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 A-LEVEL

# PHYSICS

## Unit 5 Physics in practice

Thursday 12 June 2025     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 | |
| **TOTAL** | |

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## Section A

Answer **all** questions in this section.

**0 1** This question is about interference of light.

**0 1 . 1** In a Young's double-slit experiment with a laser, the fringe spacing is determined to be $4.5\ \text{mm} \pm 2\%$.

The distance between the double slit and the screen is measured using a metre ruler as $0.503\ \text{m} \pm 0.2\%$.

The double-slit spacing is $0.05\ \text{mm} \pm 5\%$.

Determine the wavelength of the light.
Go on to determine its absolute uncertainty.

**[4 marks]**

wavelength = ____________________ ± ____________________ m

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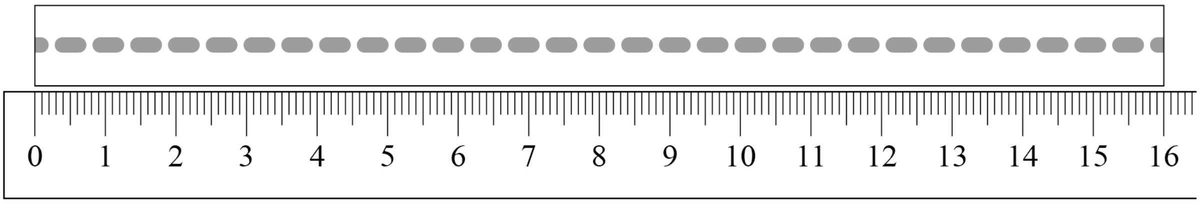
A student does another Young's double-slit experiment to determine the wavelength of light from a different laser.

**Figure 1** shows the whole screen and the fringe pattern produced on it.
A ruler is shown next to the screen. The smallest division of this ruler is $1 \text{ mm}$.

**Figure 1**




**0 1 . 2** Explain why the student determines the fringe spacing by making the measurement across multiple fringes.

**[1 mark]**

**0 1 . 3** Determine an accurate value for the fringe spacing.
Annotate **Figure 1** to show the readings you take from the ruler.

**[2 marks]**

fringe spacing = ____________________ mm

**Question 1 continues on the next page**

**0 1 . 4** Calculate the percentage uncertainty in your answer to Question **01.3**.

**[2 marks]**

percentage uncertainty = ± ____________________ %

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**0 1 . 5** The student now compares the double-slit pattern shown in **Figure 1** with the pattern from a diffraction grating.

$W_1$ is the width of the pattern that fits on the screen using the double slit, as shown in **Figure 1**.

The same screen and the same laser are used for both patterns. The distance between the screen and the diffraction grating is the same as the distance between the screen and the double slit.

The student ensures that the zero order ($n = 0$) for the diffraction-grating pattern is in the centre of the screen.

$W_2$ is the maximum width of the pattern that fits on the screen using the diffraction grating.

$W_1$ and $W_2$ are measured with the same measuring device.

Discuss whether $W_2$ has a smaller percentage uncertainty than $W_1$.

wavelength of laser light = $550\ \text{nm}$
diffraction-grating spacing = $5.0 \times 10^{-6}\ \text{m}$
distance between screen and diffraction grating = $0.503\ \text{m}$

**[3 marks]**

12

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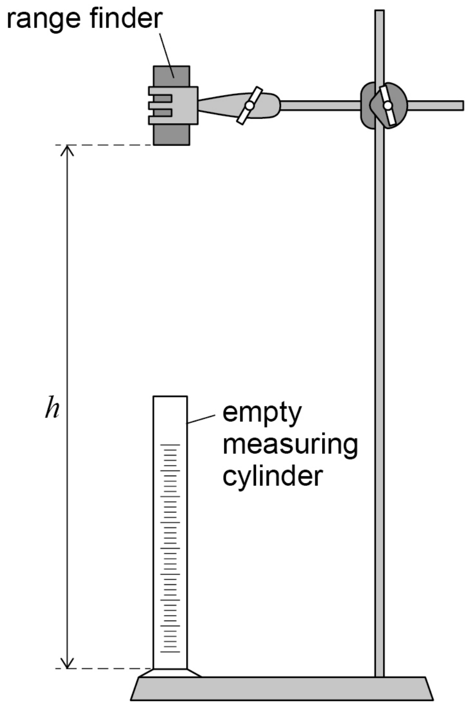
**0 2** This question is about an experiment to determine the speed of light in water using a range finder.

The range finder measures the time between the emission of a pulse of light and the reception of the reflected pulse.

The range finder then converts this time into a distance, based on the assumption that the light is travelling in air. The speed of light in air is $3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$.

**Figure 2** shows the range finder measuring the distance $h$ to the bottom of an empty measuring cylinder.

**Figure 2**




The distance reading on the range finder is $l$.

$l$ is equal to $h$ when the measuring cylinder is empty.

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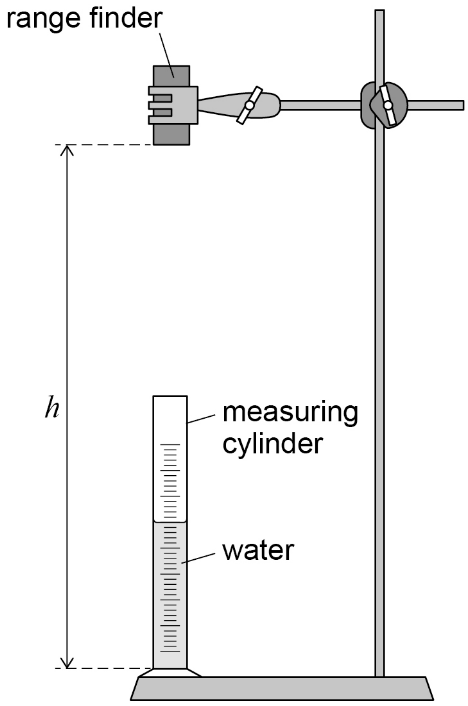
**Figure 3** shows the same arrangement after a volume $V$ of water has been added to the measuring cylinder.

**Figure 3**




The pulse of light now travels through the air and the water and is reflected from the bottom of the measuring cylinder back to the range finder.

**0 2 . 1** Explain why $l$ is now greater than $h$.

**[2 marks]**

**Question 2 continues on the next page**

**Turn over ►**

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$V$ is varied and the reading $l$ on the range finder is recorded.
$h$ is kept constant throughout the experiment.

**Table 1** shows measurements of $V$ and $l$ from the experiment.

**Table 1**

| $V$ / $10^{-6}$ m$^3$ | $l$ / $10^{-3}$ m |
|---|---|
| 100 | 527 |
| 120 | 533 |
| 140 | 538 |
| 160 | 544 |
| 200 | 555 |

**0 2 . 2** Draw, on **Figure 4**, a graph of $l$ against $V$.
Use a false origin on the $l$ axis.

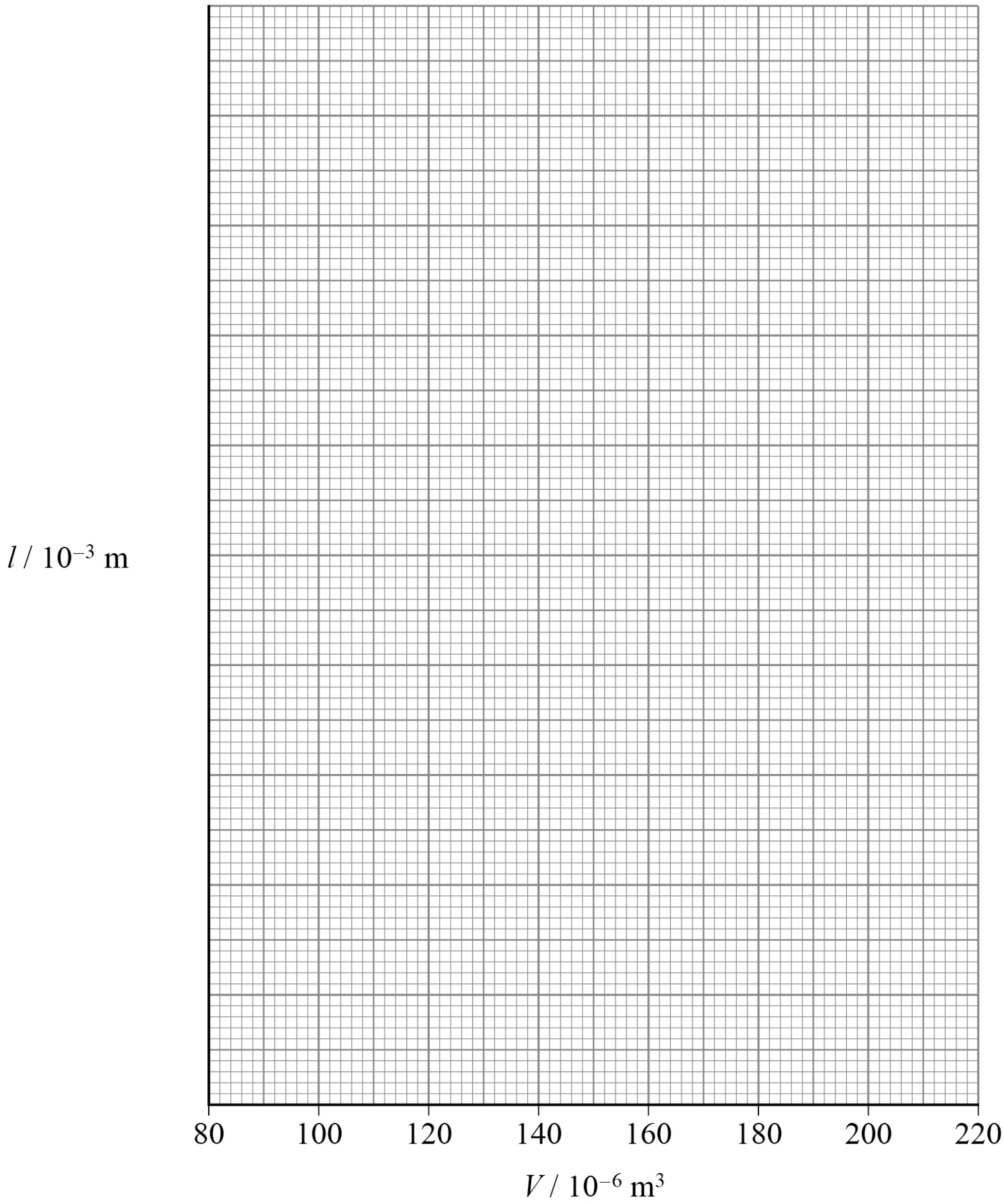
**[4 marks]**

**0 3 . 3** Determine the gradient of your graph.

**[2 marks]**

gradient = ____________________

**Figure 4**




**Question 2 continues on the next page**

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The relationship between $V$ and $l$ is given by

$$4V\left(\frac{c}{c_{\mathrm{w}}} - 1\right) = (l - h)\pi d^2$$

where

$c_{\mathrm{w}}$ is the speed of light in water
$d$ is the diameter of the measuring cylinder.

**0 2 . 4** Determine $c_{\mathrm{w}}$.

$d = 3.93 \times 10^{-2}$ m

**[3 marks]**

$c_{\mathrm{w}} =$ ____________________ m s$^{-1}$

**0 2 . 5** $h$ is the $y$-intercept of the graph of $l$ against $V$.

Determine $h$.

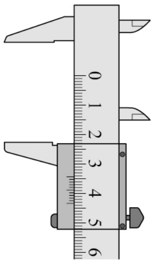
**[2 marks]**

$h =$ ____________________ m

The internal diameter of a different measuring cylinder is measured using vernier calipers.

**Figure 5** shows part of the vernier calipers.

**Figure 5**

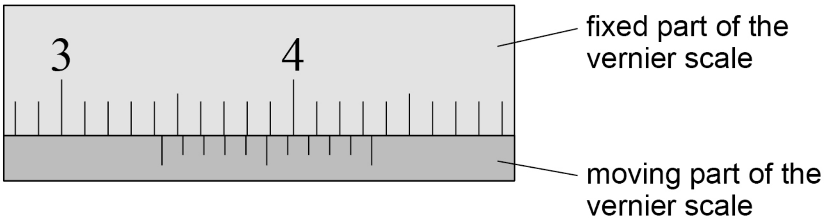



**0 2 . 6** Draw, on **Figure 5**, an empty measuring cylinder to show how its **internal** diameter is measured.

**[1 mark]**

**0 2 . 7** **Figure 6** shows part of the scale on the vernier calipers when measuring the internal diameter of the measuring cylinder.

**Figure 6**




The smallest division on the fixed part of the scale is 1 mm.

State the internal diameter of this measuring cylinder.

**[1 mark]**

internal diameter = ____________________ mm

15

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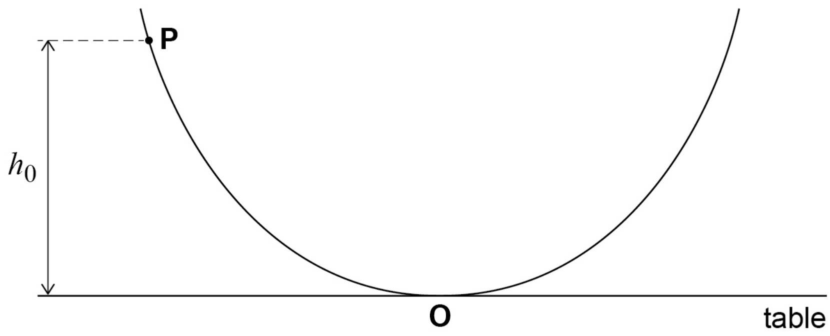
**0 3** This question is about the damped oscillations of a ball on a curved track.

**Figure 7** shows the curved track on a table.

**Figure 7**




A black pen is used to make a mark at point **P** on the track at a height $h_0$ above the table. $h_0$ is less than $1 \text{ m}$.

**0 3 . 1** Explain how to measure $h_0$ accurately using a metre ruler.
Other laboratory equipment is also available.
You may annotate **Figure 7** as part of your answer.

**[2 marks]**

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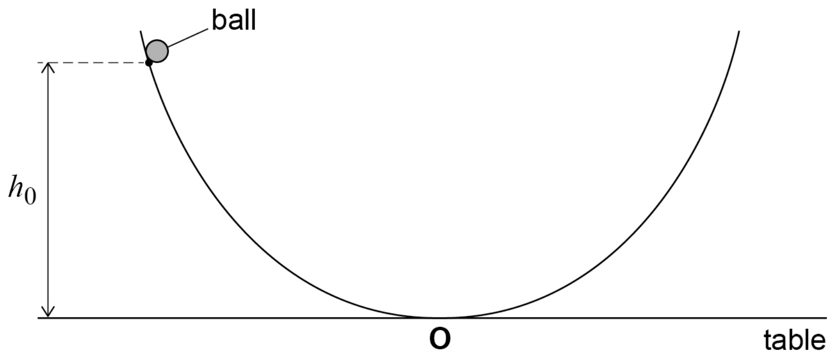
The lowest point on the ball is placed level with **P** as shown in **Figure 8**.

**Figure 8**




The ball is released from a height $h_0$ and rolls along the track.

The oscillations of the ball about point **O** are damped. The height reached by the ball after each oscillation decreases until the ball eventually comes to rest at **O**.

A student suggests that the height reached by the ball at the end of each oscillation decreases exponentially.

**0 3 . 2** After one complete oscillation, the lowest point on the ball reaches a height $h_1$.

Describe how to make an accurate measurement of $h_1$ with a metre ruler.
You do not need to repeat information from your answer to Question **03.1**.

**[2 marks]**

**Question 3 continues on the next page**

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**0 3 . 3** The ball is released from $h_0 = 751$ mm.

The height reached by the ball is measured after each oscillation.
**Table 2** shows the data.

**Table 2**

| **Number of complete oscillations** | **Height / mm** |
|---|---|
| 1 | 642 |
| 2 | 545 |
| 3 | 474 |

Determine whether the height reached by the ball decreases exponentially with the number of oscillations.

**[2 marks]**

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**0 3 . 4** The student suggests that the time for each oscillation of the ball is constant.

Describe how this suggestion could be tested using a stopwatch.
Go on to explain how to ensure the accuracy of the measurement.

**[3 marks]**

9

**END OF SECTION A**

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## Section B

Answer **all** questions in this section.

**0 4** The Voyager 2 spacecraft was launched in 1977 and has travelled to the edge of the Solar System. It was designed to operate until 2023 when it would be at a distance of $2.0 \times 10^{13}$ m from the Sun.

**0 4 . 1** Satellites in orbit around the Earth use solar panels for power. Voyager 2 has a similar power requirement to these satellites.

Explain why solar panels are **not** suitable to power Voyager 2 when it is at a distance of $2.0 \times 10^{13}$ m from the Sun.

Support your answer with a calculation.

distance from the Earth to the Sun = $1.5 \times 10^{11}$ m

**[3 marks]**

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**0 4 . 2** Voyager 2 is powered by radioisotope thermoelectric generators (RTGs). In these RTGs, the radioactive decay of plutonium-238 provides heat which is converted into electrical energy.

When Voyager 2 was launched in 1977 the RTGs were able to supply the spacecraft with a total power of $471 \mathrm{~W}$.

Calculate the power available from the RTGs after 46 years.
Assume that the efficiency of the RTGs remains constant.

half-life of plutonium-238 = 87.7 years

**[3 marks]**

power = ______________________ W

**Question 4 continues on the next page**

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**0 4 . 3** In 1981 Voyager 2 passed the planet Saturn and collected the following data at a point in Saturn's atmosphere:

- temperature at the point was $143\ \text{K}$
- pressure at the point was $1.2 \times 10^5\ \text{Pa}$
- $25\%$ of the particles were helium atoms
- $75\%$ of the particles were hydrogen molecules.

Estimate the density of Saturn's atmosphere at this point.

molar mass of helium atoms $= 4.0\ \text{g mol}^{-1}$
molar mass of hydrogen molecules $= 2.0\ \text{g mol}^{-1}$

**[3 marks]**

density = ______________________ $\text{kg m}^{-3}$

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**0 4 . 4** Voyager 2 does not have any rockets or thrusters to provide a driving force.

In 1989 it passed Neptune travelling at a speed $v$.
The distance between Neptune and the Sun is $4.5 \times 10^{12}$ m.

In 2023 Voyager 2 had a speed of $1.53 \times 10^{4}$ m s$^{-1}$ when it was at a distance of $2.0 \times 10^{13}$ m from the Sun.

The mass of Voyager 2 is 722 kg.

Calculate $v$.
You should only consider the effect of the Sun's gravitational field on Voyager 2.

**[3 marks]**

$v$ = ____________________ m s$^{-1}$

12

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**ANSWER IN THE SPACES PROVIDED**

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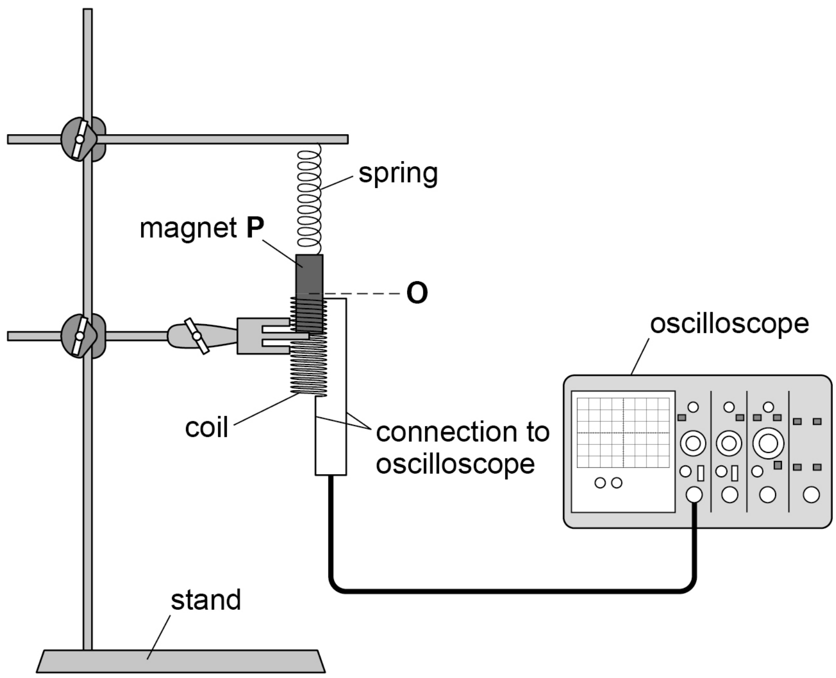
**0 5** A magnet **P** is suspended from a spring. **P** is initially stationary and in equilibrium, with its centre of mass at position **O**.

**Figure 9** shows **P** in this equilibrium position in a coil of wire.
The coil is connected to an oscilloscope. The oscilloscope has a very high resistance.

**Figure 9**




**P** is pulled a distance $y$ below **O** and released. **P** oscillates about **O**.

**0 5 . 1** Explain why the oscillations of **P** induce an emf across the coil.

**[2 marks]**

______________________________________________________________________

______________________________________________________________________

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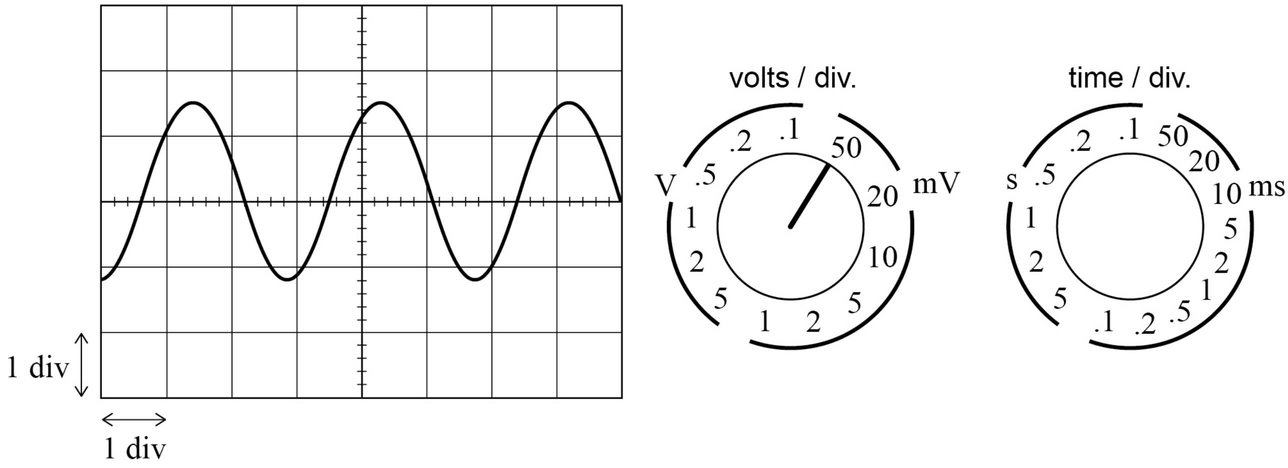
**Question 5 continues on the next page**

**Figure 10** shows the controls on the oscilloscope and the trace on the screen as **P** oscillates about **O**.

**Figure 10**




**0 5 . 2** Determine the peak value of the voltage shown in **Figure 10**.

**[3 marks]**

peak value = ____________________ mV

The spring has a stiffness of $29.3\ \text{N m}^{-1}$.
The mass $m$ of **P** is $250\ \text{g}$.

**0 5 . 3** Determine the time-base setting on the oscilloscope.
State the unit for this time-base setting.

**[3 marks]**

time-base = ____________________ unit ____________________

Do not write outside the box

**0 5 . 4** **P** has a magnetic flux density of $B$ at its poles.

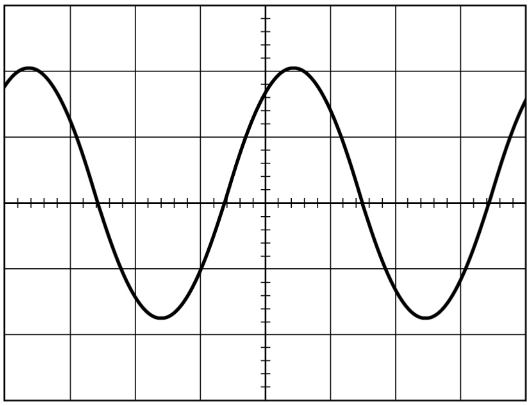
**P** is replaced with magnet **Q** that has:

- a mass of $2m$
- a magnetic flux density of $2B$ at its poles.

The height of the spring is adjusted so that the centre of mass of **Q** is initially at **O** as in **Figure 9**.
**Q** is then pulled down by the same distance $y$ and released.
The settings on the oscilloscope are **not** changed.

**Figure 11** shows the oscilloscope screen as **Q** oscillates about **O**.

**Figure 11**



Explain the differences between the trace in **Figure 11** and the trace in **Figure 10**.
Support your answer with calculations.

**[4 marks]**

**Question 5 continues on the next page**

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**0 5 . 5** After several oscillations, **Q** comes to rest.

The oscilloscope acts like a high-resistance voltmeter.

The oscilloscope is replaced with an ammeter that is connected across the coil.
**Q** is pulled down by the same distance $y$ and released.

Explain the effect of replacing the oscilloscope with the ammeter on the time taken for **Q** to come to rest.

**[4 marks]**

16

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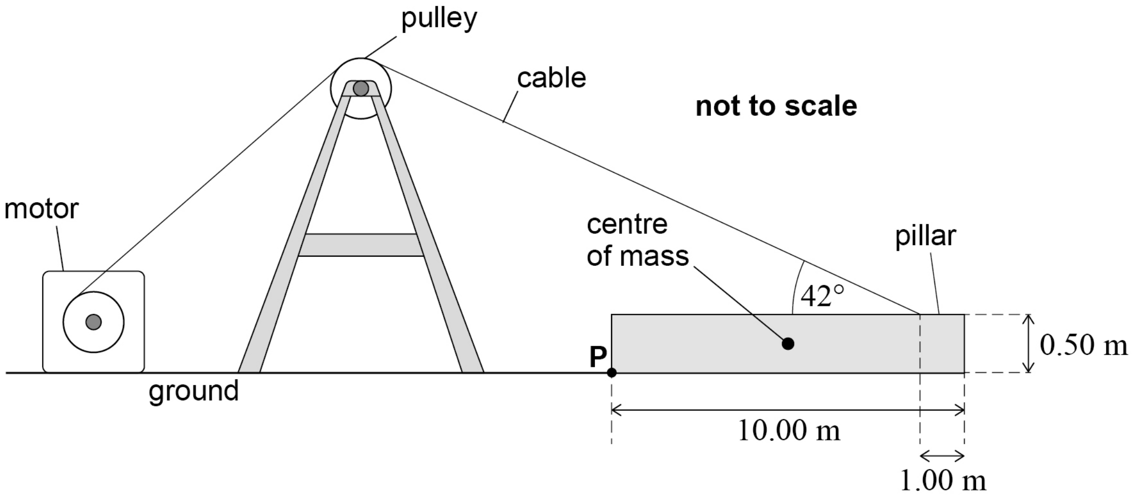
**0 6** Stone pillars are used in buildings.

A stone pillar is initially flat on the ground. **Figure 12** shows how a steel cable and a frictionless pulley are used to raise the pillar to a vertical position.
As the pillar is raised, it pivots about point **P**.

**Figure 12**




The pillar is of uniform cross-section and has a length of $10.00\ \mathrm{m}$ and a thickness of $0.50\ \mathrm{m}$.
The cable is attached to the pillar at a distance of $1.00\ \mathrm{m}$ from its right-hand edge.

**0 6 . 1** Explain why the horizontal component of the tension in the cable has a moment about **P**.

**[1 mark]**

______________________________________________

______________________________________________

______________________________________________

The minimum tension needed so that the pillar pivots about **P** is $74\ \mathrm{kN}$.
The pillar is of uniform density.

**0 6 . 2** Calculate the weight of the pillar.
Assume that all of the forces are coplanar.

**[3 marks]**

weight = ______________________ N

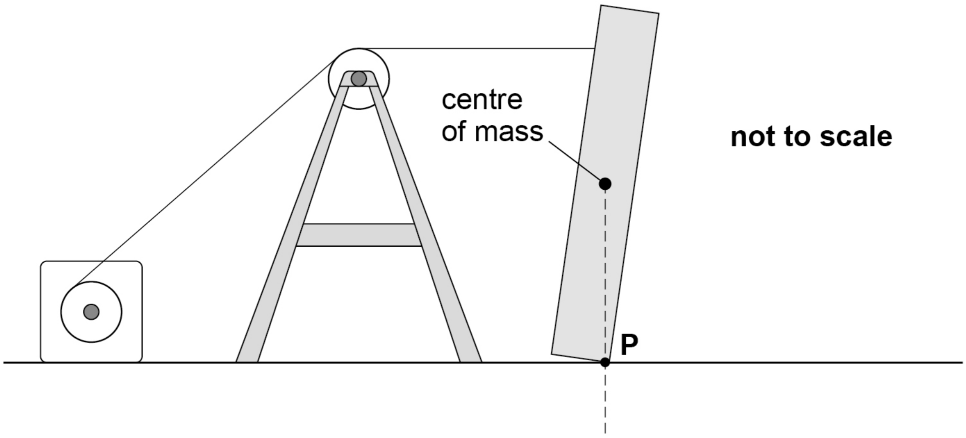
**Question 6 continues on the next page**

**Turn over ►**

A motor pulls the cable and raises the pillar.

**Figure 13** shows the pillar when its centre of mass is directly above **P**. The cable is now horizontal.

**Figure 13**




**0 6 . 3** The output power of the motor varies as the pillar is lifted slowly from its initial position to the position shown in **Figure 13**. The motor rotates with a constant angular speed.

State and explain the changes in the output power as the pillar is lifted.

**[4 marks]**

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A different pillar **B** has the same dimensions as the original pillar but has a greater weight.
When the system is used to raise **B**, the maximum tension in the cable is $85\ \mathrm{kN}$.

**0 6 . 4** The breaking stress of the cable is $699\ \mathrm{MPa}$.
For safety reasons, the maximum stress in the cable must not exceed $20\%$ of the breaking stress.

Calculate the minimum diameter of cable required to raise **B** safely.

**[3 marks]**

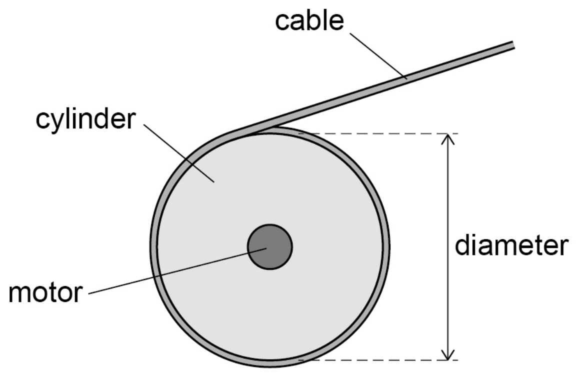
minimum diameter = ____________________ $\mathrm{m}$

**Question 6 continues on the next page**

The motor is attached to a cylinder which winds the cable to raise **B**.

**Figure 14** shows the cylinder attached to the cable.

**Figure 14**




The maximum torque produced by the motor is $8.88 \times 10^3$ N m.

**0 6 . 5** Calculate the minimum diameter of cylinder required to raise **B**.
Ignore the diameter of the cable in your calculation.

**[2 marks]**

diameter = ____________________ m

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**0 6 . 6** When the motor is producing its maximum torque:

- the cylinder rotates with an angular speed of $0.075 \text{ rad s}^{-1}$
- the voltage across the motor is $240 \text{ V}$
- the current in the motor is $3.9 \text{ A}$.

Calculate the percentage efficiency of the motor when delivering maximum torque to raise **B**.

**[3 marks]**

efficiency = ____________________ %

**16**

**END OF QUESTIONS**

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