AQA

Please write clearly in block capitals.

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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.

For Examiner's Use	
Question	Mark
1	
2	
3	
TOTAL	

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.

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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 (✓) **one** box.

[1 mark]

- [ ] 6.0×10^{-5}
- [ ] 3.0×10^{-4}
- [ ] 9.0×10^{-3}
- [x] 4.5×10^{-2} ✓

$$\frac{T_{1\,max}}{T_{2\,min}} = \frac{300 \times 10^{-6}}{1/150} = 4.5 \times 10^{-2}$$

$$T_{2\,min} = \frac{1}{f_{max}}$$

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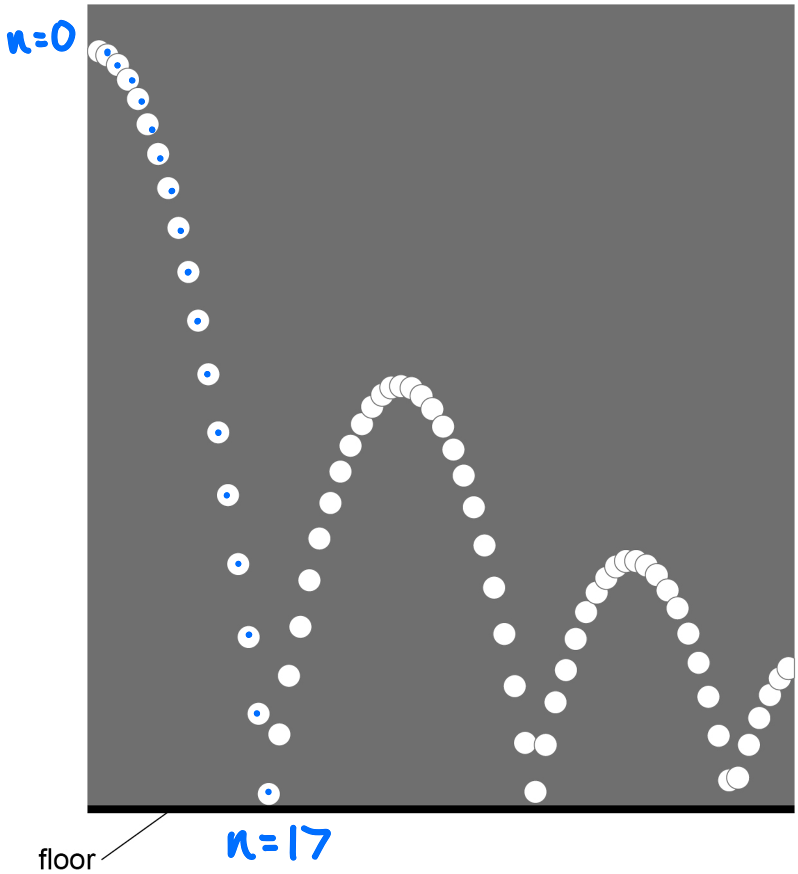
0 1 . 2 **Figure 1** shows images produced in an experiment in which a bouncing ball is illuminated by a stroboscope.
The stroboscope flashes at a constant frequency.

Figure 1



Suggest why T_1 must be very short for this experiment.

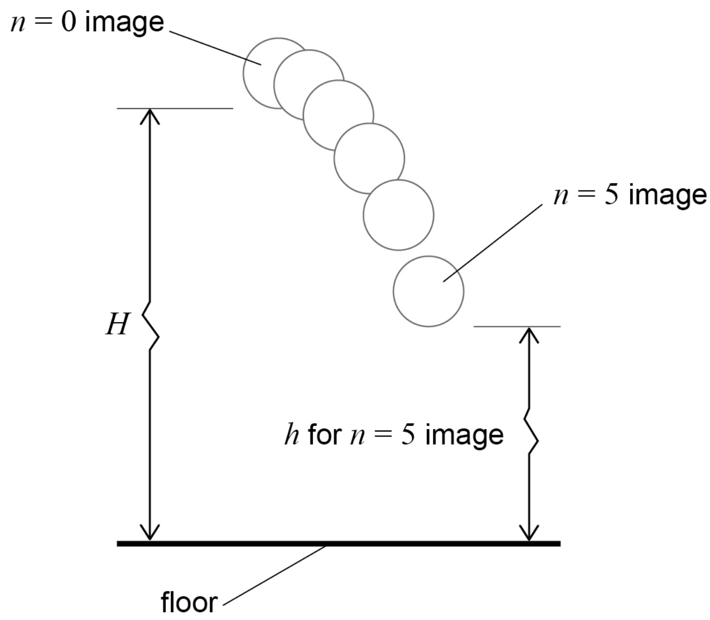
[1 mark]

So images of the ball are not blurred. ✓

Question 1 continues on the next page

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.

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

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

$$y = mx + c$$

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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.

[3 marks]

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

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

The following data are recorded.

$H = 1550$ mm
$f = 31.0$ Hz

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

0 1 . 4 Determine u_0.

[3 marks]

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

When $h=0$, $n=17$ ✓ (from Fig 1)

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

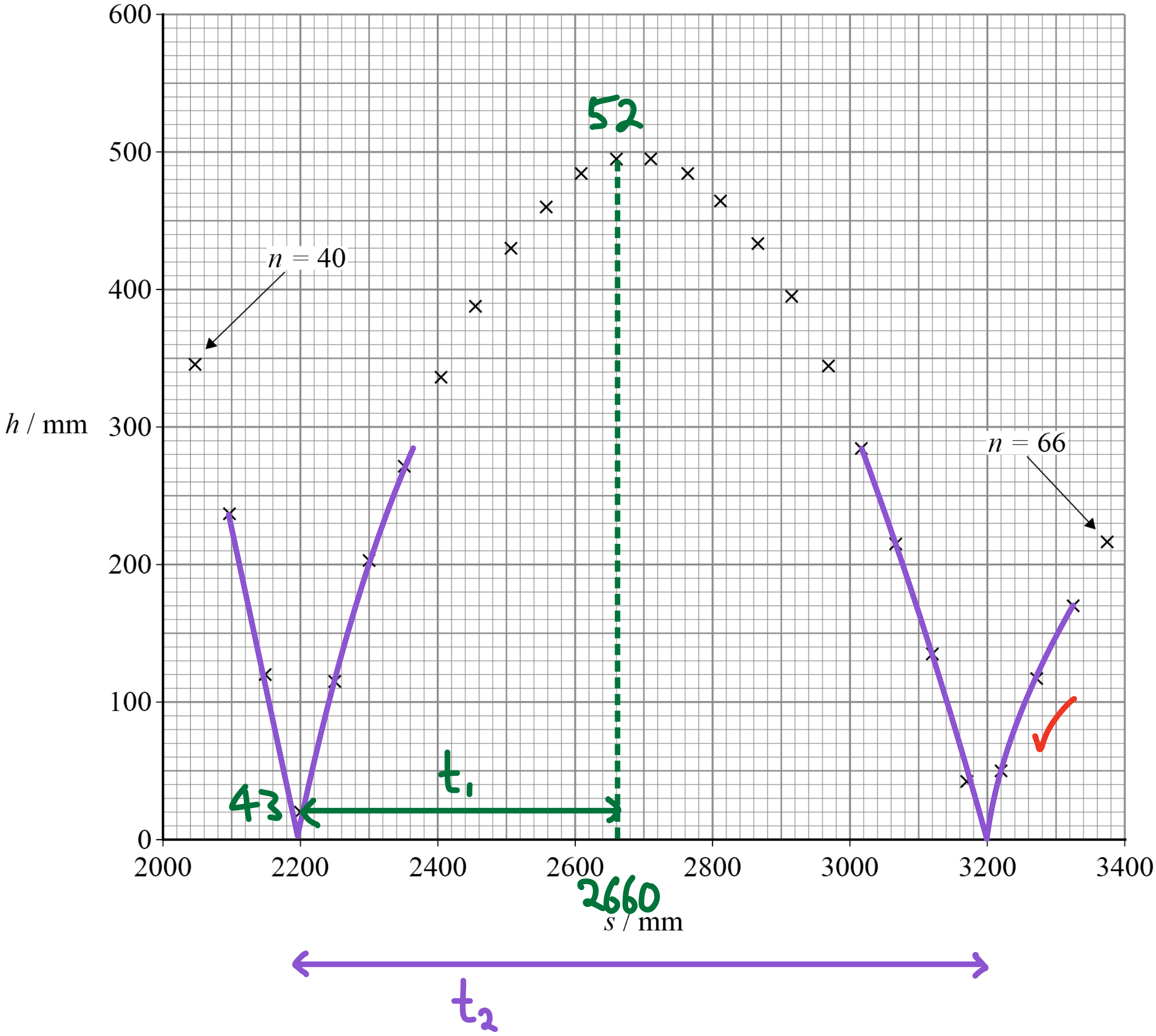
$u_0 = 0.142$

$u_0 =$ 0.142 ✓ m s^{-1}

Question 1 continues on the next page

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



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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]

$v = \frac{s}{t} = \frac{2660-2200}{0.290} = 15.86 \text{ ms}^{-1}$ ✓

$T = \frac{1}{f} = \frac{1}{31}$

$t_1 = 9 \times \frac{1}{31} = 0.290\text{s}$

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]

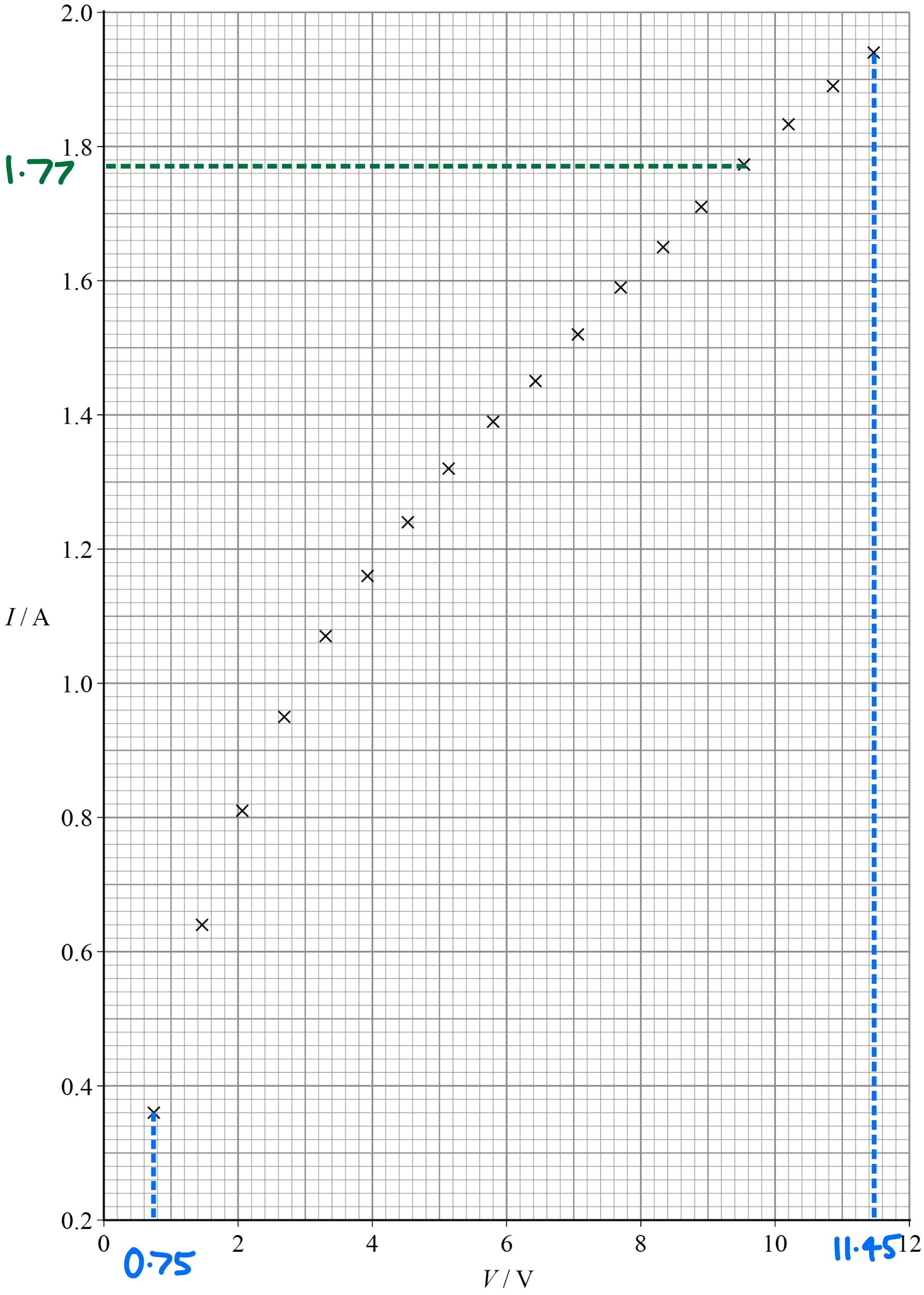
$t_2 = \frac{s}{v} = \frac{3200-2190}{1586} = 0.6368$ ✓

time = 0.64s ✓ s

13

0 2 **Figure 4** is a plot of current–voltage data for a filament lamp **L**.

Figure 4



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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 $2.5\ \text{Hz}$.

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.

Question 2 continues on the next page

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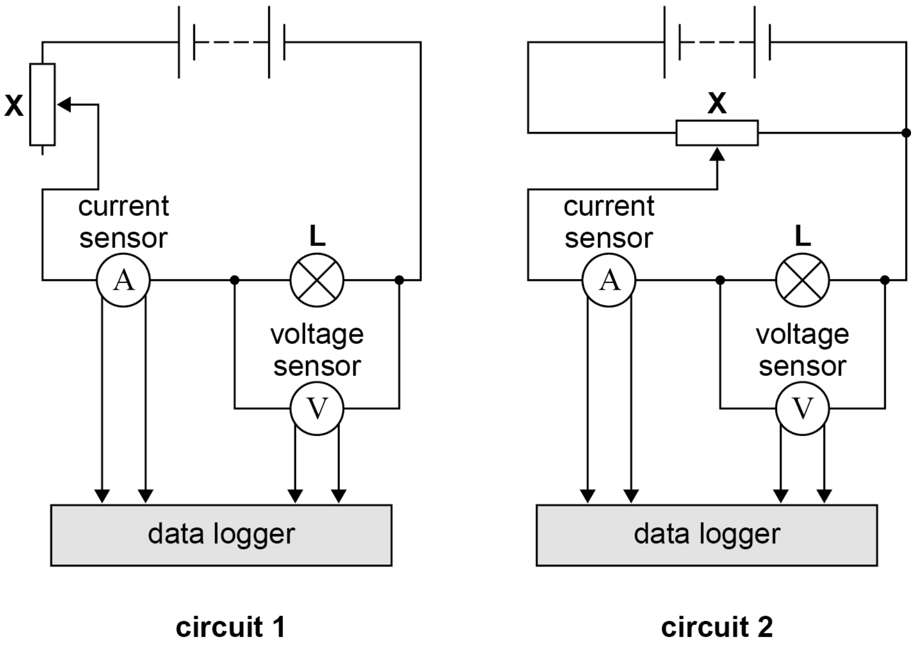
0 2 . 3 **Figure 5** shows two circuits that can be used to collect current–voltage data.

Figure 5



The dc supply has an emf of $12\ \text{V}$ 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 $14.9\ \Omega$
- when **X** is set to maximum resistance, the resistance of **L** is $2.3\ \Omega$.

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

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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]

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

$R_L = 2.3\ \Omega$

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

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

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

$\therefore$ Circuit 1 cannot produce all this data ✓

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

Question 2 continues on the next page

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

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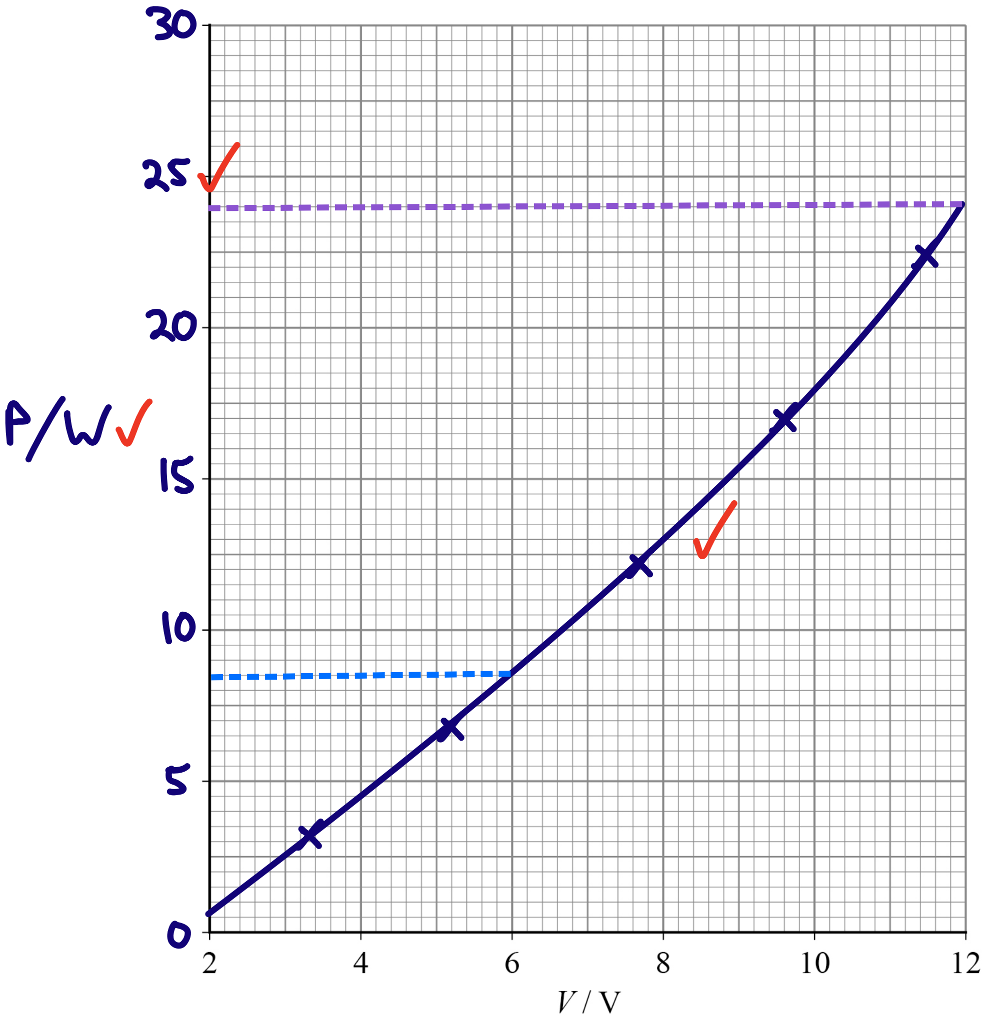
0 2 . 5 Plot on **Figure 6** a graph of P against V.
You should use only the data in your completed **Table 2**.

[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]

$P_r = 24\,W$ (from Fig 6 at 12 V)

In series, V of second lamp = 6.0 V

∴ read off P at 6.0 V = 8.5 W ✓

percentage = 71 ✓ %

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

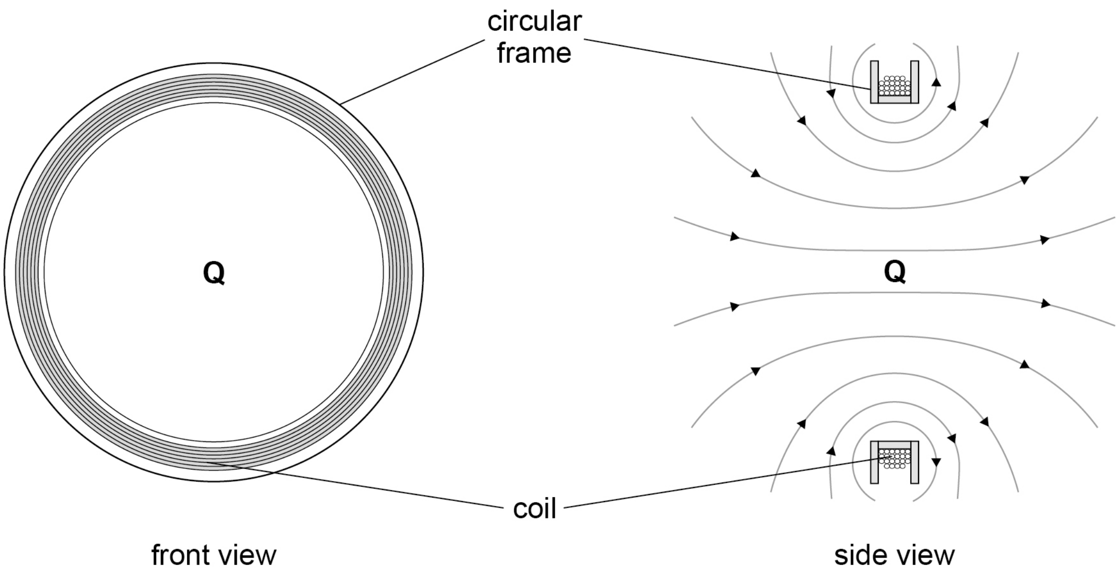
$$= \frac{2 \times 8.5}{24} \times 100 = 70.8\,\%$$

16

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.

Figure 7a **Figure 7b**



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 ∴ no induced emf.

Question 3 continues on the next page

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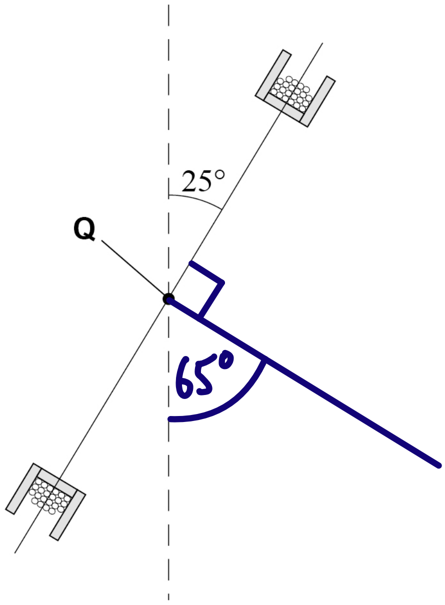
B_H is measured at **Q** with the coil vertical.

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]

$$\% B_H = \frac{B_H - B_H \cos 25°}{B_H} \times 100 = (1 - \cos 25) \times 100$$
$$= 9.37$$

percentage change = 9.4 %

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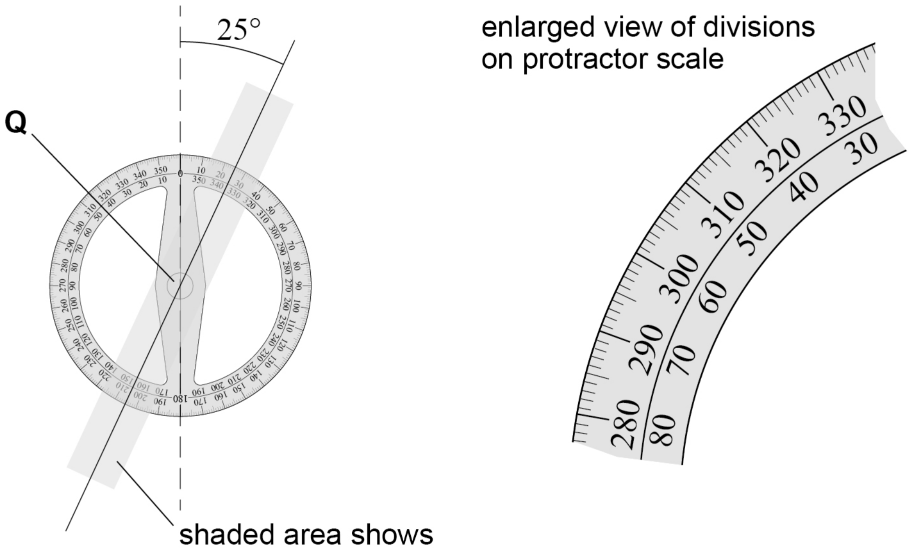
0 3 . 3 **Figure 9** shows a protractor being used to measure the angle through which the coil is rotated.

Figure 9



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

[3 marks]

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

Absolute uncertainty in θ = 1°, due to 0.5° in each of the two readings (at 0° and 25°).

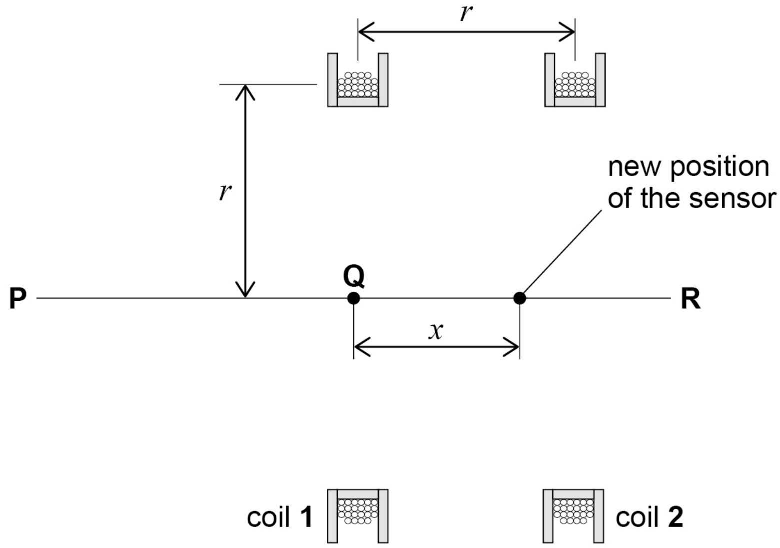
percentage uncertainty = 4.0 %

Question 3 continues on the next page

Turn over ►

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**.

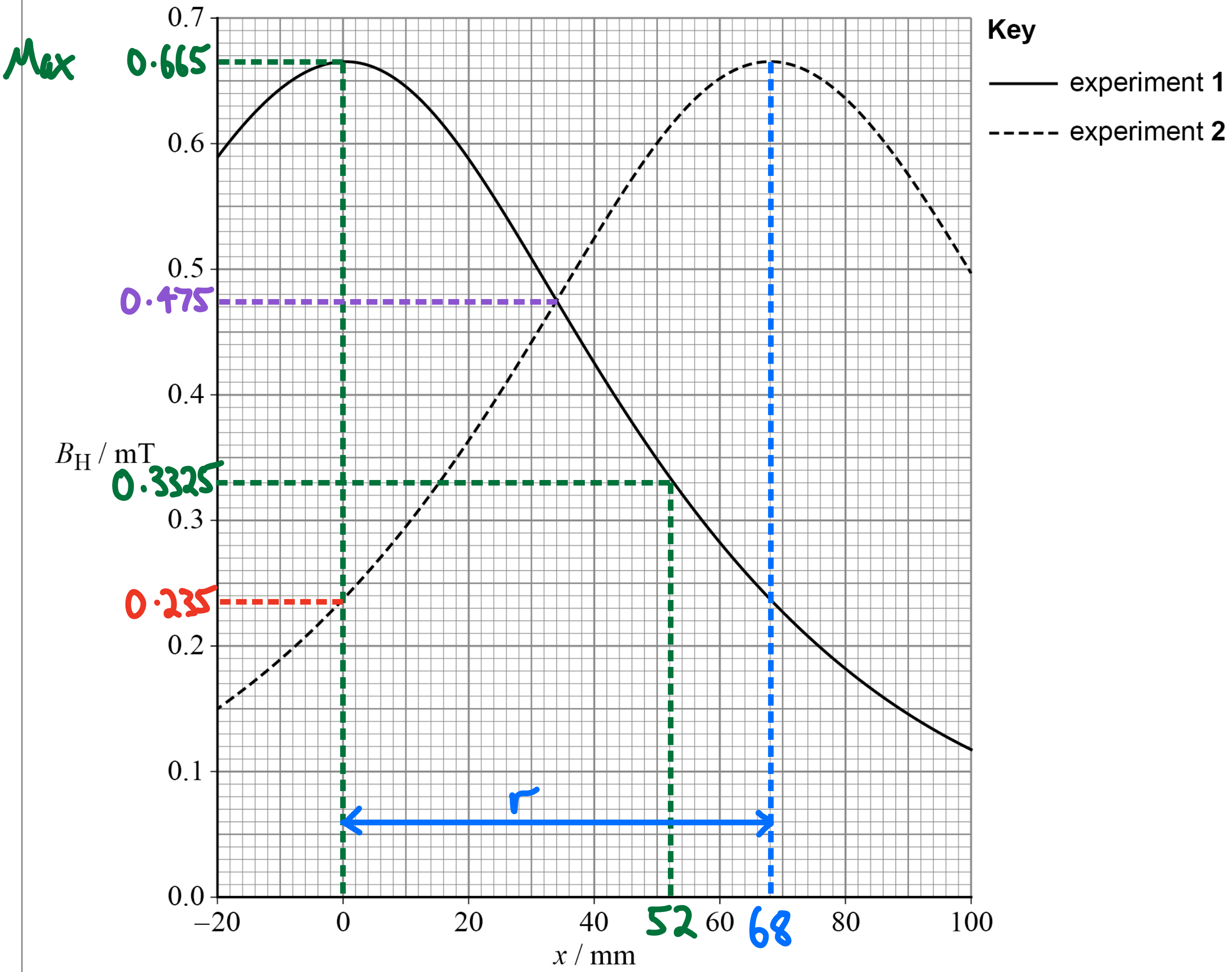
The four different experiments investigate how B_H varies with x, the displacement of the sensor from **Q** along **PR**.

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 at Q = 0.665 mT

[2 marks]

$x_{0.5}$ at $B_H/2$ = 0.665/2 = 0.3325 ∴ $x_{0.5}$ = 52 mm ✓

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

$\frac{x_{0.5}}{r}$ = 0.76 ✓

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In experiment **3**, the current in both coils is $225\ \text{mA}$ 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 = 0.95 ✓✓ 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. ✓

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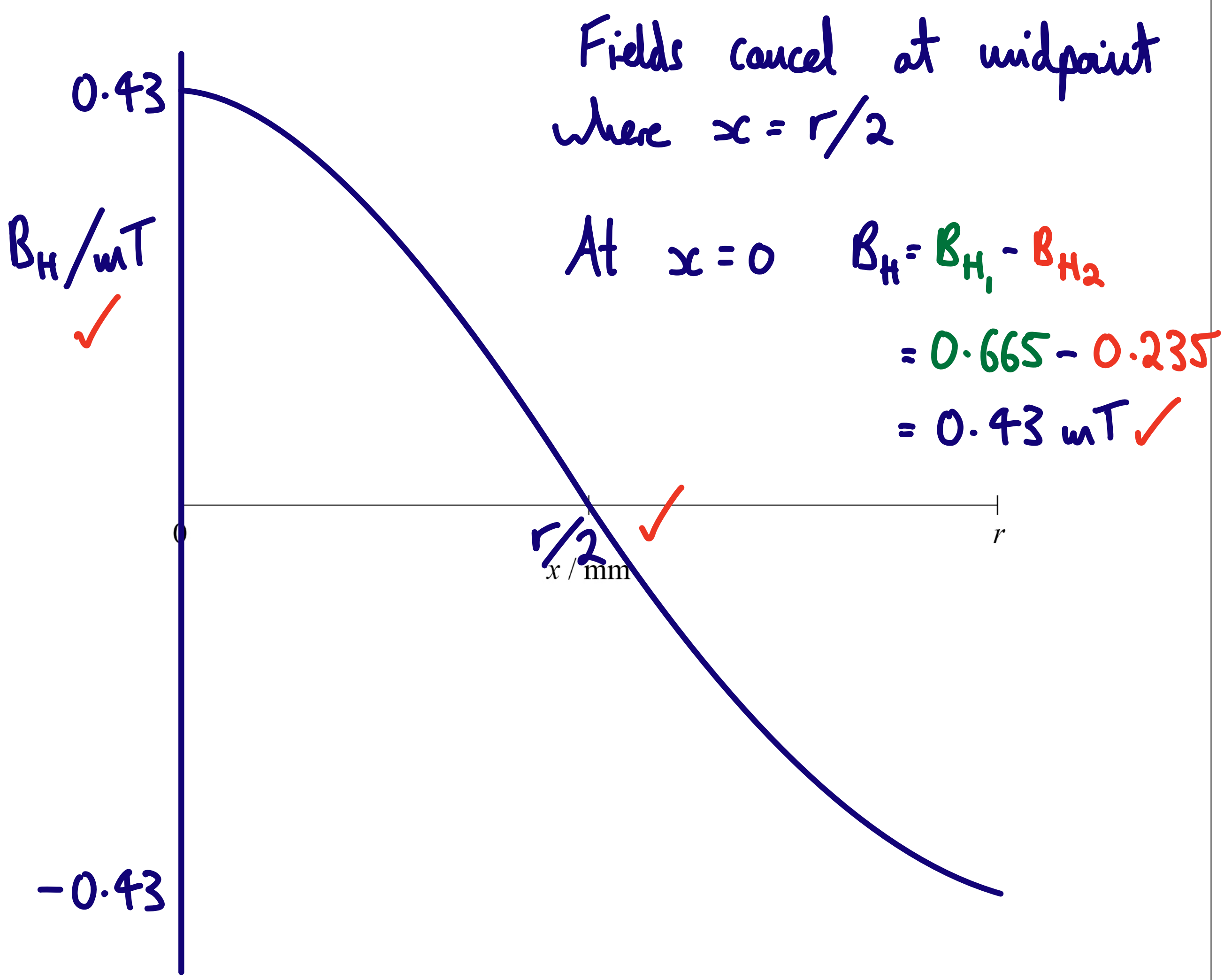
0 3 . 7 In experiment **4**, the current in coil **2** is reversed so that the direction of the magnetic field produced by coil **2** is also reversed.
The magnitudes of the currents in coil **1** and coil **2** are still 225 mA.

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

16

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