# Maths skills – M0.5 Using calculators to find and use power, exponential and logarithmic functions

### Tutorials

Learners may be tested on their ability to:

* estimate the number of bacteria grown over a certain length of time.

Note: this is an A Level mathematical skill, not assessed at AS Level

Different models of calculators have different ways of entering powers and using them. Some examples of different calculator symbols include: ‘*xy*’, ‘10*x*’, ‘^’ and ‘exp’.

But let’s look at logs first. Logarithms (or logs) can have any positive value as their base, but the two bases used in biology are 10, referred to as common logs, and the base 2.71828…etc , the value for e, referred to as natural logs. On a calculator, log to the base 10 is the button with log written on it, which can be written as “*log(x)*”. Log to the base e has the calculator button ln and is written as “*ln(x)*”

|  |  |
| --- | --- |
| Common log | Natural log |
| Base-10 | Base-e |
| *log(x)* | *ln(x)* |
| log | In |

You need to know how to use the natural log and common log buttons.

Have a go at working out both the natural and common logs of 3  105.

You should end up with 5.477 for common logs and 12.611 for natural logs.

You also need to know how to use the exponential function on your calculator. You may be expected to estimate the number of bacteria grown over a certain length of time. Bacterial cells multiply exponentially. If a culture of bacteria increases by a factor of 2 (which means the population doubles) in one generation, then the formula to find the number of cells, N, after $n$ generations is:

$N=N\_{0}×2^{n}$ *N*0 = initial number *n =* number of divisions, or generations

N0, the initial number at time zero, multiplied by 2 to the power little n where little n is the number of divisions, or generations..

For example, one bacterial cell will divide about every 20 min under standard conditions.

The cells produced will form a sequence of numbers:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Division 0 | Division 1 | Division 2 | Division 3 | Division 4 | Division 5 | Division 6 | Division 7 |
| 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 |

For example, after the 6th division there will be 64 cells. The formula to calculate the number in the nth generation is given by the formula N = *N0 x 2n* where *n* is the number of generations.

So, how many cells will there be after 4 hours?

You have to work out how many divisions there have been in 4 hours. The bacteria divide once every 20 minutes, which is three times an hour. Therefore, in 4 hours the bacteria will divide 12 times. Little n will be equal to 12. You then put this into the original equation.

You started with one bacterial cell, so N0=1

So the number of cells, capital N, is equal to 1 x 2 to the power 12. Which means there are 4096 bacterial cells after 4 hours

60 minutes / 20 minutes = 3 divisions an hour

4 x 3 = 12 divisions

$N=N\_{0}×2^{n}$ = 1 x 212 = 4096 bacterial cells

To do this calculation successfully you need to know how to enter exponential powers into your calculator.

It is important for you to get to know how to put numbers into your calculator to get the right answers out of it.

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