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Centre number

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Candidate number

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Surname Matheson

Forename(s) Lewis

Candidate signature 

I declare this is my own work.

A-level PHYSICS

Paper 3
Section A

A Level Physics Online . com

Thursday 15 June 2023

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.

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.

For Examiner's Use	
Question	Mark
1	
2	
3	
TOTAL	



Section A

Answer **all** questions in this section.

0 1

A stroboscope emits bright flashes of white light.
The duration of each flash and the frequency of the flashes can be varied.

Table 1 shows information about the stroboscope.

Table 1

	Minimum	Maximum
Duration of each flash / μs	60	300
Frequency of flashes / Hz	1	150

The duration of each flash is T_1 .

The time from the start of a flash to the start of the next flash is T_2 .

The duty cycle of a stroboscope is defined as $\frac{T_1}{T_2}$.

0 1 . 1

What is the maximum duty cycle of the stroboscope?

Tick (\checkmark) **one** box.

[1 mark]

6.0×10^{-5}

3.0×10^{-4}

9.0×10^{-3}

4.5×10^{-2}

$$\frac{T_1 \text{ max}}{T_2 \text{ min}} = \frac{300 \times 10^{-6}}{1/150} = 4.5 \times 10^{-2}$$

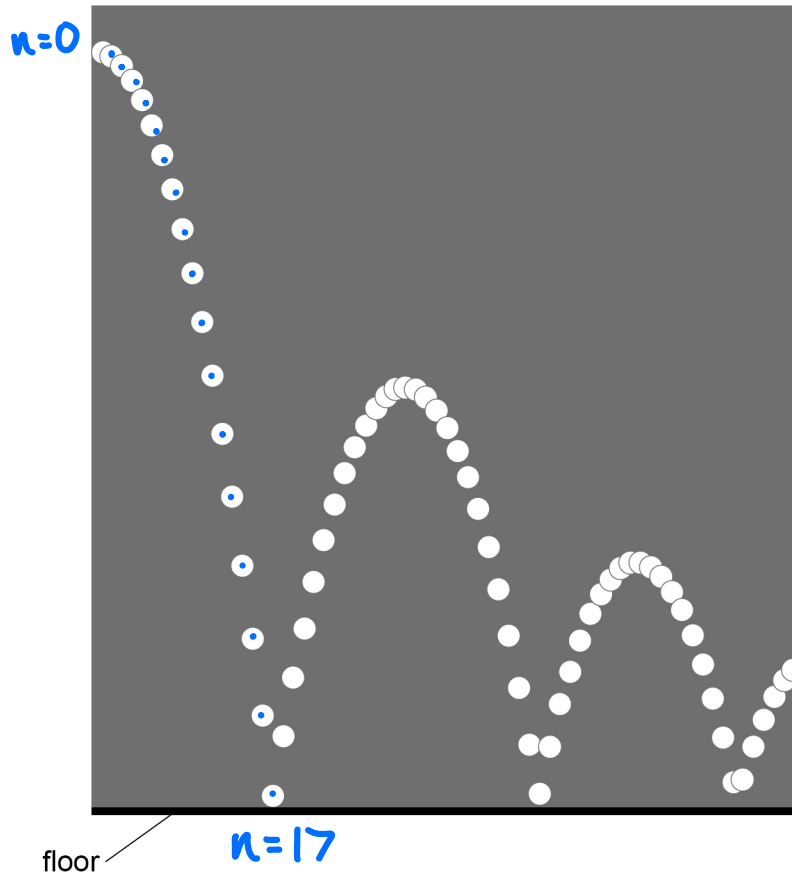
$$T_2 \text{ min} = \frac{1}{f_{\text{max}}}$$



0 1 . 2

Figure 1 shows images produced in an experiment in which a bouncing ball is illuminated by a stroboscope. The stroboscope flashes at a constant frequency.

Figure 1



Suggest why T_1 must be very short for this experiment.

[1 mark]

So images of the ball are not blurred. ✓

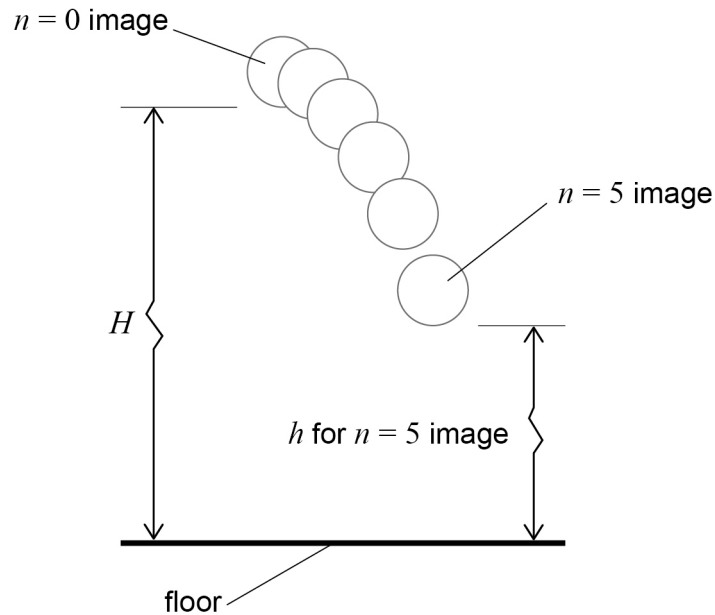
Question 1 continues on the next page

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Figure 2 shows the first six images starting with $n = 0$, where n is the image number.

Figure 2



The images are used to determine:

H , the vertical distance from the bottom of the ball to the floor when $n = 0$

h , the vertical distance from the bottom of the ball to the floor for each non-zero value of n .

The $n = N$ image is produced at the instant that the ball hits the floor for the first time. For n between 0 and N it can be shown that

$$H - h = \frac{u_0 n}{f} + \frac{g}{2} \left(\frac{n}{f} \right)^2$$

where

u_0 is the vertical velocity of the ball when $n = 0$

g is the acceleration due to gravity

f is the frequency of the flashes.

$$\frac{H-h}{n} = \frac{u_0}{f} + \frac{gn}{2f^2} \quad \checkmark$$

$$\frac{H-h}{n} = \frac{g}{2f^2} n + \frac{u_0}{f}$$

$$y = mx + c$$



0 1 . 3 In order to find g , a graph is plotted with values of $\frac{H-h}{n}$ on the y -axis.

Suggest what is plotted on the x -axis.
Go on to explain how g is determined from this graph.

Plot $\frac{H-h}{n}$ against n , gradient = $\frac{g}{2f^2}$ ✓ [3 marks]

$$\therefore g = \text{gradient} \times 2f^2 \quad \checkmark$$

The following data are recorded.

$$H = 1550 \text{ mm}$$

$$f = 31.0 \text{ Hz}$$

The graphical analysis of data from **Figure 1** gives g as 9.79 m s^{-2} .

0 1 . 4 Determine u_0 .

$$H-h = \frac{u_0 n}{f} + \frac{g}{2} \left(\frac{n}{f}\right)^2$$

[3 marks]

When $h=0$, $n=17$ ✓ (from Fig 1)

$$1.550 - 0 = \frac{u_0 \times 17}{31.0} + \frac{9.79}{2} \left(\frac{17}{31}\right)^2 \quad \checkmark$$

$$u_0 = 0.142$$

$$u_0 = \underline{0.142} \quad \checkmark \quad \text{m s}^{-1}$$

Question 1 continues on the next page

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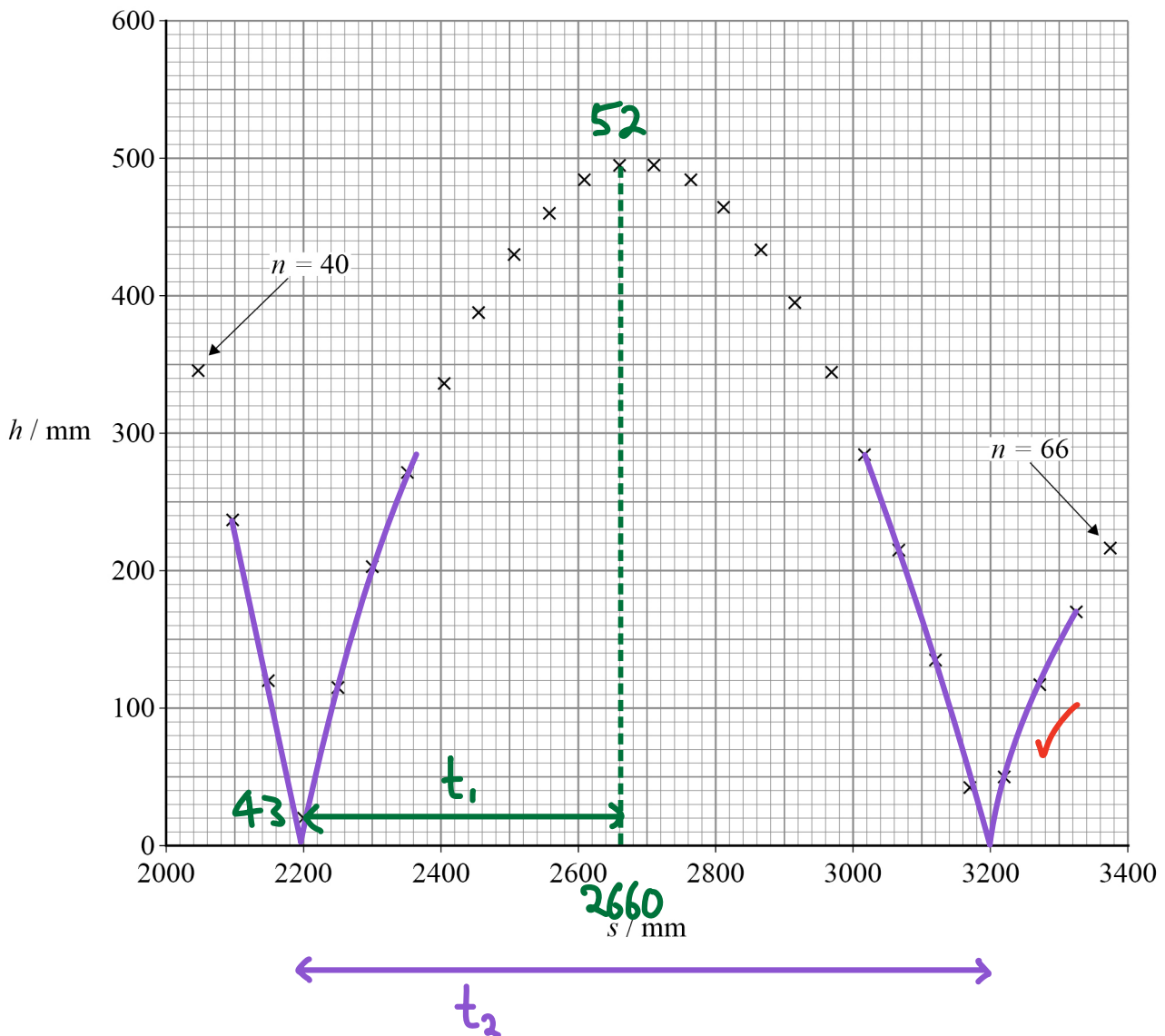
Figure 3 shows positions of the bottom of the ball for $n = 40$ to $n = 66$

In this range of positions, the ball makes contact with the floor for the second and third times.

Values of h , the vertical distance from the bottom of the ball to the floor, are plotted on the y -axis.

Values of s , the horizontal displacement from a point on the floor below the centre of the $n = 0$ image, are plotted on the x -axis.

Figure 3



- 0 1 . 5 Determine, in mm s^{-1} , the horizontal velocity of the ball between the second and third contacts of the ball with the floor.

[2 marks]

$$v = \frac{s}{t} = \frac{2660 - 2200}{0.290} = 1586 \text{ mm s}^{-1}$$

$$T = \frac{1}{f} = \frac{1}{31.0}$$

$$t_1 = 9 \times \frac{1}{31.0} = 0.290 \text{ s}$$

52-43

horizontal velocity = 1590 mm s^{-1}

- 0 1 . 6 Determine the time between the second and third contacts. Annotate **Figure 3** to show your method.

[3 marks]

$$t_2 = \frac{s}{v} = \frac{3200 - 2190}{1586} = 0.6368$$

time = 0.64 s s

13

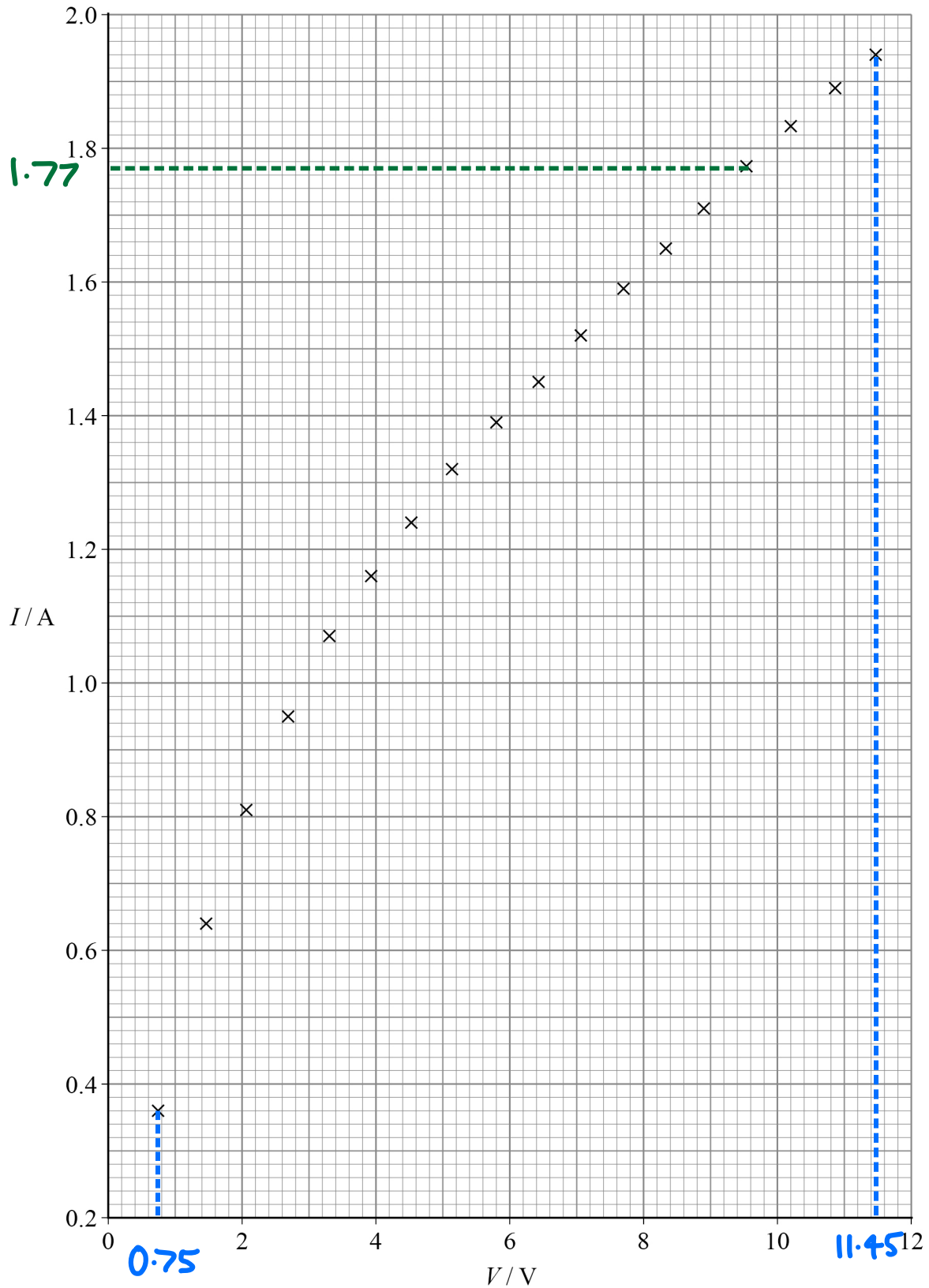
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0 2

Figure 4 is a plot of current–voltage data for a filament lamp L.

Figure 4



The current I was measured as the voltage V across L was increased at a steady rate.

These data were obtained using a current sensor and a voltage sensor connected to a data logger.

The logger recorded data at a rate of 2.5 Hz.

0 2 . 1 Determine, in V s^{-1} , the rate of increase of V .

[2 marks]

$$T = \frac{1}{f} = \frac{1}{2.5} = 0.40 \text{ s}$$

17 time intervals from first to last

$$\Delta t = 17 \times T = 17 \times 0.40 = 6.8 \text{ s}$$

$$\frac{\Delta V}{\Delta t} = \frac{11.45 - 0.75}{6.8} = 1.574$$

rate of increase of $V =$ 1.6 ✓✓ V s^{-1}

0 2 . 2 State **two** advantages of using data logging for this experiment.

[2 marks]

1 Data can be collected at a high rate. ✓

2 Reduces the impact of statistical error involved in manually reading data. ✓

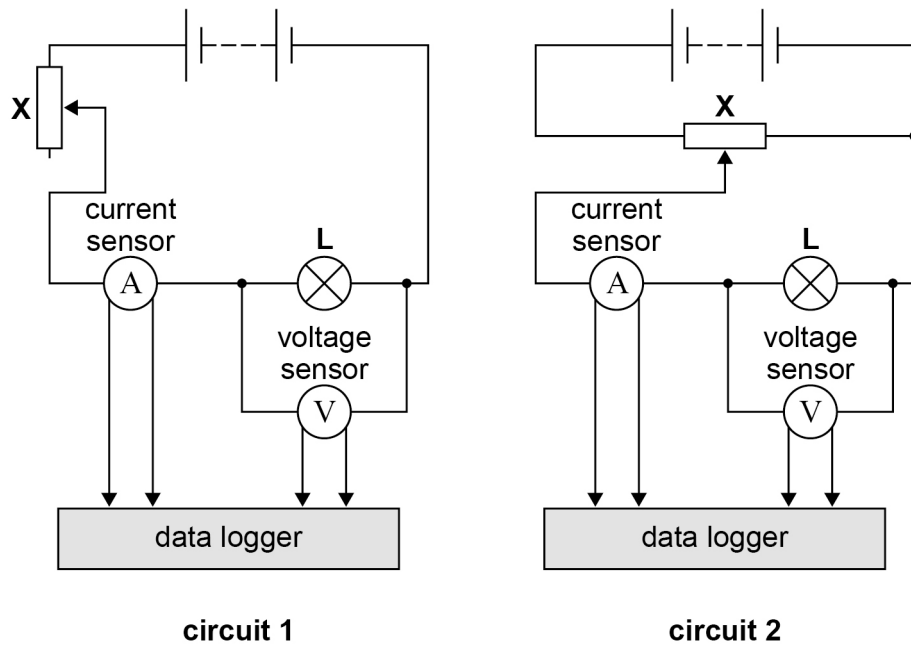
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0 2 . 3 Figure 5 shows two circuits that can be used to collect current–voltage data.

Figure 5



The dc supply has an emf of 12 V and negligible internal resistance.
The current sensor and the voltage sensor behave as ideal meters.

In circuit 1:

- **X** is used as a variable resistor with a maximum resistance of 14.9 Ω
- when **X** is set to maximum resistance, the resistance of **L** is 2.3 Ω .

In circuit 2, **X** is used as a potential divider.



Discuss, with reference to circuit **1** and circuit **2**, whether either circuit can produce all the data shown in **Figure 4**.

Support your answer with a calculation.

[4 marks]

$$\text{Circuit 1} \quad R_{X(\text{max})} = 14.9 \, \Omega$$

$$R_L = 2.3 \, \Omega$$

$$R_{T(\text{max})} = R_X + R_L = 14.9 + 2.3 = 17.2 \, \Omega$$

$$\therefore I_{\text{min}} = \frac{V}{R_{T(\text{max})}} = \frac{12}{17.2} = 0.70 \, \text{A} \checkmark$$

On Fig 4, $I_{\text{min}} = 0.36 < I_{\text{min}}$ in circuit 1

\therefore Circuit 1 cannot produce all this data \checkmark

Circuit 2: p.d across lamp L can be varied between 0V and 12V \checkmark . \therefore it can produce the data in Fig 4. \checkmark

Question 2 continues on the next page

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Table 2 shows some values of V that are plotted on **Figure 4** and corresponding results for I and for the power P dissipated in L .

Table 2

V/V	I/A	P/W
3.30	1.07	3.53
5.17	1.32	6.82 ✓
7.69	1.59	12.2
9.58	1.77 ✓	17.0 ✓
11.47	1.94	22.3

$$P = VI$$

0 2 . 4 Complete **Table 2**.

[3 marks]

From Fig 4

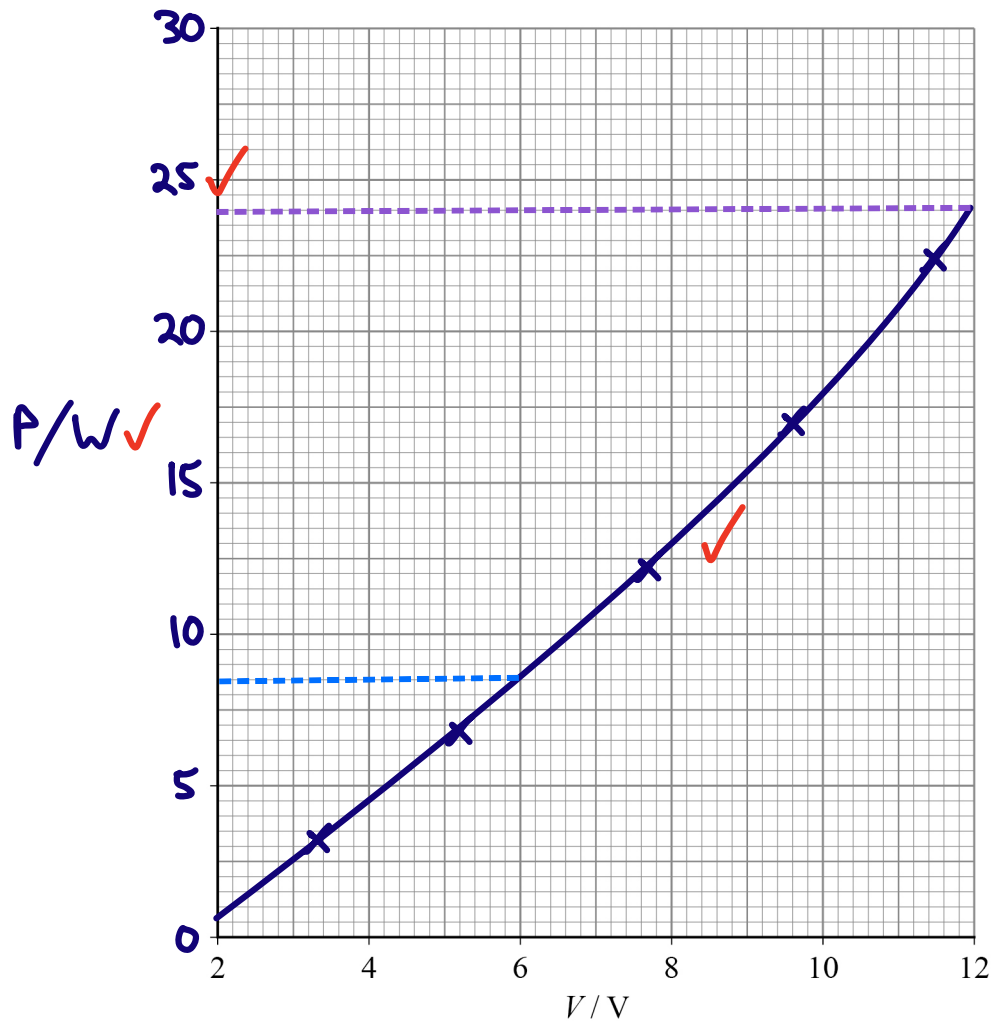


0 2 . 5

Plot on **Figure 6** a graph of P against V .
You should use only the data in your completed **Table 2**.

[3 marks]

Figure 6



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0 2 . 6

L is connected to a 12 V power supply of negligible internal resistance.
L then dissipates its rated power P_r .

A second lamp, identical to L, is now connected in series with L.

Determine the percentage of P_r that is dissipated in this circuit.

[2 marks]

$$P_r = 24 \text{ W (from Fig 6 at 12 V)}$$

In series, V of second lamp = 6.0 V

$$\therefore \text{read off } P \text{ at } 6.0 \text{ V} = 8.5 \text{ W } \checkmark$$

$$\text{percentage} = \frac{71 \checkmark}{100} \%$$

$$\% = \frac{P + P}{P_r} \times 100$$

$$= \frac{2 \times 8.5}{24} \times 100 = 70.8 \%$$

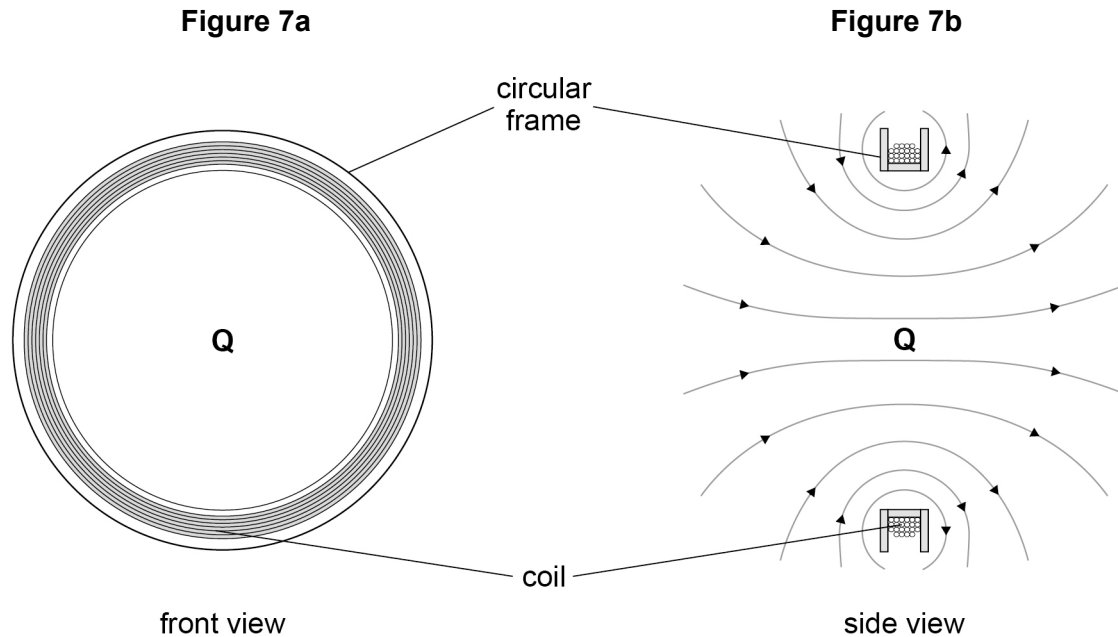
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0 3

Figure 7a shows the front view of a vertical coil mounted on a circular frame.

Figure 7b is a side view showing a section through the frame and coil. A constant direct current in the coil produces magnetic flux represented by the magnetic field lines on this diagram.



Point **Q** is at the centre of the coil.

A sensor placed at **Q** detects B_H , the horizontal component of the magnetic flux density.

The effect of the Earth's magnetic field at **Q** is negligible.

0 3 . 1

Discuss whether a search coil is a suitable sensor to detect B_H .

[2 marks]

A search coil needs to be cut by a changing flux. In this case the flux is constant \therefore no induced emf. So it's not suitable.

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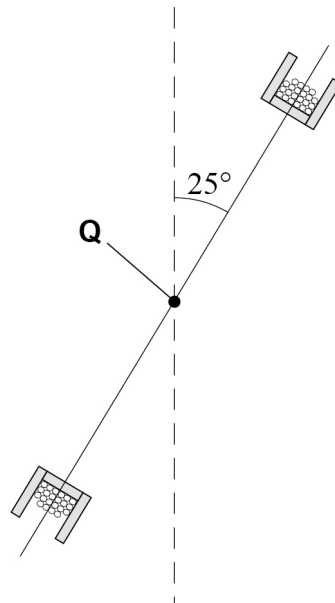
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B_H is measured at **Q** with the coil vertical.

The coil is now rotated about **Q** through 25° as shown in **Figure 8**.
The current in the coil does not change.

Figure 8



A new measurement of B_H is made with the coil fixed in this new position.

0 3 . 2

Determine the percentage change in B_H produced by this rotation of the coil.
Show your working.

[2 marks]

$$\% B_H = \frac{\cancel{B_H} - \cancel{B_H} \cos 25^\circ}{\cancel{B_H}} \times 100 = (1 - \cos 25^\circ) \times 100 \checkmark$$

$$= 9.37$$

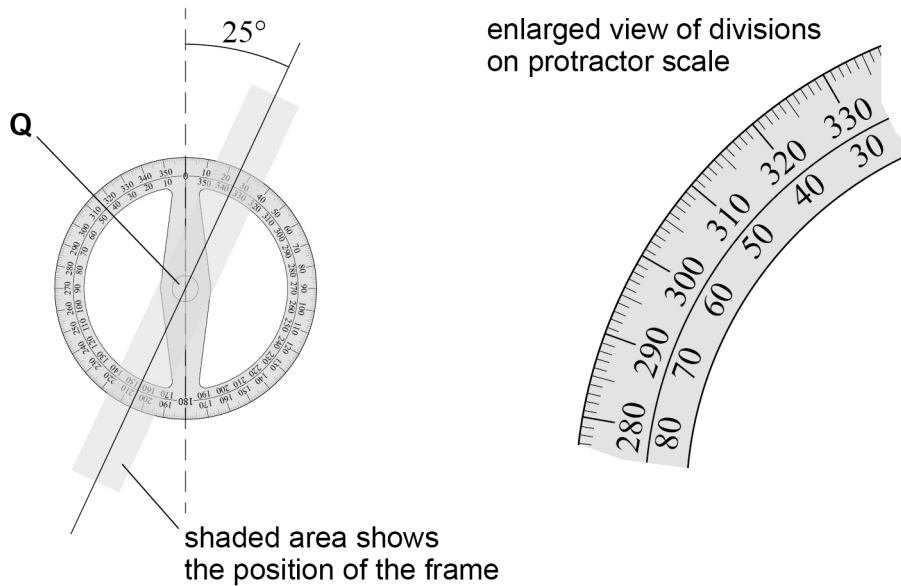
percentage change = 9.4 \checkmark %



0 3 . 3

Figure 9 shows a protractor being used to measure the angle through which the coil is rotated.

Figure 9



Estimate the percentage uncertainty in this result.
Justify your answer.

[3 marks]

$$\% \text{ uncertainty} = \frac{1}{25} \times 100 = 4.0\%$$

Absolute uncertainty in $\theta = 1^\circ$, due to 0.5° ✓ in each of the two readings ✓ (at 0° and 25°).

percentage uncertainty = 4.0 ✓ %

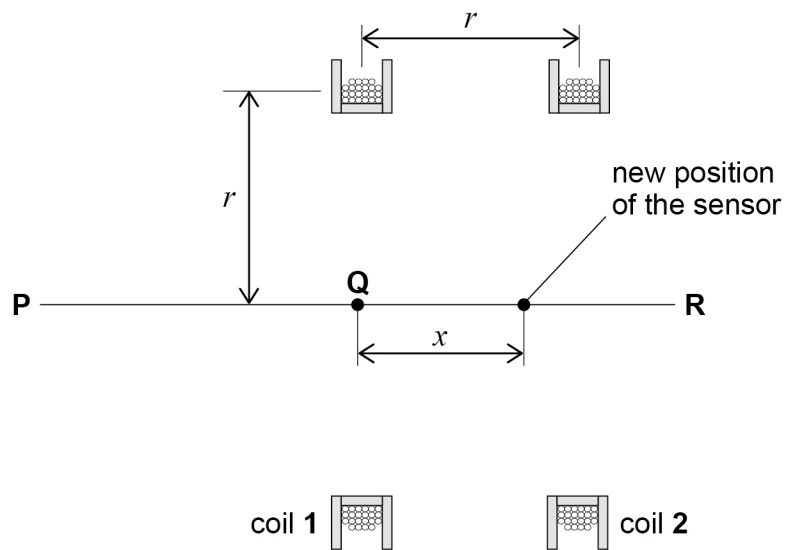
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Figure 10 shows an arrangement of two vertical coils.
Four experiments are done using this arrangement.

Figure 10



Coil **1** and coil **2** are identical and have a radius r .
The coils are separated by a distance r and have a common axis **PR**.
Q is at the centre of coil **1**.

The four different experiments investigate how B_H varies with x , the displacement of the sensor from **Q** along **PR**.

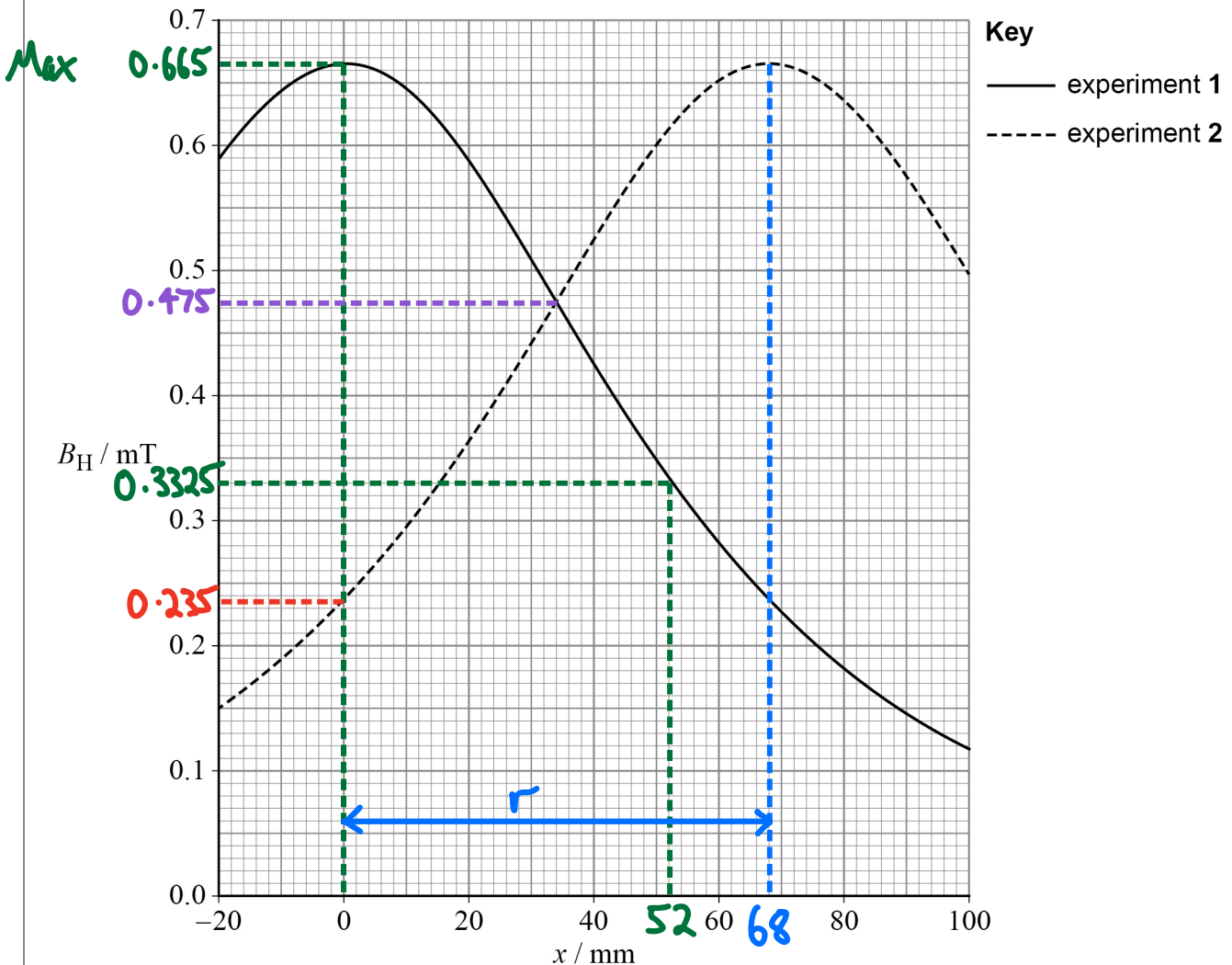
In experiment **1**, the current in coil **1** is 225 mA and the current in coil **2** is zero.

In experiment **2**, the current in coil **1** is zero and the current in coil **2** is 225 mA.



Figure 11 shows the results of experiment 1 and experiment 2.

Figure 11



0 3 4 During experiment 1, B_H is measured with the sensor at **Q**.

The sensor is then moved along **PR** until the value of B_H is halved.

The distance from **Q** to the sensor is $x_{0.5}$

Determine $\frac{x_{0.5}}{r}$

$$B_H \text{ at } Q = 0.665 \text{ mT}$$

[2 marks]

$$x_{0.5} \text{ at } B_H/2 = 0.665/2 = 0.3325 \therefore x_{0.5} = 52 \text{ mm} \checkmark$$

$$r = 68 \text{ mm} \quad \frac{x_{0.5}}{r} = \frac{52}{68} = 0.7647$$

$$\frac{x_{0.5}}{r} = \underline{0.76} \checkmark$$

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In experiment 3, the current in both coils is 225 mA so that the magnetic fields produced by coil 1 and coil 2 are combined.

The resultant B_H has a constant maximum value in the region between $x = \frac{r}{4}$ and

$$x = \frac{3r}{4}$$

0 3 . 5 Deduce, in mT, the value of B_H in this region.

[2 marks]

Add up two values of B_H when it is the same for coil 1 and 2 = 2×0.475
= 0.95 mT

$$B_H = \underline{0.95} \checkmark \checkmark \text{ mT}$$

0 3 . 6 State **two** characteristics of the magnetic field lines in this region. (uniform field) [2 marks]

1 Field lines are parallel. ✓

2 They are evenly spaced. ✓



0 3 . 7

In experiment 4, the current in coil 2 is reversed so that the direction of the magnetic field produced by coil 2 is also reversed.

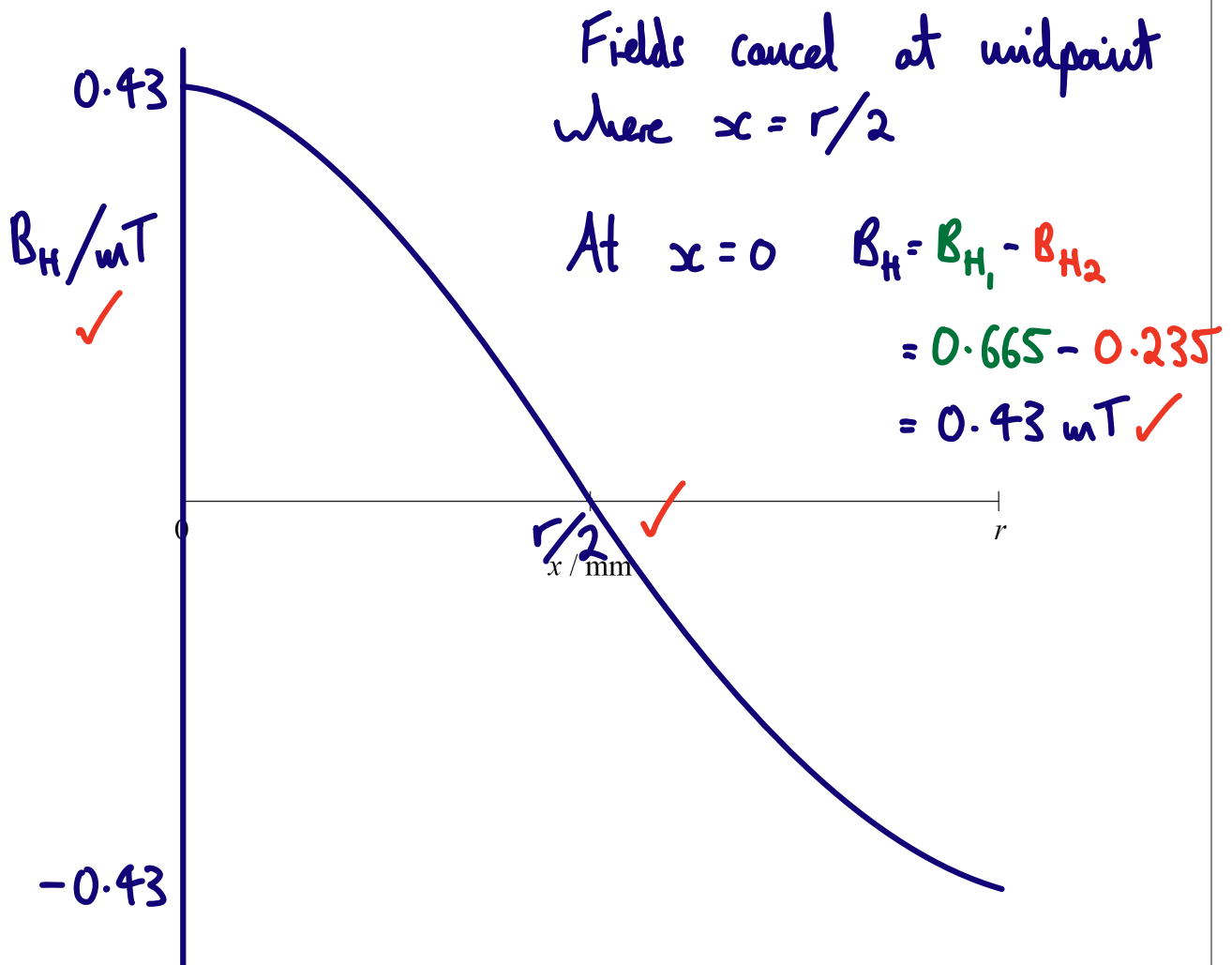
The magnitudes of the currents in coil 1 and coil 2 are still 225 mA.

Sketch a graph to show how B_H varies between $x = 0$ and $x = r$.

The x -axis has been provided for you.

Your graph should include numerical values on your B_H axis that correspond to $x = 0$ and $x = r$.

[3 marks]



END OF QUESTIONS

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