air one-half of its total flight time
 (D) the vertical component of the velocity is equal to zero
11. A mass m is attached to a spring with a spring constant k . If the mass is set into motion by a displacement d from its equilibrium position, what would be the speed, v , of the mass when it returns to equilibrium position?
- (A) $v = \sqrt{\frac{kd}{m}}$ (B) $v = d\sqrt{\frac{k}{m}}$ (C) $v = \frac{kd}{mg}$ (D) $v^2 = \frac{mgd}{k}$
12. A fan blows the air and gives it kinetic energy. An hour after the fan has been turned off, what has happened to the kinetic energy of the air?
- (A) it disappears (B) it turns into potential energy (C) it turns into thermal energy
 (D) it turns into sound energy
13. A rock is dropped from the top of a tall tower. Half a second later another rock, twice as massive as the first, is dropped. Ignoring air resistance,
- (A) the distance between the rocks increases while both are falling.
 (B) the acceleration is greater for the more massive rock.
 (C) they strike the ground more than half a second apart.
 (D) they strike the ground with the same kinetic energy.
14. Which of the following is true for a system consisting of a mass oscillating on the end of an ideal spring?
- (A) The kinetic and potential energies are equal to each other at all times.
 (B) The maximum potential energy is achieved when the mass passes through its equilibrium position.
 (C) The maximum kinetic energy and maximum potential energy are equal, but occur at different times.
 (D) The maximum kinetic energy occurs at maximum displacement of the mass from its equilibrium position
15. From the top of a high cliff, a ball is thrown horizontally with initial speed v_0 . Which of the following graphs best represents the ball's kinetic energy K as a function of time t ?

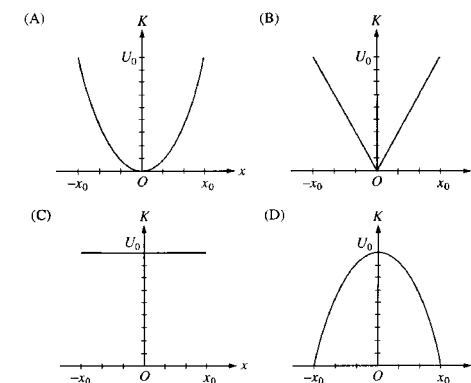
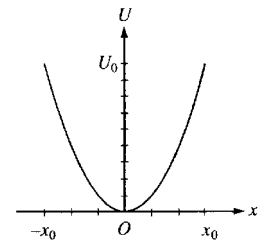


Questions 18-19

A ball swings freely back and forth in an arc from point I to point IV, as shown. Point II is the lowest point in the path, III is located 0.5 meter above II, and IV is 1 meter above II. Air resistance is negligible.



18. If the potential energy is zero at point II, where will the kinetic and potential energies of the ball be equal?
- (A) At point II (B) At some point between II and III
 (C) At point III (D) At some point between III and IV
19. The speed of the ball at point II is most nearly
- (A) 3.0 m/s (B) 4.5 m/s (C) 9.8 m/s (D) 14 m/s
20. The figure shows a rough semicircular track whose ends are at a vertical height h . A block placed at point P at one end of the track is released from rest and slides past the bottom of the track. Which of the following is true of the height to which the block rises on the other side of the track?
- (A) It is equal to $h/4$ (B) It is equal to $h/2$
 (C) It is equal to h
 (D) It is between zero and h ; the exact height depends on how much energy is lost to friction.
21. The graph shown represents the potential energy U as a function of displacement x for an object on the end of a spring moving back and forth with amplitude x_0 . Which of the following graphs represents the kinetic energy K of the object as a function of displacement x ?



22. A child pushes horizontally on a box of mass m which moves with constant speed v across a horizontal floor. The coefficient of friction between the box and the floor is μ . At what rate does the child do work on the box?
- (A) μmgv (B) mgv (C) $\mu mg/v$ (D) $\mu mg/v$

Thermodynamics

1. A 1.0-m-long section of iron railroad gets warmed by the Sun from 25°C to 40°C. The coefficient of thermal linear expansion for iron is $1.2 \times 10^{-5} \text{ } ^\circ\text{C}^{-1}$. How much did the length of the iron rail change?
(A) -0.18 cm
(B) -0.18 mm
(C) 0 cm
(D) 0.18 mm
(E) 0.18 cm
2. You have 20 moles of a gas in a 1-m^3 sealed container at 125°C. How many atmospheres of pressure are inside the container?
(A) 0.1 atm
(B) 0.6 atm
(C) 1.0 atm
(D) 1.2 atm
(E) 1.8 atm
3. If you have 2 moles of gas at room temperature (25°C), then what is the internal energy of the gas?
(A) 720 J
(B) 3,600 J
(C) 7,200 J
(D) 36,000 J
(E) 72,000 J

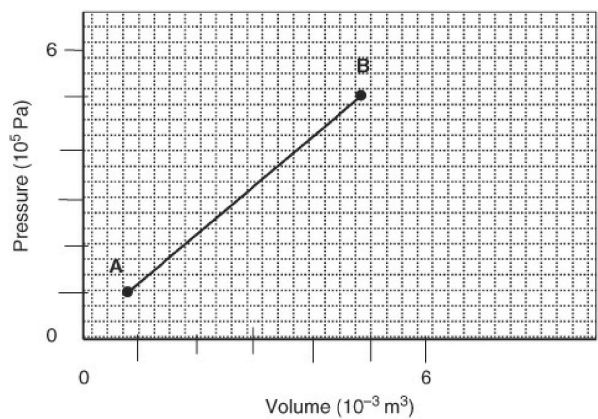
4. The mass of an oxygen atom is $5 \times 10^{-26} \text{ kg}$. What is the average speed of an oxygen molecule at room temperature (25°C)?
(A) 50 m/s
(B) 100 m/s
(C) 250 m/s
(D) 500 m/s
(E) 1,000 m/s
5. In an adiabatic process, 0.5 moles of gas at 1,000 K expand to reach a final temperature of 500 K. How much work was done?
(A) -5,000 J
(B) -3,000 J
(C) 0 J
(D) 3,000 J
(E) 5,000 J
6. An engine converts 5,000 J of thermal energy into 2,500 J of work. What is the efficiency of the engine?
(A) 10 percent
(B) 20 percent
(C) 50 percent
(D) 100 percent
(E) 200 percent
7. An ideal heat engine has an efficiency rate of 20 percent. If the heat reservoir has a temperature of 200°C, then what is the temperature of the heat sink?
(A) 0°C
(B) 50°C

- (C) 110°C
- (D) 200°C
- (E) 300°C

8. If 500 J of work was done on a volume of gas in a container with a moveable piston at a constant atmospheric pressure, what was the change in gas volume?

- (A) -0.05 m^3
- (B) -0.005 m^3
- (C) 0 m^3
- (D) 0.005 m^3
- (E) 0.05 m^3

9. The pressure, volume, and temperature of a gas were changed from Point A (low temperature) to Point B (high temperature) as shown in this graph. How much work was done by the gas?



- (A) -1,200 J

- (B) -120 J
- (C) 0 J
- (D) 120 J
- (E) 1,200 J

10. In which of the following processes is no work done on or by the gas?

- (A) Adiabatic
- (B) Isobaric
- (C) Isothermal
- (D) Isochoric
- (E) None, all of the processes do work

Optics

1. When a beam of light is refracted through a prism, the beam is spread into what colors?
 - (A) Violet, blue, green, yellow, orange, and red
 - (B) Blue, violet, green, yellow, red, and orange
 - (C) Green, yellow, orange, red, blue, and violet
 - (D) Red, orange, yellow, green, blue, and violet
 - (E) Orange, red, yellow, green, blue, and violet
2. Why does a piece of glass disappear when immersed in a liquid with the same index of refraction?
 - (A) The liquid would be dark, and the glass could not be seen.
 - (B) The liquid and the glass would be the same color.
 - (C) With the indices the same, light is not refracted, and the glass is not seen.
 - (D) The glass would be seen at a certain angle.
 - (E) The liquid causes the glass to melt.
3. What is the focal point of a concave mirror with a radius of 100 cm?
 - (A) 50 cm
 - (B) 200 cm
 - (C) 150 cm
 - (D) 1 m
 - (E) 0.5 mm
4. Historians have recorded that Archimedes used mirrors or lenses to burn the Spartan fleet. If he had used mirrors, what would be the focal length of the mirrors Archimedes used to burn the Spartan ships 2 km at sea? Could these be easily made?
 - (A) 1 km, no
 - (B) 1 km, yes
 - (C) 4 km, no
 - (D) 4 km, yes
 - (E) 4 m, yes
5. If a person were nearsighted, what shape lens would correct the person's vision?
 - (A) Concave-convex
 - (B) Convex-convex
 - (C) Concave-concave
 - (D) Convex-concave
 - (E) Flat-convex
6. To correct for chromatic aberration, what type of lens should be used?
 - (A) Convex-concave
 - (B) Two lenses of different refraction
 - (C) A lens that causes red and blue to refract to the same focal point
 - (D) A convex-convex lens mated with a concave-concave lens
 - (E) Concave-convex
7. In a specular reflection, if the incident light beam hits the surface at 45° to normal, at what angle will the reflected beam come from the surface?
 - (A) 90°
 - (B) 30°
 - (C) It will be broken into colors

(D) 45°

(E) 60°

8. Why is it safer to use matte surfaces on surgical instruments rather than polished surfaces during laser surgery?

(A) A matte surface is easier to clean.

(B) A polished surface is easier to clean.

(C) A polished surface would diffuse the laser beam.

(D) A matte surface would diffuse the laser beam.

(E) Laser-safe eyewear should be worn during surgery.

9. An archerfish spits a stream of water at insects above the water surface to knock them down and eat them. If the fish sees an insect at θ degrees under water, how should the fish aim its spit stream to hit the insect?

(A) Much less than θ degrees

(B) Much greater than θ degrees

(C) Slightly greater than θ degrees

(D) Slightly less than θ degrees

(E) At θ degrees

10. To keep as much of the laser beam energy inside a laser fiber, a coating is sometimes placed on the fiber to produce total reflection in the fiber. What refractive index should the coating have?

(A) It should be opaque.

(B) It should be mirrored.

(C) It should be higher than that of the fiber.

(D) It should be lower than that of the fiber.

(E) It should have a critical angle of greater than 41° .

(D) 45°

(E) 60°

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