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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

* 9 7 7 3 0 9 8 0 4 2 *

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.

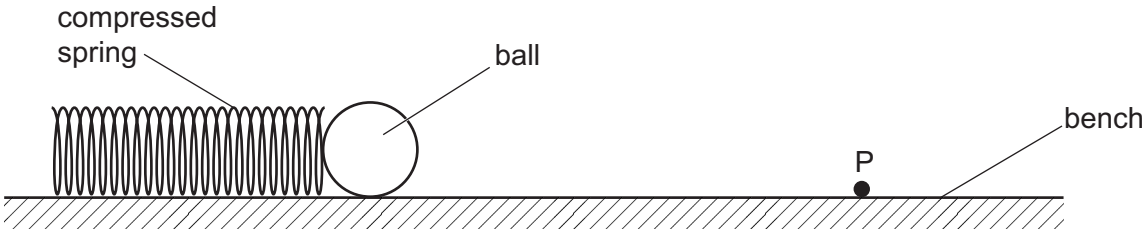


Fig. 1.1

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, ρ 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.

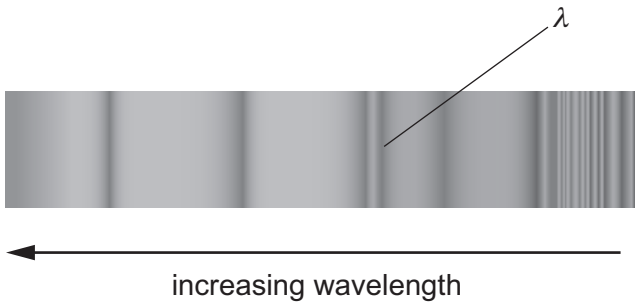


Fig. 2.1

The wavelength of one of the lines in the absorption spectrum is λ. The wavelength of this spectral line in the laboratory is λ_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 λ 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 λ 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 λ are given in Table 2.1.

Table 2.1

$d / 10^{21}$ km	$\frac{d}{c} / 10^{15}$ s	λ / 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 3.00×10^5 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 λ / nm against $\frac{d}{c} / 10^{15}$ s. Include error bars for $\frac{d}{c}$. [2]

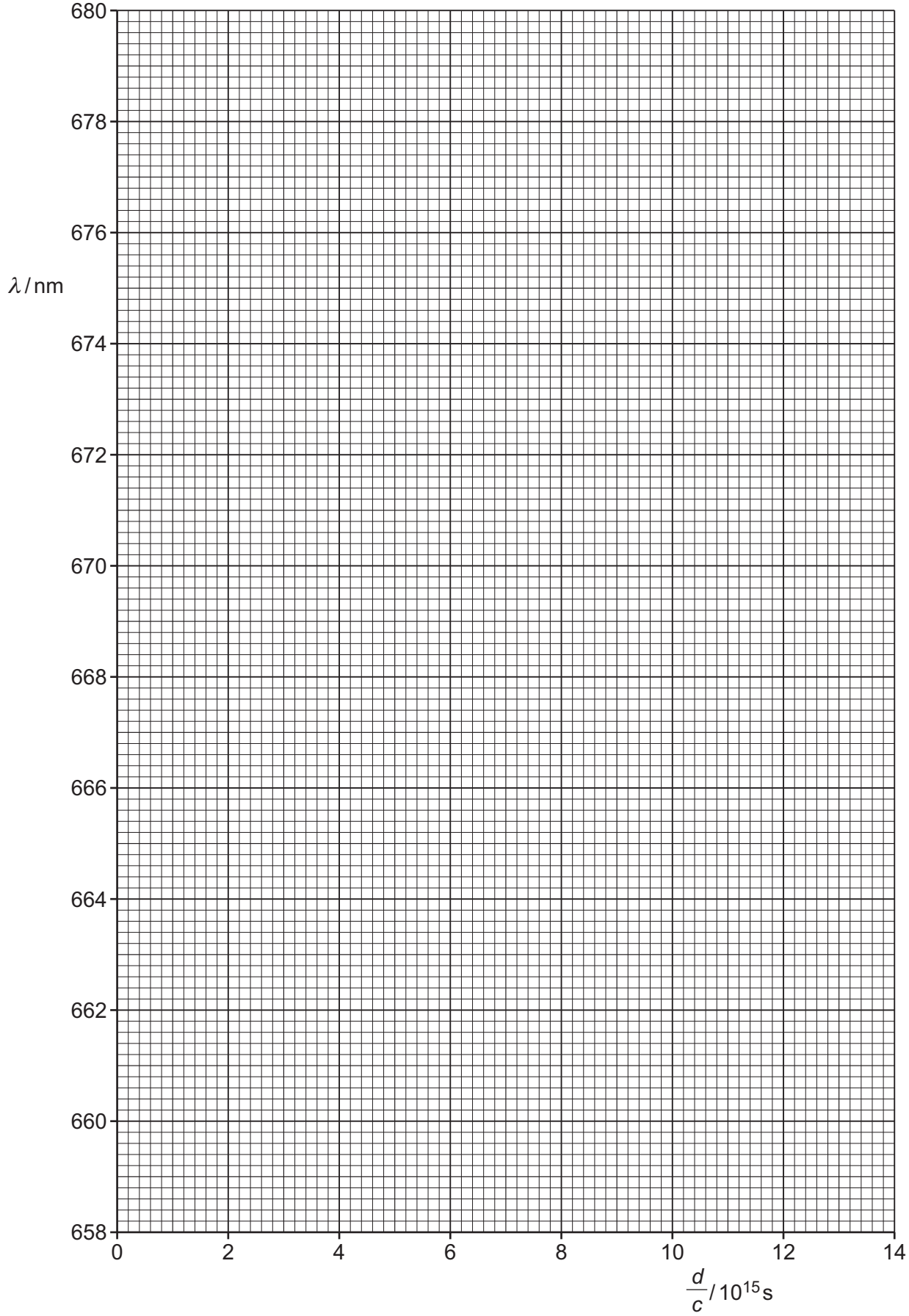
(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Label both lines. [2]

(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 λ_0 and H. Include appropriate units.

λ_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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