

- 1 A student is investigating the force between two charged metal spheres S and T, as shown in Fig. 1.1.

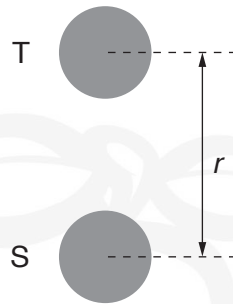


Fig. 1.1

Each sphere may be charged by connecting the positive lead from a power supply to the sphere and then removing the lead. The electromotive force (e.m.f.) of the power supply used to charge sphere T is V .

The force F between the two charged spheres may be determined by attaching sphere S to a top pan balance.

For a constant charge on sphere S, it is suggested that the relationship between F and V is

$$F = \frac{\alpha V}{r^2}$$

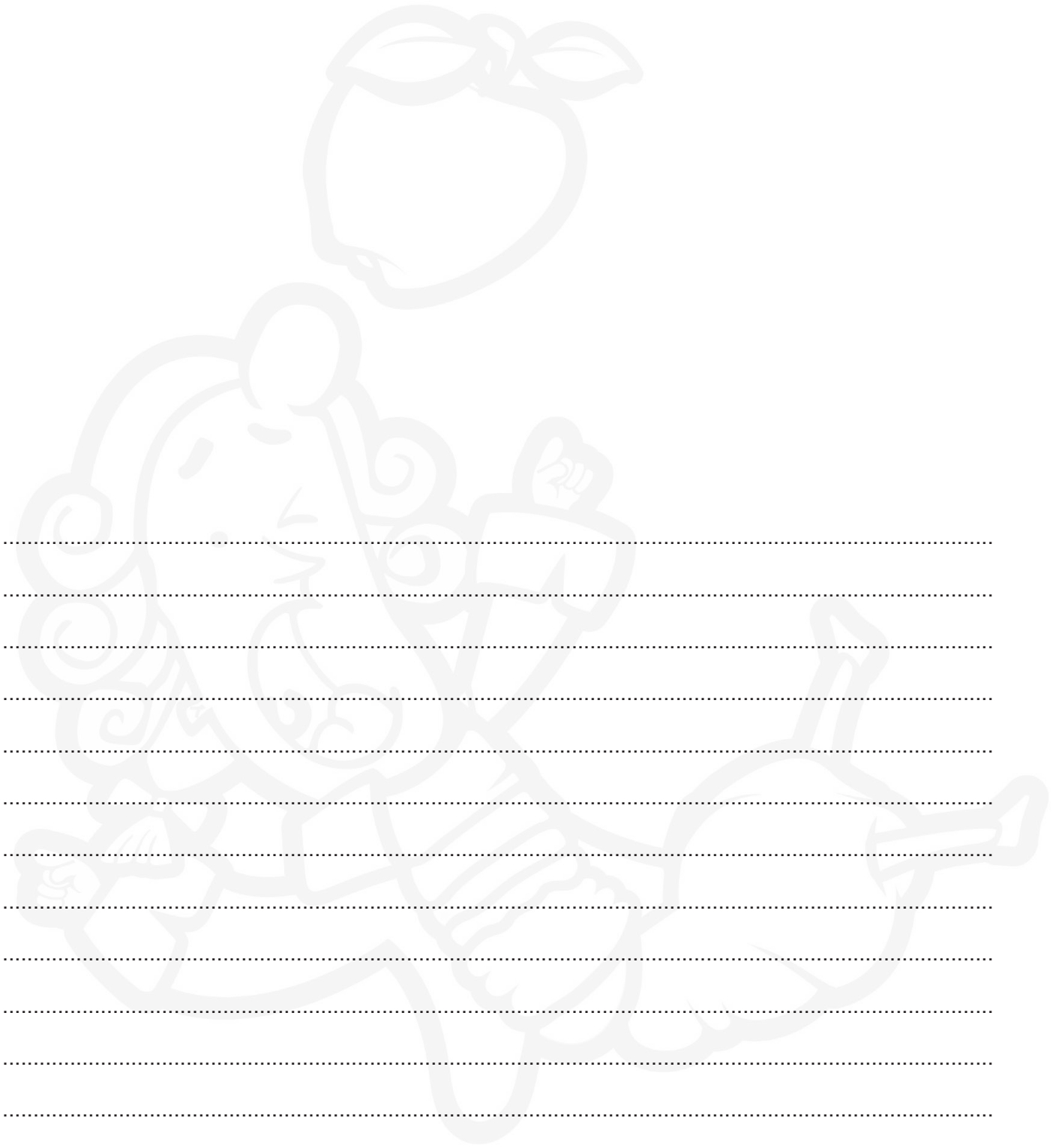
where r is the distance between the centres of the spheres and α is a constant.

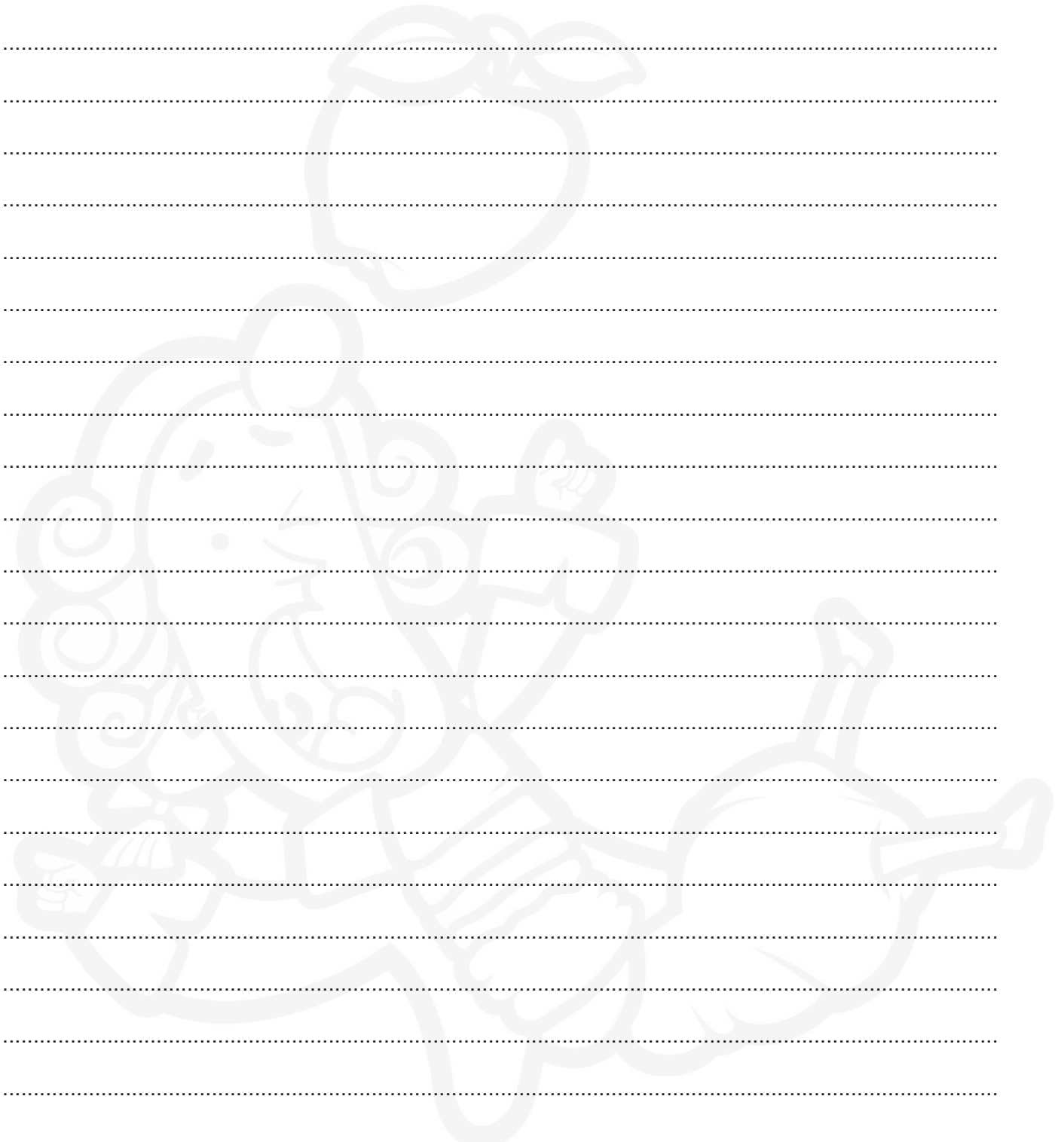
Design a laboratory experiment to test the relationship between F and V . Explain how your results could be used to determine a value for α .

You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- 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





- 2 A student is investigating monochromatic light passing through a diffraction grating. A series of maxima are produced on a screen, as shown in Fig. 2.1.

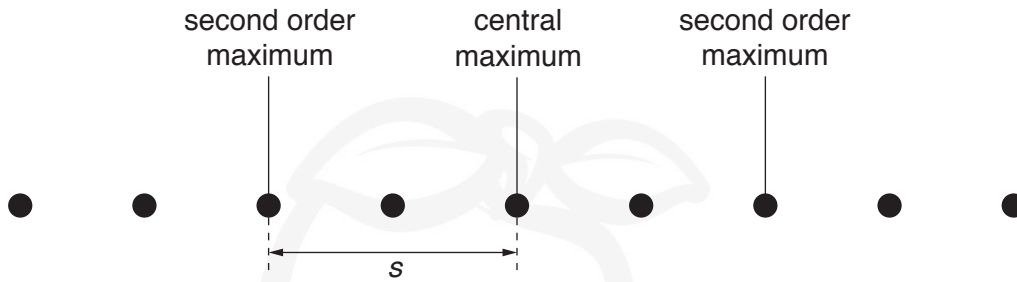


Fig. 2.1

The student measures the distance s between the central maximum and the second order maximum on the screen.

The experiment is repeated for different wavelengths of light.

It is suggested that s and the wavelength λ are related by the equation

$$\frac{s^2}{s^2 + D^2} = 4N^2\lambda^2$$

where D is the distance between the diffraction grating and the screen and N is the number of lines per unit length of the diffraction grating.

- (a) A graph is plotted of $\frac{1}{s^2}$ on the y -axis against $\frac{1}{\lambda^2}$ on the x -axis.

Determine expressions for the gradient and y -intercept.

gradient =

y -intercept =

[1]

(b) Values of λ and s are given in Fig. 2.2.

$\lambda/10^{-7}\text{m}$	s/m	$\frac{1}{\lambda^2}/10^{12}\text{m}^{-2}$	$\frac{1}{s^2}/\text{m}^{-2}$
4.3	0.62 ± 0.02		
4.8	0.72 ± 0.02		
5.3	0.82 ± 0.02		
5.8	0.92 ± 0.02		
6.2	1.02 ± 0.02		
6.6	1.10 ± 0.02		

Fig. 2.2

Calculate and record values of $\frac{1}{\lambda^2}/10^{12}\text{m}^{-2}$ and $\frac{1}{s^2}/\text{m}^{-2}$ in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{s^2}$. [2]

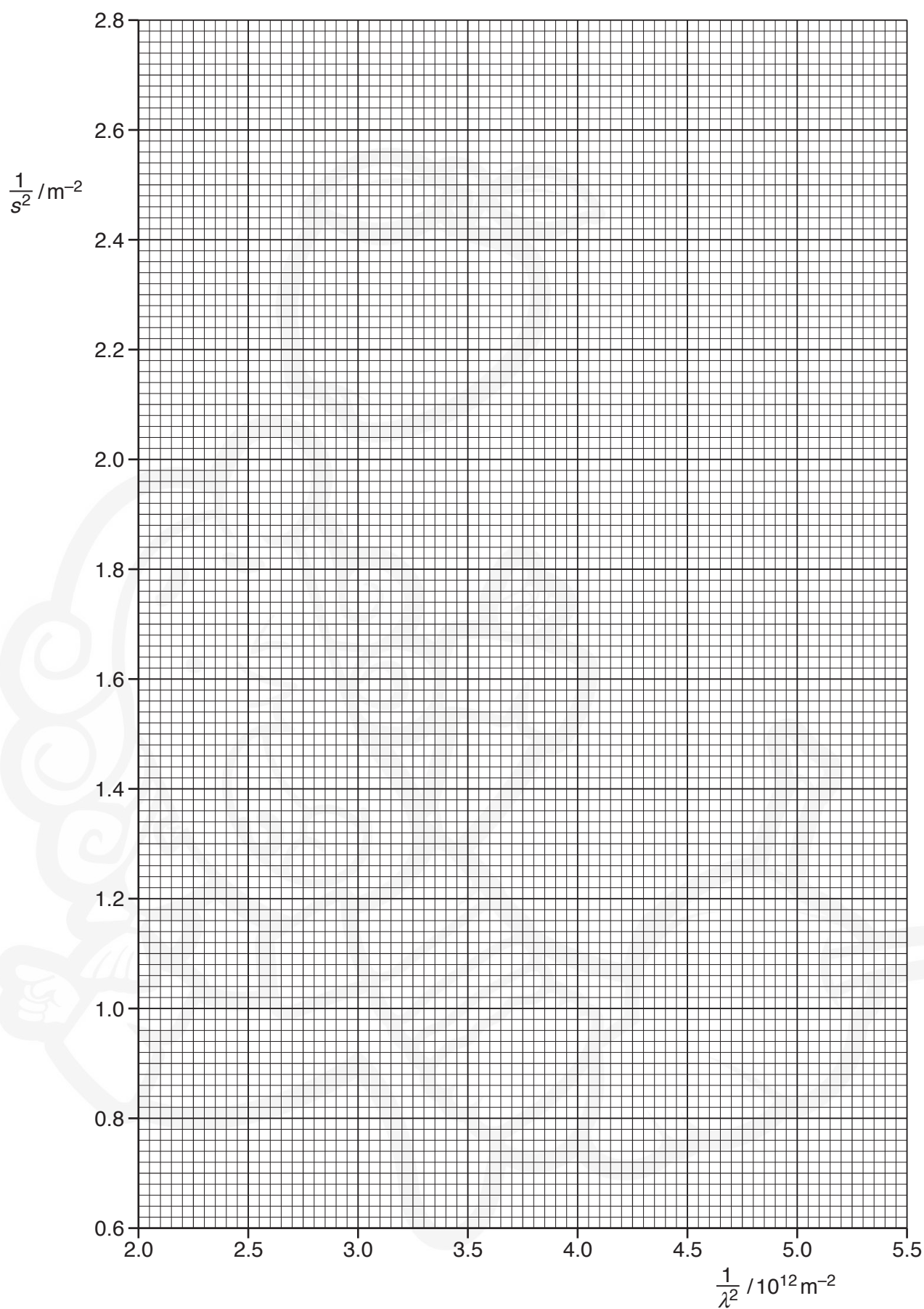
(c) (i) Plot a graph of $\frac{1}{s^2}/\text{m}^{-2}$ against $\frac{1}{\lambda^2}/10^{12}\text{m}^{-2}$.

Include error bars for $\frac{1}{s^2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [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) (i) Using your answers to (a), (c)(iii) and (c)(iv), determine the values of D and N . Include appropriate units.

D =

N = [3]

- (ii) Determine the percentage uncertainty in N .

percentage uncertainty in N = % [1]

[Total: 15]