



Cambridge International AS & A Level

CANDIDATE
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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.

- 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.

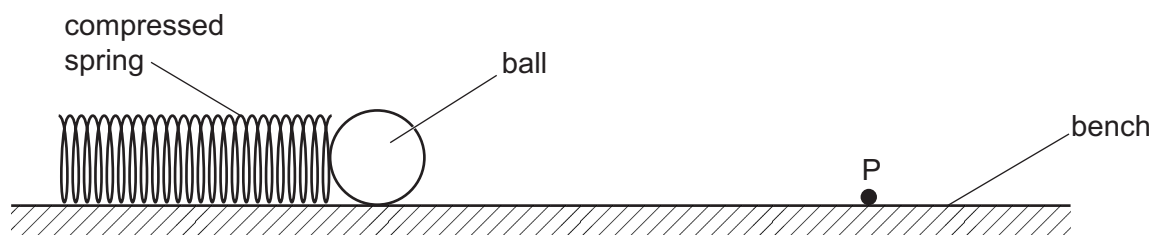


Fig. 1.1

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.





Diagram

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[15]



- 2 A student investigates light from different galaxies.

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

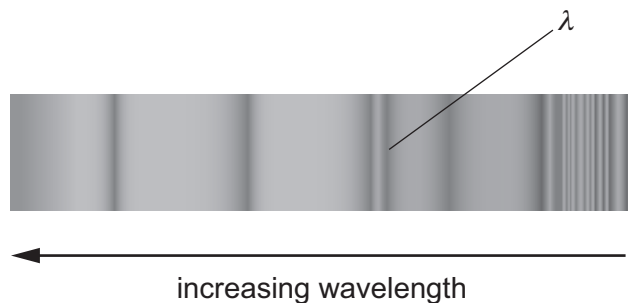


Fig. 2.1

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]



(b) Values of d and λ are given in Table 2.1.

Table 2.1

$d/10^{21} \text{ km}$	$\frac{d}{c}/10^{15} \text{ s}$	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 $3.00 \times 10^5 \text{ km s}^{-1}$.

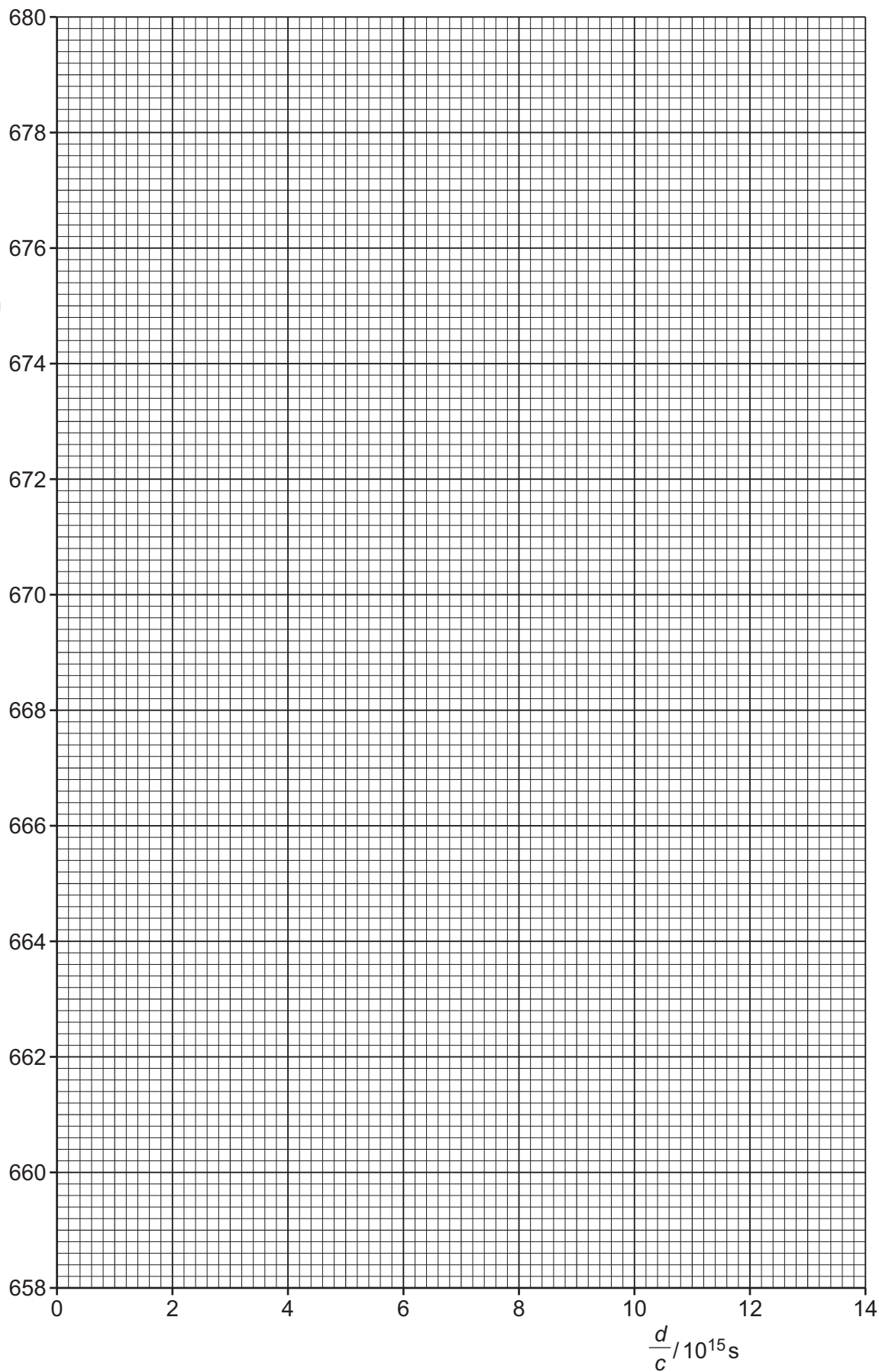
Calculate and record values of $\frac{d}{c}/10^{15} \text{ s}$ in Table 2.1. Include the absolute uncertainties in $\frac{d}{c}$.
[2]

- (c) (i) Plot a graph of λ/nm against $\frac{d}{c}/10^{15} \text{ s}$. 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]



λ/nm





- (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]





Cambridge International AS & A Level

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PHYSICS

9702/52

Paper 5 Planning, Analysis and Evaluation

October/November 2025

1 hour 15 minutes

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No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
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INFORMATION

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1 Fig. 1.1 shows a model wind turbine with blades, each of length L , placed in moving air.

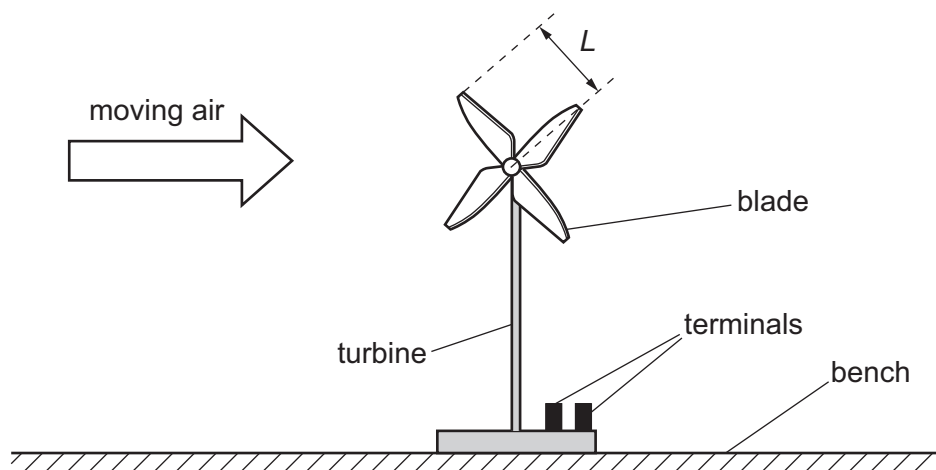


Fig. 1.1

The area of the circle swept by the blades of the turbine is A .

The output of the turbine has two terminals. The turbine is connected to a resistor of resistance R . At a speed v of the moving air, the current in the resistor is I .

The atmospheric pressure is P and the thermodynamic temperature of the air is T .

It is suggested that I is related to v by the relationship

$$\frac{I^2 R}{Q} = \frac{APv^3}{2T}$$

where Q is a constant.

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

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine a value for Q .

In your plan you should include:

- the procedure to be followed
- the measurements to be taken
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- any safety precautions to be taken.





Diagram

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.





..... [15]



- 2 A student observes the orbits of some of the moons around the planet Saturn, as shown in Fig. 2.1.

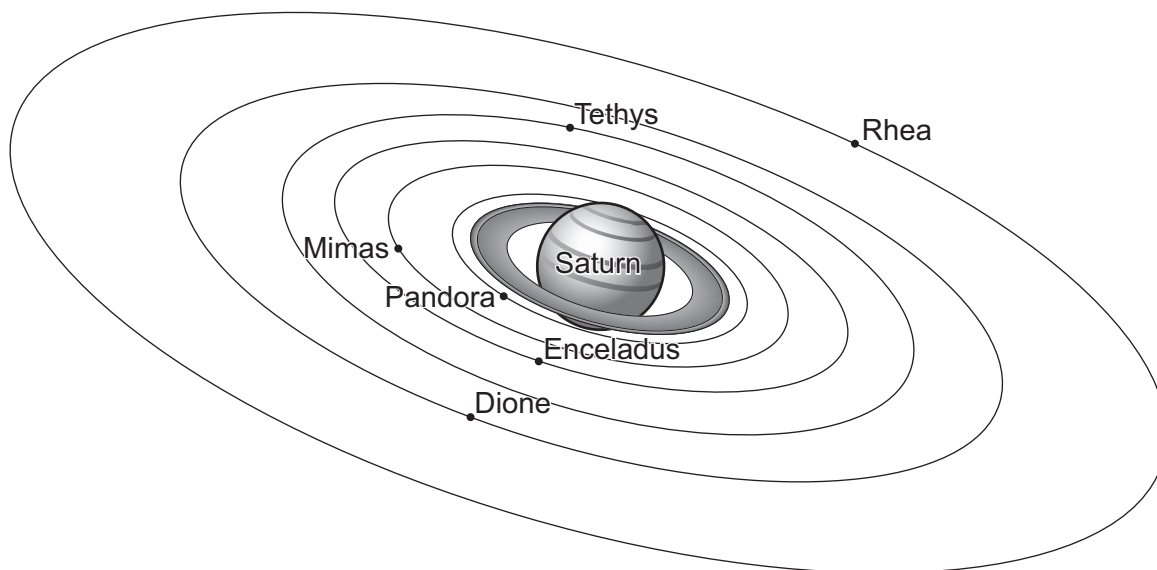


Fig. 2.1 (not to scale)

For the moon Pandora, the period of the orbit and the mean distance from the centre of Saturn are determined.

The measurements of period T and mean distance r are repeated for other moons.

It is suggested that T and r are related by the equation

$$T = \frac{2\pi r^n}{k}$$

where n and k are constants.

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

Determine expressions for the gradient and y -intercept.

gradient = ...

y -intercept = ...

[1]



(b) Values of r and T are given for different moons in Table 2.1.

Table 2.1

moon	$r/10^8\text{ m}$	$T/10^3\text{ s}$	$\lg(r/10^8\text{ m})$	$\lg(T/10^3\text{ s})$
Pandora	1.42	52 ± 5		
Mimas	1.86	81 ± 5		
Enceladus	2.38	120 ± 10		
Tethys	2.95	170 ± 10		
Dione	3.77	240 ± 20		
Rhea	5.28	390 ± 30		

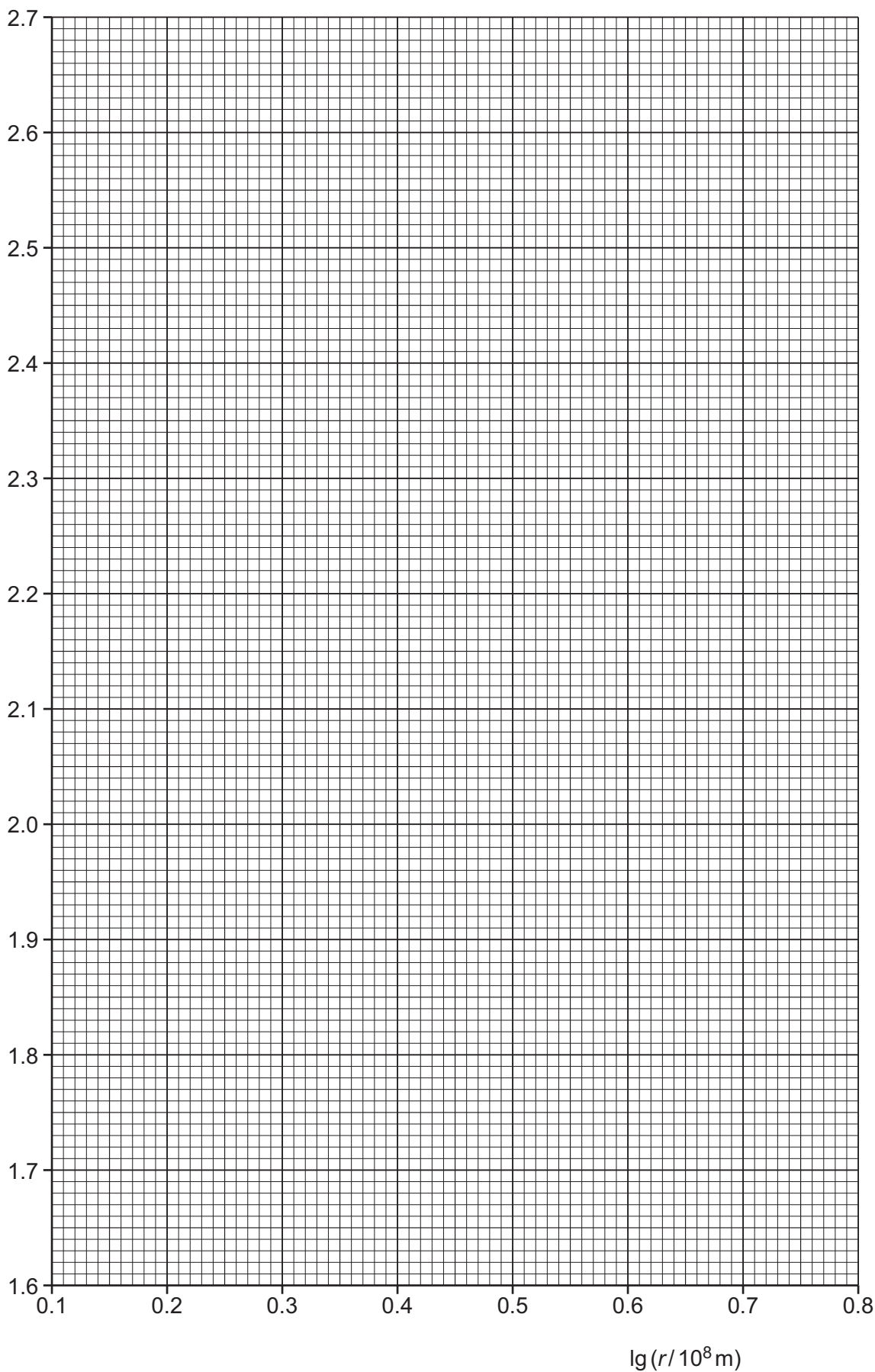
Calculate and record values of $\lg(r/10^8\text{ m})$ and $\lg(T/10^3\text{ s})$ in Table 2.1. Include the absolute uncertainties in $\lg(T/10^3\text{ s})$. [2]

- (c) (i) Plot a graph of $\lg(T/10^3\text{ s})$ against $\lg(r/10^8\text{ m})$. Include error bars for $\lg(T/10^3\text{ s})$. [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]



$\lg(T/10^3\text{s})$





- (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 k . Include the absolute uncertainties in n and k . You need not be concerned with units.

n = ...

k = ...

[3]

- (e) Titan is another moon of Saturn. The orbit of Titan has a period of 1.38×10^6 s.

Determine the value of r for Titan.

r = ... m [1]

[Total: 15]





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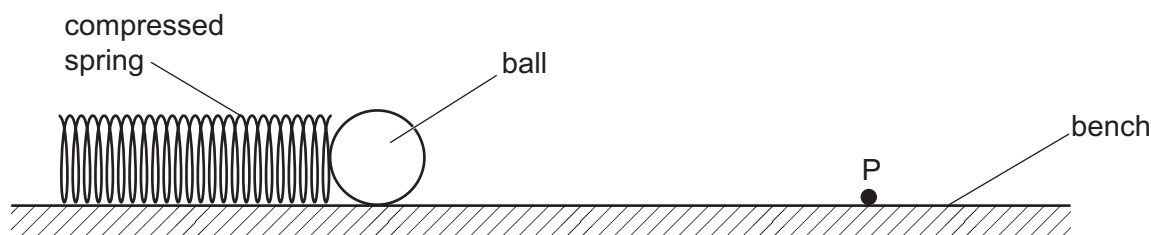


Fig. 1.1

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
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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.

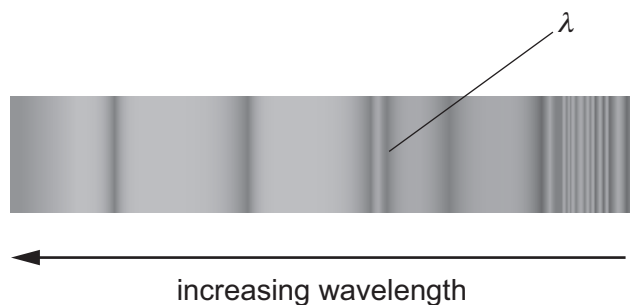


Fig. 2.1

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]



(b) Values of d and λ are given in Table 2.1.

Table 2.1

$d/10^{21} \text{ km}$	$\frac{d}{c}/10^{15} \text{ s}$	λ/nm
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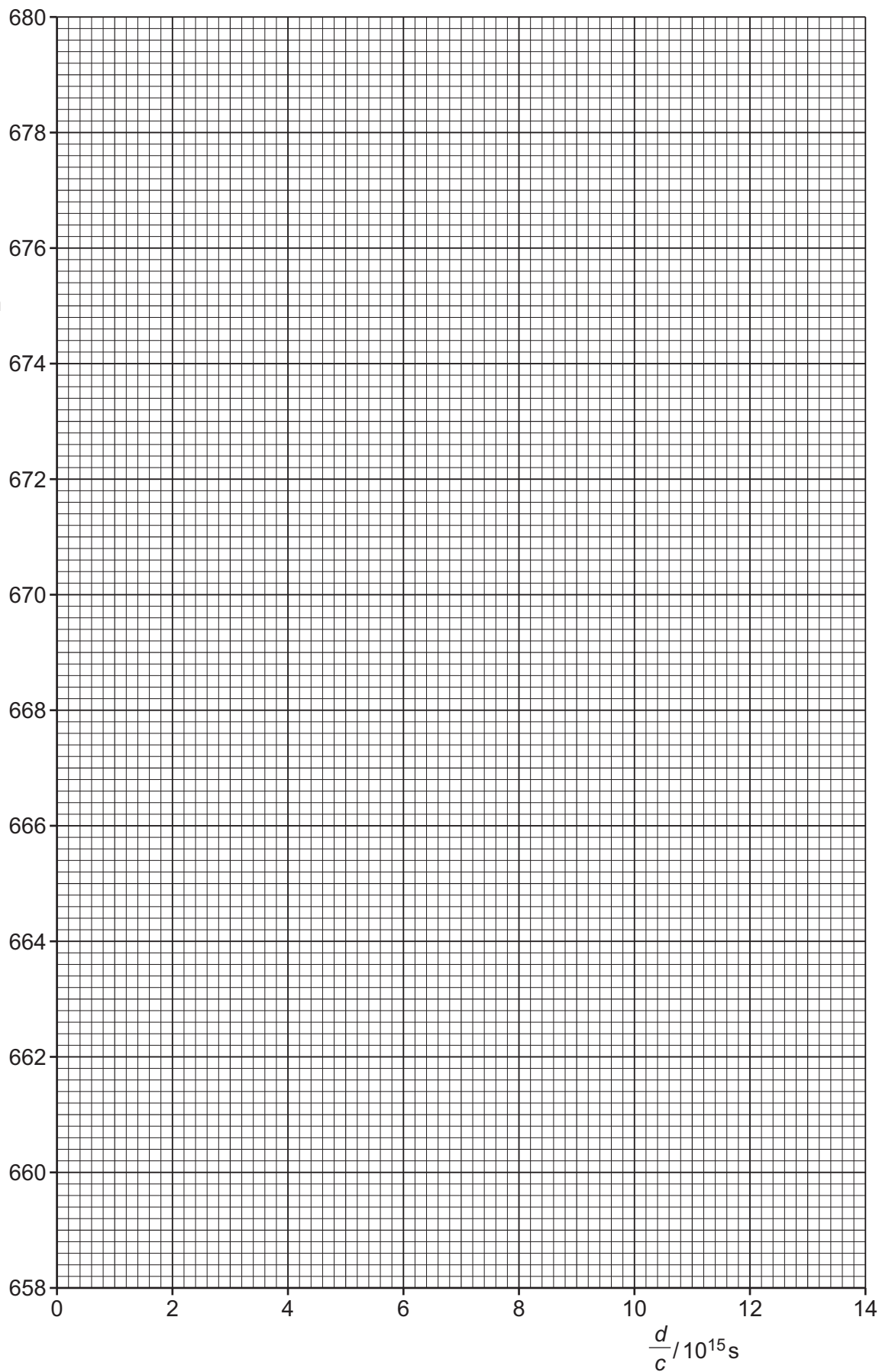
Calculate and record values of $\frac{d}{c}/10^{15} \text{ s}$ in Table 2.1. Include the absolute uncertainties in $\frac{d}{c}$.
[2]

- (c) (i) Plot a graph of λ/nm against $\frac{d}{c}/10^{15} \text{ s}$. 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]



λ/nm





- (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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PHYSICS

9702/54

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1 Fig. 1.1 shows a horizontal turntable.

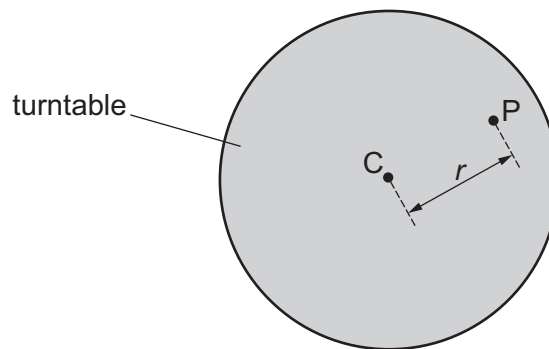


Fig. 1.1

Point C is at the centre of the turntable. Point P is a distance r from the centre.

Fig. 1.2 shows a side view of a d.c. motor attached to the turntable with a belt.



Fig. 1.2

The motor is used to rotate the turntable at frequency f_0 . The motor is switched off and the turntable continues to rotate at frequency f_0 .

A sphere of adhesive putty of mass m is dropped onto the turntable at point P. The frequency of the turntable is now f .

It is suggested that f is related to m by the relationship

$$\frac{Kf_0}{f} = \beta K + mr^2$$

where β and K are constants.

Plan a laboratory experiment to test the relationship between f and m .

Draw a diagram showing the arrangement of your equipment.

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

In your plan you should include:

- the procedure to be followed
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Diagram

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..... [15]



- 2 A student places a slide with a double slit on a support clamped to the bench as shown in Fig. 2.1.

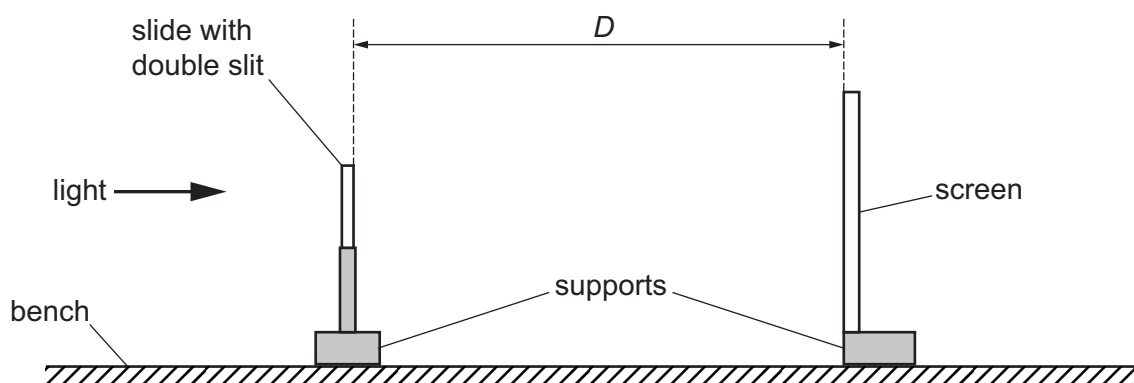


Fig. 2.1

The distance between the slide and the screen is D .

The separation s of the slits is determined.

Light from a laser is incident normally on the double slit. An interference pattern is observed on the screen. The distance w across 10 fringes is measured. The distance y between the centres of adjacent fringes is calculated using the equation

$$y = \frac{w}{10}.$$

The experiment is repeated with slides of different slit separation s .

It is suggested that y and s are related by the equation

$$\lambda = \frac{sy}{D}$$

where λ is the wavelength of the incident light.

- (a) A graph is plotted of y on the y -axis against $\frac{1}{s}$ on the x -axis.

Determine an expression for the gradient.

gradient = ... [1]



(b) Values of s and w are given in Table 2.1.

Table 2.1

s/mm	$\frac{1}{s}/\text{mm}^{-1}$	w/mm	y/mm
0.18 ± 0.01		33.0	
0.21 ± 0.01		28.9	
0.24 ± 0.01		25.1	
0.27 ± 0.01		22.6	
0.31 ± 0.01		19.6	
0.38 ± 0.01		15.9	

Calculate and record values of $\frac{1}{s}/\text{mm}^{-1}$ and y/mm in Table 2.1. Include the absolute uncertainties in $\frac{1}{s}$. [2]

(c) (i) Plot a graph of y/mm against $\frac{1}{s}/\text{mm}^{-1}$. Include error bars for $\frac{1}{s}$. [2]

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

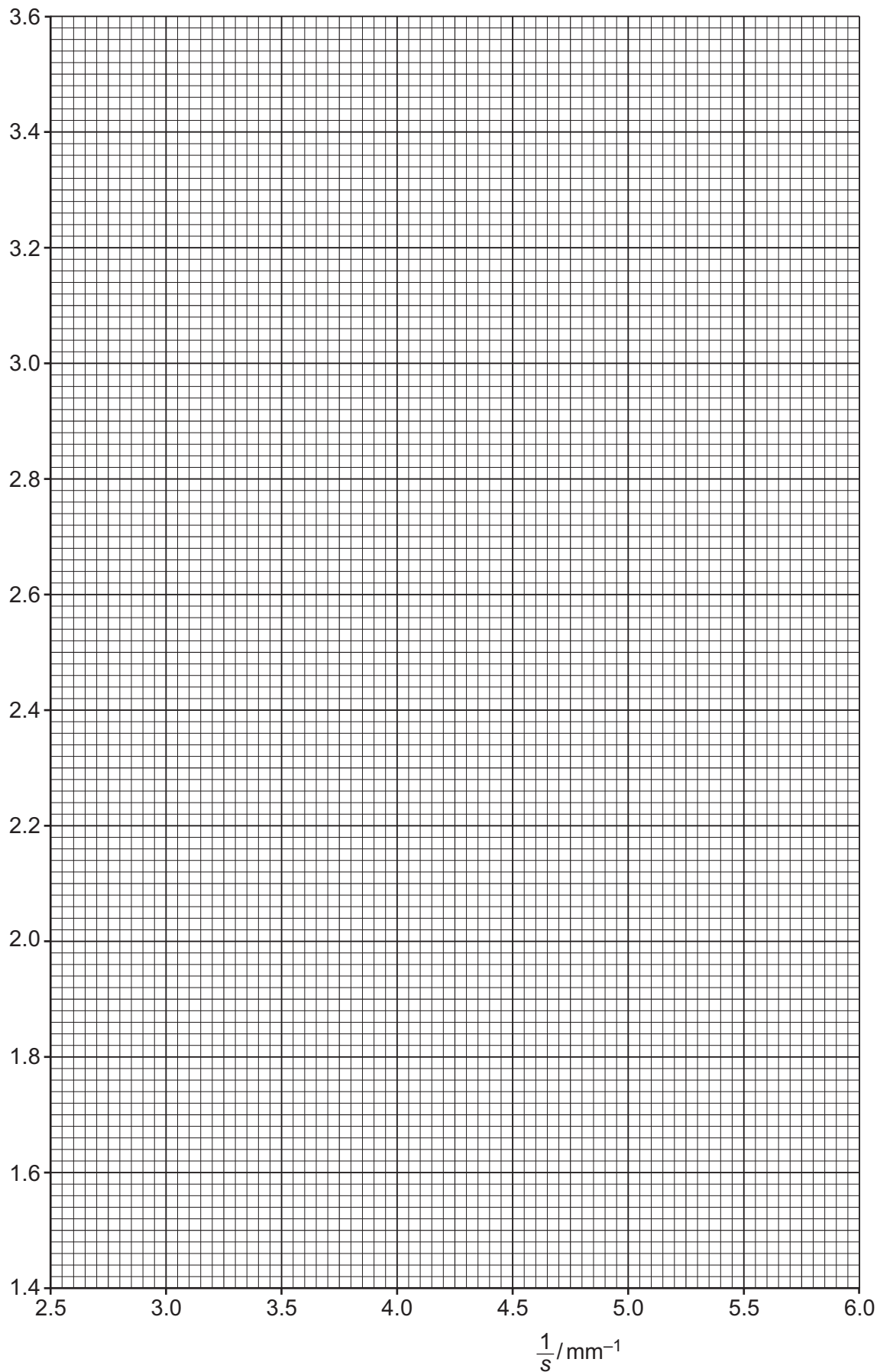
(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = ... [2]





y/mm





(d) The distance between the slide and the screen is measured several times:

0.929 m 0.918 m 0.913 m 0.918 m 0.927 m.

Determine the mean distance D . Include the absolute uncertainty.

$D = \dots\dots\dots$ m [1]

(e) (i) Using your answers to (a), (c)(iii) and (d), determine the value of λ . Include an appropriate unit.

$\lambda = \dots\dots\dots$ [2]

(ii) Determine the percentage uncertainty in λ .

percentage uncertainty in $\lambda = \dots\dots\dots$ % [1]

(f) The experiment is repeated. Determine the slit separation s that gives a value of y of (0.500 ± 0.005) cm. Include the absolute uncertainty.

$s = \dots\dots\dots$ m [2]

[Total: 15]

