# Maths skills – M3 Graphs

### M3.1 – Translate information between graphical, numerical and algebraic forms

Numerical data is often presented graphically in biology so you need to be familiar with different types of graphs and how to interpret information from them such as reading co-ordinates and describing the relationship between the variables.

When describing graphical data you need to make sure you refer to both the x axis and y axis variables, using co-ordinates if possible. In addition you need to accurately describe the relationship between the variables using data from the graph.

### M3.2 – Plot two variables from experimental or other data

Plotting numerical values on to a graph is a key skill and must be done accurately. There are several different ways to present results depending on what data you have. When only a single variable is collected (e.g. number of leaves of a plant) then a bar chart or histogram is used. If the collected data has two variables (e.g. time and concentration) then a line graph/scatter-plot is used.

In a line graph a line (or curve) of best-fit should be drawn to indicate any trends you have identified. The line must be smooth and have a balance of data points above and below the line. Sometimes extrapolation of data to extend the line of best fit to a particular point is used to predict values beyond the existing data set based on the trend of that experimental data.

Calibration curves and lines are used to plot the relationship between two variables so that the resulting curve or line can be used to read off the value of an unknown sample

### M3.3 – Understand that *y = mx + c* represents a linear relationship

A linear (straight) sloping line shows that the dependent variable on the y axis is proportional to the independent variable on the x axis. This is represented by the equation *y = mx + c* where “m” is the gradient of the line and “c” is the value of the intercept on the y axis.

A linear relationship is positive if the line slopes up from left to right, and negative if the line slopes down from left to right.

### M3.4 – Determine the intercept of a graph

An intercept is where the line crosses either the x or y axis. In linear graphs with the general equation y = mx + c, “c” represents the y-intercept, where the line crosses the y-axis and so can be read straight off the graph.

In addition to the intercept of a graph, the intersection of two or more data series from a graph is where two different graphs on the same axes intersect.

### M3.5 – Calculate rate of change from a graph showing a linear relationship

A key feature of line graphs is that the gradient of the line represents the rate at which the quantity on the y axis is increasing as the quantity on the x axis increases. The steeper the line, the greater the rate of change. For straight line graphs the rate of change stays constant, however for curved graphs the rate of change is different at each point.

The gradient of straight line graphs is represented by the letter “m” in the equation y = mx + c. To calculate the gradient, we can use the formula gradient equals the change in y divided by the change in x:

$$Gradient=\frac{'change in y'}{'change in x'} $$

To use this formula you take two points on the line of the graph. Measuring the vertical distance between the points gives the change in y, and measuring the horizontal distance between the points gives the change in x. Dividing the change in y by the change in x gives the gradient of the line (“m”).

### M3.6 – Draw and use the slope of a tangent to a curve as a measure of rate of change

For curved graphs the gradient is different at different points on the curve. To work out the gradient at a particular point on the graph a straight-line tangent to a curve is drawn so it touches the curve only at that singular point.

Once you have drawn the tangent to a curve you can then work out the gradient of the tangent in the same way as for straight line graphs. This will give you the rate of change of the curve at that particular point.

### Questions:

Question 1

Data for the concentration of maltose (mmol dm-3) over a period of time (min) was collected for an enzyme-controlled reaction:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Time / min** | 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 |
| **Maltose /** **mmol dm−3** | 0 | 29 | 52 | 70 | 81 | 88 | 92 | 95 | 97 | 99 | 100 |

1. Plot the data using a suitable scale and draw a curve of best fit.
2. Describe the relationship between the two variables.
3. Use tangents to work out the rates of reaction for the graph at 1 minute, 3 minutes, 5 minutes, 7 minutes and 9 minutes.
4. Use the data you obtain to plot a graph of rate of reaction over time.
5. Describe the pattern of rate of reaction over time.

Question 2

Students studied the possible impact of the size of the rabbit population on the size of the dandelion population by recording how many dandelions are present in sample areas with differing sizes of rabbit populations during the summer and winter months. They collected the following data:

**Summer**

|  |  |
| --- | --- |
| **Number of rabbits** | **Number of dandelions** |
| 2 | 35 |
| 4 | 30 |
| 6 | 25 |
| 8 | 20 |
| 10 | 15 |

**Winter**

|  |  |
| --- | --- |
| **Number of rabbits** | **Number of dandelions** |
| 2 | 30 |
| 4 | 23 |
| 6 | 16 |
| 8 | 9 |
| 10 | 2 |

1. Plot the data on the graph using scales 0-10 for the x axis and 0-50 for the y-axis.
2. Describe the relationship between the number of rabbits and the number of dandelions.
3. Extrapolate the data to work out how many dandelions there would be with no rabbits present if the trend continued for both summer and winter.
4. Linear graphs have the general equation y = mx + c where “m” represents the gradient of the line and “c” represents the y-intercept. Work out the equations of the lines for the graphical data for both summer and winter data sets.

### Answers:

Question 1 (M3.1, M3.2, M3.5 and M3.6)

Data for the concentration of maltose (mmol dm-3) over a period of time (min) was collected for an enzyme-controlled reaction:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Time / min** | 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 |
| **Maltose /** **mmol dm−3** | 0 | 29 | 52 | 70 | 81 | 88 | 92 | 95 | 97 | 99 | 100 |

1. Plot the data using a suitable scale and draw a curve of best fit.

Concentration of Maltose (mmol dm-3)

Time (min)

1. Describe the relationship between the two variables. Concentration of maltose increases over time. The concentration of maltose increases quickly from 0 mmol dm-3 to 81 mmol dm-3 over a period of 4 minutes. Maltose concentration continues to increase over the next 7 minutes at a slower rate, from 81 mmol dm-3 to 100 mmol dm-3
2. Use tangents to work out the rates of reaction for the graph at 1 minute, 3 minutes, 5 minutes, 7 minutes and 9 minutes. Exact data will depend on how the student has plotted their tangents to calculate the gradients for each point. However rate of reaction (gradient) data should decrease over time.
3. Use the data you obtain to plot a graph of rate of reaction over time. Graph should be appropriate to the data from question iii).
4. Describe the pattern of rate of reaction over time. Rate of reaction decreases over time. Quantitative statements should be included (check these against the graph plotted).

Question 2 (M3.1, M3.2, M3.3, M3.4 and M3.5)

Students studied the possible impact of the size of the rabbit population on the size of the dandelion population by recording how many dandelions are present in sample areas with differing sizes of rabbit populations during the summer and winter months. They collected the following data:

**Summer**

|  |  |
| --- | --- |
| **Number of rabbits** | **Number of dandelions** |
| 2 | 35 |
| 4 | 30 |
| 6 | 25 |
| 8 | 20 |
| 10 | 15 |

**Winter**

|  |  |
| --- | --- |
| **Number of rabbits** | **Number of dandelions** |
| 2 | 30 |
| 4 | 23 |
| 6 | 16 |
| 8 | 9 |
| 10 | 2 |

1. Plot the data on the graph using scales 0-10 for the x axis and 0-50 for the y-axis.
2. Describe the relationship between the number of rabbits and the number of dandelions. As the number of rabbits increases the number of dandelions decreases.
3. Extrapolate the data to work out how many dandelions there would be with no rabbits present if the trend continued for both summer and winter. Summer: 40, Winter: 37
4. Linear graphs have the general equation y = mx + c where “m” represents the gradient of the line and “c” represents the y-intercept. Work out the equations of the lines for the graphical data for both summer and winter data sets.

Summer: y = -2.5x + 40 🡪 y = 40 – 2.5x

Winter: y = -3.5x + 37 🡪 y = 37 – 3.5x

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