Introduction to LaTeX

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Introduction

- LaTeX is a typesetting system that allows you to create scientific documents of high quality.
- To use LaTeX we need to install in our computer two different components: a LaTeX editor and MiKTeX.
- Another possibility is just to use Overleaf.

Why LaTeX?

- It makes beautiful documents (especially mathematics).
- It was created by scientists, for scientists.
- It is powerful and can be extended with packages.

Writing a document

The first thing we have to tell LaTeX is which type of document we are going to write. It could be:

- An article.
- A book.
- A letter.
- Slides.

We will use `\documentclass[options]{class}` to declare the object we are going to write. Once the document is declared we have to open it and close it at the end.

```
\documentclass{article}
\begin{document}
Hello World
\end{document}
```

Front Matter

It refers to the beginning of each document, where the title, the name(s) of the author(s) and other relevant information is declared.

- Title: `\title{title of the document}`
- Author: `\author{Sergi Quintana}`
- Date: `\date{Today}`

Once the information is set, we can include it with `\maketitle`.

```
\documentclass{beamer}
\title{Introduction to \Latex}
\author{Sergi Quintana}
\date{9th January 2023}

\begin{document}

\maketitle
```

Structure of the document

In a document usually we have sections, subsections and so on. The hierarchy of those parts is :

- `\part{...}`
- `\section{...}`
- `\subsection{...}`
- `\subsubsection{...}`
- `\paragraph{...}`
- `\subparagraph{...}`

Some of the commands are class-dependent. For example if our document class is a book, we can use the command `\chapter{}`.

Cross-References

A cross-reference is used to refer to other parts of the document like figures, tables, mathematical expressions,sections...

There are **two** important elements while doing cross references:

- The identifier. We have to label the object with an identifier. `\label{marker}`.
- The reference. Once an object has been labeled we can refer to it using `\ref{marker}`.

  We can also refer the page of an element with `\pageref{marker}`.

```
\section{My Section}\label{My section}.

As explained in \ref{My section} this is how it works.
```

Footnotes

We can also include a footnote in our document by using the command:

- `\footnote{text}`

The number of each footnote will be automatically generated.

Environments

Environments are objects that allow us to increase the quality of our document. All environments have the same structure:

```
\begin{environment-name}
. . .
\end{environment-name}
```

We will now review some of the most used environments.

Abstract:

It is the first environment that we might use in our document and will be automatically placed after the `\maketitle` command.

```
\begin{abstract}
    This is an abstract for a document.
\end{abstract}
```

Itemize,enumerate and description

Those three environments are used to produce lists. The syntax is the same for the three.

```
\begin{environment}
    \item Bla, bla, bla.
    \item Bla, bla, bla.
    \item Bla, bla, bla.
\end{environment}
```

For example the code:

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

produces

- Item 1
- Item 2

Itemize,enumerate and description

The enumerate works as following:

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

produces

1. Item 1
2. Item 2

And the description:

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

produces

First Item 1

Second Item 2

Math typesetting

One of the most important reasons for using its the possibility to typesetting mathematical expressions.

There are two ways of writing a formula:

- In text. For this we will write the formula between two $.

  For example:

  ```
  The solution is $x=3$.
  ```

  Will produce the following:

  The solution is $x = 3$.

- A centered formula. We can write a mathematical expression in the middle of the document.

  For example:

  ```
  \begin{equation}
      x + y = 3
  \end{equation}
  ```

  Will produce:

$$x + y = 3 \tag{1}$$

Notice that the previous expression was labeled with a (1). We can then do a reference with:

```
\begin{equation}\label{eq1}
    x + y = 3
\end{equation}
As we can see in \ref{eq3} bla bla bla
```

This will produce:

$$x + y = 3 \tag{2}$$

As we can see in 2 bla bla bla

If we don't want the number to appear we can use $*$.

```
\begin{equation*}
    x + y = 3
\end{equation*}
```

Produces:

$$x + y = 3$$

There are multiple ways of introducing equations. Other examples are:

```
\begin{align*}
    x + y = 3
\end{align*}
```

$$x + y = 3$$

Or for example:

```
$$ x+ y = 3$$
```

$$x + y = 3$$

To deal with the mathematical environment we use the package `asmath`.

Let's review the most common mathematical symbols.

- Greek letters: Examlpes are `\alpha \beta \gamma \rho`
  Which create $\alpha, \beta, \gamma, \rho$
- Binary operations: `\times \otimes \oplus \cup \cap`
  Which create $\times \otimes \oplus \cup \cap$
- Relation operators:
  `< > \subset \supset \subseteq \supseteq`
  Which create $<>\subset\supset\subseteq\supseteq$.
- Others: `\int \oint \sum \prod \infty`
  Which create $\int \oint \sum \prod \infty$.

Subscripts and Superscripts

The use of superscripts and subscripts is very common in mathematical expressions.

- To write a subscript we use _.
- To write a superscript we use ^.

For example, to write an integral we would do:

```
$$\int\limits_0^1 x^2 + y^2 \ dx$$
```

$$\int\limits_0^1 x^2 + y^2 \ dx$$

And withouth the `\limits` command:

```
$$\int_0^1 x^2 + y^2 \ dx$$
```

$$\int_0^1 x^2 + y^2 \ dx$$

What happens if the subscript or superscript is more than one character long?

Suppose we want to write $x_{23} + y^{ji} = 3$ The following code will be incorrect:

```
$$x_23 + y^ji = 3$$
```

$$x_23 + y^j i = 3$$

This is because if the expression contains long superscripts or subscripts, these need to be collected in braces.

The right expression is:

```
$$x_{23} + y^{ji} = 3$$
```

$$x_{23} + y^{ji} = 3$$

We can also use them in operators like sums or products.

```
\sum_{i=1}^{\infty} \frac{1}{n^s} =
    \prod_p \frac{1}{1 - p^{-s}}
```

Will produce

$$\sum_{i=1}^{\infty} \frac{1}{n^s} = \prod_p \frac{1}{1 - p^{-s}}$$

Notice that in the previous code we have seen how to do a fraction `\frac{nominator}{denominator}`.

Brackets and Parentheses

Parentheses and brackets are very common in mathematical formulas.

Some of the common braces are: LaTeX Syntax $\leftrightarrow$ Outcome

- Parentheses. `(x+y)` $\leftrightarrow (x+y)$
- Brackets. `[x+y]` $\leftrightarrow [x+y]$
- Braces. `\{x+y\}` $\leftrightarrow \{x+y\}$
- Angle brackets. `\langle x+y \rangle` $\leftrightarrow \langle x+y \rangle$
- Pipes. `|x+y|` $\leftrightarrow |x+y|$
- Double pipes. `\|x+y\|` $\leftrightarrow \|x+y\|$

Sometimes the parenthesis needs to be resized for aesthetic reasons. For example:

$$F = G \left(\frac{m_1 m_2}{r^2} \right)$$

To produce the previous outcome, the following code is wrong:

```
F = G ( \frac{m_1 m_2}{r^2} )
```

Since it will produce:

$$F = G(\frac{m_1 m_2}{r^2})$$

To avoid this, we will add !\left and !\right to (and) respectively, to dynamically resize the parenthesis. The correct syntax would be:

```
$$F = G \left( \frac{m_1 m_2}{r^2} \right)$$
```

The same can be done with brackets. The following code:

```
$$\left[  \frac{ N } { \left( \frac{L}{p} \right)  - (m+
    n) }  \right]$$
```

Will produce:

$$\left[\frac{N}{\left(\frac{L}{p}\right) - (m+n)} \right]$$

We can also impose a size with the following:

- `\bigl( \Bigl( \biggl( \Biggl(` Produces $\bigl(\Bigl(\biggl(\Biggl($
- `\bigr] \Bigr] \biggr] \Biggr]` Produces $\bigr] \Bigr] \biggr] \Biggr]$
- `\bigl\{ \Bigl\{ \biggl\{ \Biggl\{` Produces $\bigl\{ \Bigl\{ \biggl\{ \Biggl\{$

Matrices

With the help of the package `mathtools` we can deal with matrices.

$$\begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_m \end{pmatrix} \neq \begin{Bmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_m \end{Bmatrix} \neq \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_m \end{bmatrix} \neq \begin{vmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_m \end{vmatrix} \neq \begin{Vmatrix} \alpha_1 \\ \alpha_2 \\ \vdots \\ \alpha_m \end{Vmatrix}$$

The first is created with:

```
\begin{pmatrix}
  \alpha_{1} \\
  \alpha_{2} \\
  \vdots \\
  \alpha_{m} \\
\end{pmatrix}
```

For the second we replace `pmatrix` for `Bmatrix`.

The third is done with `bmatrix`.

The fourth is done with `vmatrix`.

The fifth is done with `Vmatrix`.

We can inlcude more columns to a particular matrix using .

For example:

```
\begin{pmatrix}
  \alpha_{1} & \hdots & \beta_{1}\\
  \alpha_{2} & \hdots & \beta_{2} \\
  \vdots& \hdots & \vdots \\
  \alpha_{m} & \hdots & \beta_{m} \\
\end{pmatrix}
```

Will produce:

$$\begin{pmatrix} \alpha_1 & \hdots & \beta_1 \\ \alpha_2 & \hdots & \beta_2 \\ \vdots & \hdots & \vdots \\ \alpha_m & \hdots & \beta_m \end{pmatrix}$$

Underbrace and Overbrace

An example is:

```
$$\underbrace{u'-P(x)u^2-Q(x)u-R(x)}_{\text{=0, since~$
    u$ is a particular solution.}}$$
```

Which will produce:

$$\underbrace{u' - P(x)u^2 - Q(x)u - R(x)}_{\text{=0, since } u \text{ is a particular solution.}}$$

The opposite can be done with overbrace:

```
$$\overbrace{u'-P(x)u^2-Q(x)u-R(x)}^{\text{=0, since~$u
    $ is a particular solution.}}$$
```

$$\overbrace{u' - P(x)u^2 - Q(x)u - R(x)}^{\text{=0, since } u \text{ is a particular solution.}}$$

Floating objects: Tables and Figures

They are the most common objects we might want to include in our document.

Floating objects have their own "life" inside a document, which means that they are independent of the rest of the text.

Tables

There are two enviroments to create tables:

- `\tabular`.
- `\table`.

With `\tabular` we can create a table, but `\table` will be usefull to create the floating object.

Tables: tabular

The syntaxt for building a table with `\tabular` is:

```
\begin{tabular}{properties}
. . .
\end{tabular}
```

In properties we can specify the number of columns and their **alignment**. Those are:

- `r` : right.
- `l` : left.
- `c` : centered.

Also we can separate columns with a vertical line. For that we type (|). For example, to create a table with four columns, with the first centered and the other ones aligned to the left. Also, the first column is separated with a vertical line.

```
\begin{tabular}{c|lll}
. . .
\end{tabular}
```

To move from one row to another we use `\\`.

To change from one column to another we use `&` .

Let's now create a table:

```
\begin{tabular}{l|c|c}
     & Female & Male \\ \hline
     Faculty & 0 & 12 \\
     Research fellows & 1 & 1 \\
     Ph.D & 1 & 9 \\ \hline
\end{tabular}
```

	Female	Male
Faculty	0	12
Research fellows	1	1
Ph.D	1	9

Two important things:

- We can leave an empty cell.
- To draw an horizontal line we use `\hline`.

We can create cells that combine more than one column using `\multicolumn`.

```
\begin{tabular}{l|c|c}
    \hline
    \multicolumn{3}{c}{Gender separation} \\ \hline
    & Female & Male \\ \hline
    Faculty & 0 & 12 \\
    Research fellows & 1 & 1 \\
    Ph.D & 1 & 9 \\ \hline
\end{tabular}
```

Gender separation		
	Female	Male
Faculty	0	12
Research fellows	1	1
Ph.D	1	9

Notice that `\multicolumn{}{}{}` requires three arguments: amount of columns to unify, alignment, text.

Table: table

The environment `\table` is an outer environment with respect to `\tabular`.

The syntax is:

```
\begin{table}[position]
    \label{tab1}
    \caption{table-caption}
    \begin{tabular}
        ...
    \end{tabular}
\end{table}
```

Key things:

- We have to specify table position. Usual locations are:
  - `t` : top of the page.
  - `b`: bottom of the page.
  - `p`: in a page containng only floating objects.
  - `h`: here.
- The command `\caption{table-caption}` will produce a caption on the table.

As an example, the following code:

```
\begin{table}
    \caption{Our first table}
    \label{Table1}
    \begin{tabular}{l|c|c}
        \hline
        \multicolumn{3}{c}{Gender separation} \\ \hline
        & Female & Male \\ \hline
        Faculty & 0 & 12 \\
        Research fellows & 1 & 1 \\
        Ph.D & 1 & 9 \\ \hline
    \end{tabular}
\end{table}
As we can see at \ref{Table1} bla bla bla.
```

Table: Our first table

Gender separation		
	Female	Male
Faculty	0	12
Research fellows	1	1
Ph.D	1	9

As we can see at 1 bla bla bla.

Figures

Figures are created though the environment `\figure`.

This environment has exactly the same structure as the environment `\table`. The syntax is:

```
\begin{figure}[position]
    \label{marker}
    \caption{caption-text}
    ...
\end{figure}
```

But this will only create the Figure object.

Figure: caption-text

...

It is very likely that we have the figure saved in some image format like ".png" or ".jpeg". To include the figure in our object we must use the `\includegraphics[options]{filename}` command.

Let's see how it works:

```
\begin{figure}[h]
    \label{marker}
    \caption{caption-text}
    \includegraphics[scale=0.5]{testimage.png}
\end{figure}
```

Figure: caption-text

Notice that in the options box we are using `scale`. This will allow to include the Figure scaled to the desired size.

We can use other commands like

```
\includegraphics[width=10cm,height=10cm]{testimage.png}
```

The other used option is `angle` which allows to rotate the figure.

Including bibliography: BibTeX

One of the most important things we might want to do is deal with bibliography in an efficient manner.

The idea is to create a database of bibliographies saved in a file with extension ".bib".

Then to cite a particular paper we just need to type: `\cite{mypaper}`.

Also, this will create bibliography section in our paper including the citations.

Since there are different ways of creating a reference, we can specify our preferred using `\bibliographystyle{style-file}`.

First create a file and include a bibliography. They look like:

```
@article{CameronTaber,
author = {Cameron, Stephen and Taber, Christopher},
year = {2004},
month = {02},
pages = {132-182},
title = {Estimation of Educational Borrowing Constraints Using Returns to Schooling},
volume = {112},
journal = {Journal of Political Economy},
}
```

Then we can do the in text citation, and also we can include bibliography at the end of the document with:

```
\usepackage{apacite}
\bibliographystyle{apacite}
\bibliography{mybibliography}
```

Managing Packages

As we have just seen before, we can include more packages in our document that will help us increase the amount of things that can be done.

To import a package we just need to type `\usepackage[options]{package-name}`.

Some useful packages are:

- `natbib`: It is used to improve the format of our citations.
- `footmisc`: It helps with the format of footnotes.
- `babel`: It helps translate default names to other languages. For example "Abstract.
- `fontenc`: It includes more orthographical characters like for example, accents.
- `geometry`: It allows to configure everything related to the margins of the document.

- `float`: It helps us to modify some properties of our floating objects. For example, it creates the new position specifier (H).
- `graphicx`: It is a fancy way to introduce graphics and images in a document.
- `color and xcolor`: Allow us to introduce colored text.
- `longtable`: Allows tables to span over more than a single page.

Beamer

Beamer is the LaTeX class of document that is used for creating presentations.

The main features are:

- Tractability of mathematical formulae.
- Allows to format all the slides in a simple way.
- The output is a pdf file.

Frames and Structure

The main environment of a beamer document are `frames`. They allow to create the different slides. To create a `frame` we do:

```
\begin{frame}[options]{title}{subtitle}
    content
\end{framE}
```

Notice that titles and subtitles can also be specified using `\frametitle{Title}` and `\framesubtitle{Subtitle}`.

Let's create an example frame.

```
\begin{frame}{Example Frame}{Latex Course}
    content
\end{framE}
```

Example Frame

Latex Course

content

Frames and Structure

The first frame in the presentation will be the title page. To do that we use `\titlepage`.

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However, before creating the first frame, we establish the basic elements:

- `\title{}`.
- `\subtitle{}`.
- `\author{}`.
- `\institution{}`.
- `\date{}`.

Dynamic Effects

There are two main types of dynamic effects:

- Overlays: to hide part of an slide and uncover it during the explanation.

  They will generate different slides within a frame.

- Transitions.

We will now see an example.

Overlays

The simplest way to create an overlay is with the \pause command. The slide will be showed up to the first \pause; then what come next will be uncovered up to the following \pause and so on. One example is:

```
\begin{frame}{Example Frame}
    \begin{itemize}
        \item Shown from first slide on.
        \pause
        \item Shown from second slide on.
        \begin{itemize}
            \item Shown from second slide on.
            \pause
            \item Shown from third slide on.
        \end{itemize}
        \item Shown from third slide on.
        \pause
        \item Shown from fourth slide on.
        \end{itemize}
\end{framE}
```

Example Frame

- Shown from first slide on.

Example Frame

- Shown from first slide on.
- Shown from second slide on.
  - Shown from second slide on.

Example Frame

- Shown from first slide on.
- Shown from second slide on.
  - Shown from second slide on.
  - Shown from third slide on.
- Shown from third slide on.

Example Frame

- Shown from first slide on.
- Shown from second slide on.
  - Shown from second slide on.
  - Shown from third slide on.
- Shown from third slide on.
- Shown from fourth slide on.

Overlays

Another more flexible way to create overlays is \onslide. The syntax is:

```
\onslide<overlay specification>{text}
```

Basically, we can choose on which slides what information appears. An example is:

```
\begin{frame}
    \onslide<1>{Shown on first slide.}
    \onslide<2-3>{Shown on second and third slides.}
    \onslide<4->
    Shown from the fourth slide on.
    \begin{itemize}
        \item Also shown from the fourth slide on.
    \end{itemize}
    \onslide Shown on all slides.
\end{framE}
```

Shown on first slide.

Shown on all slides.

Shown on second and third slides.

Shown on all slides.

Shown on second and third slides.

Shown on all slides.

Shown from the fourth slide on.

- Also shown from the fourth slide on.

Shown on all slides.

Other examples can be obtained used \item and \color.

```
\begin{frame}
    \begin{itemize}
        \item This line is black in all slides
        \color<1>[rgb]{0.75,0.75,0.75}
        \item Gray in the first slide, black in others.
        \color<-2>[rgb]{0.75,0.75,0.75}
        \item Gray in slides 1 and 2, black in others.
        \color<-3>[rgb]{0.75,0.75,0.75}
        \item All gray but the last.
    \end{itemize}
\end{framE}
```

- This line is black in all slides
- Gray in the first slide, black in others.
- Gray in slides 1 and 2, black in others.
- All gray.

- This line is black in all slides
- Gray in the first slide, black in others.
- Gray in slides 1 and 2, black in others.
- All gray.

- This line is black in all slides
- Gray in the first slide, black in others.
- Gray in slides 1 and 2, black in others.
- All gray.

Transition Effects

Transition effects are used by advanced users.

One has to be cautious, since an abuse of these effects might be negative for the quality of the presentation.

Each transition effect has its own command, but the syntax is almost the same:

```
\transsomething<overlay specification>[options]
```

If the command is added in the end of the frame, it affect the transition to the next frame.

Options may include `duration = <seconds>` and `direction=<0,90,180 or 270>`.

Some of the effects are:

\transblindshorizontal
\transblindsvertical
\transboxin
\transboxout
\transdissolve
\transglitter
\transsplitverticalin
\transsplitverticalout
\transsplithorizontalin
\transsplithorizontalout
\transwipe
\transduration

Back Up Slides

They are useful to address questions from the audience.

To deal with back up slides we will use the `appendix`. Once we introduce the command `\appendix` we can add extra slides, that will not count in the presentation.

We can then label slides to make a reference to them and with the command:

```
\hyperlink{specified label}{\beamerbutton{button text}}
```

we will create a button to go to the slide.

Go to slide

Appendix Slide

Click here to go back Go Back!

The code for this frame is:

```
\appendix
\begin{frame}  [fragile]\label{slide2}
\frametitle{Appendix Slide}
Click here to go back \hyperlink{slide1}{\beamerbutton{Go
    Back}}!

\end{framE}
```