Dalhousie LaTeX Workshop

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What is LaTeX and why should I care about it?

History Donald Knuth needed a typesetting system for writing the second edition of the Art of Computer Programming (1977) and developed TeX. For example, we can typeset summation $\frac{1}{N}\sum_{i=0}^{N} x_i$ with:

```
\frac{1}{N} \sum_{i=0}^N x_i
```

Leslie Lamport developed a standardized version called LaTeX to incorporate TeX with various document styles.

Why should I care?

1. Care about content, not formatting
2. Math
3. Creating scientific artifacts (papers, posters, diagrams)
4. Thinking like a scientist

Workshop Overview

Goal: Feel comfortable with most common LaTeX use cases.

Format: Presentation / Challenges / Competition - Interactive!

Overview

1. Basics of Typesetting	**Challenge:** Create Document.
2. Mathematics	**Challenge:** Recreate a formula.
3. Tables	**Challenge:** Create Table.
4. Diagrams	**Challenge:** Create Diagram.
5. Algorithms	**Challenge:** Create Algorithm.
6. Advanced LaTex (Macros)	**Challenge:** Create Macro.
7. LaTex Ecosystem: Presentations, Posters, Thesis, Templates, Bibliographies, Other Packages.	

Competition We will provide a document with all of the elements above and your challenge will be to recreate the document in LaTeX.

Basics of Typesetting: The Environment

Interactive

Go to https://overleaf.com/
(1) create an account (if need be)
(2) create a new project (blank document)

```
\documentclass{article}
\usepackage{graphicx} % Required for inserting images
\title{Workshop}
\author{Domenic Rosati}
\date{November 2024}
\begin{document}
\maketitle
\section{Introduction}
\end{document}
```

Basics of Typesetting: The Document

`\documentclass{article}` creates the class of document that gives a whole host of styling and commands specific to that document.

Many commands use the following syntax: `\documentclass[12pt]{article}` where the brackets are some function argument like set font to 12pt.

Document classes all have different *document structures*.
Here is a basic document structure hierarchy you will use a lot:

```
\section{section header}
.. some text
\subsection{another header}]
\subsubsection{another}
\paragraph{This para starts like this}
\subparagraph{Subpara start}
```

Basics of Typesetting: The Document

Referencing text: LaTeX provides a nice way for cross-referencing text, figures, equations, and bibliographic references.

You tag most things with `\label{yourlabel}` and reference them with `\ref{yourlabel}`

For example this slide is labeled as Slide 6. In TeXthis looks like:

```
Slide~\ref{slideref} % tilde means stay on same line
```

Basics of Typesetting: Structure

Another common element used to structure text is the `\begin{itemize/enumerate}` which defines a new text environment.

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

- Unordered Item 1
- Unordered Item 2

Basics of Typesetting: Layouting

Some useful layout tips LaTeX or the style you are using doesn't always get things right a few commands that are helpful are:

```
\\ or \newline % adds a new line
\pagebreak or \newpage
\hfill or \vfill % fills the space
\vspace{1em} \hspace{1em} % adds space
\vspace{-1em} \hspace{-1em} % removes space
\quad % adds 4 spaces
\& % \ escapes &
\noindent % makes sure there is no indent.
```

Basics of Typesetting: Type!

Styling Bold: `\textbf{...}`
Italics: `\textit{...}`
Underline: `\underline{...}`
Emphasis: `\emph{...}`

Font sizes & styles:
Tiny `{\tiny this text is small}`
`Monospace` Code `{\texttt{Llama2-7B}}`
Small Caps `\textsc{Small Caps}`
color `\textcolor{red}{color}` (Requires `\usepackage{xcolor}`)

Basics of Typesetting: Figures

If we add the package `\usepackage{graphicx}`, then we can include pictures with `\includegraphics{resnet_loss}`. We often want to add a figure environment:

```
\begin{figure}[h] % place the figure h/t/b
\centering % center the figure
\includegraphics[width=0.75\textwidth]{resnet_loss}
\caption{A nice plot.}
\label{fig:resnet_loss}
\end{figure}
```

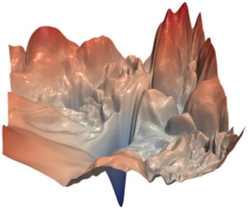


Figure: The loss landscape of a Resnet54 [1]

Document Recreation Minichallenge

Recreate the following PDF using what we learned so far.
Note: `\TeX{}` and `\LaTeX{}` are the verbs for the outputs TeX and LaTeX.
QR Code:
Github Link:
`challenges/challenge_1_document`

Typesetting Formulas

Inline Formulas `\( ... \)` or `$ ... $` and block math environments `\[ ... \]` or `$$ ... $$`.

super and subscript	x^{i}_{j}	`$x^{i}_{j}$`
greek	$\{\epsilon,\pi,\delta\}$	`$\{ \epsilon,\pi,\delta \}$`
fractions	$\frac{1}{2}$	`$\frac{1}{2}$`
summation	$\sum_{i=0}^N x_i$	`$\sum_{i=0}^N x_i$`
set operators	$\in \cup \cap \subseteq$	`$\in \cup cap \subseteq$`
vectors	$\vec{a} \cdot \vec{b}$	`$\vec{a} \cdot \vec{b}^\top$`

Resources:

- symbol pallet **Ω**
- `https://detexify.kirelabs.org/`
- `https://www.overleaf.com/learn/latex/List_of_Greek_letters_and_math_symbols`

Getting it right

Fonts

Calligraphic $\mathcal{L}$: `\mathcal{L}`
Boldface $\mathbf{A}$: `\mathbf{A}`
Blackboard $\mathbb{E}$: `\mathbb{E}`
Regular Text ϵ therefore δ: `$\text{ therefore }$`

Example:

$$y \sim \mathcal{N}(\mathbf{0}, \mathbf{1})$$

```
\[
y \sim \mathcal{N}(\mathbf{0}, \mathbf{1})
\]
```

Alignment and Math Environments

Use `align` environment with & to align equations.

$$\begin{aligned} 2x - 5y &= 8 \\ 3x + 9y &= -12 \end{aligned}$$

```
\begin{align*}
2x - 5y &=  8 \\
3x + 9y &=  -12
\end{align*}
```

Math Environments

When you can you should use standard math environments.

```
\begin{remark}
...
\end{remark}
\begin{definition}
...
\end{definition}
\begin{theorem}
...
\end{theorem}
\begin{lemma}
...
\end{lemma}
\begin{proof}
...
\end{proof}
```

Formula Recreation Minichallenge

Hint: make sure to use

```
\usepackage{amsmath}
\usepackage{amsfonts}
```

There is also the use of some symbols and verbs (like `\underset{}{}`) that you will need to look up.

Spacing tips: you can use `\quad` or `\ ` or `\:` to adjust spacing.
QR Code:
Github Link:

If you are finished keep going at: `https://texnique.xyz/`

Typesetting Algorithms

There are a variety of different packages for typesetting algorithms and pseudocode. We will use `\usepackage{algorithm}` and `\usepackage{algpseudocode}` in the `\begin{algorithmic}` environment.

Some basic commands:

`\Require`	The inputs and initial state
`\State`	Steps in the algorithm
`\gets`	assignment
`\Comment`	a comment
`\While{}\EndWhile{}`	While loop
`\If{}\ElsIf{}\EndIf{}`	Conditionals
`\For{}\EndFor{}`	For loops
`\Call{}{}`	Function calling

```
\begin{algorithm}[H]
\caption{An algorithm with caption}\label{alg:cap}
\begin{algorithmic}[1]
\Require $n \geq 0$
\Ensure $y = x^n$
\State $y \gets 1$
\State $X \gets x$
\State $N \gets n$
\While{$N \neq 0$}
\If{$N$ is even}
    \State $X \gets X \times X$
    \State $N \gets \frac{N}{2}$  \Comment{This is a commen
\ElsIf{$N$ is odd}
    \State $y \gets y \times X$
    \State $N \gets N - 1$
\EndIf
\EndWhile
\end{algorithmic}
\end{algorithm}
```

Algorithm 1 An algorithm with caption

```
Require: $n \geq 0$
Ensure: $y = x^n$
$y \leftarrow 1$
$X \leftarrow x$
$N \leftarrow n$
while $N \neq 0$ do
    if $N$ is even then
        $X \leftarrow X \times X$
        $N \leftarrow \frac{N}{2}$                          ▷ This is a comment
    else if $N$ is odd then
        $y \leftarrow y \times X$
        $N \leftarrow N - 1$
    end if
end while
```

Algorithms Recreation Minichallenge

challenges/challenge_3_algorithms

Typesetting Tables

Tables might be the hardest thing to typeset since they can get messy very fast.

A basic table uses the `tabular` environment and looks like the following:

```
\begin{tabular}{c c c}
 cell1 & cell2 & cell3 \\
 cell4 & cell5 & cell6 \\
 cell7 & cell8 & cell9
\end{tabular}
```

`\begin{tabular}{c c c}` indicates the table has three columns that are each centered `c`. The parameters of the tabular environment define how columns are formatted, their size, their alignment, and column separators.

The rows are separated by new lines `\\` with cells separated by `&`.

Typesetting Tables

However this is what that table would look like:

cell1	cell2	cell3
cell4	cell5	cell6
cell7	cell8	cell9

Some improvements:

- Use the table environment
- Use the `\centering` command
- Use horizontal and vertical lines
- Use booktabs

Typesetting Tables

```
\usepackage{booktabs}
...
\begin{table}
\centering
\begin{tabular}{l | c c}
 \toprule
 cell1 & cell2 & cell3 \\
 \midrule
 cell4 & cell5 & cell6 \\
 cell7 & cell8 & cell9 \\
 \bottomrule
\end{tabular}
\caption{
    My Table \label{tab:table_1}
}
\end{table}
```

Typesetting Tables

cell1	cell2	cell3
cell4	cell5	cell6
cell7	cell8	cell9

Table: My Table

Table 1 is a little bit better but adding more cells can make tables get messy quite quickly.

Tips for Typesetting Tables

Horizontal Spacing between rows

```
cell1 & cell2 & cell3 \\ [4ex]
cell1 & cell2 & cell3 \\ [0.5ex]
```

Text Spans multiple rows / columns

```
\usepackage{multirow}
...
\multicolumn{3}{|c|}{Column} \\
\multirow{2}{*}{cell1} & cell2 & cell3 \\
 & cell2 & cell3 \\
```

Change line length

```
cell1 & cell2 & cell3 \\
\cline{2-3}
 & cell2 & cell3  \\
```

Protip: Use pandas `to_latex` method for creating and maintaining tables.

```python
import pandas as pd
df = pd.read_csv('./raw_results.csv')
pivot = raw_data.pivot_table(
    values='Value',
    index='Category',
    columns='Subcategory',
    aggfunc=['mean', 'std']
)
# Export pivot table to LaTeX
latex_table = pivot.to_latex(
    float_format="%.2f",
    escape=False
)
```

Table Recreation Minichallenge

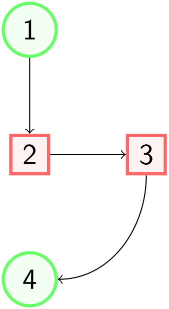
challenge_4_tables

Typesetting Diagrams

Why shouldn't I just use google draw?

- Content over Style
- Collaboration
- Ease of modification

```
\usepackage{tikz}
\usetikzlibrary{positioning}
```



```
\begin{tikzpicture}[
roundnode/.style={circle, draw=green!60,
fill=green!5, very thick, minimum size=7mm},
squarednode/.style={rectangle, draw=red!60,
fill=red!5, very thick, minimum size=5mm},
]
%Nodes
\node[squarednode] (maintopic)                         {2};
\node[roundnode]   (uppercircle)  [above=of maintopic] {1};
\node[squarednode] (rightsquare)  [right=of maintopic] {3};
\node[roundnode]   (lowercircle)  [below=of maintopic] {4};

%Lines
\draw[->] (uppercircle.south) -- (maintopic.north);
\draw[->] (maintopic.east) -- (rightsquare.west);
\draw[->] (rightsquare.south) .. controls +(down:7mm)
and +(right:7mm) .. (lowercircle.east);
\end{tikzpicture}
```

Diagram Recreation Minichallenge

challenge_5_diagrams

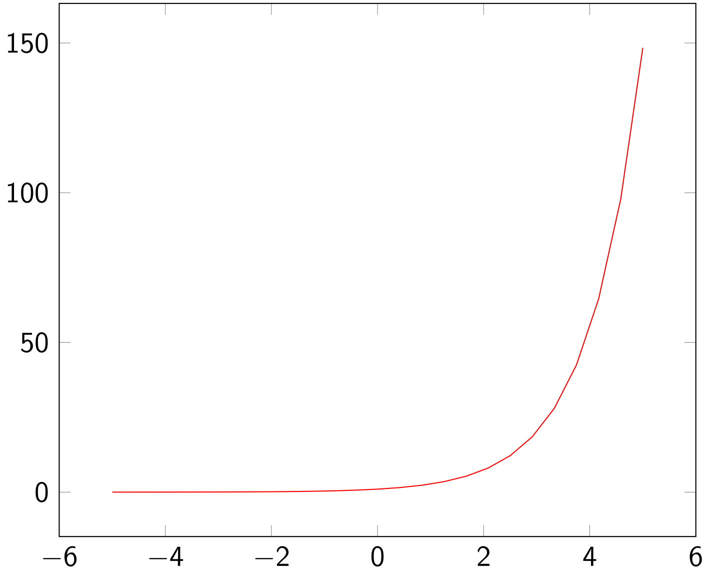
Typesetting Plots

Why shouldn't I just use matplotlib?

- Maintenance
- Aesthetics

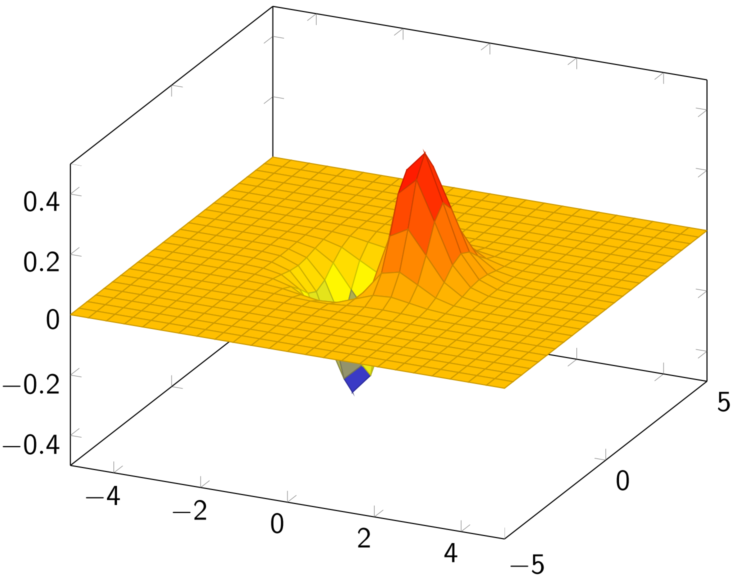
```
\usepackage[margin=0.25in]{geometry}
\usepackage{pgfplots}
\pgfplotsset{width=10cm,compat=1.9}

% We will externalize the figures
\usepgfplotslibrary{external}
\tikzexternalize
...
\begin{tikzpicture}
\begin{axis}
\addplot[color=red]{exp(x)};
\end{axis}
\end{tikzpicture}
```


150
100
50
0
−6
−4
−2
0
2
4
6

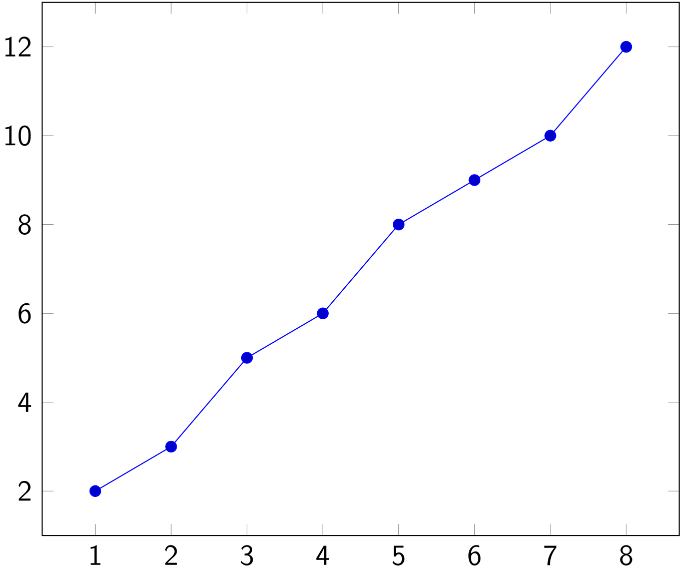
3d plots

```
\begin{tikzpicture}
\begin{axis}
\addplot3[
    surf,
]
{exp(-x^2-y^2)*x};
\end{axis}
\end{tikzpicture}
```


0.4
0.2
0
−0.2
−0.4
−4
−2
0
2
4
−5
0
5

Plotting Data

```
\begin{tikzpicture}
    \begin{axis}
    \addplot
    coordinates {
        (1,2) (2,3) (3,5) (4,6) (5,8) (6,9) (7,10) (8,12)
    };
    \end{axis}
\end{tikzpicture}
```


12
10
8
6
4
2
1
2
3
4
5
6
7
8

Plot Recreation Minichallenge

challenge_6_plots

See: `https://latexdraw.com/` for comprehensive tutorials on latex plotting and diagramming.

LaTeX Ecosystem

- Presentations (like this one): Beamer
- Posers: Beamerposter
- Other documents: overleaf temapltes
- Bibliography management: Bibtex, Natbib, Biblatex
- Other Packages: TeX Packages

Citations and References

```
\usepackage{natbib}
\bibliographystyle{unsrtnat}
...
\section{My Paper}
According to \citet{} ....
This has been studied by many works \citep{}.
Our results differ (see \citealp{})...
...
\bibliography{bibliography}
```

```
bibliography.bib
```

```
@misc{knuthwebsite,
    author    = "Donald Knuth",
    title     = "Knuth: Computers and Typesetting",
    url       = "http://www-cs-faculty.stanford.edu/\~{}unc
}
```

Citation flow demo

get paper bibtex from semantic scholar

Advanced LaTeX

- Stylesheets
- Macros, Commands
- Large scale documents
- Tikz, Pgfplots

```
\newcommand{\R}{\mathbb{R}} \\
\newcommand{\bb}[1] \\{\mathbb{#1}}
\( \bb{R} \) \\
```

Additional Learning Resources

1. Overleaf
2. `https://www.youtube.com/@DrTrefor`
3. Looking at the source of arXiv papers
4. `https://texnique.xyz/`
5. Michelle Krummel Latex
6. Me / Other Grad students at Dal
7. `https://www.learnlatex.org/en/`

Competition

Paper recreation challenge.

1. Choose a paper from the TinyPapers track from ICRL: `https://openreview.net/group?id=ICLR.cc/2024/TinyPapers#tab-invite-to-present-notable`
2. Create a new overleaf project using the ICLR template `https://iclr.cc/Conferences/2024/CallForPapers`
3. Fill it in copying the paper as best you can.

The most faithful recreation wins!

What is allowed?

- Taking screenshots of figures and diagrams
- Looking things up
- Asking for help

What is not allowed?

- Finding the TeX source of the paper
- Taking screenshots of tables

Ask for help!

References

[1] Hao Li et al. *Visualizing the Loss Landscape of Neural Nets*. 2018. arXiv: 1712.09913 [cs.LG]. URL: https://arxiv.org/abs/1712.09913.