



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9702/51

May/June 2022

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- 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.

- 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.

- 1 Two parallel metal plates, each of area A , are separated by a small distance d , as shown in Fig. 1.1.

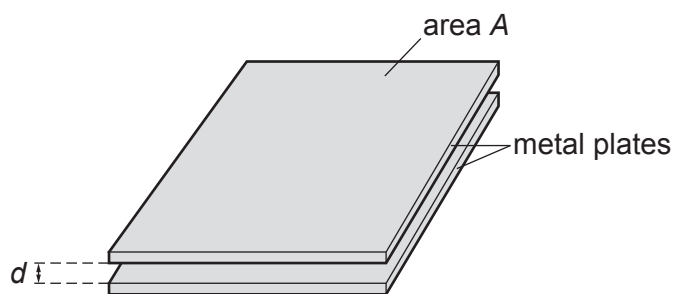


Fig. 1.1 (not to scale)

The plates are initially charged using a power supply.

The plates are then connected to an uncharged capacitor. The potential difference V across the capacitor is measured.

It is suggested that V is related to d by the relationship

$$\frac{W}{V} = 1 + \frac{Cd}{KA}$$

where C is the capacitance of the capacitor, and K and W are constants.

Plan a laboratory experiment to test the relationship between V and d .

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for K and W .

In your plan you should include:

- 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

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[illegible]

- 2 A student investigates the relationship between the luminosity L of a star and its mass M for a set of stars known as main-sequence stars.

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

$$L = SZM^n$$

where S is the luminosity of the Sun, and Z and n are constants.

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

Determine expressions for the gradient and y -intercept.

gradient =

y -intercept =

[1]

(b) Values of M and L are given in Table 2.1.

Table 2.1

$M/10^{30} \text{ kg}$	$L/10^{28} \text{ W}$	$\lg (M/10^{30} \text{ kg})$	$\lg (L/10^{28} \text{ W})$
4.8 ± 0.4	1.4		
6.4 ± 0.4	3.1		
12 ± 2	32		
23 ± 2	350		
43 ± 4	3600		
91 ± 4	66 000		

Calculate and record values of $\lg (M/10^{30} \text{ kg})$ and $\lg (L/10^{28} \text{ W})$ in Table 2.1.
Include the absolute uncertainties in $\lg (M/10^{30} \text{ kg})$.

[2]

(c) (i) Plot a graph of $\lg (L/10^{28} \text{ W})$ against $\lg (M/10^{30} \text{ kg})$.
Include error bars for $\lg (M/10^{30} \text{ kg})$.

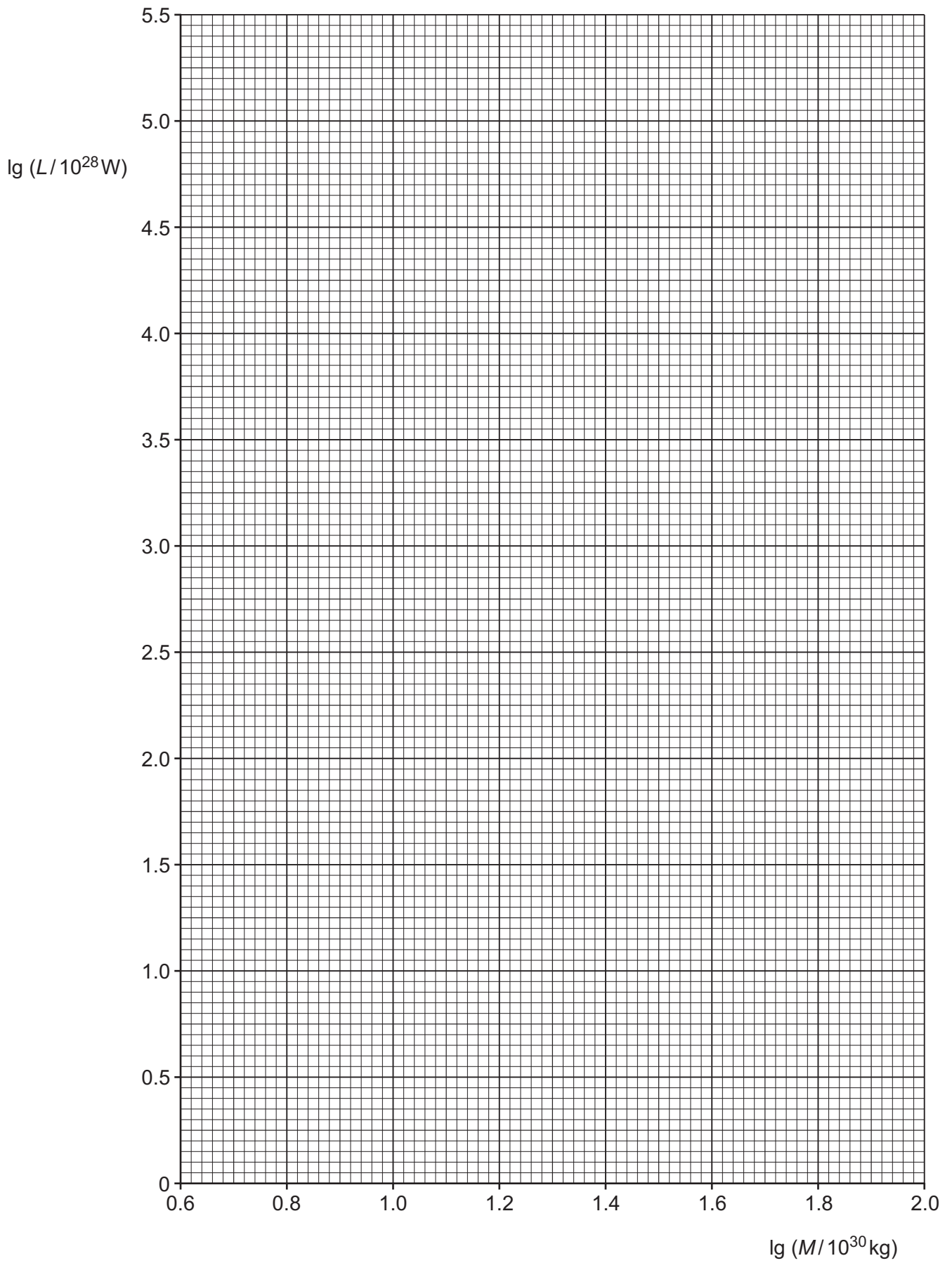
[2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Label both lines.

[2]

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

gradient = [2]



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

y -intercept = [2]

- (d) Using your answers to (a), (c)(iii) and (c)(iv), determine the values of n and Z . Include the absolute uncertainties in your values. You need not be concerned with units.

Data: $S = 3.85 \times 10^{26} \text{ W}$

$n = \dots\dots\dots$

$Z = \dots\dots\dots$ [3]

- (e) Another main-sequence star has a mass of $3.0 \times 10^{30} \text{ kg}$.

Determine the luminosity L of this star.

$L = \dots\dots\dots \text{ W}$ [1]

[Total: 15]