What is LaTeX and Why do I need it?

LaTeX (pronounced Lay-tek, or Latex if you are weird) is a typesetting language (and compiler) for writing and formatting text, mathematical equations, drawing technical diagrams and much more. It significantly simplifies and speeds up these tasks, while producing a better quality visual when compared to more standard text editors such as word.

It is the perfect tool for tasks and assignments such as:

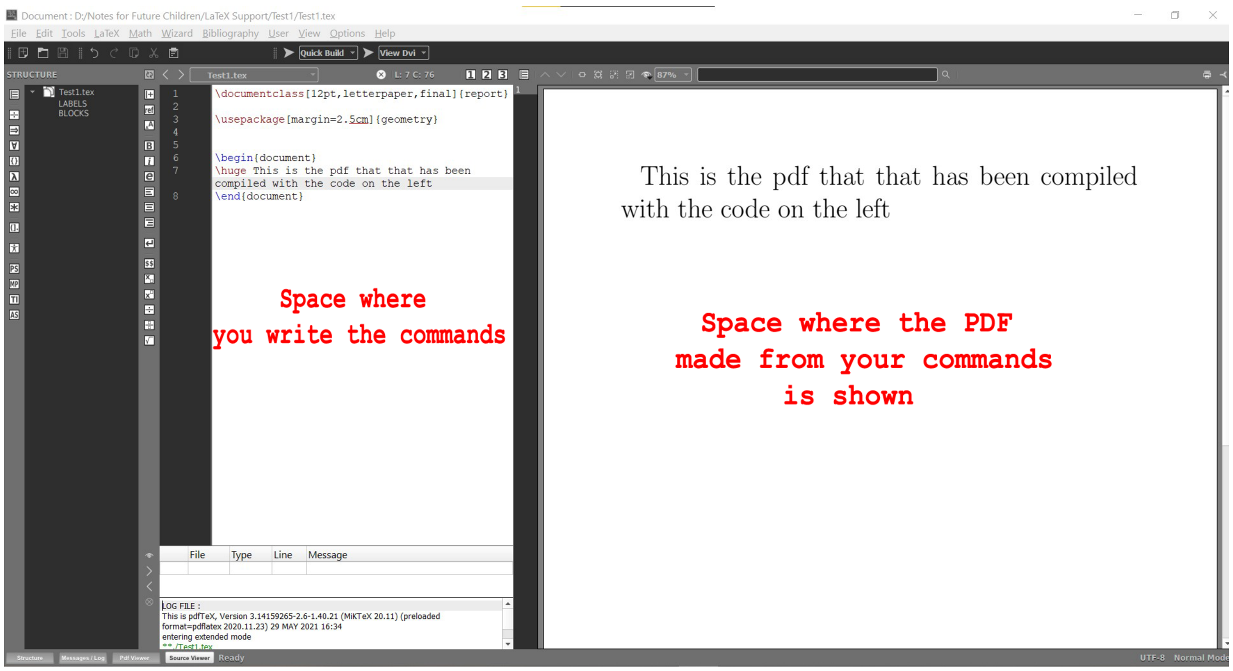
- Lab Reports
- Math & Physics problem sets
- Taking notes for for courses
- English & History Essays (especially for citations)
- Handouts
- Information Pamphlets/Brochures
- Even this document has been put together with LaTeX

LaTeX has been designed specifically for use in an academic environment, however its applications can go far beyond school purposes.

Idea Behind LaTeX and Set-Up

LaTeX is a computer language. When code written in this language is input into a LaTeX compiler, it produces a PDF-file like the one you are reading right now. So how do you get all of this to work?

There are programs that allow you to type your code and see the compiled pdf file together on one screen. These are called IDEs (Integrated Development Environment). Here is an example of this format:


Document : D:/Notes for Future Children/LaTeX Support/Test1/Test1.tex
File Edit Tools LaTeX Math Wizard Bibliography User View Options Help
Quick Build
View Dvi
STRUCTURE
Test1.tex
LABELS
BLOCKS
Test1.tex
L: 7 C: 76
87%
Space where you write the commands
Space where the PDF made from your commands is shown
File Type Line Message
Structure
Messages / Log
Pdf Viewer
Source Viewer
Ready
UTF-8
Normal Mode

```
\documentclass[12pt,letterpaper,final]{report}

\usepackage[margin=2.5cm]{geometry}


\begin{document}
\huge This is the pdf that that has been
compiled with the code on the left
\end{document}
```

This is the pdf that that has been compiled with the code on the left

```
LOG FILE :
This is pdfTeX, Version 3.14159265-2.6-1.40.21 (MiKTeX 20.11) (preloaded
format=pdflatex 2020.11.23) 29 MAY 2021 16:34
entering extended mode
**./Test1.tex
```

Figure 1: TeXMaker IDE. You can type your type on the left and see what pdf they produce on the right

You can consider two types of IDEs: online and offline.

The best known example of an online IDE is `https://www.overleaf.com`. It works similar to google docs, where you can edit and share projects online and having access to all features of LaTeX.

There are many different offline IDEs, each with their own advantages and disadvantages. The key difference is really just the user interface. Click **here** to learn how to install and set up TeXMaker with a MiKTeX compiler (there are different versions of LaTeX and we will be learning the basics with the MiKTeX one.)

Commands and Environments

Commands

At a basic level, we can split LaTeX code into two types of elements: Commands and environments.

Commands do one specific action. All commands begin with a \ symbol.

For example, compiling

\alpha \beta \gamma

on the pdf will print:

$$\alpha \; \beta \; \gamma$$

This is an example of a simple print command. There are also commands that are meant to be applied to text and symbols. For example, bolding text.

An input of:

```
\textbf{ this is bold text }
```

prints an output of:

this is bold text

Notice how the content that has the bolding rule applied to it is in curly brackets. Curly brackets are used around input that is mandatory for a command to work. Square brackets are used for optional input, to "fine tune" what the command does. We will have more examples of this later, as it is applicable to both commands and environments.

Environments

An environment is a section of your code which is interpreted according to a specific set of rules and can often apply different effects to its content depending on the context. Often times, environments have their own commands which are usable only in within them.

To "place" a section of your code inside an environment, it must be enclosed by begin and end commands:

```
\begin{nameofenvironment}
Your code is here
\end{nameofenvironment}
```

Beginning a Document

Before you begin typing up your text, you must generally define what kind of document you will be writing, so that LaTeX knows how to properly format your content.

This is done with a document class statement:

\documentclass[option1,option2,...]{ your document style}

There are 10 key document styles available. Book, Article and Report are the three used most commonly. This choice can affect the structure of margins, page numbering, the way sections/chapters are labelled etc.

For most school assignments, Article and Report will work best. To learn more about the differences between these options you can click **here** and **here**

*Note how the document class is placed into curly brackets, as it is essential input for this command to work.

Optional elements can be things such as font size, paper size. For example this handout has the following layout:

\documentclass[12pt,letterpaper,final]{report}

*The final option is used to state that this is not a draft, but a final version of the work. The output should therefore include all elements that have been coded (As an example, if the draft option was used, images would just be replaced by rectangles of appropriate size).

Now that we have defined the general structure of our document, we can actually begin writing our code. To do so we must "create" its environment:

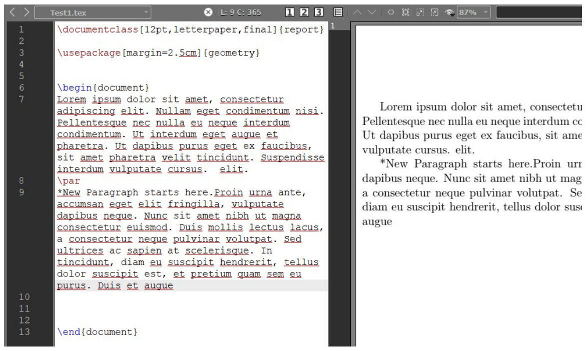
```
\begin{document}
All of your code you want to be displayed on the pdf goes here
\end{document}
```

Writing text

In LaTeX you can write plain text directly. The compiler will use your text to create a paragraph. It will fill the line and break it at the margin. The paragraph by default will be left aligned and have a straight right edge.

In order to begin a new paragraph, you must indicate a break. There are a few ways to do this:

To indicate a new paragraph, you can simply write \par at the end of the previous one. Note that this will automatically indent the new paragraph. If you do not like indents, you can write \noindent before you start writing text for the new paragraph.



```
\documentclass[12pt,letterpaper,final]{report}

\usepackage[margin=2.5cm]{geometry}


\begin{document}
Lorem ipsum dolor sit amet, consectetur
adipiscing elit. Nullam eget condimentum nisi.
Pellentesque nec nulla eu neque interdum
condimentum. Ut interdum eget augue et
pharetra. Ut dapibus purus eget ex faucibus,
sit amet pharetra velit tincidunt. Suspendisse
interdum vulputate cursus.  elit.
\par
*New Paragraph starts here.Proin urna ante,
accumsan eget elit fringilla, vulputate
dapibus neque. Nunc sit amet nibh ut magna
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a consectetur neque pulvinar volutpat. Sed
ultrices ac sapien at scelerisque. In
tincidunt, diam eu suscipit hendrerit, tellus
dolor suscipit est, et pretium quam sem eu
purus. Duis et augue



\end{document}
```
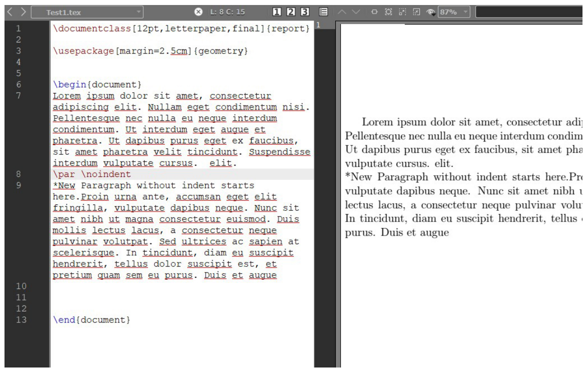

```
    Lorem ipsum dolor sit amet, consectetu
Pellentesque nec nulla eu neque interdum cc
Ut dapibus purus eget ex faucibus, sit ame
vulputate cursus. elit.
    *New Paragraph starts here.Proin urı
dapibus neque. Nunc sit amet nibh ut mag
a consectetur neque pulvinar volutpat. Se
diam eu suscipit hendrerit, tellus dolor sus
augue
```

(a) New paragraph made with \par command



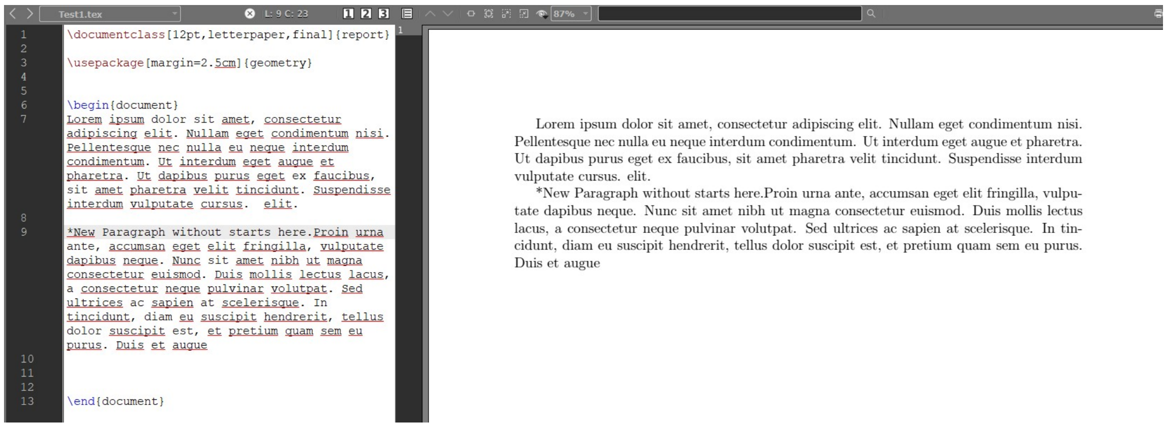
```
\documentclass[12pt,letterpaper,final]{report}

\usepackage[margin=2.5cm]{geometry}


\begin{document}
Lorem ipsum dolor sit amet, consectetur
adipiscing elit. Nullam eget condimentum nisi.
Pellentesque nec nulla eu neque interdum
condimentum. Ut interdum eget augue et
pharetra. Ut dapibus purus eget ex faucibus,
sit amet pharetra velit tincidunt. Suspendisse
interdum vulputate cursus.  elit.
\par \noindent
*New Paragraph without indent starts
here.Proin urna ante, accumsan eget elit
fringilla, vulputate dapibus neque. Nunc sit
amet nibh ut magna consectetur euismod. Duis
mollis lectus lacus, a consectetur neque
pulvinar volutpat. Sed ultrices ac sapien at
scelerisque. In tincidunt, diam eu suscipit
hendrerit, tellus dolor suscipit est, et
pretium quam sem eu purus. Duis et augue



\end{document}
```

```
    Lorem ipsum dolor sit amet, consectetur adi
Pellentesque nec nulla eu neque interdum condim
Ut dapibus purus eget ex faucibus, sit amet pha
vulputate cursus. elit.
*New Paragraph without indent starts here.Pr
vulputate dapibus neque. Nunc sit amet nibh
lectus lacus, a consectetur neque pulvinar volu
In tincidunt, diam eu suscipit hendrerit, tellus
purus. Duis et augue
```

(b) Indent taken away with \noindent

Figure 2: Examples of \par command

You can also just leave a blank line in your code between your old and new paragraph. This will work identical to the \par command.



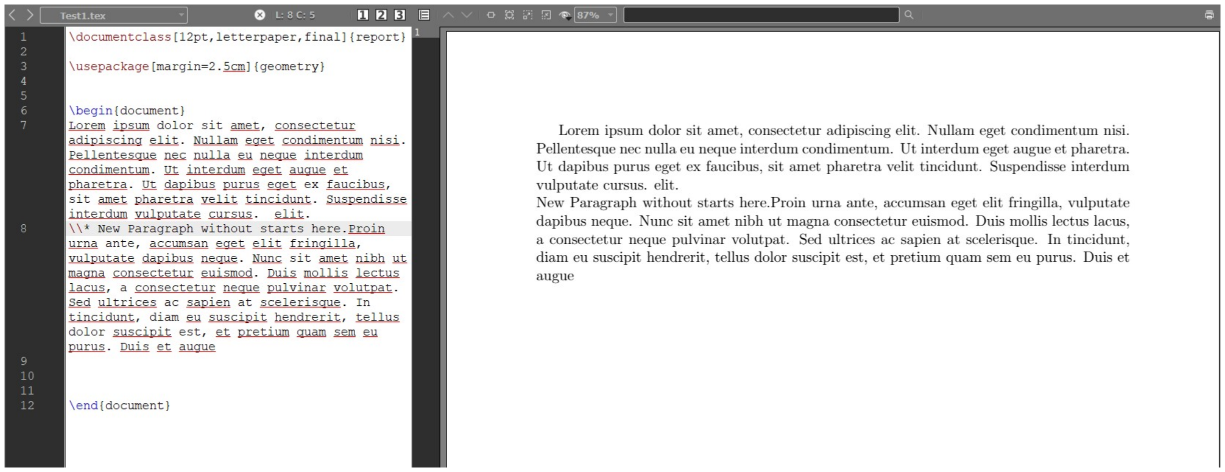
```latex
\documentclass[12pt,letterpaper,final]{report}

\usepackage[margin=2.5cm]{geometry}


\begin{document}
Lorem ipsum dolor sit amet, consectetur
adipiscing elit. Nullam eget condimentum nisi.
Pellentesque nec nulla eu neque interdum
condimentum. Ut interdum eget augue et
pharetra. Ut dapibus purus eget ex faucibus,
sit amet pharetra velit tincidunt. Suspendisse
interdum vulputate cursus.  elit.

*New Paragraph without starts here.Proin urna
ante, accumsan eget elit fringilla, vulputate
dapibus neque. Nunc sit amet nibh ut magna
consectetur euismod. Duis mollis lectus lacus,
a consectetur neque pulvinar volutpat. Sed
ultrices ac sapien at scelerisque. In
tincidunt, diam eu suscipit hendrerit, tellus
dolor suscipit est, et pretium quam sem eu
purus. Duis et augue



\end{document}
```

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nullam eget condimentum nisi. Pellentesque nec nulla eu neque interdum condimentum. Ut interdum eget augue et pharetra. Ut dapibus purus eget ex faucibus, sit amet pharetra velit tincidunt. Suspendisse interdum vulputate cursus. elit.

*New Paragraph without starts here.Proin urna ante, accumsan eget elit fringilla, vulputate dapibus neque. Nunc sit amet nibh ut magna consectetur euismod. Duis mollis lectus lacus, a consectetur neque pulvinar volutpat. Sed ultrices ac sapien at scelerisque. In tincidunt, diam eu suscipit hendrerit, tellus dolor suscipit est, et pretium quam sem eu purus. Duis et augue

Figure 3: Starting a new paragraph with line space

You can also use commands that simply begin a new line. \\ will place your text on a new line. You can optionally use \\∗. This will also create a new line, but will prevent from breaking to a new page). You can learn more **here**.



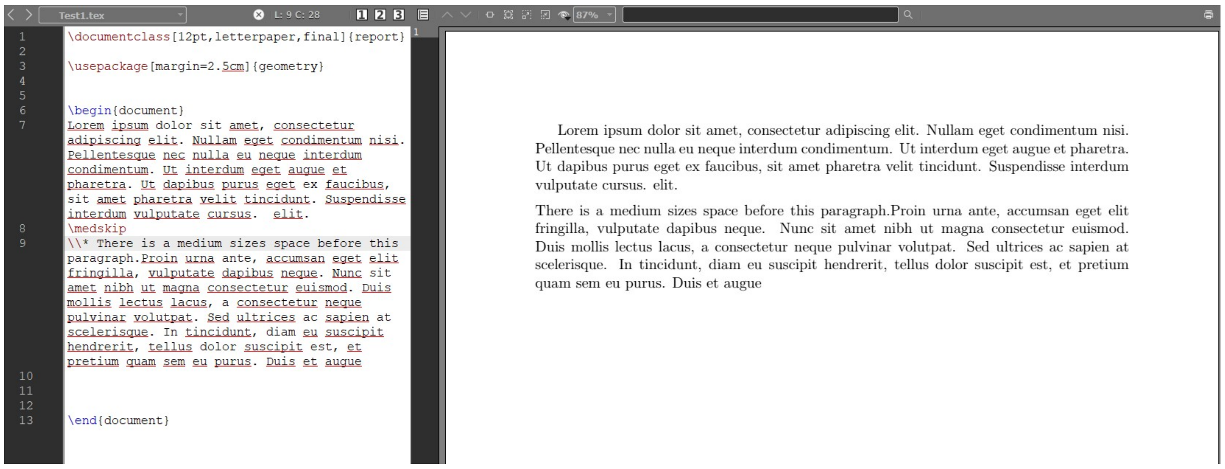
```latex
\documentclass[12pt,letterpaper,final]{report}

\usepackage[margin=2.5cm]{geometry}


\begin{document}
Lorem ipsum dolor sit amet, consectetur
adipiscing elit. Nullam eget condimentum nisi.
Pellentesque nec nulla eu neque interdum
condimentum. Ut interdum eget augue et
pharetra. Ut dapibus purus eget ex faucibus,
sit amet pharetra velit tincidunt. Suspendisse
interdum vulputate cursus.  elit.
\\* New Paragraph without starts here.Proin
urna ante, accumsan eget elit fringilla,
vulputate dapibus neque. Nunc sit amet nibh ut
magna consectetur euismod. Duis mollis lectus
lacus, a consectetur neque pulvinar volutpat.
Sed ultrices ac sapien at scelerisque. In
tincidunt, diam eu suscipit hendrerit, tellus
dolor suscipit est, et pretium quam sem eu
purus. Duis et augue



\end{document}
```

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nullam eget condimentum nisi. Pellentesque nec nulla eu neque interdum condimentum. Ut interdum eget augue et pharetra. Ut dapibus purus eget ex faucibus, sit amet pharetra velit tincidunt. Suspendisse interdum vulputate cursus. elit.
New Paragraph without starts here.Proin urna ante, accumsan eget elit fringilla, vulputate dapibus neque. Nunc sit amet nibh ut magna consectetur euismod. Duis mollis lectus lacus, a consectetur neque pulvinar volutpat. Sed ultrices ac sapien at scelerisque. In tincidunt, diam eu suscipit hendrerit, tellus dolor suscipit est, et pretium quam sem eu purus. Duis et augue

Figure 4: Paragraphs made by starting a new line

Sometimes it is beneficial to separate your paragraphs with some vertical space. This is possible with the following commands:

- \smallskip
- \medskip
- \bigskip



```
\documentclass[12pt,letterpaper,final]{report}

\usepackage[margin=2.5cm]{geometry}


\begin{document}
Lorem ipsum dolor sit amet, consectetur
adipiscing elit. Nullam eget condimentum nisi.
Pellentesque nec nulla eu neque interdum
condimentum. Ut interdum eget augue et
pharetra. Ut dapibus purus eget ex faucibus,
sit amet pharetra velit tincidunt. Suspendisse
interdum vulputate cursus.  elit.
\medskip
\\* There is a medium sizes space before this
paragraph.Proin urna ante, accumsan eget elit
fringilla, vulputate dapibus neque. Nunc sit
amet nibh ut magna consectetur euismod. Duis
mollis lectus lacus, a consectetur neque
pulvinar volutpat. Sed ultrices ac sapien at
scelerisque. In tincidunt, diam eu suscipit
hendrerit, tellus dolor suscipit est, et
pretium quam sem eu purus. Duis et augue



\end{document}
```

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nullam eget condimentum nisi. Pellentesque nec nulla eu neque interdum condimentum. Ut interdum eget augue et pharetra. Ut dapibus purus eget ex faucibus, sit amet pharetra velit tincidunt. Suspendisse interdum vulputate cursus. elit.

There is a medium sizes space before this paragraph.Proin urna ante, accumsan eget elit fringilla, vulputate dapibus neque. Nunc sit amet nibh ut magna consectetur euismod. Duis mollis lectus lacus, a consectetur neque pulvinar volutpat. Sed ultrices ac sapien at scelerisque. In tincidunt, diam eu suscipit hendrerit, tellus dolor suscipit est, et pretium quam sem eu purus. Duis et augue

Figure 5: Medium vertical space between paragraphs

It is also possible to create section, subsection, subsubsection and subsubsubsection headers using the respective commands:

- \section{Header goes here}
- \subsection{Subheader goes here}
- ...

They look identical to the headers and subheaders used in this handout. Note that the way indexing is carried out depends on the document class. This handout uses a “report” style. Indexing therefore starts at 0, with the section represented by the second digit.E.G:

This code:

\subsection{This is a numbered section header}

Produces an output of:

0.0.1 This is a numbered subsection header

This is a subsection, therefore it is represented by the third digit.

If you do not want them to be numbered, add a * symbol between the word “section” and the { symbol.

An input of: \subsection*{Writing Math}

Yields an output of:

Writing Math

One of the key strong points of LaTeX is its versatility when it comes to writing mathematical expressions. For this purpose, the language offers three types of environments specifically made for writing math.

*Note that all special symbols such as greek letters (almost all print commands), superscripts, subscripts and fraction can only be used inside a math environment. Otherwise, the compiler will show an error and not produce any output.

The math environments of LaTeX are the only environments which are not declared by **\begin{environmentname} \end{environmentname}**

*All math environments will italicize your letters and will ignore any spaces between words or symbols.

For example, the input of **$ s p a c e$**
Will yield:

space

Here are more details on each type of environment

- Inline math environment
  - The inline math environment is declared by enclosing your code with brackets preceded by backslashes. E.G. \(Your math here \)
  - Alternatively you can use single dollar bill signs (not begin/end statements). E.G: $ Your math equations are here$. This is however an outdated method, not supported by LaTeX.
  - It is intended for writing math within paragraphs and all symbols (including fractions, superscripts and subscripts) are scaled to fit on a line (hence the name).
- Displaystyle math environment
  - Enclosed by square brackets preceded with backslashes. E.G: \[Your math goes here \] .
  - It is also possible to declare a displaystyle environment by enclosing code in double dollar bill signs. E.G: $$ Your math equations here $$. This is however is an outdated method, not supported by LaTeX.
  - This environment will automatically center your equations on the page, leaving a bit of white space above and below the environment.
  - This math environment is meant to display equations as clearly as possible. It will enlarge fractions, superscripts and subscripts to make them as visible as possible
- Inline displaystyle
  - Enclosed by brackets preceded by backslash. Has a \displaystyle command at beginning. E.G: \(\displaystyle Your code is here \). (Just like in a normal inline environment, you can use single dollar bill signs)
  - This environment is a combination of the inline and displaystyle math environments.

- It does not centre your equations and allows you to write in within a paragraph, or anywhere in text. It still enlarges small parts of your formulae to make them more visible.
- This is useful when you want to write left-aligned equations.
- This is not really an environment of its own. It is just that the inline math environment is given display style properties (enlarged fractions, subscripts,superscripts etc.) with the \displaystyle command

Math Commands

Here are a couple of commands on writing the most basic math:

^{ superscript here } - this is placed after the symbol you would like to put the superscript on.

_ {subscript here } - this is placed after the symbol that you would like to have the subscript

\frac{numerator}{denominator} - this command is used to produce a fraction.
\cdot - produces a multiplication dot

\times - produces a multiplication x.

Let's combine all of these elements together to write the formula for kinetic energy.

The input of:

$ $ E_{k} = \frac{1 }{2} \cdot mv^{2} $ $

Produces the output of:

$$E_k = \frac{1}{2} \cdot mv^2$$

Now let's look at the difference between inline and displaystyle math:

$$\text{Inline: } \tfrac{a^2}{b^2}$$
$$\text{Displaystyle: } \dfrac{a^2}{b^2}$$

Equation environment

There are other math environments with a variety of specific functions (aligning equations, breaking over long lines etc.).

One of the most common is the "equation" environment. It has the same properties as the display style environment, but is designed to only hold one equation. At the end of the line, it automatically numbers that equation.

This number increases by one each time you write a new equation in such an environment by 1.

For example the following input:

```
\begin{equation}
E_{k} = \frac{1 }{2} \cdot mv^{2}
\end{equation}
```

Yields:

$$E_k = \frac{1}{2} \cdot mv^2 \tag{1}$$

Now let’s use this same environment to write the equation for potential energy:

```
\begin{equation}
E_{p} =mgh
\end{equation}
```

This outputs:

$$E_p = mgh \tag{2}$$

Notice how this equation is now assigned the number 2.

Practice

Try and recreate the following text in a separate document on your own:

0.1 Standard Notation Mathematical Notation in Physics and Beyond

Newton's Second Law is one of the key foundations of classical mechanics. It has the following equation:

$$F = ma \tag{1}$$

Some modern physicists choose to write it as:

$F = a \cdot m$

They are completely wrong. This is why the wrong equation is not numbered. Therefore equation 3 is the right one

This difficulty with choosing convenient notation extends far beyond simple equations like Newton's second law.

These worrying examples were first created in depth by German mathematician Jens Fehlau in 2020. On his twitter, he posted multiple equations that broke the most basic conventions. According to the author, the intention was to produce something visually uncomfortable to create a comedic effect. Here are a couple of examples:

$$\times^3 = \times \times \times \times \times$$

$$\frac{\pi}{2} = \pi.5$$

Despite this being a seemingly innocent joke, it is important to understand its potential consequences.

Figure 6: Sample Caption

And we can also reference this as Figure 6