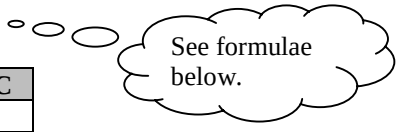
Hire a Coach

Suppose the cost of hiring a coach consists of a basic charge of £28 plus £15 per hour.
An Excel spreadsheet can be used to calculate the total cost for hiring the coach for different times.
A graph can be drawn to illustrate the relationship between the total cost and the time.

How to do it….

1 First ***find a formula*** that relates the total cost to the time for which the coach is hired.
The total cost is £28 plus £15 per hour. For h hours the total cost in £ is $C = 28 + 15h$.

2 Use the formula to ***set up a spreadsheet table***.
Put headings h (for number of hours) and C (for cost in £) at the top of columns A and B.
Use 0 as the first value of h. Enter 0 in cell A2.
Write a spreadsheet version of the formula in cell B2 to calculate the cost.
Write a spreadsheet formula in cell A3 to calculate the next value of h.



	A	B	C
1	***h***	***C***	
2	0	28	
3	1		

Numerical values

	A	B	C
1	***h***	***C***	
2	0	=28+15*A2	
3	=A2+1		

Formulae

3 Use '***fill down***' to complete the table as far as $h = 8$. The results are shown below:

	A	B	C
1	***h***	***C***	
2	0	28	
3	1	43	
4	2	58	
5	3	73	
6	4	88	
7	5	103	
8	6	118	
9	7	133	
10	8	148	

Numerical values

	A	B	C
1	***h***	***C***	
2	0	=28+15*A2	
3	=A2+1	=28+15*A3	
4	=A3+1	=28+15*A4	
5	=A4+1	=28+15*A5	
6	=A5+1	=28+15*A6	
7	=A6+1	=28+15*A7	
8	=A7+1	=28+15*A8	
9	=A8+1	=28+15*A9	
10	=A9+1	=28+15*A10	

Formulae

4 To draw the graph, highlight the values in columns A and B and use the Chart Wizard to draw a ***scatter graph*** (choose the line with points).

When setting up the graph, write in a title and labels, remove the legend and choose to use both major and minor gridlines. Keep your graph on the same sheet as the table.

Your graph should be ***linear***. This means that the graph is a ***straight line***.

5 Follow these instructions to format the graph as shown below:

a Use the **View** menu to show the **Chart Toolbar**.

This gives a clear background.

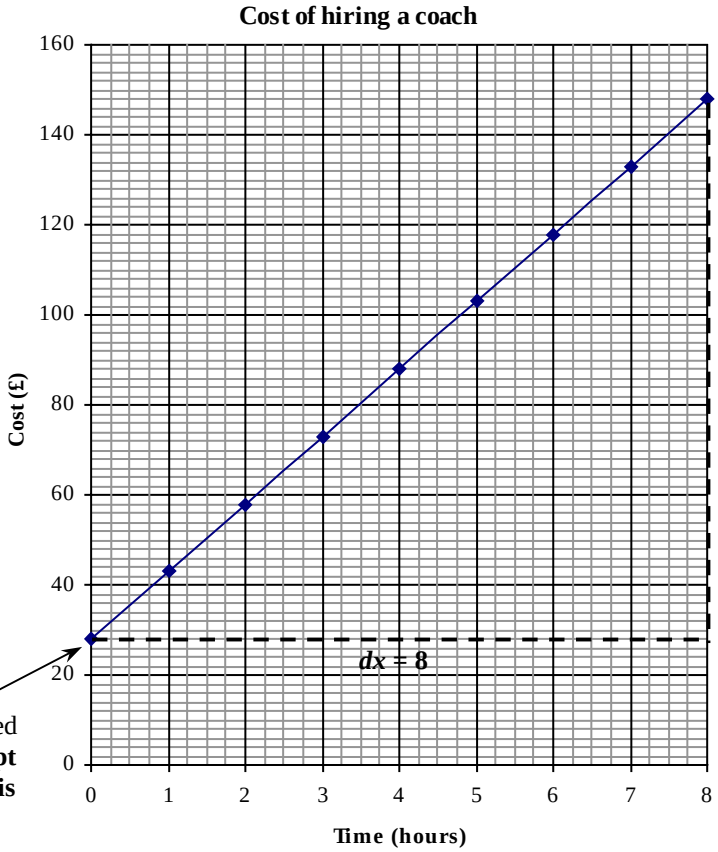
b On the Chart toolbar select **Plot Area**
In the **Plot Area properties** set both the **Border** and **Area** to '**None**'

c On the Chart toolbar select **Value (X) Axis Minor Gridlines**
In the **Patterns** properties set **Colour** to a mid-shade of grey, rather than Automatic (black)
In the **Scale** properties set Maximum: 8
Major unit: 1
Minor unit: 0.25 (so each small square = ¼ hour)
(leaving other items as they are eg Minimum: 0 and Value (Y) axis crosses at: 0)

d On the Chart toolbar select **Value (Y) Axis Minor Gridlines**
In the **Patterns** properties set **Colour** to the mid-shade of grey you used in c
In the **Scale** properties set Maximum: 160
Major unit: 20
Minor unit: 2

This makes the major gridlines stand out.

Here are some important facts about the line:



dy
= 148 – 28
= 120

Gradient (sometimes called slope) is a measure of how steep a line is.
To find the gradient a triangle is drawn between 2 points on the line (shown by dotted lines).
To find the gradient the distance in the *y* direction (*dy*) is divided by the distance in the *x* direction (*dx*).

Gradient (slope) of this line

$$\frac{dy}{dx} = \frac{120}{8}$$
$$= 15$$

This is called the **intercept on the *y* axis £28**

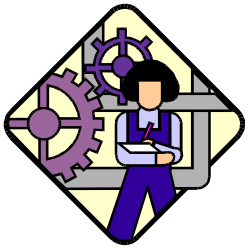
Note the connections between the formula $C = 28 + 15h$ and the intercept and gradient of the line.
The ***intercept on the y axis*** is equal to the ***constant*** in the formula, 28
In this example it represents the basic charge, £28
The ***gradient*** (slope) of the line is equal to the ***coefficient of h*** in the formula, 15
In this example it represents the charge rate per hour, £15.

Print your graph and ***check its gradient and intercept*** agree with those given above.

Many situations can result in linear graphs. Here is another example:

The Widget Production Line

On the widget production line, 15 minutes is spent on setting up the equipment before production can start. After the production process starts, it takes 12 seconds to produce each widget.
An Excel spreadsheet can be used to give the time required to produce a batch of any size. The spreadsheet described below will give times for batches of sizes 50, 100, ……up to 1000.



How to do it….

1 First ***find a formula*** that relates the time to the number of widgets produced.

It is important to be consistent with the units used for time. Note that 12 seconds = $\frac{12}{60} = 0.2$ minutes

The total production time is 15 minutes plus 0.2 minutes per widget.
For n widgets the total time is given by $T = 15 + 0.2n$.

2 Use the formula to ***set up a spreadsheet table***.
Put headings n (for number of widgets) and T (for time in minutes) at the top of columns A and B.
Use 0 as the first value of n. Enter 0 in cell A2.
Write a spreadsheet version of the formula in cell B2 to calculate the time.
Write a spreadsheet formula in cell A3 to calculate the next value of n.

See formulae below.

	A	B	C
1	***n***	***T***	
2	0	15	
3	50		

Numerical values

	A	B	C
1	***n***	***T***	
2	0	=15+0.2*A2	
3	=A2+50		

Formulae

3 Use ***'fill down'*** to complete the table as far as n = 1000.
The first few rows are shown below.

NB Take care to extend *your* table to *n* = 1000

	A	B	C
1	***n***	***T***	
2	0	0	
3	50	25	
4	100	35	
5	150	45	
6	200	55	
7	…	…..	

Numerical values

	A	B	C
1	***n***	***T***	
2	0	=15+0.2*A2	
3	=A2+50	=15+0.2*A3	
4	=A2+50	=15+0.2*A4	
5	=A2+50	=15+0.2*A5	
6	=A2+50	=15+0.2*A6	
7	….	…..	

Formulae

4 To draw the graph, highlight the values in columns A and B and use the Chart Wizard to draw a ***scatter graph*** (choose the line with points). When setting up the graph, write in a title and labels, remove the legend and choose to use both major and minor gridlines.

5 ***Format the graph*** as follows:
Plot Area - clear
Number of widgets axis - major gridlines at intervals of 200, minor gridlines at intervals of 20
Total time axis - major gridlines at intervals of 50, minor gridlines at intervals of 5

6 ***Print your graph***.
Find the intercept and gradient of the line ***and explain what relationship your answers have with the formula for T***.

In the last example the line has a ***negative gradient.***

Heating Oil

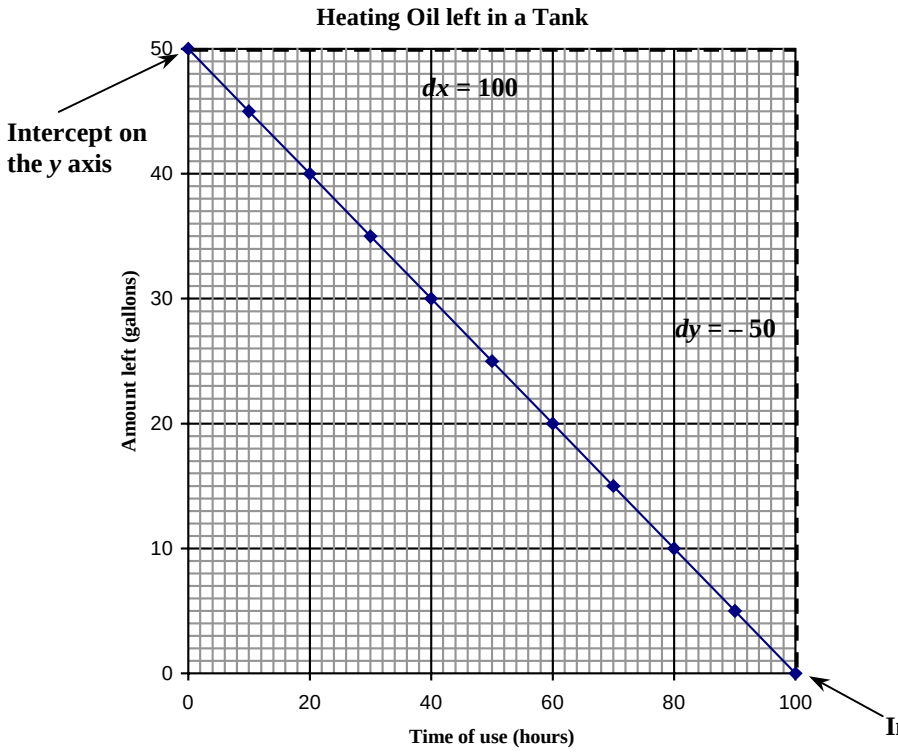
A tank is filled with 50 gallons of oil. The oil is used at a rate of half a gallon per hour to heat a building. Excel can be used to draw a graph to show how the amount of oil in the tank reduces as it is used up. The spreadsheet described below gives the amount left for times up to 100 hours.

How to do it….

1 First ***find a formula*** relating the amount of oil left to the time in hours for which it has been used.
0.5 gallon is used each hour so the amount of oil ***used*** in h hours is $0.5h$ gallons.
The amount of oil ***left*** is G gallons where $G = 50 - 0.5h$

2 Use the formula to ***set up a spreadsheet table***.
Use values of h from 0 to 100 at intervals of 10 hours.

3 ***Draw a graph*** and ***format it to look like the graph given below***:



The line is going down from left to right – this is because the amount of oil in the tank is decreasing.

The value of dy is negative.

Gradient (slope) of this line

$$\frac{dy}{dx} = \frac{-50}{100}$$
$$= -0.5$$

The intercept on the y axis gives the initial amount of oil in the tank, 50 gallons.
The gradient gives the rate at which the amount of oil is changing, – 0.5 gallons per hour.
This rate is ***negative*** because the amount of oil in the tank is ***reducing*** as time goes by.
Note the significance of the intercept on the x axis.
There is no oil left after 100 hours.

4 ***Print your graph*** and ***check that all the details match those on the sketch above***.

Teacher Notes

Unit Intermediate Level, Using algebra, functions and graphs

Skills used in this activity:
- drawing linear graphs using Excel (or another spreadsheet)
- finding and interpreting gradients and intercepts

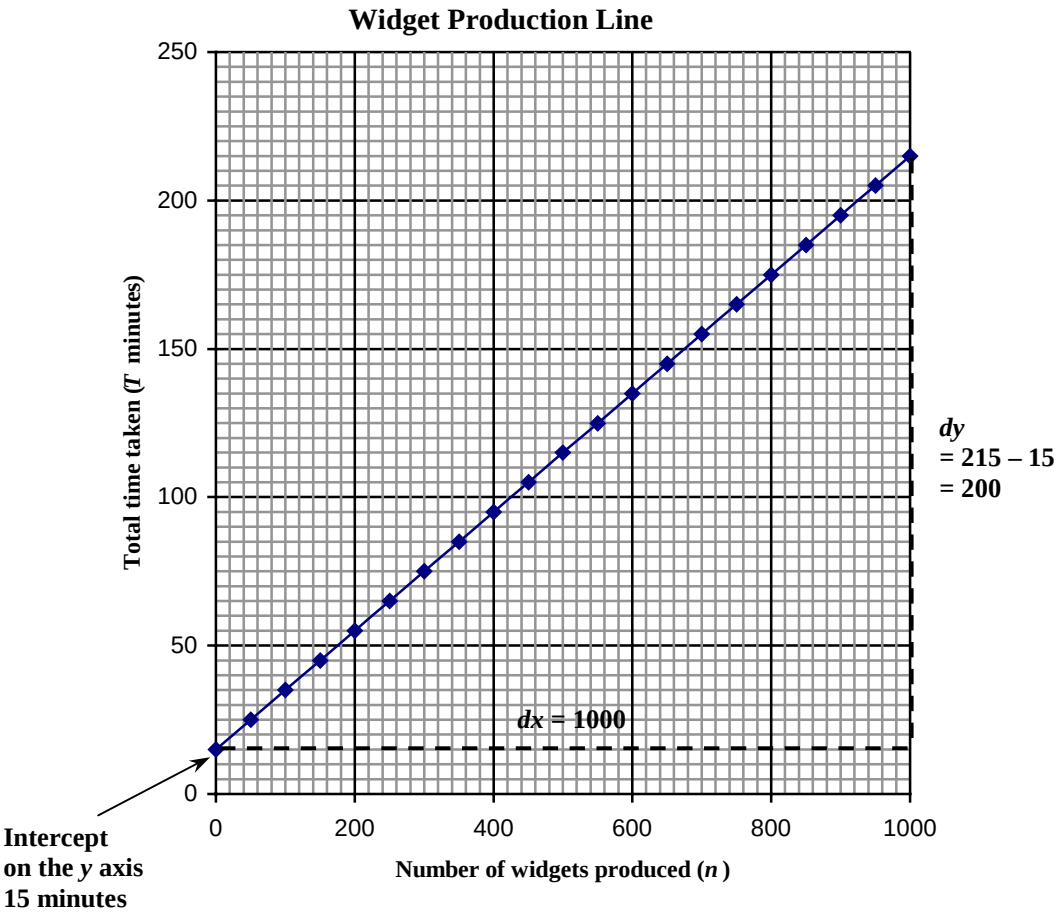
Preparation
Students need to be familiar with Excel. In particular they must know how to enter spreadsheet formulae, use 'fill-down' and draw a graph using the scatter graph option.

Notes on Activity
This activity can be used at the start of the course to introduce linear graphs.
The worksheet requires students to draw a graph using formulae in Excel. It then introduces the concepts of gradient and intercept and shows how these relate to values in the formula. A second example is given for practice, before the final example brings in the idea of a negative gradient.

Answers to Example 2

Intercept = 15 = constant term (time taken in minutes to prepare the production line)

Gradient (slope) = $\frac{dy}{dx} = \frac{200}{1000} = 0.2$ (number of minutes per widget when production starts)



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