OXFORD
INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

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# OXFORD AQA INTERNATIONAL AS
# PHYSICS

## Unit 1 Mechanics, materials and atoms

Tuesday 23 January 2018 06:00 GMT Time allowed: 2 hours

A

**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.

**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.
- 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** Complete the equation for the radioactive decay of $^{42}_{19}\mathrm{K}$.

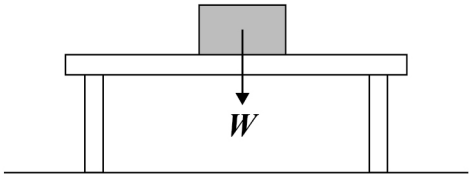
**[2 marks]**

$$^{42}_{19}\mathrm{K} \longrightarrow \underline{\quad}\,\mathrm{Ca} + \underline{\quad}\,\underline{\quad} + \bar{\nu}_e$$

**2**

**0 2** **Figure 1** shows an object of weight $W$ on a table.

**Figure 1**




A student wrongly suggests that $W$ and the normal reaction at the table form an action–reaction pair according to Newton's third law.

**0 2 . 1** State which force actually forms the action–reaction pair to $W$.

**[1 mark]**

**0 2 . 2** Justify your answer.

**[1 mark]**

**2**

Do not write outside the box

**0 3** A particle has a rest energy of 942 MeV

**0 3 . 1** State what is meant by the rest energy of a particle.

**[2 marks]**

_____

_____

_____

_____

**0 3 . 2** Convert 942 MeV into joule.

**[1 mark]**

942 MeV = _____ J

3

**Turn over for the next question**

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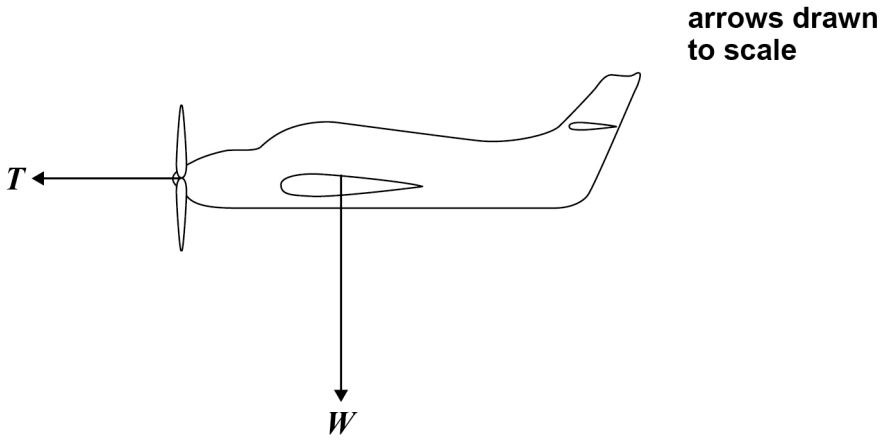
**0 4** **Figure 2** shows an aircraft that is descending. The horizontal and vertical components of velocity are constant. The thrust $T$ and the weight $W$ are shown. The lengths of the arrows indicate the magnitudes of the forces. There is no resultant moment on the aircraft.

**Figure 2**




Draw and label on **Figure 2** arrows of suitable lengths to represent the lift $L$ and the drag $D$ that act on the aircraft.

**[3 marks]**

3

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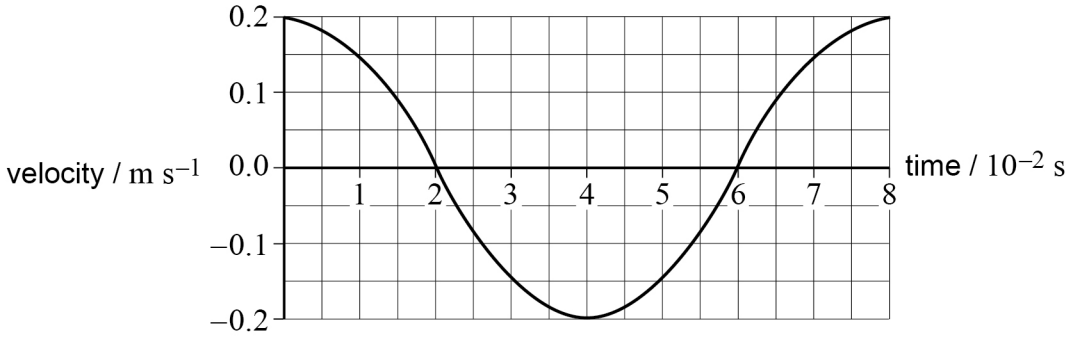
**0 5** **Figure 3** and **Figure 4** are identical velocity–time graphs for an object oscillating about a fixed point.

**0 5 . 1** Determine using **Figure 3** the maximum acceleration of the oscillating object.

**[3 marks]**

**Figure 3**

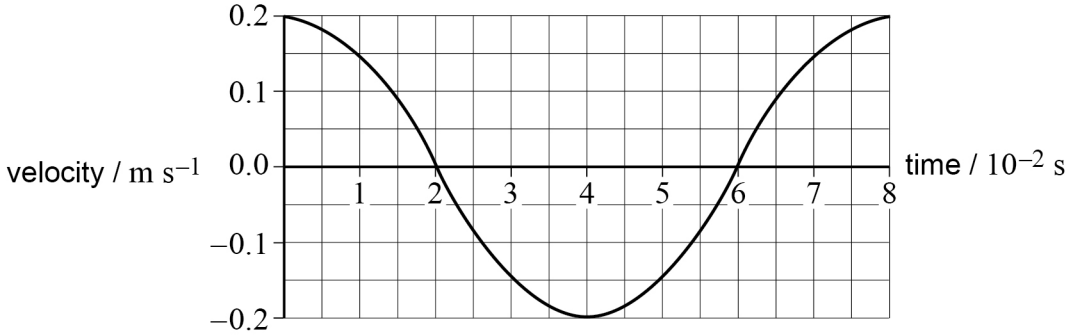



maximum acceleration = _____ m s$^{-2}$

**0 5 . 2** Determine using **Figure 4** the maximum displacement of the object from the fixed point.

**[3 marks]**

**Figure 4**




maximum displacement = _____ m

6

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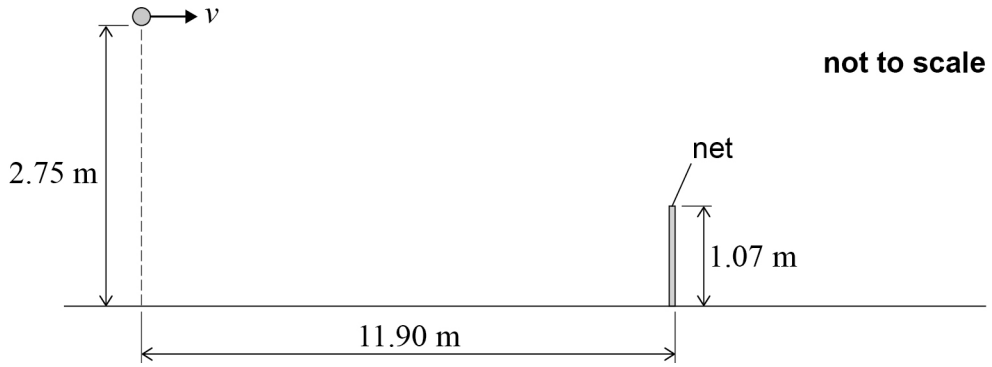
**0 6** A tennis ball is served horizontally as shown in **Figure 5**. The bottom of the ball is $2.75\ \text{m}$ above the ground and a horizontal distance of $11.9\ \text{m}$ from the net. The top of the net is $1.07\ \text{m}$ above the ground.
Assume air resistance is negligible in this question.

**Figure 5**




**0 6 . 1** Show that the time taken for the bottom of the ball to fall to $1.07\ \text{m}$ above the ground is approximately $0.6\ \text{s}$

**[2 marks]**

**0 6 . 2** Calculate the minimum initial horizontal velocity $v$ that the ball must have to get over the net.

**[1 mark]**

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

Do not write outside the box

**0 6 . 3** Later in the game, the ball has a horizontal component of velocity of $42\ \mathrm{m\ s^{-1}}$ and a downward vertical component of velocity of $26\ \mathrm{m\ s^{-1}}$

Determine the resultant velocity of the ball.
You may use a calculation or a scale drawing.

**[4 marks]**

magnitude of resultant velocity = _____ $\mathrm{m\ s^{-1}}$

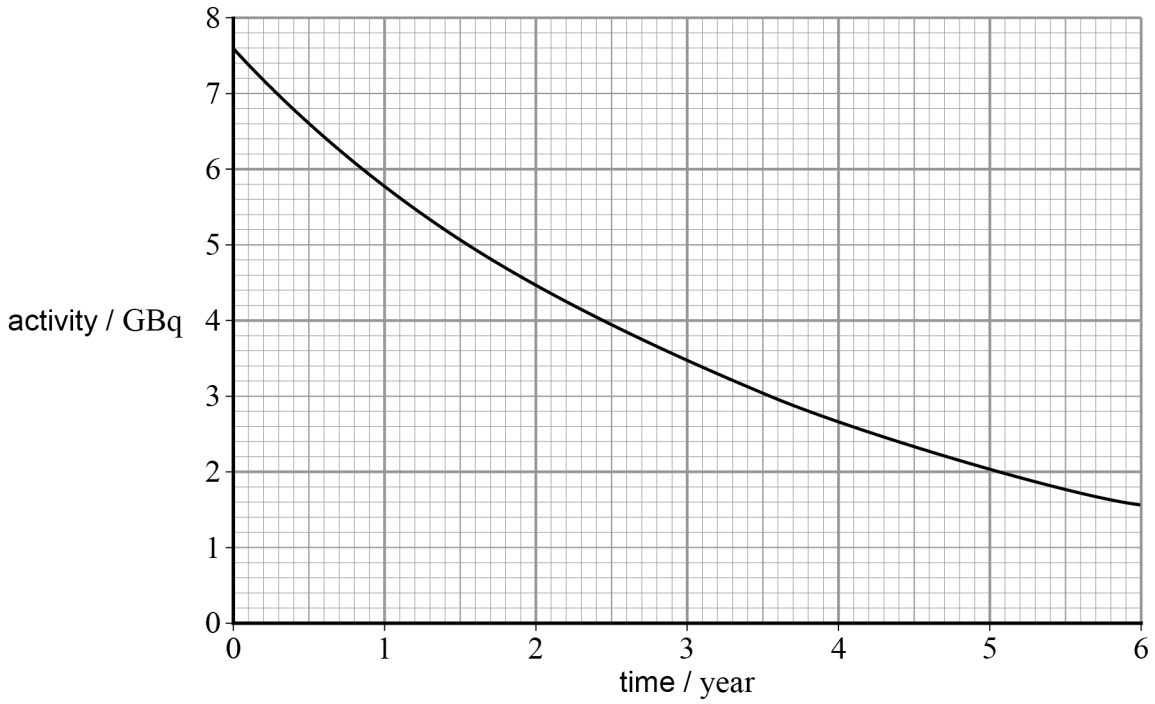
direction of resultant velocity = _____

7

Do not write outside the box

**0 7** Promethium-147 $\left({}^{147}_{61}\mathrm{Pm}\right)$ is a radioactive nuclide that emits $\beta^-$ particles.
**Figure 6** shows the variation with time of the activity of a ${}^{147}_{61}\mathrm{Pm}$ source.

**Figure 6**




**0 7 . 1** Determine, using **Figure 6**, an accurate value for the half-life of ${}^{147}_{61}\mathrm{Pm}$.

**[3 marks]**

half-life = _____ year

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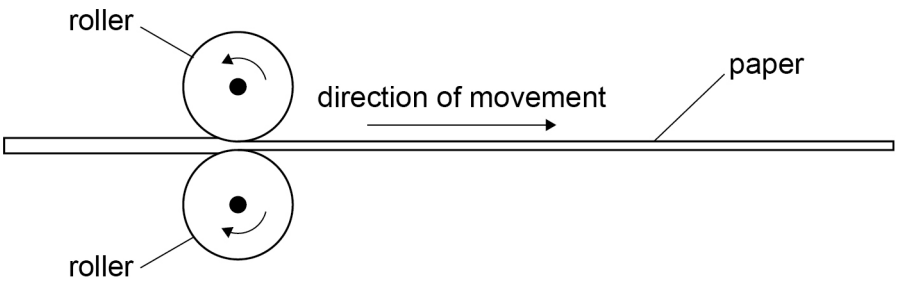
**0 7 . 2** Paper is made by passing it between two rollers as shown in **Figure 7**.

**Figure 7**




$^{147}_{61}\mathrm{Pm}$ is often used in the process of controlling the thickness of the paper.

Describe how $^{147}_{61}\mathrm{Pm}$ is used in this process and the radioactive properties that make $^{147}_{61}\mathrm{Pm}$ suitable for this purpose.

**[4 marks]**

7

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**0 8** **Figure 8** shows a section of a suspension bridge. The bridge deck is supported by a single cable attached to a vertical tower.

**Figure 8**

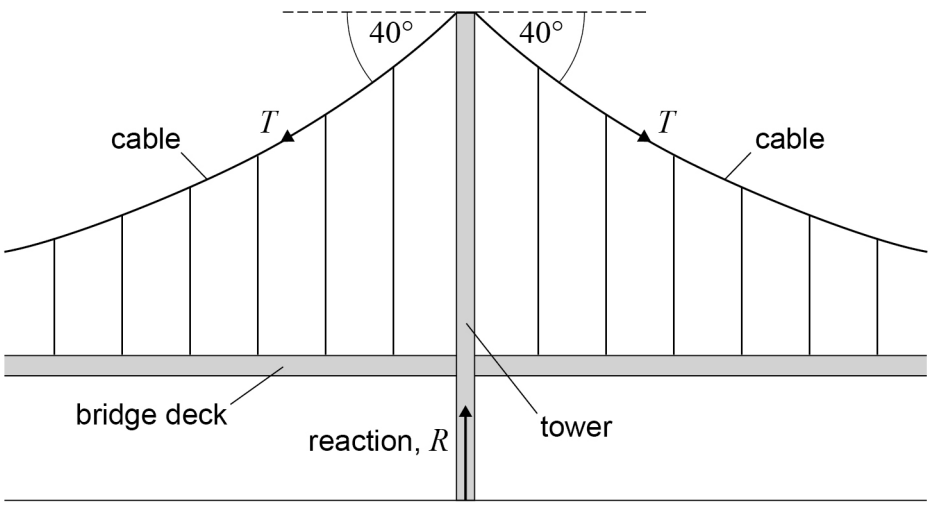
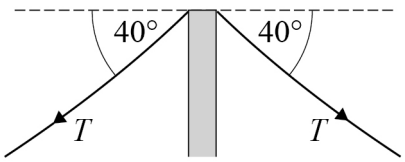



**Figure 9** is an enlarged view of the cable and the top of the tower. The cable makes an angle of $40°$ to the horizontal where it meets the tower.

The tension $T$ in each section of the cable is $1.2 \times 10^8$ N
The weight of the cable is negligible.

**Figure 9**




**0 8 . 1** Calculate the magnitude of the resultant force exerted on the tower by the cable.

**[2 marks]**

resultant force = _____ N

Do not write outside the box

**0 8 . 2** The mass of the tower is $7.1 \times 10^6$ kg

Calculate the magnitude of the reaction $R$ of the ground on the base of the tower.

**[2 marks]**

magnitude of $R$ = _____ N

**0 8 . 3** The cable has a cross-sectional area of $1.8\ \text{m}^2$ and an unstretched length of $1300\ \text{m}$
The cable is made from steel with a Young modulus of $2.1 \times 10^{11}$ Pa

Calculate the extension of the cable.

**[3 marks]**

extension = _____ m

**Question 8 continues on the next page**

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**0 8 . 4** The breaking stress of the steel cable is $4.7 \times 10^8$ Pa
However, it begins to undergo large plastic deformation at much smaller stresses.

Explain what is meant by breaking stress and by plastic deformation.

**[2 marks]**

breaking stress _____

_____

plastic deformation _____

_____

**0 8 . 5** Explain why the bridge is designed so that, normally, the stress in the cable is significantly less than the breaking stress.

**[1 mark]**

_____

_____

_____

**10**

**Turn to page 14 for the next question**

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**Turn over for the next question**

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**ANSWER IN THE SPACES PROVIDED**

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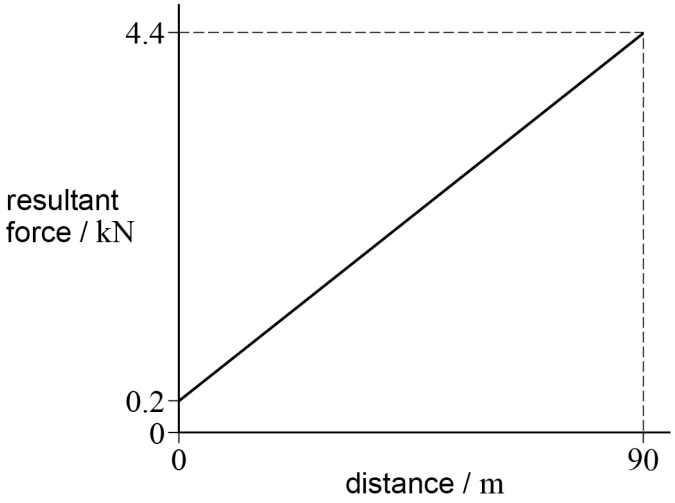
**0 9** A car of mass 1400 kg starts from rest and travels along a horizontal road for 90 m
**Figure 10** shows the variation with distance of the resultant force on the car.

**Figure 10**




**0 9 . 1** Describe the motion of the car over the 90 m journey.

**[1 mark]**

_____

_____

_____

**0 9 . 2** Calculate the initial acceleration of the car.

**[2 marks]**

initial acceleration = _____ $m\ s^{-2}$

Do not write outside the box

**0 9 . 3** Show that the useful work done accelerating the car over the 90 m journey is about $2 \times 10^5$ J

**[3 marks]**

**0 9 . 4** Calculate the speed of the car after it has travelled 90 m

**[2 marks]**

final speed = _____ m $s^{-2}$

**0 9 . 5** Discuss how the resistive forces experienced by the car change over the 90 m journey.

**[2 marks]**

_____

_____

_____

_____

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_____

10

**Turn over ►**

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## Section B

Answer **all** questions in this section.

**1 0** Time-lapse photography can be used to show the changing positions of an object at regular time intervals. The different positions are displayed in a single photograph.

A ball is dropped from rest and its motion is analysed using time-lapse photography to determine a value for the acceleration due to gravity, $g$.

**Figure 11** shows a full-scale representation of a time-lapse photograph of the ball as it falls. The position of the ball is shown from time $t = 0$ and then at $40\ \mathrm{ms}$ intervals.

**1 0 . 1** Show, on **Figure 11**, the distance you would measure to give an accurate value for $g$. Label this distance $s$.

**[1 mark]**

**1 0 . 2** Justify your answer to question **10.1**

**[1 mark]**

_____

_____

_____

_____

**1 0 . 3** Measure distance $s$ using a ruler with a $\mathrm{mm}$ scale.

**[1 mark]**

$s$ = _____

Do not write outside the box

**Figure 11**

**Question 10 continues on the next page**

Do not write outside the box

**1 0 . 4** Determine, using $s = \frac{1}{2} g t^2$ and your value for $s$, a value for $g$.

**[1 mark]**

$g$ = _____ m s$^{-2}$

**1 0 . 5** Estimate the percentage uncertainty in your measurement of $s$.

**[1 mark]**

percentage uncertainty in $s$ = _____ %

**1 0 . 6** The percentage uncertainty in $t$ is $0.8\%$

Use this and your values from question **10.4** and question **10.5** to calculate the absolute uncertainty in your value for $g$.

**[3 marks]**

absolute uncertainty in $g$ = ± _____ m s$^{-2}$

8

**Turn to page 20 for the next question**

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**Turn over for the next question**

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**ANSWER IN THE SPACES PROVIDED**

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**1 1 . 1** Define impulse.

**[1 mark]**

**1 1 . 2** A vehicle-safety engineer investigates airbags. A car has a dummy in the driver's seat and crashes into a wall so that the airbag inflates as shown in **Figure 12**. The force $F$ experienced by the dummy's head is monitored.

**Figure 12**

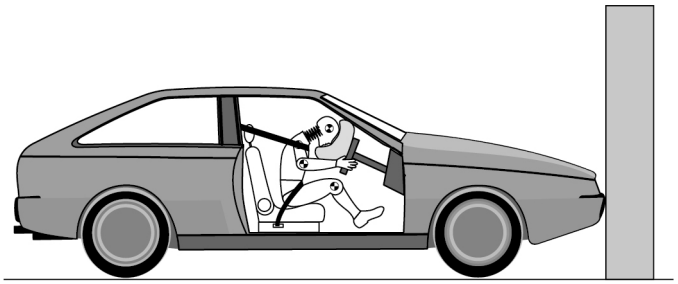
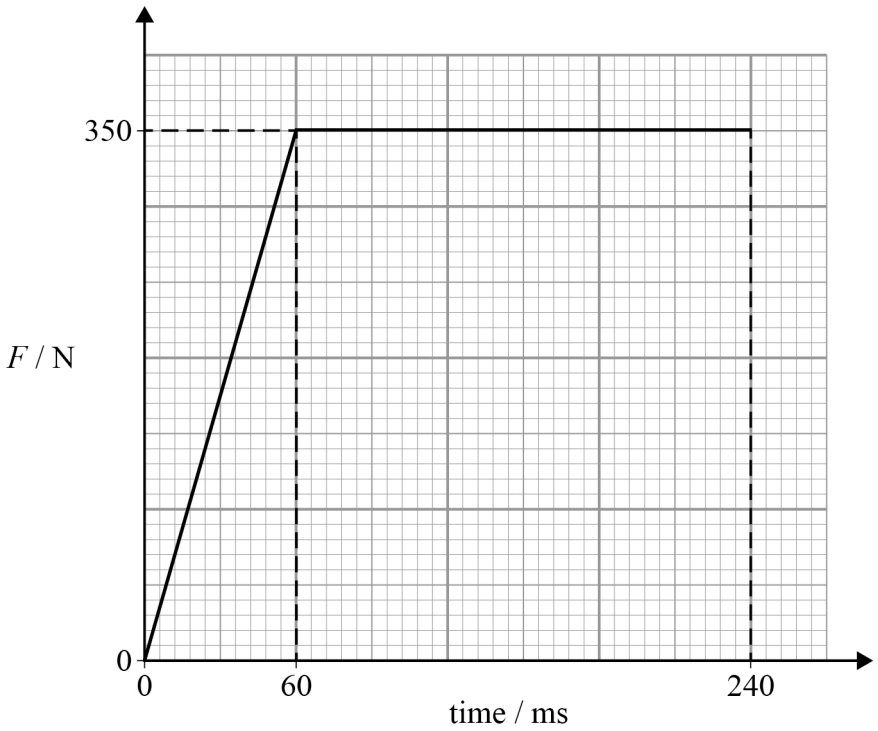


**Figure 13** is a graph showing the variation of $F$ with time from when the head first touches the airbag until it stops moving.

**Figure 13**



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Show that the impulse experienced by the head is approximately $75\ \mathrm{N\ s}$

**[3 marks]**

**1 1 . 3** The dummy's head has a mass of $4.8\ \mathrm{kg}$

Calculate the initial velocity of the head.

**[2 marks]**

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

**1 1 . 4** In other safety tests car **A**, without a crumple zone, hits the wall at $12\ \mathrm{m\ s^{-1}}$ and rebounds at $8\ \mathrm{m\ s^{-1}}$
Car **B** has a crumple zone. It also hits the wall at $12\ \mathrm{m\ s^{-1}}$ but does not rebound.

State **two** reasons why a dummy in car **A** would be likely to be more damaged than a dummy in car **B**.

**[2 marks]**

_____

_____

_____

_____

_____

_____

8

**Turn over ►**

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## Section C

Each of Questions **12** to **25** 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 answer 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.

**1 2** Which list contains symbols for SI fundamental base units only?

**[1 mark]**

**A** A, kg, m, N, s

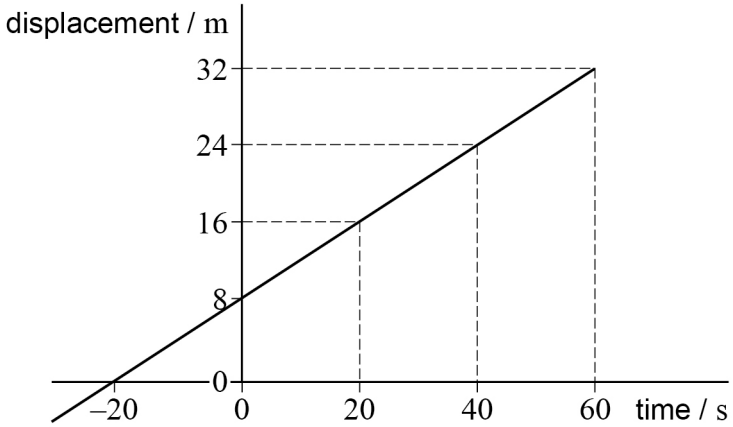
**B** A, K, m, mol, s

**C** C, kg, m, mol, rad

**D** J, K, kg, m, s

Do not write outside the box

**1 3** The graph shows the variation with time of the displacement of a moving vehicle from a fixed point.




What are the velocity and displacement of the moving vehicle 20 s after it passes the fixed point?

**[1 mark]**

| | Velocity / m s$^{-1}$ | Displacement / m | |
|---|---|---|---|
| **A** | 0.53 | 8 | ⬭ |
| **B** | 0.40 | 8 | ⬭ |
| **C** | 0.53 | 16 | ⬭ |
| **D** | 0.40 | 16 | ⬭ |

**1 4** Which list contains the names of vector quantities only?

**[1 mark]**

**A** acceleration, force, momentum, power, weight ⬭

**B** acceleration, displacement, power, velocity, weight ⬭

**C** displacement, force, momentum, velocity, weight ⬭

**D** displacement, length, momentum, weight, work done ⬭

**Turn over ►**

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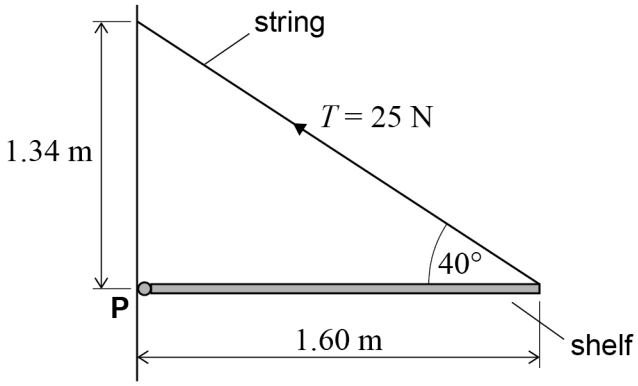
**1 5** The diagram shows a shelf, hinged at **P** and supported by a string.
The tension $T$ in the string is $25\ \text{N}$




What is the moment of $T$ about **P**?

**[1 mark]**

**A** $1.34 \times 25 \tan 40$

**B** $1.60 \times 25 \cos 40$

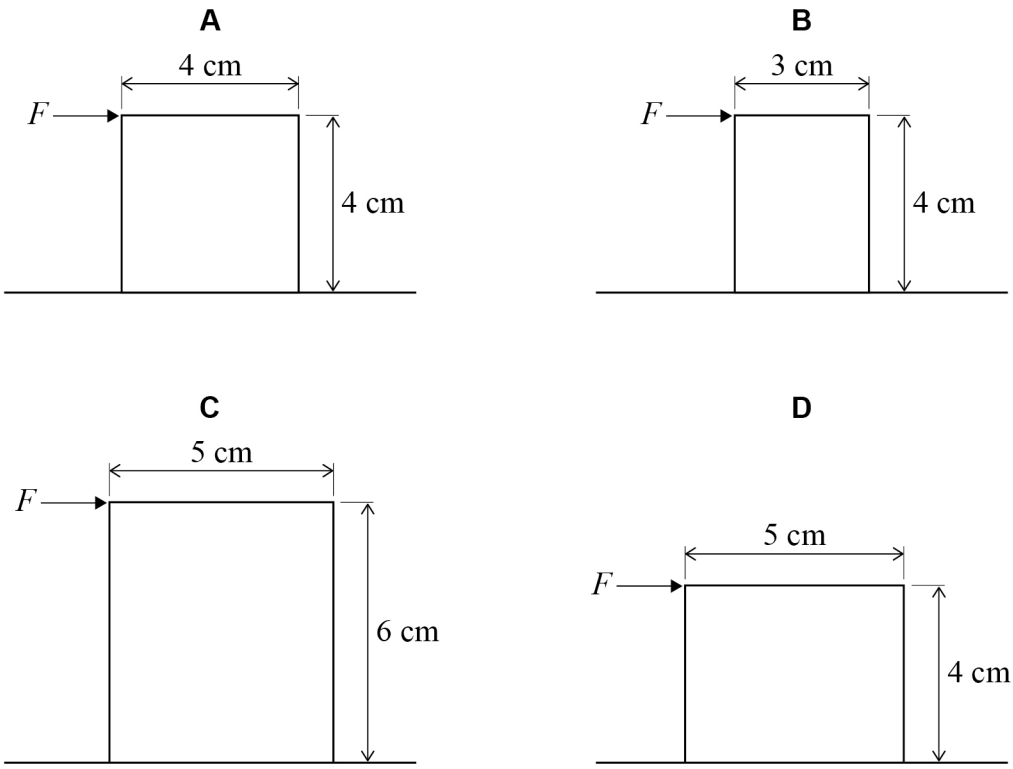
**C** $1.34 \times 25 \sin 40$

**D** $1.60 \times 25 \sin 40$

Do not write outside the box

**1 6** The solid objects below all have the same weight. Each object experiences a horizontal force on its top edge. None of the objects slide along the surface.

Which object requires the smallest force to cause it to move?




**[1 mark]**

**A** ⬭

**B** ⬭

**C** ⬭

**D** ⬭

**Turn over for the next question**

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**1 7** A moving train accelerates uniformly at $0.70\ \mathrm{m\ s^{-2}}$ up to a speed of $55\ \mathrm{m\ s^{-1}}$
The train travels $1875\ \mathrm{m}$ during this acceleration.

What are the average speed of the train and the time taken for the acceleration?

**[1 mark]**

| | Average speed of the train / $\mathrm{m\ s^{-1}}$ | Time taken / s | |
|---|---|---|---|
| **A** | 37.5 | 50 | ⬭ |
| **B** | 37.5 | 107 | ⬭ |
| **C** | 48.2 | 19 | ⬭ |
| **D** | 48.2 | 138 | ⬭ |

**1 8** Two spheres of equal mass, **P** and **Q**, are dropped and fall until reaching their terminal speeds.
**P** has a larger diameter than **Q**.

Which line describes the magnitudes of **Q**'s initial acceleration and terminal speed compared with those for **P**?

**[1 mark]**

| | Initial acceleration of Q | Terminal speed of Q | |
|---|---|---|---|
| **A** | less than for **P** | greater than for **P** | ⬭ |
| **B** | less than for **P** | same as for **P** | ⬭ |
| **C** | same as for **P** | same as for **P** | ⬭ |
| **D** | same as for **P** | greater than for **P** | ⬭ |

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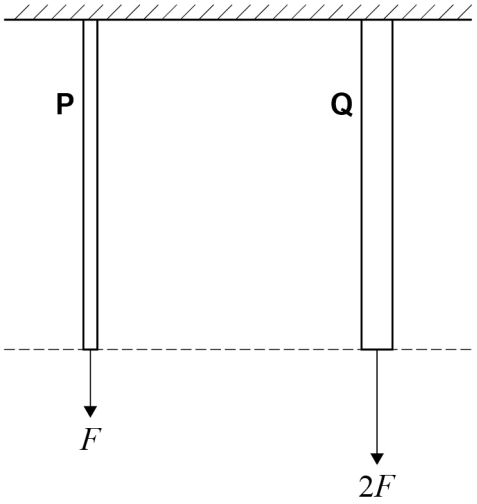
**1 9** Two wires, **P** and **Q**, have the same original length. They are stretched so that they have the same extensions.




The tensile force in **P** is $F$ and the tensile force in **Q** is $2F$.
**P** has a diameter $d$ and **Q** has a diameter $2d$.
**P** is made from a material of Young modulus $E$.

What is the Young modulus of the material from which **Q** is made?

**[1 mark]**

**A** $\frac{E}{4}$ ⬭

**B** $\frac{E}{2}$ ⬭

**C** $E$ ⬭

**D** $2E$ ⬭

**Turn over for the next question**

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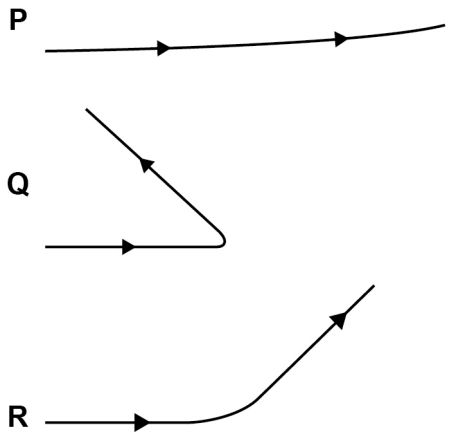
**2 0** **P**, **Q** and **R** are the paths of alpha particles in Rutherford's alpha-scattering experiment. All of the alpha particles have the same initial energy and the paths are drawn to the same scale.




Which row identifies the order of the paths starting with the smallest distance of closest approach and ending with the greatest distance of closest approach to the target nucleus?

**[1 mark]**

**A** P, Q, R

**B** Q, R, P

**C** Q, P, R

**D** R, P, Q

**2 1** What is the specific charge of an alpha particle relative to the specific charge of a proton?

**[1 mark]**

**A** $\frac{1}{4}$

**B** $\frac{1}{2}$

**C** 2

**D** 4

Do not write outside the box

**2 2** $^{207}$Pb can be formed from a series of decays beginning with $^{211}$Pb. Only alpha particles and beta particles are emitted in the series.

How many alpha and beta particles are emitted in the series?

**[1 mark]**

**A** 1 alpha particle and 1 beta particle

**B** 1 alpha particle and 2 beta particles

**C** 2 alpha particles and 1 beta particle

**D** 2 alpha particles and 2 beta particles

**2 3** A detector is placed 50 cm from a gamma source that has a half-life of 40 s
The corrected count rate is found to be 1400 count $s^{-1}$

What will be the corrected count rate 4.0 minutes later when the detector is 2.0 m from the gamma source?

**[1 mark]**

**A** 1.37 count $s^{-1}$

**B** 2.73 count $s^{-1}$

**C** 5.47 count $s^{-1}$

**D** 10.9 count $s^{-1}$

**2 4** What are the products of the radioactive decay of a free neutron?

**[1 mark]**

**A** an antineutron and two gamma rays

**B** a proton, an antiproton and an antineutrino

**C** a proton, an electron and an antineutrino

**D** a proton, a positron and a neutrino

Do not write outside the box

**2 5** Which statement about hazards from radioactive sources is **not** correct?

**[1 mark]**

**A** Exposure times should be minimised by keeping sources in lead boxes when not being used. ⬭

**B** A person cannot be contaminated from a sealed source of beta radiation if they are more than $1\ \mathrm{m}$ from the source. ⬭

**C** Radioactive sources are kept in lead boxes because alpha, beta and gamma radiation cannot penetrate lead. ⬭

**D** Radioactive sources should always be handled with tongs to prevent direct contamination of the skin. ⬭

**END OF QUESTIONS**

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**ANSWER IN THE SPACES PROVIDED**

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