A

Surname _____

Other Names _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

A-level

PHYSICS

Paper 1

7408/1

Time allowed: 2 hours

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

JUN227408101

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 85.**
- **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

Two stable isotopes of helium are $^{4}_{2}He$ and $^{3}_{2}He$.

0 1 . 1

An atom of $^{4}_{2}\mathrm{He}$ is produced in a rock that contains uranium. It is produced following the radioactive decay of a $^{238}_{92}\mathrm{U}$ atom. The decay also creates an atom of thorium (Th).

Write an equation for the decay of $^{238}_{92}\mathrm{U}$.

[2 marks]

$^{238}_{92}\mathrm{U} \longrightarrow$

[Turn over]

0 1 . 2

A $^{3}_{2}\mathrm{He}$ nucleus can be produced by the decay of a tritium nucleus $^{3}_{1}\mathrm{H}$.

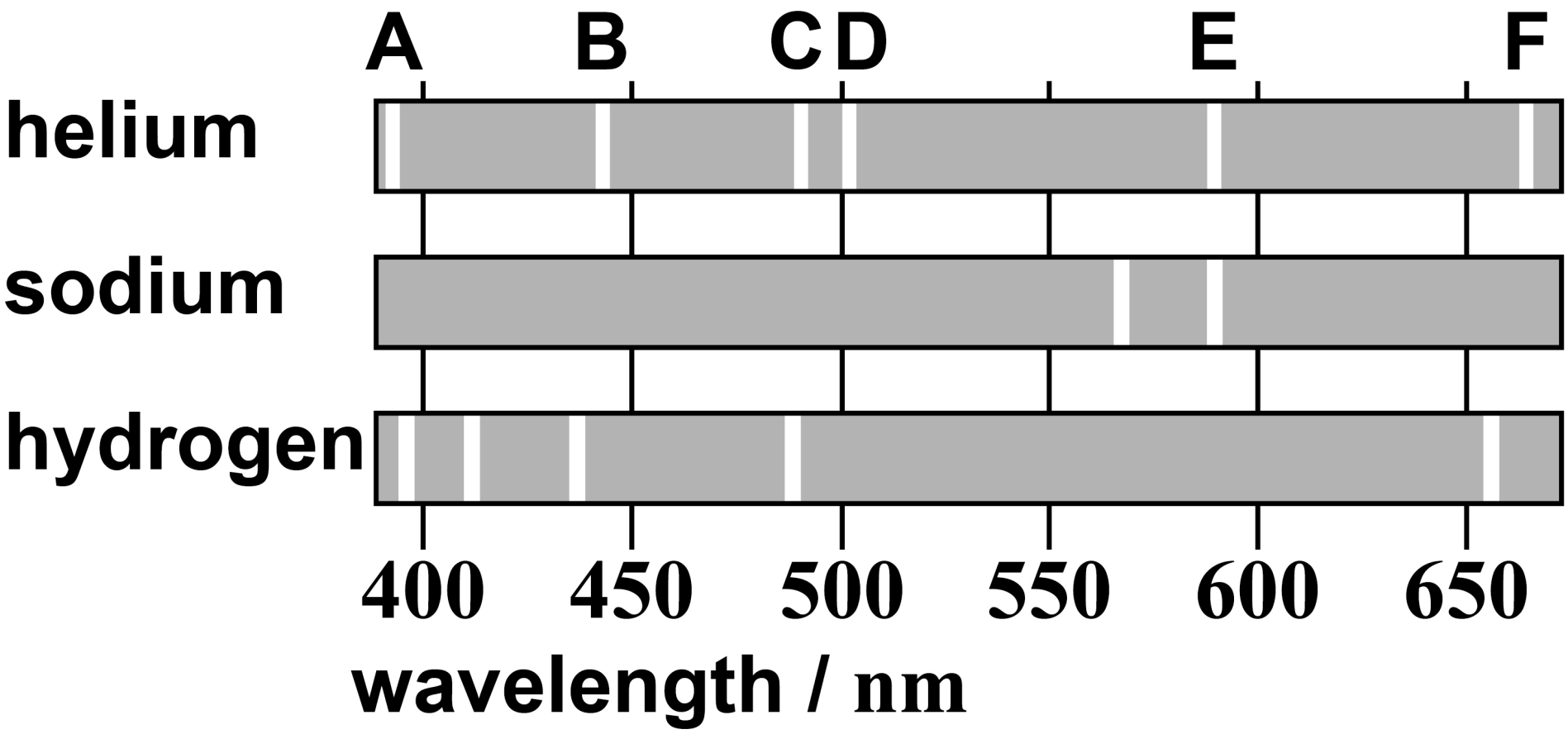
State and explain which exchange particle is responsible for this decay.
[2 marks]

[Turn over]

Helium was discovered by analysing the light in the ABSORPTION spectrum of the Sun.

FIGURE 1 shows the positions of the brightest lines, labelled A to F, in the EMISSION spectrum of helium. The brightest lines in the emission spectra of sodium and hydrogen are also shown.

FIGURE 1



0 1 . 3

Before helium was identified, some scientists suggested that the lines of the helium spectrum seen in the absorption spectrum of the Sun were due to the presence of sodium and hydrogen.

Discuss, with reference to the lines A to F in FIGURE 1, on the opposite page, the evidence for and against this suggestion. [2 marks]

10

0 1 . 4

Calculate, in eV, the change in energy level responsible for the spectral line labelled E in FIGURE 1, on page 8.
[3 marks]

change in energy level = _____ **eV**

[Turn over]

0 1 . 5

Explain, with reference to the processes within an atom, the difference between an emission spectrum and an absorption spectrum. [3 marks]

13

[Turn over]

BLANK PAGE

0 2

Carbon-14 decays into nitrogen-14 with the release of a beta (β^-) particle and an antineutrino ($\overline{\nu_e}$).

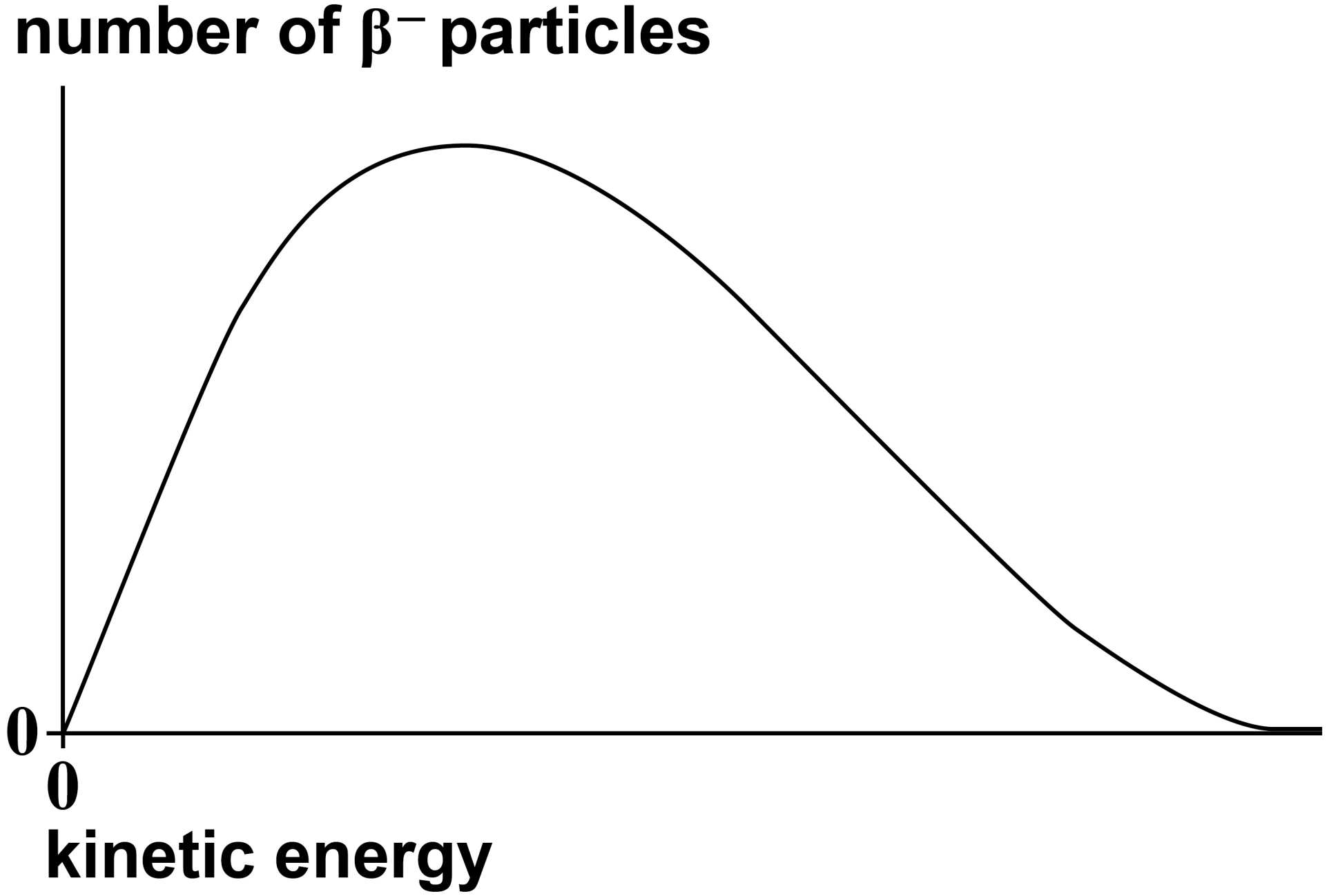
0 2 . 1

State the change of quark character in β^- decay. [1 mark]

0 2 . 2

FIGURE 2 shows the distribution of kinetic energies of β^- particles from the decay of carbon-14.

FIGURE 2



Explain how FIGURE 2 supports the existence of the antineutrino. [2 marks]

The existence of the antineutrino was confirmed by experiments in which antineutrinos interact with protons. The equation for this interaction is:

$$\overline{\nu_e} + p \longrightarrow e^+ + X$$

0 2 . 3

Identify particle X. [1 mark]

0 2 . 4

The positron released in this interaction is annihilated when it encounters an electron.

A pair of gamma photons is then produced.

Particle X can be absorbed by a nucleus. This produces another gamma ray.

TABLE 1, on page 20, contains data for three gamma photons detected during an antineutrino–proton interaction experiment.

[Turn over]

TABLE 1

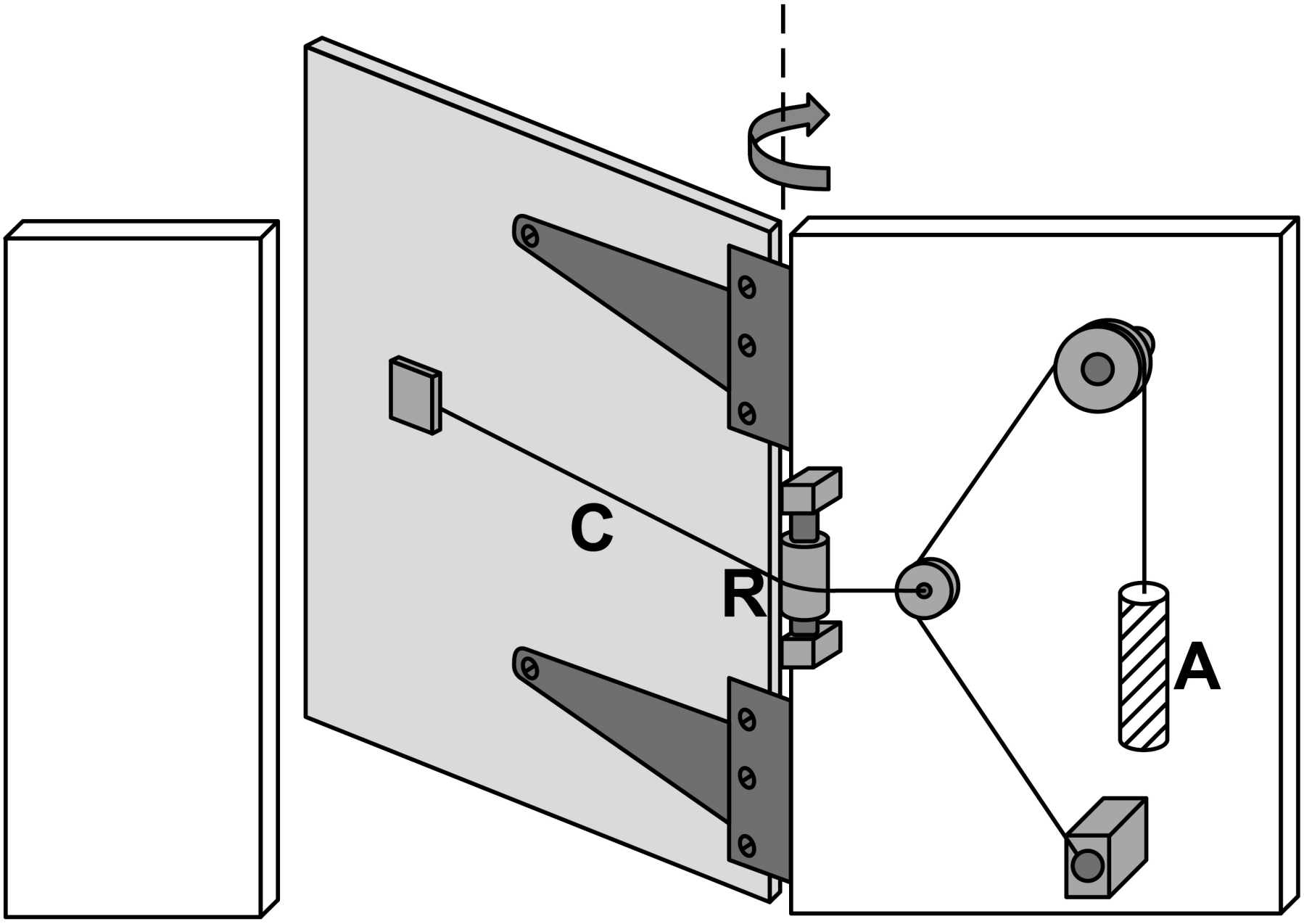
Gamma photon	Photon energy / J
G1	5.0×10^{-14}
G2	6.6×10^{-14}
G3	1.0×10^{-13}

Deduce which of the three gamma photons could have been produced by positron annihilation. [3 marks]

0 3

FIGURE 3 shows a garden gate with a pulley system designed to close the gate.

FIGURE 3



The pulley system raises weight A when the gate is opened. When the gate is released, A falls. The horizontal cable C passes over pulley R. The tension in cable C causes the gate to close.

Weight A is a solid cylinder with the following properties:

diameter = 4.8×10^{-2} m

length = 0.23 m

weight = 35 N

TABLE 2 gives the density of three available materials.

TABLE 2

Material	Density / kg m^{-3}
concrete	2.4×10^{3}
iron	7.8×10^{3}
brass	8.6×10^{3}

[Turn over]

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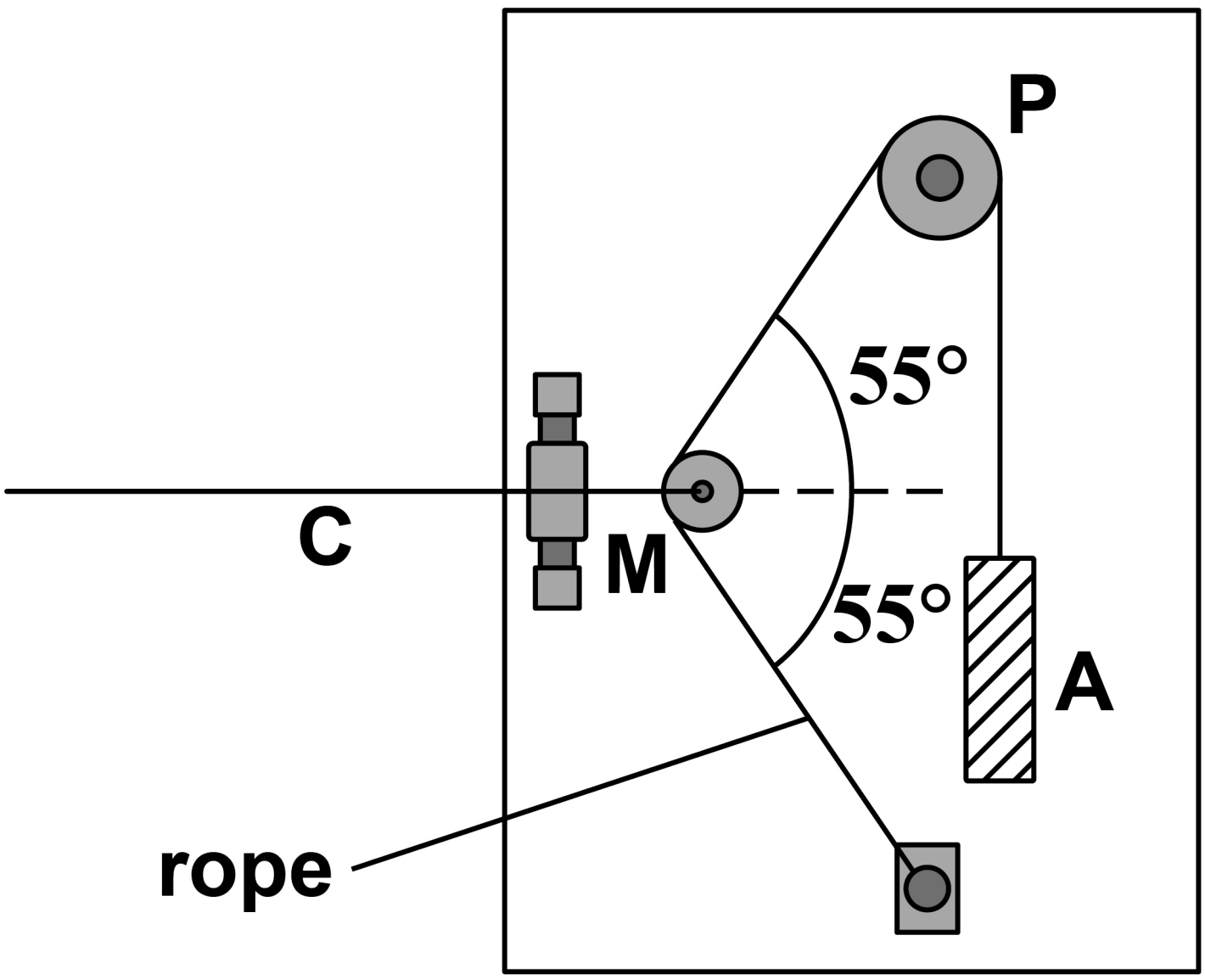
0 3 . 1

Deduce which ONE of the three materials is used for A. [3 marks]

FIGURE 4 shows the pulley arrangement when the gate is closed.

FIGURE 4



Pulleys P and M are frictionless so that the tension in the rope attached to A is equal to the weight of A.
A weighs 35 N and the weight of moveable pulley M is negligible.

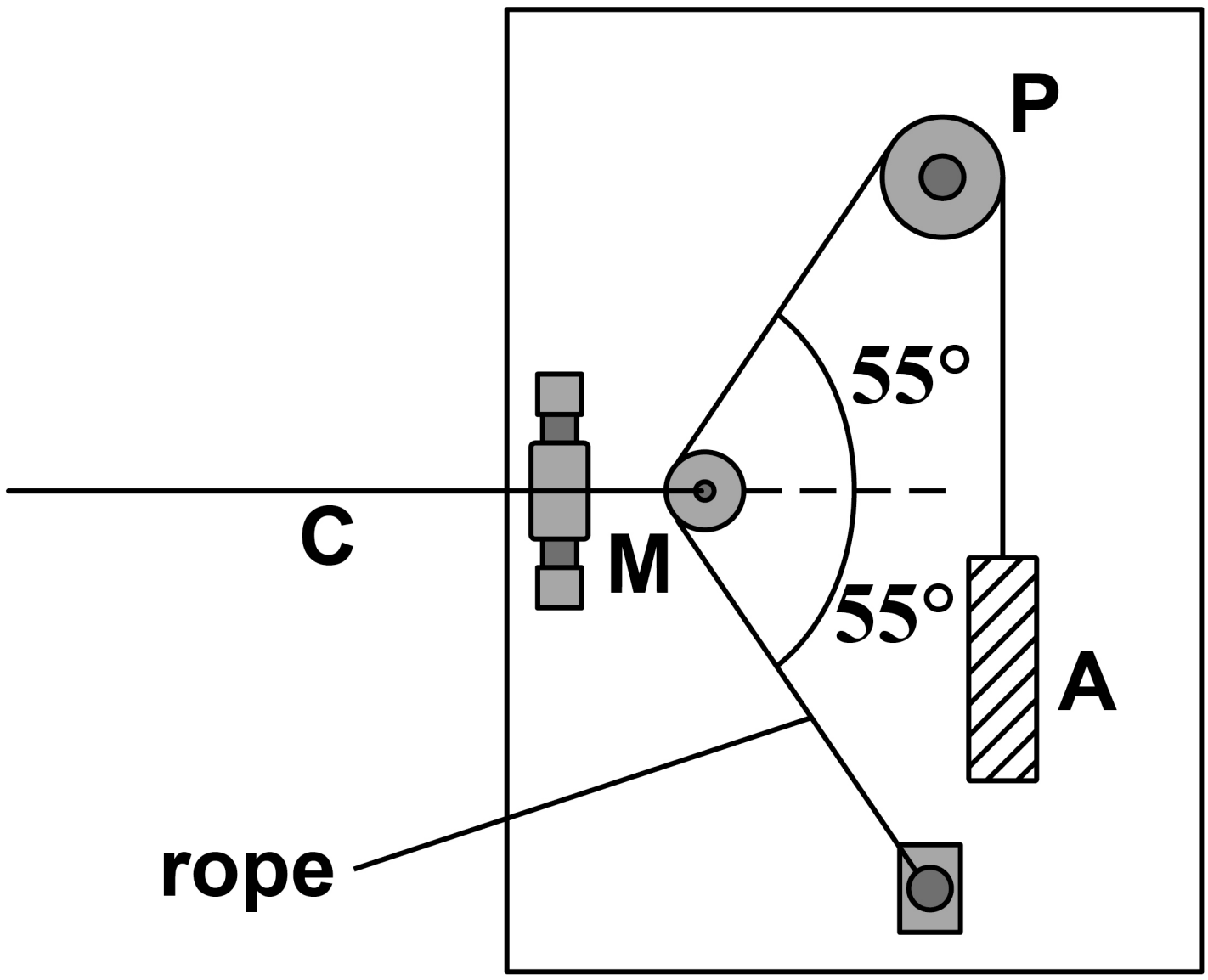
0 3 . 2

Calculate the tension in the horizontal cable C when the gate is closed.
[2 marks]

tension = _____ N

[Turn over]

Repeat of FIGURE 4



0 3 . 3

Pulley M is pulled to the left as the gate is opened.

Explain why this increases the tension in the horizontal cable C. [2 marks]

[Turn over]

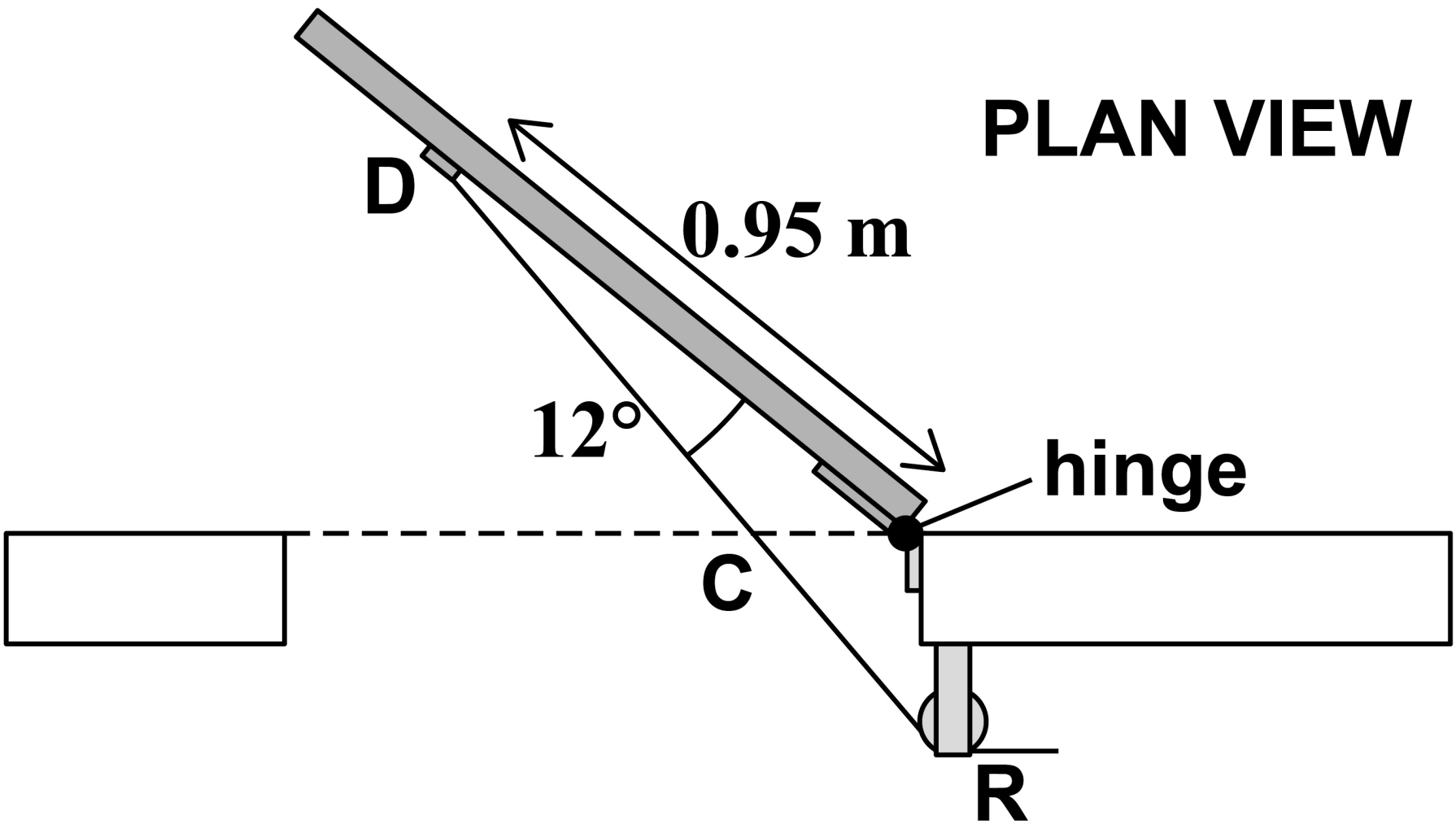
0 3 . 4

FIGURE 5 shows a plan view with the gate open. The horizontal cable C passes over pulley R and is attached to the door at D.

The angle between the door and the horizontal cable C is $12°$.

The horizontal distance between the hinge and D is $0.95\ \text{m}$.

FIGURE 5



The tension in the horizontal cable C is now 41 N.

Calculate the moment of the tension about the hinge. [2 marks]

moment = _____ N m

[Turn over]

0 3 . 5

The same system is attached to an identical gate with stiffer hinges. Now the system does not supply a sufficiently large moment to close the gate.

Discuss TWO independent changes to the design to increase the moment about the hinges due to horizontal cable C.
[4 marks]

1

2 _____

_____

_____

_____

_____

_____

_____

_____

_____

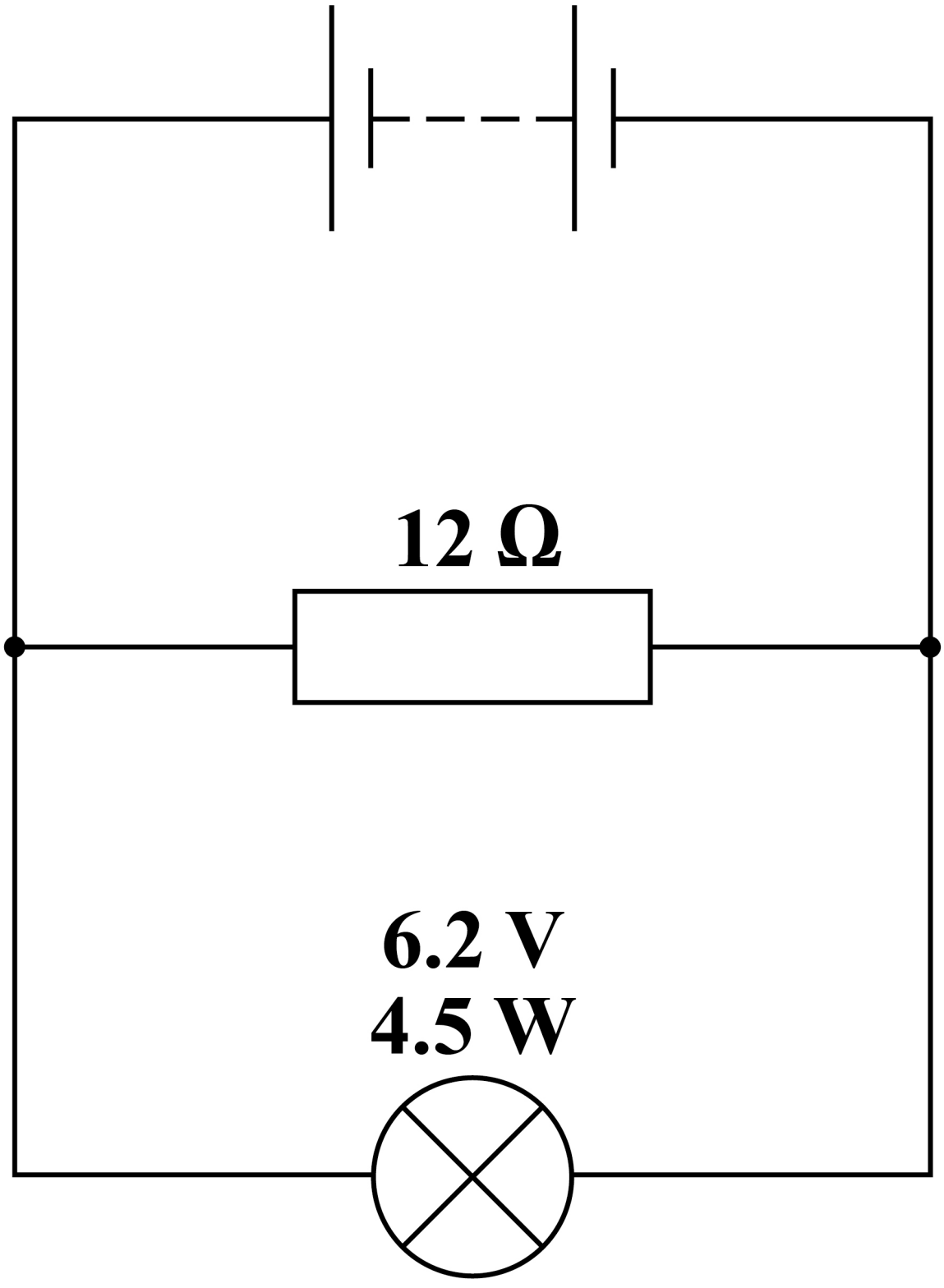
[Turn over]

13

0 4

A student assembles the circuit in FIGURE 6.

FIGURE 6



The battery has an internal resistance of 2.5 Ω.

0 4 . 1

Show that the resistance of the 6.2 V, 4.5 W lamp at its working potential difference (pd) is about 9 Ω. [1 mark]

0 4 . 2

The terminal pd across the battery is 6.2 V.

Calculate the emf of the battery. [3 marks]

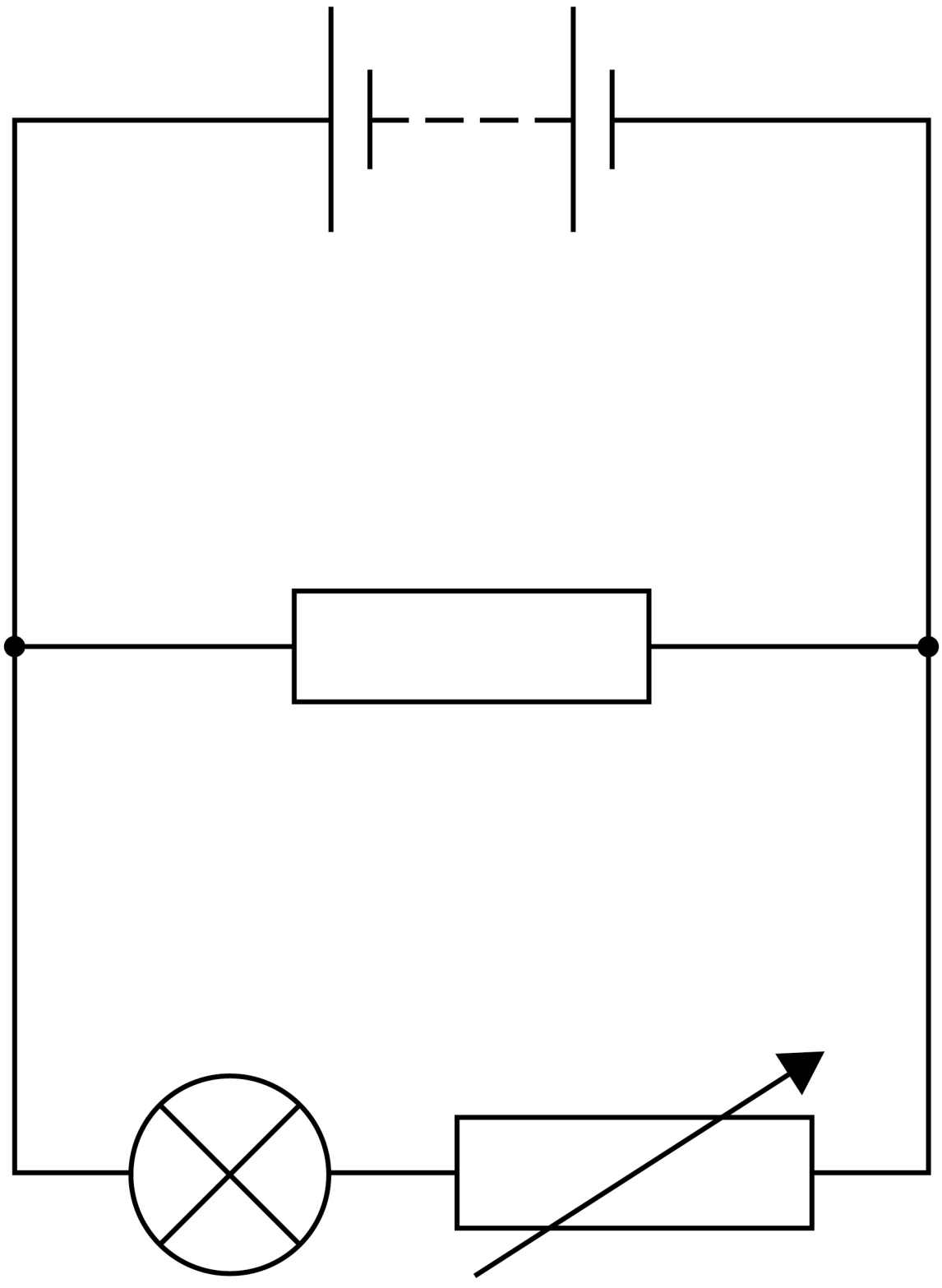
emf = _____ V

[Turn over]

The student makes a variable resistor to control the brightness of the lamp.

FIGURE 7 shows her circuit.

FIGURE 7



0 4 . 3

She uses a resistance wire with a diameter of $0.19\ \text{mm}$ to make the variable resistor.
A $5.0\ \text{m}$ length of this wire has a resistance of $9.0\ \Omega$.

Calculate the resistivity of the wire.
[3 marks]

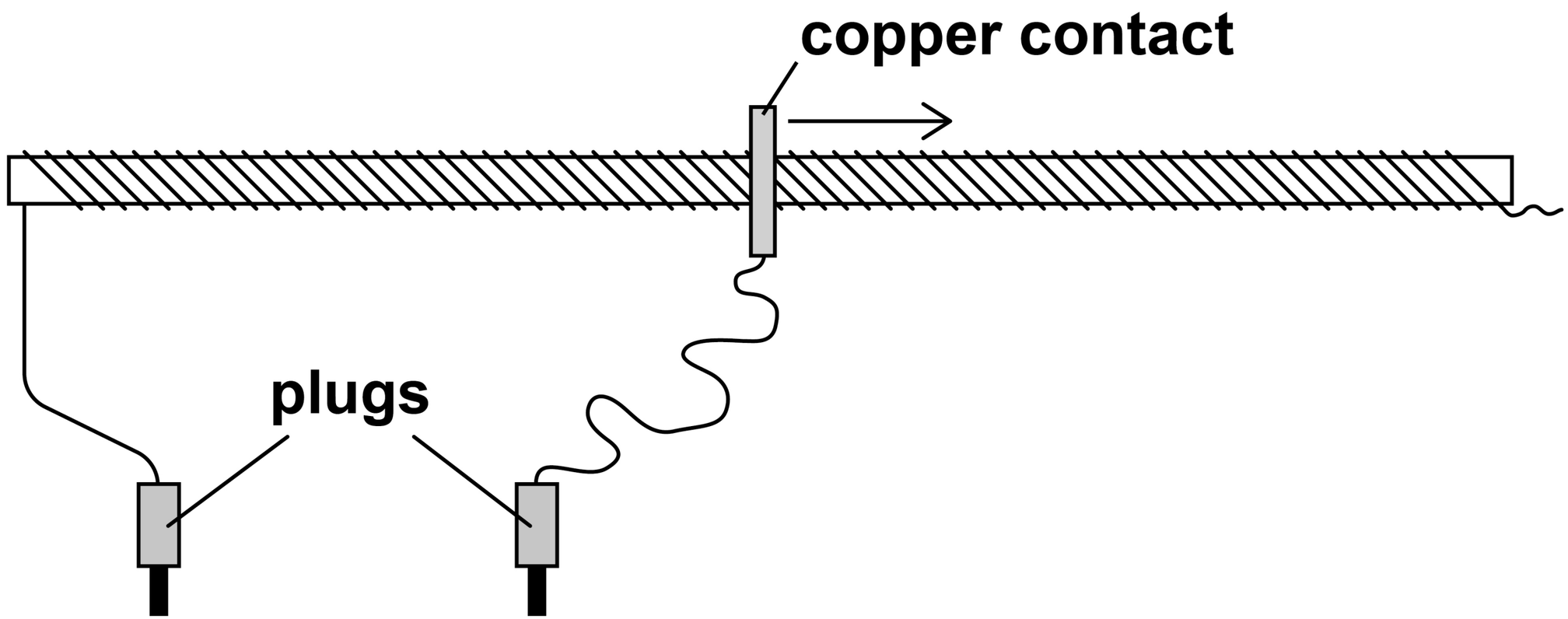
resistivity = _____ $\Omega\ \text{m}$

[Turn over]

0 4 . 4

FIGURE 8 shows the $5.0\ \mathrm{m}$ length of wire wrapped around a tube to make the variable resistor.

FIGURE 8



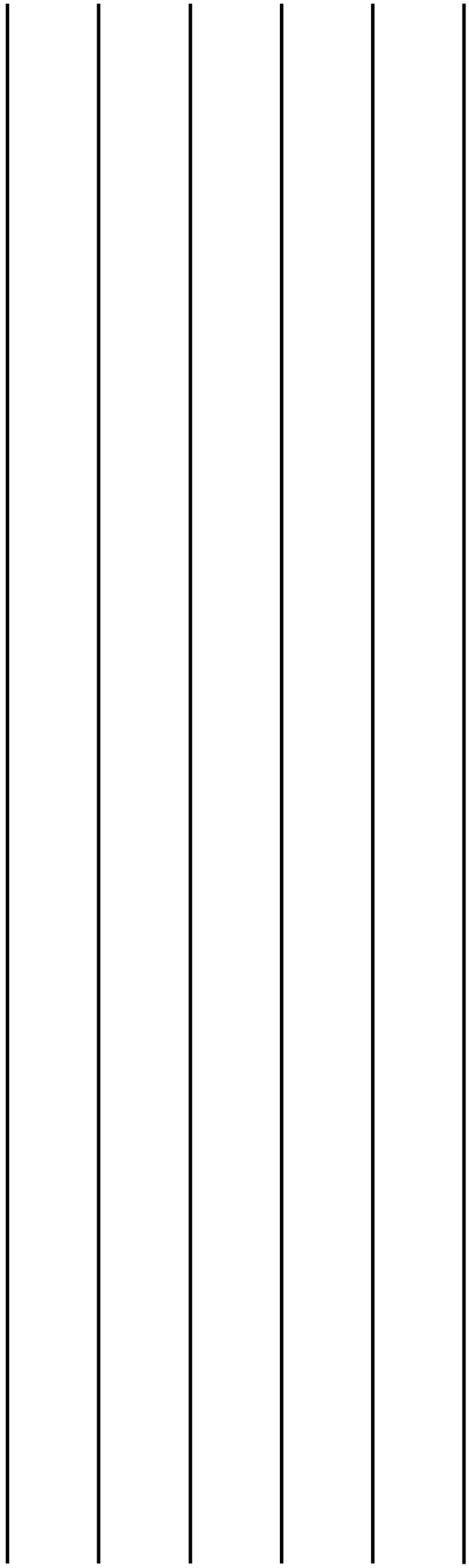
Two plugs connect the variable resistor into the circuit. A moveable copper contact is used to vary the length of wire in series with the lamp.

When the contact is placed on the tube at one particular position, the lamp is dim. The contact is then moved slowly to the right as shown in FIGURE 8.

Explain, without calculation, what happens to the brightness of the lamp as the contact is moved. [2 marks]

[Turn over]

40



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[Turn over]

0 4 . 5

The student now makes a different circuit by connecting the variable resistor IN PARALLEL with the lamp.

The contact is returned to its original position on the tube as shown in FIGURE 8, on page 38, and the lamp is dim. The contact is again slowly moved to the right.

Explain, without calculation, what happens to the brightness of the lamp as the contact is moved. [2 marks]

4 3

4 3

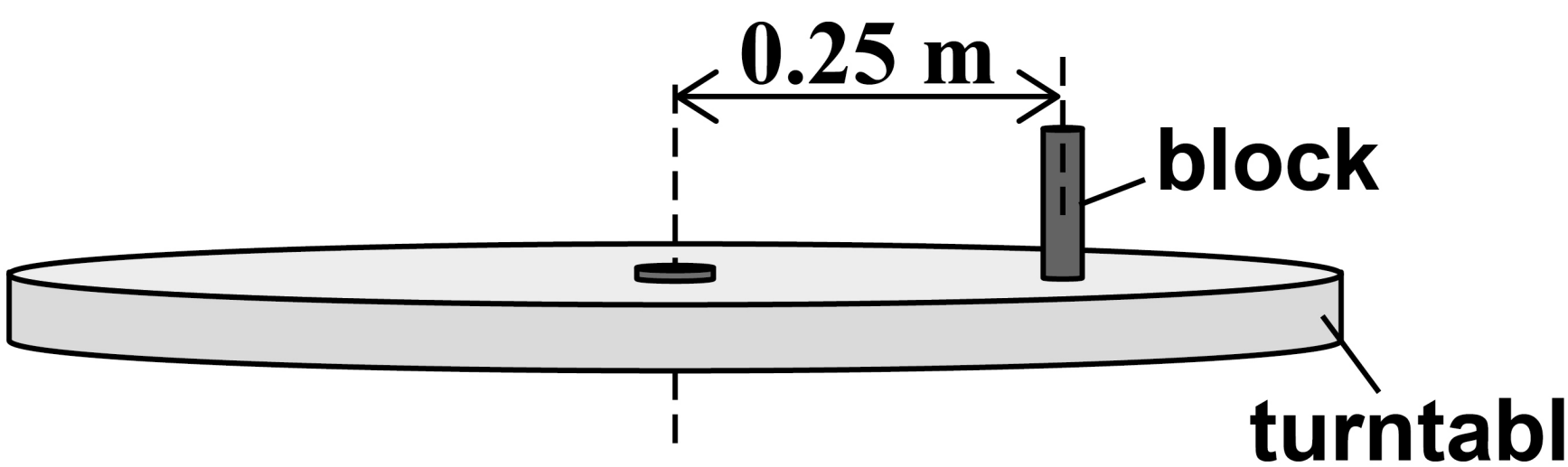
[Turn over]

0 5

A teacher sets up a demonstration to show the relationship between circular motion and simple harmonic motion (SHM).

She places a block on a turntable at a point $0.25\ \text{m}$ from its centre, as shown in FIGURE 9.

FIGURE 9



The turntable rotates with an angular speed of $1.8\ \text{rad}\ \text{s}^{-1}$ and the block does not slip.

0 5 . 1

Calculate the time taken for the turntable to complete one revolution. [2 marks]

time = _____ s

[Turn over]

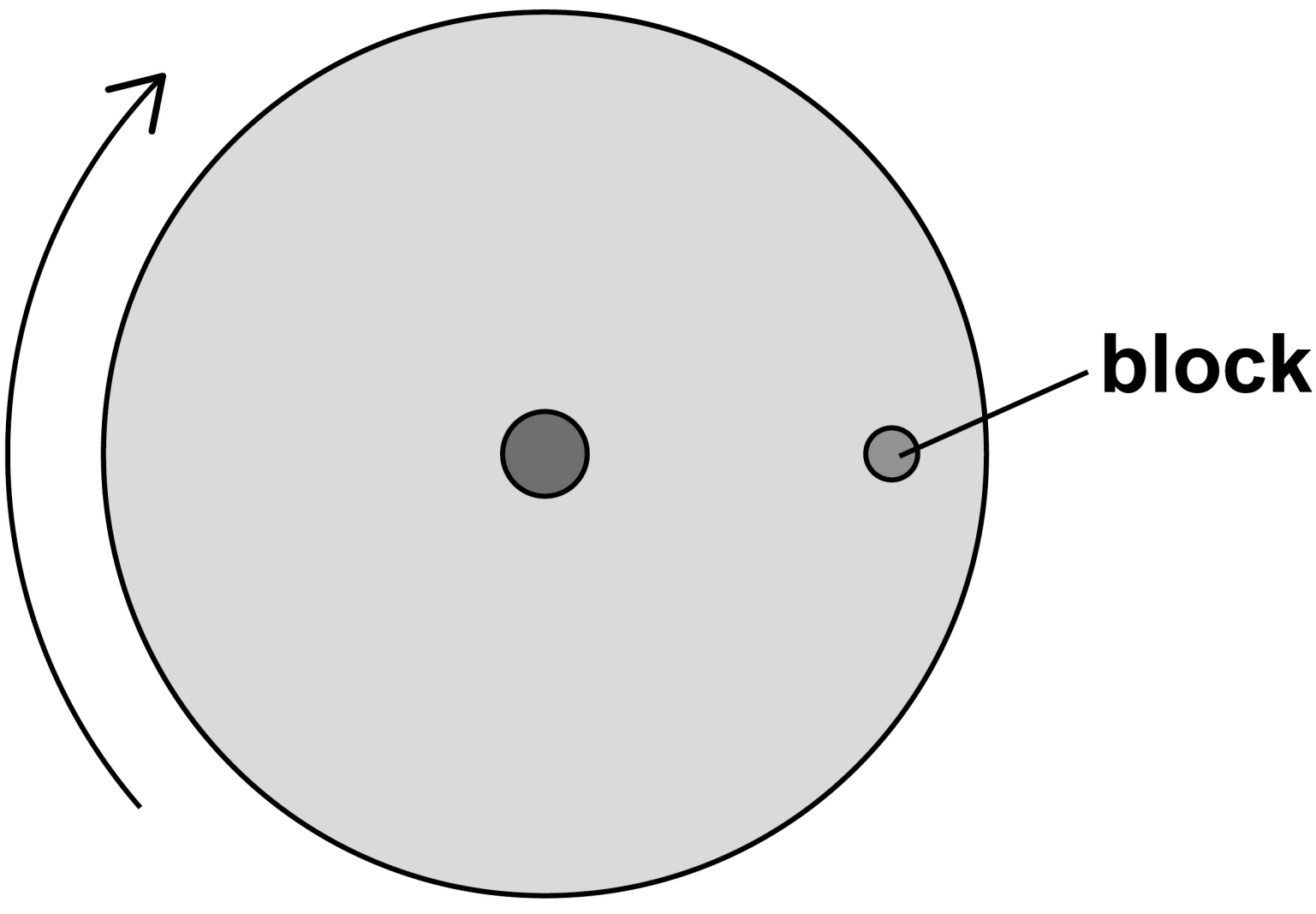
0 5 . 2

FIGURE 10 shows a plan view of the turntable and block.

The turntable rotates in a clockwise direction.

Draw an arrow on FIGURE 10 to show the direction of the resultant force on the block. [1 mark]

FIGURE 10



0 5 . 3

The mass of the block is $0.12\ \text{kg}$.

Calculate the magnitude of the resultant force on the block. [2 marks]

magnitude of force = _____ N

0 5 . 4

Describe, with reference to one of Newton's laws of motion, the evidence that a resultant force is acting on the block. [2 marks]

0 5 . 5

The teacher adjusts the angular speed of the turntable so that the block completes one rotation every 2.50 s.
She sets up a simple pendulum above the centre of the turntable so that it swings in phase with the movement of the block.

Calculate the length of the simple pendulum. [2 marks]

length = _____ m

[Turn over]

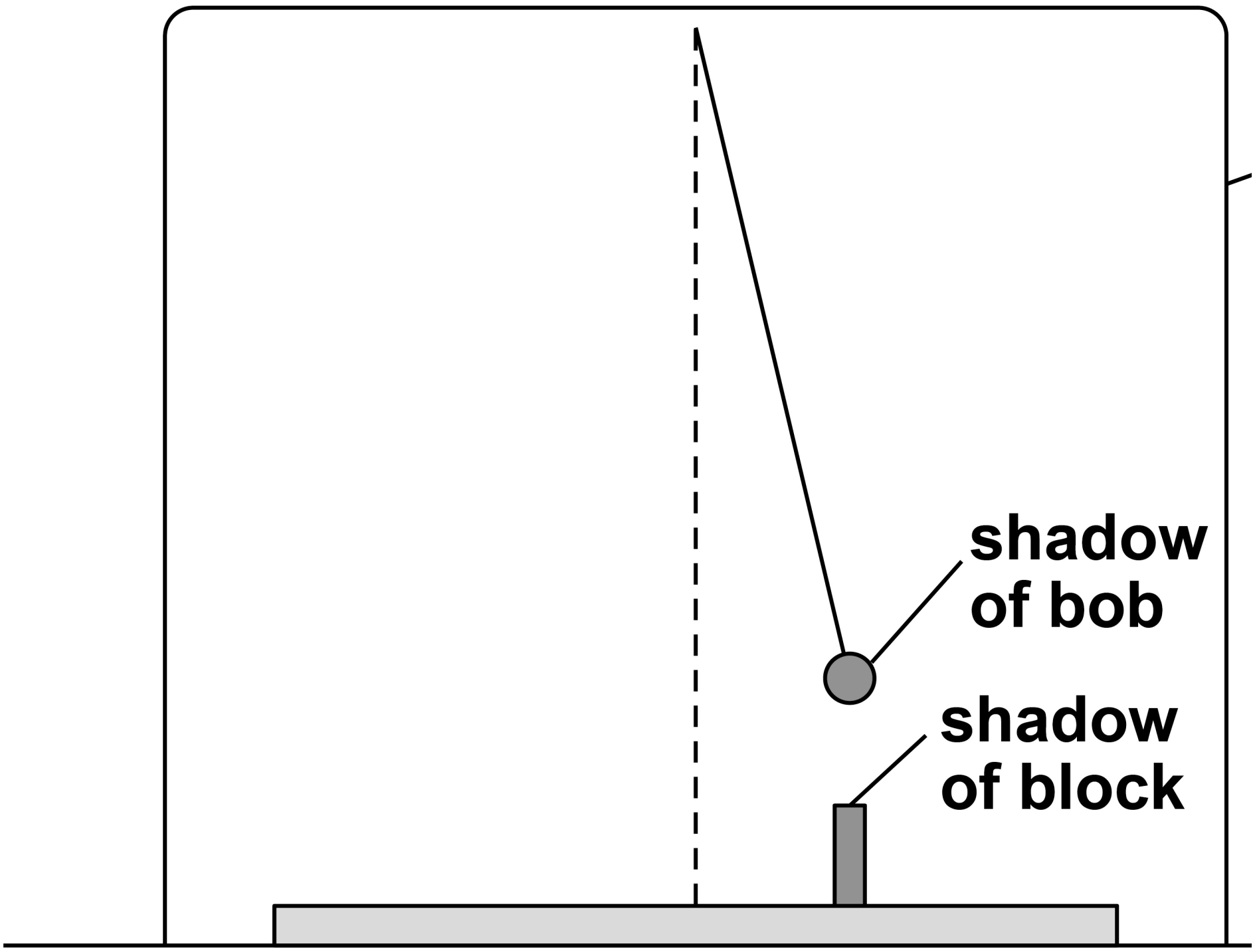
0 5 . 6

A lamp is used to project shadow images of the block and pendulum bob on a screen.

Both shadows appear to move with SHM across the screen.

FIGURE 11, on the opposite page, shows the images on the screen at one instant.

FIGURE 11



[Turn over]

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Initially the shadows move in phase with the same amplitude.

Air resistance affects the motion of the pendulum.

Suggest the effect this has on the amplitude relationship and the phase relationship between the moving shadows. [2 marks]

amplitude _____

_____

_____

phase _____

_____

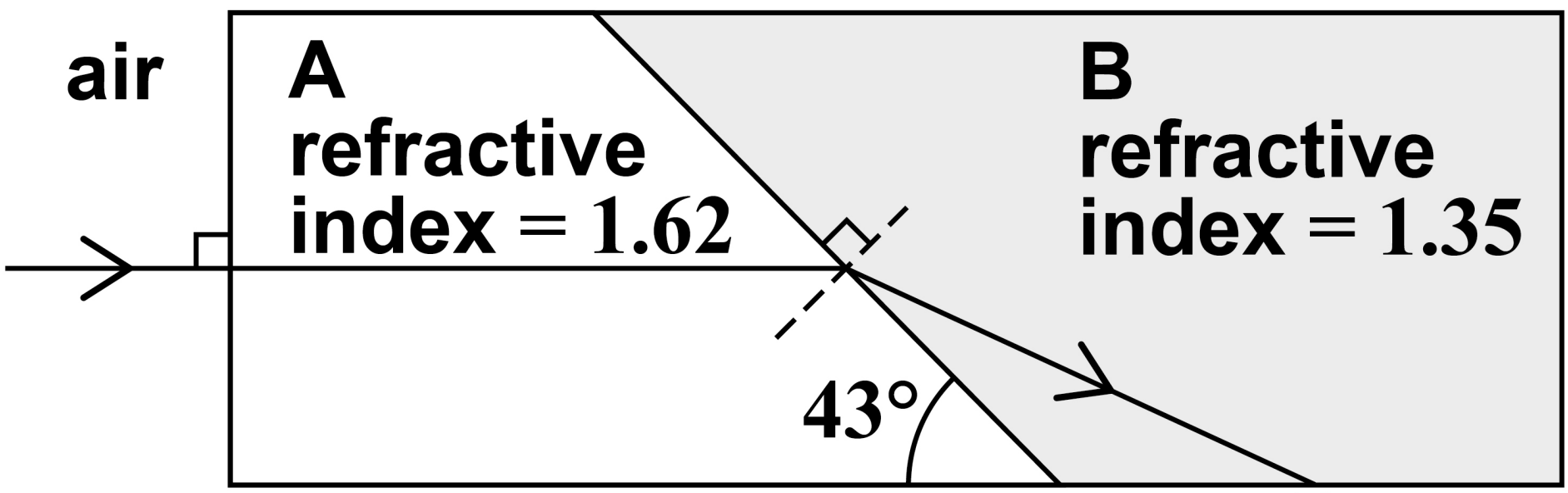
_____

_____

0 6

Two transparent prisms A and B of different refractive indices are placed in contact to produce a rectangular block. FIGURE 12 shows the path of a ray, incident normally on A, refracting as it crosses the boundary between the prisms. They are NOT drawn to scale.

FIGURE 12



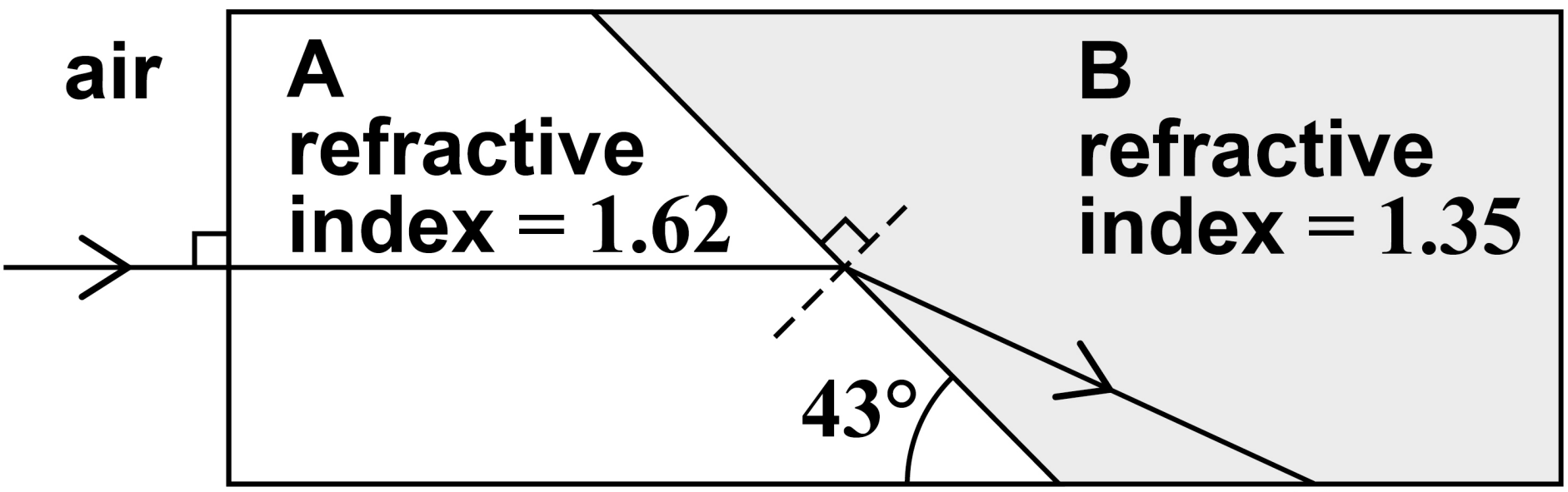
0 6 . 1

Explain how the path of the ray shows that the refractive index of A is greater than the refractive index of B. [1 mark]

0 6 . 2

Show that the angle of refraction of the ray in B is about $60°$. [2 marks]

Repeat of FIGURE 12



0 6 . 3

Draw, on FIGURE 12 above, the path of the ray immediately after it reaches P.

Justify your answer with calculations.
[3 marks]

6

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[Turn over]

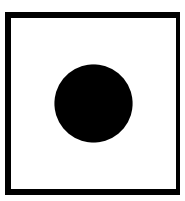
SECTION B

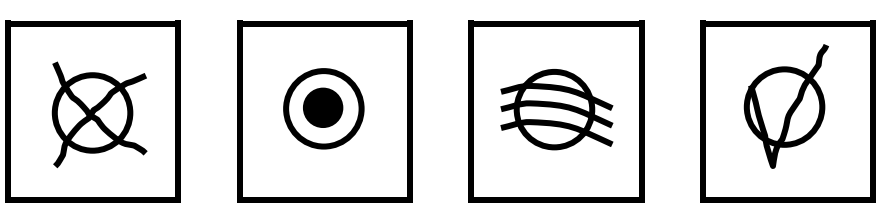
Each of Questions 07 to 31 is followed by four responses, A, B, C and D.

For each question select the best response.

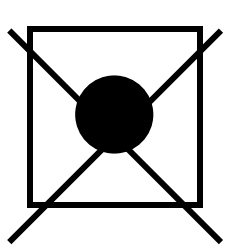
Only ONE answer per question is allowed.

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

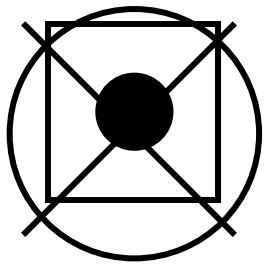
CORRECT METHOD 

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 7

Which two quantities have the base unit $kg\ m^2\ s^{-2}$? [1 mark]

○ **A kinetic energy and momentum**

○ **B kinetic energy and Young modulus**

○ **C work done and the moment of a couple**

○ **D work done and pressure**

0 8

Which gives SI prefixes in descending order of magnitude? [1 mark]

○ **A G p m**

○ **B M G n**

○ **C m n μ**

○ **D m μ p**

0 9

A car travels at $100\ \text{km}\ \text{h}^{-1}$ on a motorway.

What is an estimate of its kinetic energy? [1 mark]

- ○ **A** 10^4 J
- ○ **B** 10^6 J
- ○ **C** 10^8 J
- ○ **D** 10^{10} J

1 0

What is the specific charge of a $^{13}_{6}C$ nucleus? [1 mark]

○ **A** $4.4 \times 10^{7}\ C\ kg^{-1}$

○ **B** $5.2 \times 10^{7}\ C\ kg^{-1}$

○ **C** $8.3 \times 10^{7}\ C\ kg^{-1}$

○ **D** $2.1 \times 10^{8}\ C\ kg^{-1}$

[Turn over]

1 1

Which row describes the variation with distance of the strong nuclear force? [1 mark]

		ATTRACTIVE	REPULSIVE
○	A	beyond 3 fm	from 0.5 fm to 3 fm
○	B	from 0.5 fm to 3 fm	beyond 3 fm
○	C	from 0.5 fm to 3 fm	up to 0.5 fm
○	D	up to 0.5 fm	from 0.5 fm to 3 fm

1 2

Which statement is correct? [1 mark]

○ **A All strange particles are mesons.**

○ **B Strange particles are always created in pairs.**

○ **C Strangeness can only change in strong interactions.**

○ **D Strangeness can only have a value of 0 or -1**

[Turn over]

1 3

Which combination of quarks is possible? [1 mark]

○ **A sd**

○ **B sū**

○ **C sūd**

○ **D ud**

1	4

In photoelectricity, V_S is the stopping potential.

What quantity is eV_S? [1 mark]

○ **A energy of an incident photon**

○ **B maximum kinetic energy of a photoelectron**

○ **C threshold frequency × the Planck constant**

○ **D work function**

[Turn over]

1 5

A fluorescent tube contains a gas.

The coating of the tube
[1 mark]

○ **A** **becomes ionised by the gas and emits photons of ultraviolet light.**

○ **B** **absorbs photons of ultraviolet light from the gas and emits visible light.**

○ **C** **absorbs photons of ultraviolet light from the gas and emits photoelectrons.**

○ **D** **absorbs several photons of visible light from the gas and then emits one photon of ultraviolet light.**

1 6

Which row gives evidence for the wave nature of electrons and evidence for the particulate nature of light? [1 mark]

		Wave nature of electrons	Particulate nature of light
○	A	electron diffraction	photoelectric effect
○	B	electron diffraction	single-slit diffraction
○	C	photoelectric effect	single-slit diffraction
○	D	photoelectric effect	electron diffraction

[Turn over]

1	7

Which particle has the smallest de Broglie wavelength? [1 mark]

○ **A** an electron moving at $4 \times 10^3\ \text{m s}^{-1}$

○ **B** a proton moving at $4 \times 10^3\ \text{m s}^{-1}$

○ **C** an electron moving at $8 \times 10^5\ \text{m s}^{-1}$

○ **D** a proton moving at $8 \times 10^5\ \text{m s}^{-1}$

1	8

A longitudinal wave of frequency 660 Hz travels through a medium.

The wave speed is 330 m s^{-1}.

Which statement describes the motion of a particle in the wave? [1 mark]

○ **A** It is travelling at a speed of 330 m s^{-1}.

○ **B** It moves in phase with a particle in the wave 25 cm away.

○ **C** It oscillates with a time period of 1.5 ms.

○ **D** It changes direction 660 times every second.

1	9

The frequency of the first harmonic of a standing wave on a string is f.
The tension in the string is T.
The tension is increased to $4T$ without changing the length or mass of the string.

Which harmonic has a frequency $2f$ after this change? [1 mark]

○ **A first**

○ **B second**

○ **C third**

○ **D fourth**

2	0

Light of wavelength 5.2×10^{-7} m is used in a Young's double-slit experiment. The distance from the slits to the screen is 1.5 m.

The width of ten fringes is 3.5 cm.

What is the separation of the two slits? [1 mark]

○ **A** 2.2×10^{-5} m

○ **B** 9.9×10^{-5} m

○ **C** 1.1×10^{-4} m

○ **D** 2.2×10^{-4} m

2	1

Monochromatic light of wavelength 5.8×10^{-7} m is incident normally on a plane transmission diffraction grating that has a slit separation of 2.5×10^{-6} m.

How many maxima are produced by the grating? [1 mark]

○ **A** 4

○ **B** 5

○ **C** 8

○ **D** 9

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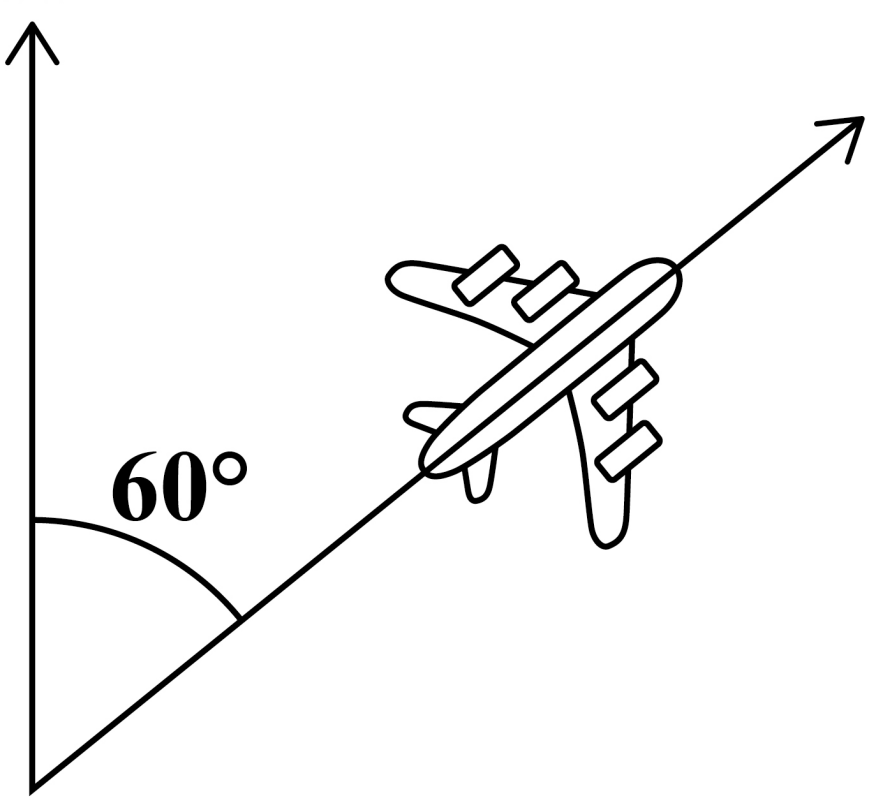
[Turn over]

2	2

An aeroplane flies horizontally at $150\ \text{m s}^{-1}$ along a bearing $60°$ east of north.



How far north from its starting position is the aeroplane after one hour?
[1 mark]

○ **A 270 km**

○ **B 470 km**

○ **C 510 km**

○ **D 540 km**

[Turn over]

2 3

A ball is thrown vertically upwards and returns to its original position 2.4 s later. The effect of air resistance is negligible.

What is the total distance travelled by the ball? [1 mark]

○ **A 5.9 m**

○ **B 7.1 m**

○ **C 14 m**

○ **D 28 m**

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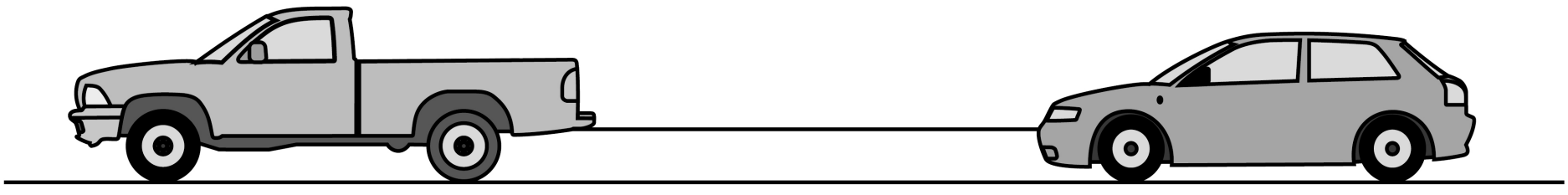
[Turn over]

2	4

A truck of mass 2.1×10^3 kg tows a car of mass 1.3×10^3 kg along a horizontal road.

The total resistive force on the car is 1100 N.

The acceleration of the car and truck is 2.3 m s^{-2}.



What is the tension in the tow rope?
[1 mark]

○ **A** **3000 N**

○ **B** **4100 N**

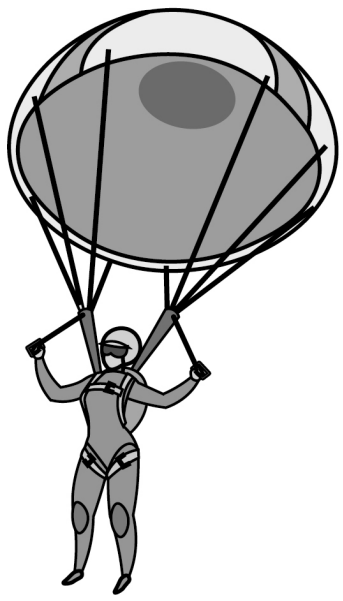
○ **C** **7800 N**

○ **D** **8900 N**

[Turn over]

2	5

A parachutist descends to the ground at a constant speed with the parachute open.



Which force, together with the parachutist's weight, makes a pair according to Newton's third law of motion? [1 mark]

○ **A** the drag force on the parachutist from the air

○ **B** the tension in the strings of the parachute

○ **C** the gravitational force of the parachutist on the Earth

○ **D** the lift force on the parachute from the air

[Turn over]

2	6

A tennis ball has a mass of $58\ \text{g}$.
The ball is dropped from rest from a height of $1.8\ \text{m}$ above the ground and falls vertically.
The ball rebounds vertically to a height of $1.1\ \text{m}$.
The effect of air resistance is negligible.

What is the change in momentum of the ball during its collision with the ground?
[1 mark]

○ **A** $0.040\ \text{N s}$

○ **B** $0.075\ \text{N s}$

○ **C** $0.215\ \text{N s}$

○ **D** $0.614\ \text{N s}$

2	7

A mass M is suspended from a spring. When the mass is at rest at the equilibrium position, the elastic potential energy stored is E.
An extra mass of $2M$ is added to the spring and the spring extends while still obeying Hooke's law.

What is the total elastic energy stored when the system is at rest at the new equilibrium position? [1 mark]

○ **A** $2E$

○ **B** $3E$

○ **C** $4E$

○ **D** $9E$

2	8

Two wires P and Q are made of the same material and have the same cross-sectional area.
P has an original length L and is subject to a tensile force F. P extends a distance x.
Q has an original length $2L$ and is subject to a tensile force $2F$.

Which statement is correct? [1 mark]

○ **A** The stress in P and the stress in Q are the same.

○ **B** The extension of Q is $2x$.

○ **C** The strain of Q is double the strain of P.

○ **D** The value of $\frac{\text{stress}}{\text{strain}}$ for P is half that of Q.

2	9

The current in a metallic conductor is 1.5 mA.

How many electrons pass a point in the conductor in two minutes? [1 mark]

- ○ **A** 1.1×10^{18}
- ○ **B** 1.9×10^{19}
- ○ **C** 1.4×10^{20}
- ○ **D** 2.0×10^{29}

3	0

Which value of resistance CANNOT be made by combining three $10\ \Omega$ resistors? [1 mark]

○ **A** $3.3\ \Omega$

○ **B** $6.7\ \Omega$

○ **C** $15\ \Omega$

○ **D** $25\ \Omega$

[Turn over]

3 1

A particle performs simple harmonic motion with a time period of $1.4\ \text{s}$ and an amplitude of $12\ \text{mm}$.

What is the maximum speed of the particle? [1 mark]

○ **A** $8.6\ \text{mm s}^{-1}$

○ **B** $27\ \text{mm s}^{-1}$

○ **C** $54\ \text{mm s}^{-1}$

○ **D** $110\ \text{mm s}^{-1}$

END OF QUESTIONS

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