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Centre Number _____

Candidate Number _____

Candidate Signature _____

A-level

PHYSICS

Paper 3

Section A

7408/3A

Monday 3 June 2019

Afternoon

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 70 minutes on this section.

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]



For this paper you must have:

- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet
- A Diagram Booklet.

INSTRUCTIONS

- Use black ink or black ball-point pen.
- Answer ALL questions.
- You must answer the questions in the spaces provided. Do NOT write on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- 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).
- Show all your working.



INFORMATION

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 45.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

DO NOT TURN OVER UNTIL TOLD TO DO SO



SECTION A

Answer ALL questions in this section.

0 1

FIGURE 1 shows a sealed radioactive source used in schools and colleges.

FIGURE 1

**0 1 . 1**

State TWO safety procedures to reduce risk when using this type of source. [2 marks]

Safety procedure 1 _____



Safety procedure 2 _____

[Turn over]



01.2 A sealed source contains radium-226 ($^{226}_{88}\text{Ra}$).

$^{226}_{88}\text{Ra}$ decays by emitting α and β^- particles to produce $^{206}_{82}\text{Pb}$ which is stable.

FIGURE 2, on page 2 of the Diagram Booklet, is a graph of neutron number N against proton number Z , showing the different ways that $^{226}_{88}\text{Ra}$ can decay into $^{206}_{82}\text{Pb}$.

Points A to M represent all the unstable nuclei that may be formed as $^{226}_{88}\text{Ra}$ decays into $^{206}_{82}\text{Pb}$.

Determine the number of routes by which B can change into K. [1 mark]

- 01.3** Identify which of the nuclei A to M are common to all the possible ways that ${}^{226}_{88}\text{Ra}$ decays into ${}^{206}_{82}\text{Pb}$. [3 marks]

[Turn over]



01.4

The sealed source emits γ radiation in addition to α and β^- particles.

A student uses the sealed source to investigate the inverse-square law for γ radiation. The student begins by making measurements to find the count rate A_b for the background radiation.

State and explain procedures

- to eliminate systematic error in the measurements used to find A_b
- to reduce the percentage uncertainty in A_b .

[3 marks]

[Turn over]



01.5 **FIGURE 3, on page 4 of the Diagram Booklet, shows an aluminium absorber placed between the sealed source and a radiation detector. This is to make sure that only γ radiation from the source reaches the detector.**

The sealed source emits:

- **α particles with energy E_k between 3.8 MeV and 7.8 MeV**
- **β^- particles with energy E_k between zero and 5.5 MeV.**

FIGURE 4, on page 5 of the Diagram Booklet, shows how the range of β^- particles in aluminium depends on E_k .

Deduce the minimum thickness of the aluminium absorber that should be used in the experiment. [3 marks]

minimum thickness = _____ mm

[Turn over]



01.6

Ionisation takes place inside the detector.

The effective distance travelled by γ radiation from the source is $(d + e)$.

The distance e , shown in FIGURE 5, on page 6 of the Diagram Booklet, cannot be measured directly.

From the inverse-square law for γ radiation, it can be shown that

$$(d + e) = \sqrt{\frac{k}{A}}$$

where A is the count rate, corrected for background radiation

k is a constant.

The student plots the graph of d against $\frac{1}{\sqrt{A}}$

shown in FIGURE 6, on page 7 of the Diagram Booklet.

Deduce k using FIGURE 6.

Explain your reasoning.

Give a suitable unit for your result.

[5 marks]



$k =$ _____ unit _____

0	1
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.

7

 Determine e using FIGURE 6. [2 marks]

$e =$ _____ mm

[Turn over]



0	2
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FIGURE 7, on page 8 of the Diagram Booklet, shows apparatus used to investigate the rate at which water flows through a horizontal cylindrical tube T of internal diameter d and length L .

The apparatus ensures that the water level in the can is at a constant height h above the centre of T.

Water flows out of T at a steady rate.

0	2	.	1
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The volume flow rate through T is Q , where Q is in $\text{m}^3 \text{s}^{-1}$.

A student wants to measure Q as water flows through T.

Outline a procedure the student should follow to measure Q .

Include in your answer

- the measuring instruments used**
- how uncertainty in the measurements can be reduced.**

[4 marks]

02.2 It can be shown that

$$Q = \frac{\pi \rho g h d^4}{128 L \eta}$$

where ρ is the density of water
 g is the gravitational field strength
 η is a property of the water called the
 coefficient of viscosity.

What is the SI unit for η ?

Tick (✓) ONE box. [1 mark]

☐

$\text{N m}^{-1} \text{ s}$

☐

$\text{N m}^{-2} \text{ s}$

☐

$\text{N m}^{-1} \text{ s}^{-1}$

☐

$\text{N m}^{-2} \text{ s}^{-1}$



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02.3

An experiment is carried out to determine η by a graphical method.

The rate at which water flows out of T is varied by adjusting the height of the drain tube as shown in FIGURE 8, on page 9 of the Diagram Booklet.

During the experiment the temperature is kept constant.

Q is found for different values of h and a graph of these data is plotted, with Q on the vertical axis.

The percentage uncertainty in the gradient of the graph is 6.4%.

The dimensions of tube T are measured and the uncertainties in these data are calculated.

The percentage uncertainty

- in d is 2.9%
- in L is 1.8%.

The percentage uncertainties in ρ and g are negligible.

Deduce the percentage uncertainty in the result for η . [2 marks]

percentage uncertainty in η = _____

[Turn over]



02.4

In a different experiment, the horizontal tube T is connected to a vertical glass tube.

Marks have been made at regular intervals on the glass tube.

The student measures and records the vertical distance y between each of the marks and the centre of T.

She seals the open end of T and fills the glass tube with water, as shown in FIGURE 9, on the opposite page.

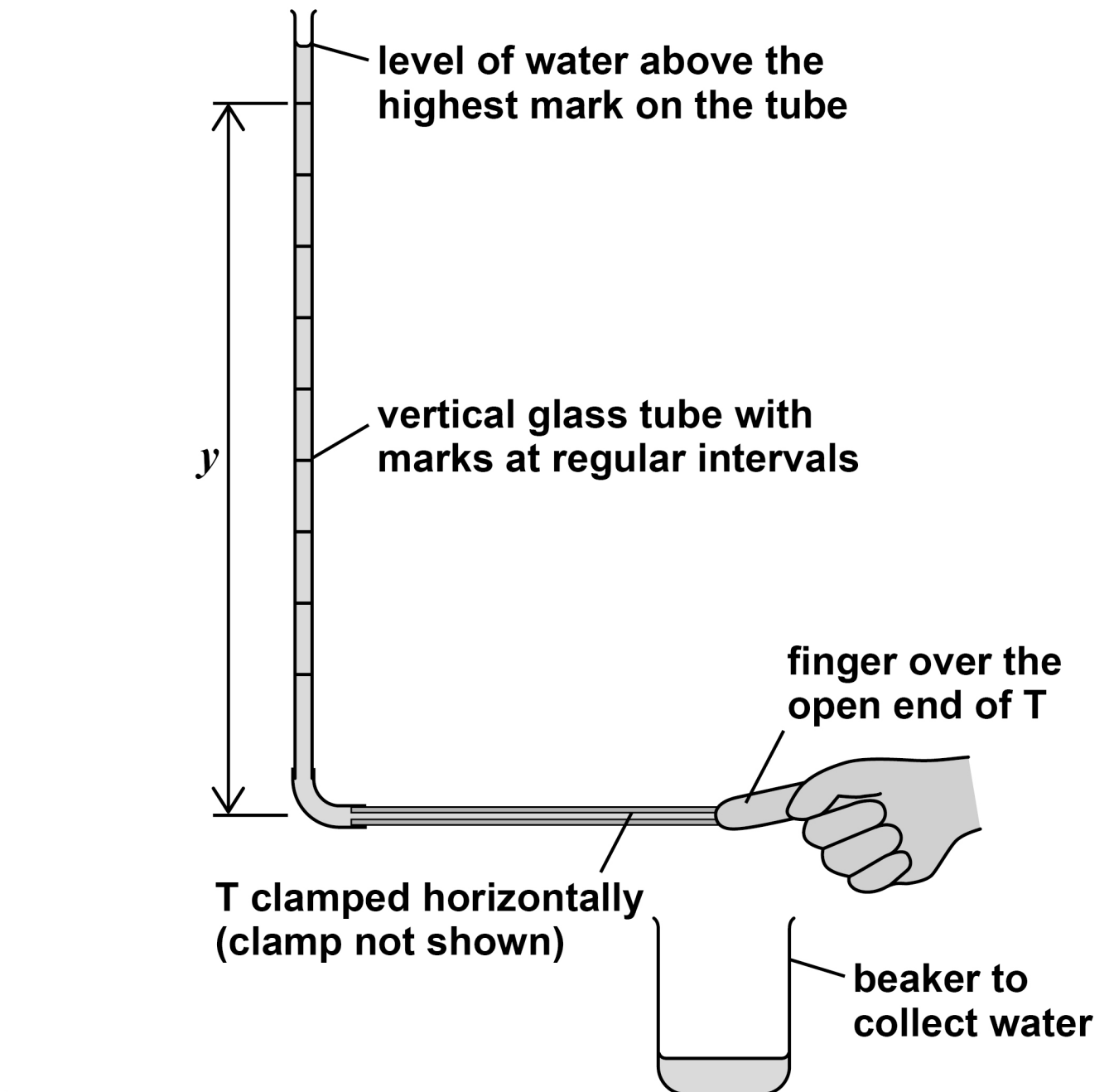
T is opened and water flows into a beaker. When the water level falls to the highest mark on the tube, she starts a stopwatch.

She records the time t for the water to reach each of the other marks.

Explain how the student could check that the glass tube was vertical.

You may wish to add detail to FIGURE 9 to illustrate your answer. [1 mark]

FIGURE 9

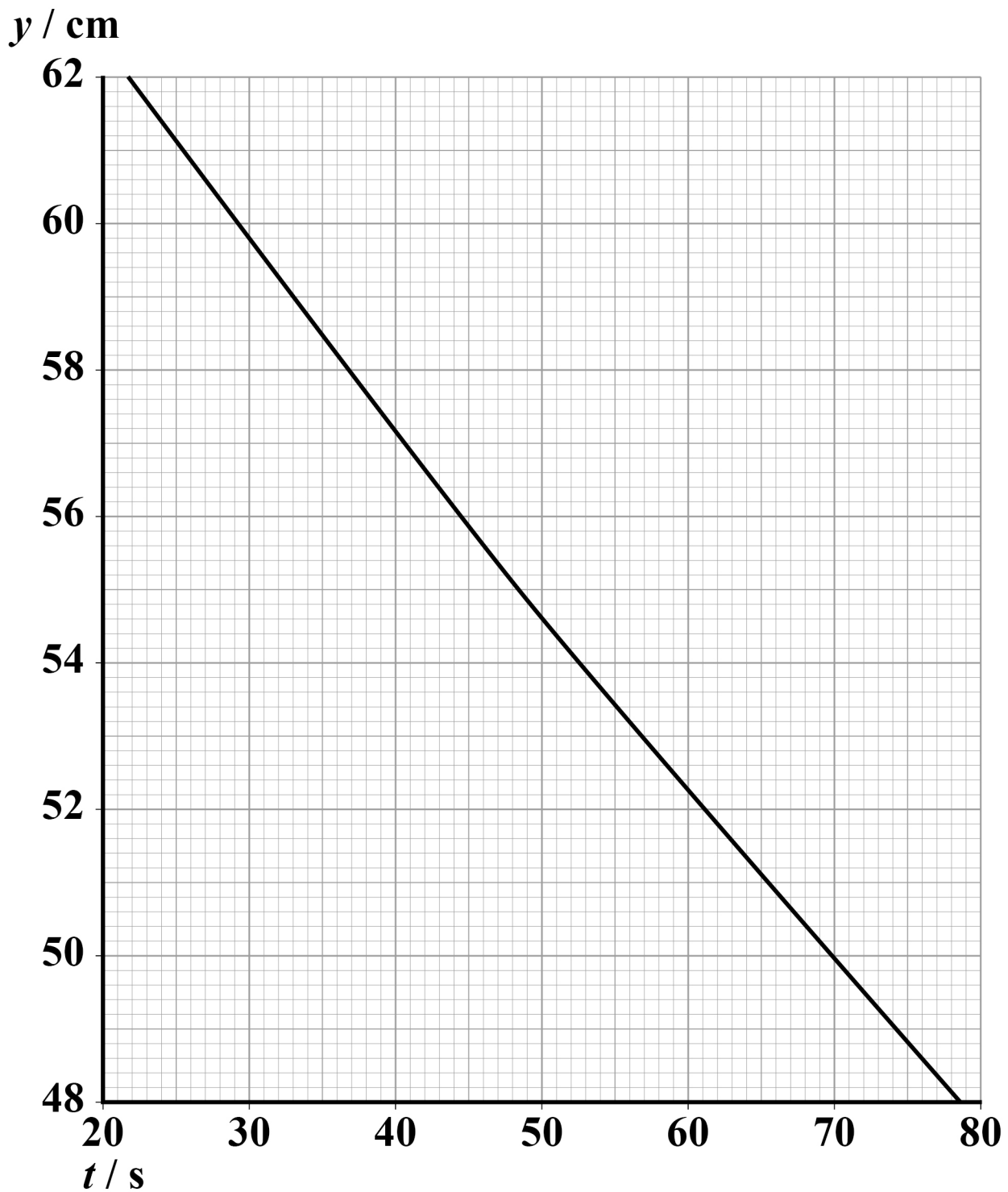


[Turn over]



02.5 FIGURE 10 shows part of the graph drawn from the student's data.

FIGURE 10



It can be shown that y decreases exponentially with t .

Show that λ , the decay constant for this process, is about $4.5 \times 10^{-3} \text{ s}^{-1}$.
[2 marks]

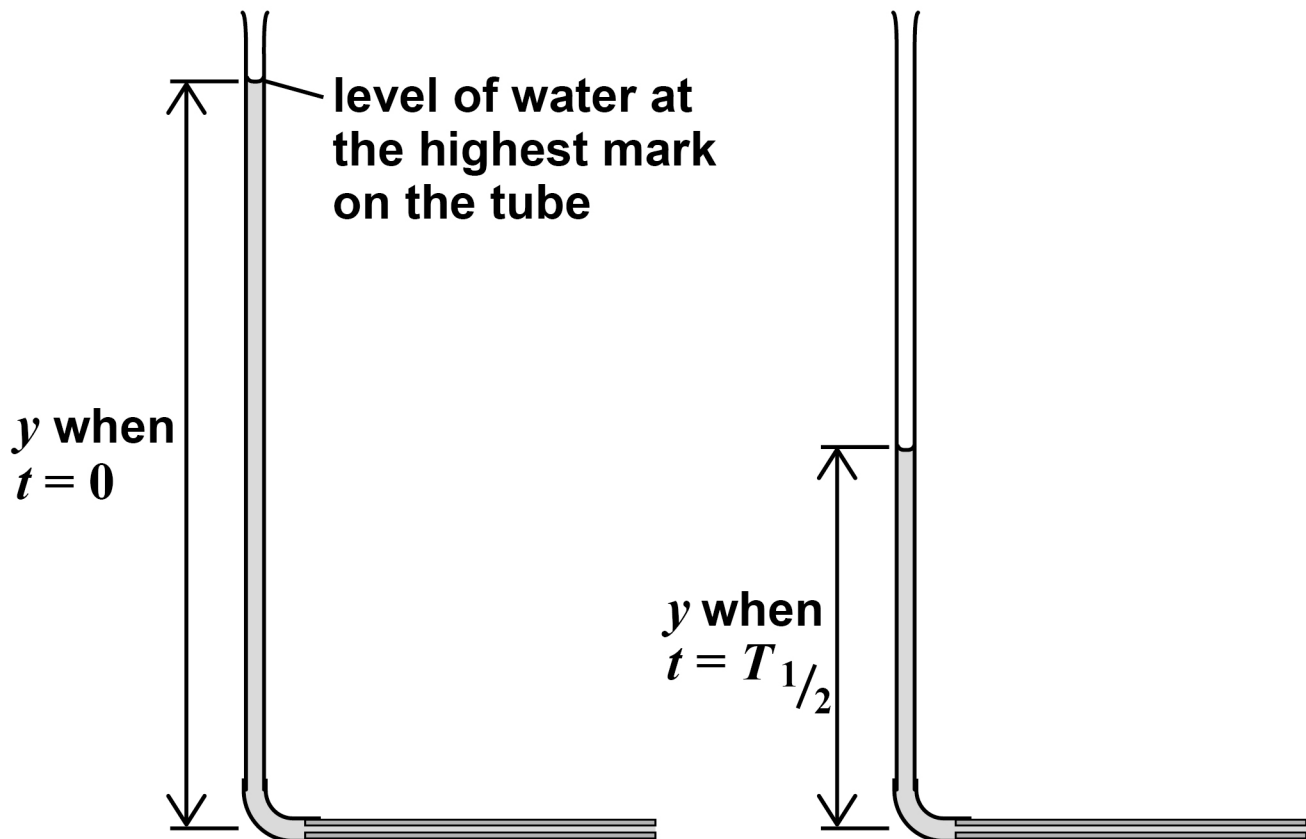
$$\lambda = \underline{\hspace{4cm}} \text{ s}^{-1}$$

[Turn over]



02.6 $T_{1/2}$ is the time for y to decrease by 50%, as shown in FIGURE 11.

FIGURE 11



25

Determine $T_{1/2}$. [1 mark]

$T_{1/2}$ = _____ s

[Turn over]



- 02.7** The apparatus is adjusted so that the glass tube is inclined at 30° to the horizontal tube T, as shown in FIGURE 12, on page 10 of the Diagram Booklet.

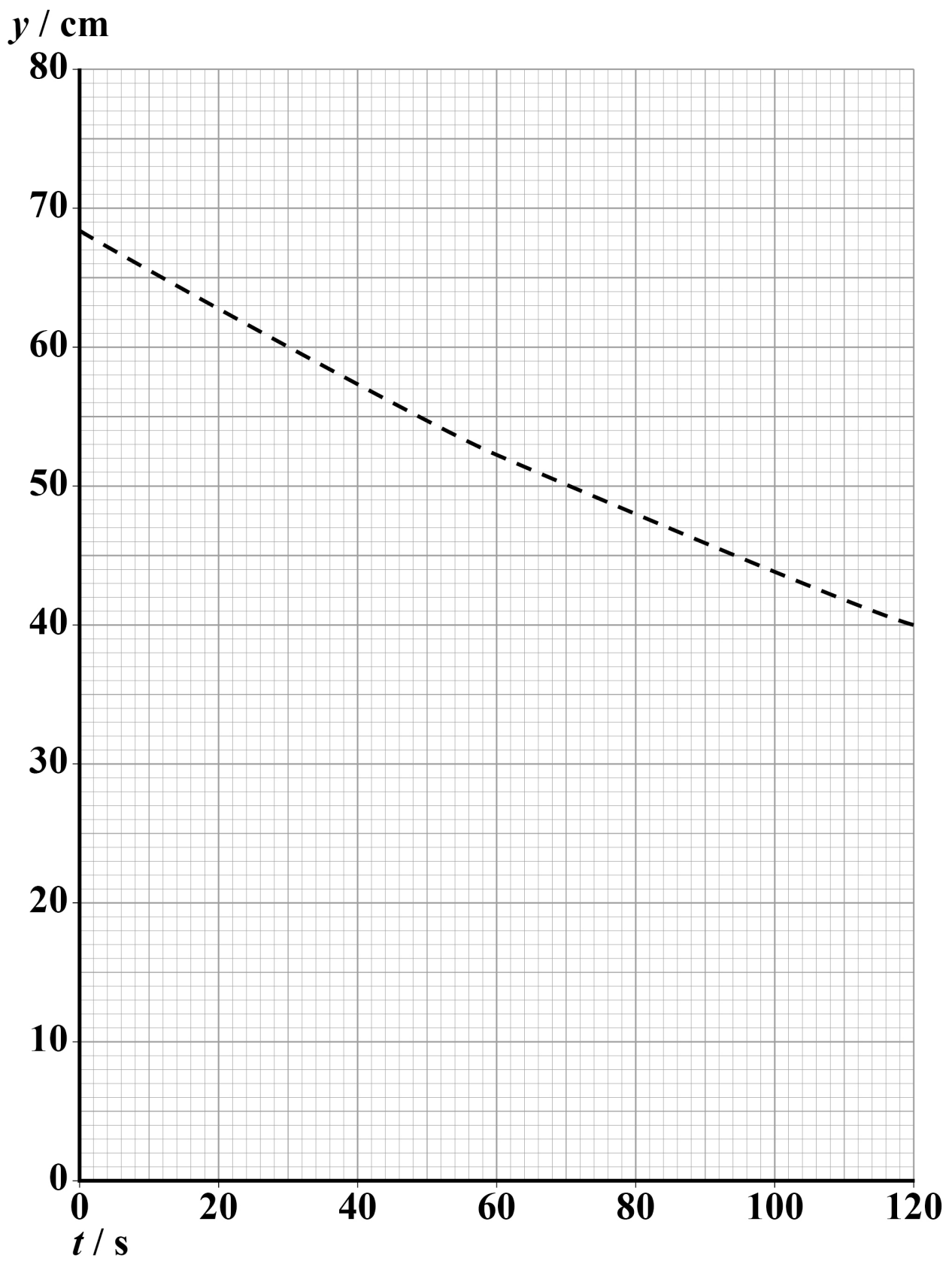
The student measures and records the new values of y , the mean vertical distance between each of the marks and the centre of T.

She then carries out the experiment as before, recording new values of t corresponding to each new value of y .

Draw a line on FIGURE 13, on the opposite page, to show the graph produced using the modified apparatus.

The dashed line is the original graph when the glass tube was vertical as shown in FIGURE 9, on page 21. [2 marks]

FIGURE 13



[Turn over]



0	3
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A stationary wave is formed on a stretched wire.

FIGURE 14, on page 11 of the Diagram Booklet, shows the wire, fixed at one end, supported by two bridges and passing over a pulley.

A 0.500 kg mass is attached to the free end of the wire.

A uniform horizontal magnetic field is applied perpendicular to the wire between the bridges.

A signal generator is connected to each end of the wire.

The oscilloscope shown is used to determine the frequency of the output of the signal generator. The wire oscillates because the alternating current in the wire interacts with the magnetic field.

FIGURE 15, on page 12 of the Diagram Booklet, shows the first harmonic stationary wave produced when the distance x between the bridges is adjusted.

03.1 The output potential difference (pd) of the signal generator is displayed on the oscilloscope, as shown in FIGURE 16, on page 13 of the Diagram Booklet.

The time-base setting of the oscilloscope is 10 ms cm^{-1} .

Determine f , the frequency of the alternating pd. [2 marks]

$f =$ _____ Hz

[Turn over]



- 03.2** A metre ruler is placed next to the bridges supporting the wire, as shown in FIGURE 17, on page 14 of the Diagram Booklet.

Determine the wavelength λ of the stationary wave shown in FIGURE 17. [2 marks]

$\lambda =$ _____ m

- 03.3** The stationary wave is formed by two waves of frequency f and wavelength λ travelling with speed c in opposite directions.

Determine c . [1 mark]

$$c = \underline{\hspace{4cm}} \text{ m s}^{-1}$$

- 03.4** Determine, in kg m^{-1} , the mass per unit length of the wire. [2 marks]

$$\text{mass per unit length} = \underline{\hspace{4cm}} \text{ kg m}^{-1}$$

[Turn over]



03.5

A student uses digital vernier callipers to measure the diameter of a cylindrical metal rod. The student places the rod between the jaws of the callipers and records the reading indicated. Without pressing the zero button, the student removes the rod and closes the jaws.

FIGURE 18, on page 15 of the Diagram Booklet, shows the calliper readings in millimetres, before and after the jaws are closed.

Calculate the diameter d of the rod. [1 mark]

$d =$ _____ mm

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[Turn over]



0	3	.	6
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Describe relevant procedures to limit the effect of random error in the result for d . [2 marks]

[illegible]

[Turn over]



0	3	.	7
---	---	---	---

Determine the density of the rod.
The mass per unit length of the rod is
 $3.54 \times 10^{-3} \text{ kg m}^{-1}$. [3 marks]

density = _____ kg m^{-3}

END OF QUESTIONS

13



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Question	Mark
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