Rewarding Learning

Centre Number

Candidate Number

ADVANCED
General Certificate of Education
2023

Physics

Assessment Unit A2 3B

assessing

Practical Techniques and Data Analysis

[APH32]

APH32

MONDAY 26 JUNE, 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 four** 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 or part question.
You may use an electronic calculator.

1 The upwards force, or lift L, on the wings of an aircraft is given by **Equation 1.1**.

$$L = \frac{C_L \rho v^2 A}{2} \qquad \textbf{Equation 1.1}$$

where

C_L is a constant called the coefficient of lift,
ρ is the density of the air,
v is the air speed,
A is the area of the wings.

(a) Show that C_L is a quantity that has no units.

[3]

(b) To determine C_L a student placed a model aircraft into a wind tunnel. The model was connected to a spring balance that allowed the lift L to be measured. The student varied the air speed v in the wind tunnel and measured L. The student was told by the teacher that the spring balance used to measure L has a 'zero error'. The results the student obtained are given in the **Table 1.1**.

Table 1.1

v / m s^{-1}	v^2 / m^2 s^{-2}	L / N			
		Reading 1	**Reading 2**	**Reading 3**	**Average**
10.0	100	1.48	1.50	1.52	1.50
20.0	400	2.38	2.38	2.37	2.38
30.0	900	3.85	8.36	3.87	3.86
40.0	1600	5.94	5.90	5.92	5.92
50.0	2500	8.59	8.58	8.58	8.58

(i) Explain why the average value of L for an air speed of 30.0 m s^{-1} was correctly recorded as 3.86 N.

_____

_____ [1]

Using the results from **Table 1.1**, the student plotted the points on the grid in **Fig. 1.1**.

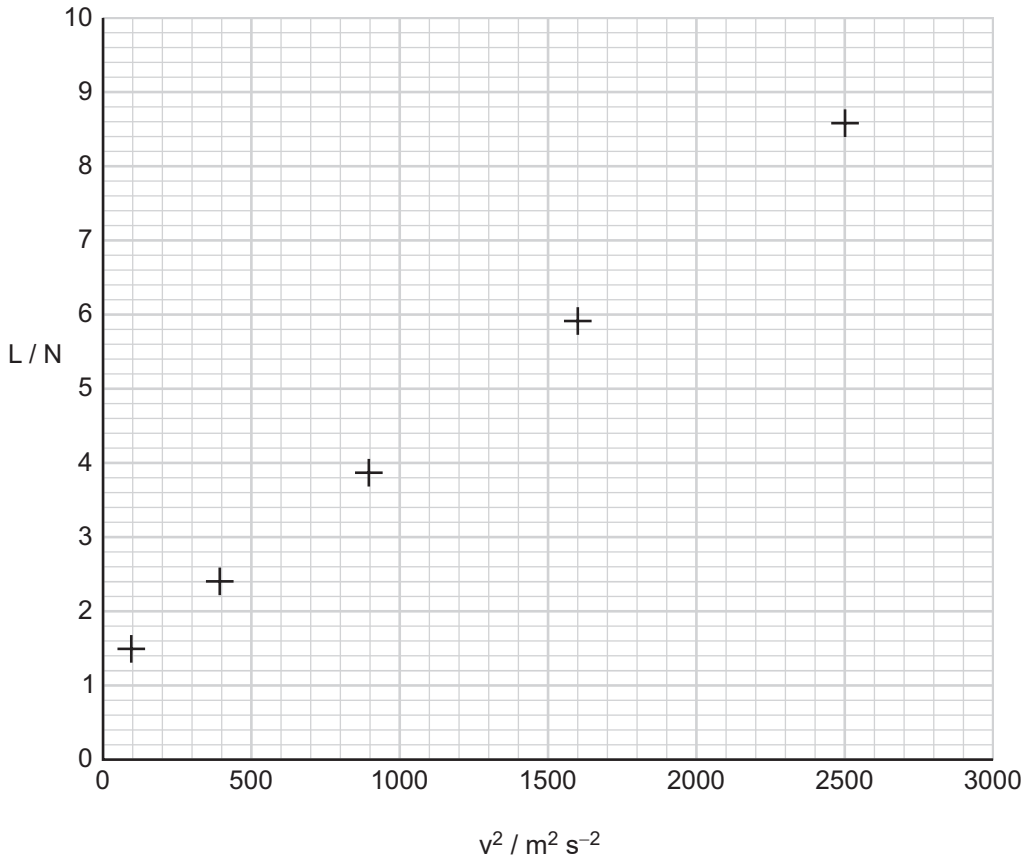

Fig 1.1

(ii) Draw the best fit line for the points plotted on **Fig. 1.1**. [1]

[Turn over

(iii) Explain how you can tell from your graph that the spring balance has a 'zero error'.

_____

_____ [1]

(iv) Determine the magnitude of the 'zero error' on the spring balance.

Zero error = _____ N [1]

(c) The density ρ of the air used in the wind tunnel was 1.23 kg m^{-3} and the area A of the wings of the model was 2.40×10^{-2} m^2.

(i) Determine the gradient of the line of best fit. State the unit of the gradient.

Gradient = _____

Unit of gradient = _____ [3]

(ii) Use the gradient to determine C_L.

C_L = _____ [3]

(iii) Explain why the 'zero error' on the spring balance does not affect the value of C_L determined in **(c)(ii)**.

_____

_____

_____ [1]

[Turn over

2 The frequency of the first mode of vibration for a stretched string is dependent on the tension of the string. A student performed an experiment using the apparatus in **Fig. 2.1** to determine the tension on the string.

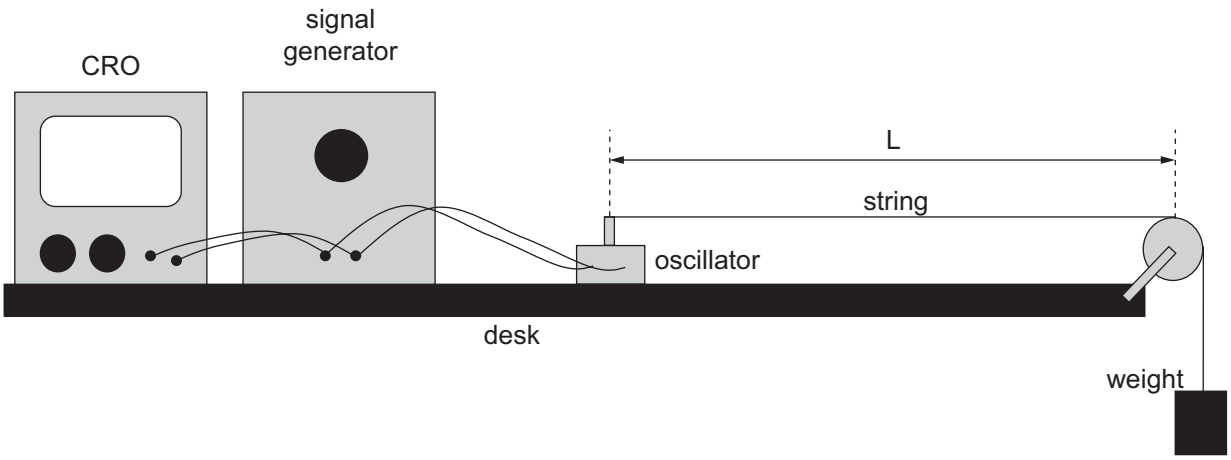

Fig. 2.1

The student increased the frequency on the signal generator until the string vibrated in the first mode of vibration. To determine an accurate value for the frequency the student attached the output from the signal generator to a CRO. The time-base setting on the oscilloscope was set to 5 ms cm^{-1}. The display on the oscilloscope screen obtained is shown in **Fig. 2.2**.

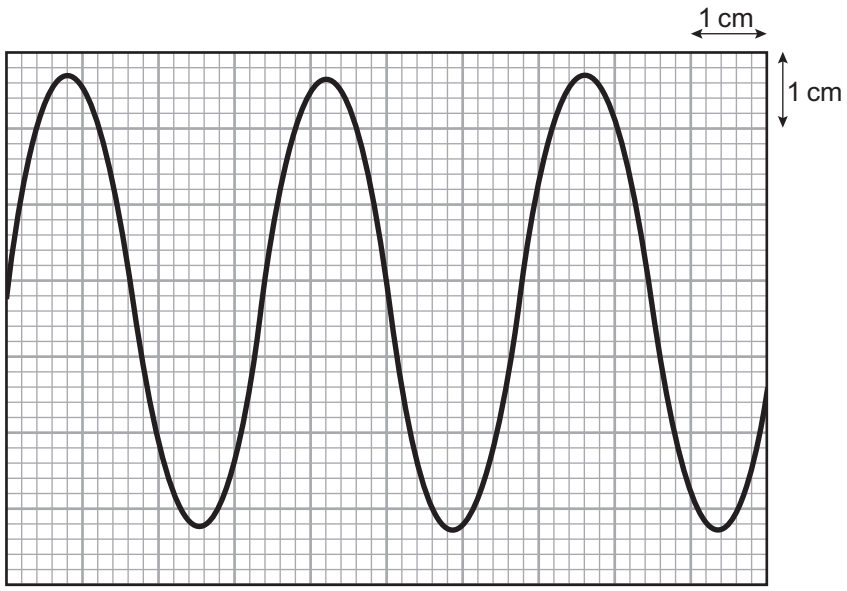

Fig. 2.2

(a) Use **Fig. 2.2** to calculate a value for the frequency of the signal that has the smallest possible percentage uncertainty. State the value of this frequency and the percentage uncertainty.

Frequency = _____ Hz

Percentage uncertainty = _____ [6]

(b) The frequency of the first mode of vibration and the tension of the string are linked by **Equation 2.1**.

$$T = 4LmF^2 \qquad \textbf{Equation 2.1}$$

where

T is the tension of the string in N,
f is the frequency of the first mode of vibration in Hz,
L is the length of the string in m,
m is the mass of the string in kg.

The student measured the mass of the string to be 0.82 g and the length to be 0.723 m.

The percentage uncertainty in the reading of the mass was 1.22% and the percentage uncertainty in the reading of the length was 0.138%.

Calculate the tension T and the percentage uncertainty of T.

T = _____ N

Percentage uncertainty = _____ % [4]

[Turn over

3 Atmospheric air pressure decreases with height above sea-level. The pressure P at a height h can be approximated by **Equation 3.1**.

$$P = P_o e^{-h/k} \qquad \textbf{Equation 3.1}$$

where P_o and k are constants.

A set of data for pressure at various heights is given in **Table 3.1**.

Table 3.1

h / m	P / kPa	
1000	92.4	
2000	78.9	
3000	71.2	
4000	65.2	
5000	56.4	
6000	49.3	

(a) (i) State the physical meaning of the constant P_o.

_____ [1]

(ii) Show that a graph of ln P against h will produce a straight-line graph from which the values of k and P_o can be determined.

[3]

(iii) Complete the last column in **Table 3.1** by calculating ln P to **2 decimal places**. Include a suitable heading and unit. [3]

(b) (i) Draw a graph of ln P (y-axis) against h (x-axis) on the grid in **Fig. 3.1**. Choose a suitable scale for the axes, plot the points and draw the best fit line for the points. [5]

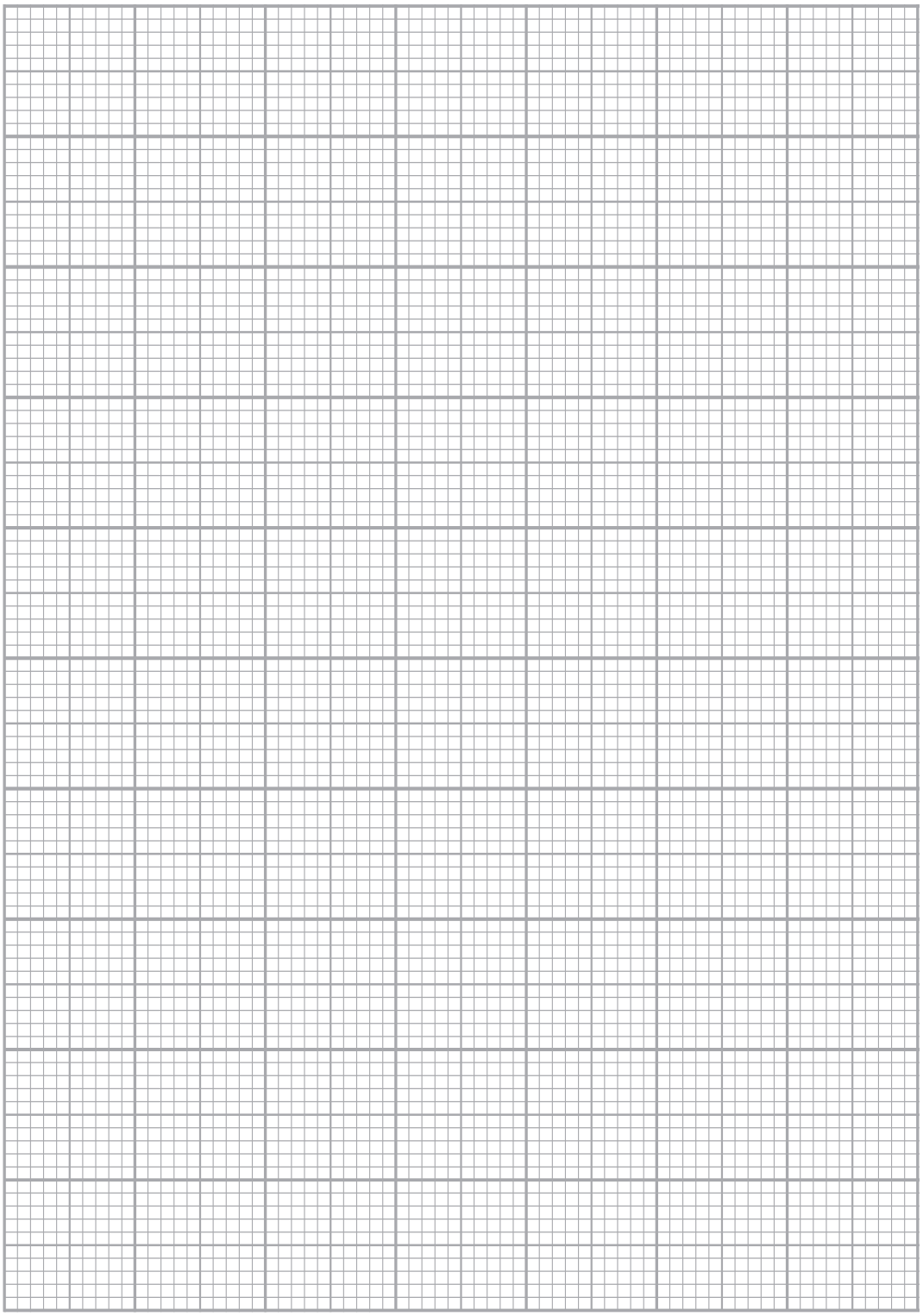

Fig. 3.1

[Turn over

(ii) Use your graph to determine a value for P_o.

P_o = _____ kPa [3]

(iii) By drawing an extreme fit line determine the absolute uncertainty in P_o.

Uncertainty = ± _____kPa [3]

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(Questions continue overleaf)

4 A student performs an experiment using a simple pendulum in order to determine the relationship between the time period of oscillation T and its length L.

(a) Describe how the student should obtain a reliable value for the time period of oscillation.

_____

_____

_____ [2]

A plot of the results obtained by the student is shown in **Fig. 4.1**.

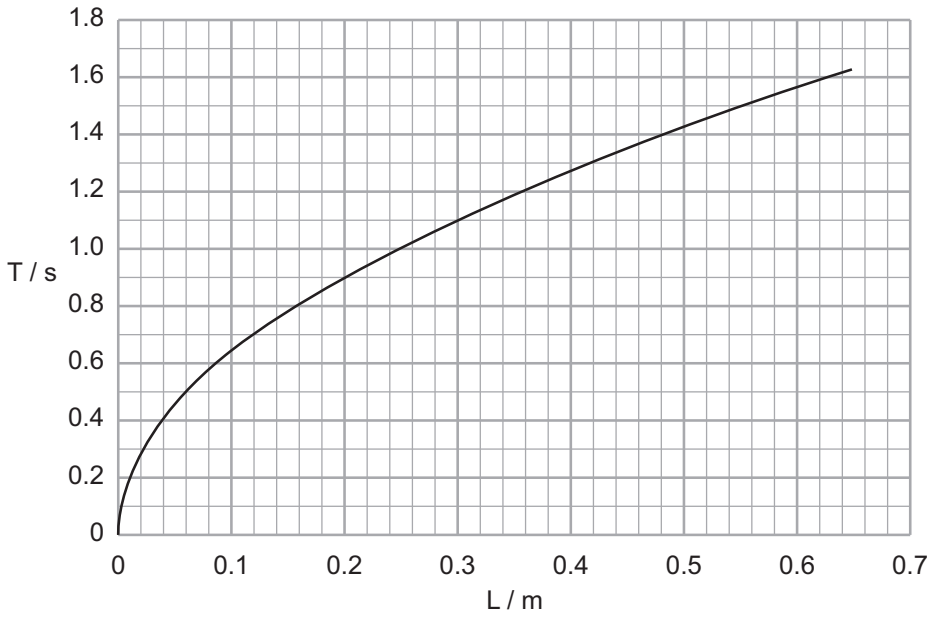

Fig. 4.1

(b) **Without calculation**, explain what feature of the graph in **Fig. 4.1** confirms that the following relationships are incorrect:

(i) $T \propto L$

_____

_____ [1]

(ii) $T \propto L^{-1}$

_____

_____ [1]

(iii) $T \propto L^{2}$

_____

_____ [1]

(c) The correct relationship between T and L is given by **Equation 4.1**.

$$T = k L^{½} \qquad \textbf{Equation 4.1}$$

Use the graph in **Fig. 4.1** to determine a reliable value for the constant k.

k = _____ [3]

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For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
Total Marks	

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