OXFORD
INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

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

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Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS
PHYSICS

Unit 1 Mechanics, materials and atoms

Wednesday 4 January 2023 07:00 GMT Time allowed: 2 hours

Materials

For this paper you must have:
- a Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate
- a protractor.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11–24	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 . 1 Distinguish between a vector quantity and a scalar quantity.

[1 mark]

0 1 . 2 State **one** example of a vector quantity and **one** example of a scalar quantity.

[1 mark]

vector quantity _____

scalar quantity _____

2

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0 2 . 1 Electrons and positrons each have a rest energy of $0.511\ \text{MeV}$.

State what is meant by rest energy.

[1 mark]

0 2 . 2 **Figure 1** shows an electron and a positron travelling towards each other just before they collide.

Figure 1

Each particle has a kinetic energy of $0.340\ \text{MeV}$ at the point of collision.

Describe, with reference to the energies involved, the outcome of the collision.

[3 marks]

4

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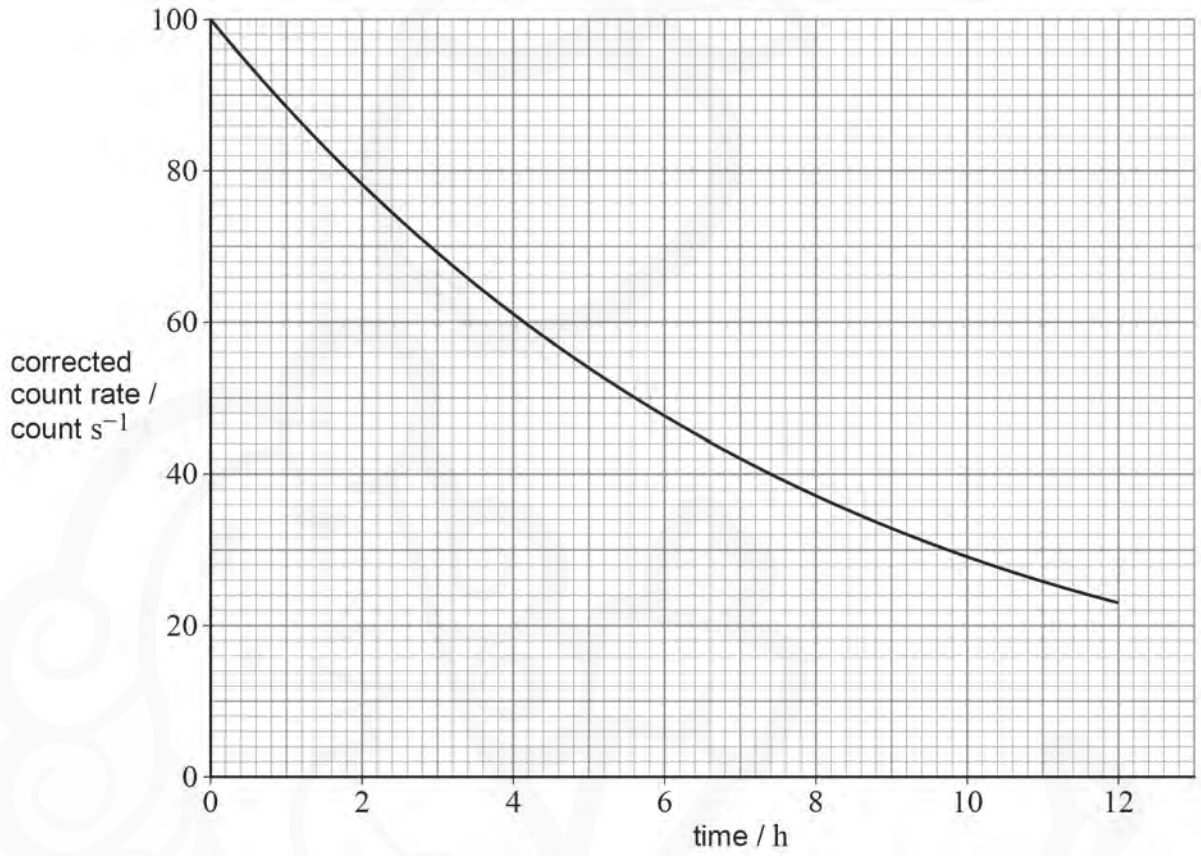
0 3 A counter is placed near to a radioactive source and the count rate is measured regularly over a 12-hour period.

Figure 2 shows the variation of corrected count rate with time.

Figure 2



0 3 . 1 State what is meant by corrected count rate.

[1 mark]

Do not write outside the box

0 3 . 2 Determine, using **Figure 2**, an accurate value for the half-life of the decay from the source.

[2 marks]

half-life = _____ h

3

Turn over for the next question

Do not write outside the box

0 4 In the Rutherford scattering experiment, alpha particles were directed at a thin gold foil.

0 4 . 1 Explain why the experiment was performed in a vacuum.

[1 mark]

0 4 . 2 State how the experimenters detected the alpha particles.

[1 mark]

0 4 . 3 Describe the measurements that were made in the Rutherford scattering experiment.

[1 mark]

3

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0 5 A beta-minus (β^-) particle is emitted when a nucleus of strontium-90 $\left(^{90}_{38}\mathrm{Sr}\right)$ decays into a nucleus of yttrium (Y).

0 5 . 1 Explain the origin of the β^- particle.

[2 marks]

0 5 . 2 State the values of A and Z for the yttrium nucleus.

[1 mark]

$A =$ _____

$Z =$ _____

0 5 . 3 In early studies of beta decay, the kinetic energies of the β^- particles were measured.

Explain how these measurements improved our understanding of what happens in beta decay.

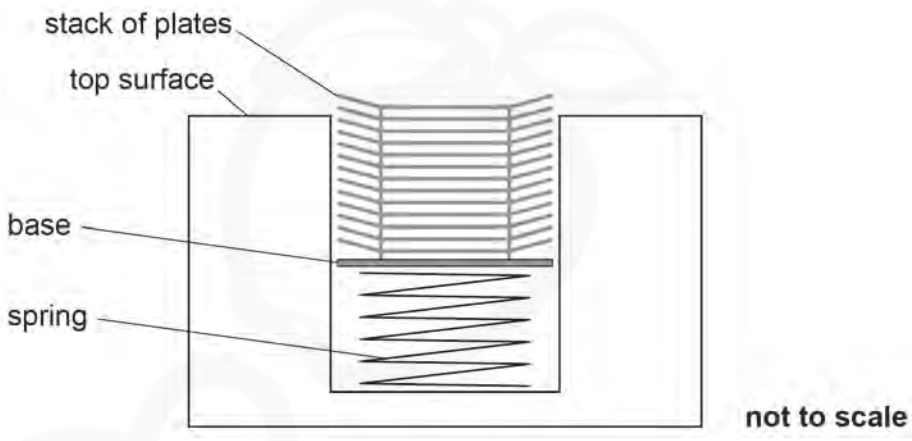
[2 marks]

5

Turn over ►

0 6 **Figure 3** shows a stack of plates in a plate holder used in a hotel kitchen. The stack of 13 plates is supported by a spring. The spring is compressed by 16.7 cm when there are 13 plates in the stack.

Figure 3



Each plate has a mass of 0.61 kg.
The spring obeys Hooke's law when supporting 13 plates.
The masses of the base and the spring are negligible.

0 6 . 1 Calculate the stiffness of the spring.

[3 marks]

stiffness = _____ $N\ m^{-1}$

Do not write outside the box

0 6 . 2 Calculate the energy stored in the spring when there are 13 plates in the holder.

[2 marks]

energy = _____ J

0 6 . 3 When a plate is added, the spring compresses so that the base moves downwards by a distance equivalent to the thickness of one plate. This ensures that the top plate is always just above the top surface of the holder.

Over time, the spring becomes weaker and its stiffness decreases.

Explain how the behaviour of the plate holder will be affected by the decrease in the stiffness of the spring.

[2 marks]

_____

_____

_____

_____

_____

7

Turn over for the next question

Do not write outside the box

0 7 A falcon is a bird of prey that catches other small birds in flight.
The falcon dives to increase its speed. Its gravitational potential energy decreases by 1900 J during the dive.

The mass of the falcon is 1.1 kg.

0 7 . 1 Calculate the vertical distance moved by the falcon as it dives.

[2 marks]

vertical distance = _____ m

0 7 . 2 The initial vertical speed of the falcon is 25 m s^{-1}.
During the dive, the falcon's wings apply a vertical force downwards, transferring 1400 J of work.

Calculate the maximum theoretical speed that the falcon could achieve in this dive.

[3 marks]

maximum speed = _____ m s^{-1}

0 7 . 3 In practice, the falcon will need to transfer more than 1400 J of work to achieve this maximum theoretical speed.

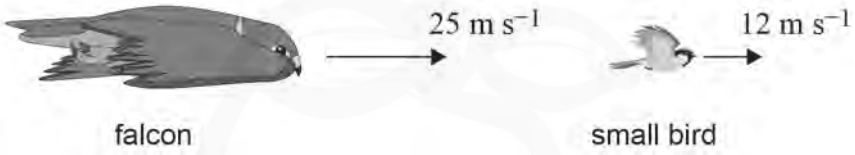
Explain why.

[2 marks]

Do not write outside the box

On another occasion, the falcon catches a small bird while gliding horizontally.
Figure 4 shows the falcon and the small bird gliding horizontally in the same direction at different constant speeds.

Figure 4



The falcon collides with the small bird and grips it tightly.
The mass of the small bird is $0.18\ \text{kg}$.
The initial speed of the falcon is $25\ \text{m s}^{-1}$.
The initial speed of the small bird is $12\ \text{m s}^{-1}$.

0 7 . 4 State the law of conservation of momentum.

[1 mark]

0 7 . 5 Calculate the speed of the falcon immediately after this collision.

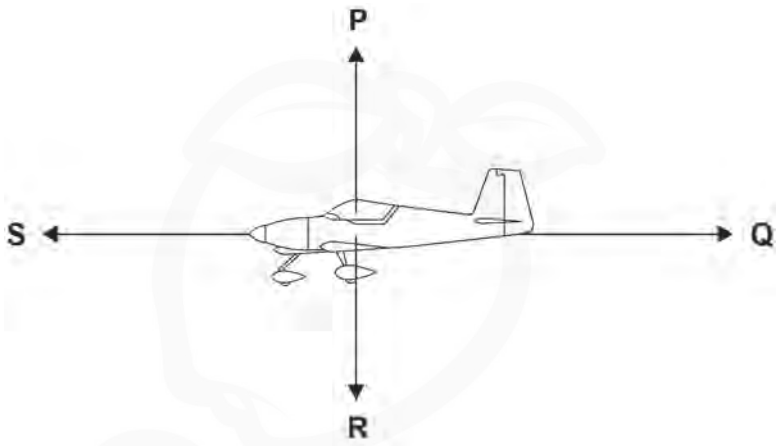
[3 marks]

speed = _____ m s^{-1}

11

0 8 **Figure 5** shows an aircraft that is initially in level flight at a constant velocity.

Figure 5



0 8 . 1 Identify the forces **P**, **Q**, **R** and **S** acting on the aircraft.

[2 marks]

P _____

Q _____

R _____

S _____

0 8 . 2 Force **S** is increased to a new constant value.

State and explain any change in the horizontal and vertical motion of the aircraft due to the increase in **S**.

[3 marks]

_____

_____

_____

_____

_____

_____

_____

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On another occasion, the aircraft is flying horizontally when force **P** is increased to $9.87\ \text{kN}$.

The aircraft climbs with constant vertical acceleration.

The weight of the aircraft is $9.60\ \text{kN}$.

0 8 . 3 Show that the vertical acceleration of the aircraft is approximately $0.28\ \text{m s}^{-2}$.

[4 marks]

0 8 . 4 The aircraft climbs with this constant acceleration through a vertical distance of $500\ \text{m}$.

Show that the magnitude of the vertical component of the velocity of the aircraft at the end of the climb is approximately $17\ \text{m s}^{-1}$.

[2 marks]

Question 8 continues on the next page

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0 8 . 5 During the climb, the aircraft has a constant horizontal component of velocity of 70 m s^{-1}.

Calculate the aircraft's resultant velocity at the end of the climb.

[4 marks]

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

angle of the resultant velocity to the horizontal = _____ °

15

END OF SECTION A

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Turn over for Section B

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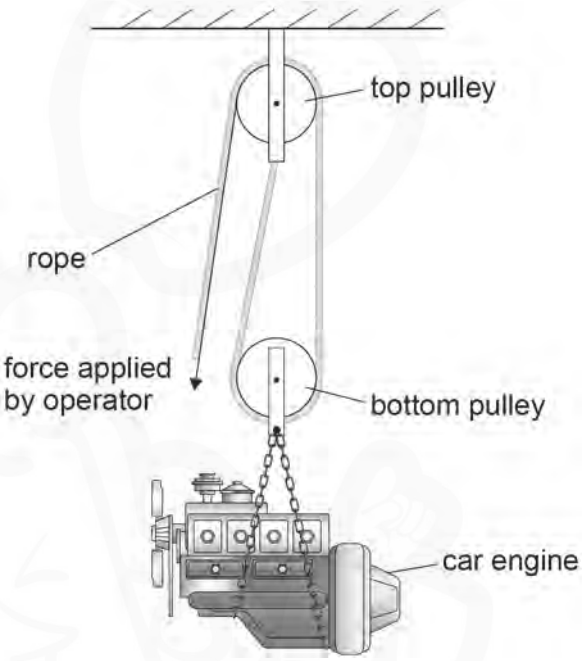
Section B

Answer **all** questions in this section.

0 9 **Figure 6** shows a system of frictionless pulleys used to lift a car engine.

Figure 6



A single light rope is threaded around the top pulley and the bottom pulley. The operator applies a force to the free end of the rope. The bottom pulley and the car engine move upwards at a constant speed.

The engine has a mass of 140 kg.
The force applied by the operator is 720 N.
The engine moves vertically upwards by 1.2 m.
The extension of the rope is negligible compared with the distance moved by the engine.

0 9 . 1 Show that the work done by the operator is approximately 1700 J.

[2 marks]

Do not write outside the box

0 9 . 2 Calculate the efficiency of the pulley system.

[2 marks]

efficiency = _____

0 9 . 3 Deduce the weight of the bottom pulley.

[2 marks]

weight = _____ N

0 9 . 4 The engine is now held in a fixed position.
The tension in the whole rope is 720 N.
The rope is made from a material with a Young modulus of 1.8×10^9 Pa.
The rope's cross-sectional area is 1.5×10^{-4} m^2.
The unstretched length of the rope is 8.50 m.

Calculate the extension of the rope when the engine is held in the fixed position.

[2 marks]

extension = _____ m

8

Turn over ►

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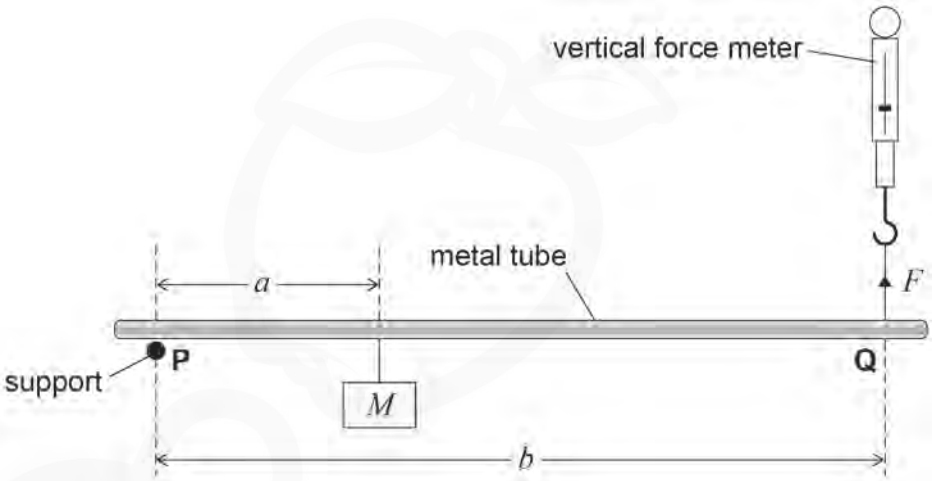
1 0 The apparatus in **Figure 7** is used to determine the mass M of a load, using the principle of moments.

Figure 7



A uniform metal tube of weight w is kept horizontal by a support at **P** and by a vertical force F applied by a force meter at **Q**.
P and **Q** are the same distance from their respective ends of the metal tube.
A load of mass M is suspended from the metal tube at a distance a from **P**.
The distance between **P** and **Q** is b.

The distance a is varied over the range $0.100\ \text{m}$ to $0.700\ \text{m}$.
The force F needed to keep the metal tube horizontal is measured for each value of a.
Throughout the experiment $b = 0.800\ \text{m}$.

1 0 . 1 Show, by taking moments about **P**, that

$$F = \frac{Mg}{b}a + \frac{w}{2}$$

[1 mark]

Question 10 continues on the next page

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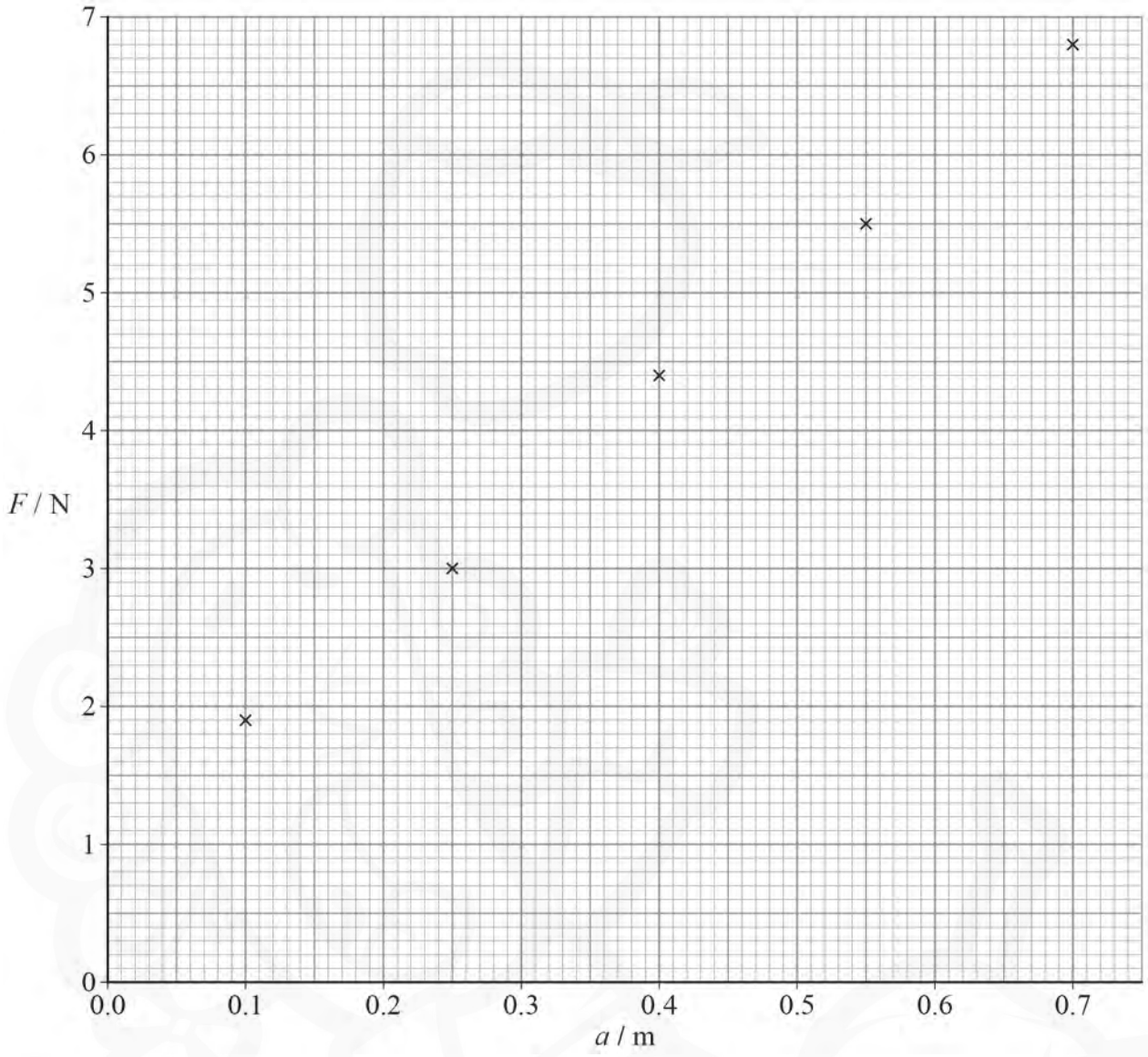
Figure 8 is a plot of F against a.

Figure 8



1 0 . 2 Draw a best-fit line on **Figure 8**.

[1 mark]

Do not write outside the box

10.3 Determine M.

[3 marks]

M = _____ kg

10.4 The force meter has a zero error.

Determine, using **Figure 8**, a value for the zero error.

$w = 2.6$ N

[2 marks]

zero error = _____ N

10.5 Explain whether the zero error on the force meter has an effect on the value of M calculated in Question **10.3**.

[1 mark]

_____

_____

_____

8

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 1 A value for g is $9.81\ \text{m s}^{-2}$.

What is the uncertainty suggested by this value?

[1 mark]

A 1% ⬭

B 0.5% ⬭

C 0.1% ⬭

D 0.01% ⬭

1 2 Which is in equilibrium?

[1 mark]

A a car moving round a bend at constant speed ⬭

B a rocket moving vertically with constant acceleration ⬭

C a ball falling vertically at terminal speed ⬭

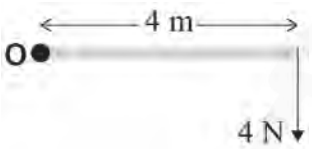
D a train moving horizontally with constant acceleration ⬭

Do not write outside the box

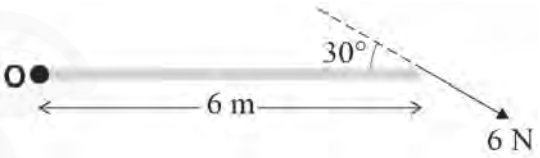
1 3 In which diagram is the moment of the force about **O** the greatest?

[1 mark]

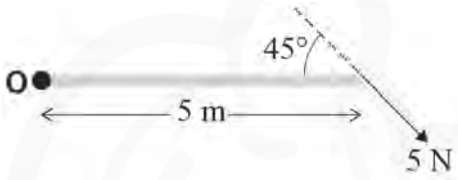
A



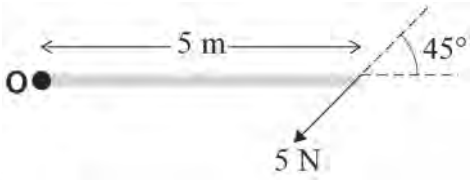
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

1 4 Which row gives the fundamental (base) unit for the quantity indicated?

[1 mark]

	Quantity	Fundamental (base) unit	
A	energy	kg m s^{-2}	⬭
B	force	kg m s^{-1}	⬭
C	moment	$\text{kg m}^2\text{ s}^{-2}$	⬭
D	momentum	$\text{kg m}^2\text{ s}^{-2}$	⬭

Turn over ►

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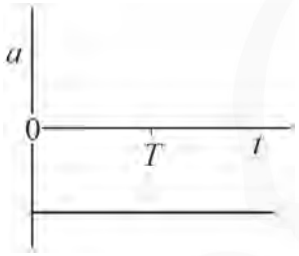
1 5 A ball is thrown vertically upwards. It reaches its maximum height at time T and then falls. Air resistance is negligible.

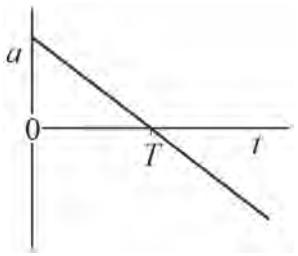
Which graph shows the variation of the acceleration a of the ball with time t?

[1 mark]

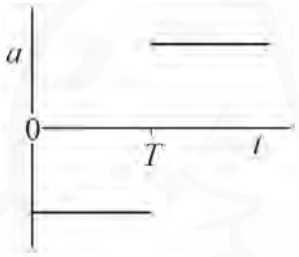
A



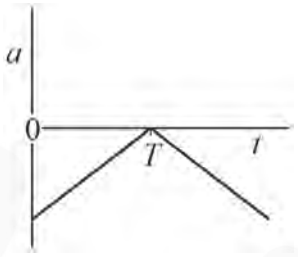
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

1 6 Which is correct?

[1 mark]

A The area under a distance–time graph is equivalent to speed. ⬭

B The area under a speed–time graph is equivalent to acceleration. ⬭

C The gradient of a speed–time graph is equivalent to distance. ⬭

D The gradient of a distance–time graph is equivalent to speed. ⬭

1 7 A ball is dropped from the fifth floor of a building.

Which single change will increase the terminal speed of the ball?

[1 mark]

A increasing the weight of the ball ⬭

B increasing the radius of the ball ⬭

C roughening the surface of the ball ⬭

D dropping the ball from a higher floor ⬭

1 8 Which situation does **not** contain an action–reaction pair according to Newton's third law of motion?

[1 mark]

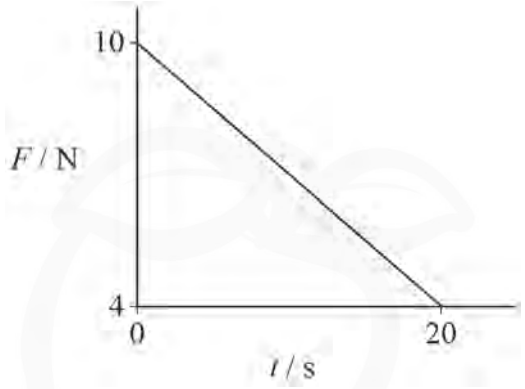
A the weight of a car and the gravitational force on the Earth due to the car ⬭

B the gravitational force of the Earth on a box and the reaction of the box on the Earth ⬭

C the frictional force of a tyre on the road and the frictional force of the road on the tyre ⬭

D the force exerted by an athlete's foot on a starting block and the reaction of the starting block on the athlete's foot ⬭

1 9 The graph shows the variation of force F with time t for an object accelerating from rest.



What is the magnitude of the momentum of the object after 20 s?

[1 mark]

A 140 N s ⬭

B 120 N s ⬭

C 60 N s ⬭

D 0.30 N s ⬭

2 0 An object is accelerated by a resultant force F and travels a distance s in the direction of the force. The average power used during the acceleration is P. The time taken is t.

A second object is accelerated using a resultant force of $3F$ and travels a distance $2s$ in the direction of the force. The average power developed during this acceleration is $0.5P$.

The second object accelerates for a time of

[1 mark]

A $0.33t$. ⬭

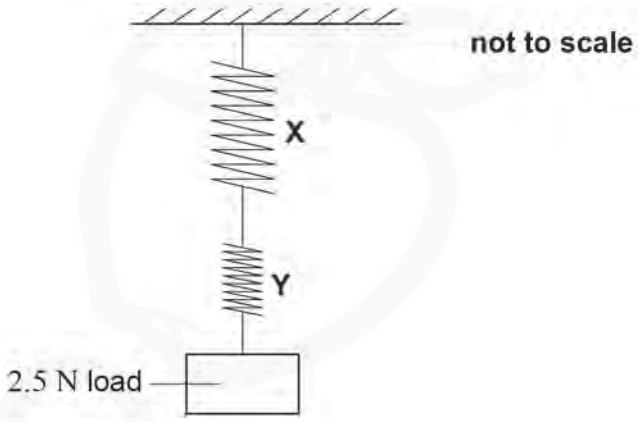
B $1.3t$. ⬭

C $3.0t$. ⬭

D $12t$. ⬭

Do not write outside the box

2 1 In the diagram below, spring **X** has a spring constant of $15\ \text{N m}^{-1}$ and an unstretched length of $8.0\ \text{cm}$.
Spring **Y** has a spring constant of $30\ \text{N m}^{-1}$ and an unstretched length of $4.0\ \text{cm}$.
The load has a weight of $2.5\ \text{N}$.



The springs have negligible weight and obey Hooke's law.

What is the total length of **X** and **Y** when in equilibrium?

[1 mark]

A 0.18 m ⬭

B 0.25 m ⬭

C 0.30 m ⬭

D 0.37 m ⬭

2 2 $^{208}_{82}\text{Pb}$ can be formed from $^{232}_{92}\text{U}$ by a series of alpha and beta-minus (β^-) decays.

How many β^- particles are emitted in the decay series?

[1 mark]

A 0 ⬭

B 2 ⬭

C 8 ⬭

D 10 ⬭

Do not write outside the box

2 3 A radioactive source has an initial activity of 4.8×10^8 Bq. The product of the decay is stable.
After exactly 1 day, the activity has fallen to 1.2×10^7 Bq.

What is the half-life of the decay?

[1 mark]

A 3.2 h ⬭

B 4.5 h ⬭

C 5.3 h ⬭

D 12 h ⬭

2 4 Technetium-99m is used in medical diagnostics.

Which row shows the emissions from technetium-99m and the reason for its use?

[1 mark]

	Emissions	Reason for use	
A	alpha and beta	Alpha and beta emissions have opposite charges that cancel each other out, limiting damage to patients.	⬭
B	beta	Beta emissions are absorbed by the body so that none can escape from the patient to damage medical staff.	⬭
C	gamma	Gamma emissions are uncharged so will not affect electrical equipment.	⬭
D	gamma	Gamma emissions can escape from the patient and be detected outside.	⬭

14

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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