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
7. LaTex Ecosystem: Presentations, Posters, Thesis, Templates, Bibliographies, Other Packages.

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

If you are bored...

https://texnique.xyz/

Project files

Project files are available here

Figure: Caption

`https://tinyurl.com/dal-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 8. In TeXthis looks like:

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

Pro Tip: Use Clever Ref

```
\usepackage{cref}
\cref{sec:results}
\Cref{app:datasets-used}
```

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 & or _
\noindent % makes sure there is no indent.
```

Basics of Typesetting: Type!

Styling Bold: \textbf{...}
Italics: \textit{...}
<u>Underline</u>: \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}
```
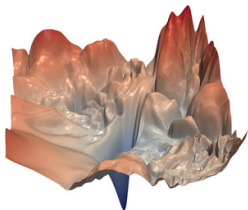

Figure: The loss landscape of a Resnet54 [1]

Document Recreation Minichallenge

Recreate the following PDF using what we learned so far.

Note: \TeX{} and \LaTeX{} are the verbs for the outputs T_EX and L^AT_EX.

Challenge PDF: challenge_1_document.pdf

Github Link: https://tinyurl.com/dal-latex-challenge-1

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 **A**: \mathbf{A}
Blackboard $\mathbb{E}$: \mathbb{E}
Regular Text ϵ therefore δ: 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.

$$2x - 5y = 8$$
$$3x + 9y = -12$$

```
\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

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 or ask.

Spacing tips: you can use \quad or \ or \: to adjust spacing.
Github Link: https://tinyurl.com/dal-latex-challenge-2

Remember to use: https://detexify.kirelabs.org/

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 commer
\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: $y = x^n$
 1: $y \leftarrow 1$
 2: $X \leftarrow x$
 3: $N \leftarrow n$
 4: **while** $N \neq 0$ **do**
 5:     **if** N is even **then**
 6:         $X \leftarrow X \times X$
 7:         $N \leftarrow \frac{N}{2}$ ▷ This is a comment
 8:     **else if** N is odd **then**
 9:         $y \leftarrow y \times X$
10:         $N \leftarrow N - 1$
11:     **end if**
12: **end while**

Algorithms Recreation Minichallenge

Link: https://tinyurl.com/dal-latex-challenge-3

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
)
```
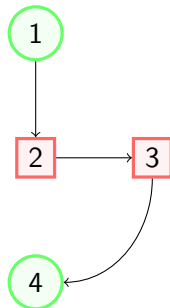
Table Recreation Minichallenge

Link: https://tinyurl.com/dal-latex-challenge-4

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

https://tinyurl.com/dal-latex-challenge-5

Typesetting Plots

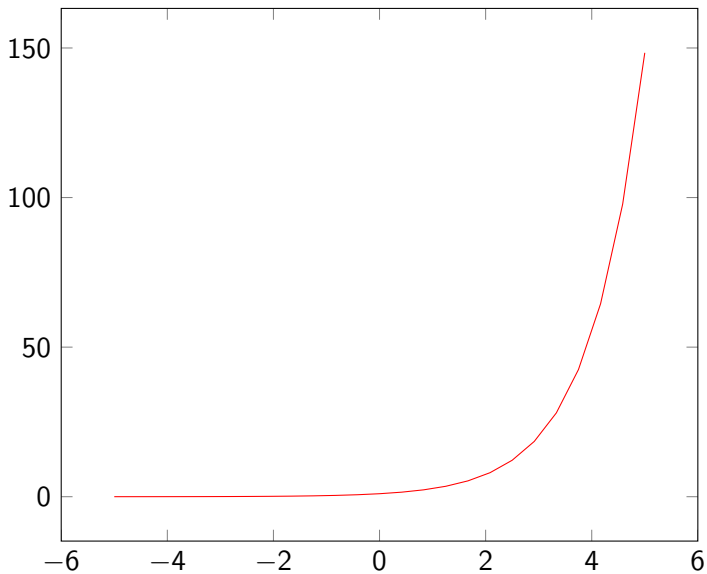Why shouldn't I just use matplotlib?

- ▶ 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}
```
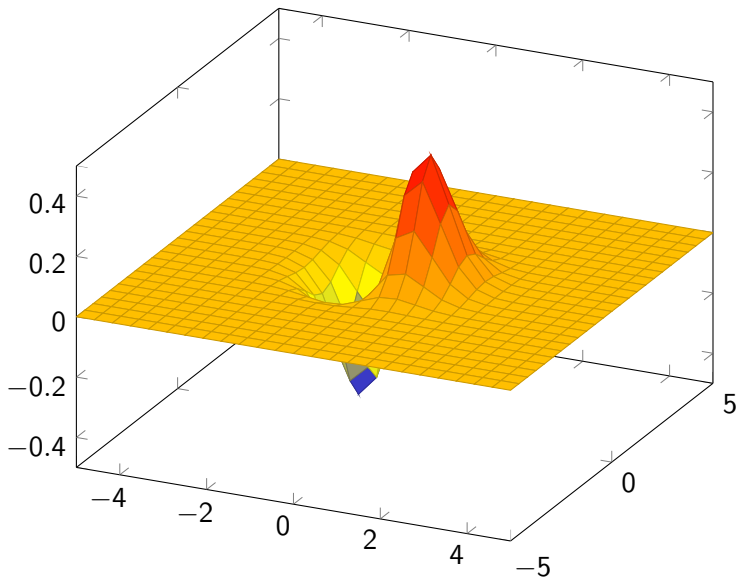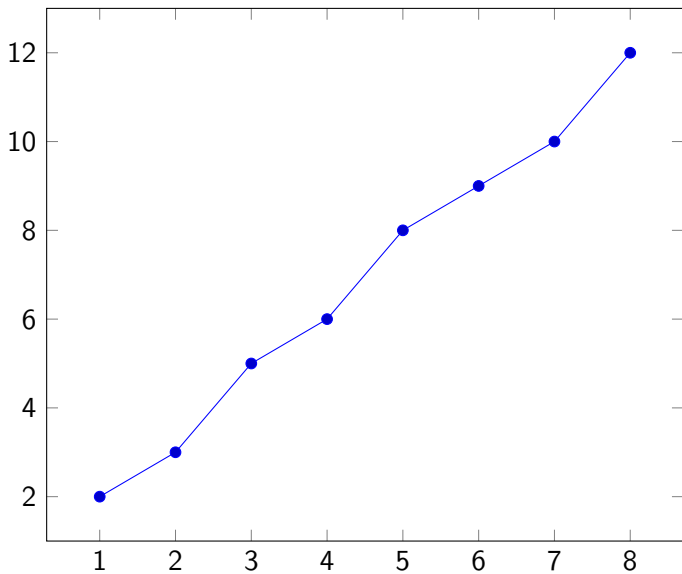
3d plots

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

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}
```

Plot Recreation Minichallenge

Link: https://tinyurl.com/dal-latex-challenge-6
See: https://latexdraw.com/ for comprehensive tutorials on latex plotting and diagramming.

LaTeXEcosystem

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

Dal Specific: There is a Dal poster template on overleaf (if you search), I made a Dal presentation template (ask me), Vlado and Mike maintain the thesis template:
`https://web.cs.dal.ca/~vlado/dalcsthesis/`. There are other things (RAD templates) others have maintained.

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/\~{}un
}
```

Citation flow demo

get paper bibtex from semantic scholar

Citation Styles

There are various citation: packages like bibtex, biblatex, natbib

You will need to be careful when setting the bibliography, bibliography style, citations, and bibtex entries.

Bibtex Entries `https://www.bibtex.com/e/entry-types/`
Common mistake: using @misc when @article is available.

When to use citep/citet/citealp/cite If your citation style supports it you should use `\citep` when its a parenthesis citation and you are not directly referring to the citation as a noun. If you using the citation as a noun, use `citet`. Avoid extra parenthesis in a parenthesis by using `\citealp`.

Do not refer to a `\cite` directly. "[1] shows blah." Instead say "Lou et al. [1] shows blah.

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 Youtube
6. Me / Other Grad students at Dal
7. `https://www.learnlatex.org/en/`

Competition

Paper recreation challenge (1 hour)

1. Choose a paper from the TinyPapers track from ICRL:
   https://tinyurl.com/dal-latex-tiny-papers
2. Create a new overleaf project using the ICLR template
   https://tinyurl.com/dal-latex-iclr-template
3. Fill it in copying the paper as best you can.

The most faithful and challenging recreation wins! Judged by Frank and I

Submit to domenic.rosati@dal.ca

Competition

The most faithful and challenging 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 (they should be tables)

Ask for help!

Finished? `https://texnique.xyz/`

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.