Introduction to LaTeX

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MA498 - Dissertation in Mathematics

Objectives of this session

What is LaTeX?

The LaTeX source file

Inside the body of the text

Typesetting mathematics

Internal references

Objectives of this session

By the end of this session you will hopefully

- Understand what LaTeX is.
- Understand the process of document creation using LaTeX.
- Be able to locate and open LaTeX editor on the lab PCs.
- Create a new document from scratch or template.
- Compile and view output documents.
- Understand basic structure of a LaTeX source file.
- Use sectioning commands to structure a document.
- Know how to use some standard environments.
- Be able to typeset general mathematical formula.

If time permits. . .

If time permits, we may also see the following:

- Referencing document elements: label, ref and pageref.
- How to create a basic bibliography.
- Understanding LaTeX compiler errors.
- Where to go for help.

TEX and LATEX

TEX is software created by Donald Knuth for the typesetting of mathematics.

LATEX is a later variant of this, created by Leslie Lamport, and is the subject of these two seminars.

Both of them provide:

- document markup language, and
- document preparation system.

What is a markup language?

A markup language is a system for annotating text.
These annotations are instructions detailing

- the logical structure of the document, and
- the presentational aspects of the document.

The content of a document is therefore mixed with instructions to format the document.

LaTeX source files need to be **compiled** to see the final form.

As such, it is **not** a WYSIWYG approach to document formatting.

Special characters

LaTeX is a **compiled** programming language, and therefore has special characters reserved for the compiler's use.

\# $ % & ~ _ { } ^ \

Symbol	Reserved function
\	Indicates a LaTeX command
{ }	Contains arguments (parameters) for commands
%	Indicates a comment
$	Starts/ends a maths environment
^ _	Superscript and subscript operators

Table: A table of special characters and their function.

Whitespace

The following are all treated as a single blank space by LaTeX:

1. a single blank space
2. several consecutive blank spaces
3. tabs
4. single line breaks

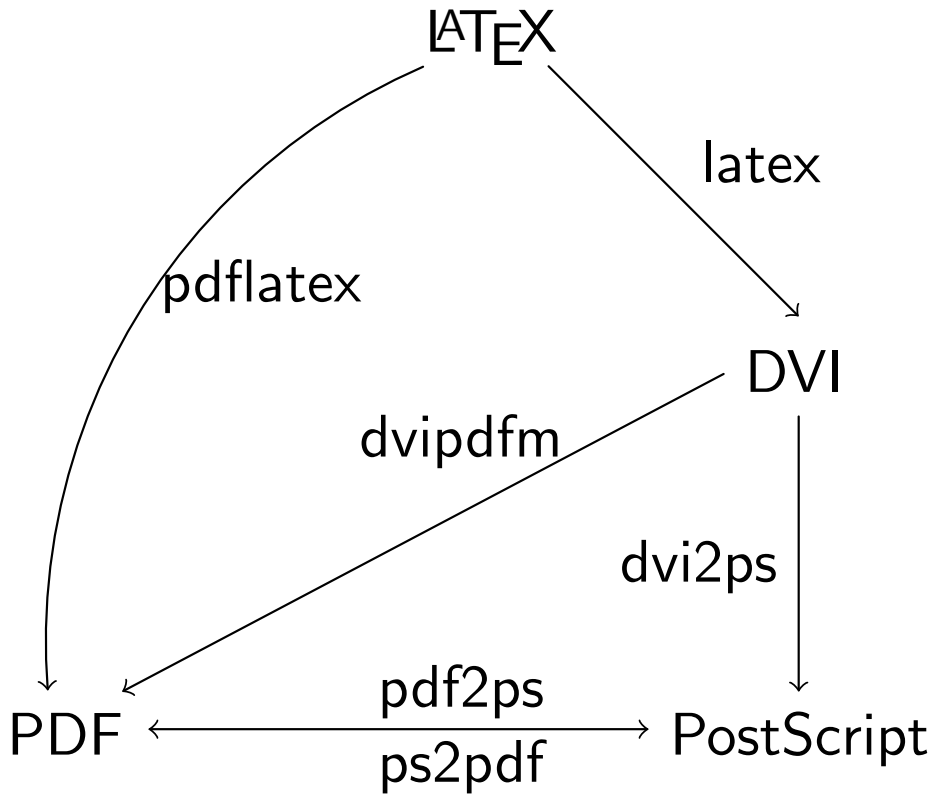
One or more empty lines between two lines of text defines a change of paragraph.

A basic LaTeX document

```
% hello.tex - A very basic source file
\documentclass{book}

\begin{document}

     Hello,            world!

\end{document}
```

Document preparation with LaTeX

A LaTeX source file can be compiled to produce output files of various formats.



The format you choose, and the process you follow to produce this, will depend on variety of reasons.

Working with LaTeX

LaTeX source files can be created using any basic **text editor**.

The network PCs provide two solutions:

- TeXnicCenter
- WinShell

Starting with TEXnicCenter

1. Star the application from its shortcut folder:

   Start → **Programs** → **Editors** → **TeXnicCenter**

2. Create a new file

   File → **New...**

3. Enter the following basic latex file and save it (as hello.tex).

```
% hello.tex - A very basic source file
\documentclass{book}

\begin{document}
Hello, world! I'm using \LaTeX.
\end{document}
```

4. Compile (or Build) using the menu option or the **Ctrl + F7**.
5. View the document you have created (**F5**).

A more useful example

Go to the Moodle course page to download a basic template file to work with.

1. Save it to a folder in your home directory.
2. Open it up in TeXnicCenter via **File** $\rightarrow$ **Open**.

The structure of a LaTeX source file

The first (non-commented) line must declare the document type.

```
\documentclass{. . .}
```

Next are customisation lines. Lines with

```
\usepackage{. . .}
```

call upon optional packages that bring additional features to LaTeX.
Further lines may define your own specialisations.
This section is known as the **pre-amble**.
The body of the text starts with

```
\begin{document}
```

The document is then ended with

```
\end{document}
```

Anything after this is ignored.

Document classes

The `documentclass` command declares the type of document.

Each type of document has associated to it some basic formatting features and default values.

Of the standard ones that come with LaTeX, the ones of most relevant to you will be:

book	for real books (i.e. multiple chapter affairs)
article	for articles in scientific journals, presentations, abstract reports, program documentation, ...
report	for longer reports, small books, thesis, ...
letter	for writing letters
beamer	for writing presentations

For your dissertation you should use the `book` document class.

Sectioning commands

LaTeX provides various section commands to break up a document.

Command
`\part{`*part*`}`
`\chapter{`*chapter*`}`
`\section{`*section*`}`
`\subsection{`*subsection*`}`
`\subsubsection{`*subsubsection*`}`

None of these are available in the `letter` class, and only the `book` and `report` class support chapters.

Additional document content elements

LaTeX provides a variety of **environments** to help you typeset your document.

Some standard environments that LaTeX provides includes:

- list
- table
- figure
- equation
- quote
- verbatim (e.g. to quote program code)

Environments are declared using

```
\begin{environment_name}
. . .
\end{environment_name}
```

List environments

LaTeX provides 3 very simple list environments.
The `itemize` environment

```
\begin{itemize}
  \item Item 1
  \item Item 2
\end{itemize}
```

which produces

- Item 1
- Item 2

List environments

LaTeX provides 3 very simple list environments.
The `enumerate` environment

```
\begin{enumerate}
  \item Item 1
  \item Item 2
\end{enumerate}
```

which produces

1. Item 1
2. Item 2

List environments

LaTeX provides 3 very simple list environments.
The `description` environment

```
\begin{description}
  \item[Name 1] Item 1
  \item[Name 2] Item 2
\end{description}
```

which produces

Name 1 Item 1

Name 2 Item 2

Text formatting commands

```
\underline{This underlines text.}
```

<u>This underlines text.</u>

```
\textbf{This bolds text.}
```

This bolds text.

```
\textit{This italicises text.}
```

This italicises text.

```
\texttt{This sets text in typewrite mode.}
```

`This sets text in typewrite mode.`

Mathematical symbols

Arithmetical operators

Symbol	Code
$+$	`+`
$-$	`-`
$\times$	`\times`
$/$	`/`
$\frac{x}{y}$	`\frac{x}{y}`
x^n	`x^n`
x_n	`x_n`
$\sqrt{x}$	`\sqrt{x}`
$\sqrt[n]{x}$	`\sqrt[n]{x}`

Mathematical functions

LaTeX operators are functions written as a word. Basic ones include:

Operator	Code
$\sin$, $\cos$, $\tan$	`\sin{}, \cos{}, \tan{}`
$\arcsin$, $\arccos$, $\arctan$	`\arcsin{}, \arccos{}, \arctan{}`
$\ln$, $\exp$	`\ln{}, \exp{}`
$\lim$	`\lim{}`
$\int$	`\int{}`
$\sum$	`\int{}`
$\prod$	`\prod{}`
$\bigcup$	`\bigcup`
$\bigcap$	`\bigcap`

Mathematical symbols

There are also basic logical symbols

Logical symbol	Code
$\forall$	`\forall`
$\exists$	`\exists`
$\neg$	`\neg`
$\wedge$	`\wedge`
$\vee$	`\vee`

Brackets, braces and delimiters

Finally, LaTeX offers a whole host of brackets, braces and delimiters.

```
          ()    []    \{\}    ||    \|\|
\langle \rangle   \lfloor \rfloor   \lceil \rceil
```

The latter three produce:

$$\langle\rangle \lfloor\rfloor \lceil\rceil$$

Their sizes can be adjusted using the following automatic modifiers

```
\left( \right)   \bigl( \bigr)   \Bigl( \Bigr)
       \biggl( \biggr)  \Biggl( \Biggr)
```

$$() \quad \left() \quad \bigl() \quad \Bigl() \quad \Biggl()$$

Displaying mathematics inside text

Any objects in bodies of text you wish to be formatted as mathematics, that is **text mode maths**, should be enclosed between single $ symbols.

```
Find all $x$ which satisfy the quadratic
equation $x^2 + 3x -1 = 7$.
```

Find all x which satisfy the quadratic equation $x^2 + 3x - 1 = 7$.

```
We then compute the integral
$\int_0^1 x dx = \frac{1}{2}$.
```

We then compute the integral $\int_0^1 x dx = \frac{1}{2}$.

Unnumbered mathematical environments

When maths occurs outside of text blocks, it is referred to as **display mode maths**.

LaTeX offers two ways of formatting display mode maths in unnumbered single lines.

```
$$\cos^2 \theta + \sin^2 \theta = 1$$
```

$$\cos^2 \theta + \sin^2 \theta = 1$$

```
\[
y^x = \exp{x\ln{y}}
\]
```

$$y^x = \exp x \ln y$$

Numbered mathematical environments

The `equation` environment is the first of the numbered equation environments

```
\begin{equation}
  \mathcal{C}
    = \left\{
        (x,y) \in \mathbb{R}^2 \mid x^2 + y^2 = 1
      \right\}
\end{equation}
```

$$\mathcal{C} = \left\{(x, y) \in \mathbb{R}^2 \mid x^2 + y^2 = 1\right\} \tag{1}$$

Numbered mathematical environments

The gather environment formats centres multiple lines of equations on the page.

```
\begin{gather}
  \Gamma(z)
    = \int_0^\infty t^{z - 1} e^{-t} dt \\
  \binom{n}{k}
    = \frac{n!}{(n - k)!k!}.
\end{gather}
```

$$\Gamma(z) = \int_0^\infty t^{z-1} e^{-t} dt \tag{2}$$

$$\binom{n}{k} = \frac{n!}{(n-k)!k!}. \tag{3}$$

Numbered mathematical environments

The `align` environment aligns multiple lines of equations along a single column at points identified by an &.

```
\begin{align}
   \sum_{n=0}^k a_n x^n
     &= a_0 + a_1 x + \ldots + a_n x^n\\
   \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}
   \begin{pmatrix} 1 & 1 \\ 0 & -1 \end{pmatrix}
     &= I
\end{align}
```

$$\sum_{n=0}^{k} a_n x^n = a_0 + a_1 x + \ldots + a_n x^n \tag{4}$$

$$\begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & -1 \\ 0 & 1 \end{pmatrix} = I \tag{5}$$

Additional mathematical environments

The `alignat` environment aligns multiple lines of equations along multiple columns at points identified by an &.

```
\begin{alignat}{6}
f(x)
  &= a_0 &+ a_1 x &+ a_2 x^2 &+ a_3 x^3 &+ \ldots \\
x f(x)
  &=     &+ a_0 x &+ a_1 x^2 &+ a_2 x^3 &+ \ldots \\
-x^2 f(x)
  &=     &        &- a_0 x^2 &- a_1 x^3 &- \ldots
\end{alignat}
```

$$
\begin{aligned}
f(x) &= a_0 + a_1 x + a_2 x^2 + a_3 x^3 + \ldots && (6)\\
x f(x) &= \quad + a_0 x + a_1 x^2 + a_2 x^3 + \ldots && (7)\\
-x^2 f(x) &= \quad\quad - a_0 x^2 - a_1 x^3 - \ldots && (8)
\end{aligned}
$$

Additional mathematical environments

```
\begin{multline}
  \left\{
    (x,y,z) \in \mathbb{R}^3 \mid x + y + z = 5
  \right\} \\
  \cap \left\{
    (x,y,z) \in \mathbb{R}^3 \mid xy + yz + zx = 8
  \right\} \\
  \cap \left\{
    (x,y,z) \in \mathbb{R}^3 \mid x^2 + y^2 + z^2 = 4
  \right\}
\end{multline}
```

$$\left\{(x,y,z) \in \mathbb{R}^3 \mid x + y + z = 5\right\} \\ \cap \left\{(x,y,z) \in \mathbb{R}^3 \mid xy + yz + zx = 8\right\} \\ \cap \left\{(x,y,z) \in \mathbb{R}^3 \mid x^2 + y^2 + z^2 = 4\right\} \quad (9)$$

Typesetting tables

There are two environments for tables.

- The `table` handles information external to the table - allowing you to add captions and number tables.
- The `tabular` handles the actual formatting of the table contents directly.

```
\begin{table}
 \begin{tabular}{c | c c}
  1 & 2 & 3 \\
  4 & 5 & 6
\end{tabular}
\caption{An introductory table}
\end{table}
```

1	2	3
4	5	6

Table: An introductory table

Including graphics files

The `includegraphics` command can be used to embed pictures into LaTeX, but the `figure` environment provides helpful features.

```
\begin{figure}[h]
\includegraphics[width=0.5\linewidth]{quadratic}
\caption{Including a picture file.}
\end{figure}
```

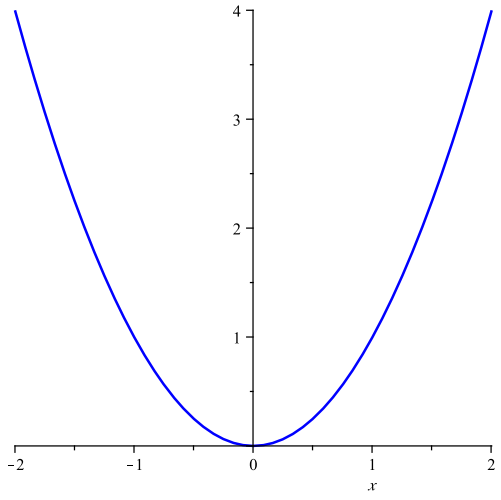


Figure: Including a picture file.

Referencing other parts of the document

Almost anything in your document can be labelled uniquely.

```
\chapter{The First chapter}
\label{chapter_1}

\begin{equation}
\label{unit_circle}
x^2 + y^2 = 1
\end{equation}
```

$$x^2 + y^2 = 1 \tag{10}$$

These labels can be referenced

```
Look at equation (\ref{unit_circle})
on page \pageref{chapter_1}
in Chapter \ref{chapter_1}
```