



Surname _____

Forename(s) _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

AS

PHYSICS

Paper 2

7407/2

Wednesday 22 May 2024

Afternoon

Time allowed: 1 hour 30 minutes

**You are advised to spend about
35 minutes on Section C**

[Turn over]



J U N 2 4 7 4 0 7 2 0 1

On the front of this book, write your surname and forename(s), your centre number, your candidate number and add your signature.

MATERIALS

For this paper you must have:

- **a pencil and a ruler**
- **a scientific calculator**
- **a Data and Formulae Booklet**
- **a protractor.**

INSTRUCTIONS

- **Use black ink or black ball-point pen.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do not write on blank pages.**



- **If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).**
- **Do all rough work in this book. Cross through any work you do not want to be marked.**
- **Show all your working.**

INFORMATION

- **The marks for questions are shown in brackets.**
- **The maximum mark for this paper is 70.**
- **You are expected to use a scientific calculator where appropriate.**
- **A Data and Formulae Booklet is provided as a loose insert.**

DO NOT TURN OVER UNTIL TOLD TO DO SO



SECTION A

Answer ALL questions in this section.

0	1
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A hacksaw blade is a thin flexible strip of metal.

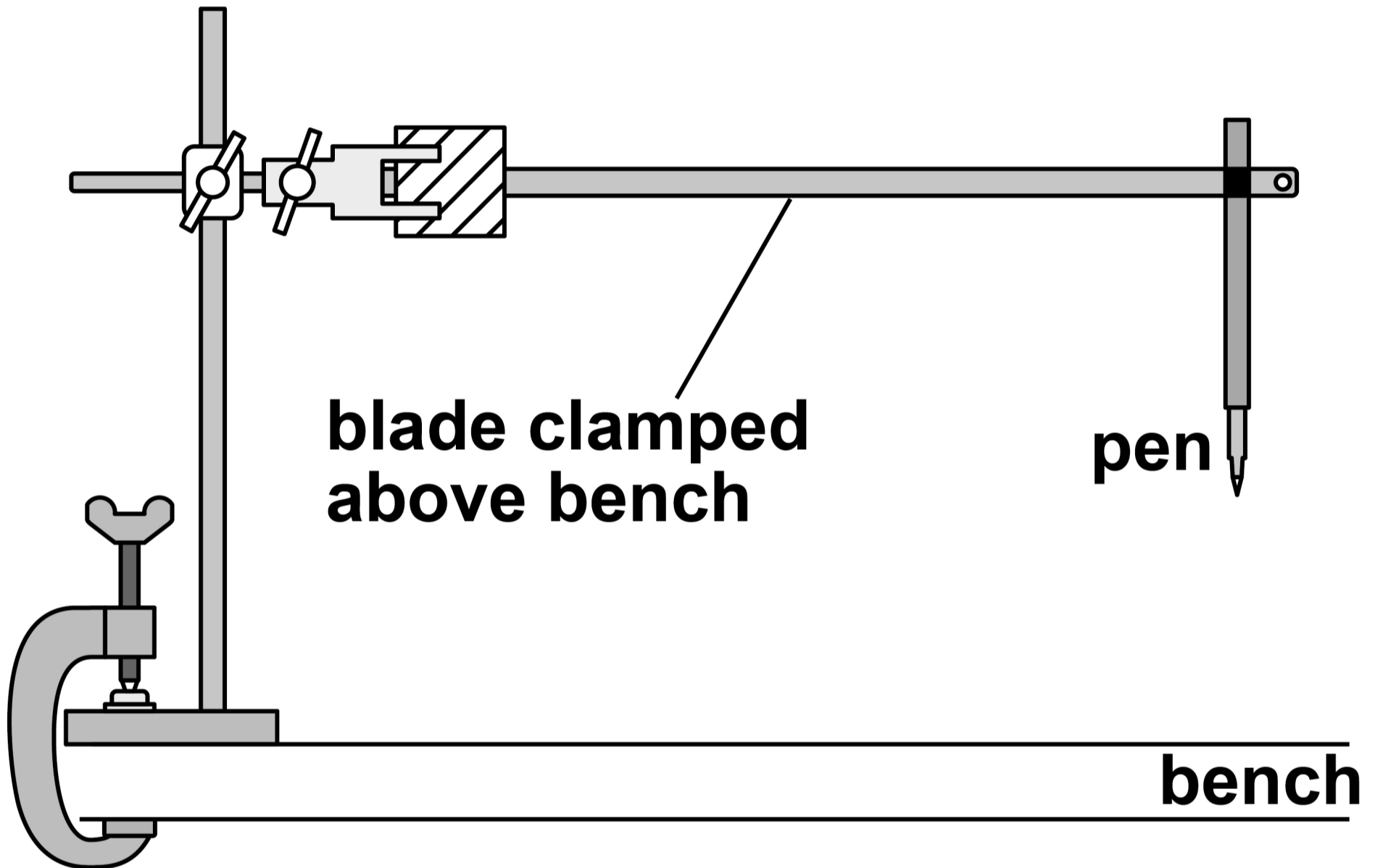
FIGURE 1, on the opposite page, shows a blade clamped between two blocks above a horizontal bench.

A pen is attached to the free end of the blade.



FIGURE 1

**VIEW OF HACKSAW BLADE
FROM SIDE**



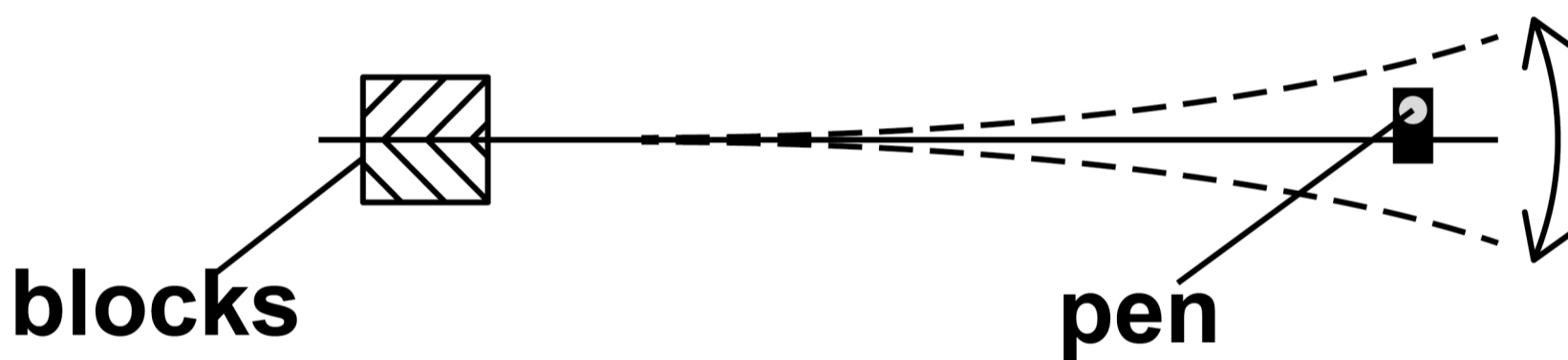
[Turn over]

The free end of the blade is displaced and released.

The blade oscillates in a horizontal plane as shown in FIGURE 2.

FIGURE 2

VIEW OF HACKSAW BLADE FROM ABOVE



The time for each oscillation is T .

0 1 . 1

TABLE 1 shows repeated measurements of $60T$.

TABLE 1

MEASUREMENTS OF $60T / s$			
25.20	25.05	24.97	25.10

Show that T is about 0.42 s. [1 mark]

[Turn over]



FIGURE 3, below and on the opposite page, shows a trolley placed on a ramp that is inclined at a small angle to the bench.

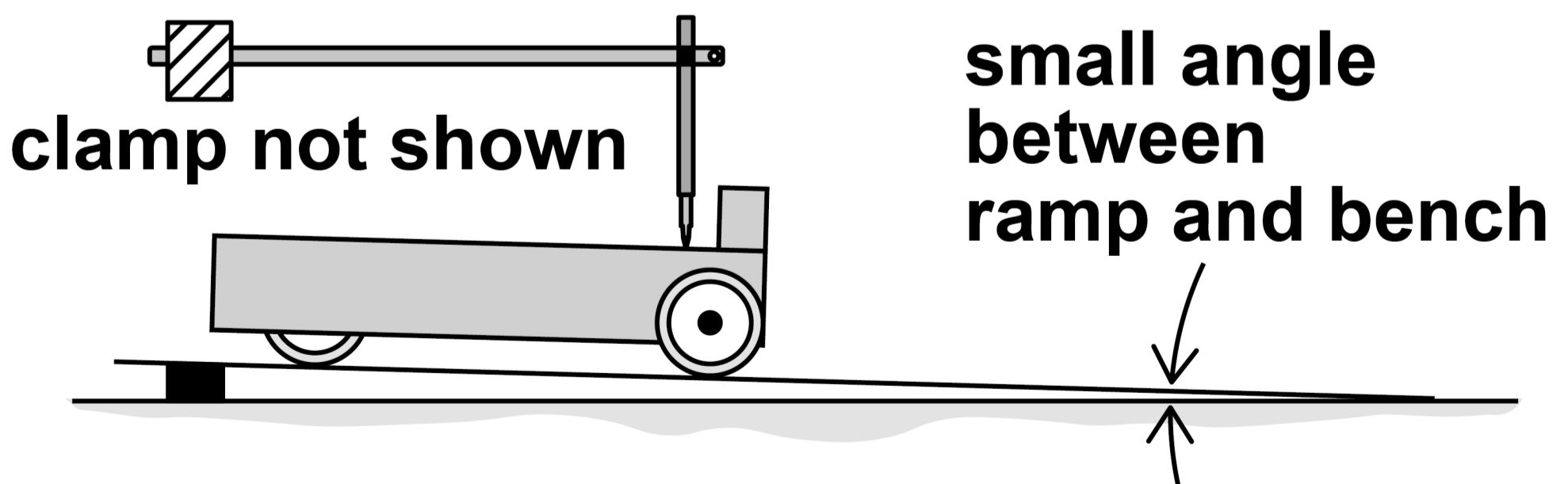
A piece of graph paper is fixed to the upper surface of the trolley.

The blade and pen are positioned so that the tip of the pen rests on the graph paper.

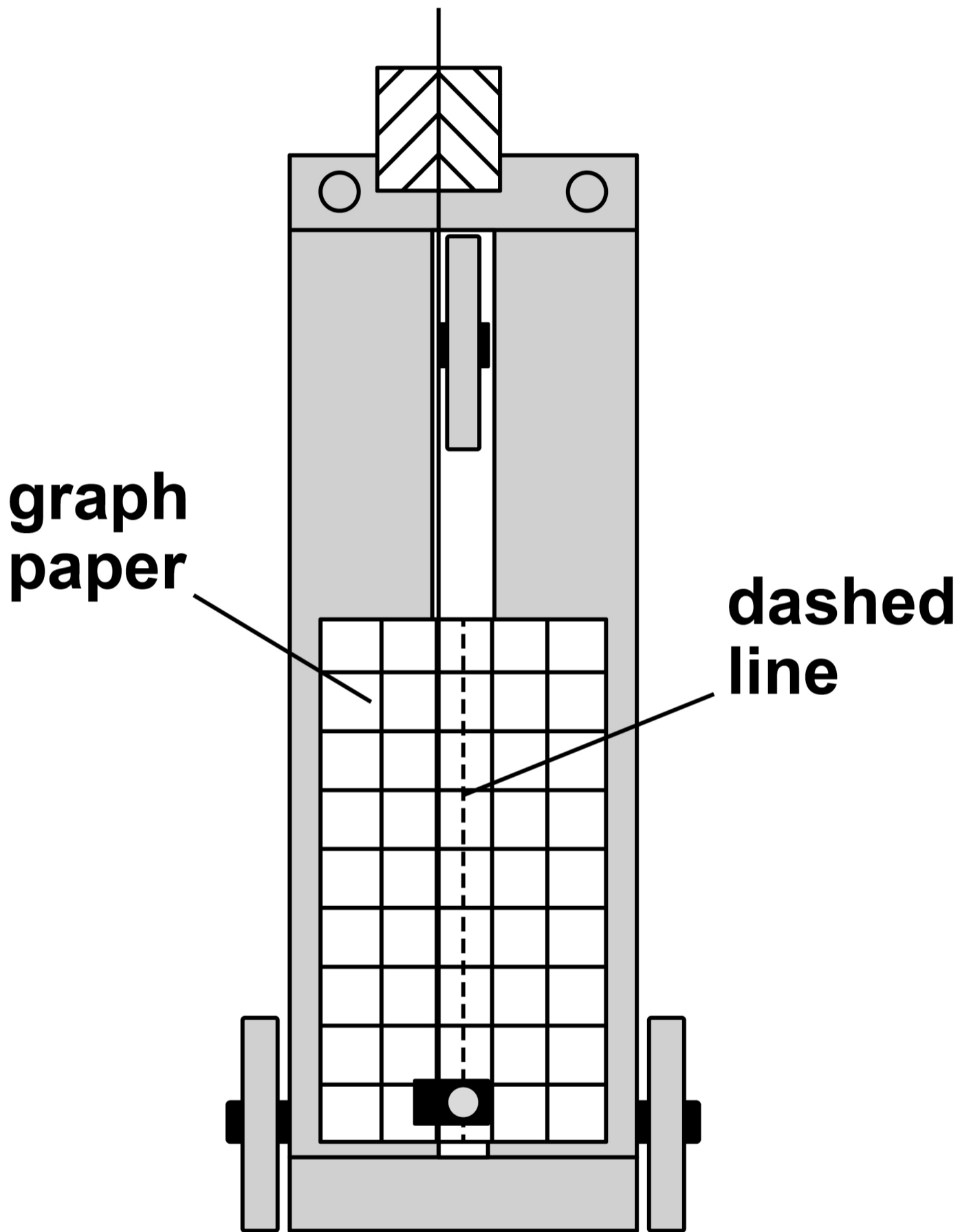
The dashed line shows the rest position of the pen.

FIGURE 3

SIDE VIEW



**view of trolley
from above**



[Turn over]



The free end of the blade is displaced as shown in FIGURE 4A, on the opposite page.

The blade and the trolley are then both released at the same moment.

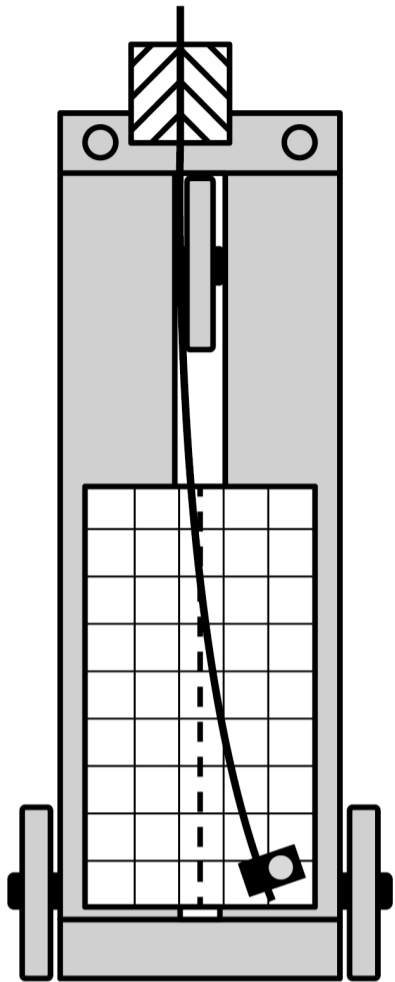
The blade oscillates horizontally.

The pen remains in contact with the graph paper as the trolley moves.

FIGURES 4B and 4C, on the opposite page, show the trolley as it moves down the ramp with uniform acceleration.

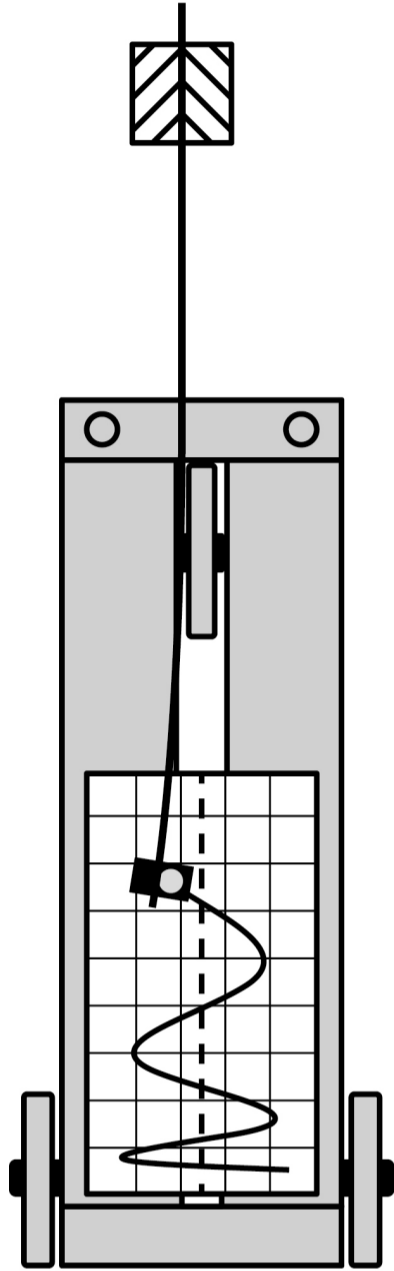


FIGURE 4A



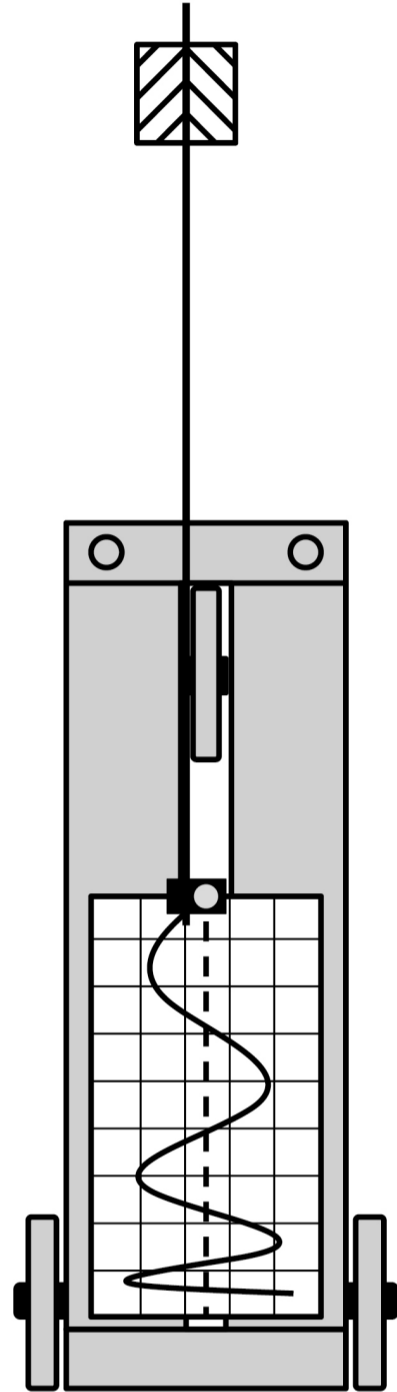
**trolley and
blade at
moment
of release**

FIGURE 4B



**trolley
moving
down ramp**

FIGURE 4C



**trolley
moving
down ramp**

[Turn over]



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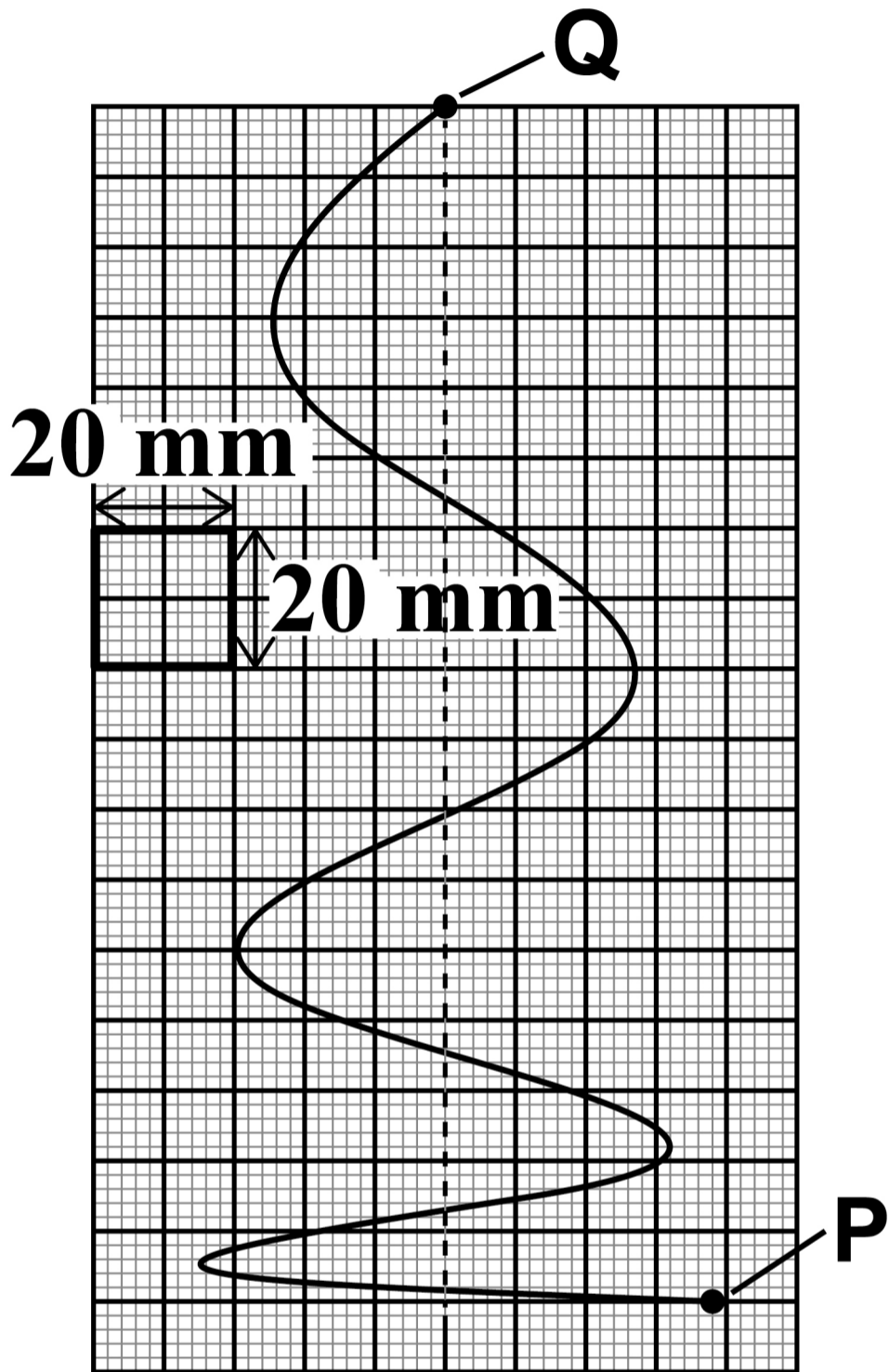
FIGURE 5, on page 14, shows the graph paper.

Points P and Q mark the start and end of the continuous line drawn by the pen after the trolley is released.

[Turn over]



FIGURE 5



T_{PQ} is the time for the pen to draw the line from P to Q.

s is the displacement of the trolley during T_{PQ} .

0	1	.	2
---	---	---	---

Determine T_{PQ} .

Assume that the time for each full oscillation of the blade is 0.42 s.

[2 marks]

$T_{PQ} =$ _____ s

[Turn over]



0	1	.	3
---	---	---	---

Determine s .

The scale of the graph paper is shown on **FIGURE 5**, on page 14. [1 mark]

$s =$ _____ **m**

0	1	.	4
---	---	---	---

Determine the acceleration a of the trolley. [2 marks]

$a =$ _____ **m s⁻²**



0	1	.	6
---	---	---	---

The percentage uncertainty in T_{PQ} is 0.46%.

Determine the percentage uncertainty in your result for a . [2 marks]

percentage uncertainty = _____ %



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[Turn over]

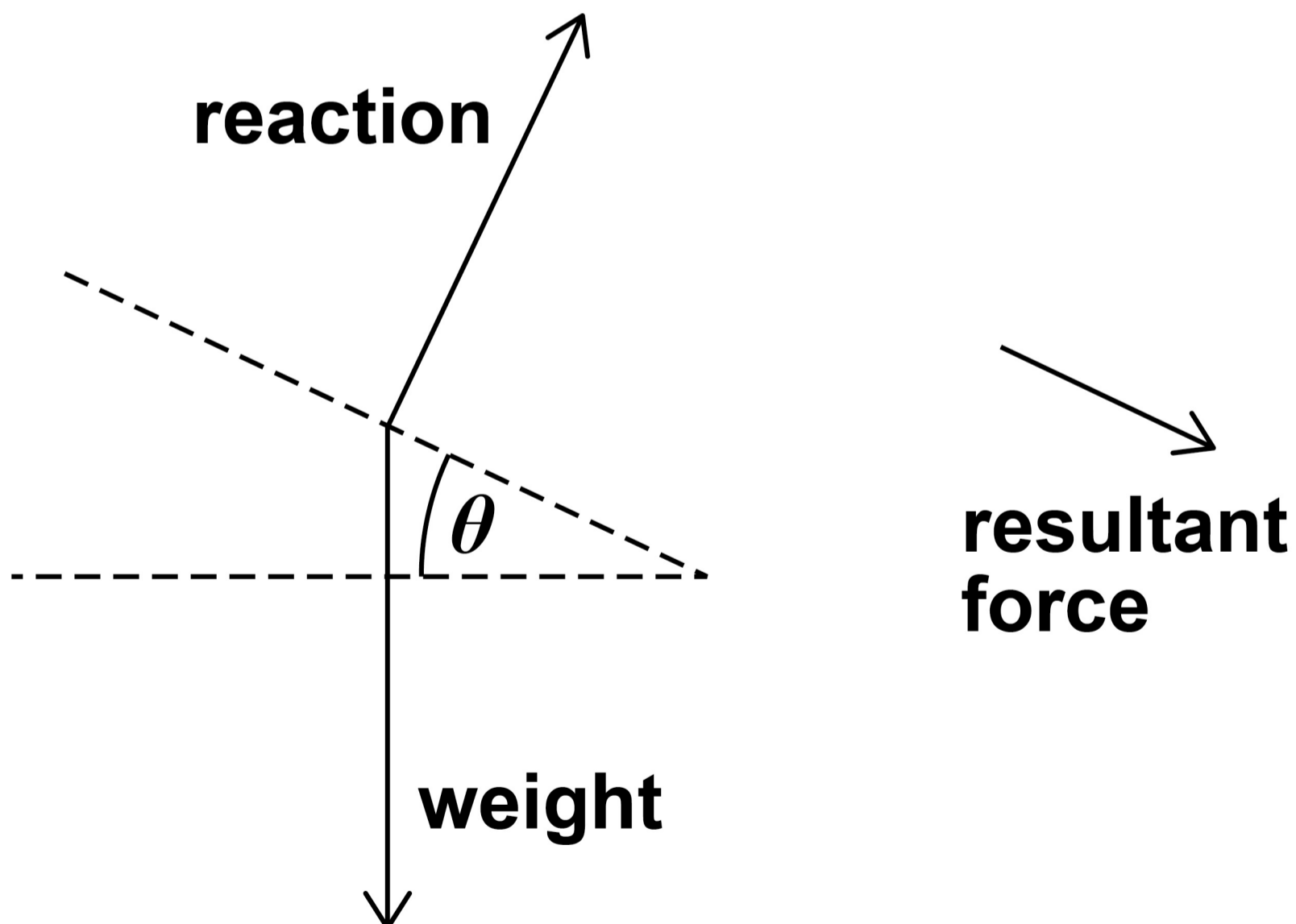


01.7

FIGURE 6 is a diagram drawn by a student to explain why the trolley accelerates.

The diagram is incomplete because the student has ignored the friction forces involved.

FIGURE 6



Using FIGURE 6 it can be shown that:

$$g = \frac{a}{\sin \theta}$$

where a is the acceleration of the trolley.

The student determines g using this equation.

State and explain how the student's value of g compares with 9.81 m s^{-2} . [2 marks]

[Turn over]

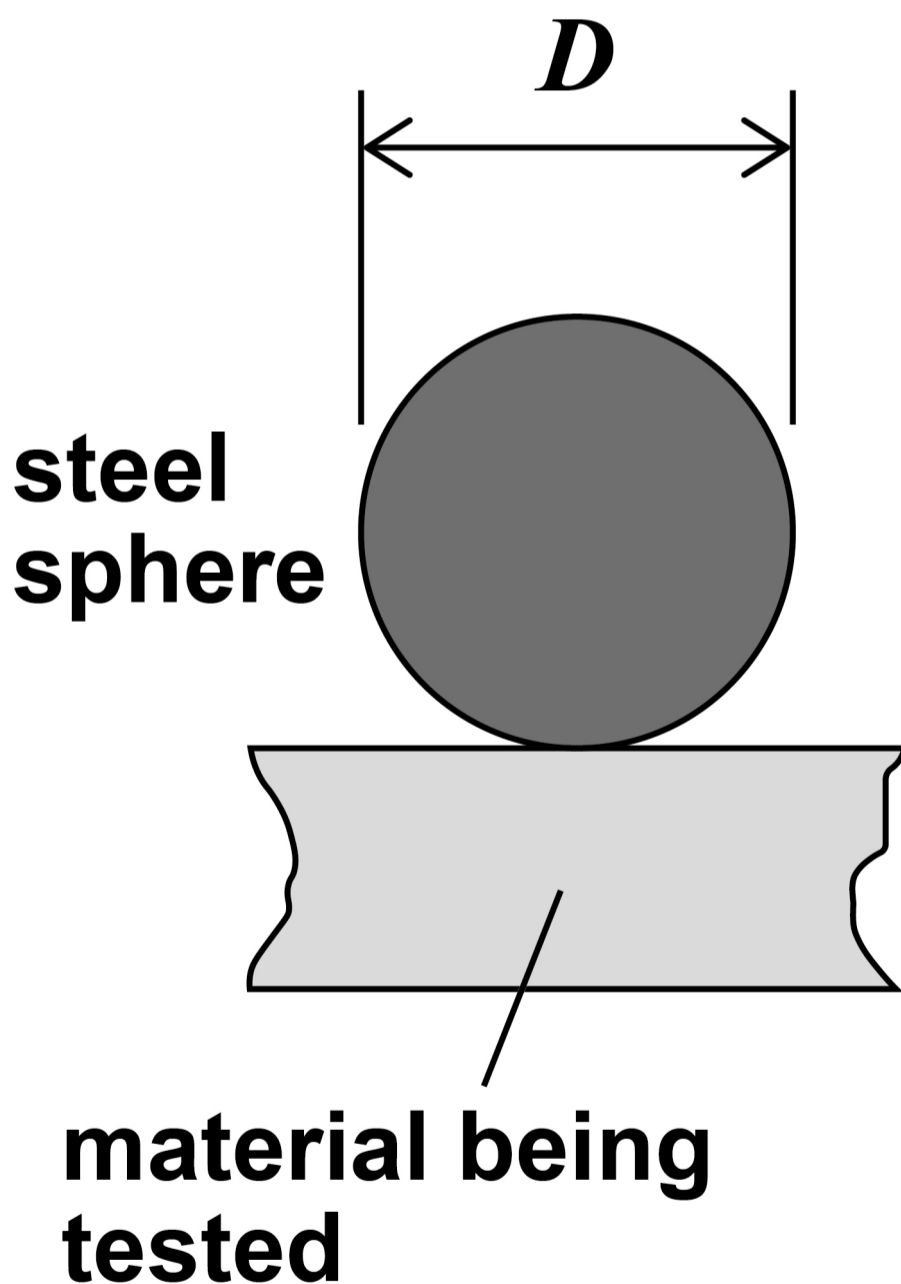


0	2
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The Brinell test determines the hardness of the surface of a material.

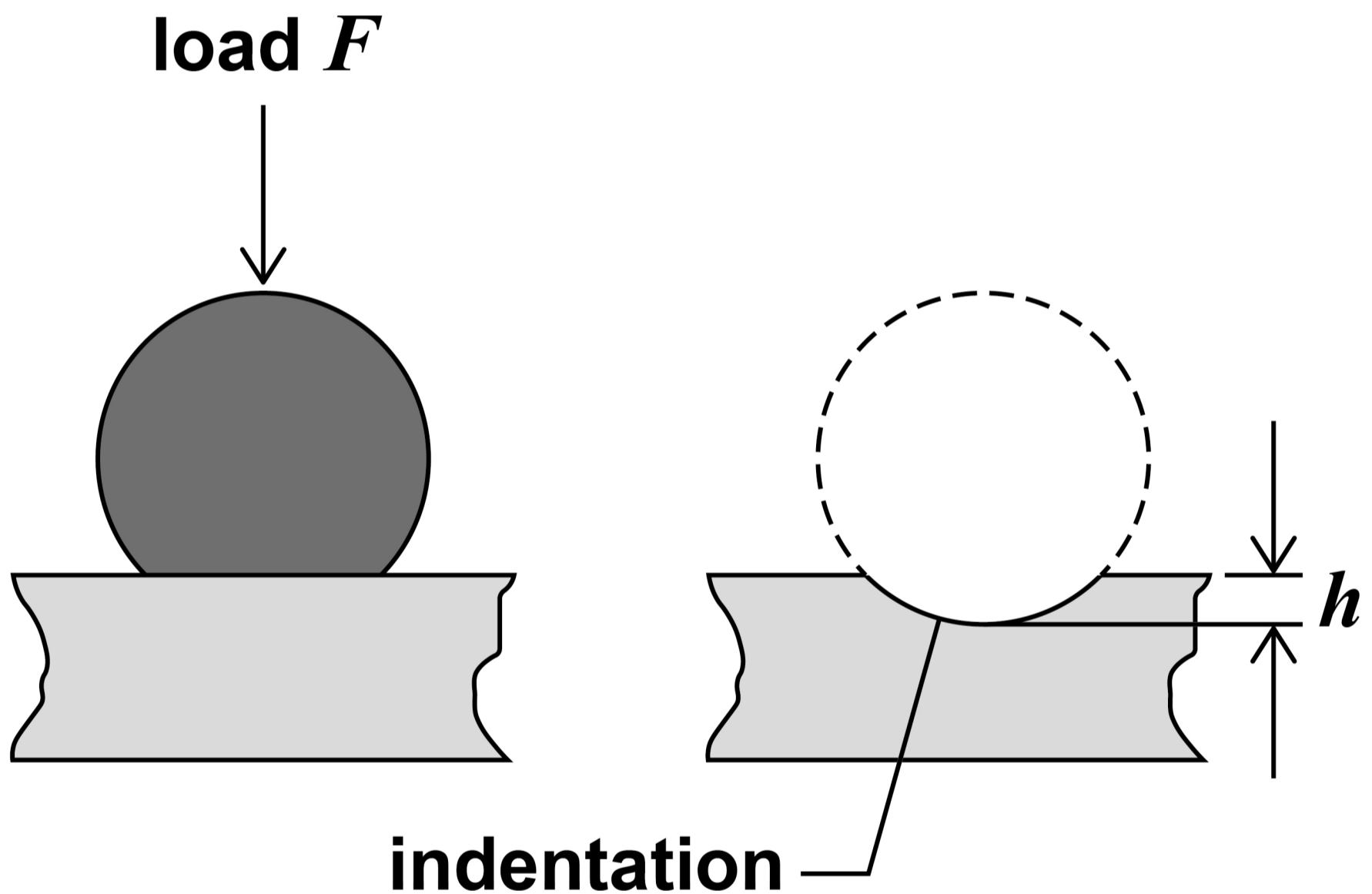
FIGURE 7 shows a steel sphere on the surface of a material being tested.

FIGURE 7



In the test, a load F is applied to a steel sphere of diameter D and an indentation of depth h is produced in the material. FIGURE 8 shows one test.

FIGURE 8



[Turn over]



The Brinell hardness number B is given by

$$B = \frac{F}{\pi g D h}$$

where F is in N, g is in N kg^{-1} and D and h are in mm.

The unit of B is kg mm^{-2} .

Using the same steel sphere, the value of h was measured for five materials.

B was calculated for each material.

For each material:

- F was the same
- $D = 10.0$ mm.



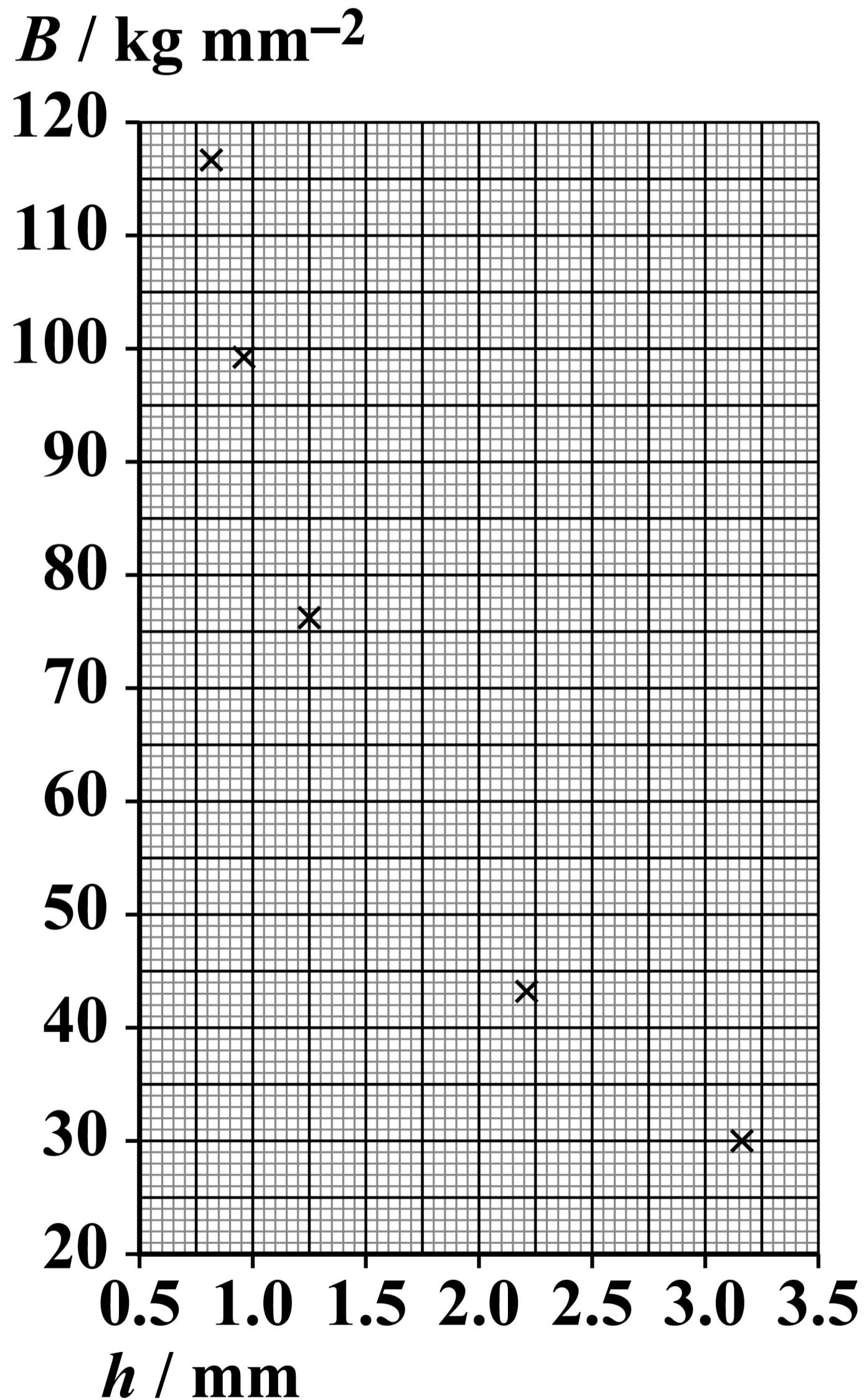
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[Turn over]



FIGURE 9 is a plot of B against h .

FIGURE 9



0	2	.	1
---	---	---	---

Determine the value of F that was used to produce FIGURE 9. [1 mark]

$F =$ _____ N

[Turn over]



0	2	.	2
---	---	---	---

Brass was not one of the five materials tested.

When brass was tested using these values of F and D , the value of $h = 1.60$ mm.

Determine, using FIGURE 9, on page 26, B for brass. [2 marks]

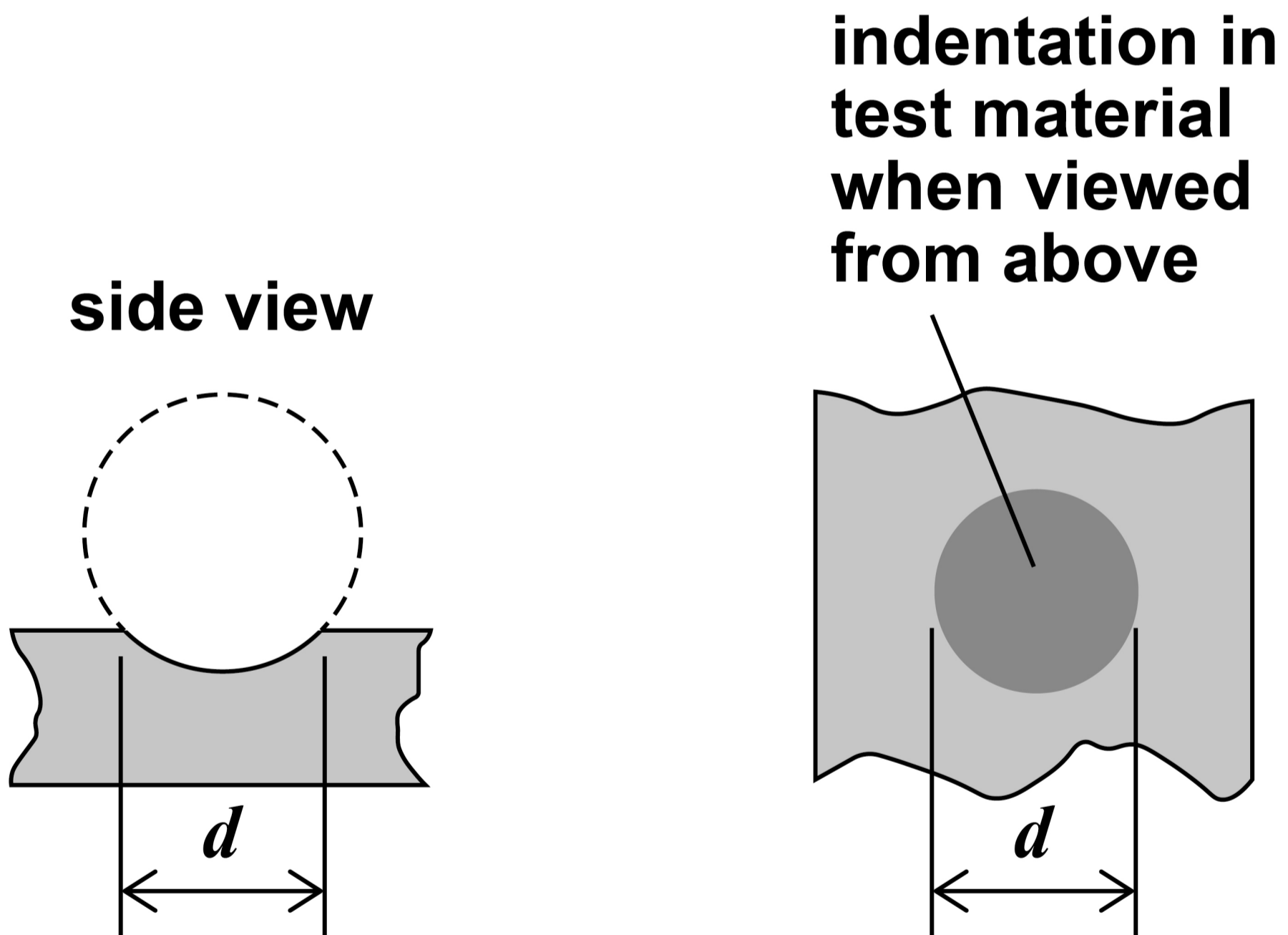
B for brass = _____ kg mm⁻²



The Brinell hardness number can be determined by measuring the diameter d of the circular indentation rather than h .

FIGURE 10 shows d .

FIGURE 10



For the indentation created in brass,
 $d = 7.33$ mm.



0	2	.	4
---	---	---	---

Suggest a suitable instrument that could have been used to measure this value of d . [1 mark]

[Turn over]



SECTION B

Answer ALL questions in this section.

0	3
----------	----------

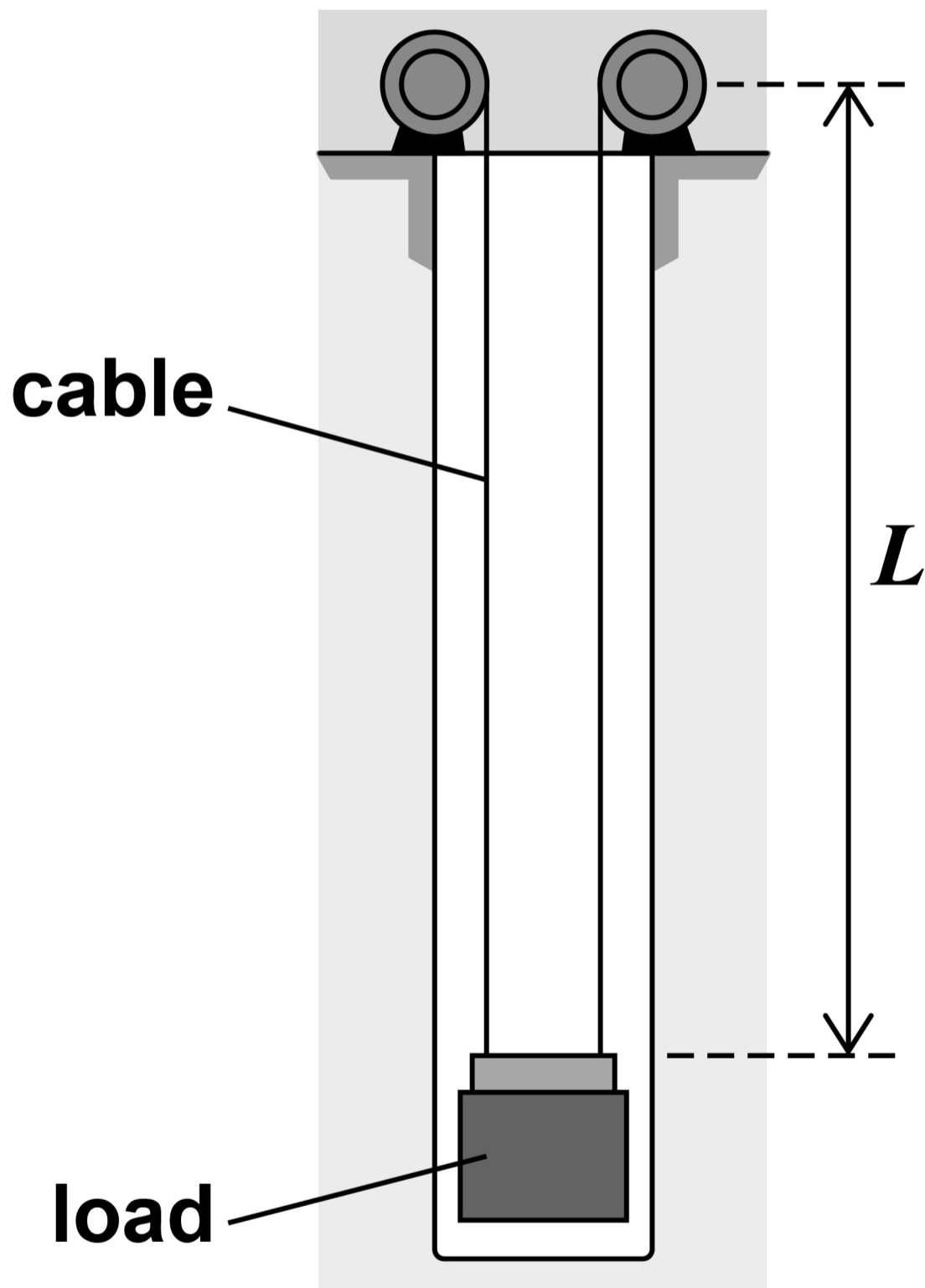
FIGURE 11, on page 34, shows an energy storage system. The system uses a load suspended from two long steel cables in a vertical tunnel. Energy is stored when the load is raised. Electricity is generated when the load falls.

[Turn over]



FIGURE 11

The diagram is not drawn to scale.



When the load is at its lowest point, each cable has a vertical length L .



The total mass of the two vertical cables is 3.7×10^4 kg.

Each cable has a cross-sectional area of 9.6×10^{-3} m².

0 3 . 1

Calculate L .

density of steel = 7.4×10^3 kg m⁻³
[2 marks]

$L =$ _____ m

[Turn over]



03.2

The load is accelerated from its lowest point. The mass of the load is 2.8×10^5 kg.

The maximum tension in each cable is 1.6×10^6 N during the acceleration.

Calculate the initial acceleration of the load. [4 marks]



initial acceleration = _____ m s^{-2}

[Turn over]



03.3

For safety, the breaking stress of each steel cable must be at least three times the maximum stress produced during the initial acceleration.

breaking stress for steel = 890 MPa

Deduce whether this system operates safely. [2 marks]



[Turn over]



03.4

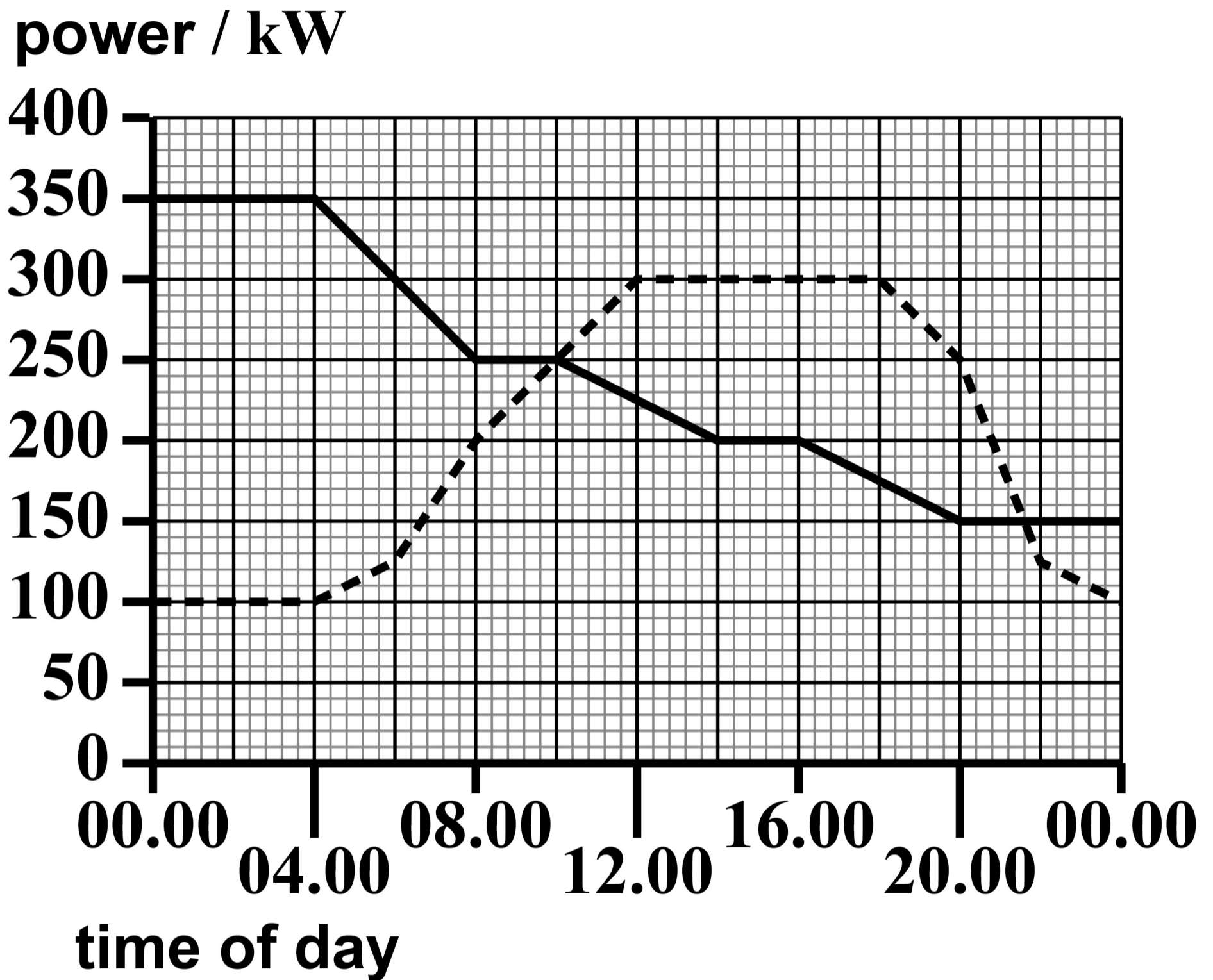
A village combines the storage system with a wind turbine to provide energy.

FIGURE 12, on the opposite page, shows how the output power of the wind turbine varies with time during one particular day.

The power demand of the village is also shown.



FIGURE 12

**KEY**

— turbine output

---- demand of village

[Turn over]



When the power demand is greater than the output power of the wind turbine, the load in the storage system descends and generates electricity to match the demand. When the load has fully descended and the storage system is empty, electrical power is provided by the National Grid.

The efficiency of the energy transfer from the storage system to the village is 85%.

The maximum energy stored by the storage system is 760 MJ.



Deduce whether the storage system and the wind turbine can together provide all the electrical energy needed by the village from 10.00 until 14.00. [4 marks]

[Turn over]

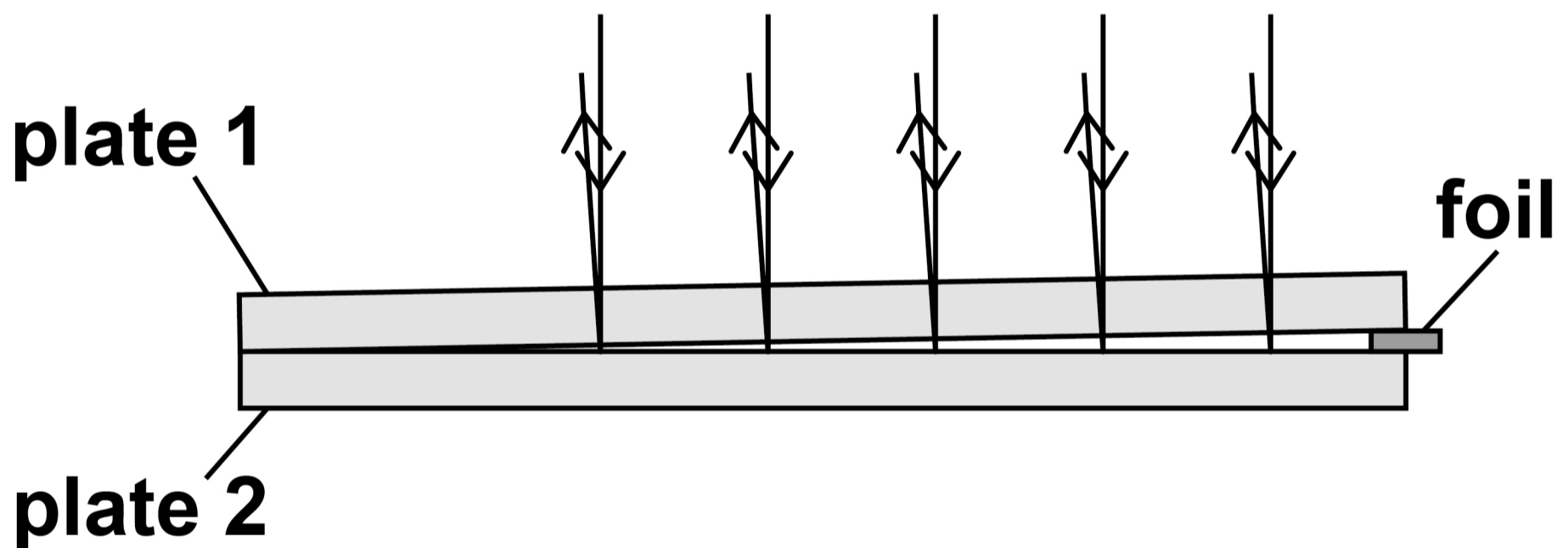


04

FIGURE 13 shows an arrangement used to determine the thickness of metal foil using interference of light.

FIGURE 13

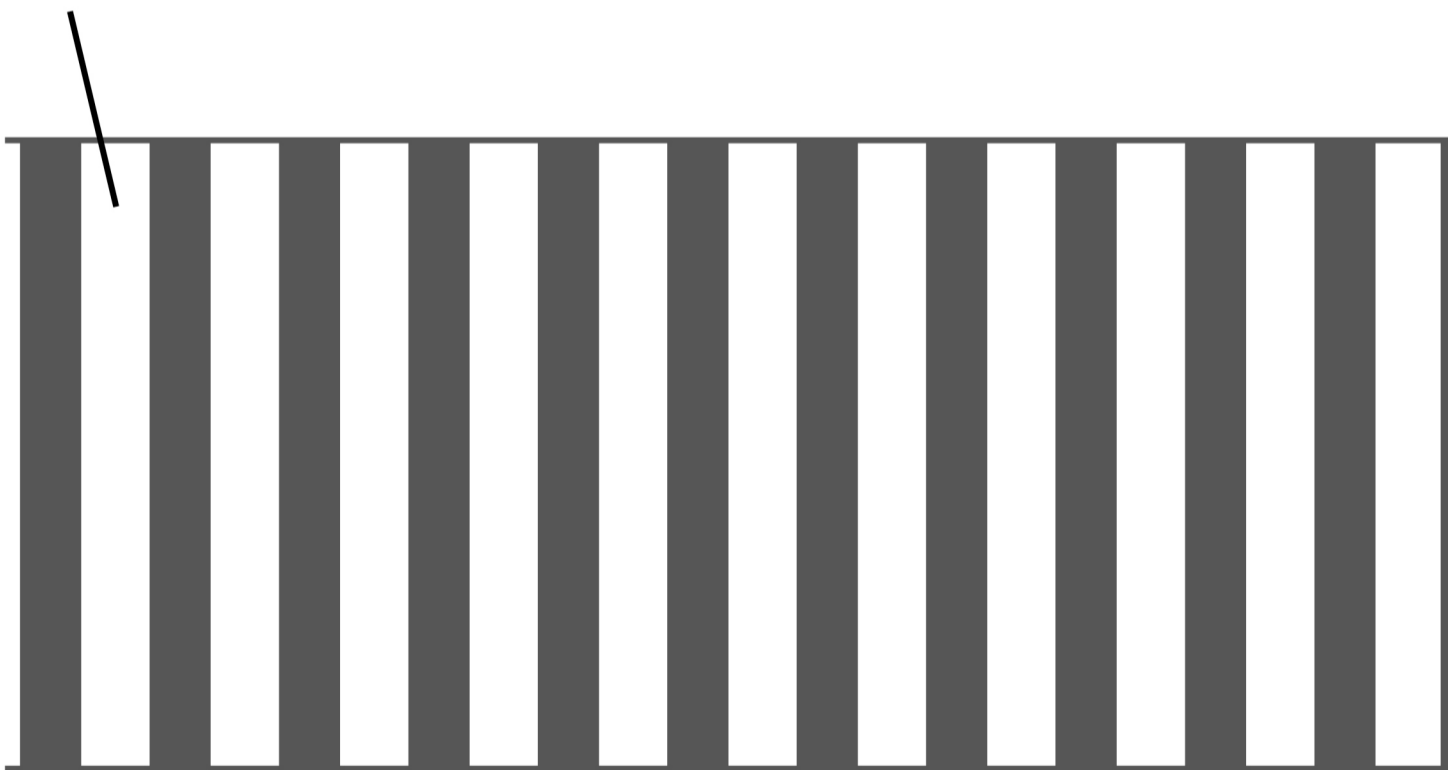
The diagram is not drawn to scale.



Two thin glass plates are separated by the foil at one end. Monochromatic light is incident on the glass plates from above. A series of bright fringes is observed when viewed from above, as shown in FIGURE 14.

FIGURE 14

bright fringe



[Turn over]

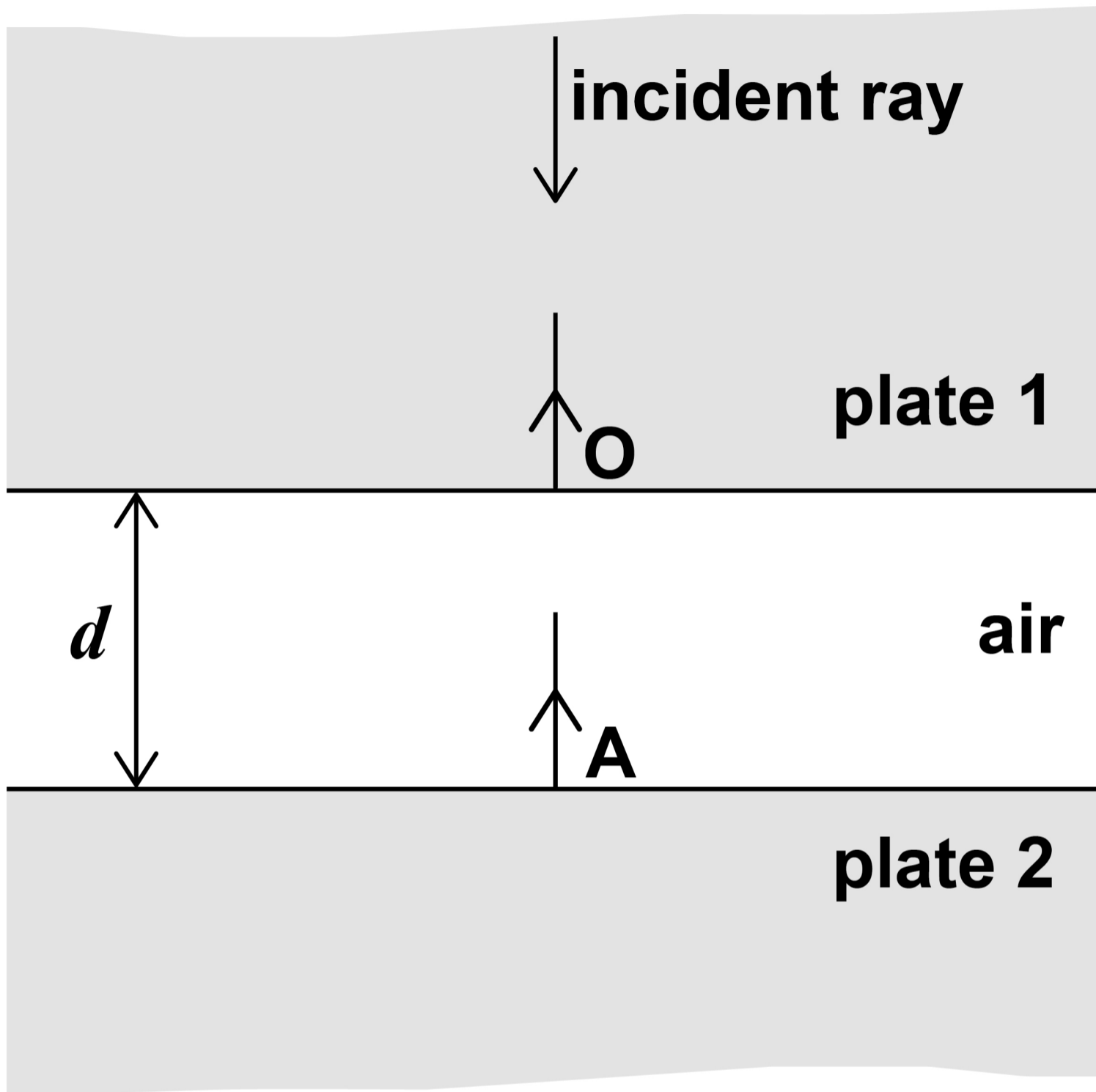


FIGURE 15, on the opposite page, shows part of the arrangement where a bright fringe occurs.

The angle between the two plates caused by the foil in FIGURE 13, on page 44, is very small. This allows the following approximations to be made for FIGURE 15:

- **the plates are parallel to each other**
- **the light rays travel perpendicular to both plates.**

FIGURE 15



[Turn over]



Some of the incident light is reflected at O. The remainder of the light is transmitted through the air gap and is reflected at A.

The reflected light from A combines at O with the reflected light from O.

At O, there is a phase difference between the reflected light from A and the reflected light from O.

This phase difference is caused by:

- **the path difference due to the air gap**
- **the reflection at A.**

At A the phase of the light that is reflected is changed by 180° .

At O there is no change to the phase of the light that is reflected or that is transmitted.



The thickness OA of the air gap is d .

0 4 . 1

Deduce the relationship between d and the wavelength λ of light that produces a bright fringe. [3 marks]

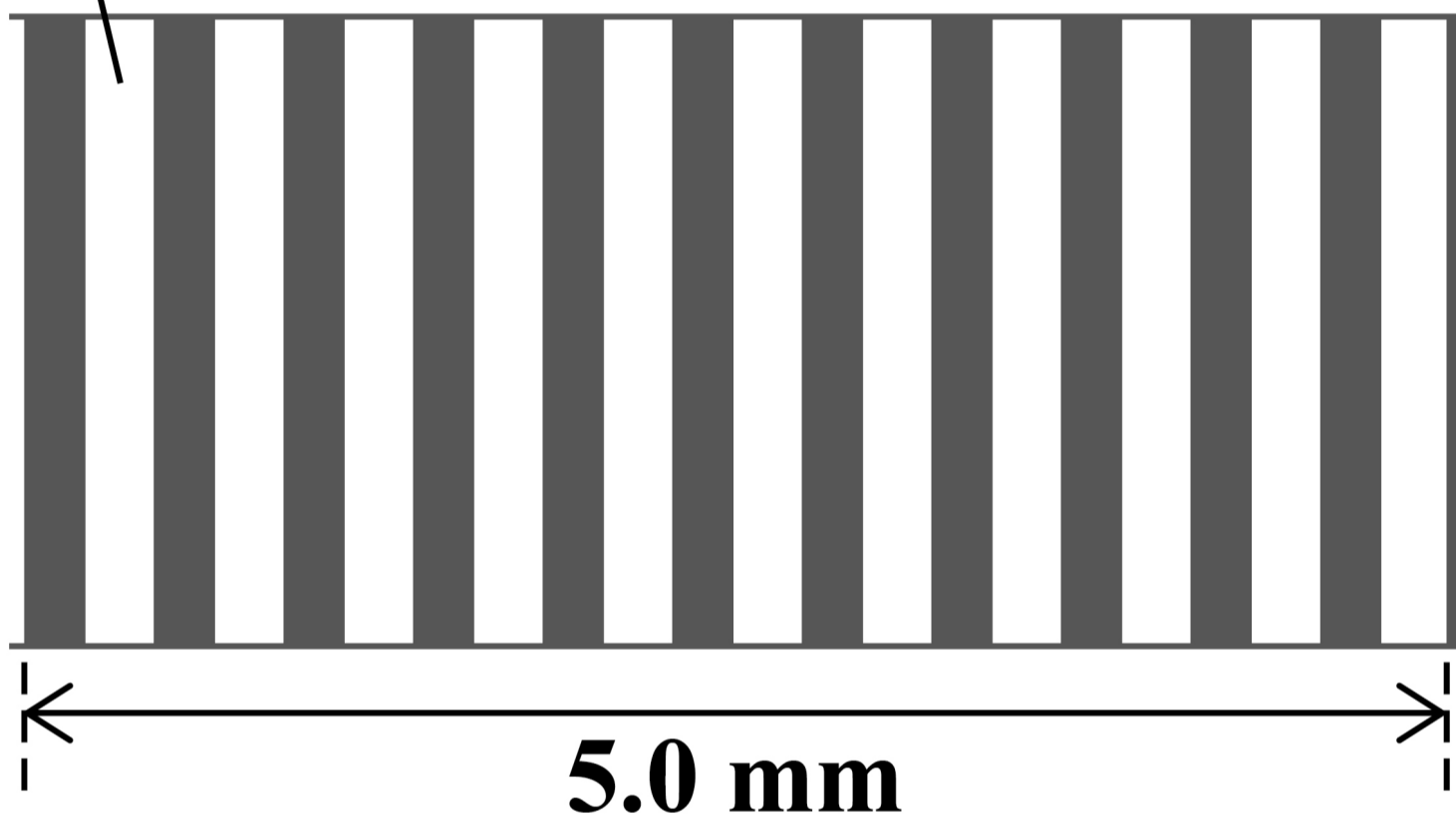
[Turn over]



FIGURE 16 shows a small part of the fringe pattern as viewed from above.

FIGURE 16

bright fringe

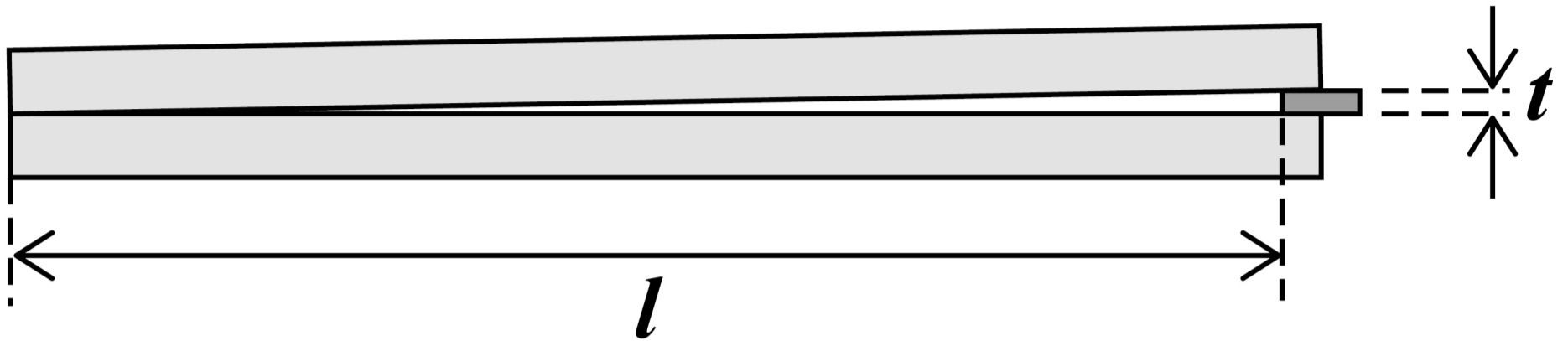


The distance between the centre of one bright fringe and the centre of the next bright fringe is s .

The thickness of the foil is t and the length of each glass plate up to the edge of the foil is l as shown in FIGURE 17, on the opposite page.



FIGURE 17



It can be shown that

$$\frac{t}{l} = \frac{\lambda}{2s}$$

[Turn over]



04.2

Determine t using FIGURE 16, on page 50.

$$\lambda = 590 \text{ nm}$$

$$l = 6.0 \text{ cm}$$

[2 marks]

$$t = \underline{\hspace{15em}} \text{ m}$$



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[Turn over]



0 4 . 3

The space between the plates is now filled with water. The same light source is used, and t and l remain the same as before.

Deduce how the distance s will change when water fills the space between the plates.

**refractive index of water = 1.3
[3 marks]**



SECTION C

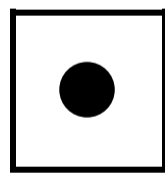
Each of Questions 05 to 34 is followed by four responses, A, B, C and D.

For each question select the best response.

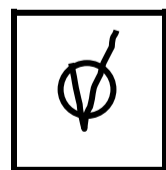
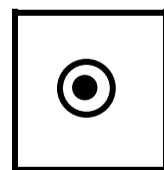
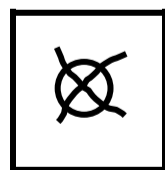
Only ONE answer per question is allowed.

For each question, completely fill in the circle alongside the appropriate answer.

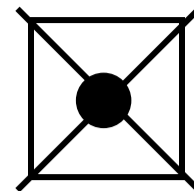
CORRECT METHOD



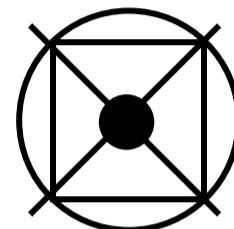
WRONG METHODS



If you want to change your answer you must cross out your original answer as shown.



If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.



You may do your working in the blank space around each question but this will not be marked. Do NOT use additional sheets for this working.

[Turn over]



0	5
---	---

A sequence of radioactive decays starts with nuclide P and ends with an isotope of P.

Which is a possible sequence for these decays? [1 mark]

- A one alpha decay followed by four β^- decays**
- B one alpha decay followed by two β^- decays**
- C two alpha decays followed by two β^- decays**
- D two alpha decays followed by one β^- decay**

0	6
---	---

The current in a circuit is **0.33 A**.

How many electrons pass a point in the circuit in **7.0 minutes**? [1 mark]

A 1.4×10^{19}

B 1.2×10^{20}

C 8.7×10^{20}

D 8.0×10^{21}

[Turn over]



0	7
---	---

Monochromatic light of wavelength 520 nm is incident normally on a diffraction grating.

The third-order maximum occurs at a diffraction angle θ .

Light of wavelength λ is incident normally on the same grating.

The fourth-order maximum also occurs at angle θ .

What is λ ? [1 mark]

A 260 nm

B 390 nm

C 690 nm

D 780 nm



08

The alpha particle, positron and proton have different charge-to-mass ratios.

Which row shows the particles that have the greatest and the smallest value of this ratio? [1 mark]

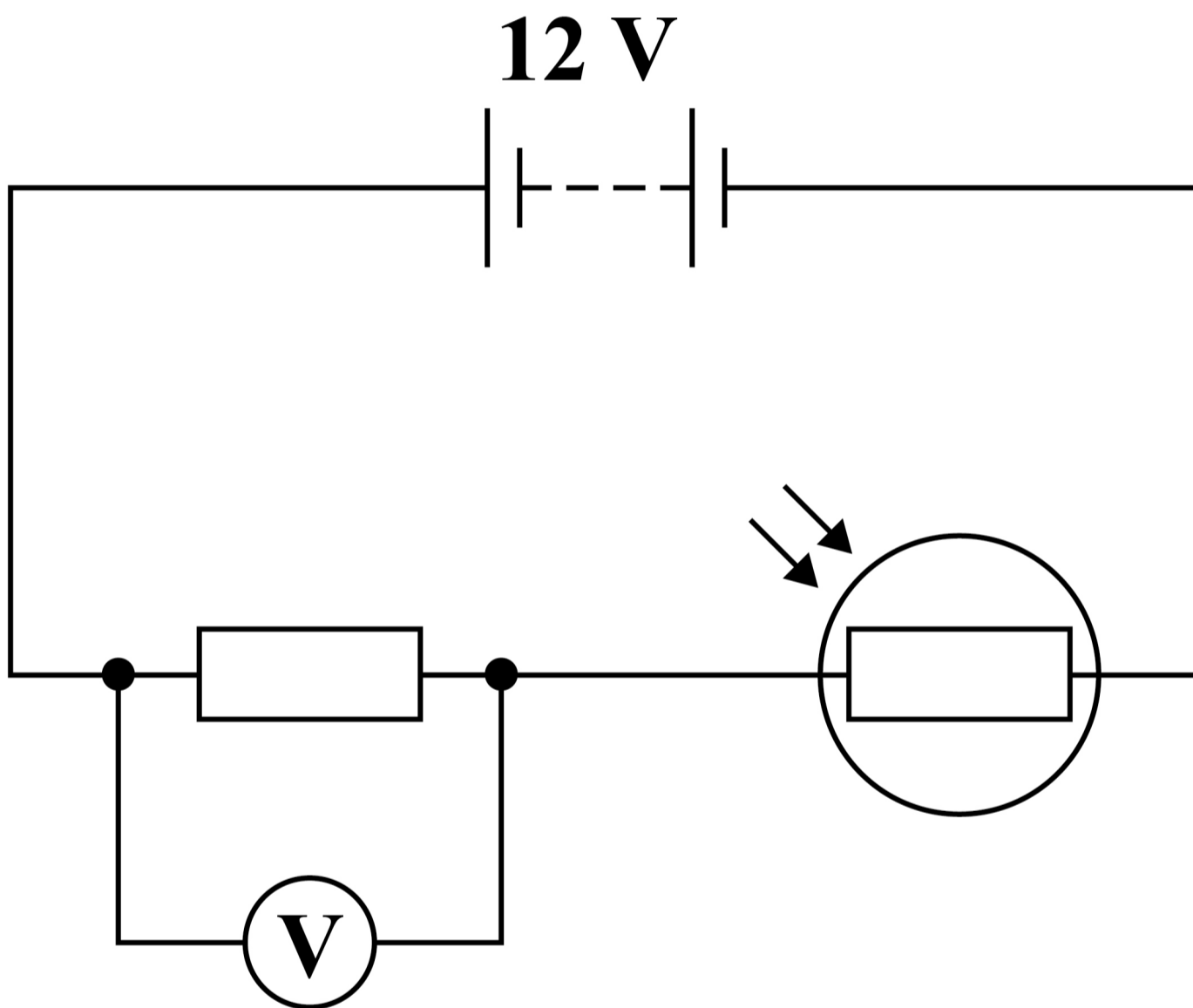
	GREATEST CHARGE-TO- MASS RATIO	SMALLEST CHARGE-TO- MASS RATIO
<input type="radio"/> A	positron	alpha particle
<input type="radio"/> B	positron	proton
<input type="radio"/> C	alpha particle	proton
<input type="radio"/> D	alpha particle	positron

[Turn over]



09

A circuit contains a battery with an emf of 12 V and negligible internal resistance.



At a certain light intensity, the LDR has a resistance of $480\ \Omega$ and the voltmeter reading is $2.0\ \text{V}$.

At a different light intensity, the resistance of the LDR is R and the voltmeter reading is now $8.0\ \text{V}$.

What is R ? [1 mark]

A $48\ \Omega$

B $96\ \Omega$

C $120\ \Omega$

D $160\ \Omega$

[Turn over]



1	0
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A wire obeys Hooke's law.

When the wire is extended by ΔL , the elastic strain energy is E_s and the tension in the wire is T .

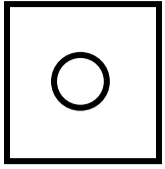
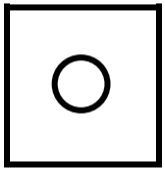
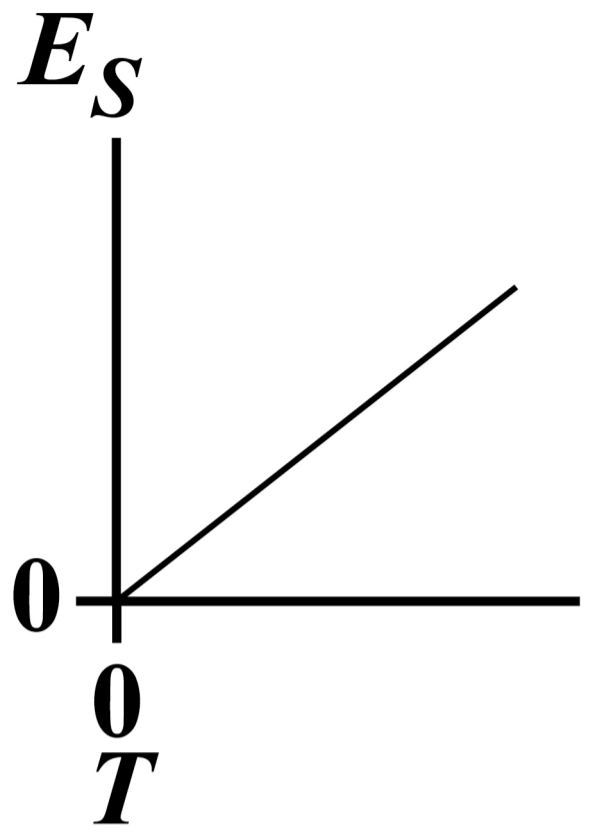
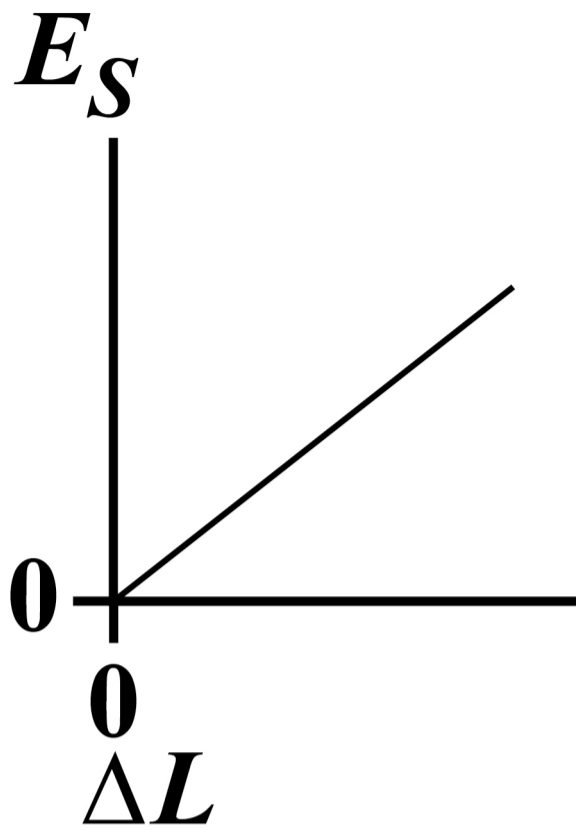
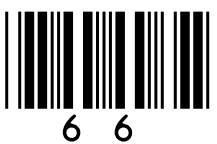
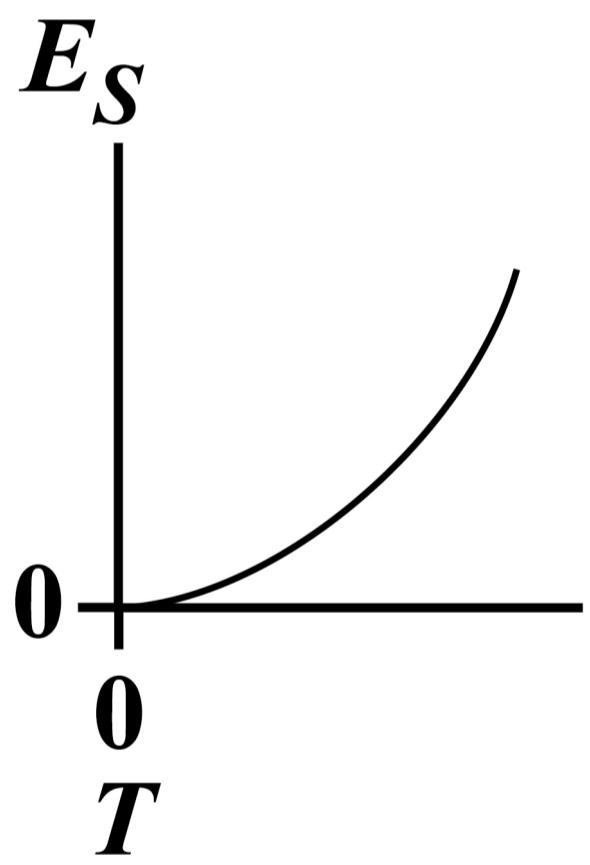
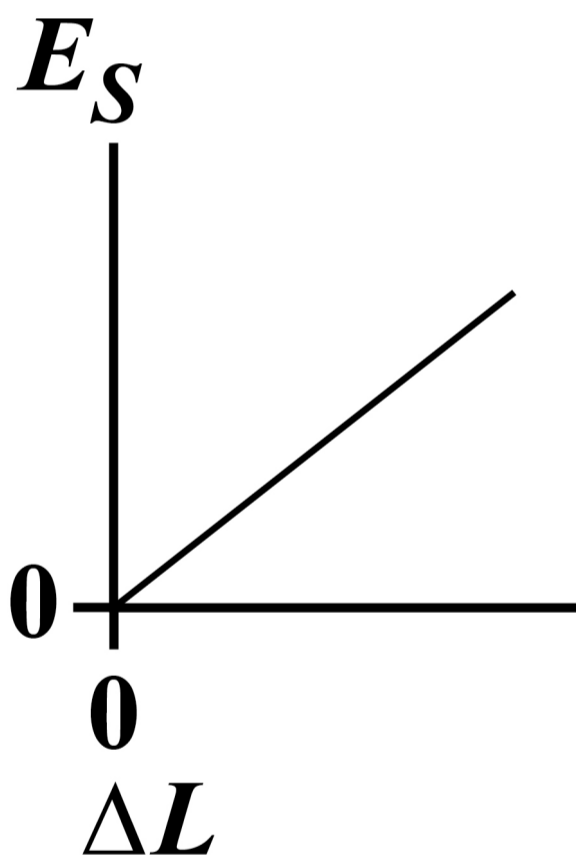
Which pair of graphs, on pages 66 and 67, shows the variation of E_s with ΔL and the variation of E_s with T ? [1 mark]

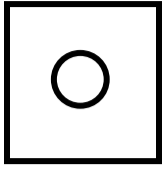
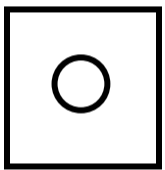
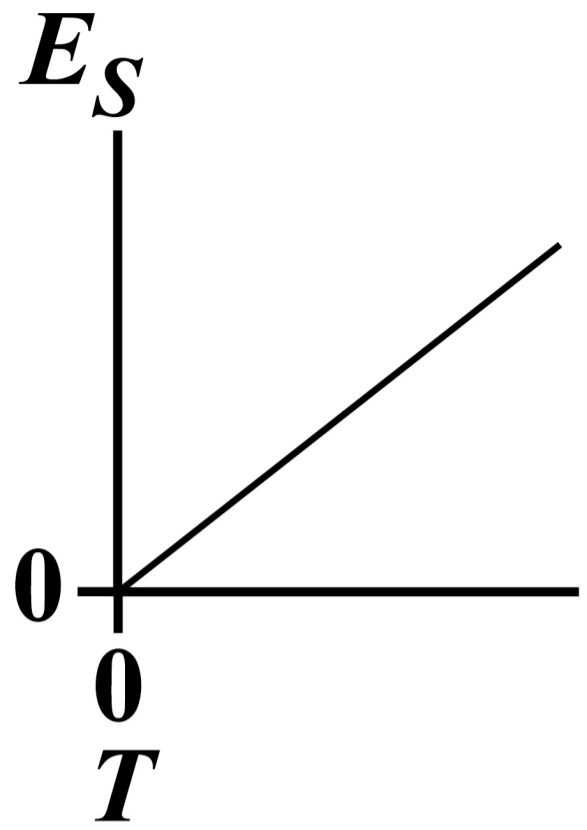
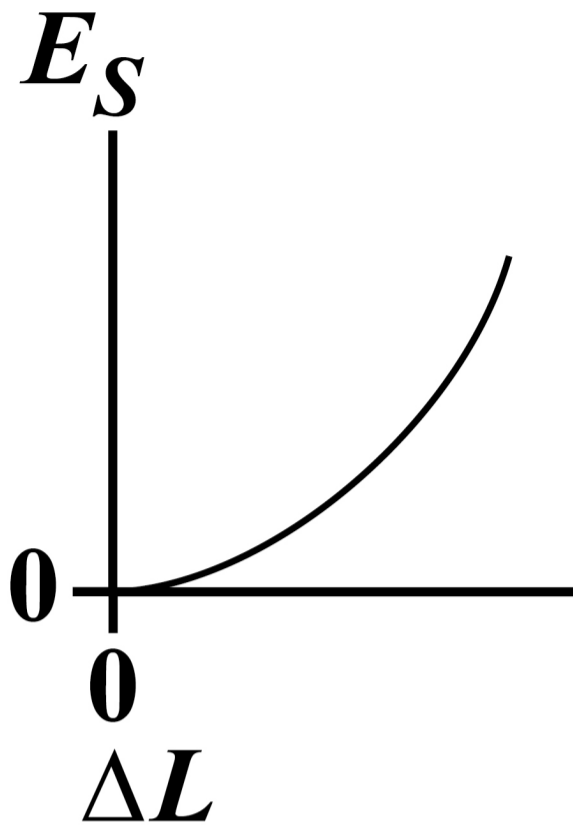
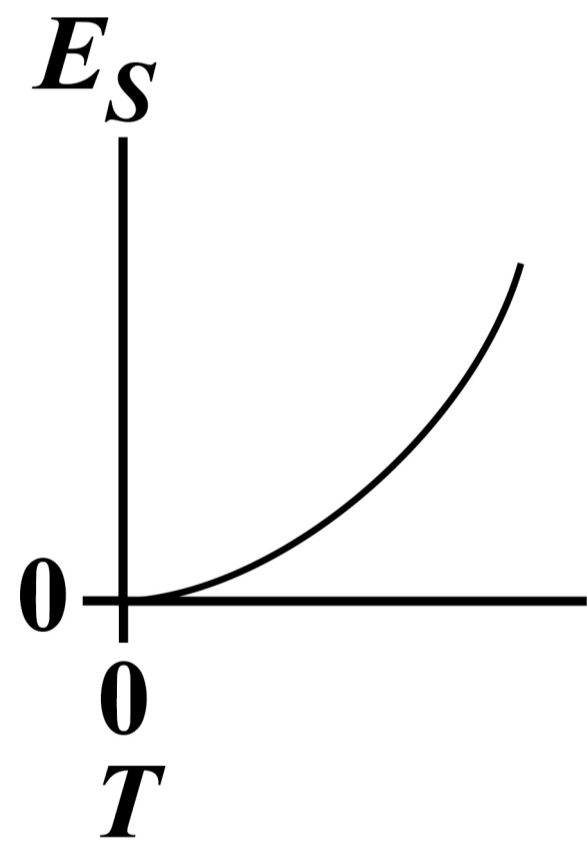
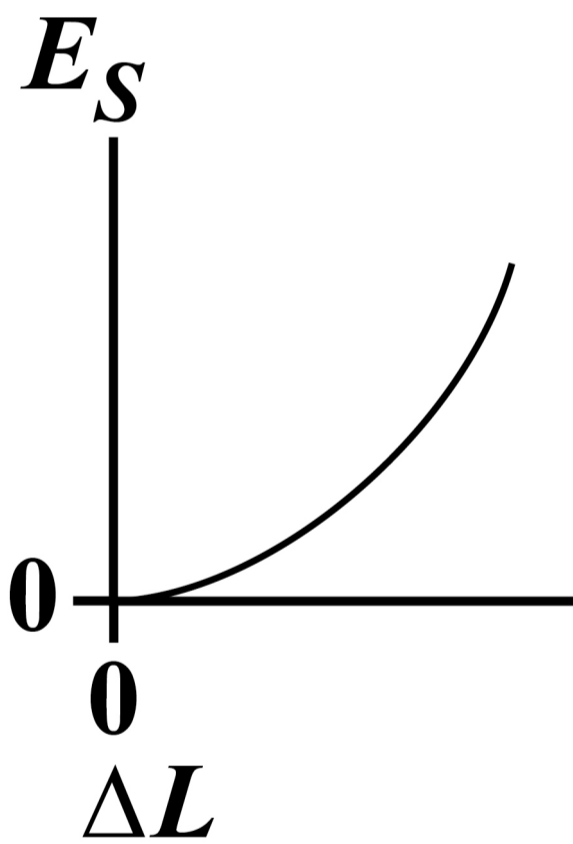


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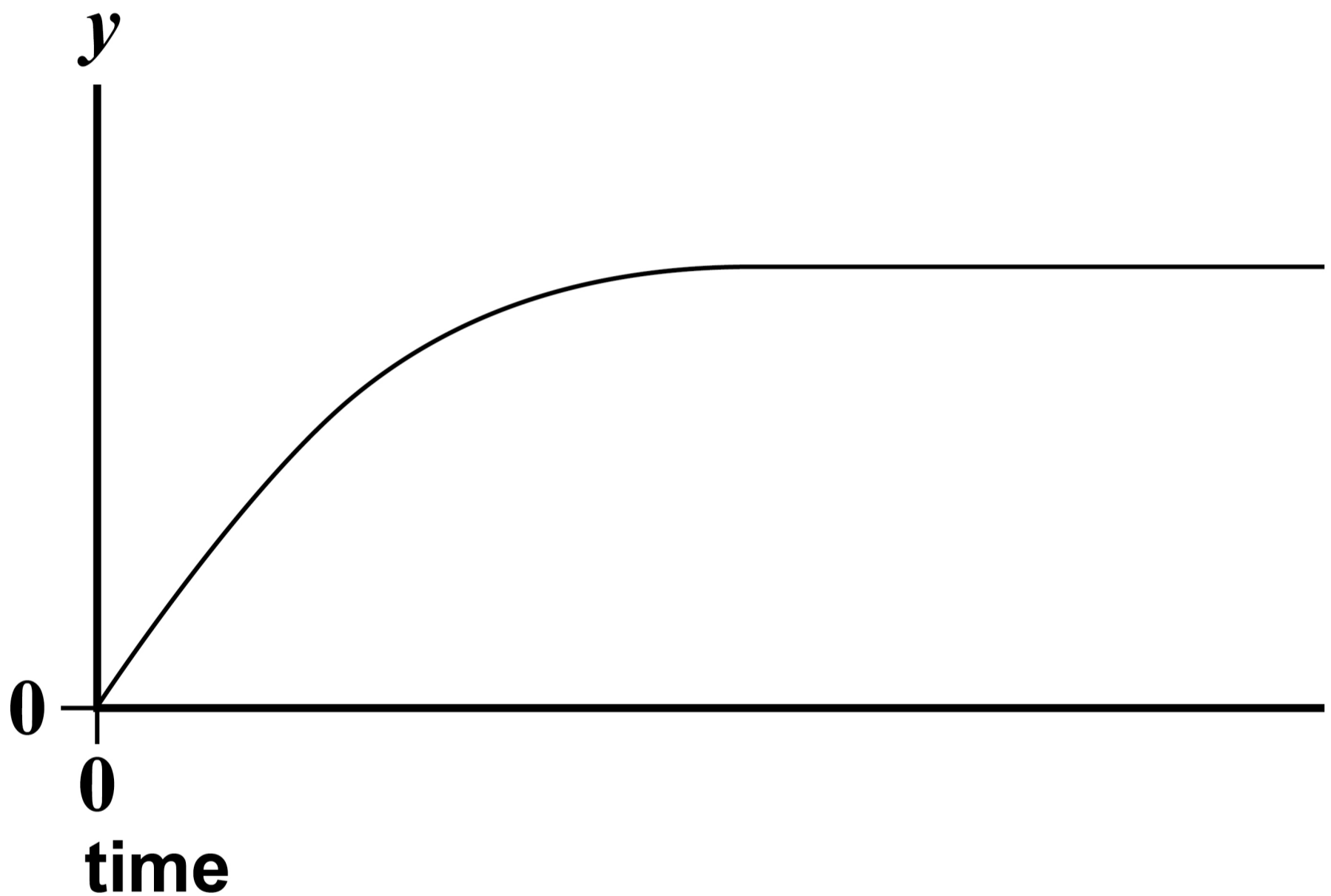


**A****B**

**C****D****[Turn over]**

1	1
---	---

The graph shows the variation with time of a quantity y for an object as it falls through the air.



Which row gives y and the amount of air resistance? [1 mark]

	y	AIR RESISTANCE
<input type="radio"/>	A distance	negligible
<input type="radio"/>	B distance	not negligible
<input type="radio"/>	C speed	negligible
<input type="radio"/>	D speed	not negligible

[Turn over]

1 2

An electric pump forces water continually through a horizontal pipe at a speed of 4.0 m s^{-1} .

cross-sectional area of the pipe = $5.0 \times 10^{-4} \text{ m}^2$

density of water = $1.0 \times 10^3 \text{ kg m}^{-3}$

**What is the useful power of the pump?
[1 mark]**

A 4.0 W

B 8.0 W

C 16 W

D 32 W



1	3
---	---

A current of 4.0 A in a resistor produces a power of 8.0 W.

What is the potential difference across this resistor when the power is 32 W?
[1 mark]

A 2.0 V

B 4.0 V

C 8.0 V

D 16 V

[Turn over]



1	4
---	---

Monochromatic radiation from light source P is incident on a metal surface and photoelectrons are emitted.

When monochromatic radiation from light source Q is used, no photoelectrons are emitted.

Which property of the radiation from P must be greater than that from Q?
[1 mark]

A frequency

B intensity

C speed

D wavelength



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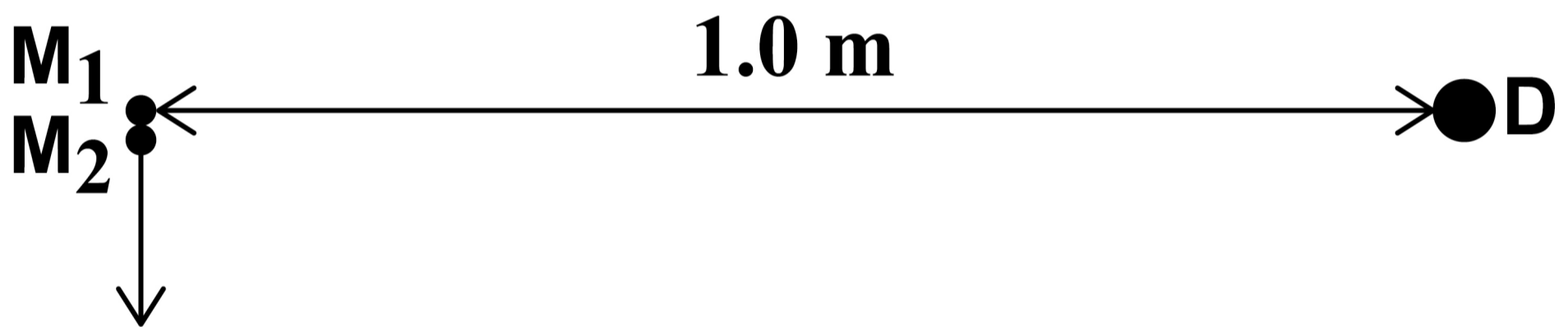
[Turn over]



1	5
---	---

Sources M_1 and M_2 emit coherent microwaves of wavelength 5.0 cm.

When M_1 and M_2 are very close, a maximum of intensity occurs at a point D that is 1.0 m away.



M_2 is moved away from M_1 along the line perpendicular to M_1D .

The next maximum of intensity occurs at D when the distance between M_1 and M_2 is

A 5.0 cm

B 10 cm

C 16 cm

D 32 cm

[1 mark]

[Turn over]



1	6
---	---

The quark structure of the antiparticle of the K^+ meson is

A $u\bar{s}$

B $\bar{u}d$

C $\bar{u}s$

D $\bar{d}s$

[1 mark]



1	7
---	---

What is the de Broglie wavelength of a positron travelling at 5% of the speed of light? [1 mark]

A $2.7 \times 10^{-16} \text{ m}$

B $2.7 \times 10^{-14} \text{ m}$

C $4.9 \times 10^{-13} \text{ m}$

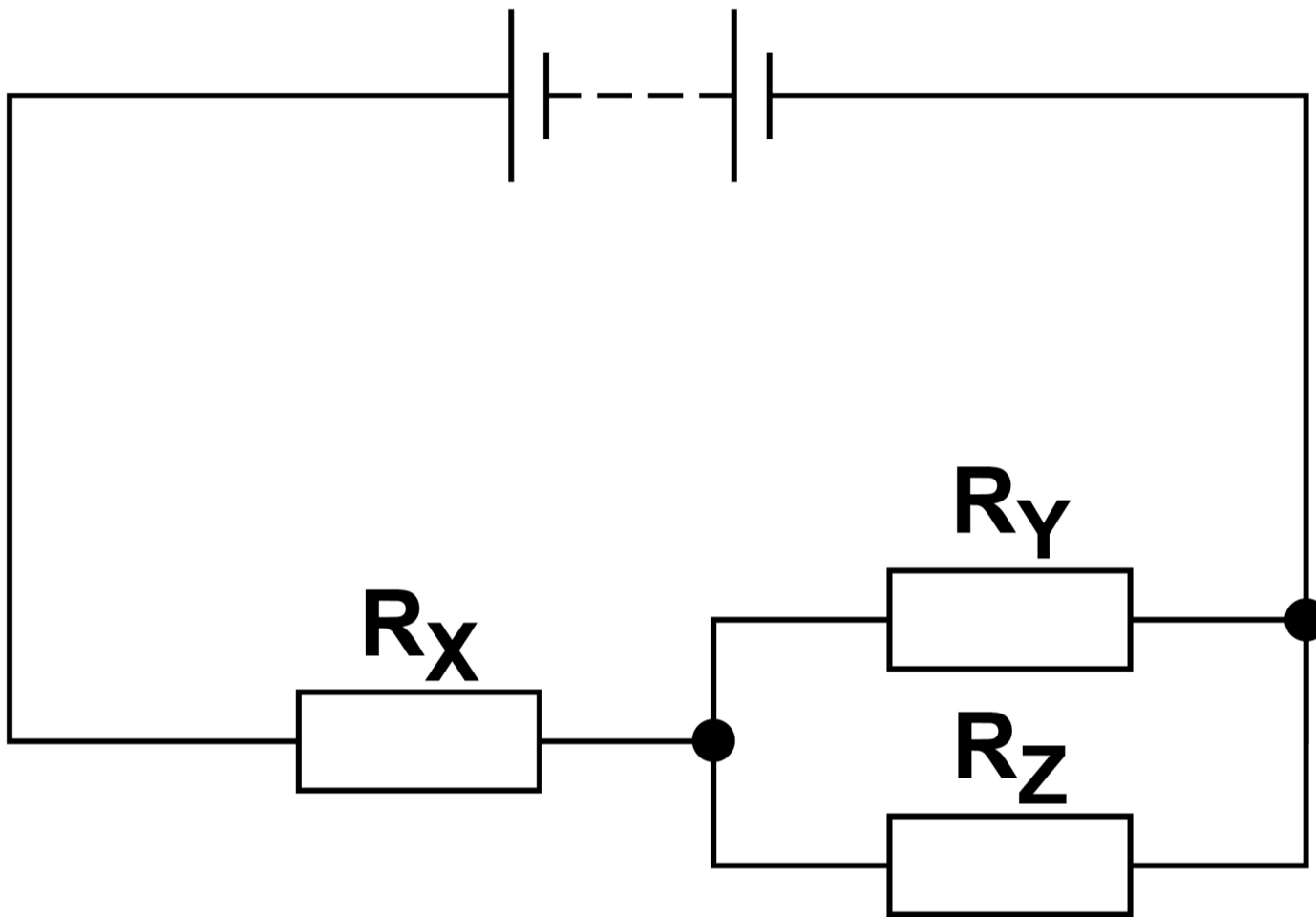
D $4.9 \times 10^{-11} \text{ m}$

[Turn over]



1 8

A circuit contains a battery and three identical resistors R_x , R_y and R_z .



What is $\frac{\text{power in } R_X}{\text{power in } R_Y}$? [1 mark]

A 0.25

B 0.5

C 2

D 4

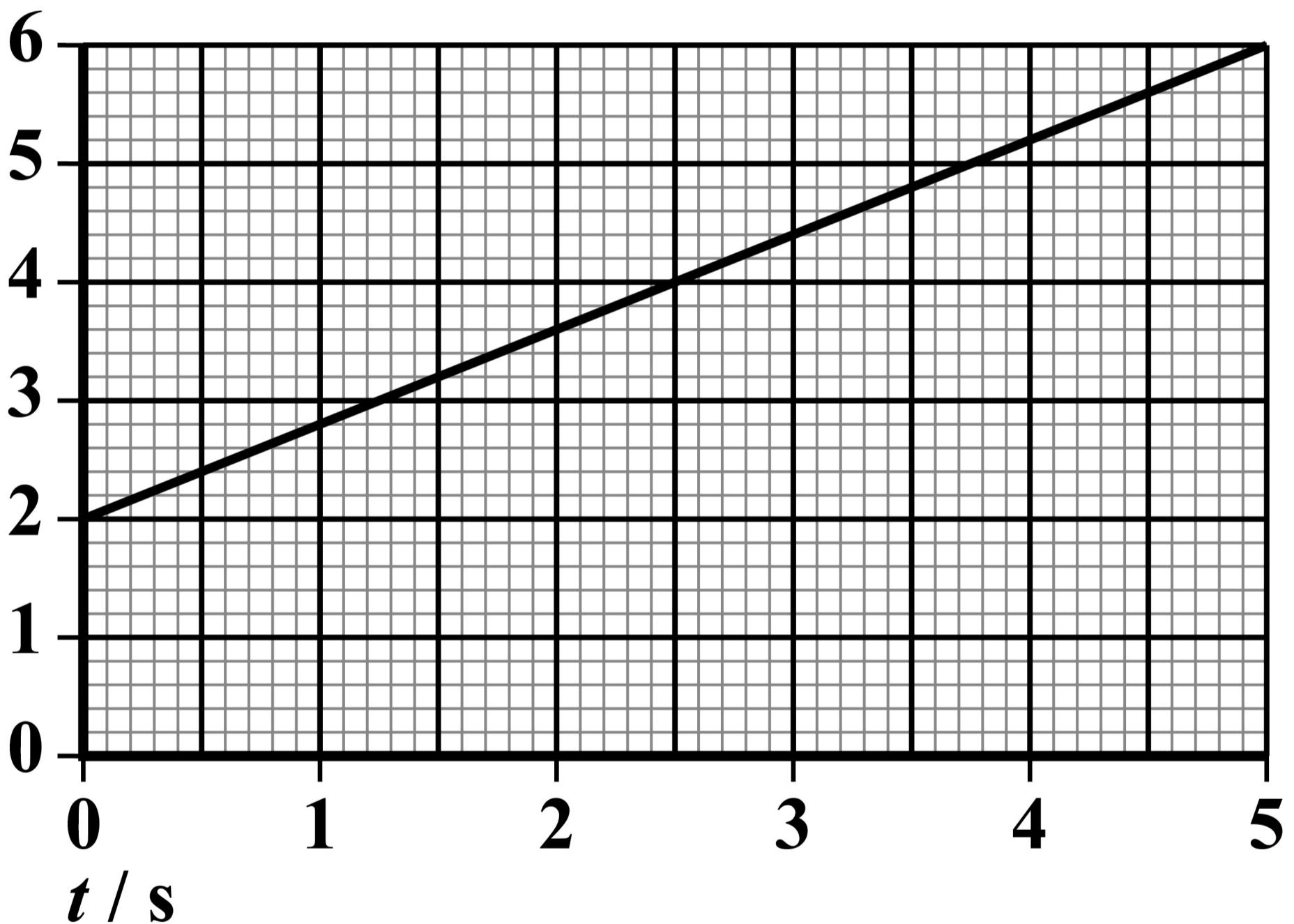
[Turn over]



19

The graph shows the variation with time t of the acceleration of an object moving in a straight line.

acceleration / m s^{-2}



When $t = 0$ the speed of the object is 4.0 m s^{-1} .

What is the speed of the object when $t = 5.0 \text{ s}$? [1 mark]

A 10 m s^{-1}

B 14 m s^{-1}

C 20 m s^{-1}

D 24 m s^{-1}

[Turn over]



2	0
---	---

**An object is released and falls from rest.
Air resistance is negligible.**

**After falling for time t , the momentum of
the object is**

- A constant.**
- B proportional to \sqrt{t} .**
- C proportional to t .**
- D proportional to t^2 .**

[1 mark]



2	1
---	---

The cladding of a step-index optical fibre

- A must not be transparent.**
- B must have a higher refractive index than the core.**
- C reduces signal loss.**
- D reduces material dispersion.**

[1 mark]

[Turn over]



2	2
---	---

A cricket ball of mass 0.16 kg travels at a speed of 35 m s^{-1} towards a bat.

When the ball is hit, it is in contact with the bat for 52 ms.

As a result, the ball travels in the opposite direction with a speed of 30 m s^{-1} .

What is the average force on the ball from the bat? [1 mark]

A 0.015 N

B 0.20 N

C 15 N

D 200 N



2	3
---	---

A horse starts walking from point X on a circular track of circumference 60 m.

The speed of the horse is a constant 2.0 m s^{-1} .

What is the horse's displacement from X after 45 s? [1 mark]

A 19 m

B 30 m

C 38 m

D 90 m

[Turn over]



2	4
---	---

Which statement is true? [1 mark]

A A brittle fracture occurs after little or no elastic deformation.

B A brittle fracture occurs after little or no plastic deformation.

C In a plastic deformation, energy stored is proportional to stress.

D In a plastic deformation, stress is proportional to strain.



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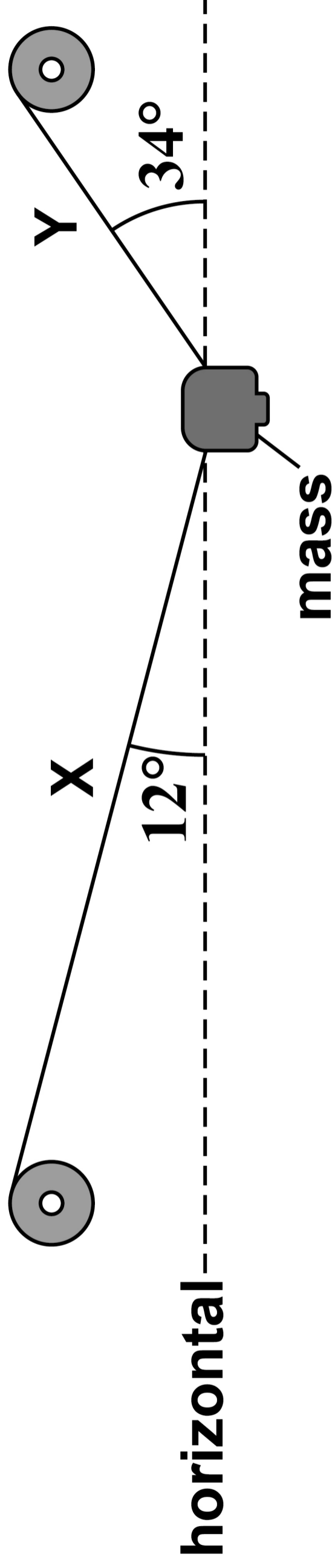
[Turn over]





25

A mass is held stationary by two cables X and Y.





The tension in X is 390 N.

What is the tension in Y? [1 mark]

A 145 N

B 380 N

C 390 N

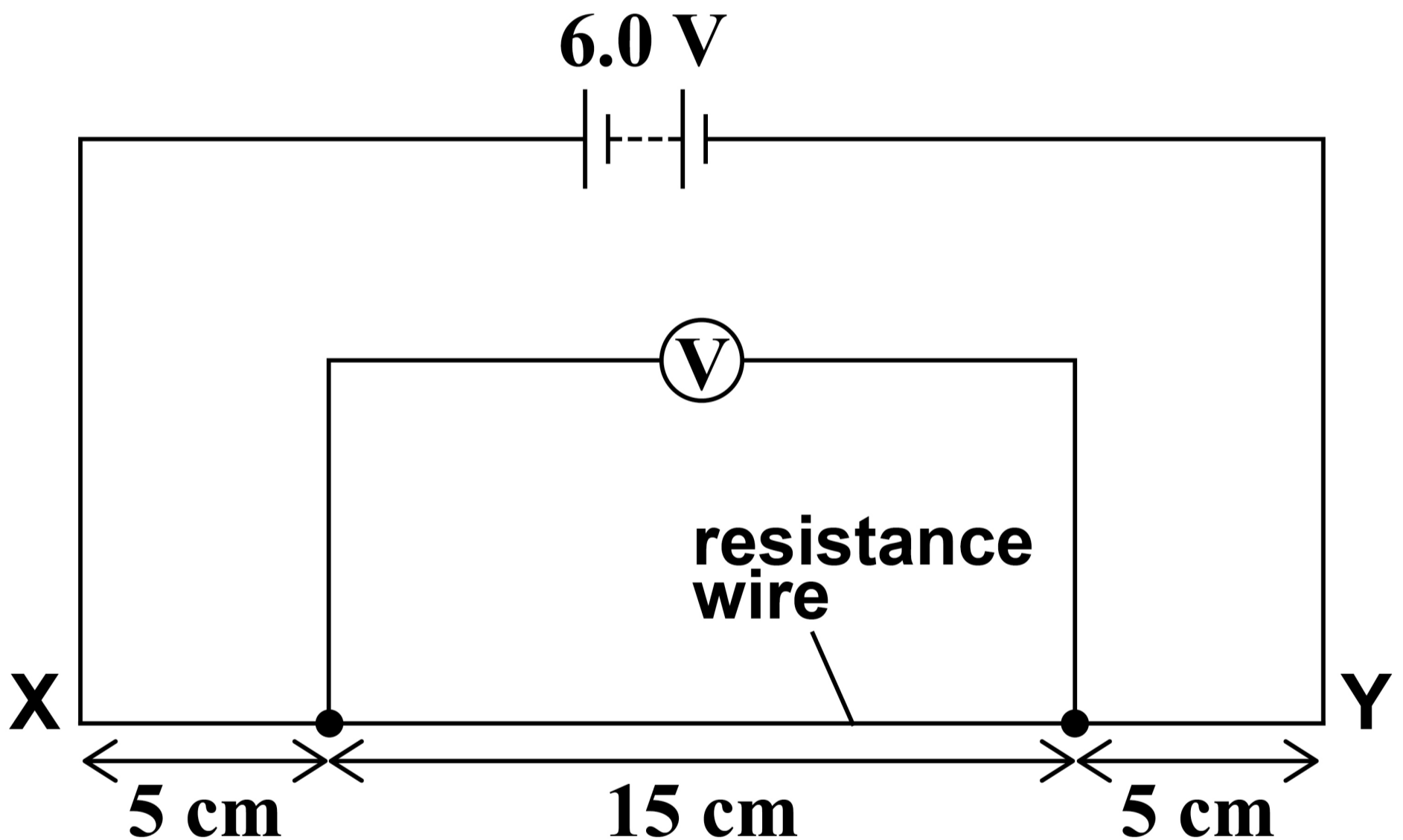
D 460 N

[Turn over]

2 6

A resistance wire XY of length 25 cm has constant cross-section.

The wire is connected to a battery of emf 6.0 V and negligible internal resistance.



What is the reading on the voltmeter?
[1 mark]

A 1.8 V

B 2.4 V

C 3.6 V

D 4.5 V

[Turn over]



27

The electric motor of a lift raises a load of 750 N at a constant speed. The load moves through a vertical distance of 3.0 m in 1.5 s . As the load is being raised, the current in the motor is 12 A and the potential difference across the motor is 200 V .

What is the efficiency of the lift?
[1 mark]

A 16%

B 63%

C 88%

D 94%



2	8
---	---

An aluminium wire has a length of 12 cm and a volume of $3.7 \times 10^{-4} \text{ m}^3$. The resistivity of aluminium is $2.7 \times 10^{-8} \Omega \text{ m}$.

What is the resistance of the wire?
[1 mark]

A $1.1 \times 10^{-6} \Omega$

B $8.8 \times 10^{-6} \Omega$

C $1.1 \times 10^{-2} \Omega$

D $8.8 \times 10^{-2} \Omega$

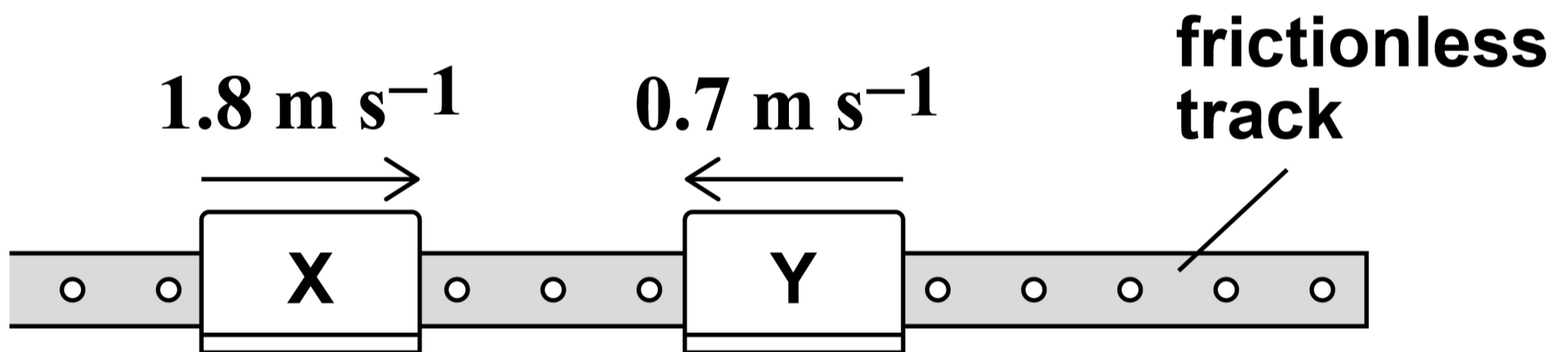
[Turn over]



29

Glider X of mass 400 g travels at 1.8 m s^{-1} to the right on a horizontal, frictionless track.

Glider Y of mass 300 g travels towards X at 0.7 m s^{-1} .



X and Y collide.

Immediately after the collision, Y travels to the right at a speed of 0.9 m s^{-1} .

What are the speed and direction of movement of X immediately after the collision? [1 mark]

- A 0.6 m s^{-1} to the left**
- B 0.6 m s^{-1} to the right**
- C 1.7 m s^{-1} to the left**
- D 1.7 m s^{-1} to the right**

[Turn over]



3	0
---	---

A stationary wave is formed due to superposition between a progressive wave and its reflection.

Both the progressive wave and its reflection are polarised.

Which statement about the progressive wave and its reflection is true at an antinode? [1 mark]

A They must be longitudinal waves.

B They must be coherent.

C They must have different frequencies.

D They must be polarised in the same plane.



3	1
---	---

Three non-parallel coplanar forces act on a body.

Which is not required for the forces to be in equilibrium? [1 mark]

A The sum of the forces in any direction must be zero.

B The sum of the moments of the forces about any point in the plane must be zero.

C The lines of action of the forces must pass through the centre of mass of the body.

D The resultant of any two forces must be the same magnitude as the third force.

[Turn over]





3	2
---	---

Which row, on the opposite page, is correct for both a progressive wave and a stationary wave? [1 mark]



PROGRESSIVE WAVE	STATIONARY WAVE
Some of the particles do not vibrate.	All the particles vibrate in phase with each other.
None of the particles vibrate with the same amplitude.	All the particles vibrate with the same amplitude.
All the particles vibrate.	Some of the particles do not vibrate.
All the particles vibrate in phase with each other.	None of the particles vibrate in phase with each other.

A

B

C

D

[Turn over]

3	3
---	---

A student investigates the characteristics of a power supply.

The experimental data are plotted on a graph with:

- pd (potential difference) across the power supply plotted on the y -axis**
- current in the power supply plotted on the x -axis.**

The axes intersect at $(0,0)$.



What feature of the graph represents the emf of the power supply? [1 mark]

A the area enclosed by the line and the x -axis

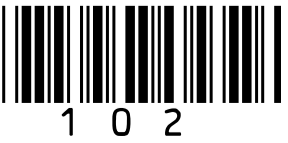
B the magnitude of the gradient of the line

C the intercept on the x -axis

D the intercept on the y -axis

[Turn over]





3 4

Which row shows SI prefixes in order of increasing magnitude? [1 mark]

	SMALLEST			LARGEST
<input type="radio"/> A	f	p	μ	c
<input type="radio"/> B	f	p	c	μ
<input type="radio"/> C	p	f	μ	c
<input type="radio"/> D	p	f	c	μ

END OF QUESTIONS

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For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5–34	
TOTAL	

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