A

Surname _____

Forename(s) _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

A-level
PHYSICS

Paper 3
Section A
7408/3A

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.

[Turn over]

JUN237408 3A01

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At the front of this book, write your surname and forename(s), your centre number, your candidate number and add your signature.

MATERIALS

For this paper you must have:

- **a pencil and a ruler**
- **a scientific calculator**
- **a Data and Formulae Booklet**
- **a protractor.**

[Turn over]

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.**
- **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.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

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 $\frac{T_1}{T_2}$.

[Turn over]

8

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0 1 . 1

What is the maximum duty cycle of the stroboscope? [1 mark]

Tick (✓) ONE box.

- ☐ 6.0×10^{-5}
- ☐ 3.0×10^{-4}
- ☐ 9.0×10^{-3}
- ☐ 4.5×10^{-2}

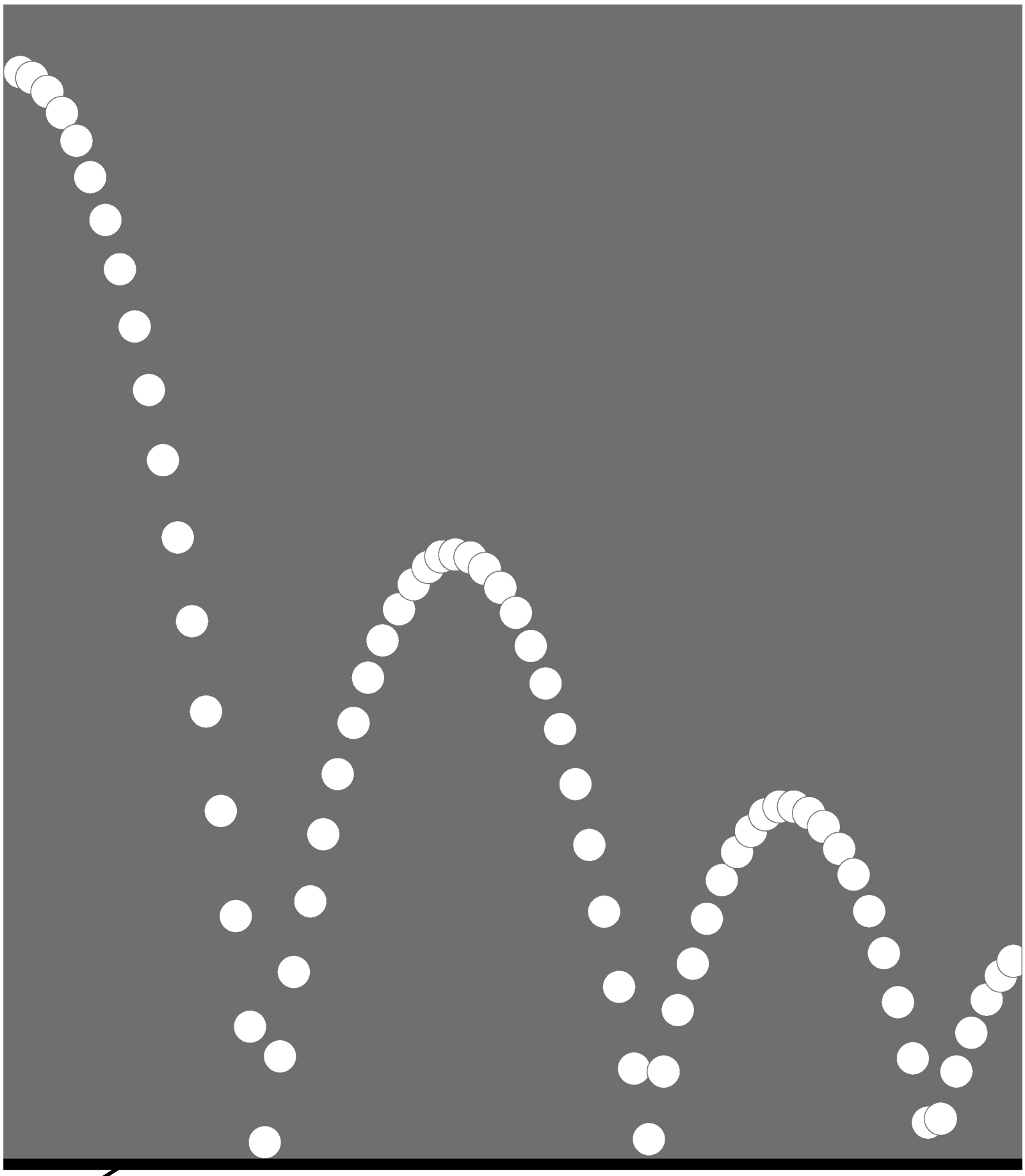
0 1 . 2

FIGURE 1, on the opposite page, shows images produced in an experiment in which a bouncing ball is illuminated by a stroboscope.

The stroboscope flashes at a constant frequency.

Suggest why T_1 must be very short for this experiment. [1 mark]

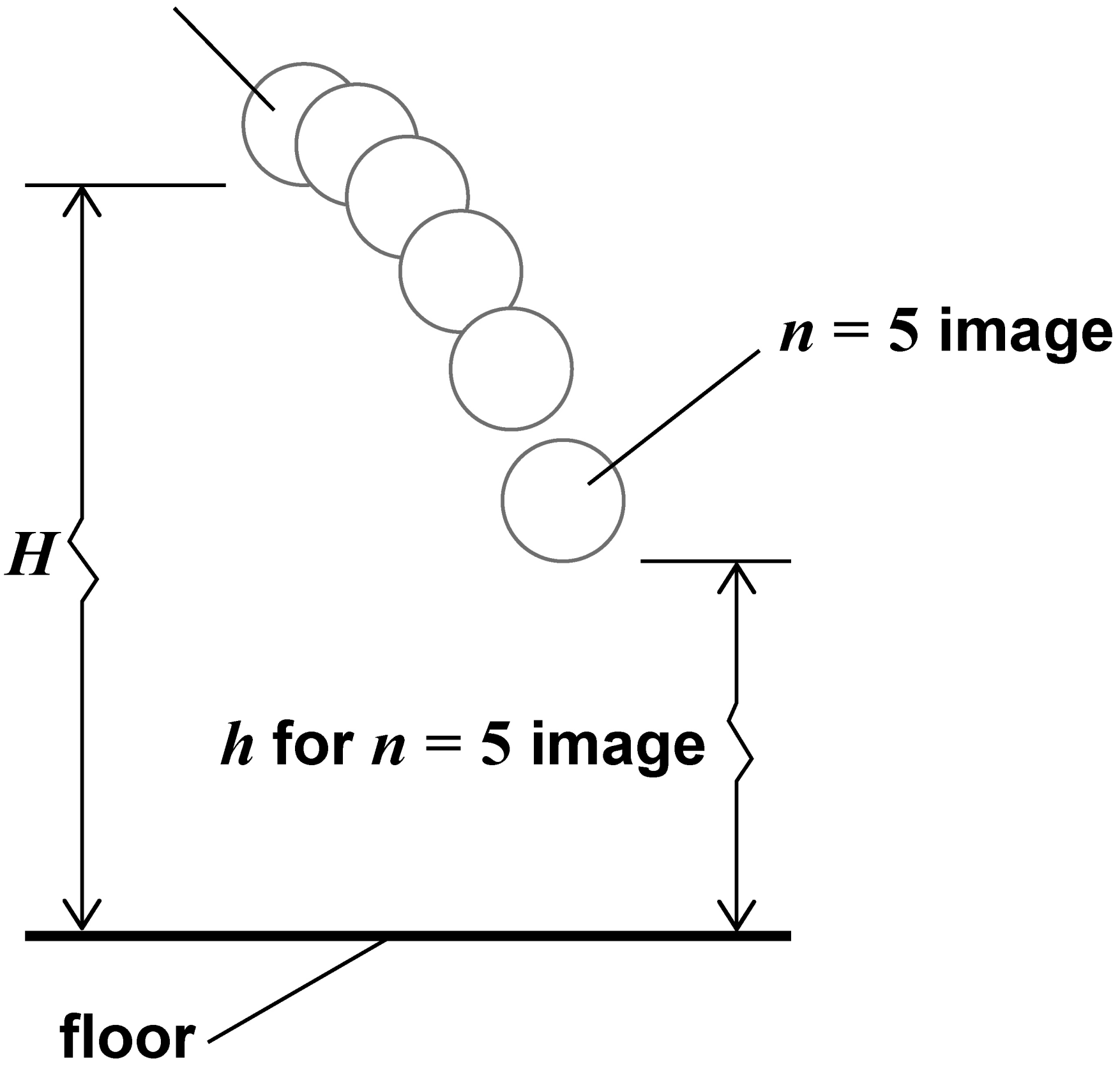
FIGURE 1



[Turn over]

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.

[Turn over]

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.

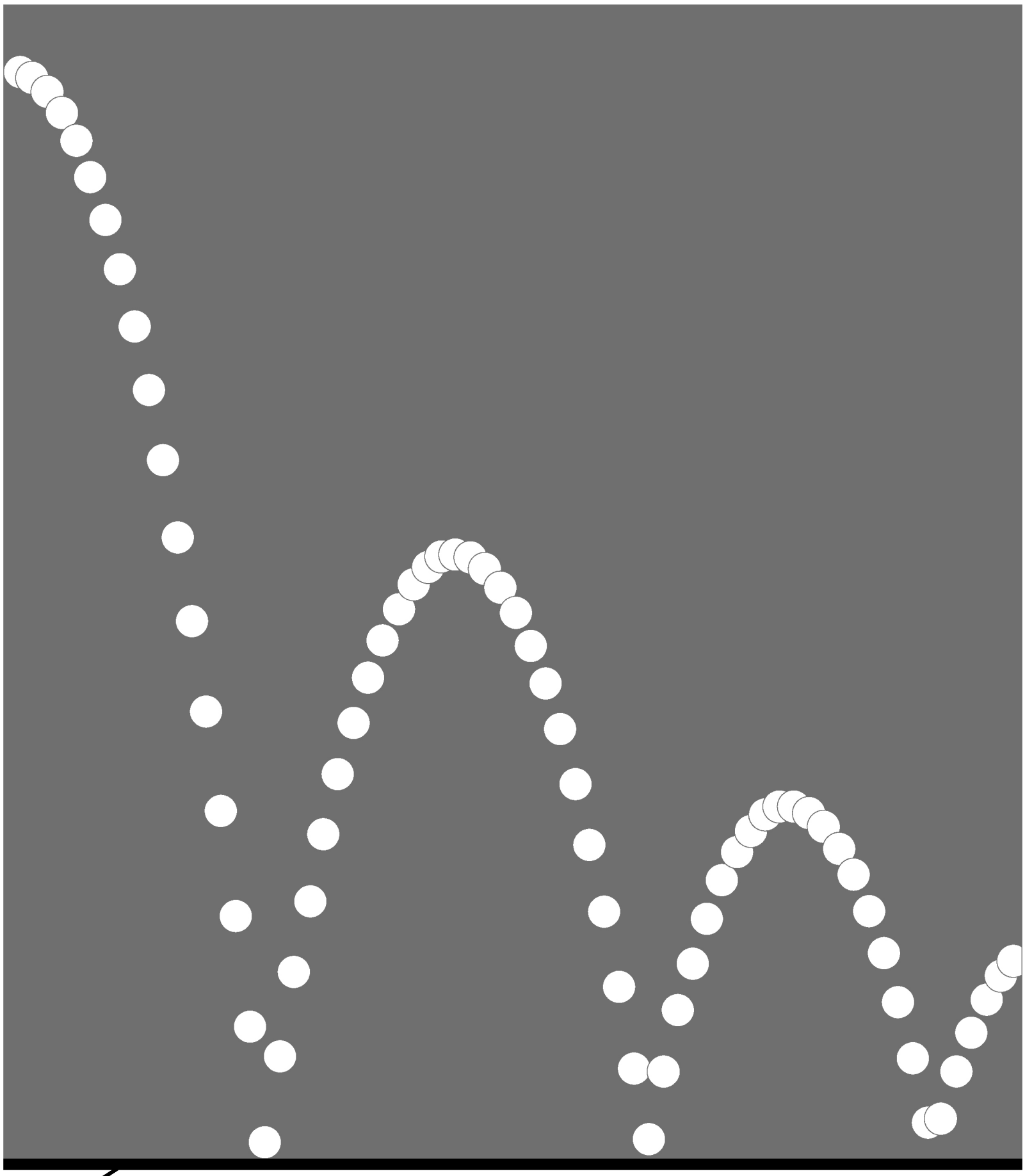
0 1 . 3

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]

REPEAT OF FIGURE 1



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]

u_0 = _____ m s^{-1}

FIGURE 3, on page 21, 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.

[Turn over]

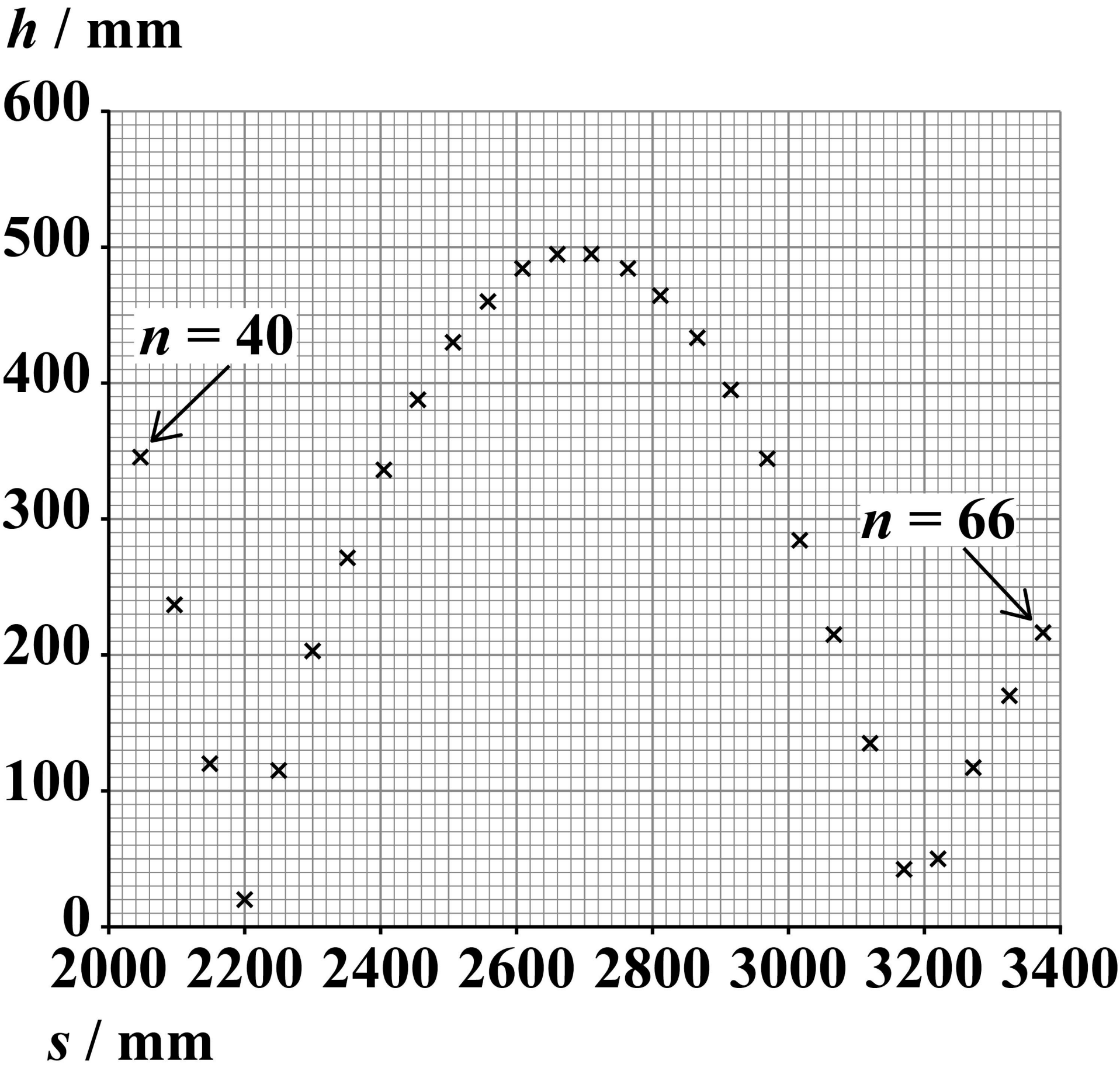
0 1 . 5

Determine, in $\mathrm{mm\ s^{-1}}$, the horizontal velocity of the ball between the second and third contacts of the ball with the floor. [2 marks]

horizontal velocity =

_____ **$\mathrm{mm\ s^{-1}}$**

FIGURE 3



[Turn over]

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0 1 . 6

Determine the time between the second and third contacts.

Annotate FIGURE 3, on page 21, to show your method. [3 marks]

time = _____ s

[Turn over]

13

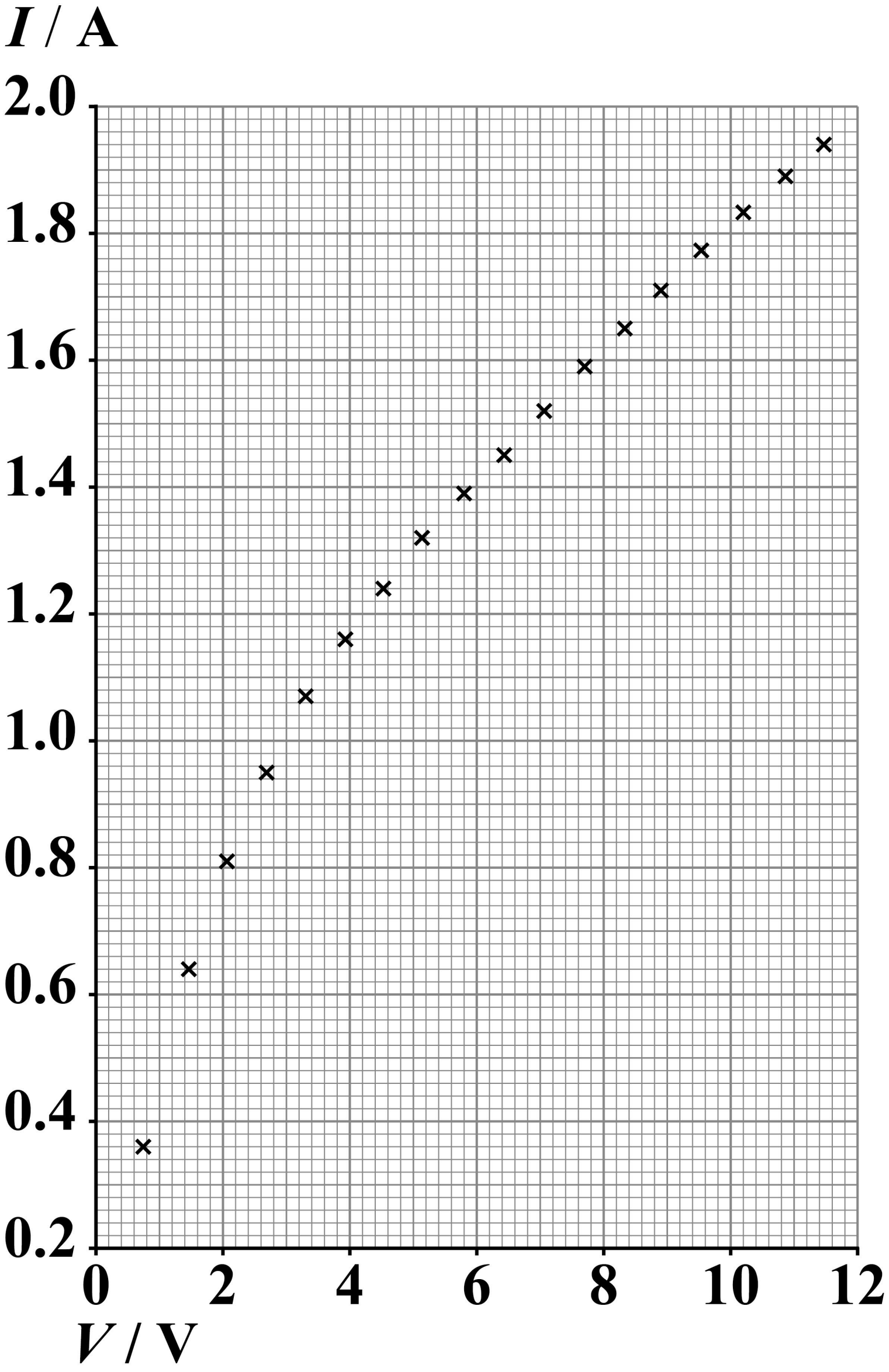
0	2

FIGURE 4, on the opposite page, is a plot of current–voltage data for a filament lamp L.

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 $2.5\ \mathrm{Hz}$.

FIGURE 4



[Turn over]

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0 2 . 1

Determine, in $\mathrm{V\ s^{-1}}$, the rate of increase of V. [2 marks]

rate of increase of V = _____ $\mathrm{V\ s^{-1}}$

[Turn over]

0 2 . 2

State TWO advantages of using data logging for this experiment. [2 marks]

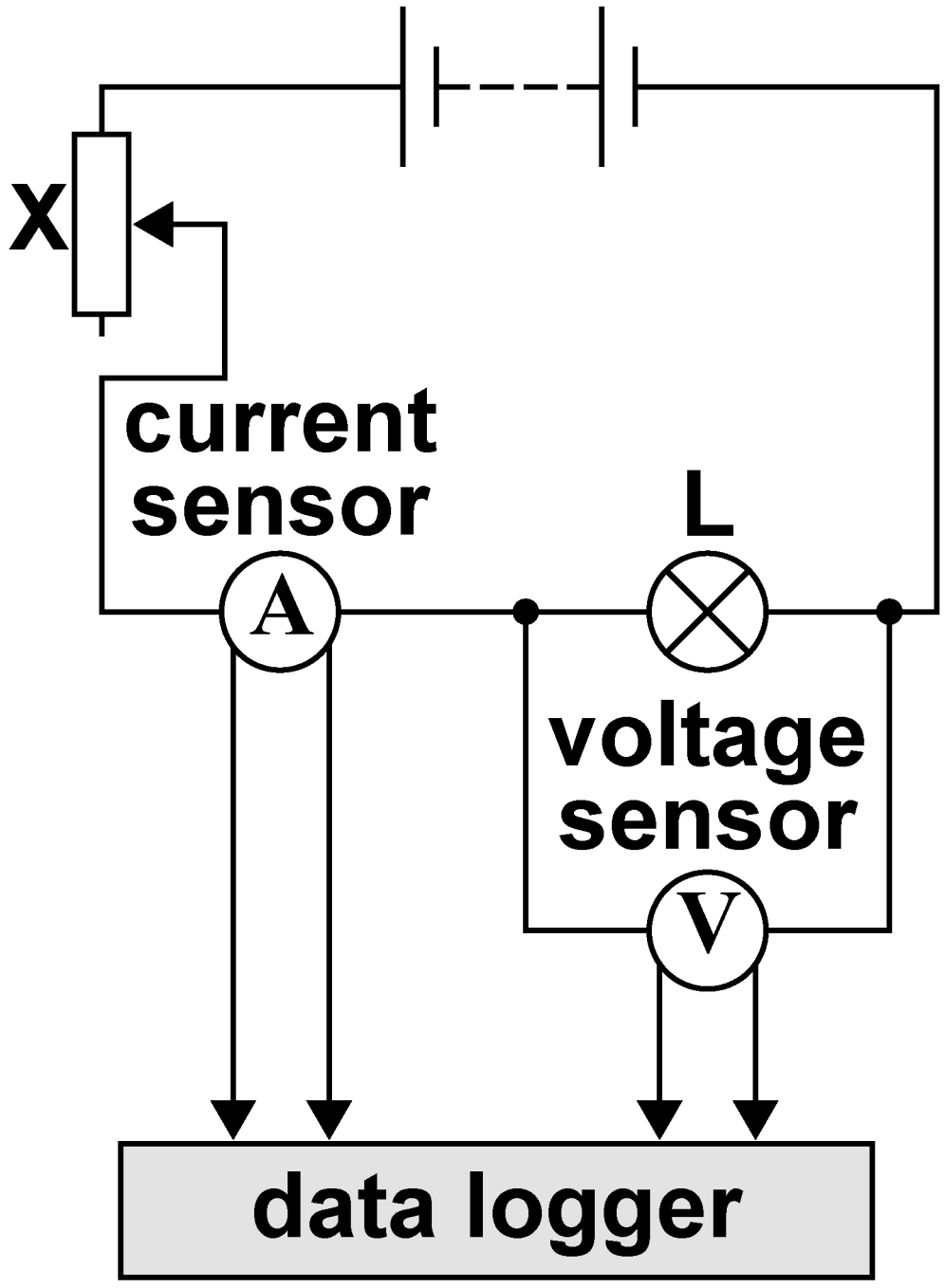
1

2

0 2 . 3

FIGURE 5 shows two circuits that can be used to collect current–voltage data.

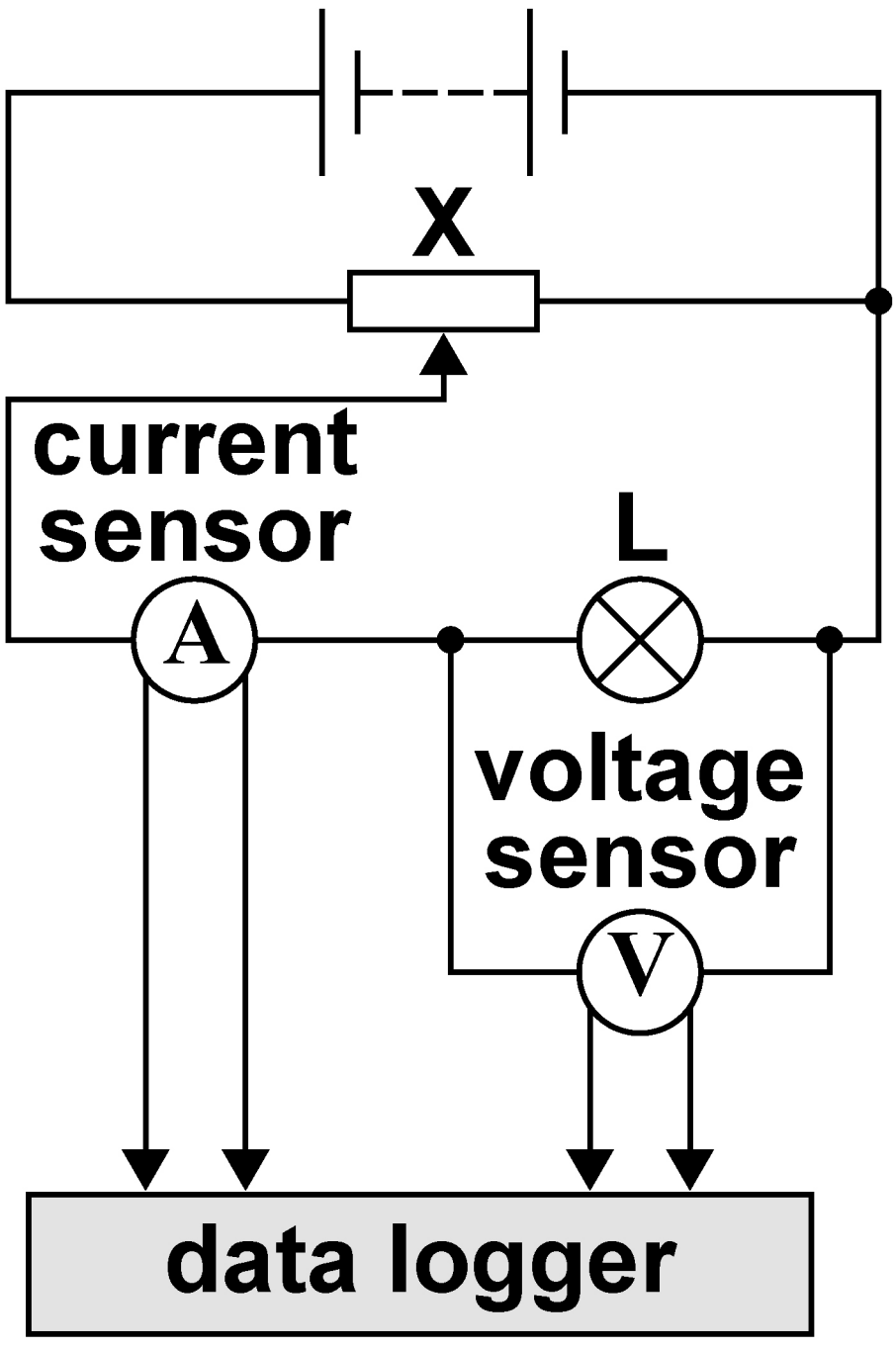
FIGURE 5



circuit 1

[Turn over]

FIGURE 5 continued



circuit 2

The dc supply has an emf of $12\ \mathrm{V}$ 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.

Question 02.3 continues on the next page.

Discuss, with reference to circuit 1 AND circuit 2, whether either circuit can produce all the data shown in FIGURE 4, on page 25.

Support your answer with a calculation.
[4 marks]

[Turn over]

TABLE 2 shows some values of V that are plotted on FIGURE 4, on page 25, 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	
7.69	1.59	12.2
9.58		
11.47	1.94	22.3

0 2 . 4

Complete TABLE 2. [3 marks]

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[Turn over]

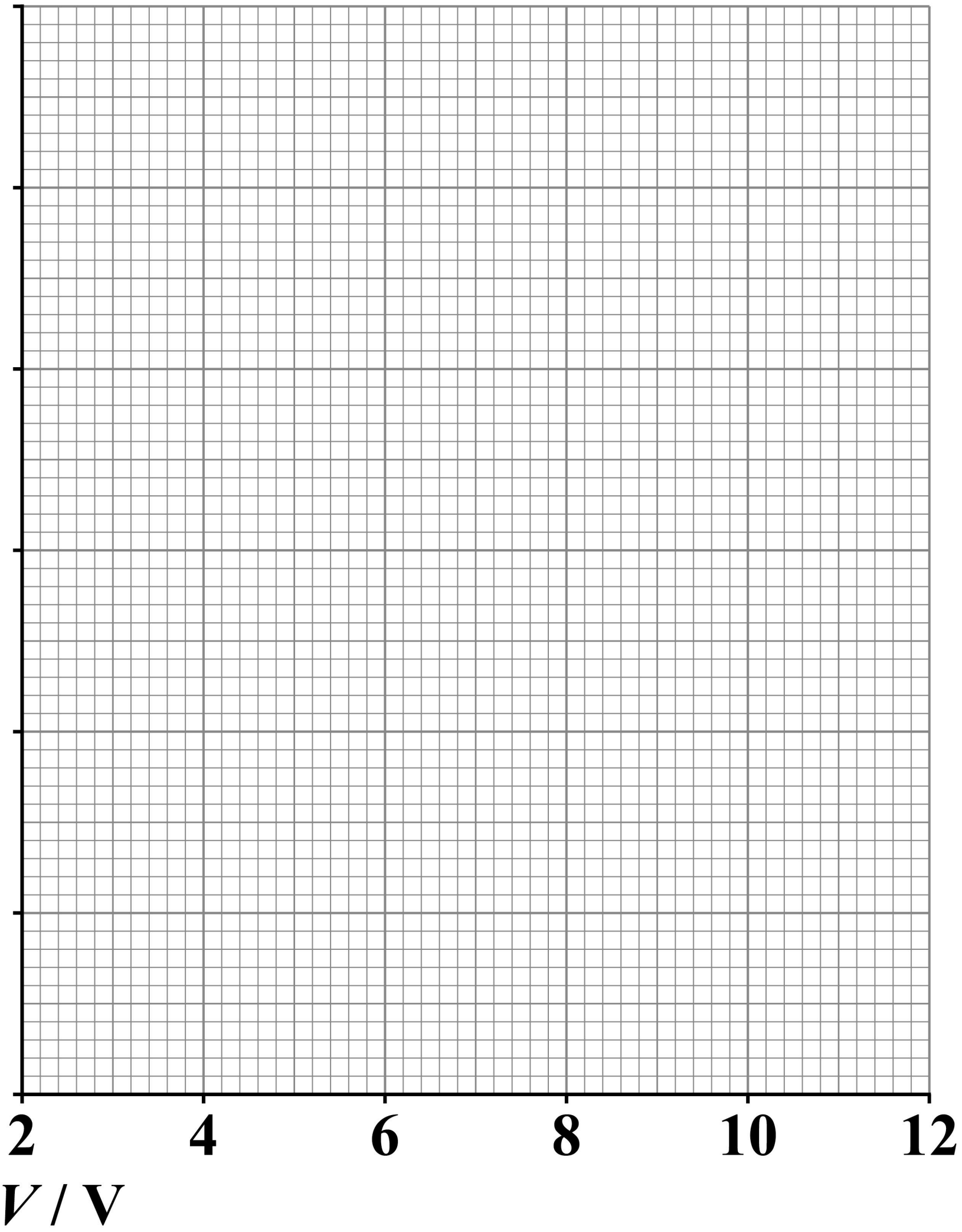
0 2 . 5

Plot on FIGURE 6 a graph of P against V.

FIGURE 6 is provided on the opposite page.

You should use only the data in your completed TABLE 2, on page 34.
[3 marks]

FIGURE 6



[Turn over]

0 2 . 6

L is connected to a $12\ \mathrm{V}$ 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]

percentage = _____ **%**

16

[Turn over]

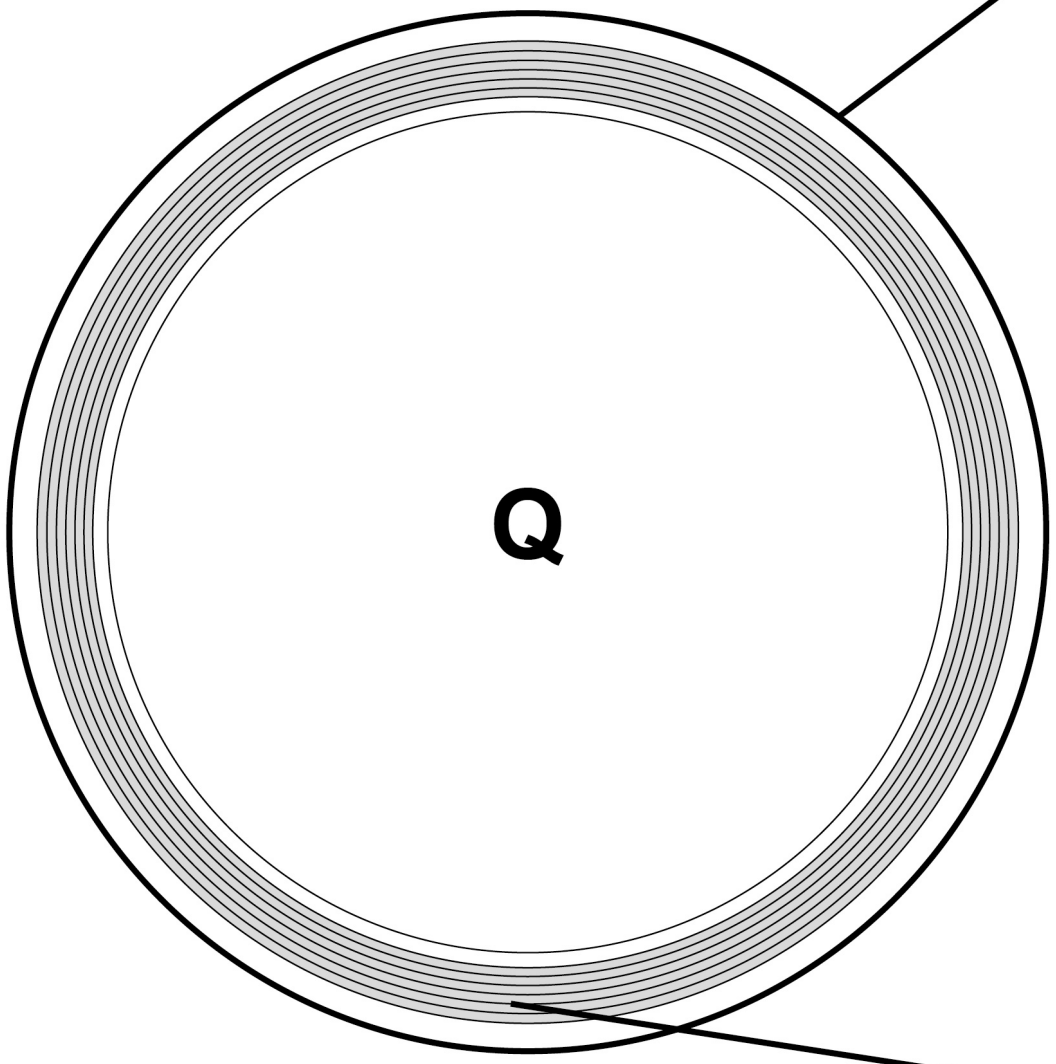
0 3

FIGURE 7a, on the opposite page, shows the front view of a vertical coil mounted on a circular frame.

FIGURE 7b, on the opposite page, 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.

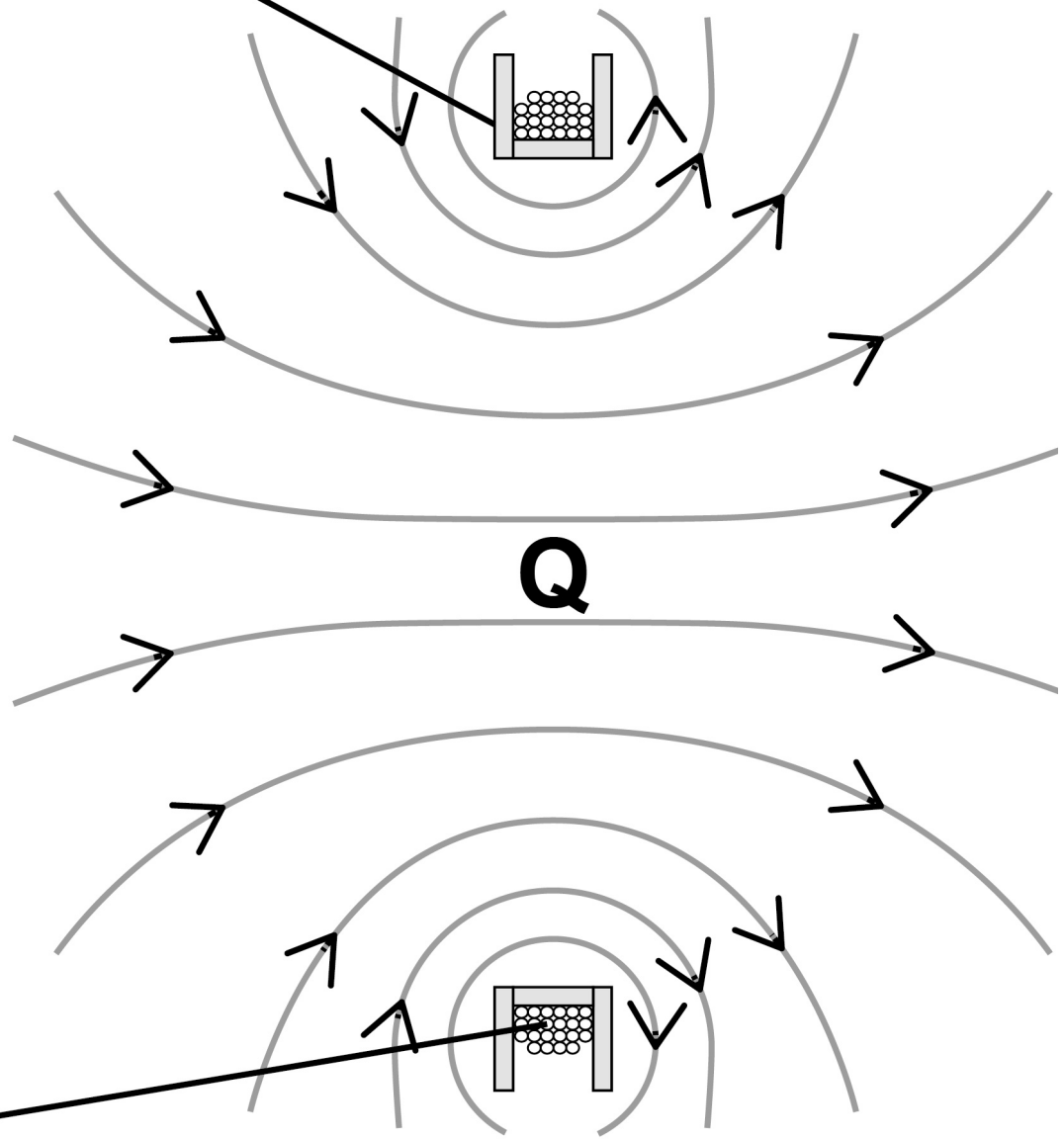
Point Q is at the centre of the coil.
A sensor placed at Q detects B_{H}, the horizontal component of the magnetic flux density.
The effect of the Earth's magnetic field at Q is negligible.

FIGURE 7a



front view

FIGURE 7b



side view

[Turn over]

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0 3 . 1

Discuss whether a search coil is a suitable sensor to detect B_H. [2 marks]

[Turn over]

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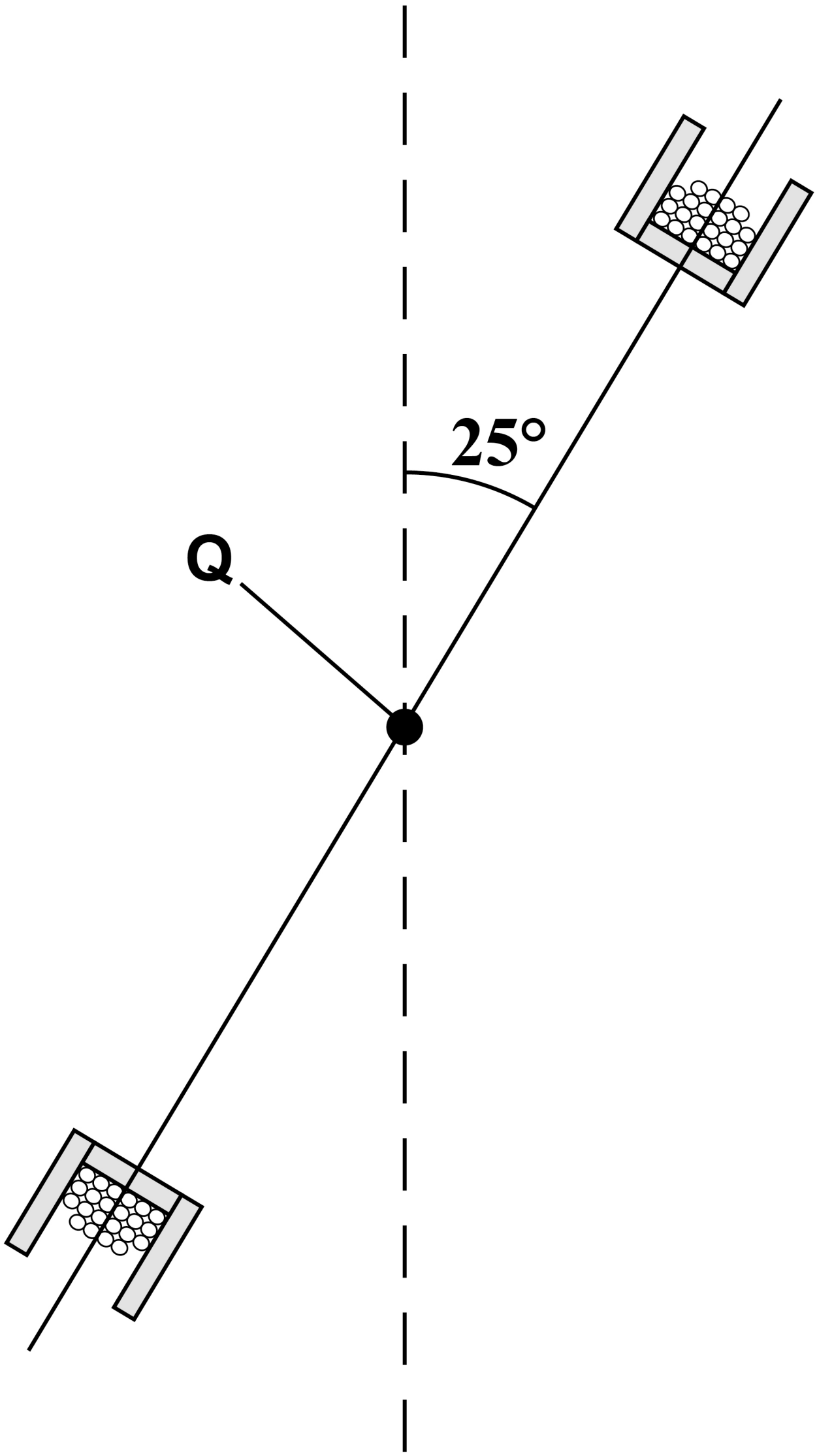
B_H is measured at Q with the coil vertical.

The coil is now rotated about Q through 25° as shown in FIGURE 8, on page 46.

The current in the coil does not change.

[Turn over]

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]

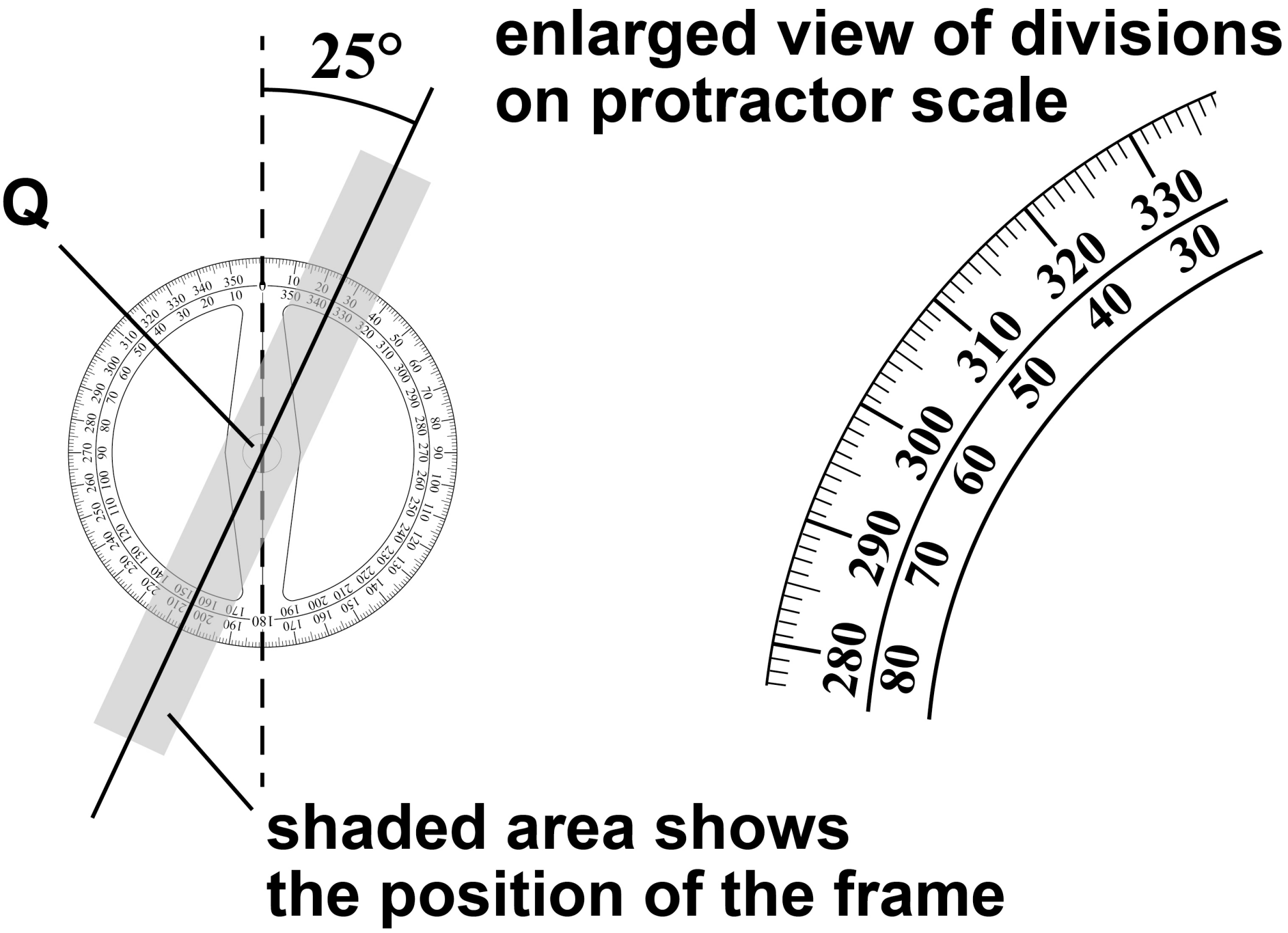
percentage change = _____ %

[Turn over]

0 3 . 3

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

FIGURE 9



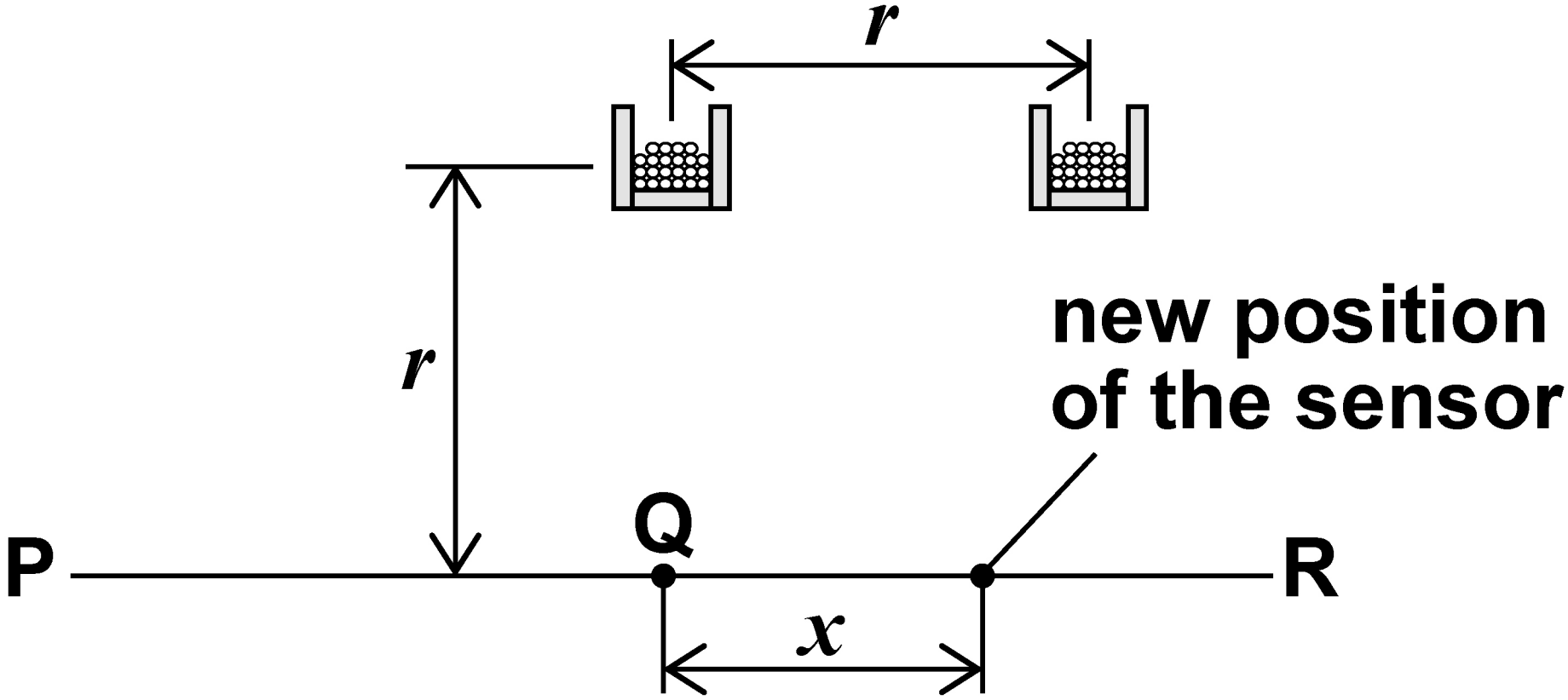
Estimate the percentage uncertainty in this result.
Justify your answer. [3 marks]

percentage uncertainty = _____ %

[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.

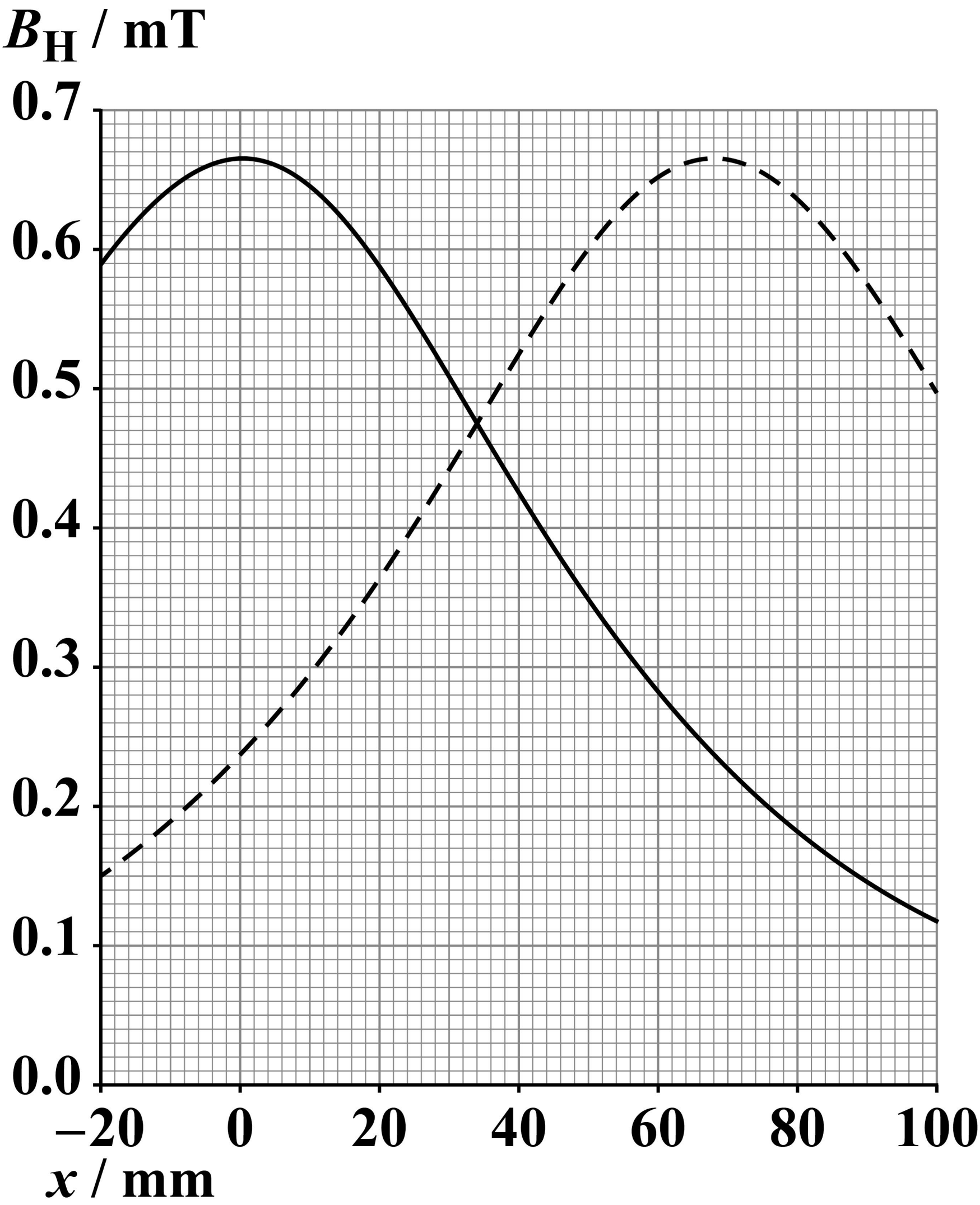
In experiment 1, the current in coil 1 is $225\ \mathrm{mA}$ and the current in coil 2 is zero.

In experiment 2, the current in coil 1 is zero and the current in coil 2 is $225\ \mathrm{mA}$.

FIGURE 11, on page 52, shows the results of experiment 1 and experiment 2.

[Turn over]

FIGURE 11


B_H / mT
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
–20
0
20
40
60
80
100
x / mm
KEY
—— experiment 1
– – – experiment 2

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 $\frac{x_{0.5}}{r}$ [2 marks]

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

In experiment 3, the current in both coils is $225\ \mathrm{mA}$ 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]

B_H = _____ mT

[Turn over]

0 3 . 6

State TWO characteristics of the magnetic field lines in this region.
[2 marks]

1

2

BLANK PAGE

[Turn over]

0 3 . 7

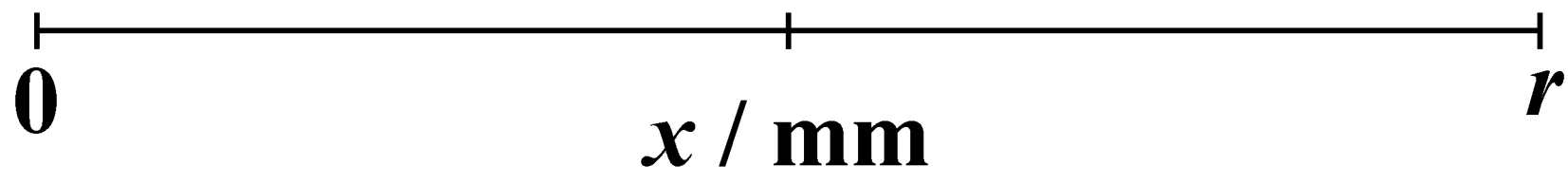
In experiment 4, the current in coil 2 is reversed so that the direction of the magnetic field produced by coil 2 is also reversed.

The magnitudes of the currents in coil 1 and coil 2 are still $225\ \mathrm{mA}$.

On the opposite page, 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

Additional page, if required.

Write the question numbers in the left-hand margin.

Additional page, if required.

Write the question numbers in the left-hand margin.

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For Examiner's Use	
Question	Mark
1	
2	
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TOTAL	