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(2010 – 2016)

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Author	Jawad Tariq Cell: +92 333 4900840 jawadtariq1@gmail.com
Published by	Green Hall Resource Center
Printed by	Sadaat Printers, Urdu Bazar, Lahore.
Composed Department	Sharjeel Khan, Salman Buksh, Hayat, Shahab, Waqas, Adnan, M. Awais
Graphics Department	Rashid Mehmood, Raja Naveed Mumtaz , Sheraz
Legal Advisor	Mian Tariq Ahmad (Advocate Supreme Court) Room No. 10, 11, 12 Al-Majeed Centre 1-Mozang Road, Lahore. Tel: 042-37236145, Fax: 042-37241367
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PREFACE

Physics paper 5 is an important component of A level Physics, which is taught at the end of second academic year of A levels. So students don't get enough time to practice this paper. Any proper solutions or guide for this paper is not available in market. This compilation will help students to prepare paper 5 in very limited time. The book provides a format to attempt complete paper according to Cambridge International Examination requirement. Step by step answer along with diagram is provided in the planning question. The book also focuses on tackling the analysis conclusions and evaluation question with special emphasis in calculating the uncertainties.

Constructive criticism and suggestions to make the subsequent editions more useful would be appreciated and thankfully acknowledged.

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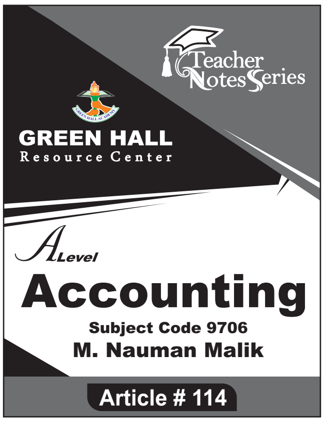

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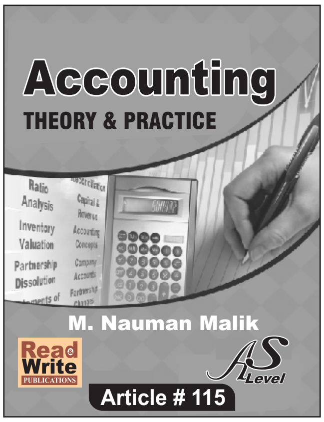

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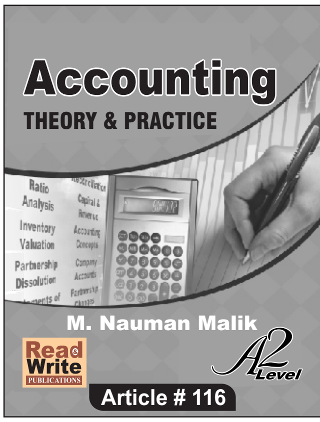

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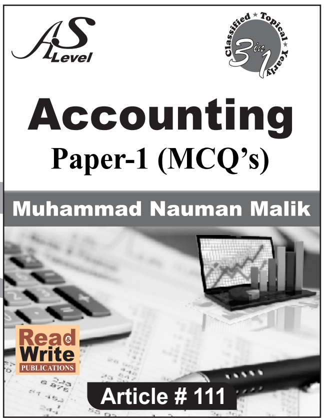

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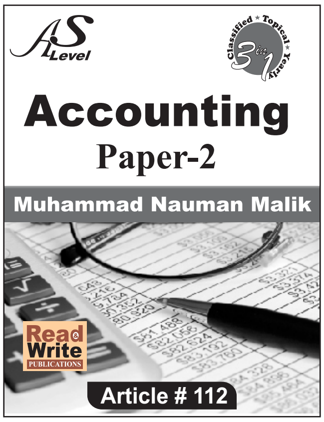

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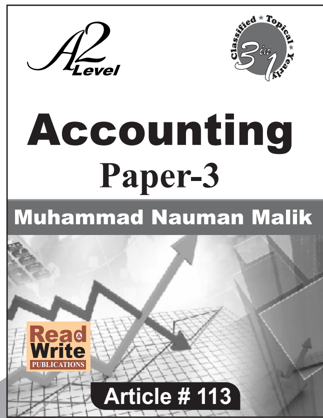

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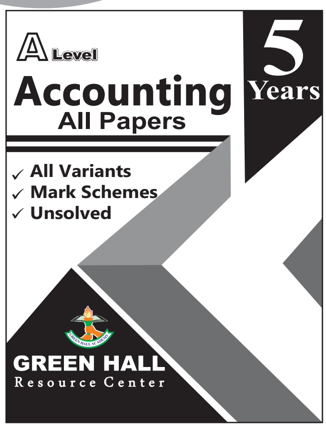

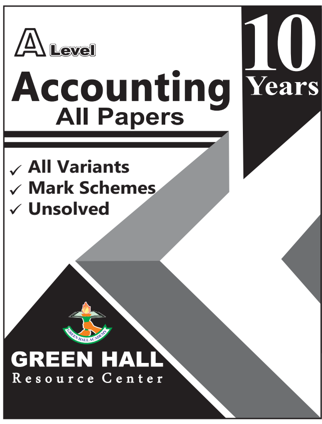

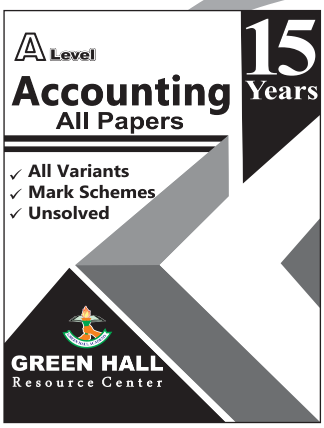

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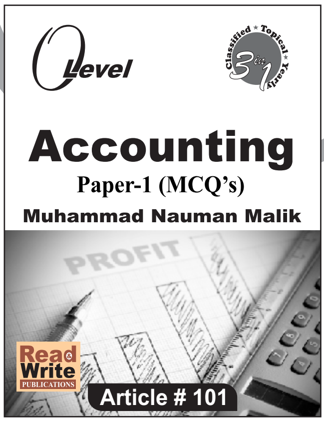

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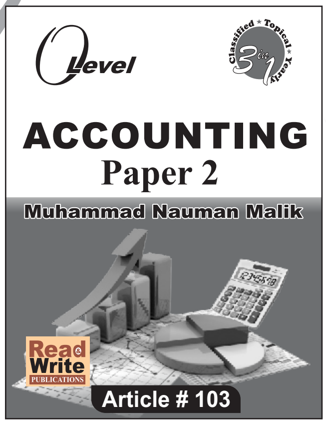

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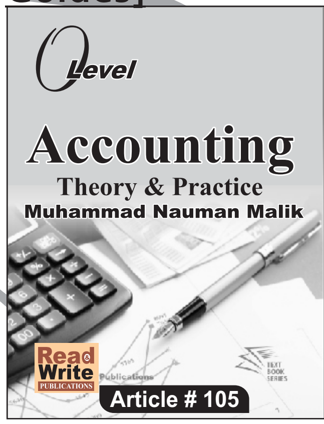

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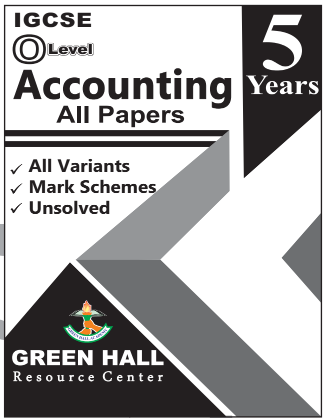

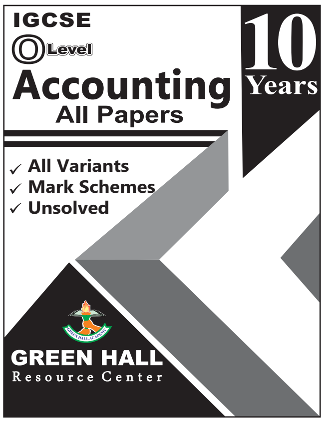

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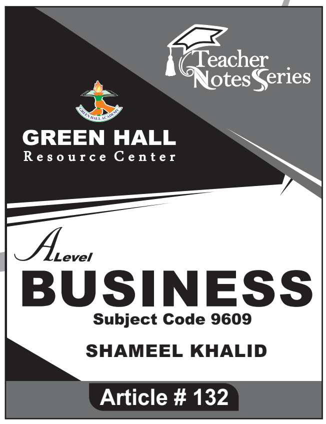

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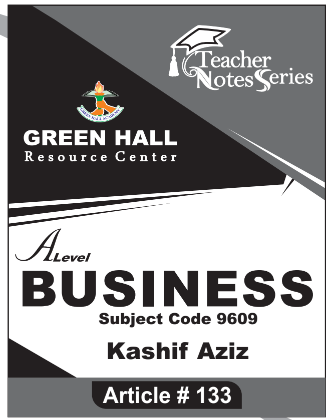

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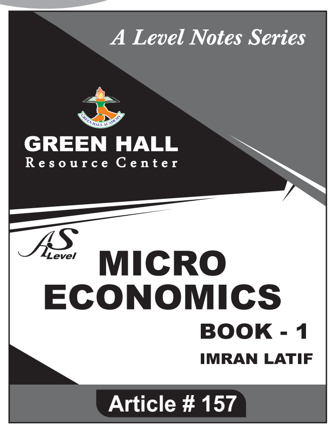

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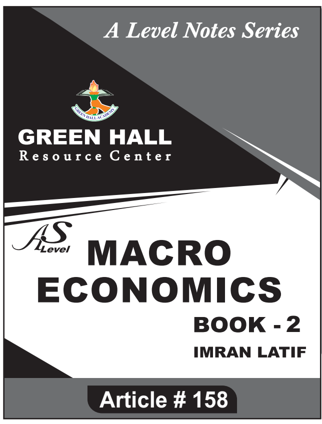

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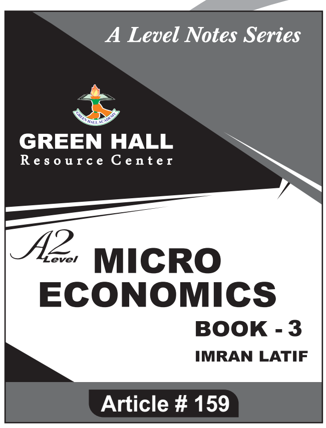

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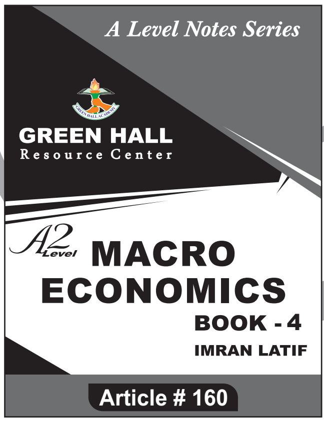

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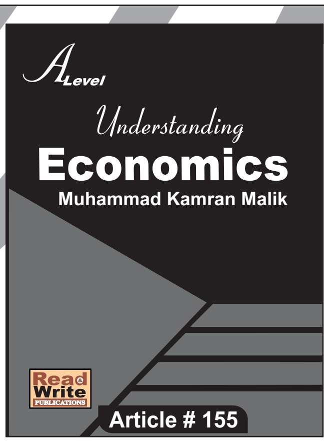

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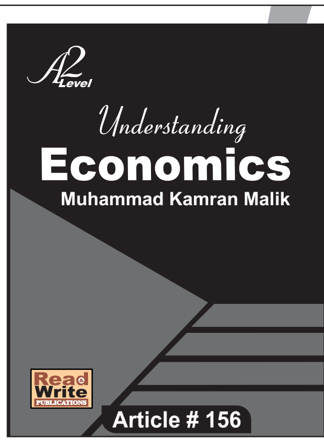

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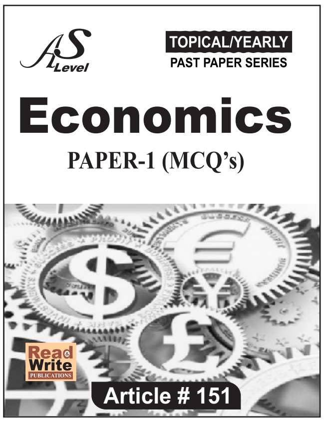

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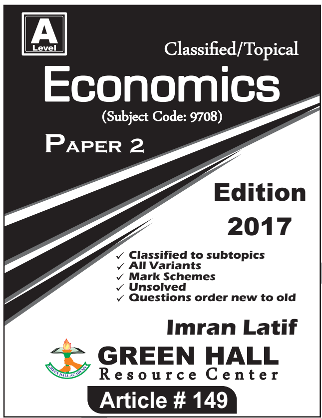

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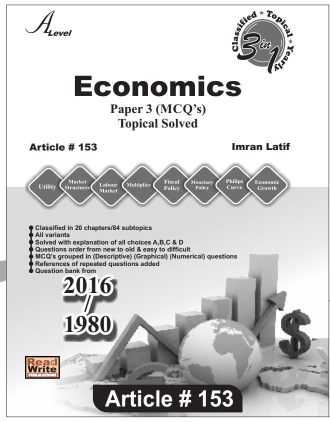

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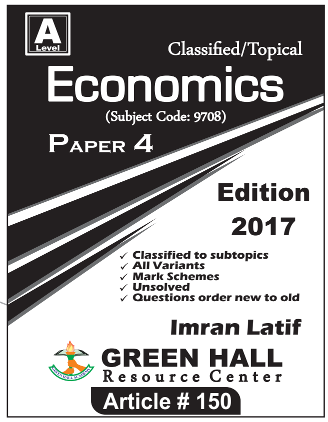

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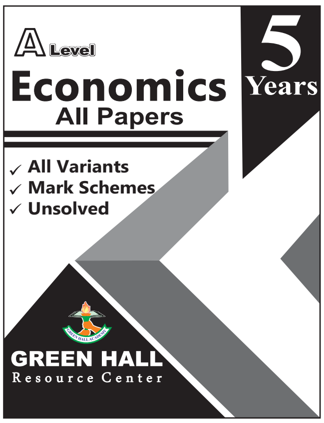

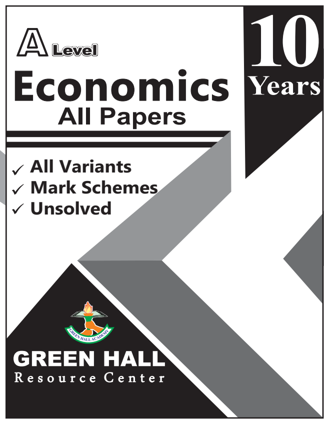

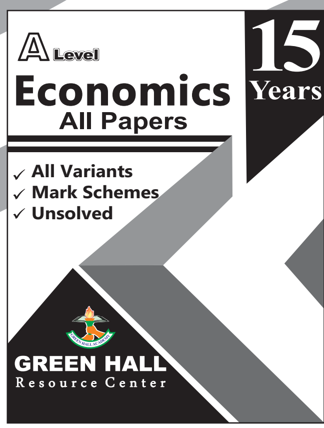

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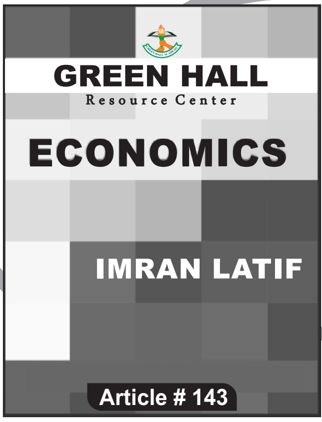

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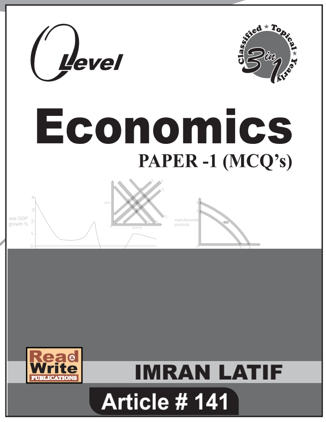

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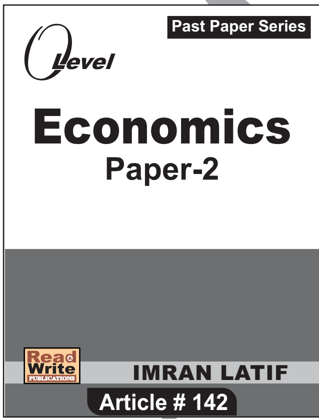

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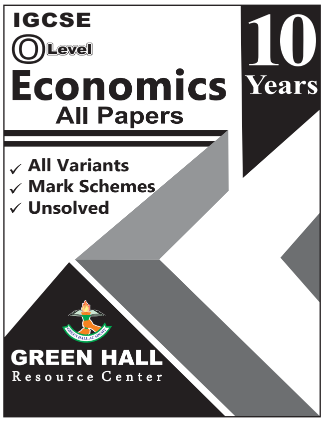

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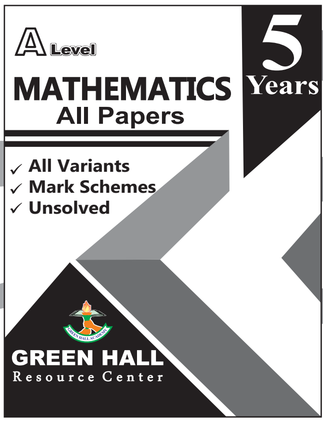

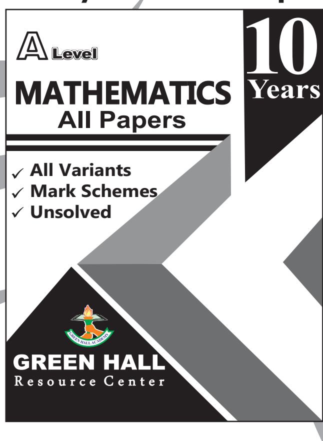

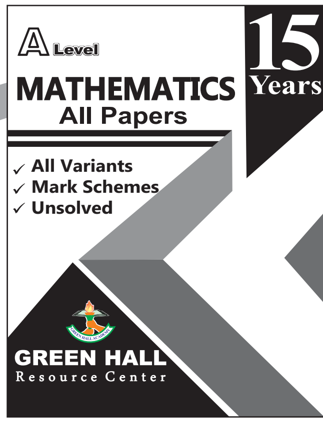

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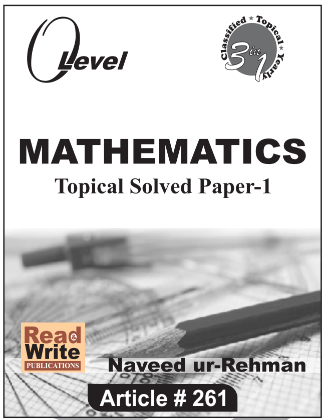

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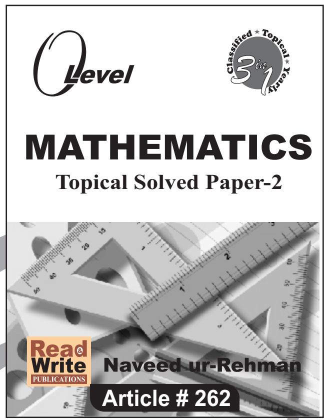

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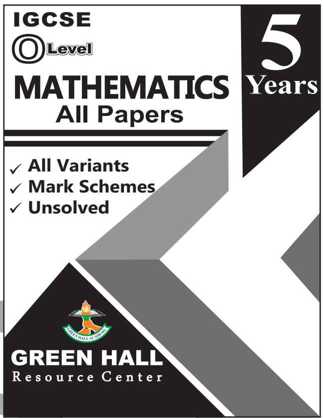

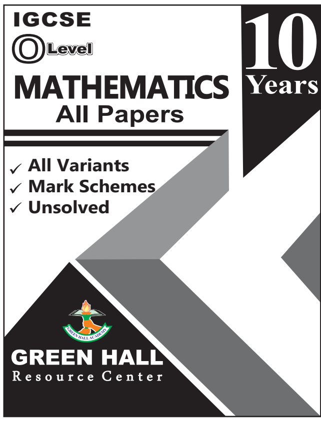

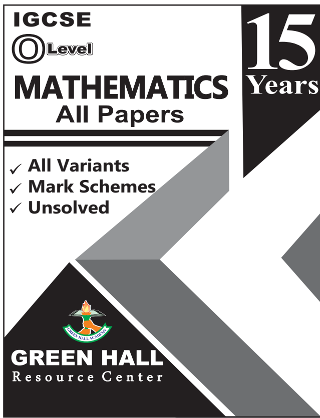

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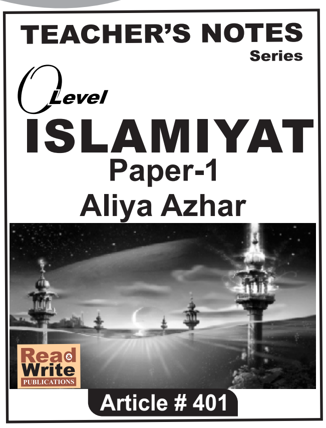

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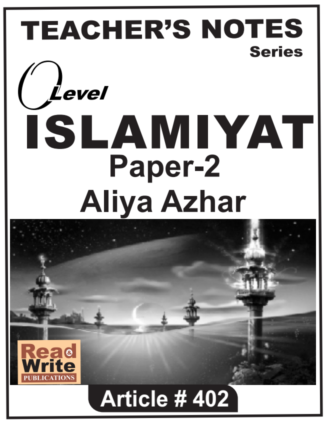

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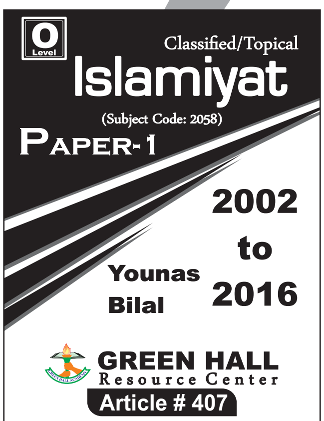

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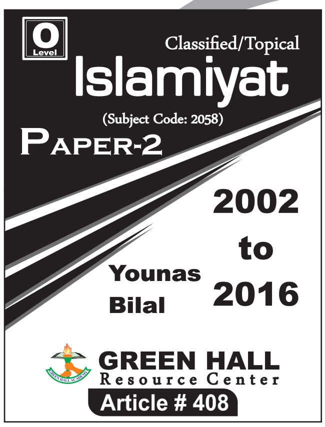

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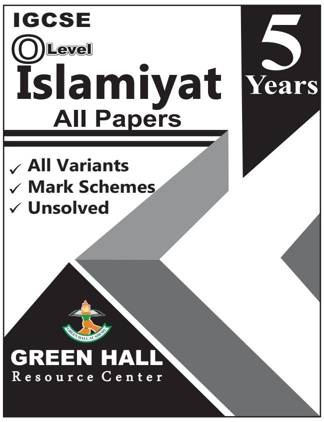

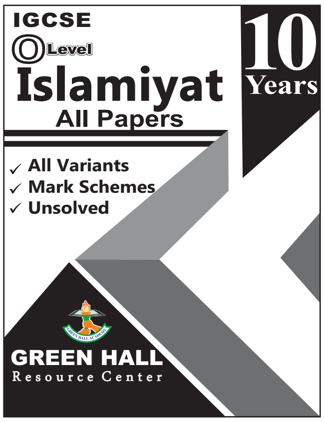

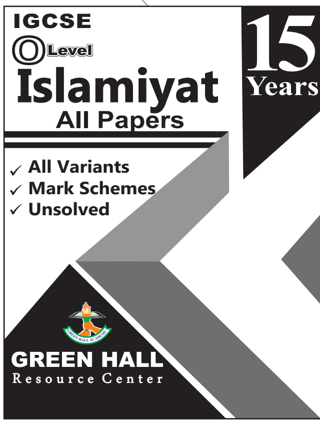

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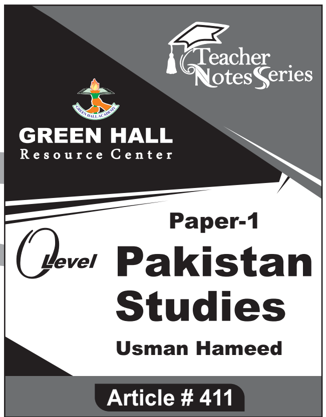

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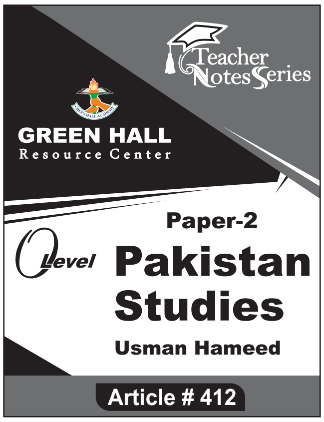

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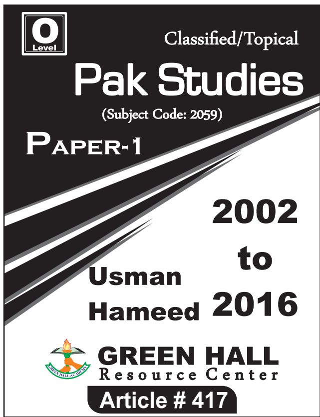

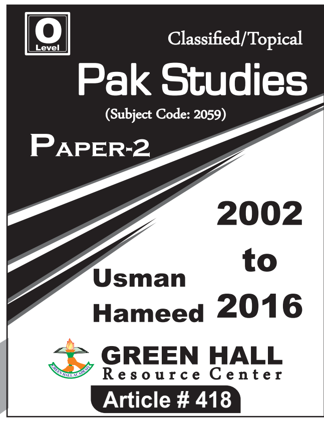

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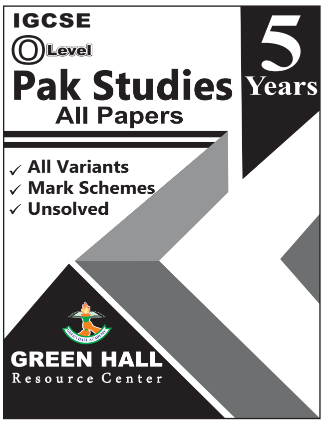

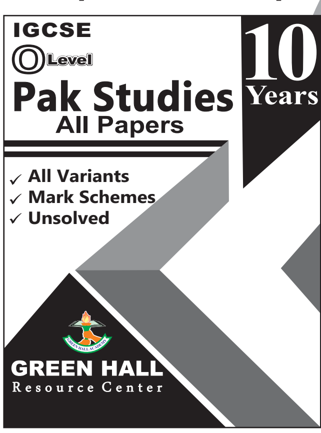

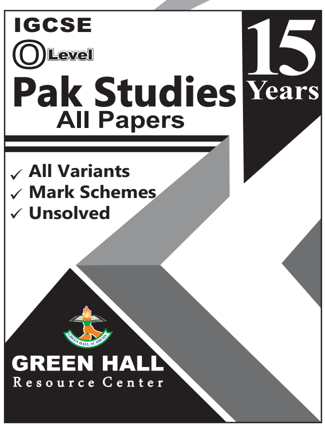

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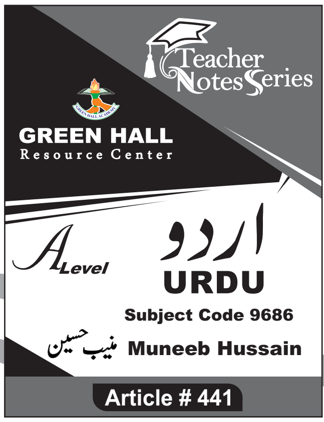

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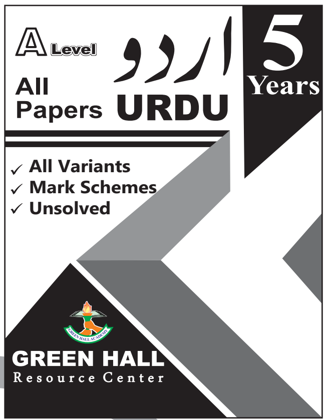

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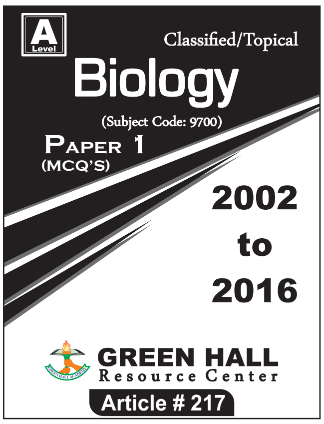

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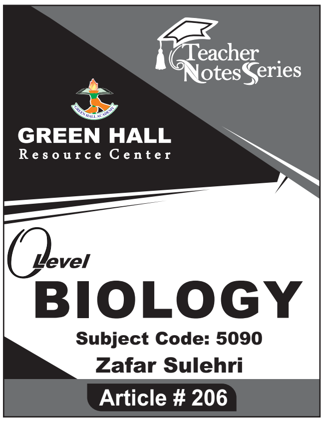

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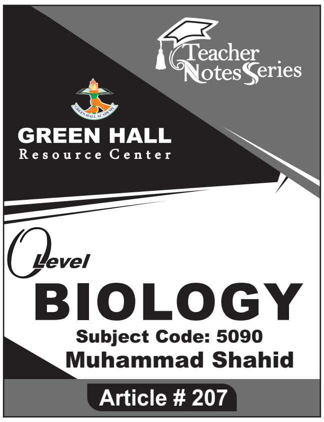

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[Yearly Past Papers]

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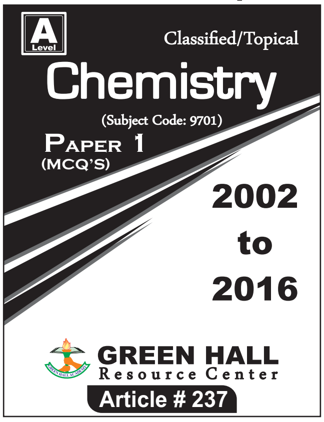

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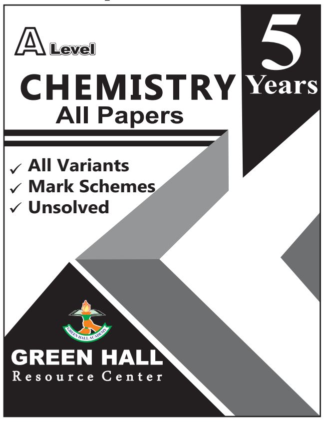

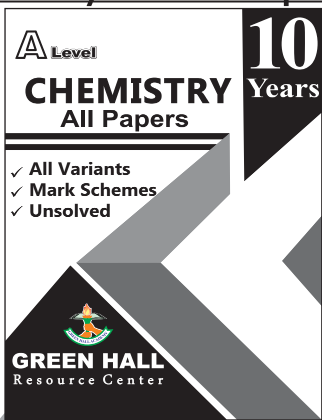

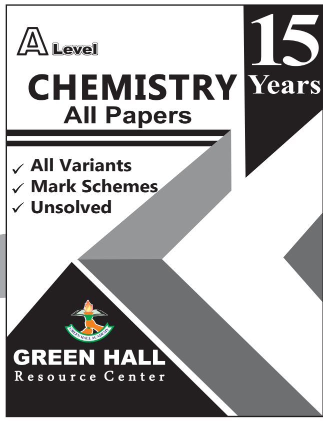

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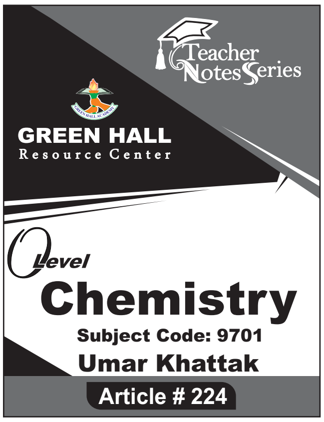

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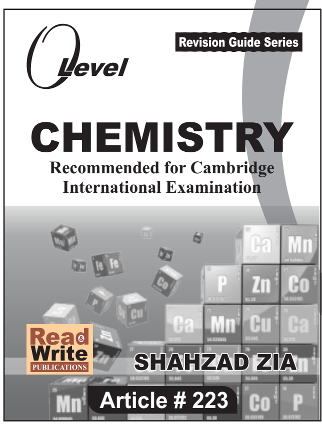

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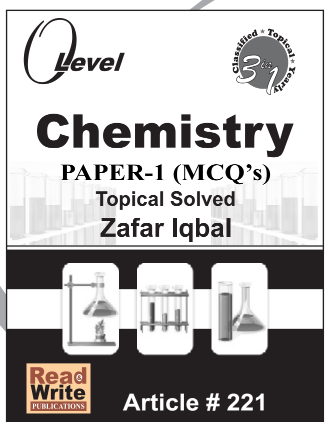

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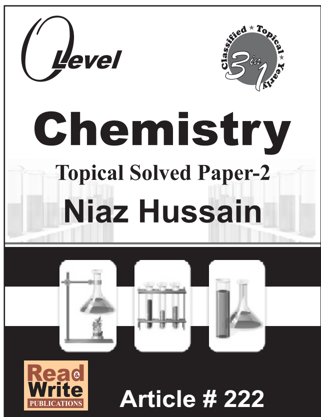

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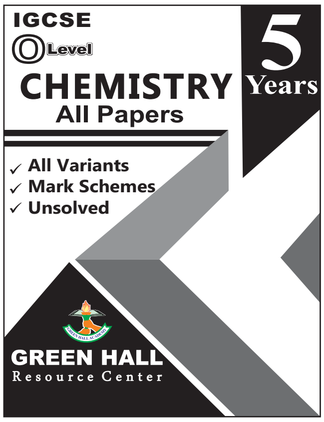

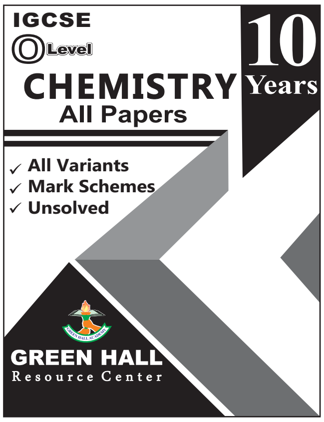

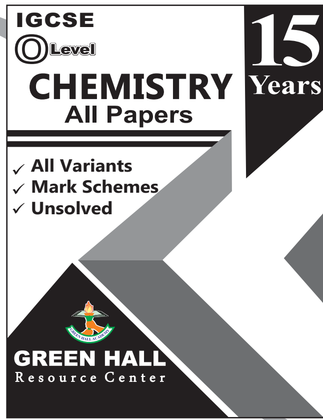

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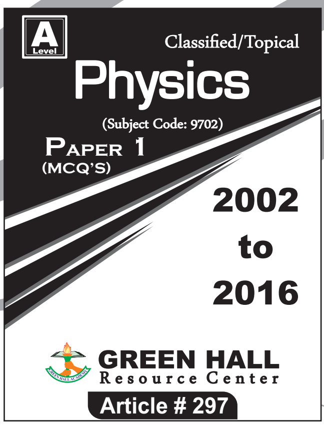

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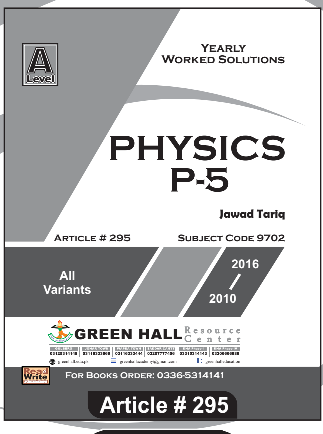

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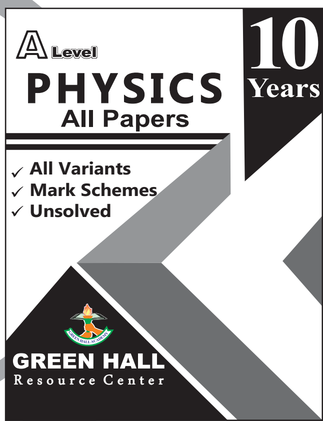

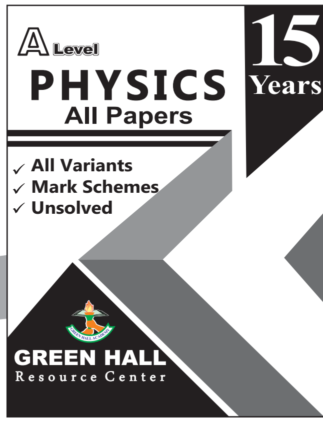

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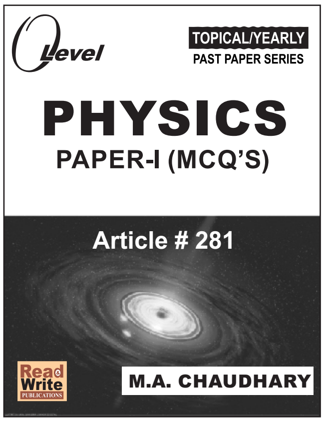

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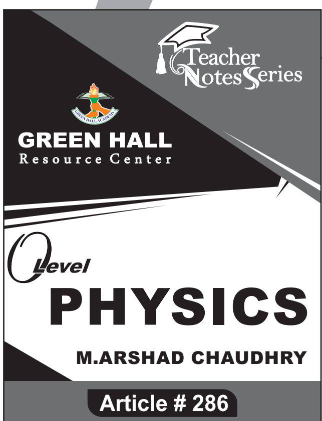

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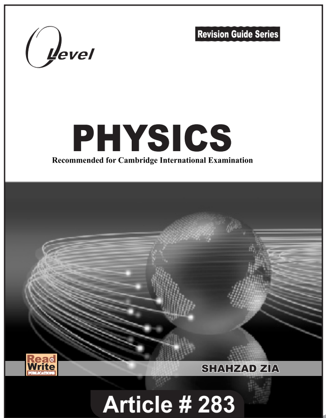

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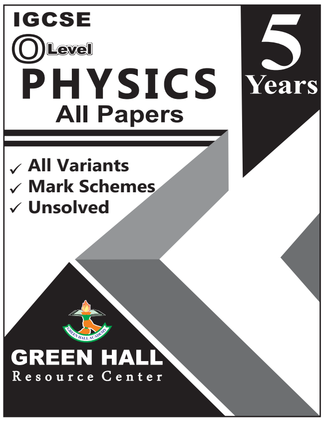

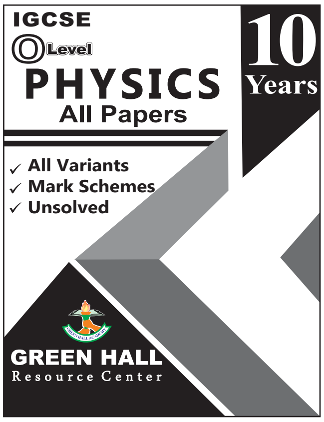

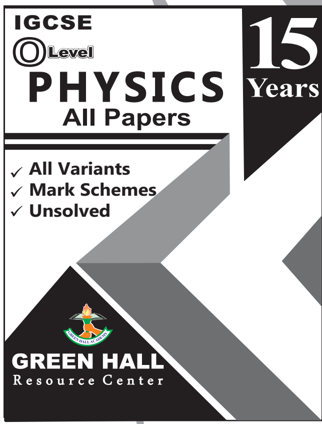

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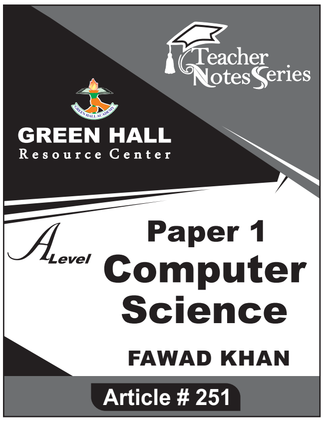

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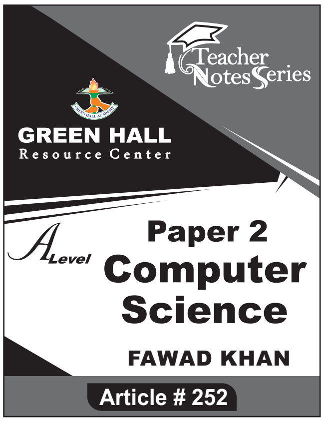

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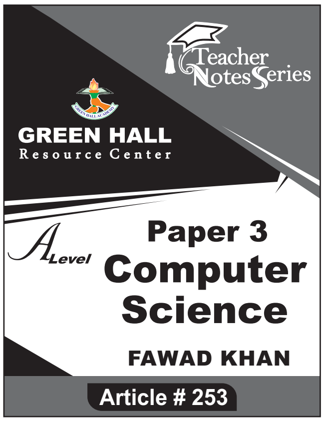

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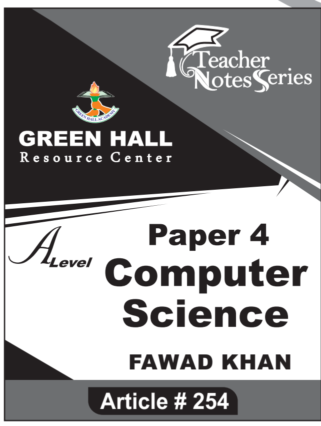

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[Yearly Past Papers]

O-Level

[Yearly Past Papers]

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Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2016**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

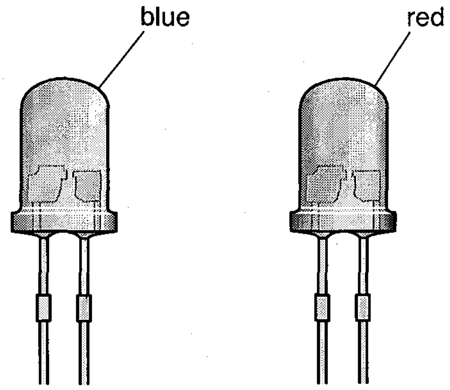
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

DC (LEG/SG) 109582/2

[Turn over

1 A student is investigating the characteristics of different light-emitting diodes (LEDs). Fig. 1.1 shows examples of LEDs and the circuit symbol for an LED.



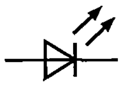
circuit symbol: 

Fig 1.1

Each LED needs a minimum potential difference V across it to emit light. The student is investigating the relationship between V and the wavelength λ of the light emitted by the LED for several different LEDs.

It is suggested that the relationship is

$$V = k\lambda^n$$

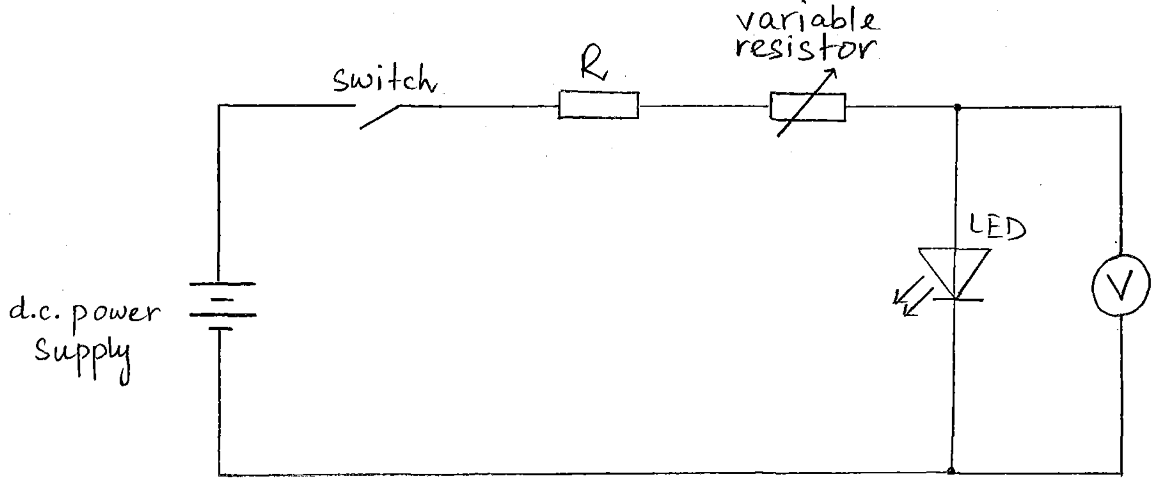
where k and n are constants.

Design a laboratory experiment to test the relationship between V and λ. Explain how your results could be used to determine values for k and n. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any safety precautions to be taken.

[15]

Diagram



Defining the problem:
Independent Variable: Wavelength λ
Dependent Variable: Potential difference V
Constant: Temperature
Procedure:
Connect variable resistor in series to change potential difference accross LED. Keep the resistance of variable resistor to maximum value in the beginning. Slowly reduce the resistance of variable resistor to increase the potential difference V accross LED. Measure the value of potential difference V from voltmeter when LED just emits light. Record the wavelength of light of given LED from its data sheet. Repeat the experiment for LEDs which emit light of

different wavelength λ. Record the data in a given table.

Tabulation:

Number of Observation	λ/m	V/V	lg(λ/m)	lg(V/V)

Analysis of data:

Plot a graph of lg(V/V) against lg(λ/m).

Graph would give straight line with gradient = n and y-intercept = lgK.

$$\lg V = n \lg \lambda + \lg K$$

$$n = \text{gradient}$$

$$\lg K = \text{y-intercept}$$

$$K = 10^{\text{y-intercept}}$$

Safety precaution:

Wear safety gloves to avoid electric shock.

Additional details:

1- Perform the experiment in dark room so that low intensity light is detected easily.

2. Repeat the experiment for same λ. Measure more values of V and take average.

3. Use light detector to detect light when LED just emits.

4. Use protective resistor in series to prevent short circuits.

2 A student is investigating how the extension of a loaded wire depends on the diameter of the wire.

The apparatus is set up as shown in Fig. 2.1.

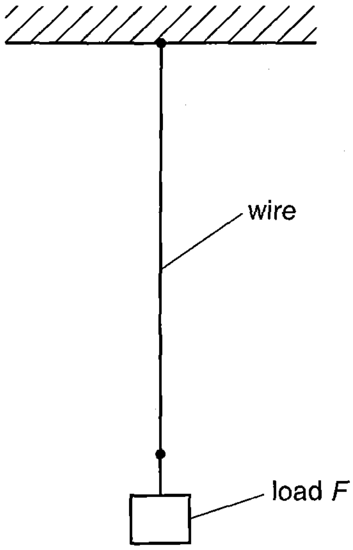


Fig. 2.1

A load F is applied to the wire and the extension e is measured.

The experiment is repeated for wires of the same material and same initial length L but different diameter d.

It is suggested that e and d are related by the equation

$$e = \frac{4LF}{\pi E d^2}$$

where E is a constant.

(a) A graph is plotted of e on the y-axis against $\frac{1}{d^2}$ on the x-axis.

Determine an expression for the gradient.

$$e = \frac{4LF}{\pi E d^2}$$

$$e = \frac{4LF}{\pi E}\left(\frac{1}{d^2}\right)$$

$$y = m \quad x$$

gradient = $\frac{4LF}{\pi E}$ [1]

(b) Values of *d* and *e* are given in Fig. 2.2.

$d/10^{-3}$m	$e/10^{-3}$m	$\frac{1}{d^2}/10^{6}m^{-2}$
0.28 ± 0.02	11.3	12.8 ± 1.8
0.32 ± 0.02	8.6	9.77 ± 1.2
0.38 ± 0.02	6.0	6.93 ± 0.73
0.46 ± 0.02	4.1	4.73 ± 0.41
0.56 ± 0.02	2.7	3.19 ± 0.23
0.72 ± 0.02	1.7	1.93 ± 0.11

Fig. 2.2

Calculate and record values of $\frac{1}{d^2}/10^6\,m^{-2}$ in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{d^2}$. [3]

(c) (i) Plot a graph of $e/10^{-3}$ m against $\frac{1}{d^2}/10^6\,m^{-2}$.

Include error bars for $\frac{1}{d^2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

Gradient of best fit line:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{(11.4 - 3.5)10^{-3}}{(13-4)10^{6}}$$

$$= 8.8 \times 10^{-10}$$

Gradient of worst acceptable line:

$$\text{gradient} = \frac{(10.1-3.5)10^{-3}}{(13-4.2)10^{6}}$$

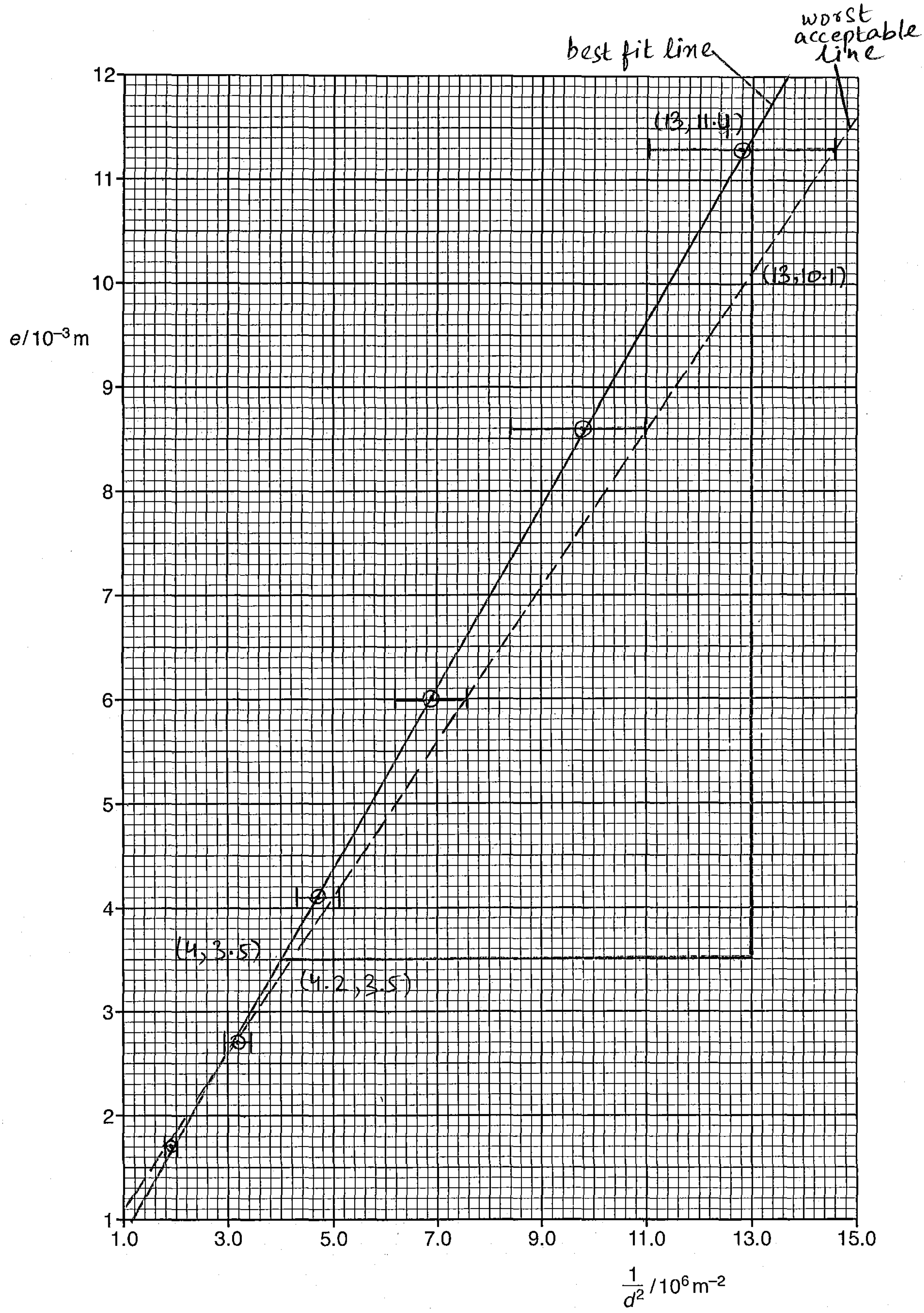
$$= 7.5 \times 10^{-10}$$

$$\Delta \text{gradient} = (8.8 - 7.5)10^{-10}$$

$$= 1.3 \times 10^{-10}$$

$$= 1 \times 10^{-10} (1sf)$$

gradient = $(9 \pm 1) \times 10^{-10}$ [2]



worst acceptable line
best fit line
(13, 11.4)
(13, 10.1)
(4, 3.5)
(4.2, 3.5)
$e/10^{-3}$ m
$\frac{1}{d^2}/10^6\,m^{-2}$
1
2
3
4
5
6
7
8
9
10
11
12
1.0
3.0
5.0
7.0
9.0
11.0
13.0
15.0

(d) **(i)** Using your answers to **(a)** and **(c)(iii)**, determine the value of *E*. Include an appropriate unit.

Data: $L = 2.50 \pm 0.01\,\text{m}$ and $F = 19.0 \pm 0.5\,\text{N}$.

$$\frac{4LF}{\pi E} = \text{gradient}$$

$$E = \frac{4LF}{\pi \times \text{gradient}}$$

$$E = \frac{4 \times 2.5 \times 19}{\pi \times 9 \times 10^{-10}}$$

$$E = 6.7 \times 10^{10}$$

Units: $\frac{m \times N}{m/m^{-2}}$

$= N\,m^{-2}$

$E =$ $6.7 \times 10^{10}\ N\,m^{-2}$ [2]

(ii) Determine the percentage uncertainty in *E*.

$$\frac{\Delta E}{E} \times 100 = \left[\frac{\Delta L}{L} + \frac{\Delta F}{F} + \frac{\Delta \text{gradient}}{\text{gradient}}\right] \times 100$$

$$= \left[\frac{0.01}{2.50} + \frac{0.5}{19.0} + \frac{1}{9}\right] \times 100$$

$$= 14\%$$

percentage uncertainty in $E =$ 14 % [1]

(e) The experiment is repeated with a thinner wire of diameter $0.23 \pm 0.02\,\text{mm}$. The wire is of the same material and initial length.

Determine the extension *e* of the wire when the same load is added to it. Include the absolute uncertainty in your answer.

$$e = \left[\frac{4LF}{\pi E}\right] \times \left[\frac{1}{d^2}\right]$$

$$e = \text{gradient} \times \frac{1}{d^2}$$

$$e = 9 \times 10^{-10} \times \frac{1}{(0.23 \times 10^{-3})^2}$$

$$e = 17.0 \times 10^{-3}$$

$$\frac{\Delta e}{e} = \frac{\Delta \text{gradient}}{\text{gradient}} + 2\frac{\Delta d}{d}$$

$$\Delta e = \left[\frac{1}{9} + \frac{2(0.02)}{0.23}\right] \times 17 \times 10^{-3}$$

$$\Delta e = 0.3 \times 10^{-3}$$

$e =$ $(17.0 \pm 0.3) \times 10^{-3}$ m [2]

[Total: 15]

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2016**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
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CAMBRIDGE
International Examinations

1 A student is investigating the acceleration of a trolley moving up an inclined plane as shown in Fig. 1.1.

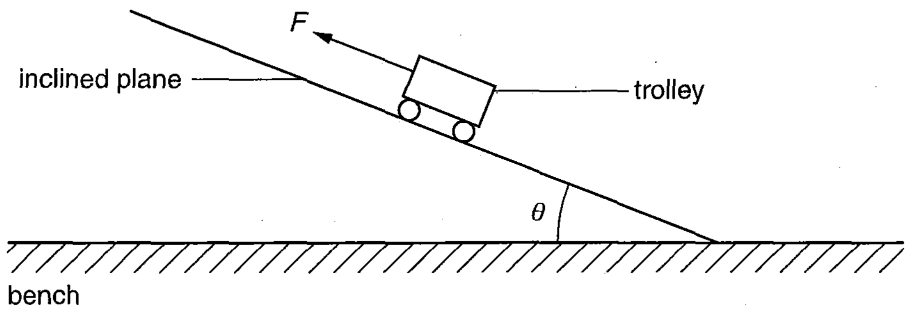


Fig. 1.1

The student is investigating the relationship between the acceleration a of the trolley and the angle θ of the inclined plane when a force F is applied to the trolley.

It is suggested that the relationship is

$$ma = F - (mg\sin\theta + k)$$

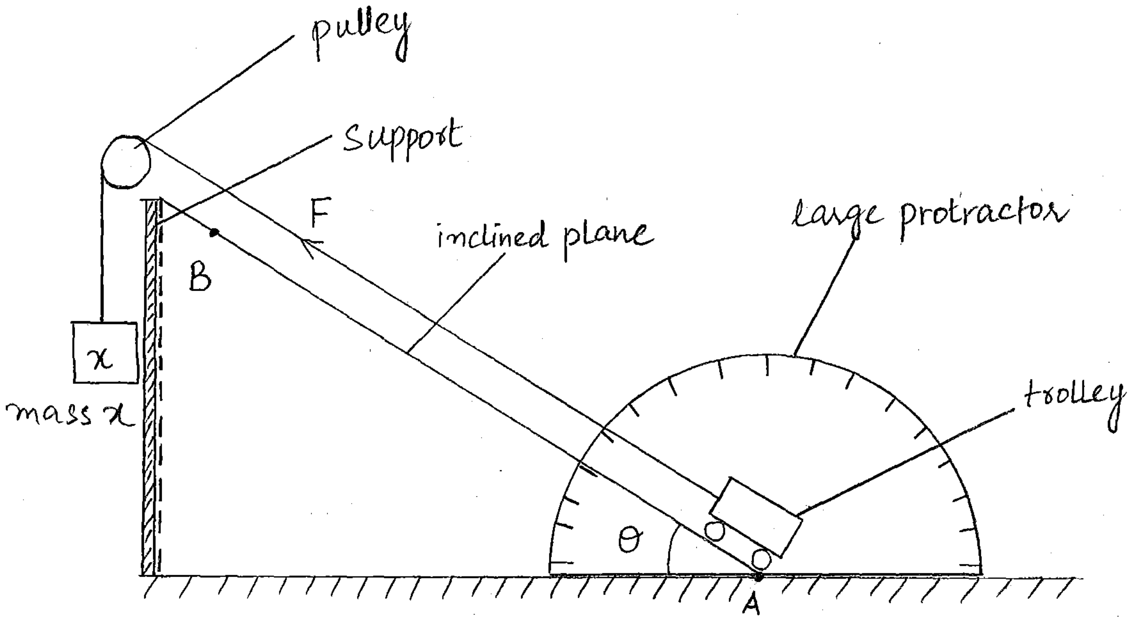
where g is the acceleration of free fall, m is the mass of the trolley and k is a constant.

Design a laboratory experiment to test the relationship between a and θ. Explain how your results could be used to determine a value for k. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any safety precautions to be taken.

[15]

Diagram



Defining the problem:
Independent variable: Angle θ
Dependent variable: Acceleration a
Constant: Force F

Procedure:
Measure the angle θ using large protractor. Measure the length AB with meter rule. Measure time t taken by trolley to cover the distance AB using stopwatch. Make sure that trolley is at rest at point A. Calculate the acceleration a of trolley using the relationship, $a = 2AB/t^2$, according to second equation of motion. Measure mass m of trolley and mass x with digital balance.

Measure force F by using the formula, $F = xg$. Perform the experiment for at least five more different values of θ. Record the data in given table.

Tabulation:

Number of Observation	$\theta/°$	t_1/s	t_2/s	t_{av}/s	$\sin\theta$	a/ms^{-2}

Analysis of data:

$$a = -g\sin\theta + (F-k)/m$$

Plot a graph of a against $\sin\theta$. Graph would be a straight line with gradient, $-g$.

$$y\text{-intercept} = (F-k)/m$$

$$k = F - (m \times y\text{-intercept})$$

Safety Precaution:

Use sand tray to catch falling mass x and to prevent injury.

Additional Details:

1- Use same trolley throughout the experiment.
2- Take longer distance AB to reduce uncertainty in value of acceleration.
3- Use smooth and frictionless pulley to minimize frictional force.
4. Repeat the experiment for same value of θ and take average value of acceleration.

2 A student is investigating how the resistance of a wire depends on the diameter of the wire.

The circuit is set up as shown in Fig. 2.1.

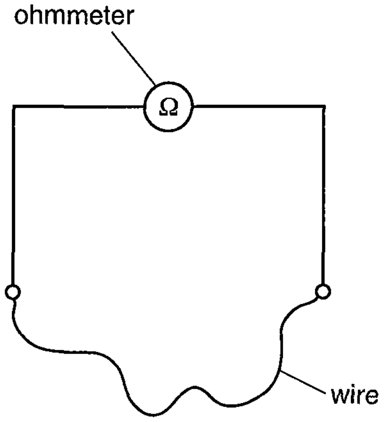


Fig. 2.1

The resistance R of the wire is measured using an ohmmeter.

The experiment is repeated for wires of the same material and same length L but different diameter d.

It is suggested that R and d are related by the equation

$$R = \frac{4\rho L}{\pi d^2}$$

where ρ is a constant.

(a) A graph is plotted of R on the y-axis against $\frac{1}{d^2}$ on the x-axis.

Determine an expression for the gradient.

$$R = \frac{4\rho L}{\pi d^2}$$

$$R = \frac{4\rho l}{\pi}\left[\frac{1}{d^2}\right]$$

gradient = $4\rho L/\pi$ [1]

(b) Values of *d* and *R* are given in Fig. 2.2.

$d/10^{-3}$ m	R/Ω	$(1/d^2)/10^6 m^{-2}$
0.91 ± 0.01	1.6	1.21 ± 0.03
0.56 ± 0.01	4.4	3.19 ± 0.11
0.46 ± 0.01	6.6	4.73 ± 0.21
0.38 ± 0.01	9.7	6.93 ± 0.36
0.32 ± 0.01	13.9	9.77 ± 0.61
0.27 ± 0.01	19.5	13.7 ± 1.0

Fig. 2.2

Calculate and record values of $\frac{1}{d^2}/10^6\,m^{-2}$ in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{d^2}$. [3]

(c) **(i)** Plot a graph of R/Ω against $\frac{1}{d^2}/10^6\,m^{-2}$.

Include error bars for $\frac{1}{d^2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

Gradient of best fit lines:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{17 - 3}{(12 - 2.2)10^6}$$

$$= 1.43 \times 10^{-6}$$

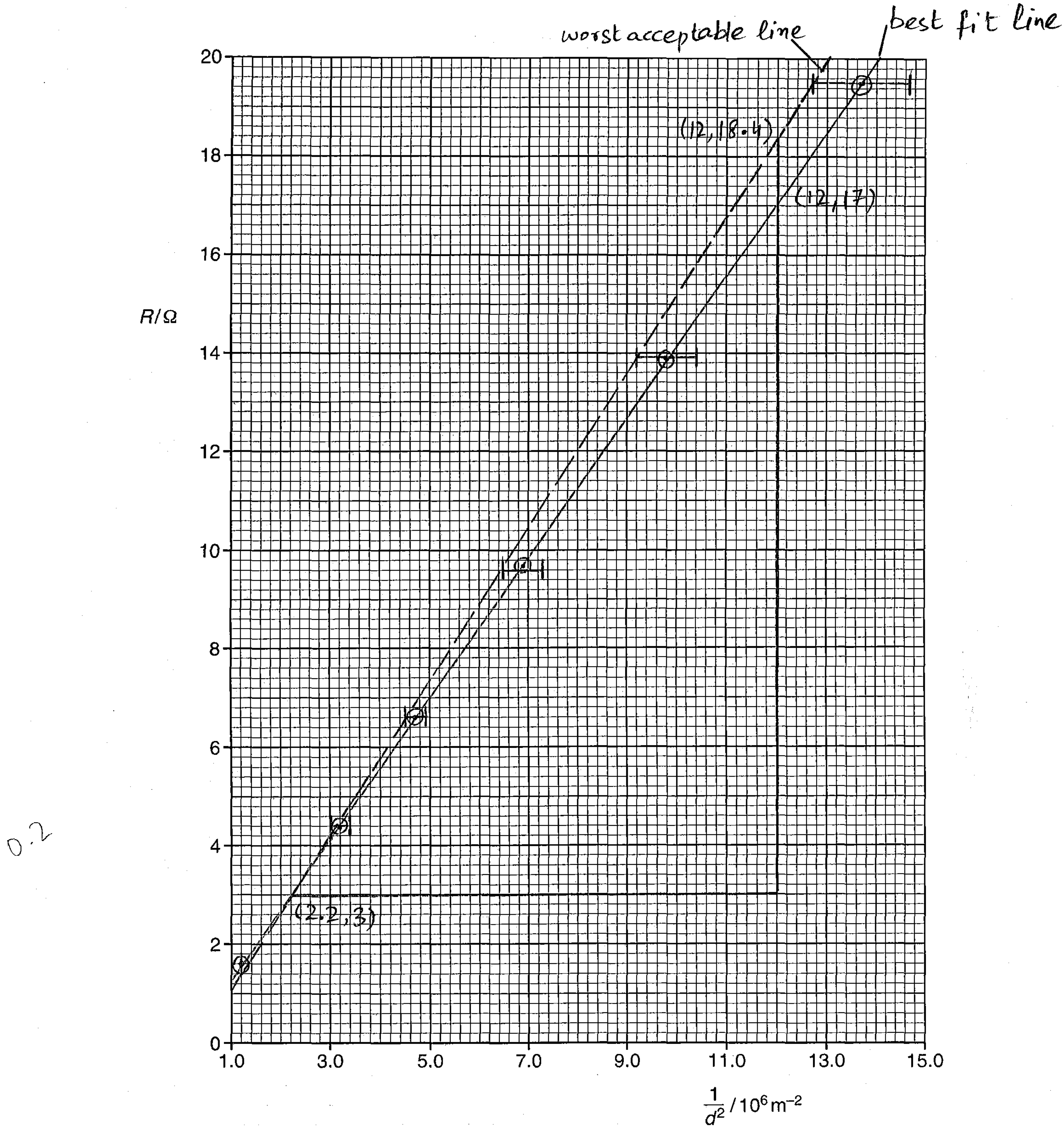
Gradient of worst acceptable lines:

$$\text{gradient} = \frac{18.4 - 3}{(12 - 2.2)10^6}$$

$$= 1.57 \times 10^{-6}$$

$$\Delta \text{gradient} = (1.57 - 1.43)10^{-6} = 0.14 \times 10^{-6}$$

gradient = $(1.43 \pm 0.14) \times 10^{-6}$ [2]


worst acceptable line
best fit line
(12, 18.4)
(12, 17)
(2.2, 3)
R/Ω
20
18
16
14
12
10
8
6
4
2
0
1.0
3.0
5.0
7.0
9.0
11.0
13.0
15.0
$\frac{1}{d^2}$ / 10^6 m^{-2}
0.2

(d) **(i)** Using your answers to **(a)** and **(c)(iii)**, determine the value of ρ. Include an appropriate unit.

Data: $L = 1.00 \pm 0.01$ m.

$$\text{gradient} = \frac{4\rho L}{\pi}$$

$$\rho = \frac{\text{gradient} \times \pi}{4L}$$

$$\rho = \frac{1.43 \times 10^{-6} \times \pi}{4 \times 1.00}$$

$$\rho = 1.12 \times 10^{-6}$$

units: $\frac{\Omega m^2}{m} = \Omega m$

ρ = 1.12×10^{-6} Ω m [2]

(ii) Determine the percentage uncertainty in ρ.

$$\rho = \frac{\text{gradient} \times \pi}{4L}$$

$$\frac{\Delta\rho}{\rho} \times 100 = \left[\frac{\Delta \text{gradient}}{\text{gradient}} + \frac{\Delta L}{L}\right] \times 100$$

$$= \left[\frac{0.14 \times 10^{-6}}{1.43 \times 10^{-6}} + \frac{0.01}{1}\right] \times 100 = 11\%$$

percentage uncertainty in ρ = 11 % [1]

(e) The experiment is repeated with a thinner wire of diameter 0.23 ± 0.01 mm. The wire is of the same material and length.

Determine the resistance R of the wire. Include the absolute uncertainty in your answer.

$$R = \frac{4\rho L}{\pi}\left[\frac{1}{d^2}\right]$$

$$R = \text{gradient}\left[\frac{1}{d^2}\right]$$

$$R = 1.43 \times 10^{-6}\left[\frac{1}{0.23 \times 10^{-3}}\right]^2$$

$$R = 27.0\,\Omega$$

$$\frac{\Delta R}{R} = \frac{\Delta \text{gradient}}{\text{gradient}} + 2\frac{\Delta d}{d}$$

$$\frac{\Delta R}{27} = \frac{0.14 \times 10^{-6}}{1.43 \times 10^{-6}} + \frac{2(0.01)}{0.23}$$

$$\Delta R = 5\,\Omega$$

R = 27 ± 5 Ω [2]

[Total: 15]

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

5917905208

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2016**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

DC (LEG/JG) 117176/2

CAMBRIDGE International Examinations

[Turn over

1 A student is investigating the motion of magnets falling through a vertical copper pipe as shown in Fig. 1.1.

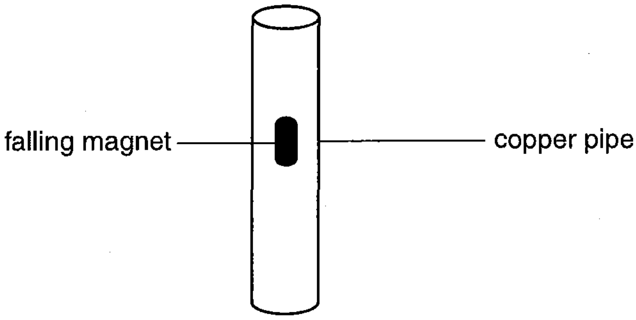


Fig. 1.1

The student releases a magnet above the copper pipe. The magnet has speed v as it leaves the pipe.

It is suggested that the relationship between v and B is

$$v = v_0 e^{-\lambda B}$$

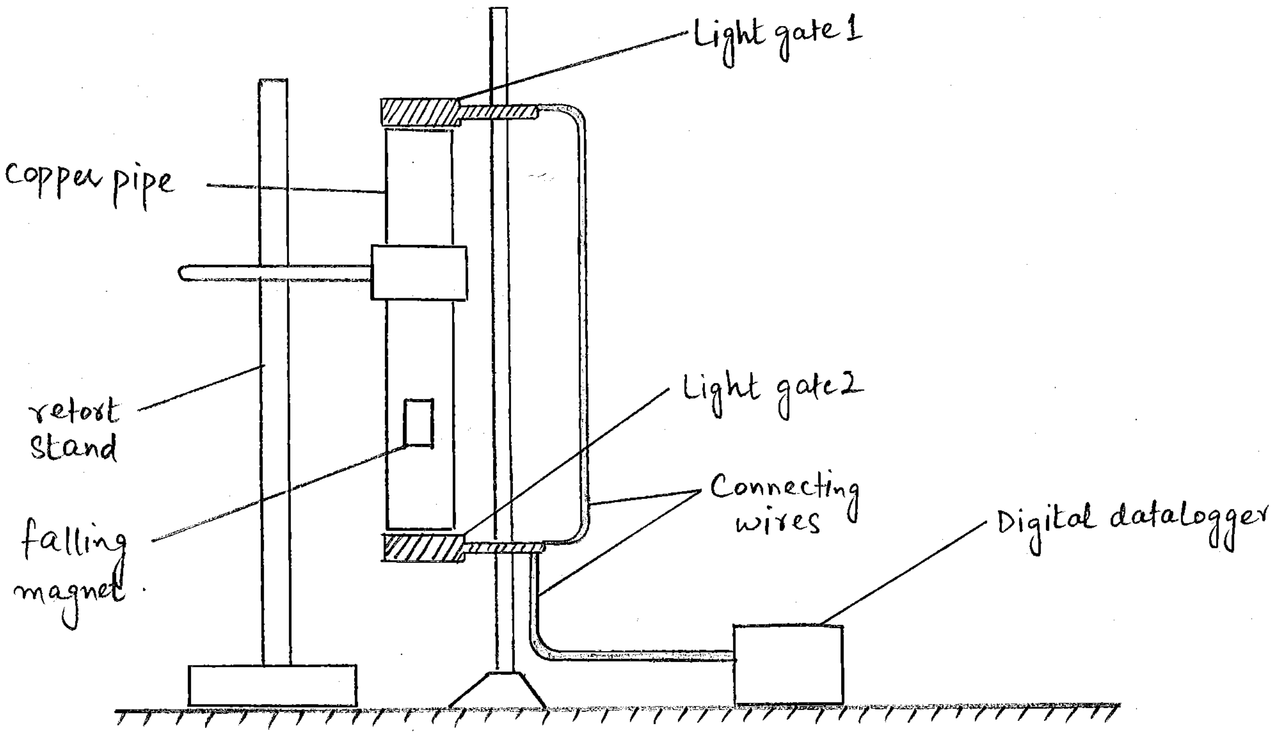
where B is the magnetic flux density at the poles of the magnet and v_0 and λ are constants.

Design a laboratory experiment to test the relationship between v and B. Explain how your results could be used to determine values of v_0 and λ. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any safety precautions to be taken.

[15]

Diagram



Defining the problem:

Independent variable: Magnetic flux density B

Dependent variable: Speed v

Constant: Starting position of the magnet

Procedure:

Measure magnetic flux density B at the poles of magnet using Hall probe. Release the magnet just from the upper end of the pipe. Measure the time taken by magnet to travel through the pipe using light gates and digital datalogger. Measure length L of pipe with meter rule. Calculate velocity v by using the relationship, v = gt where g is acceleration due to gravity. Use plumb line to ensure copper pipe is in vertical position.

Perform the experiment with magnets of different magnetic flux density B. Record the data in given table.

Tabulation:

Number of observation	B/T	t_1/s	t_2/s	t/s	V/ms^{-1}	$\ln(V/ms^{-1})$

Analysis of data:

Plot a graph of $\ln V$ against B. Graph would be a straight line with gradient, $-\lambda$ and y-intercept, $\ln V_0$. $\ln V = -\lambda B + \ln V_0$

gradient $= -\lambda$ y-intercept $= \ln V_0$

$\lambda = -$gradient $V_0 = e^{\text{y-intercept}}$.

Safety precaution:

Use sand tray to catch falling magnet and soften its fall.

Additional details:

1. Adjust Hall probe perpendicular to the magnetic field at poles to get maximum value of B.
2. Use Hall probe to measure B at both poles of magnet and take the average.
3. Keep mass and shape of magnet constant throughout the experiment.
4. Repeat the experiment for same value of B to get more values of time t and take average.

2 A student is investigating a circuit containing capacitors.

The capacitors are initially uncharged. A capacitor of capacitance *Y* is charged by connecting it to a power supply. The charge is then shared with another capacitor of capacitance *C* connected between the terminals P and Q, as shown in Fig. 2.1.

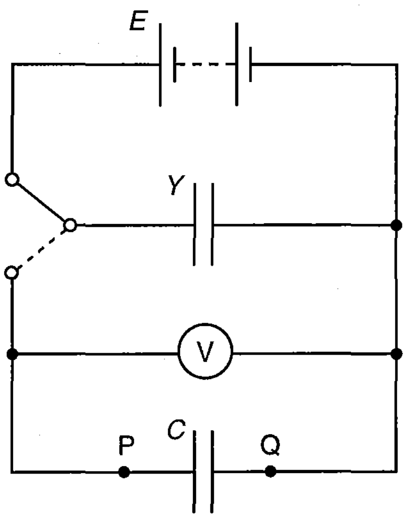


Fig. 2.1

A voltmeter is used to measure the maximum potential difference *V* between P and Q.

The experiment is repeated by adding additional capacitors, each of capacitance *C*, in series between P and Q.

The total capacitance *X* between P and Q may be determined by the equation

$$X = \frac{C}{n}$$

where *n* is the number of capacitors in series.

It is suggested that *V* and *X* are related by the equation

$$YE = (X + Y)V$$

where *E* is the e.m.f. of the power supply.

(a) A graph is plotted of $\frac{1}{V}$ on the *y*-axis against *X* on the *x*-axis.

Determine expressions for the gradient and *y*-intercept.

$$YE = (X + Y)V$$

$$V = \frac{YE}{X+Y}$$

$$1/V = \frac{X}{YE} + \frac{Y}{YE}$$

$$1/V = \left[\frac{1}{YE}\right]X + \frac{1}{E}$$

gradient = 1/YE

y-intercept = 1/E

[1]

(b) Values of n and V are given in Fig. 2.2.

Data: $C = (2.7 \pm 0.4) \times 10^{-3}$ F

n	V/V	$X/10^{-3}$ F	$\frac{1}{V}/\text{V}^{-1}$
1	1.20	2.7 ± 0.4	0.833
2	1.95	1.4 ± 0.2	0.513
3	2.35	0.90 ± 0.14	0.426
4	2.75	0.68 ± 0.10	0.364
5	2.90	0.54 ± 0.08	0.345
6	3.05	0.45 ± 0.07	0.450

Fig. 2.2

Calculate and record values of $X/10^{-3}$ F and $\frac{1}{V}/\text{V}^{-1}$ in Fig. 2.2.

Include the absolute uncertainties in X. [3]

(c) **(i)** Plot a graph of $\frac{1}{V}/\text{V}^{-1}$ against $X/10^{-3}$ F.

Include error bars for X. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

Gradient of best fit line:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{0.77 - 0.45}{(2.5 - 1.05)10^{-3}}$$

$$= 220$$

Gradient of worst acceptable line:

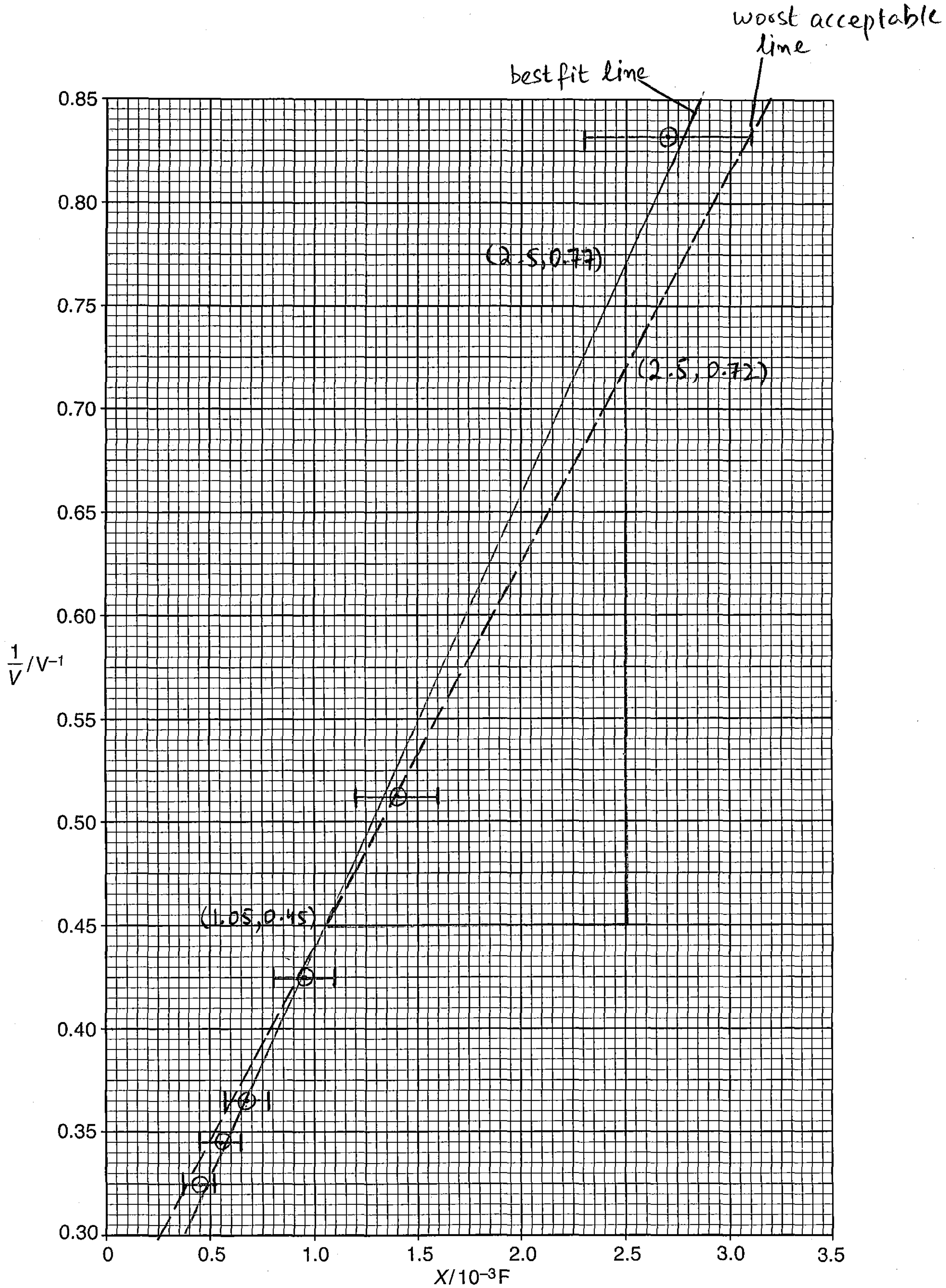
$$\text{gradient} = \frac{0.72 - 0.45}{(2.5 - 1.05)10^{-3}}$$

$$= 190$$

$$\Delta \text{gradient} = 220 - 190$$

$$= 30$$

gradient = 220 ± 30 [2]


woost acceptable line
best fit line
(2.5, 0.77)
(2.5, 0.72)
(1.05, 0.45)
0.85
0.80
0.75
0.70
0.65
0.60
$\frac{1}{V}$ / V^{-1}
0.55
0.50
0.45
0.40
0.35
0.30
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
X / 10^{-3} F

(iv) Determine the y-intercept of the line of best fit. Include the absolute uncertainty in your answer.

y-intercept of best fit line:

$y = mx + c$

$0.77 = 220(2.5\times10^{-3}) + c$

$c = 0.22$

y-intercept of worst acceptable line:

$0.72 = 190(2.5\times10^{-3}) + c$

$c = 0.25$

$\Delta c = 0.25 - 0.22$

$= 0.03$

y-intercept = ...0.22 ± 0.03.... [2]

(d) (i) Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of E and Y. Include an appropriate unit for Y.

$\text{y-intercept} = \frac{1}{E}$

$E = \frac{1}{\text{y-intercept}}$

$E = \frac{1}{0.22} = 4.55\,V$

$\text{gradient} = \frac{1}{YE}$

$Y = \frac{1}{\text{gradient} \times E}$

$Y = \frac{1}{220 \times 4.55}$

$Y = 1.0 \times 10^{-3}$

Units of Y: F

E = ...4.55.... V

Y = ...1.0×10^{-3} F....

[2]

(ii) Determine the percentage uncertainty in Y.

$Y = \frac{1}{\text{gradient} \times E}$

$$\frac{\Delta Y}{Y} \times 100 = \left[\frac{\Delta \text{gradient}}{\text{gradient}} + \frac{\Delta E}{E}\right] \times 100$$

$$= \left[\frac{30}{220} + \frac{0.03}{0.22}\right] \times 100 = 27\%$$

percentage uncertainty in Y = ...27.... % [1]

[Total: 15]

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1996370832

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2016**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

DC (NF/JG) 117177/2

[Turn over

1 A student uses a Hall probe to investigate the magnetic flux density due to a U-shaped electromagnet, as shown in Fig. 1.1.

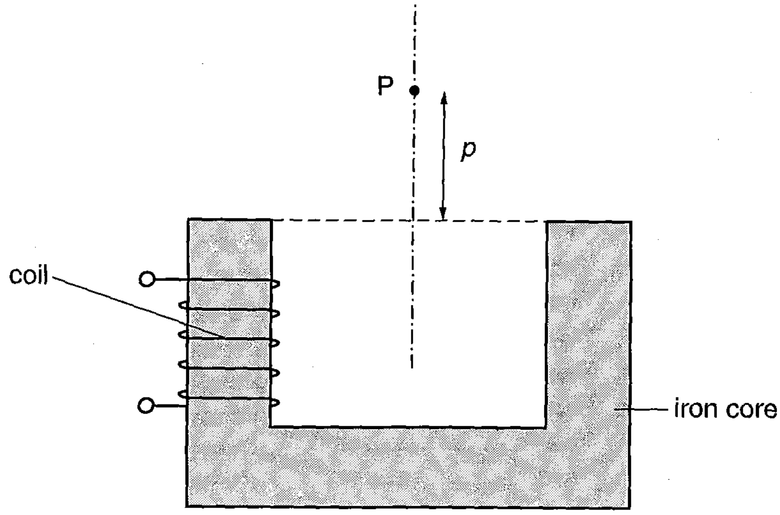


Fig. 1.1

Point P is equidistant from the poles of the electromagnet and distance p is the vertical distance between P and the top of the electromagnet. The magnetic flux density is B at point P.

It is suggested that the relationship between B and p is

$$B = kNIe^{-\alpha p}$$

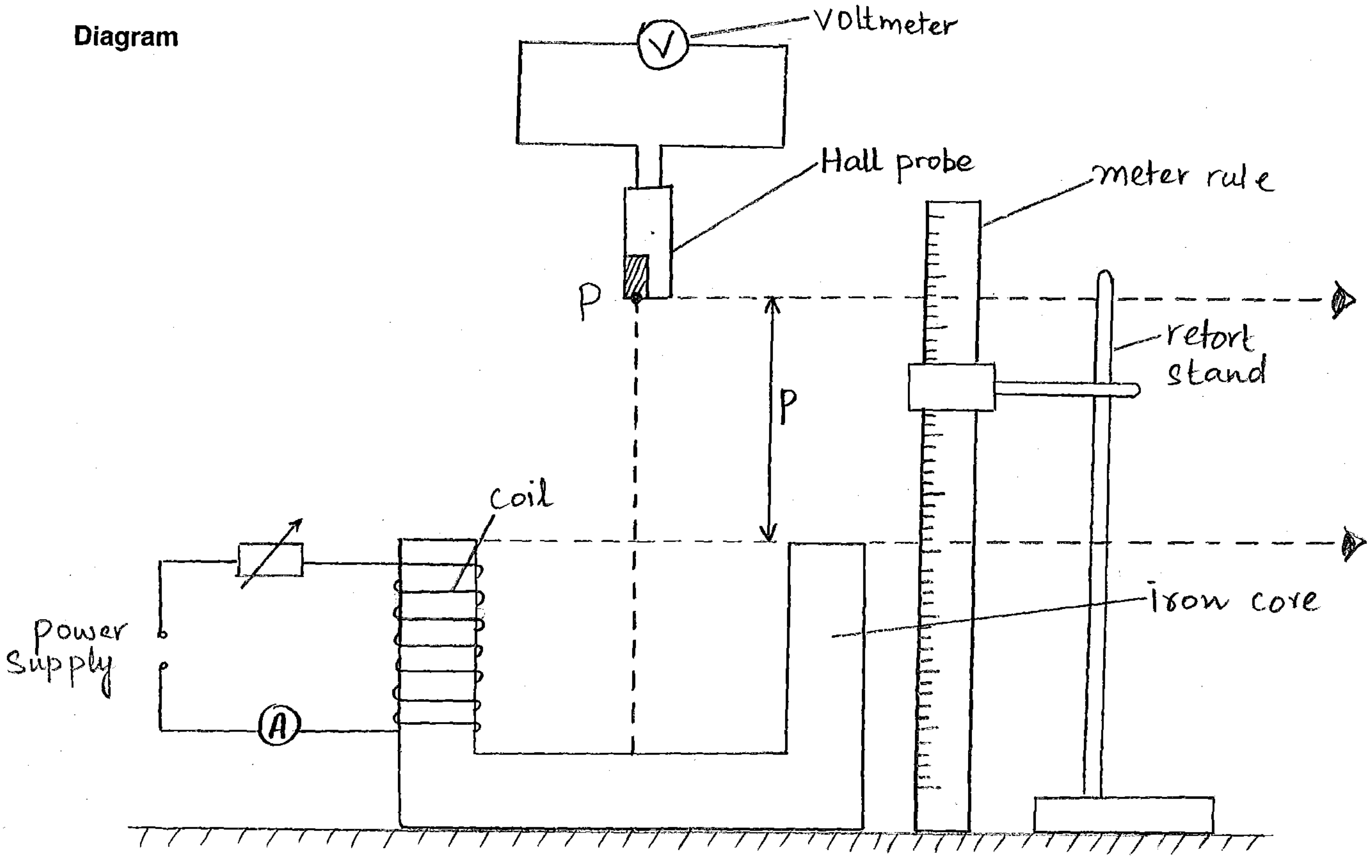
where N is the number of turns on the coil, I is the current in the coil and α and k are constants.

Design a laboratory experiment using a Hall probe to test the relationship between B and p. Explain how your results could be used to determine values for α and k. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- the procedure to be followed,
- the measurements to be taken,
- the control of variables,
- the analysis of the data,
- any safety precautions to be taken.

[15]

Diagram



Defining the problem:
Independent variable: Distance p.
Dependent variable: Magnetic flux density B
Constant: Current in a coil.
Procedure:
Measure distance p from meter rule. Calibrate Hall probe with known value of magnetic flux density. Measure the voltage V at point P from voltmeter. Work out the value of magnetic flux density B at that point. Adjust the variable resistor so that current in the coil is constant throughout the experiment. Repeat the experiment for different values of p. Record the data in a given table.

Measure current through the coil from ammeter.

Tabulation:

Number of Observation	p/m	V/V	B/T	ln (B/T)

Analysis of data:

$$\ln B = -\alpha p + \ln(NkI)$$

Plot a graph of ln B against p. Graph must be a straight line with gradient, $-\alpha$.

gradient $= -\alpha$

$\alpha = -$ gradient

y-intercept $= \ln(NkI)$

$k = e^{\text{y-intercept}}/NI$

Safety Precautions:

Wear safety gloves while dealing with coil because it may become hot due to flow of current.

Additional details:

1- Use large current and large number of turns to produce measurable magnetic flux density.

2. Set Hall probe perpendicular to magnetic field to get maximum voltmeter reading.

3. Avoid parallax error while measuring the value of p

4. Repeat the experiment for the same value of p and reversed Hall probe and take the average.

[Total: 15]

2 A student is investigating the characteristics of different light-emitting diodes (LEDs). Each LED needs a minimum potential difference across it to emit light.

The circuit is set up as shown in Fig. 2.1.

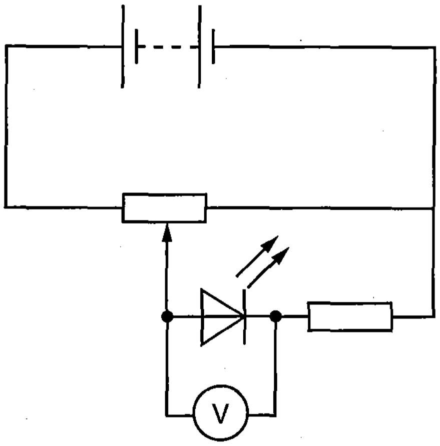


Fig. 2.1

The potentiometer is adjusted until the LED just emits light. The potential difference V across the LED is measured.

The experiment is repeated for LEDs that emit light of different wavelength λ.

It is suggested that V and λ are related by the equation

$$V = p\lambda^q$$

where p and q are constants.

(a) A graph is plotted of $\lg V$ on the y-axis against $\lg \lambda$ on the x-axis.

Determine expressions for the gradient and y-intercept.

$$V = p\lambda^q$$

$$\lg V = \lg p + \lg \lambda^q$$

$$\lg V = q \lg \lambda + \lg p$$

$$y = mx + c$$

gradient = q

y-intercept = $\lg p$

[1]

(b) Values of λ and V are given in Fig. 2.2.

$\lambda/10^{-9}$ m	V/V	lg ($\lambda/10^{-9}$ m)	lg (V/V)
630	1.9 ± 0.1	2.799	0.279 ± 0.023
620	2.0 ± 0.1	2.792	0.301 ± 0.022
590	2.3 ± 0.1	2.771	0.362 ± 0.019
520	3.1 ± 0.1	2.716	0.491 ± 0.014
490	3.7 ± 0.1	2.690	0.568 ± 0.012
470	4.1 ± 0.1	2.672	0.613 ± 0.011

Fig. 2.2

Calculate and record values of lg ($\lambda/10^{-9}$ m) and lg (V/V) in Fig. 2.2.
Include the absolute uncertainties in lg (V/V). [3]

(c) **(i)** Plot a graph of lg (V/V) against lg ($\lambda/10^{-9}$ m).
Include error bars for lg (V/V). [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph.
Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

Gradient of best fit line:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{0.63 - 0.325}{2.666 - 2.782}$$

$$= -2.63$$

Gradient of worst acceptable line:

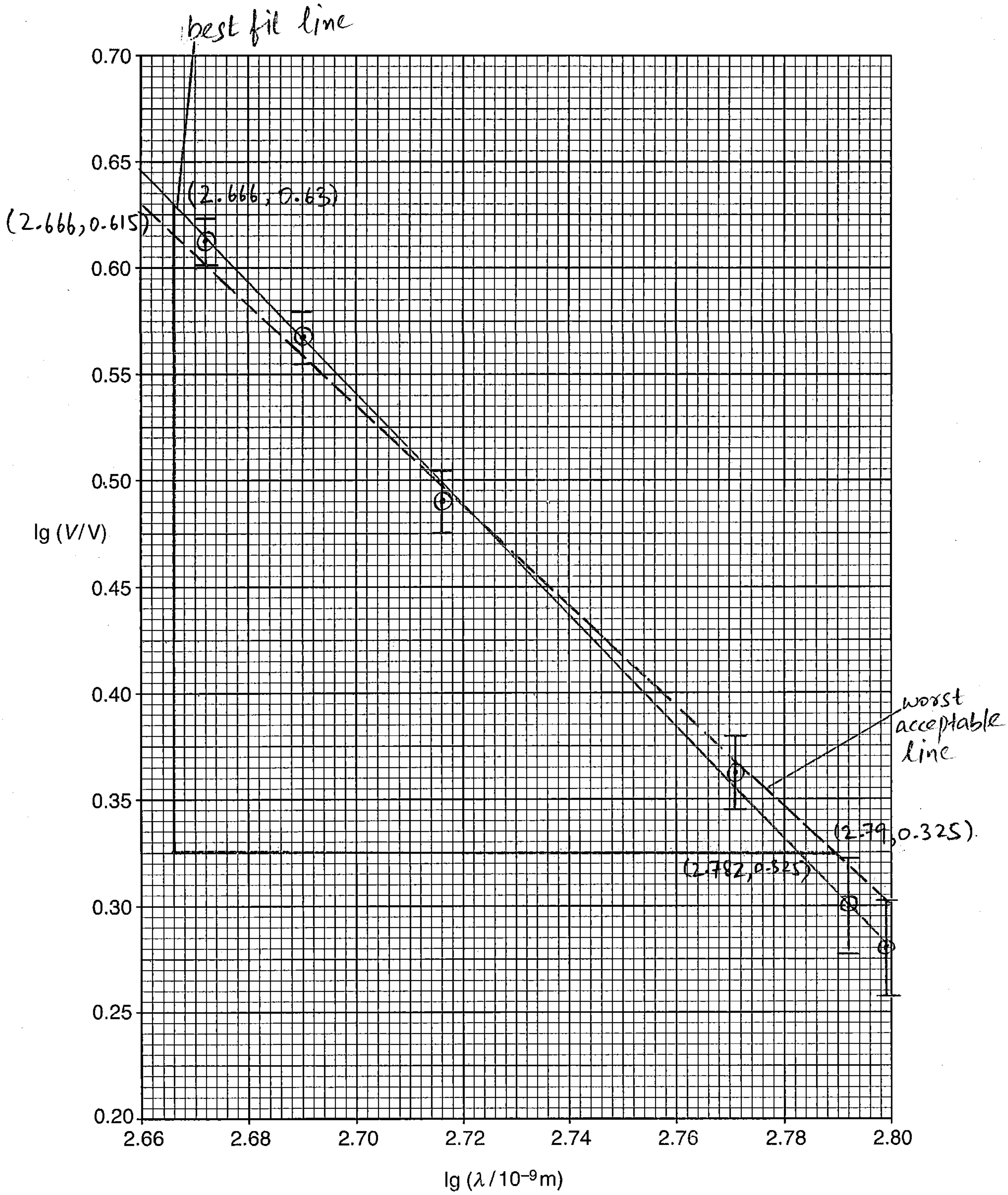
$$\text{gradient} = \frac{0.615 - 0.325}{2.666 - 2.79}$$

$$= -2.34$$

$$\Delta \text{gradient} = 2.63 - 2.34$$

$$= 0.3$$

gradient = -2.6 ± 0.3 [2]


best fit line
(2.666, 0.63)
(2.666, 0.615)
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
lg (V/V)
worst acceptable line
(2.79, 0.325)
(2.782, 0.325)
2.66
2.68
2.70
2.72
2.74
2.76
2.78
2.80
lg (λ / 10⁻⁹ m)

(iv) Determine the y-intercept of the line of best fit. Include the absolute uncertainty in your answer.

y-intercept of best fit line:

$y = mx + c$

$0.63 = -2.63(2.666) + c$

$c = 7.6$

y-intercept of worst acceptable line:

$0.615 = -2.34(2.666) + c$

$c = 6.9$

$\Delta c = 7.6 - 6.9 = 0.7$

y-intercept = 7.6 ± 0.7 [2]

(d) Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of p and q. You need not be concerned with units.

$\lg p = y\text{-intercept}$

$p = 10^{y\text{-intercept}}$

$p = 10^{7.6}$

$p = 3.98 \times 10^7$

$q = \text{gradient}$

$q = -2.6$

p = 3.98×10^7

q = -2.6

[2]

(e) A similar experiment is carried out with a diode emitting infra-red radiation of wavelength 950 nm. Determine the minimum potential difference V needed to emit this radiation.

$V = p\lambda^q$

$V = 3.98 \times 10^7 \times 950^{-2.6}$

$V = 0.72\,V$

V = 0.72 V [1]

[Total: 15]

Cambridge International Examinations
Cambridge International Advanced Level

Cambridge International A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2015**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

DC (ST/SW) 94471/2

CAMBRIDGE International Examinations

[Turn over

1 A student is investigating simple harmonic motion using an electric vibrator. A plate is attached to the top of the electric vibrator. A small mass is placed on the metal plate as shown in Fig. 1.1.

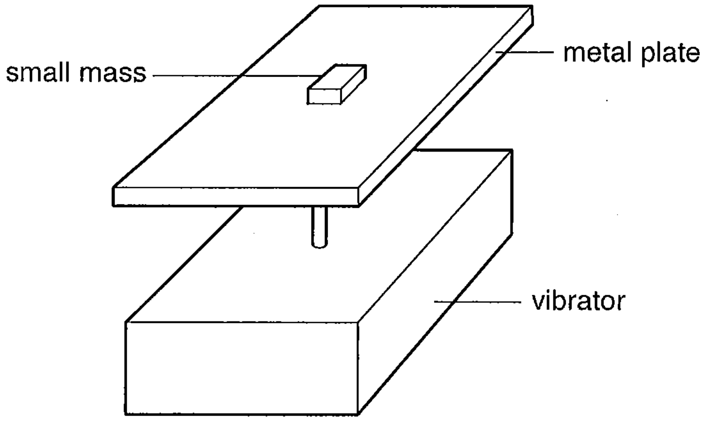


Fig. 1.1

An alternating potential difference (p.d.) is applied to the vibrator. For a given peak p.d. V, there is a maximum frequency f at which the small mass remains in contact with the plate. The contact between the small mass and plate is lost when the frequency is greater than f.

It is suggested that the relationship between f and V is

$$k = \pi^2 f^2 V$$

where k is a constant.

Design a laboratory experiment to test the relationship between f and V. Explain how your results could be used to determine a value for k. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

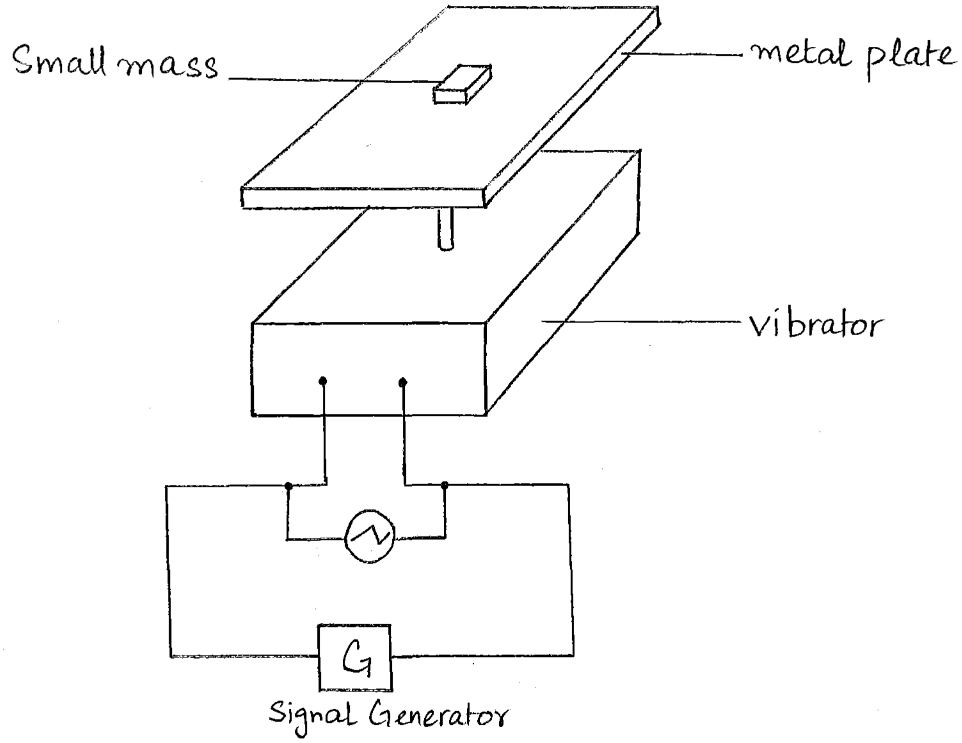
(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram



Defining the problem:

Independent variable: Peak p.d. V

Dependent variable: Maximum frequency f

Constant: Position of the small mass.

Procedure:

For certain value of V, slowly increase the frequency from signal generator. Wait for the noise of mass leaving the metal plate. Measure the frequency f, at which mass leaves the metal plate from signal generator. Measure the value of peak p.d. V from c.r.o. Repeat the experiment for the same value of V and take average of f. Perform the experiment at atleast five more different values of V. Record the data in given table.

Tabulation:

Number of Observation	V/V	f_1/s^{-1}	f_2/s^{-1}	f/s^{-1}	$\frac{1}{V}/V^{-1}$	f^2/s^{-2}

Analysis of data: $f^2 = \frac{K}{\lambda^2}\left(\frac{1}{V}\right)$

Plot a graph of f^2 against 1/V. Graph would be a straight line through origin with gradient, $\frac{K}{\lambda^2}$

$$\text{gradient} = K/\lambda^2$$

$$K = \text{gradient} \times \lambda^2$$

Safety Precaution:

Use safety screen to prevent injury from mass leaving the vibrating plate.

Additional details:-

1- Clean the surface of metal plate and small mass before starting the experiment.

2- Wait for vibrator to oscillate evenly.

3- Use spirit level to keep the plate horizontal.

4- Peak p.d. V can be calculated from c.r.o by, V = amplitude (height) x y-gain

Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student is investigating the performance of a motor vehicle.

The vehicle is driven at a constant speed v on a test track, as shown in Fig. 2.1.

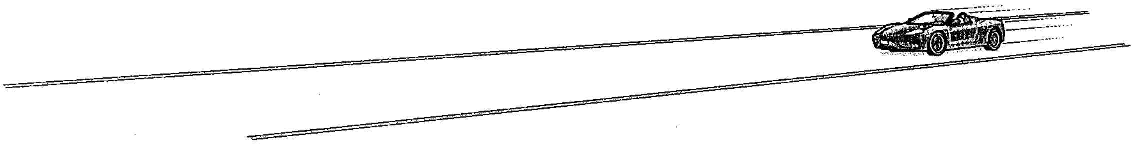


Fig. 2.1

The performance P of the vehicle is the distance travelled per unit volume of fuel, measured in kilometres per litre (km l^{-1}). This is obtained from the vehicle's computer system.

The experiment is repeated for different speeds.

It is suggested that P and v are related by the equation

$$P = kv^m$$

where k and m are constants.

(a) A graph is plotted of lg P on the y-axis against lg v on the x-axis.

Determine expressions for the gradient and y-intercept.

$P = kv^m$

$\lg P = \lg k + \lg v^m$

$\lg P = m \lg v + \lg k$

gradient = m

y-intercept = $\lg K$

[1]

(b) Values of v and P are given in Fig. 2.2.

v/km h^{-1}	P/km l^{-1}	lg (v/km h^{-1})	lg (P/km l^{-1})
50	20.5 ± 0.5	1.699	1.312 ± 0.011
61	16.0 ± 0.5	1.785	1.204 ± 0.014
71	13.0 ± 0.5	1.851	1.114 ± 0.017
80	11.0 ± 0.5	1.903	1.041 ± 0.020
90	9.5 ± 0.5	1.954	0.978 ± 0.023
99	8.0 ± 0.5	1.996	0.903 ± 0.027

Fig. 2.2

Calculate and record values of lg (v/km h^{-1}) and lg (P/km l^{-1}) in Fig. 2.2.
Include the absolute uncertainties in lg (P/km l^{-1}). [3]

(c) (i) Plot a graph of lg (P/km l^{-1}) against lg (v/km h^{-1}).
Include error bars for lg (P/km l^{-1}). [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph.
Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit line:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{1.28 - 1}{1.725 - 1.935}$$

$$= -1.33$$

gradient of worst acceptable line:

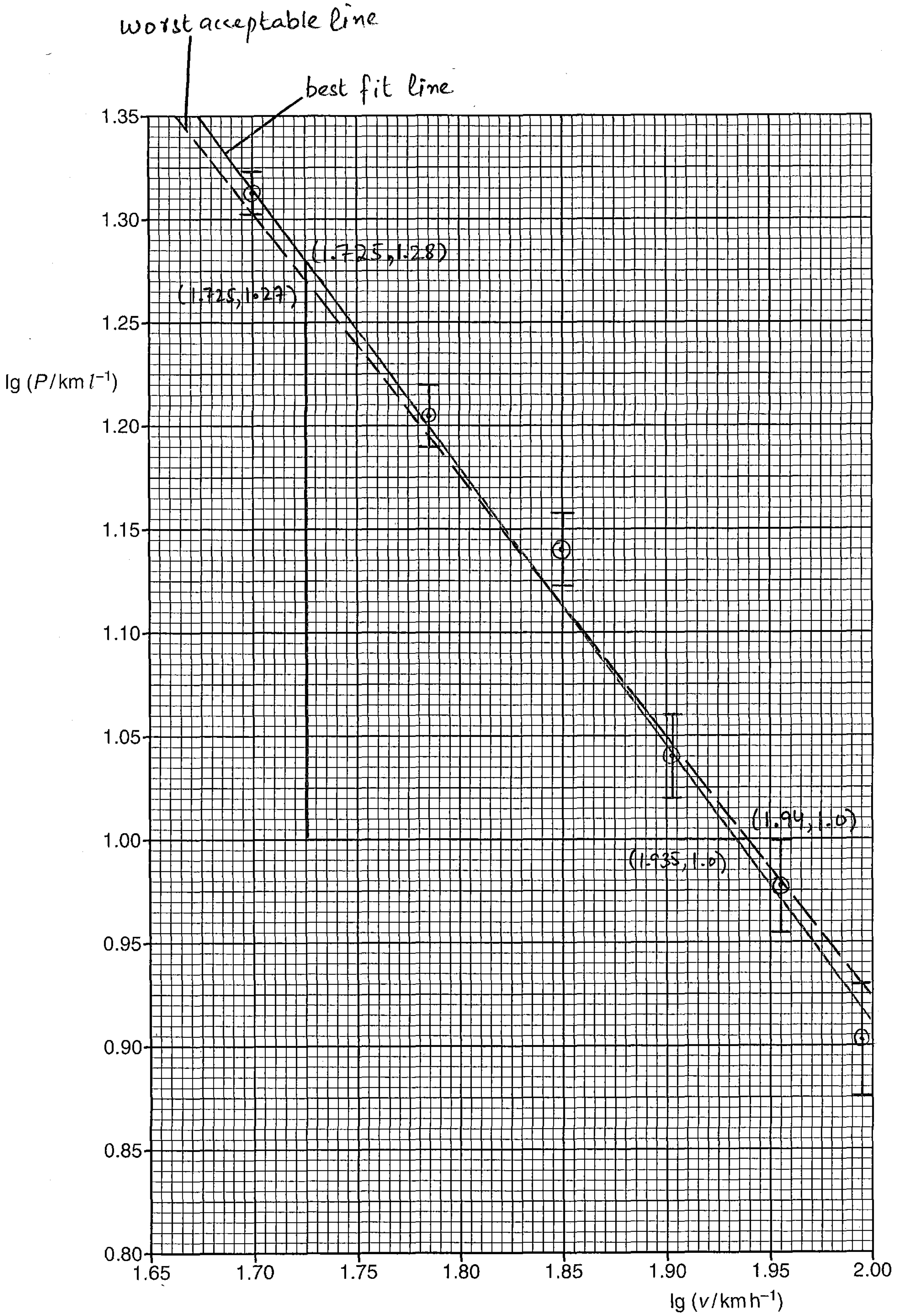
$$\text{gradient} = \frac{1.27 - 1}{1.725 - 1.94}$$

$$= -1.26$$

$$\Delta\text{gradient} = 1.33 - 1.26$$

$$= 0.07$$

gradient = -1.33 ± 0.07 [2]


worst acceptable line
best fit line
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
lg (P/km l^{-1})
(1.725,1.28)
(1.725,1.27)
(1.94,1.0)
(1.935,1.0)
1.65
1.70
1.75
1.80
1.85
1.90
1.95
2.00
lg (v/km h^{-1})

(iv) Determine the y-intercept of the line of best fit. Include the uncertainty in your answer.

y-intercept of best fit line:

$y = mx + c$

$1.28 = -1.33(1.725) + c$

$c = 3.6$

y-intercept of worst fit line:

$y = mx + c$

$1.27 = -1.26(1.725) + c$

$c = 3.4$

$\Delta c = 3.6 - 3.4 = 0.2$

y-intercept = 3.6 ± 0.2 [2]

(d) (i) Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of k and m. You need not be concerned with the units of k and m.

m = gradient

$m = -1.33$

$\lg K$ = y-intercept

$K = 10^{\text{y-intercept}}$

$K = 10^{3.6} = 3980$

k = 3980

m = −1.33

[2]

(ii) Determine the percentage uncertainty in k.

$\Delta K = 10^{\text{y-intercept}} - 10^{\text{y-intercept (min)}}$

$= 10^{3.6} - 10^{3.4} = 1470$

$\frac{\Delta K}{K} \times 100 = \frac{1470}{3980} \times 100 = 37\%$

percentage uncertainty in k = 37 %
[1]

Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2015**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

DC (RW/JG) 94470/2

CAMBRIDGE International Examinations

[Turn over

1 A student is investigating how the intensity of the reflection of sound from a wall varies with the thickness of foam attached to the wall, as shown in Fig. 1.1.

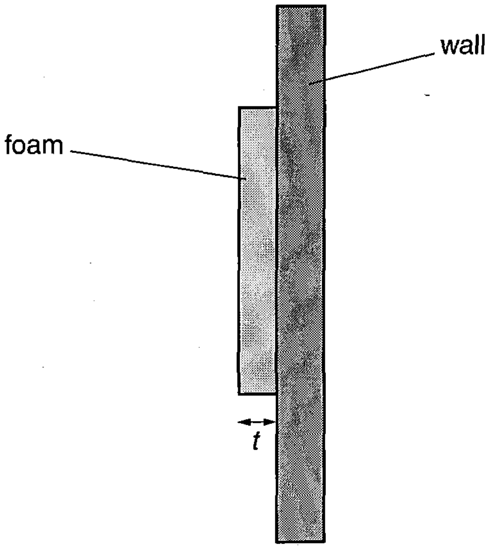


Fig. 1.1

It is suggested that the intensity I of the reflected sound is related to the thickness t of the foam by the relationship

$$I = I_0 e^{-\alpha\rho t}$$

where I_0 is the intensity of the sound before reflection, ρ is the density of the foam and α is a constant.

Design a laboratory experiment to test the relationship between I and t. Explain how your results could be used to determine a value for α. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

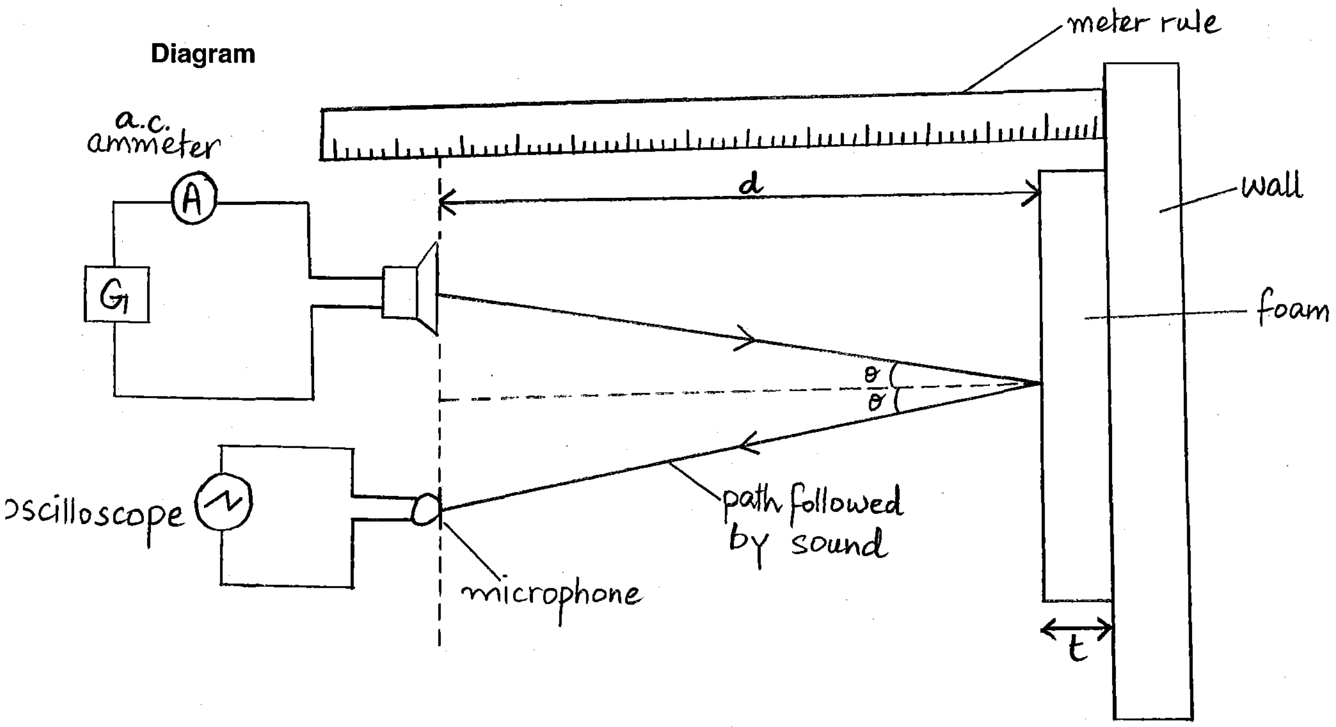
(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram



Defining the problem:
Independent Variable: Thickness t of the foam.
Dependent variable: Intensity I of reflected sound.
Constant: Distance between speaker and foam.
Intensity I_o of incident sound
Procedure:
Measure thickness t of the foam with vernier caliper. Measure length l and width w with meter rule. Measure mass m of the foam with digital balance. Calculate the density ρ of the foam by the relation, $\rho = m/(l \times w \times t)$. Place the foam along the wall. Use meter rule to make sure that the distance between speaker and foam is constant throughout the experiment. Switch on the signal generator to

incident sound on foam. Measure the amplitude of reflected sound I from oscilloscope. Repeat the experiment with the foams of different thicknesses. Record the data in the given table.

Tabulation:

Number of Observation	t/m	I/Wm^{-2}	$\ln(I/Wm^{-2})$

Analysis of data:

$$I = I_0 e^{-\alpha\rho t}$$

$$\ln I = -\alpha\rho(t) + \ln I_0$$

Plot a graph of ln I against t. A graph would be a straight line with gradient, $-\alpha\rho$.

$$\text{gradient} = -\alpha\rho$$

$$\alpha = -\text{gradient}/\rho$$

Safety precaution:

Use ear plugs to prevent damage to ears.

Additional details:

1. Carry out experiment in quiet room to avoid external noise.
2. Keep the frequency of incident sound constant.
3. Position the speaker and microphone such that their angles are constant with mean position.
4. Use tubes along the path of sound to avoid reflections.

Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student is investigating a circuit containing two horizontal parallel plates separated by an insulator.

The circuit is set up as shown in Fig. 2.1.

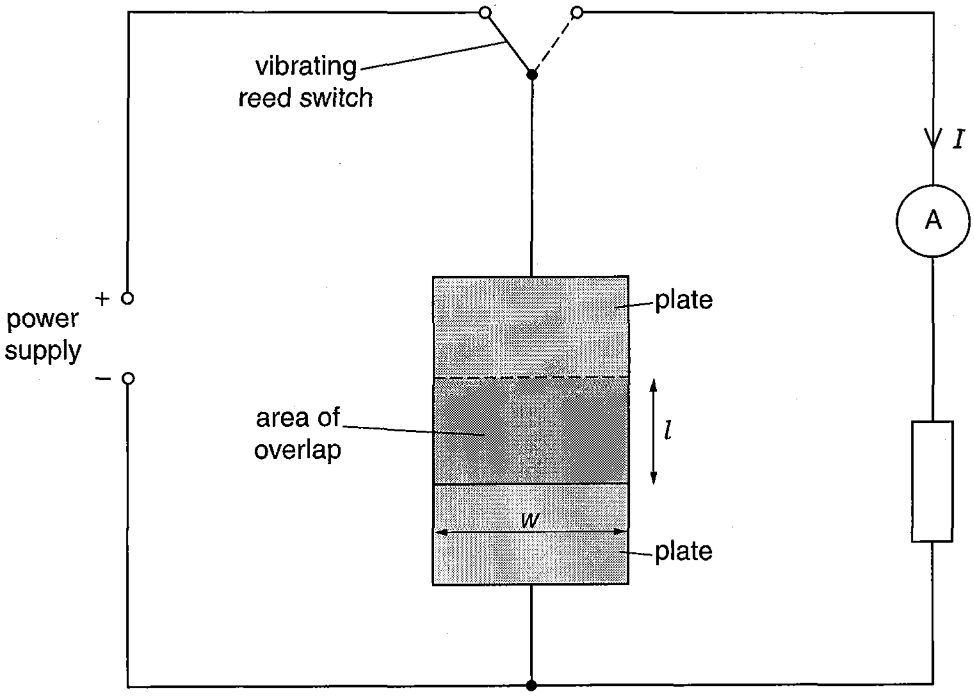


Fig. 2.1

An experiment is carried out to investigate how the current I varies with the area X of overlap of the parallel plates. The student measures the length l of overlap. To determine the area X of overlap, the student uses the relationship

$$X = wl$$

where w is the width of the plates.

It is suggested that I and X are related by the equation

$$\frac{I}{fX} = \frac{\varepsilon E}{d}$$

where E is the e.m.f. of the power supply, f is the frequency of the vibrating reed switch, d is the separation of the two parallel plates and ε is a constant.

(a) A graph is plotted of I on the y-axis against X on the x-axis.
Determine an expression for the gradient.

$$\frac{I}{fX} = \frac{\varepsilon E}{d}$$

$$I = \frac{\varepsilon E f}{d}(X)$$

$$y = m(x)$$

$$\text{gradient} = \frac{\varepsilon E f}{d}$$

gradient = $\varepsilon E f / d$ [1]

(b) The width w of the plates has a value of 0.300 ± 0.005 m.

Values of l and I are given in Fig. 2.2.

l/m	I/10^{-6} A	X / 10^{-2} m^2
0.160 ± 0.005	4.6	4.8 ± 0.2
0.180 ± 0.005	5.3	5.4 ± 0.2
0.210 ± 0.005	6.2	6.3 ± 0.3
0.240 ± 0.005	7.1	7.2 ± 0.3
0.270 ± 0.005	8.0	8.1 ± 0.3
0.300 ± 0.005	8.8	9.0 ± 0.3

Fig. 2.2

Calculate and record values of X/10^{-2} m^2 in Fig. 2.2. Include the uncertainties in X. [3]

(c) (i) Plot a graph of I/10^{-6} A against X/10^{-2} m^2. Include error bars for X. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

Gradient of best fit line

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{(9.15-4.15)10^{-6}}{(9.3-4.3)10^{-2}}$$

$$= 1.00 \times 10^{-4}$$

Gradient of worst fit line

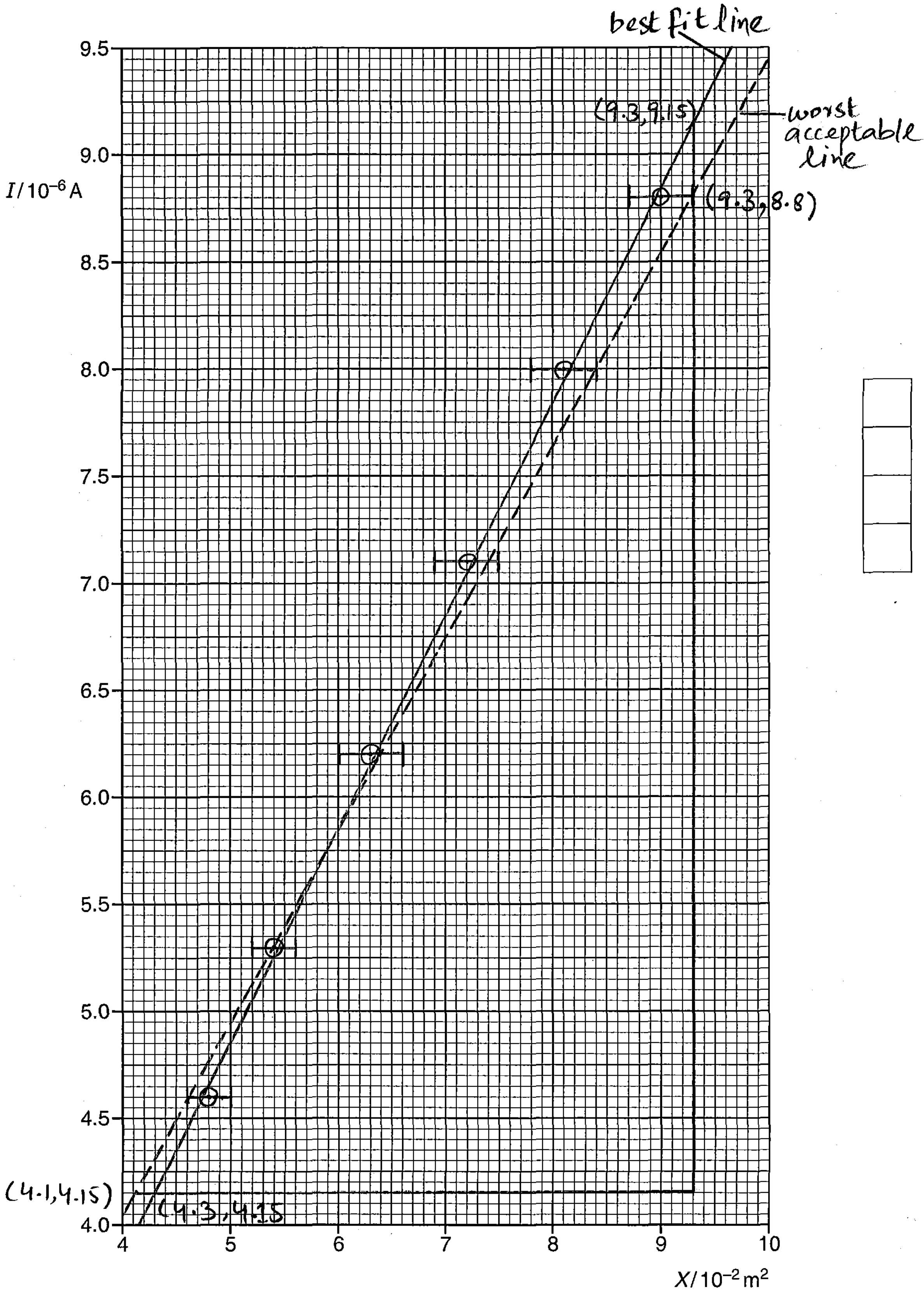
$$\text{gradient} = \frac{(8.8-4.1)10^{-6}}{(9.3-4.3)10^{-2}}$$

$$= 0.94 \times 10^{-4}$$

gradient = $(1.00 \pm 0.06) \times 10^{-4}$ [2]

$$\Delta\,\text{gradient} = (1.00 - 0.94) \times 10^{-4}$$

$$= 0.06 \times 10^{-4}$$



best fit line
worst acceptable line
(9.3,9.15)
(9.3,8.8)
(4.1,4.15)
(4.3,4.15
$I/10^{-6}$ A
$X/10^{-2}$ m^2
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
4
5
6
7
8
9
10

(d) (i) Using your answers to **(a)** and **(c)(iii)**, determine the value of ε. Include an appropriate unit.

Data: $E = 12.0 \pm 0.2\,\text{V}$, $f = 400 \pm 10\,\text{Hz}$ and $d = 0.0030 \pm 0.0002\,\text{m}$.

From Best fit:

gradient $= \varepsilon E f/d$

$$1.00\times10^{-4} = \frac{(\varepsilon \times 12 \times 400)}{0.003}$$

$$\varepsilon = 6.25\times10^{-11}$$

From worst fit:

$$0.94\times10^{-4} = \frac{\varepsilon\times12.2\times410}{0.0028}$$

$$\varepsilon = 5.37\times10^{-11}$$

$\varepsilon =$ $6.25\times10^{-11}\ \text{A}\,\text{m}^{-1}\,\text{Hz}^{-1}\,\text{V}^{-1}$ [2]

(ii) Determine the percentage uncertainty in your value of ε.

$$\varepsilon = \frac{\text{gradient}\times d}{Ef}$$

$$\frac{\Delta\varepsilon}{\varepsilon}\times100 = \left[\frac{\Delta\text{gradient}}{\text{gradient}} + \frac{\Delta d}{d} + \frac{\Delta E}{E} + \frac{\Delta f}{f}\right]\times100$$

$$= \left[\frac{0.06}{1} + \frac{0.0002}{0.003} + \frac{0.2}{12} + \frac{10}{400}\right]\times100$$

$$= 17\%$$

percentage uncertainty = 17 % [1]

(e) The experiment is repeated with two square plates of length $0.500 \pm 0.001\,\text{m}$ which completely overlap. Determine the frequency f of the reed switch that will produce a current of $5.0 \pm 0.1\,\mu\text{A}$. Include the absolute uncertainty in your answer.

Data: $E = 12.0 \pm 0.2\,\text{V}$ and $d = 0.0030 \pm 0.0002\,\text{m}$.

$$f = \frac{I\times d}{X\varepsilon E} = \frac{5\times10^{-6}\times0.003}{(0.5\times0.5)\times6.25\times10^{-11}\times12} = 80\,\text{Hz}.$$

$$\Delta f = \left[\frac{\Delta I}{I} + \frac{\Delta d}{d} + \frac{\Delta X}{X} + \frac{\Delta\varepsilon}{\varepsilon} + \frac{\Delta E}{E}\right]f$$

$$= \left[\frac{0.1}{5} + \frac{0.0002}{0.003} + \frac{0.001}{0.25} + \frac{0.88}{6.25} + \frac{0.2}{12}\right]\times80$$

$$= 20\,\text{Hz}.$$

$f =$ 80 ± 20 Hz [2]

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9328967468

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2015**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

DC (LEG/FD) 97178/3

CAMBRIDGE
International Examinations

[Turn over

1 A student is investigating the angle at which a glass cylinder containing oil topples, as shown in Fig. 1.1.

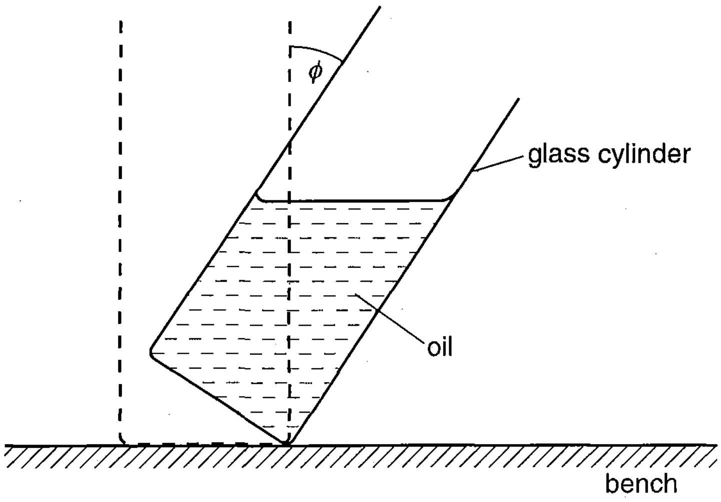


Fig. 1.1

A cylinder containing a mass m of oil can be tilted through a maximum angle ϕ from the vertical before it topples.

It is suggested that the relationship between m and ϕ is

$$\frac{1}{\tan\phi} = \frac{am}{\rho d^3} + b$$

where d is the diameter of the cylinder, ρ is the density of the oil and a and b are constants.

Design a laboratory experiment to test the relationship between ϕ and m. Explain how your results could be used to determine values for a and b. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

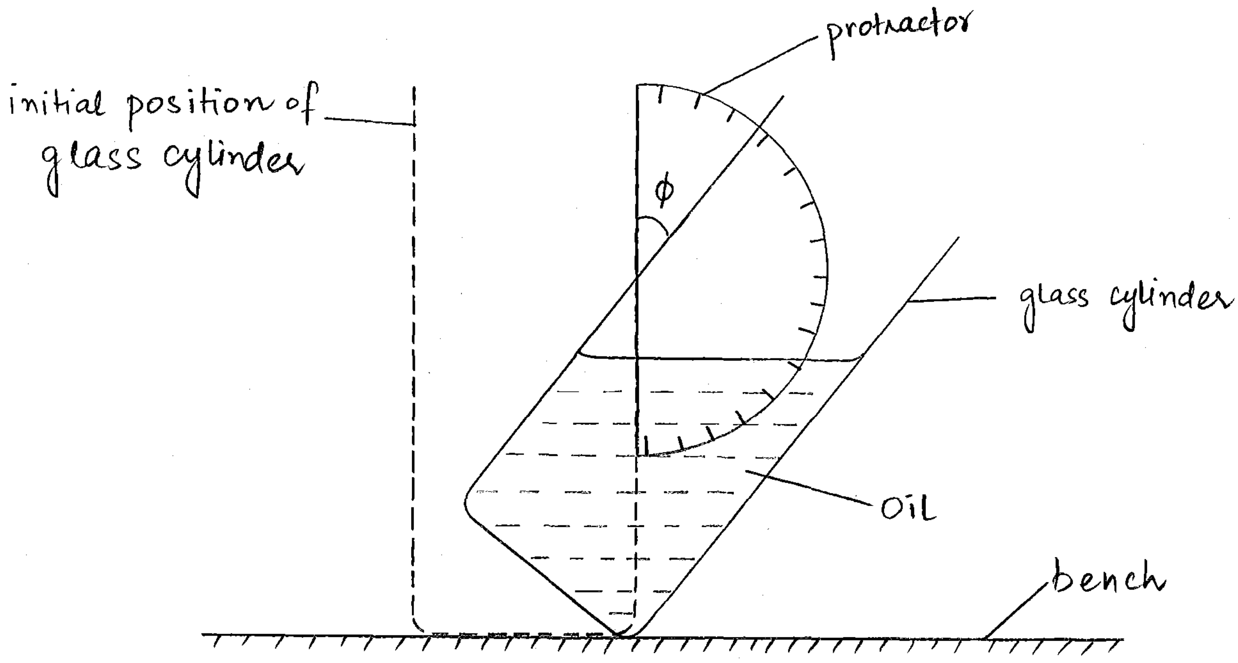
(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram



Defining the problem:
Independent variable: Mass m
Dependent variable: $\tan\phi$
Constant: Temperature of the oil
Procedure:
Measure the mass of empty glass cylinder using digital balance. Pour oil in the cylinder and measure combined mass of oil and cylinder. Calculate the mass m of oil by using relationship, m = mass of cylinder and oil − mass of cylinder. Measure volume V of oil using measuring cylinder. Calculate density ρ of oil using the formula, $\rho = m/V$. Slightly tilt the glass cylinder containing oil and measure the angle ϕ at

which cylinder topples using large protractor. Use vernier caliper to measure diameter d of cylinder. Repeat the experiment for different mass of oil and record the data in given table.

Tabulation:

Number of Observations	m/Kg	$\phi_1/°$	$\phi_2/°$	$\phi/°$	$\frac{1}{\tan\phi}$

Analysis of data: $\frac{1}{\tan\phi} = \frac{a}{pd^3}(m) + b$

Plot a graph of $1/\tan\phi$ against m.

gradient $= a/pd^3$

a = gradient $\times pd^3$, b = y-intercept

Safety Precaution:

Use lid for glass cylinder to prevent oil from spilling.

Additional Details:

1. Measure diameter of cylinder from different positions and take average.
2. Use video frame by frame playback to determine value of ϕ.
3. Use a cylinder which has same diameter at all the positions.
4. Perform the experiment on rough surface to prevent cylinder from sliding.

Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student is investigating an electrical circuit containing a length of nichrome wire.

The circuit is set up as shown in Fig. 2.1.

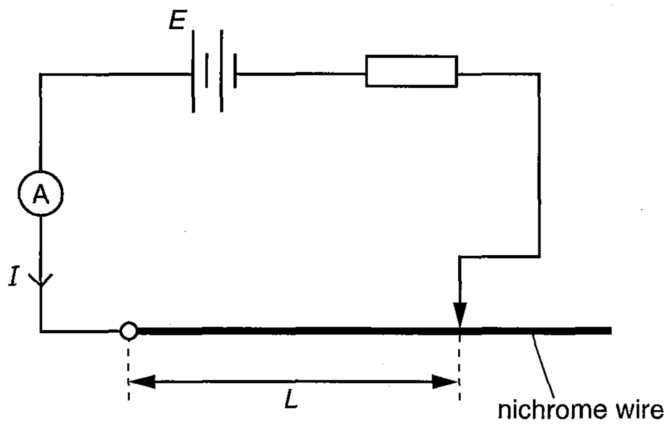


Fig. 2.1

The length L of the wire in the circuit is varied and the current I is measured.

It is suggested that I and L are related by the equation

$$\frac{1}{I} = \frac{4\rho L}{\pi E d^2} + \frac{r}{E}$$

where E is the e.m.f. of the battery, d is the diameter of the wire and ρ and r are constants.

(a) A graph is plotted of $\frac{1}{I}$ on the y-axis against L on the x-axis.

Determine expressions for the gradient and y-intercept.

$$\frac{1}{I} = \frac{4\rho L}{\pi E d^2} + \frac{r}{E}$$

$$\frac{1}{I} = \frac{4\rho}{\pi E d^2}(L) + \frac{r}{E}$$

$$y = m \quad x + c$$

gradient = $\frac{4\rho}{\pi E d^2}$

y-intercept = r/E

[1]

(b) Values of L and I are given in Fig. 2.2.

$L/10^{-2}$ m	I/A	$(1/I)A^{-1}$
40.0	0.24 ± 0.01	4.17 ± 0.17
48.0	0.20 ± 0.01	5.00 ± 0.25
60.0	0.17 ± 0.01	5.88 ± 0.35
70.0	0.15 ± 0.01	6.67 ± 0.44
80.0	0.13 ± 0.01	7.69 ± 0.59
92.0	0.12 ± 0.01	8.33 ± 0.69

Fig. 2.2

Calculate and record values of $\frac{1}{I}/A^{-1}$ in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{I}/A^{-1}$. [3]

(c) **(i)** Plot a graph of $\frac{1}{I}/A^{-1}$ against $L/10^{-2}$ m.

Include error bars for $\frac{1}{I}/A^{-1}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient of best fit line:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{8.7 - 5.25}{(95-52)10^{-2}}$$

$$= 8.0$$

Gradient of worst acceptable line:

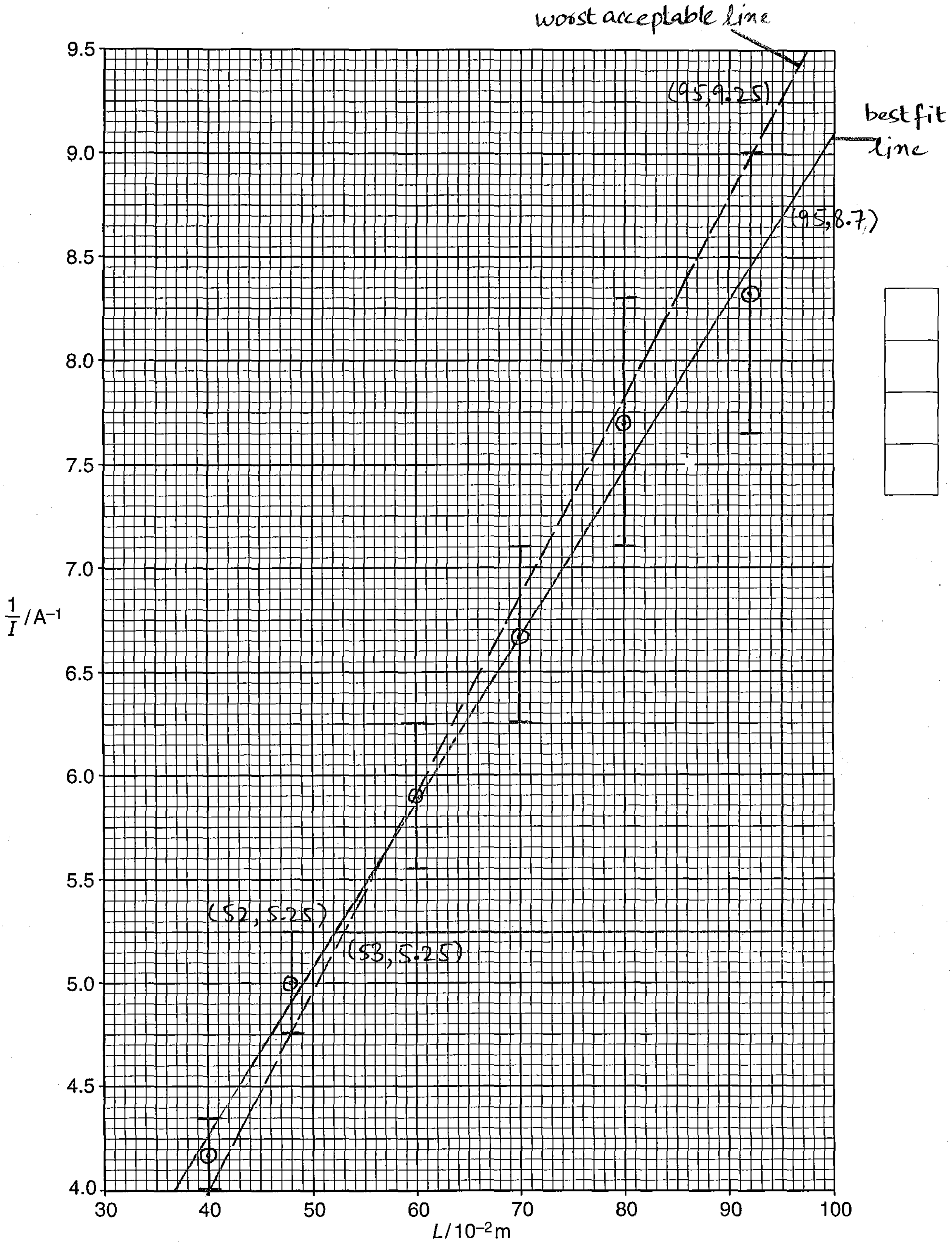
$$\text{gradient} = \frac{9.25 - 5.25}{(95-52)10^{-2}}$$

$$= 9.3$$

$$\Delta\,\text{gradient} = 9.3 - 8.0$$

$$= 1.3$$

gradient = 8.0 ± 1.3 [2]


worst acceptable line
best fit line
(95,9.25)
(95,8.7)
(52,5.25)
(53,5.25)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
$\frac{1}{I}$ / A^{-1}
30
40
50
60
70
80
90
100
$L / 10^{-2}$ m

(iv) Determine the y-intercept of the line of best fit. Include the absolute uncertainty in your answer.

y-intercept of best fit line:
$y = mx + c$
$8.7 = 8.0(95 \times 10^{-2}) + c$
$c = 1.1$

y-intercept of worst acceptable line:
$y = mx + c$
$9.25 = 9.3(95 \times 10^{-2}) + c$
$c = 0.42$

$\Delta C = 1.1 - 0.4 = 0.7$

y-intercept = 1.1 ± 0.7 [2]

(d) (i) Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of ρ and r. Include appropriate units.

Data: $E = 3.2 \pm 0.1$ V and $d = 0.31 \pm 0.01$ mm.

$\frac{r}{E}$ = y-intercept

$\frac{r}{3.2} = 1.1$

$r = 3.5$

units: $V \times A^{-1} = \frac{V}{A} = \Omega$

gradient $= 4\rho/\pi E d^2$

$\rho = \frac{\pi E d^2}{4} \times$ gradient

$= \frac{\pi \times 3.2 \times (0.31 \times 10^{-3})^2 \times 8.0}{4}$

$= 1.9 \times 10^{-6}$

units: Ωm

ρ = $1.9 \times 10^{-6}\ \Omega m$

r = $3.5\ \Omega$

[2]

(ii) Determine the percentage uncertainty in ρ.

$\rho = (\pi E d^2 \times \text{gradient})/4$

$$\frac{\Delta \rho}{\rho} \times 100 = \left[\frac{\Delta E}{E} + 2\frac{\Delta d}{d} + \frac{\Delta \text{gradient}}{\text{gradient}}\right] \times 100$$

$$= \left[\frac{0.1}{3.2} + \frac{2(0.01)}{0.31} + \frac{1.3}{8.0}\right] \times 100$$

$= 26\%$

percentage uncertainty in ρ = 26 % [1]

Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2015**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

DC (LEG/FD) 97183/3

CAMBRIDGE
International Examinations

[Turn over

1 A beaker contains water and some metal blocks as shown in Fig. 1.1.

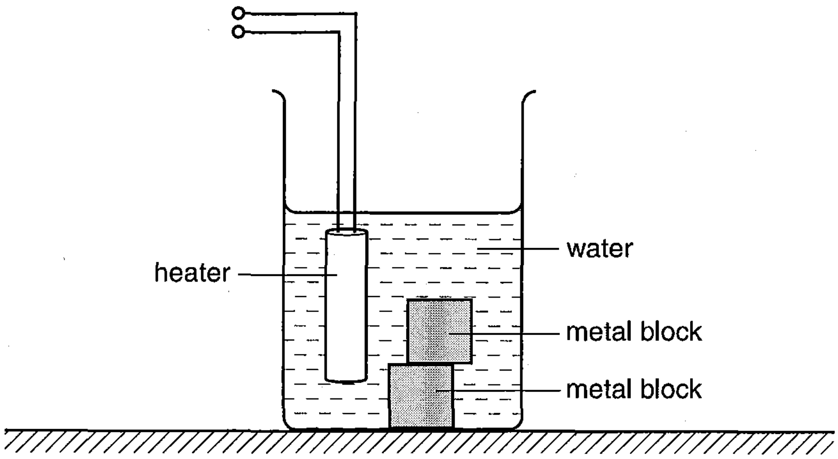


Fig. 1.1

A student uses an electrical heater to produce a particular temperature increase in the water.

It is suggested that the electrical energy E supplied to the heater is related to the mass m of metal blocks by the relationship

$$E = am + b$$

where a and b are constants.

Design a laboratory experiment to test the relationship between E and m. Explain how your results could be used to determine values for a and b. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

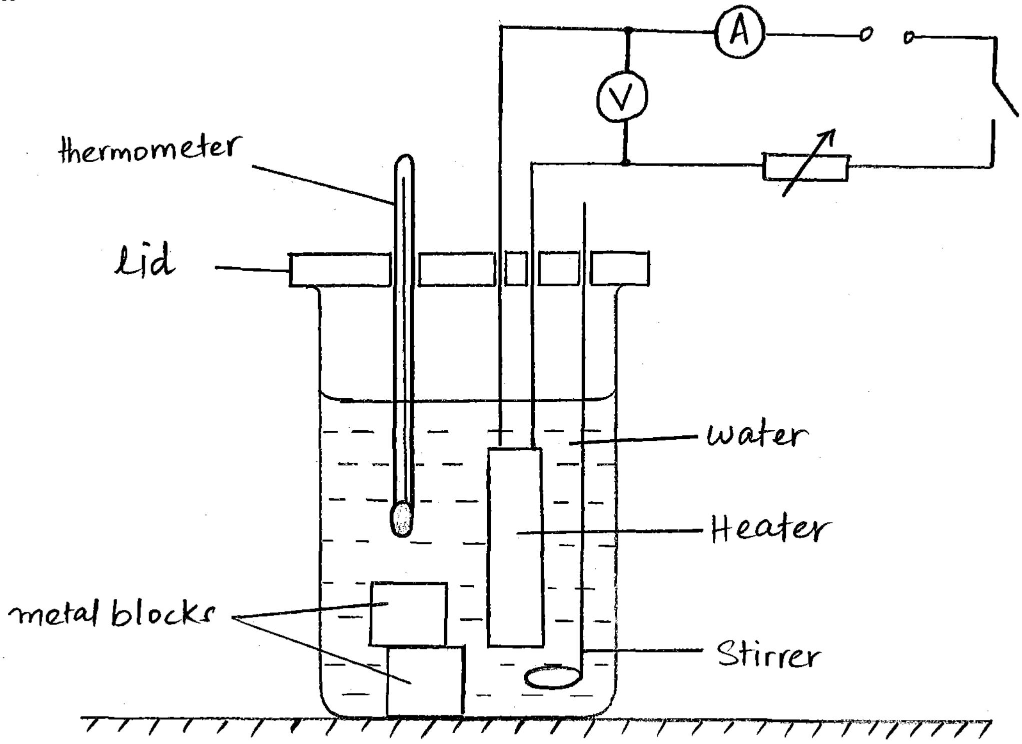
(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram



Defining the problem:
Independent variable: Mass m of metal blocks
Dependent variable: Energy E
Constant: Temperature change of water
Procedure:
Measure mass m of metal blocks using digital balance. Take fix volume of water in a beaker. Close the switch to heat the water. Measure voltage V across the heater and current I in the heater from voltmeter and ammeter respectively. Measure initial temperature and specific temperature change from thermometer. Measure time t for specific temperature change using stopwatch. Calculate energy E, using the relationship, E = VIt. Stir

the water to keep metal blocks and water in thermal equilibrium. Perform the experiment for different values of mass m and record the data in a given table.

Tabulation:

Number of Observation	m/Kg	V/V	I/A	t/s	E/J

Analysis of data:

Plot a graph of E against m. Graph would be a straight line with gradient 'a' and y-intercept 'b'.

a = gradient

b = y-intercept.

Safety Precautions:

Wear safety gloves and use tongs to handle hot metal blocks to prevent burns.

Additional detail:

1. Add insulation to sides of beaker to prevent energy losses.
2. Use large temperature change to reduce percentage uncertainty in time.
3. Keep the starting temperature and mass of water constant.
4. Adjust variable resistor to ensure voltage and current is constant.

Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student is investigating circular motion.

A small mass m attached to a larger mass P is rotated at constant speed in a horizontal circle, as shown in Fig. 2.1.

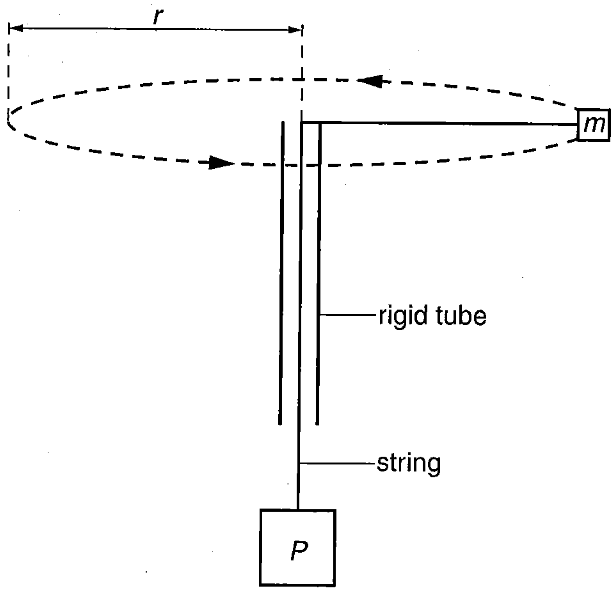


Fig. 2.1

The student changes the radius r of the circle and measures the time t for ten revolutions. The student then determines the period T of a revolution and then the speed v.

It is suggested that v and r are related by the equation

$$Pg = \frac{mv^2}{r}$$

where g is the acceleration of free fall.

(a) A graph is plotted of v^2 on the y-axis against r on the x-axis.
Determine an expression for the gradient.

$$Pg = \frac{mv^2}{r}$$

$$v^2 = \frac{Pg}{m}(r)$$

$$y = mx$$

gradient = Pg/m [1]

(b) The speed v is given by

$$v = \frac{2\pi r}{T}.$$

Values of r and t are given in Fig. 2.2.

r/m	t/s	T/s	v / m s^{-1}	v^2/m^{2}s^{-2}
0.160	3.4 ± 0.2	0.34	2.96	8.74 ± 1.03
0.280	4.0 ± 0.2	0.40	4.40	19.3 ± 1.9
0.400	4.8 ± 0.2	0.48	5.24	27.4 ± 2.3
0.520	5.4 ± 0.2	0.54	6.05	36.6 ± 2.7
0.640	6.0 ± 0.2	0.60	6.70	44.9 ± 3.0
0.760	6.6 ± 0.2	0.66	7.24	52.3 ± 3.2

Fig. 2.2

Calculate and record values of T/s, v/m s^{-1} and v^2/m^{2}s^{-2} in Fig. 2.2. Include the absolute uncertainties in v^2. [3]

(c) **(i)** Plot a graph of v^2/m^{2}s^{-2} against r/m. Include error bars for v^2. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

Gradient of best fit line:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{49.5 - 15}{0.7 - 0.24}$$

$$= 75$$

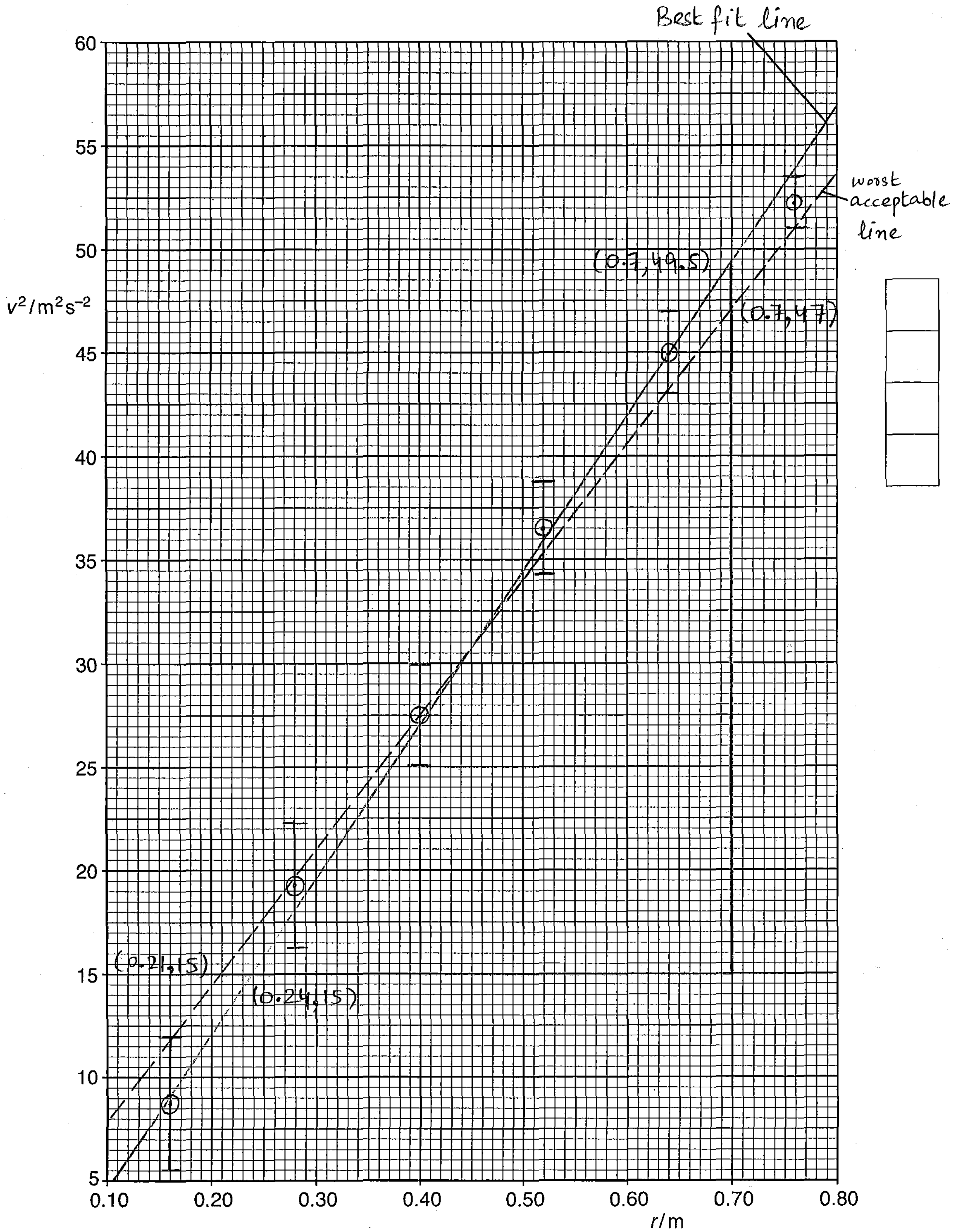
Gradient of worst acceptable line:

$$\text{gradient} = \frac{47 - 15}{0.7 - 0.21}$$

$$= 66$$

Δgradient $= 75 - 66 = 9$

gradient = 75 ± 9 [2]


Best fit line
worst acceptable line
(0.7,49.5)
(0.7,47)
(0.21,15)
(0.24,15)
$v^2 / m^2 s^{-2}$
60
55
50
45
40
35
30
25
20
15
10
5
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
r / m

(d) (i) Using your answers to **(a)** and **(c)(iii)**, determine the value of *P*. Include an appropriate unit.

Data: $g = 9.81\,\mathrm{m\,s^{-2}}$ and $m = 0.025 \pm 0.001\,\mathrm{kg}$.

gradient = Pg/m

$$P = \frac{\text{gradient} \times m}{g}$$

$$P = \frac{75 \times 0.025}{9.81}$$

$$P = 0.19$$

Units: $\frac{m\,s^{-2} \times kg}{m\,s^{-2}} = kg$

$P =$ 0.19 kg [2]

(ii) Determine the percentage uncertainty in your value of *P*.

$$P = \frac{\text{gradient} \times m}{g}$$

$$\frac{\Delta P}{P} \times 100 = \left[\frac{\Delta\text{gradient}}{\text{gradient}} + \frac{\Delta m}{m}\right] \times 100$$

$$= \left[\frac{9}{75} + \frac{0.001}{0.025}\right] \times 100 = 16\%$$

percentage uncertainty = 16 % [1]

(e) (i) The experiment is repeated with a small mass *m* of 0.040 kg. Determine the speed *v* when the radius *r* is $0.500 \pm 0.005\,\mathrm{m}$.

$$Pg = \frac{mv^2}{r}$$

$$v = \left[\frac{Pgr}{m}\right]^{1/2} = \left[\frac{0.19 \times 9.81 \times 0.5}{0.040}\right]^{1/2} = 4.83\,\mathrm{m\,s^{-1}}$$

$v =$ 4.83 $\mathrm{m\,s^{-1}}$ [1]

(ii) Determine the percentage uncertainty in your value of *v*.

$$v = \left[\frac{Pgr}{m}\right]^{1/2}$$

$$\frac{\Delta v}{v} \times 100 = \frac{1}{2}\left[\left(\frac{\Delta P}{P} \times 100\right) + \left(\frac{\Delta r}{r} \times 100\right)\right] = \frac{1}{2}\left[16 + \left(\frac{0.005}{0.5} \times 100\right)\right]$$

$$= 8.5\%$$

percentage uncertainty = 8.5 % [1]

Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5858621285

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2014**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
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Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

1 A ball rolls forwards and backwards on a curved track as shown in Fig. 1.1.

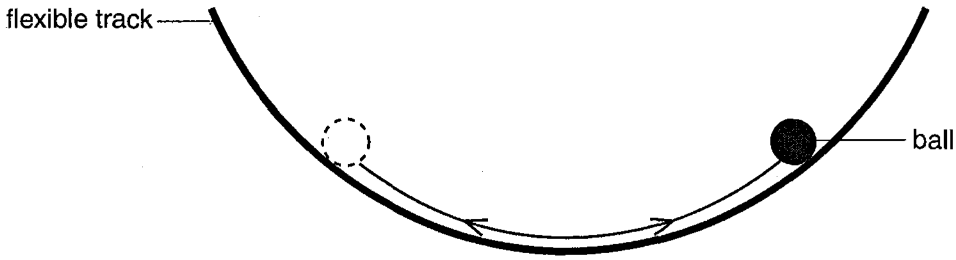


Fig. 1.1

It is suggested that the period T of the oscillations is related to the radius r of the ball and the radius of curvature C of the track by the relationship

$$T^2 = \frac{28\pi^2}{5g}(C - r)$$

where g is the acceleration of free fall.

You are provided with a flexible track. Design a laboratory experiment to test the relationship between T and r. Explain how your results could be used to determine a value for C. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

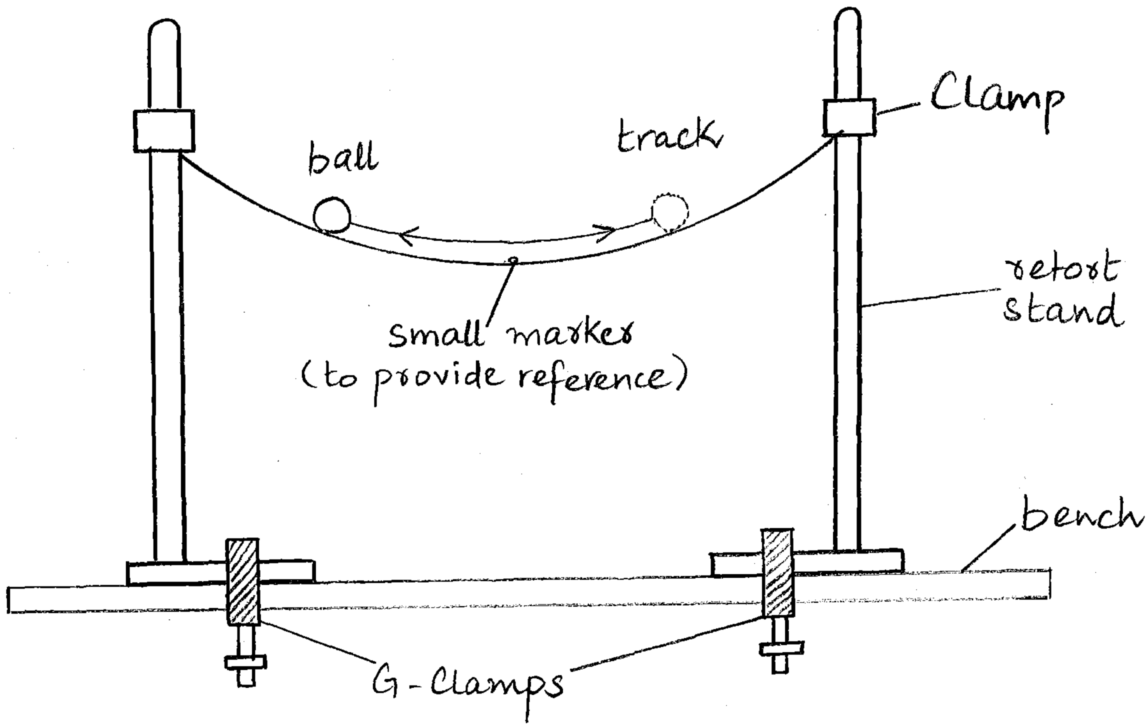
(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram



Defining the problem:

Independent Variable: Radius r of the ball.

Dependent Variable: Time period T.

Constant: Radius of curvature C.

Procedure:

Measure the diameter of ball with micrometer screw guage. Release the ball from top of the track. Measure the time t of n oscillations with stopwatch. Calculate the time period T, using the relationship, T = t/n. Take at least ten oscillations to reduce uncertainty in time period. Calculate radius r, using relationship, radius = diameter/2. Perform the experiment with the balls of different radii. Record the data in given table.

Tabulation :-

Numbers of observation	r/m	t_1/s	t_2/s	$<t>$/s	T/s	T^2/s^2

Data Analysis:

$$T^2 = -\frac{28\pi^2}{5g}(r) + \frac{28\pi^2 C}{5g}$$

Plot a graph of T^2 against r.

y-intercept $= \frac{28\pi^2 C}{5g} = -$gradient $\times C$.

$C = -$(y-intercept)/ gradient.

Safety precaution:

Place sand tray below the track to prevent balls rolling on to floor.

Additional Details:

1. Use the balls of same material throughout the experiment.
2. Measure diameter of balls from several different positions and take the average.
3. Clean the flexible track and balls before performing the experiment.
4. Put a mark on centre of the track for reference to measure time period.

Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student is investigating a circuit containing an operational amplifier (op-amp).

The circuit is set up as shown in Fig. 2.1.

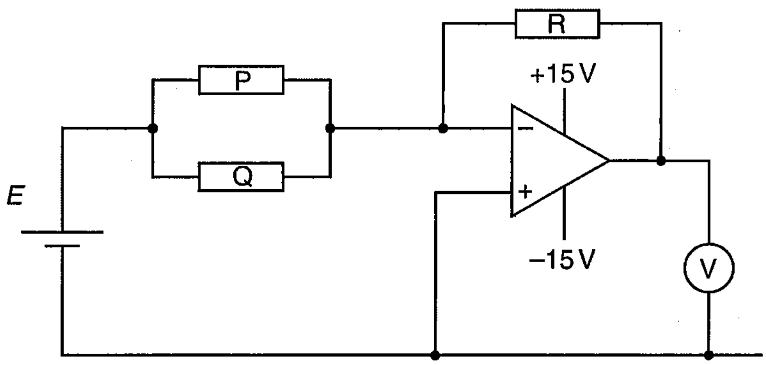


Fig. 2.1

The op-amp is connected to a +15V and −15V power supply.

An experiment is carried out to investigate how the reading *V* on the voltmeter varies with the resistance *Q* of resistor Q.

It is suggested that *V* and *Q* are related by the equation

$$V = -ER\left(\frac{1}{P} + \frac{1}{Q}\right)$$

where *E* is the e.m.f. of the cell, *P* is the resistance of resistor P and *R* is the resistance of resistor R.

(a) A graph is plotted of $\frac{V}{E}$ on the *y*-axis against $\frac{1}{Q}$ on the *x*-axis.

Determine expressions for the gradient and the *y*-intercept in terms of *P* and *R*.

$$V = -ER\left[\frac{1}{P} + \frac{1}{Q}\right]$$

$$\frac{V}{E} = -R\left[\frac{1}{Q}\right] + \left[-\frac{R}{P}\right]$$

$$y = m\,x + c$$

gradient = $-R$

y-intercept = $-R/P$

[1]

(b) The e.m.f. E of the cell has a value of 1.6 ± 0.1 V.

Values of V and Q are given in Fig. 2.2.

$Q/10^3\,\Omega$	V/V	$\frac{1}{Q}/10^{-3}\Omega^{-1}$	$\frac{V}{E}$
0.15	-8.2 ± 0.1	6.67	-5.13 ± 0.38
0.22	-6.0 ± 0.1	4.55	-3.75 ± 0.30
0.33	-4.4 ± 0.1	3.03	-2.75 ± 0.23
0.50	-3.3 ± 0.1	2.00	-2.06 ± 0.19
0.66	-2.8 ± 0.1	1.52	-1.75 ± 0.17
0.90	-2.4 ± 0.1	1.11	-1.50 ± 0.16

Fig. 2.2

Calculate and record values of $\frac{1}{Q}/10^{-3}\Omega^{-1}$ and $\frac{V}{E}$ in Fig. 2.2.

Include the absolute uncertainties in $\frac{V}{E}$. [3]

(c) **(i)** Plot a graph of $\frac{V}{E}$ against $\frac{1}{Q}/10^{-3}\Omega^{-1}$. Include error bars for $\frac{V}{E}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{-1.2-(-4.5)}{(0.7-5.7)10^{-3}}$$

$$= -660$$

gradient of worst fit:

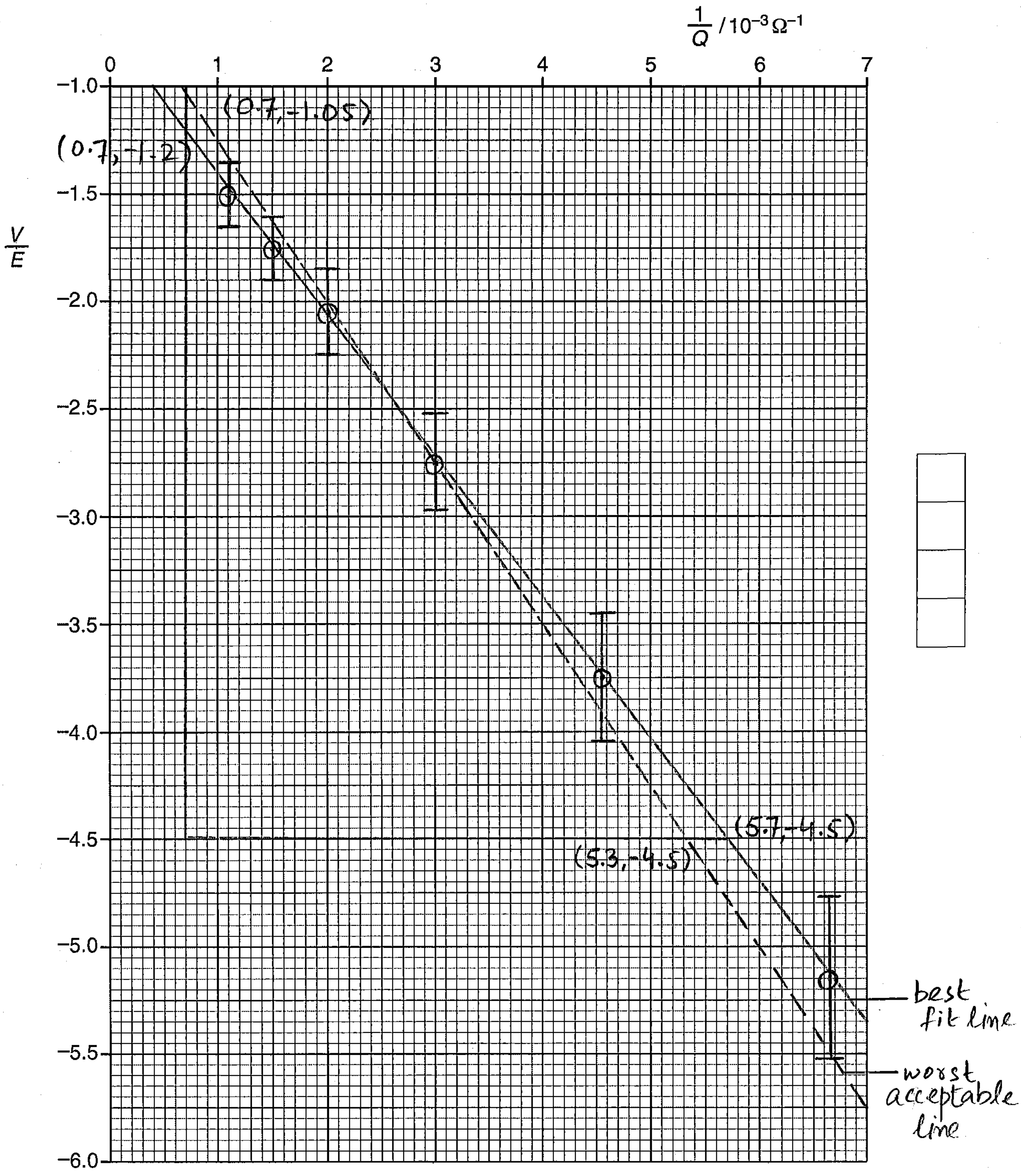
$$\text{gradient} = \frac{-1.05-(-4.5)}{(0.7-5.3)10^{-3}}$$

$$= -750$$

$$\Delta\text{gradient} = 750 - 660$$

$$= 90$$

gradient = -660 ± 90 [2]


$\frac{1}{Q}$ / $10^{-3}\,\Omega^{-1}$
0
1
2
3
4
5
6
7
$\frac{V}{E}$
−1.0
−1.5
−2.0
−2.5
−3.0
−3.5
−4.0
−4.5
−5.0
−5.5
−6.0
(0.7, −1.05)
(0.7, −1.2)
(5.7, −4.5)
(5.3, −4.5)
best fit line
worst acceptable line

(iv) Determine the y-intercept of the line of best fit. Include the uncertainty in your answer.

Best fit:

$y = mx + c$

$-1.2 = -660(0.7 \times 10^{-3}) + c$

$c = -0.738$

Worst fit:

$-1.05 = -750(0.7 \times 10^{-3}) + c$

$c = -0.525$

$\Delta c = 0.738 - 0.525 = 0.2$

y-intercept = -0.7 ± 0.2 [2]

(d) (i) Using your answers to **(c)(iii)** and **(c)(iv)**, determine the values of P and R. Include appropriate units.

$-R$ = gradient

$-R = -660$

$R = 660$

unit: $\frac{1}{\Omega^{-1}} = \Omega$

$-\frac{R}{P}$ = y-intercept

$\frac{-660}{P} = -0.738$

$P = 890$

units: Ω

P = $890\ \Omega$

R = $660\ \Omega$

[2]

(ii) Determine the percentage uncertainty in P.

$P = \frac{-R}{y\text{-intercept}}$

$\frac{\Delta P}{P} \times 100 = \left[\frac{\Delta R}{R} + \frac{\Delta\, y\text{-intercept}}{y\text{-intercept}}\right] \times 100$

$= \left[\frac{90}{660} + \frac{0.2}{0.7}\right] \times 100$

$= 42\%$

percentage uncertainty = 42 % [1]

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2014**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

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DC (NF/SW) 76986/2

[Turn over

1 Two identical coils are connected together and arranged as shown in Fig. 1.1.

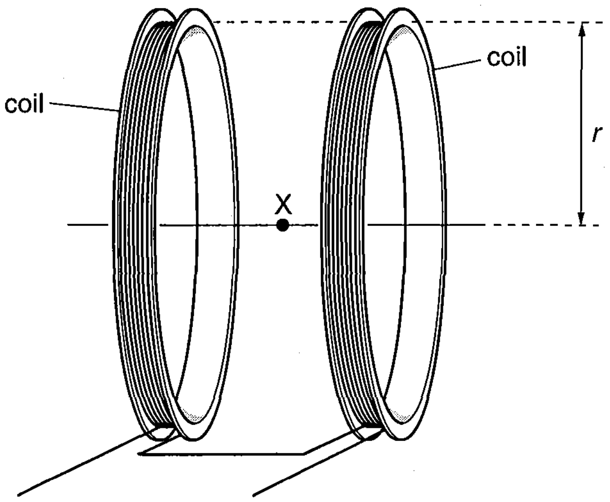


Fig. 1.1

The coils are in the vertical plane and are parallel to each other. When the coils are connected to a power supply, there is a magnetic field between them.

It is suggested that the magnetic flux density B of the field at the point X is related to the radius r of the coils by the relationship

$$B = \frac{0.72\mu_0 NI}{r}$$

where N is the number of turns on each coil, I is the current in the coils and μ_0 is the permeability of free space.

Design a laboratory experiment that uses a Hall probe to test the relationship between B and r and determine a value for μ_0. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

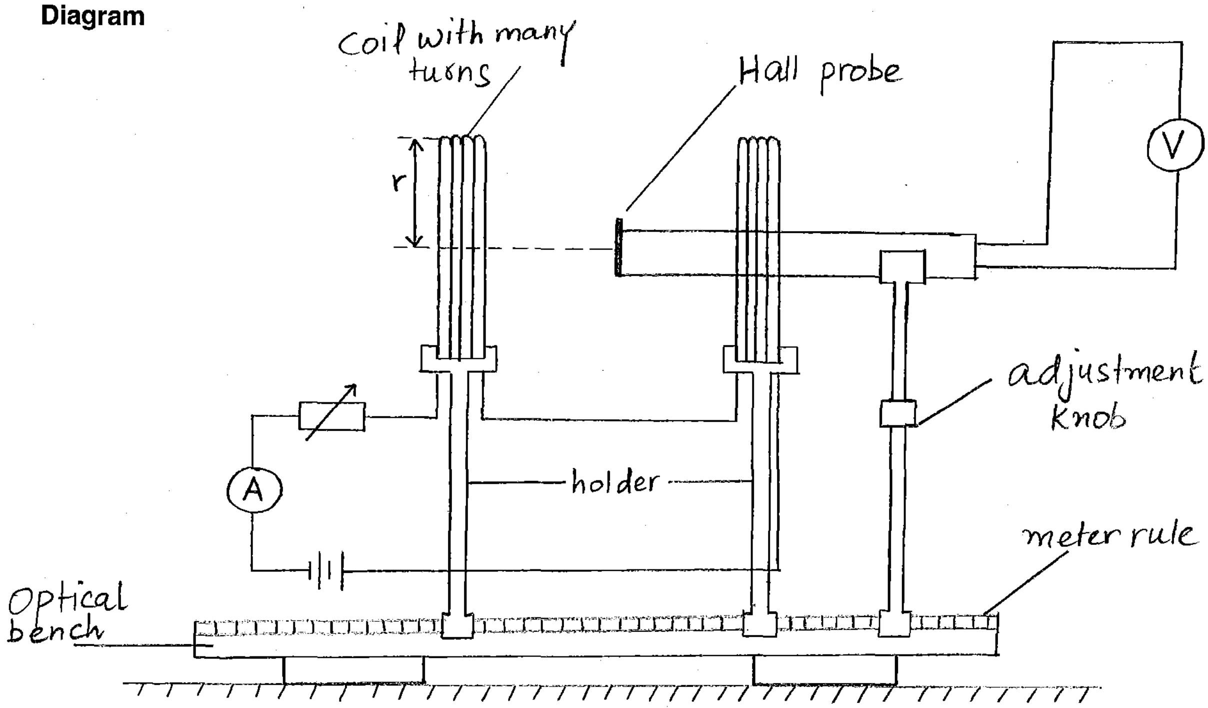
(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram



Defining the problem:
Independent Variable: Radius r of the coils.
Dependent Variable: Magnetic flux density B.
Constant: Number of turns of the coil
Current in the coil
Procedure:
Measure the diameter d of the coil with vernier calipers. Calculate the radius r of the coils by using the relationship, $r = d/2$
Calibrate Hall probe with a known magnetic flux density. Place the Hall probe between center of two coils. Measure the hall voltage and work out the value of magnetic flux density. Keep the number of turns of each coil constant throughout the experiment.

Repeat the experiment with coils of different radii. Record the readings in the given table.

Tabulation:

Number of Observation	r/m	$\frac{1}{r}/m^{-1}$	B/T

Analysis of data:

$B = 0.72\mu_0 NI(1/r)$

$y = m\ (x)$

Plot a graph of B against $1/r$. Graph would be a straight line through origin.

gradient $= 0.72\mu_0 NI$

$\mu_0 = \text{gradient}/(0.72NI)$

Safety Precaution:

Switch off the circuit when not in use to avoid overheating of coils.

Additional details:

1. Use large current and large number of turns to create large magnetic field.
2. Use set square to keep Hall probe perpendicular to the direction of magnetic field.
3. Measure the diameter of coils from several different positions and take average.
4. Use rheostat and ammeter to keep the current constant.

Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student investigates the oscillations of a simple pendulum attached to a pole on the side of a building, as shown in Fig. 2.1.

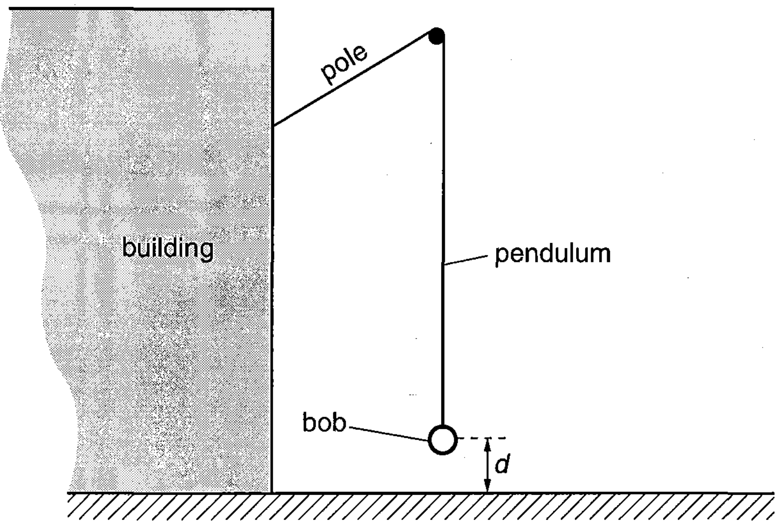


Fig. 2.1

The student records the distance d from the ground to the centre of the pendulum bob and the time t for the pendulum to complete 10 oscillations.

It is suggested that the period T of the oscillations and the distance d are related by the equation

$$T^2 = \frac{4\pi^2}{g}(k - d)$$

where g is the acceleration of free fall and k is a constant.

(a) A graph is plotted of T^2 on the y-axis against d on the x-axis. Determine expressions for the gradient and the y-intercept in terms of g and k.

$$T^2 = \frac{4\pi^2}{g}(K - d)$$

$$T^2 = -\frac{4\pi^2}{g}(d) + \frac{4\pi^2}{g}K$$

gradient = $-4\pi^2/g$

y-intercept = $4\pi^2 K/g$

[1]

(b) For each value of d the measurement of t is repeated. Values of d and t are given in Fig. 2.2.

d/m	t/s	t/s	$\langle t \rangle$/s	T/s	T^2/s^2
0.45 ± 0.05	56.4	56.4	56.4	5.64	31.8
0.70 ± 0.05	55.4	55.6	55.5	5.55	30.8
1.00 ± 0.05	54.6	54.2	54.4	5.44	29.6
1.20 ± 0.05	53.4	53.8	53.6	5.36	28.7
1.45 ± 0.05	52.9	52.5	52.7	5.27	27.8
1.65 ± 0.05	51.6	52.0	51.8	5.18	26.8

Fig. 2.2

Calculate and record values of mean t/s, T/s and T^2/s^2 in Fig. 2.2. [2]

(c) **(i)** Plot a graph of T^2/s^2 against d/m. Include error bars for d. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit line:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{31.5 - 27}{0.52 - 1.63}$$

$$= -4.05$$

gradient of worst fit line:

$$\text{gradient} = \frac{31.35 - 27}{0.52 - 1.64}$$

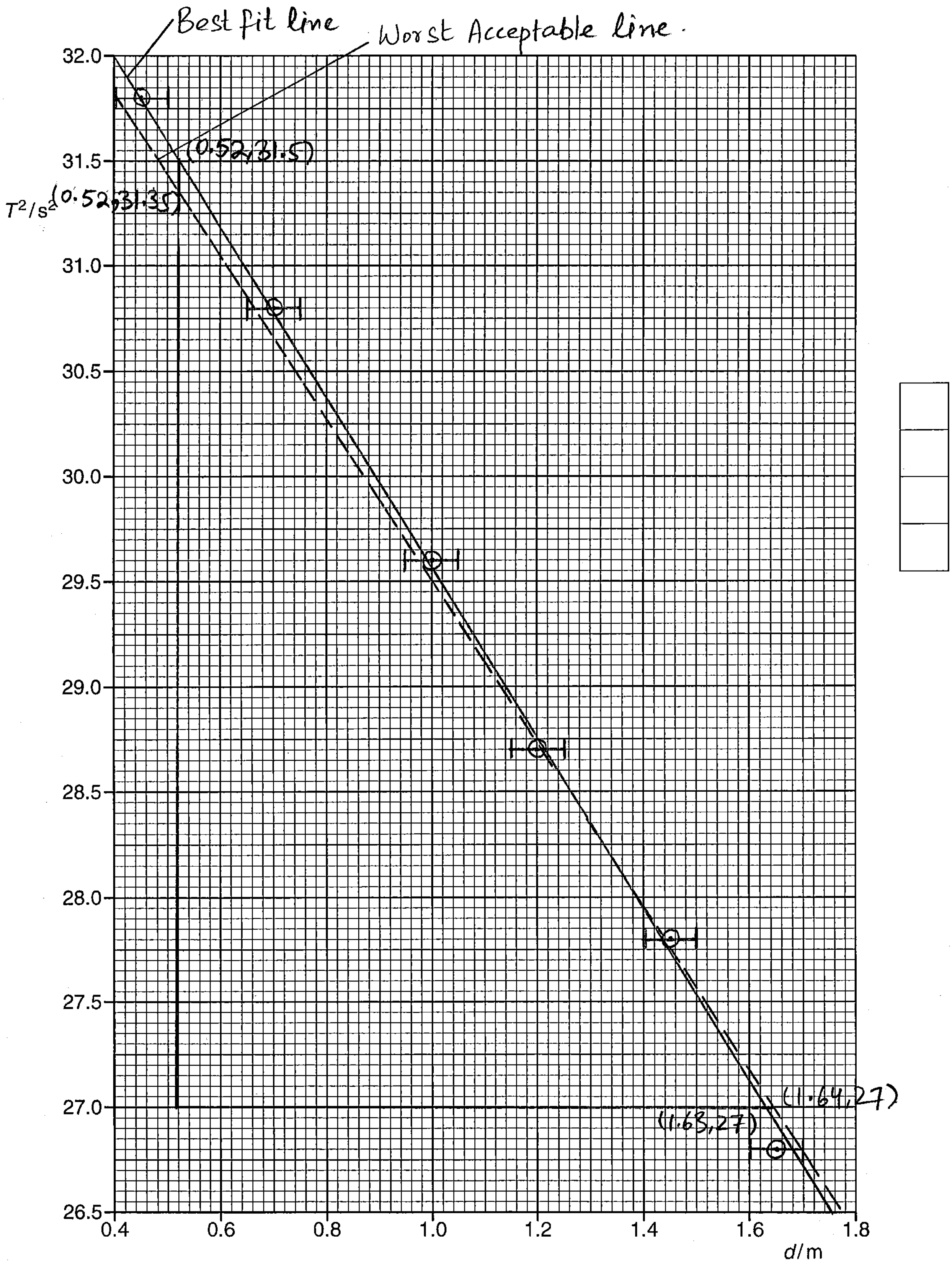
$$= -3.88$$

gradient = -4.1 ± 0.2 [2]

$$\Delta\,\text{gradient} = 4.05 - 3.88$$

$$= 0.17$$

$$= 0.2$$


Best fit line
Worst Acceptable line .
(0.52,31.5)
(0.52,31.35)
(1.64,27)
(1.63,27)
T^2/s^2
32.0
31.5
31.0
30.5
30.0
29.5
29.0
28.5
28.0
27.5
27.0
26.5
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
d/m

(iv) Determine the y-intercept of the line of best fit. Include the uncertainty in your answer.

Best fit line

$y = mx + c$

$31.5 = -4.05(0.52) + c$

$c = 33.6$

Worst fit line

$y = mx + c$

$31.35 = -3.88(0.52) + c$

$c = 33.4$

$\Delta c = 33.6 - 33.4 = 0.2$

y-intercept = 33.6 ± 0.2 [2]

(d) (i) Using your answers to **(c)(iii)** and **(c)(iv)**, determine values for g and k. Include appropriate units.

$-4\pi^2/g = \text{gradient}$

$g = -4\pi^2/\text{gradient}$

$g = -4\pi^2/(-4.05)$

$g = 9.74$

units of g: $\dfrac{1}{s^2/m} = ms^{-2}$

$y\text{-intercept} = 4\pi^2 k/g$

$33.6 = 4\pi^2 k/9.74$

$K = 8.29$

units: $s^2 \times ms^{-2} = m$

g = 9.74 ms^{-2}

k = 8.29 m

[2]

(ii) Determine the percentage uncertainties in g and k.

$g = -4\pi^2/\text{gradient}$

$\dfrac{\Delta g}{g} \times 100 = \dfrac{\Delta \text{gradient}}{\text{gradient}} \times 100$

$= \dfrac{0.2}{4.1} \times 100$

$= 4.9\%$

$K = (g \times y\text{-intercept}) / 4\pi^2$

$\dfrac{\Delta K}{K} \times 100 = \left[\dfrac{\Delta g}{g} + \dfrac{\Delta y\text{-intercept}}{y\text{-intercept}}\right] \times 100$

$= 4.9 + \left(\dfrac{0.2}{33.6} \times 100\right)$

$= 5.5\%$

percentage uncertainty in g = 4.9 %

percentage uncertainty in k = 5.5 %

[2]

Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3280309247

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2014**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

DC (SJF/CGW) 77200/2

CAMBRIDGE International Examinations

[Turn over

1 A student investigates the power dissipated by a lamp connected to a model wind turbine as shown in Fig. 1.1.

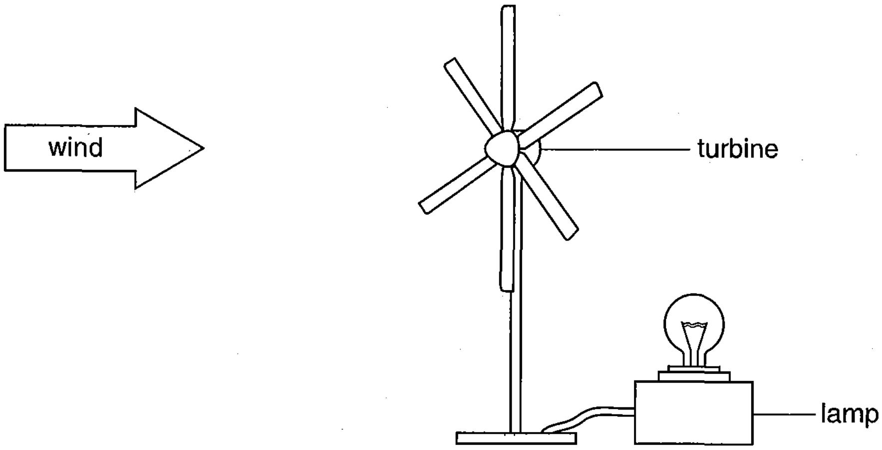


Fig. 1.1

The power P dissipated in the lamp depends on the angle θ between the axis of the turbine and the direction of the wind, as shown by the top view in Fig. 1.2.

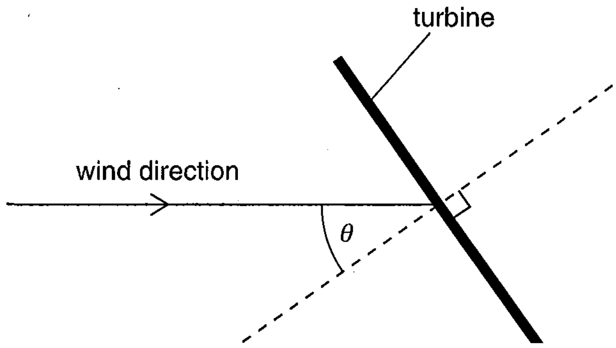


Fig. 1.2

It is suggested that

$$P = k\cos\theta$$

where k is a constant.

Design a laboratory experiment to test the relationship between P and θ and determine a value for k. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

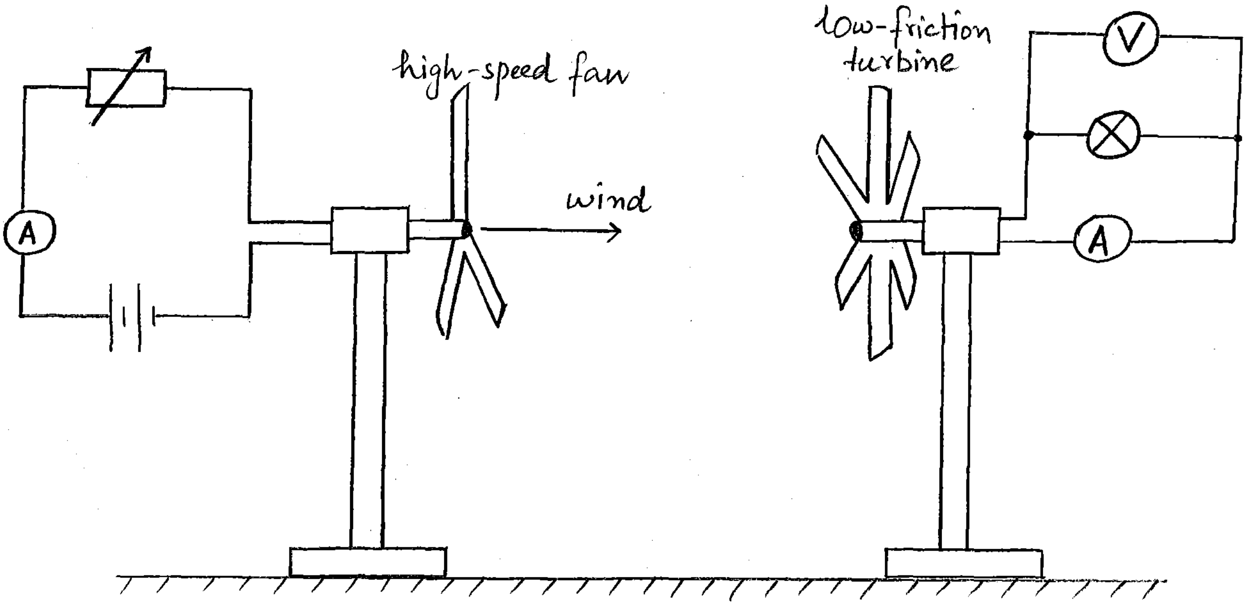
(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram



Defining the problem:
Independent variable: cos θ
Dependent variable: Power P
Constant: Speed of the air
Procedure:
Measure the angle θ between the axis of the turbine and the direction of wind with protractor. Workout the value of cos θ. As the turbine rotates, power would be dissipated by the lamp. Measure voltage V accross lamp from voltmeter and current I through the lamp from ammeter. Calculate the power dissipated in the lamp by using the relationship, $P = VI$. Adjust the position of turbine to vary θ. Perform the experiment for

different values of cos θ.

Tabulation:-

Number of Observation	θ/°	cos(θ)	I/A	V/V	P/W

Analysis of data:

$$P = k\cos\theta$$

Plot a graph of P against cos θ. Graph would be a straight line through origin with gradient, equal to k.

$$k = \text{gradient}$$

Safety Precaution:

Avoid touching fast moving blades of fan and turbine to prevent any injury.

Additional Detail:

1. Use high-speed fan for large wind and measurable voltmeter and ammeter readings.
2. Ensure that the distance between the fan and turbine is constant.
3. Measure the voltmeter and ammeter readings, once they get stable.
4. Avoid external sources of wind by closing the windows and switching off fans and air conditioners.

Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student investigates electrical resonance in a circuit containing a capacitor and a coil connected in parallel.

The circuit is set up as shown in Fig. 2.1.

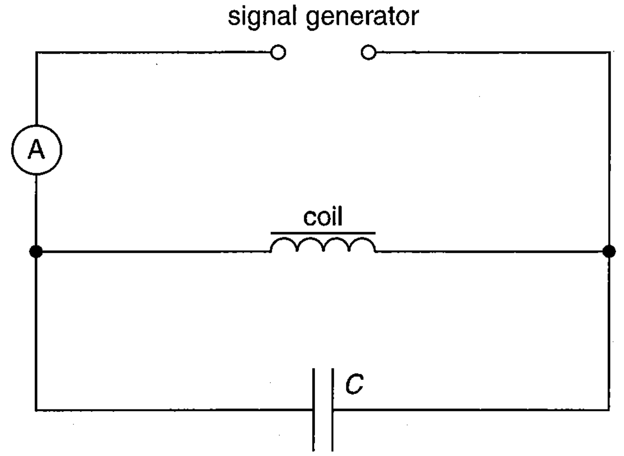


Fig. 2.1

The resonant frequency f is the frequency at which the current measured by the ammeter is a minimum.

An experiment is carried out to investigate how f varies with the capacitance C of the capacitor.

It is suggested that f and C are related by the equation

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where L is a constant for the circuit.

(a) A graph is plotted of f^2 on the y-axis against $\frac{1}{C}$ on the x-axis. Determine an expression for the gradient in terms of L.

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$f^2 = \frac{1}{4\pi^2 L}\left[\frac{1}{C}\right]$$

$$y = m x$$

gradient = $1/4\pi^2 L$ [1]

(b) Values of f and C are given in Fig. 2.2.

$C/10^{-4}$F	f/Hz	$\frac{1}{C}/10^3\,\text{F}^{-1}$	$f^2/10^3\,\text{Hz}^2$
2.5 ± 10%	149	4.0 ± 0.4	22.2
3.0 ± 10%	134	3.3 ± 0.3	18.0
3.5 ± 10%	123	2.9 ± 0.3	15.1
4.4 ± 10%	107	2.3 ± 0.2	11.4
6.6 ± 10%	82	1.5 ± 0.2	6.7
8.8 ± 10%	65	1.1 ± 0.1	4.2

Fig. 2.2

Calculate and record values of $\frac{1}{C}/10^3\,\text{F}^{-1}$ and $f^2/10^3\,\text{Hz}^2$ in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{C}$. [3]

(c) **(i)** Plot a graph of $f^2/10^3\,\text{Hz}^2$ against $\frac{1}{C}/10^3\,\text{F}^{-1}$. Include error bars for $\frac{1}{C}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

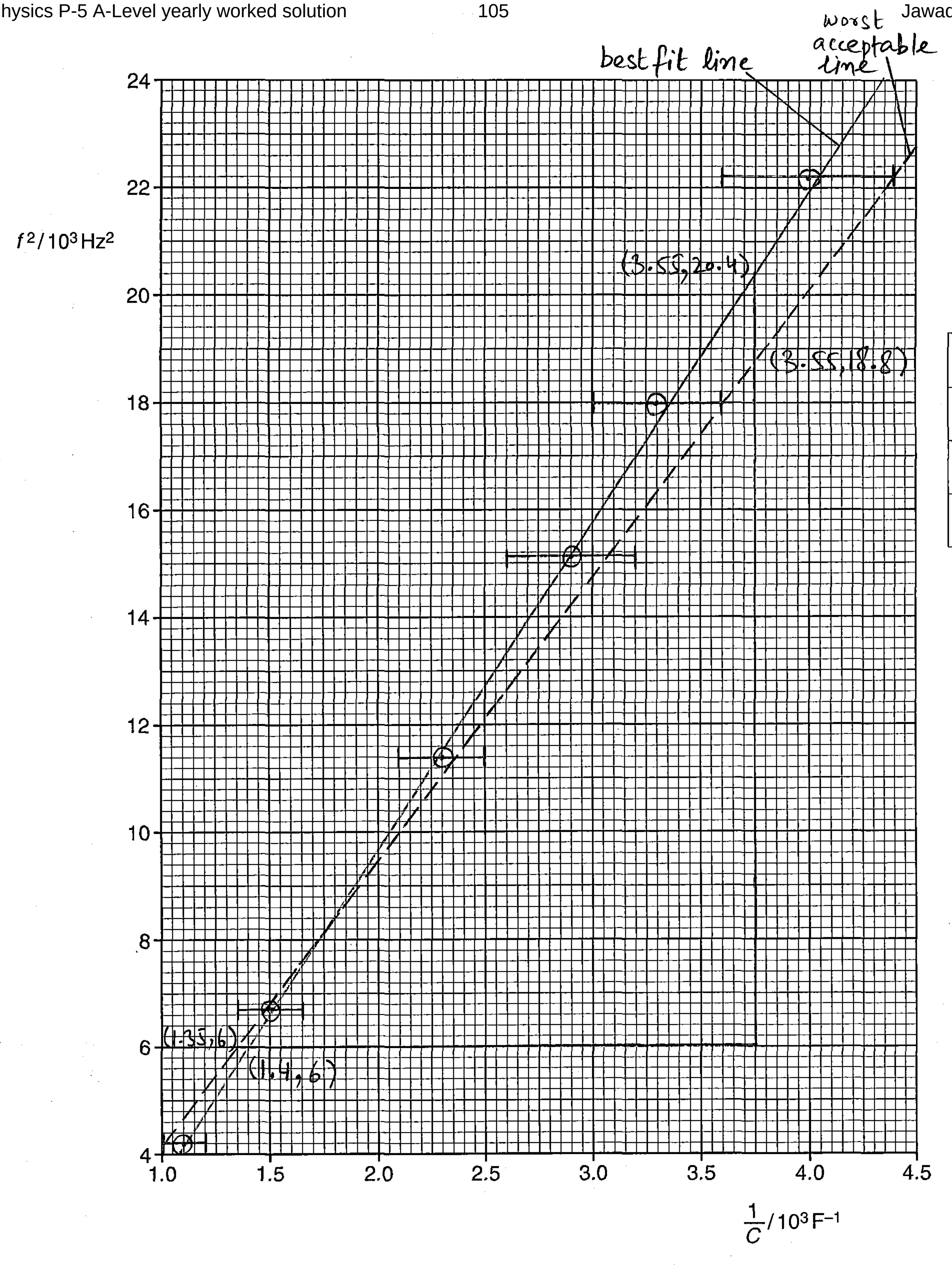
Gradient of Best fit line: Gradient of worst acceptable line:

$$\text{Gradient} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{(20.4-6)10^3}{(3.55-1.4)10^3} = 6.70$$

$$\text{Gradient} = \frac{(18.8-6)10^3}{(3.55-1.35)10^3} = 5.82$$

$$\Delta\,\text{gradient} = 6.70 - 5.82 = 0.9$$

gradient = 6.7 ± 0.9 [2]


worst acceptable line
best fit line
24
22
20
18
16
14
12
10
8
6
4
f^2 / 10^3 Hz^2
(3.55, 20.4)
(3.55, 18.8)
(1.35, 6)
(1.4, 6)
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
$\frac{1}{C}$ / 10^3 F^{-1}

(d) Using your answer to **(c)(iii)**, determine the value of *L*. Include the absolute uncertainty in your value and an appropriate unit.

From best Fit line:

$$\frac{1}{4\pi^2 L} = \text{gradient}$$

$$\frac{1}{4\pi^2 L} = 6.7$$

$$L = 3.8 \times 10^{-3}$$

From worst acceptable line:

$$\frac{1}{4\pi^2 L} = 5.82$$

$$L = 4.4 \times 10^{-3}$$

units: $\frac{1}{Hz^2 F} = F^{-1} Hz^{-2}$

$$\Delta L = (4.4 - 3.8)10^{-3} = 0.6 \times 10^{-3}$$

L = $(3.8 \pm 0.6)10^{-3}\ F^{-1} Hz^{-2}$ [3]

(e) The experiment is repeated using a capacitor of capacitance 10 μF ± 10%.

(i) Using the relationship given and your answer to **(d)**, determine the value of *f*.

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$f = \frac{1}{2\pi\sqrt{3.8 \times 10^{-3} \times 10 \times 10^{-6}}}$$

$$f = 816\ Hz$$

f = 816 Hz [1]

(ii) Determine the percentage uncertainty in the value of *f*.

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$\frac{\Delta f}{f} \times 100 = \frac{1}{2}\left[\left(\frac{\Delta L}{L} \times 100\right) + \left(\frac{\Delta C}{C} \times 100\right)\right]$$

$$= \frac{1}{2}\left[\left(\frac{0.6}{3.8} \times 100\right) + 10\right]$$

$$= 13\%$$

percentage uncertainty = 13 % [1]

Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

4912978853

PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2014**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

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At the end of the examination, fasten all your work securely together.
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DC (SJF/SW) 77217/3

CAMBRIDGE International Examinations

[Turn over

1 A thin card is inserted between two separate iron cores. A coil is wound around one core as shown in Fig. 1.1.

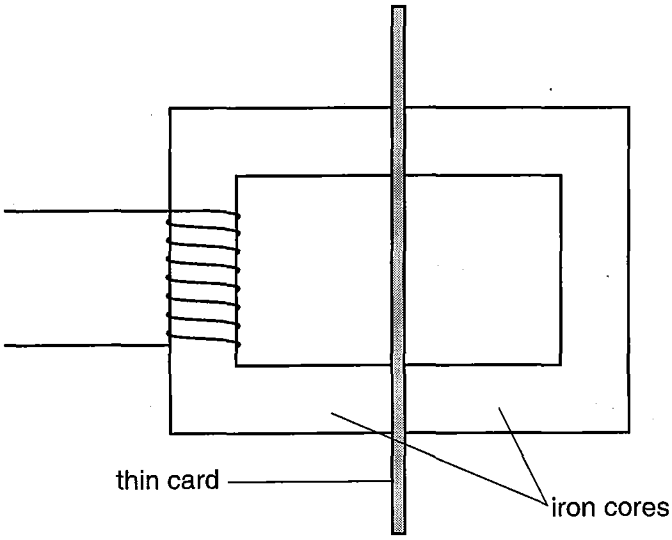


Fig. 1.1

A current in the coil may induce an e.m.f. in another coil wound on the other core. The induced e.m.f. V depends on the thickness t of the card.

A student suggests that

$$V = V_0 e^{-\sigma t}$$

where V_0 is the induced e.m.f. without card between the cores and σ is a constant.

Design a laboratory experiment to test the relationship between V and t and determine the value of σ. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

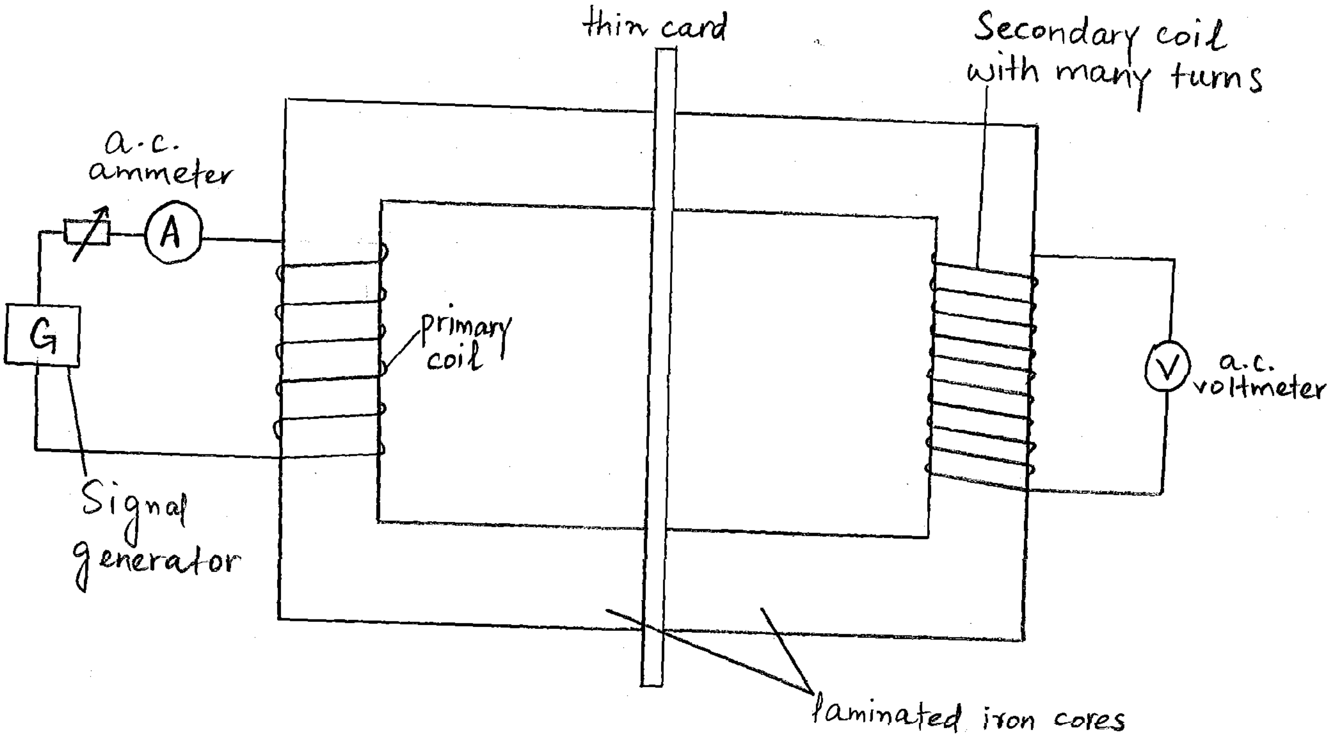
(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram



Defining the problem:

Independent variable: Thickness t of a card.

Dependent variable: The induced e.m.f. V.

Constant: Current in the primary coil

Procedure:

Measure the thickness of thin card using micrometer screw guage. Place the thin card between two laminated iron cores. Measure the induced e.m.f. from a.c. voltmeter. Adjust the rheostat to make sure current in primary coil is constant throughout the experiment. Keep the number of turns of primary and Secondary coil constant. Perform the experiment with cards of different thicknesses. Record the readings in the given table.

Tabulation:

Number of readings	t/m	V_1/V	V_2/V	$\langle V\rangle/V$	$\ln(V/V)$

Analysis of data:

$$V = V_0 e^{-\sigma t}$$

$$\ln V = -\sigma t + \ln V_0$$

$$y = mx + c$$

Plot a graph of $\ln V$ against t. Graph would be a straigh line with gradient, $-\sigma$ and y-intersept, $\ln V_0$

$$\sigma = -\text{gradient}$$

Safety Precaution:

Do not touch hot coils directly to avoid burns.

Additional details:

1- Use large number of turns on the secondary coil to induce measurable e.m.f-

2- Keep the frequency of input power supply constant.

3. Measure the thickness of card from different positions and take the average.

4. Use laminated cores and insulated wires for the coils

Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student investigates how the final velocity v of a cylinder rolling down a board varies with the height h of the board as shown in Fig. 2.1.

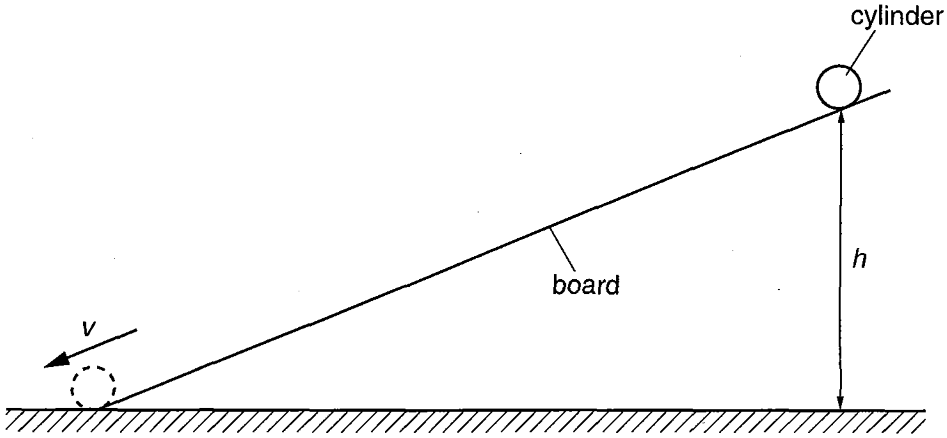


Fig. 2.1

For different values of h, the velocity v is determined using a light sensor connected to a data logger.

It is suggested that v and h are related by the equation

$$2gh = v^2Z$$

where g is the acceleration of free fall and Z is a constant.

(a) A graph is plotted of v^2 on the y-axis against h on the x-axis. Determine an expression for the gradient in terms of g and Z.

$$2gh = v^2Z$$

$$v^2 = \frac{2g}{Z}(h)$$

$$y = m(x)$$

gradient = $2g/Z$ [1]

(b) Values of h and v are given in Fig. 2.2.

h/m	v/m s^{-1}	v^2/ m^{2}s^{-2}
0.230	1.40 ± 0.05	1.96 ± 0.14
0.280	1.55 ± 0.05	2.40 ± 0.15
0.320	1.65 ± 0.05	2.72 ± 0.16
0.360	1.75 ± 0.05	3.06 ± 0.17
0.400	1.85 ± 0.05	3.42 ± 0.18
0.450	1.95 ± 0.05	3.80 ± 0.19

Fig. 2.2

Calculate and record values of v^2/m^{2}s^{-2} in Fig. 2.2. Include the absolute uncertainties in v^2. [3]

(c) (i) Plot a graph of v^2/m^{2}s^{-2} against h/m. Include error bars for v^2. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of Best fit line:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{3.56 - 2.2}{0.42 - 0.26}$$

$$= 8.5$$

Gradient of worst acceptable line:

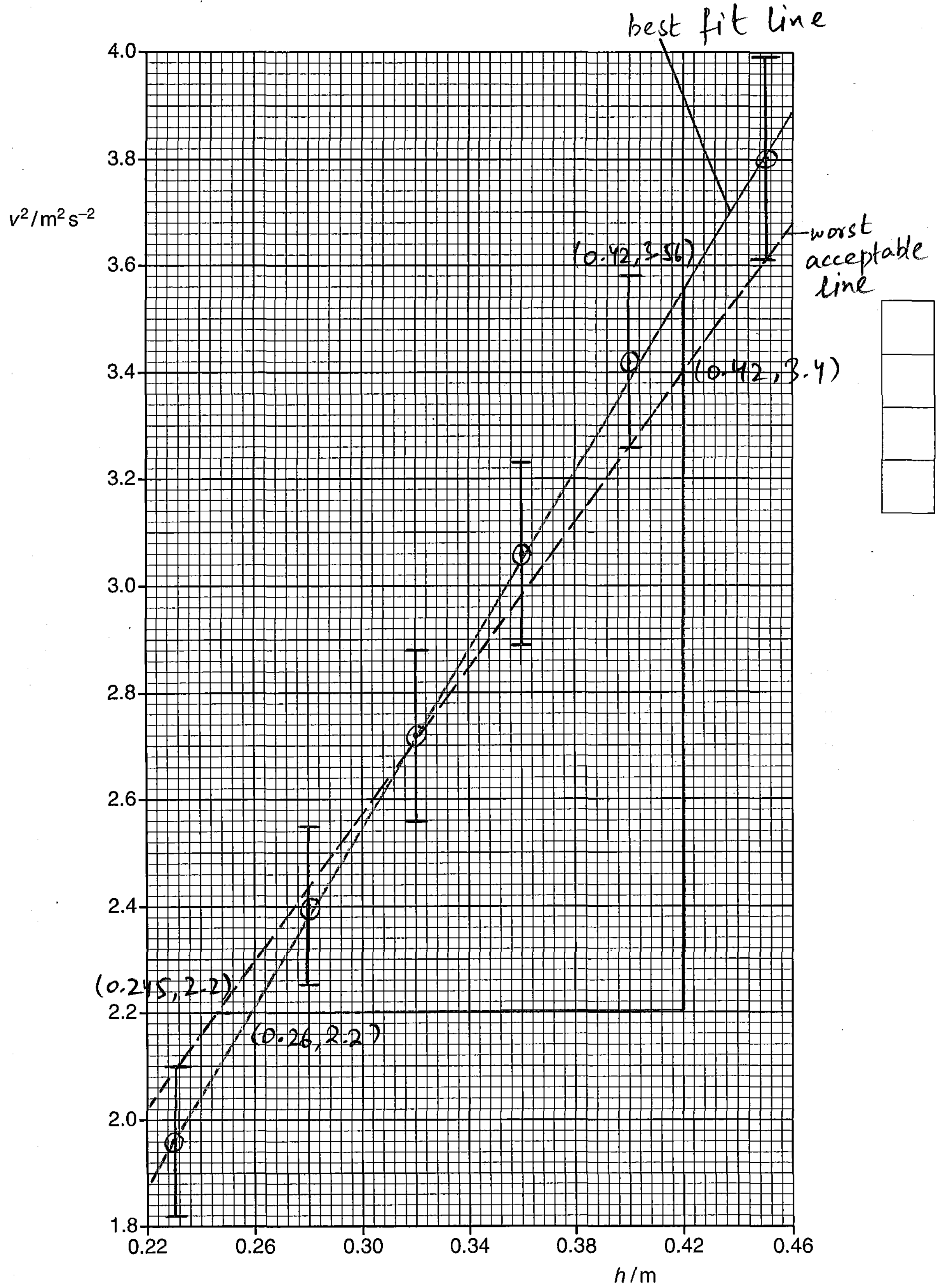
$$\text{gradient} = \frac{3.4 - 2.2}{0.42 - 0.245}$$

$$= 6.85$$

$$\Delta\,\text{gradient} = 8.5 - 6.85$$

$$= 1.6$$

gradient = 8.5 ± 1.6 [2]


best fit line
worst acceptable line
(0.42, 3.56)
(0.42, 3.4)
(0.245, 2.2)
(0.26, 2.2)
$v^2 / m^2 s^{-2}$
h / m
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
0.22
0.26
0.30
0.34
0.38
0.42
0.46

(d) The experiment is repeated with $h = 0.700$ m.

(i) Using your answer to **(c)(iii)**, determine the value of v using the relationship given.

$v^2 = \frac{2g}{Z} \times h = \text{gradient} \times h$

$v^2 = 8.5 \times 0.700$

$v = 2.44\ \text{ms}^{-1}$

v = 2.44 m s^{-1} [1]

(ii) Determine the percentage uncertainty in the value of v.

$v = (\text{gradient} \times h)^{1/2}$

$\frac{\Delta v}{v} \times 100 = \frac{1}{2} \times \frac{\Delta\text{gradient}}{\text{gradient}} \times 100 = \frac{1}{2} \times \frac{1.6}{8.5} \times 100 = 9.4\%$

percentage uncertainty = 9.4 % [1]

(e) The constant Z is given by

$$Z = \left(1 + \frac{K}{mr^2}\right)$$

where m is the mass of the cylinder and r is the radius of the cylinder.

Using your answers to **(a)** and **(c)(iii)**, determine the value of K. Include the absolute uncertainty in your value and an appropriate unit.

Data: $g = 9.81$ m s^{-2}, $m = 2.5$ kg and $r = 0.015$ m.

$\text{gradient} = \frac{2g}{Z}$

$Z = \frac{2g}{\text{gradient}}$

$Z = \frac{2(9.81)}{8.5}$

$Z = 2.31$

$\frac{\Delta Z}{Z} = \frac{\Delta\text{gradient}}{\text{gradient}} = \frac{1.6}{8.5} = 0.188$

$\frac{K}{mr^2} = Z - 1$

$K = (Z-1)(mr^2)$

$= (2.31-1)(2.5 \times 0.015^2)$

$= 7.4 \times 10^{-4}$

$\frac{\Delta K}{K} = \frac{\Delta Z}{Z}$

$\frac{\Delta K}{7.4 \times 10^{-4}} = 0.188$

$\Delta K = 1.3 \times 10^{-4}$

K = $(7.4 \pm 1.3)10^{-4}$ kg m^2 [3]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0964879652

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2013**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
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Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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DC (SM/JG) 61224/3

UNIVERSITY *of* CAMBRIDGE International Examinations

[Turn over

For Examiner's Use

1 A student is investigating the flow of water through a horizontal tube.

The rate Q (volume per unit time) at which water flows through a tube depends on the pressure difference per unit length across the tube.

The student has the use of a metal can with two holes. A narrow horizontal tube goes through the hole in the side of the can. The can is continuously supplied with water from a tap. The level of water in the can is kept constant by the position of a wide vertical tube which passes through the hole in the bottom of the can as shown in Fig. 1.1. Both tubes may be moved along the holes.

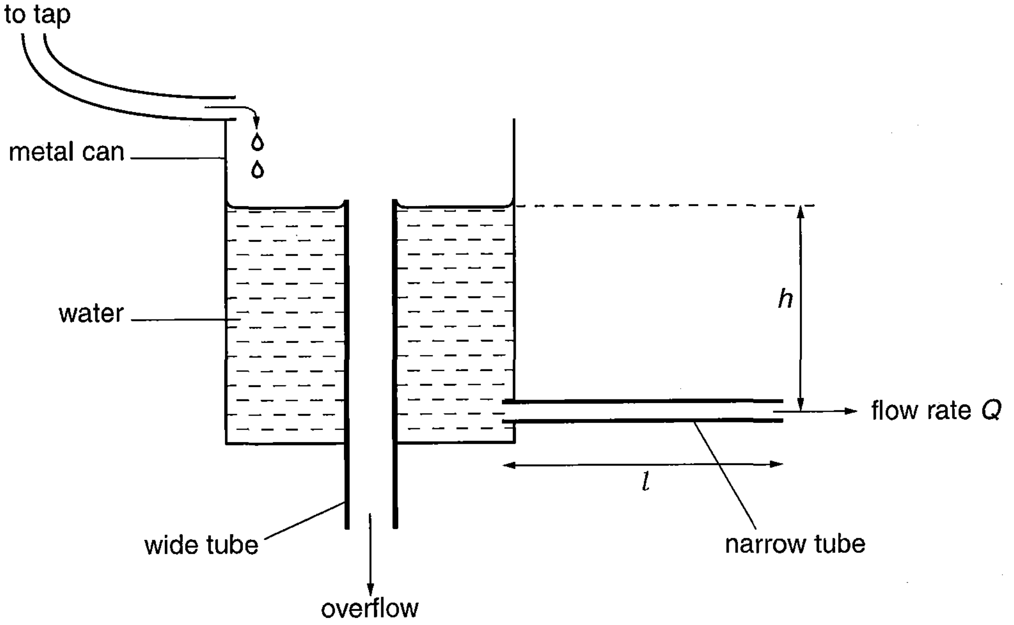


Fig. 1.1

It is suggested that the relationship between the flow rate Q of water through the narrow horizontal tube and the vertical height h is

$$Q = \frac{2\pi\rho g h d^4}{l\eta}$$

where ρ is the density of water, g is the acceleration of free fall, d is the internal diameter of the tube, l is the length of the tube and η is a constant.

Design a laboratory experiment to test the relationship between Q and h and determine a value for η. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

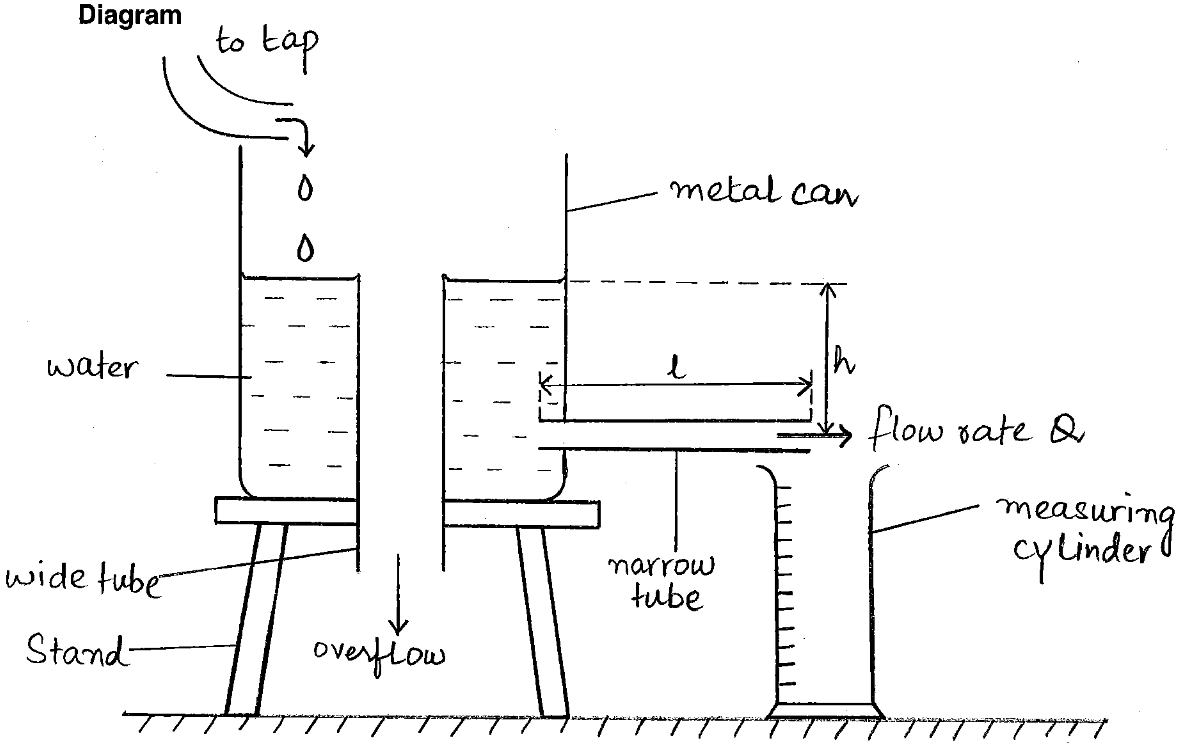
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

For Examiner's Use



Defining the problem:
Independent variable: Vertical height h
Dependent variable: Flow rate Q
Constant: length l of narrow tube.
Procedure:
Measure the vertical height h with meter rule. Measure length l and internal diameter d with vernier caliper. Measure time t with stopwatch, i.e. time taken to collect volume V in the measuring cylinder. Calculate the flowrate Q by using the relationship, $Q = V/t$. Perform the experiment for different values of h by adjusting the position of vertical tube. Record the data in the given table.

For Examiner's Use

Tabulation

Number of observation	h/m	V/m³	t_1/s	t_2/s	t/s	Q/m³s⁻¹

Analysis of data:

$$Q = \frac{2\pi\rho g d^4 (h)}{l\eta}$$

Plot a graph of Q against h. Graph would be a straight line through origin.

$$\text{gradient} = 2\pi\rho g d^4 / l\eta$$

$$\eta = \frac{2\pi\rho g d^4}{l \times \text{gradient}}$$

Safety Precaution:

Wear protective gloves while adjusting the glass tubes to avoid injury.

Additional Details:

1. Repeat the experiment for same value of h and take average of time.
2. Use bubble level to assure narrow tube is perfectly horizontal.
3. Determine density of water by measuring mass (by digital balance) and volume. $\rho = m/V$.
4. Keep the temperature of water constant throughout the experiment.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A student is investigating the discharge of capacitors.

A capacitor of capacitance *W* is charged by connecting it to a power supply of e.m.f. *E*. The charge is then shared with another capacitor of capacitance *C*, which is initially uncharged. A voltmeter is used to measure the maximum voltage *V* across the second capacitor, as shown in Fig. 2.1.

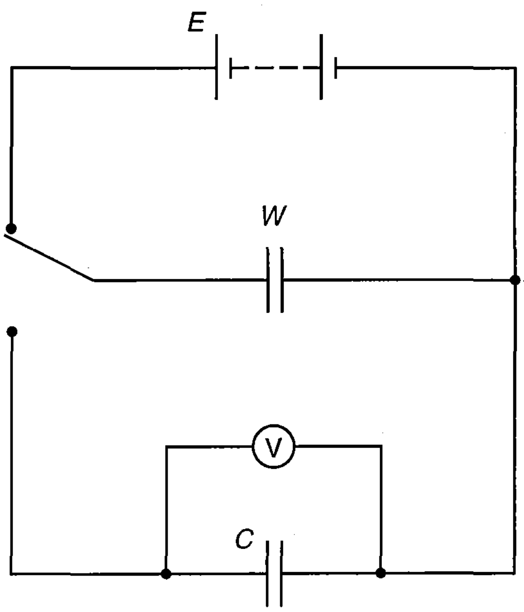


Fig. 2.1

For different values of *C*, the maximum voltage *V* is recorded.

Question 2 continues on the next page.

It is suggested that C and V are related by the equation

$$\frac{E}{V} = 1 + \frac{C}{W}.$$

For Examiner's Use

(a) A graph is plotted of $1/V$ on the y-axis against C on the x-axis. Determine expressions for the gradient and y-intercept in terms of E and W.

$$\frac{E}{V} = 1 + \frac{C}{W}$$

$$\frac{1}{V} = \frac{1}{EW}(C) + \frac{1}{E}$$

$$y = m\ x + c$$

gradient = $1/EW$

y-intercept = $1/E$

[1]

(b) Values of C and V are given in Fig. 2.2.

$C/10^{-3}$F	V/V	$\frac{1}{V}/V^{-1}$
0.69 ± 0.09	5.1	0.196
1.00 ± 0.20	4.5	0.222
1.47 ± 0.29	4.0	0.250
2.20 ± 0.44	3.3	0.303
2.67 ± 0.54	3.0	0.333
3.20 ± 0.64	2.7	0.370

Fig. 2.2

Calculate and record values of $1/V$ in Fig. 2.2. [2]

(c) **(i)** Plot a graph of $(1/V)/V^{-1}$ against $C/10^{-3}$F. Include error bars for C. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit lines:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0.364 - 0.212}{(3.1 - 0.9)10^{-3}} = 69.1$$

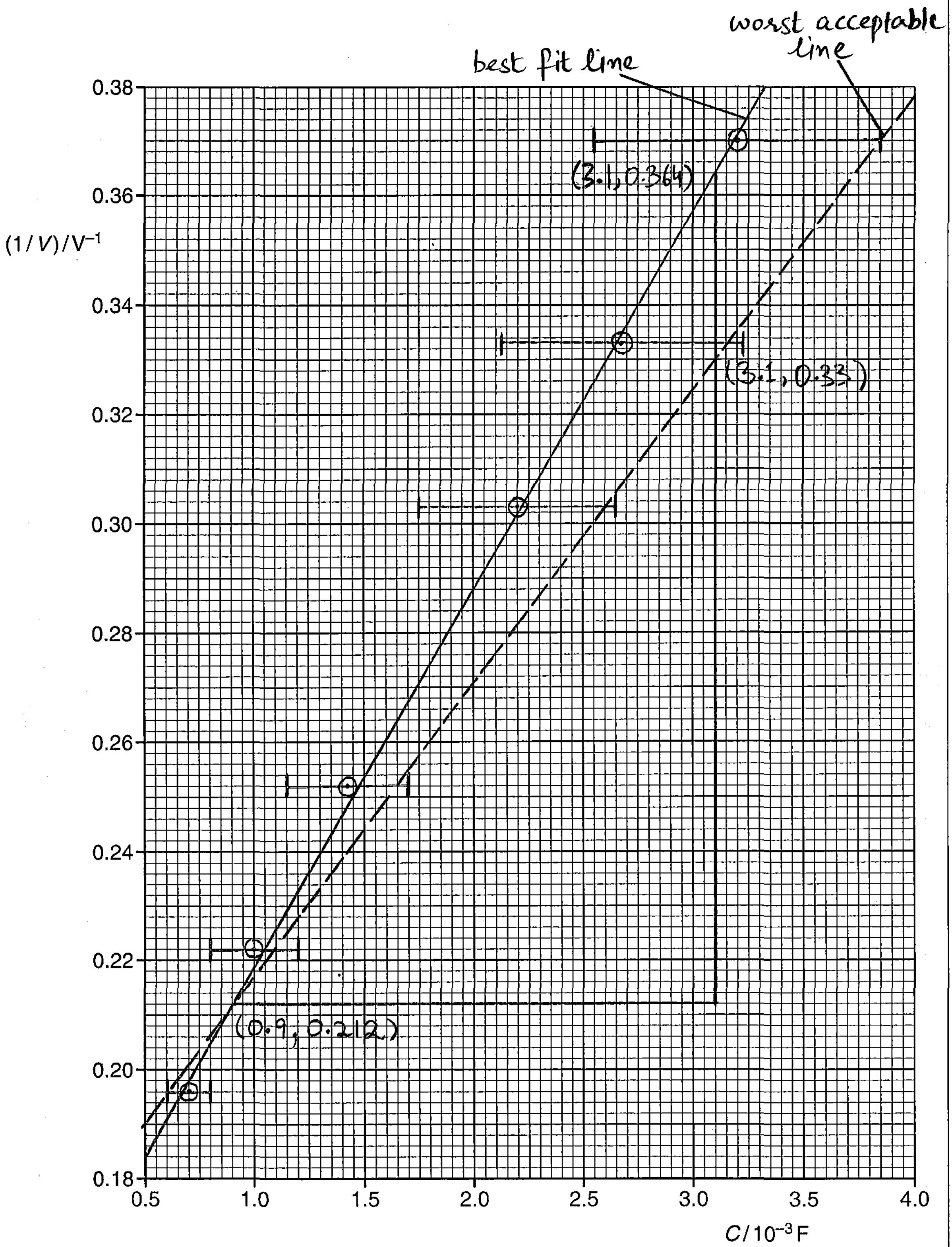
Gradient of worst acceptable line:

$$\text{gradient} = \frac{0.33 - 0.212}{(3.1 - 0.9)10^{-3}} = 53.6$$

$$\Delta\text{gradient} = 69.1 - 53.6 = 16$$

gradient = 69 ± 16 [2]

For Examiner's Use



(iv) Determine the y-intercept of the line of best fit. Include the uncertainty in your answer.

For Examiner's Use

Best fit:

$y = mx + c$

$0.364 = 69.1(3.1\times10^{-3}) + c$

$c = 0.15$

$\Delta c = 0.16 - 0.15 = 0.01$

Worst Acceptable line:

$y = mx + c$

$0.33 = 53.6(3.1\times10^{-3}) + c$

$c = 0.16$

y-intercept = 0.15 ± 0.01 [2]

(d) (i) Using your answer to **(c)(iv)**, determine a value for E. Include an appropriate unit in your answer. Include the absolute uncertainty in E.

$E = \dfrac{1}{y\text{-intercept}}$

$E = \dfrac{1}{0.15}$

$E = 6.7$

Units: $\dfrac{1}{V^{-1}} = V$

$\Delta E = \dfrac{\Delta\ y\text{-intercept}}{y\text{-intercept}} \times E$

$= \dfrac{0.01}{0.15} \times 6.67 = 0.4$

E = 6.7 ± 0.4 V [2]

(ii) Using your answers to **(c)(iii)** and **(d)(i)**, determine a value for W. Include an appropriate unit in your answer.

$\text{gradient} = \dfrac{1}{EW}$

Units: F

$W = \dfrac{1}{E \times \text{gradient}}$

$W = \dfrac{1}{6.7 \times 69} = 2.2\times10^{-3}$

W = 2.2×10^{-3} F [1]

(iii) Determine the percentage uncertainty in your value of W.

$W = \dfrac{1}{E \times \text{gradient}}$

$\dfrac{\Delta W}{W} \times 100 = \left[\dfrac{\Delta E}{E} + \dfrac{\Delta\ \text{gradient}}{\text{gradient}}\right] \times 100$

$= \left[\dfrac{0.4}{6.7} + \dfrac{16}{69}\right] \times 100$

$= 29\%$

percentage uncertainty = 29 % [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4570897825

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2013**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages.

DC (AC/JG) 61225/3

UNIVERSITY *of* CAMBRIDGE International Examinations

[Turn over

For Examiner's Use

1 A student is investigating how the peak alternating current I_0 varies with frequency f in a circuit containing a coil of wire.

It is suggested that

$$\left(\frac{V_0}{I_0}\right)^2 = R^2 + 4\pi^2 f^2 L^2$$

where R is the resistance of the coil, V_0 is the peak voltage and L is a constant.

Design a laboratory experiment to test the relationship between I_0 and f and determine a value for L. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

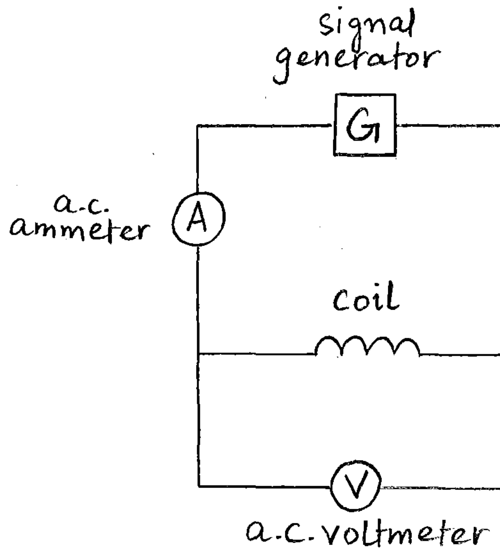
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

For Examiner's Use



Defining the problem:
Independent variable: Frequency f
Dependent variable: Peak alternating current I_o
Constant: Peak voltage V_o
Procedure:
Use signal generator to generate alternating signal of different frequencies. Read off the frequency from display of signal generator. Measure the root mean square current I_{rms} from a.c. ammeter. Calculate the value of peak alternating current I_o, using the relationship, $I_o = \sqrt{2} I_{rms}$. Use a.c. voltmeter to ensure the voltage across the coil is constant throughout the experiment. Perform the experiment for different values of

frequencies. Record the results in given table.

Tabulation:

Number of Observation	f/Hz	I_{rms}/A	I_0/A	f^2/Hz^2	$\frac{1}{I_0^2}$ / A^{-2}

Analysis of Data:

$$f^2 = \frac{V_0^2}{4\pi^2L^2}\left[\frac{1}{I_0}\right]^2 - \frac{R^2}{4\pi^2 f^2}$$

Plot a graph of f^2 against $(1/I_0)^2$. Graph would be a straight line.

$$\text{Gradient} = V_0^2/4\pi^2L^2$$

$$L = \left(\frac{V_0^2}{4\pi^2\,\text{Gradient}}\right)^{1/2}$$

Safety Precaution:

Avoid touching hot coil directly to avoid burns.

Additional detail:

1. Keep R constant by keeping the temperature constant.
2. Use low frequency alternating current to produce large current I_0
3. Adjust the signal generator to keep the value of V_0 constant.
4. Determine the value of R by using ohmeter.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 An electron beam is accelerated by a voltage V before entering a uniform electric field of electric field strength E between two parallel plates.

The electron beam travels a horizontal distance a parallel to the plates before hitting the top plate after being deflected through a vertical distance b. The path of the electrons is shown in Fig. 2.1.

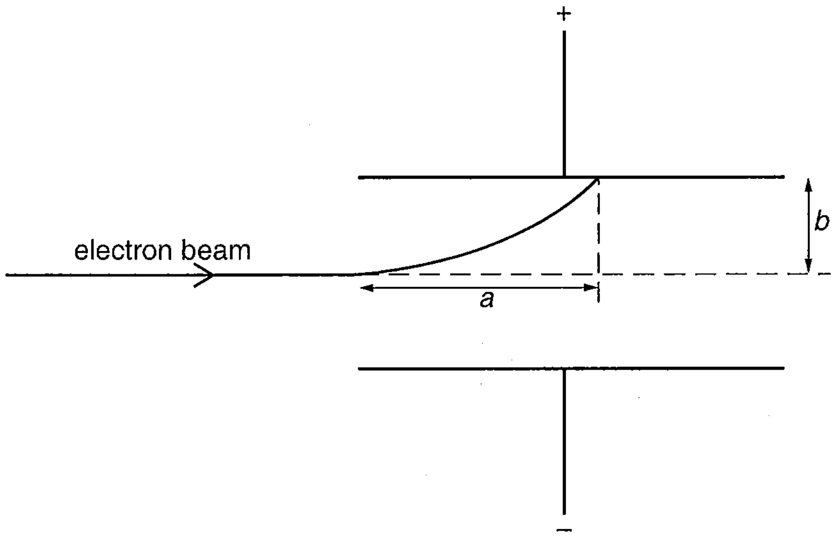


Fig. 2.1

For different values of V, the horizontal distance a is recorded.

Question 2 continues on the next page.

For Examiner's Use

It is suggested that V and a are related by the equation

$$a = \sqrt{\frac{4Vb}{E}}.$$

(a) A graph is plotted of a^2 on the y-axis against V on the x-axis. Determine an expression for the gradient in terms of E.

$$a^2 = \frac{4Vb}{E}$$

$$a^2 = \frac{4b}{E}(V)$$

gradient = $4b/E$ [1]

(b) Values of V and a are given in Fig. 2.2.

V/V	a/10^{-2}m	$a^2/10^{-4}m^2$
1000	6.6 ± 0.1	43.6 ± 1.3
1200	7.2 ± 0.1	51.8 ± 1.4
1400	7.8 ± 0.1	60.4 ± 1.6
1600	8.4 ± 0.1	70.6 ± 1.7
1800	8.9 ± 0.1	79.2 ± 1.8
2000	9.4 ± 0.1	88.4 ± 1.9

Fig. 2.2

Calculate and record values of $a^2/10^{-4}m^2$ in Fig. 2.2. Include the absolute uncertainties in a^2. [3]

(c) **(i)** Plot a graph of $a^2/10^{-4}m^2$ against V/V. Include error bars for a^2. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

Gradient of Best fit line:

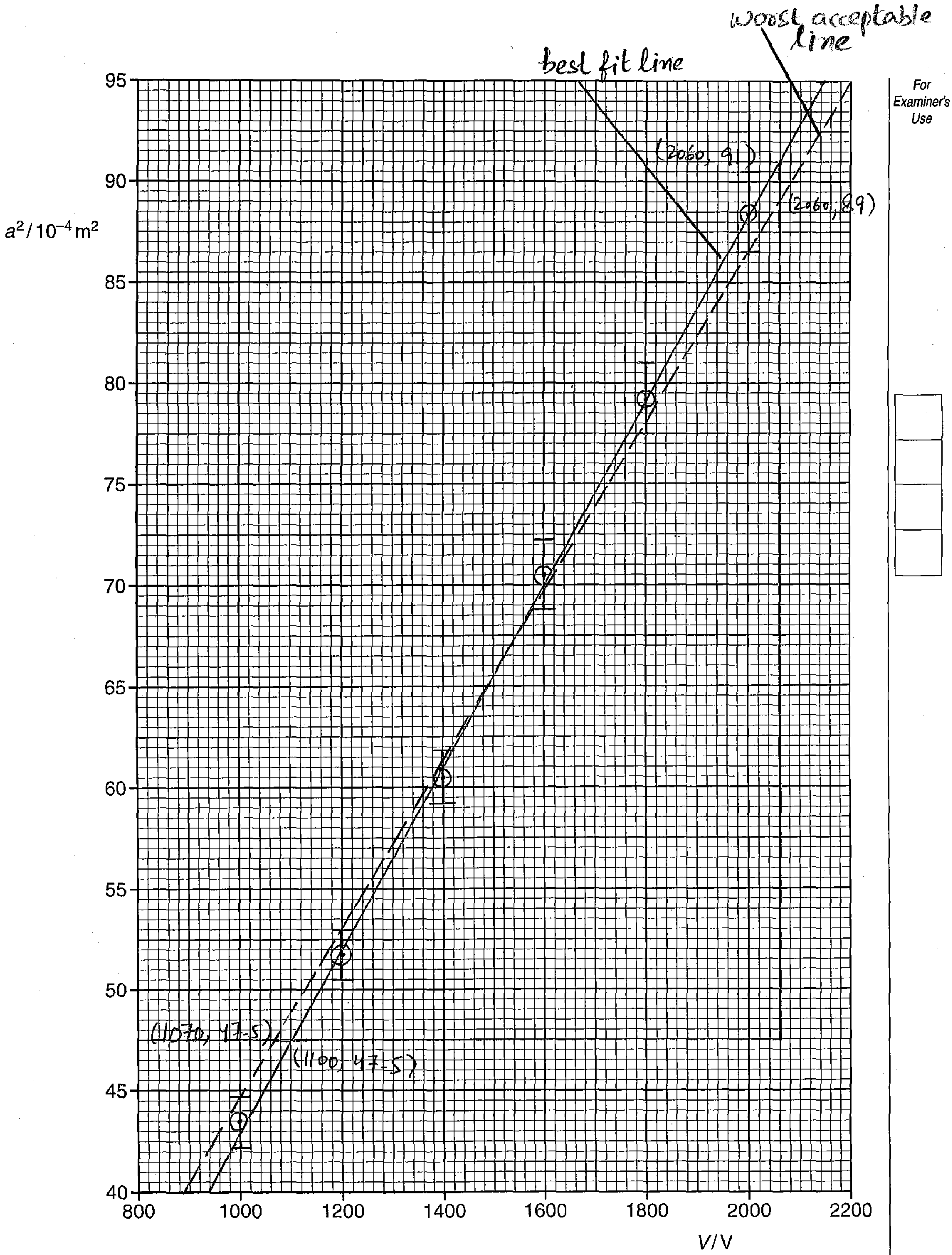
$$\text{gradient} = \frac{(91-47.5)10^{-4}}{2060-1100} = 4.53 \times 10^{-6}$$

Gradient of worst acceptable line:

$$\text{grad} = \frac{(89-47.5)10^{-4}}{2060-1070} = 4.19 \times 10^{-6}$$

$$\Delta\,\text{gradient} = (4.53-4.19)10^{-6} = 0.3 \times 10^{-6}$$

gradient = $(4.5 \pm 0.3) \times 10^{-6}$ [2]



For Examiner's Use

(d) (i) Using your answer to **(c)(iii)**, determine a value for E. Include an appropriate unit in your answer.

For Examiner's Use

Data: $b = (4.0 \pm 0.1) \times 10^{-2}$ m

$$\frac{4b}{E} = \text{gradient}$$

$$E = 4b/\text{gradient}$$

$$E = 4(4\times10^{-2})/4.5\times10^{-6}$$

$$\text{Units: } \frac{Vm}{m^2} = Vm^{-1}$$

$$\frac{\Delta E}{E} = \frac{\Delta b}{b} + \frac{\Delta \text{gradient}}{\text{gradient}}$$

$$\frac{\Delta E}{3.56\times10^4} = \frac{0.1}{4} + \frac{0.3}{4.5}$$

$$\Delta E =$$

$E =$ $(3.6 \pm 0.3)10^4\, Vm^{-1}$ [2]

(ii) Determine the percentage uncertainty in your value of E.

$$\frac{\Delta E}{E} \times 100 = \frac{0.3}{3.6} \times 100 = 8.3\%$$

percentage uncertainty = 8.3 % [1]

(e) Using your answers to **(d)**, determine a value for V to give a distance $a = 5.0 \pm 0.1$ cm. Include the absolute uncertainty in your answer.

$$a^2 = \frac{4Vb}{E}$$

$$V = \frac{a^2E}{4b}$$

$$V = \frac{(5\times10^{-2})^2 \times 3.6\times10^4}{4\times4\times10^{-2}}$$

$$V = 560V$$

$$\frac{\Delta V}{V} = \frac{2\Delta a}{a} + \frac{\Delta E}{E} + \frac{\Delta b}{b}$$

$$\frac{\Delta V}{560} = 2\left[\frac{0.1}{5}\right] + \frac{0.3}{3.6} + \frac{0.1}{4.0}$$

$$\Delta V = 80V$$

$V =$ 560 ± 80 V [2]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2013**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
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At the end of the examination, fasten all your work securely together.
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This document consists of **8** printed pages.

DC (KN/CGW) 64672/2

UNIVERSITY *of* CAMBRIDGE
International Examinations

[Turn over

For Examiner's Use

1 An aluminium ring is placed on a coil with the rod of a metal retort stand passing through their centres, as shown in Fig. 1.1.

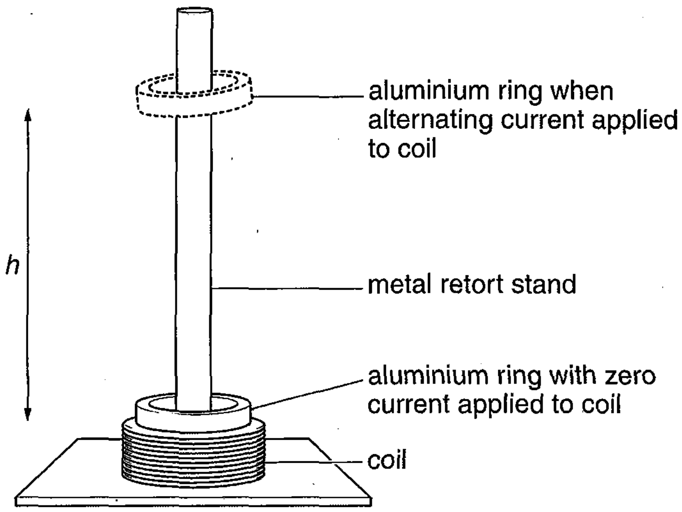


Fig. 1.1

When an alternating current of frequency f is applied to the coil, the ring rises until it is in equilibrium at a height h above the coil.

It is suggested that the relationship between h and f is

$$h = kf^n$$

where k and n are constants.

Design a laboratory experiment to test the relationship between h and f and determine values for k and n. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

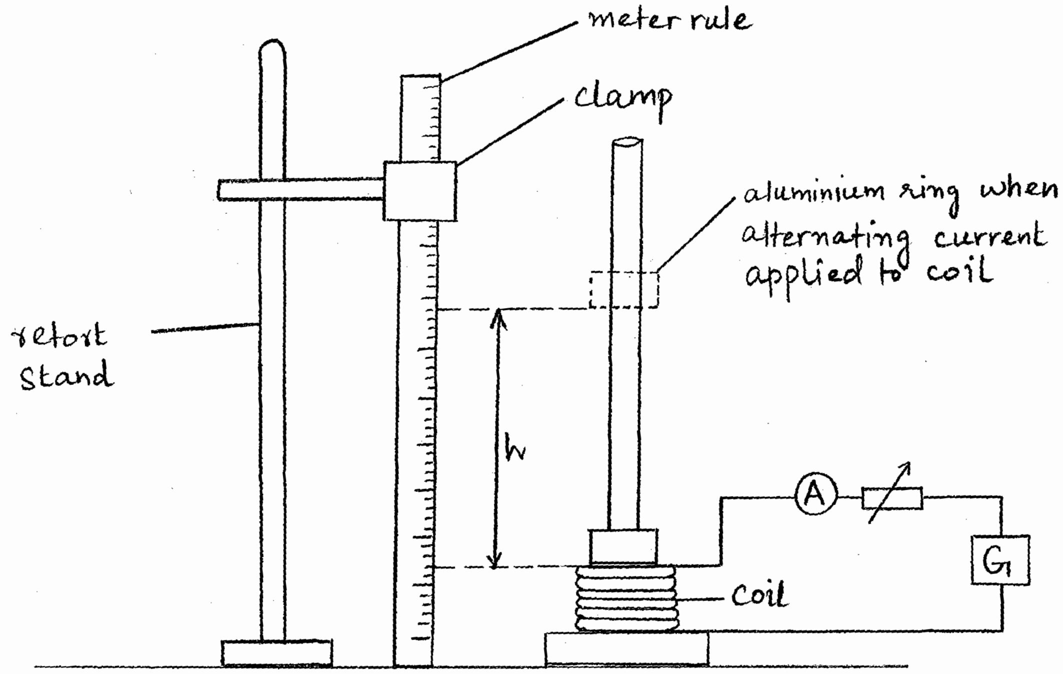
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

For Examiner's Use

Diagram



Defining the problem:

Independent variable: Frequency f.

Dependent variable: Height h.

Constant: Root mean square current in coil.

Procedure:

Measure the frequency of alternating current in coil from signal generator. Set meter rule vertically to measure height h with the help of retort stand. Measure height h using meter rule. For the same value of frequency, measure h from opposite sides of ring and take average. Use rheostat and a.c. ammeter to ensure root mean square current in the coil is constant. Vary

For Examiner's Use

frequency f from signal generator. Perform the experiment for different values of frequency.

Tabulation:

Number of Observation	f/Hz	h_1/m	h_2/m	h/m	$lg(f/Hz)$	$lg(h/m)$

Analysis of data:

$$h = kf^n$$

$$lg\, h = n\, lg f + lg\, k$$

Plot a graph of lg h against lg f. A graph would be a straight line with gradient, n

n = gradient $lg\, k$ = y-intercept

$k = 10^{y\text{-intercept}}$.

Safety Precaution:

Wear safety gloves to prevent burns from hot coil.

Additional details:

1- Use large current and more number of turns to get large value of h.

2. Avoid parallax error while measuring the value of h.

3. Use set square to check meter rule is exactly vertical.

4 Use insulated wire for coil to avoid short circuit.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A student is investigating resonance of the air column in a tube using the apparatus shown in Fig. 2.1.

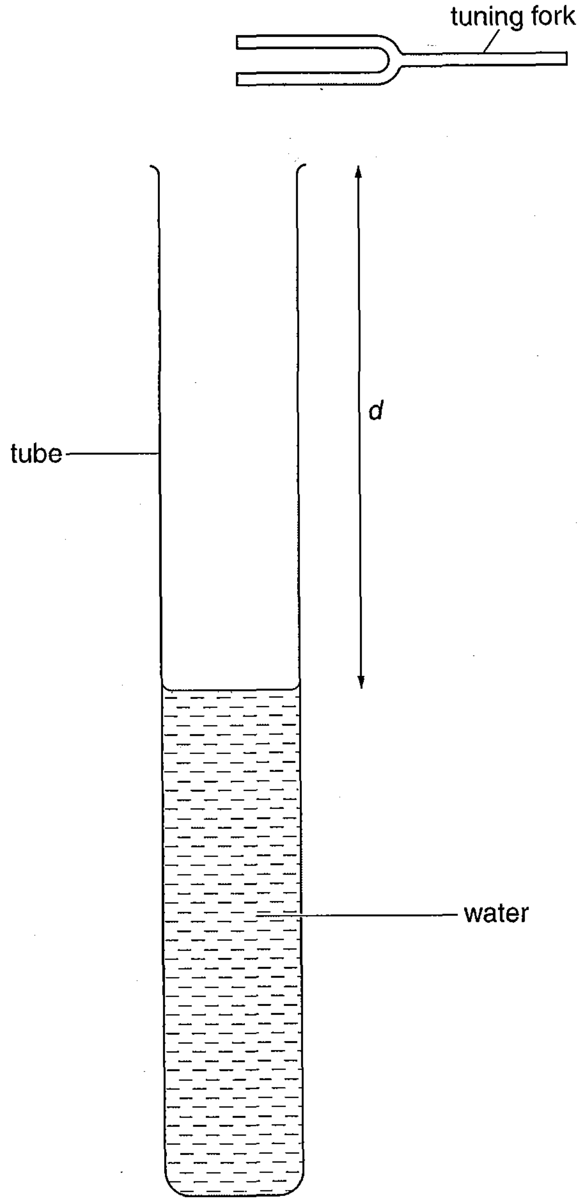


Fig. 2.1

For different tuning forks, the water level is adjusted until resonance occurs. For each tuning fork, the frequency f and distance d are recorded.

Question 2 continues on the next page.

For Examiner's Use

It is suggested that f and d are related by the equation

$$4(d+k) = \frac{v}{f}$$

where v is the speed of sound in air and k is a constant.

(a) A graph is plotted of d on the y-axis against $\frac{1}{f}$ on the x-axis. Determine expressions for the gradient and y-intercept in terms of k and v.

$$4d + 4k = \frac{v}{f}$$

$$d = \frac{v}{4}\left(\frac{1}{f}\right) - k$$

gradient = $v/4$

y-intercept = $-k$ [1]

(b) Values of f and d are given in Fig. 2.2.

f/Hz	d/cm	$\frac{1}{f}/10^{-3}$ s
320	24.5 ± 0.5	3.13
340	23.0 ± 0.5	2.94
378	20.5 ± 0.5	2.65
428	18.0 ± 0.5	2.34
480	16.0 ± 0.5	2.08
512	15.0 ± 0.5	1.95

Fig. 2.2

Calculate and record values of $\frac{1}{f}/10^{-3}$ s in Fig. 2.2. [2]

(c) **(i)** Plot a graph of d/cm against $\frac{1}{f}/10^{-3}$ s. Include error bars for d. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

Gradient of best fit line:

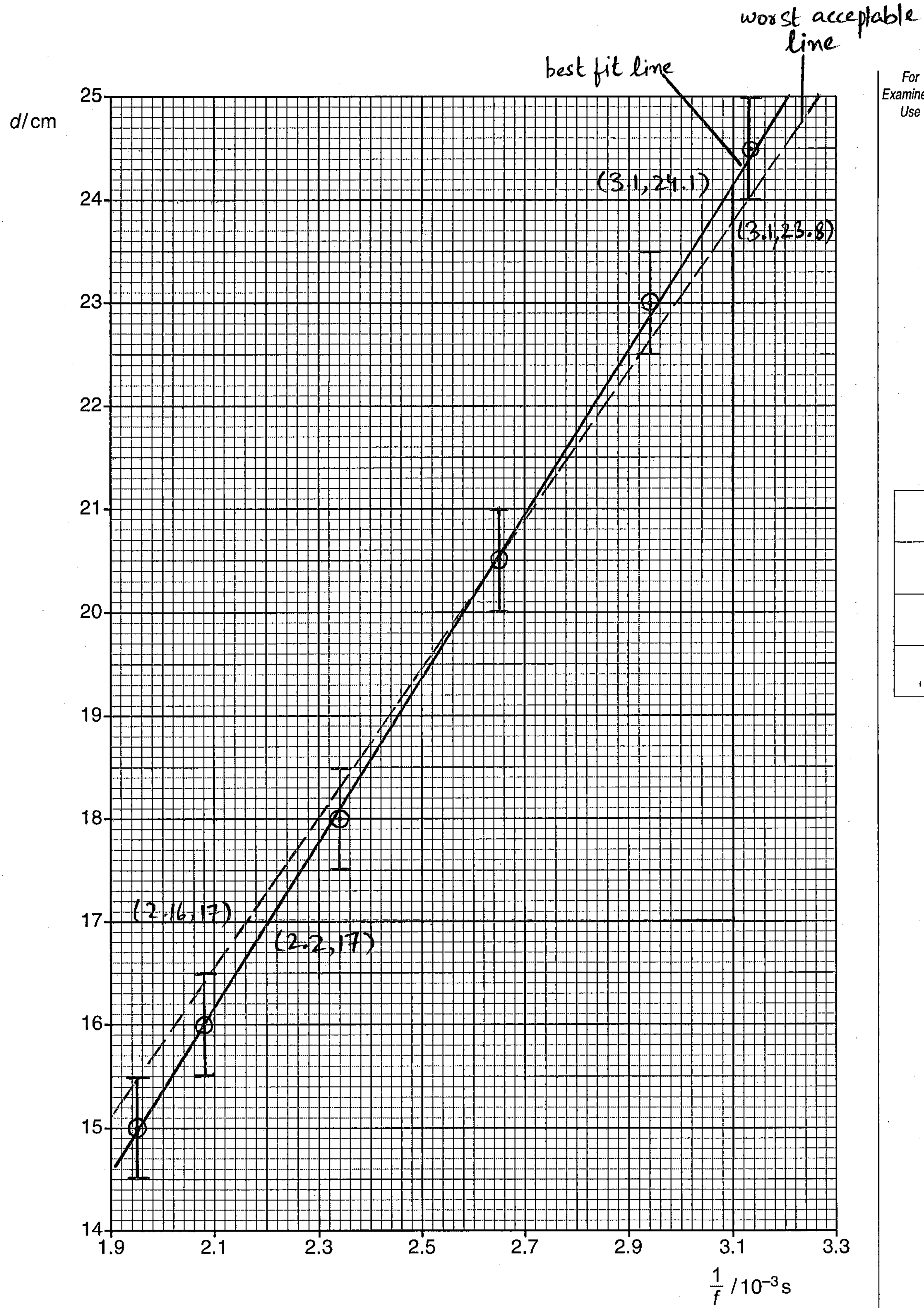
$$\text{gradient} = \frac{24.1 - 17}{(3.1 - 2.2)10^{-3}} = 7889$$

Gradient of worst acceptable line:

$$\text{gradient} = \frac{23.8 - 17}{(3.1 - 2.16)10^{-3}} = 7234$$

$$\Delta \text{gradient} = 7889 - 7234 = 655 \simeq 700$$

gradient = 7900 ± 700 [2]



For Examiner's Use

For Examiner's Use

(iv) Determine the *y*-intercept of the line of best fit. Include the uncertainty in your answer.

From best fit line:

$y = mx + c$

$24.1 = 7889(3.1\times10^{-3}) + c$

$c = -0.36$

From worst acceptable line:

$23.8 = 7234(3.1\times10^{-3}) + c$

$c = 1.37$

$\Delta c = 1.37 - (-0.36) = 1.73$

y-intercept = -0.36 ± 1.73 [2]

(d) Using your answers to **(c)(iii)** and **(c)(iv)**, determine values for *k* and *v*. Include appropriate units in your answers. Include the absolute uncertainties in *k* and *v*.

$K = -\text{y-intercept}$

$K = -(-0.36)$

$K = 0.36$ units: cm

$\Delta K = \Delta\text{y-intercept}$

$= \pm 1.73$

$V = 4 \times \text{gradient}$

$V = 4 \times \frac{7889}{100} = 315\ ms^{-1}$

$\Delta V = 4\Delta\,\text{grad} = 7 \times 4 = 21$

k = 0.36 ± 1.73 cm

v = $315 \pm 21\ ms^{-1}$

[2]

(e) **(i)** The experiment is repeated with a tuning fork of unknown frequency. The distance *d* is measured as 31.0 ± 0.5 cm. Determine the frequency of the tuning fork.

$d = \text{Gradient}\left[\frac{1}{f}\right] - K$

$f = \frac{\text{Gradient}}{d+K}$

$= \frac{7889}{31+0.36} = 252\ Hz$

f = 252 Hz [1]

(ii) Determine the percentage uncertainty in your value of *f*.

$\frac{\Delta f}{f} \times 100 = \left[\frac{\Delta\text{Gradient}}{\text{Gradient}} + \frac{\Delta(d+K)}{d+K}\right] \times 100$

$= \left[\frac{700}{7900} + \frac{(0.5+1.73)}{31.0+0.36}\right] \times 100$

$= 16\%$

percentage uncertainty = 16 % [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2013**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

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UNIVERSITY *of* CAMBRIDGE
International Examinations

[Turn over

For Examiner's Use

1 A student is investigating how the resistance R of nichrome in the form of a wire varies with temperature θ.

It is suggested that

$$R = R_0(1 + \alpha\theta)$$

where R_0 is the resistance at 0 °C, α is a constant and θ is the temperature measured in °C.

Design a laboratory experiment to test the relationship between θ and R and determine the value of α. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

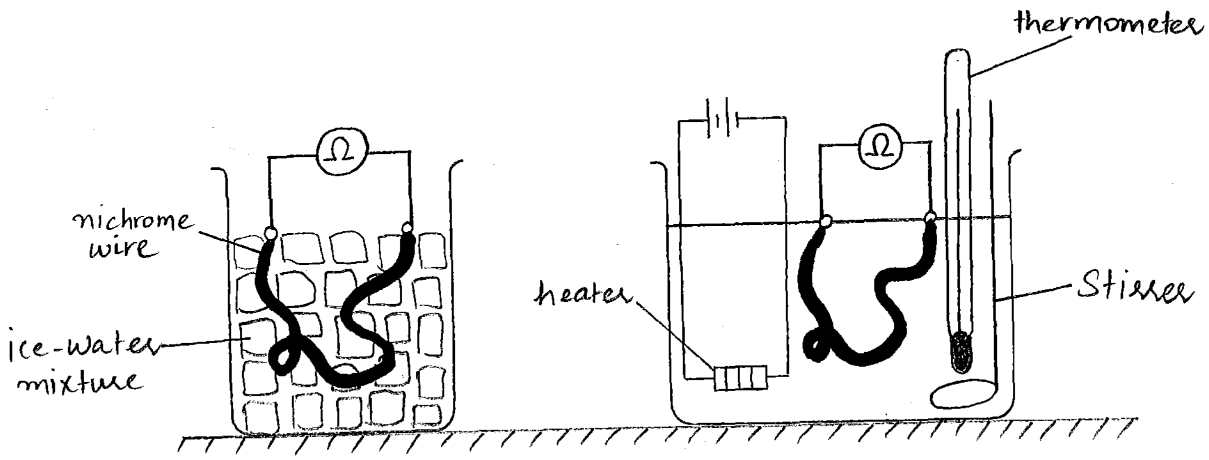
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

For Examiner's Use



Defining the problem:
Independent variable: Temperature θ
Dependent variable: Resistance R of nichrome wire
Constant: Length and cross-sectional area of wire.

Procedure:
Heat the water in a container using heater. Stir the water continuously to maintain thermal equilibrium. Measure the temperature θ from thermometer. Measure the corresponding value of resistance R of nichrome wire from ohmeter. Similarly, measure the resistance R of nichrome wire at different temperatures. Now place the nichrome wire in ice-water

mixture. Measure the resistance R_0 at $0°C$.
Record the data in a given table.

Tabulation:-

Number of Observation	$\theta / °C$	R_1/Ω	R_2/Ω	R/Ω

Analysis of data:- $R = \alpha R_0(\theta) + R_0$
Plot a graph of R against θ. Graph would be a straight line with gradient, αR_0 and y-intercept, R_0.

gradient = αR_0

α = gradient/R_0

Safety precaution:
Wear gloves to prevent injury from hot water and use goggles to prevent splashes from hot water.

Additional details:
1- Use long and thin wire to increase its resistance.
2 Use insulated wires and connector.
3- Use thermocouple to measure quick temperature changes accurately.
4- Wait for temperature to stabilise.
5- Use water bath to set temperature instead of heater.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

For Examiner's Use

2 A student is investigating the stopping distance for a motorcycle with high-performance brakes. A motorcyclist riding and stopping a motorcycle on a test track is recorded on film.

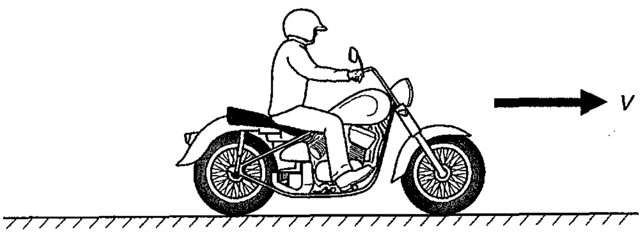


Fig. 2.1

The stopping distance d is measured for different speeds v.

Question 2 continues on the next page.

It is suggested that v and d are related by the equation

$$d = \frac{v^2}{2a} + vt$$

where a is the deceleration of the motorcycle and t is the thinking time of the rider.

(a) A graph is plotted of $\frac{d}{v}$ on the y-axis against v on the x-axis. Determine expressions for the gradient and y-intercept in terms of a and t.

gradient = 1/2a

y-intercept = t

[1]

(b) Values of v and d are given in Fig. 2.2.

v/m s^{-1}	d/m	(d/v)/s
10 ± 1	13.0 ± 0.5	1.30 ± 0.18
15 ± 1	24.5 ± 0.5	1.63 ± 0.14
20 ± 1	39.5 ± 0.5	1.98 ± 0.12
25 ± 1	57.5 ± 0.5	2.30 ± 0.11
30 ± 1	79.0 ± 0.5	2.63 ± 0.10
35 ± 1	103.0 ± 0.5	2.94 ± 0.09

Fig. 2.2

Calculate and record values of $\frac{d}{v}$/s in Fig. 2.2. Include the absolute uncertainties in $\frac{d}{v}$. [3]

(c) (i) Plot a graph of $\frac{d}{v}$/s against v/m s^{-1}. Include error bars for $\frac{d}{v}$. Do **not** include horizontal error bars for v. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

Gradient of best fit line:

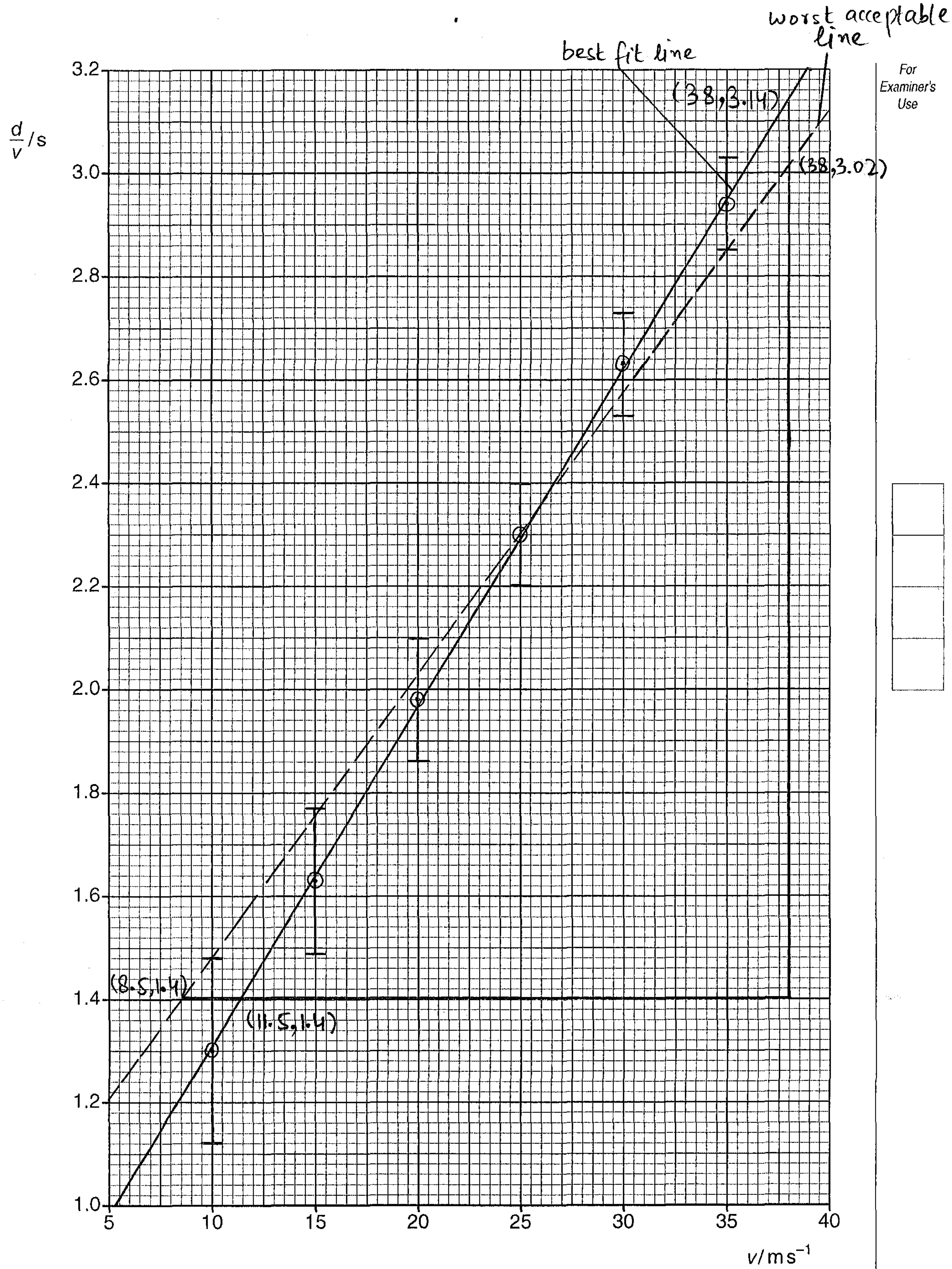
$$\text{gradient} = \frac{(3.14 - 1.4)}{38 - 11.5} = 0.066$$

Gradient of worst acceptable line:

$$\text{gradient} = \frac{3.02 - 1.4}{38 - 8.5} = 0.055$$

$$\Delta\,\text{gradient} = 0.066 - 0.055 = 0.011$$

gradient = 0.066 ± 0.011 [2]



For Examiner's Use

(iv) Determine the y-intercept of the line of best fit. Include the uncertainty in your answer.

For Examiner's Use

y-intercept of best fit line:

$y = mx + c$

$1.2 = 0.066(8.5) + c$

$c = 0.64$

y-intercept of worst acceptable line:

$y = mx + c$

$1.4 = 0.055(8.5) + c$

$c = 0.93$

$\Delta c = 0.93 - 0.64 = 0.29$

y-intercept = 0.64 ± 0.29 [2]

(d) (i) Using your answers to **(c)(iii)** and **(c)(iv)**, determine values for a and t. Include an appropriate unit for each value.

$\text{gradient} = \frac{1}{2a}$

$a = \frac{1}{2 \times \text{gradient}}$

$a = \frac{1}{2 \times 0.066}$

$a = 7.6$

Units: $\frac{1}{s/ms^{-1/2}} = ms^{-2}$

$t = \text{y-intercept}$

$t = 0.64$

Units: s

a = 7.6 ms^{-2}

t = 0.64 s

[2]

(ii) Using your answers to **(c)(iii)** and **(c)(iv)**, determine the percentage uncertainty in a and t.

$a = \frac{1}{2 \times \text{gradient}}$

$\frac{\Delta a}{a} \times 100 = \frac{\Delta \text{gradient}}{\text{gradient}} \times 100$

$= \frac{0.011}{0.066} \times 100$

$= 17\%$

$t = \text{y-intercept}$

$\frac{\Delta t}{t} \times 100 = \frac{\Delta \text{y-intercept}}{\text{y-intercept}} \times 100$

$= \frac{0.29}{0.64} \times 100 = 45\%$

percentage uncertainty in a = 17 %

percentage uncertainty in t = 45 %

[1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9154682361

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2012**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
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Answer **all** questions.
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[Turn over

1 A fairground ride carries passengers in chairs which are attached by metal rods to a rotating central pole, as shown in Fig 1.1. When the pole rotates with angular velocity ω, the rods make an angle θ to the vertical.

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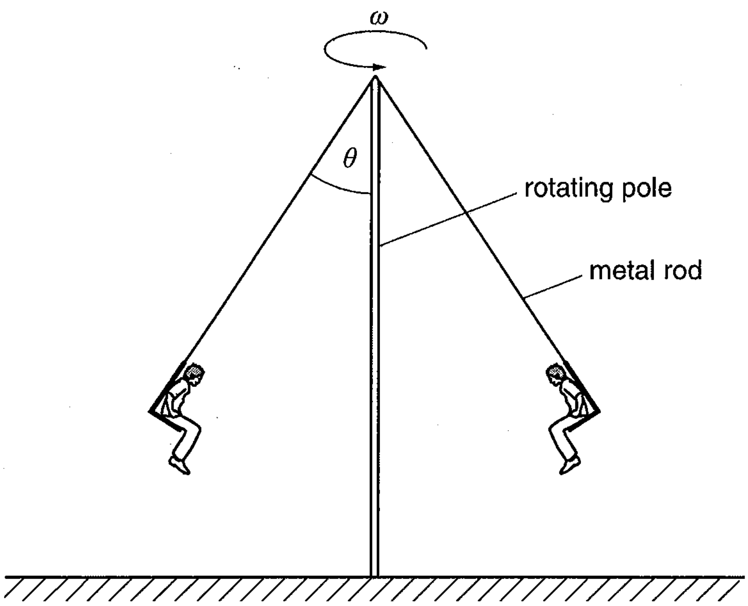

Fig 1.1

It is suggested that $\cos\theta$ is inversely proportional to ω^2.

Design a laboratory experiment, using a small object to represent an occupied chair, to test the relationship between θ and ω. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

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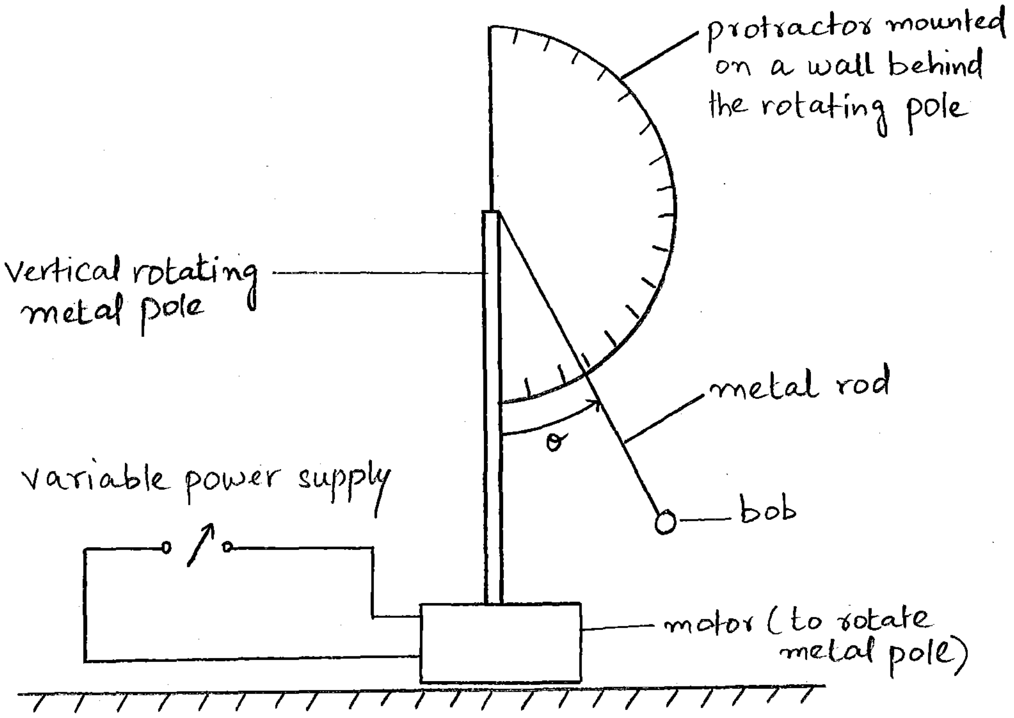

Defining the problem:
Independent Variable: Angular frequency ω
Dependent variable: Angle θ
Constant: Mass of bob, length of metal rod.
Procedure:
Use fiducial mark on floor and observe the motion of bob from top. For certain speed, measure time t for 20 complete rotations of bob with stopwatch. Calculate the time period T for one complete rotation, using the relationship, $T = t/20$. Calculate angular frequency ω by using relationship $\omega = 2\pi/T$. Measure angle θ from the protractor mounted on the wall. Vary the speed of motor by adjusting the variable

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power supply to change ω. Perform the experiment for five more different values of ω.

Tabulation:

Number of Observation	t_1/s	t_2/s	t/s	T/s	ω/rads^{-1}	θ/°	cosθ	$\frac{1}{\omega^2}$/s^2rad^{-2}

Analysis of data:

Plot a graph of cos θ against $1/\omega^2$. The relationship between cos θ and ω^2 is valid if graph is a straight line through origin. ($\cos\theta \propto 1/\omega^2$)

Safety Precaution:

Use a protective screen to avoid injury in case bob detaches from the rotating pole.

Additional Details:

1- Use high-speed motor to produce large value of θ.

2. Use slow motion video to observe the rotational motion of bob.

3. Wait for motion to become stable before measuring the value of θ.

4. Use set square to ensure vertical pole is perfectly in vertical position.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

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2 A current-carrying wire is clamped at each end, as shown in Fig 2.1. A student investigates how the deflection y at the centre of the wire varies with the current I.

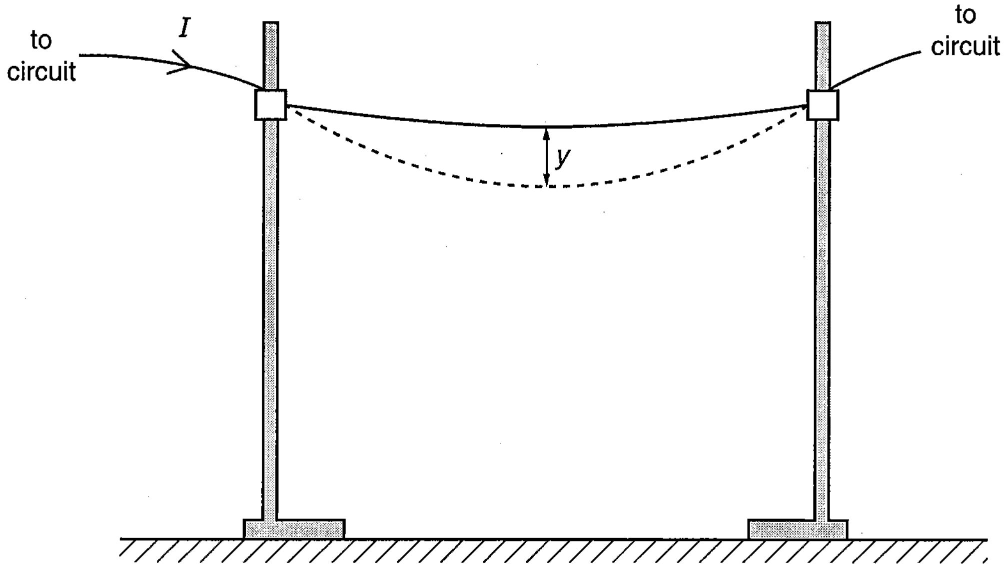

Fig. 2.1

For different currents, the deflection is recorded.

Question 2 continues on the next page.

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It is suggested that y and I are related by the equation

$$y = sI^r$$

where r and s are constants.

(a) A graph is plotted of lg y on the y-axis against lg I on the x-axis. Determine expressions for the gradient and y-intercept in terms of r and s.

$y = sI^r$

$\lg y = r \lg I + \lg s$

$y = mx + c$

gradient = r

y-intercept = $\lg s$ [1]

(b) Values of I and y are given in Fig. 2.2.

$I/10^{-2}$ A	y/mm	lg ($I/10^{-2}$ A)	lg (y/mm)
50	2.6 ± 0.2	1.699	0.415 ± 0.033
60	3.4 ± 0.2	1.778	0.531 ± 0.026
70	4.4 ± 0.2	1.845	0.643 ± 0.020
80	5.4 ± 0.2	1.903	0.732 ± 0.016
90	6.6 ± 0.2	1.954	0.820 ± 0.013
95	7.2 ± 0.2	1.978	0.857 ± 0.012

Fig. 2.2

Calculate and record values of lg ($I/10^{-2}$ A) and lg (y/mm) in Fig. 2.2. Include the absolute uncertainties in lg (y/mm). [3]

(c) **(i)** Plot a graph of lg (y/mm) against lg ($I/10^{-2}$ A). Include error bars for lg (y/mm). [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

Gradient of Best fit line:

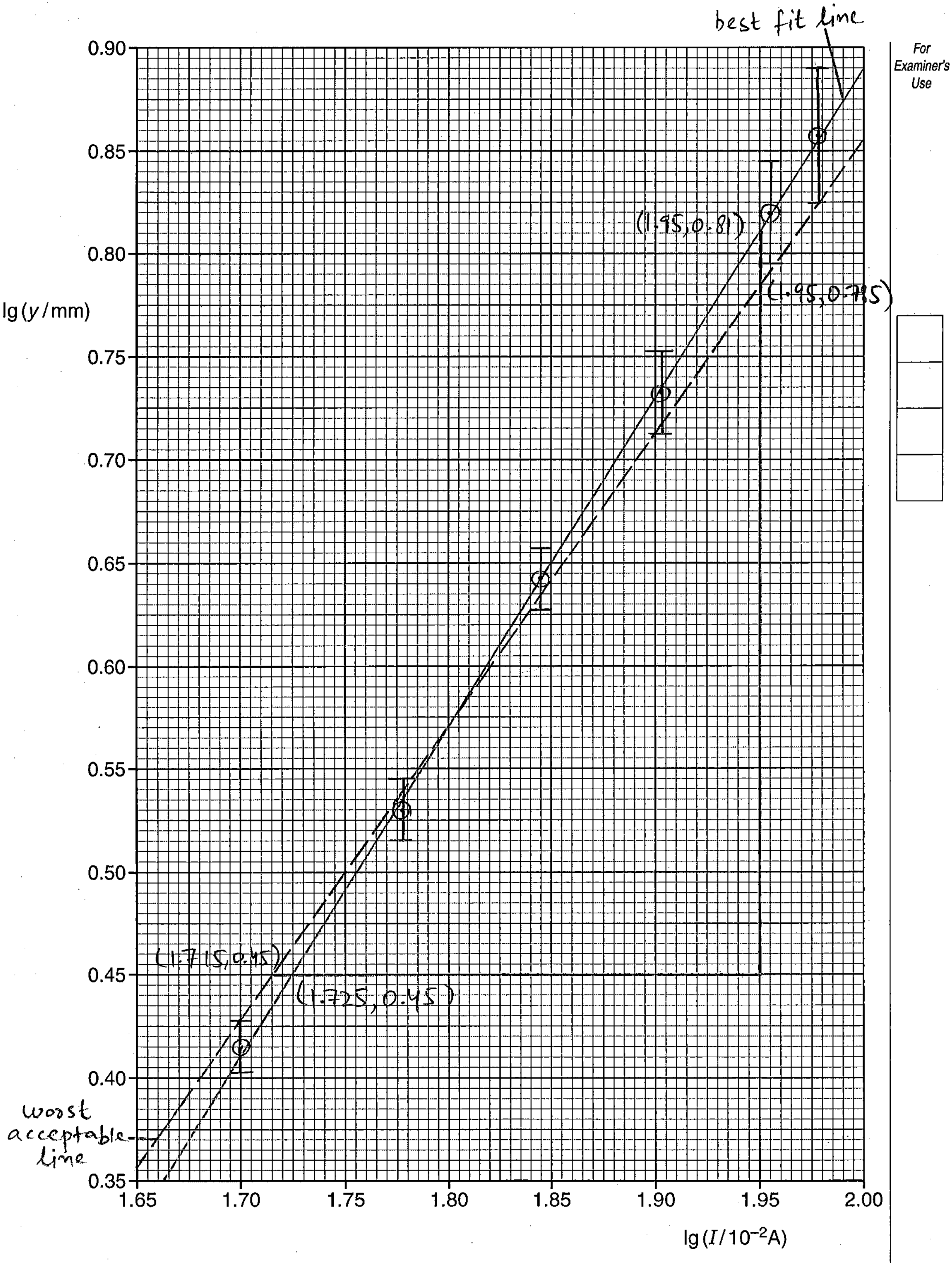
$$\text{gradient} = \frac{0.81 - 0.45}{1.95 - 1.725} = 1.6$$

Gradient of worst acceptable line:

$$\text{gradient} = \frac{0.785 - 0.45}{1.95 - 1.715} = 1.4$$

Δ gradient $= 1.6 - 1.4 = 0.2$

gradient = 1.6 ± 0.2 [2]


best fit line
For Examiner's Use
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
lg (y / mm)
(1.95, 0.81)
(1.95, 0.785)
(1.715, 0.45)
(1.725, 0.45)
worst acceptable line
1.65
1.70
1.75
1.80
1.85
1.90
1.95
2.00
lg (I / 10^-2 A)

(iv) Determine the y-intercept of the line of best fit. Include the uncertainty in your answer.

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From best fit line

$y = mx + c$

$0.45 = 1.6(1.725) + c$

$c = -2.31$

From worst acceptable line:

$y = mx + c$

$0.45 = 1.4(1.715) + c$

$c = -1.95$

$\Delta c = 2.31 - 1.95 = 0.4$

y-intercept = -2.3 ± 0.4 [2]

(d) Using your answers to **(c)(iii)** and **(c)(iv)**, determine values for r and s. Include the uncertainties in your answers. You need not be concerned with the units of r and s.

r = gradient

$= 1.6$

Δr = Δ gradient

$= 0.2$

$\lg s$ = y-intercept

$s = 10^{y\text{-intercept}}$.

r = 1.6 ± 0.2

s = $(5 \pm 6) \times 10^{-3}$ [3]

From best fit line,

$s = 10^{-2.31}$

$s = 4.9 \times 10^{-3}$

From worst acceptable line:

$s = 10^{-1.95}$

$s = 11 \times 10^{-3}$

$\Delta s = [11 - 4.9] \times 10^{-3} = 6.1 \times 10^{-3}$

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8256494037

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2012**

1 hour 15 minutes

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1 A hot air balloon is tied to the ground using a rope. As the wind blows with speed v, the rope makes an angle θ to the horizontal, as shown in Fig 1.1.

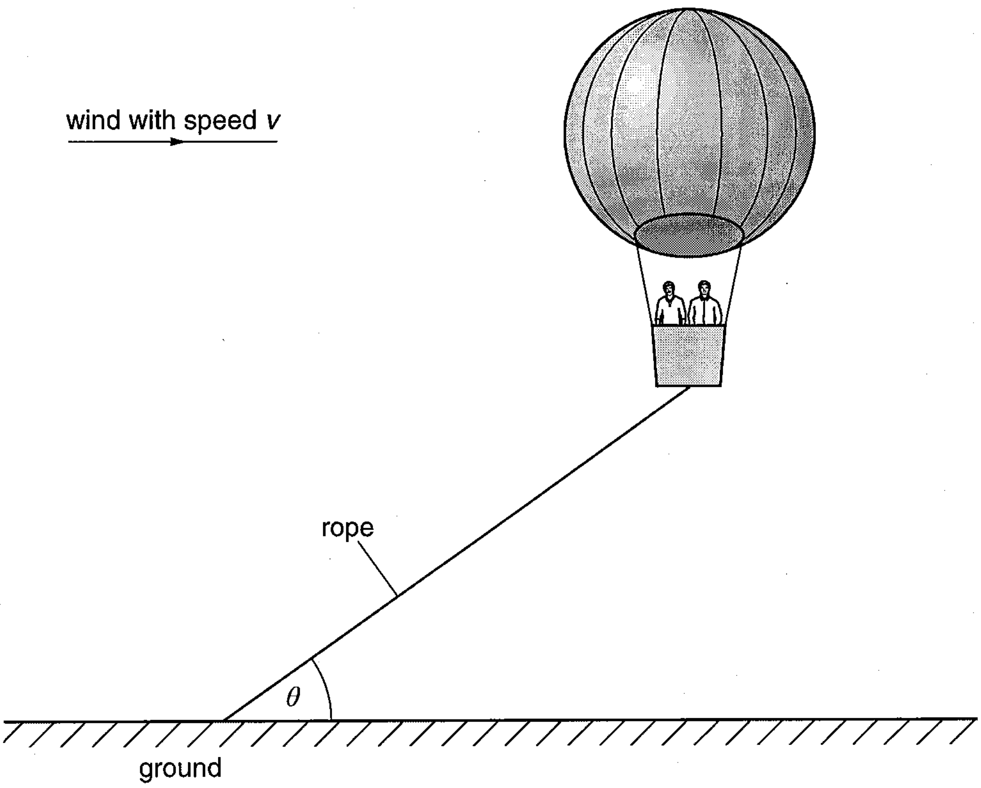

Fig 1.1

It is suggested that $\tan\theta$ is inversely proportional to v^2.

To model the hot air balloon in the laboratory, a balloon filled with helium is used. Design a laboratory experiment using a small helium-filled balloon to test the relationship between θ and v. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

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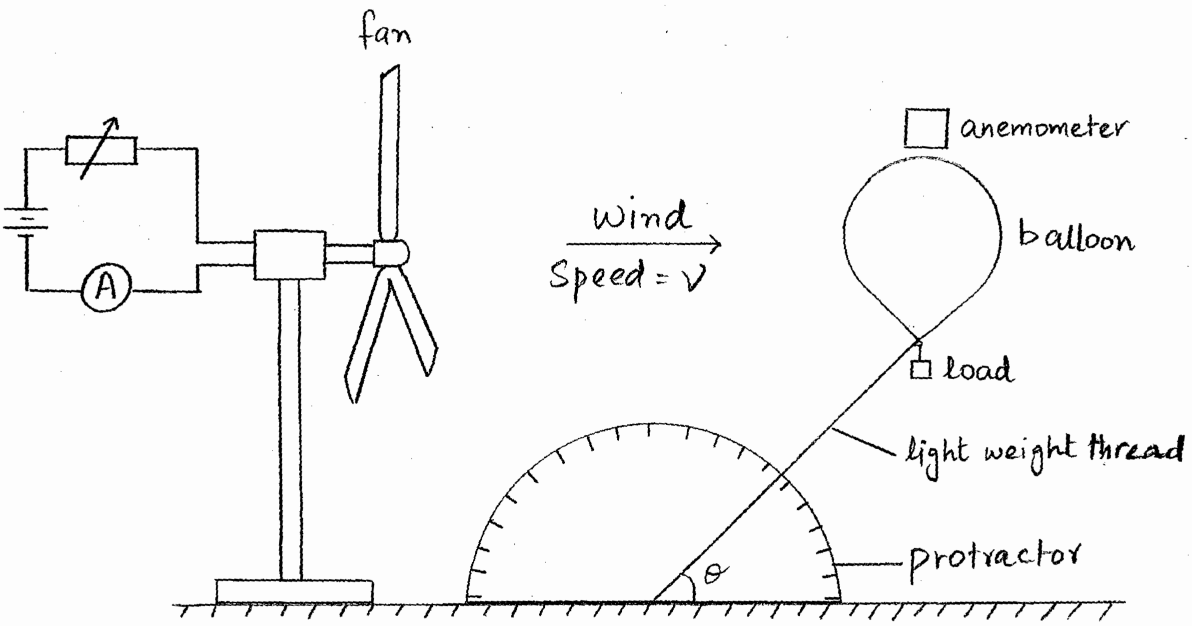

Defining the problem:
Independent variable: Wind speed v.
Dependent variable: Angle θ
Constant: Size and shape of balloon
Procedure:
Switch on the fan and wait till the balloon get stable. Measure the speed of wind using anemometer. Measure angle θ from large protractor. Vary the speed of wind by adjusting the resistance of rheostat. Perform the experiment for five different values of v. Suspend mass with the balloon to increase its stability. Record the data in the given table.

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Tabulation:

Number of observation	v / ms^{-1}	$\theta / °$	$\frac{1}{v^2} / s^2m^{-2}$	$\tan\theta$

Analysis of data:
Plot a graph of $\tan\theta$ against $1/v^2$.
The given relationship is valid if graph is a straight line through origin

Safety Precaution:
Stay away from the blades of fan to prevent any injury

Additional Details:
1- Use high-speed fan to produce measurable deflection
2- Measure wind speed exactly at a point where the balloon is positioned
3. Switch off the air conditioners and fans and keep the windows shut to avoid draughts.
4. Adjust the height of fan so that air flow is horizontally alligned to the balloon
5. Wait for balloon to become stable.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A student investigates how the resonant length L of a loaded wire varies with frequency f.

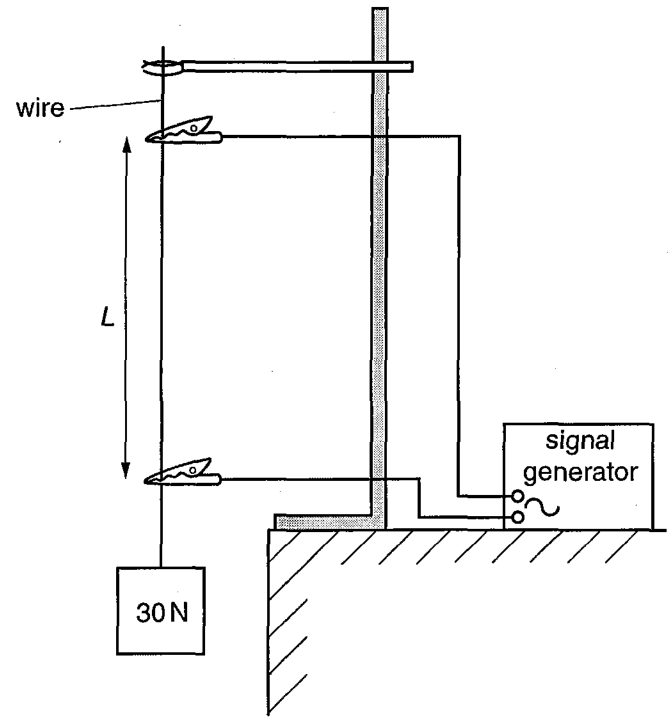

Fig. 2.1

For six different frequencies, the student records the length L.

Question 2 continues on the next page.

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It is suggested that f and L are related by the equation

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

where T is the tension in the wire and μ is a constant.

(a) A graph is plotted of f on the y-axis against $1/L$ on the x-axis. Determine an expression for the gradient in terms of T and μ.

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

$$f = \frac{1}{2}\sqrt{\frac{T}{\mu}}\left[\frac{1}{L}\right]$$

gradient = $\frac{1}{2}\sqrt{\frac{T}{\mu}}$ [1]

(b) Values of f and L are given in Fig. 2.2.

f/Hz	$L/10^{-2}$m	$(1/L)/\text{m}^{-1}$
256	54.5 ± 0.5	1.84 ± 0.02
294	48.0 ± 0.5	2.08 ± 0.02
330	42.5 ± 0.5	2.35 ± 0.03
350	40.0 ± 0.5	2.50 ± 0.03
396	35.5 ± 0.5	2.82 ± 0.04
440	32.0 ± 0.5	3.13 ± 0.05

Fig. 2.2

Calculate and record values of $(1/L)/\text{m}^{-1}$ in Fig. 2.2. Include the absolute uncertainties in $1/L$. [3]

(c) (i) Plot a graph of f/Hz against $(1/L)/\text{m}^{-1}$. Include error bars for $1/L$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

Gradient of best fit line:

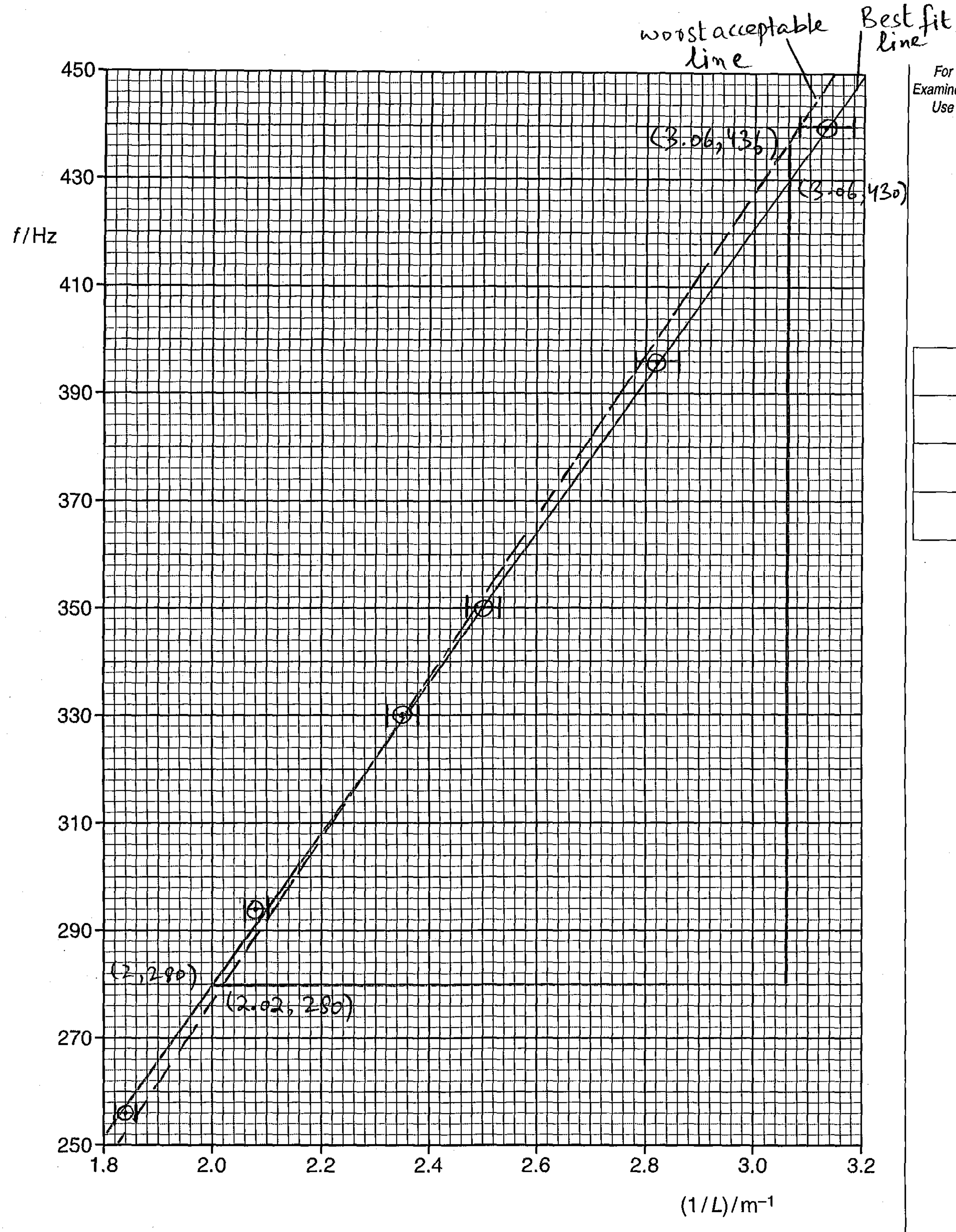
$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{430 - 280}{3.06 - 2} = 142$$

Gradient of worst acceptable line:

$$\text{gradient} = \frac{436 - 280}{3.06 - 2.02} = 150$$

gradient = 142 ± 8 [2]

Δ gradient = 150 − 142 = 8



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(d) **(i)** The tension T in the wire is 30 ± 3N. Using your answer to **(c)(iii)**, determine the value of μ. Include an appropriate unit in your answer.

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$$\text{gradient} = \frac{1}{2}\sqrt{\frac{T}{\mu}}$$

$$\mu = \frac{T}{4 \times \text{gradient}^2}$$

$$\mu = \frac{30}{4 \times 142^2} = 3.72 \times 10^{-4}$$

μ = 3.72×10^{-4} [2]

(ii) Determine the percentage uncertainty in μ.

$$\mu = \frac{T}{4\,\text{gradient}^2}$$

$$\frac{\Delta\mu}{\mu} \times 100 = \left[\frac{\Delta T}{T} + 2\frac{\Delta\,\text{gradient}}{\text{gradient}}\right]100 = \left[\frac{3}{30} + \frac{2(8)}{142}\right]100 = 21\%$$

percentage uncertainty = 21 % [1]

(e) An expression for μ is

$$\mu = \rho\pi r^2$$

where the density ρ of the wire is 8800 kg m^{-3} and r is the radius of the wire.

(i) Using your answer to **(d)(i)**, determine a value for r.

$$\mu = \rho\pi r^2$$

$$r = \left[\frac{\mu}{\rho\pi}\right]^{1/2}$$

$$r = \left[\frac{3.72 \times 10^{-4}}{8800 \times \pi}\right]^{1/2}$$

$r = 1.16 \times 10^{-4}\,\text{m}$

r = 1.16×10^{-4} m [1]

(ii) Determine the percentage uncertainty in your value of r.

$$\frac{\Delta r}{r} \times 100 = \frac{1}{2}\left[\frac{\Delta\mu}{\mu} \times 100\right] = \frac{1}{2}(21) = 10.5\%$$

percentage uncertainty = 10.5 % [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

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PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2012**

1 hour 15 minutes

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No Additional Materials are required.

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1 As a bar magnet is dropped through a coil, an e.m.f. is induced in the coil. The maximum e.m.f. E is induced as the magnet leaves the coil with speed v.

It is suggested that E is directly proportional to v.

Design a laboratory experiment to test the relationship between E and v. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

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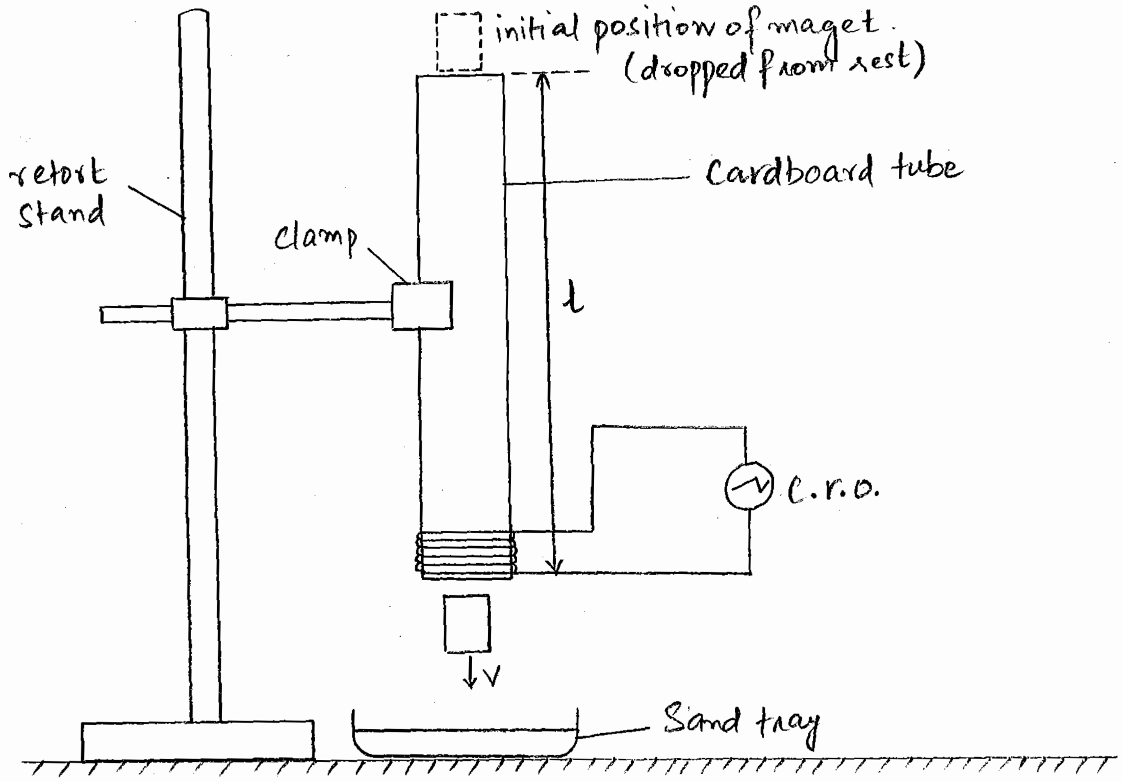

Defining the problem:

Independent variable: Speed v

Dependent variable: Maximum induced e.m.f. E

Constant: Number of turns on the coil.

Procedure:

Measure the length of cardboard tube using meter rule. Speed v can be determined using second equation of motion. According to second equation of motion, $2 \times g \times l = v^2 - 0^2$.

So, $v = \sqrt{2gl}$ where g is acceleration due to gravity. As a bar magnet pass through a coil, measure maximum induced e.m.f. E using C.R.O. Use cardboard tubes of different lengths for range of values of v. Record

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the data in a given table

Tabulation:

Number of Observation	l/m	v/ms^{-1}	E/V	

Analysis of data:

Plot a graph of E against v. The relationship is valid if graph is a straight line through origin.

Safety Precaution:

Place a sand tray under the cardboard tube to catch falling magnet.

Additional details:-

1- Use coil with large number of turns to induce measurable e.m.f. E

2- For same value of v, measure the induced e.m.f. E twice and take average.

3- Use the same magnet throughout the experiment

4. Use short coil so that v is nearly constant.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 Different light-emitting diodes (LEDs) can emit electromagnetic radiation of different wavelengths.

A student uses the circuit of Fig. 2.1 to investigate the minimum potential difference required to cause an LED to emit its characteristic wavelength.

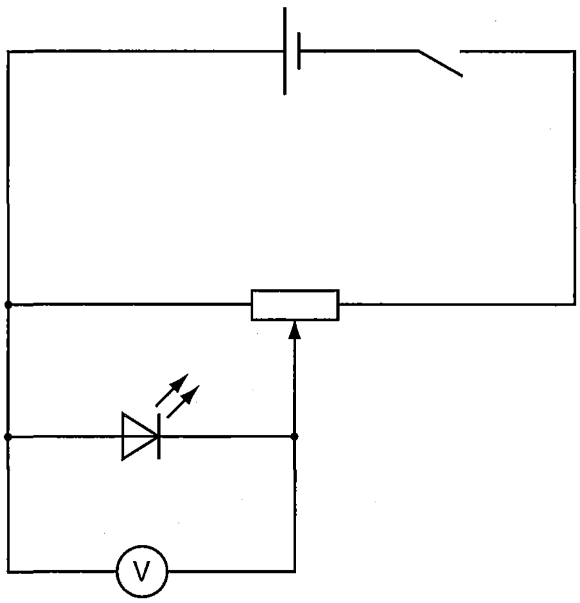

Fig. 2.1

For different LEDs emitting radiation of wavelength λ, the minimum potential difference V is recorded.

Question 2 continues on the next page.

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It is suggested that V and λ are related by the equation

$$\frac{hc}{\lambda} = B + eV$$

where c is the speed of light in a vacuum, e is the elementary charge, h is the Planck constant and B is a constant.

(a) A graph is plotted of V on the y-axis against $1/\lambda$ on the x-axis. Determine expressions for the gradient and y-intercept in terms of B, c, e and h.

$$eV = \frac{hc}{\lambda} - B$$

$$V = \frac{hc}{e}\left[\frac{1}{\lambda}\right] - \frac{B}{e}$$

gradient = hc/e

y-intercept = $-B/e$

[1]

(b) Values of λ and V are given in Fig. 2.2.

$\lambda/10^{-9}$m	V/V	$(1/\lambda)/10^{6}\,m^{-1}$
950	0.60 ± 0.05	1.05
875	0.70 ± 0.05	1.14
655	1.20 ± 0.05	1.53
560	1.55 ± 0.05	1.79
505	1.80 ± 0.05	1.98
430	2.25 ± 0.05	2.33

Fig. 2.2

Calculate and record values of $(1/\lambda)/10^{6}\,m^{-1}$ in Fig. 2.2. [2]

(c) (i) Plot a graph of V/V against $(1/\lambda)/10^{6}\,m^{-1}$. Include error bars for V. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit line:

$$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{2.1 - 0.9}{(2.2 - 1.28)10^{6}}$$

$$= 1.3 \times 10^{-6}$$

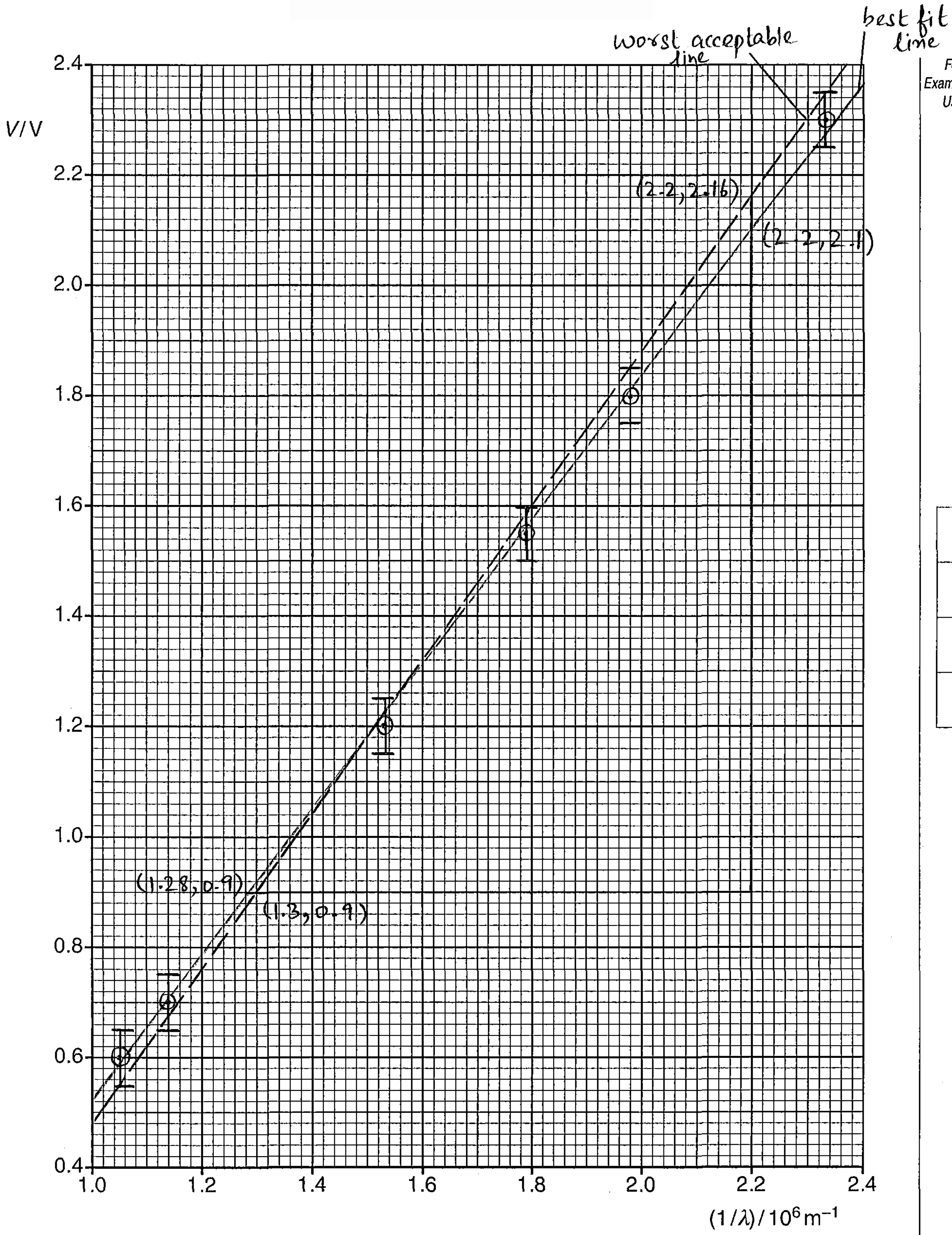
gradient of worst acceptable line:

$$\text{gradient} = \frac{2.16 - 0.9}{(2.2 - 1.3)10^{6}}$$

$$= 1.4 \times 10^{-6}$$

gradient = $(1.3 \pm 0.1)10^{-6}$ [2]

$$\Delta\,\text{gradient} = (1.4 - 1.3)10^{-6} = 0.1 \times 10^{-6}$$



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(iv) Determine the *y*-intercept of the line of best fit. Include the uncertainty in your answer.

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y-intercept of best fit line: y-intercept of worst acceptable line:

$y = mx + c$ $\quad$ $y = mx + c$

$2.1 = 1.3\times10^{-6}(2.2\times10^{6}) + c$ $\quad$ $2.16 = 1.4\times10^{-6}(2.2\times10^{6}) + c$

$c = -0.76$ $\quad$ $c = -0.92$

$\Delta c = 0.92 - 0.76 = 0.16$

y-intercept = -0.76 ± 0.16 [2]

(d) (i) Using your answer to **(c)(iii)**, determine a value for *h*.

Data: $c = 3.0\times10^{8}\,\mathrm{m\,s^{-1}}$ and $e = 1.6\times10^{-19}\,\mathrm{C}$.

gradient = hc/e

$h = \dfrac{\text{gradient}\times e}{c}$

$h = \dfrac{1.3\times10^{-6}\times1.6\times10^{-19}}{3.0\times10^{8}} = 6.9\times10^{-34}$

h = 6.9×10^{-34} Js [1]

(ii) Determine the percentage uncertainty in your value of *h*.

$h = \dfrac{\text{gradient}\times e}{c}$

$\dfrac{\Delta h}{h}\times100 = \dfrac{\Delta\,\text{gradient}}{\text{gradient}}\times100 = \dfrac{0.1}{1.3}\times100 = 7.7\%$

percentage uncertainty = 7.7 % [1]

(e) Using your answer to **(c)(iv)**, determine a value for *B*. Include an appropriate unit and the absolute uncertainty in your answer.

$-\dfrac{B}{e} = \text{y-intercept}$ $\quad$ $\dfrac{\Delta B}{B} = \dfrac{\Delta\,\text{y-intercept}}{\text{y-intercept}}$

$-\dfrac{B}{1.6\times10^{-19}} = -0.76$ $\quad$ $\dfrac{\Delta B}{1.22\times10^{-19}} = \dfrac{0.16}{0.76}$

$B = 1.22\times10^{-19}$ $\quad$ $\Delta B = 0.3$

Units: J

B = $(1.2 \pm 0.3)10^{-19}$ J [2]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

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PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2012**

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[Turn over

1 Two identical light sources are viewed from a distance, as shown in Fig 1.1. When the angle θ between the light sources is large, they are seen as separate.

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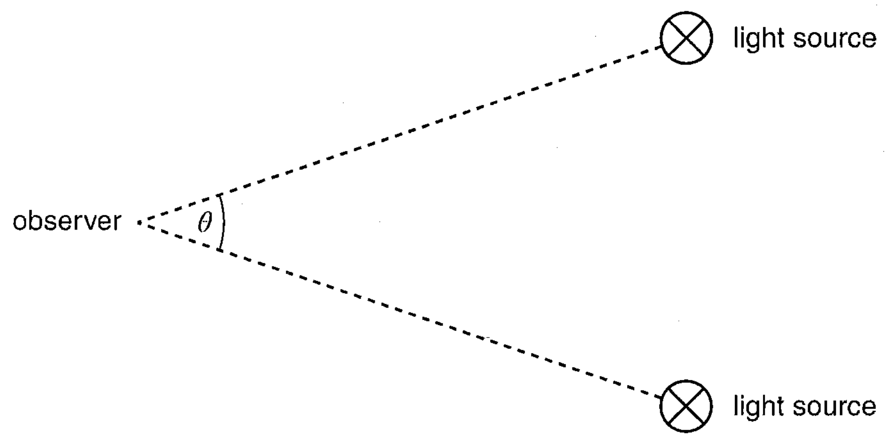


Fig 1.1 (not to scale)

The sources are moved closer together. At a particular angle θ_1 the two sources appear as a single source.

It is suggested that θ_1 is directly proportional to the wavelength λ of the light from the sources.

Design a laboratory experiment using two light sources to test the relationship between θ_1 and λ. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

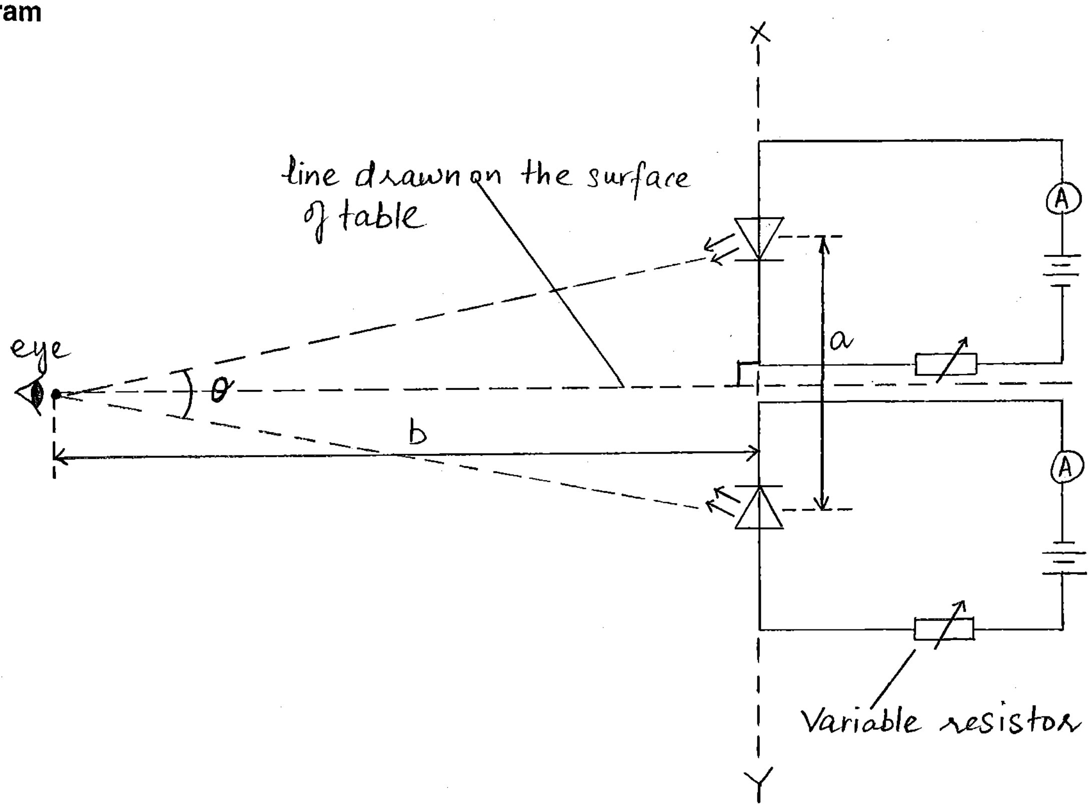
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

For Examiner's Use



Defining the problem:

Independent variable: Wavelength λ

Dependent variable: Angle θ

Constant: Intensity of light sources

Procedure:

Record the wavelength of the light from the data sheet of specific LED. Initially, place LEDs apart from each other, such that they appear as two different light sources. Then slowly move LEDs closer together along the line XY, until they appear as a single light source. Measure the distance between two LEDs, 'a' and distance b using meter rule. Calculate angle θ from the relationship, $\tan\left(\frac{\theta}{2}\right) = \frac{a/2}{b}$.

For Examiner's Use

$\theta = 2\tan^{-1}(a/2b)$. Carry out the experiment in dark room. Repeat the experiment with LEDs, which emit light of different wavelength, λ. Record the data in a given table.

Tabulation:

Number of Observation	λ/m	a/m	b/m	θ/°

Analysis of data:

Plot a graph of θ against λ. The relationship is valid if graph is a straight line through origin.

Safety Precaution:

Intense light may damage eyes. So wear dark glasses while performing the experiment.

Additional details:

1- Use large distances to reduce uncertainty in value of θ.

2. Use vernier caliper to measure distance between light sources more precisely.

3. View the light sources from same eye.

4. Use set square to ensure position of observer is perpendicular to the line, along which LEDs are placed.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A trolley is attached to springs, as shown in Fig 2.1. When the trolley is displaced and then released, the trolley oscillates.

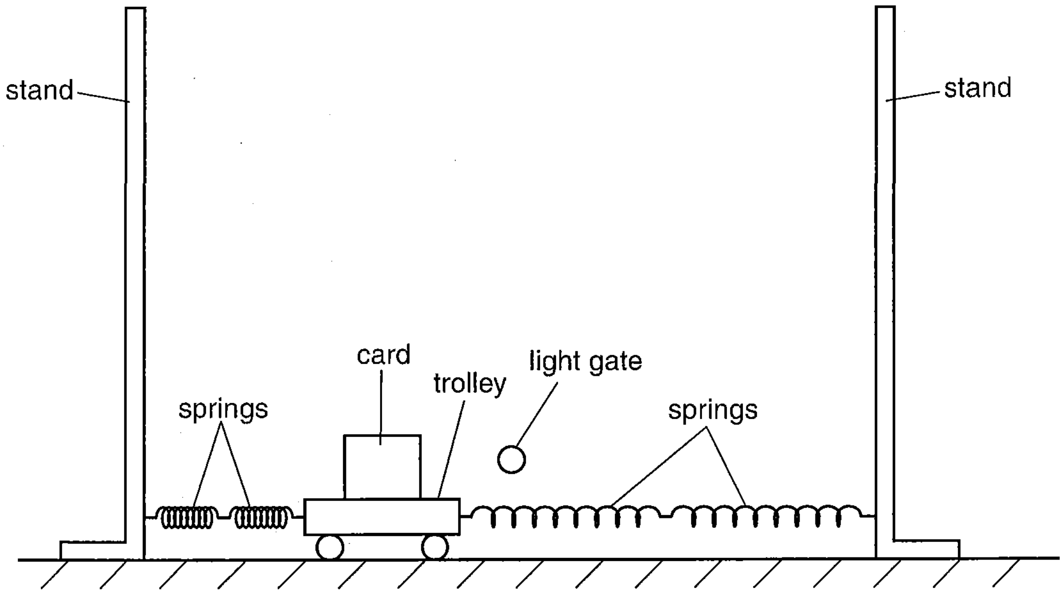


Fig. 2.1

A student investigates how the maximum speed *v* of a trolley varies with the total mass *M* of the trolley.

The maximum speed is determined using the time *t* taken for the card to pass through a light gate connected to an electronic timer. The length of the card is 5.0 ± 0.1 cm.

Question 2 continues on the next page.

For Examiner's Use

It is suggested that v and M are related by the equation

$$v = A\sqrt{\frac{k}{M}}$$

where A is the initial displacement and k is the spring constant of the springs.

(a) A graph is plotted of v^2 on the y-axis against $1/M$ on the x-axis. Determine an expression for the gradient in terms of A and k.

$$v^2 = A^2\frac{k}{M}$$

$$v^2 = A^2k\left[\frac{1}{M}\right]$$

gradient = A^2K [1]

(b) Values of M and t are given in Fig. 2.2.

M/kg	t/s	$(1/M)$/kg^{-1}	v^2/m^{2}s^{-2}
0.75	0.046 ± 0.002	1.33	1.18 ± 0.15
1.25	0.058 ± 0.002	0.800	0.74 ± 0.08
1.75	0.068 ± 0.002	0.571	0.54 ± 0.05
2.25	0.078 ± 0.002	0.444	0.41 ± 0.02
2.75	0.086 ± 0.002	0.363	0.34 ± 0.02
3.25	0.092 ± 0.002	0.308	0.30 ± 0.01

Fig. 2.2

Calculate and record values of $(1/M)$/kg^{-1} and v^2/m^{2}s^{-2} in Fig. 2.2. Include the absolute uncertainties in v^2. [3]

(c) **(i)** Plot a graph of v^2/m^{2}s^{-2} against $(1/M)$/kg^{-1}. Include error bars for v^2. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit line:

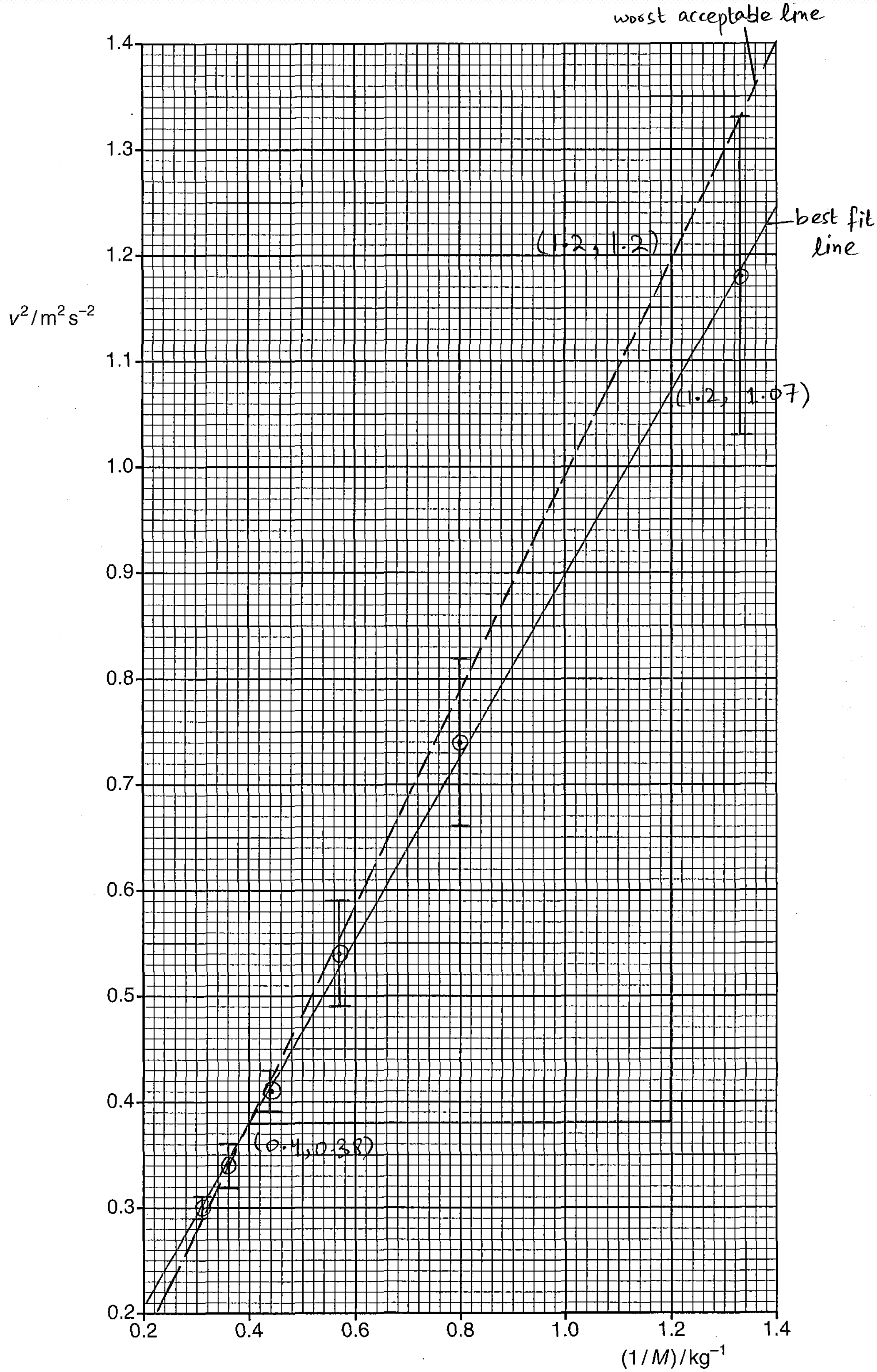
$$\text{gradient} = \frac{1.07 - 0.38}{1.2 - 0.4} = 0.86$$

gradient of worst acceptable line:

$$\text{gradient} = \frac{1.2 - 0.38}{1.2 - 0.4} = 1.02$$

$$\Delta\text{gradient} = 1.02 - 0.86 = 0.16$$

gradient = $0.86 - 0.16$ [2]



For Examiner's Use

For Examiner's Use

(d) (i) The value of A is 0.200 ± 0.005 m. Using your answer to **(c)(iii)**, determine a value for k. Include an appropriate unit in your answer.

$$\text{gradient} = A^2 K$$

$$K = \frac{\text{gradient}}{A^2}$$

Units: N/m

$$K = \frac{0.86}{0.2^2}$$

$$K = 21.5$$

k = 21.5 Nm^{-1} [2]

(ii) Determine the percentage uncertainty in your value of k.

$$K = \text{gradient}/A^2$$

$$\frac{\Delta K}{K} \times 100 = \left[\frac{\Delta \text{gradient}}{\text{gradient}} + 2\frac{\Delta A}{A}\right] \times 100$$

$$= \left[\frac{0.16}{0.86} + \frac{2(0.005)}{0.2}\right] \times 100$$

$$= 9.5\%$$

percentage uncertainty = 9.5 % [1]

(e) The experiment is repeated using the same springs and a trolley with total mass 0.75 kg. The initial displacement is 0.100 ± 0.005 m. Determine the maximum speed of the trolley. Include the absolute uncertainty in your answer.

Spring constant of 4 springs in series $= \frac{21.5}{4} = 5.38$

$$V = A\sqrt{\frac{K}{M}}$$

$$V = 0.2\sqrt{\frac{5.38}{0.75}}$$

$$V = 0.54 \ ms^{-1}$$

v = 0.54 ± 0.04 ms^{-1} [2]

$$\frac{\Delta V}{V} = \frac{\Delta A}{A} + \frac{1}{2}\frac{\Delta K}{K}$$

$$\frac{\Delta V}{0.54} = \frac{0.005}{0.2} + \frac{1}{2}\left(\frac{2.0}{21.5}\right)$$

$$\Delta V = 0.04$$

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2011**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
Total	

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UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

1 When light is incident on the front of a photocell, an e.m.f. is generated in the photocell.

A student wishes to investigate the effect of adding various thicknesses of glass in front of a photocell. This may be carried out in the laboratory by varying the number of identical thin glass sheets between a light source and the front of the photocell.

It is suggested that the e.m.f. V is related to the number n of glass sheets by the equation

$$V = V_0 e^{-\alpha n t}$$

where t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the e.m.f. for $n = 0$.

Design a laboratory experiment to determine the absorption coefficient of glass. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

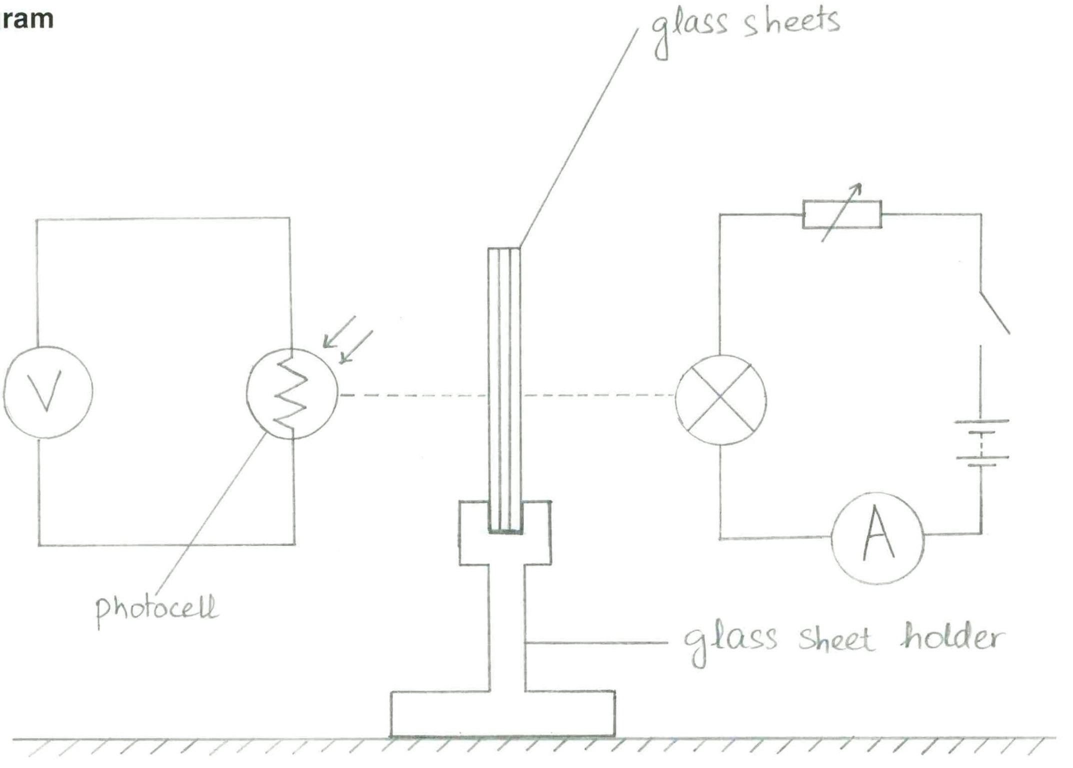
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

For Examiner's Use



Defining the problem:

Independent variable: Number of glass sheets (n)

Dependent variable: e.m.f. V

Constant: Output power of the lamp.

Procedure:

Measure thickness t of a glass sheet with micrometer screw guage. Take many readings of thickness using different glass sheets and take average. Place a glass sheet between lamp and photocell. Measure the e.m.f. V generated in the photocell from voltmeter. Repeat the experiment by varying the number of thin glass sheets between lamp and photocell. Remove the glass sheets between lamp and photocell and measure V_o from voltmeter. Perform the

For Examiner's Use

experiment in dark room. Record the results in given table.

Tabulation:

Number of observation	nt/m	V_1/V	V_2/V	V/V	ln(V/V)

Analysis of data:

$\ln V = -\alpha nt + \ln V_0$

Plot a graph of ln V against nt. Graph will be a straight line with gradient $-\alpha$ and y-intercept, $\ln V_0$.

$$\text{gradient} = -\alpha$$

$$\alpha = -\text{gradient}.$$

Safety precaution:

Wear gloves to prevent burns from hot lamp and to prevent cuts from glass.

Additional details:

1- Clean glass sheets before performing experiment.

2- Use high intensity light source to generate large V.

3. Keep the orientation of photocell and glass sheets with respect to lamp constant throughout the experiment.

4. Use variable resistor and ammeter to ensure current in the lamp is constant.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A student is investigating how a volume of nitrogen gas is affected by the pressure exerted on it.

A sample of nitrogen gas is trapped in a vertical tube of uniform cross-sectional area by a small volume of oil. Pressure is applied by a pump. The applied pressure is measured on a gauge, as shown in Fig. 2.1.

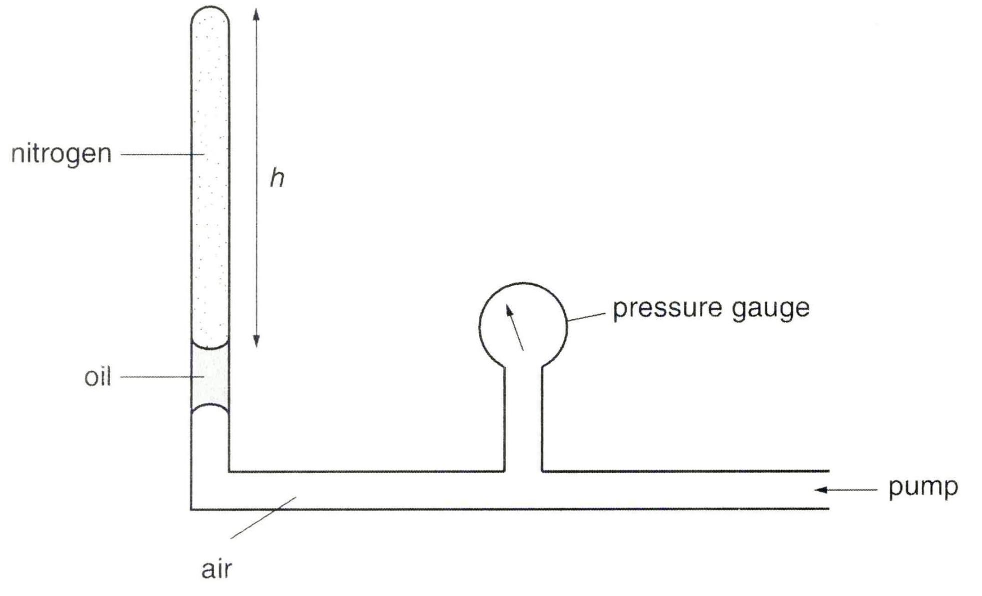


Fig. 2.1

The temperature T of the nitrogen is 290 K.

An experiment is carried out to investigate how the height h of nitrogen trapped in the tube varies with the pressure p.

Question 2 continues on the next page.

For Examiner's Use

It is suggested that p and h are related by the equation

$$pAh = NkT$$

where A is the cross-sectional area of the tube, k is the Boltzmann constant and N is the number of molecules of nitrogen gas.

(a) A graph is plotted of p on the y-axis against $\frac{1}{h}$ on the x-axis. Express the gradient in terms of N.

$pAh = NkT$

$p = \frac{NkT}{A}\left(\frac{1}{h}\right)$

gradient = NkT/A [1]

(b) Values of p and h are given in Fig. 2.2.

p / 10^5 Pa	h / 10^{-3} m	$(1/h)$ / m^{-1}
1.10	400 ± 5	2.50 ± 0.03
1.22	360 ± 5	2.70 ± 0.04
1.38	320 ± 5	3.13 ± 0.05
1.57	280 ± 5	3.57 ± 0.06
1.83	240 ± 5	4.16 ± 0.09
2.09	210 ± 5	4.76 ± 0.11

Fig. 2.2

Calculate and record values of $\frac{1}{h}$ in Fig. 2.2. Include the absolute uncertainties in $\frac{1}{h}$.

[3]

(c) **(i)** Plot a graph of p / 10^5 Pa against $\frac{1}{h}$ / m^{-1}. Include error bars for $\frac{1}{h}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

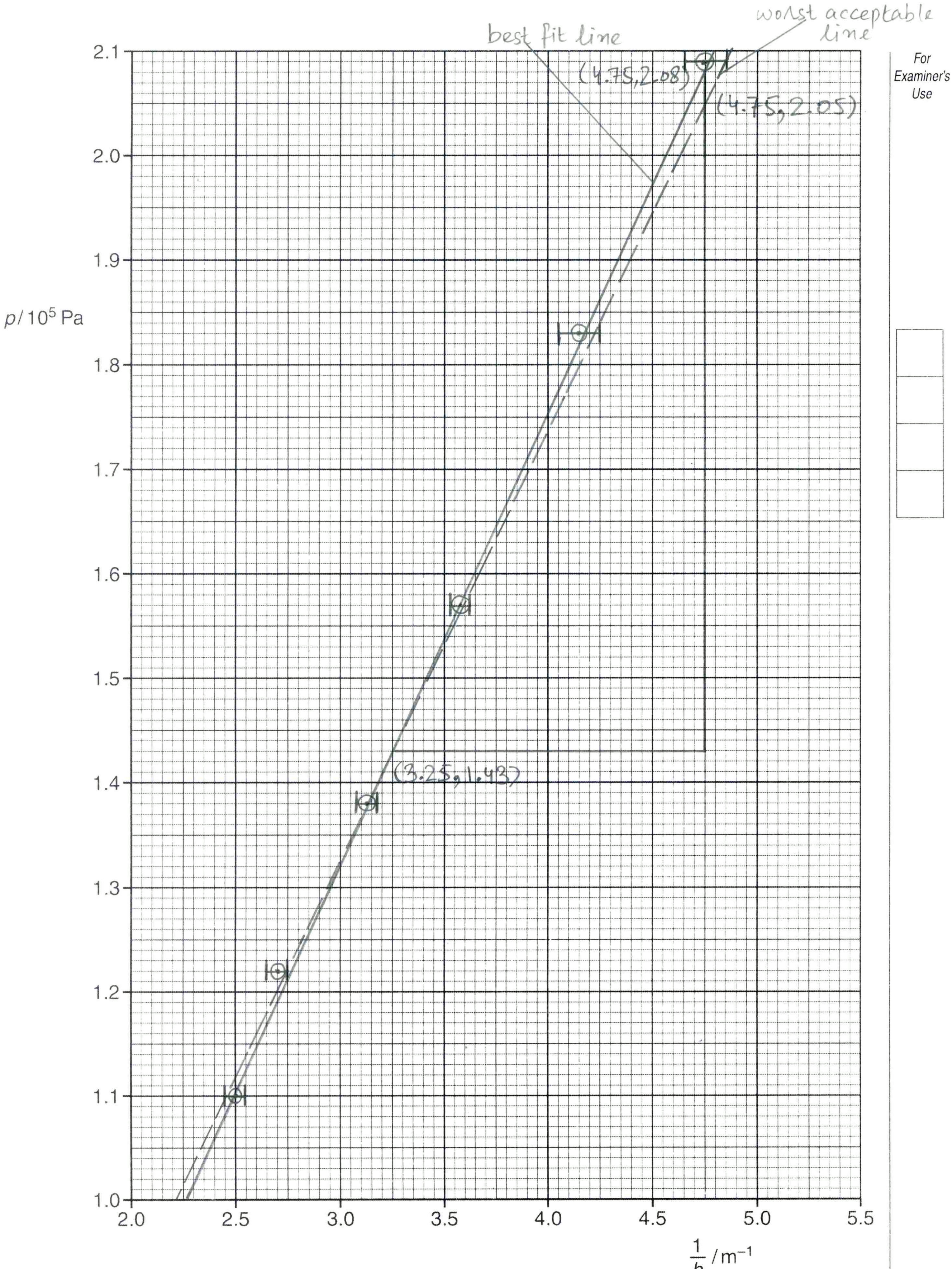
gradient of best fit line: gradient of worst acceptable line:

gradient $= \frac{(2.05-1.43)10^5}{4.75-3.25}$ gradient $= \frac{(2.08-1.43)10^5}{4.75-3.25}$

$= 4.1 \times 10^4$ $= 4.3 \times 10^4$

Δgradient $= (4.3-4.1)10^4 = 0.2 \times 10^4$

gradient = $(4.1 \pm 0.2) \times 10^4$ [2]



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(d) In this experiment, $A = 3.14 \times 10^{-6}\,m^2$ and $k = 1.38 \times 10^{-23}\,JK^{-1}$. Using your answer in **(c)(iii)**, determine the value of N. Include the absolute uncertainty in your value.

For Examiner's Use

From best fit line:

gradient = NKT/A

$N = \dfrac{\text{gradient} \times A}{KT}$

$N = \dfrac{4.1\times10^4 \times 3.14\times10^{-6}}{1.38\times10^{-23}\times 290}$

$= 3.2\times10^{19}$

From worst acceptable line:

$N = \dfrac{4.3\times10^4 \times 3.14\times10^{-6}}{1.38\times10^{-23}\times 290}$

$N = 3.4\times10^{19}$

$\Delta N = (3.4-3.2)10^{19} = 0.2\times10^{19}$

N = $(3.2 \pm 0.2)\times10^{19}$ [2]

(e) **(i)** The pressure is reduced so that $p = 1.10 \times 10^5$ Pa and the temperature decreases by 12 ±1 K.

Determine h using the relationship given and your answer in **(d)**.

$pAh = NKT$

$h = \dfrac{3.2\times10^{19}\times1.38\times10^{-23}\times 278}{1.10\times10^5\times3.14\times10^{-6}}$

$h = 0.36$

h = 0.36 [2]

(ii) Determine the percentage uncertainty in your value of h.

$h = \dfrac{NKT}{pA}$

$\dfrac{\Delta h}{h}\times100 = \left[\dfrac{\Delta N}{N}\times100\right] + \left[\dfrac{\Delta T}{T}\times100\right] = \left[\dfrac{0.2\times10^{19}}{3.2\times10^{19}}\times100\right] + \left[\dfrac{1}{278}\times100\right]$

$= 6.6\%$

percentage uncertainty = 6.6 % [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6655069171

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2011**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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For Examiner's Use	
1	
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Total	

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UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

For Examiner's Use

1 A student wishes to investigate projectile motion.

A small ball is rolled with velocity v along a horizontal surface. When the ball reaches the end of the horizontal surface, it falls and lands on a lower horizontal surface. The vertical displacement of the ball is p and the horizontal displacement of the ball is q, as shown in Fig 1.1.

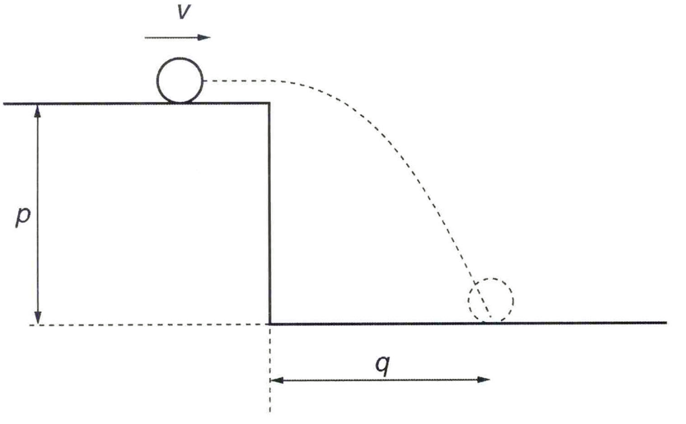


Fig. 1.1

It is suggested that

$$gq^2 = 2pv^2$$

where g is the acceleration of free fall.

Design a laboratory experiment to investigate how q is related to p and how v may be determined from the results. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

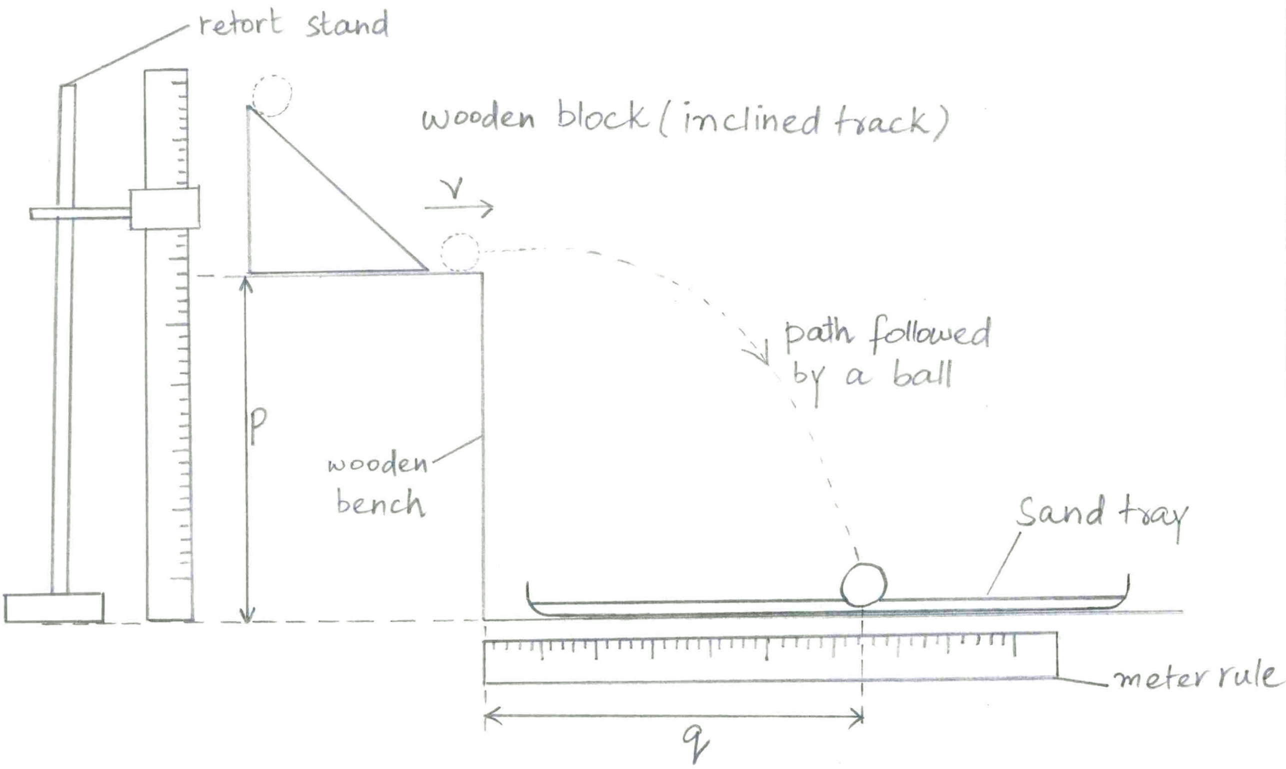
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

For Examiner's Use

Diagram



Defining the problem:

Independent variable: Vertical displacement p

Dependent variable: Horizontal displacement q

Constant: velocity v

Procedure:

Measure the vertical displacement p from meter rule. Release the ball from same height on the track so that it rolls with constant velocity v along a horizontal surface each time. Measure the horizontal displacement covered by using meter rule. Adjust the position of wooden bench to vary vertical displacement p. Use spirit level to ensure that the moved surface remains horizontal when the height is adjusted. Perform the experiment for different values of p. Record the data in given table.

For Examiner's Use

Tabulation:

Number of Observation	p/m	q_1/m	q_2/m	q/m	q^2/m^2

Analysis of data:

$$q^2 = (2v^2/g)\,p$$

Plot a graph of q^2 against p. Graph would be a straight line through origin

$$\text{gradient} = 2v^2/g$$

$$v = \left(\frac{1}{2} \times g \times \text{gradient}\right)^{1/2}$$

Safety Precaution:

Use safety screen to prevent ball causing injury.

Additional details:

1- Measure q, i.e. distance between the start of track and center of the crater in sand.

2- Use set square to ensure that the ball leaves the table at 90°.

3. Repeat the experiment for many readings of q and take the average.

4. Use high density ball to minimise the effects of air resistance.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A student is investigating a non-inverting operational amplifier (op-amp) circuit.

The circuit is set up as shown in Fig. 2.1.

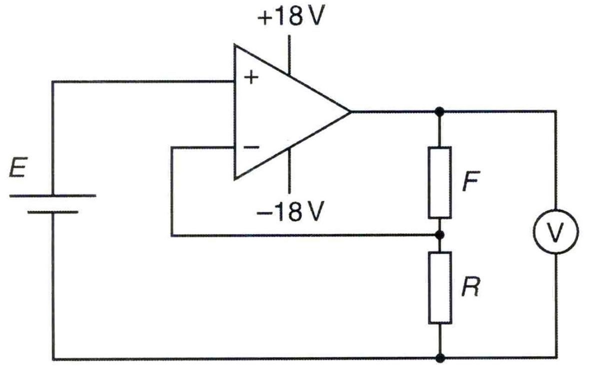


Fig. 2.1

The op-amp is connected to a +18 V and –18 V power supply.

E is the e.m.f. of the cell, which has a value of 1.6 ± 0.1 V.

An experiment is carried out to investigate how the reading *V* on the voltmeter varies with resistance *R*.

Question 2 continues on the next page.

It is suggested that V and R are related by the equation

$$V = \frac{F}{R}E + E$$

where F is the resistance of the fixed resistor in the circuit.

(a) A graph is plotted of $\frac{V}{E}$ on the y-axis against $\frac{1}{R}$ on the x-axis. Express the gradient in terms of F.

$$V = \frac{F}{R}E + E$$

$$\frac{V}{E} = F\left[\frac{1}{R}\right] + 1$$

gradient = F [1]

(b) Values of R and V are given in Fig. 2.2.

R/Ω	V/V	$\frac{1}{R}/10^{-3}\Omega^{-1}$	$\frac{V}{E}$
150	14.4 ± 0.1	6.7	9.0 ± 0.6
220	10.4 ± 0.1	4.5	6.5 ± 0.5
330	7.4 ± 0.1	3.0	4.6 ± 0.4
470	5.6 ± 0.1	2.1	3.5 ± 0.3
680	4.4 ± 0.1	1.5	2.8 ± 0.2
860	3.8 ± 0.1	1.2	2.4 ± 0.2

Fig. 2.2

Calculate and record values of $\frac{1}{R}/10^{-3}\Omega^{-1}$ and $\frac{V}{E}$ in Fig. 2.2. Include the absolute uncertainties in $\frac{V}{E}$. [3]

(c) **(i)** Plot a graph of $\frac{V}{E}$ against $\frac{1}{R}/10^{-3}\Omega^{-1}$. Include error bars for $\frac{V}{E}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

Gradient of Best fit line:

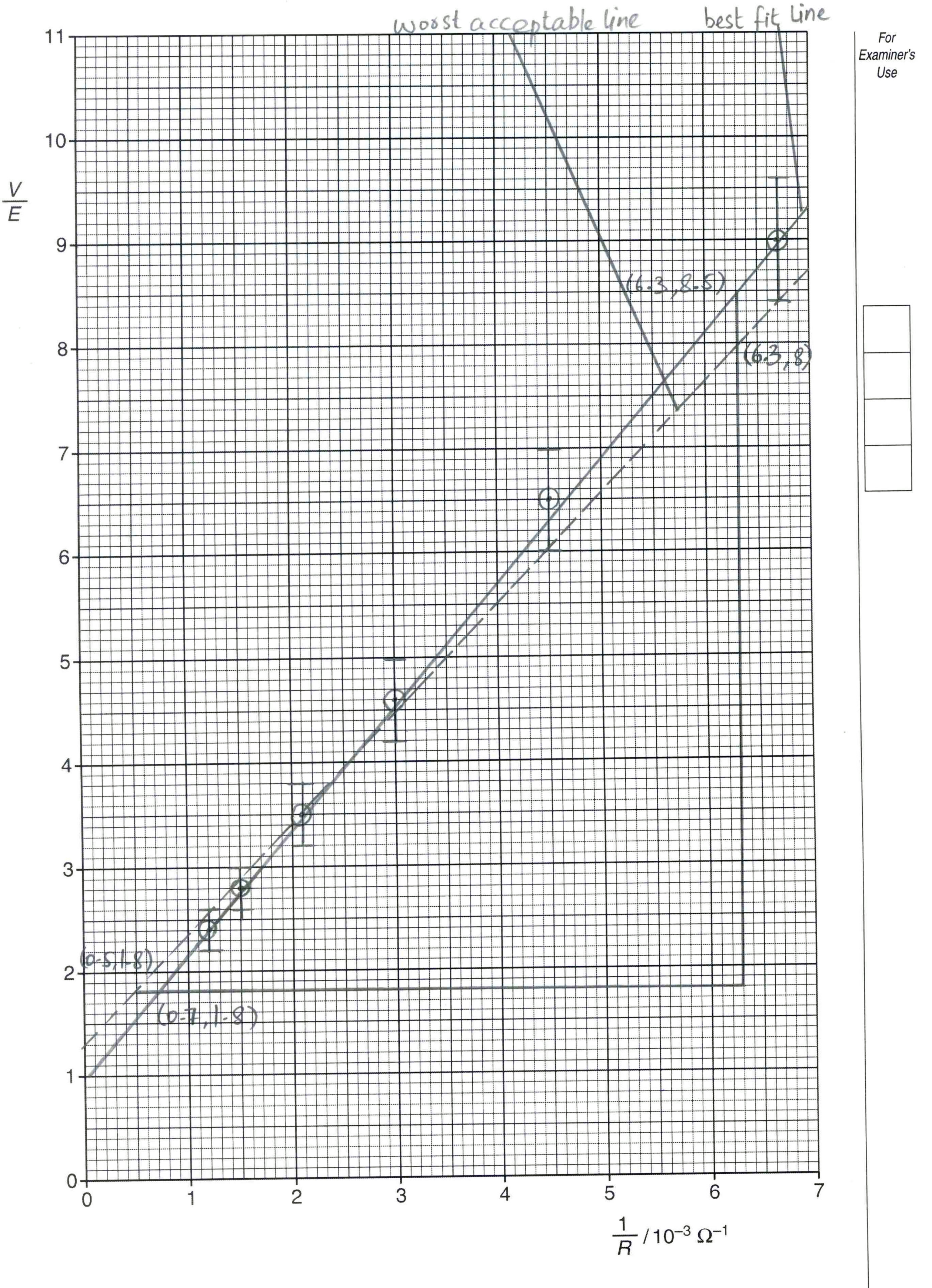
$$\text{gradient} = \frac{8.5 - 1.8}{(6.3 - 0.7)10^{-3}} = 1200$$

Gradient of worst acceptable line:

$$\text{Gradient} = \frac{8 - 1.8}{(6.3 - 0.5)10^{-3}} = 1100$$

gradient = 1200 ± 100 [2]

Δ gradient = 1200 − 1100 = 100


worst acceptable line
best fit line
(6.3, 8.5)
(6.3, 8)
(0.5, 1.8)
(0.7, 1.8)
V/E
1/R / 10^{-3} Ω^{-1}
0
1
2
3
4
5
6
7
8
9
10
11
For Examiner's Use

(d) Using your answer in **(c)(iii)**, determine the value of *F*. Include the absolute uncertainty in your value and an appropriate unit.

For Examiner's Use

$F = \text{Gradient} = 1200$

$\Delta F = \Delta \text{Gradient} = 100$

Units: $\frac{1}{\Omega^{-1}} = \Omega$

$F =$ $1200 \pm 100\ \Omega$ [2]

(e) For one measurement, *R* has a value of 120 Ω ± 5%.

(i) Determine the value of $\frac{V}{E}$ using the relationship given and your answer in **(d)**.

Include the absolute uncertainty in your answer.

$V = \frac{F}{R}E + E$

$\frac{V}{E} = \frac{F}{R} + 1$

$\frac{V}{E} = \frac{1200}{120} + 1 = 11.0$

$\Delta \frac{V}{E} = \left[\frac{\Delta F}{F} + \frac{\Delta R}{R}\right]\frac{V}{E}$

$= \left[\frac{100}{1200} + \frac{0.05}{120}\right] 11$

$= 0.9$

$\frac{V}{E} =$ 11.0 ± 0.9 [2]

(ii) Determine the expected voltmeter reading.

$\frac{V}{E} = 11.0$

$\frac{V}{1.6} = 11.0$

$V = 11.0 \times 1.6$

$V = 17.6\ V$

voltmeter reading = 17.6 V [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2011**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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Total	

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DC (SJF/DJ) 34176/3

UNIVERSITY of CAMBRIDGE International Examinations

For Examiner's Use

1 A current-carrying coil produces a magnetic field.

It is suggested that the strength *B* of the magnetic field at the centre of a flat circular coil is inversely proportional to the radius *r* of the coil.

Design a laboratory experiment that uses a Hall probe to test the relationship between *B* and *r*. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

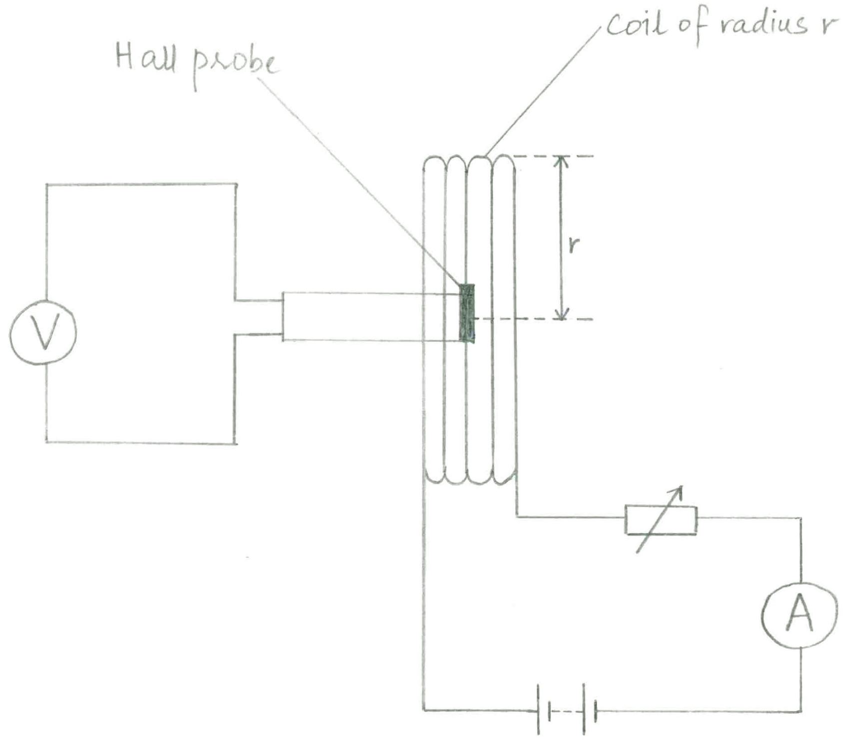
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

For Examiner's Use



Defining the problem:

Independent variable: Radius r of the coil.

Dependent variable: Strength of magnetic field, B.

Constant: Number of turns of the coil.

Procedure:

Measure the diameter d of the coil with vernier caliper. Calculate the radius r of the coil by using the relationship, $r = d/2$. Calibrate the Hall probe with known magnetic field strength. Adjust the Hall probe in the center of coil such that the voltmeter gives maximum reading. Measure the Hall voltage V from voltmeter. Work out the value of magnetic field strength B. Repeat the experiment

For Examiner's Use

with coils of different radii until you have six sets of readings. Record the results in given table.

Tabulation:

Number of Observation	r/m	V/V	$\frac{1}{r}/m^{-1}$	B/T

Analysis of data:

Plot a graph of B against 1/r. The suggested relationship is valid if graph is a straight line through origin.

Safety Precaution:

Wear gloves to prevent burns from hot coil.

Additional details:

1- Use large number of turns and large current to generate large magnetic field strength B.
2. Measure the diameter of coil from different positions and take average.
3. Use optical bench to keep Hall probe and coil in same orientation throughout the experiment.
4. Repeat the experiment with Hall probe reversed and find the average value of B for same radius of coil.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A scientist is observing some of the moons orbiting the planet Jupiter.

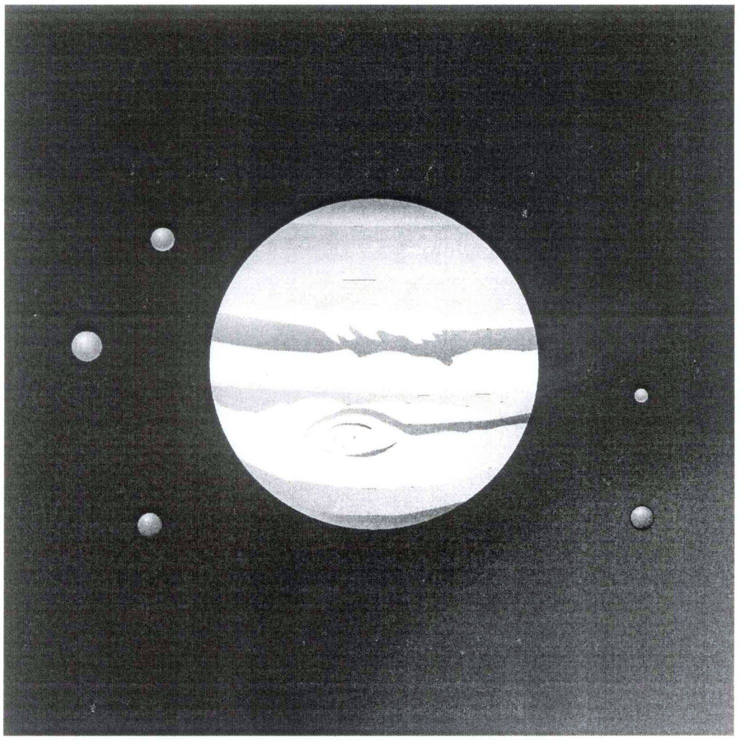


Fig. 2.1

For six different moons, the scientist records the distance *r* from the centre of Jupiter and the period *T* of the orbit.

Question 2 continues on the next page.

For Examiner's Use

It is suggested that T and r are related by the equation

$$T^2 = kr^3$$

where k is a constant.

(a) A graph is plotted of lg T on the y-axis against lg r on the x-axis. Determine the value of the gradient and express the y-intercept in terms of k.

$\lg T^2 = \lg k + \lg r^3$

$2 \lg T = 3 \lg r + \lg k$

$\lg T = \frac{3}{2} \lg r + \frac{\lg k}{2}$

gradient = 3/2

y-intercept = $\lg k/2$ [1]

(b) Values of r and T are given in Fig. 2.2.

$r/10^6$ m	$T/10^3$ s	lg (r/m)	lg (T/s)
129	24 ± 4	8.111	4.38 ± 0.07
181	42 ± 4	8.258	4.62 ± 0.04
422	154 ± 8	8.625	5.19 ± 0.02
671	304 ± 8	8.827	5.48 ± 0.01
1070	590 ± 15	9.029	5.77 ± 0.01
1880	1420 ± 15	9.274	6.152 ± 0.005

Fig. 2.2

Calculate and record values of lg (r/m) and lg (T/s) in Fig. 2.2. Include the absolute uncertainties in lg (T/s). [3]

(c) **(i)** Plot a graph of lg (T/s) against lg (r/m). Include error bars for lg (T/s). [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit line:

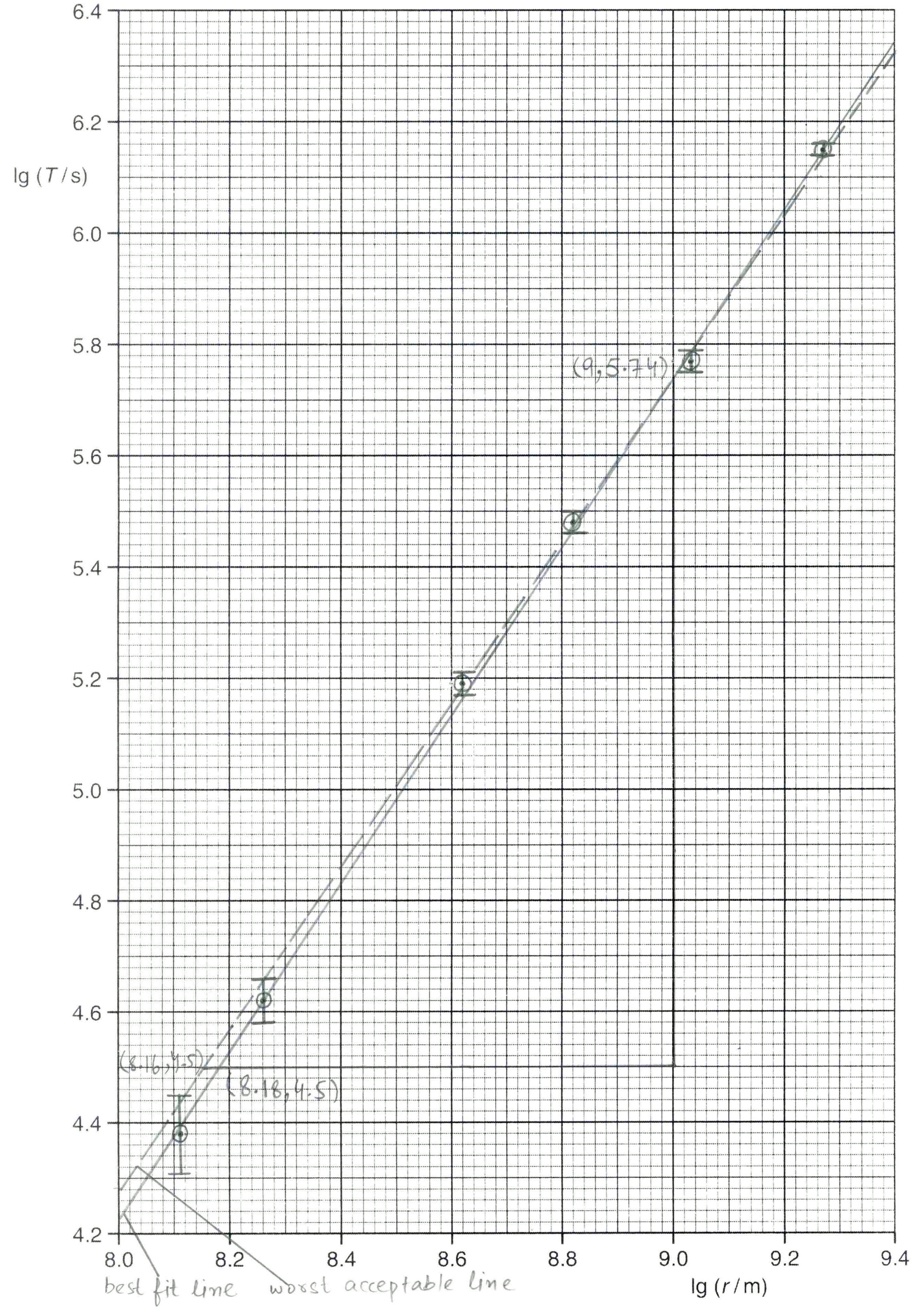
$$\text{gradient} = \frac{5.74 - 4.5}{9 - 8.18} = 1.51$$

gradient of worst acceptable line:

$$\text{gradient} = \frac{5.74 - 4.5}{9 - 8.16} = 1.48$$

Δgradient = 1.51 − 1.48 = 0.03

gradient = 1.51 ± 0.03 [2]



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For Examiner's Use

(iv) Determine the y-intercept of the line of best fit. Include the uncertainty in your answer.

y-intercept of best fit line:

$y = mx + c$

$4.5 = 1.51(8.18) + c$

$c = -7.9$

y-intercept of worst acceptable line:

$y = mx + c$

$4.5 = 1.48(8.16) + c$

$c = -7.6$

$\Delta c = 7.9 - 7.6 = 0.3$

y-intercept = -7.9 ± 0.3 [2]

(d) The constant k is given by

$$k = \frac{4\pi^2}{GM}$$

where the universal gravitational constant $G = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$ and M is the mass of Jupiter.

(i) Using your answer to **(c)(iv)**, determine the value of k. Include the uncertainty in your answer.

$y\text{-intercept} = \frac{\lg k}{2}$

$k = 10^{2 \times y\text{-intercept}}$

$k = 10^{2\times(-7.9)}$

$k = 1.6 \times 10^{-16}$

$\Delta k = 10^{2 \times y\text{-intercept(max)}} - 10^{2 \times y\text{-intercept}}$

$= 10^{(2\times -8.2)} - 10^{(2\times -7.9)}$

$= 1.1 \times 10^{-16}$

$k = (1.6 \pm 1.1) \times 10^{-16}$ $\mathrm{kg\,N^{-1}\,m^{-2}}$ [2]

(ii) Determine the value of M.

$M = \frac{4\pi^2}{G \times k}$

$M = \frac{4\pi^2}{6.67\times10^{-11} \times 1.6 \times 10^{-16}}$

$M = 3.7 \times 10^{27}\,\mathrm{kg}$

$M = 3.7 \times 10^{27}$ kg [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2011**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

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1 A changing e.m.f. in a coil can induce an e.m.f. in another coil.

Fig. 1.1 shows a coil (coil X), which is wound on a cardboard tube.

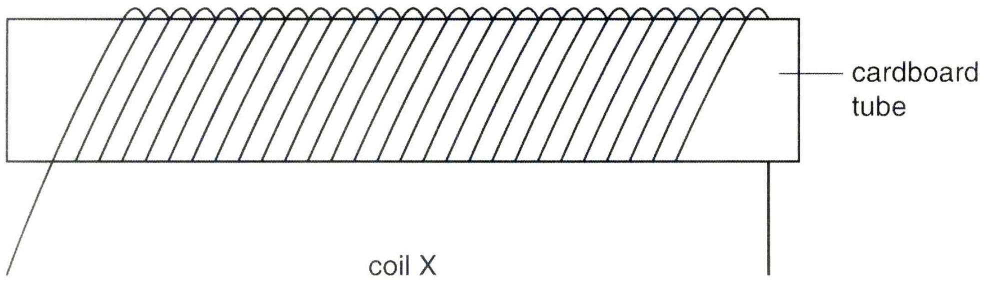

Fig. 1.1

Coil X has cross-sectional area *A*.

A student winds another coil (coil Y) tightly around coil X. The student wishes to investigate how the e.m.f. *V* in coil Y depends on *A*.

It is suggested that *V* is directly proportional to *A*.

Design a laboratory experiment to investigate the suggested relationship. You should draw, on page 3, a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

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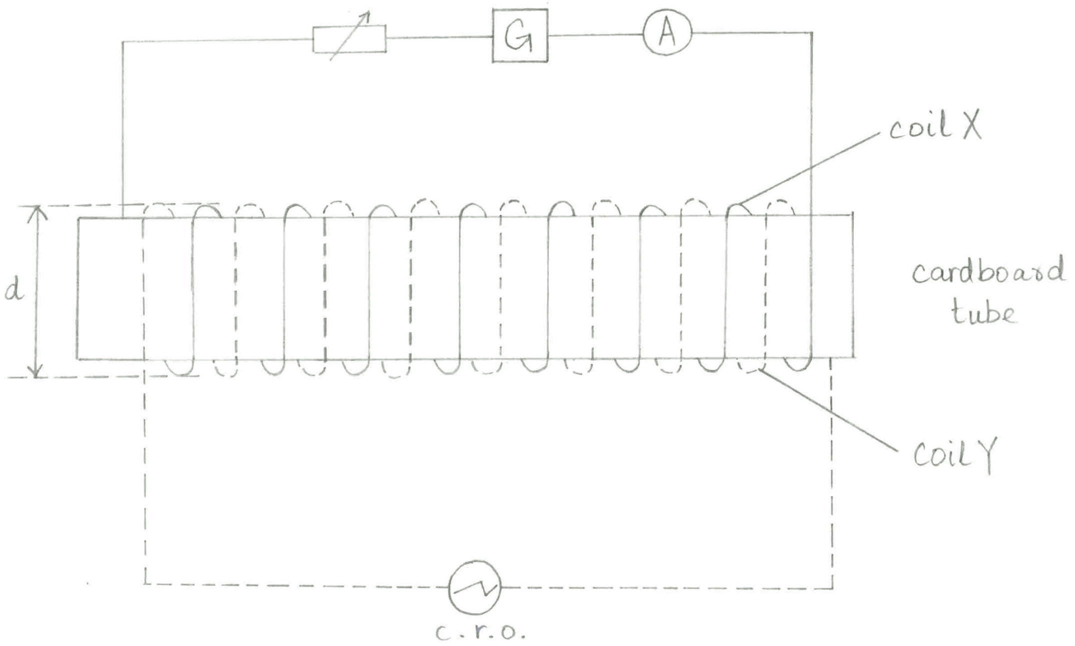

Defining the problem:

Independent variable: Cross-sectional area A

Dependent variable: e.m.f. V

Constant: Current in coil X.

Procedure:

Measure the diameter d of coil X with vernier calipers. Calculate the cross-sectional area A by using the relationship, $A = \pi(d/2)^2$. Measure the e.m.f. V generated in coil Y from c.r.o. V can be calculated from the relationship, V = height x y-gain on c.r.o. Adjust variable resistor to ensure current in coil X is constant. Repeat the experiment with coils of different cross-sectional area A to obtain

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at least six sets of readings. Record the result in given table.

Tabulation:

Number of observation	d/m	A/m²	V/V	

Analysis of data:

Plot a graph of V against A. The suggested relationship is valid if graph is a straight line through the origin.

Safety Precaution:

Wear gloves to prevent burns from hot coils.

Additional details:

1- Use large number of turns and large current in coil X to produce measure V.

2. Keep the frequency of the power supply constant.

3. Measure diameter d of the coil from different positions and take average.

4. Avoid external alternating magnetic fields, because they can effect the value of V.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

2 A student is investigating how a mass attached to a trolley affects the motion of the trolley.

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The trolley is attached to a mass *m* by a string, passing over a pulley, as shown in Fig. 2.1.

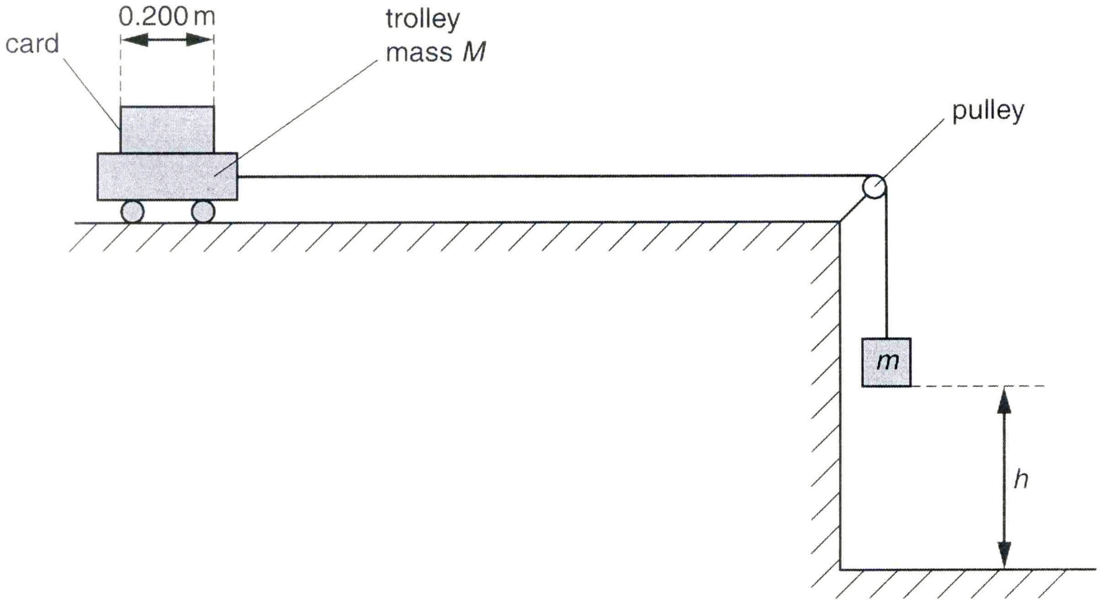


Fig. 2.1

A piece of card of length 0.200 m is fixed to the trolley. The mass *M* of the trolley and card is 0.800 kg.

The mass *m* is released and falls through a fixed height *h*, accelerating the trolley. When the mass *m* hits the ground, the trolley continues to move with constant velocity *v*.

This velocity *v* is determined by measuring the time *t* for the card to pass fully through a light gate connected to a timer.

Question 2 continues on the next page.

It is suggested that v and m are related by the equation

$$mg = (m + M)\frac{v^2}{2h}$$

where g is the acceleration of free fall.

(a) A graph is plotted of v^2 on the y-axis against $\frac{m}{m+M}$ on the x-axis. Express the gradient in terms of g.

$$v^2 = 2gh\left[\frac{m}{m+M}\right]$$

gradient = $2gh$ [1]

(b) Values of m and t are given in Fig. 2.2.

m / kg	t / 10^{-3} s	$\frac{m}{m+M}$	v / m s^{-1}	v^2 / m^2 s^{-2}
0.100	174 ± 2	0.111	1.15	1.32 ± 0.03
0.200	132 ± 2	0.200	1.52	2.31 ± 0.07
0.300	112 ± 2	0.272	1.79	3.19 ± 0.11
0.400	102 ± 2	0.333	1.96	3.84 ± 0.15
0.500	95 ± 2	0.385	2.11	4.43 ± 0.19
0.600	90 ± 2	0.429	2.22	4.94 ± 0.22

Fig. 2.2

Calculate and record values of $\frac{m}{m+M}$, v and v^2 in Fig. 2.2. Include the absolute uncertainties in v^2. [3]

(c) **(i)** Plot a graph of v^2/m^{2}s^{-2} against $\frac{m}{m+M}$. Include error bars for v^2. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit line:

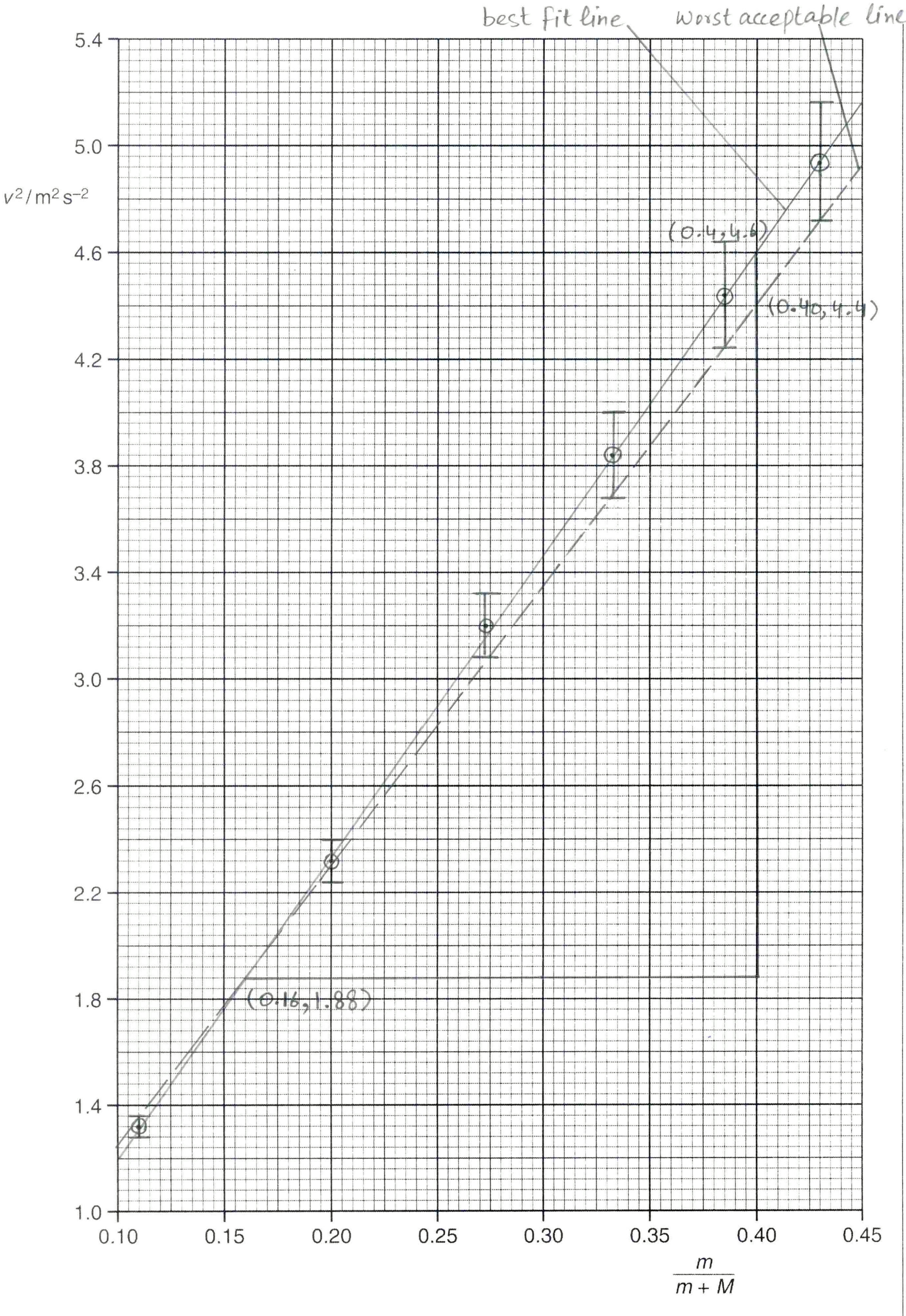
$$\text{gradient} = \frac{4.6 - 1.88}{0.40 - 0.16} = 11.3$$

gradient of worst acceptable line:

$$\text{gradient} = \frac{4.4 - 1.88}{0.40 - 0.16} = 10.5$$

$$\Delta\text{gradient} = 11.3 - 10.5 = 0.8$$

gradient = 11.3 ± 0.8 [2]



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(d) In this experiment $h = 0.600\,\text{m}$. Using your answer to **(c)(iii)**, determine the value of g. Include the absolute uncertainty in your value.

For Examiner's Use

gradient = $2gh$

$g = \frac{\text{gradient}}{2h}$

$g = \frac{11.3}{2 \times 0.6}$

$g = 9.4\,\text{ms}^{-2}$

$\frac{\Delta g}{g} = \frac{\Delta\,\text{gradient}}{\text{gradient}}$

$\frac{\Delta g}{9.4} = \frac{0.8}{11.3}$

$\Delta g = 0.7$

$g =$ 9.4 ± 0.7 $\text{m}\,\text{s}^{-2}$ [2]

(e) A 1.00 kg mass is added to the trolley and the experiment is repeated using the same range of values of m as in **(b)**.

Determine the **largest** possible value of v that the trolley will gain, using the relationship given and your answer to **(d)**. Include the absolute uncertainty in your answer.

$v^2 = 2gh\left[\frac{m}{m+M}\right]$, $g = 9.4\,\text{ms}^{-2}$

$h = 0.6\,\text{m}$

$m = 0.6\,\text{kg}$

$M = 0.8 + 1 = 1.8\,\text{kg}$

$v^2 = 2 \times 9.4 \times 0.6\left[\frac{0.6}{0.6+1.8}\right]$

$v^2 = 2.83$

$v = 1.68\,\text{ms}^{-1}$

$v =$ 1.68 ± 0.06 $\text{m}\,\text{s}^{-1}$ [3]

$v = \left(2gh\left[\frac{m}{m+M}\right]\right)^{1/2}$

$\frac{\Delta v}{v} = \frac{1}{2} \times \frac{\Delta g}{g}$

$\frac{\Delta v}{1.68} = \frac{1}{2} \times \frac{0.7}{9.4}$

$\Delta v = 0.06$

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2010**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
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The number of marks is given in brackets [ ] at the end of each question or part question.

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1 A hammer is often used to force a nail into wood. The faster the hammer moves, the deeper the nail moves into the wood.

This can be represented in a laboratory by a mass falling vertically onto a nail.

It is suggested that the depth d of the nail in the wood (see Fig. 1.1) is related to the velocity v of the mass at the instant it hits the nail by the equation

$$d = kv^n$$

where k and n are constants.

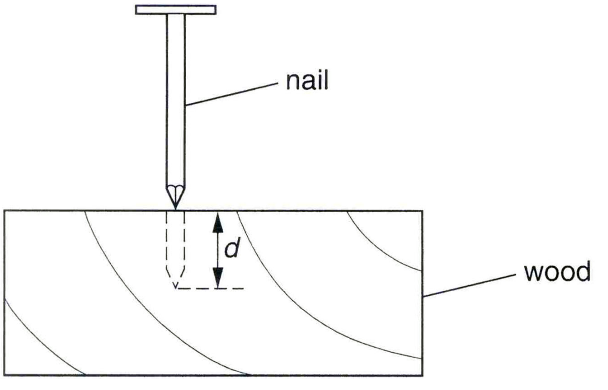


Fig. 1.1

Design a laboratory experiment to investigate the relationship between v and d so as to determine a value for n. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

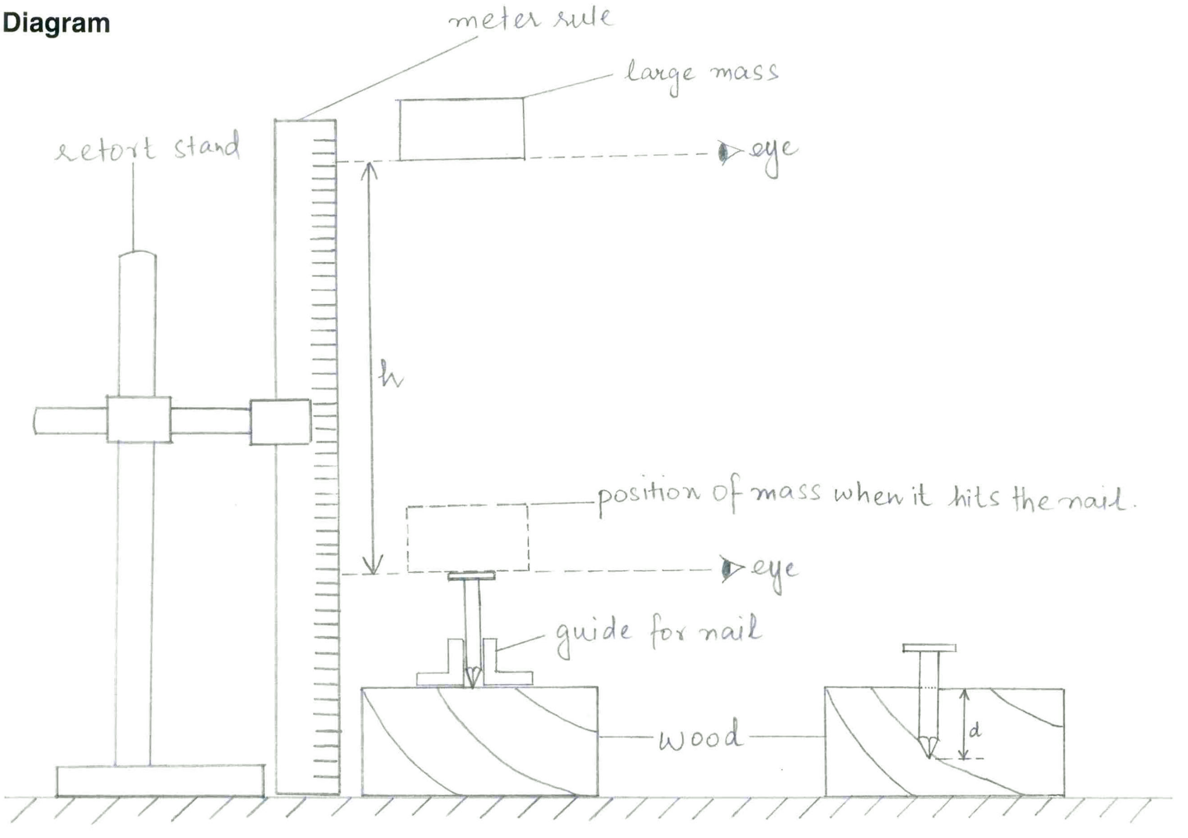
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

For Examiner's Use

Diagram



Defining the problem:
Independent variable: Velocity v
Dependent variable: depth d.
Constant: Mass falling onto the nail.
Procedure:
Hold the mass at height h above the head of the nail. Measure height h from meter rule. Drop the mass from height h. The mass will force the nail into the wood to depth d. Calculate the velocity v of the mass at instant it hits the nail using the equation, $v^2 = 2gh$ where $g = 9.81\ ms^{-2}$. Mark the nail at a point up to which it goes into the wood. Measure the depth d with vernier caliper. Change the height

For Examiner's Use

h to vary v. Repeat the experiment for different values of v to obtain at least six sets of readings. Record the results in the given table.

Tabulation:

Number of observation	h/m	v/ms⁻¹	d/m	lg(v/ms⁻¹)	lg(d/m)

Analysis of data:

$$\lg d = n \lg v + \lg K$$

Plot a graph of lg d against lg v. Graph would be a straight line with gradient n.

gradient = n , y-intercept = lg K

n = gradient.

Safety precaution:

Keep away from the falling mass to prevent injury.

Additional details:

1- Avoid parallax error while measuring the value of h.

2. Repeat the experiment for same value of h and take average of d.

3. Use set square to ensure nail is perfectly vertical.

4. Use large mass and thin nail to produce large d.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 The reactance X_c of a capacitor is defined as

$$X_c = \frac{V_0}{I_0}$$

where V_0 is the peak voltage across the capacitor and I_0 is the peak current through the capacitor.

An experiment is carried out to investigate how the reactance of a capacitor varies with the frequency f of the a.c. supply to the capacitor.

The equipment is set up as shown in Fig. 2.1.

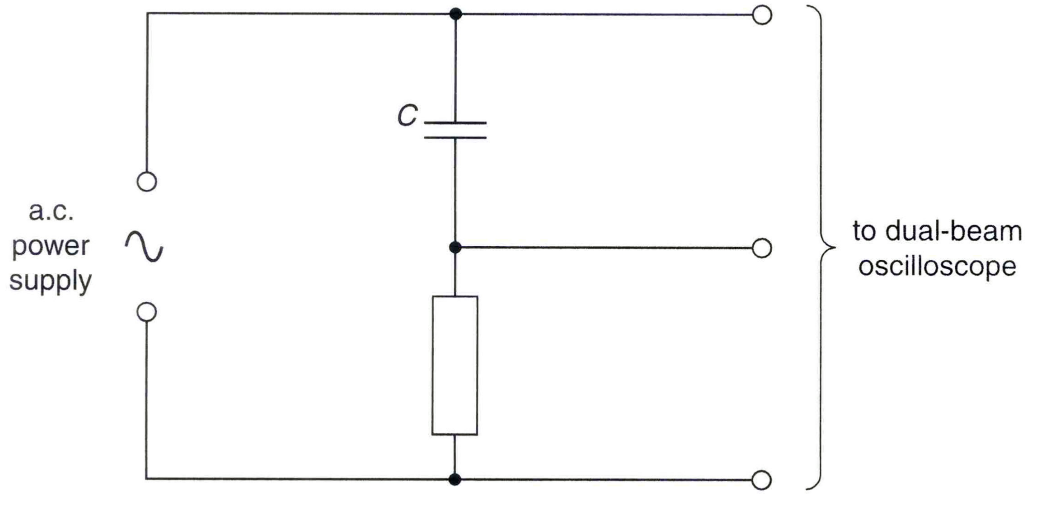


Fig. 2.1

The dual-beam oscilloscope is used to determine values of V_0 and I_0.

Question 2 continues on the next page.

For Examiner's Use

It is suggested that X_c and f are related by the equation

$$X_c = \frac{1}{2\pi f C}$$

where C is the capacitance of the capacitor.

(a) A graph is plotted with X_c on the y-axis and $\frac{1}{f}$ on the x-axis. Express the gradient in terms of C.

$$X_c = \frac{1}{2\pi C}\left[\frac{1}{f}\right]$$

gradient = $1/2\pi C$ [1]

(b) Values of f, V_0 and I_0 are given in Fig. 2.2.

f/Hz	V_0/V	I_0/10^{-3}A	$\frac{1}{f}$/10^{-3}s	X_c/Ω
220	5.0 ± 0.2	15 ± 0.2	4.55	333 ± 18
250	5.0 ± 0.2	17 ± 0.2	4.00	294 ± 15
300	5.0 ± 0.2	21 ± 0.2	3.33	238 ± 12
350	5.0 ± 0.2	24 ± 0.2	2.86	208 ± 10
400	5.0 ± 0.2	28 ± 0.2	2.50	179 ± 8
450	5.0 ± 0.2	31 ± 0.2	2.22	161 ± 7

Fig. 2.2

Calculate and record values of $\frac{1}{f}$ and X_c in Fig. 2.2. Include the absolute uncertainties in X_c. [3]

(c) (i) Plot a graph of X_c/Ω against $\frac{1}{f}$/10^{-3}s. Include error bars for X_c. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit line:

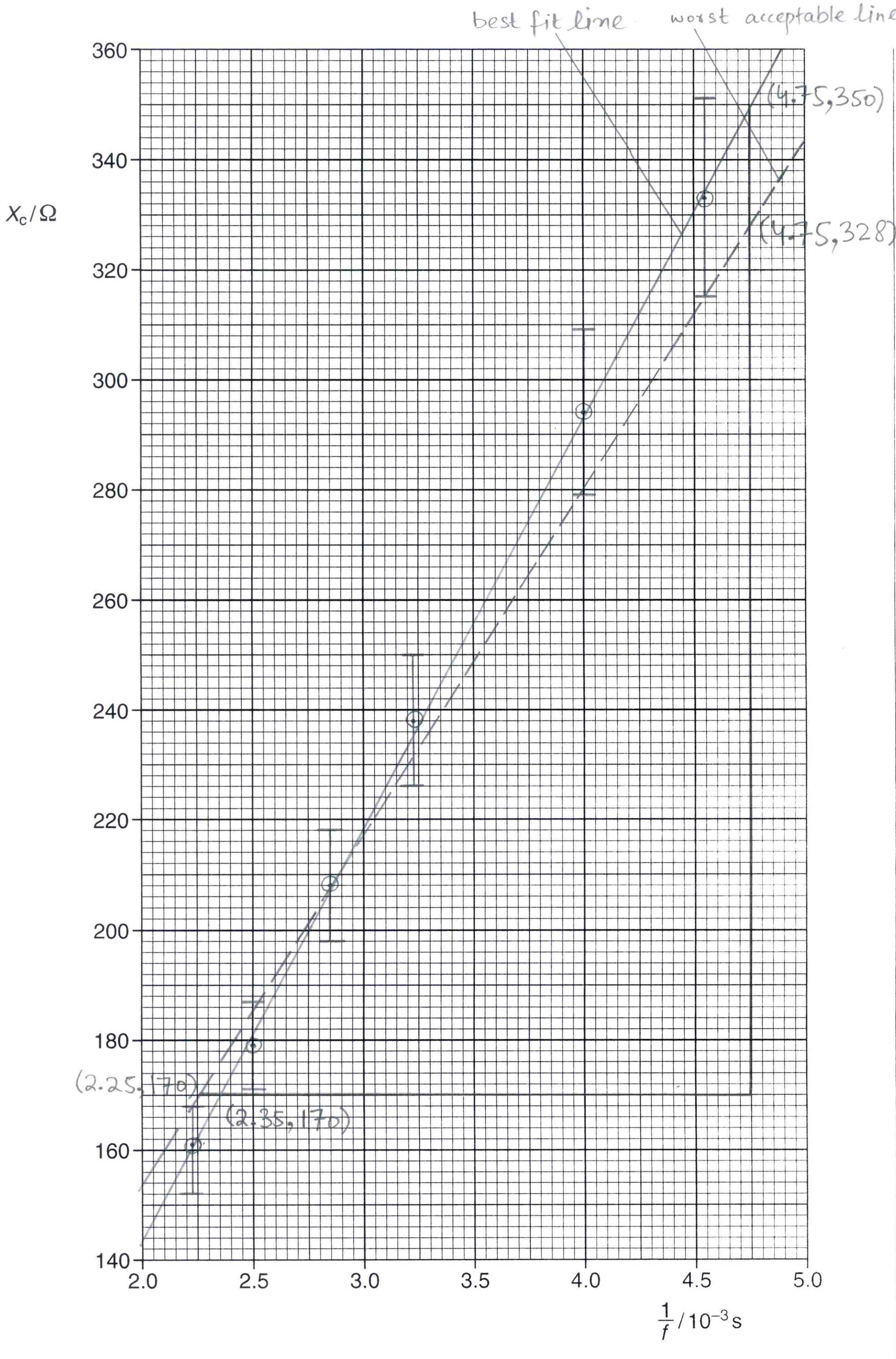
$$\text{gradient} = \frac{350-170}{(4.75-2.35)10^{-3}}$$
$$= 75000$$

gradient of worst acceptable line:

$$\text{gradient} = \frac{328-170}{(4.75-2.25)10^{-3}}$$
$$= 63000$$

$$\Delta\text{gradient} = 75000 - 63000$$
$$= 12000$$

gradient = 75000 ± 12000 [2]



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(d) Using your answer to **(c)(iii)**, determine the value of *C*. Include the absolute uncertainty in your value and an appropriate unit.

For Examiner's Use

From best fit line:

gradient = $1/2\pi C$

$C = 1/2\pi \times \text{gradient}$

$C = \dfrac{1}{2\pi \times 75000} = 2.1 \times 10^{-6}$

From worst acceptable line:

$C = \dfrac{1}{2\pi \times \text{gradient}}$

$C = \dfrac{1}{2\pi \times 63000} = 2.5 \times 10^{-6}$

$\Delta C = (2.5 - 2.1) \times 10^{-6} = 0.4 \times 10^{-6}$

C = $(2.1 \pm 0.4) \times 10^{-6}$ F [3]

(e) The time constant τ is defined as $\tau = CR$ where *R* is the total resistance of the circuit.

(i) *C* is placed in a circuit with total resistance 220 kΩ. Determine the value of τ.

$\tau = CR$

$= (2.1 \times 10^{-6}) \times (220 \times 10^{3})$

$= 0.46$

τ = 0.46 s [1]

(ii) The percentage uncertainty in the total resistance of the circuit is ±10%. Determine the percentage uncertainty in τ.

$\tau = CR$

$\dfrac{\Delta\tau}{\tau} \times 100 = \left[\dfrac{\Delta C}{C} \times 100\right] + \left[\dfrac{\Delta R}{R} \times 100\right]$

$= \left[\dfrac{0.4 \times 10^{-6}}{2.1 \times 10^{-6}} \times 100\right] + 10\% = 29\%$

percentage uncertainty = 29 % [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0043403827

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2010**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

For Examiner's Use

1 A current in a flat circular coil produces a magnetic field.

A student suggests that the strength B of the magnetic field is related to the distance x from the centre of the coil (see Fig. 1.1) by the equation

$$B = B_0 e^{-px}$$

where B_0 is the strength of the magnetic field for $x = 0$, and p is a constant.

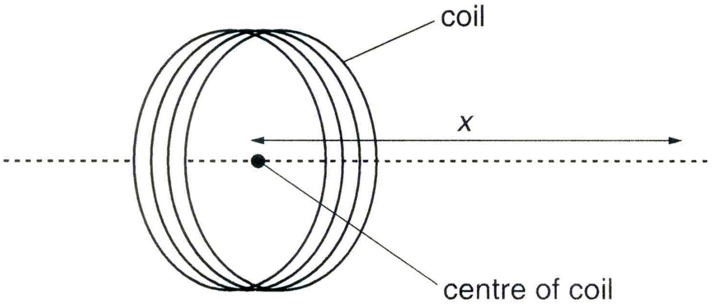


Fig. 1.1

Design a laboratory experiment that uses a Hall probe to investigate the relationship between B and x. You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

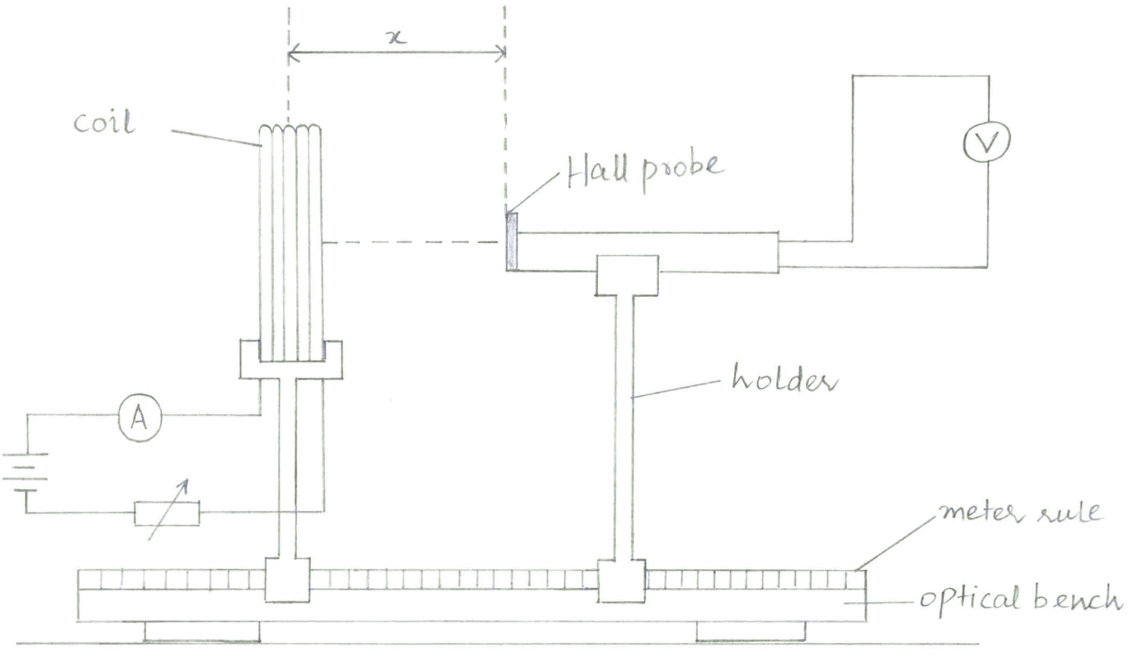
(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

For Examiner's Use



Defining the problem:

Independent variable: Distance x

Dependent variable: Strength of the magnetic field, B

Constant: Current in the coil

Procedure:

Measure distance x using meter rule. Calibrate the Hall probe using known magnetic field strength. Adjust the Hall probe perpendicular to magnetic field's direction to obtain maximum voltmeter reading. Measure the voltmeter reading. Work out the strength B of magnetic field. Place the Hall probe at the center of the coil ($x = 0$) and measure B_o using Hall

For Examiner's Use

probe. Perform the experiment at five more different values of x. Record the data in a given table.

Tabulation:-

Number of observation	x/m	V/V	B/T	ln(B/T)

Analysis of data:

$$\ln B = -px + \ln B_0$$

Plot a graph of ln B against x. The relationship is valid if graph is a straight line.

Safety precaution:

Wear safety gloves to prevent burns from hot coil.

Additional details:

1- Use large current and large number of turns to produce large B.

2- Use set square to keep Hall probe in same orientation throughout the experiment.

3- Avoid parallax error while measuring the value of x.

4- Repeat the experiment with Hall probe reversed and find average values of B for each distance x.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A student is investigating how the period T of a simple pendulum depends on its length l as shown in Fig. 2.1.

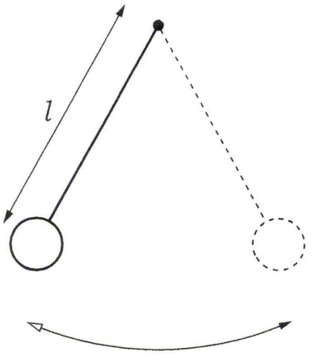


Fig. 2.1

The time t for 10 oscillations is recorded for a pendulum of length l. The period T of the pendulum is determined. The procedure is then repeated for different lengths.

Question 2 continues on the next page.

For Examiner's Use

It is suggested that T and l are related by the equation

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where g is the acceleration of free fall.

(a) A graph is plotted of T^2 on the y-axis against l on the x-axis. Express the gradient in terms of g.

$$T^2 = \frac{4\pi^2}{g}(l)$$

gradient = $4\pi^2/g$ [1]

(b) Values of l and t are given in Fig. 2.2.

l / cm	t / s	T/s	T^2/s^2
90.0	18.9 ± 0.1	1.89	3.57 ± 0.04
80.0	17.9 ± 0.1	1.79	3.20 ± 0.04
70.0	16.7 ± 0.1	1.67	2.79 ± 0.03
60.0	15.5 ± 0.1	1.55	2.40 ± 0.03
50.0	14.1 ± 0.1	1.41	1.99 ± 0.03
40.0	12.6 ± 0.1	1.26	1.59 ± 0.03

Fig. 2.2

Calculate and record values of T and T^2 in Fig. 2.2. Include the absolute uncertainties in T^2. [3]

(c) **(i)** Plot a graph of T^2 / s^2 against l / cm. Include error bars for T^2. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

Gradient of best fit line:

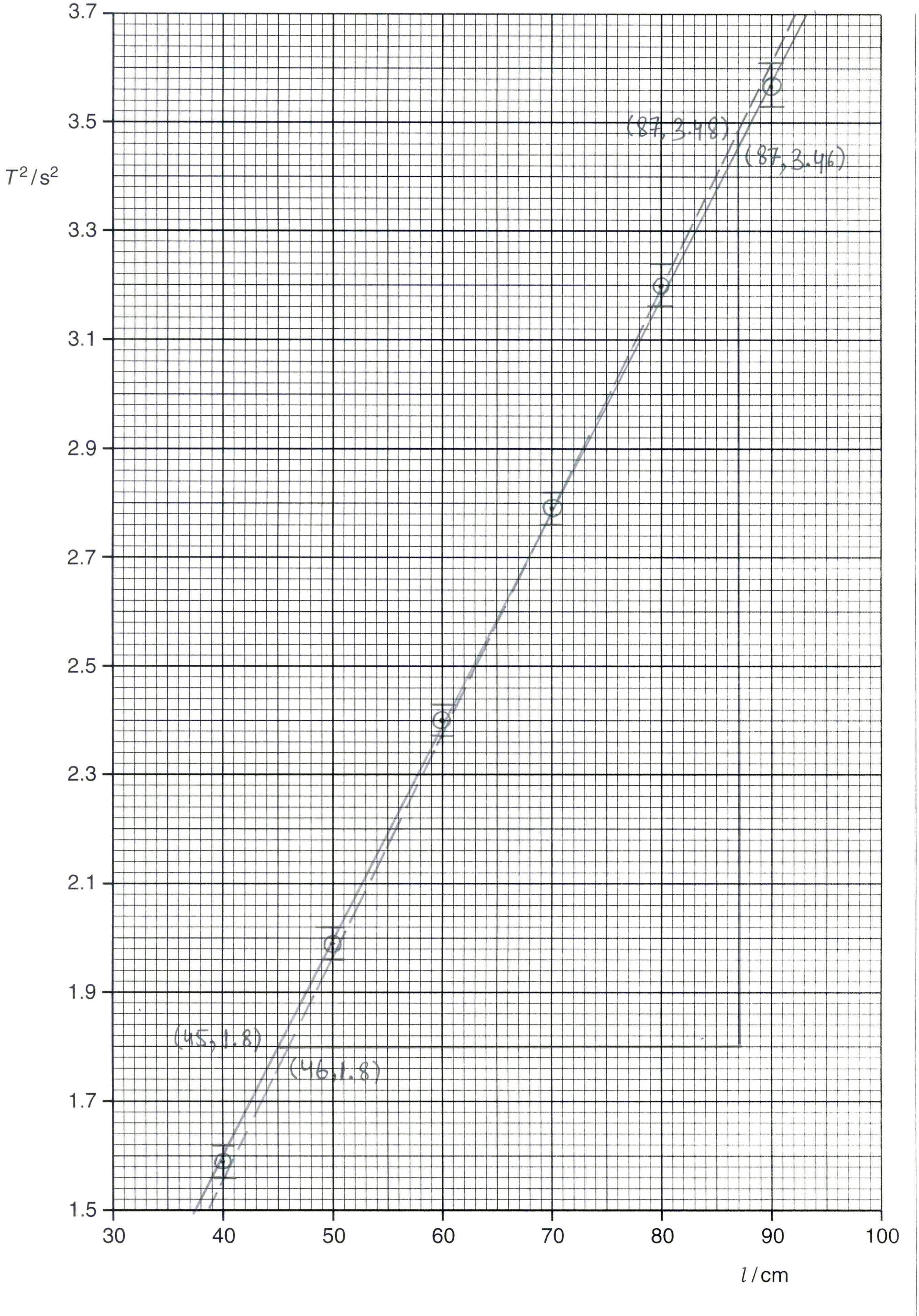
$$\text{gradient} = \frac{3.46 - 1.8}{87 - 45} = 0.040$$

Gradient of worst acceptable line:

$$\text{gradient} = \frac{3.48 - 1.8}{87 - 46} = 0.041$$

gradient = 0.040 ± 0.001 [2]

$$\Delta\,\text{gradient} = 0.041 - 0.040 = 0.001$$



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(d) Using your answer to **(c)(iii)**, determine the value of *g*. Include the absolute uncertainty in your value and an appropriate unit.

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$$\text{gradient} = 4\pi^2/g$$

$$g = \frac{4\pi^2}{\text{gradient}}$$

$$g = \frac{4\pi^2}{0.040}$$

$$g = 987$$

$$\frac{\Delta g}{g} = \frac{\Delta\text{gradient}}{\text{gradient}}$$

$$\frac{\Delta g}{987} = \frac{0.001}{0.040}$$

$$\Delta g = 25 = 30 \text{ (1 s.f.)}$$

g = 990 ± 30 cm s^{-2} [3]

(e) **(i)** Using your answer to **(d)**, determine the value of *l* that is required to give a period of 1.0 s.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$l = \frac{Tg}{4\pi^2}$$

$$l = \frac{1 \times 990}{4\pi^2}$$

$$l = 25.1 \text{ cm}$$

l = 25.1 cm [1]

(ii) Determine the percentage uncertainty in your value of *l*.

$$l = Tg/4\pi^2$$

$$\frac{\Delta l}{l} \times 100 = \left[\frac{\Delta T}{T} \times 100\right] + \left[\frac{\Delta g}{g} \times 100\right]$$

$$= \left[\frac{0.01}{1} \times 100\right] + \left[\frac{30}{990} \times 100\right]$$

$$= 4\%$$

percentage uncertainty = 4 % [1]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0893553513

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2010**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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2	
Total	

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[Turn over

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1 Fig. 1.1 shows a coil (coil X).

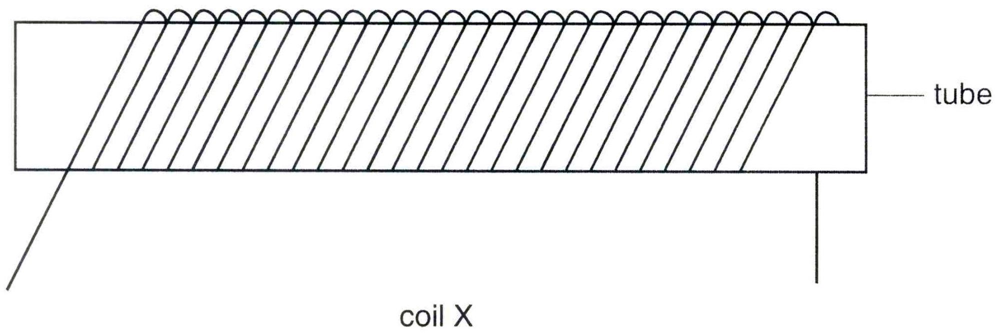

Fig. 1.1

A student winds another coil (coil Y) tightly around coil X.

A changing e.m.f. in coil X induces an e.m.f. in coil Y.

The student wishes to investigate how the e.m.f. *V* in coil Y depends on the frequency *f* of the current in coil X.

It is suggested that *V* is directly proportional to *f*.

Design a laboratory experiment to investigate the suggested relationship. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

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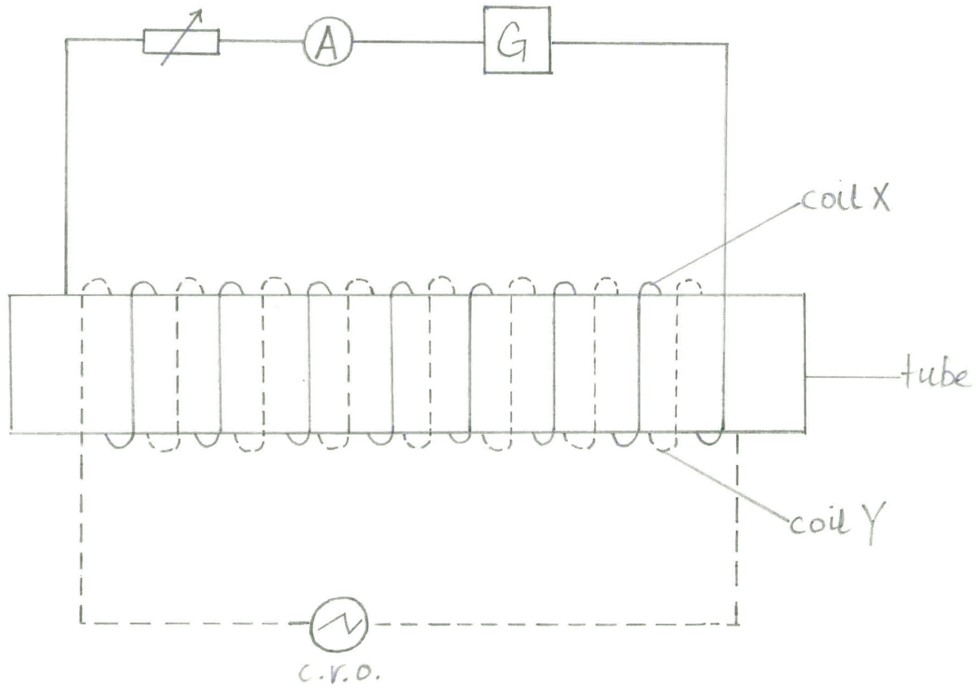

Defining the problem:

Independent variable: Frequency f

Dependent variable: e.m.f. V

Constant: Number of turns on coil Y.

Procedure:

Measure the frequency f of the current in coil X by reading off value from signal generator. Measure the induced e.m.f. V in coil Y from c.r.o. V= height x y-gain on c.r.o. Adjust variable resistor to keep current constant in coil X. Repeat the experiment for different values of frequency f until you have at least six sets of readings. Record the results in given table.

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Tabulation:

Number of Observation	f/Hz	V_1/V	V_2/V	V/V

Analysis of data:
Plot a graph to V against f. The given relationship is valid if graph is a straight line through origin.

Safety Precaution:
Wear gloves to prevent burns from hot coil.

Additional details:
1- Use large current and large number of turns for both coils to increase V.
2. Keep coil X and coil Y at same relative positions throughout the experiment.
3. Use iron core to increase induced e.m.f. V.
4. Use insulated wire for coils.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A student is investigating how the period T of a simple pendulum depends on its length l, as shown in Fig. 2.1.

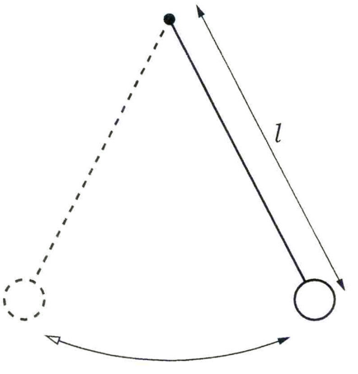


Fig. 2.1

The time t for 10 oscillations is recorded for a pendulum of length l. The period T of the pendulum is determined. The procedure is then repeated for different lengths.

Question 2 continues on the next page.

$$T = al^b$$

where a and b are constants.

(a) A graph is plotted of lg T on the y-axis and lg l on the x-axis. Determine expressions for the gradient and y-intercept in terms of a and b.

$T = a l^b$

$\lg T = \lg a + b \lg l$

$\lg T = b \lg l + \lg a$

gradient = b

y-intercept = $\lg a$ [1]

(b) Values of l and t are given in Fig. 2.2.

l / cm	t / s	T / s	lg (l / cm)	lg (T / s)
95.0	19.6 ± 0.2	1.96	1.978	0.292 ± 0.009
85.0	18.4 ± 0.2	1.84	1.929	0.265 ± 0.009
75.0	17.4 ± 0.2	1.74	1.875	0.241 ± 0.010
65.0	16.2 ± 0.2	1.62	1.813	0.210 ± 0.011
55.0	14.8 ± 0.2	1.48	1.740	0.170 ± 0.012
45.0	13.4 ± 0.2	1.34	1.653	0.127 ± 0.013

Fig. 2.2

Calculate and record values of T / s, lg (l / cm) and lg (T / s) in Fig. 2.2. Include the absolute uncertainties in lg (T / s). [3]

(c) **(i)** Plot a graph of lg (T / s) against lg (l / cm). Include error bars for lg (T / s). [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

Gradient of best fit line:

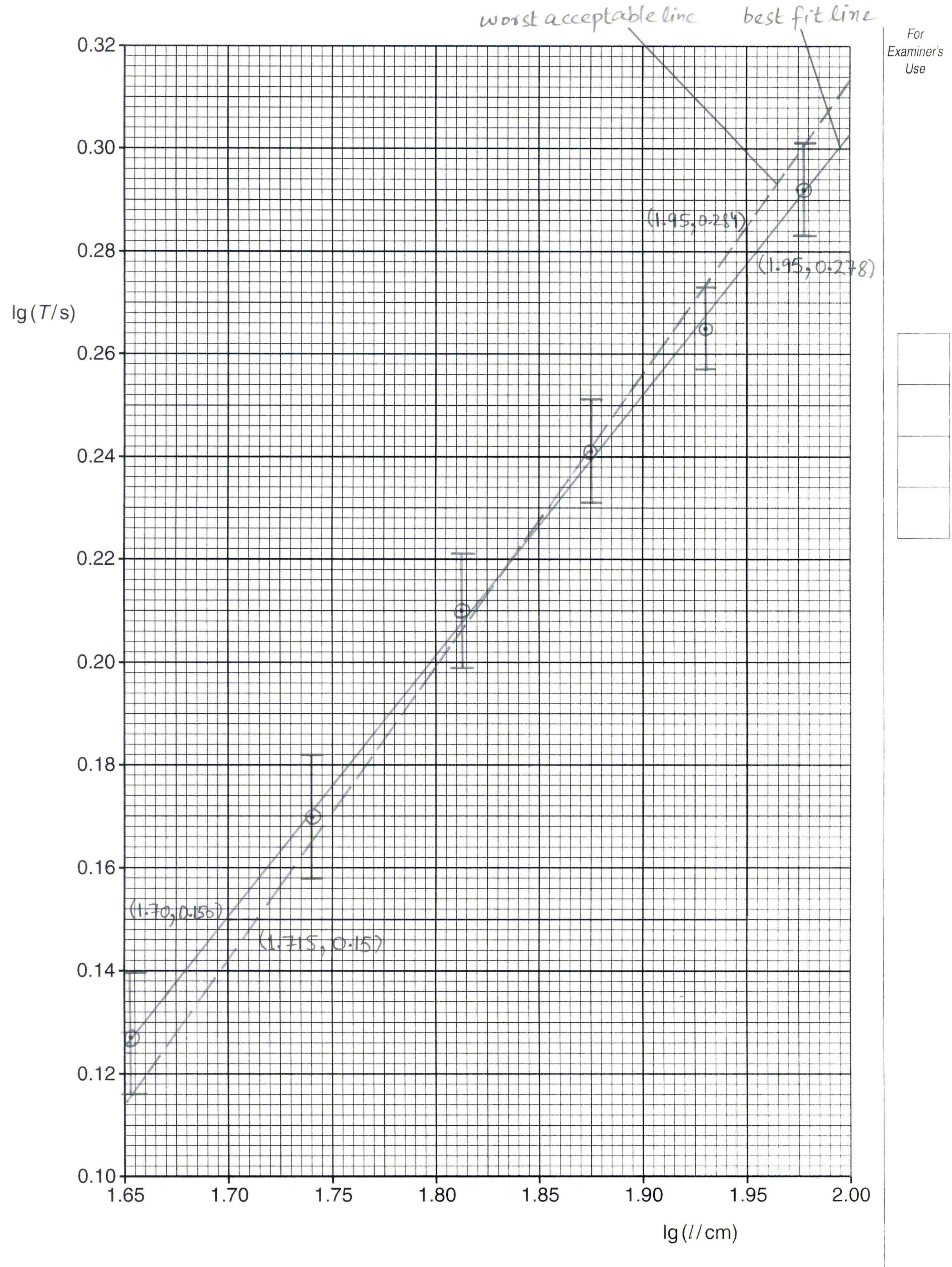
$$\text{gradient} = \frac{0.278 - 0.15}{1.95 - 1.70} = 0.51$$

Gradient of worst acceptable line:

$$\text{gradient} = \frac{0.284 - 0.15}{1.95 - 1.715} = 0.57$$

$$\Delta\text{gradient} = 0.57 - 0.51 = 0.06$$

gradient = 0.51 ± 0.06 [2]



worst acceptable line
best fit line
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0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
lg (T/s)
(1.95, 0.284)
(1.95, 0.278)
(1.70, 0.150)
(1.715, 0.15)
1.65
1.70
1.75
1.80
1.85
1.90
1.95
2.00
lg (l/cm)

(iv) Determine the y-intercept of the line of best fit. Include the uncertainty in your answer.

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y-intercept of best fit line:

$y = mx + c$

$0.15 = 0.51(1.7) + c$

$c = 0.72$

y-intercept of worst acceptable line:

$y = mx + c$

$0.15 = 0.57(1.715) + c$

$c = 0.83$

$\Delta c = 0.83 - 0.72 = 0.11$

y-intercept = 0.72 ± 0.11 [2]

(d) Using your answers to **(c)(iii)** and **(c)(iv)**, determine values for a and b. Include the uncertainties in your answers. You need not be concerned with the units of a and b.

$\lg a = y\text{-intercept}$

$\lg a = 0.72$

$a = 10^{0.72}$

$a = 5.2$

$b = \text{gradient} = 0.51$

$\Delta b = \Delta\text{gradient} = 0.06$

$\Delta a = 10^{y\text{-intercept}} - 10^{y\text{-intercept(min)}}$

$= 10^{0.72} - 10^{0.61}$

$= 1.2$

$a = 5.2 \pm 1.2$

$b = 0.51 \pm 0.06$

[3]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0672696684

PHYSICS **9702/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2010**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
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Total	

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DC (KN/SW) 21449/3

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

1 A student wishes to determine the resistivity of aluminium.

The resistivity ρ of a conductor is defined as

$$\rho = \frac{RA}{l}$$

for a conductor of resistance R, cross-sectional area A and length l.

Fig. 1.1 shows the typical dimensions of a strip of aluminium of lengths c, d and t. The resistivity of aluminium is about $10^{-8}\,\Omega$m.

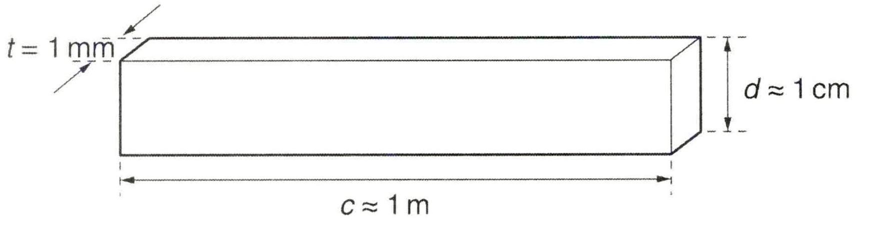

Fig. 1.1 (not to scale)

Design a laboratory experiment to determine the resistivity of aluminium using this strip. The usual apparatus of a school laboratory is available, including a metal cutter.

You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

[15]

Diagram

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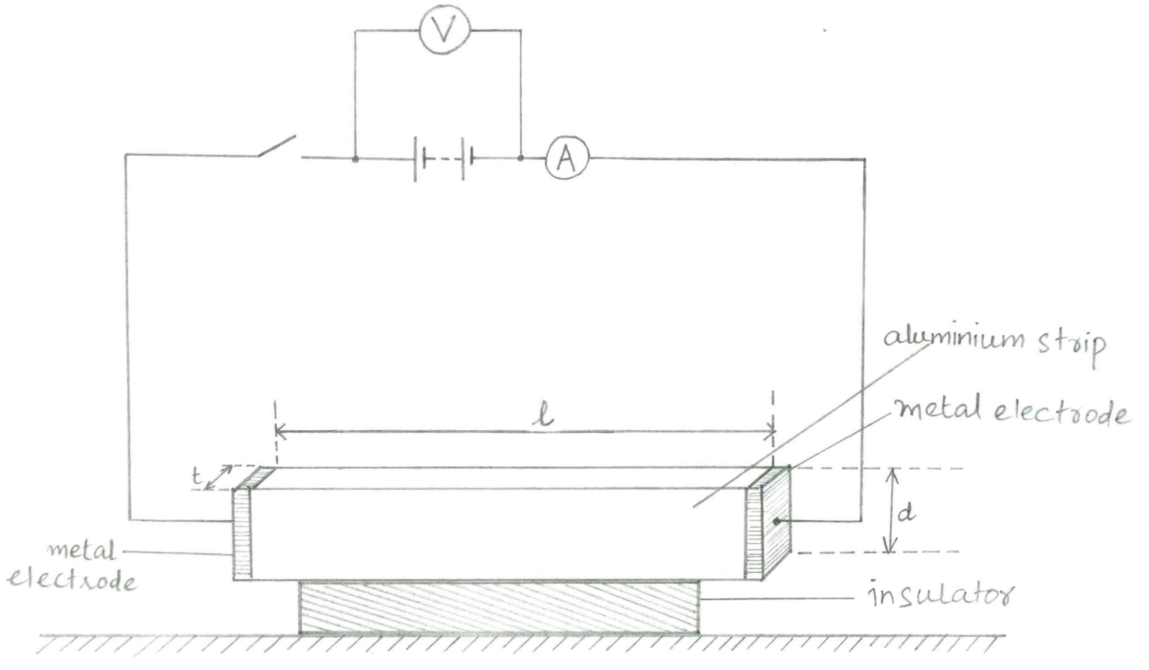

Defining the problem:

Independent variable: Length l

Dependent variable: Resistance

Constant: t, d and temperature.

Procedure:

Cut the 1 meter long aluminium strip into several smaller strips of different lengths l using metal cutter. Measure the length l of each strip with meter rule. Measure the dimensions d and t with micrometer screw guage. Calculate the cross-sectional area A using the relationship, A = d x t. Connect the small aluminium strip in the orientation shown in the diagram. Measure the voltage V from voltmeter and current I in the

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metal strip from ammeter. Calculate the resistance R of metal strip, using the relationship, R = V/I. Perform the experiment using aluminium strips of different lengths l. Record the data in a given table.

Tabulation:

Number of observation	l/m	V/V	I/A	R/Ω	

Analysis of data: $R = \frac{\rho}{A}[l]$

Plot a graph of R against l. Graph will be a Straight line through origin.

gradient = ρ/A.

ρ = gradient × A.

Safety Precaution: Wear gloves to avoid cuts from sharp edges of metal strip.

Additional details:

1- Measure d and t from several different positions and take the average.

2. Use electrodes and connecting wires of very low resistance.

3- Connect variable resistor in series to reduce (control) current and hence reduce heating effect.

4. Use more sensitive voltmeter and ammeter to measure current and voltage accurately.

For Examiner's Use	Defining the problem	Methods of data collection	Method of analysis	Safety considerations	Additional detail

For Examiner's Use

2 A student is investigating how the discharge of a capacitor through a resistor depends on the resistance of the resistor.

The equipment is set up as shown in Fig. 2.1.

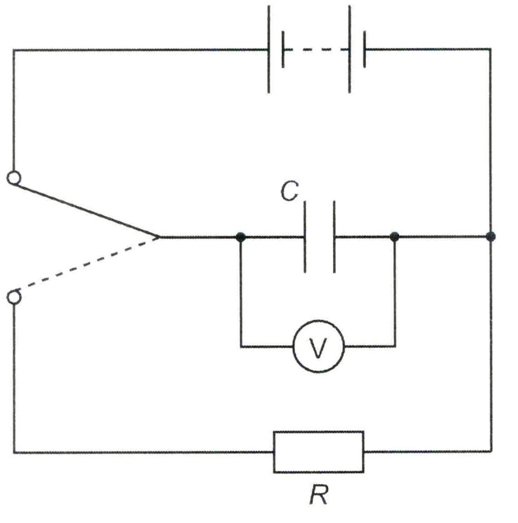

Fig. 2.1

The student charges the capacitor of capacitance *C* and then discharges it through a resistor of resistance *R*. After 15.0 s the student records the potential difference *V* across the capacitor. The student repeats this procedure for different values of *R*.

Question 2 continues on the next page.

It is suggested that V and R are related by the equation

$$V = V_0 e^{-\frac{t}{CR}}$$

where V_0 is the initial potential difference across the capacitor and t is the time over which the capacitor has discharged.

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(a) A graph is plotted of ln V on the y-axis against $\frac{1}{R}$ on the x-axis. Express the gradient in terms of C.

$\ln V = \ln V_0 + e^{-t/CR}$

$\ln V = -\frac{t}{C}\left[\frac{1}{R}\right] + \ln V_0$

gradient = $-t/C$ [1]

(b) Values of R and V for t = 15.0 s are given in Fig. 2.2.

R/kΩ	V/V	$\frac{1}{R}$/10^{-6} Ω^{-1}	ln (V/V)
6.67	3.6 ± 0.2	150	1.28 ± 0.06
10.0	5.0 ± 0.2	100	1.61 ± 0.04
15.0	6.4 ± 0.2	66.6	1.86 ± 0.03
20.0	7.2 ± 0.2	50.0	1.97 ± 0.03
30.0	8.0 ± 0.2	33.3	2.08 ± 0.03

Fig. 2.2

Calculate and record values of $\frac{1}{R}$/10^{-6} Ω^{-1} and ln (V/V) in Fig. 2.2. Include the absolute uncertainties in ln (V/V). [3]

(c) (i) Plot a graph of ln (V/V) against $\frac{1}{R}$/10^{-6} Ω^{-1}. Include error bars for ln (V/V). [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient of best fit line:

gradient = $\frac{1.91 - 1.3}{(58-148)10^{-6}}$

= -6800

gradient of worst acceptable line:

gradient = $\frac{1.95 - 1.3}{(58-144)10^{-6}}$

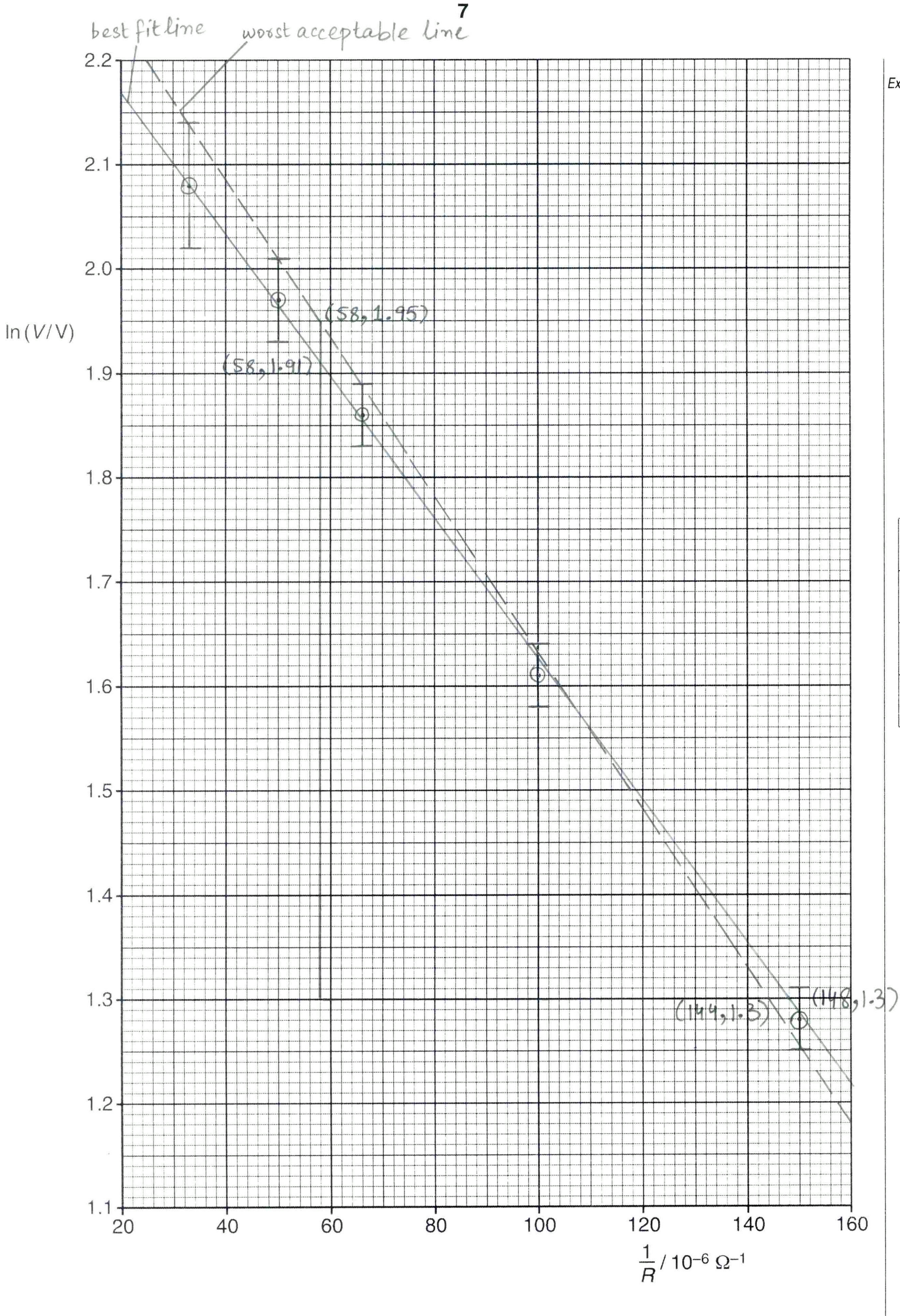
= -7600

Δ gradient = 7600 − 6800

= 800

gradient = -6800 ± 800 [2]

7



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(d) (i) Using your answer to **(c)(iii)**, determine the value of *C*. Include an appropriate unit.

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$t = 15\,s$

$\text{gradient} = -\frac{t}{C}$

units: F

$C = \frac{-t}{\text{gradient}}$

$C = \frac{15}{6800}$

$C = 2.21 \times 10^{-3}$

C = 2.21×10^{-3} F [2]

(ii) Determine the percentage uncertainty in your value of *C*.

$C = -t/\text{gradient}$

$\frac{\Delta C}{C} \times 100 = \frac{\Delta \text{gradient}}{\text{gradient}} \times 100 = \frac{800}{6800} \times 100 = 12\%$

percentage uncertainty = 12 % [1]

(e) Determine the value of *R* for which the capacitor will discharge to 10% of its original potential difference in 15.0 s. Include the absolute uncertainty in your answer.

$V = \frac{V_0}{10}$

$V = V_0 e^{-t/CR}$

$\frac{V_0}{10} = V_0 e^{-t/CR}$

$\ln 0.1 = -\frac{t}{CR}$

$\ln 0.1 = -\frac{15}{(2.21 \times 10^{-3})R}$

$R = 2900\,\Omega$

$\frac{\Delta R}{R} = \frac{\Delta C}{C} = \frac{\Delta \text{gradient}}{\text{gradient}}$

$\frac{\Delta R}{2900} = \frac{800}{7800}$

$\Delta R = 300$

R = 2900 ± 300 Ω [2]