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Cambridge Assessment International Education

# Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*9773098042*

**PHYSICS** **9702/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2025**

**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.


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**1** On a bench, a steel ball of radius $r$ is used to compress a spring by a distance $x$. The ball is held at rest in this position, as shown in Fig. 1.1.

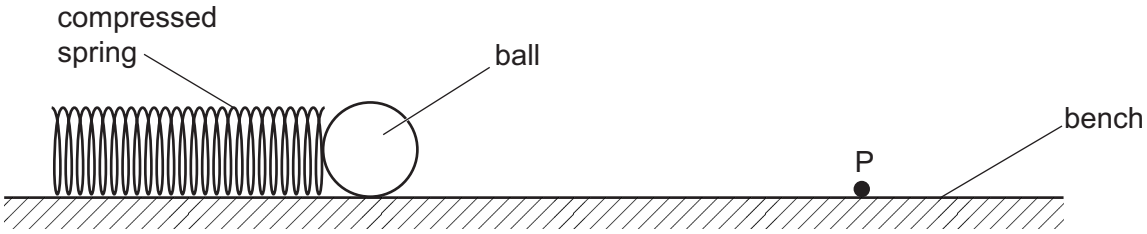



**Fig. 1.1**

The ball is released and rolls along the bench. At a fixed point P, the ball has speed $v$. The speed of the ball at P is determined using **one** light gate connected to a timer.

Several steel balls of different radii are available.

It is suggested that $v$ is related to $r$ by the relationship

$$v^2 = \frac{Ykx^2}{r^n\rho}$$

where $k$ is the spring constant of the spring, $\rho$ is the density of the steel, and $Y$ and $n$ are constants.

Plan a laboratory experiment to test the relationship between $v$ and $r$.

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for $Y$ and $n$.

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.

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**Diagram**

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**2** A student investigates light from different galaxies.

Fig. 2.1 shows the lines in the absorption spectrum from a distant galaxy.

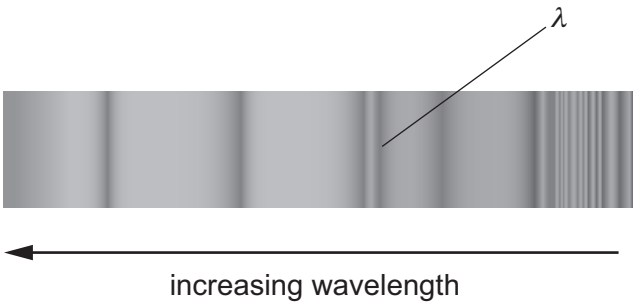



**Fig. 2.1**

The wavelength of one of the lines in the absorption spectrum is $\lambda$. The wavelength of this spectral line in the laboratory is $\lambda_0$.

The observations of the same spectral line are repeated for different galaxies.

The student determines the distance $d$ of each galaxy from the Earth.

It is suggested that $\lambda$ and $d$ are related by the equation

$$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{Hd}{c}$$

where $c$ is the speed of light in free space and $H$ is the Hubble constant.

**(a)** A graph is plotted of $\lambda$ on the $y$-axis against $\frac{d}{c}$ on the $x$-axis.

Determine expressions for the gradient and $y$-intercept.

gradient = .....

$y$-intercept = .....

[1]

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**(b)** Values of $d$ and $\lambda$ are given in Table 2.1.

**Table 2.1**

| $d / 10^{21}$ km | $\frac{d}{c} / 10^{15}$ s | $\lambda$ / nm |
|---|---|---|
| 0.48 ± 0.12 | | 658.4 |
| 1.04 ± 0.12 | | 661.2 |
| 1.45 ± 0.12 | | 664.2 |
| 1.80 ± 0.12 | | 665.7 |
| 2.85 ± 0.12 | | 672.4 |
| 3.75 ± 0.12 | | 678.2 |

The value of $c$ is $3.00 \times 10^5$ km s$^{-1}$.

Calculate and record values of $\frac{d}{c} / 10^{15}$ s in Table 2.1. Include the absolute uncertainties in $\frac{d}{c}$. [2]

**(c) (i)** Plot a graph of $\lambda$ / nm against $\frac{d}{c} / 10^{15}$ s. Include error bars for $\frac{d}{c}$. [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]

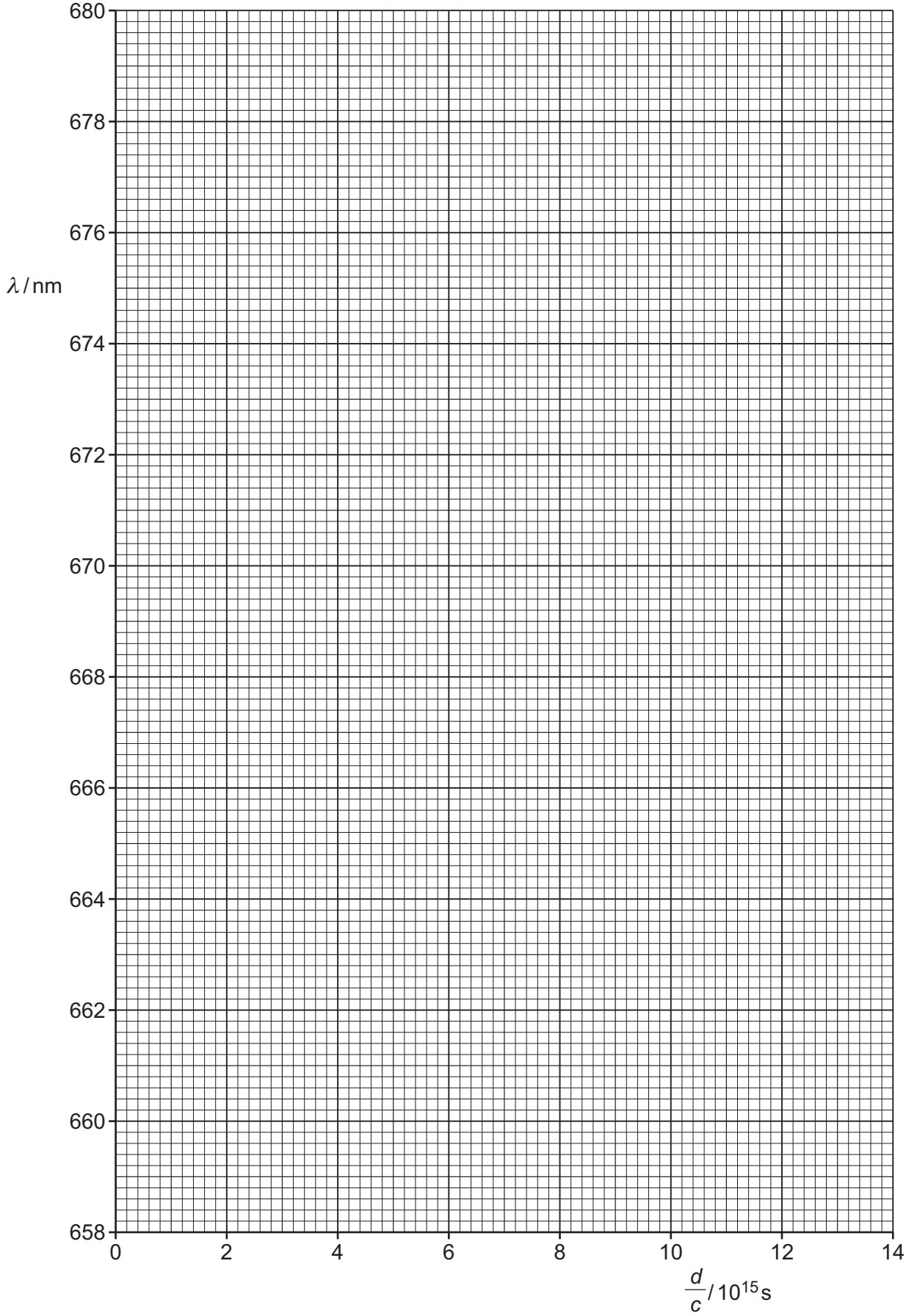
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**(iv)** Determine the *y*-intercept of the line of best fit. Include the absolute uncertainty in your answer.

*y*-intercept = ..... [2]

**(d)** Using your answers to **(a)**, **(c)(iii)** and **(c)(iv)**, determine the values of $\lambda_0$ and $H$. Include appropriate units.

$\lambda_0$ = .....

$H$ = .....
[2]

**(e)** Hubble's law suggests that the age $T$ of the universe is related to $H$ by

$$T = \frac{1}{H}.$$

Determine a value for $T$. Include the absolute uncertainty in your answer.

$T$ = ..... s [2]

[Total: 15]

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