Using a log scale to display data

Thursday, 7 February 2019 10:06 AM

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 why we would need to use a different scale to represent large numbers
- Understand what logarithms are
- Understand how to use logarithms
- How to find logs of numbers

RECAP:

This is the final lesson in the series on Core: Data Analysis.
We have looked at how we can interpret and display the following types of data:

- Categorical
  - Nominal
  - Ordinal
- Numerical
  - Discrete
  - Continuous

We have looked at how we can use bar charts, segmented bar charts and histograms to give the data some meaning and how we can write concise statements as part of a report to describe the data.

We are very used to having scales on the horizontal axes, which count up in single digits.

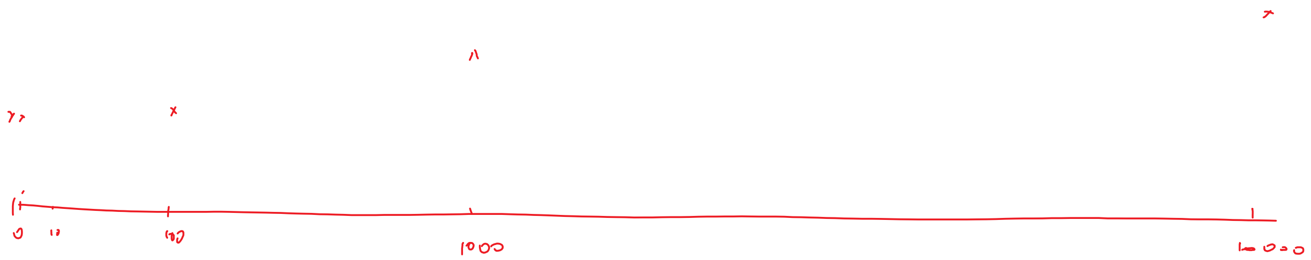
What if we ended up with values which got bigger and bigger!

I'm counting bacteria

Imagine I've done an experiment and I want to plot the following points:

X	1	10	100	1000	10000	100000
Y	5	4.5	6	9.8	14.6	-7

Trying to draw that scale on a convention graph would be almost impossible.
The scale would be so poor as to brake any information (or correlation) the data might be able to tell me.



It would be good, therefore, to be able to come up with a new way of describing numbers such that we can draw them on a graph with a more uniform distance between the points.

This is done by looking at describing numbers using **powers** or **indices**.

The table could be expressed as:

X	10^0	10^1	10^2	10^3	10^4	10^5
Y	5	4.5	6	9.8	14.6	-7

$10^0 = 1$

$10^1 = 10$

$10^2 = 100$

$10^3 = 1000$

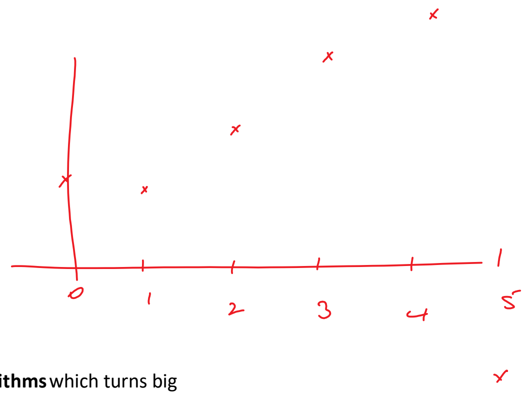
$10^4 = 10\,000$

What if we changed 10^0 to be represented by the number 0.
What if we changed 10^1 to be represented by the number 1.
What if we changed 10^2 to be represented by the number 2.

Then we would have a way to draw the graph!

Hence, our table would become:

X	1	10	100	1000	10000	100000
NEW	0	1	2	3	4	5
Y	5	4.5	6	9.8	14.6	-7



We need a way to work this out and, as it happens, there is something called **logarithms** which turns big numbers into more manageable numbers which we can plot on graphs.

Small numbers and Logarithms

We can also represent small numbers using logarithms.
Small numbers might be:

0.1

0.01

0.001

0.0001

It's all about the BASE

Sorry Meghan … it's not about the BASS but the BASE.
Logarithms are described as having a BASE.

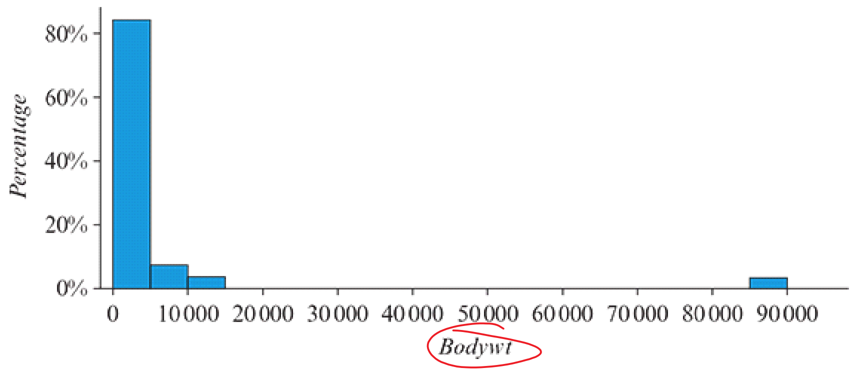
Most of the time we use Base 10.
Whilst it's not important to know about the other bases, we do need to know how to use the calculator to work out logarithms for us.

Example:
Extracted from the Cambridge Further Mathematics text book:

- Find the log of 45, correct to two significant figures
- Find the number whose log is 2.7125 correct to the nearest whole number.

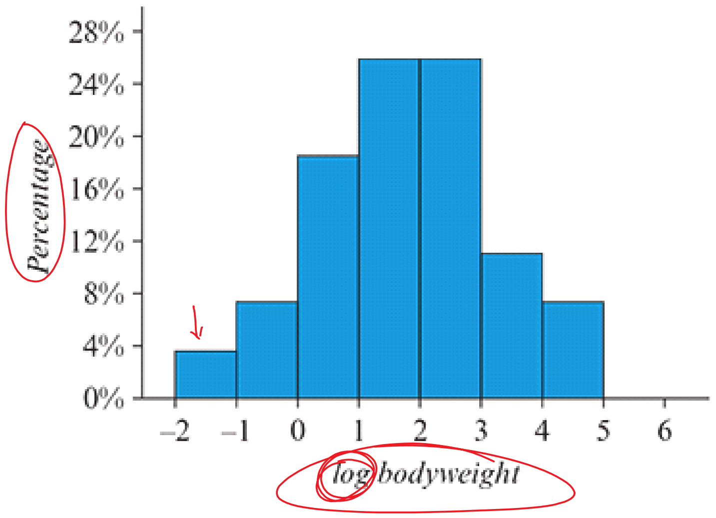
Changing how a graph looks using logarithms

Look at the following graph (which is taken from the Cambridge Further Mathematics Series):



This graph looks awful! It shows the body weights of a number of species of animal.
It doesn't really show us anything important
As it has large numbers, we can use logarithms to help us change the graph into something more meaningful:

log -2 = 0·01



Now we know about how logs can be used ... and how to read them and change them, we can answer questions which use them.

Example:
Taken from the Cambridge Further Textbook Series

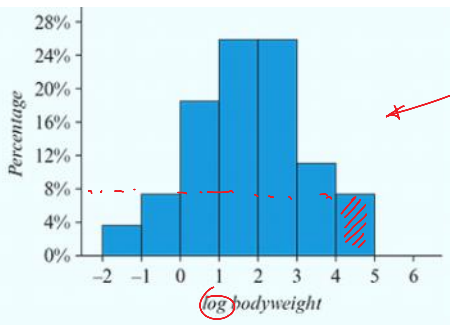
The histogram shows the distribution of the weights of 27 animal species plotted on a log scale.

a What body weight (in kg) is represented by the number 4 on the log scale?

b How many of these animals have body weights more than 10 000 kg?

c The weight of a cat is 3.3 kg. Use your calculator to determine the log of its weight correct to two significant figures.

d Determine the weight (in kg) whose log weight is 3.4 (the elephant). Write your answer correct to the nearest whole number.



Firstly, how do we know the data has been given in terms of logarithms?

a) $10^4 = 10\,000$ Kg

b) 8% of 27 = 2 animals

c) $\log_{10} 3.3 = 0.52$

d) $10^{3.4} = 2512$

Using the CAS to draw a graph of log weights

Taken from the Cambridge Further Textbook Series

The weights of 27 animal species (in kg) are recorded below.

1.4	470	36	28	1.0	12 000	2600	190	520
10	3.3	530	210	62	6700	9400	6.8	35
0.12	0.023	2.5	56	100	52	87 000	0.12	190

Construct a histogram to display the distribution:

a of the body weights of these 27 animals and describe its shape

b of the log body weights of these animals and describe its shape.