# Why LATEX?

- Allows documents to be prepared in a standard form. No need for user to decide on size or style of titles.
- Easy to produce accurate mathematical formulas.
- Sections and equations are numbered automatically and easily referenced.
- Automatic reference to papers or books.
- The only realistic method of preparing mathematical reports - using Word with mathematics is not much fun.
- Freely available – easy to install on a PC directly from the internet.

# Producing a LATEX Document

1. Create or edit a plain text file. By convention, always use the `.tex` extension. We will be using the editor within TeXnicCenter.
2. Process the file, then eliminate errors if required. There is a choice of formats for output. We will only produce `.pdf` files.
3. View the output on screen using Adobe Acrobat. Can also print output from Acrobat.
4. Different from WYSIWYG (What You See Is What You Get) word processors like MS Word.

# A Sample Document

```
\documentclass{article}

\begin{document}
\title{Short Article}
\author{Richard Purvis}
\maketitle

\section{First Section}
This illustrates the use of sections
and subsections.
\subsection{A subsection}
This includes further text.
\subsection{Another subsection}
Automatic
numbering of sections and subsections.

\section{Second Section}
Sub-sub-sections can also be included.

\end{document}
```

Short Article

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## 1 First Section

This illustrates the use of sections and subsections.

### 1.1 A subsection

This includes further text.

### 1.2 Another subsection

This shows how the automatic numbering of sections and subsections works.

## 2 Second Section

Sub-sub-sections can also be included. The method of numbering sections, sub-sections etc can easily be altered.

# Structure of a LATEX Document

- All LATEXcommands start with a backslash.

- Every LATEXfile must begin with

  `\documentclass{xxxxxxx}`

  where `xxxxxxx` describes the type of document to be produced.

- Commonly used document classes are `report`, `article` and `book`.

- Changing the document class changes the appearance of the final document.

- Next include commands to define useful quantities or load extra packages.

  `\usepackage{graphicx}`

  This allows easy insertion of figures. See later.

- Commands such as `usepackage` and `newcommand` which appear here are like commands appearing in the `<head>` section of HTML files. They do not appear directly in the final document.

- The body of the document starts with

  `\begin{document}`

- The document is then usually split up into

  `\chapter, \section, \subsection,`

  `\subsubsection`

  with `chapter` not available for document class `article`.

- Use of section headings is

  `\chapter{Title of First Chapter}`

- Numbering of sections etc. is governed by the document class.

- Document finishes with

  `\end{document}`

- Starting a new line in the input file does not force new line in output document.

- A blank line will start a new paragraph.

- Some characters have special meaning,

  `&, %, {, }, #, _, ^, ~`

  For these symbols use `\&` etc.

- To obtain `\`, use `\backslash`.

- Use of `\begin{..}` and `\end{...}` mirrors use of tags in HTML – `<B> ... </B>`.

- Material appearing between `\begin{center}` and `\end{center}` will be centred.

- Lists with bullet points are formed using `itemize`, as in these notes.

- For numbered lists use `enumerate`

```
\begin{enumerate}
\item  First Point.
\item  Second Point.
All subsequent lines are indented.
\end{enumerate}
```

This produces

1. First Point.
2. Second Point. All subsequent lines are indented.

- Un-numbered equation,

```
\[
a^2+b^2=c^2
\]
```

$$a^2+b^2=c^2$$

- Numbered equation

```
\begin{equation}
a^2+b^2=c^2
\end{equation}
```

$$a^2+b^2=c^2 \tag{1}$$

# Mathematics in LaTeX

- Mathematics can appear either as a displayed equation or in the middle of a line of text.

- Surround the mathematics by $, as in,

```
In text the equation $a^2+b^2=c^2$
appears in the line.
```

gives output

In text the equation $a^2+b^2=c^2$ appears in the line.

- Displayed equations are produced by surrounding the mathematics by `\[` and `\]` (no equation number) or `\begin{equation}` and `\end{equation}`.

- The method of numbering equations depends on the `documentclass`, usually either (1), (2), (3), or (1.1), (1.2) . . . (2.1) . . . . This can easily be customised in the header.

- Variables in equations are italic.

- Functions such as sine and cosine are conventionally in roman type.

  `$\cos(2a)$` produces $\cos(2a)$.

- Commands for common functions appear on p. 27 of the notes.

- Powers (or superscripts) are shown using `^`, and subscripts use `_`.

  `$a^b_c$` produces $a^b_c$.

- Curly brackets are used to group terms and do not appear in output.

  `$a^bc$` produces $a^bc$, while `$a^{bc}$` produces $a^{bc}$.

- Other common use of super/sub-scripts are in limits.

  `$\int_0^{2y} 2x dx=[x^2]_0^{2y}$`

  produces

  $\int_0^{2y} 2x dx = [x^2]_0^{2y}$

- Always make sure curly brackets balance correctly.

- `\{` produces a curly bracket { in the output.

- `\quad` and `\qquad` insert space in mathematics.

- `\qquad` is the same as `\quad\quad`, and is usual space between two equations.

## Variable Size Brackets

- Often brackets of different size are needed to group terms in equations.

- The same holds for other brackets and things like modulus signs ( `\vert`, |).

- LaTeXwill also automatically size brackets if you use `\left(` and `\right)`

  ```
  \[
  (a^b+c^d), \qquad \left(a^b+ c^d\right)
  \]
  ```

  produces

  $$(a^b + c^d), \qquad \left(a^b + c^d\right)$$

## Referencing equations

Use `\label` and `\ref` to refer to an equation by number

```
The function
\begin{equation}
f(x)=x\cos(x)+\tan(x)
\label{eq:fdefn}
\end{equation}
has derivative
\begin{equation}
f'(x)=\cos(x)-x\sin(x)+\sec^2(x)
\label{eq:fderiv}
\end{equation}
Expression (\ref{eq:fderiv}) follows
immediately from (\ref{eq:fdefn}).
```

The function

$$f(x) = x\cos(x) + \tan(x) \qquad (2)$$

has derivative

$$f'(x) = \cos(x) - x\sin(x) + \sec^2(x) \qquad (3)$$

Expression (3) follows immediately from (2).

## Symbols

- Greek letters are obtained using `$\alpha$, $\beta$` to give $\alpha$, $\beta$
- Lists of greek letters and other symbols appear on pp 35–42 of your notes.
- To use AMS symbols you need to include `\usepackage{amsmath,amsfonts}`

## Fractions

Fractions are obtained using
`\frac{Numerator}{Denominator}`

```
\begin{equation}
\int_1^2 \frac{\sin(x)}{\cos(x)} dx
=\left[-\log(\cos(2))\right]_1^2.
\end{equation}
```

This produces

$$\int_1^2 \frac{\sin(x)}{\cos(x)} dx = [-\log(\cos(2))]_1^2. \qquad (4)$$

## Aligning Equations

The `eqnarray` environment allows equations on multiple lines to be aligned.

```
\begin{eqnarray*}
\int_0^a \frac{1}{\sqrt{a^2-x^2}}dx
&=&
\int_{\theta=0}^{\frac{\pi}{2}}
\frac{a\cos\theta}{a\sqrt{1-\sin^2\theta}}
\> d\theta
\\
&=&\int_0^{\frac{\pi}{2}}\> d\theta
=\frac{\pi}{2}
\end{eqnarray*}
```

$$\begin{aligned}\int_0^a \frac{1}{\sqrt{a^2-x^2}}\,dx &= \int_{\theta=0}^{\frac{\pi}{2}} \frac{a\cos\theta}{a\sqrt{1-\sin^2\theta}}\,d\theta,\\ &= \int_0^{\frac{\pi}{2}} d\theta = \frac{\pi}{2}\end{aligned}$$

- The characters between the two &s are aligned (centred in a column).
- A new line is started with \\
- `eqnarray*` does not number equations.
- The \> inserts a small amount of space before the `dx`

```
\begin{eqnarray}
x&=&r\cos\theta,
\label{eq:xdefn}
\\
y&=&r\sin\theta
\label{eq:ydefn}
\\[20pt]
x^2+y^2&=&
r^2\cos^2\theta+r^2\sin^2\theta
\nonumber
\\
&=&r^2
\end{eqnarray}
where (\ref{eq:xdefn}) and (\ref{eq:ydefn})
are the definitions of $x$ \& $y$ in polars.
```

no eq. number is displayed.

- Produces output

$$x = r\cos\theta, \quad (5)$$
$$y = r\sin\theta \quad (6)$$
$$x^2+y^2 = r^2\cos^2\theta+r^2\sin^2\theta = r^2 \quad (7)$$

where (5) and (6) are the definitions of $x$ & $y$ in polars.

- The `eqnarray` includes equation numbers for each line.
- `\nonumber` before the \\ end-of-line means that line is not numbered.
- Extra space between lines can be included after the \\ by `[20pt]` or `[0.5cm]`, where the amount of space appears in the square brackets.