OXFORD
INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

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

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I declare this is my own work.

INTERNATIONAL AS
PHYSICS

Unit 1 Mechanics, materials and atoms

Tuesday 5 January 2021 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 State **two** precautions for the safe use of a gamma source in a school laboratory.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

2

0 2 . 1 State what is meant by the rest energy of a particle.

[1 mark]

_____

_____

0 2 . 2 Calculate, in MeV, the rest energy of an electron.

[2 marks]

rest energy = _____ MeV

3

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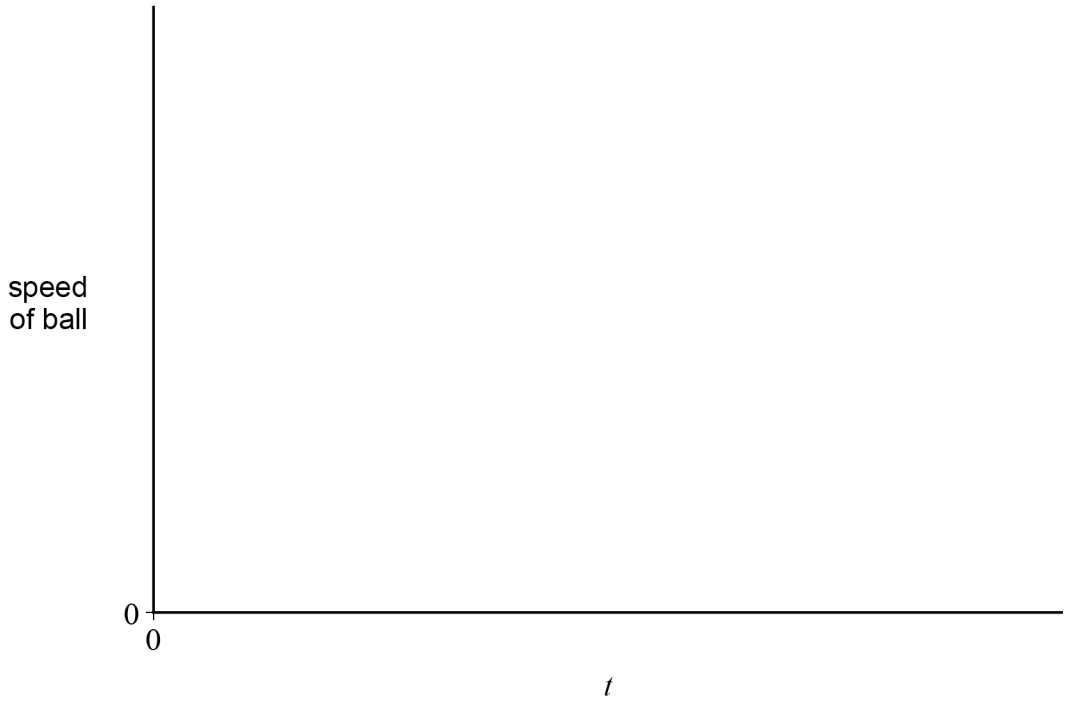
0 3 A tennis ball of mass 58 g has a rough surface.
A cricket ball of mass 160 g has a smooth surface.
Assume that the balls have the same diameter.
Both balls are dropped from the roof of a tall building at the same time and they fall through the air to the ground.

Sketch, on the axes below, graphs to show the variations with time t of the speed of each ball.

Label your graphs with a **T** for the tennis ball and a **C** for the cricket ball.
No calculations are required.

[3 marks]



3

Turn over for the next question

Do not write outside the box

0 4 . 1 An object is made to rotate by a couple acting about an axis through its centre of mass.

State what is meant by a couple.

[2 marks]

0 4 . 2 State how a single force applied to an object can cause the object to rotate.

[1 mark]

3

Do not write outside the box

0 5 In the decay of a nucleus of nitrogen-12, an electron neutrino (ν_e) and another particle **X** are emitted from the nucleus.

The decay is shown in the equation below.

$$^{12}_{7}\mathrm{N} \rightarrow \; ^{\text{-----}}_{6}\mathrm{C} \; + \; \mathbf{X} \; + \; ^{\text{-----}}_{\text{-----}}\nu_e$$

0 5 . 1 Identify **X**.

[1 mark]

X = _____

0 5 . 2 State the nucleon number of the nucleus produced by this decay.

[1 mark]

nucleon number = _____

0 5 . 3 Complete below the missing data for the neutrino.

[1 mark]

$$^{\text{-----}}_{\text{-----}}\nu_e$$

0 5 . 4 Explain why the existence of the neutrino was suggested before the particle was observed.

[2 marks]

_____

_____

_____

_____

_____

5

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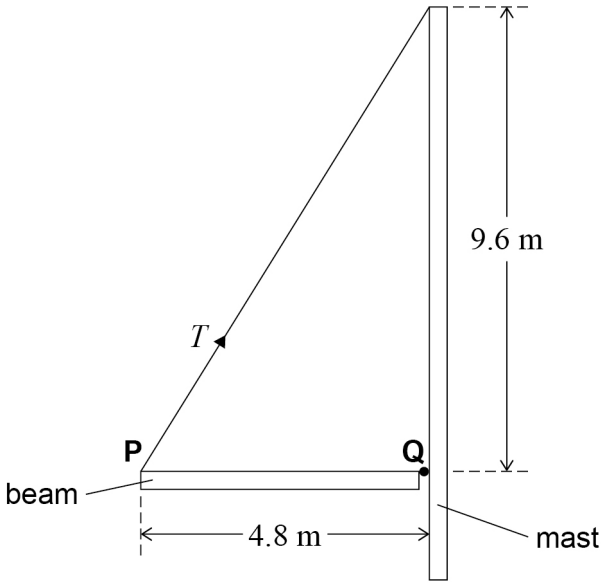
0 6 **Figure 1** shows the mast of a sailing boat.
A uniform horizontal beam **PQ** is attached by a pivot to the mast at **Q**. The beam is supported by a light inextensible rope attached to the top of the mast and to the free end of the beam at **P**.
The tension in the rope is T.

Figure 1



0 6 . 1 The mass of the beam is 12 kg.

Calculate T by taking moments about **Q**.

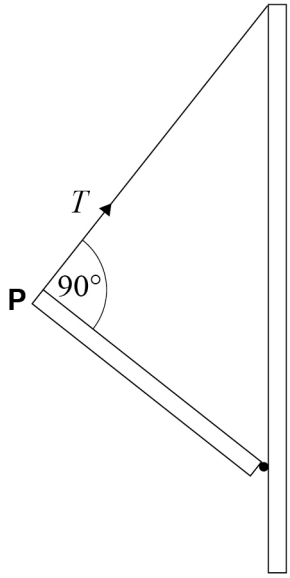
[4 marks]

$T =$ _____ N

Do not write outside the box

0 6 . 2 The end **P** of the beam is now raised by shortening the rope until it makes an angle of $90°$ to the beam as shown in **Figure 2**.

Figure 2



The magnitude of T varies as **P** is raised.

Explain the variation in the magnitude of T.
Calculations are not required.

[2 marks]

6

Do not write outside the box

0 7 In an experiment to determine the acceleration due to gravity, a steel ball is dropped from rest.
The time t taken for the ball to fall a distance h is measured for a range of values of h.
All of the measurements are shown in **Table 1**.

Table 1

h / m	t / s
0.5	0.35
1.0	0.48
1.5	0.6
2.0	0.67

0 7 . 1 Describe **three** ways in which the procedure and the recording of results could be improved.
Refer to **Table 1** in your answer.

[3 marks]

1 _____

_____

_____

_____

2 _____

_____

_____

_____

3 _____

_____

_____

_____

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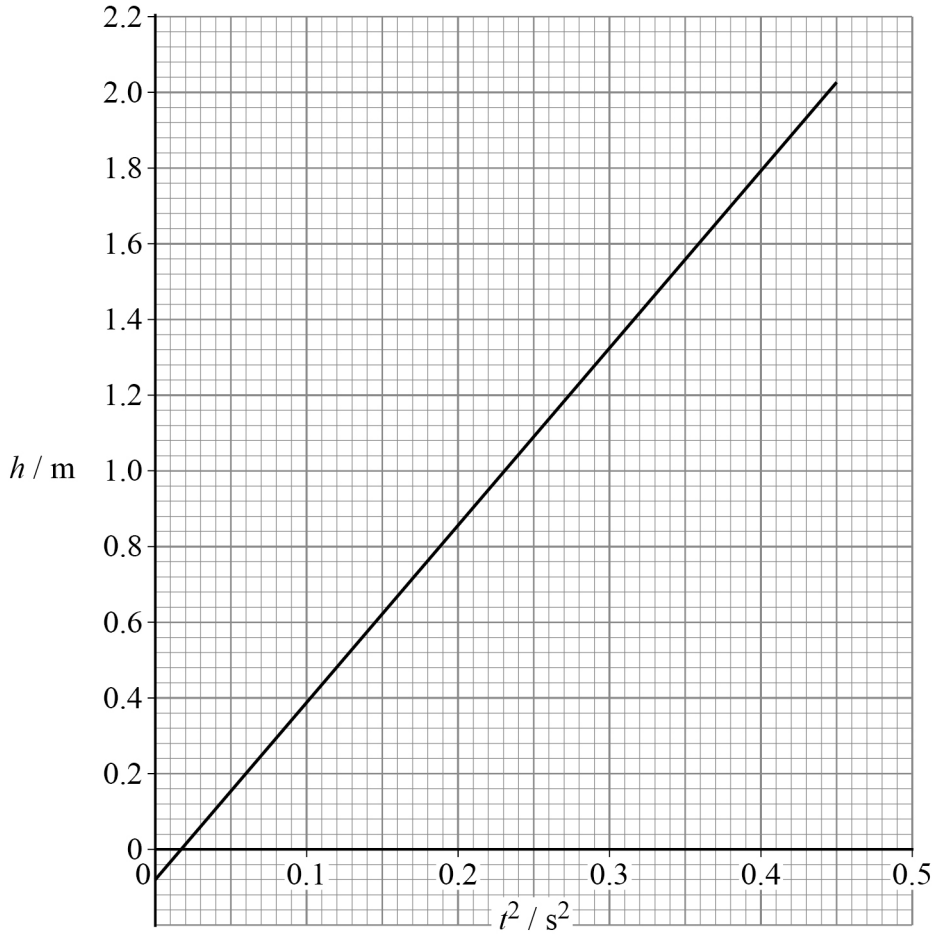
Figure 3 shows the best-fit line of a graph of h against t^2 for this experiment.

Figure 3



0 7 . 2 Determine, using **Figure 3**, a value for the acceleration due to gravity.

[3 marks]

acceleration due to gravity = _____ $m\ s^{-2}$

Question 7 continues on the next page

Do not write outside the box

0 7 . 3 The best-fit line in **Figure 3** does not go through the origin.

Suggest a systematic error that could account for this.

[1 mark]

_____

_____

_____

0 7 . 4 Draw a labelled diagram of the arrangement of apparatus you would use to measure t to an appropriate resolution.

[2 marks]

9

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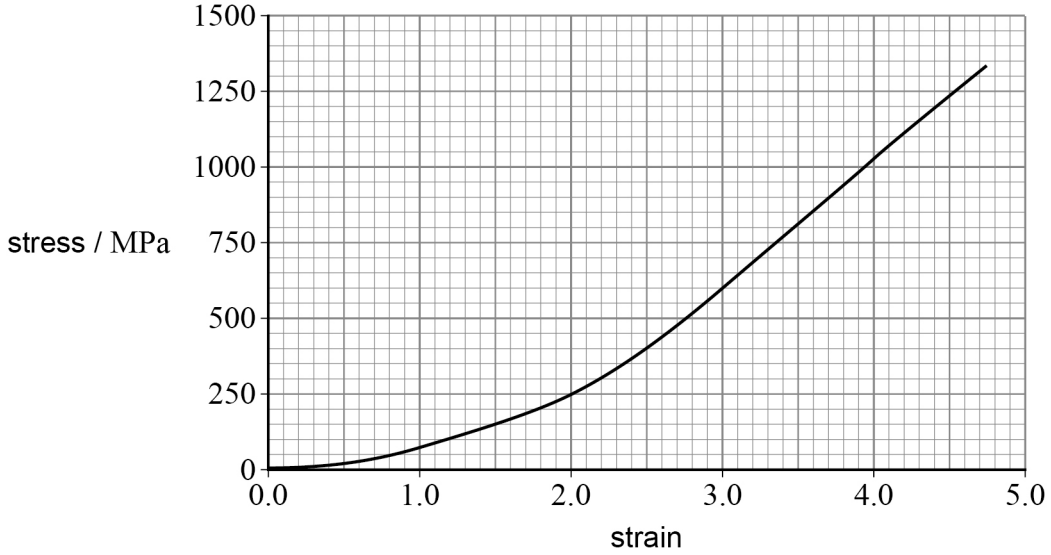
0 8 A strand of spider web silk is tested by increasing the tension in it until it breaks. **Figure 4** shows a stress–strain graph for the strand.

Figure 4



0 8 . 1 Explain whether or not the graph in **Figure 4** shows that the strand is elastic.

[2 marks]

0 8 . 2 The original length of this strand is 1.8 cm.

Show that the length of the strand just before it breaks is approximately 10 cm.

[2 marks]

Question 8 continues on the next page

Do not write outside the box

0 8 . 3 The work done per unit volume in stretching the strand is equivalent to the area under a stress–strain curve.
The volume of the strand remains constant as it stretches.

The initial diameter of the strand is 8.0×10^{-6} m.

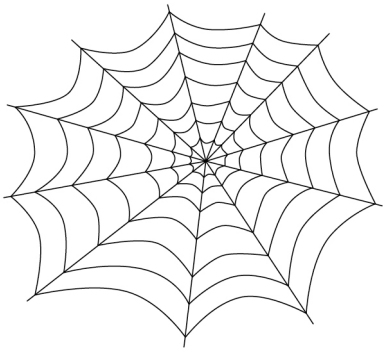
Determine the energy needed to break the strand.

[4 marks]

energy = _____ J

0 8 . 4 **Figure 5** shows the spider's web.

Figure 5



An insect flies into the web. The kinetic energy of the insect is much greater than the value of energy calculated in Question **08.3**.

Suggest why the web is unlikely to break.

[1 mark]

_____

_____

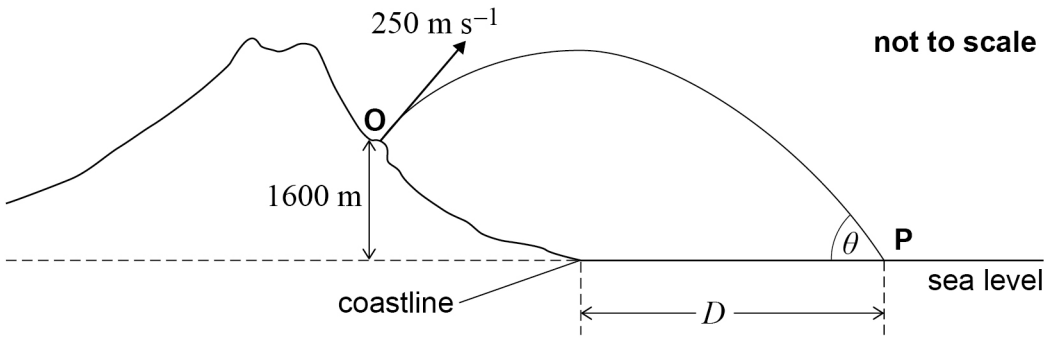
9

Do not write outside the box

0 9 A rock is ejected from point **O** on the side of a volcano and hits the sea at **P**.
Figure 6 shows the trajectory of the rock.
The mass of the rock is $3.70\ \text{kg}$ and its initial speed is $250\ \text{m s}^{-1}$.
O is $1600\ \text{m}$ above sea level.

Assume that air resistance is negligible.

Figure 6



0 9 . 1 Show that the kinetic energy of the rock as it enters the sea at **P** is approximately $1.7 \times 10^5\ \text{J}$.

[3 marks]

0 9 . 2 Show that the speed of the rock at **P** is approximately $300\ \text{m s}^{-1}$.

[1 mark]

Question 9 continues on the next page

Do not write outside the box

The horizontal component of velocity of the rock at **O** is $167\ \mathrm{m\ s^{-1}}$.

0 9 . 3 Show that the vertical component of the velocity of the rock at **P** is approximately $260\ \mathrm{m\ s^{-1}}$.

[2 marks]

0 9 . 4 The rock enters the sea at **P** at an angle of θ to the horizontal.

Calculate θ.

[1 mark]

$\theta =$ _____ °

0 9 . 5 The rock reaches its maximum height when it is exactly above the coastline.

Calculate D, the distance of **P** from the coastline.

[3 marks]

$D =$ _____ m

10

END OF SECTION A

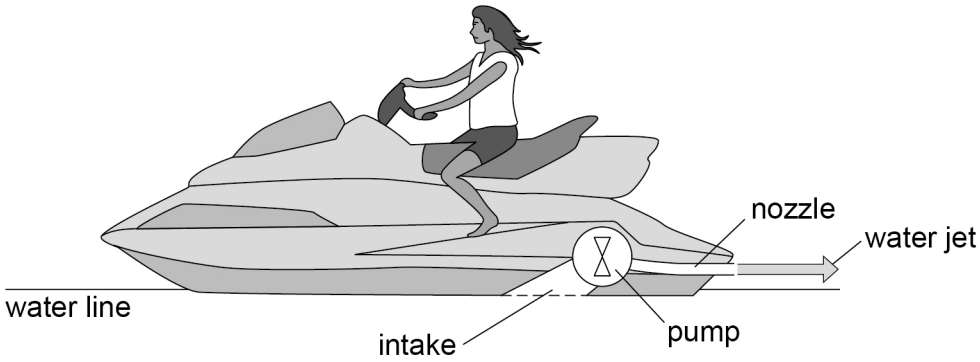
Do not write outside the box

Section B

Answer **all** questions in this section.

1 0 **Figure 7** shows a jet ski moving horizontally in a straight line.
The jet ski takes in water through an intake below the water line.
A pump ejects the water horizontally at high speed through a nozzle at the back of the jet ski.
The jet ski and rider have a combined mass of $521\ \mathrm{kg}$.

Figure 7



1 0 . 1 The rider accelerates the jet ski uniformly from rest to its top speed of $27\ \mathrm{m\ s^{-1}}$ in a distance of $63\ \mathrm{m}$.

Show that the resultant force accelerating the jet ski is approximately $3.0\ \mathrm{kN}$.

[3 marks]

Question 10 continues on the next page

Do not write outside the box

1 0 . 2 Explain, in terms of momentum, how the jet ski is propelled forwards.

[2 marks]

_____

_____

_____

_____

_____

1 0 . 3 During the acceleration, the jet ski ejects $78\ \mathrm{kg}$ of water per second through the nozzle.

Calculate the speed at which the water is ejected from the nozzle.

[2 marks]

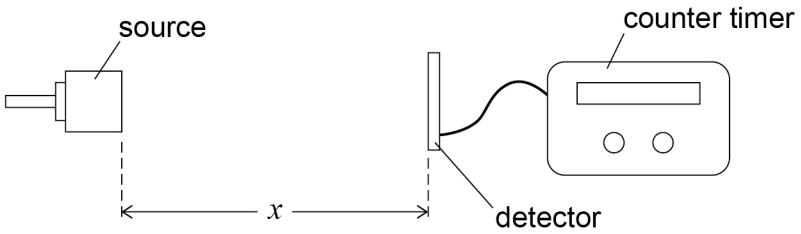
speed = _____ $\mathrm{m\ s^{-1}}$

7

Do not write outside the box

1 1 **Figure 8** shows the apparatus used to verify the inverse-square law for gamma rays. The distance x between the source and a detector is measured.
The detector is connected to a counter timer and the count rate C is measured for different values of x.

Figure 8



A student suggests that C is given by $C = \frac{k}{x^2}$ where k is a constant.

1 1 . 1 The count rate was measured three times for $x = 0.520$ m.
Table 2 shows the data recorded.

Table 2

Elapsed time / minute	5.00	5.00	10.00
Total count	2246	2263	4458

Calculate the mean count rate in counts per minute.

[1 mark]

mean count rate = _____ counts per minute

Question 11 continues on the next page

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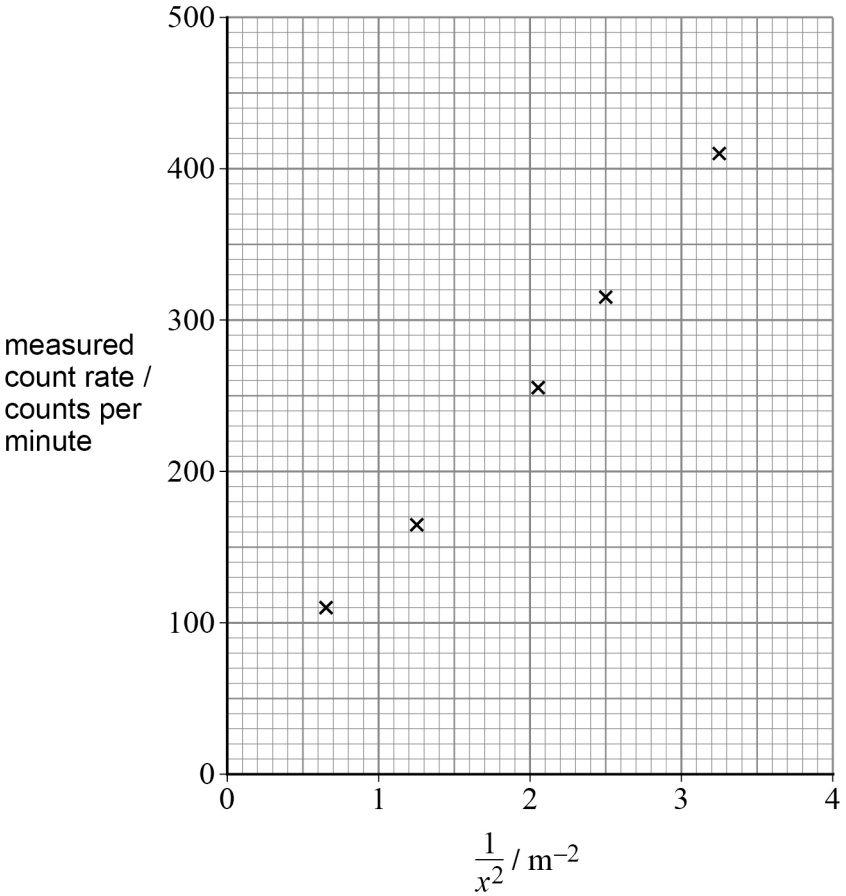
Figure 9 shows a plot of C against $\frac{1}{x^2}$ for all of the other measured values of C and x.

Figure 9



1 1 . 2 Plot, on **Figure 9**, your answer to Question **11.1**.

[1 mark]

1 1 . 3 Draw a line of best fit on **Figure 9**.

[1 mark]

Do not write outside the box

1 1 . 4 Determine the gradient of your best-fit line on **Figure 9**.

[3 marks]

gradient = _____ counts $\text{min}^{-1}\ \text{m}^2$

1 1 . 5 Explain whether or not **Figure 9** supports the student's suggestion that $C = \frac{k}{x^2}$.

[1 mark]

_____

_____

_____

1 1 . 6 State the physical quantity represented by the intercept on the y-axis.

[1 mark]

_____

_____

1 1 . 7 Determine the value of the intercept on the y-axis.

[1 mark]

value of the intercept = _____ counts per minute

9

END OF SECTION B

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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 3 N force and a 4 N force act on an object at right angles to each other. A third force of 8 N also acts on the object.
All of the forces are coplanar.

What is a possible resultant force on the object?

[1 mark]

A 1 N

B 10 N

C 14 N

D 15 N

1 3 What is **not** a possible unit for kinetic energy?

[1 mark]

A μJ

B kg m s^{-2}

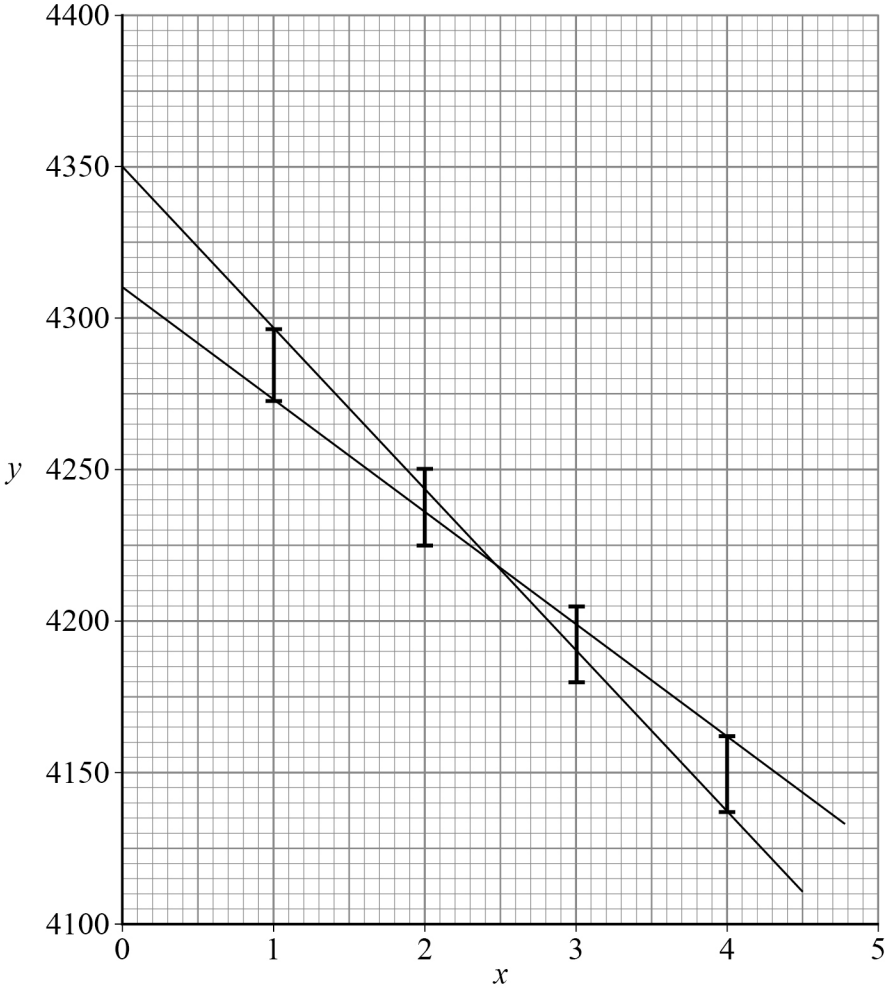
C eV

D Ws

Do not write outside the box

1 4 What is the percentage uncertainty in the value of the y-intercept that can be deduced from this graph?

[1 mark]



A 0.5% ⬭

B 0.9% ⬭

C 5% ⬭

D 9% ⬭

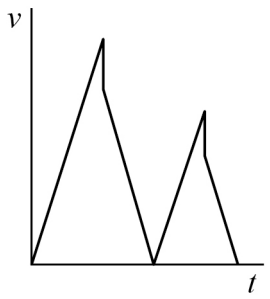
Do not write outside the box

1 5 A ball is dropped onto a horizontal floor.
The ball bounces twice. The ball loses some energy each time it bounces.
Ignore the effect of air resistance and the time that the ball is in contact with the floor.

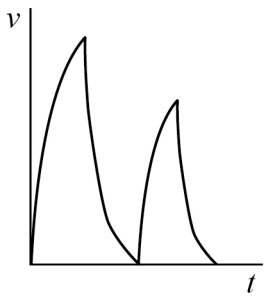
Which graph shows the variation of velocity v of the ball with time t?

[1 mark]

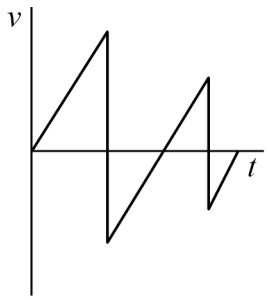
A



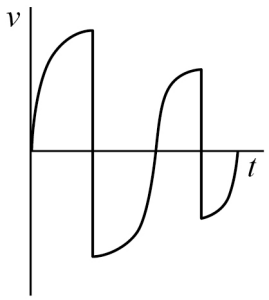
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

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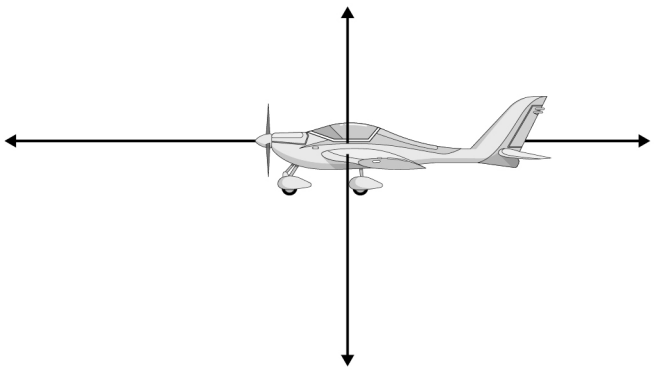
1 6 The diagram shows an aircraft and the forces acting on it.

The lengths of the arrows indicate the magnitude of the forces.



Which row describes the horizontal and vertical components of velocity of the aircraft?

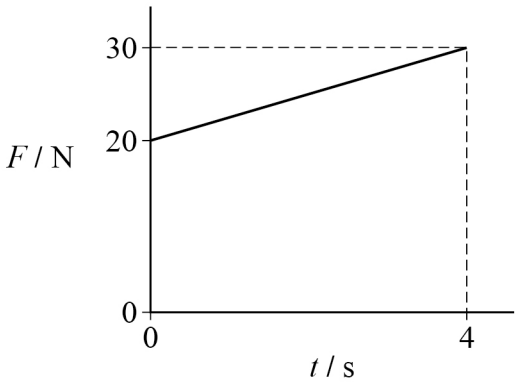
[1 mark]

	Horizontal component of velocity	Vertical component of velocity	
A	constant to the left	constant downwards	⬭
B	constant to the left	increasing downwards	⬭
C	increasing to the left	constant downwards	⬭
D	increasing to the left	increasing downwards	⬭

Turn over for the next question

Do not write outside the box

1 7 A force F acts on an object.
The graph shows the variation of F with time t.



What is the impulse received by the object during the time shown by the graph?

[1 mark]

A 2.5 kg m s^{-1}

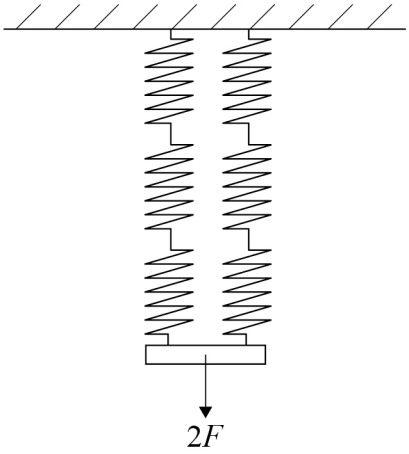
B 10 kg m s^{-1}

C 30 kg m s^{-1}

D 100 kg m s^{-1}

Do not write outside the box

1 8 When a single spring of stiffness k is stretched by a force F, the extension is Δl.
The diagram shows a network of six single springs of stiffness k being stretched by a force $2F$.



What is the total extension of the network of springs?

[1 mark]

A $\frac{4}{3}\Delta l$

B $\frac{3}{2}\Delta l$

C $3\Delta l$

D $6\Delta l$

Turn over for the next question

Do not write outside the box

1 9 When an elevator of mass 400 kg raises a load of mass 900 kg the efficiency is 60%.
The useful work done by the elevator is the work done in lifting the load.
When moving through a height h, the total energy input to the elevator is 3.4×10^5 J.

What is h?

[1 mark]

A 16 m ⬭

B 23 m ⬭

C 44 m ⬭

D 64 m ⬭

2 0 The table shows observations and deductions from the Rutherford scattering experiment when carried out with copper-63 and gold-197 atoms.

Which row has a correct observation and a deduction that may be made from that observation?

[1 mark]

	Observation	Deduction	
A	a small number of alpha particles are deviated through angles of more than 90°	atomic nuclei are very small	⬭
B	many alpha particles are deviated through angles of more than 90°	atomic nuclei carry a positive charge	⬭
C	copper foil deflects particles through greater angles than gold foil	a copper nucleus contains more nucleons than a gold nucleus	⬭
D	a minority of alpha particles pass through the foil without deviation	atomic nuclei are small and positively charged	⬭

Do not write outside the box

2 1 Which pair of particles has the same magnitude of specific charge?

[1 mark]

A $^{3}_{2}\mathrm{He}$ nucleus and $^{3}_{1}\mathrm{H}$ nucleus

B $^{2}_{1}\mathrm{H}$ nucleus and $^{1}_{1}\mathrm{H}$ nucleus

C proton and positron

D beta particle and positron

2 2 Which row shows two particles that can mutually annihilate and the energy produced in their annihilation?

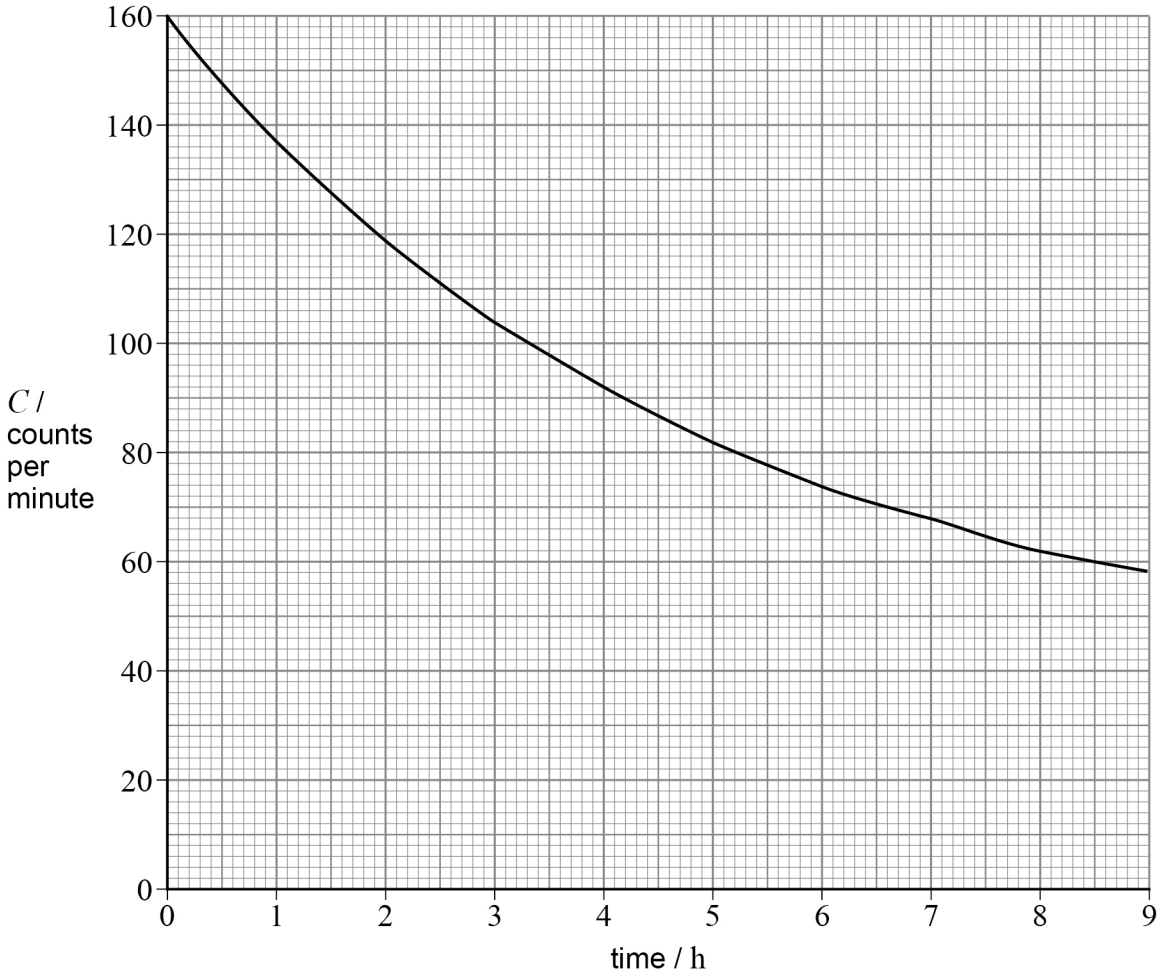
[1 mark]

	1st particle	2nd particle	Energy produced / MeV
A	proton	proton	1860
B	proton	proton	930
C	proton	antiproton	1860
D	proton	antiproton	930

Turn over for the next question

Do not write outside the box

2 3 A detector is placed near a source of radiation.
The total count rate C is plotted against time.
The background count rate is 40 counts per minute.



What is the half-life of the source?

[1 mark]

A 1.9 h

B 3.3 h

C 5.2 h

D 8.8 h

Do not write outside the box

2 4 A detector is placed near to a radioactive source **S**.
Absorbers are placed between **S** and the detector.
The table shows the corrected count rate for radiation from **S** with and without absorbers present.

Absorber	**Corrected count rate / counts s^{-1}**
none	480
one sheet of thin card	340
4 mm of aluminium	340

What is emitted from **S**?

[1 mark]

A α radiation only ⬭

B α and β radiations only ⬭

C α and γ radiations only ⬭

D α, β and γ radiations ⬭

2 5 Which statement concerning background radiation is correct?

[1 mark]

A Background radiation is made up of alpha, beta and gamma radiation only. ⬭

B All background radiation comes from naturally occurring sources. ⬭

C Some background radiation comes from sources not on the Earth. ⬭

D All background radiation can be absorbed by a lead screen. ⬭

14

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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

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

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