Introduction to LaTeX

Writing papers the right way

Cheng XU

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Contents

Getting Started with LaTeX

Introduction

- LaTeX is a document preparation system and document markup language.
- It can be used to typeset articles, books, slides, posters, even graphics.
- Pros:
  - It separates presentation/format from contents.
  - Since the source codes are plaintext, it works well with version control system such as git.
  - Highly customizable through various of packages.
- Cons:
  - There is no graphic interface to support WYSIWYG style editing.
  - Not suitable to produce unstructured documents.

Installation

- Windows/Linux
  - TeXLive `https://www.tug.org/texlive/`
  - Online installer:
    - Windows
      `http://mirror.ctan.org/systems/texlive/tlnet/install-tl-windows.exe`
    - Linux
      `http://mirror.ctan.org/systems/texlive/tlnet/install-tl-unx.tar.gz`
  - Offline ISO file: `http://mirror.ctan.org/systems/texlive/Images/`
- Mac
  - MacTeX `http://www.tug.org/mactex/`
  - Or install through Homebrew (`https://brew.sh`)

```
# Install Homebrew
ruby -e "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install)"
# Install MacTeX
brew cask install mactex
```

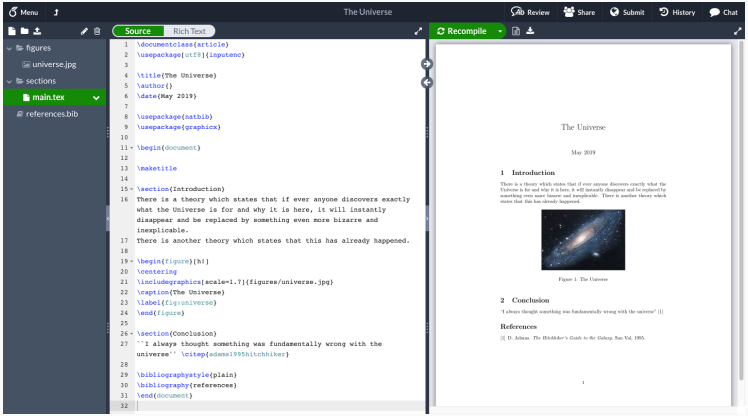
- TeXLive/MacTeX release major updates around May each year.
  It is recommended to uninstall the old version and install the new version annually.

LaTeX editor

- LaTeX source codes are plaintext. So you can use any editor you like.
- Visual Studio Code [Recommend]
  - `https://code.visualstudio.com`
  - LaTeX Workshop `https://github.com/James-Yu/LaTeX-Workshop`
  - Code Spell Checker `https://github.com/streetsidesoftware/vscode-spell-checker`
- Vim/Neovim
  - `https://www.vim.org` | `https://neovim.io`
  - Vimtex `https://github.com/lervag/vimtex`
- Emacs
  - `https://www.gnu.org/s/emacs`
  - AUCTeX `https://www.gnu.org/software/auctex`
- TeXstudio
  - `https://www.texstudio.org`

Overleaf

- Overleaf (`https://www.overleaf.com/`) is a online, collaborative LaTeX editor
- Free for personal use
- $15/month to share project among up to 10 collaborators



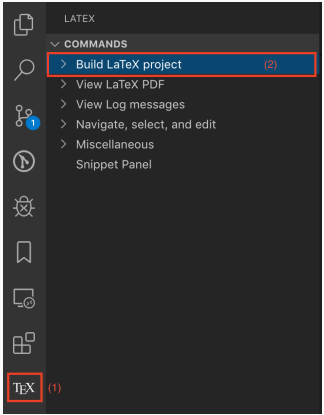
A Basic Document

Hello, LaTeX!

- Create `hello.tex` file with following content.

```
% this is hello.tex
\documentclass{article}
\begin{document}
Hello, \LaTeX!
\end{document}
```

- Compile it
  - Click the build button in your LaTeX editor/IDE
  - OR using command line: `latexmk -pdf hello`
- Open `hello.pdf` to preview the result



Compile LaTeX Project in VSCode

Example of A Complex Document

- Download the source code from
  `https://github.com/xu-cheng/latex-tutorial/archive/master.zip`
- The example document is located in the `example` folder. It contains:
  - `main.tex` The main tex source
  - `preamble.tex` A subfile to store format definitions
  - `tikz-example.tex` A figure drawn using tikz
  - `ref.bib` A database of references
- Use `latexmk -pdf main` to compile the document
- Access the same example in Overleaf:
  `https://www.overleaf.com/read/qsthqbjphhrz`

Comment, Command and Environment

- `%` starts a comment. e.g. `% this is hello.tex`
- `\` starts a command.

```
\command % a command
\command{} % also a command
\command{arg} % a command with an argument
\command{arg1}{arg2} % a command with multiple arguments
\command[opt arg]{arg} % [] is for optional argument
```

- `\begin{} ... \end{}` denotes an environment

```
\begin{envname}
  inside the environment
\end{envname}
% LaTeX environment can take arguments
\begin{envname}{arg} \end{envname}
\begin{envname}[opt arg]{arg} \end{envname}
```

Source File Structure

- A document starts with `\documentclass{...}` command to specify the template
- Common templates include:
  - `article`
  - `book`
  - `report`
  - `letter`
  - `beamer` (slides)
  - `standalone` (graphics)
  - `acmart` (ACM template)
  - `IEEEtrans` (IEEE template)
- Template class can accept options, e.g. `\documentclass[a4paper,10pt]{article}`

Class Options for `article`, `report`, `book`, `letter`

`10pt`, `11pt`, `12pt`	Set font size.
`a4paper`, `letterpaper`, ...	Defines the paper size.
`fleqn`	Typesets displayed formulae left-aligned instead of centred.
`leqno`	Places the numbering of formulae on the left hand side instead of the right.
`titlepage`, `notitlepage`	Specifies whether a new page should be started after the document title or not.
`onecolumn`, `twocolumn`	Typeset the document in one column or two columns.
`twoside, oneside`	Specifies whether double or single sided output should be generated.
`landscape`	Changes the layout of the document to print in landscape mode.
`openright, openany`	Makes chapters begin either only on right hand pages or on the next page available.

Source File Structure

- The region after `\documentclass` and before `\begin{document}` is called preamble.
- You can load packages and define format of the document here, e.g. `\usepackage{amsmath}`
- Package can be loaded with options, e.g. `\usepackage[style=ieee]{biblatex}`
- To find the package document:
  - Run `texdoc <pkg_name>` in command line
  - `http://www.texdoc.net`
- You start the body of the text with `\begin{document}`.
- Finally, `\end{document}` denotes the end of the document.

Typesetting Text

Syntax

- The main body of LaTeX code is plain text.
- LaTeX treats contiguous spaces or a single linebreak as a single space.
  It starts a new paragraph after empty lines.

```
It does not matter whether
you enter one or several
spaces        after a word.

An empty line starts a new
paragraph.
```

It does not matter whether you enter one or several spaces after a word.

An empty line starts a new paragraph.

- `\\` or `\newline` starts a new line without starting a new paragraph.

Special Characters and Symbols

- Certain characters are reserved, you need to use escape command to typeset them.

```
\# \$ \% \^{} \& \_ \{ \} \~{}
\textbackslash
```

$ % ^ & _ { } ~ \

- `` `text' `` and ``` ``text'' ``` typeset ‘single quoted text’ and “double quoted text”
- There are four kinds of dashes
  - **hyphen**: `-`, e.g. part-time
  - **en-dash**: `--`, e.g. Pages 1–10
  - **em-dash**: `---`, e.g. yes—or no?
  - **minus sign**: `-` inside math environment, e.g. -1
- Use `\ldots` instead of `...` to typeset ellipsis, e.g. a, b, c, …

Font Face & Size

`\textrm{...}`	roman	`\textsf{...}`	sans serif
`\texttt{...}`	`typewriter`		
`\textmd{...}`	medium	`\textbf{...}`	**bold face**
`\textup{...}`	upright	`\textit{...}`	*italic*
`\textsl{...}`	*slanted*	`\textsc{...}`	SMALL CAPS
`\emph{...}`	*emphasized*	`\textnormal{...}`	document font

Font Face Commands

- Put the text inside the above commands to change the font face.
  e.g. `\textbf{this text will be in bold face}`

Font Face & Size

`\tiny`	tiny font
`\scriptsize`	very small font
`\footnotesize`	quite small font
`\small`	small font
`\normalsize`	normal font
`\large`	large font
`\Large`	large font
`\LARGE`	very large font
`\huge`	huge
`\Huge`	largest

Font Size Commands

- These commands will affect font size in the following text
- Use `{ ... }` to limit its effect range e.g. `{\small small size text}`

Spacing

- Use package *geometry* to change the paper margin

```
\usepackage[top=3cm,bottom=3cm,left=2.5cm,right=2.5cm]{geometry}
```

- To force a new page, use:
  - `\newpage` : create a new page
  - `\clearpage` : create a new page and flush all the floats
  - `\cleardoublepage` : In addition to `\clearpage`, it makes the next page a right-hand page for two-sided printing
- Force a space using `~` (unbreakable) or `\ ` (breakable)
- Insert horizontal/vertical spaces with `\hspace{1em}` or `\vspace{1ex}`
- Create a line break and insert vertical spaces using `\\ [1ex]`
- Fill space using `\hfill` or `\vfill`

unit	meaning
pt	a point is approximately 1/72.27 inch
mm	a millimeter
cm	a centimeter
in	inch
ex	roughly the height of an ‘x’ (lowercase) in the current font
em	roughly the width of an ‘M’ (uppercase) in the current font
mu	math unit equal to 1/18 em

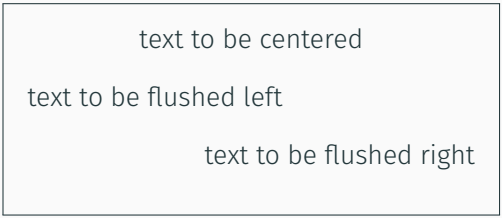
Length Unit in LaTeX

Alignment

```
\begin{center}
  text to be centered
\end{center}

\begin{flushleft}
  text to be flushed left
\end{flushleft}

\begin{flushright}
  text to be flushed right
\end{flushright}
```



Hyphenation

- LaTeX hyphenates words whenever necessary
- You can custom the hyphenation using `\hyphenation{<word list>}` in the preamble
- For example, `\hyphenation{FORTRAN Hy-phen-a-tion}` instructs:
  - Prevents “FORTRAN”, “Fortran” and “fortran” from being hyphenated
  - Allow “hyphenation” to be hyphenated as well as “Hyphenation”
- Or use `\-` inserts a discretionary hyphen into a word

```
I think this is: su\-per\-cal\-%
i\-frag\-i\-lis\-tic\-ex\-pi\-%
al\-i\-do\-cious
```

I think this is: supercalifragilis-ticexpialidocious

- `\mbox{...}` causes its argument to be kept together under all circumstances

```
My phone number will change soon.
It will be \mbox{0116 291 2319}.
```

My phone number will change soon. It will be 0116 291 2319.

Document Structure

- LaTeX is built off the idea *structure* over *formatting*
- You can structure the documents using following commands

```
\part{part name} % only available in book
\chapter{chapter name} % available in book and report
\section{section name}
\subsection{subsection name}
\subsubsection{subsubsection name}
```

- The star version commands (e.g. `\section*{}`) suppress the numbering and are not added in the table of contents.
- `\tableofcontents` can be used to create table of contents.
- Use `\appendix` to put rest of content in the appendix.
- For large project, you can put each chapter/section in a separated file. Then use `\input{file_name}` to include them in the root file.

List Structures

- There are three list structures in LaTeX

```
\begin{enumerate}
  \item Item 1
  \item Item 2
\end{enumerate}
\begin{itemize}
  \item Item 1
  \item Item 2
\end{itemize}
\begin{description}
  \item[key1] Item 1
  \item[key2] Item 2
\end{description}
```

1. Item 1
2. Item 2

- Item 1
- Item 2

key1 Item 1

key2 Item 2

List Structures

- You can use them in nested fashion

```
\begin{enumerate}
  \item Level 1
        \begin{enumerate}
          \item Level 2
        \end{enumerate}
  \item Level 1
        \begin{itemize}
          \item Level 2
        \end{itemize}
\end{enumerate}
```

1. Level 1
   1.1 Level 2
2. Level 1
   - Level 2

List Structures

- Use package *enumitem* to custom the list format

```
\usepackage{enumitem}
\setlist{noitemsep,partopsep=0pt,topsep=.8ex}
\setlist[enumerate,1]{label=\arabic*.,ref=\arabic*}
\newlist{inlineenum}{enumerate*}{1}
\setlist[inlineenum]{label=(\roman*),ref=(\roman*)}

\begin{itemize}[label=-]
  \item Item
\end{itemize}
```

Math

- Common mathematical packages

```
\usepackage{amsmath}
\usepackage{amssymb}
\usepackage{amsfonts}
\usepackage{mathrsfs}
\usepackage{latexsym}
```

- List of mathematical symbols
  `https://www.caam.rice.edu/~heinken/latex/symbols.pdf`
- "Short Math Guide for LaTeX" (access by `texdoc short-math-guide`) for comprehensive guide

Math Mode & Environment

- There are two math mode
  - Inline math mode: `$\sum_k^n k$` or `\(\sum_k^n k\)` to typeset $\sum_k^n k$
  - Display math mode: `$$\sum_k^n k$$` or `\[\sum_k^n k\]` to typeset

$$\sum_k^n k$$

- Use `equation` environment to number the equation in display mode

```
\begin{equation}
  E = mc^2
\end{equation}
```

$$E = mc^2 \tag{1}$$

- Use `\tag` to change the equation label

```
\begin{equation}
  1 + 1 = 3 \tag{dumb}
\end{equation}
```

$$1 + 1 = 3 \tag{dumb}$$

Math Mode & Environment

- Use `align` environment to align multiple equations

```
\begin{align}
  B' &=-\nabla \times E, \\
  E' &=\nabla \times B - 4\pi j,
\end{align}
```

$$B' = -\nabla \times E, \tag{2}$$
$$E' = \nabla \times B - 4\pi j, \tag{3}$$

- Use `\nonumber` to disable the number for some lines

```
\begin{align}
  a &= b + c \nonumber \\
    &= d + e
\end{align}
```

$$\begin{aligned} a &= b + c \\ &= d + e \end{aligned} \tag{4}$$

Math Mode & Environment

- `align*` environment disable the number entirely

```
\begin{align*}
  B' &=-\nabla \times E, \\
  E' &=\nabla \times B - 4\pi j,
\end{align*}
```

$$B' = -\nabla \times E,$$
$$E' = \nabla \times B - 4\pi j,$$

- `gather` / `gather*` display a set of consecutive equations, centered and with no alignment

```
\begin{gather*}
  2x - 5y =  8 \\
  3x^2 + 9y =  3a + c
\end{gather*}
```

$$2x - 5y = 8$$
$$3x^2 + 9y = 3a + c$$

Math Symbols

- The following symbols that can be used directly in math environment

```
+ - = ! / ( ) [ ] < > | ' : *
```

$+ - = ! / ( ) [ ] < > | ' : *$

- Greek letters

```
\alpha, \beta, \gamma, \pi, \phi, \varphi
```

$\alpha, \beta, \gamma, \pi, \phi, \varphi$

- Operators

```
\cos(2\theta) = \cos^2\theta-\sin^2\theta
\lim\limits_{x \to \infty} \exp(-x) = 0
a \bmod b
x \equiv a \pmod{b}
\log{(N)}
```

$$\cos(2\theta) = \cos^2\theta - \sin^2\theta$$
$$\lim_{x \to \infty} \exp(-x) = 0$$
$$a \bmod b$$
$$x \equiv a \pmod{b}$$
$$\log{(N)}$$

Math — Custom Operators

- You can define your own operators

```
\operatorname{arg\,max}_a f(a) =
\operatorname*{arg\,max}_b f(b)
```

$$\operatorname{arg\,max}_a f(a) = \operatorname*{arg\,max}_b f(b)$$

- If it is frequently used,

```
% declared in preamble
\DeclareMathOperator*{\argmax}{arg\,max} % or \DeclareMathOperator{\argmax}{arg\,max}

% then used in the document
\[ \argmax_c f(c) \]
```

Math — Power, Indices, Fraction, Root

- Powers and indices are equivalent to superscripts and subscripts in normal text mode. The caret (`^`) character is used to raise something, and the underscore (`_`) is for lowering. If more than one expression is raised or lowered, they should be grouped using curly braces (`{` and `}`).

```
k_{n+1} = n^2 + k_n^2 - k_{n-1}
n^{22}
f(n) = n^5 + 4n^2 + 2 |_{n=17}
\sum_{i=1}^{n} i
\lim_{x \to \infty} \frac{1}{x}
```

$$k_{n+1} = n^2 + k_n^2 - k_{n-1}$$
$$n^{22}$$
$$f(n) = n^5 + 4n^2 + 2|_{n=17}$$
$$\sum_{i=1}^{n} i$$
$$\lim_{x \to \infty} \frac{1}{x}$$

- Fraction and root

```
\frac{n!}{k!(n-k)!} = \binom{n}{k}
\sqrt{2}
\sqrt[n]{1+x+x^2+x^3+\dots+x^n}
```

$$\frac{n!}{k!(n-k)!} = \binom{n}{k}$$
$$\sqrt{2}$$
$$\sqrt[n]{1+x+x^2+x^3+\cdots+x^n}$$

Math — Delimiters

- Brackets, braces and delimiters

```
( a ), [ b ], \{ c \}, | d |, \| e \|,
\langle f \rangle, \lfloor g \rfloor,
\lceil h \rceil, \ulcorner i \urcorner
```

$(a), [b], \{c\}, |d|, \|e\|,$
$\langle f \rangle, \lfloor g \rfloor,$
$\lceil h \rceil, \ulcorner i \urcorner$

- Automatic sizing

```
\left(\frac{x^2}{y^3}\right)
P\left(A=2\middle|\frac{A^2}{B}>4\right)
\left\{\frac{x^2}{y^3}\right\}
```

$\left(\frac{x^2}{y^3}\right)$
$P\left(A = 2\middle|\frac{A^2}{B} > 4\right)$
$\left\{\frac{x^2}{y^3}\right\}$

- Manual sizing

```
( \big( \Big( \bigg( \Bigg(
```

$(\big(\Big(\bigg(\Bigg($

Math — Matrix

- Matrices

```
\begin{matrix}
  a & b & c \\
  d & e & f \\
  g & h & i
\end{matrix}
```

$$\begin{matrix} a & b & c \\ d & e & f \\ g & h & i \end{matrix}$$

```
\begin{pmatrix}
  a & b & c \\
  d & e & f \\
  g & h & i
\end{pmatrix}
```

$$\begin{pmatrix} a & b & c \\ d & e & f \\ g & h & i \end{pmatrix}$$

- Other matrix environment with different delimiter: `bmatrix`, `Bmatrix`, `vmatrix`, and `Vmatrix`

Math — Array

- Array

```
\begin{array}{c|c}
  1 & 2 \\
  \hline
  3 & 4
\end{array}
```

$$\begin{array}{c|c} 1 & 2 \\ \hline 3 & 4 \end{array}$$

```
f(x) = \left\{
\begin{array}{ll}
  x & \text{if } x > 0, \\
  0 & \text{otherwise}.
\end{array}\right.
```

$$f(x) = \left\{ \begin{array}{ll} x & \text{if } x > 0, \\ 0 & \text{otherwise}. \end{array} \right.$$

- Cases

```
f(x) = \begin{cases}
  x & \text{if } x > 0, \\
  0 & \text{otherwise}.
\end{cases}
```

$$f(x) = \begin{cases} x & \text{if } x > 0, \\ 0 & \text{otherwise}. \end{cases}$$

Math Fonts

`\mathnormal{...}`	$\mathnormal{ABCDEF\ abcdef\ 123456}$
`\mathrm{...}`	$\mathrm{ABCDEF\ abcdef\ 123456}$
`\mathit{...}`	$\mathit{ABCDEF\ abcdef\ 123456}$
`\mathbf{...}`	$\mathbf{ABCDEF\ abcdef\ 123456}$
`\mathsf{...}`	$\mathsf{ABCDEF\ abcdef\ 123456}$
`\mathtt{...}`	$\mathtt{ABCDEF\ abcdef\ 123456}$
`\mathfrak{...}`	$\mathfrak{ABCDEF\ abcdef\ 123456}$
`\mathcal{...}`	$\mathcal{ABCDEF}$
`\mathbb{...}`	$\mathbb{ABCDEF}$

Math Fonts

Math Spacing

LaTeX code	Description
`\qquad`	twice of `\quad` (= 36 mu)
`\quad`	space equal to the current font size (= 18 mu)
`\,`	3/18 of `\quad` (= 3 mu)
`\:`	4/18 of `\quad` (= 4 mu)
`\;`	5/18 of `\quad` (= 5 mu)
`\!`	-3/18 of `\quad` (= -3 mu)
`\ `	space after backslash, equivalent of space in normal text

Spacing in Math

Math — Dots

LaTeX code	Output	Description
`\dots`	$\dots$	generic dots. It automatically manages whitespaces according to the context, it's a higher level command.
`\ldots`	$\ldots$	the output is similar to the previous one, but there is no automatic whitespace management; it works at a lower level.
`\cdots`	$\cdots$	These dots are centered relative to the height of a letter.
`\vdots`	$\vdots$	vertical dots
`\ddots`	$\ddots$	diagonal dots
`\hdotsfor{n}`		to be used in matrices, it creates a row of dots spanning *n* columns.

Dots in Math

LaTeX code	Output	Description
`A_1,A_2,\dotsc,`	$A_1, A_2, \dots,$	for “dots with commas”
`A_1+\dotsb+A_N`	$A_1 + \dotsb + A_N$	for “dots with binary operators/relations”
`A_1 \dotsm A_N`	$A_1 \dotsm A_N$	for “multiplication dots”
`\int_a^b \dotsi`	$\int_a^b \dotsi$	for “dots with integrals”
`A_1\dotso A_N`	$A_1 \dotso A_N$	for “other dots” (none of the above)

Semantic Dots in Math

- It is recommended to use these semantically oriented commands.

Figure and Table

- To create a float block to place figure or table

```
% for figure
\begin{figure} ... \end{figure}
% for table
\begin{table} ... \end{table}
% star version put it across multiple columns
\begin{figure*} ... \end{figure*}
\begin{table*} ... \end{table*}
```

- Positioning can be denoted as an optional argument

```
\begin{figure}[placement specifier] ... \end{figure}
```

Figure and Table

Specifier	Description
h	Place the float here, i.e., approximately at the same point it occurs in the source text (however, not exactly at the spot)
t	Position at the top of the page.
b	Position at the bottom of the page.
p	Put on a special page for floats only.
!	Override internal parameters LaTeX uses for determining “good” float positions.
H	Places the float at precisely the location in the LaTeX code. Require `\usepackage{float}`.

Placement Specifier for Floats

- You can use single or multiple specifiers. LaTeX will attempt to apply the rules in descending priority. e.g. `\begin{figure}[tbhp] ... \end{figure}`.
- Use `\FloatBarrier` to prevent floats from being moved over it. (Require `\usepackage{placeins}`)

Figure

- `\usepackage{graphicx}` is commonly required to insert the figure.
- Use `\includegraphics[opt]{figure-path}` to add the figure
  `opt` can be `width=.5\linewidth`, `height=10cm`, or `scale=0.5`, etc.
- `\textwidth` means the width of current page, `\linewidth` means the width of the current column.
- Image can be in .png/.jpg/.pdf/.eps format. It is recommended to use .pdf or .eps vector formats.
- Common tools to draw the figure:
  - inkscape `https://inkscape.org`
  - tikz `texdoc tikz`, `https://github.com/xiaohanyu/awesome-tikz`
  - gnuplot `http://www.gnuplot.info`
  - matplotlib `https://matplotlib.org` or seaborn `https://seaborn.pydata.org`
  - `https://www.flaticon.com` offers many vector graph assets.

Caption

- Use `\caption{}` to add the caption, `\caption*{}` to suppress the numbering.
- Package *caption* provides the command `\captionof{<type>}{<caption text>}` that lets you typeset a caption without a floating environment.
- It also allows to custom the caption format.

```
\usepackage{caption}
\captionsetup{format=plain, font=small, labelfont=bf}
```

Figure

- An example of full figure block

```
\begin{figure}[t] % put the figure at the top of the page
  \centering
  \includegraphics[width=.8\linewidth]{path-to-the-figure-file}
  \caption{The caption of this figure}
\end{figure}
```

TikZ Figure

- You can create a tikz figure in a standalone file.

```
\documentclass[tikz]{standalone}
\usetikzlibrary{positioning}
\begin{document}
\begin{tikzpicture}
  \node[draw] (start) { Start };
  \node[draw, right=2cm of start] (end) { End };
  \draw[-latex] (start) -- (end);
\end{tikzpicture}
\end{document}
```

- The standalone file can be compiled directly or included in the document.

```
% need to pass additional `-shell-escape` argument to the compiler
\usepackage[mode=buildnew]{standalone}

\begin{figure}[t]
  \centering
  \includestandalone[width=0.8\linewidth]{./figure} % without the `.tex` extension
  \caption{TikZ Figure in Article}
\end{figure}
```

Formatting Tables

- The *tabular* environment defines the table
- Use package *booktabs* to create professional table

```
\centering\small
\begin{tabular}{llr}
  \toprule
  \multicolumn{2}{c}{Item} &            \\
  \cmidrule(r){1-2}
  Animal    & Description & Price (\$) \\
  \midrule
  Gnat      & per gram    & 13.65      \\
            & each        & 0.01       \\
  Gnu       & stuffed     & 92.50      \\
  Emu       & stuffed     & 33.33      \\
  Armadillo & frozen      & 8.99       \\
  \bottomrule
\end{tabular}
```

Item		
Animal	Description	Price ($)
Gnat	per gram	13.65
	each	0.01
Gnu	stuffed	92.50
Emu	stuffed	33.33
Armadillo	frozen	8.99

- More guidance: `https://en.wikibooks.org/wiki/LaTeX/Tables`
- *excel2latex* can be used to generate LaTeX code from excel table

Subfloats

- Use package *subcaption* to create subfigures or subtables

```
\begin{figure}
  \centering
  \begin{subfigure}[b]{0.5\textwidth}
    \includegraphics[width=\textwidth]{gull}
    \caption{A gull}
  \end{subfigure}
  ~%add desired spacing between images, e.g. ~, \quad, \hfill, \\ etc.
  \begin{subfigure}[b]{0.5\textwidth}
    \includegraphics[width=\textwidth]{tiger}
    \caption{A tiger}
  \end{subfigure}
  \caption{Pictures of animals}
\end{figure}
```

References

- You can use `\label{<label name>}` to make a label

```
\section{Section Title}\label{sec:label-a}
\begin{figure}
  ...
  \caption{figure caption}\label{fig:label-b}
\end{figure}
\begin{equation}
  E=mc^2 \label{eqn:lable-c}
\end{equation}
```

- Use `\ref{<label name>}` to reference them
- Use package *hyperref* to generate pdf hyperlink and create url
  e.g. `\url{https://google.com}`
- Use package *cleveref* for auto infer reference types
  e.g. `\cref{fig:label}` is equivalence to `Fig.~\ref{fig:label}`
- Use `\footnote{...}` to insert footnote

Theorems

- There are many packages to offer theorem environments.
- Here, we use `\usepackage{amsthm,thmtools}`
- Declare the theorem environments (document `texdoc thmtools`)

```
\declaretheorem[style=plain]{axiom}
\declaretheorem[style=definition]{definition}
\declaretheorem[style=definition]{example}
\declaretheorem[style=plain]{lemma}
\declaretheorem[style=plain]{theorem}
\declaretheorem[style=remark]{remark}
```

- Use it in the document

```
\begin{theorem}[Euclid]
  For every prime $p$, there is a prime $p'>p$.
  In particular, there are infinitely many primes.
\end{theorem}
```

- `\usepackage{thm-restate}` to repeat the same theorem multiple times

Algorithms

- There are two common packages to typeset algorithm:
  - *algorithm2e*
  - *algorithmicx*
- Example using algorithm2e:

```
\begin{algorithm}[H]
  \caption{How to write algorithms}
  \KwData{this text}
  \KwResult{learn to write algorithm}
  initialization\;
  \While{not at end of this document}{
    read current\;
    \eIf{understand}{
      go to next section\;
      current section becomes this one\;
    }{
      go back to the beginning\;
    }
  }
\end{algorithm}
```

Algorithm 1: How to write algorithms

Data: this text
Result: learn to write algorithm
initialization;
while *not at end of this document* **do**
    read current;
    if *understand* **then**
        go to next section;
        current section becomes this one;
    else
        go back to the beginning;

Source Code Highlight

- Using package *listings* to highlight the source code.

```
\begin{lstlisting}[language=Python]
def fib():
  a, b = 0, 1
  while 1:
    yield a
    a, b = b, a + b
\end{lstlisting}
```

```
def fib():
  a, b = 0, 1
  while 1:
    yield a
    a, b = b, a + b
```

- Alternatively, use `\lstinputlisting[opt]{file path}` to read code from another file.
- Package *minted* offers more features and better highlights. But it requires:
  - Install Pygments `http://pygments.org`
  - Pass additional argument `-shell-escape` to the compiler

Bibliography

- `.bib` file acts as a database of references, and only includes in the bibliography those references you cite in your paper

```bibtex
@article{nameofentry,
  author  = {John Doe and Jane Doe},
  title   = {The title of the work},
  journal = {The name of the journal},
  year    = 1993,
  pages   = {201--213},
  month   = 7,
  volume  = 4
}
```

```bibtex
@inproceedings{nameofentry,
  author    = {Doe, John and Doe, Jane},
  title     = {The title of the work},
  booktitle = {The name of the proceedings},
  year      = 2019,
  pages     = {100--110},
  month     = 1,
  address   = {Conference location},
}
```

- More examples can be found in
  - `http://web.mit.edu/rsi/www/pdfs/bibtex-format.pdf`
  - `https://www.verbosus.com/bibtex-style-examples.html`

Bibliography

- Use `\cite{nameofentry}` to cite the referenced paper in the main text
- There are two solutions to typeset bibliography
  - BibTeX: old and widely support

```
cite some paper~\cite{paperentry}.
\bibliographystyle{IEEEtrans}
\bibliography{path to bib file}
```

  - BibLaTeX: new and have more features, document: `texdoc biblatex`

```
\usepackage[style=ieee,giveninits=true,doi=false]{biblatex}
\addbibresource{path to bib file}
\begin{document}
cite some paper~\cite{paperentry}.
\printbibliography
\end{document}
```

Advanced Usages

More Packages

- **Color**: *color*, *xcolor*

```
\usepackage{color}
\usepackage[table,dvipsnames]{xcolor}
```

- **Draw Boxes**: *tcolorbox*
- **Draw Graphics**: *tikz*, *overpic*
- **Slides**: *beamer*
- **Poster**: *tikzposter*
- **Miscellaneous**: *microtype*, *footmisc*, *balance*

Define Commands and Environment

- Define command using: `\newcommand{\name}[num]{definition}`

```
\newcommand{\highlight}[1]{%
  {\color{red} #1}%
}
\highlight{Text in red}
```

Text in red

- Define environment using: `\newenvironment{name}[num]{before}{after}`

```
\newenvironment{response}{%
  \begingroup
  \textbf{Response}: \itshape
}{%
  \endgroup
}
\begin{response}
  Some response.
\end{response}
```

Response: *Some response.*

- More information: `https://en.wikibooks.org/wiki/LaTeX/Macros`

LaTeX Engines

- There are several LaTeX engines
  - pdflatex: most commonly used
  - xelatex and lualatex: new, offer more features
    - better font support, typeset other language than English, etc
- To compile LaTeX manually, you usually need run multiple commands

```
pdflatex root_file
bibtex root_file # or `biber root_file` if using biblatex
pdflatex root_file
pdflatex root_file
```

- Or use `latexmk` to automatically run commands for you

```
latexmk -pdf root_file # use pdflatex
latexmk -xelatex root_file # use xelatex
latexmk -lualatex root_file # use lualatex
```

- Some LaTeX editors (such as VSCode with LaTeX Workshop, Vim with vimtex) use `latexmk` under the hook

Other Command Line Tools

- latexmk
  - In addition to build project, it can also be used to clean up auxiliary files

    ```
    latexmk -c
    ```

  - It is highly customizable. You can create `.latexmkrc` file to configure `latexmk`. document: `texdoc latexmk`

    ```
    # use pdflatex by default, so you don't need to pass `-pdf` argument
    $pdf_mode = 1;
    # -synctex=1 allow easy jumps between latex source and pdf file
    # -file-line-error make latex report file and line number when there is an error
    $pdflatex = 'pdflatex -synctex=1 -file-line-error %O %S';
    ```

- **chktex**: Lint the LaTeX source code for common problem. document: `texdoc chktex`
- **latexindent**: Format the LaTeX source code. document: `texdoc latexindent`
- **latexdiff**: Marking up difference between LaTeX files. document: `texdoc latexdiff`

Further Readings

- LaTeX Wikibooks: `https://en.wikibooks.org/wiki/LaTeX`
- The Not So Short Introduction to LaTeX 2_ε: `texdoc lshort`
- Short Math Guide for LaTeX: `texdoc short-math-guide`
- The TeX FAQ List: `https://texfaq.org`
- LaTeX Stack Exchange: `https://tex.stackexchange.com`
- Always remember to use Google when you encounter problems

Thanks
Questions?