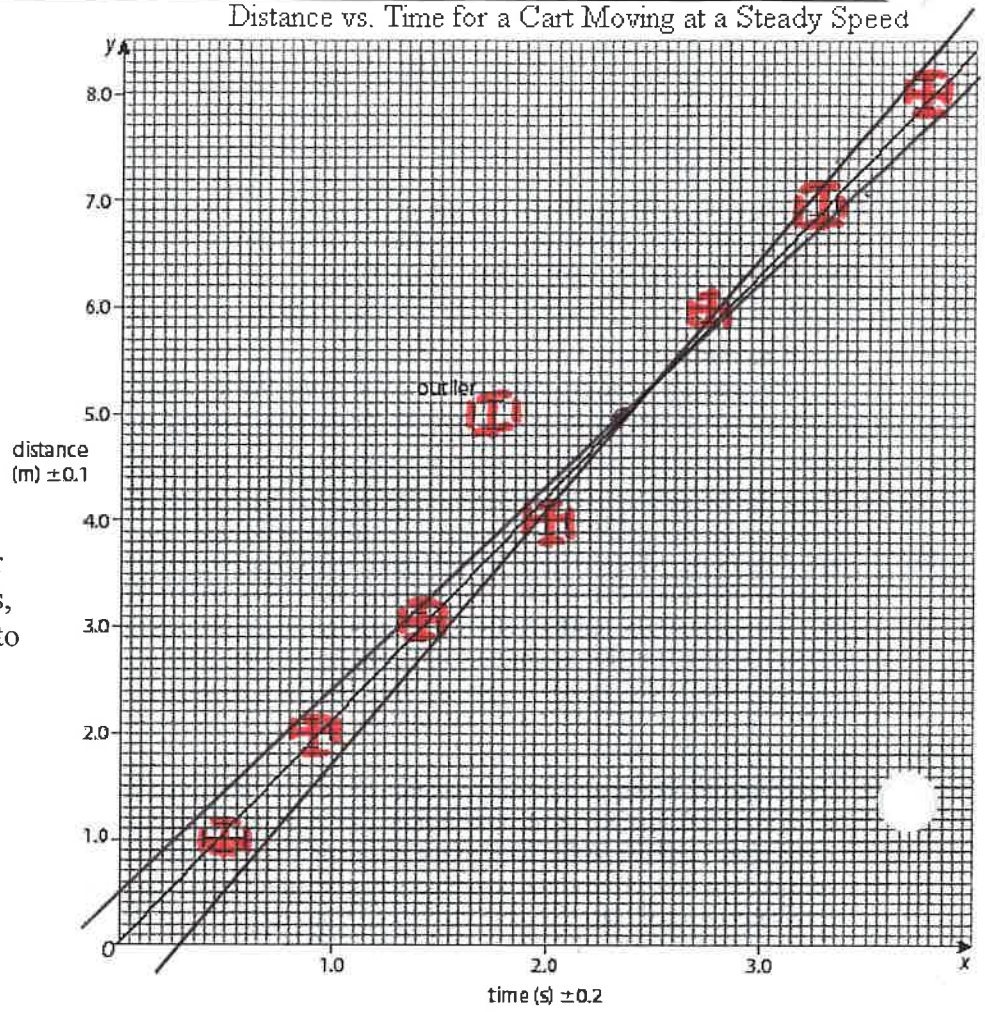
Practice – Analyzing Data Graphically

An experiment was done to determine the relationship between the distance a cart moved and the time it took to do this. The data is already graphed below with error bars and a best-fit line.



1. Calculate the slope of the best-fit line. Show your work, including equation and substitution with units.

$$\text{slope} = \frac{\Delta y}{\Delta x}$$

(0,0) (3.7, 7.8)

$$\frac{7.8\,m}{3.7\,s} = 2.1\,\frac{m}{s}$$

2. Write the experimental relationship for this data. (Substitute specific symbols, the slope and y-intercept with units into the general equation for a line.)

$y = mx + b$ (m: slope; b: y-intercept)

$d = vt + 0m$ (slope = velocity)

3. Compare your experimental relationship to a math model for this experiment and make a conclusion about the meaning of the slope of the best-fit line.

Using $d = vt$ (for constant speed) this slope indicates the velocity of the cart is $2.1\,\frac{m}{s}$.

4. Use a ruler and sharp pencil to draw in the max/min lines. Calculate the slopes of these lines and find the range of slopes. Finally, write the value for the slope with its uncertainty. (Remember, slope uncertainty = ½ range.)

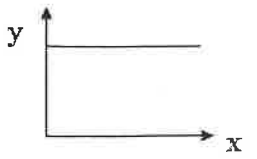
max slope = $2.3\,\frac{m}{s}$

min. slope = $2.0\,\frac{m}{s}$

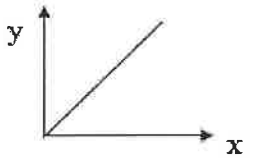
Report as $\boxed{2.1\,\frac{m}{s} \pm 0.2\,\frac{m}{s}}$

$\pm\frac{1}{2}$ range $\left(2.3\,\frac{m}{s} - 2.0\,\frac{m}{s}\right) = 0.15\,\frac{m}{s} \rightarrow 0.2\,\frac{m}{s}$

Graphical Representations of Relationships Between Data Sets

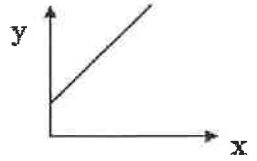
1. 

Name: constant **General equation:** $y = c$

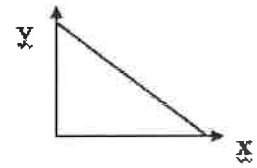
2. 

Name: direct, proportional **Proportion:** $y \propto x$

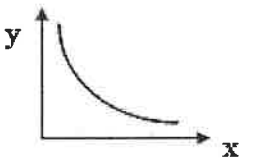
Constant of proportionality "c" = slope **General equation:** $y = cx$

3. 

Name: linear (not proportional) positive slope **General equation:** $y = mx + b$

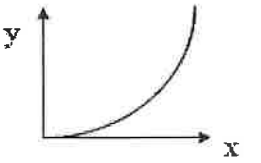
4. 

Name: linear negative slope **General equation:** $y = mx + b$ (m: negative)

5. 

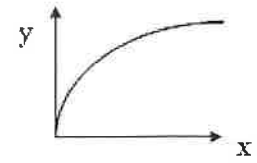
Name: inverse **Proportion:** $y \propto \frac{1}{x}$ or x^{-1}

General equation: $y = \frac{c}{x}$ or cx^{-1}

6. 

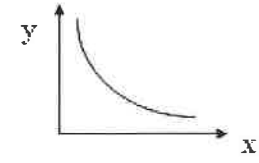
Name: quadratic **Proportion:** $y \propto x^2$

General equation: $y = cx^2$

7. 

Name: square root **Proportion:** $y \propto \sqrt{x}$

General equation: $y = c\sqrt{x}$

8. 

Name: inverse quadratic or inverse square **Proportion:** $y \propto \frac{1}{x^2}$

General equation: $y = \frac{c}{x^2}$

If linearizing the graph does not give a straight line, then the equation is not verified.

Note: "C" does not necessarily equal one.

Graph Straightening

Linearizing (straightening) a graph: No error bars in a linearized graph.

Transforming a non-linear graph into a linear one by an appropriate transformation of the variables and re-plotting of the data points.

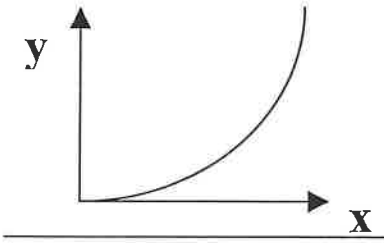
Purpose: easy to extrapolate answers

To find the constant of proportionality and write the experimental equation so the relationship can be compared to a mathematical model.

For each relationship shown below, give the name and the general equation for it.
Then, show the transformed variables that should be graphed in order to straighten the graph.

1.

Original Graph

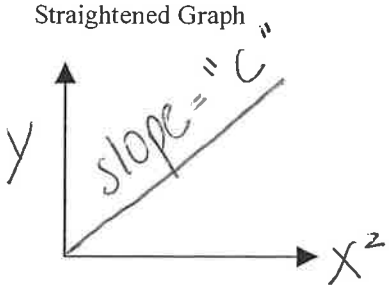


Name and General Equation: quadratic, $y = cx^2$, $y \propto x^2$

Transformation of variables:

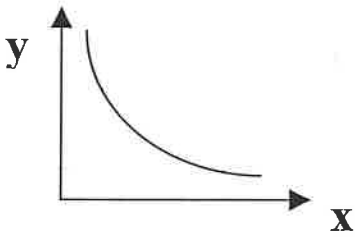
x	y	x^2
2	4	2^2
3	9	3^2

Straightened Graph



2.

Original Graph

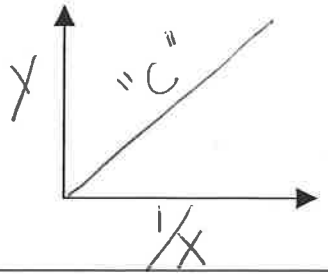


Name and General Equation: inverse, $y = \frac{c}{x}$

Transformation of variables:

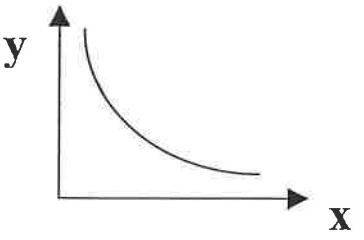
x	y	$\frac{1}{x}$
1	1	$\frac{1}{1}$
2	$\frac{1}{2}$	$\frac{1}{2}$

Straightened Graph



3.

Original Graph

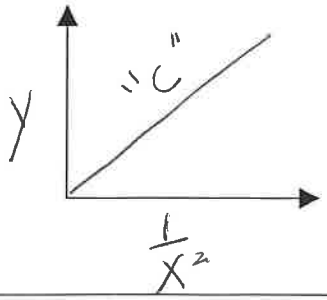


Name and General Equation: inverse quadratic, $y = \frac{c}{x^2}$

Transformation of variables:

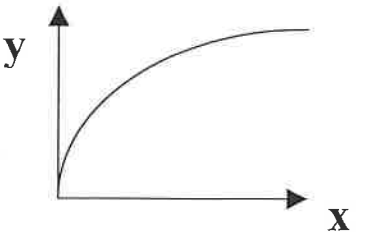
x	y	$\frac{1}{x^2}$
1	1	$\frac{1}{1^2}$
2	$\frac{1}{4}$	$\frac{1}{2^2}$

Straightened Graph



4.

Original Graph

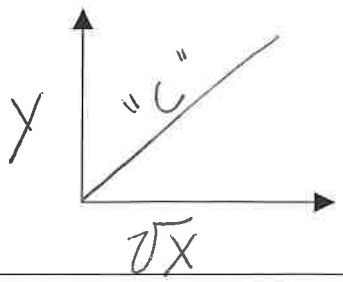


Name and General Equation: square root, $y = c\sqrt{x}$

Transformation of variables:

x	y	$\sqrt{x}$
1	$\sqrt{1}$	$\sqrt{1}$
2	$\sqrt{2}$	$\sqrt{2}$

Straightened Graph



How does straightening the graph help in writing the experimental equation for a non-linear relationship?

In each case, the slope of the straightened graph is the constant of proportionality in the general equation.