# Maths skills – M2.5 Using logarithms

### Tutorials

Learners may be tested on their ability to:

* Use a logarithmic scale in the context of microbiology

e.g. growth rate of a microorganism such as yeast

### Logarithms

Logarithms are powers to which a base is raised. For example, if we take the following expression:

‘10 to the power 2’ (written as 102)

10 is the base,

2 is the power.

102 = 100

Since 10 to the power 2 equals 100, log of 100 equals 2 because the log of 100 equals the power to which the base of 10 is raised.

Log to the base 10 is written log with a subscript 10 (log10), but in general the term log is taken to mean log to the base 10.

*the power of 10 that gives 100 is 2*

log 100 = 2

Logarithms are really useful for providing a better scale when dealing with quantities that vary considerably.

For example, imagine sketching a graph where the scale goes from zero to 100,000, but with values such as 10 and 50 that are of interest.

If you were to plot this on a normal scale, lower values would all clump together. If however, you plotted the log of each value, the points on the graph would be much easier to separate. If, on this scale of zero to 100,000 you had values to plot at points 10, 50 100, 3,000 and 90,000, you could plot the value that was equal to these as powers to which 10 is raised.

So Log 10 is equal to 1 because the power that base 10 has to be raised to give a value of 10, is 1.

Log 50 is 1.7. This is because 10 raised to the power 1.7 equals 50.

Log 100 is 2,

and Log 3000 equals 3.48, because 10 to the power 3.48 equals 3000.

Finally log 90,000 equals 4.95. So on your graph, instead of plotting 10, 50, 100, 3000 and 90,000, you would plot 1, 1.7, 2, 3.48 and 4.95. You can see that these are much more sensible numbers to use to make visual comparisons.

Logarithm scales are used when measuring sizes of earthquake – the Richter scale. So an earthquake that measures 6 has a value of 10 to the power 6, and is much smaller than an earthquake that measures 7 because this one is 10 to the power 7, a factor of 10 times larger. It is the log of the value that is recorded.

Mostly we use log to the base 10, written as log. But occasionally we use log to the base 2.7182818…. the number goes on for ever… this is the number *e*. You will see it written as *l*n, which is simply another way of writing log to the base *e*. *e* is the exponential function, and is used, for example, when looking at the growth of populations.

Logarithms are very useful in microbiology when studying the growth rates of microorganisms. As discussed in section M0.5, bacterial cells multiply exponentially with one bacterial cell usually dividing every 20 minutes or so under standard conditions. The cells produced will form a sequence of numbers:

1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024 …

If you plot these data in the standard way you get an exponential growth curve that looks like this:

Number of bacterial cells

Time (min)

However, if instead you plot the data using a logarithmic scale (or take the log of each number and plot these values) you get a straight line relationship like this, because the logarithm is the power to which a base is raised, and if you plot the log you are taking a power relationship and plotting it as a linear relationship.

Number of bacterial cells

Time (min)

Data plotted using a logarithmic scale can be more manageable when visualising and interpreting the exponential relationship.

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