

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL A-LEVEL PHYSICS

Unit 5 Physics in practice

Tuesday 9 June 2026

08:00 UK Time

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	
TOTAL	



Section AAnswer **all** questions in this section.**0 1**

Figure 1 shows a metal ruler R_1 of width w .
The ends of the ruler are labelled **A** and **B**.

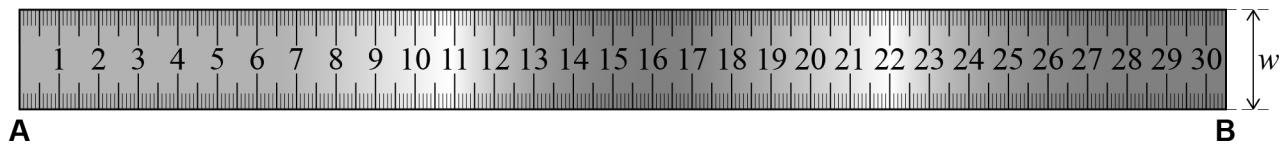
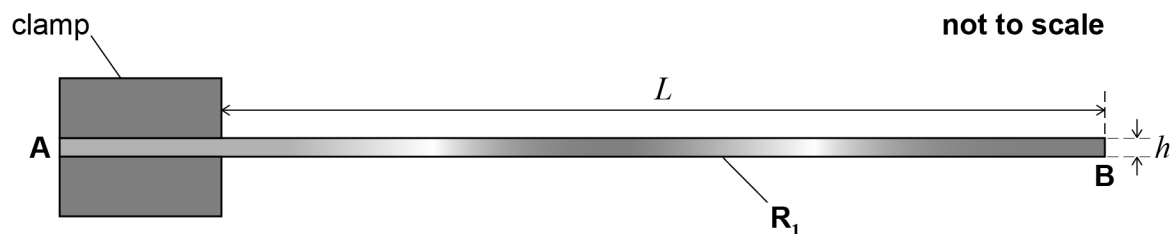
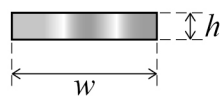
Figure 1

Figure 2 is a side view of R_1 held horizontally in a clamp.

Figure 2

The length of the unclamped part of R_1 is L .
The thickness of R_1 is h .

Figure 3 shows the cross-section of R_1 .

Figure 3

0 1 . 1 Explain how to determine h , w and L accurately.

[4 marks]

h _____

w _____

L _____

Question 1 continues on the next page

Turn over ►

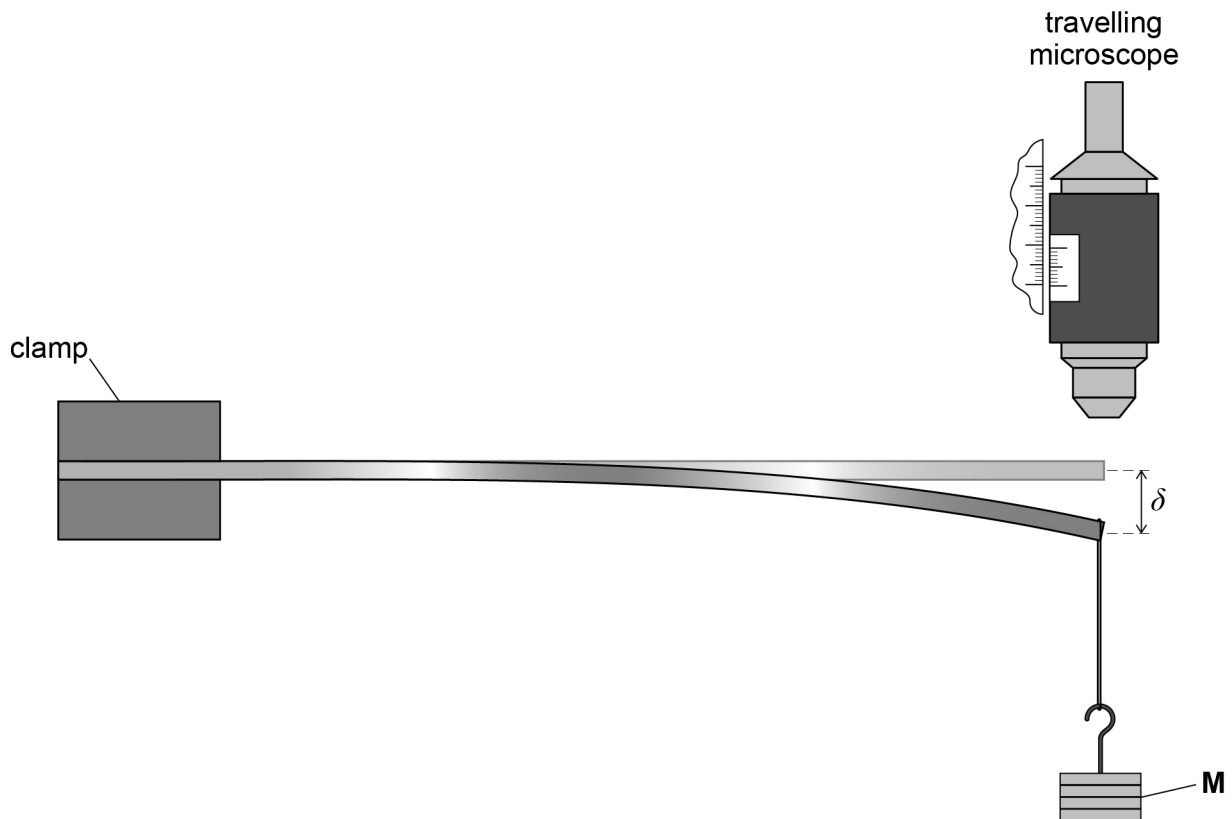


A student suspends a mass **M** from the end of **R₁** causing a vertical deflection δ .

They use a travelling microscope to measure δ .

Figure 4 shows **R₁**, **M** and the travelling microscope.

Figure 4



A travelling microscope is a measuring device with a vernier scale. The microscope can be moved up and down to focus on an object at a set distance from the microscope.

Initially the student makes a measurement of **R₁** when it is undeflected. In order to do this, the student:

1. moves the microscope until the end of **R₁** is in focus
2. takes a reading from the vernier scale.

The student then suspends **M** from the end of **R₁** and repeats steps 1 and 2.

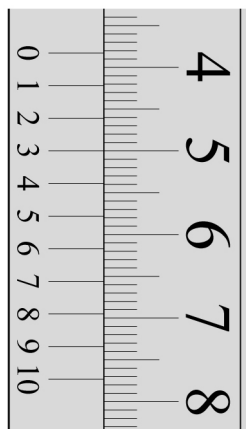
0 1 . 2

Figure 5 shows the vernier scale of the microscope when R_1 is undeflected and when R_1 is deflected.

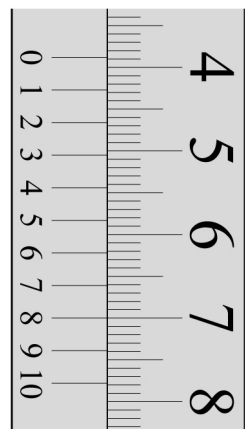
The main scale has a resolution of 1 mm.

Figure 5

undeflected



deflected



Determine δ in mm.

[2 marks]

$\delta =$ _____ mm

Question 1 continues on the next page

Turn over ►

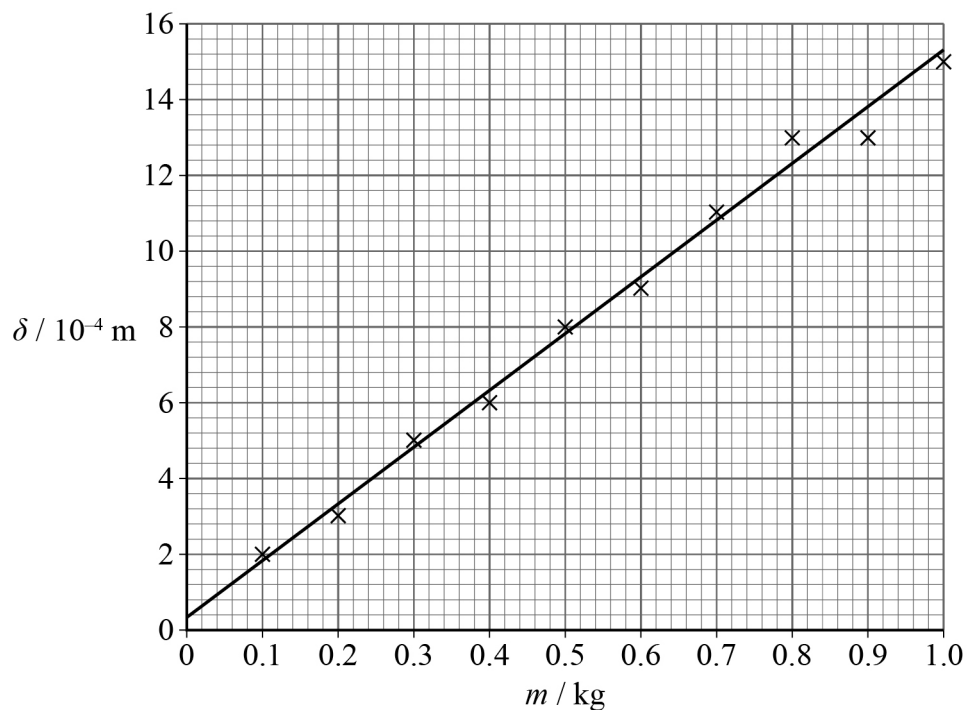


0 1 . 3

The student varies the mass m of **M** and δ is measured.

Figure 6 shows the variation of δ with m .

Figure 6



δ is given by

$$\delta = \frac{4mgL^3}{Ewh^3}$$

where E is the Young modulus of the metal used to make **R**₁ and g is the acceleration due to gravity.

Determine E .

$$L = 25.4 \text{ cm}$$

$$w = 59.3 \text{ mm}$$

$$h = 3.35 \text{ mm}$$

[4 marks]

$E =$ _____ Pa



Question 1 continues on the next page

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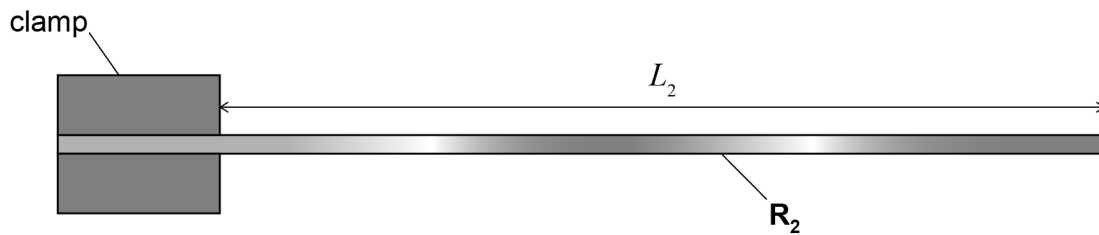
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0 1 . 4

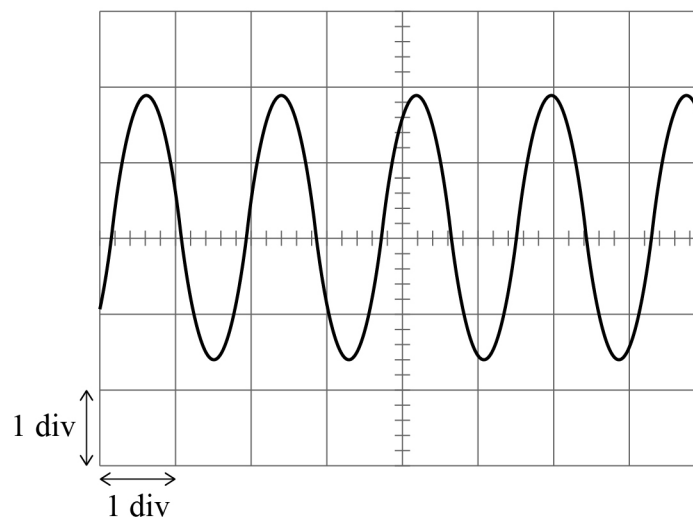
Figure 7 shows a different ruler $\mathbf{R}_2$ clamped at one end. The length of the unclamped part of $\mathbf{R}_2$ is L_2 .

Figure 7

The unclamped end of $\mathbf{R}_2$ is pulled down and released. $\mathbf{R}_2$ oscillates and emits sound.

A microphone detects the sound emitted by $\mathbf{R}_2$ as it oscillates.

The microphone is connected to an oscilloscope. **Figure 8** shows the oscilloscope screen.

Figure 8

The time base setting is 10 ms div^{-1} .

The frequency of the sound is equal to the frequency f of the oscillation of $\mathbf{R}_2$.
 f is given by

$$f = k \sqrt{\frac{E_2}{\mu L_2^4}}$$

Where E_2 is the Young modulus of the metal used to make $\mathbf{R}_2$, μ is the mass per unit length of $\mathbf{R}_2$ and k is a constant.

Determine E_2 using **Figure 8**.

$$\mu = 0.808 \text{ kg m}^{-1}$$

$$k = 1.59 \times 10^{-6} \text{ m}^2$$

$$L_2 = 0.12 \text{ m}$$

[4 marks]

$$E_2 = \text{_____ Pa}$$

14

Turn over for the next question

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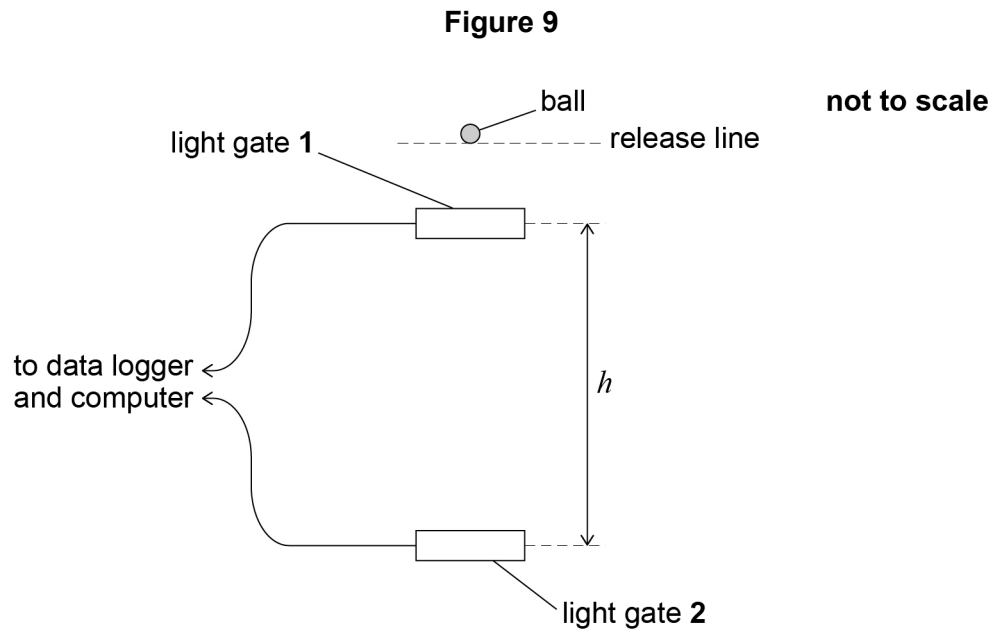
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0	2
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A ball is dropped through two light gates to determine the acceleration g due to gravity.

Figure 9 shows the ball and the two light gates connected to a data logger and computer.



Question 2 continues on the next page

Turn over ►



The ball is released from the same height above light gate **1** each time.

The computer records the time t for the ball to travel between light gate **1** and light gate **2**.

The vertical distance h between the light gates is varied by raising or lowering light gate **2**.

t is recorded for a range of values of h .

Table 1 shows these data.

Table 1

h / m	t / s	$t^2 / \text{_____}$
0.100	0.06	
0.500	0.21	
1.000	0.33	0.11
1.300	0.39	0.15
1.600	0.45	0.20

0 2 . 1 Write a unit for t^2 in **Table 1** and in **Figure 10**.

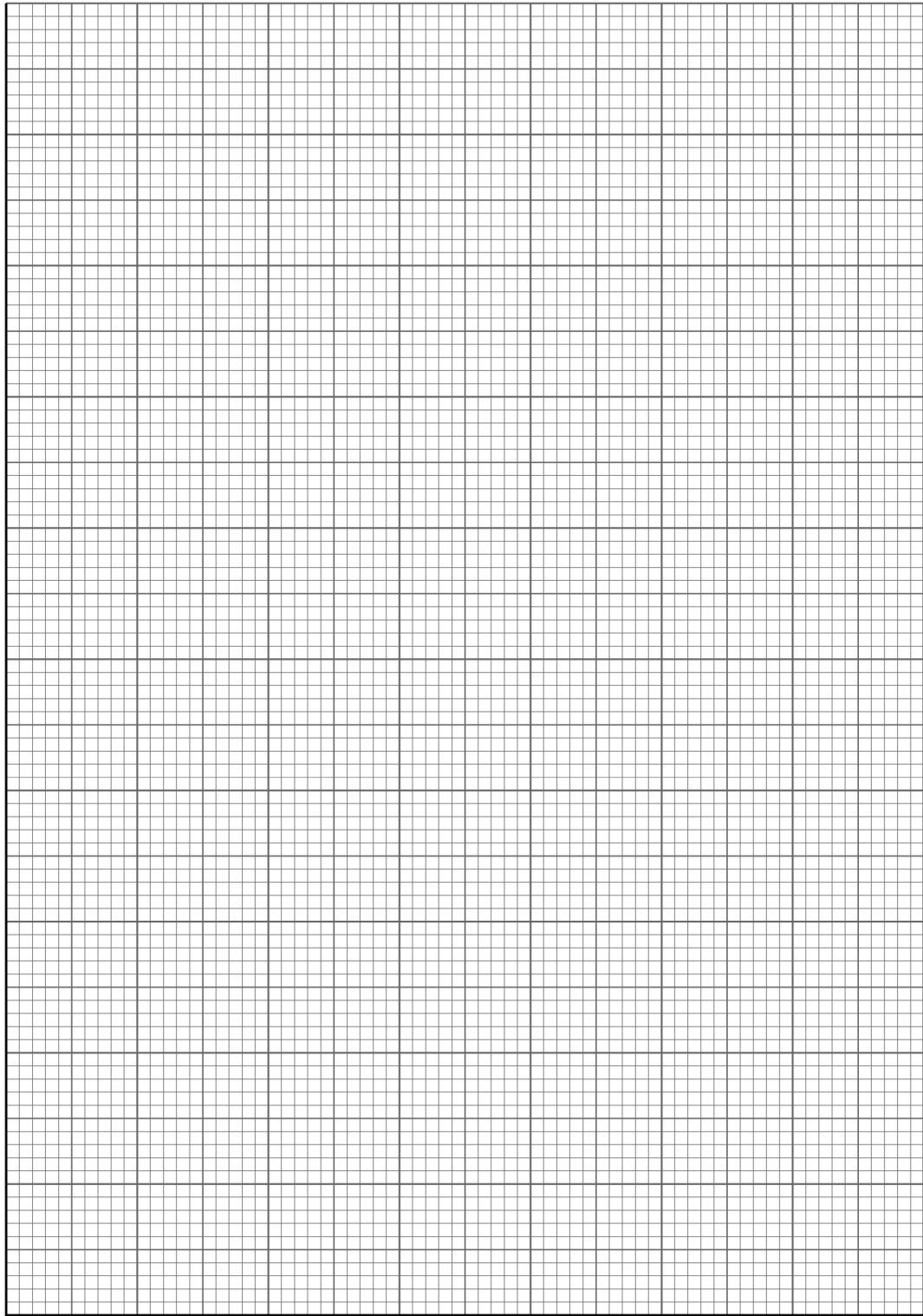
[1 mark]

0 2 . 2 Complete **Table 1**.

[1 mark]

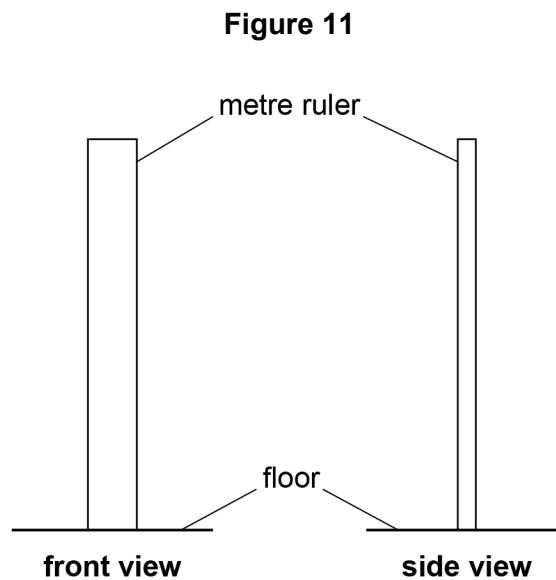


0 2 . 3

Plot a graph of t^2 against h on **Figure 10**.**[4 marks]**Do not write
outside the
box**Figure 10** $t^2 / \text{_____}$  h / m **Turn over ►**

In another experiment to measure g a different ball is dropped in front of a metre ruler and videoed on a smartphone. This allows the vertical position of the ball to be determined as it falls vertically from rest.

Figure 11 shows a front view and a side view of the ruler in position.



0 2 . 5

Explain how to ensure that the ruler is vertical.
You may annotate **Figure 11** as part of your answer.

[2 marks]

Question 2 continues on the next page

Turn over ►



0 2 . 6

Figure 12a shows part of the video image just before the ball is released.

Figure 12b shows part of the video image after the ball has fallen for a short time.

Figure 12a

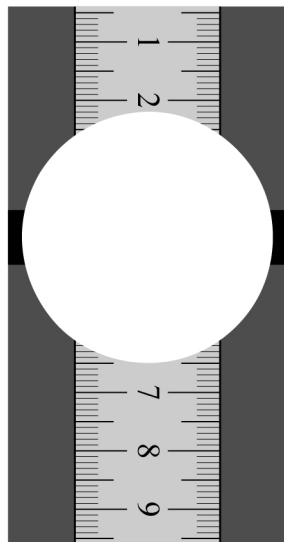
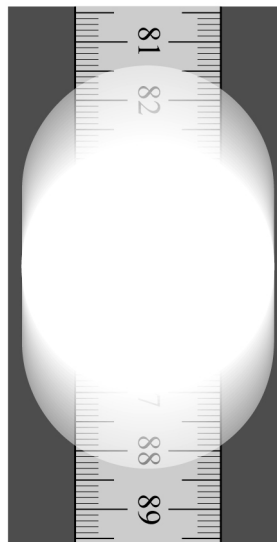


Figure 12b



The image of the ball in **Figure 12b** is blurred because the image is not taken instantly. The image is taken over a very small time Δt . During Δt the ball falls a small distance.

Determine Δt using **Figure 12a** and **Figure 12b**.

Use $g = 9.81 \text{ m s}^{-2}$ in this calculation.

Assume that air resistance is negligible.

[4 marks]

$\Delta t =$ _____ s



0	2	.	7
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The smartphone is held too close to the experiment. This produces parallax error in the video.

The student uses this video to measure the height the ball has fallen through.

Explain the effect of parallax error on this measurement.

[1 mark]

16

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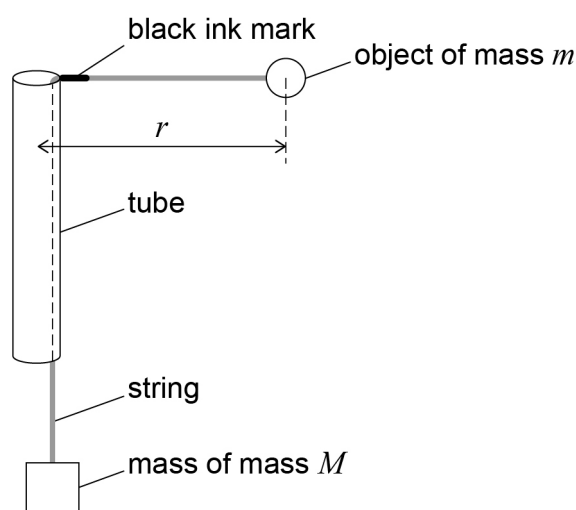
0 3

This question is about an experiment to investigate centripetal force. A small object of mass m moves in a horizontal circle at a constant speed.

Figure 13 shows the object attached to a string that passes through a smooth tube and is attached to a mass of mass M . The string is marked with black ink.

A student holds the tube and causes the object to rotate in a horizontal circle with radius r .

Figure 13



The student moves the tube so that the object moves in a horizontal circle with the black ink mark aligned with the top of the tube.

The period T of the object and the radius r are determined.

0 3 . 1

Describe how you would determine T accurately using a stopwatch.

[1 mark]

Question 3 continues on the next page

Turn over ►



0	3	.	2
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 For this situation

$$g = \frac{4\pi^2 mr}{MT^2}$$

where g is the acceleration due to gravity.

$$T = 0.39 \text{ s} \pm 0.02 \text{ s}$$

$$m = 0.050 \text{ kg} \pm 2\%$$

$$M = 0.200 \text{ kg} \pm 1\%$$

$$r = 0.150 \text{ m} \pm 0.001 \text{ m}$$

Determine:

- a value for g
- the absolute uncertainty in g .

[3 marks]

$g =$ _____ $\text{m s}^{-2} \pm$ _____ m s^{-2}



0 3 . 3

The student repeats the experiment using a tube made of a rough material. They obtain a value for T of $0.34 \text{ s} \pm 0.02 \text{ s}$ when $r = 0.150 \text{ m} \pm 0.001 \text{ m}$. This is different from the value for T given in Question **03.2**.

The student suggests that the difference in T is due to friction between the string and the tube.

Discuss whether the student is correct.

[2 marks]

6**END OF SECTION A****Turn over ►**

Section B

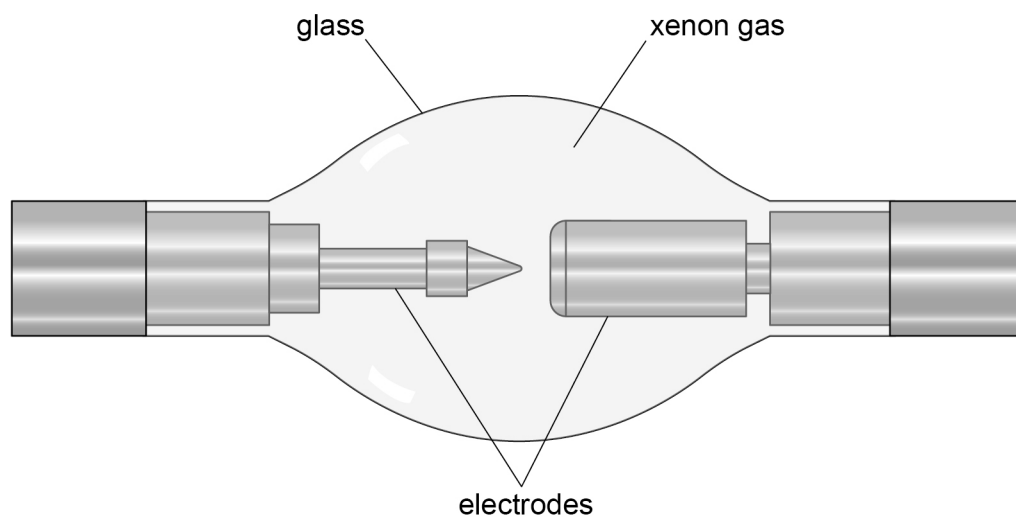
Answer **all** questions in this section.

0	4
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An IMAX projector is a type of cinema projector.

Figure 14 shows an arc lamp used to produce the white light for the projector.

Figure 14



The arc lamp consists of two metal electrodes in a glass tube filled with xenon gas. A voltage is applied across the two metal electrodes. A very large current of electrons and xenon ions passes between the electrodes, creating a very hot plasma.

The electrons and ions collide with the electrodes.

Suggest how the arc lamp produces white light.

- explain how photons are emitted
- explain why white light is produced.

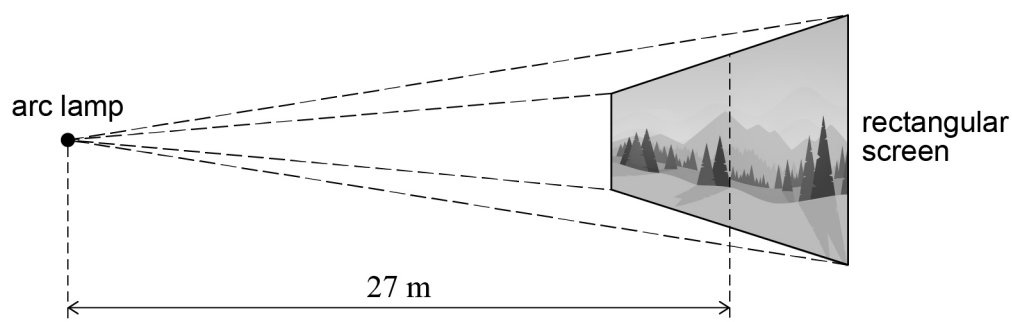
This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Turn over ►



Figure 15 shows the arc lamp and the emitted white light illuminating a rectangular screen.

Figure 15



6000 W of visible light produced by the arc lamp is evenly distributed over the screen.

0 4 . 2

A cinema claims the beam from the arc lamp is bright enough to be seen from the Moon by a human eye.

Discuss whether this claim is true.

area of rectangular screen = 432 m²

distance between arc lamp and centre of screen = 27 m

distance to Moon = 3.8×10^8 m

smallest intensity visible to human eye = 10^{-10} W m⁻²

[3 marks]



0 4 . 3

The input power of the lamp is 15 kW.
The electrodes are cooled by water that passes through holes in the electrodes.
The flow rate of the water is 22 kg per minute.

Calculate the maximum increase in temperature of the water as it flows through the electrodes.
Assume that all of the waste energy is used to increase the temperature of the water.

specific heat capacity of water = $4200 \text{ J kg}^{-1} \text{ K}^{-1}$

[2 marks]

increase in temperature = _____ K

0 4 . 4

Two IMAX projectors can be used to give a person a 3D experience of the image of an object.

The person experiences the 3D image when each eye sees a different image of the object.

Each IMAX projector projects a different image of the object.

Each projector has a separate polaroid filter in front of it.

The person wears glasses with polaroid filters to watch a movie in 3D.

Explain how this arrangement can be used to show a different image to each eye.

[2 marks]

Question 4 continues on the next page

Turn over ►



0 4 . 5

Figure 16 shows a person wearing glasses with polaroid filters.

Figure 16



The person in **Figure 16** has tilted his head and the 3D effect is lost.

Explain why the 3D effect is lost.

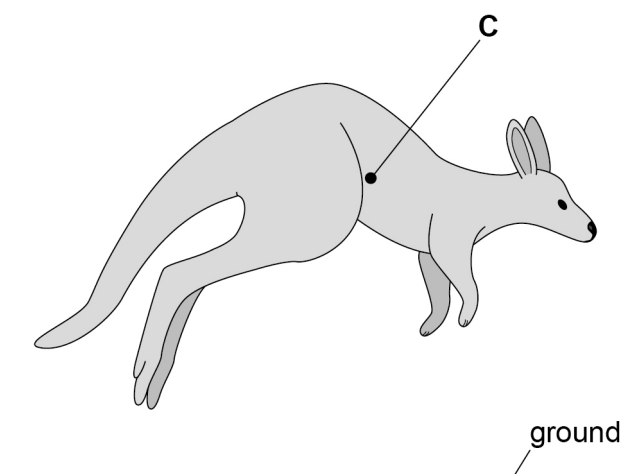
[1 mark]



0 5

A kangaroo is an animal that moves around by jumping. **Figure 17** shows a kangaroo in the middle of a jump.

Figure 17



C is the centre of mass of the kangaroo.

While in the air during a jump, the kangaroo:

- has a constant horizontal component of velocity of 6.9 m s^{-1}
- travels a horizontal distance of 6.0 m .

Assume that air resistance is negligible throughout Question 05.

0 5 . 1

Calculate the maximum change in height of **C**.

[3 marks]

maximum change in height = _____ m

Question 5 continues on the next page

Turn over ►



0 5 . 2

Figure 18a shows the kangaroo as its feet just touch the ground as it lands.

Figure 18b shows the kangaroo just before its feet leave the ground as it jumps.

Figure 18a

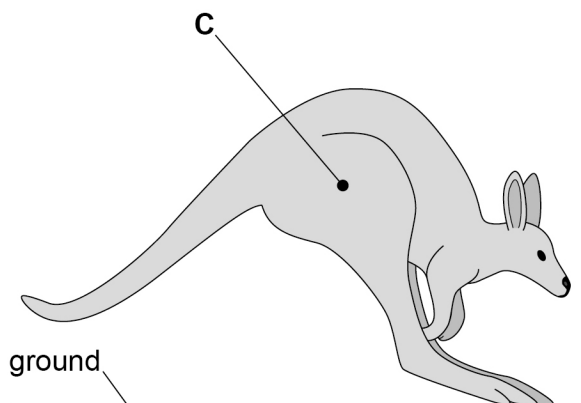
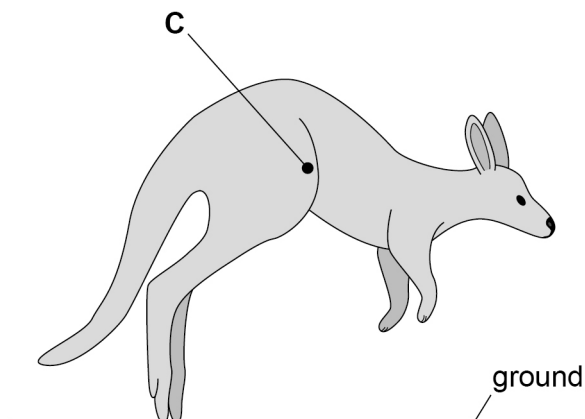


Figure 18b



A contact force from the ground acts on the kangaroo as it lands and as it takes off. These forces do not cause the kangaroo to rotate.

Draw, on **Figure 18a** and on **Figure 18b**, the contact force from the ground acting on the kangaroo.

Explain why the forces you have drawn do not cause the kangaroo to rotate.

[3 marks]

Question 5 continues on the next page

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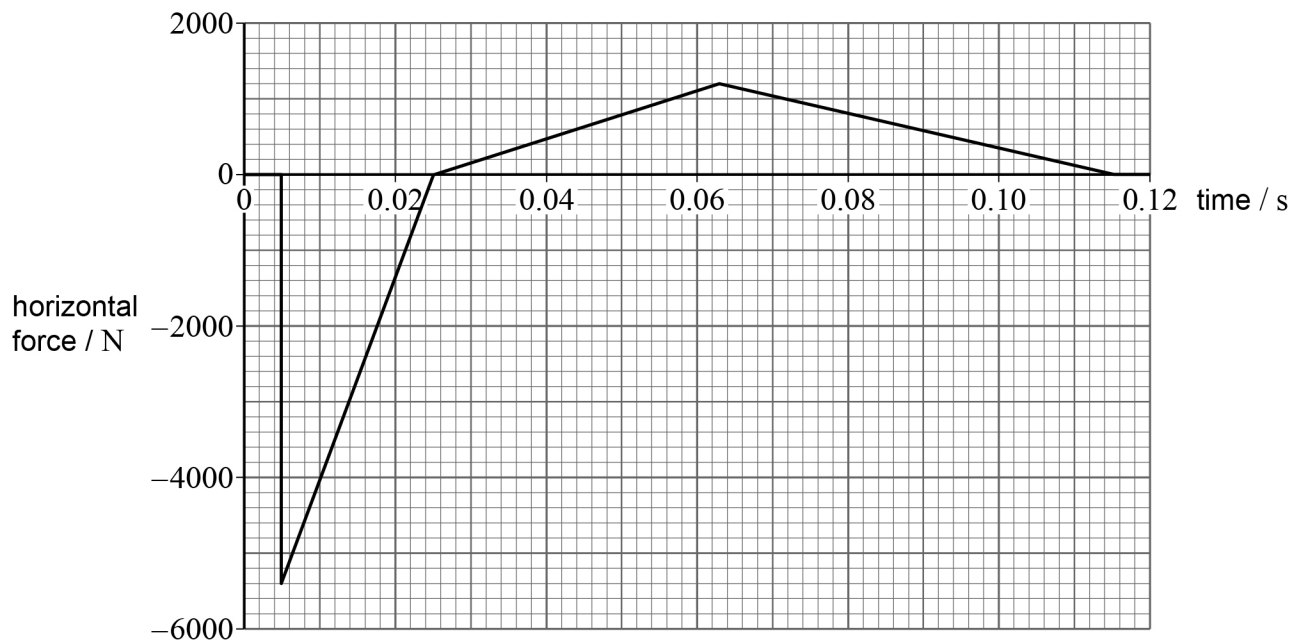
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Figure 19 shows the variation of the horizontal component of the contact force with time. The graph shows the time from just before the kangaroo's feet come into contact with the ground until just after they leave the ground.

Figure 19



0 5 . 3

Explain why the horizontal velocity of the kangaroo is the same before and after the contact with the ground.
Support your answer with calculations.

[4 marks]

The horizontal component of the kangaroo's velocity is at a minimum at a time of 0.025 s. The vertical component of the kangaroo's velocity is zero at this time.

The mass of the kangaroo is 52 kg.

0 5 . 4

Show that the minimum speed of the kangaroo during the time shown in **Figure 19** is approximately 6 m s^{-1} .

[2 marks]

0 5 . 5

In this jump, the kangaroo touches the ground at a speed of 8.1 m s^{-1} . 30% of the kinetic energy transferred as the kangaroo lands is stored in elastic tissues called tendons in its legs.

The maximum force exerted on the tendons as it lands is 6300 N.
The force acts along the length of the tendons.

Determine the total spring constant of the kangaroo's tendons.
Assume that the kangaroo's tendons obey Hooke's law.

[4 marks]

spring constant = _____ N m^{-1}

16

Turn over ►



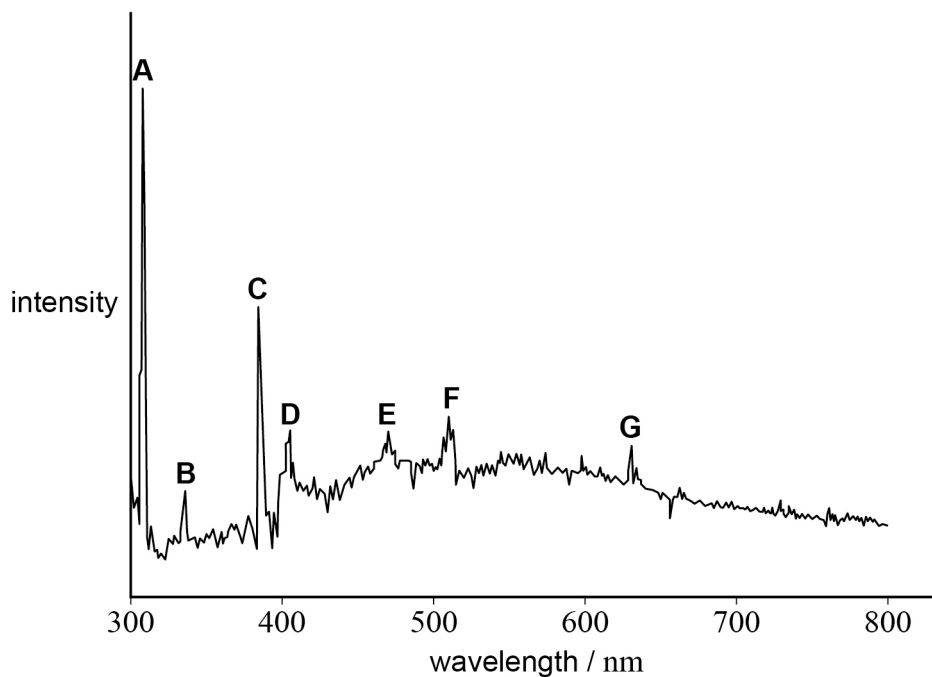
0 6

Comets are balls of ice and dust in space.

A diffraction grating is used to analyse the light from a comet. The spectrum produced is used to determine the materials that the comet is made of.

Figure 20 shows the variation of intensity with wavelength for light from one comet.

Figure 20

**0 6 . 1**

The diffraction grating has 200 lines per mm.

Identify which peak, **A** to **G**, corresponds to a first-order maximum with a diffraction angle of 3.5° .

[2 marks]

peak = _____

0	6	.	2
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Ammonia emits a photon with an energy of $5.92 \times 10^{-19} \text{ J}$.

Identify which peak, **A** to **G**, shows the presence of ammonia in the comet.

[1 mark]

peak = _____

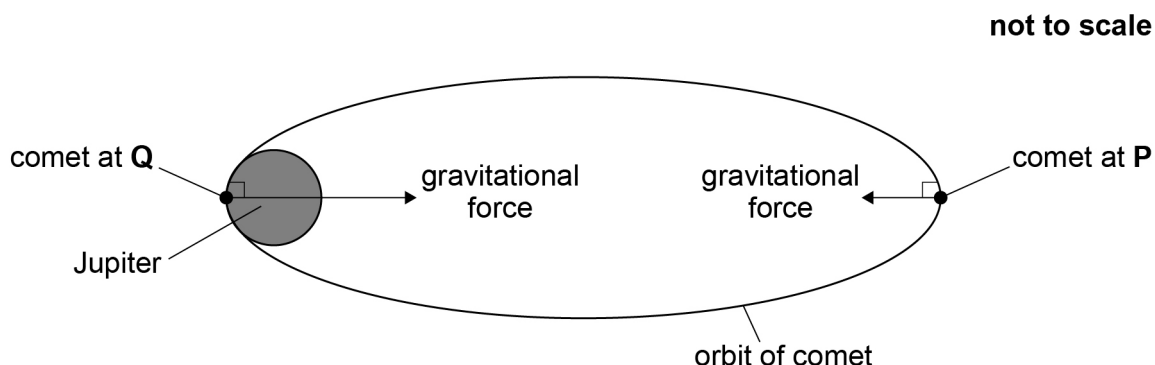
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The comet is in a non-circular orbit around Jupiter.
Figure 21 shows the comet at two positions **P** and **Q** in its orbit.

Figure 21



The comet is at its maximum distance from Jupiter at **P**.
 The comet is at its minimum distance from Jupiter at **Q**.
 The gravitational force from Jupiter is perpendicular to the linear velocity of the comet at **P** and at **Q**.

The comet collides with Jupiter at **Q** with a speed of $5.12 \times 10^4 \text{ m s}^{-1}$.

radius of Jupiter = $6.99 \times 10^7 \text{ m}$

mass of Jupiter = $1.90 \times 10^{27} \text{ kg}$

distance of **P** from centre of Jupiter = $1.82 \times 10^8 \text{ m}$

0 6 . 3

Show, using conservation of energy, that the speed of the comet at **P** is approximately $2.0 \times 10^4 \text{ m s}^{-1}$.

[3 marks]



At **P** and **Q**, the comet's:

- orbital moment of inertia is mr^2
- angular speed is $\frac{v}{r}$

where r is the distance from the centre of Jupiter.

0 6 . 4

Show that the orbital angular momentum of the comet is conserved for this orbit.

[3 marks]

0 6 . 5

State the magnitude of the torque acting on the comet.
Justify your answer.

[2 marks]

torque = _____ N m

Question 6 continues on the next page

Turn over ►



0	6	.	6
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The collision of the comet with Jupiter transfers a kinetic energy of 1×10^{19} J to Jupiter.

The diameter of the comet is estimated to be 300 m.

Estimate the density of the comet.

[2 marks]

density = _____ kg m^{-3}



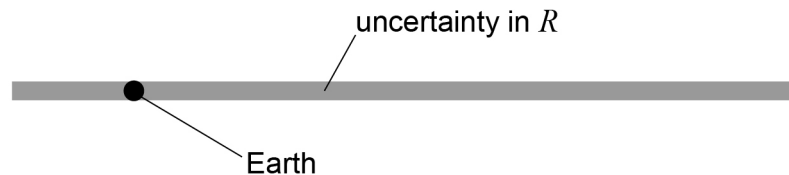
0 6 . 7

Astronomers discover a comet that might hit Earth.

Astronomers use measurements of the comet's current position to calculate its closest distance R to the Earth. Due to uncertainty in these measurements, there is an uncertainty in R .

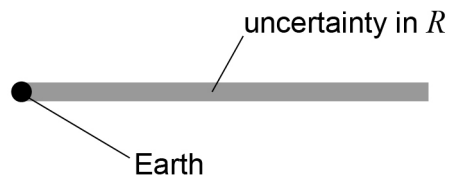
Figure 22 shows this uncertainty in R using the data available at one time. R is calculated to be somewhere along the grey line.

Figure 22



Further measurements of the comet's position are taken. **Figure 23** shows the uncertainty in R using the data available at a later time.

Figure 23



Further measurements continue to be taken until it is determined that the comet will not hit the Earth.

Explain why this sequence of measurements initially leads to an increase in the probability of an impact, until the probability suddenly drops to zero.

[2 marks]

15

END OF QUESTIONS



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