OCR
Oxford Cambridge and RSA

Thursday 15 June 2023 – Morning

A Level Physics B (Advancing Physics)

H557/03 Practical skills in physics

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number						Candidate number				

First name(s) ____________________

Last name ____________________

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

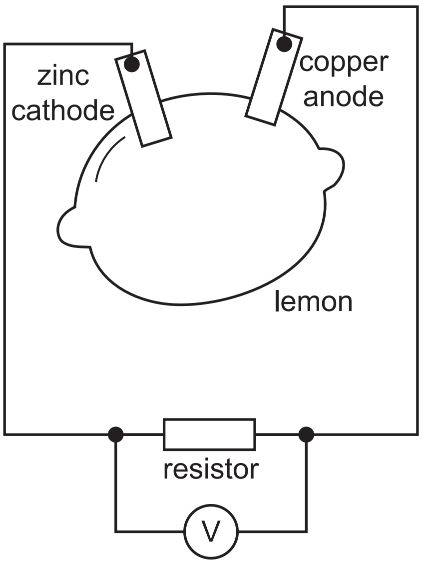
INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

Section A

1 A cell can be made by inserting a zinc cathode and a copper anode into a lemon. A high resistance voltmeter is used in the circuit shown in **Fig. 1.1** to measure the p.d. across the lemon when different resistors are placed across the cell.

Fig. 1.1



(a) **Table 1** below shows the data recorded.

Table 1

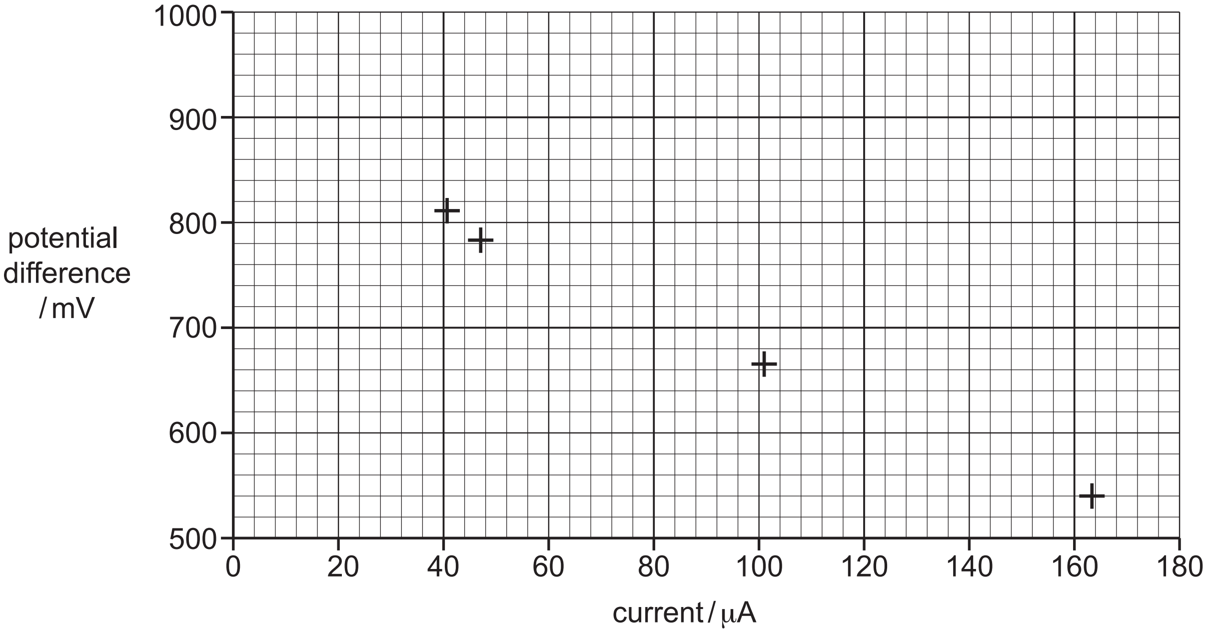
resistance / kΩ	potential difference / mV	current / μA
3.3	540	164
6.6	666	101
10.0	738	
13.3	765	
16.6	784	47
20.0	812	41

(i) Calculate the current and complete the missing rows in **Table 1**.

[1]

(ii) Plot the missing points on the graph in **Fig. 1.2** and draw the line of best fit. **[2]**

Fig. 1.2



(iii) Find the gradient of the line of best fit and hence calculate the lemon's internal resistance, in ohms, Ω. Show your working.

Internal resistance = ... Ω **[3]**

(iv) A student suggests that two lemon cells in series could be used to run a 1.5 V, 0.45 W filament lamp. Explain why this is not correct.

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.... **[2]**

(b)* The experiment is repeated with two lemon cells in series and with two lemon cells in parallel.

For two lemons in series, the emf expression is found to be

$2\varepsilon = V + 2I_{series}r$

where ε is the emf of one lemon cell and r is the internal resistance of a single lemon cell.

Describe the effects of these combinations on the relationship between current and potential difference. In your answer, you should:

- derive the emf expression for two lemon cells connected in parallel in terms of ε and r.
- compare the gradients and intercepts of all three experiments and sketch the V-I graphs to compare the two lemon V-I relationships to the graph for one lemon in **Fig. 1.2**.

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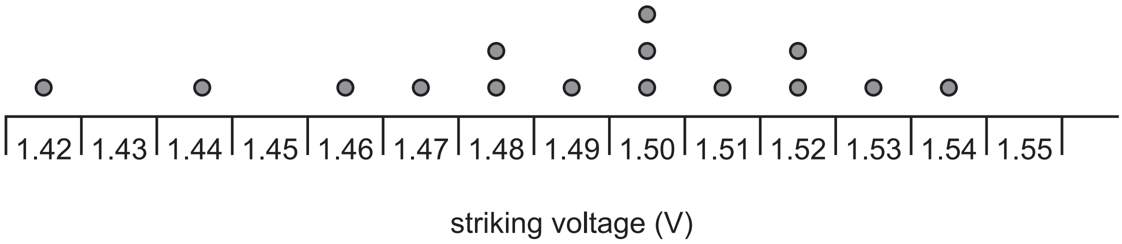
.... **[6]**

2 This question is about an experiment to determine the value of the Planck constant *h*.

A student increases the potential difference across a blue LED until it just starts to glow. The student measures the value of this pd using a multimeter. This is known as the 'striking voltage'. The measurement is repeated, and a dot-plot is drawn, as shown in **Fig. 2.1**.

Fig. 2.1



(a) **(i)** Calculate the mean value of striking voltage and its absolute uncertainty.

Mean striking voltage = ... ± .... V **[2]**

(ii) Describe **one** significant cause of uncertainty in this measurement and suggest a method which would reduce the uncertainty.

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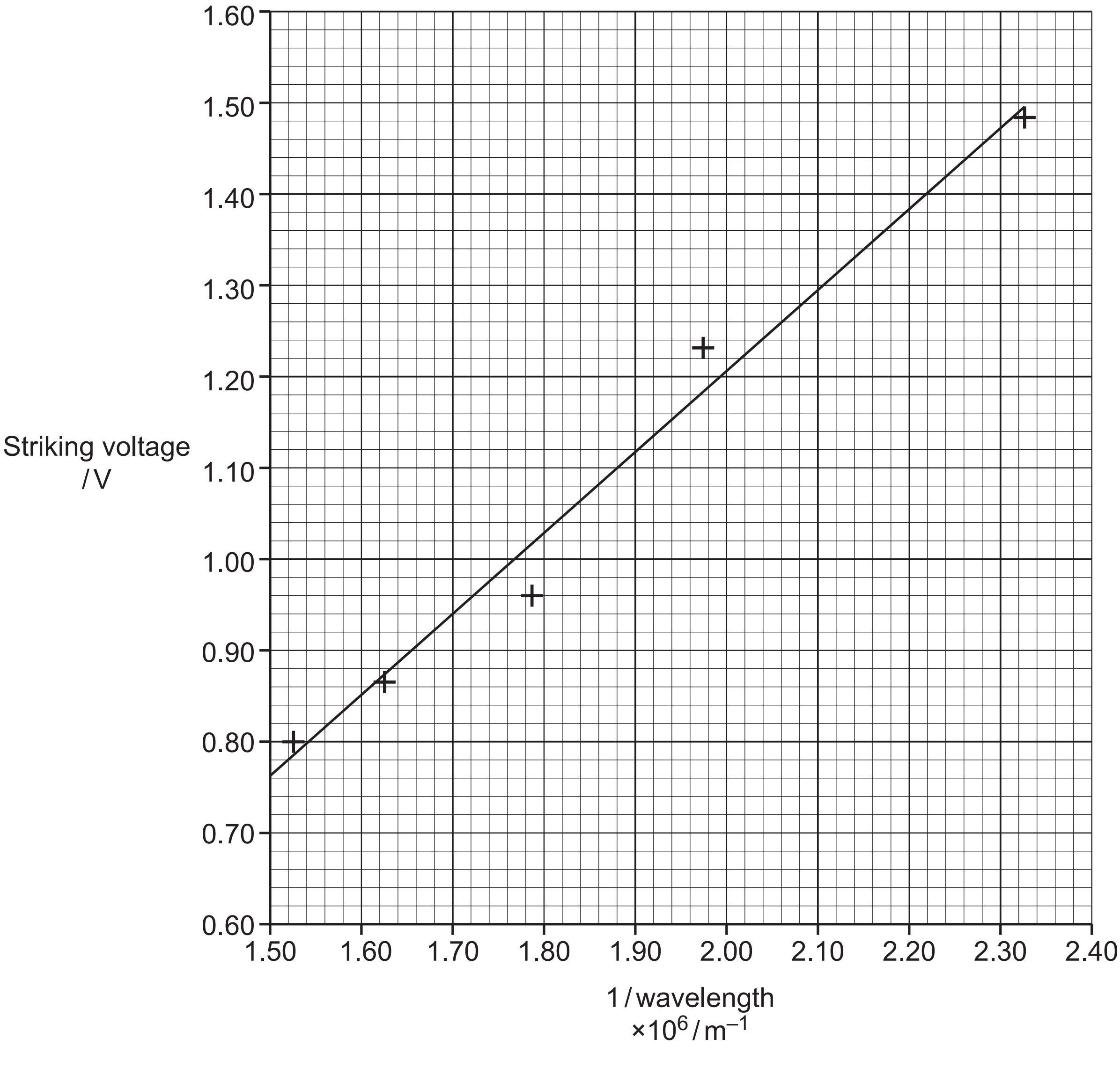
.... **[2]**

(b) The student then repeats the measurement of striking voltage for LEDs of different colours. She refers to the manufacturer's data to find the value of wavelength for each LED and plots a graph of 1/wavelength (on the x-axis) against striking voltage (on the y-axis). The graph is shown in **Fig. 2.2**.

The gradient of this line of best fit = 8.90×10^{-7} V m.

Fig. 2.2



(i) Using the value for uncertainty found in **(a)(i)**, add vertical error bars to all the plotted points and draw a steepest acceptable line through the error bars. **[2]**

(ii) Hence calculate the absolute uncertainty of the gradient value.

Absolute uncertainty of gradient = ± .... V m **[2]**

(c) (i) Show that the Planck constant, $h = gradient \times \frac{e}{c}$.

[2]

(ii) The gradient of the line of best fit is 8.90×10^{-7} V m.
Use this value to calculate a value of the Planck constant.
Include a value for absolute uncertainty in your answer.

Planck constant = ... ± .... J s **[3]**

3 This question is about the discharge of a capacitor.

(a) You are provided with the following apparatus:

variable power supply (0 – 12 V)
capacitor of unknown capacitance
resistor of value 4.7 kΩ
multimeter
leads and switches
stopwatch

Describe a method to record the potential difference, V, across the capacitor as it discharges, using the apparatus listed. Include a circuit diagram in your answer.

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.... **[4]**

(b) Values of V as the capacitor discharges through the 4.7 kΩ resistor are recorded at 10 s intervals in **Table 3**.

Table 3

time t / s	potential difference across capacitor V / V	ln V	
0	7.00	1.946	
10	4.54	1.513	
20	2.97		
30	1.98		
40	1.35	0.300	
50	0.94	–0.062	

(i) Capacitor discharge is an example of exponential decay and follows the equation

$V = V_0 e^{\frac{-t}{RC}}$.

Complete the ln V column in **Table 3** and then perform a mathematical test on the data to show that it follows exponential decay.

You may use the extra column in the table for your working. **[3]**

(ii) Show that the value of the time constant, τ is approximately 25 s.

[1]

(iii) Calculate the value of the capacitance.

Capacitance = ... F **[1]**

(c) There is a general rule of thumb used by electronic engineers that the time taken for a capacitor to discharge completely is 5τ.

(i) Starting from the equation given in **(b)(i)** and repeated below show that when $t = 5\tau$, the energy stored in the capacitor, $E = 4.5 \times 10^{-5}\, E_0$, where E_0 is the energy stored in the fully charged capacitor.

$$V = V_0 e^{\frac{-t}{RC}}$$

[3]

(ii) Justify why this rule of thumb is useful to engineers.

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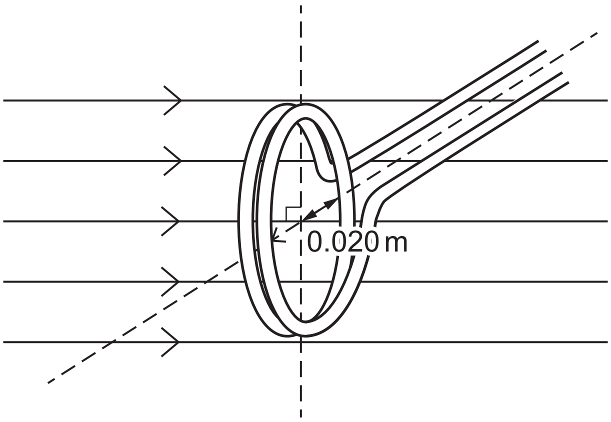
Section B begins on page 12

Section B

4 This question is about inducing an emf in a coil of wire.

Fig. 4.1 shows a coil of wire perpendicular to a uniform magnetic field.

Fig. 4.1



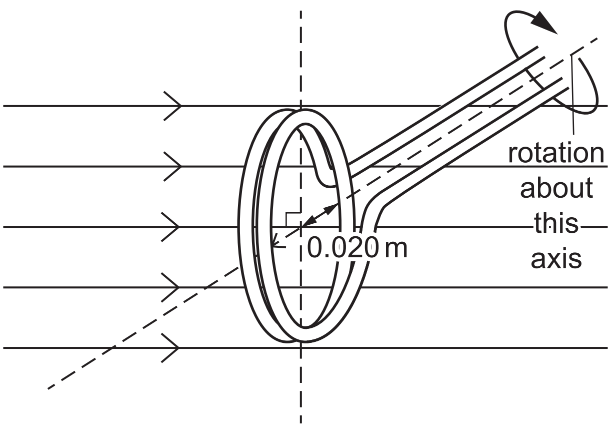
(a) (i) The coil has 10 turns of radius 0.020 m. The field strength is 5.0 mT.

Show that the flux linkage of the coil is about 6.3×10^{-5} Wb.

[2]

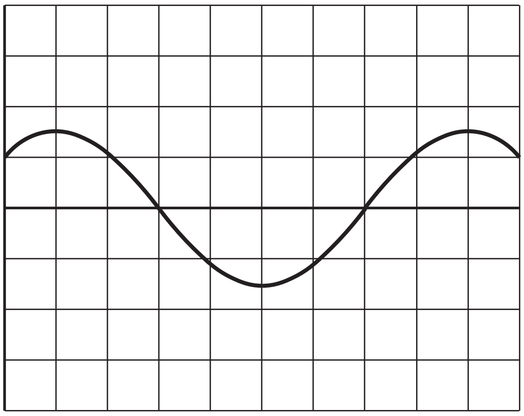
The coil is rotated at a constant rate as shown in **Fig. 4.2**. An emf is produced across the coil.

Fig. 4.2



An oscilloscope trace of the emf produced is shown in **Fig. 4.3**.

Fig. 4.3



(ii) Suggest and explain why the trace has the shape shown on **Fig. 4.3**.

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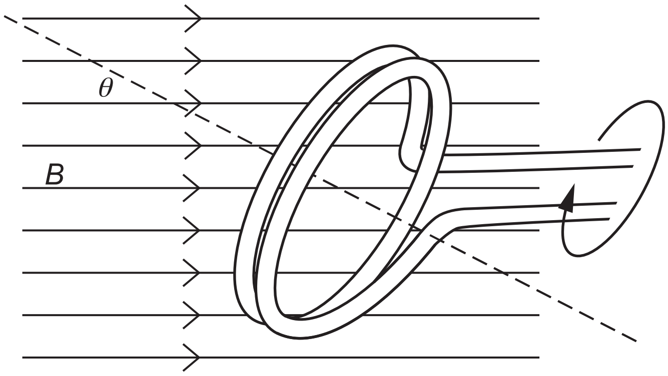
.... **[2]**

(iii) The horizontal divisions on the trace representing time are set at 0.625 s/div.
Using the trace shown in **Fig. 4.3**, calculate the angular frequency, ω, of the coil.

Angular frequency, ω = ... rad s^{-1} **[3]**

(iv) The angle θ, that the normal to the plane of the coil makes with the field lines varies with time as the coil rotates. Angle θ is shown in **Fig. 4.4**.

Fig. 4.4

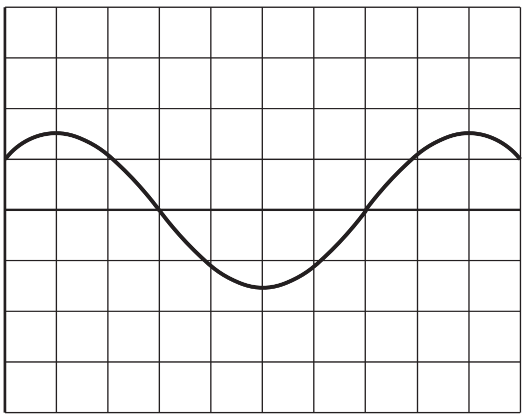


By considering θ, show that the flux in the coil can be given by $\phi = BA\cos\omega t$.

[2]

(b) The original trace of the coil is shown in **Fig. 4.5**.

Fig. 4.5



The number of turns of the coil is changed to 20. Nothing else is changed.

(i) Add to **Fig. 4.5** a drawing of the trace produced by the 20-turn coil. **[2]**

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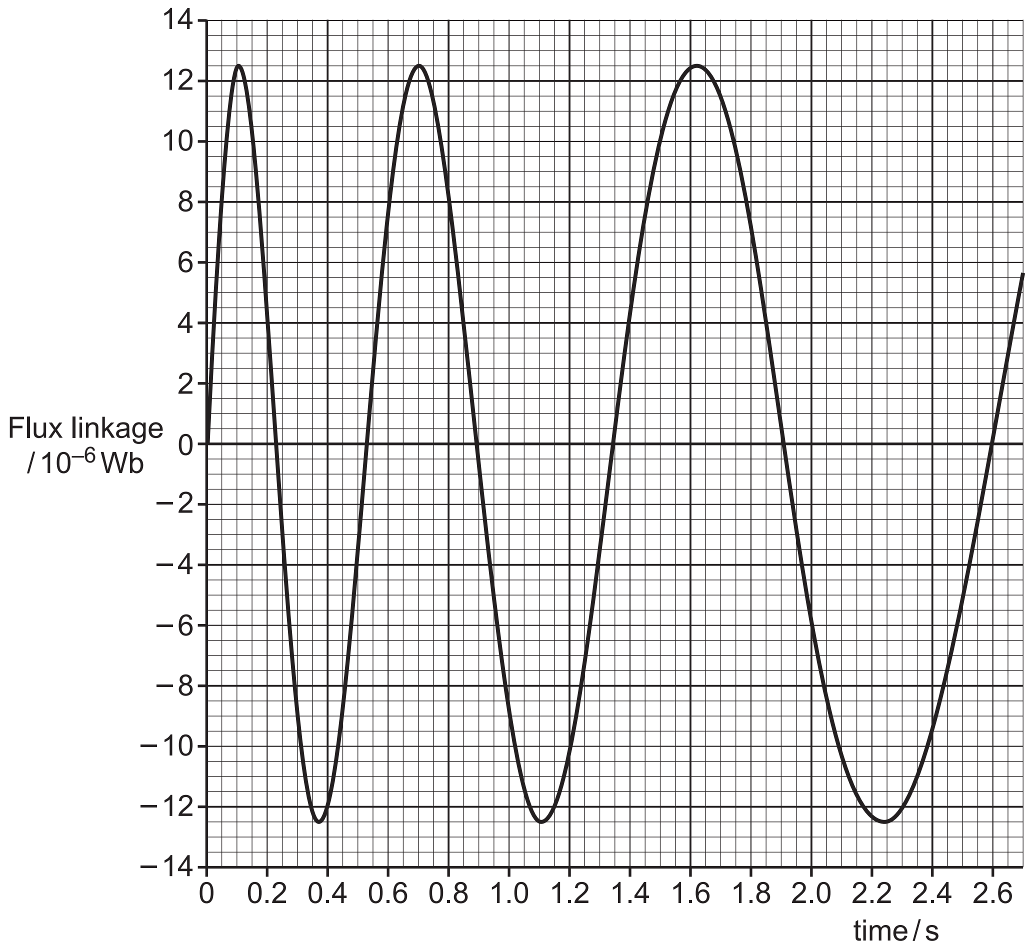
Question 4(b) continues on page 16

The driving force spinning the coil is removed. **Fig. 4.6** shows how the flux linkage varies with time for three whole revolutions.

Fig. 4.6



(ii) Using the graph in **Fig. 4.6**, estimate the emf induced in the coil at the instant the flux linkage is zero at 0.23 s. Show all your working.

emf = ... V **[3]**

(iii)* It is suggested that the peak emf generated by the coil falls by the same fraction in each cycle.

Explain how this suggestion can be tested by using data from **Fig. 4.6**.

Carry out your test on the data and state your conclusions.

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END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).