SPECIMEN MATERIAL v1.0

Please write clearly in block capitals.

Centre number	
Candidate number	
Surname	
Forename(s)	
Candidate signature	

A-level
PHYSICS

Paper 3A

Specimen materials (set 2)

Materials

For this paper you must have:

- a pencil
- a ruler
- a scientific calculator
- a Data and Formulae booklet.

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.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- 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 calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

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.

For examiner's use	
Question	Mark
1	
2	
3	
TOTAL	

7408/3A

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

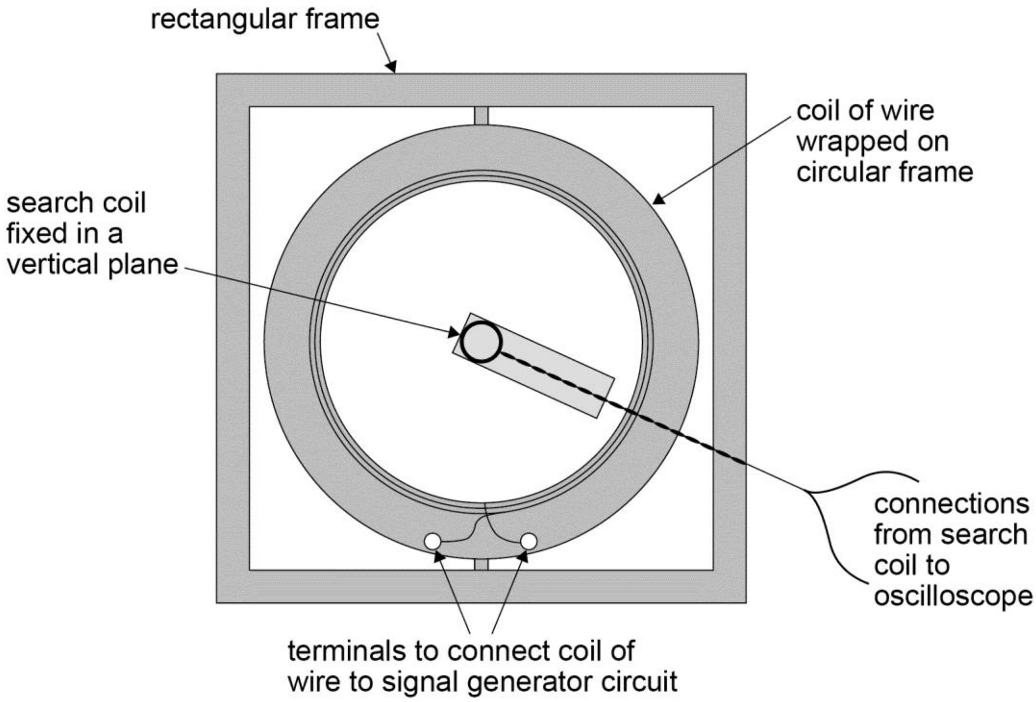
Section A

Answer **all** question(s) in this section.

0 1 This question is about experiments to investigate the magnetic flux density around a current-carrying conductor.

A student is provided with apparatus shown in **Figure 1**.

Figure 1



The apparatus consists of a circular frame on which is wound a coil of wire. This arrangement is mounted inside a rectangular frame.

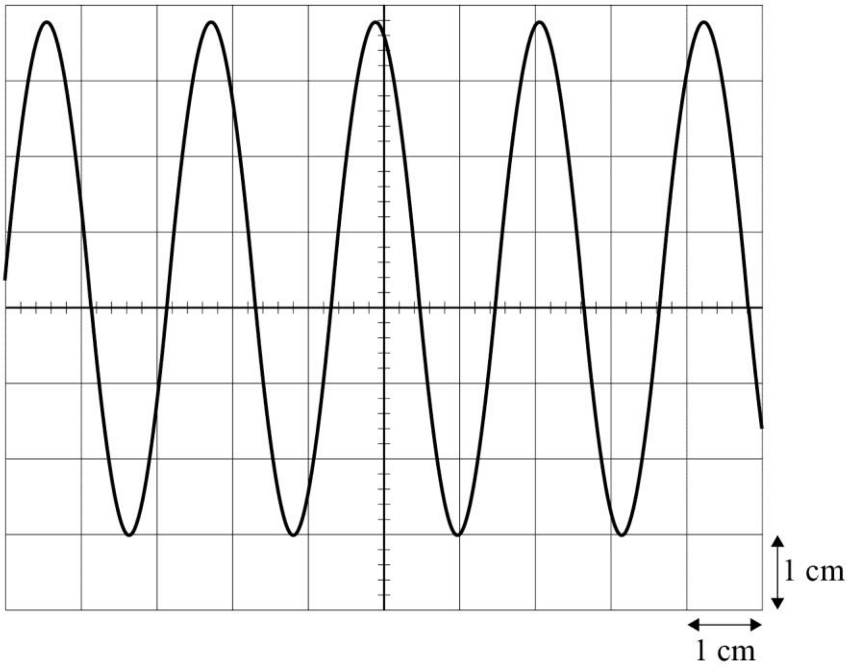
The student clamps a search coil so it is co-axial with the circular coil then arranges the apparatus so that both frames and the search coil lie in the same vertical plane.

The coil of wire is connected to a signal generator and the search coil is connected to an oscilloscope. When a sinusoidal alternating current is passed through the coil an alternating emf is induced in the search coil.

The induced emf displayed on the oscilloscope is shown in **Figure 2**.

Question 1 continues on the next page

Figure 2



0 1 . 1 Determine, using **Figure 2**, the frequency of the current in the coil.

Time-base setting of the oscilloscope is $0.2\ \text{ms cm}^{-1}$.

[2 marks]

frequency = ______________ Hz

0 1 . 2 Determine, using **Figure 2**, the root mean square (rms) voltage of the emf induced in the search coil.

y-voltage gain of the oscilloscope = $10\ \text{mV cm}^{-1}$

[2 marks]

rms voltage = ______________ V

0 1 . 3 **Figure 3** and **Figure 4** show the search coil and B_{peak}, the peak magnetic flux density produced by the current in the circular coil, when the apparatus is viewed from above.

Figure 3 shows the direction of B_{peak} when the search coil is arranged as in **Figure 1**.

Figure 4 shows the direction of B_{peak} when the circular frame is rotated through an angle θ.

The shaded area in these diagrams shows how the flux linked with the search coil changes as the circular coil is rotated.

Figure 3

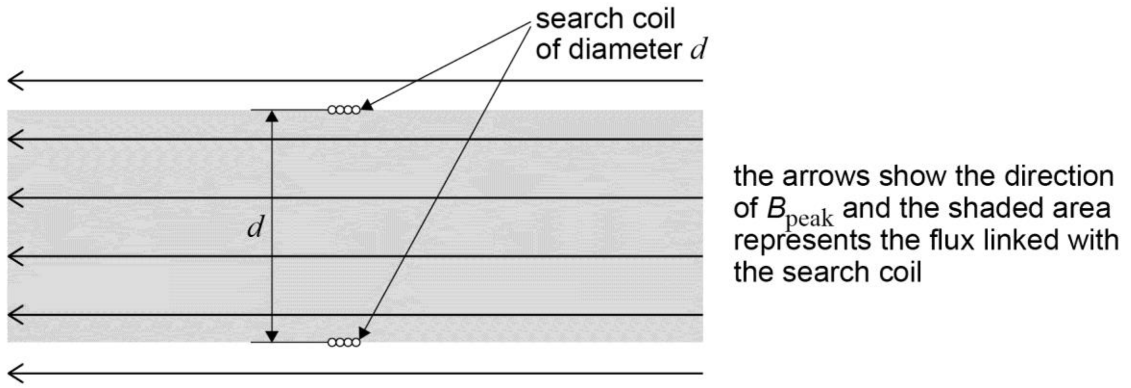
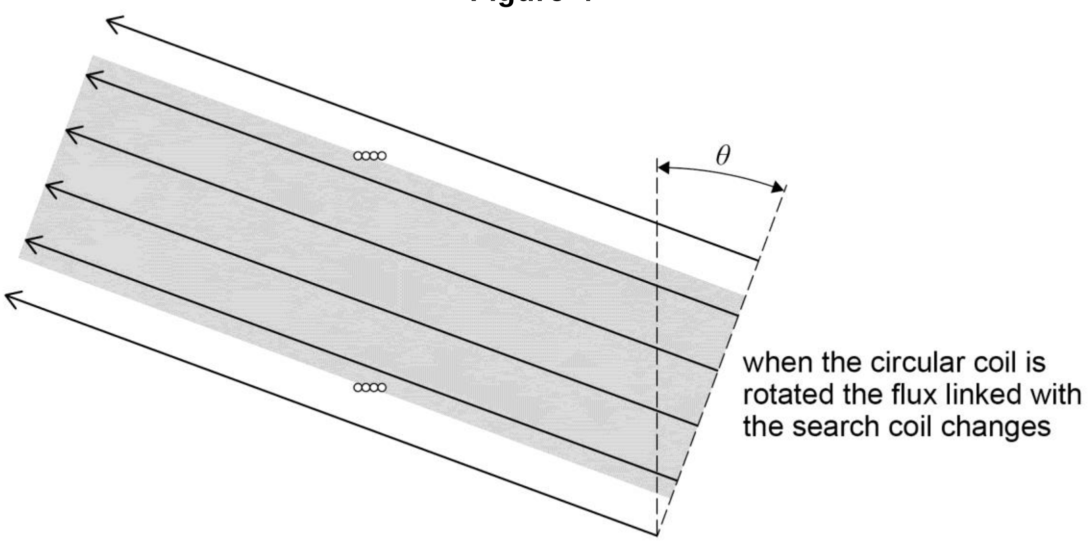


Figure 4

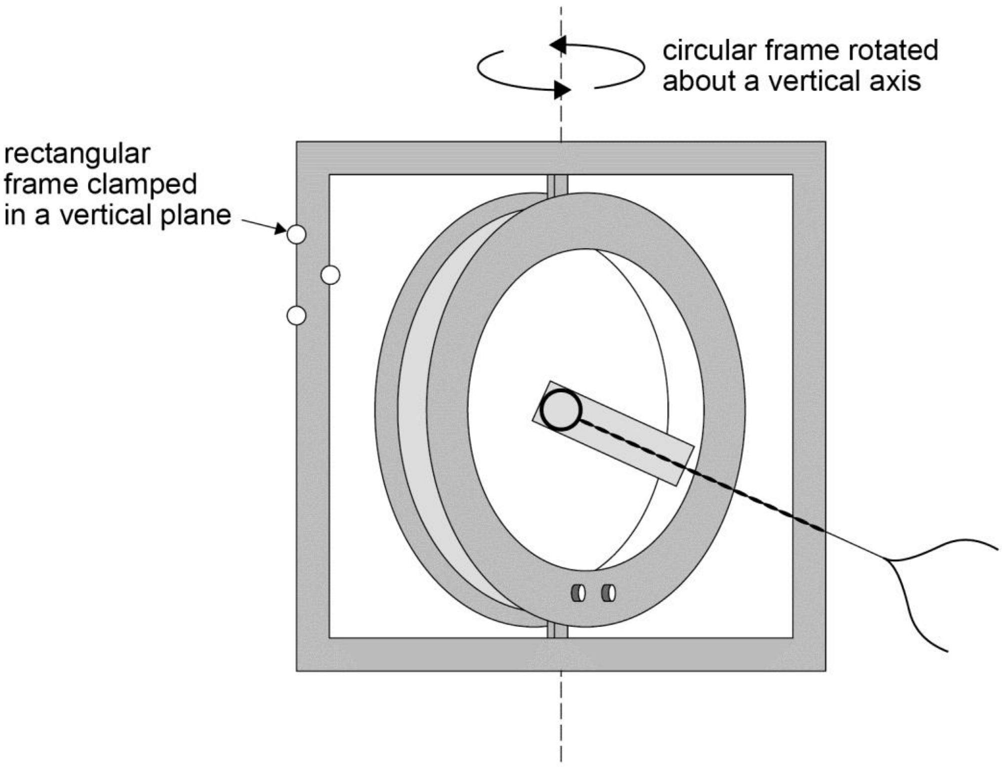


Explain why the flux linked with the coil is directly proportional to $\cos\theta$.

[2 marks]

0 1 . 4 The student clamps the rectangular frame so that it remains in a vertical plane. Without changing the position of the search coil she rotates the circular frame about a vertical axis so that it is turned through an angle, as shown in **Figure 5**.

Figure 5



She turns off the time-base on the oscilloscope so that a vertical line is displayed on the screen. Keeping the y-voltage gain at $10\,\mathrm{mV\ cm^{-1}}$ she records the length l of the vertical line and the angle θ through which the circular frame has been rotated. She measures further results for l as θ is increased as shown in **Table 1**.

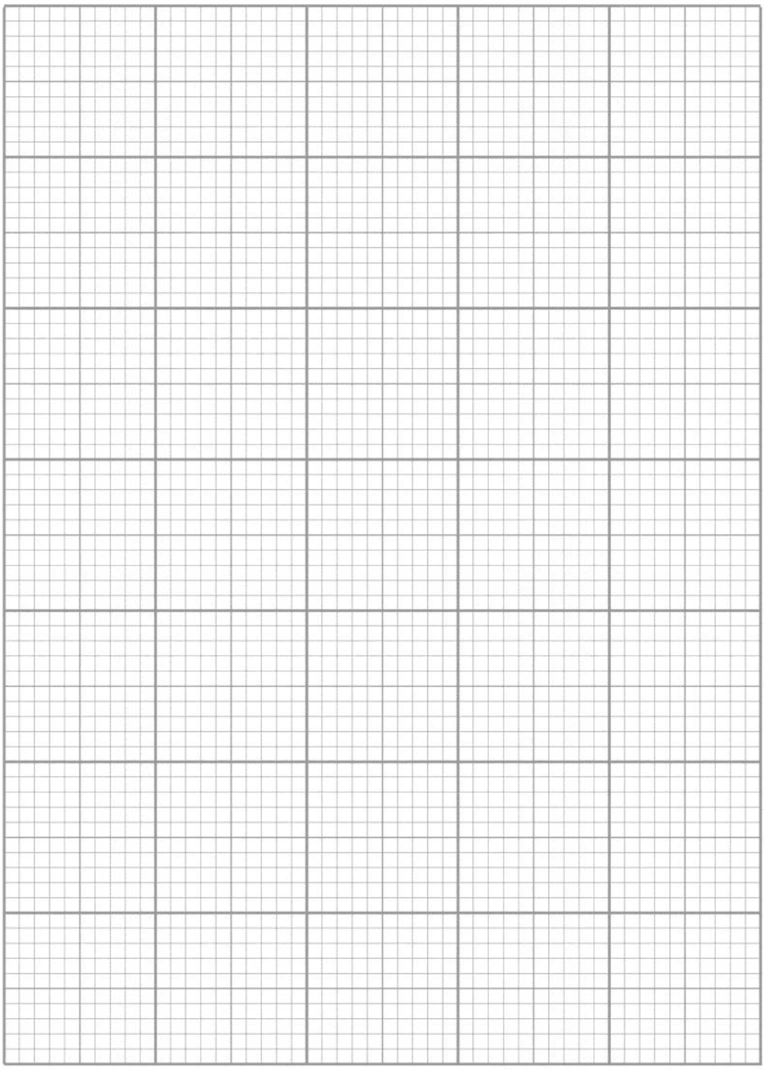
Table 1

θ/degree	l/cm	$\cos\theta$
10	6.7	
34	5.6	
50	4.4	
60	3.4	
72	2.1	
81	1.1	

Plot on **Figure 6** a graph to test if these data confirm that l is directly proportional to $\cos\theta$. Use the additional column in **Table 1** to record any derived data you use.

[4 marks]

Figure 6



0 1 . 5 State and explain whether the graph you have drawn confirms the suggestion that l is directly proportional to $\cos\theta$.

[1 mark]

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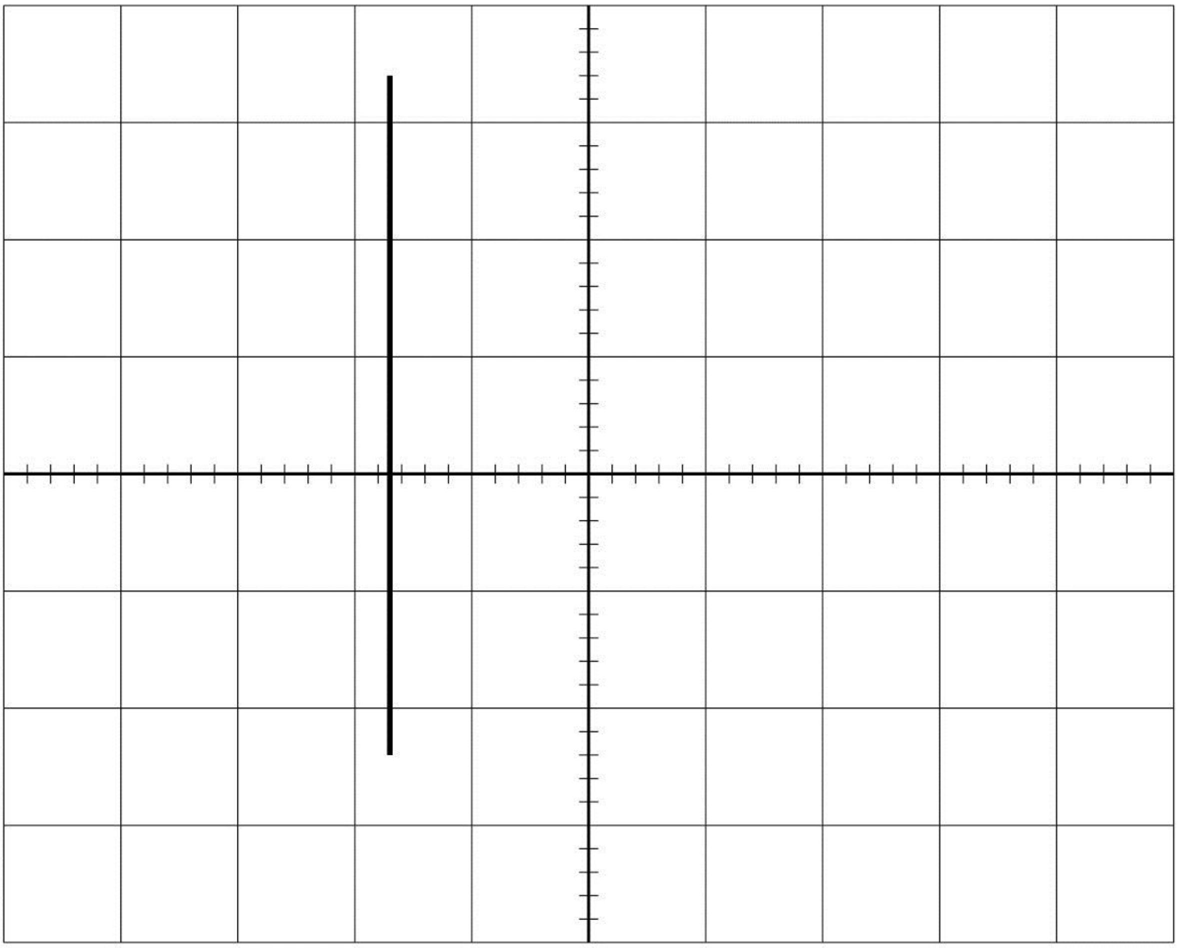
Question 1 continues on the next page

0 1 . 6 When the time-base is switched off, the trace on the oscilloscope appears as shown in **Figure 7**.

Figure 7



Describe **two** adjustments the student should make to the trace to reduce the uncertainty in l.

You should refer to specific controls on the oscilloscope. You may use **Figure 7** to illustrate your answer.

[4 marks]

0 1 . 7 The student adjusts the signal generator so that the frequency of the current in the circular coil is doubled.

State and explain any changes she should make to the settings of the oscilloscope in **Question 1.6** so that she can repeat the experiment.

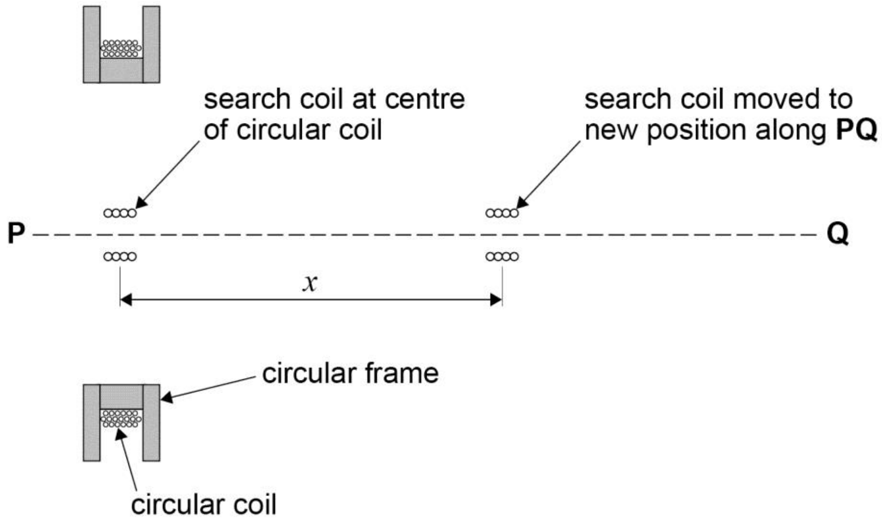
[3 marks]

Question 1 continues on the next page

0 1 . 8 The apparatus is re-arranged as in **Figure 1** so that both coils lie in the same vertical plane and are co-axial along a line **PQ**.

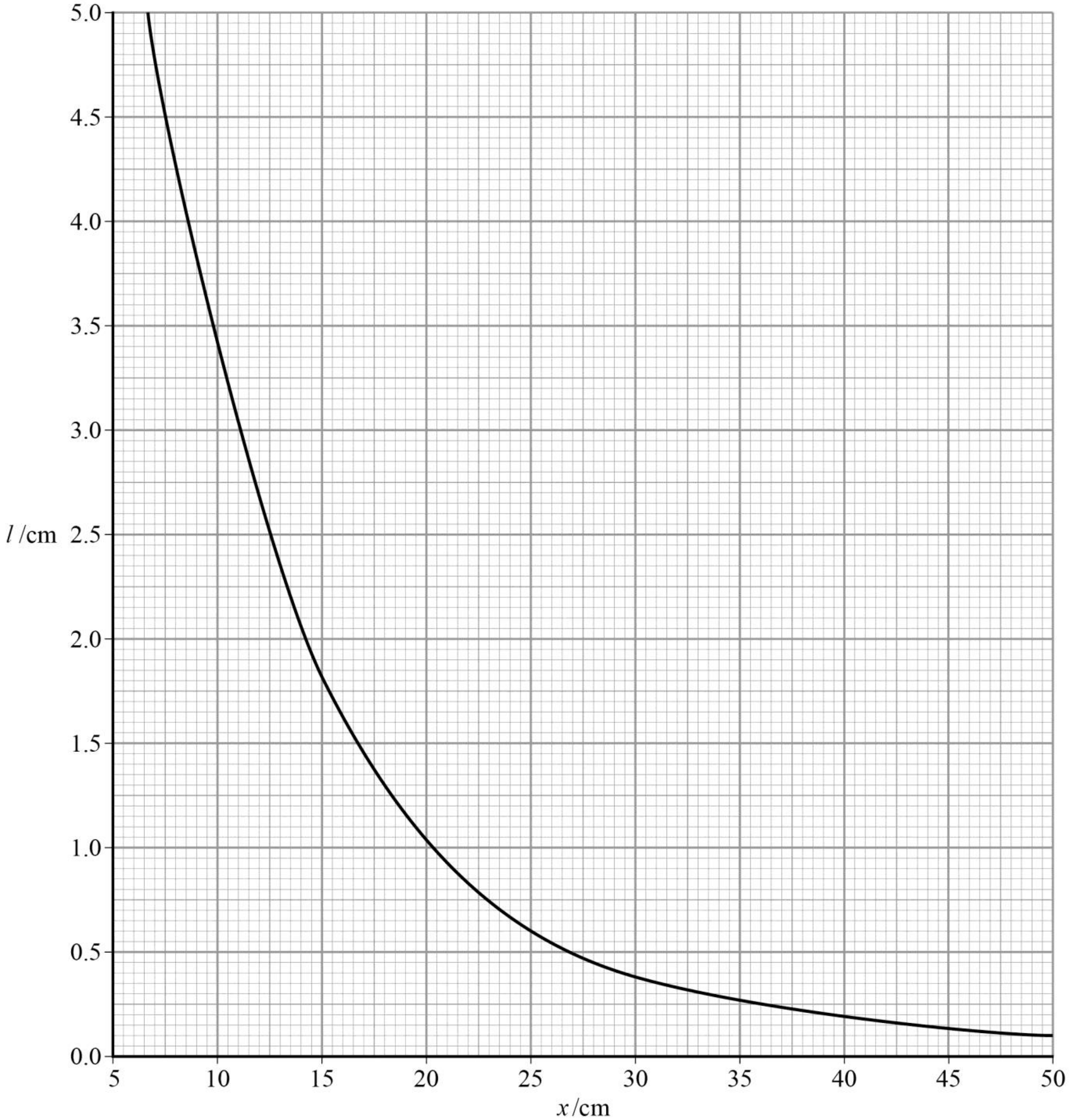
The search coil is then moved a distance x along **PQ**, as shown in **Figure 8**.

Figure 8



The values of l corresponding to different values of x are recorded. A graph of these data is shown in **Figure 9**.

Figure 9



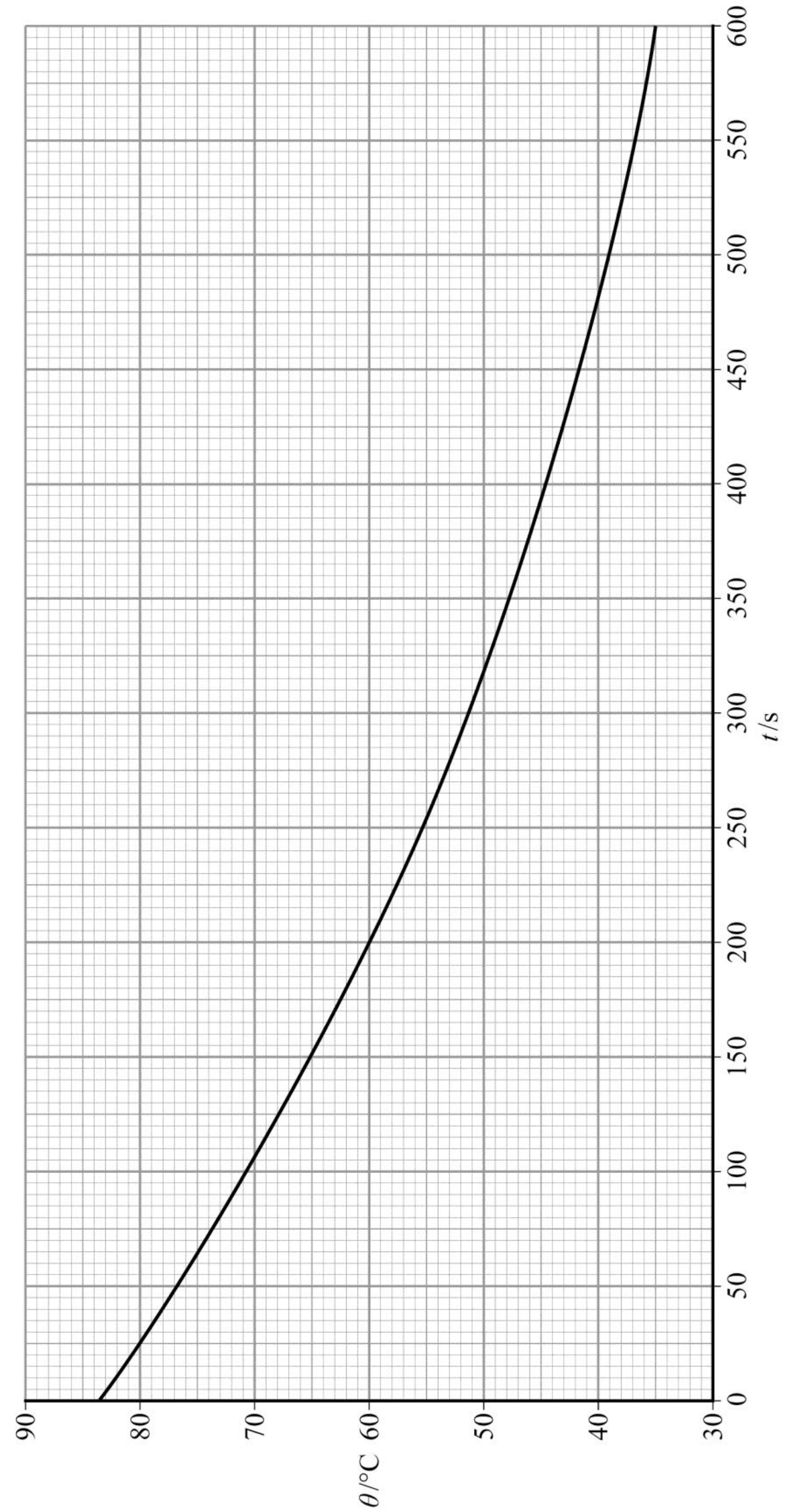
It is suggested that l decreases exponentially as x increases.

Explain whether **Figure 9** supports this suggestion.

[2 marks]

0 2 A temperature sensor is connected to a data logger to monitor how the temperature θ of a fixed mass of recently-boiled water varies with time t, over an interval of 600 s. These data are processed to produce the graph shown in **Figure 10.**

Figure 10



0 2 . 1 Determine the temperature θ_1 of the water when t is 190 s.

[1 mark]

θ_1 = ______________ °C

0 2 . 2 Determine the gradient G_1 of the graph at t is 190 s.

[3 marks]

G_1 = ______________

0 2 . 3 When $t = 370$ s the temperature $\theta_2 = 46.6$ °C and the gradient $G_2 = -0.0645$.

The room temperature θ_R is given by $\dfrac{G_1\theta_2 - G_2\theta_1}{G_1 - G_2}$.

Evaluate θ_R.

[1 mark]

θ_R = ______________ °C

Question 2 continues on the next page

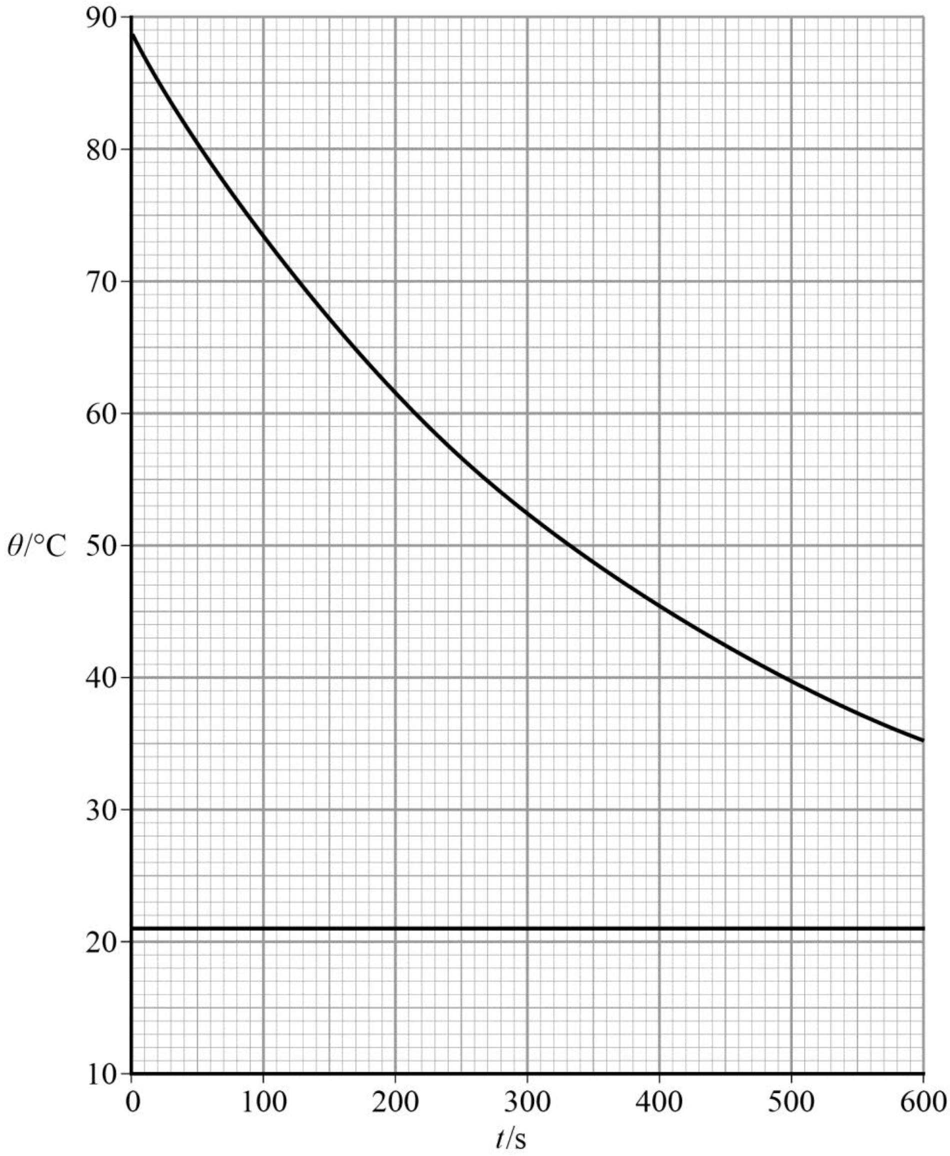
0 2 . 4 It can be shown that when a hot object at a temperature θ is allowed to cool in a draught, the rate at which the temperature decreases is directly proportional to the temperature difference $(\theta - \theta_R)$ between the object and the surroundings.

A student realises that $(\theta - \theta_R)$ will decrease exponentially with time and designs an experiment in which two temperature sensors are connected to a data logger.

- Sensor 1 is placed in a beaker of recently-boiled water.
- Sensor 2 measures the air temperature in the room.
- The data logger is programmed to record the output from the sensors as the water cools for 600 s.

The output data from the sensors are processed to produce the graph shown in **Figure 11.**

Figure 11



$(\theta - \theta_R)$ will decrease exponentially in the same way that the potential difference (pd) across a discharging capacitor decreases with time.

When a capacitor discharges, the pd across the capacitor falls to $\frac{1}{e}$ of an initial value in a time called the **time constant**. Electronic engineers assume that a capacitor becomes fully discharged in a time equal to **5 time constants**.

Estimate the time taken for the water to cool down to room temperature.

[4 marks]

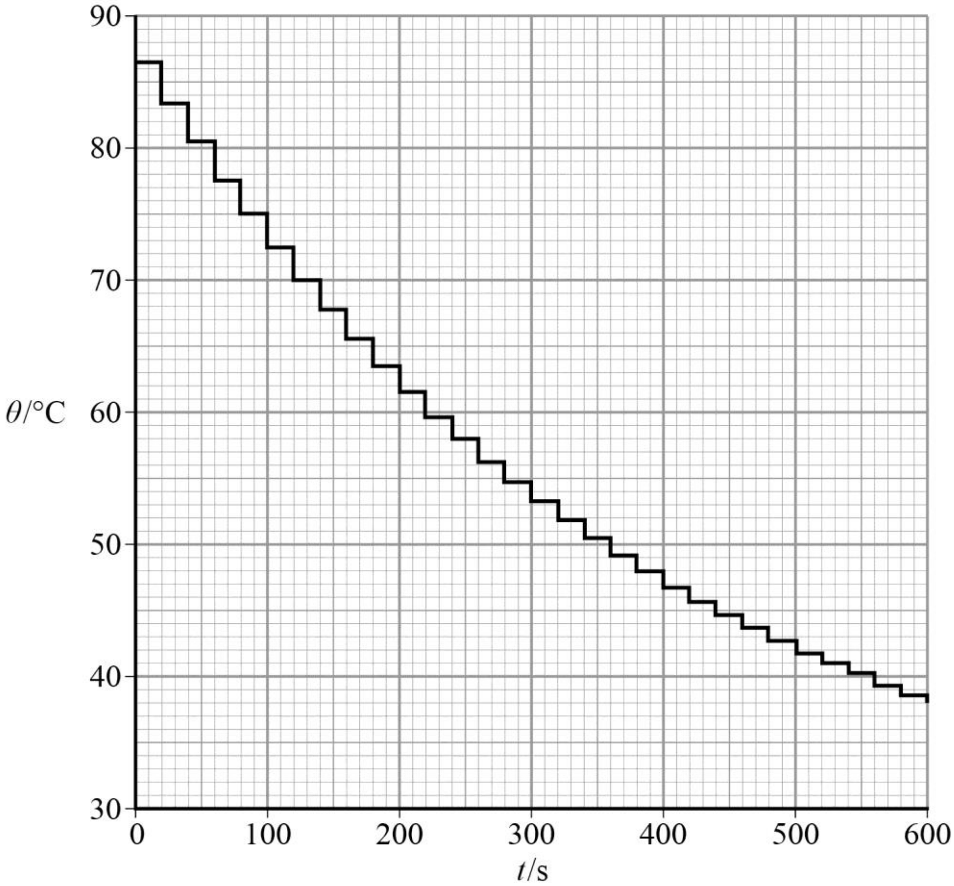
time taken = ________________ s

Question 2 continues on the next page

0 2 . 5 Another student carries the out the experiment using the same mass of recently-boiled water and beaker as before.

The output data for sensor 1 from this student's experiment are shown in **Figure 12**.

Figure 12



Account for the differences between these results and the way they are displayed, with those shown in **Figure 11.**

You should include appropriate quantitative detail in your answer.

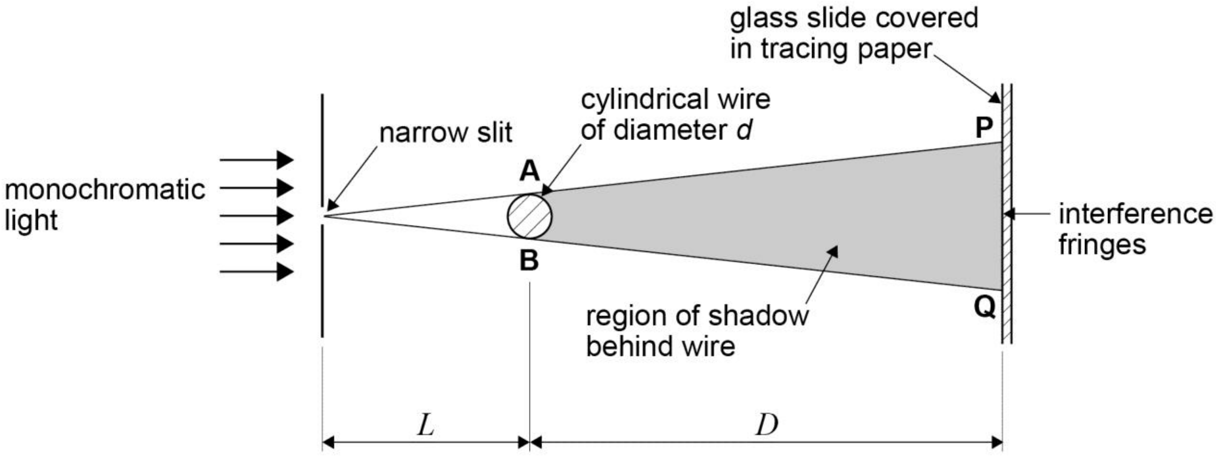
[5 marks]

14

Turn over for the next question

0 3 A student carries out an experiment to determine the diameter of a cylindrical wire based on the theory of Young's double-slit experiment, using the arrangement shown in **Figure 13**.

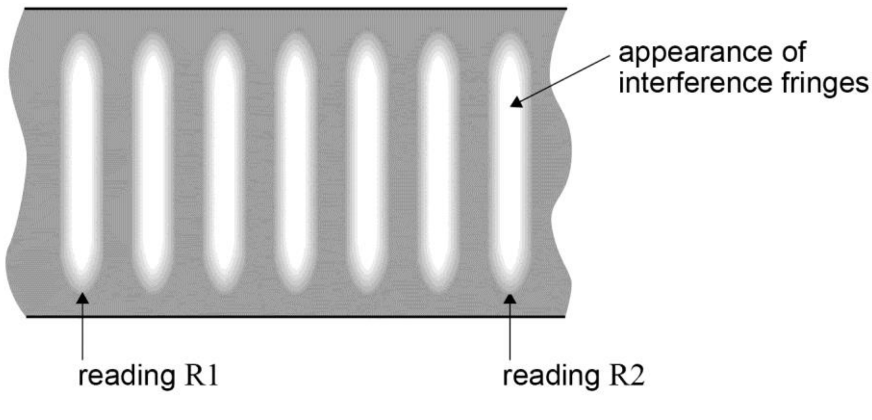
Figure 13



The wire is mounted vertically in front of a single narrow slit which is illuminated by monochromatic light. The wire produces a shadow between points **P** and **Q** on a glass slide covered with tracing paper. The light diffracts as it passes the wire. Points **A** and **B** act as coherent sources causing interference fringes to be seen between **P** and **Q**.

The student uses a metre ruler to measure the distances L and D shown in **Figure 13**. **Figure 14** shows the pattern of interference fringes between **P** and **Q**. The student takes readings from a vernier scale to indicate the positions of the centres of two of the fringes.

Figure 14



The student's measurements are shown in **Table 2.**

Table 2

L/mm	D/mm	R1/mm	R2/mm
46	395	8.71	11.16

0 3 . 1 Determine the spacing of the interference fringes w using **Figure 13** and the data in **Table 2**.

Give your answer to an appropriate number of significant figures.

[2 marks]

w = ____________________ m

0 3 . 2 Determine the diameter d of the wire.

wavelength of the monochromatic light = 589.3 nm

[2 marks]

d = ____________________ m

0 3 . 3 Estimate the number of interference fringes seen between **P** and **Q**.

[3 marks]

number of interference fringes = ________________________

0 3 . 4 The student uses a micrometer screw gauge to confirm his result for d.

Describe a suitable procedure that the student should carry out before using the micrometer to ensure that the measurements are not affected by systematic error.

[2 marks]

___

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___

___

0 3 . 5 To reduce the impact of random error, the student takes several measurements of the diameter at different points along the wire so that he can calculate a mean value for d.

These measurements are shown in **Table 3**.

Table 3

d/mm
0.572
0.574
0.569
0.571
0.566
0.569

Use the data from **Table 3** to determine the percentage uncertainty in the student's result for d.

[2 marks]

percentage uncertainty = ____________________ %

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END OF QUESTIONS