

The image features a central purple rounded rectangle with the text "MathBlox" in white. Surrounding this central element are various decorative graphics: a blue circle in the top left, a grey circle with a dark grey dot and diagonal lines in the top left, a large grey circle with a red dot and a dotted pattern in the top right, a small red dot in the top right, a grey circle with a white dot in the middle right, a grey circle with diagonal lines in the middle left, a large grey ring in the bottom left, a green circle in the bottom left, a green circle with a white dot in the bottom left, a row of five colored squares (grey, green, red, orange, blue) at the bottom, and a small orange robot-like character with large eyes in the bottom right.

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# Intro

Hello, my name is Blocky. I'm going to guide you through this booklet!



# Intro

- Factorials
- Absolute Values
- Summation
- Product
- Limits
- Differentiation
- Integrals
- Complex Numbers

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We'll go over all these subjects in this booklet, on your own terms of course!





# Factorials

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# Factorial



This is the Factorial Block. It looks like an exclamation mark, but there is no need to say everything before it extra loud.



# Factorial

$$5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$$

$$x! = x \times (x - 1) \times (x - 2) \times \dots$$

The factorial of a value is multiplying it by all integers below it, except negative values and zero.





# Absolute Values

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# Factorial



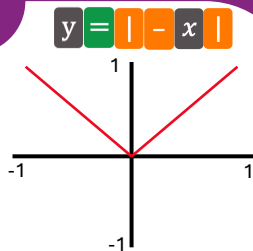
This is a pair of Absolute Value Blocks. Just like brackets, they go on both sides of whatever you want to take the absolute value of.





# Absolute Values

An absolute value is indicated by two straight lines next to a value. It means that everything between these lines will become positive. Look at the graph for example.



$$| -x | = x \text{ if } x \geq 0$$

$$| -x | = -x \text{ if } x < 0$$

Fun fact: The root of the square of a value is the same as the absolute value.

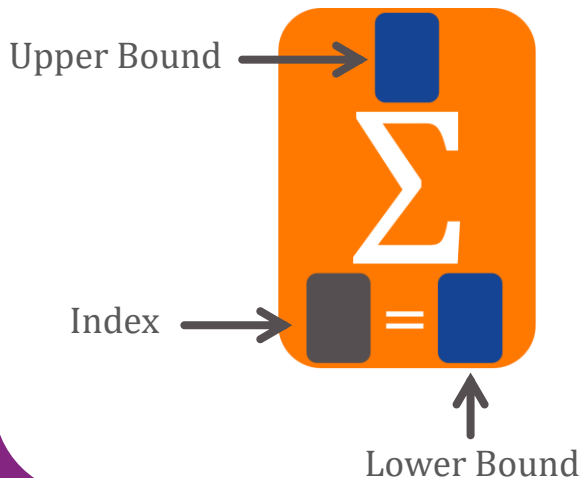
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# Summation

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# Summation



This is the Summation Block. You can use it if you want to add up a lot of things that follow a pattern.



# Summation

Lets look at some examples. Usually we use  $i$  as our index, but feel free to use other letters!



A large orange square block containing a white summation symbol  $\Sigma$ . A small blue square with the number 3 is at the top, and a small grey square with  $i = 0$  is at the bottom.

$$\sum_{i=0}^3 i = 6$$



$$= 0 + 1 + 2 + 3$$

# Summation

Here is another  
exmple. Now, the  
lower bound is  
not zero!



$$\sum_{i=3}^5 i^2 = 50$$

$$= 3^2 + 4^2 + 5^2$$

# Summation

The bounds can even be letters. This summation adds up the first  $n$  even numbers.


$$\sum_{i=0}^n 2i =$$



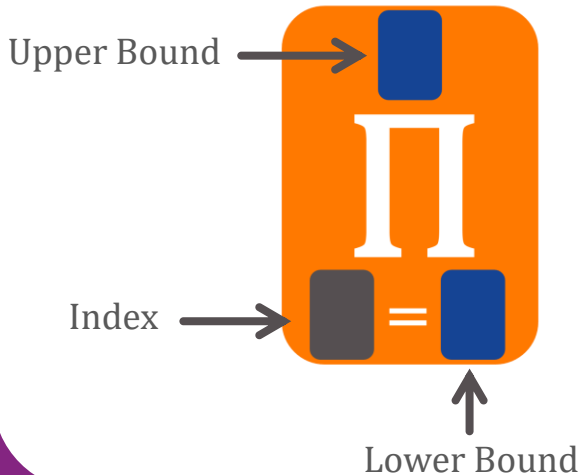

$$n(n+1)$$



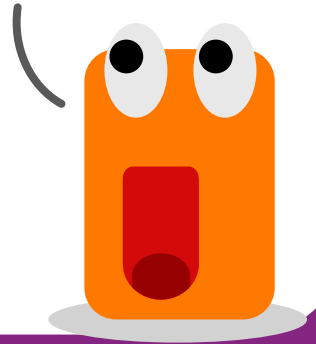
Product

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# Product



This is the Product Block. It works very similar to the Summation. You can use it if you want multiply a lot of things that follow a pattern.





# Product

Lets look at some examples. Usually we use  $i$  as our index, but feel free to use other letters!



$$\prod_{i=1}^3 i = 6$$

$$= 1 \times 2 \times 3$$

# Product

$$\prod_{i=0}^n 2i =$$

$$= 2^n \times n!$$

We can also simplify the product of the first  $n$  even numbers. Can you figure out why this is the case?



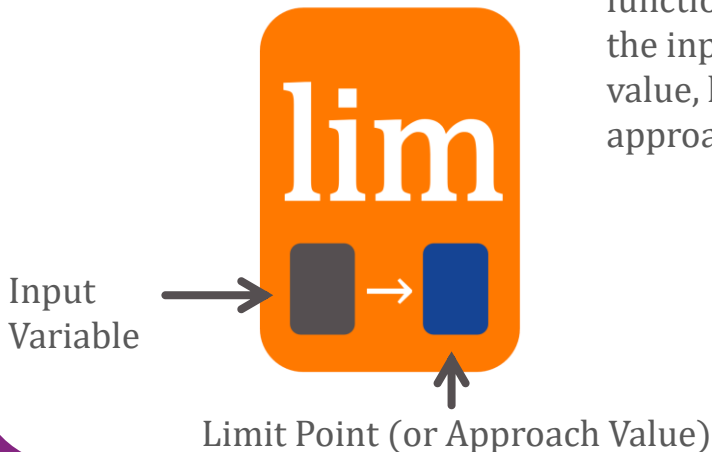


Limits

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# Limits

This is the Limit Block. You can use it to find what a function or sequence does as the input nears a certain value, like division by zero or approaching infinity!



# Limits

Lets look at some examples. For basic functions, a limit works just like plugging in.



$$\lim_{x \rightarrow 3} x^2 = 3^2 = 9$$

# Limits

$$\lim_{x \rightarrow \infty} \left( 1 \div x \right)$$

$$= 0$$

Using limits, we can also study what happens when the input approaches infinity!



# Limits

We can even use limits when simply plugging in fails!



$$\lim_{x \rightarrow 1} \frac{x^2 - 1}{x - 1} = 2$$

This works because we are now allowed to factor out  $x-1$

# Limits

$$\lim_{x \rightarrow \infty} \left( 1 + \frac{1}{x} \right)^x = e$$

$$\approx 2.718$$

Even the  $e$  block is defined using a limit! If you grow something by  $1/x$  many times ( $x$  times), it approaches  $e$ .





# Differentiation

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# Differentiation

This is the Differentiation Block. You can use it if you want to know the slope of the graph at a certain point.

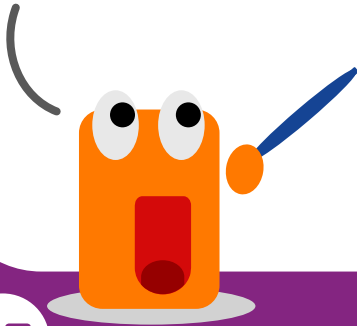
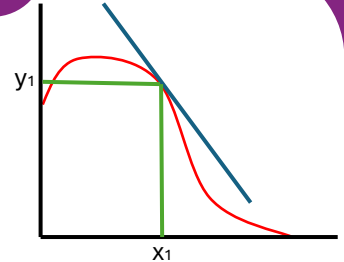


The function you are differentiating

Variable you are differentiating; Usually  $x$

# Differentiation

You can use the derivative to figure out the minima and maxima of a graph, this is where the slope of the graph is **0**



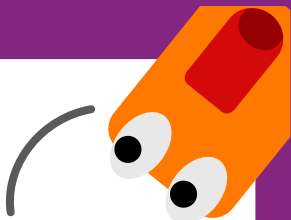
$$p'(x) = \frac{d}{dx} p(x)$$

# Differentiation

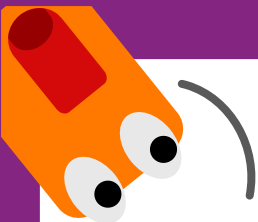
$$\frac{d}{dx} a = 0$$

$$\frac{d}{dx} ax = x$$

$$\frac{d}{dx} x^n = n \times x^{n-1}$$



Here are three of the most elementary differentiation rules.



# Differentiation

Here is a way to solve more complicated derivatives: the chain rule.

Most formulas can be broken into the following:

$$h(x) = f(g(x))$$

$$h'(x) = f'(g(x)) \times g'(x)$$

This is a complicated formula to help you understand I'll give some examples on the next page!

# Differentiation

Let's look at the following derivative:

$$\frac{d}{dx} (4x^2 - 2x^3)$$

This can be written as:

$$(u)^3$$

Where:

$$u = 4x^2 - 2x$$

From the previous definition we can see that:

$$u = g(x)$$

# Differentiation

Using the elementary differentiation calculations, we can see that:

$$\frac{d}{dx} (4x^2 - 2x + 8x - 2) = g'(x)$$

and

$$\frac{d}{du} (u^3 = 3u^2 = f) = f'(u)$$

# Differentiation

Now we have all elements of the chain rule equation, so we can fill it in:

$$h'(x) = f'(g(x)) \times g'(x)$$

So:

$$h'(x) = 3(4x^2 - 2x)^2 \times (8x - 2)$$

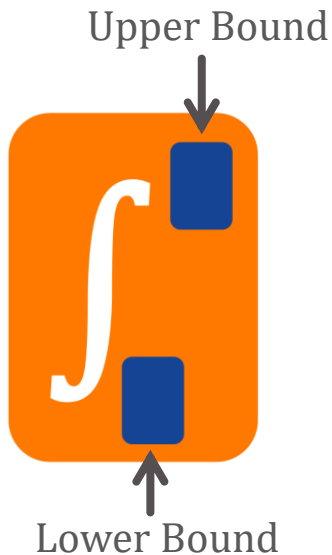




# Integration

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# Integrals

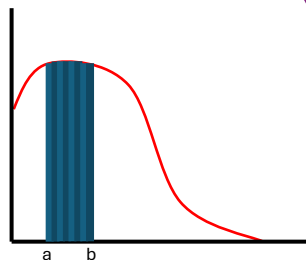


This is the Integration Block. You can use it if you want to calculate the area below a graph between two values of  $x$ .




# Integrals

The integral is a mathematical operation where you calculate the area under a graph. This is done by summation of infinitely many strips of an infinitely small thickness. The integral is the mathematical opposite of differentiation.




$$\int_a^b p(x) dx$$

# Integrals



As I said, an integral is basically the opposite of a differentiation; you can also call them antiderivatives.


$$\int a \, dx = ax + c$$

The **c** is a constant variable, because:


$$\frac{d}{dx} ax + c = a$$

# Integrals

$$\int a x^n dx =$$

$$\left( a x^{n+1} \right) \div (n+1) + c \quad \text{In which} \quad n \neq -1$$

Because:

$$\frac{d}{dx} \left( a x^{n+1} \right) \div (n+1) + c = a x^n$$



# Imaginary Numbers

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# Complex Numbers

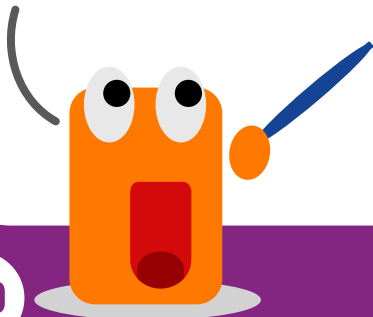


is called an Imaginary  
Number, this is defined as:

$$i^2 = -1$$

You would think this is impossible,  
but it is a definition, same as:

$$x^0 = 1$$



# Complex Numbers

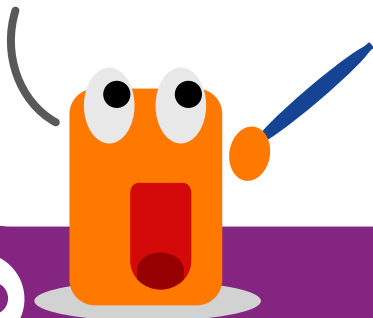
All multiples of  $i$  are called Imaginary Numbers. If you add or subtract a real number from that, you have constructed a Complex Number



Imaginary



Complex





# Complex Numbers

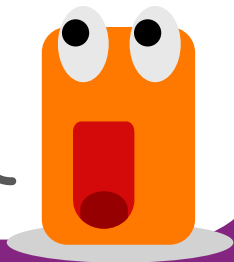
$$4i + 6i + 2 = 10i + 2$$

$$(i + 6) \times i = i^2 + 6i =$$

$$6i - 1$$

Recall the previous definition

Here are a few examples on how to work with Imaginary Numbers.



The background features a collection of abstract geometric shapes. On the left, there are several overlapping circles in shades of blue, green, and grey, some with diagonal hatching. In the center, a large grey circle is partially visible. On the right, a large grey circle contains a prominent red circle, with a smaller grey circle and a red dot nearby. A pattern of small grey dots is also visible on the right side. The overall design is modern and minimalist.

# Group 4

**Charlotte Parks**  
**Daniëlle van der Vlist**  
**Irati Zabalbeitia**  
**Jelle Vuursteen**  
**Nathan Palsma**  
**Thies Harms**

**Industrial Design Engineering**  
**Project Design for Specific Users**

**UNIVERSITY OF TWENTE.**

