OXFORD
INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

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

Surname ______________________________

Forename(s) ______________________________

Candidate signature ______________________________
I declare this is my own work.

INTERNATIONAL AS
PHYSICS

Unit 1 Mechanics, materials and atoms

Tuesday 9 May 2023 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	
11–24	
TOTAL	

Do not write outside the box

Section A

Answer **all** questions in this section.

0 1 State the fundamental (base) units for the newton (N).

[1 mark]

fundamental (base) units = ______________________

1

0 2 Calculate the specific charge of an alpha particle.

[2 marks]

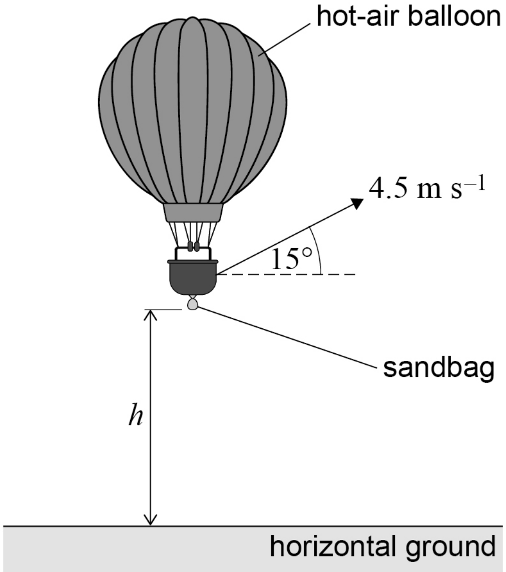
specific charge = ______________________ $C\ kg^{-1}$

2

Do not write outside the box

0 3 **Figure 1** shows a hot-air balloon rising at an angle of $15°$ to the horizontal.

Figure 1



The balloon is travelling at a constant velocity of $4.5\ \text{m s}^{-1}$.
A sandbag is released from the balloon at a height h above the ground.
The sandbag takes $2.5\ \text{s}$ to reach the ground.

The air resistance on the sandbag is negligible.

0 3 . 1 Calculate h.

[4 marks]

h = ____________________ m

Turn over ►

Do not write outside the box

0 3 . 2 The balloon continues to travel at the same constant velocity.

Explain why the sandbag is always vertically below the balloon until the sandbag lands.

[2 marks]

6

Do not write outside the box

0 4 A train of mass 1.5×10^5 kg is travelling at a constant velocity on a horizontal track. The driving force F of the train is equal in magnitude to the resistive force R on the train.

0 4 . 1 The kinetic energy of the train is 5.5×10^7 J.
The train's engines produce a useful power of 3.7×10^6 W.

Calculate R.

[3 marks]

$R =$ ____________________ N

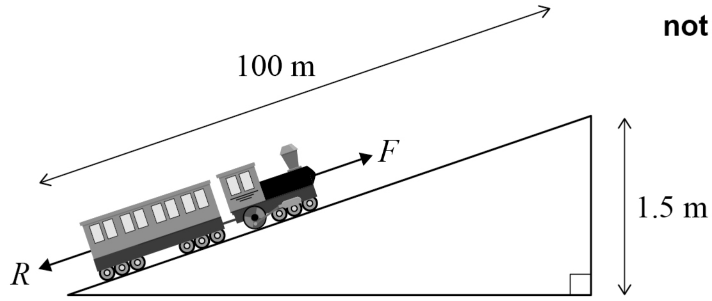
Question 4 continues on the next page

Do not write outside the box

0 4 . 2 The train now ascends a slope of constant gradient. The train rises 1.5 m vertically for every 100 m of track.
F is still equal in magnitude to R.

Figure 2

not to scale



Calculate the acceleration of the train.

[3 marks]

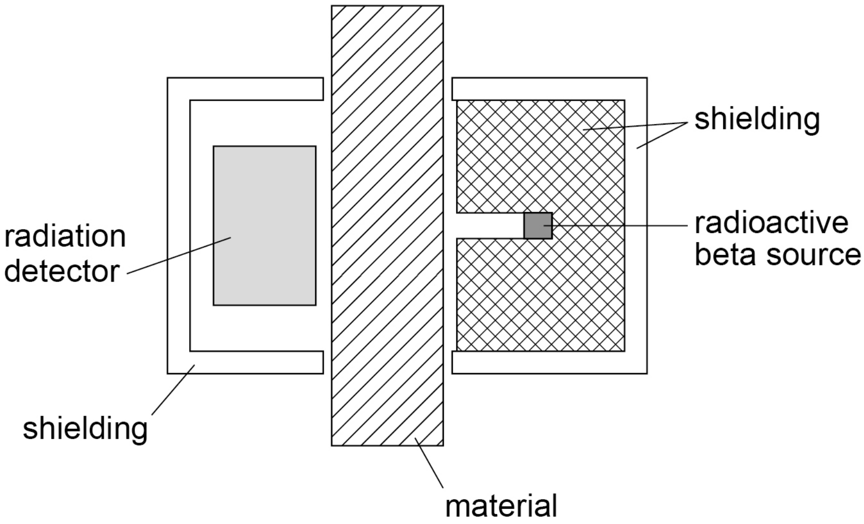
acceleration = ____________________ $m\ s^{-2}$

6

Do not write outside the box

0 5 **Figure 3** shows part of a gauge used to measure the thickness of a variety of materials. The gauge uses a radioactive beta source and a radiation detector.

Figure 3



0 5 . 1 Explain why a gamma source is not suitable for determining the thickness of paper.

[2 marks]

____

____

____

____

____

____

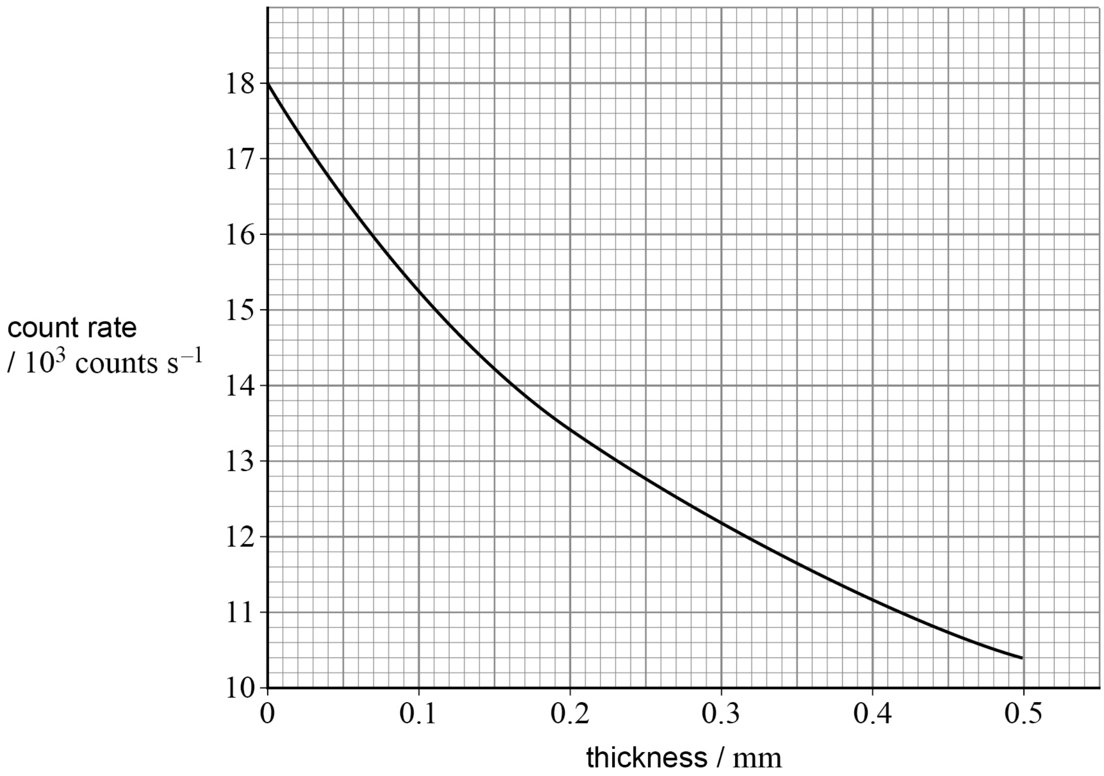
Question 5 continues on the next page

Before the gauge in **Figure 3** can be used, it must be calibrated.
Count rates are measured for a range of paper thicknesses and a calibration curve is drawn to show the variation of count rate with thickness.

Background radiation is negligible in this situation.

Figure 4 shows the calibration curve for paper.

Figure 4



0 5 . 2 A paper of thickness 40 μm is tested.

Determine the count rate for this thickness.

[1 mark]

count rate = ____________________ counts s^{-1}

Do not write outside the box

The beta source in the gauge has a half-life of 3.0 years.

0 5 . 3 Explain, without calculation, whether the same calibration curve can be used after one year.

[2 marks]

---

0 5 . 4 The gauge is used 6.0 years after the calibration shown in **Figure 4**.

Calculate the count rate measured by the detector at this time for paper with a thickness of 0.30 mm.

[2 marks]

count rate = ______________________ counts s^{-1}

0 5 . 5 The same gauge is used to determine the thickness of aluminium foil.
The zero-thickness count rate is the same as in **Figure 4**.
Before the gauge is used, a new calibration curve must be produced for aluminium.

Sketch, on **Figure 4**, a curve to show the variation of count rate with thickness for aluminium foil.

[1 mark]

8

0 6 **Figure 5** shows a boy swimming in a pool.
The boy swims in a straight line from point **A** to point **B** and then returns.
The distance from **A** to **B** is 25 m.

Figure 5

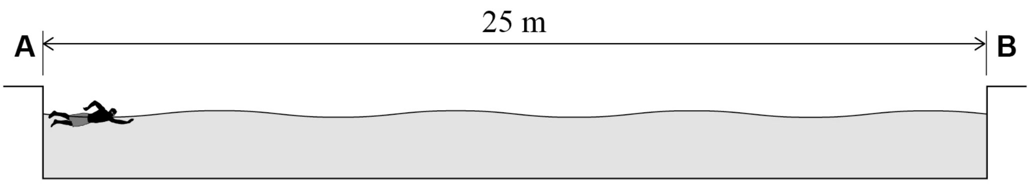
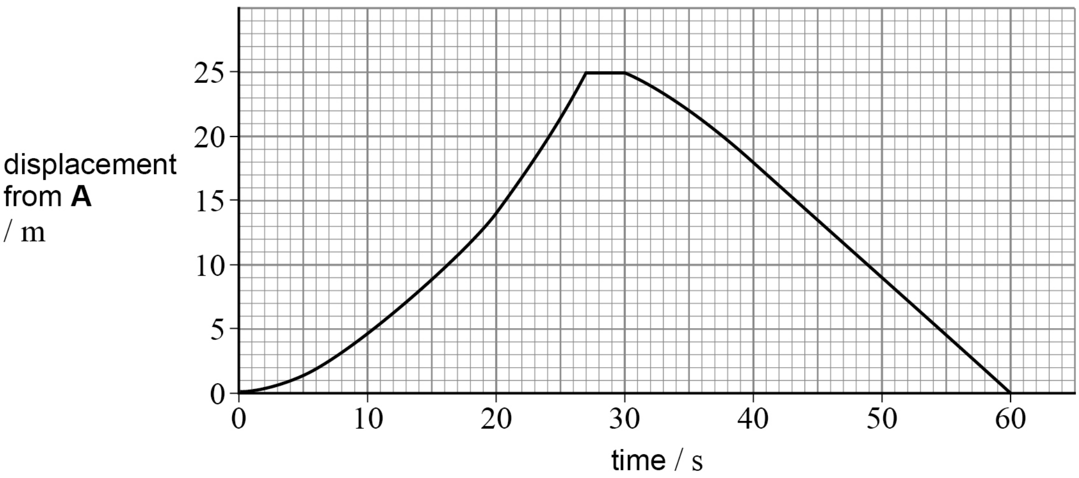


Figure 6 shows the variation with time of the boy's displacement from **A**.

Figure 6



0 6 . 1 Explain how you would use **Figure 6** to determine the maximum speed of the boy.

[2 marks]

____

____

____

____

____

Do not write outside the box

0 6 . 2 Calculate the average speed of the boy during the first $50\ s$ of his swim.

[3 marks]

average speed = ____________________ $m\ s^{-1}$

0 6 . 3 Calculate the average velocity of the boy during the first $50\ s$ of his swim.

[2 marks]

magnitude of average velocity = ____________________ $m\ s^{-1}$

direction of average velocity = ____________________

7

Turn over ►

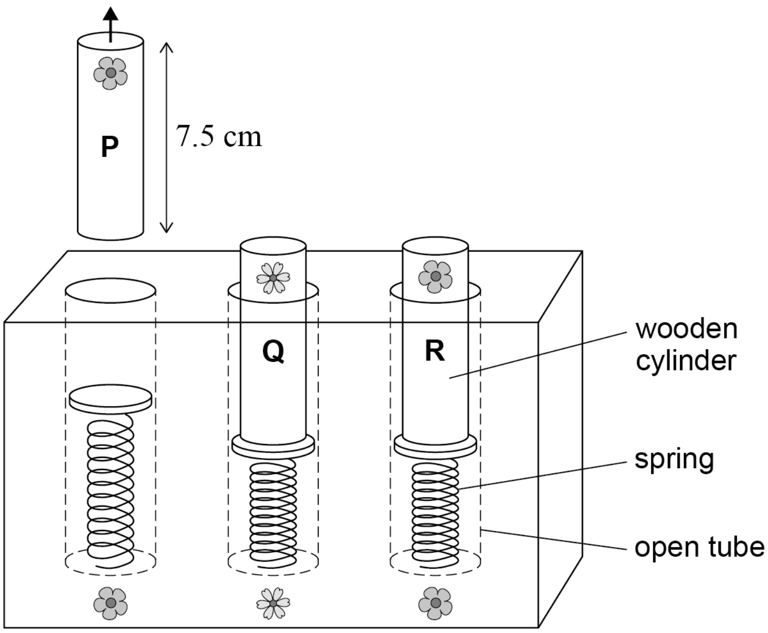
0 7 **Figure 7** shows a toy with solid wooden cylinders **P**, **Q** and **R**. Identical springs are fixed at the bottom of the open vertical tubes.

The cylinders are placed into the tubes.

The weight of the cylinders causes negligible compression of the springs. The springs obey Hooke's law and air resistance is negligible.

A child pushes cylinder **P** down so that the spring is compressed. The child releases **P** and it is launched upwards.

Figure 7



0 7 . 1 **P** has length 7.5 cm, cross-sectional area 1.5 cm^2 and mass 8.1 g.

Calculate, in kg m^{-3}, the density of the wood.

[2 marks]

density = ______________________ kg m^{-3}

Do not write outside the box

When a cylinder is launched, 60% of the elastic potential energy stored in the spring is transferred to the cylinder.

0 7 . 2 When the spring has been compressed by a distance x, the cylinder then rises through a height h.

Show that x and h are related by the following equation:

$$h = \frac{0.3kx^2}{mg}$$

where k is the spring constant and m is the mass of the cylinder.

[2 marks]

0 7 . 3 Cylinders **P** and **Q** are identical.
The child pushes **P** down to compress the spring by 2.5 cm.
After release, **P** rises through a height of 17 cm.

The child then pushes **Q** down to compress the spring by 1.5 cm and releases it.

Calculate h for cylinder **Q**.

[2 marks]

$h =$ ____________________ cm

Question 7 continues on the next page

Turn over ►

Do not write outside the box

0 7 . 4 Cylinder **R** is the same size as **P** but has half the mass.
The child launches **R**, using the same initial spring compression that was used for **P**.

Explain how h for **R** compares with h for **P**.

[2 marks]

8

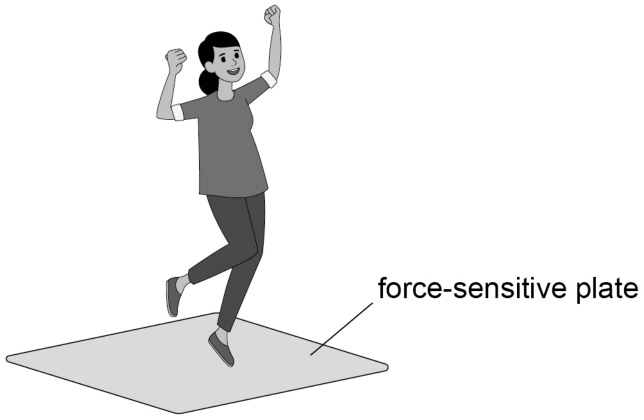
Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 8 A student stands on a force-sensitive plate and then jumps upwards and lands as shown in **Figure 8**.

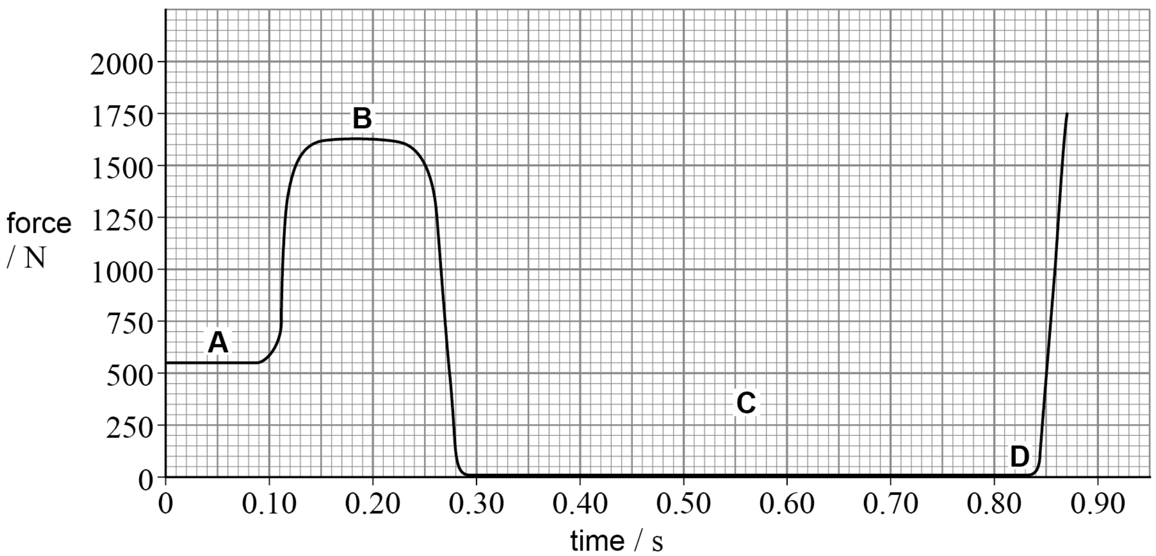
Figure 8



A data logger attached to the plate measures the variation with time of the force exerted by the student on the plate.

Figure 9 shows the variation of force with time as the student stands (**A**), jumps up (**B**), is in the air (**C**) and begins to land (**D**).

Figure 9



0 8 . 1 Show that the mass of the student is approximately $56\ kg$.

[1 mark]

Do not write outside the box

0 8 . 2 Show that the student gains approximately $150\ \mathrm{kg\ m\ s^{-1}}$ of momentum when she jumps up. Use the part of the graph labelled **B**.

[3 marks]

0 8 . 3 Calculate the speed of the student as she leaves the plate.
Use your answer to Question **08.2**.

[1 mark]

speed = ____________________ $\mathrm{m\ s^{-1}}$

0 8 . 4 Calculate the time the student is in the air.
Use your answer to Question **08.3** and a suitable equation of motion.

[2 marks]

time = ____________________ s

0 8 . 5 Determine, using section **C** of **Figure 9**, the time the student is in the air, as recorded by the data logger.

[1 mark]

time = ____________________ s

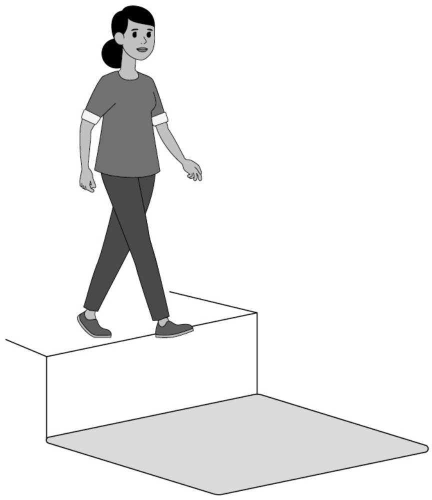
Do not write outside the box

0 8 . 6 Explain, without further calculation, whether your answer to Question **08.4** or your answer to Question **08.5** has the smaller uncertainty.

[1 mark]

0 8 . 7 Next, the student steps off a platform onto the force-sensitive plate, as shown in **Figure 10**.

Figure 10



The student steps off the platform twice:

- the first time that she lands, she keeps her legs straight
- the second time that she lands, she bends her knees, increasing the time taken to decelerate.

Explain how increasing the time taken to decelerate affects the force on the plate. Refer to one of Newton's laws of motion in your answer.

[3 marks]

12

END OF SECTION A

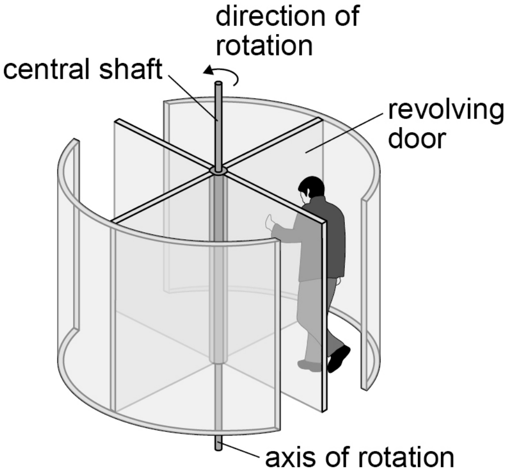
Do not write outside the box

Section B

Answer **all** questions in this section.

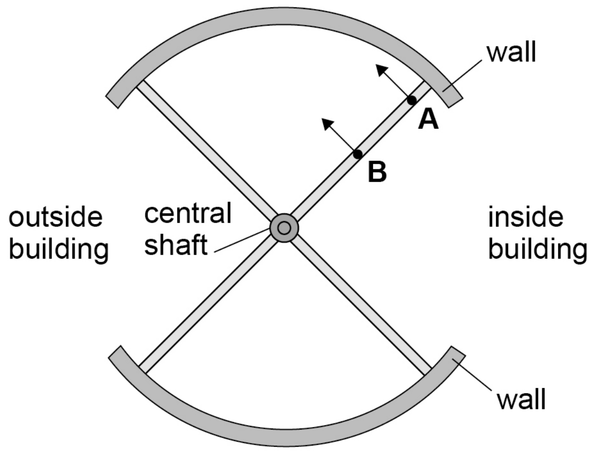
0 9 **Figure 11** shows a man entering a revolving door, pushing the door to make it turn. The door turns anticlockwise, viewed from above.

Figure 11



side view

Figure 12



view from above

0 9 . 1 **Figure 12** shows two positions **A** and **B** where the door can be pushed to make it turn.

The door does not turn until the applied moment is greater than a particular value.

Compare the minimum force required to turn the door when pushing at **A** with the minimum force required when pushing at **B**.
Explain your answer.

[1 mark]

____

____

____

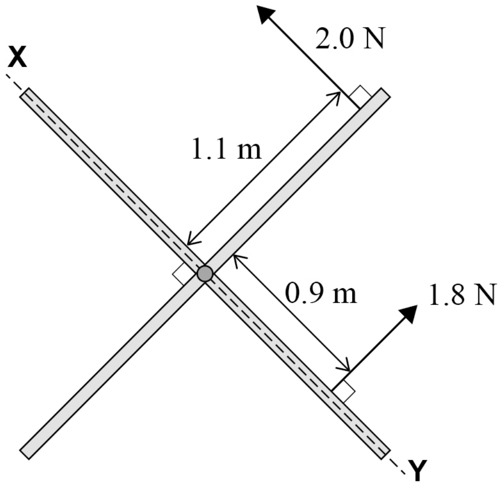
Question 9 continues on the next page

Do not write outside the box

Two people are in different sections of the revolving door. They exert forces on the door, as shown in **Figure 13**. These forces are applied at the same height above the ground.

Figure 13

not to scale



view from above

0 9 . 2 Explain whether the 1.8 N and the 2.0 N forces in **Figure 13** are a couple.

[1 mark]

____

____

____

0 9 . 3 Calculate the resultant moment exerted by the people on the door.

[1 mark]

moment = ____________________ Nm

Do not write outside the box

The centre of mass of the revolving door is at the axis of rotation, at the central shaft. The centre of mass of the door does not move.

A reaction force F acts from the shaft to the door.

0 9 . 4 Determine the magnitude of F and the angle between F and the line **XY** on **Figure 13**.

[3 marks]

magnitude of F = ____________________ N

angle = ____________________ °

0 9 . 5 Draw on **Figure 13** an arrow to represent the direction of F and label the angle between F and the line **XY**.

[1 mark]

7

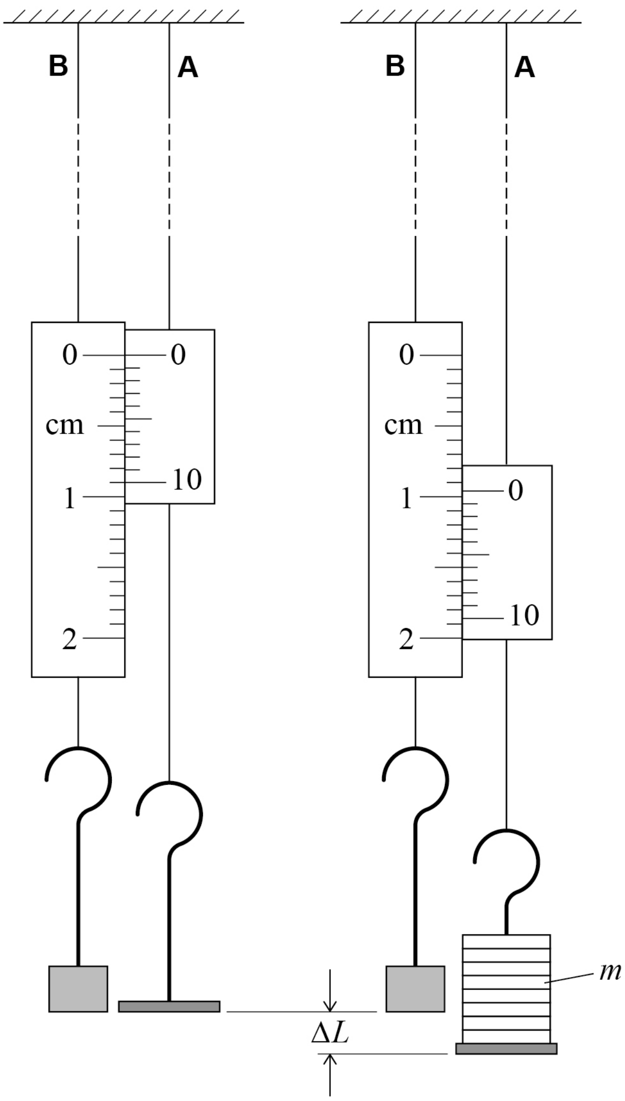
Do not write outside the box

1 0 **Figure 14** shows apparatus used to determine the Young modulus of a metal. Two identical wires **A** and **B** are made from this metal. **B** has a constant length. The length of **A** is compared with the length of **B**. The wires are suspended from a fixed support.

A student adds mass m to the load on **A** and measures the extension ΔL produced using a vernier scale. The student repeats this process for different values of m.

Figure 14 shows the vernier scale reading with $m = 0$
Figure 15 shows the vernier scale reading with $m = 4.0$ kg.

Figure 14 **Figure 15**



1 0 . 1 State the value of ΔL shown in **Figure 15**.

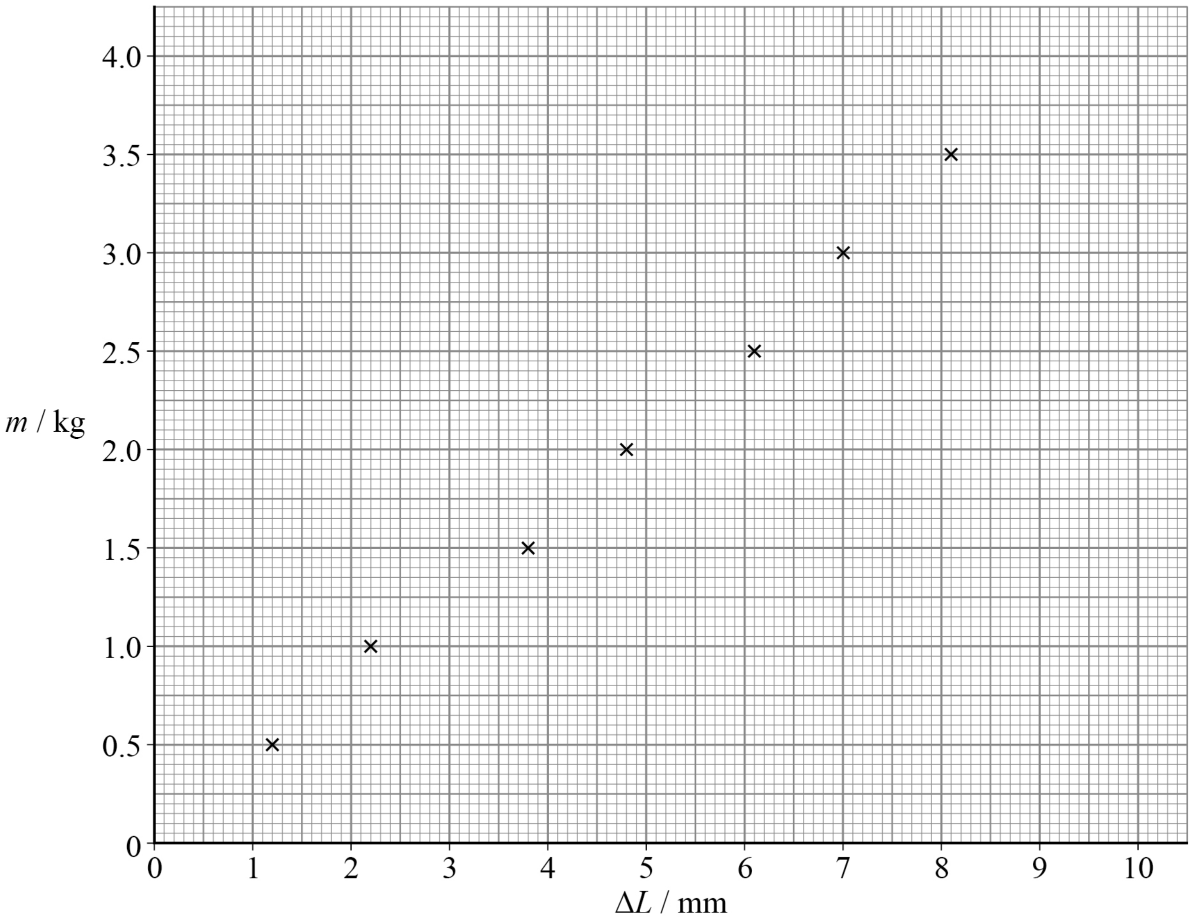
[1 mark]

$\Delta L =$ ____________________ mm

Do not write outside the box

Some of the data collected by the student are plotted on the grid in **Figure 16**.

Figure 16



1 0 . 2 Plot, on **Figure 16**, your value of ΔL from Question **10.1**.

[1 mark]

1 0 . 3 Draw a line of best fit.
Determine, in kg m^{-1}, the gradient.

[3 marks]

gradient = ____________________ kg m^{-1}

Turn over ►

Do not write outside the box

1 0 . 4 The original length of **A** is 2.600 m.
The cross-sectional area of **A** is 1.00×10^{-7} m^2.

Determine the Young modulus of the metal.

[2 marks]

Young modulus = ____________________ Pa

1 0 . 5 Wire **A**, in the arrangement in **Figures 14** and **15**, is replaced with a thinner wire of the same metal.
The same measuring instruments are used.

Suggest how the uncertainty in the value of the Young modulus is affected by this change.

[2 marks]

____

____

____

____

____

9

END OF SECTION B

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 1 Which is **not** a unit for energy?

[1 mark]

A eV

B $kg\ m^2\ s^{-2}$

C kW h

D N s

Turn over for the next question

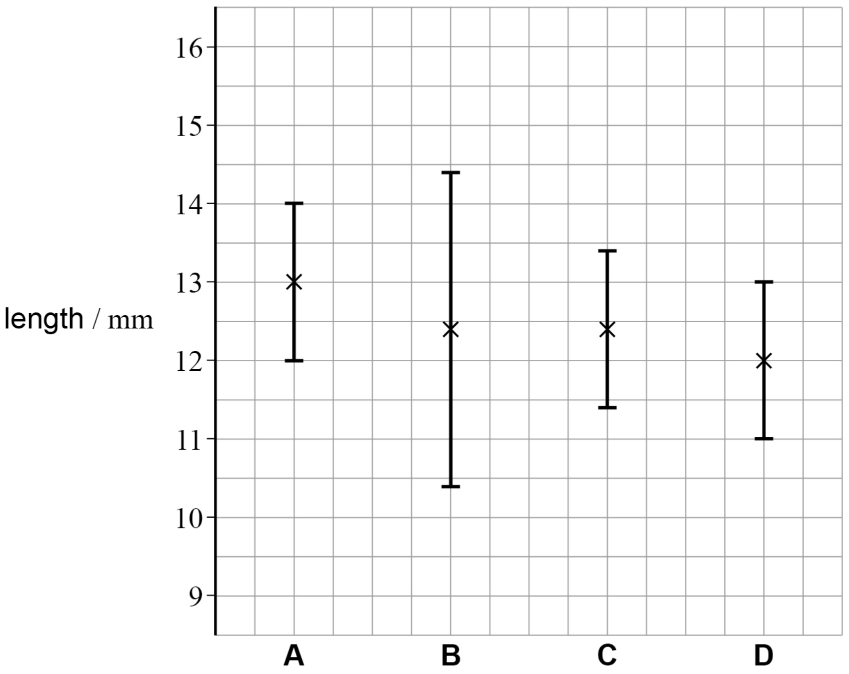
Do not write outside the box

1 2 An object's length is measured.
The five measurements are:

length / mm	10	12	12	14	14

What is the correct way of plotting this length and its error bar?

[1 mark]



A ⬭

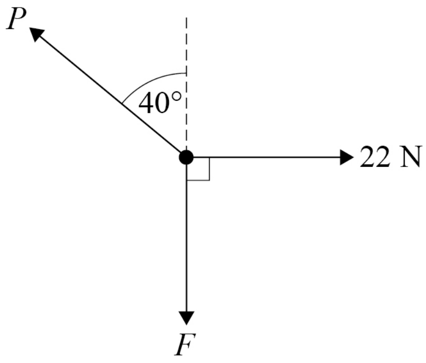
B ⬭

C ⬭

D ⬭

Do not write outside the box

1 3 Three coplanar forces P, F and $22\ \text{N}$ are in equilibrium.



not to scale

What is the magnitude of F?

[1 mark]

A $34\ \text{N}$ ⬭

B $29\ \text{N}$ ⬭

C $26\ \text{N}$ ⬭

D $18\ \text{N}$ ⬭

1 4 Which row contains two scalar quantities?

[1 mark]

A	velocity	mass	⬭
B	speed	distance	⬭
C	weight	momentum	⬭
D	time	acceleration	⬭

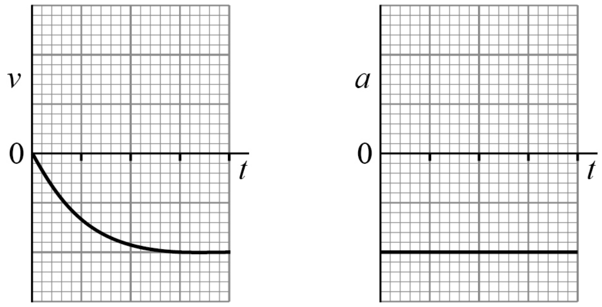
Do not write outside the box

1 5 A stone is dropped vertically from rest. It experiences air resistance.

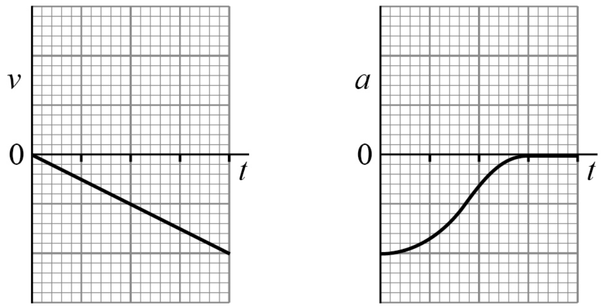
Which pair of graphs shows the variation with time of the velocity v and acceleration a for the motion of the stone?

[1 mark]

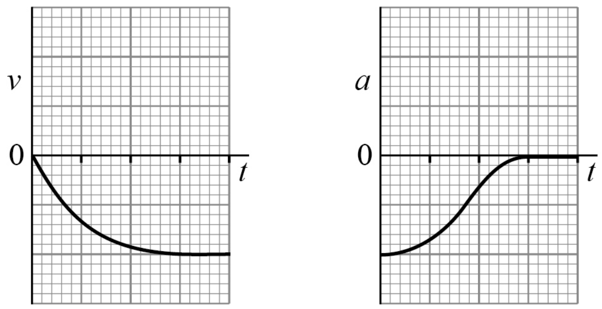
A



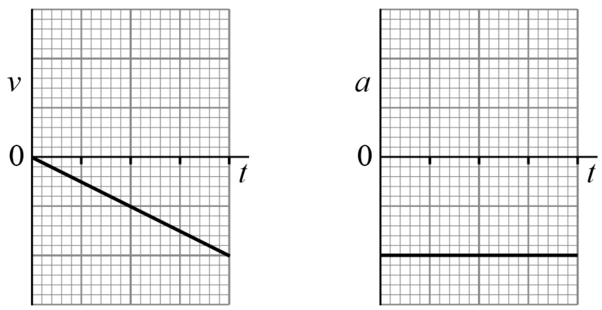
B



C



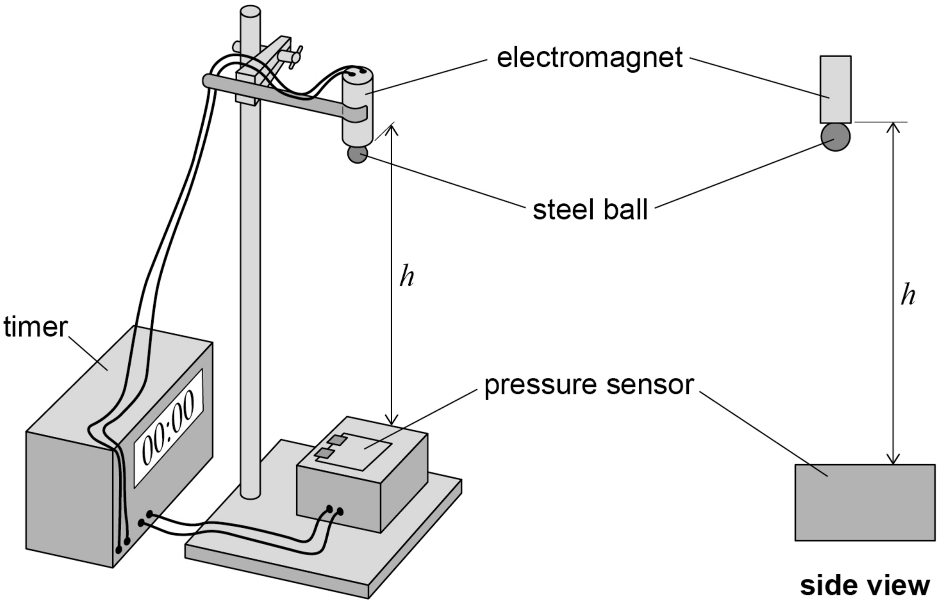
D



1 6 A student uses the apparatus shown to determine a value for g.

When the switch is turned off, the steel ball is released by the electromagnet and the timer starts.
When the ball hits the pressure sensor, the timer stops and records the time t for the ball to fall to the pressure sensor.

The student calculates g using $g = \frac{2h^2}{t}$.



Which change to the experimental procedure will reduce the **systematic** error in the experiment?

[1 mark]

A subtract the diameter of the ball from h ⬭

B take repeat readings and calculate an average ⬭

C use a timer with a better resolution ⬭

D increase h ⬭

Do not write outside the box

1 7 Which is always a property of a brittle solid?

[1 mark]

A It has a high stiffness.

B It has a low breaking stress.

C It stores little elastic strain energy before breaking.

D It undergoes little plastic deformation before breaking.

1 8 Which quantity is given by the area under the stress–strain graph for a stretched material?

[1 mark]

A the energy stored

B the energy stored per unit volume

C the Young modulus

D the Young modulus per unit volume

1 9 Two wires **P** and **Q** are made of the same material.

The diameter of **P** is d and the diameter of **Q** is $2d$.

The length of **P** is $3l$ and the length of **Q** is l.

What is $\dfrac{\text{stiffness of } \mathbf{P}}{\text{stiffness of } \mathbf{Q}}$?

[1 mark]

A $\dfrac{1}{12}$

B $\dfrac{1}{6}$

C $\dfrac{3}{4}$

D $\dfrac{4}{3}$

2 0 The Rutherford scattering experiment provided evidence for a new model of the atom.

What is different about Rutherford's model compared with the previous model?

[1 mark]

A The atom is neutrally charged overall. ⬭

B The atom contains negatively charged electrons. ⬭

C The negative charge is concentrated in the centre of the atom. ⬭

D The mass is concentrated in the centre of the atom. ⬭

2 1 An anti-hydrogen atom consists of a positron and an anti-proton.

Which row shows the charge and the mass of the anti-hydrogen atom?

[1 mark]

	Charge / C	Mass / kg	
A	zero	-1.7×10^{-27}	⬭
B	zero	1.7×10^{-27}	⬭
C	3.2×10^{-19}	1.7×10^{-27}	⬭
D	3.2×10^{-19}	-1.7×10^{-27}	⬭

2 2 Which quantity is conserved during pair production?

[1 mark]

A kinetic energy ⬭

B mass ⬭

C momentum ⬭

D velocity ⬭

2 3 What are the missing particles in this decay equation?

$$^{10}_{6}C \rightarrow ^{10}_{5}B + ? + ?$$

[1 mark]

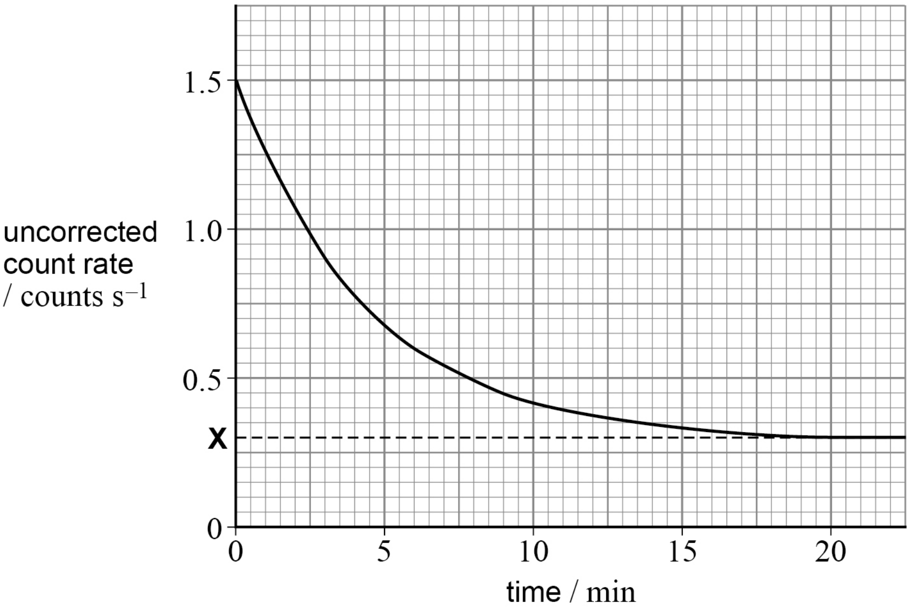
A electron and neutrino ⬭

B electron and antineutrino ⬭

C positron and neutrino ⬭

D positron and antineutrino ⬭

2 4 The graph shows the variation of uncorrected count rate with time, recorded by a detector near a radioactive source.
The average background count rate is labelled **X**.



What is the half-life of the radioactive source?

[1 mark]

A 3 min ⬭

B 4 min ⬭

C 6 min ⬭

D 19 min ⬭

END OF QUESTIONS

14

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required. Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required. Write the question numbers in the left-hand margin.**