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

Tuesday 7 May 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	
11–24	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 On one occasion, an electron and a positron are created by pair production when a high-energy photon interacts with the nucleus of an atom.

The rest energy of an electron is $0.51\ \text{MeV}$.

0 1 . 1 Show that the photon must have a minimum energy of approximately $1.6 \times 10^{-13}\ \text{J}$.

[1 mark]

0 1 . 2 On another occasion, an electron–positron pair is created by a photon with an energy of $2.1 \times 10^{-13}\ \text{J}$.

Deduce how energy is conserved on this occasion.

[2 marks]

3

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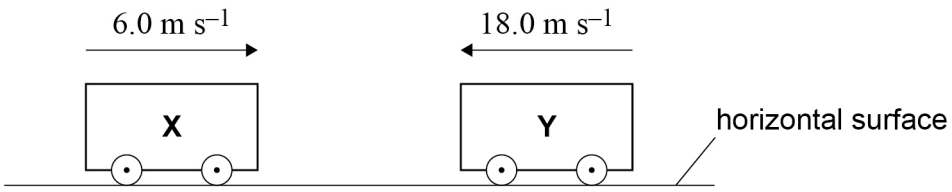
0 2 . 1 Explain why momentum is a vector quantity.

[1 mark]

0 2 . 2 **Figure 1** shows two trucks **X** and **Y** that are moving towards each other on a horizontal surface.

Figure 1



X has a mass of $4.8\ \text{kg}$ and is moving to the right at a speed of $6.0\ \text{m s}^{-1}$.
Y has a mass of $2.4\ \text{kg}$ and is moving to the left at a speed of $18.0\ \text{m s}^{-1}$.

The two trucks collide.

Show that truck **X** changes direction during the collision.

[3 marks]

4

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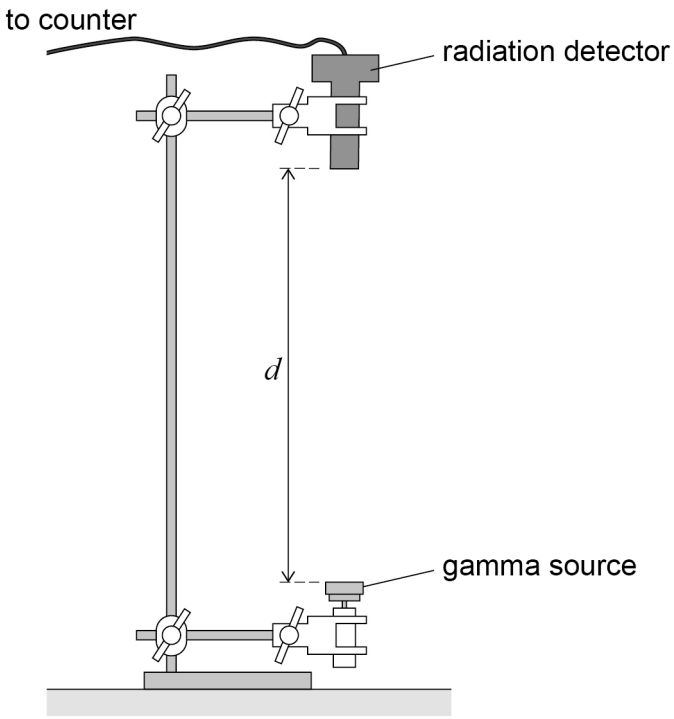
0 3 **Figure 2** shows the apparatus that a student uses to investigate the inverse-square law for gamma radiation. The student uses a source of gamma radiation together with a radiation detector to determine the count rate.

Figure 2



The student uses a ruler to measure the vertical distance d between the **top** of the gamma source and the **bottom** of the radiation detector.

0 3 . 1 Explain how measuring d as shown in **Figure 2** introduces a systematic error.

[2 marks]

Do not write outside the box

0 3 . 2 Describe the steps needed to make the determination of the count rate accurate.

[2 marks]

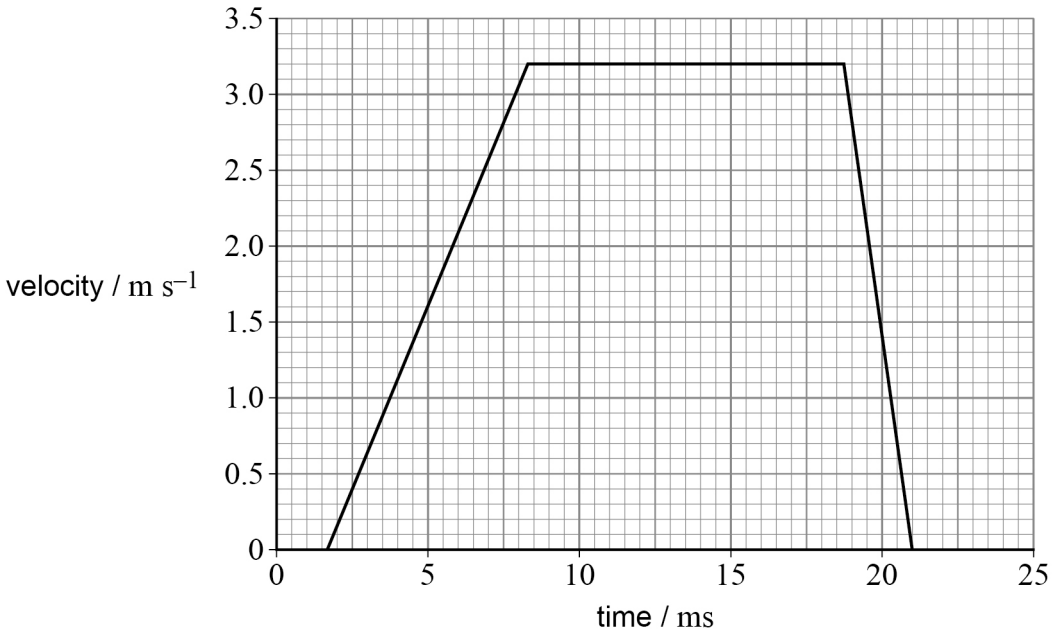
4

Turn over for the next question

Do not write outside the box

0 4 **Figure 3** is a velocity−time graph for an object travelling in a straight line.

Figure 3



0 4 . 1 Determine the average speed of the object during the time it is moving.

[3 marks]

speed = _____ m s^{-1}

0 4 . 2 The mass of the object is 0.54 kg.

Determine the magnitude of the resultant force required to bring the object to rest.

[2 marks]

magnitude of resultant force = _____ N

5

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0 5 A solution containing a nuclide of technetium-99m is prepared for use in medical diagnosis.

An isotope of molybdenum (Mo) undergoes beta-minus decay to produce a nucleus of technetium-99m (Tc-99m).

0 5 . 1 Complete the decay equation.

[2 marks]

$$\underline{\quad}^{\quad}_{42}\mathrm{Mo} \rightarrow \underline{\quad}^{99\mathrm{m}}\mathrm{Tc} + \underline{\quad}^{\quad}\beta^{-} + \underline{\quad}$$

0 5 . 2 Technetium-99m is metastable.

Explain what is meant by metastable.

[2 marks]

0 5 . 3 The half-life of technetium-99m is 6.0 hours.

A sample of technetium-99m has an initial activity of 384 MBq.

Calculate the time taken for the activity of the sample to decrease to 1.50 MBq.

[2 marks]

time taken = _____ hours

Question 5 continues on the next page

Turn over ►

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0 5 . 4 A patient is injected with the solution containing technetium-$99\mathrm{m}$ and the radiation is detected outside of the body.

Explain why technetium-$99\mathrm{m}$ is an appropriate nuclide for use in medical diagnosis.

[2 marks]

8

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0 6 . 1 State the **two** conditions for a body to be in equilibrium.

[2 marks]

1 _____

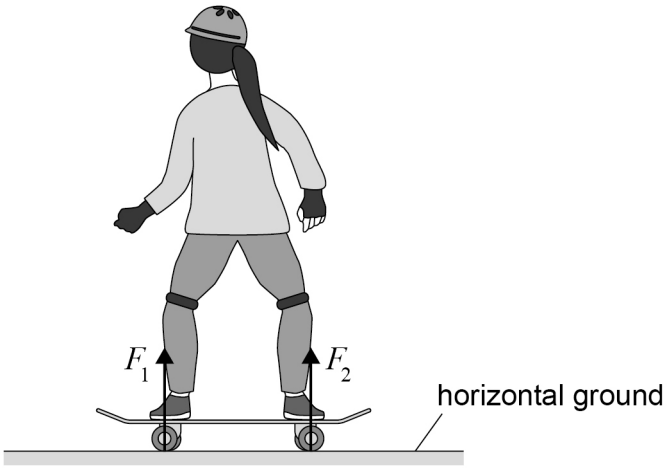
_____

2 _____

_____

Figure 4 shows a child on a skateboard. The skateboard is in equilibrium.
The centre of mass of the skateboard is at its midpoint.

Figure 4



0 6 . 2 F_1 and F_2 are the normal reaction forces of the ground acting on the skateboard.
The weight of the child is $360\ \text{N}$.
The mass of the skateboard is $4.8\ \text{kg}$.
The centre of mass of the child is directly above the centre of mass of the skateboard.

Calculate F_1.

[2 marks]

$F_1 =$ _____ N

Question 6 continues on the next page

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0 6 . 3 The child now changes her position so that the skateboard is balanced on a horizontal bar at **P** as shown in **Figure 5**.

The skateboard is again in equilibrium.

Figure 5

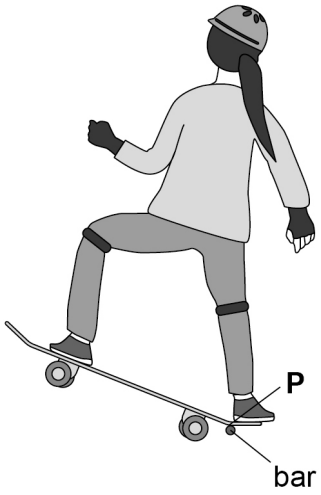
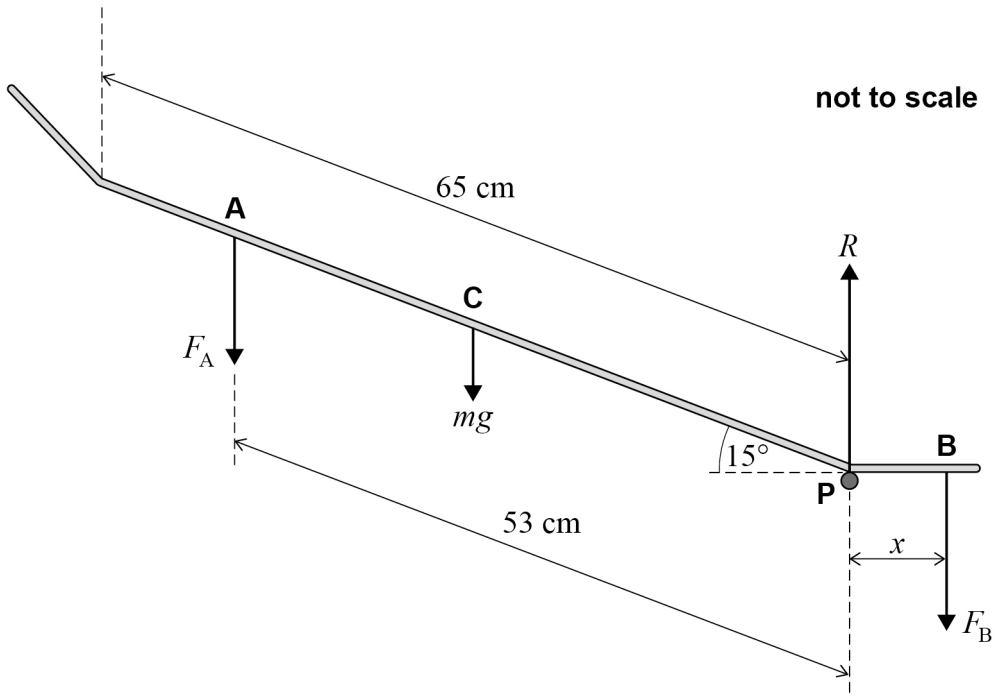


Figure 6 shows the forces acting on the skateboard and the important distances.
The bar at **P** exerts a vertical force R on the skateboard.
The skateboard is at an angle of $15°$ to the horizontal.

Figure 6



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The child's left foot exerts a vertical force F_A at **A**.
Her right foot exerts a vertical force F_B at **B**.

$F_B = 11F_A$

B is a horizontal distance x from **P**.

Calculate x.

[4 marks]

$x =$ _____ cm

8

Turn over ►

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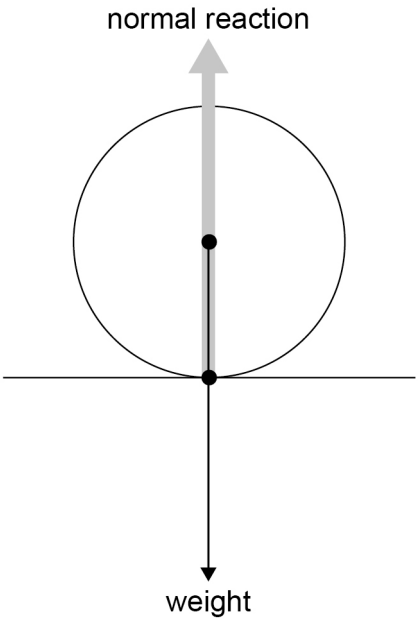
0 7 **Figure 7** shows the two forces acting on the wheel of a stationary racing car that is standing on a horizontal surface.

Figure 7



0 7 . 1 The two forces in **Figure 7** are equal in magnitude and act in opposite directions.

Give **one** reason why the two forces are not an action–reaction pair according to Newton's third law.

[1 mark]

Do not write outside the box

During a race, the racing car enters a straight horizontal section of the track and accelerates. The driving force of the racing car is constant.

0 7 . 2 Explain why the racing car reaches a constant speed.
Refer to one of Newton's laws of motion in your answer.

[3 marks]

0 7 . 3 The racing car is fitted with a system that helps it to overtake another car.

When the system is not in use, as shown in **Figure 8**, the flaps are positioned so that there is no gap between them.
When the system is in use, as shown in **Figure 9**, the flaps rotate so that there is an air gap between them.

Figure 8

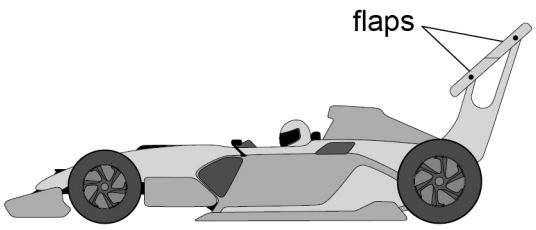
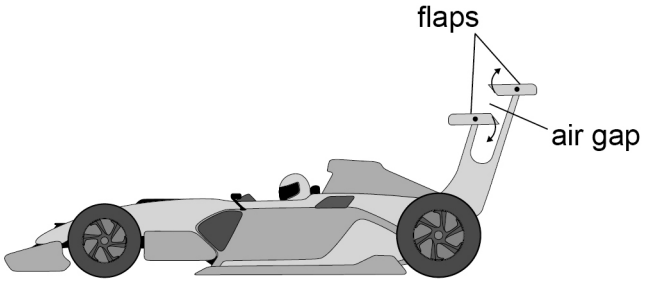


Figure 9



Explain why using the system enables the racing car to overtake the other car.

[2 marks]

6

Turn over ►

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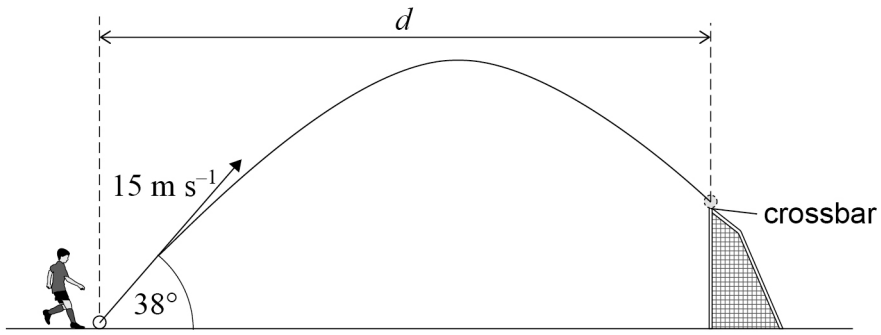
0 8 **Figure 10** shows a football player kicking a football. The initial velocity of the ball is $15\ \text{m s}^{-1}$ at an angle of $38°$ to the horizontal.

The bottom of the ball hits the top of the crossbar.
Assume that air resistance is negligible.

Figure 10



0 8 . 1 Calculate the vertical component of the initial velocity of the ball.

[1 mark]

vertical component of initial velocity = _____ m s^{-1}

0 8 . 2 Show that the maximum height gained by the ball is approximately $4.3\ \text{m}$.

[2 marks]

maximum height = _____ m

Do not write outside the box

0 8 . 3 Show that the time between the ball being kicked and it reaching its maximum height is approximately 0.94 s.

[2 marks]

0 8 . 4 The top of the crossbar is at a height of 2.56 m.

Calculate the time between the ball being kicked and it hitting the crossbar.

[3 marks]

time = _____ s

Question 8 continues on the next page

Do not write outside the box

0 8 . 5 The ball travels a horizontal distance d before hitting the crossbar.

Calculate d.

[2 marks]

$d =$ _____ m

0 8 . 6 To calculate d, it was assumed that air resistance was negligible.

Describe the effect that air resistance will have on the flight of the ball.

[2 marks]

_____

_____

_____

_____

_____

_____

12

END OF SECTION A

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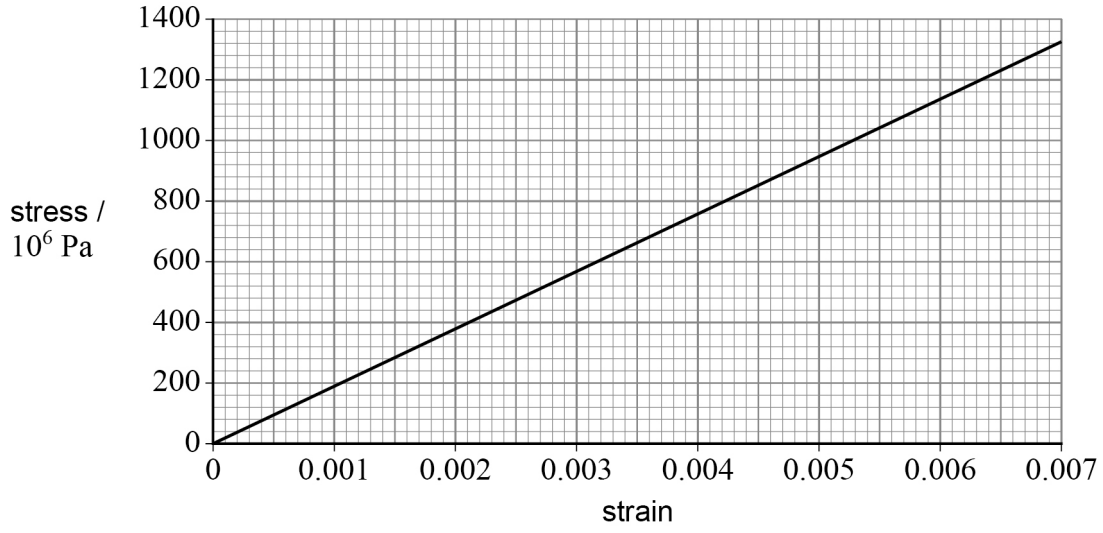
Section B

Answer **all** questions in this section.

0 9 **Figure 11** shows the variation of stress with strain for a type of steel.

Figure 11



0 9 . 1 Show that the Young modulus of the steel is approximately 200 GPa.

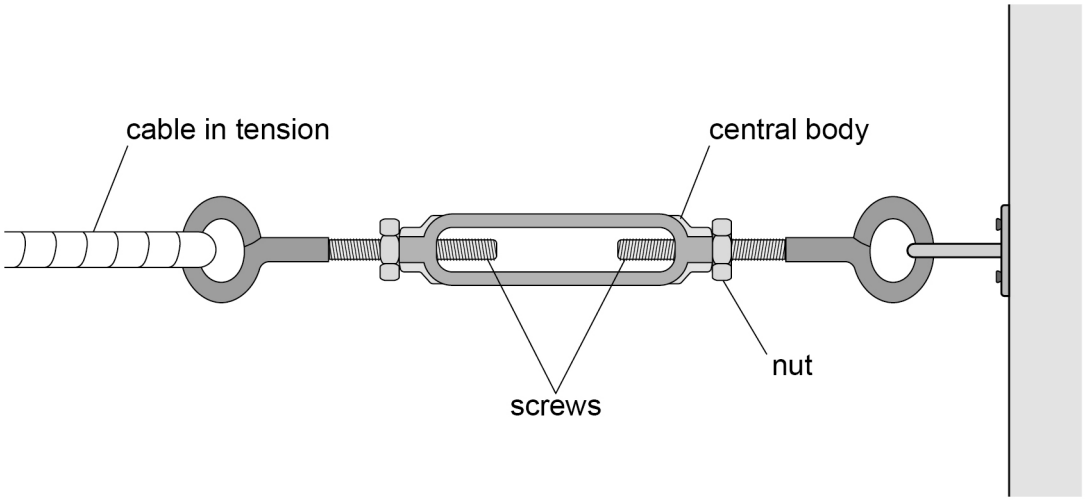
[1 mark]

Question 9 continues on the next page

A length of steel cable is attached to a wall using a device called a turnbuckle. The other end of the cable is also fixed.

Figure 12 shows the turnbuckle.

Figure 12



The turnbuckle is used to adjust the tension in the cable. As the central body is rotated, the separation of the screws changes. This change depends on the direction of rotation and the amount of rotation of the central body.

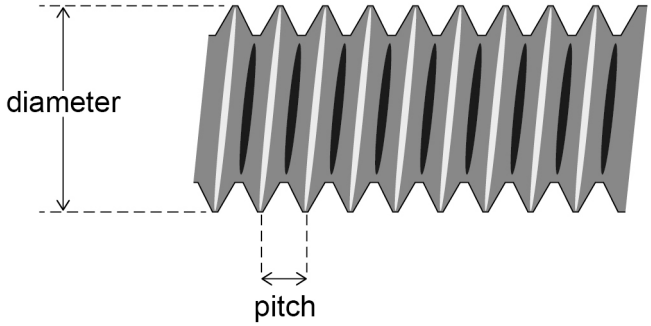
0 9 . 2 State and explain what must be done to the turnbuckle to increase the tension in the cable.

[1 mark]

Do not write outside the box

Figure 13 shows a section of one screw from the turnbuckle.
With one complete rotation of the central body, both screws move through a distance of one pitch relative to the central body.

Figure 13



Both screws have the same diameter and the same pitch.

The diameter of each screw is $14\ \text{mm}$.

0 9 . 3 For one complete rotation of the central body, the extension of the cable is $1.3\ \text{mm}$.

Determine the ratio $\frac{\text{diameter}}{\text{pitch}}$.

[1 mark]

$$\frac{\text{diameter}}{\text{pitch}} = \underline{\qquad\qquad}$$

The cable is initially under tension with a stress of $210\ \text{MPa}$. The unstretched length of the cable is $1.8\ \text{m}$.

0 9 . 4 Determine, using **Figure 11**, the initial strain in the cable.

[1 mark]

$$\text{strain} = \underline{\qquad\qquad}$$

Question 9 continues on the next page

Do not write outside the box

The central body is now turned through eight complete rotations.

0 9 . 5 Calculate the new strain in the cable.

[2 marks]

strain = _____

0 9 . 6 The cross-sectional area of the cable is $3.7 \times 10^{-5}\ \text{m}^2$.

Calculate the new tension in the cable.

[3 marks]

tension = _____ N

9

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

1 0 A student investigates the friction on a block that slides across a horizontal surface.

The student places the block onto the surface as shown in **Figure 14**.
The student compresses the spring by moving the block a distance x to the left, as shown in **Figure 15**.
When the student releases the block, it accelerates across the surface. Friction then causes the block to decelerate and come to rest as shown in **Figure 16**.

Figure 14

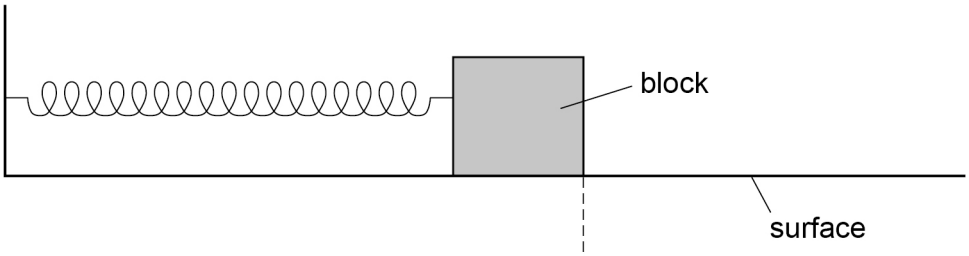


Figure 15

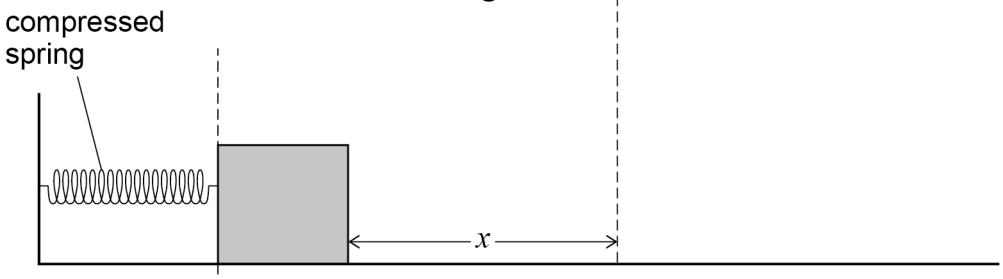
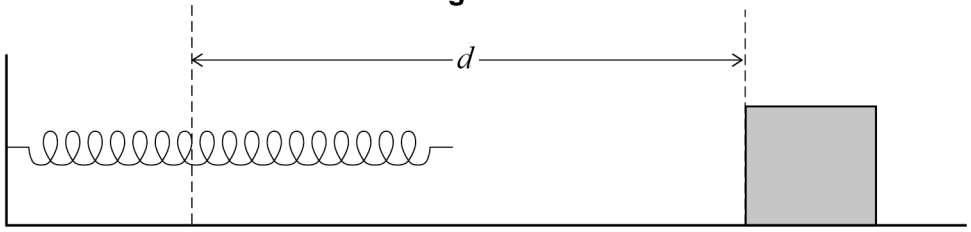


Figure 16



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The student makes repeated measurements of distance d.

Table 1 shows the recorded values of d for one particular value of x.

Table 1

d / mm	79	82	81	79	80

1 0 . 1 Calculate the percentage uncertainty in the mean value of d.

[2 marks]

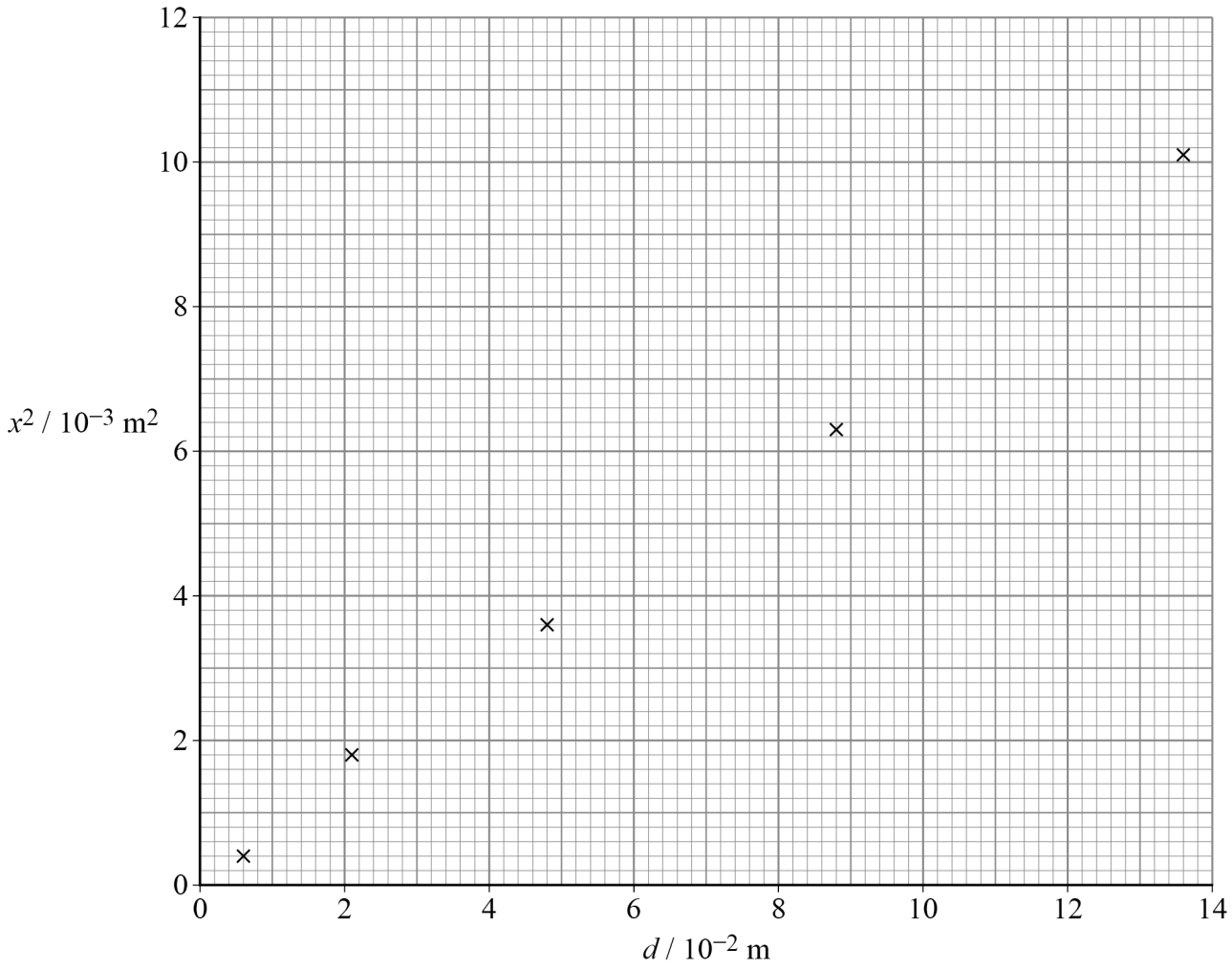
percentage uncertainty = _____

Question 10 continues on the next page

The student determines mean values of d for a range of values of x.

Figure 17 shows the student's plot of x^2 against d.

Figure 17



1 0 . 2 Draw a best-fit line on **Figure 17**.

[1 mark]

Do not write outside the box

The frictional force F between the surface and the block is related to the weight W of the block by the equation

$$F = \mu W$$

where μ is a constant.

The elastic potential energy E in the compressed spring is given by

$$E = \frac{1}{2}kx^2$$

where k is the spring constant of the spring.

1 0 . 3 Show that $x^2 = \dfrac{2\mu mgd}{k}$

where m is the mass of the block.

[1 mark]

1 0 . 4 Determine μ using **Figure 17**.

$k = 60 \text{ N m}^{-1}$
$m = 0.75 \text{ kg}$

[3 marks]

$\mu =$ _____

7

END OF SECTION B

Turn over ►

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 An object of mass m falls from rest through a vertical distance s, reaching a velocity v.

The work done by air resistance during this fall is:

[1 mark]

A $m(gs - \frac{v^2}{2})$ ⬭

B $mgs + \frac{v^2}{2}$ ⬭

C $m(\frac{v^2}{2} - gs)$ ⬭

D $mgs - \frac{v^2}{2}$ ⬭

Do not write outside the box

1 2 A nucleus of $^{170}_{74}\mathrm{W}$ decays by alpha emission to form nuclide **X**.

What is the specific charge of the nucleus of **X**?

[1 mark]

A $2.21 \times 10^{7}\ \mathrm{C\ kg^{-1}}$ ⬭

B $3.99 \times 10^{7}\ \mathrm{C\ kg^{-1}}$ ⬭

C $4.18 \times 10^{7}\ \mathrm{C\ kg^{-1}}$ ⬭

D $4.23 \times 10^{7}\ \mathrm{C\ kg^{-1}}$ ⬭

1 3 A rocket of mass m moves upwards with an acceleration a. It experiences a drag force D.

The thrust of the rocket is:

[1 mark]

A $m(a-g)-D$ ⬭

B $m(a+g)-D$ ⬭

C $m(a-g)+D$ ⬭

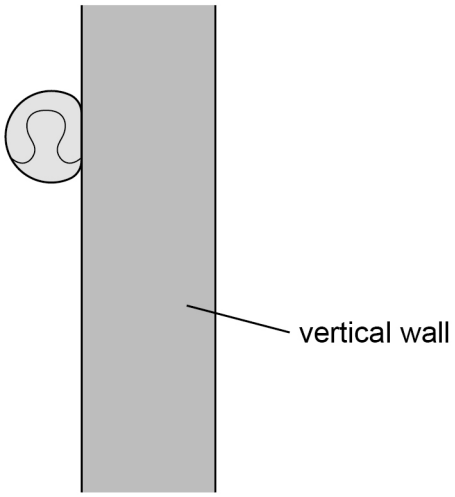
D $m(a+g)+D$ ⬭

Turn over for the next question

Do not write outside the box

1 4 A ball is travelling horizontally when it hits a vertical wall. The ball compresses when it hits the wall.

side view



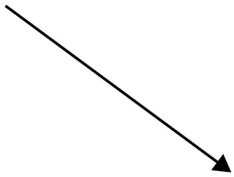
What is the direction of the resultant force acting on the ball when the compression is at a maximum?

[1 mark]

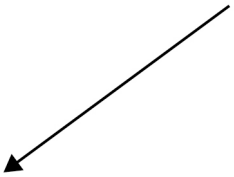
A

B

C



D



A ⬭

B ⬭

C ⬭

D ⬭

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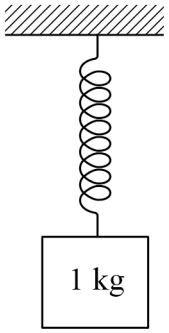
1 5 Arrangements of springs are used to suspend different masses.
All the springs are identical.

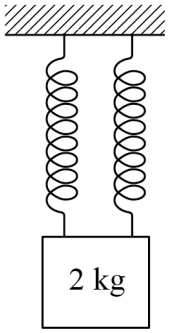
Which arrangement of springs has the greatest extension?

[1 mark]

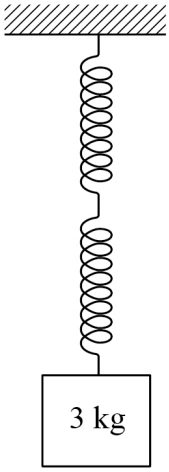
A



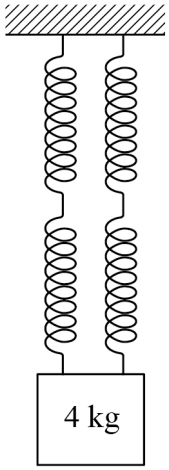
B



C



D



A ⬭

B ⬭

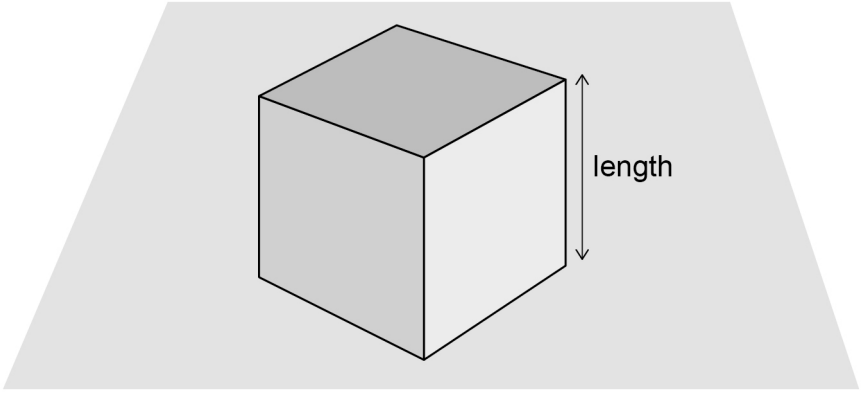
C ⬭

D ⬭

Turn over ►

Do not write outside the box

1 6 A cube is resting on a surface.



A student makes the following measurements:

weight = 0.50 ± 0.01 N
length = 0.025 ± 0.001 m

The student calculates the pressure applied to the bottom of the block to be $800\ \text{N m}^{-2}$.

What is the percentage uncertainty in the calculated value of pressure?

[1 mark]

A 2% ⬭

B 4% ⬭

C 6% ⬭

D 10% ⬭

Do not write outside the box

1 7 A spacecraft of constant mass is initially at rest.
A constant resultant force F acts on the spacecraft.
The change in momentum of the spacecraft is Δp.
The change in kinetic energy of the spacecraft is ΔE_k.

Which row shows the relationship between Δp and F and between ΔE_k and F?

[1 mark]

A	$\Delta p \propto F$	$\Delta E_k \propto F$	⬭
B	$\Delta p \propto F$	$\Delta E_k \propto F^2$	⬭
C	$\Delta p \propto F^2$	$\Delta E_k \propto F$	⬭
D	$\Delta p \propto F^2$	$\Delta E_k \propto F^2$	⬭

1 8 Nuclide **X** is radioactive.

Which decay series produces an isotope of nuclide **X**?

[1 mark]

A α, β^+, β^+ ⬭

B α, β^-, β^- ⬭

C $\alpha, \alpha, \beta^+, \beta^+$ ⬭

D $\alpha, \alpha, \beta^-, \beta^-$ ⬭

Turn over for the next question

Do not write outside the box

1 9 A car is being driven at a speed of $13.8\ \text{m s}^{-1}$.

The driver takes a time of $0.72\ \text{s}$ to react to a hazard and apply the brakes.

The brakes cause a deceleration of $6.9\ \text{m s}^{-2}$ which brings the car to rest.

What is the total distance travelled by the car from the point at which the driver sees the hazard?

[1 mark]

A $10\ \text{m}$ ⬭

B $14\ \text{m}$ ⬭

C $24\ \text{m}$ ⬭

D $38\ \text{m}$ ⬭

2 0 What is the unit of power in SI fundamental (base) units?

[1 mark]

A kg m s^{-1} ⬭

B kg m s^{-2} ⬭

C $\text{kg m}^2\ \text{s}^{-2}$ ⬭

D $\text{kg m}^2\ \text{s}^{-3}$ ⬭

2 1 A car of mass $1200\ \text{kg}$ is travelling up a slope with an incline of $15°$.
The car travels at a constant velocity of $20\ \text{m s}^{-1}$.
The motor provides a constant power output of $150\ \text{kW}$.

What is the magnitude of the resistive forces acting on the car?

[1 mark]

A $3000\ \text{N}$ ⬭

B $3900\ \text{N}$ ⬭

C $4500\ \text{N}$ ⬭

D $11\ 000\ \text{N}$ ⬭

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2 2 What was observed in the Rutherford scattering experiment?

[1 mark]

A Few of the alpha particles passed through the gold foil undeflected. ⬭

B Most alpha particles were deflected through a small angle. ⬭

C Very few of the alpha particles were deflected through a large angle. ⬭

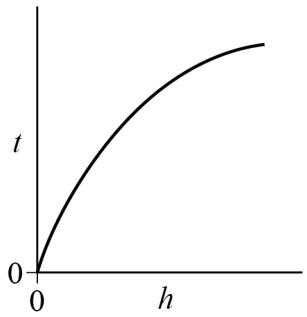
D About half of the particles were deflected through angles between $0°$ and $90°$. ⬭

2 3 An object is released from rest from height h above the ground.
The object takes a time t to reach the ground.

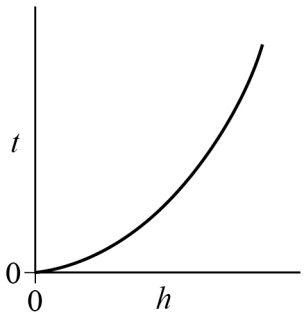
Which graph shows the variation of t with h?

[1 mark]

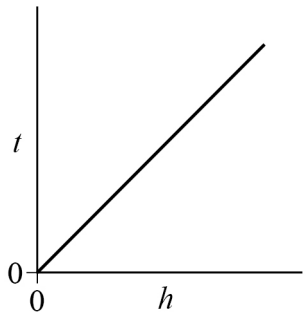
A



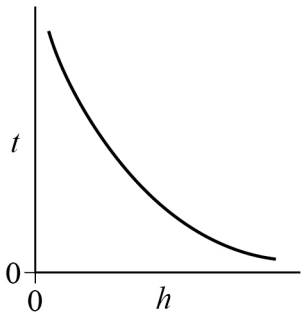
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Turn over ►

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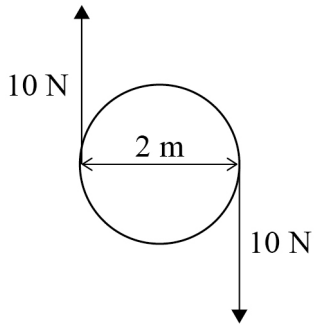
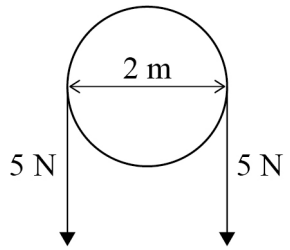
2 4 Which diagram shows a couple with a moment of $20\ \text{N m}$?

[1 mark]

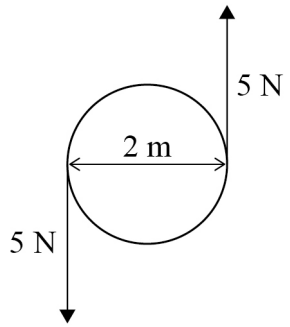
A



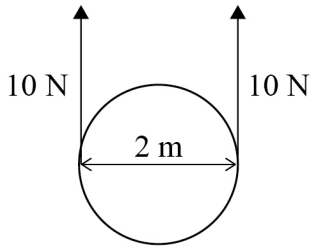
B



C



D



14

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