Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

A-level PHYSICS

Paper 3
Section A

Tuesday 17 June 2025 Morning

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.

Materials

For this paper you must have:
- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet
- 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.
- 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.
- Show all your working.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
TOTAL	

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.

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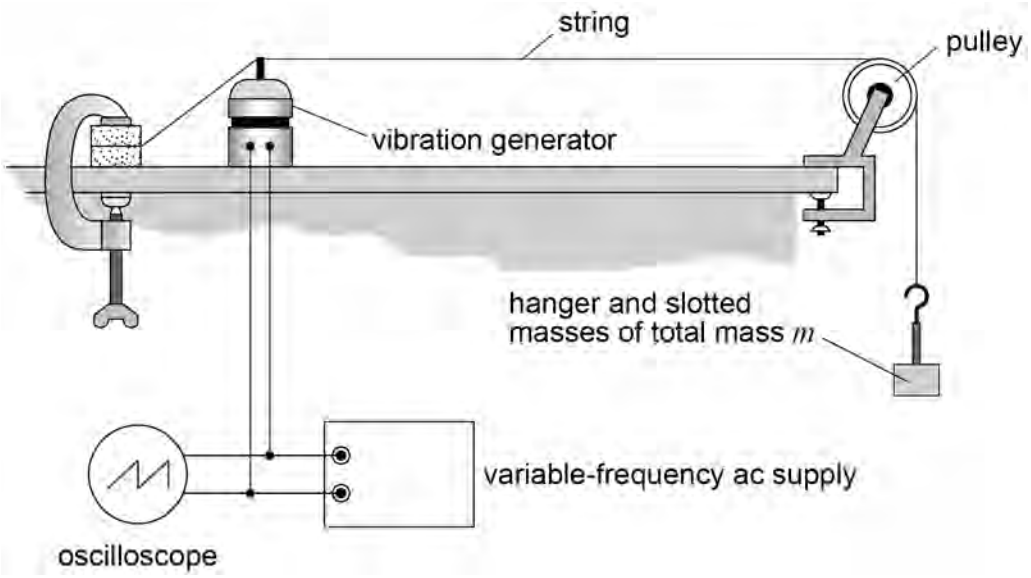
Section A

Answer **all** questions in this section.

0 1 This question is based on an investigation into how the frequency of the first-harmonic stationary wave on a string varies with tension (required practical activity 1).

Figure 1 shows the arrangement for this investigation.

Figure 1



The tension in the string is equal to the weight mg of the total mass m tied to the string.

The frequency is changed until the first-harmonic stationary wave appears on the string. This frequency f is determined using the oscilloscope.

The process is repeated for different values of m.

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0 1 . 1 Identify **two** control variables for the arrangement shown in **Figure 1**.

You may annotate **Figure 1** as part of your answer.

[2 marks]

1 _____

_____

2 _____

_____

0 1 . 2 The total mass m is made from a mass hanger and up to three slotted masses.

One 20 g, one 50 g and one 100 g slotted mass are provided.
The hanger has a mass of 100 g.

The hanger must not be removed from the string.

Which statement is correct?

Tick (✓) **one** box.

[1 mark]

m has a maximum range of 170 g. ☐

m has a maximum of 7 different values. ☐

m values are evenly distributed across the range. ☐

Question 1 continues on the next page

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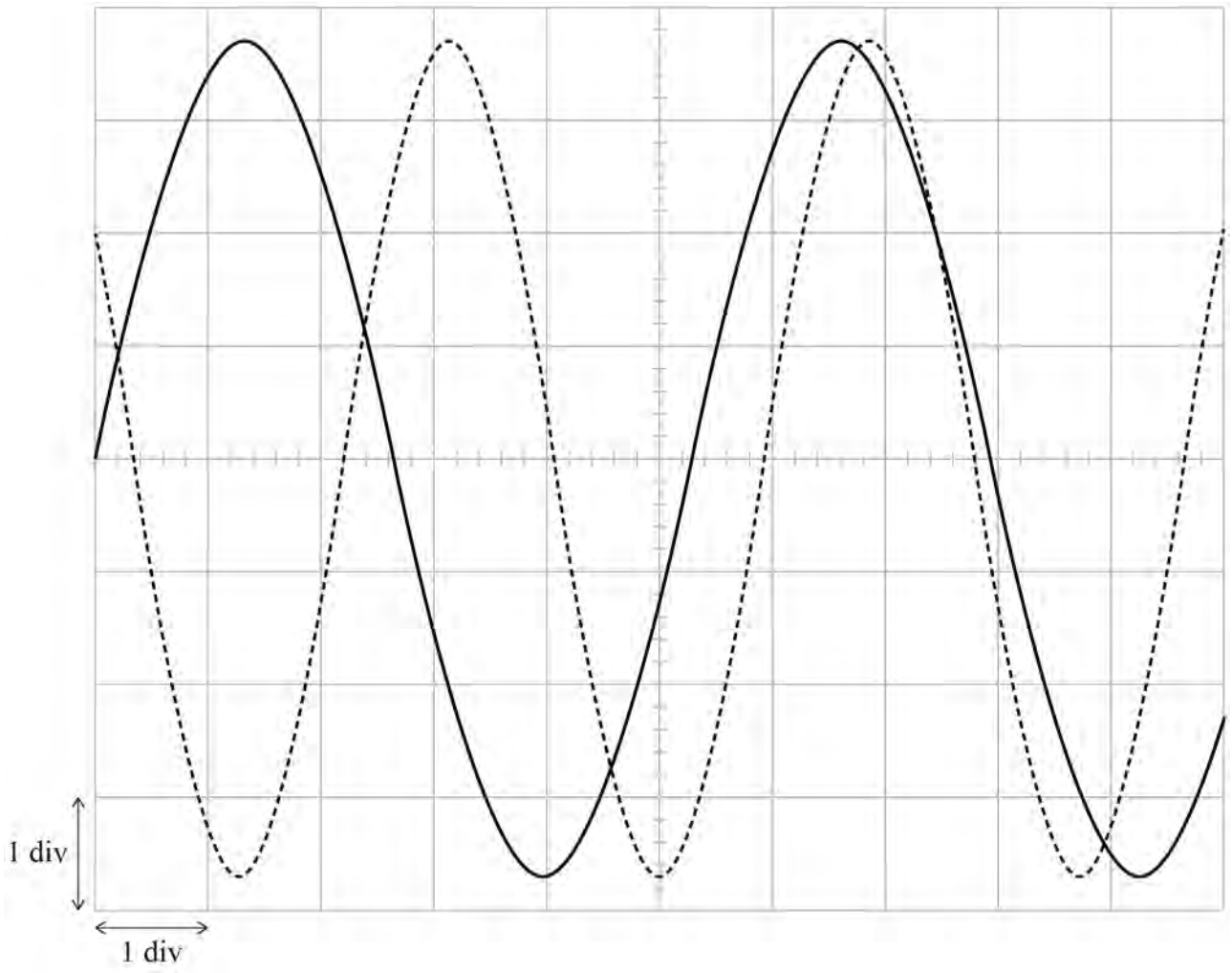
The frequency f is calculated using the waveform displayed on the oscilloscope.
Figure 2 shows the waveforms displayed on the oscilloscope when $m = 100$ g and when $m = 200$ g.

Figure 2



The y-voltage gain setting is $5\ \text{V div}^{-1}$.
The time-base setting is $20\ \text{ms div}^{-1}$.

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0 1 . 3 Determine V_{rms}, the root mean square voltage of the ac supply.

[2 marks]

V_{rms} = _____ V

0 1 . 4 Determine the period of the waveform on **Figure 2** when m = 100 g.

[1 mark]

period = _____ ms

0 1 . 5 Deduce whether **Figure 2** shows the expected result of doubling m from 100 g to 200 g.

[2 marks]

_____

_____

_____

8

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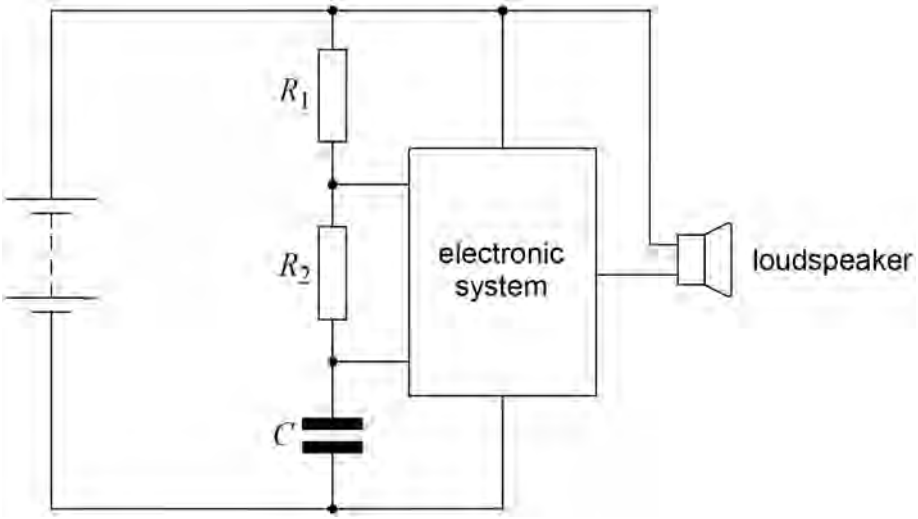
0 2 **Figure 3** shows a circuit that causes a loudspeaker to emit 'clicks' at a constant rate. The time T between successive clicks depends on the resistances R_1 and R_2 and the capacitance C.
You do not need to know any details about the electronic system.

Figure 3



A student uses a stopwatch to determine T.
Table 1 shows the student's repeated measurements of $20T$.

Table 1

$20T$ / s	**$20T$ / s**	**$20T$ / s**	**$20T$ / s**	**$20T$ / s**
19.22	18.91	19.36	19.04	19.45

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0 2 . 1 Suggest why the student measures $20T$.

[1 mark]

0 2 . 2 Suggest why the student repeats their measurements of $20T$.

[1 mark]

0 2 . 3 Determine the percentage uncertainty in the student's result for T.
Assume that all the data in **Table 1** are valid.

[2 marks]

percentage uncertainty in T = _____ %

Question 2 continues on the next page

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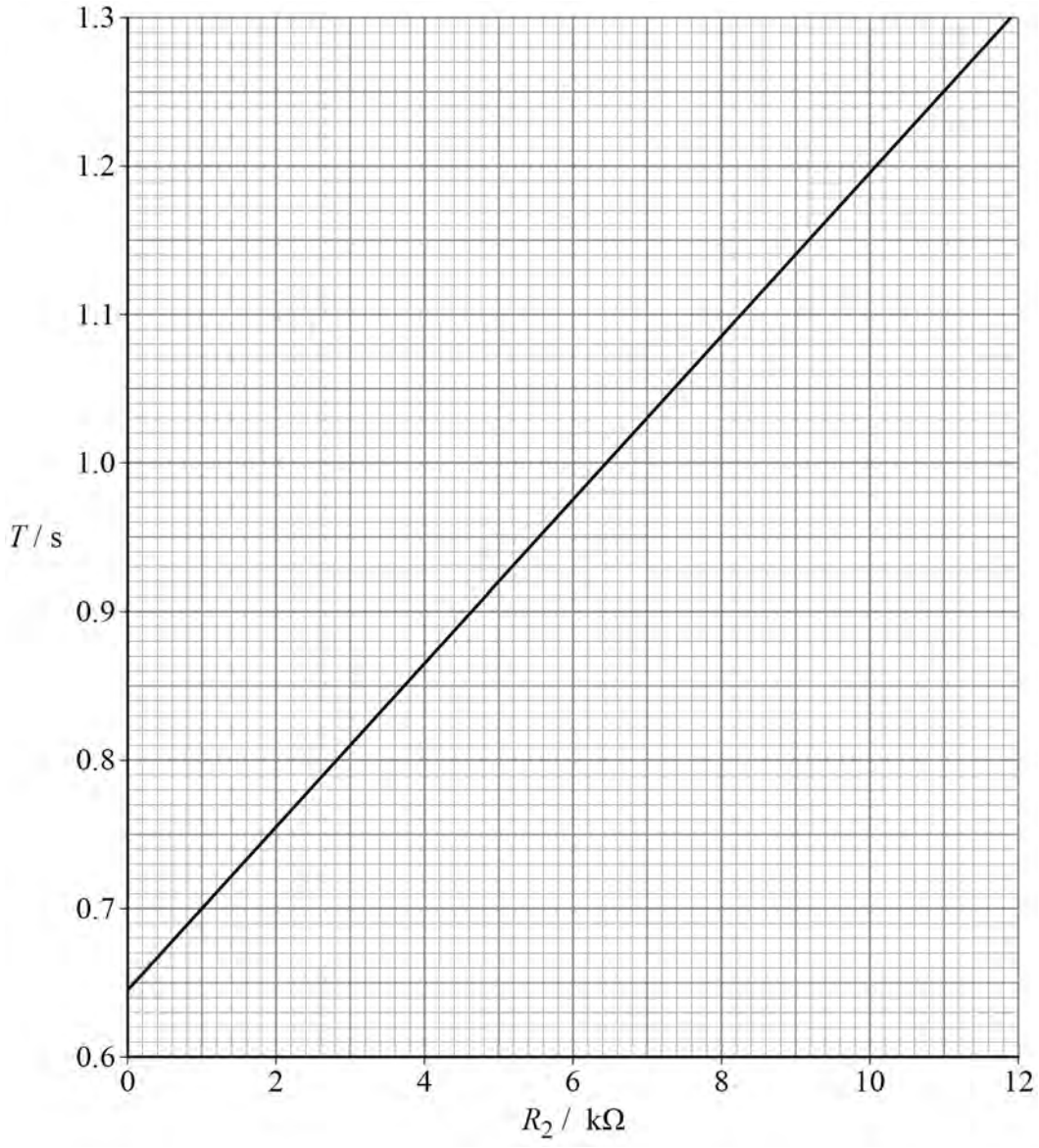
The student determines T for different values of R_2.
The values of R_1 and C are not changed.

The student produces the graph in **Figure 4**.

Figure 4



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0 2 . 4 It can be shown that

$$T = (R_1 + 2R_2)C \ln 2$$

Determine C and R_1.

[5 marks]

$C =$ _____ F

$R_1 =$ _____ Ω

Question 2 continues on the next page

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0 2 . 5 The student has access to a range of fixed and variable resistors.
The student wants to modify the circuit in **Figure 3** so that T can be varied continuously from a minimum of 0.70 s to a maximum of 1.25 s.

Show how the student can achieve this by combining two resistors to make R_2.
You should use information from **Figure 4**.

[3 marks]

12

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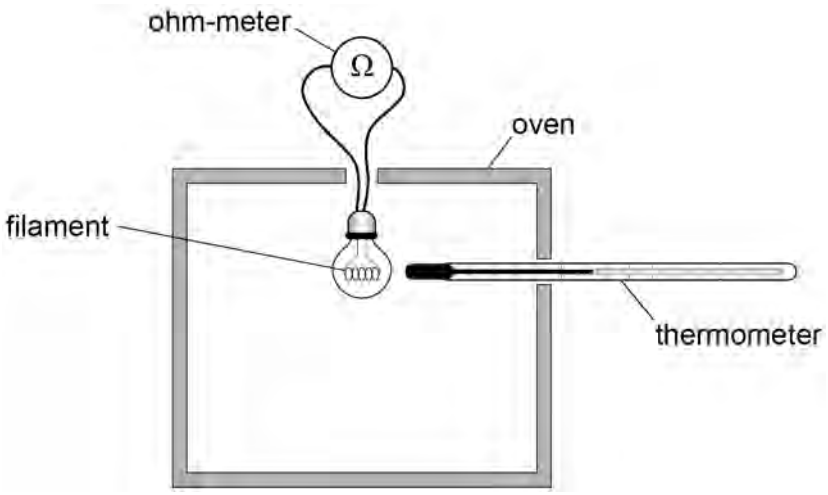
0 3 **Figure 5** shows apparatus to investigate how the resistance R of a lamp filament varies with the absolute temperature T of the filament.

Figure 5



The lamp is inside an oven.

The oven temperature is increased to a steady value.
The filament is at the same temperature as the inside of the oven.

The temperature T in kelvin is determined using the thermometer.
An ohm-meter is connected to the filament to determine R at temperature T.

The oven temperature is increased to new steady values and further readings of T and R are recorded.

Question 3 continues on the next page

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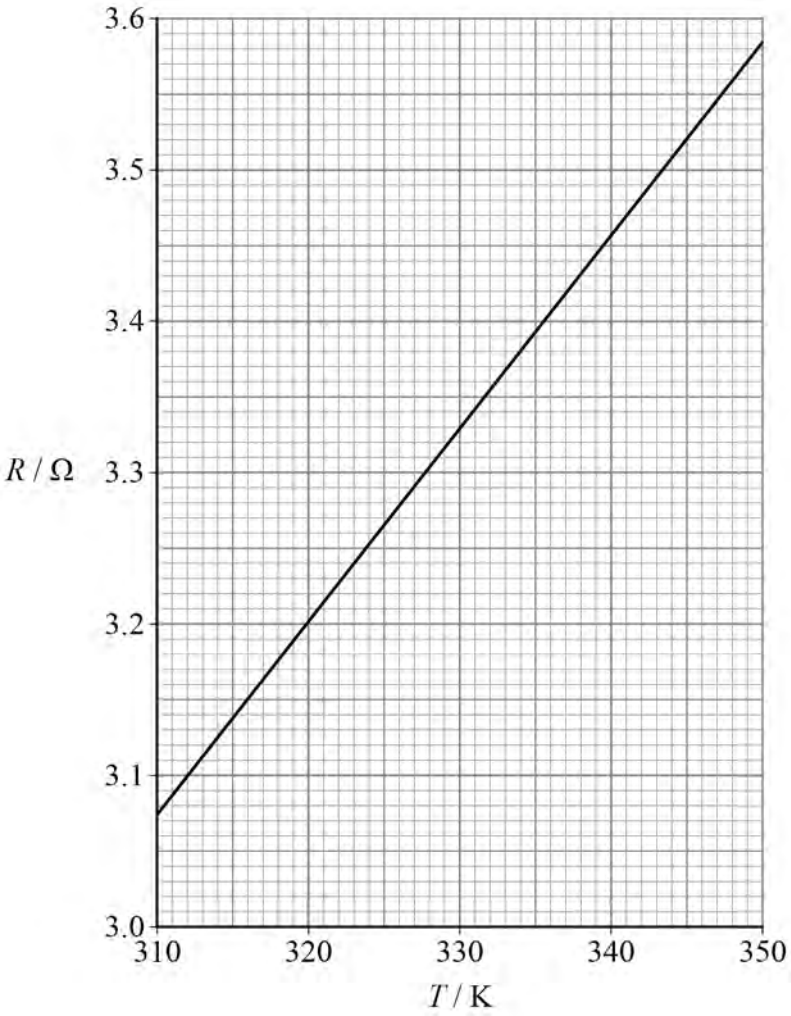
Figure 6 shows the variation of R with T.

Figure 6



It can be shown that:

$$\frac{R - R_0}{R_0} = \alpha\left(T - T_0\right)$$

where:

R_0 is the resistance of the filament at temperature T_0

α is a constant.

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0 3 . 1 Determine α using the graph in **Figure 6**.
State an appropriate SI unit for your answer.

$R_0 = 2.83\ \Omega$ when $T_0 = 291\ \text{K}$

[3 marks]

α = _____ unit = _____

Question 3 continues on the next page

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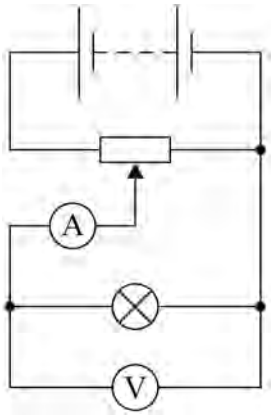
In a different investigation, a student investigates how the electrical power P transferred in the same filament lamp varies for values of T greater than $800\ \text{K}$.

The student assumes that α is constant for all values of T.

Figure 7 shows the circuit that the student uses.
The temperature of the filament is controlled by the energy supplied to it from the battery.

Figure 7



0 3 . 2 Explain how the ammeter and voltmeter readings are used to determine values of P and T.

[2 marks]

P

T

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Question 3 continues on the next page

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For a steady value of T, $P = P_1 + P_2$

where:

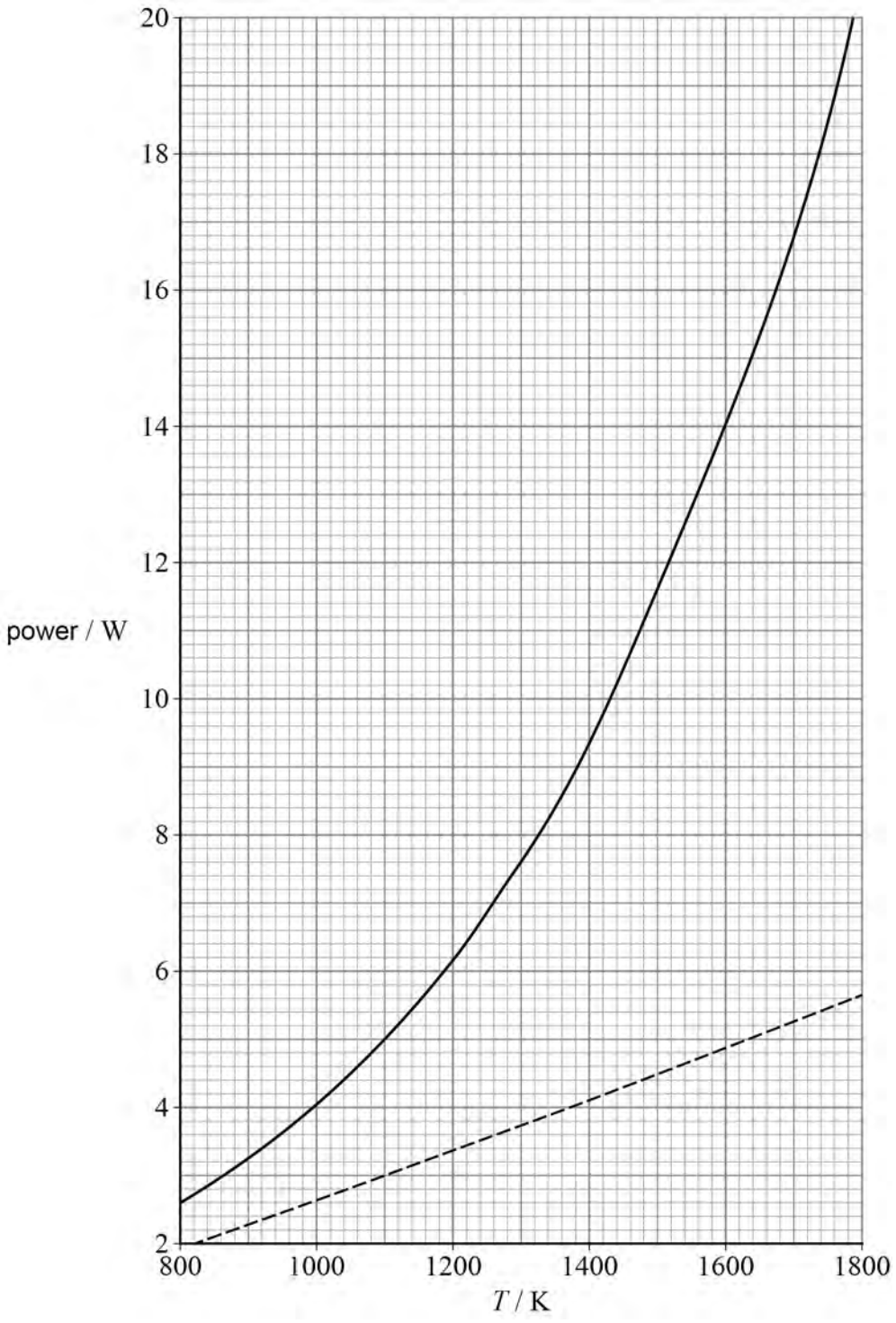
P_1 is the rate of heat transfer from the filament by radiation

P_2 is the rate of heat transfer from the filament by all other processes.

In **Figure 8**:

- the solid line shows how P varies with T
- the dashed line shows how P_2 varies with T.

Figure 8



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0 3 . 3 Complete **Table 2**.

[3 marks]

Table 2

T / K	P / W	P_1 / W	P_2 / W
960	3.7	1.2	2.5
1100		2.0	3.0
1370			
1680	16.2	11.0	

Question 3 continues on the next page

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0 3 . 4 It can be shown that $P_1 \propto T^n$ where n is an integer.

Determine n.

In your answer you should:
- use **Table 3** to organise the data you will plot
- plot a suitable graph on **Figure 9**.

[5 marks]

Table 3

T / K	P_1 / W		
960	1.2		
1100	2.0		
1370			
1680	11.0		

n = _____

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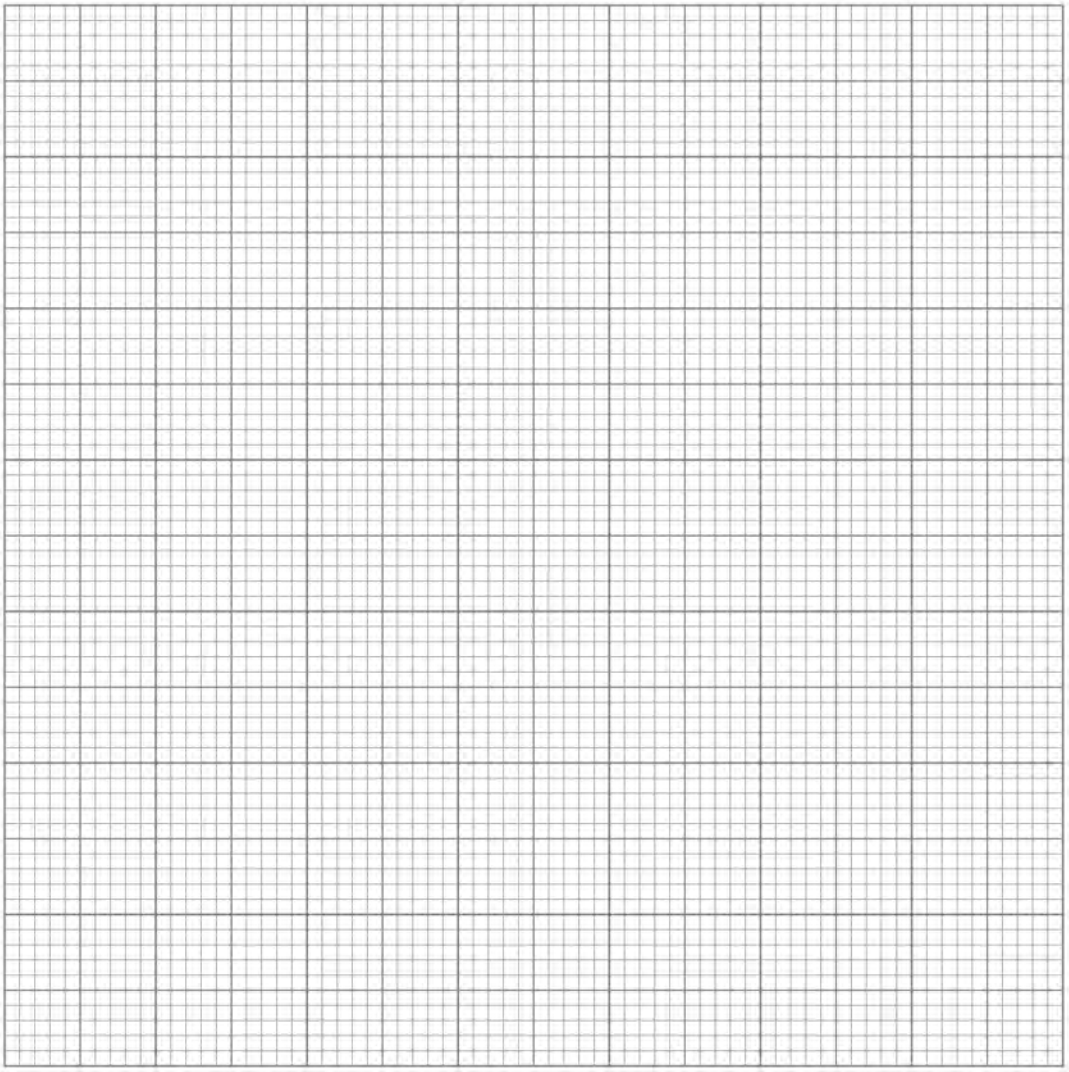
Figure 9



13

Turn over for the next question

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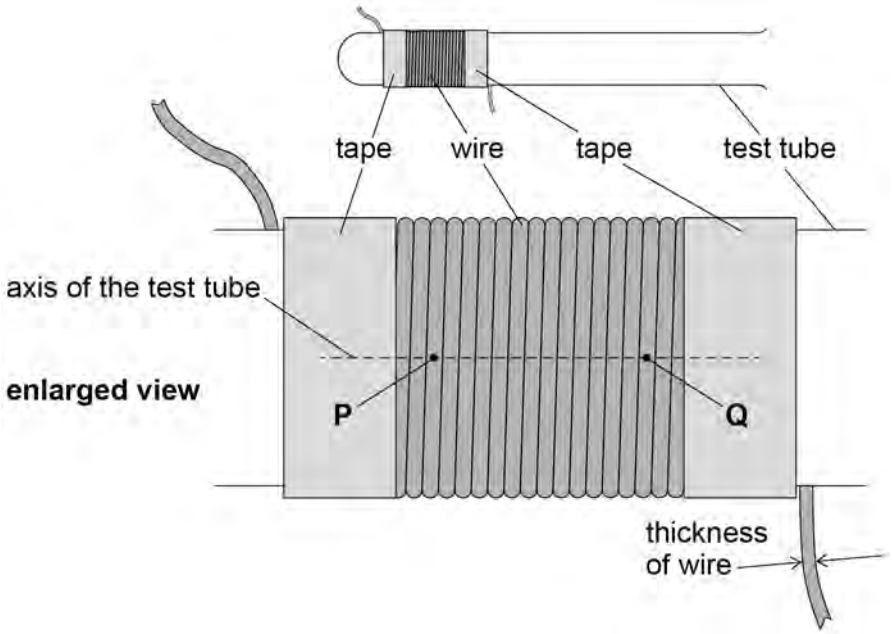
0 4 This question is about the vertical oscillations of a test tube in a liquid.

Figure 10 shows some wire wound tightly around a test tube.
The ends of the wire are secured with tape.

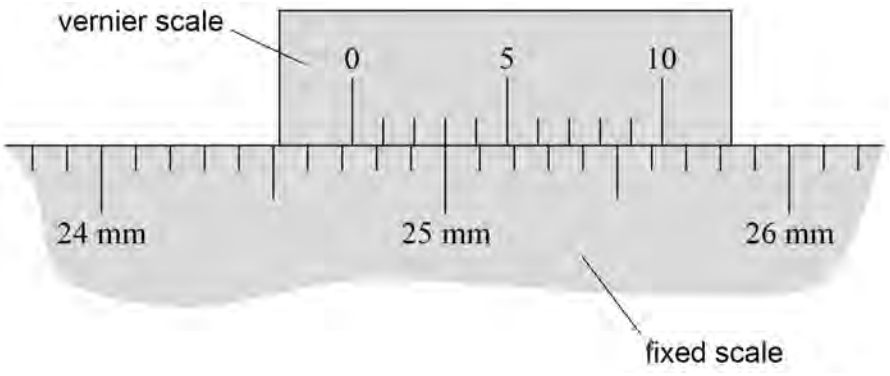
Figure 10



P and **Q** are points marked on the wire, as shown in the enlarged view in **Figure 10**.
A travelling microscope with a vernier scale is used to measure the distance between **P** and **Q**.
The microscope reading at **P** is 9.26 mm.

Figure 11 shows the microscope reading at **Q**.

Figure 11



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0 4 . 1 Show that the wire has a thickness of approximately $1.2\ \text{mm}$.

[2 marks]

0 4 . 2 The external diameter of the test tube is $18.0\ \text{mm}$.

Deduce the length of wire between **P** and **Q**.

[3 marks]

length of wire = _____ mm

Question 4 continues on the next page

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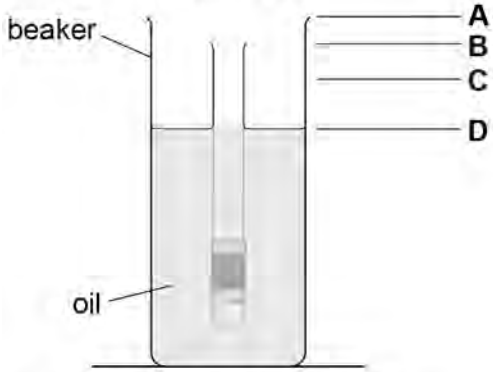
A student investigates vertical oscillations of the test tube in a liquid.

Figure 12 shows the test tube and wire floating at rest in a beaker of dark-coloured oil.
The part of the test tube below the surface cannot be seen clearly through the oil.

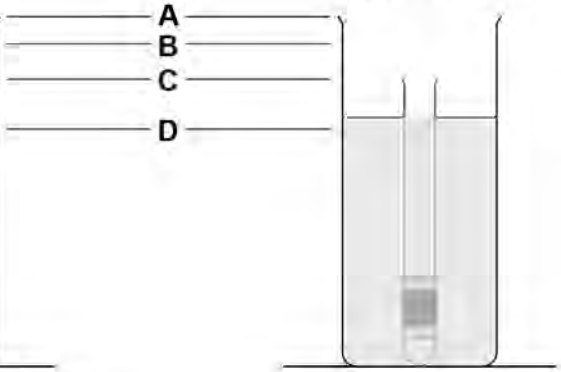
The test tube is then pushed downwards as far as possible, as shown in **Figure 13**.

Figure 12



test tube initially at rest

Figure 13



test tube at the position of release

The test tube is now released from the position shown in **Figure 13**.
The test tube oscillates vertically with simple harmonic motion of period T.

0 4 . 3 A horizontal fiducial mark is used to reduce uncertainty in the measurement of T.
The fiducial mark is to be placed level with one of the positions **A**, **B**, **C** or **D** shown in **Figures 12** and **13**.

Identify the correct position for the fiducial mark.
Go on to explain why you chose this position.

[2 marks]

position = _____

_____

_____

_____

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0 4 . 4 When the total mass of the test tube, wire and tape is constant, it can be shown that:

$$T \propto \frac{1}{\sqrt{\text{density of the liquid}}}$$

When the test tube oscillates in the oil, T is 0.587 s.
The density of the oil is 8.49×10^2 kg m^{-3}.

The test tube is cleaned and placed in an identical beaker containing milk.
When the test tube oscillates in the milk, T is 0.534 s.

Determine the density of the milk.

[2 marks]

density = _____ kg m^{-3}

0 4 . 5 Due to damping, only a small number of oscillations occurs after the test tube is released.

The student wants to produce a greater number of oscillations for a particular liquid **without** changing T.

State and explain **two** ways in which the apparatus can be modified to achieve this.

[3 marks]

1 _____

_____

_____

_____

2 _____

_____

_____

_____

12

END OF QUESTIONS

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