OXFORD AQA

INTERNATIONAL QUALIFICATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

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Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS

PHYSICS

Unit 1 Mechanics, materials and atoms

Wednesday 8 January 2025 07:00 GMT Time allowed: 2 hours

Materials

For this paper you must have:

- a Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate
- a protractor.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- 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.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12–25	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 One conclusion from the Rutherford scattering experiment is that most of the mass of an atom is in the nucleus.

State **two** other conclusions from the experiment.

[2 marks]

1 _____

_____

2 _____

_____

2

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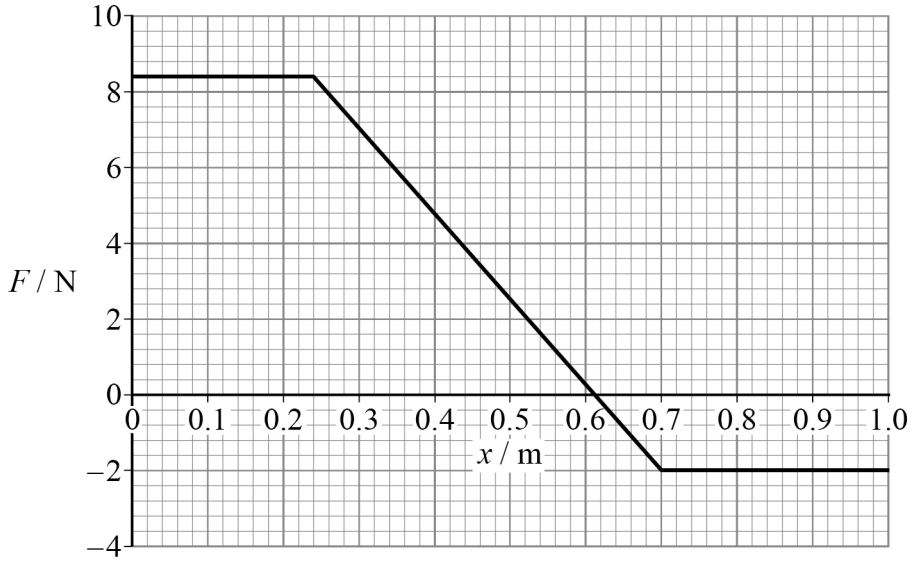
0 2 An object is initially stationary at point **O**.
The object is acted on by a resultant force F and moves in a straight horizontal line away from **O**.

Figure 1 shows the variation of F with the displacement x of the object from **O**.

Figure 1



Determine the kinetic energy of the object when $x = 1.0$ m.

[3 marks]

kinetic energy = _____ J

3

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0 3 **Figure 2** shows an aircraft of constant weight W accelerating along a horizontal runway before take-off.

Figure 3 shows the aircraft accelerating and climbing after take-off.

Figure 2

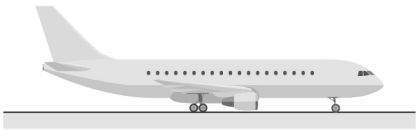
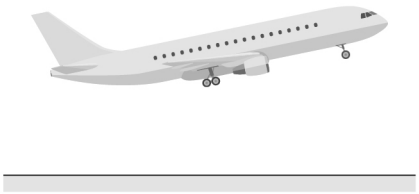


Figure 3



Three of the forces acting on the aircraft are:

L, the lift generated by the aircraft's wings
C, the contact force between the aircraft and the ground
D, the drag experienced by the aircraft.

Explain any changes in L, C and D that happen as the aircraft accelerates along the runway and takes off.

[3 marks]

L _____

_____

_____

_____

C _____

_____

_____

_____

D _____

_____

_____

_____

3

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0 4 Nucleus X decays to form a helium-4 nucleus and a neutron.

The equation for the decay is:

$$^{A}_{Z}X \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$$

0 4 . 1 Determine the difference between the specific charge of X and the specific charge of the helium-4 nucleus.

[3 marks]

difference in specific charge = _____ $C\ kg^{-1}$

0 4 . 2 X is stationary when the decay occurs.

Compare the motion of the helium-4 nucleus and the motion of the neutron immediately after the decay.

[3 marks]

_____

_____

_____

_____

_____

_____

_____

_____

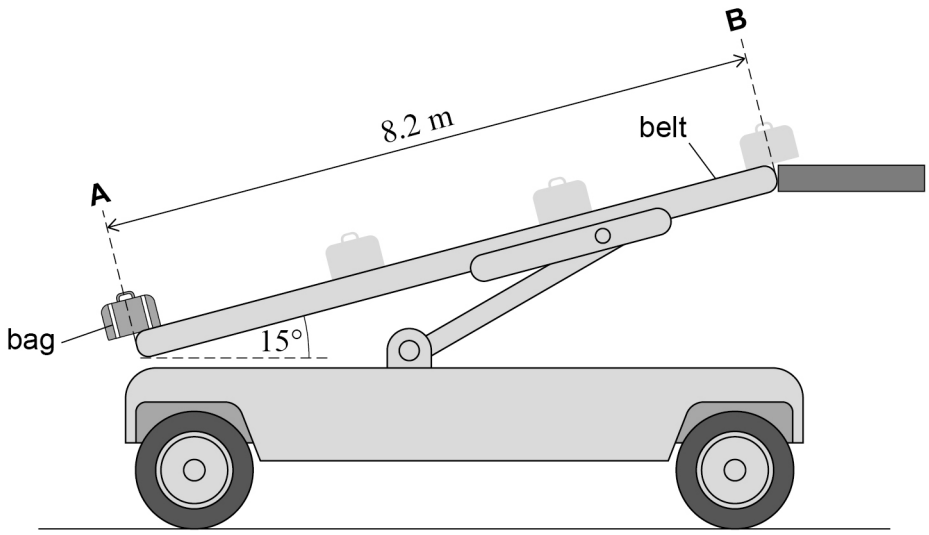
6

Do not write outside the box

0 5 Identical bags, each with a mass of 22 kg, are moved from point **A** to point **B** on a belt system as shown in **Figure 4**.
Each bag travels a distance of 8.2 m along the belt and gains gravitational potential energy at the rate of 43 W.

Figure 4

not to scale



The belt is at an angle of 15° to the horizontal.

0 5 . 1 Calculate the time taken for a bag to move from **A** to **B**.

[3 marks]

time = _____ s

Do not write outside the box

0 5 . 2 More bags are added to the belt without changing its speed.
The belt is driven by a motor that has an input power of $1.2\ \text{kW}$.
The maximum efficiency of the system is 31%.

Determine the maximum number of bags that can be on the belt at the same time without changing the speed of the belt.

[2 marks]

maximum number of bags = _____

5

Turn over for the next question

Do not write outside the box

0 6 The nuclide americium-241 decays by emitting alpha and gamma radiation.

0 6 . 1 Describe an experiment to demonstrate that the intensity of the **gamma** radiation emitted by a point source of americium-241 follows an inverse-square law.

In your answer, describe how to:
- make the necessary measurements
- perform the investigation safely and accurately
- process the measurements to demonstrate the inverse-square law graphically.

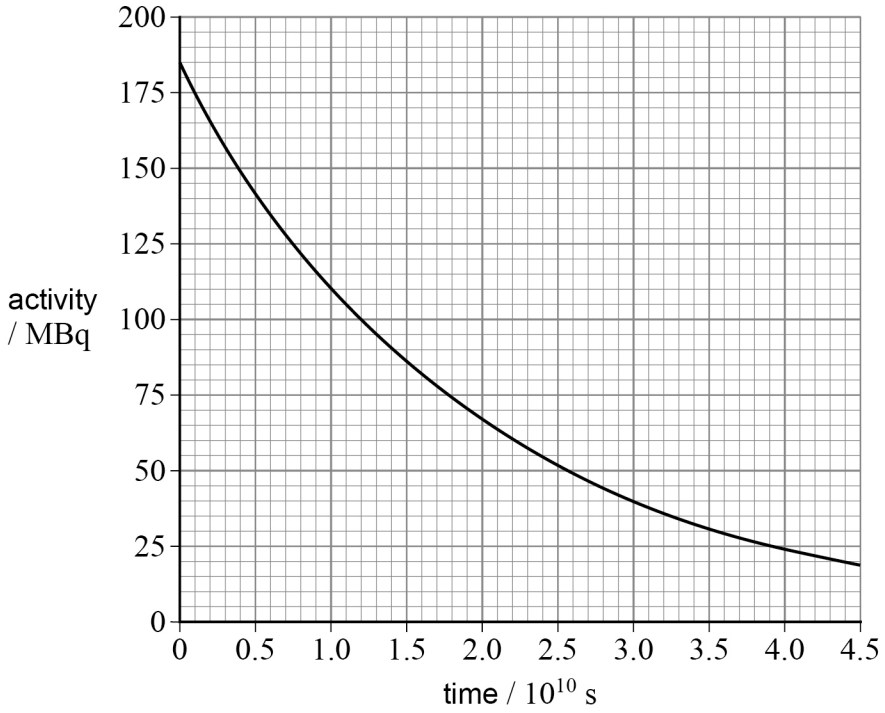
You may draw a diagram to help your description.

[5 marks]

Do not write outside the box

0 6 . 2 **Figure 5** shows how the activity of an americium-241 source changes with time.

Figure 5



Determine the time taken for the activity to fall to $\frac{1}{16}$ of the initial value.

[3 marks]

time = _____ s

8

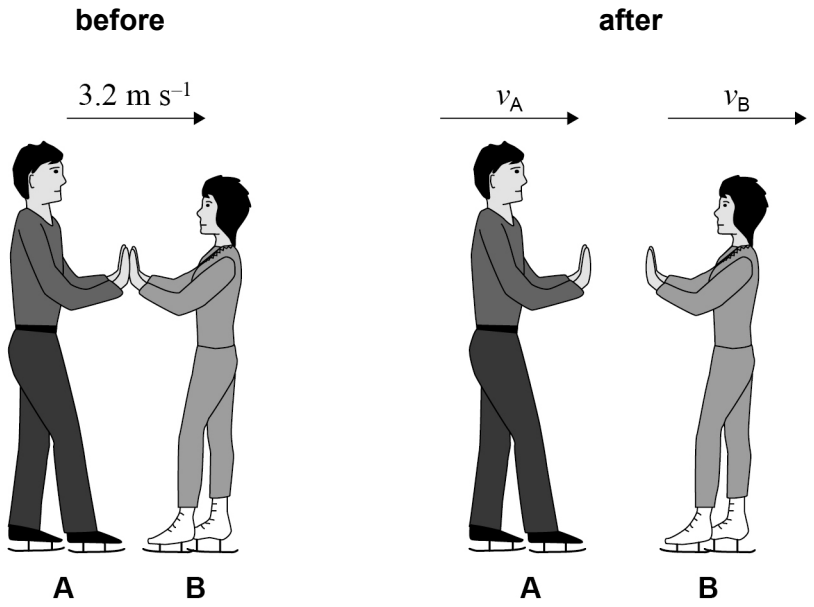
Turn over ►

Do not write outside the box

0 7 **Figure 6** shows two ice skaters **A** and **B**. Both skaters are initially moving horizontally in the same direction at a constant speed of $3.2\ \text{m s}^{-1}$.

A pushes against **B** and applies a constant force of $410\ \text{N}$ for $0.15\ \text{s}$.
A and **B** continue to move in the same direction.
The speed of **A** changes to v_A and the speed of **B** changes to v_B.

Figure 6



0 7 . 1 **B** has a mass of $56\ \text{kg}$.

Calculate the distance travelled by **B** while the force of $410\ \text{N}$ acts.
Assume that no other forces act on **B**.

[3 marks]

distance = _____ m

Do not write outside the box

0 7 . 2 The mass of **A** is greater than the mass of **B**.

Deduce, without calculation, whether **A** or **B** has the greater magnitude of acceleration.

[2 marks]

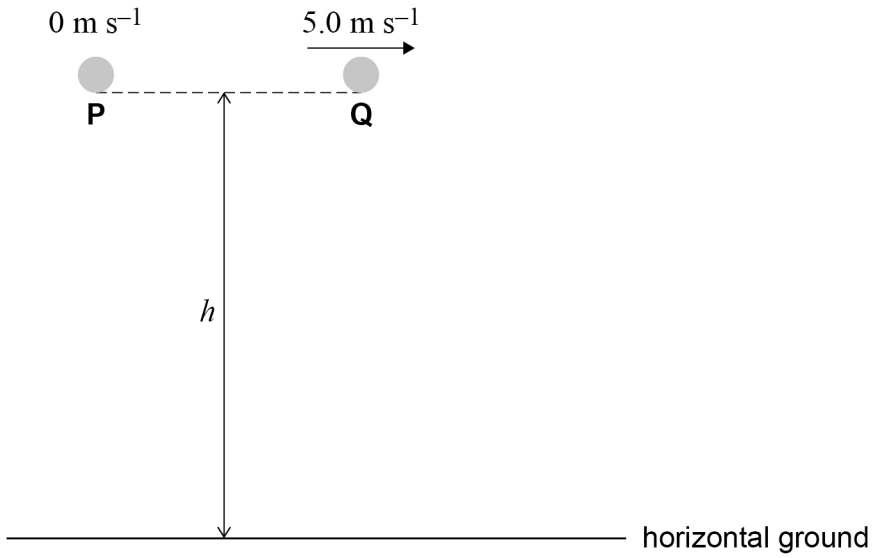
5

Turn over for the next question

0 8 Two identical steel balls **P** and **Q** are released from the same height h above horizontal ground as shown in **Figure 7**.
P is released from rest.
Q is projected with an initial horizontal velocity of $5.0\ \text{m s}^{-1}$.

The air resistance on the steel balls is negligible.

Figure 7



0 8 . 1 Explain why **P** and **Q** hit the ground at the same time.

[1 mark]

Do not write outside the box

P hits the ground with a speed of $4.2\ \text{m s}^{-1}$.

0 8 . 2 Calculate h.

[1 mark]

$h =$ _____ m

0 8 . 3 **Q** hits the ground with a speed v and at an angle θ to the vertical.

Determine, using a scale diagram, v and θ.

[4 marks]

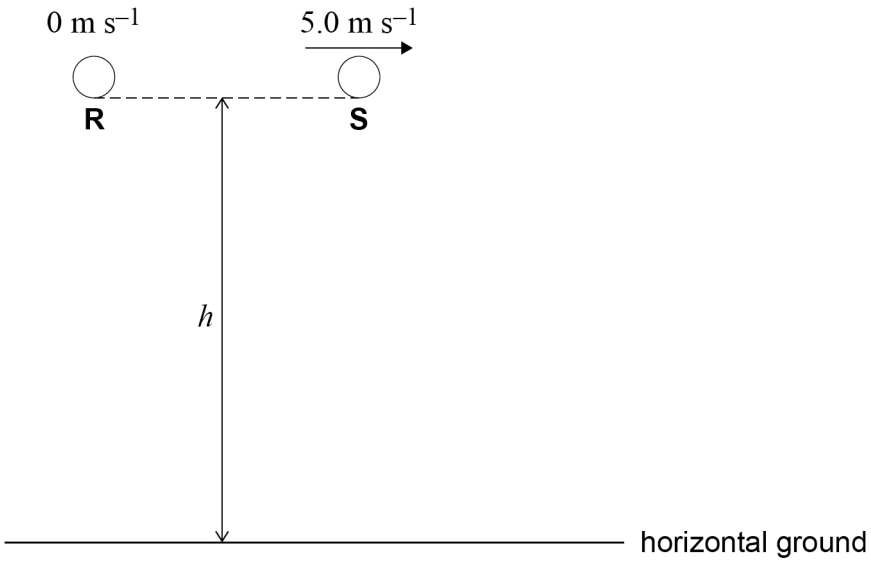
$v =$ _____ m s^{-1} $\theta =$ _____ °

Question 8 continues on the next page

The procedure is repeated using plastic balls **R** and **S** as shown in **Figure 8**.

R and **S**:
- are identical to each other
- have a greater diameter than **P** and **Q**
- have a smaller mass than **P** and **Q**.

Figure 8



0 8 . 4 Explain any difference between the time taken for **steel** ball **P** and **plastic** ball **R** to reach the ground.

[2 marks]

Do not write outside the box

0 8 . 5 The horizontal component of velocity of **steel** ball **Q** when it hits the ground is v_Q.
The horizontal component of velocity of **plastic** ball **S** when it hits the ground is v_S.

Explain the difference between v_Q and v_S.

[2 marks]

10

Turn over for the next question

Do not write outside the box

0 9 The nuclide tritium-3 ($^{3}_{1}H$) decays to the nuclide Z by β^- emission.

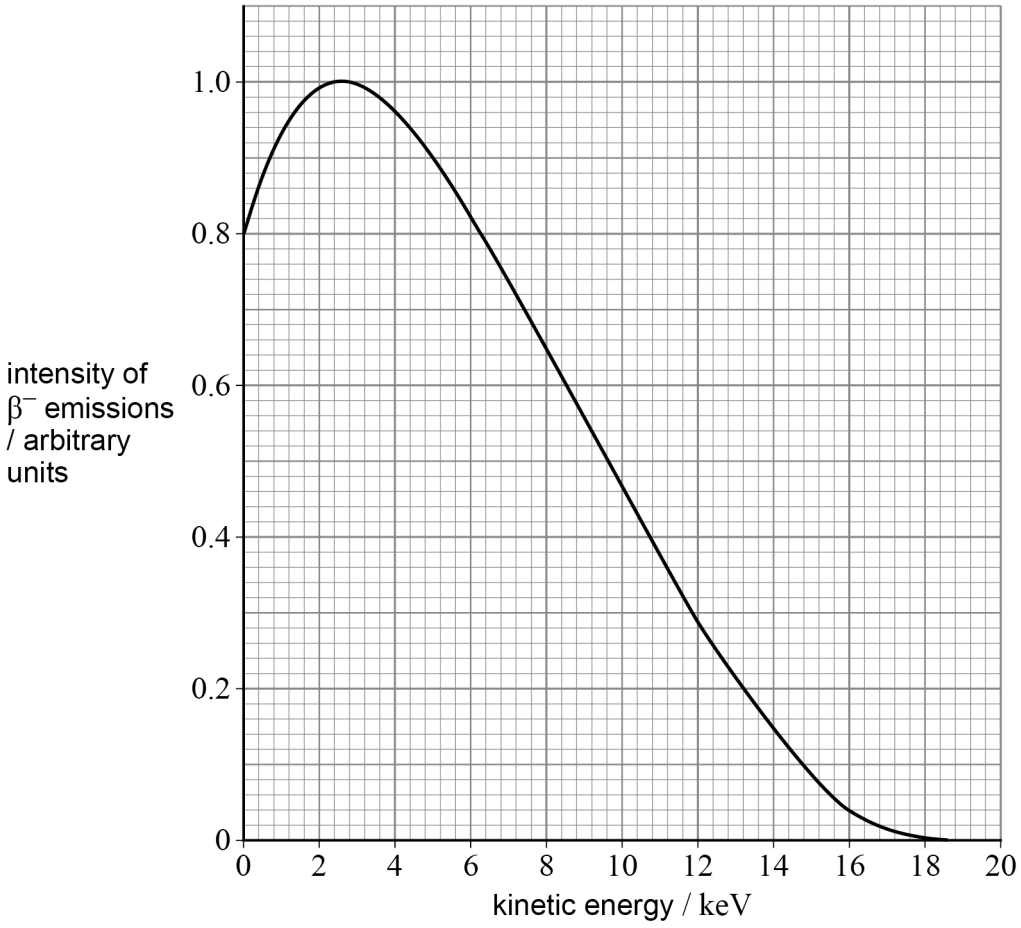
0 9 . 1 Complete the decay equation for tritium.

[1 mark]

$$^{3}_{1}H \rightarrow \overset{\cdots\cdots}{\cdots\cdots}Z + \overset{\cdots\cdots}{\cdots\cdots}\beta^- + {}^{0}_{0}\bar{\nu}_e$$

Figure 9 shows the variation with kinetic energy of the intensity of β^- emissions from tritium-3.

Figure 9



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0 9 . 2 Determine the speed of a beta-minus particle that is at the peak intensity shown in **Figure 9**.
Ignore relativistic effects.

[3 marks]

speed = _____ m s^{-1}

0 9 . 3 Explain how **Figure 9** gives evidence for the existence of the neutrino.

[3 marks]

0 9 . 4 State the minimum and maximum energies of the neutrinos released in the decay of tritium-3.

[1 mark]

minimum energy = _____ keV

maximum energy = _____ keV

8

END OF SECTION A

Turn over ►

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ANSWER IN THE SPACES PROVIDED

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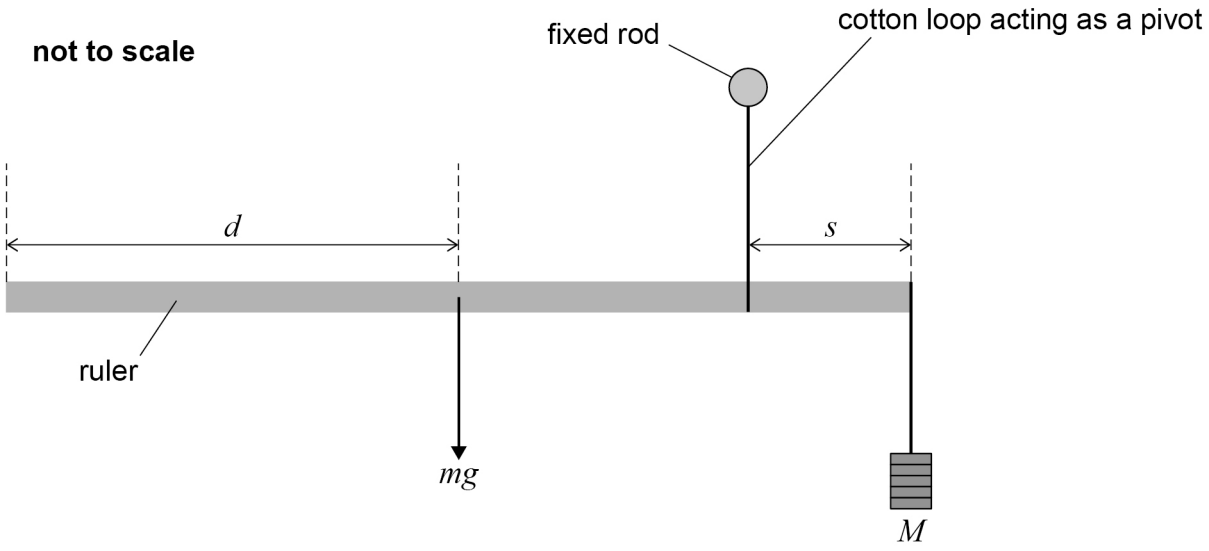
Section B

Answer **all** questions in this section.

1 0 **Figure 10** shows apparatus used to determine the mass m of a uniform ruler.
The ruler is supported by a cotton loop that acts as a pivot.
A known mass M is hung from one end of the ruler.
The position of the ruler is adjusted until it is horizontal and in equilibrium.
The horizontal distance between M and the pivot is s.
The distance from the end of the ruler to its centre of mass is d.

Figure 10



1 0 . 1 Show that the relationship between M and s is given by

$$M = md\left(\frac{1}{s}\right) - m$$

[1 mark]

Question 10 continues on the next page

Do not write outside the box

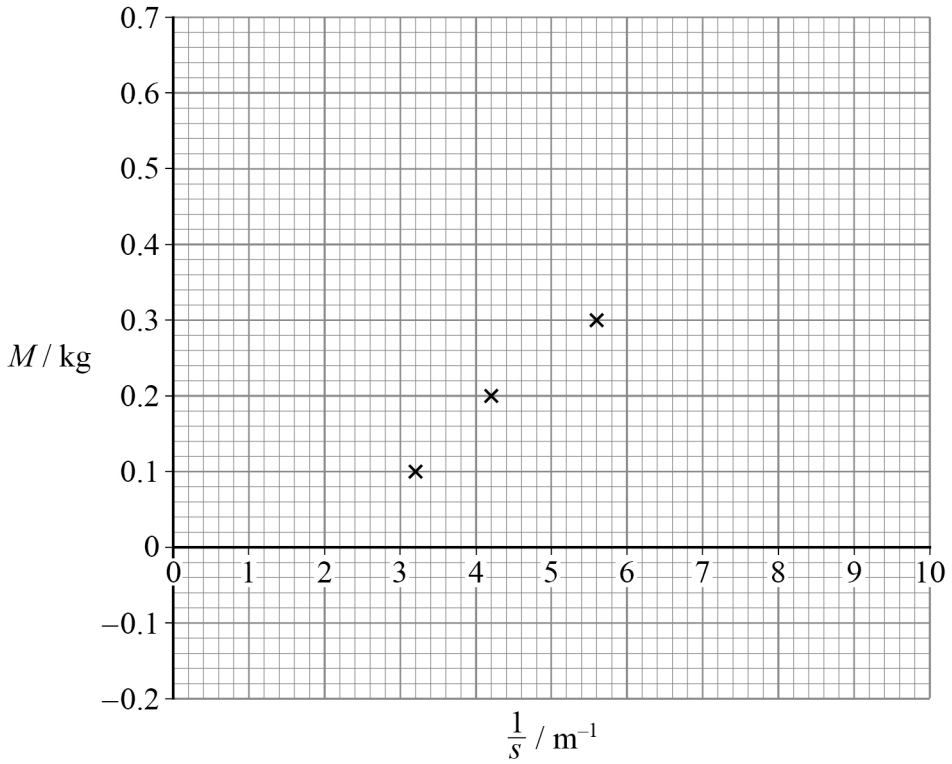
Table 1 shows values of M and $\frac{1}{s}$.

Table 1

M / kg	0.10	0.20	0.30	0.40	0.50	0.60
$\frac{1}{s}$ / $\mathbf{m^{-1}}$	3.22	4.26	5.62	6.71	8.00	9.35

Figure 11 is a plot of M against $\frac{1}{s}$.

Figure 11



1 0 . 2 Plot on **Figure 11** the remaining points from **Table 1**.

[1 mark]

1 0 . 3 Draw on **Figure 11** the line of best fit.

[1 mark]

Do not write outside the box

1 0 . 4 Determine m.

[1 mark]

$m =$ _____ kg

1 0 . 5 Determine d.

[3 marks]

$d =$ _____ m

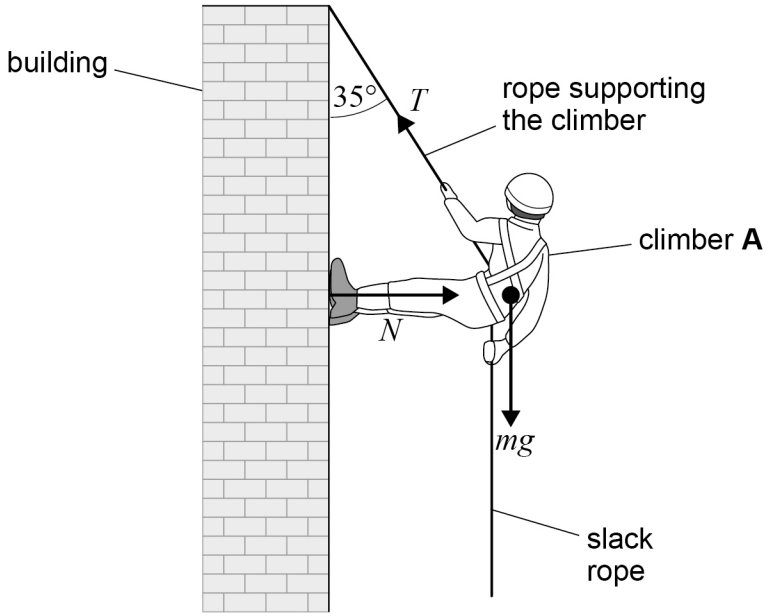
7

Turn over for the next question

Do not write outside the box

1 1 **Figure 12** shows a stationary climber **A** of weight $750\ \text{N}$ on the vertical side of a building. **A** is supported by a rope and his legs are perpendicular to the building.

Figure 12



The section of the rope supporting **A** is in tension T and makes an angle of $35°$ to the vertical.
A normal contact force N acts on **A**'s feet where they touch the building.
The weight of the rope is negligible.

1 1 . 1 The section of the rope supporting **A** has an unstretched length of $1.80\ \text{m}$.
The extension of the rope is $40\ \text{mm}$.

The Young modulus of the rope material is $260\ \text{MPa}$.

Calculate the diameter of the rope.

[4 marks]

diameter = _____ mm

Do not write outside the box

1 1 . 2 **A** moves down the rope and then stops lower down the building.
His legs are again perpendicular to the building.

The magnitudes of T and N are different from their magnitudes when **A** is in the position shown in **Figure 12**.

State and explain the differences.

[3 marks]

T _____

_____

_____

N _____

_____

_____

_____

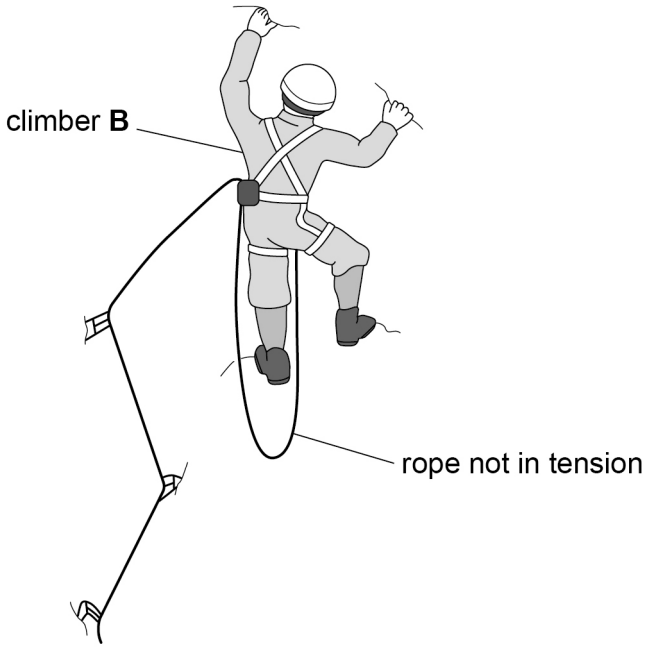
_____

Question 11 continues on the next page

Do not write outside the box

1 1 . 3 **Figure 13** shows climber **B** who is climbing up a cliff. **B** is attached to a safety rope that is not in tension. The bottom end of the safety rope is fixed in place.

Figure 13



If **B** falls, the rope stops her after a short distance.

The ropes used in **Figure 12** and **Figure 13** have the same diameter but are made from different materials.

For safety reasons, the rope in **Figure 13** has a much lower stiffness than the rope in **Figure 12**.

Explain why.

[2 marks]

END OF SECTION B

9

Do not write outside the box

Section C

Each of the questions in this section 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 pages for this working.

1 2 A tensile force acts on a metal wire of initial length L and cross-sectional area A.
This force causes an extension ΔL. The Young modulus of the metal is E.

What is the stiffness k of the wire?

[1 mark]

A $\frac{EA}{L}$ ⬭

B $\frac{EL}{A}$ ⬭

C $\frac{EL}{A(\Delta L)^2}$ ⬭

D $\frac{E(\Delta L)^2}{AL}$ ⬭

Do not write outside the box

1 3 An object of mass m is supported by two non-vertical strings.
The magnitudes of the tensions in the strings are T_1 and T_2.

Which statement is correct?

[1 mark]

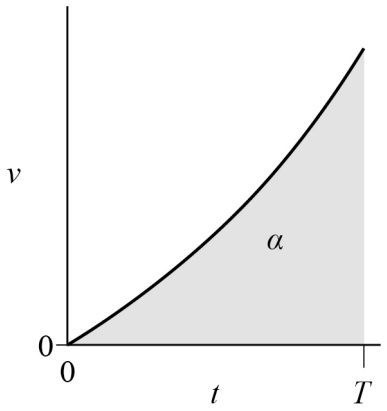
A $T_1 + T_2 = mg$ ⬭

B $T_1 + T_2 > mg$ ⬭

C $T_1 + T_2 < mg$ ⬭

D $T_1 + T_2 + mg = 0$ ⬭

1 4 The thrust of a rocket engine has magnitude F and acts in the same direction as the direction of travel.
The graph shows the variation of the velocity v of the rocket with time t.



The area under the graph is α.

The gradient of the graph is μ at time $t = T$.

Which statement is correct?

[1 mark]

A At $t = T$, the acceleration of the rocket is $\frac{F}{\alpha}$ ⬭

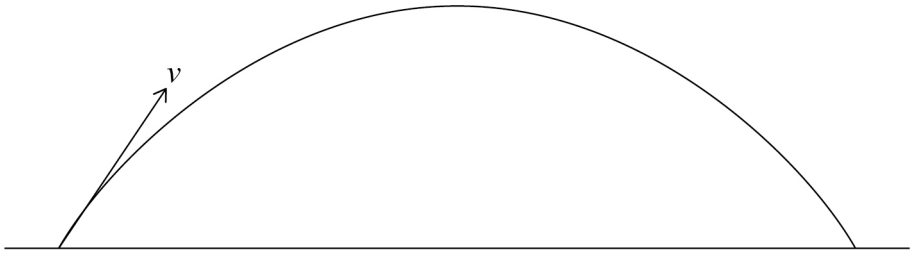
B The total increase in kinetic energy of the rocket is $F\alpha$ ⬭

C The average mass of the rocket is $\frac{F}{\mu}$ ⬭

D At $t = T$, the power applied to the rocket is $F\mu$ ⬭

Do not write outside the box

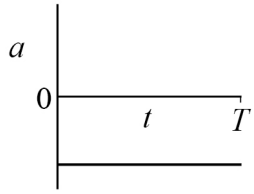
1 5 An object is projected into the air at time $t = 0$ as shown. It lands when $t = T$.
Air resistance is negligible.



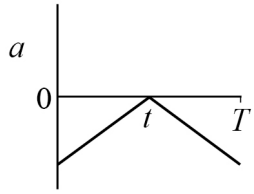
Which graph shows the variation with t of the acceleration a of the object?

[1 mark]

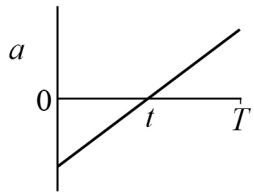
A



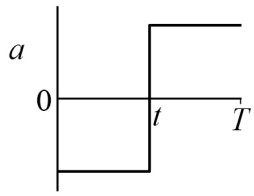
B



C



D



Do not write outside the box

1 6 Trolley **P** has a mass m and moves with a velocity v on a horizontal surface.
P collides with a stationary trolley **Q**.
Q has a mass m. The collision is elastic.

What are the velocities of **P** and **Q** immediately after the collision?

[1 mark]

	Velocity of **P**	Velocity of **Q**	
A	$\frac{v}{2}$	$\frac{v}{2}$	⬭
B	$\frac{3v}{2}$	$\frac{3v}{2}$	⬭
C	$-v$	0	⬭
D	0	v	⬭

1 7 A radioactive nuclide X emits alpha particles.
The energy from the alpha particles is used to power a device.

Each alpha particle has an initial kinetic energy of $5.9\ \mathrm{MeV}$.
The device requires an input power of $0.20\ \mathrm{mW}$.

What is the minimum number of nuclei of X that must decay every second to power the device?

[1 mark]

A 1.9×10^{-8} ⬭

B 2.1×10^{8} ⬭

C 3.0×10^{10} ⬭

D 2.1×10^{14} ⬭

Do not write outside the box

1 8 An electron is accelerated from rest by a constant force F over a distance of $8.5\ \text{cm}$.
The final velocity of the electron is $6.2 \times 10^{6}\ \text{m s}^{-1}$.

What is the magnitude of F?

[1 mark]

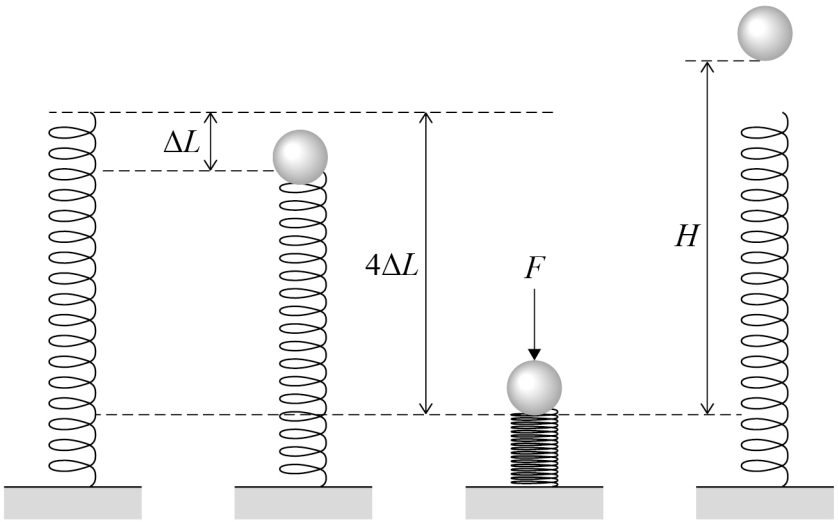
A $2.1 \times 10^{-18}\ \text{N}$ ⬭

B $4.1 \times 10^{-18}\ \text{N}$ ⬭

C $2.1 \times 10^{-16}\ \text{N}$ ⬭

D $4.1 \times 10^{-16}\ \text{N}$ ⬭

1 9 A light spring is placed on the floor and is in equilibrium.
A ball of mass $130\ \text{g}$ is placed on the top of the spring, causing the spring to compress by a distance ΔL.
A force F is then applied to the top of the ball so that the spring compression increases to $4\Delta L$.
F is removed, causing the ball to move vertically through a distance H.
The spring has a spring constant of $58\ \text{N m}^{-1}$ and obeys Hooke's law.



What is the maximum value of H?

[1 mark]

A $0.044\ \text{m}$ ⬭

B $0.088\ \text{m}$ ⬭

C $0.18\ \text{m}$ ⬭

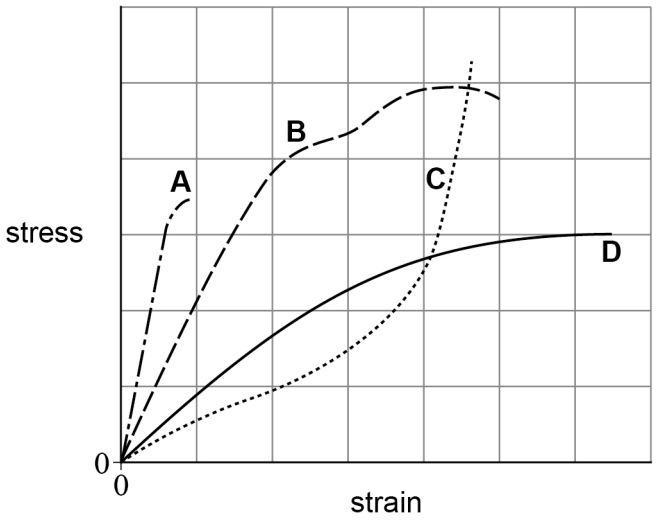
D $0.35\ \text{m}$ ⬭

Turn over ►

Do not write outside the box

2 0 Which stress–strain curve shows the greatest work done per unit volume?

[1 mark]



A ⬭

B ⬭

C ⬭

D ⬭

2 1 A student measures the diameter and the mass of a solid metal ball.
She uses her values to calculate the density of the metal.

The student quotes the density as:

$$\rho = 8000 \pm 120 \text{ kg m}^{-3}$$

The uncertainty in the measurement of the diameter of the ball is 0.4%.

What is the uncertainty in the measurement of the mass?

[1 mark]

A 0.3% ⬭

B 0.7% ⬭

C 1.1% ⬭

D 1.5% ⬭

Do not write outside the box

2 2 The radius R_a of a gold atom is approximately $140\ \text{pm}$.
The radius R_n of the nucleus of the gold atom is approximately $7.0\ \text{fm}$.

What is $\frac{R_a}{R_n}$?

[1 mark]

A 5.0×10^{-8} ⬭

B 5.0×10^{-5} ⬭

C 2.0×10^{4} ⬭

D 2.0×10^{7} ⬭

2 3 Which pair of particles can be produced in a single pair-production event?

[1 mark]

A electron and proton ⬭

B electron and antineutrino ⬭

C electron and positron ⬭

D electron and neutron ⬭

Turn over for the next question

Do not write outside the box

2 4 A radioactive source emits β^- and γ rays only.
The corrected count rate from the source is measured over a long period of time.

Four different sets of absorbers are placed between the source and the detector.
The corrected count rate is measured for each set of absorbers.

The sets of absorbers are:

- a 10 cm air gap only
- a 10 cm air gap and a 4 mm thick aluminium sheet
- a 20 cm air gap only
- a 20 cm air gap and a 4 mm thick aluminium sheet.

Which row shows possible corrected count rates for each set of absorbers?

[1 mark]

	Corrected count rates / s^{-1}				
	10 cm air gap only	**10 cm air gap and aluminium sheet**	**20 cm air gap only**	**20 cm air gap and aluminium sheet**	
A	600	300	150	100	⬭
B	600	300	150	150	⬭
C	600	300	300	150	⬭
D	600	300	225	75	⬭

2 5 The nuclide $^{232}_{90}\text{Th}$ decays to the nuclide $^{208}_{82}\text{Pb}$ by a series of α decays and β^- decays.

How many β^- decays are there in the decay chain?

[1 mark]

A 4 ⬭

B 6 ⬭

C 8 ⬭

D 10 ⬭

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END OF QUESTIONS

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