



Logarithms

**Year 11 General Maths
Units 1 and 2**

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Learning Objectives

By the end of the lesson I would hope that you have an understanding and be able to apply to questions the following concepts:

- Understand what a logarithm is
- Understand why we need to use logarithms
- Know how to find the logarithm of a number using a CAS
- Know how to do logarithmic transformations
- Understand what it means to be an order of magnitude



Recap

Logarithms will be a relatively new concept to most of the people doing Mathematics. They are a really important concept and are used extensively in **Further Mathematics and Mathematical Methods**.

Data Analysis in Further Mathematics expects you to fully understand what a logarithm is, why it is used and how to convert from “normal numbers” to “logs” and back again.



What are logs?

An old one ... but still a good one!



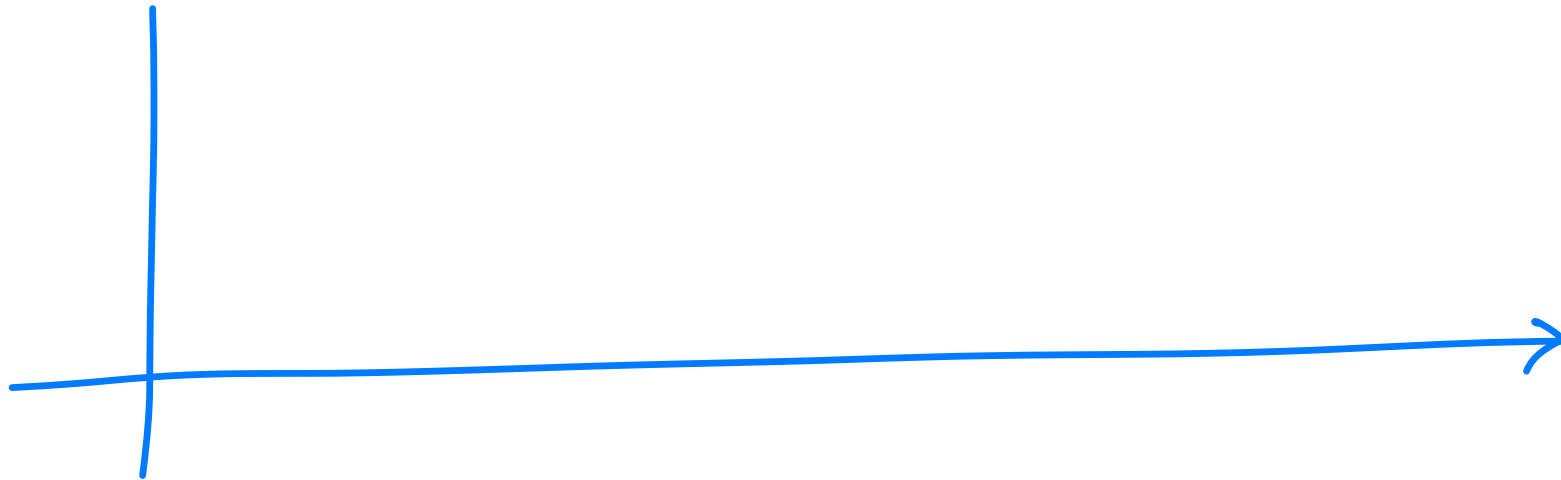
What are logs?

If ever you see the word log it is short for the word logarithm.

Logs are a mathematics **fudge** which allows us to turn **really big numbers** into **much smaller numbers**.

Not all graphs have a nice number system ... so we use redraw the graph to make it fit into a nicer number system

1 - 10 000 000



Powers powers everywhere

We know that the following numbers can all be expressed in a different way:

1, 10, 100, 1000, 10000, 100000, 100000 ...

We can use powers.

Standard :	1	10	100	1000	10 000	100 000
powers :	10^0	10^1	10^2	10^3	10^4	10^5 ..
logs :	0	1	2	3	4	5



Logs are just powers of 10

So we know that a logarithm just stands for a number to a power of 10.

So, for example:

Write the number 100 as a power of 10 and then write down its logarithm.

$$100 = 10^2$$

$$\log_{10} 100 = 2$$

$$1000 = 10^3$$

$$\log_{10} 1000 = 3$$



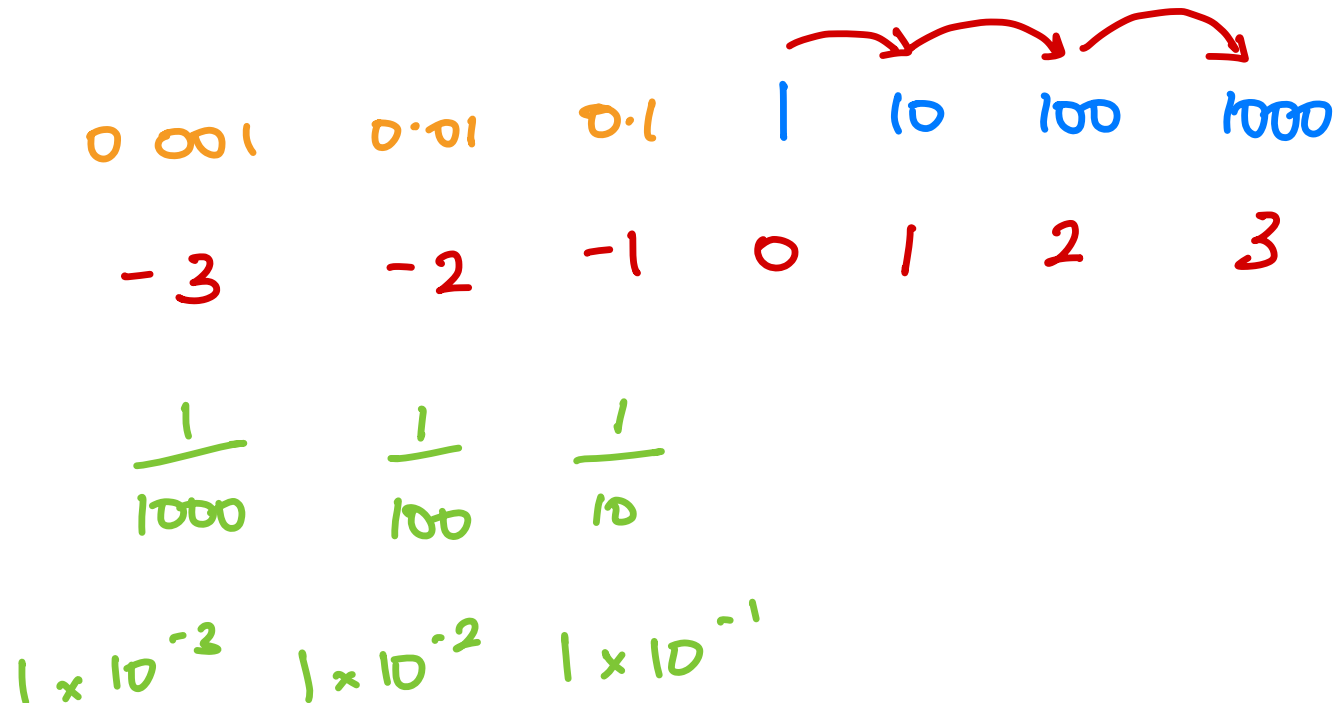
Logs can be negative too!

We know that the following numbers can also be expressed as a power of 10 (but this time a **negative power of 10**).

0.1, 0.01, 0.001, 0.0001, 0.00001, 0.000001 ...

This means we can turn really small numbers into a log scale too!

Such fun!



Example of negative logs

Write the number 0.001 as a power of 10 and then write down its logarithm.

Note: Whilst I look a "short cut" here to find the negative power, be very careful of short cuts! They are useful when you know when to use it and **when not** to use it.

$$0.001 = 1 \times 10^{-3}$$

$$\therefore \log_{10} 0.001 = -3$$



Not all numbers are nice and easy ...

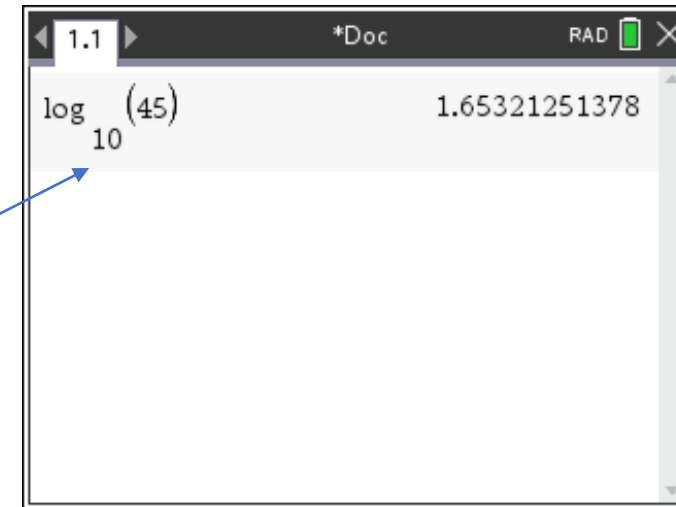
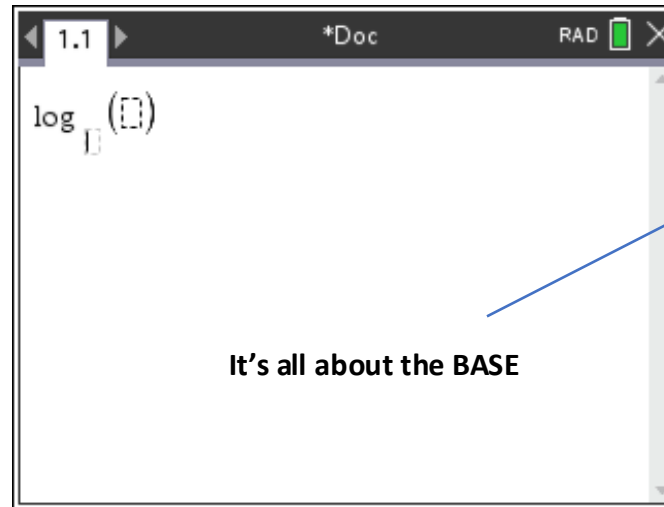
As much as it would be awesome to limit logs to those numbers which have only a one and some zeros in them ... all numbers can be expressed as a log.

We just end up with decimal numbers.

Enter the use of the CAS to help us!

The general formula to go from a number to it's log is to use the CAS and use the Log function:

Log(number)



Note: When you don't put a BASE into the CAS it will automatically assume it's a power of 10 (or base 10) you're looking for

$$10^{1.6532...}$$

$$\log_{10} 45 = 1.6532...$$

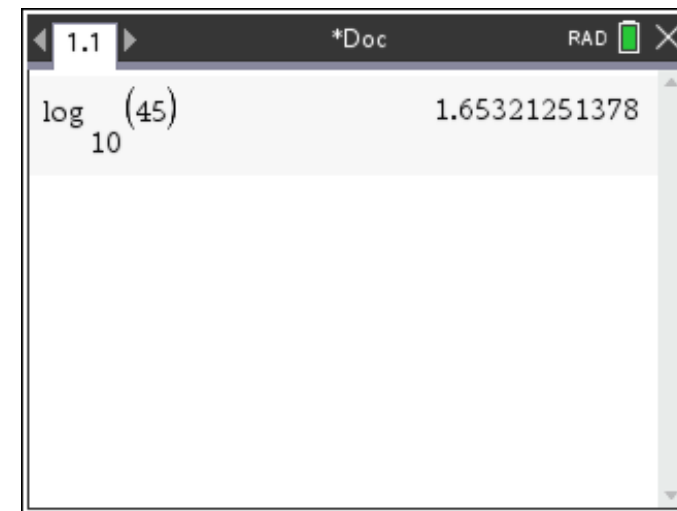


Quick check

It's important to remember what the number the CAS is showing actually means:

$$\log_{10} 45 = \underline{1.6532125\dots}$$

$$10^{1.6532125\dots} = 45$$



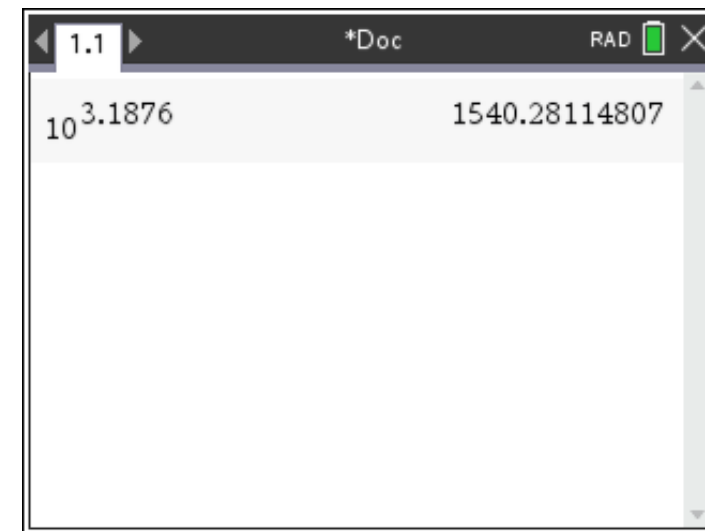
Finding a number from its logarithm

What we do forwards we need to be able to backwards.

When they give us a LOG number, we need to be able to turn it back into the real number it represents!!!

Example: Find the number whose log is 3.1876, **correct to one decimal place.**

Again, we need to use the CAS for any number which isn't a whole number!



$$\log_{10} x = 3.1876$$

$$10^{3.1876} = x$$

$$x = \underline{\underline{1540.3}}$$



Orders of magnitude

We often hear, in the news, the words “order of magnitude”. This is just another way to expressing by how many factors of 10 something has grown by.

Order of magnitude 1 means it's 10 times bigger.

$$10^1 = 10$$

Order of magnitude 2 means it's 100 times bigger.

$$10^2 = 100$$

Order of magnitude 6 means it's 1 000 000 times bigger!!!

$$10^6 = 1\,000\,000$$

This is made easier when we turn a number into **standard form**.



Example

What is the order of magnitude of 1200?

$$1200 = 1.2 \times 10^3$$

$$\therefore \text{order of mag} = 3$$



Back to transformations

In the previous lesson we looked at transforming curves into straight lines. This helped us find the equations for the curves. We looked at **squared transformations** and **reciprocal transformations**. There is one more we need to look at and that is **logarithmic transformations**.



Example: Logarithmic transformation using the CAS

For the given table of values, perform a $\log_{10}(x)$ transformation to check if this gives a straight line, as the graph of y against x is not a straight line.

x	5	10	150	500
y	3.1	4.0	7.5	9.1



Example: Logarithmic transformation using the CAS

Plot the heartbeat/minute of mammals against the logarithm of their body weight.

Mammal	Body weight (g)	Heartbeat/minute
Shrew	2.5	1400
Chick	50	400
Rabbit	1000	205
Monkey	5000	190
Tree kangaroo	8000	192
Giraffe	900 000	65
Elephant	5 000 000	30
Blue whale	170 000 000	16



Example

Using the logarithmic values from the table shown, how many times heavier than a rabbit is a giraffe? Give your answer to the nearest hundred.

Mammal	Body weight (g)	Heartbeat/minute
Shrew	2.5	1400
Chick	50	400
Rabbit	1000	205
Monkey	5000	190
Tree kangaroo	8000	192
Giraffe	900 000	65
Elephant	5 000 000	30
Blue whale	170 000 000	16

Mammal	Body weight (g)	$\log(\text{weight})$
Shrew	2.5	0.40
Chick	50	1.70
Rabbit	1000	3.00
Monkey	5000	3.70
Tree kangaroo	8000	3.90
Giraffe	900 000	5.95
Elephant	5 000 000	6.70
Blue whale	170 000 000	8.23

Note: In moving from 1 to 2 on a log scale, we are increasing by a factor of 10

$$5.95 - 3 = 2.95$$

$$10^{2.95} = 891.25 \dots$$
$$= 900$$



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Work to complete

The work I am asking to be completed for this topic is shown below.

This is the minimum work which should be completed. The more questions which are answered the better your chance of success in exams. Questions towards the end of the exercises and in the Chapter Review are the best practice you can do.

Questions to complete:

Exercise 9D:

Extension:



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