



# Solving exponentials equations using logarithms

Year 10 Mathematics

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## Learning Objectives

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

- To know how to solve exponential equations by rewriting in logarithmic form using the given base
- To be able to solve an exponential equation using base 10
- To be able to use technology to evaluate logarithms



## Recap of past learning

If you are watching this in order, you will now know:

- How to convert “normal numbers” into logarithmic numbers
- What a log graph looks like
- How to manipulate logs by:
  - Adding
  - Multiplying
  - Raising them to a power
- As well as some of the more important log rules

All of the above means we can now start to use the learning to **solve equations**.

$$\log_a x + \log_a y = \log_a(xy)$$

$$\log_a x - \log_a y = \log_a\left(\frac{x}{y}\right)$$

$$\log_a(x^n) = n\log_a(x)$$

$$\log_a 1 = 0$$

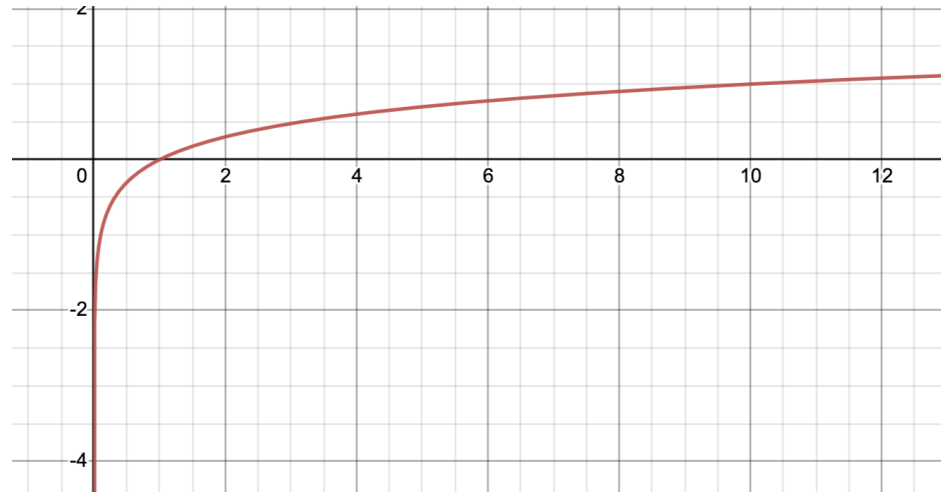
$$\log_a a = 1$$

$$\log_a\left(\frac{1}{x}\right) = \log_a(x^{-1}) = -\log_a x$$

$$a^x = y$$



$$\log_a(y) = x$$

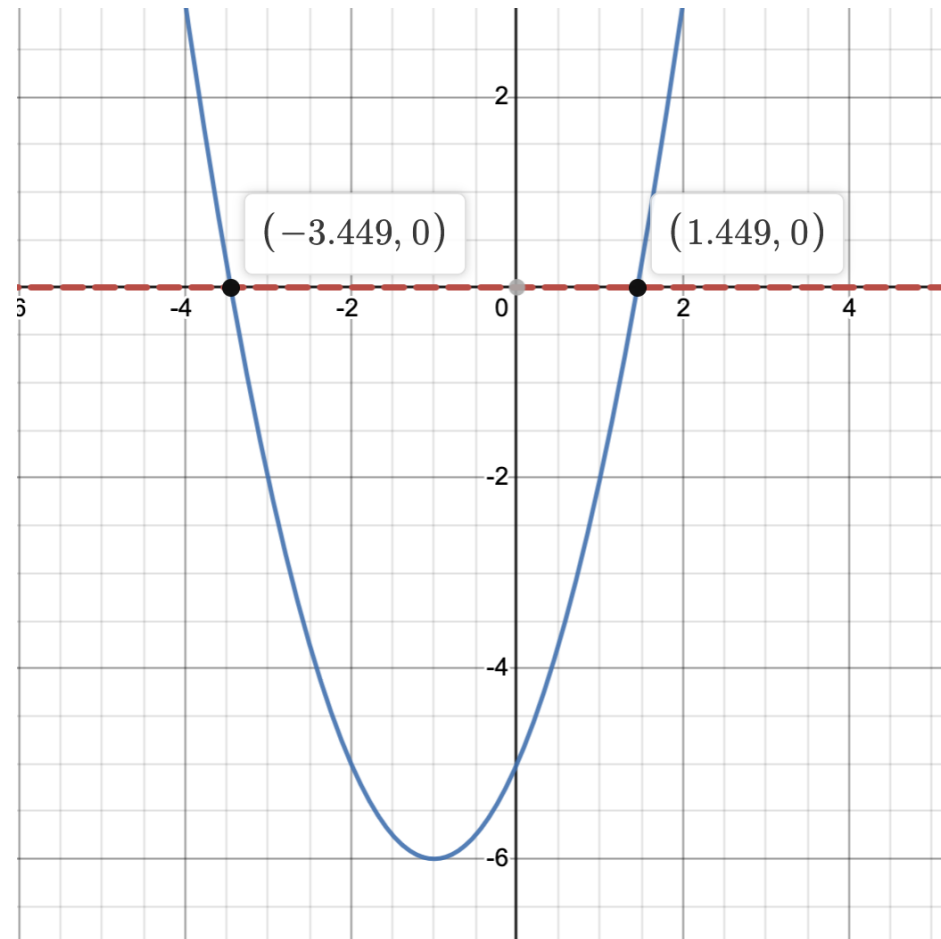


## What is an equation?

This is where we have an expression equals to something. Generally, we want to be able to find the value of a pronumeral (or unknown) which will make the equation true on both sides.

It's useful to think of this as finding the **points of intersection** of two graphs!

When we have something like  $x^2 + 2x - 5 = 0$  what we are really doing is finding the crossing points of the graph  $x^2 + 2x - 5$  and the line  $y = 0$



## Finding the solutions to harder questions

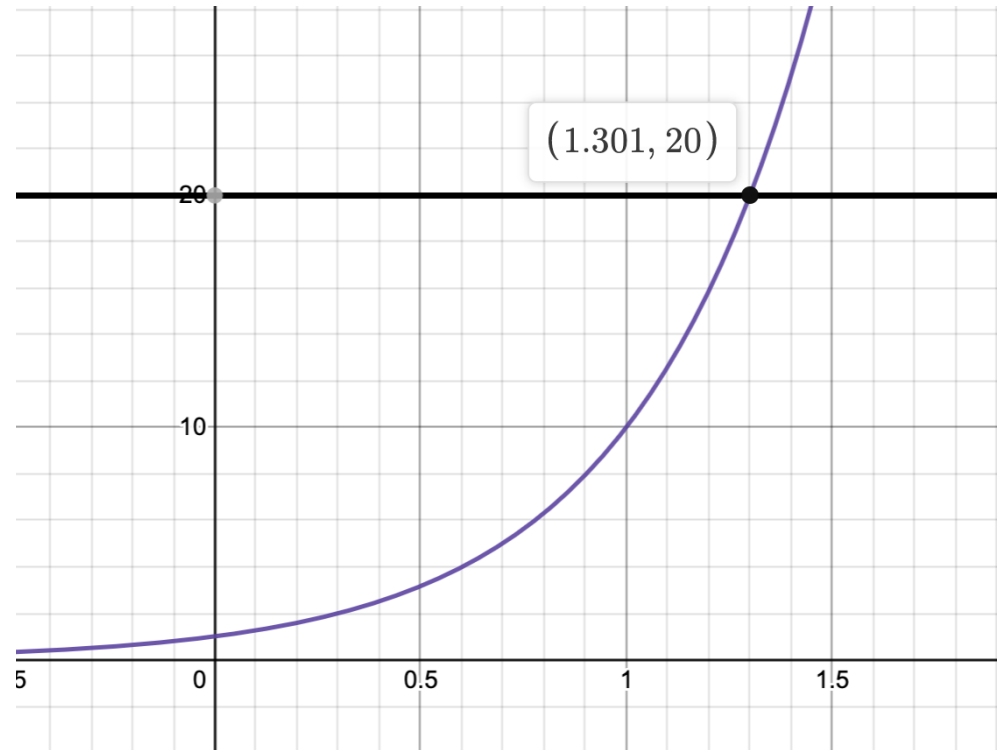
It's not easy to find the solutions using pencil and paper methods to the following:

$$10^x = 20$$

We could draw a graph!

$$y = 10^x$$

$$y = 20$$



Hold on .. This look nothing like the logarithm graph!!!



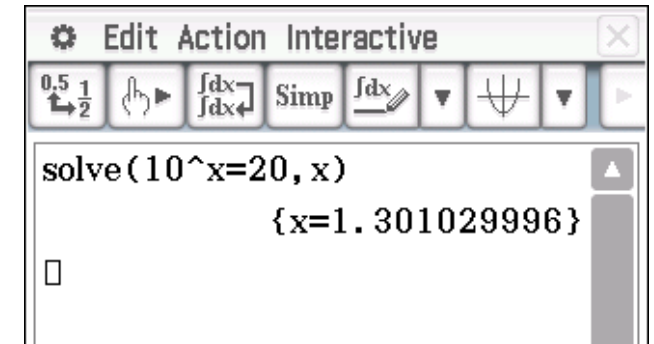
## What if we don't have access to Desmos?

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Then we can use the CAS to solve this for us:

$$10^x = 20$$

$$y = 10^x$$
$$y = 10^{1.30103}$$



## Another way to solve this

Then we can use the CAS to solve this for us:

$$10^x = 20$$

$$x = \log_{10} 20$$

$$10^x = 20$$

$$\log_{10} 20 = x$$

0.5 1/2  $\int dx$   $\int dx$  Simp  $\int dx$   $\int dx$

⚙ Edit Action Interactive

```
solve(10^x=20, x)
      {x=1.301029996}
```

0.5 1/2  $\int dx$   $\int dx$  Simp  $\int dx$   $\int dx$

⚙ Edit Action Interactive

```
solve(10^x=20, x)
      {x=1.301029996}
log(10, 20)
      1.301029996
```



## Example: Solving using the given base

Solve the following using the given base. Round your answer to three decimal places.

a  $2^x = 7$

b  $50 \times 1.1^x = 100$

a.  $2^x = 7$

$$\log_2 7 = x$$

$$x = \underline{\underline{2.807}}$$

b.  $\underline{50} \times 1.1^x = 100$

$$1.1^x = 2$$

$$\log_{1.1} 2 = x$$

$$x = \underline{\underline{7.272}}$$





## Example: Solving using base 10

Solve using base 10 and evaluate, correct to three decimal places.

a  $3^x = 5$

b  $1000 \times 0.93^x = 100$

$$a. \quad \log_{10} 3^x = \log_{10} 5$$

$$x \cdot \log_{10} 3 = \log_{10} 5$$

$$x = \frac{\log_{10} 5}{\log_{10} 3}$$

$$x = \underline{\underline{1.465}}$$

b.  $1000 \times 0.93^x = 100$

$$0.93^x = 0.1$$

$$\log_{10} 0.93^x = \log_{10} 0.1$$

$$x \cdot \log_{10} 0.93 = \log_{10} 0.1$$

$$x = \frac{\log_{10} 0.1}{\log_{10} 0.93}$$

$$= \underline{\underline{31.729}}$$



## Change of base formula

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This is a little outside of the “standard” Year 10 course, but it’s interesting to look at something called the “Change of Base” formula

$$a^x = y$$
$$\log_b a^x = \log_b y$$

$$x \cdot \log_b a = \log_b y$$

$$x = \frac{\log_b y}{\log_b a}$$

$$\log_a y = \frac{\log_b y}{\log_b a}$$

$$a^x = y$$
$$\log_a y = \underline{\underline{x}}$$



## Example: Change of base formula

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Let's see how this might be applied:

Use the change of base formula to write the following with a base of 10:

$$\log_2 7$$

$$\log_2 7 = \frac{\log_{10} 7}{\log_{10} 2}$$



## Learning Objectives: Recapped

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