Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME: Solved Papers

CENTRE NUMBER

CANDIDATE NUMBER

8119336502

PHYSICS **9702/52**

Paper 5 Planning, Analysis and Evaluation **February/March 2020**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **8** pages. Blank pages are indicated.

1 Fig. 1.1 shows a bar magnet attached to a spring.

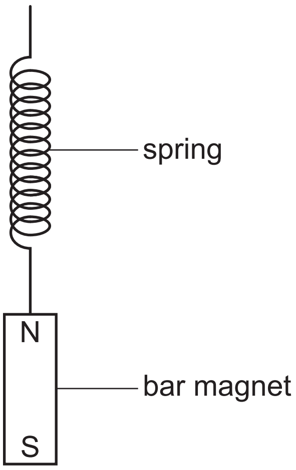


Fig. 1.1

The bar magnet is displaced a distance x from its equilibrium position and released. It then oscillates vertically.

A student investigates how the maximum induced electromotive force (e.m.f.) E in a coil placed below the magnet depends on x.

It is suggested that the relationship between E and x is

$$E = \alpha BNx\sqrt{\frac{k}{m}}$$

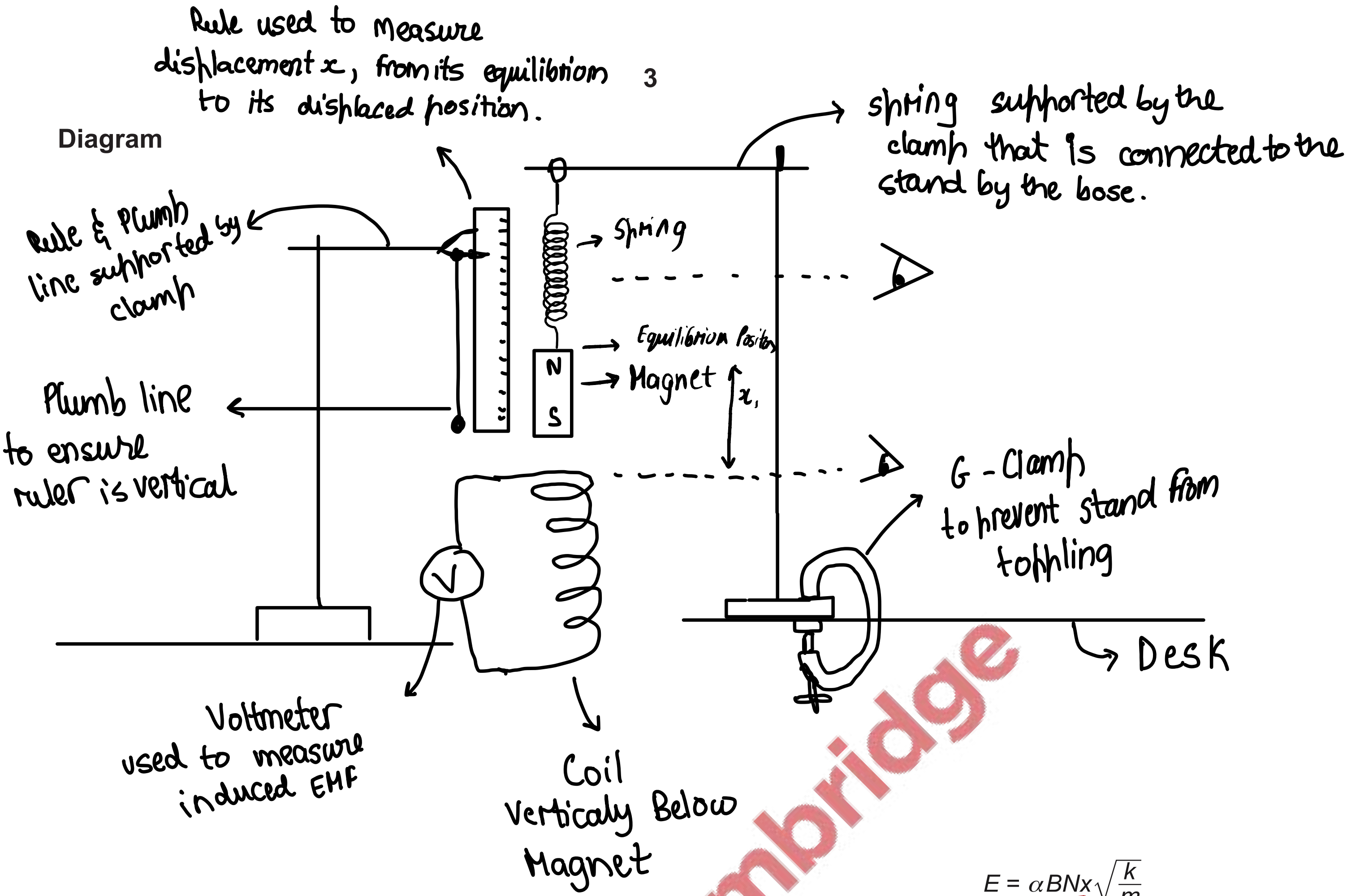
where B is the magnetic flux density at one of the poles of the bar magnet, N is the number of turns on the coil, k is the spring constant, m is the mass of the magnet and α is a constant.

Design a laboratory experiment to test the relationship between E and x.
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:

- 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.

Diagram



$$E = \alpha BNx\sqrt{\frac{k}{m}}$$

Defining the Problem:

Independent Variable : x, the displacement is the independant variable

Dependant Variable : E, induced E.M.F is the dependant variable.

Variables to be kept constant : keep B, N, M and K constant.

Methods of data collection.

- To find E, the induced EMF : Read the voltmeter Reading connected to the coil
- To find x, the displacement : Mark the initial equilibrium position of the magnet when it is staionary and measure is displacement from its equilibrium position using the ruler which is made sure to be vertical via the help of a plumb line. The displacement X will be the diffrence from its displaced position & its Equilibrium position.
- To find M, the mass of the magnet : Use a weighing scale.
- To find N, the number of turns count the number of turns manually.
- To Find B : Use a Hall Probe, and adjust the Probe until maximum value

Method of Analysis:

Plot a graph of E/V (y axis) against x/m (x axis)

The relationship will be valid if a straight line passing through the origin is produced.

$E = \alpha BNx\sqrt{\frac{k}{m}}$

$E = \alpha BN\sqrt{\frac{K}{m}}\,x$ — E → y; $\alpha BN\sqrt{\frac{K}{m}}$ → gradient; x → x

gradient $= \alpha BN\sqrt{\frac{K}{m}}$

$\therefore \alpha = \frac{BN}{\text{gradient}}\sqrt{\frac{m}{K}}$

Additional Details:

- Use safety goggles to prevent injury to eyes from detached spring.
- Use sandbox incase magnet falls
- G-Clamp on stand to prevent it from toppling
- Keep distance from equilibrium position & coil constant
- Check unstreached length of magnet has not changed
- F=kx, to determine determine F (weight of the magnet) use F=ma, and determine k by k = F/x
- B can be measured using a Hall Probe
- Use a vedio camera to determine the max value on the voltmeter, play it back in slow motion & view it to get the max value.
- Repeat the experiment for each x & average E.

[15]

2 A student investigates the discharge of a capacitor through a resistor as shown in Fig. 2.1.

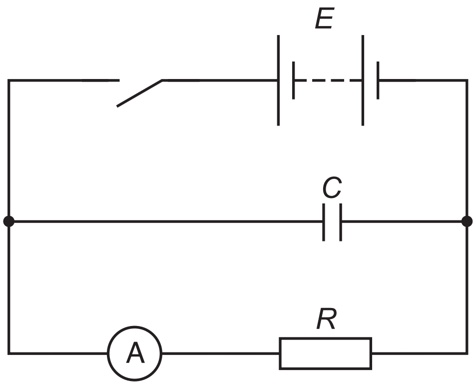


Fig. 2.1

The student initially closes the switch and charges the capacitor. The switch is then opened and a stop-watch is started. The capacitor discharges through the resistor. At different times t the current I is measured.

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

$$I = \frac{E}{R}e^{-\left(\frac{t}{RC}\right)}$$

where E is the e.m.f. of the power supply, C is the capacitance of the capacitor and R is the resistance of the resistor.

(a) A graph is plotted of $\ln I$ on the y-axis against t on the x-axis.

Determine expressions for the gradient and the y-intercept.

$\ln I = \ln(E/R) + \ln(e^{-(t/RC)})$

$\ln I = \frac{-t}{RC} + \ln(E/R)$

$\ln I = t \times -\frac{1}{RC} + \ln(E/R)$

y, x, m, c

gradient = $-1/CR$

y-intercept = $\ln(E/R)$

[1]

(b) Values of t and I are given in Table 2.1.

Table 2.1

Use 3SF for value, 1-2 sf for uncertainity

t/s	I/μA	ln(I/μA)
0	46 ± 2	3.83 ± 0.04
12	40 ± 2	3.69 ± 0.05
24	34 ± 2	3.53 ± 0.06
36	28 ± 2	3.33 ± 0.07
48	24 ± 2	3.18 ± 0.08
60	20 ± 2	3.00 ± 0.1

ln(48) − ln(46) ≈ 0.04

ln(42) − ln(40) ≈ 0.05

ln(36) − ln(34) ≈ 0.06

Calculate and record values of ln(I/μA) in Table 2.1.
Include the absolute uncertainties in ln(I/μA). [2]

(c) **(i)** Plot a graph of ln(I/μA) against t/s.
Include error bars for ln(I/μA). [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 line of Best Fit:

Points: (10, 3.71) (45, 3.2)

$m_B = \frac{3.2 - 3.71}{45 - 10} = -0.01457$

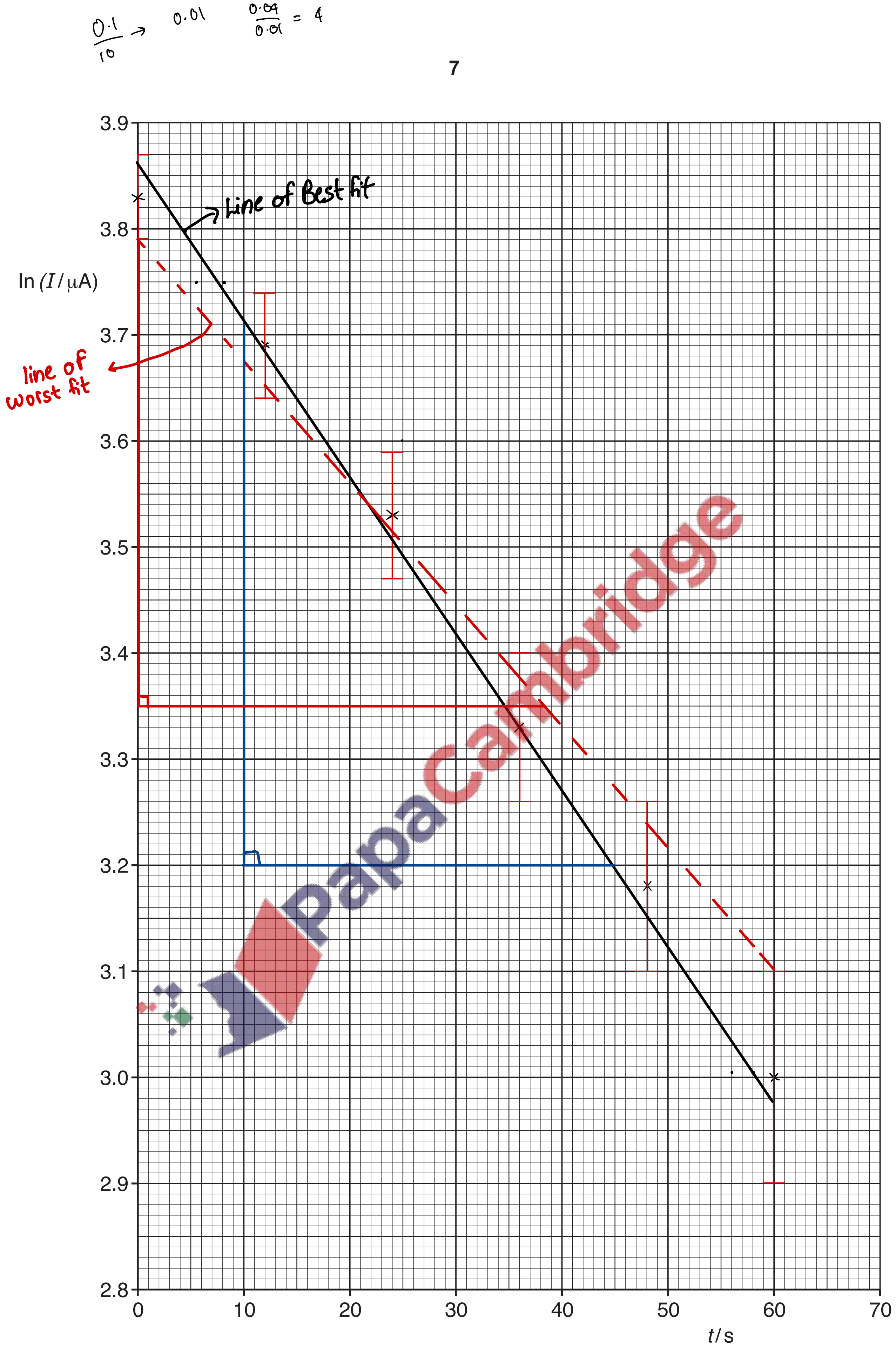
Gradient of line of Worst Fit:

Points: (0, 3.79) (38, 3.35)

$m_w = \frac{3.35 - 3.79}{38 - 0} = -0.011578$

Uncertainity = Gradient of line of Best fit − Gradient of line of worst fit
= −0.01457 − (−0.011578)
= ± 0.003

gradient = −0.0146 ± 0.003 [2]


0.1 / 10 → 0.01
0.04 / 0.01 = 4
ln (I / μA)
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
0
10
20
30
40
50
60
70
t / s
Line of Best fit
line of worst fit
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(iv) Determine the y-intercept of the line of best fit. Do **not** include the absolute uncertainty in your answer.

y-intercept = 3.86 [1]

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

Data: $R = 150\,\text{k}\Omega$

$$\text{gradient} = \frac{-1}{CR} \qquad -0.0146 = \frac{-1}{C \times 150 \times 10^3} \qquad C = \frac{-1}{-0.0146 \times 150 \times 10^3}$$

$$= 4.566 \times 10^{-4} \approx 4.57 \times 10^{-4}$$

unit $C = \frac{q}{V} = CV^{-1}$

$$\ln\left(\frac{E}{R}\right) = y\text{-intercept}$$

$$\ln(E/R) = 3.86$$

$$E = e^{3.86} \times 10^{-6} \times 150 \times 10^3 = 7.12$$

C = 4.57×10^{-4} CV^{-1}

E = 7.12 V [3]

(ii) The percentage uncertainty in the resistance R of the resistor is 5%.

Determine the absolute uncertainty in C.

$$\%\ \text{Uncertainity} = 0.05 + \left(\frac{\text{uncertainty gradient}}{\text{gradient}} \times 100\right) = \left(5 + \left(\frac{0.003}{0.0146} \times 100\right)\right)$$

$$= 25.55\%$$

Absolute uncertainty = $C \times$ % uncertainty

=

absolute uncertainty in C = 1.17×10^{-4} CV^{-1} [1]

(e) Using your results, determine the value of I after the capacitor has discharged through the resistor for 2.0 minutes.

$$I = \frac{E}{R} e^{-\left(\frac{t}{RC}\right)}$$

$$I = \frac{7.12}{150 \times 10^3} \times e^{-\left(\frac{2 \times 60}{150 \times 10^3 \times 4.57 \times 10^{-4}}\right)}$$

$$= 8.244 \times 10^{-6}$$

$$\approx 8.24 \times 10^{-6}$$

I = 8.24×10^{-6} A [1]

[Total: 15]