



Rewarding Learning

ADVANCED
General Certificate of Education
2019

Centre Number

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Candidate Number

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Physics

StemUp Model Solution

Assessment Unit A2 3B

assessing

Practical Techniques
and Data Analysis



[APH32]

APH32

FRIDAY 10 MAY, MORNING

TIME

1 hour.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all five** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 50.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.

You may use an electronic calculator.



- 1 The current I through a fixed resistor was measured as the potential difference V across it was varied. The values obtained were plotted on the grid of **Fig. 1.1**.

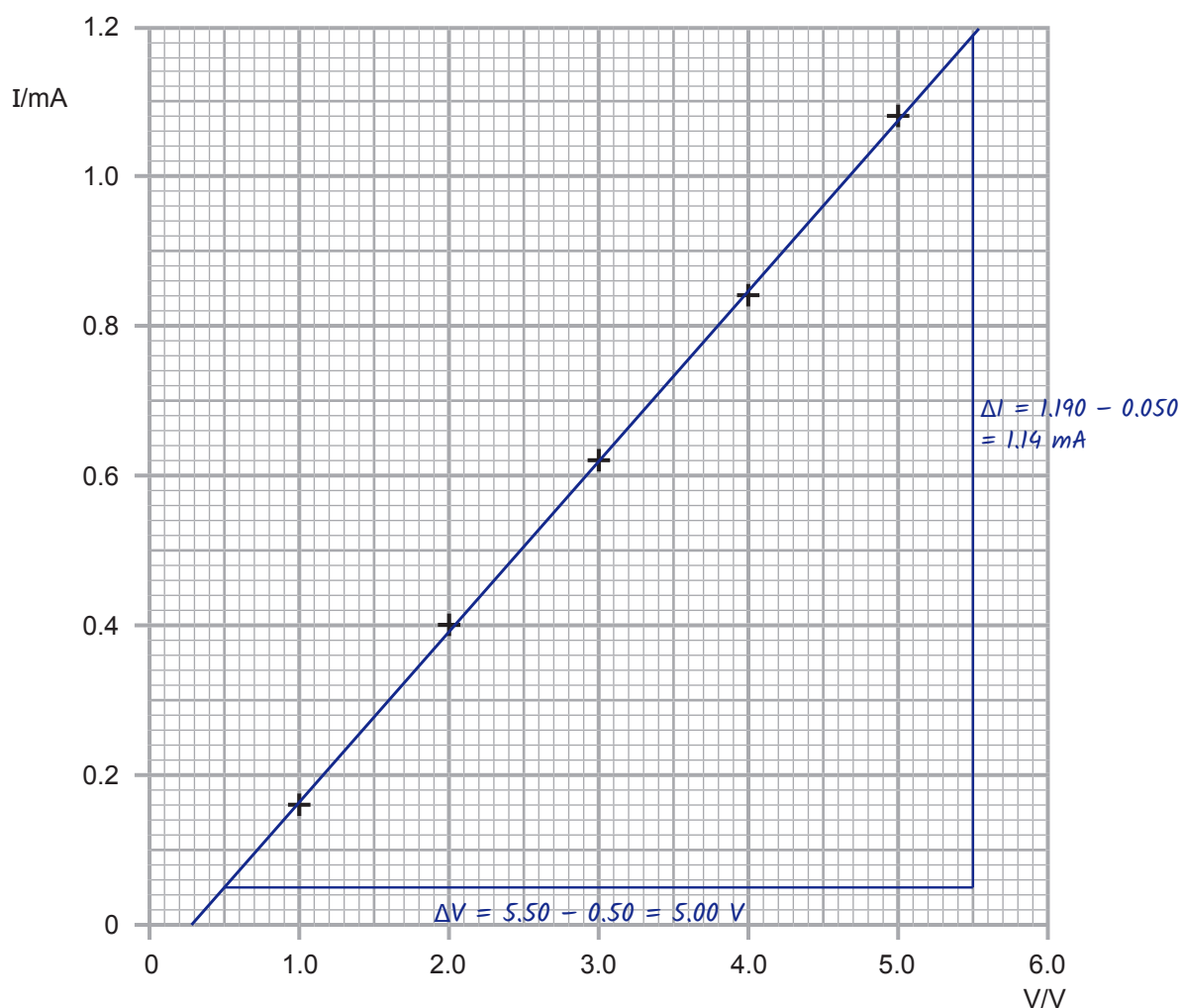


Fig. 1.1

(a) Draw the best fit straight line for the plotted points.

[1]



- (b) (i) Calculate the gradient of the graph. State the unit of the gradient.

Large triangle on my line: (0.50 V, 0.050 mA) to (5.50 V, 1.190 mA)

$$\text{gradient} = \Delta I / \Delta V = (1.190 - 0.050) \times 10^{-3} / (5.50 - 0.50)$$

$$= 1.14 \times 10^{-3} / 5.00 = 2.28 \times 10^{-4} \text{ A V}^{-1}$$

$$\text{Gradient} = \underline{2.28 \times 10^{-4}}$$

$$\text{Unit of gradient} = \underline{\text{A V}^{-1} (= \Omega^{-1})}$$

[3]

- (ii) The manufacturer states the resistance of the resistor as $4.2 \text{ k}\Omega \pm 10\%$. Use the graph to confirm if the resistance of the resistor falls within the range claimed.

$$R = 1 / \text{gradient} = 1 / 2.28 \times 10^{-4} = 4386 \Omega = 4.39 \text{ k}\Omega$$

$$10\% \text{ of } 4.2 \text{ k}\Omega = 0.42 \text{ k}\Omega, \text{ so range} = 3.78 \text{ k}\Omega \text{ to } 4.62 \text{ k}\Omega$$

4.39 kΩ lies between 3.78 kΩ and 4.62 kΩ, so yes, the resistance

is within the range claimed.

[4]

[Turn over]



(c) The ammeter used to obtain the values of current for the graph has a 'zero error'.

(i) What is meant by the term 'zero error'?

A zero error is when the meter shows a non-zero reading when the true value is zero, i.e. it does not read zero when no current flows (p.d. is zero).

[1]

(ii) Explain how the graph in **Fig. 1.1** indicates that there is a 'zero error' in the ammeter.

The best fit line does not go through the origin: it cuts the V axis at about 0.28 V instead of passing through (0, 0).

[1]

(iii) Calculate the magnitude of the 'zero error'.

Zero error = y-intercept c of the line (value of I when $V = 0$)

$y = mx + c$ using (5.50, 1.190): $1.190 = 0.228 \times 5.50 + c$

$c = 1.190 - 1.254 = -0.064 \text{ mA}$, so magnitude = 0.064 mA

Zero error = 0.064 mA

[3]





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20APH3205

- 2 Two light styrofoam balls are covered in a thin layer of aluminium foil and attached at either end of a string.

The string is suspended from its mid-point and the styrofoam balls are given an equal charge q . They repel each other as shown in **Fig. 2.1**.

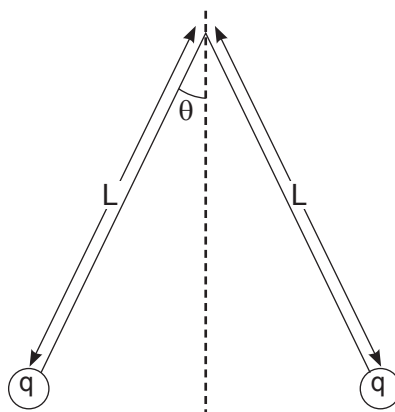


Fig. 2.1

The amount of charge q is given by **Equation 2.1**.

$$q = 2L \sin\theta \sqrt{\frac{mg \tan\theta}{k}} \quad \text{Equation 2.1}$$

where:

L is equal to half the total length of the string

θ is the angle between the string and the vertical

$$k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ F}^{-1} \text{ m.}$$

m is the mass of each styrofoam ball

g is the acceleration of free fall.



To find the charge q , L is varied and the angle θ is recorded for each L value.

- (a) A straight line graph is to be plotted that will allow a value of q to be determined.

Show that a graph of $\frac{1}{L}$ against $\sin\theta\sqrt{\tan\theta}$ will result in a straight line graph that goes through the origin.

$$q = 2L \sin\theta \sqrt{(mg \tan\theta / k)}, \text{ so } 1/L = (2/q) \sqrt{(mg/k)} \sin\theta \sqrt{\tan\theta}$$

Compare with $y = mx + c$: $y = 1/L$, $x = \sin\theta \sqrt{\tan\theta}$,

gradient $m = (2/q) \sqrt{(mg/k)}$ which is a constant, and $c = 0$,

so the graph is a straight line through the origin ($y = mx$).

[3]

- (b) How is a value of q determined from the graph of $\frac{1}{L}$ against $\sin\theta\sqrt{\tan\theta}$?

Find the gradient of the line; gradient = $(2/q) \sqrt{(mg/k)}$, so $q = (2 /$
gradient) $\times \sqrt{(mg/k)}$.

[1]

[Turn over



- 3 **Fig. 3.1** shows a container of circular cross-section area A with a tube of cross-section area B connected to it. A liquid added to the container will flow out through the tube.

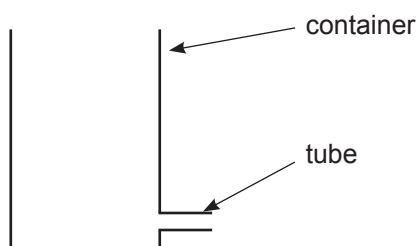


Fig. 3.1

The time t taken for the level of the liquid to fall through a height h in the container is given by **Equation 3.1**.

$$t = \frac{A}{B} \sqrt{\frac{2h}{g}} \quad \text{Equation 3.1}$$

where g is the acceleration of free fall, 9.81 m s^{-2} .

(a) Show that the right-hand side of **Equation 3.1** has the unit of time.

A and B : m^2 , h : m , g : m s^{-2}

$\text{RHS unit} = (\text{m}^2 / \text{m}^2) \times \sqrt{(\text{m} / \text{m s}^{-2})} = 1 \times \sqrt{(\text{s}^2)} = \text{s}$

which is the unit of time.

[2]



- (b) The time t taken for the liquid to fall through a height h of 0.250 ± 0.002 m is 10.3 ± 0.3 s. The diameter of the container is 9.62 ± 0.01 cm.

Calculate the cross-section area B of the tube and the percentage uncertainty in B .

$$A = \pi d^2 / 4 = \pi \times (0.0962)^2 / 4 = 7.27 \times 10^{-3} \text{ m}^2$$

$$\text{Rearranging: } B = (A / t) \sqrt{2h / g}$$

$$B = (7.27 \times 10^{-3} / 10.3) \times \sqrt{2 \times 0.250 / 9.81}$$

$$B = 7.057 \times 10^{-4} \times 0.2258 = 1.59 \times 10^{-4} \text{ m}^2$$

$$\% \text{ uncertainty in } t = 0.3 / 10.3 \times 100 = 2.91 \%$$

$$\% \text{ uncertainty in } d = 0.01 / 9.62 \times 100 = 0.104 \%$$

$$\text{so } \% \text{ uncertainty in } A = 2 \times 0.104 = 0.208 \%$$

$$\% \text{ uncertainty in } h = 0.002 / 0.250 \times 100 = 0.8 \%, \text{ so in } \sqrt{h} = \frac{1}{2} \times 0.8 = 0.4 \%$$

$$\% \text{ uncertainty in } B = 2.91 + 0.208 + 0.4 = 3.518 \% \approx 3.52 \%$$

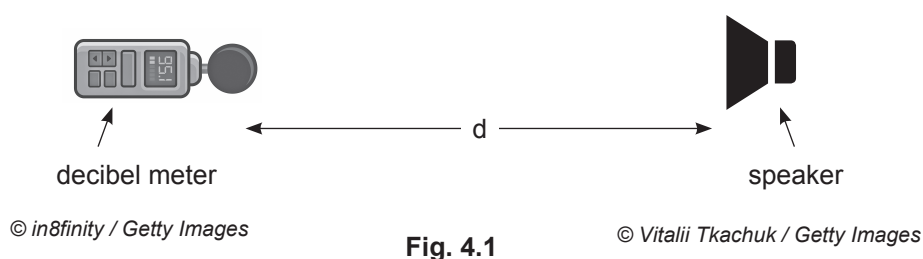
$$\text{Cross-section area} = \underline{1.59 \times 10^{-4}} \text{ m}^2$$

$$\text{Percentage uncertainty} = \underline{3.52} \% \quad [6]$$

[Turn over



- 4 In an experiment, the loudness L in decibels (dB) was measured at various distances d from a speaker. The loudness was measured using a decibel meter as shown in Fig. 4.1.



The results have been recorded in Table 4.1.

Table 4.1

d / m	L / dB				log (d / m)
	1	2	3	Average	
0.100	62.3	62.0	62.5	62.3	-1.000
0.400	50.4	50.1	49.9	50.1	-0.398
0.800	43.8	44.2	44.2	44.1	-0.097
1.200	40.0	40.3	39.8	40.0	0.079
1.600	38.1	38.3	38.4	38.3	0.204

The loudness L of a sound measured in decibels (dB) is related to the distance d away from the source of the sound as shown by Equation 4.1.

$$L = -20 \log d + 10 \log \left[\frac{P}{2\pi I_0} \right] \quad \text{Equation 4.1}$$

where P and I_0 are constants.

P is the power of the sound produced.

I_0 is the threshold intensity of hearing, equal to $1 \times 10^{-12} \text{ W m}^{-2}$.



(a) Calculate values for $\log (d / m)$ and insert them in the final column of **Table 4.1**. Record the values to 3 decimal places. [2]

(b) (i) Draw a graph of L against $\log d$ on the grid of **Fig. 4.2**. Choose a suitable scale for the axes, plot the points and draw the best fit line for the points. [5]

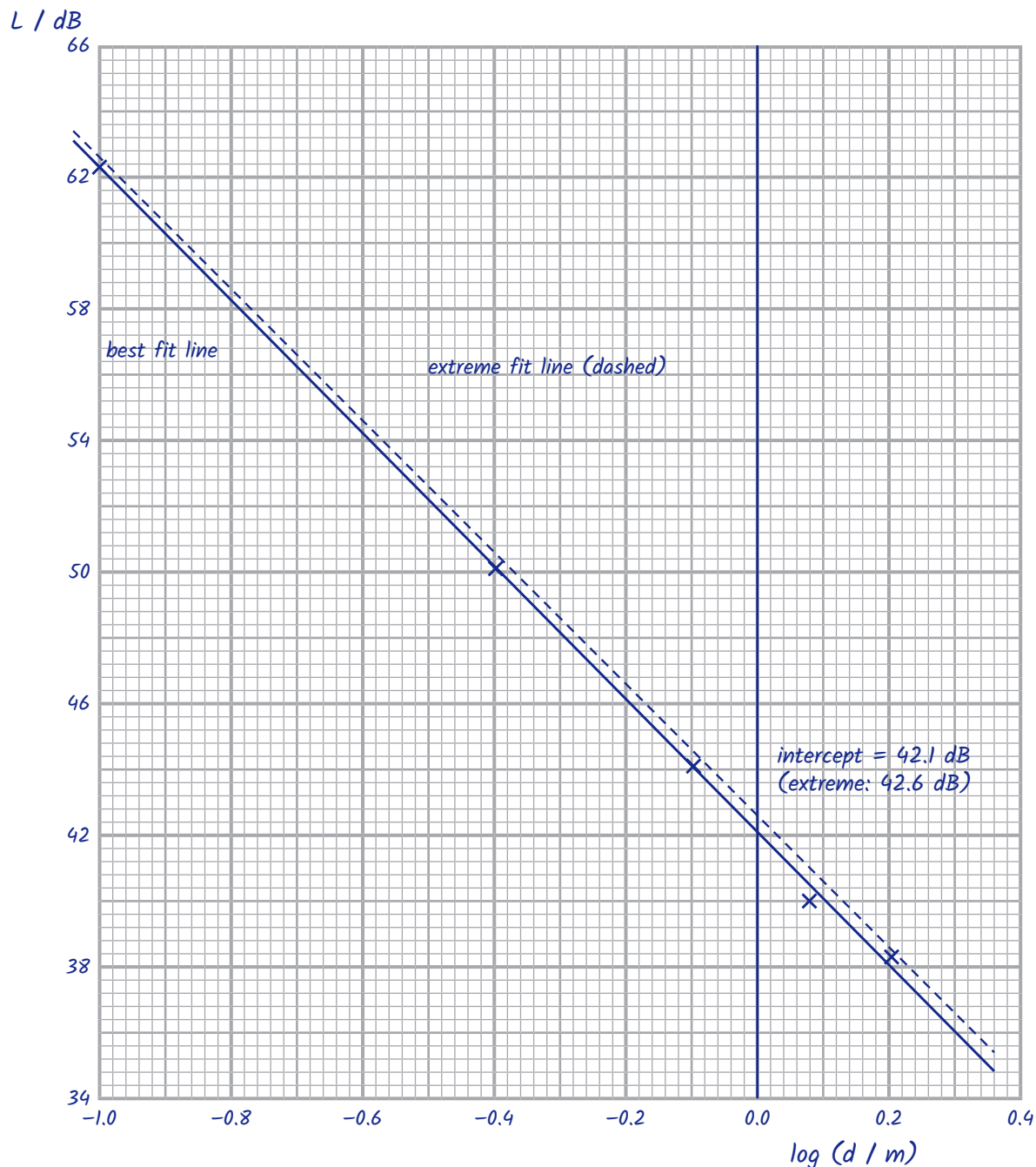


Fig. 4.2

[Turn over]



- (ii) Use your graph to find a value for the power P of the sound.

At $\log d = 0$ ($d = 1 \text{ m}$): $L = 10 \log (P / 2\pi I_0) = \text{intercept}$

Intercept read from graph = 42.1 dB

$\log (P / 2\pi I_0) = 4.21$, so $P / 2\pi I_0 = 10^{4.21} = 1.62 \times 10^4$

$P = 2\pi \times 1 \times 10^{-12} \times 1.62 \times 10^4 = 1.0 \times 10^{-7} \text{ W}$

$P = \underline{1.0 \times 10^{-7}} \text{ W}$

[3]

- (iii) Explain how, using your plotted points, the absolute uncertainty in your value of P could be obtained.

Draw an extreme fit line through the points (dashed on Fig. 4.2),

read its new intercept (42.6 dB) and calculate the new $P = 2\pi I_0$

$\times 10^{4.26} = 1.14 \times 10^{-7} \text{ W}$. Absolute uncertainty = difference in $P =$

$1.14 \times 10^{-7} - 1.0 \times 10^{-7} \approx 0.1 \times 10^{-7} \text{ W}$.

[3]





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- 5 (a) The resultant interference pattern from two sound waves is displayed on a cathode ray oscilloscope (CRO) screen. The display is shown in **Fig. 5.1a**.

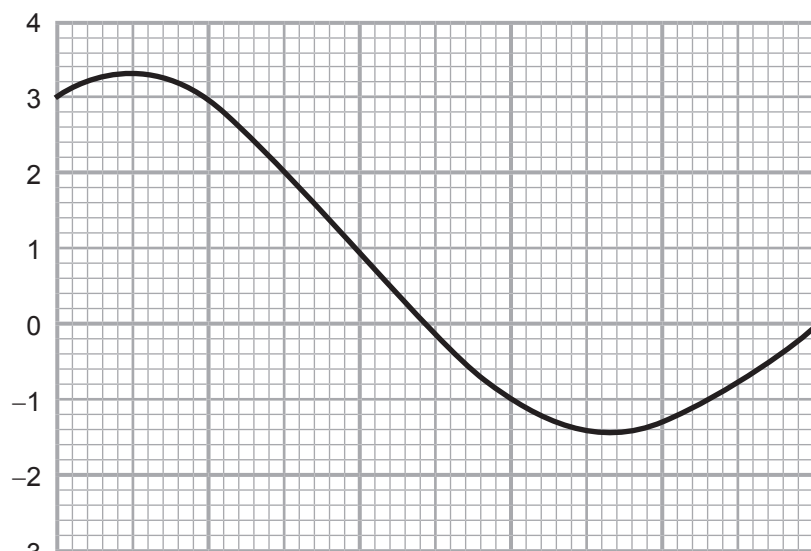
The same CRO screen, with the same settings, is then used to display the individual sound waves.

One of the sound waves that caused the interference is shown in **Fig. 5.1b**.

On **Fig. 5.1c**, draw the second wave that caused the interference.

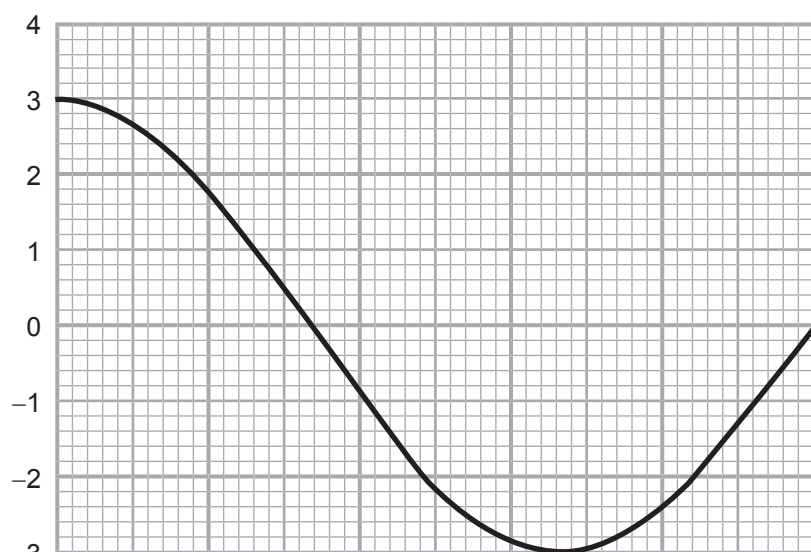
[4]





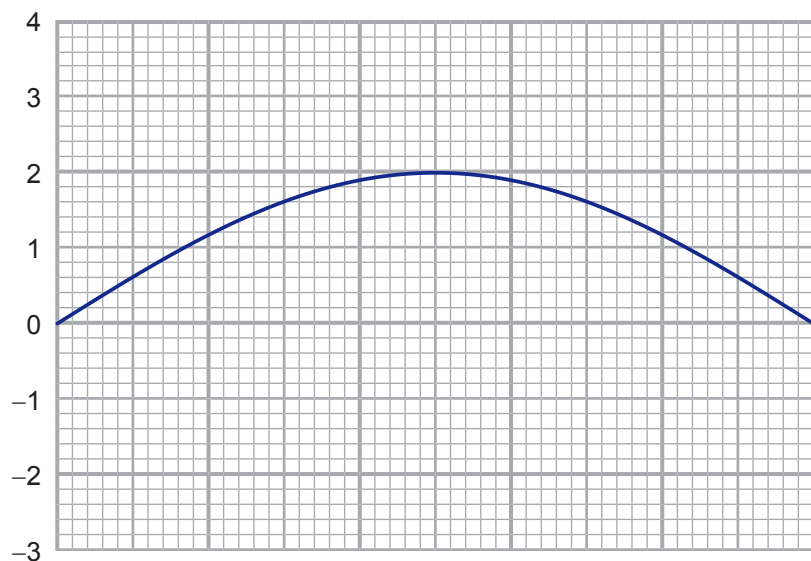
Resultant

Fig. 5.1a



Wave 1

Fig. 5.1b



Wave 2

Fig. 5.1c

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- (b) (i) The wave in **Fig. 5.1b** has a frequency of 1500 Hz. The length of the trace shown is 10 cm. What is the timebase setting on the CRO? Give an appropriate unit.

$$T_1 = 1/f = 1/1500 = 6.67 \times 10^{-4} \text{ s}$$

From Fig. 5.1b the 10 cm trace shows $\frac{3}{4}$ of a cycle: $3T_1/4 = 10 \text{ cm}$

$$\text{time for 10 cm} = \frac{3}{4} \times 6.67 \times 10^{-4} = 5.0 \times 10^{-4} \text{ s}$$

$$\text{timebase} = 5.0 \times 10^{-4} \text{ s} / 10 \text{ cm} = 5 \times 10^{-5} \text{ s cm}^{-1}$$

$$\text{Timebase setting} = \underline{5 \times 10^{-5}}$$

$$\text{Unit} = \underline{\text{s cm}^{-1}}$$

[5]

- (ii) Calculate the frequency of the wave you have drawn in **Fig. 5.1c**.

Wave 2 completes half a cycle in the 10 cm trace: $T_2/2 = 10 \text{ cm}$

$$T_2 = 20 \text{ cm} \times 5 \times 10^{-5} \text{ s cm}^{-1} = 1.0 \times 10^{-3} \text{ s} = 1000 \mu\text{s}$$

$$f_2 = 1 / T_2 = 1 / 1.0 \times 10^{-3} = 1000 \text{ Hz}$$

$$\text{Frequency} = \underline{1000} \text{ Hz}$$

[3]

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Question Number	Marks
1	
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Examiner Number

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