LaTeX Tutorial

Glenn Feng

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Figures

Images in LaTeX documents should be placed in floating environments such as `figure`. Below are examples of one- through four-image figures in the same `figure` environment. Note that packages `graphicx`, `caption`, and `subcaption` should be loaded.

One-image figure

```
\begin{figure}[htbp]
    \centering
    \includegraphics[width=0.5\textwidth]{example-image}
    \caption{An one-image figure.}
    \label{fig:1-image}
\end{figure}
```

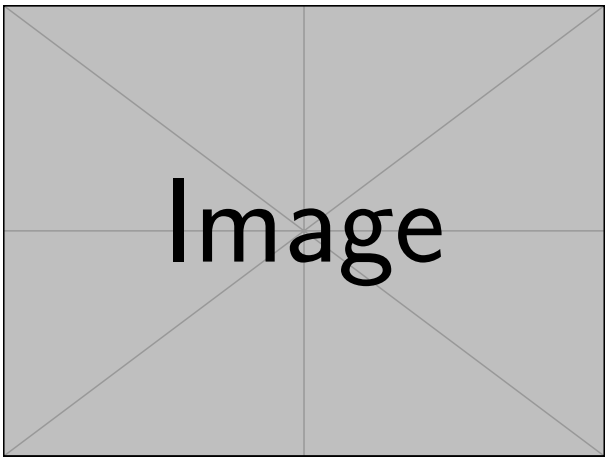
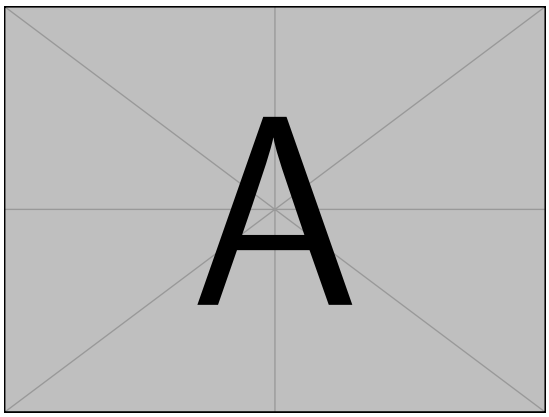


Figure 1: An one-image figure.

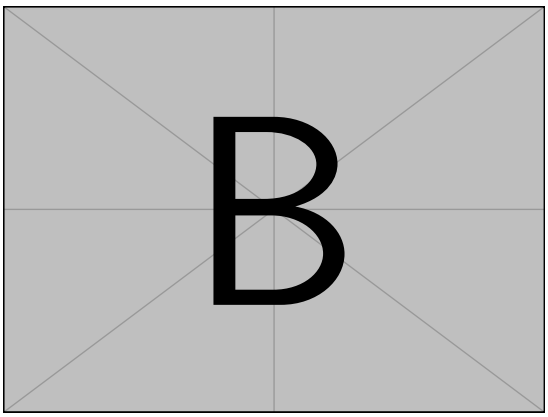
Two-image figure

```
\begin{figure}[htbp]
    \centering
    \begin{subfigure}[b]{0.45\textwidth}
        \centering
        \includegraphics[width=\textwidth]{example-image-a}
        \caption{Image A.}
```

```
        \label{fig:2-image-a}
    \end{subfigure}
    \hfill
    \begin{subfigure}[b]{0.45\textwidth}
        \centering
        \includegraphics[width=\textwidth]{example-image-b}
        \caption{Image B.}
        \label{fig:2-image-b}
    \end{subfigure}
\caption{A two-image figure}
\label{fig:2-image}
\end{figure}
```



(a) Image A.



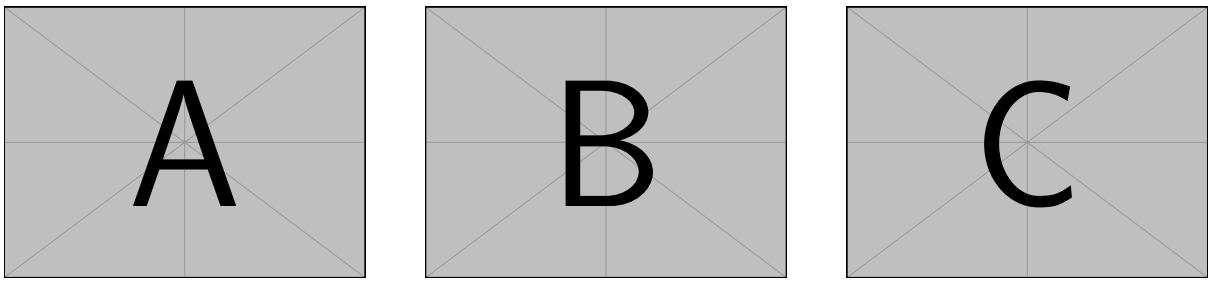
(b) Image B.

Figure 2: A two-image figure

Three-image figure

```
\begin{figure}[htbp]
    \centering
    \begin{subfigure}[b]{0.3\textwidth}
        \centering
        \includegraphics[width=\textwidth]{example-image-a}
        \caption{Image A.}
        \label{fig:3-image-a}
    \end{subfigure}
    \hfill
    \begin{subfigure}[b]{0.3\textwidth}
        \centering
        \includegraphics[width=\textwidth]{example-image-b}
        \caption{Image B.}
        \label{fig:3-image-b}
    \end{subfigure}
    \hfill
    \begin{subfigure}[b]{0.3\textwidth}
        \centering
```

```
        \includegraphics[width=\textwidth]{example-image-c}
        \caption{Image C.}
        \label{fig:3-image-c}
    \end{subfigure}
    \caption{A three-image figure.}
    \label{fig:3-image}
\end{figure}
```



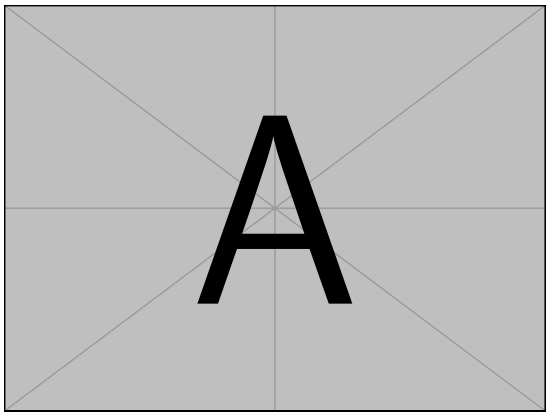
(a) Image A. **(b)** Image B. **(c)** Image C.

Figure 3: A three-image figure.

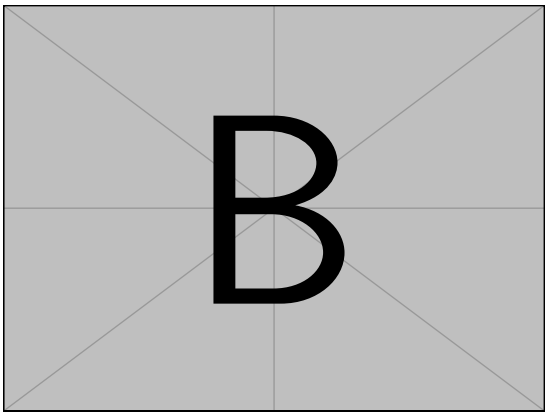
Four-image figure

```
\begin{figure}[H]
    \centering
    \begin{subfigure}[b]{0.45\textwidth}
        \centering
        \includegraphics[width=\textwidth]{example-image-a}
        \caption{Image A.}
        \label{fig:4-image-a}
    \end{subfigure}
    \hfill
    \begin{subfigure}[b]{0.45\textwidth}
        \centering
        \includegraphics[width=\textwidth]{example-image-b}
        \caption{Image B.}
        \label{fig:4-image-b}
    \end{subfigure}
    \hfill
    \begin{subfigure}[b]{0.45\textwidth}
        \centering
        \includegraphics[width=\textwidth]{example-image-c}
        \caption{Image C.}
        \label{fig:4-image-c}
    \end{subfigure}
    \hfill
    \begin{subfigure}[b]{0.45\textwidth}
        \centering
        \includegraphics[width=\textwidth]{example-image-plain}
```

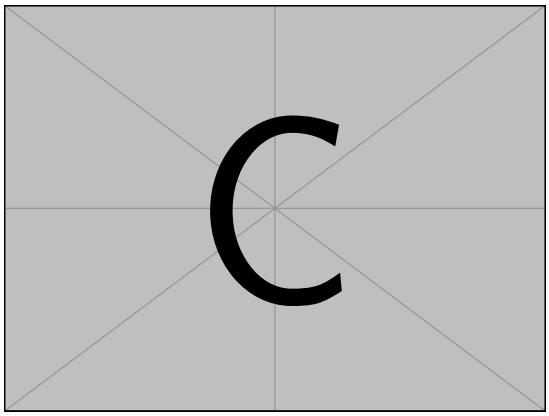
```
        \caption{Image D.}
        \label{fig:4-image-d}
    \end{subfigure}
    \caption{A four-image figure.}
    \label{fig:4-image}
\end{figure}
```



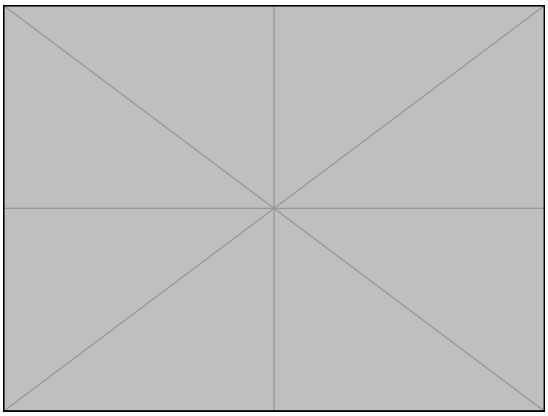
(a) Image A.



(b) Image B.



(c) Image C.



(d) Image D.

Figure 4: A four-image figure.

Tables

Tables live in a `table` float and can be simple or composed of subtables.

Basic table

```
\begin{table}[htbp]
\centering
\begin{tabular}{l | l | l}
\hline
A & B & C \\
\hline
1 & 2 & 3 \\
4 & 5 & 6 \\
```

```
\hline
\end{tabular}
\caption{A very basic table}
\label{tab:basic}
\end{table}
```

produces

A	B	C
1	2	3
4	5	6

Table 1: A very basic table

Subtables

```
\begin{table}[htbp]
    \begin{subtable}[h]{0.45\textwidth}
        \centering
        \begin{tabular}{l | l | l}
        Day & Max Temp & Min Temp \\
        \hline \hline
        Mon & 20 & 13\\
        Tue & 22 & 14\\
        Wed & 23 & 12\\
        Thurs & 25 & 13\\
        Fri & 18 & 7\\
        Sat & 15 & 13\\
        Sun & 20 & 13
       \end{tabular}
       \caption{First Week}
       \label{tab:week1}
    \end{subtable}
    \hfill
    \begin{subtable}[h]{0.45\textwidth}
        \centering
        \begin{tabular}{l | l | l}
        Day & Max Temp & Min Temp \\
        \hline \hline
        Mon & 17 & 11\\
        Tue & 16 & 10\\
        Wed & 14 & 8\\
        Thurs & 12 & 5\\
        Fri & 15 & 7\\
        Sat & 16 & 12\\
        Sun & 15 & 9
        \end{tabular}
        \caption{Second Week}
```

```
        \label{tab:week2}
    \end{subtable}
    \caption{Max and min temps recorded in the first two weeks of July}
    \label{tab:temps}
\end{table}
```

produces

Day	Max Temp	Min Temp
Mon	20	13
Tue	22	14
Wed	23	12
Thurs	25	13
Fri	18	7
Sat	15	13
Sun	20	13

(a) First Week

Day	Max Temp	Min Temp
Mon	17	11
Tue	16	10
Wed	14	8
Thurs	12	5
Fri	15	7
Sat	16	12
Sun	15	9

(b) Second Week

Table 2: Max and min temps recorded in the first two weeks of July

Multi-row/column table

We may stack multiple rows (with `multirow`) or columns together. This can also be used to change the alignment of a specific cell. For example:

```
\begin{tabular}{|l|l|l|l|}\hline
  \multirow{10}{*}{numeric literals} & \multirow{5}{*}{integers} & in decimal & \verb|8743| \\ \clin
  & & \multirow{2}{*}{in octal} & \verb|0o7464| \\ \cline{4-4}
  & & & \verb|0O103| \\ \cline{3-4}
  & & \multirow{2}{*}{in hexadecimal} & \verb|0x5A0FF| \\ \cline{4-4}
  & & & \verb|0xE0F2| \\ \cline{2-4}
  & \multirow{5}{*}{fractionals} & \multirow{5}{*}{in decimal} & \verb|140.58| \\ \cline{4-4}
  & & & \verb|8.04e7| \\ \cline{4-4}
  & & & \verb|0.347E+12| \\ \cline{4-4}
  & & & \verb|5.47E-12| \\ \cline{4-4}
  & & & \verb|47e22| \\ \cline{1-4}
  \multicolumn{3}{|l|}{\multirow{3}{*}{char literals}} & \verb|'H'| \\ \cline{4-4}
  \multicolumn{3}{|l|}{} & \verb|'\n'| \\ \cline{4-4}          %% here
  \multicolumn{3}{|l|}{} & \verb|'\x65'| \\ \cline{1-4}        %% here
  \multicolumn{3}{|l|}{\multirow{2}{*}{string literals}} & \verb|"bom dia"| \\ \cline{4-4}
  \multicolumn{3}{|l|}{} & \verb|"ouro preto\nmg"| \\ \cline{1-4}          %% here
\end{tabular}
```

produces

numeric literals	integers	in decimal	8743
		in octal	0o7464
			0O103
		in hexadecimal	0x5A0FF
			0xE0F2
	fractionals	in decimal	140.58
			8.04e7
			0.347E+12
			5.47E-12
			47e22
char literals			'H'
			'\n'
			'\x65'
string literals			"bom dia"
			"ouro preto\nmg"

Note that, by default, the vertical boarders in a `\multicolumn{}{}{}` is ignored, so must be specified if wanted.

Wrapping text in a column

Specify a fixed-width column (`p{...}`) to get automatic line-breaks:

```
\begin{tabular}{ | p{0.7\linewidth} | l | }
\hline
\lipsum[1] & Column 2 \\
\hline
\end{tabular}
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.	Column 2

Long tables

For tables spanning pages, use `longtable` with customizable headers/footers:

```
\begin{longtable}{|c|c|c|}
\hline
% Common header for all pages
\textbf{Column 1} & \textbf{Column 2} & \textbf{Column 3} \\
```

```
\hline
\endfirsthead
% Continued header for subsequent pages
\hline
\textbf{Column 1} & \textbf{Column 2} & \textbf{Column 3} \\
\hline
\endhead
% Footer for intermediate pages
\hline
\multicolumn{3}{r}{\textit{Continued on next page...}} \\
\endfoot
% Footer for last page
\hline
\multicolumn{3}{c}{\textit{End of table}} \\
\endlastfoot
% Table content
1 & A & Alpha \\
2 & B & Beta \\
...
\end{longtable}
```

`p||` columns are also available within the environment.

Equations

Load `amsfonts,amsmath,amssymb` for all documents with math. For (un)numbered equation blocks, use the `align` environment without math mode. For example:

```
\begin{align*}
x&=y          &  w &=z              &  a&=b+c\\
2x&=-y        &  3w&=\frac{1}{2}z   &  a&=b\\
-4 + 5x&=2+y  &  w+2&=-1+w          &  ab&=cb
\end{align*}
```

would produce

$$\begin{aligned} x &= y & w &= z & a &= b + c \\ 2x &= -y & 3w &= \frac{1}{2}z & a &= b \\ -4 + 5x &= 2 + y & w + 2 &= -1 + w & ab &= cb \end{aligned}$$

Similarly, long equations could also be broken in this way:

```
\begin{align*}
F ={} & \{F_{x} \in  F_{c} : (|S| > |C|) \\
      & \cap (\mathrm{minPixels}  < |S| < \mathrm{maxPixels}) \\
      & \cap (|S_{\mathrm{conected}}| > |S| - \epsilon)\}
\end{align*}
```

produces

$$
\begin{aligned}
F = \{F_x \in F_c : (|S| > |C|) \\
\cap (\text{minPixels} < |S| < \text{maxPixels}) \\
\cap (|S_{\text{conected}}| > |S| - \epsilon)\}
\end{aligned}
$$

.

Note that any operators of the RHS should align with the right of the (in)equality sign. Also, do not put `\\` in blocks unless a new line is needed, otherwise extra space would be created:

```
\begin{align*}
F ={} & \{F_{x} \in  F_{c} : (|S| > |C|) \\
      & \cap (\mathrm{minPixels}  < |S| < \mathrm{maxPixels}) \\
      & \cap (|S_{\mathrm{conected}}| > |S| - \epsilon)\} \\
\end{align*}
```

produces

$$
\begin{aligned}
F = \{F_x \in F_c : (|S| > |C|) \\
\cap (\text{minPixels} < |S| < \text{maxPixels}) \\
\cap (|S_{\text{conected}}| > |S| - \epsilon)\}
\end{aligned}
$$

.

Sometimes you may want to name a equation instead of numbering it, use `\tag{}` is this case:

```
\begin{equation}
Y= \alpha + \beta X^\top + \varepsilon \tag{Baseline} \label{eq:baseline}
\end{equation}
```

produces

$$Y = \alpha + \beta X^\top + \varepsilon. \tag{Baseline}$$

Note your math should end with punctuation if you want to embed it in a sentence.

Theorems and definitions

Use `amsthm` for theorems, definitions, remarks, etc. Define environments in the preamble:

```
\newtheorem{theorem}{Theorem}
\theoremstyle{remark}
\newtheorem*{remark}{Remark}
\theoremstyle{definition}
\newtheorem{definition}{Definition}
```

There are three styles of blocks available, `plain`, `definition`, and `remark`. To number according to sections, chapters or theorem (for corollaries), add `[anchor]` at the end of the definition in the preamble. For example, adding `\newtheorem{corollary}{Corollary}[theorem]` produces Corollary 1.1.

For a box wrapping the block, use `mdframed`. Wrap the block by `\begin{mdframed} ... \end{mdframed}` for a local change. To wrap all the blocks, put the following in the preamble:

```
\usepackage{mdframed}
\surroundwithmdframed{theorem}
\surroundwithmdframed{remark}
\surroundwithmdframed{definition}
```

Then the following code

```
\begin{theorem}[Differentiability Implies Countintuity] \label{thm:diff}
Let \(f\) be a function whose derivative exists in every point, then \(f\) is a continuous function.
\end{theorem}

\begin{corollary}
\(f\left(x,y\right)=x+y\) is continuous and differentiable everywhere.
\end{corollary}

\begin{proof}[Proof of \autoref{thm:diff}]
To prove that \( f \) is continuous at any arbitrary point \( a \) in its domain, we need to show tha
\[
\lim_{x \to a} f(x) = f(a).
\]

...
\end{proof}

\begin{theorem}
\mintinline{latex}{plain} has boldface title, italicized body. Commonly used in theorems, lemmas, co
\end{theorem}

\begin{definition}
\mintinline{latex}{definition} has boldface title, Roman body. Commonly used in definitions, conditi
\end{definition}

\begin{remark}
\mintinline{latex}{remark} has italicized title, Roman body. Commonly used in remarks, notes, annota
\end{remark}

\begin{mdframed}
\begin{theorem}[Pythagorean theorem]
\label{pythagorean}
This is a theorem about right triangles and can be summarised in the next
equation
\[ x^2 + y^2 = z^2. \]
\end{theorem}
\end{mdframed}
```

would produce

Theorem 1 (Differentiability Implies Countintuity)**.** *Let f be a function whose derivative exists in every point, then f is a continuous function.*

Corollary 1.1. *$f(x, y) = x + y$ is continuous and differentiable everywhere.*

Proof of Theorem 1. To prove that f is continuous at any arbitrary point a in its domain, we need to show that:

$$\lim_{x \to a} f(x) = f(a).$$

... □

Theorem 2. *`plain` has boldface title, italicized body. Commonly used in theorems, lemmas, corollaries, propositions and conjectures.*

Definition 1. `definition` has boldface title, Roman body. Commonly used in definitions, conditions, problems and examples.

Remark. `remark` has italicized title, Roman body. Commonly used in remarks, notes, annotations, claims, cases, acknowledgments and conclusions.

Theorem 3 (Pythagorean theorem)**.** *This is a theorem about right triangles and can be summarised in the next equation*

$$x^2 + y^2 = z^2.$$

Code

- **Inline code**: use backticks: `\verb|...|` (no highlight) or `\mintinline{python}{...}` (syntax-highlighted)
- **Display code without highlight**: use `\begin{verbatim} ... \end{verbatim}`

```
from sklearn.neural_network import MLPClassifier
```

- **Syntax-highlighted display code**: use `\begin{minted}{langeage} ... \end{minted}`

```python
from sklearn.neural_network import MLPClassifier
```

To caption a `minted` block, wrap them in a `listing` float just like figures/tables. Note that inline code snippets are non-breakable: `X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, rand`

Algorithms

Use `algorithm` + `algorithmic` packages:

```
\begin{algorithm}[htbp]
\caption{Gibbs Sampler}
\label{alg:gibbs}
\begin{algorithmic}[1]
\STATE Initialize $X_1, X_2, \ldots, X_n$ with some starting values
\FOR{$t = 1$ to $T$ (number of iterations)}
    \FOR{$i = 1$ to $n$ (number of variables)}
        \STATE Sample $X_i^{(t)}$ from the conditional distribution
        $P(X_i \mid X_1^{(t)}, \ldots, X_{i-1}^{(t)}, X_{i+1}^{(t-1)}, \ldots, X_n^{(t-1)})$
    \ENDFOR
\ENDFOR
\STATE Return the sequence $\{X_1^{(t)}, X_2^{(t)}, \ldots, X_n^{(t)}\}$ for $t = 1, \ldots, T$
\end{algorithmic}
\end{algorithm}
```

would render

Algorithm 1 Gibbs Sampler

Initialize $X_1, X_2, \ldots, X_n$ with some starting values
for $t = 1$ to T (number of iterations) **do**
  for $i = 1$ to n (number of variables) **do**
    Sample $X_i^{(t)}$ from the conditional distribution $P(X_i \mid X_1^{(t)}, \ldots, X_{i-1}^{(t)}, X_{i+1}^{(t-1)}, \ldots, X_n^{(t-1)})$
  end for
end for
Return the sequence $\{X_1^{(t)}, X_2^{(t)}, \ldots, X_n^{(t)}\}$ for $t = 1, \ldots, T$

Layout

Quotation marks: Use ``` `` ``` and ```` '' ````.

Margins: To adjust margins and paper size, use the following code in the preamble:

```
\usepackage{geometry}
\geometry{a4paper, margin=1in}
```

Fonts: It is recommended to use pdfTEX. Use `newtxtext`/`newtxmath` for Times,`newpxtext`/`newpxmath` for Palatino. To use Erewhon, put the following

```
\usepackage[space]{erewhon}
\usepackage[type1,scaled=.95]{cabin}
\usepackage[utopia,vvarbb]{newtxmath}
```

To use Garamond, paste the following

```
\usepackage[cmintegrals,cmbraces]{newtxmath}
\usepackage{ebgaramond-maths}
```

Font size: For document-level use `\documentclass[xpt]{article}`. For local adjustments, use `{\size text}`. See the following table for reference:

Command	Effect
`{\tiny Text}`	Text
`{\scriptsize Text}`	Text
`{\footnotesize Text}`	Text
`{\small Text}`	Text
`{\normalsize Text}`	Text
`{\large Text}`	Text
`{\Large Text}`	Text
`{\LARGE Text}`	Text
`{\huge Text}`	Text
`{\Huge Text}`	Text

Hyperlinks: To use hyperlinks, use `hyperref` for general links and `url` for URLs. To customize colors, do something like:

```
\usepackage[dvipsnames]{xcolor}
\usepackage{hyperref}
\definecolor{DarkNavy}{rgb}{0.0, 0.0, 0.5}
\definecolor{DeepMaroon}{rgb}{0.5, 0.0, 0.0}
\hypersetup{
  colorlinks   = true,
  linkcolor    = DarkNavy,     % for \ref and internal links
  citecolor    = DeepMaroon,   % for \cite
  urlcolor     = DarkNavy,     % for external URLs
  filecolor    = OliveGreen    % for local file links
}
```

Use the `\autoref{}` command from `hyperref` instead of `\ref{}`. For example, referring back to the images in Figures, `\autoref{fig:1-image} and \autoref{fig:2-image-a}` would produce "Figure 1 and Figure 2a". Use meaningful labels with prefix (for example, the label for Algorithm 1 is `\label{alg:gibbs}`) so that it would be easy to recall them. However, for some floats, such as algorithm boxes, the name for references might not be predefined. In these cases, use the command `\newcommand{\algorithmautorefname}{Algorithm}` to define them. If it is already defined but needs to be changed (say, capitalizing), use `\renewcommand{\algorithmautorefname}{Algorithm}`. To refer directly to the name of the section or the caption of the float, use, for example, `\nameref{sec:figure}` and `\nameref{alg:gibbs}` for "Figures and Gibbs Sampler". This works for math similarly, `\autoref{eq:baseline}` produces Equation Baseline. It also works for theorems.

Line spacing: Use `setspace` to set line spacing for texts, for example, `\onehalfspacing` for 1.5 (space) spacing. Note that this does not change spaces in other environments, such as captions. However, note that this means that the original space between lines are multiplied by 1.5. This is different from Microsoft Word or Apple Pages, which set the space between lines as 1.5 times the vertical space of texts.

Paragraph spacing: To disable indentations and use spacing to distinguish paragraphs, simply load `parskip`.

Indentations: Disable locally with `\noindent`, or load `indentfirst` to indent first paragraphs.

Forced spaces: In some cases, spaces are ignored after a command, use `~` to force it. For example, `\LaTeX~document`.

Block spaces: Use `\vspace{length}` but it automatically halts at the end of a page, use `\vspace*{length}` to force it.

Accented letters: To use accented letters directly (copying and pasting), load

```
\usepackage[utf8]{inputenc} % usually not needed (loaded by default)
\usepackage[T1]{fontenc}
```

Landscape pages: Use `\usepackage{pdflscape}` in the preamble and then

```
\clearpage
\begin{landscape}
    ...
\end{landscape}
```

when the part of the landscape page starts.

TikZ

Using TikZ for illustration makes the content clear and consistent. Use PowerPoint/Keynotes/Google Slides to make your life easier.

```
\begin{figure}[htbp]
    \centering
    \begin{tikzpicture}[
        tree/.style={rectangle, draw, fill=blue!10, text width=2cm, text centered, rounded corners},
        bootstrap/.style={ellipse, draw, fill=green!10, minimum height=1cm, text centered},
        box/.style={rectangle, draw, minimum width=1.5cm, minimum height=1.2cm, fill=red!10},
        arrow/.style={thick,->,>=stealth}
    ]

    % Original Dataset
    \node[box] (data) {Original Dataset};

    % Bootstrap Samples
    \node[bootstrap, below left=1.5cm and 2cm of data] (sample1) {Bootstrap Sample 1};
    \node[bootstrap, below=1.5cm of data] (sample2) {Bootstrap Sample 2};
    \node[bootstrap, below right=1.5cm and 2cm of data] (sample3) {Bootstrap Sample 3};

    % Decision Trees
    \node[tree, below=2cm of sample1] (tree1) {Tree 1};
    \node[tree, below=2cm of sample2] (tree2) {Tree 2};
    \node[tree, below=2cm of sample3] (tree3) {Tree 3};

    % Aggregation
    \node[box, below=1cm of tree2] (aggregate) {Aggregate Prediction};

    % Connections
    \draw[arrow] (data) -- (sample1);
    \draw[arrow] (data) -- (sample2);
    \draw[arrow] (data) -- (sample3);

    \draw[arrow] (sample1) -- (tree1);
    \draw[arrow] (sample2) -- (tree2);
    \draw[arrow] (sample3) -- (tree3);
```

```
    \draw[arrow] (tree1) -- (aggregate);
    \draw[arrow] (tree2) -- (aggregate);
    \draw[arrow] (tree3) -- (aggregate);

    \end{tikzpicture}
    \caption{Illustration of Bagged Decision Trees. Multiple bootstrap samples are drawn from the ori
    \label{fig:bagged_decision_trees}
\end{figure}
```

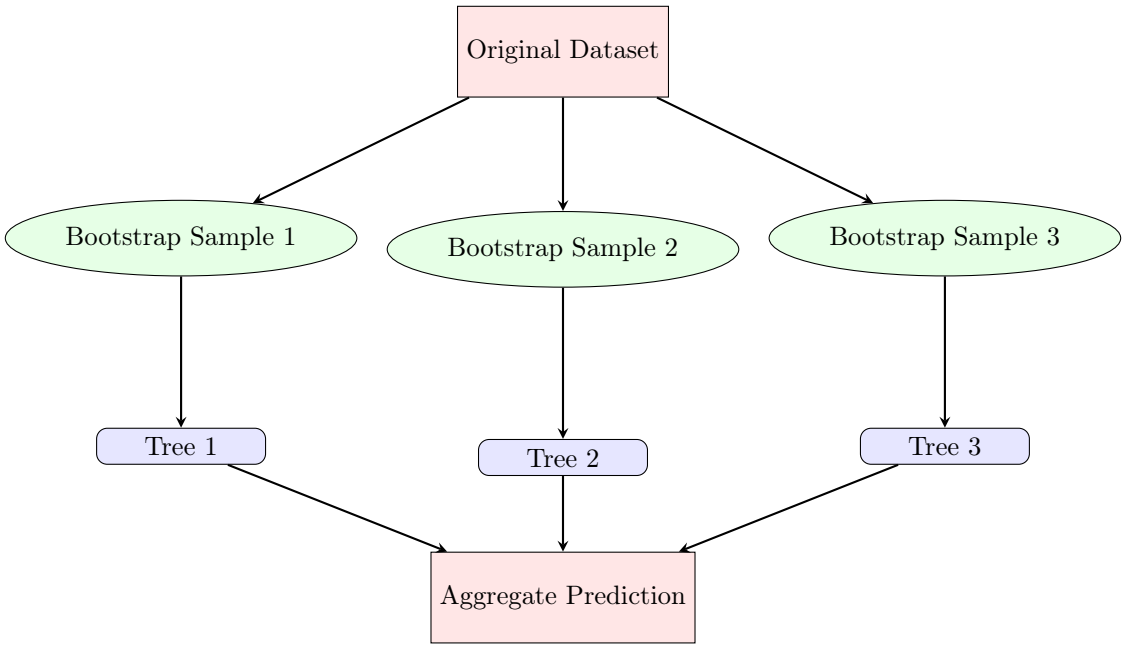


Figure 5: Illustration of Bagged Decision Trees. Multiple bootstrap samples are drawn from the original dataset, and individual decision trees are trained on each sample. The final prediction is obtained by aggregating the outputs of all trees.