OXFORD AQA

INTERNATIONAL QUALIFICATIONS

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

Wednesday 3 January 2024 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	
13–26	
TOTAL	

Do not write outside the box

Section A

Answer **all** questions in this section.

0 1 State the unit for tensile stress in SI fundamental (base) units.

[1 mark]

unit = _____

1

0 2 An LED lamp has a total power input of $7.0\ \text{W}$ and an efficiency of 75%.
A filament lamp has a total power input of $65\ \text{W}$.
The useful power transferred by the filament lamp is double the useful power transferred by the LED.

Calculate the efficiency of the filament lamp.

[2 marks]

efficiency = _____

2

Do not write outside the box

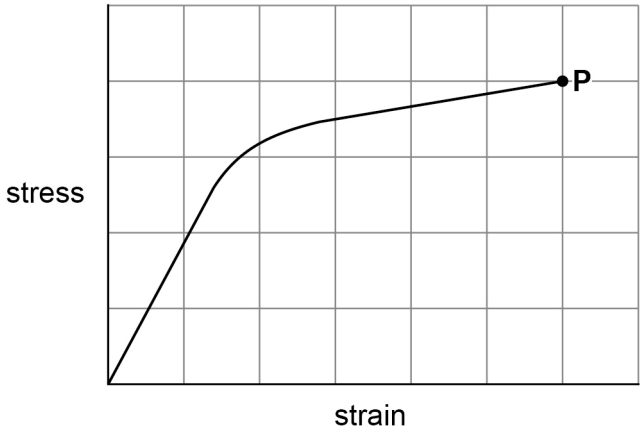
0 3 **Figure 1** shows the variation of stress with strain for material **X**. Point **P** is the breaking point of material **X**.

Material **Y** is brittle. **Y** has a greater Young modulus than **X** and the same breaking stress as **X**.

Sketch, on **Figure 1**, the variation of stress with strain for **Y**.

[2 marks]

Figure 1



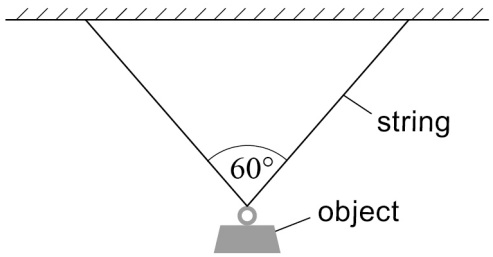
2

Turn over for the next question

Do not write outside the box

0 4 **Figure 2** shows an object of mass $2.70\ \text{kg}$ suspended by two identical light elastic strings. When the system is in equilibrium, the angle between the strings is $60°$.

Figure 2



0 4 . 1 Calculate the tension in one string.

[2 marks]

tension = _____ N

0 4 . 2 The strain in each string is 1.5×10^{-2}.
The cross-sectional area of each string is $0.75\ \text{mm}^2$.

Calculate the Young modulus of the material used to make the strings.

[2 marks]

Young modulus = _____ Pa

4

Do not write outside the box

0 5 An apple falls from a tree through a vertical height of $3\ \text{m}$.

Estimate the momentum of the apple just before it hits the ground.
Give your answer to an appropriate number of significant figures.

[3 marks]

momentum = _____ kg m s^{-1}

3

0 6 Cars **P** and **Q** are identical.

P has an initial speed of $13\ \text{m s}^{-1}$. **P** brakes with a constant braking force F.
P travels a distance x before coming to rest.

Q has an initial speed of $15\ \text{m s}^{-1}$. The same constant braking force F is applied to **Q** over the same distance x.
Q does not come to rest but continues at a new constant speed v.

Calculate v.

[3 marks]

v = _____ m s^{-1}

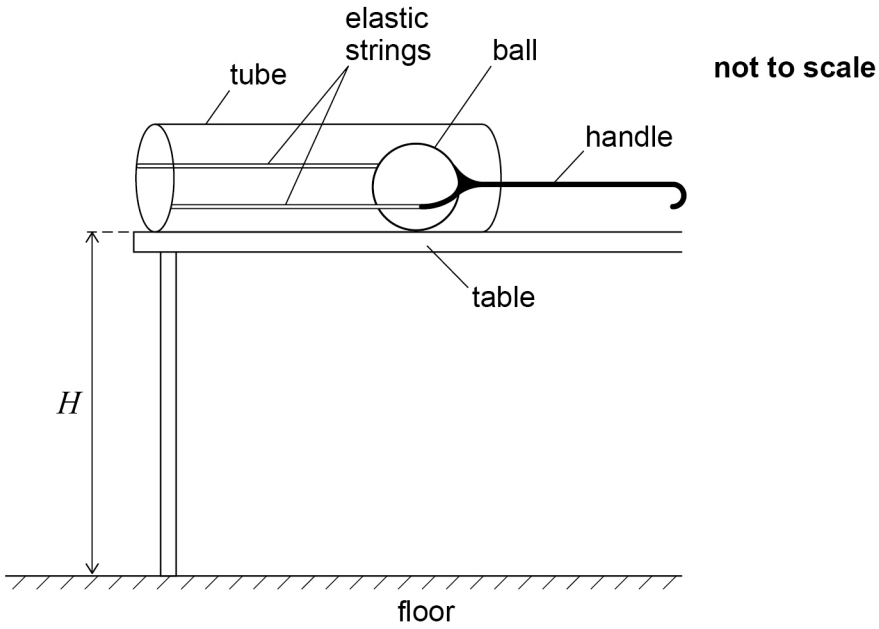
3

Turn over ►

Do not write outside the box

0 7 **Figure 3** shows apparatus that is used to investigate projectile motion. The apparatus is placed on a table at height H above the horizontal floor.

Figure 3



not to scale

A ball of mass m and two elastic strings are inside an open tube.
A handle is pulled back to stretch the elastic strings. When the handle is released, the ball is launched horizontally from the tube.
The ball leaves the tube with kinetic energy E.

0 7 . 1 The ball travels a horizontal distance D between leaving the tube and hitting the floor.

Show that

$$D = 2\sqrt{\frac{HE}{mg}}$$

[3 marks]

Do not write outside the box

0 7 . 2 State **one** assumption you made in your answer to Question **07.1**.

[1 mark]

Question 7 continues on the next page

0 7 . 3 When the handle is pulled back, the extension in each string is ΔL.
When the handle is released, 50% of the stored elastic energy is transferred into kinetic energy of the ball.

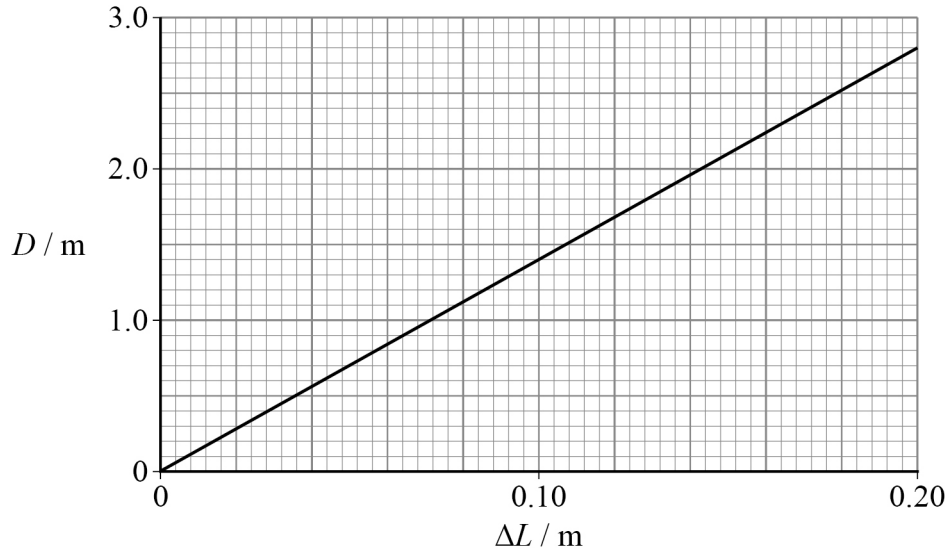
The relationship between D and ΔL is

$$D = \Delta L \sqrt{\frac{2Hk}{mg}}$$

where k is the spring constant of each string.

Figure 4 shows the variation of D with ΔL.

Figure 4



Do not write outside the box

Determine k.

$m = 30$ g
$H = 0.80$ m

[3 marks]

$k =$ _____ N m^{-1}

7

Turn over for the next question

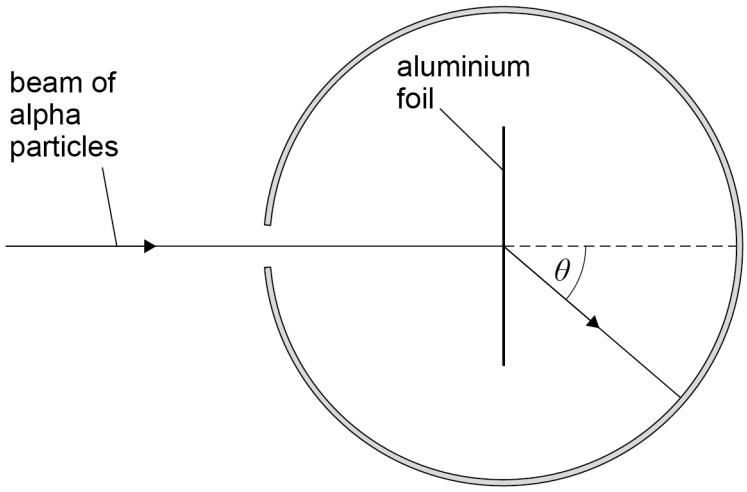
Do not write outside the box

0 8 . 1 Describe the simple model of the aluminium-27 $\left(^{27}_{13}\mathrm{Al}\right)$ atom.

[2 marks]

Figure 5 shows apparatus used in a Rutherford scattering experiment.
When a beam of alpha particles was fired at a thin aluminium foil, alpha particles were deflected out of the beam. The experimenters measured the number N of alpha particles per unit time at various deflection angles θ.

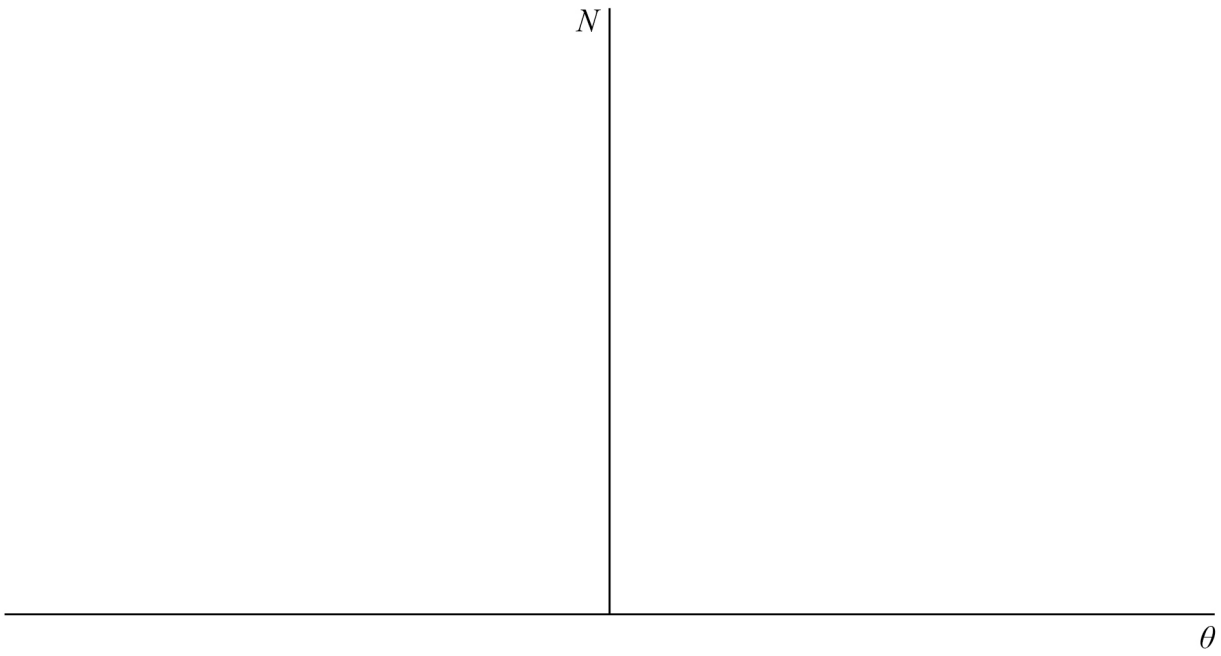
Figure 5



0 8 . 2 Sketch, on **Figure 6**, a graph of the variation of N with θ.
Label your θ-axis with a suitable scale.
No values are required on the N-axis.

[2 marks]

Figure 6



4

Turn over for the next question

Do not write outside the box

0 9 A radiation detector is used to measure a background count of 23 counts per minute.

When a gamma source is placed 10.0 cm from the detector, the measured uncorrected count rate is 410 counts per minute.

0 9 . 1 Calculate the uncorrected count rate expected when the detector is placed 30.0 cm from the gamma source.

[3 marks]

uncorrected count rate = _____ counts per minute

A student plans an experiment to verify the inverse-square law for gamma radiation in a school laboratory.

The student writes the following plan. The plan is unsafe and incomplete.
The teacher must correct it before the student is allowed to do the experiment.

Plan

1. I will hold a gamma source with gloves. My partner will hold a radiation detector.
2. My partner will vary the distance between the detector and the gamma source. The range of distances we will use is 10 cm to 1.0 m, with a measurement taken every 10 cm. He will measure the distances using a metre ruler.
3. We will take readings of the count for one minute at each distance.
4. We will plot a graph of count rate against distance. If this is a straight line, the inverse-square law is verified.

Do not write outside the box

0 9 . 2 Suggest and explain **one** correction to the plan on page 12 to improve the safety of the experiment.

[2 marks]

0 9 . 3 The student's planned experiment would not verify the inverse-square law.

Suggest and explain further improvements to the plan.

In your answer, discuss:
- any other measurements that are required
- how the accuracy can be improved
- how the data should be processed.

[6 marks]

Answer lines continue on the next page

Do not write outside the box

11

Do not write outside the box

1 0 A simple rocket is made from a plastic bottle. The rocket is propelled using water and compressed air.

Figure 7a shows the rocket being prepared for launch on a launch tube. Additional air is pumped into the bottle through the launch tube.

When the pressure in the bottle is large enough, the bottle is forced off the launch tube. The compressed air pushes the water out of the bottle as shown in **Figure 7b**. The rocket moves vertically upwards.

Figure 7a

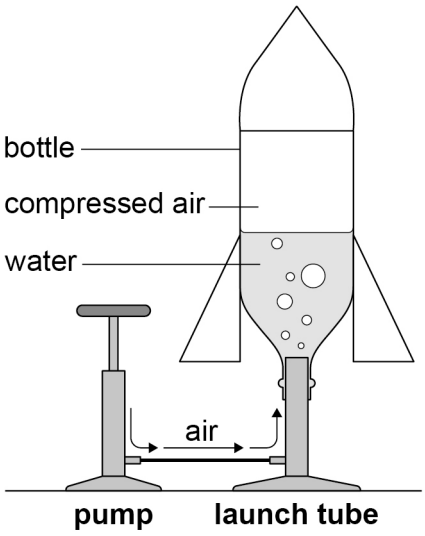
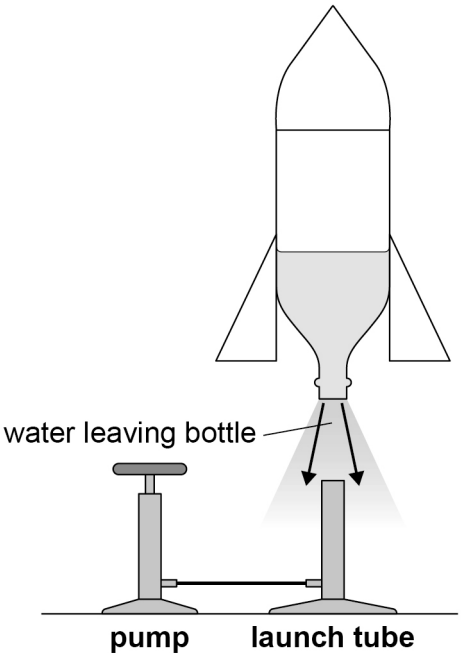


Figure 7b



1 0 . 1 Explain why the water leaving the bottom of the bottle causes the rocket to accelerate upwards.
Refer to a relevant physical law in your explanation.

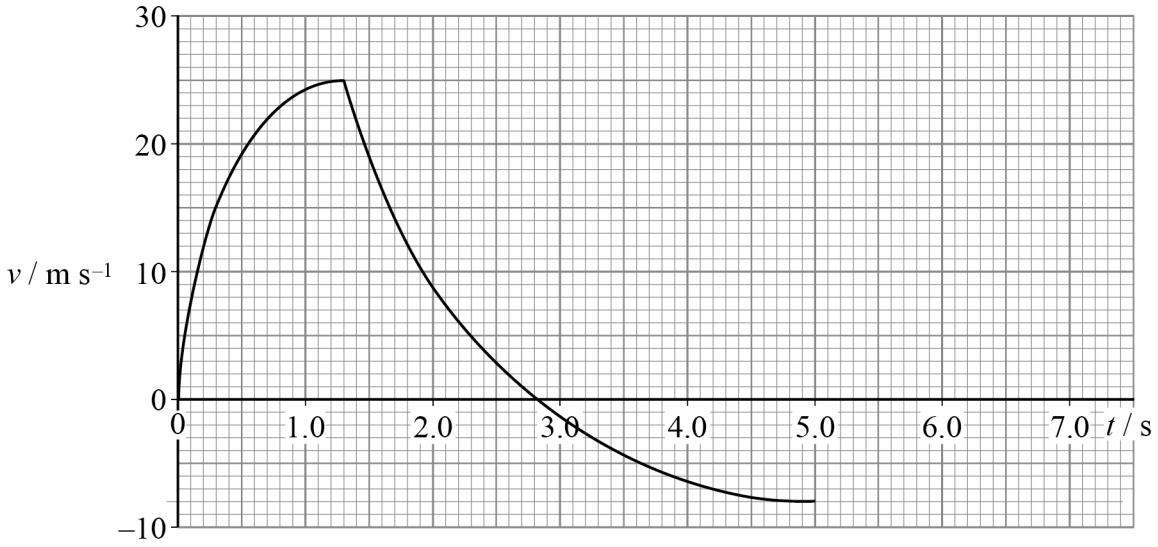
[2 marks]

Question 10 continues on the next page

Do not write outside the box

Figure 8 shows the variation of vertical velocity v of the rocket with time t for the first 5.0 s of its flight.

Figure 8



1 0 . 2 Explain how **Figure 8** shows that there is no water left in the bottle at $t = 1.3$ s.

[2 marks]

1 0 . 3 At $t = 2.8$ s, the rocket has reached its maximum height.

Determine the maximum height reached by the rocket.

[3 marks]

height = _____ m

Do not write outside the box

1 0 . 4 Determine the maximum deceleration of the rocket.

[2 marks]

maximum deceleration = _____ $\mathrm{m\ s^{-2}}$

1 0 . 5 Explain why the maximum deceleration of the rocket is greater than $9.81\ \mathrm{m\ s^{-2}}$.

[2 marks]

1 0 . 6 The rocket reaches a terminal velocity during its descent, as shown in **Figure 8**.

Explain how you would use **Figure 8** to estimate the total time of flight.

[2 marks]

13

END OF SECTION A

Do not write outside the box

Section B

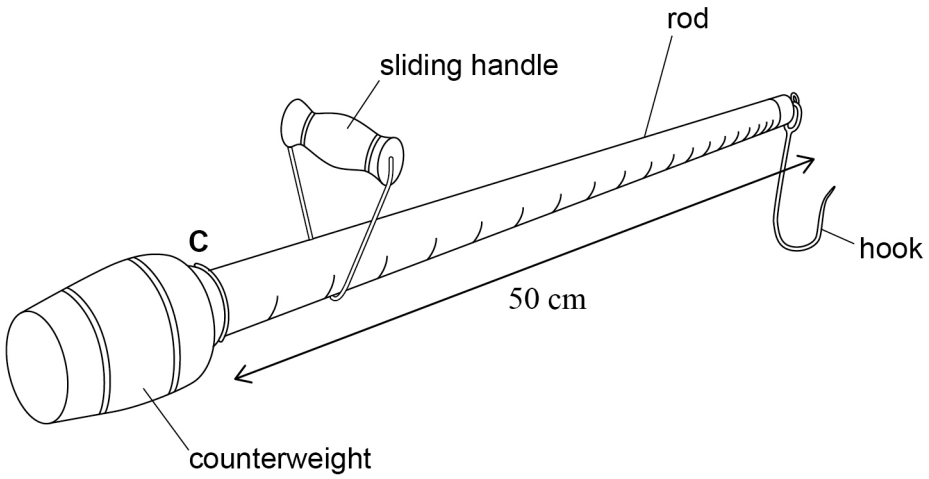
Answer **all** questions in this section.

1 1 . 1 State the principle of moments.

[2 marks]

Figure 9 shows a traditional mass balance called a Bismar scale.

Figure 9



A Bismar scale consists of a rod and counterweight of total mass $150\ \text{g}$. The counterweight is fixed to one end of the rod at point **C**. A hook of negligible mass is fixed to the other end of the rod.

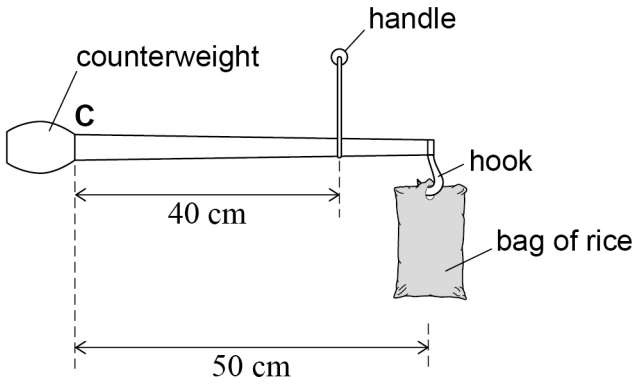
When a load is placed on the hook, a sliding handle is moved freely along the rod to balance the Bismar scale in a horizontal position.

The centre of mass of the Bismar scale is at point **C**. The length of the rod from the hook to point **C** is $50\ \text{cm}$.

Do not write outside the box

1 1 . 2 The Bismar scale is used to determine the mass of a bag of rice.
The scale is balanced when the sliding handle is $40\ \text{cm}$ away from **C**, as shown in **Figure 10**.

Figure 10



Calculate the mass of the bag of rice.

[2 marks]

mass = _____ g

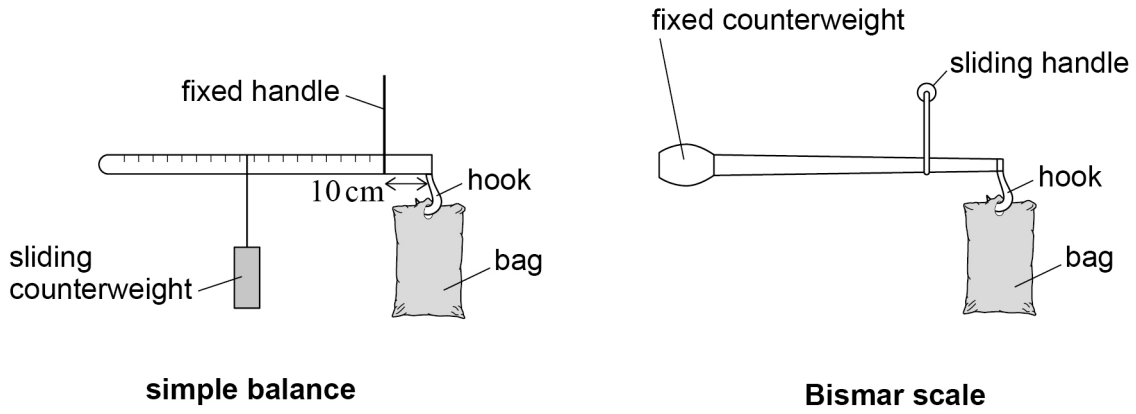
Question 11 continues on the next page

Turn over ►

Do not write outside the box

1 1 . 3 **Figure 11** shows a simple balance alongside the Bismar scale.
The simple balance has a fixed handle and a sliding counterweight.
After a bag is placed on the hook, the counterweight is moved to achieve balance.

Figure 11



simple balance **Bismar scale**

The simple balance is a uniform rod of length $50\ \text{cm}$ and mass $75\ \text{g}$, and a sliding counterweight of mass $75\ \text{g}$.

In the simple balance, the handle is fixed at $10\ \text{cm}$ from the hook.
In the Bismar scale, the minimum distance between the sliding handle and the hook is $2\ \text{cm}$.

The simple balance has evenly spaced markings.
The Bismar scale has markings that are closer together as they get closer to the hook.

Compare the advantages and disadvantages of this simple balance and this Bismar scale.

[3 marks]

Do not write outside the box

7

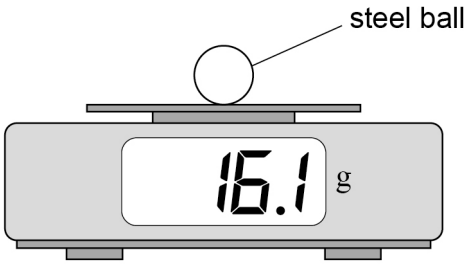
Turn over for the next question

Do not write outside the box

1 2 . 1 A student collects data to determine the density of a steel ball. He finds the mass of the steel ball using a digital balance.

Figure 12 shows the steel ball on the digital balance.

Figure 12



The balance was correctly zeroed before the ball was placed on it.

Calculate the percentage uncertainty in the reading of the mass.

[1 mark]

percentage uncertainty = _____

1 2 . 2 The student uses a vernier caliper to obtain six measurements for the diameter of the steel ball. The readings are:

15.7 mm 15.5 mm 16.3 mm 15.6 mm 15.7 mm 15.5 mm

Show that the percentage uncertainty in the mean value of the diameter is about 0.6%.

[3 marks]

Do not write outside the box

1 2 . 3 Calculate the density of the steel ball.

[2 marks]

density = _____ $\mathrm{kg\ m^{-3}}$

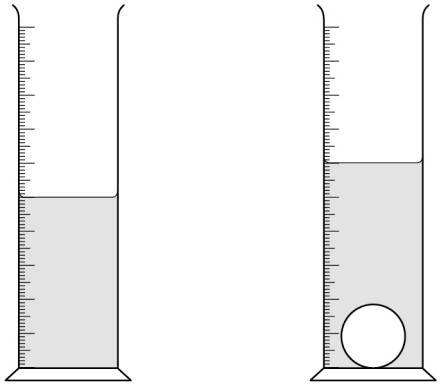
1 2 . 4 Calculate the percentage uncertainty in the density of the steel ball.

[1 mark]

percentage uncertainty = _____

1 2 . 5 When the steel ball is placed into a measuring cylinder containing water, the water level rises as shown in **Figure 13**.

Figure 13



Explain **one** reason why the student did not use this method to find the volume of the steel ball.

[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 

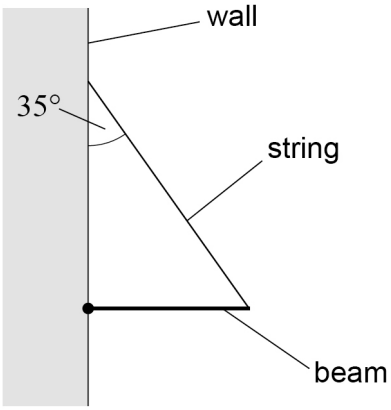
WRONG METHODS 

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 3 A uniform beam is attached by a hinge to a vertical wall and supported by a string. The string makes an angle of 35° to the wall.



The tension in the string is 25 N.

What is the weight of the beam?

[1 mark]

A 41 N 

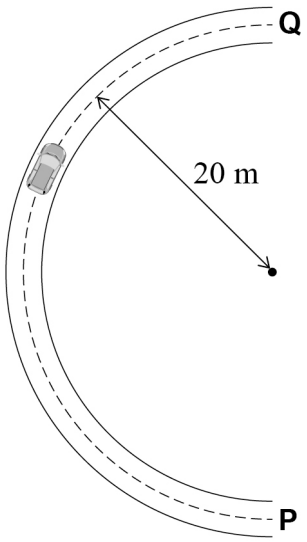
B 29 N 

C 20 N 

D 14 N 

Do not write outside the box

1 4 A car drives at a constant speed from **P** to **Q** around a semi-circular track of radius $20\ \text{m}$ in a time of $4.0\ \text{s}$.



Which row shows the magnitude of the average velocity of the car between **P** and **Q**, and the magnitude of the change in velocity from **P** to **Q**?

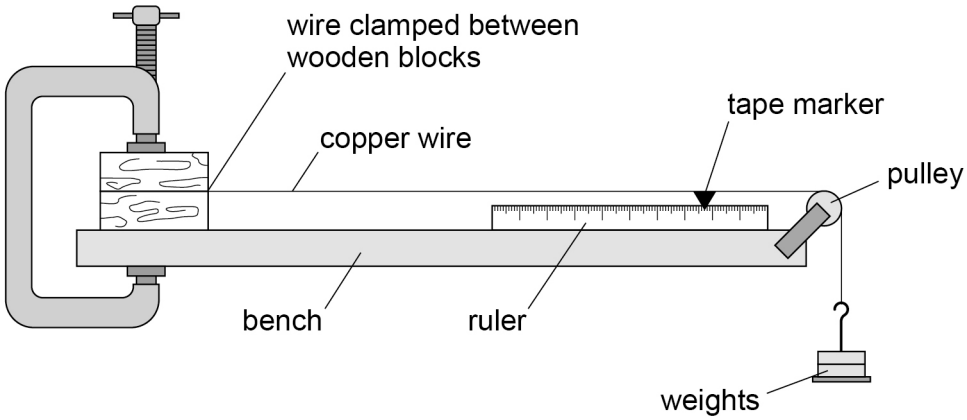
[1 mark]

	Magnitude of the average velocity / m s^{-1}	**Magnitude of the change in velocity / m s^{-1}**	
A	10	31	⬭
B	10	0	⬭
C	16	31	⬭
D	16	0	⬭

Turn over ►

Do not write outside the box

1 5 The diagram shows equipment that is used in an experiment to determine the Young modulus of copper.



The wire is clamped too loosely.

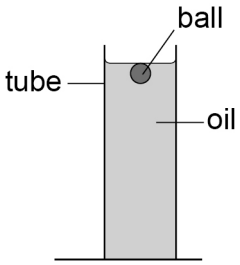
Which row shows the error that occurs due to the loose clamp and the consequence of this error?

[1 mark]

	Error	Consequence	
A	extension is overestimated	Young modulus is underestimated	⬭
B	extension is overestimated	Young modulus is overestimated	⬭
C	extension is underestimated	Young modulus is underestimated	⬭
D	extension is underestimated	Young modulus is overestimated	⬭

Do not write outside the box

1 6 A small steel ball is held below the surface of oil in a tube and released.



Which statement is correct for the ball until it reaches terminal speed?

[1 mark]

A The ball's acceleration increases. ⬭

B The ball's velocity decreases. ⬭

C The resultant force on the ball increases. ⬭

D The drag on the ball increases. ⬭

1 7 A child is ice skating with a skating aid toy.

The child has a mass of $20\ \text{kg}$. The toy has a mass of $15\ \text{kg}$.
They are initially moving together with a velocity of $1.5\ \text{m s}^{-1}$.

The child pushes the toy forwards in the same direction that she is moving.
The velocity of the toy changes to $2.0\ \text{m s}^{-1}$.

What is the speed of the child after she pushes the toy?

[1 mark]

A $0.83\ \text{m s}^{-1}$ ⬭

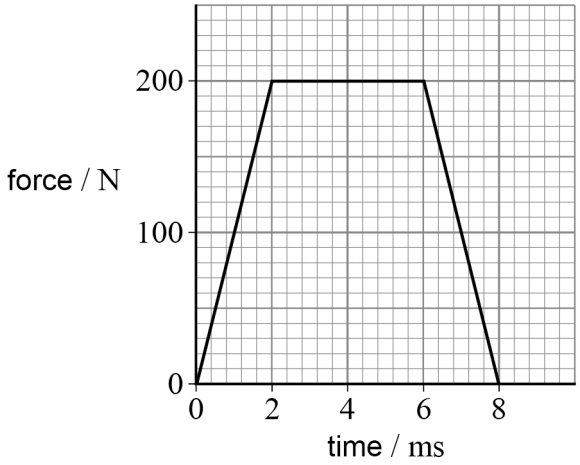
B $1.0\ \text{m s}^{-1}$ ⬭

C $1.1\ \text{m s}^{-1}$ ⬭

D $1.3\ \text{m s}^{-1}$ ⬭

Do not write outside the box

1 8 A ball is hit with a tennis racquet. The graph shows the variation of force on the ball with time.



What is the total impulse exerted on the ball?

[1 mark]

A 1.6 N s ⬭

B 1.2 N s ⬭

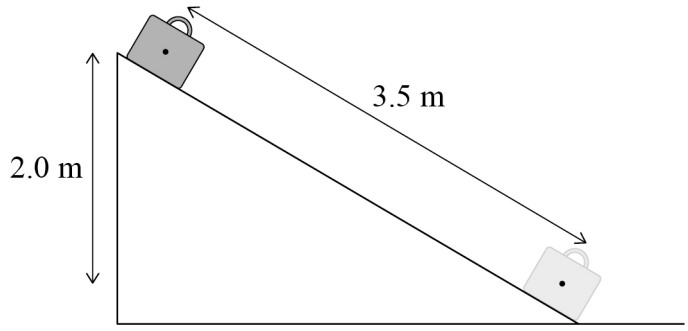
C 0.80 N s ⬭

D 0.20 N s ⬭

Do not write outside the box

1 9 A suitcase of mass $12\ \text{kg}$ slides from rest $3.5\ \text{m}$ down a ramp through a vertical height of $2.0\ \text{m}$.

The final speed of the suitcase is $1.5\ \text{m s}^{-1}$.



What is the average frictional force between the ramp and the suitcase?

[1 mark]

A $220\ \text{N}$ ⬭

B $67\ \text{N}$ ⬭

C $63\ \text{N}$ ⬭

D $14\ \text{N}$ ⬭

2 0 A $^{4}_{2}\text{He}$ nucleus has a specific charge of k.

What are the specific charges of a $^{24}_{12}\text{Mg}$ nucleus and a $^{200}_{80}\text{Hg}$ nucleus?

[1 mark]

	Specific charge of a $^{24}_{12}\text{Mg}$ nucleus	**Specific charge of a $^{200}_{80}\text{Hg}$ nucleus**	
A	k	$0.4k$	⬭
B	k	$0.8k$	⬭
C	$6k$	$0.4k$	⬭
D	$6k$	$0.8k$	⬭

Turn over ►

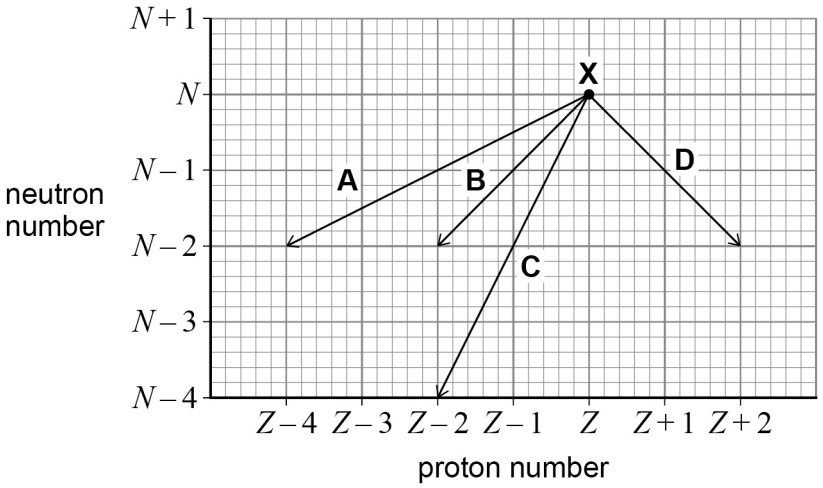
Do not write outside the box

2 1 The diagram shows a grid of neutron number against proton number.

Nuclide **X** decays by alpha emission.

Which line represents the change in neutron number and the change in proton number for **X** due to the decay?

[1 mark]



A ⬭

B ⬭

C ⬭

D ⬭

2 2 A photon produces a pair of particles.
The rest energy of a neutron is approximately 930 MeV.

Which row identifies a pair of particles that could be produced, and the corresponding minimum energy of the photon?

[1 mark]

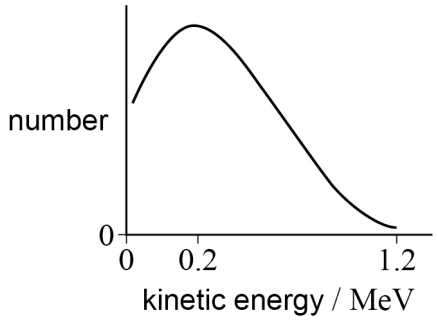
	Pair of particles	**Minimum energy of photon / MeV**	
A	neutron and antineutron	930	⬭
B	neutron and neutron	930	⬭
C	neutron and neutron	1860	⬭
D	neutron and antineutron	1860	⬭

Turn over for the next question

Do not write outside the box

2 3 Bismuth-210 decays to emit a beta particle and an antineutrino.

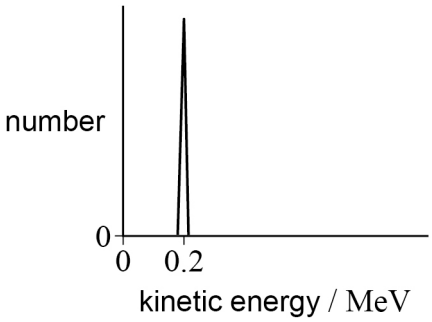
The graph shows the energy distribution of beta particles emitted from the decay of bismuth-210 nuclei.



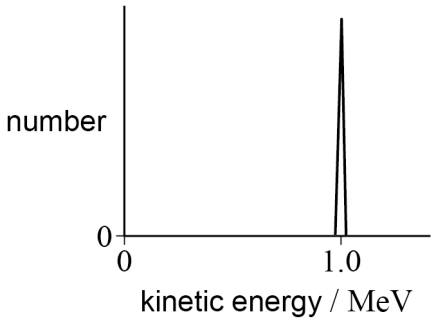
Which graph shows the most likely energy distribution of the antineutrinos emitted?

[1 mark]

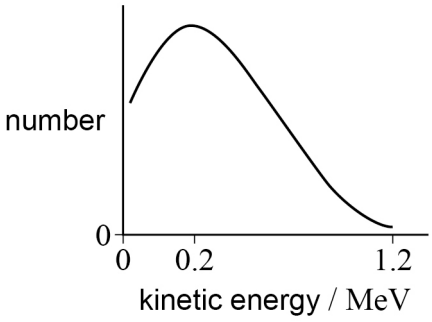
A



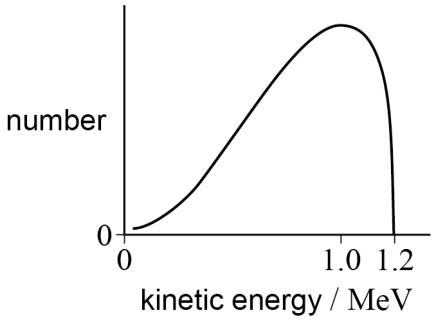
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

2 4 Which beta-decay equation is correct?

[1 mark]

A $^{20}_{8}\mathrm{O} \rightarrow {}^{20}_{9}\mathrm{F} + \beta^{-} + \nu_e$ ⬭

B $^{20}_{8}\mathrm{O} \rightarrow {}^{20}_{9}\mathrm{F} + \beta^{-} + \bar{\nu}_e$ ⬭

C $^{20}_{8}\mathrm{O} \rightarrow {}^{20}_{9}\mathrm{F} + \beta^{+} + \nu_e$ ⬭

D $^{20}_{8}\mathrm{O} \rightarrow {}^{20}_{9}\mathrm{F} + \beta^{+} + \bar{\nu}_e$ ⬭

2 5 When time $t = 6$ days, the activity of a radioactive source is 320 MBq.
When $t = 18$ days, the activity is 20 MBq.

What is the activity when $t = 0$?

[1 mark]

A 5100 MBq ⬭

B 1900 MBq ⬭

C 1300 MBq ⬭

D 640 MBq ⬭

2 6 A nucleus of barium-137 in an excited state decays to its ground state.

What is the decay process for this nucleus?

[1 mark]

A alpha emission ⬭

B beta emission ⬭

C gamma emission ⬭

D neutron emission ⬭

14

END OF QUESTIONS

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.**
	Copyright information For confidentiality purposes, all acknowledgements of third-party copyright material are published in a separate booklet. This booklet is published after each live examination series and is available for free download from www.oxfordaqa.com Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and OxfordAQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team.