A Whistle-Stop Tour of \TeX\ (Part 1)
Computing Science and Mathematics Skill Sharing

Alexander E. I. Brownlee
Nadarajen Veerapen
1. Basics
2. The \LaTeX{} pipeline
3. Software and Services
4. Typesetting
5. Floats
6. Figures
7. Tables
Basics
\documentclass{article}
\begin{document}
Hello World!
\end{document}
\documentclass{article}

\begin{document}
Hello World!
\end{document}
\documentclass[a4paper]{article}
\usepackage{xcolor}

\begin{document}
\textbf{\Huge \color{red} Hello World!}
\end{document}
A basic \LaTeX document

\documentclass[a4paper]{article}
\usepackage{xcolor}
\begin{document}
\textbf{Huge \color{red} Hello World!}
\end{document}
A basic \LaTeX{} document

\documentclass[a4paper]{article}
\title{Lorem Ipsum}
\author{Loremy McLoremface}
\begin{document}
\maketitle
\section{First Section}
Lorem ipsum dolor sit amet, [...]
\[ G(n^2; x) = \sum_{n=0}^{\infty} n^2 x^n = \frac{x(x+1)}{(1-x)^3} \]
\subsection{Subsection}
Donec ullamcorper, felis non [...] 
\begin{itemize}
\item Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit.
\item Ut porttitor. Praesent in sapien.
\end{itemize}
\end{document}
@book{garey_computers_1979,
  title = {Computers and {Intractability}: {A} {Guide} to the {Theory} of {NP}-{Completeness }},
  isbn = {0-7167-1045-5},
  publisher = {W. H. Freeman},
  author = {Garey, Michael R. and Johnson, David S.},
  year = {1979}
}

@Article{Knuth1968,
  author="Knuth, Donald E.",
  title="Semantics of context-free languages",
  journal="Mathematical Systems Theory",
  year="1968",
  volume="2",
  number="2",
  pages="127--145"
}

@misc{knuthwebsite,
  author = "Donald Knuth",
  title = "Fantasia Apocalyptica: A multimedia work for pipe organ",
  url = "http://www-cs-faculty.stanford.edu/~uno/fant.html"}
The LaTeX pipeline
\TeX{} released in 1978 by Donald Knuth

\LaTeX{} (The macro package for \TeX{}) released in early 1980s by Leslie Lamport. Current version is \LaTeX{} 2ε

pdf\TeX{} provides pdf support

\Xe\TeX{} provides default UTF-8 and better font support

Lua\TeX{} provides scripting with Lua

Con\TeX{}t not actually an engine, newer macro package with enhanced typesetting
"LaTeX diagram" by Alessio Damato is licensed under the GNU Free Documentation License
https://commons.wikimedia.org/wiki/File:LaTeX_diagram.svg
Usually, 4 steps are required to obtain the final output when a new citation is added.

**Step 1** `pdflatex` reads `.tex` file and writes citation keys and label information to `.aux` file

**Step 2** `bibtex` reads `.aux` file, looks up citations in `.bib` file and writes formatted references as `.bbl` file

**Step 3** `pdflatex` reads `.aux` and `.tex` files to resolve cross-references, reads `.bbl` to insert references and set up information for citations

**Step 4** `pdflatex` finalises citation references, page formatting and page numbers, writes `.pdf`
Usually, 4 steps are required to obtain the final output when a new citation is added.

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**Step 4** `pdflatex` finalises citation references, page formatting and page numbers, writes `.pdf`

**Did you know?**

It is possible to create documents that fail to converge to a state where cross-references do not change.

tex.stackexchange.com/questions/30674/document-requiring-infinitely-many-compiler-passes
Software and Services
Distributions: do the work of compiling documents and contain most of the commonly-used packages. These are the most popular ones, all in active development.

**TeX Live**  Multi-platform: available in most Linux package managers, Windows installers available

**MiKTeX**  Targeted specifically at Windows (wizard driven). Has a LaTeX package manager built in

**MacTeX**  TexLive, with some tweaks to make it more Mac-friendly

Editors: where you actually do the editing.

**TeXMaker**  Multi-platform

**TeXnicCenter**  Windows only

**JabRef**: desktop BibTeX manager (online ref managers also available e.g. Mendeley)
Online Editors

There are multiple online collaborative editors. The one you choose is probably going to be influenced by what your collaborators already use.

- It seems quite a few people in CSM use Overleaf.
- When we compared Overleaf to ShareLaTeX some time ago, simultaneous collaborative editing seemed to work better in Overleaf.
- ShareLaTeX is open-source and can thus be hosted privately.
- ShareLaTeX accepts knitr (R) input.
- Authorea and Papeeria accept Markdown input so are easier to use for non-LaTeX collaborators.
- Authorea shows an HTML rendering of the output (not WYSIWYG).
- Papeeria accepts gnuplot input.
Typesetting
We can reference \eqref{eqn:step1} and \eqref{eqn:step2} in the document.

\begin{align}
  y_1 &= x + 1 \label{eqn:step1} \\
  y_2 &= 3x^2 + 2x - 5 \label{eqn:step2} \\
  (g + h) &= x^{2a + 3b} \\
  e &= mc^2 \text{(mass-energy eq.)} \nonumber \\
  a, b &\in \mathbb{N} \nonumber
\end{align}

We can reference (1) and (2) in the document.

\begin{align}
  y_1 &= x + 1 \quad (1) \\
  y_2 &= 3x^2 + 2x - 5 \quad (2) \\
  (g + h) &= x^{2a+3b} \\
  e &= mc^2 \text{(mass-energy eq.)} \quad (3)
\end{align}

Use \begin{split}...\end{split} within the \texttt{align} environment to have one number for all equations. \begin{align*} is equivalent to \texttt{nonumber} on every line.
\begin{equation}
\label{equation:checkerboard}
\begin{array}{r c}
\Delta \left(x_{i,j}, x_{i-1,j} \right) \\
+ \Delta \left(x_{i,j}, x_{i+1,j} \right) \\
+ \Delta \left(x_{i,j}, x_{i,j-1} \right) \\
+ \Delta \left(x_{i,j}, x_{i,j+1} \right)
\end{array}
\end{equation}

f(x) = 4(s - 2)^2 - \sum_{i=2}^{s-1} \sum_{j=2}^{s-1} \left\{ \delta (X_{i,j}, X_{i-1,j}) + \delta (X_{i,j}, X_{i+1,j}) + \delta (X_{i,j}, X_{i,j-1}) + \delta (X_{i,j}, X_{i,j+1}) \right\}

\begin{equation}
(4)
\end{equation}
Draw what you are looking for on detexify.kirelabs.org

Look through The Comprehensive \LaTeX\ Symbol List
symbols-a4.pdf via www.ctan.org or texdoc symbols
(+14 000 symbols)
## Spaces and spacing

<table>
<thead>
<tr>
<th>Input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\</td>
<td>A space</td>
</tr>
<tr>
<td>\</td>
<td>Still one space</td>
</tr>
<tr>
<td>\</td>
<td>A space</td>
</tr>
<tr>
<td>\</td>
<td>3 spaces</td>
</tr>
<tr>
<td>,</td>
<td>A thin space, e.g., a thousands separator</td>
</tr>
<tr>
<td>~</td>
<td>An unbreakable space</td>
</tr>
<tr>
<td>\hspace{1cm}</td>
<td>A 1 cm horizontal space</td>
</tr>
<tr>
<td>\hfill</td>
<td>Take up the remaining horizontal space</td>
</tr>
<tr>
<td>\vspace{1cm}</td>
<td>A 1 cm vertical space</td>
</tr>
<tr>
<td>\vfill</td>
<td>Take up the remaining vertical space</td>
</tr>
</tbody>
</table>
## Ellipses and quotes

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ellipsis\ldots</code></td>
<td><code>ellipsis...</code></td>
</tr>
<tr>
<td>three full stops...</td>
<td>three full stops...</td>
</tr>
<tr>
<td><code>single quotation marks'</code></td>
<td>‘single quotation marks’</td>
</tr>
<tr>
<td>`&quot;double quotation marks&quot;'</td>
<td>“double quotation marks”</td>
</tr>
<tr>
<td>`&quot;double quotation marks&quot;&quot;</td>
<td>“double quotation marks”</td>
</tr>
<tr>
<td>'wrong quotation marks'</td>
<td>‘wrong quotation marks’</td>
</tr>
<tr>
<td>&quot;wrong quotation marks&quot;</td>
<td>”wrong quotation marks”</td>
</tr>
</tbody>
</table>
# Dashes and Hyphens

<table>
<thead>
<tr>
<th>Name</th>
<th>Input</th>
<th>Output</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyphen</td>
<td>-</td>
<td>-</td>
<td>inter-word</td>
</tr>
<tr>
<td>En-dash</td>
<td>--</td>
<td>–</td>
<td>page range, e.g., 1–10</td>
</tr>
<tr>
<td>Em-dash</td>
<td>---</td>
<td>—</td>
<td>punctuation dash</td>
</tr>
<tr>
<td>Minus</td>
<td>-</td>
<td>–</td>
<td>minus sign in <em>maths mode</em></td>
</tr>
</tbody>
</table>
\begin{itemize}
\item Thing A
\item Thing B
\end{itemize}

\begin{enumerate}
\item Thing 1
\item Thing 2
\end{enumerate}

\begin{itemize}
\item Thing A
\item Thing B
\end{itemize}

\begin{itemize}
\item \begin{enumerate}
\item Nested Thing 1
\item Nested Thing 2
\end{enumerate}
\end{itemize}
\begin{description}
\item [Apple] A kind of fruit. Usually red or green.
\item [Orange] Another kind of fruit, not to be compared with Apples.
\end{description}

Apple  A kind of fruit. Usually red or green.
Orange  Another kind of fruit, not to be compared with Apples.
Floats
**Floats**

*Floats* are wrappers for objects like tables and figures that allow objects to be positioned separately to the flow of text.

A float usually has:

- a caption, added with `\caption{Description here}`
- a label, added with `\label{somelabel}`

Labels must appear after or inside captions, otherwise they can label the wrong thing (e.g. the current section rather than your table).
Internally, \LaTeX will make a separate counter for each float type, so tables, figures, algorithms etc. are all separately numbered.

You can cite these numbers in the text by referencing a label, like this: Table~\ref{somelabel} (the ~ is a non-breaking space). You can also use \pageref{somelabel} to show the page that a float appears on.

It’s conventional to prefix labels with the type of float to make things more readable (some packages also use this for formatting), e.g. \label{tab:results}. Common prefixes are:

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ch</td>
<td>chapter</td>
</tr>
<tr>
<td>sec</td>
<td>section</td>
</tr>
<tr>
<td>subsec</td>
<td>subsection</td>
</tr>
<tr>
<td>fig</td>
<td>figure</td>
</tr>
<tr>
<td>eq</td>
<td>equation</td>
</tr>
<tr>
<td>lst</td>
<td>code listing</td>
</tr>
<tr>
<td>itm</td>
<td>enumerated list item</td>
</tr>
<tr>
<td>alg</td>
<td>algorithm</td>
</tr>
<tr>
<td>app</td>
<td>appendix subsection</td>
</tr>
</tbody>
</table>
LaTeX tries to place a float on the current page. If there’s not enough room, the float is moved to the top of the next page.

We can change placement by moving the float in the source, or we can tweak placement with modifiers, e.g. \begin{figure}[htb]:

- h ‘here’, roughly at the same point it occurs in the source text.
- t top of the page.
- b bottom of the page.
- p place on a special page for floats only.
- ! override LaTeX internal’s parameters for deciding ‘good’ positions.
- H precisely the same location as in the LaTeX code. Requires \usepackage{float}. Roughly equivalent to !ht.
\LaTeX{} stores floats in a stack, placing them as it finds space to do so. If you have many, sometimes this means they will jam and push to the end of the document. (more detail on the procedure here: http://tinyurl.com/hosk82o)

Note: \LaTeX{} has an internal limit of 18 floats in the stack (use \texttt{morefloats} package to increase), so look for

\begin{verbatim}
! \LaTeX{} Error: Too many unprocessed floats.
\end{verbatim}

in the output. If this happens, you can move the float around in the source so they have a chance to clear earlier.

You can also use \texttt{\textbackslash clearpage} to force a page break and clear the floats currently in the stack.
Figures
\documentclass{article}
\usepackage{hyperref}
\usepackage{graphicx}
\graphicspath{{images/} }
\begin{document}
\begin{figure}
\centering
\includegraphics[width=3cm, height=2cm]{fish.png}
\caption{Fish image from \url{https://commons.wikimedia.org/wiki/File:Fish_-_Puntius_sarana_from_Kerala_(India).png}}
\label{fig:fish1}
\end{figure}
\begin{figure}
\centering
\includegraphics[width=3cm, height=2cm]{fish.png}
\caption{Fish again}
\end{figure}
\begin{figure}
\centering
\includegraphics[width=3cm, height=2cm]{fish.png}
\caption{Something Fishy}
\end{figure}
\end{document}
\begin{figure}
\centering
\includegraphics[width=\textwidth]{fish}
\caption{Fish again}
\label{fig:fish2}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth, angle=45]{fish}
\caption{Something Fishy}
\label{fig:fish2}
\end{figure}

Figure 1: Fish image from https://commons.wikimedia.org/wiki/File:Fish_-_Puntius_sarana_from_Kerala_(India).png
Figure 2: Fish again
Figure 3: Something Fishy
We can divide floats up into subfloats, laid out in a grid. `\` marks the end of a line. Each subfloat can have its own caption and label.

**Note:** The `subfigure` and `subfig` packages are deprecated: the current recommended way to do this is via the `subcaption` package, but many templates we use frequently are not compatible with `subcaption`, e.g. Springer, IOP, IEEETran and ACM SIG.
Subfigures

Figure 1: Four identical fish. Image from https://commons.wikimedia.org/wiki/File:Fish_-_Puntius_sarana_from_Kerala_(India).png
If you’re using a style with two columns, by default the floats will be one column wide. Use the starred versions to make them span two columns:

\begin{table*} ... \end{table*}

\begin{figure*} ... \end{figure*}
A basic table

\begin{tabular}{l c r}
\hline
Animal & Description & Price \\
\hline
Gnat & per gram & 13.65 \\
& each & 0.01 \\
Gnu & stuffed & 92.59 \\
Emu & stuffed & 33.33 \\
Armadillo & frozen & 8.99 \\
\hline
\end{tabular}
A basic table with lots of lines

\begin{tabular}{|l|c|r|}
\hline
Animal & Description & Price \\
\hline
Gnat & per gram & 13.65 \\
& each & 0.01 \\
\hline
Gnu & stuffed & 92.59 \\
\hline
Emu & stuffed & 33.33 \\
\hline
Armadillo & frozen & 8.99 \\
\hline
\end{tabular}
### Merging cells (horizontally with `multirow` package)

```latex
\begin{tabular}{|l|c|r|}
\hline
\multicolumn{2}{|c|}{Item} & \multirow{2}{*}{Price} \\
\cline{1-2}
Animal & Description & \ \\
\hline
Gnat & per gram & 13.65 \\
& each & 0.01 \\
\cline{2-3}
Gnu & stuffed & 92.59 \\
Emu & stuffed & 33.33 \\
Armadillo & frozen & 8.99 \\
\hline
\end{tabular}
```

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gnat</td>
<td>per gram</td>
<td>13.65</td>
</tr>
<tr>
<td></td>
<td>each</td>
<td>0.01</td>
</tr>
<tr>
<td>Gnu</td>
<td>stuffed</td>
<td>92.59</td>
</tr>
<tr>
<td>Emu</td>
<td>stuffed</td>
<td>33.33</td>
</tr>
<tr>
<td>Armadillo</td>
<td>frozen</td>
<td>8.99</td>
</tr>
</tbody>
</table>
Less is more, nice tables with the `booktabs` package

```
\begin{tabular}{l c r}
\toprule
\multicolumn{2}{c}{Item} & \multirow{2}{*}{Price} \\
\cmidrule{1-2}
Animal & Description & \\
\midrule
Gnat & per gram & 13.65 \\
& each & 0.01 \\
Gnu & stuffed & 92.59 \\
Emu & stuffed & 33.33 \\
Armadillo & frozen & 8.99 \\
\bottomrule
\end{tabular}
```
Space matters

\newcommand{\ra}[1]{\renewcommand{\arraystretch}{#1}}
\ra{1.2}
\begin{tabular}{@{}llr@{}}
\toprule
\multicolumn{2}{c}{Item} & \multirow{2}{*}{Price} \\
\cmidrule(r){1-2}
Animal & Description & \\
\midrule
Gnat & per gram & 13.65 \\
& each & 0.01 \\
Gnu & stuffed & 92.59 \\
Emu & stuffed & 33.33 \\
Armadillo & frozen & 8.99 \\
\bottomrule
\end{tabular}
Small Guide to Making Nice Tables


- Avoid vertical lines
- Avoid “boxing up” cells, usually 3 horizontal lines are enough for a table (more if there are hierarchies)
- Avoid double horizontal lines
- Enough space between rows
- If in doubt, align left