Complex Document Preparation & LaTeX

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MCSB Bootcamp
September 12, 2019

Contents

1 Introduction

LaTeX is a document preparation system used to create professional-looking documents. It is used extensively for communication and publication of scientific documents.

1.1 Objectives

1. The main objective is to get comfortable using LaTeX for homework assignments the first year.
2. The secondary, and arguably the more important objective is to be able to use LaTeX for manuscripts.

1.2 Advantages and Disadvantages of LaTeX

Advantages:

1. Mathematical notation and referencing
2. Consistent handling of intra-document references and bibliography
3. Content and style are separated
4. Packages to do most anything (can also be a disadvantage)

Disadvantages:

1. Collaborative editing can be difficult without the use of git or Overleaf
2. Some barrier to entry

1.3 Advantages and Disadvantages of Overleaf

Advantages

- Easy compiling
- Avoid compatibility issues between different operating systems
- Contains existing templates

Disadvantages

- Requires internet connection
- It can take longer to compile

1.4 Specific Objectives

1. Understand LaTeX structure and syntax
2. Learn notation (e.g. backslashes and brackets)
3. Add a package
4. Change formatting
5. Learn the different types of mathematical equation modes (Section 4)
6. Write mathematical expressions (fractions, square roots, exponents, matrices, ect. . .)
7. Include a figure, label the figure, and reference the figure
8. Citations and reference file
9. Make a table
10. Compatibility with Mathematica, Mendeley and other reference managers, Import code from a file

2 Starting From a Blank Project

One of the advantages of Overleaf is that it has multiple templates, as well as the ability to upload an existing project and create a new blank document (Figure 1). Once familiar with LaTeX, it is recommended to use a template that has the desired style for your project. However, starting from a blank project can makes it easier to focus on learning the basic structure and syntax (Activity 1).

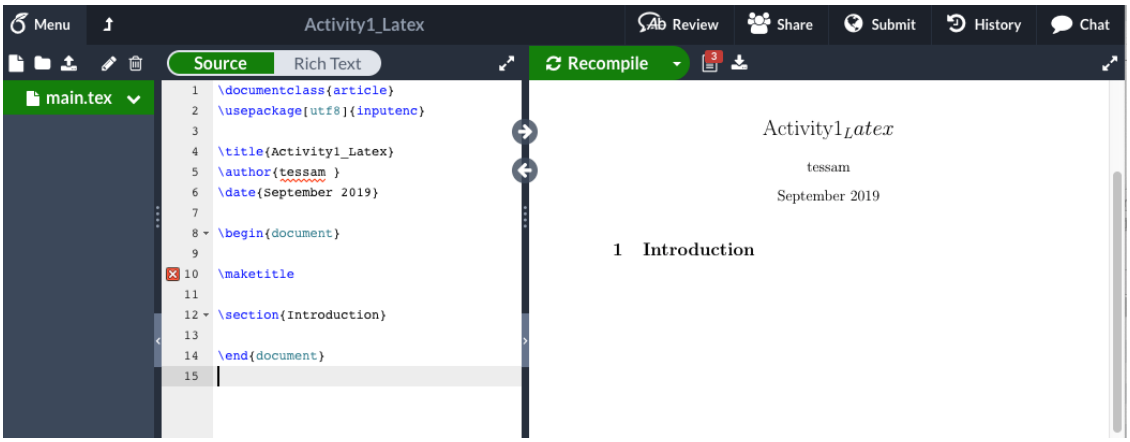


Figure 1: A blank document automatically generated by Overleaf. Overleaf displays the **Source** or the .tex code on the left side of the screen and the compiled .pdf on the right side of the screen.

Activity 1: Create a New Blank Project

1. Open a new internet browser tab, navigate to `overleaf.com`, and login.
2. Select **New Project**and then **Blank Project**.
3. Once you have named and created your project it should similar to Figure 1.

At this stage, the document contains the title and a section named "Introduction".

Overleaf creates the title in the following way:

- `\title` Project Name (Activity_Latex in Figure 1)
  Note: There is an error (indicated by the red x on line 10) because the underscore indicates a subscript in math mode of LaTeX (Section 4). Math mode is not properly indicated and therefore, there is a compilation error.
- `\author` Your User Name (tessam in Figure 1)
- `\date` Current Month Current Year (September 2019 in Figure 1)

3 LaTeX Components & Basic Syntax

3.1 LaTeX Document Components

LaTeX is separates the content of the document from the style. Therefore it is common to create one style of document with the desired appearance and then use that document as a template in future projects. Accordingly, many scientific journals create and require authors to use their LaTeX manuscript templates.

A .tex file has two components: the **preamble** and the **body of the document**.
The **preamble** is where the document type is defined, packages are loaded, and parameters are set. For example, the first line of code in Figure 1 declares the type of document (i.e. class), which controls the overall appearance of the document. In this case, the class is article, the simplest and most common LaTeX class. The preamble ends and the body of the document begins with `\begin{document}`.
The **body of the document** is the content of the document and is enclosed inside `\begin{document}` and `\end{document}`. Follow Activity 2 to change the body of the text to display "Hello World!" as in Figure 2.

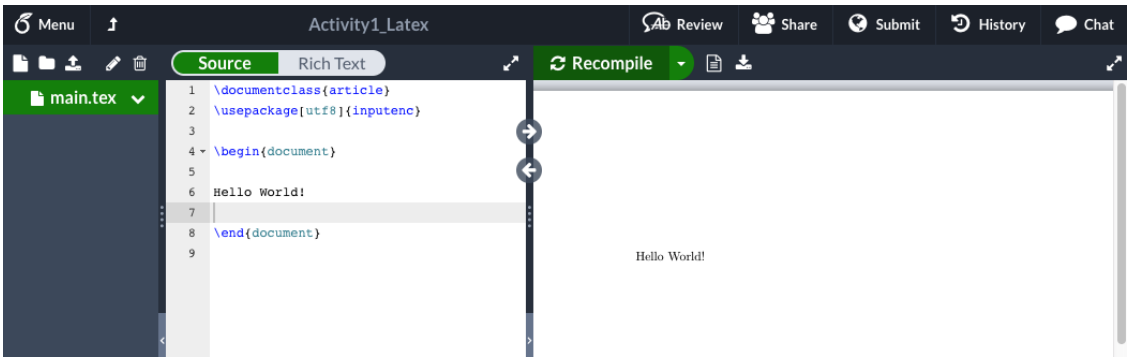


Figure 2: Display "Hello World!" using LaTeX.

Activity 2: Use LaTeX to display "Hello World!"

The Blank Project automatically generated by Overleaf (Figure 1) contains both a title and section called "Introduction". We would like for the document to simply display "Hello World" instead.

1. In the body of the document, comment out the existing text (`\maketitle` and `\section{Introduction}`) by adding a % symbol (Section 3.2).
2. Type `Hello World!` in the body of the document.
3. Recompile. Your rendered document should look like that in Figure 2.
4. You can also comment out the commands in the preamble that create the title (See Activity 1) as the title is no longer rendered.

3.2 Comments

As with any code you are writing, it can often be useful to include comments. To make a comment in LaTeX add a % symbol before the comment text (Example 3.1).

Example 3.1: Adding a Comment

```
% This is a comment
```

In Overleaf, the keyboard shortcut to comment out a line of code is Control (or Command) + Slash (/)

3.3 Document Sectioning

LaTeX can organize, number, and index chapters and sections of document. Use the command `\section{···}` to create a new section (Activity 3).

Activity 3: Add Sections

1. Add multiple sections using the command `\section{···}`.
2. Change the order of the sections around and see how the numbering changes.
3. What happens if you change the command to `\section*{···}`?

3.4 Simple Text Formatting

Simple formatting includes bolding, italicising and underlining text (Example 3.2), as well as, changing the font size (Example 3.3)

Example 3.2: Changing the Emphasis

Bold text using the `\textbf{···}` command.
Italicise text using the `\textit{···}` command.
Underline text using the `\underline{···}` command.

Example 3.3: Changing the Font Size

\Huge Text
\huge Text
\LARGE Text
\Large Text
\large Text
\normalsize Text (default size)
\small Text
\footnotesize Text
\scriptsize Text
\tiny Text

Activity 4: Replicate this Text

How would you replicate the following text, where "Hello" is in small font and italicized, "World!" is in Huge font, underlined, and bold?:

Hello **World!**

3.5 Packages

Packages can be used to change the default look of your LaTeX document, or to allow more functionalities. To use the a package a the following line in you preamble `\usepackage{···}` (Activity 5).

Activity 5: Change Text Color

The package xcolor allows you to manipulate the color in your document. In this activity, we'll use it to simply change the text color.

1. Install `xcolor` by adding `\usepackage{xcolor}` to the preamble.
2. Change of the text to red by adding the line `\color{red}` in the body of the document.

You can also define your own text color by defining your color in the preamble. We will use the RGB code (each channel ranging between 0 and 1) to define the colors.

- Add the line `\{myBlack}{rgb}{0,0,0}` to the preamble.
- Add the line `\{myWhite}{rgb}{1,1,1}` to the preamble.
- Add the line `\{myNewColor}{rgb}{0.26,0.90,0.47}` to the preamble.
- Call each color as you did before when you changed the color to red.

3.6 New Lines

Leave one full empty line between two paragraphs. Place `\\` at the end of a line to create a new line (but not create a new paragraph).

3.7 Environments

Environments are regions in the document that are formatted in a special manner depending on the type of the environment. They start with a `\begin{···}` command and end with an `\end{···}` command. Common examples include lists, centering, equations (Section 4), and figures (Section 5).

Activity 6: Test Centering Environment

Create a centering environment around the text "Hello World".
Hint: Start the environment with `\begin{center}`

3.8 Lists

Lists can either be ordered (`itemize` environment) or unordered (`enumerate` environment) (Example 3.4). In both list environments, each entry must be preceded by the control sequence `\item` (Example 3.5).

Example 3.4: Lists Rendered by the Code in Example 3.5

Ordered List:

1. First Entry
2. Second Entry

Unordered List:

- First Entry
- Second Entry

Example 3.5: Code to Render Lists

Ordered List:
```
\begin{enumerate}
    \item First Entry
    \item Second Entry
\end{enumerate}
```

Unordered List:
```
\begin{itemize}
    \item First Entry
    \item Second Entry
\end{itemize}
```

3.9 Using Templates

Rather than creating your own template from a blank document, it is usually preferable to modify an existing template to fit your needs. You can browse existing templates at `overleaf.com/gallery` or use a template from a different sources (Activity 7).

Activity 7: Upload MCSB LaTeX Template

1. Download the project MCSBLatexTemplate from Github.
2. Create a New Project by selecting Upload Project.

The compiled document will contain the following
- The main LaTeX (.tex) file: main.tex
- A bibliography (.bib) file: references.bib

Personalize the header.

4 Writing Equations

4.1 Mathematical Modes

LaTeX has two writing modes for mathematical expressions:
- **inline mode**: write formulas that are part of a text (Example 4.1)
- **display mode**: write expressions that are not part of a text or paragraph (Examples 4.2,4.3,4.4)

To write a mathematical expression in inline mode (Example 4.1), use the delimiter: `$ $`

Example 4.1: Inline Mode

What is the general solution of the differential equation, $y' = -2y$?

To write a mathematical expression in display mode (Example 4.2), use the delimiter: `$$ $$`

Example 4.2: Display Mode

What is the general solution of the following differential equation:

$$y' = -2y$$

Expressions in display mode can also be numbered (Example 4.3) using the delimiter: `\begin{equation}` `\end{equation}`

Example 4.3: Numbered Display Mode

What is the general solution of the following differential equation:

$$y' = -2y \tag{1}$$

In many cases it is useful to label an equation so that it can be referenced later (Example 4.4). Add a label using the delimiter: `\label{ }` and reference using `\ref{ }`

Example 4.4: Numbered Display Mode with Labeled Equations Referenced

What is the general solution of the following differential equation:

$$y' = -5y \tag{2}$$

The general solution of Equation 2 is $y = ce^{-5t}$

4.2 Common Math Expression Syntax

4.2.1 Subscripts & Superscripts

Subscripts and superscripts are written using the symbols `_` and `^` , respectively (Example 4.5).

Example 4.5: Subscripts and Superscripts

$$x_1 + x_1 = x_1^2$$
$$y^2 = x_1^2$$

4.2.2 Math Symbols

Mathematical Operators (e.g. summation, limits, integration) also use subscripts and superscripts in this manner (Example 4.6). Common operators and symbols are listed in Table 1, but there are also many helpful online resources. One that you may find particularly useful is `http://detexify.kirelabs.org/classify.html`, which allows you to draw a symbol and will output the command along with the required packages.

Table 1: Common operators and mathematical expressions

Description	LaTeX Markup	Render as
Limit	`\lim`	$\lim$
Summation	`\sum`	$\sum$
Integration	`\int`	$\int$
Binomials	`\binom{n}{k}`	$\binom{n}{k}$
Square roots	`\sqrt{n}`	$\sqrt{n}$

Example 4.6: Summation with Subscripts and Superscripts

$$\sum_{k=0}^{3} 2^k = 1 + 2 + 4 + 8 = 15$$

4.2.3 Fractions

Fractions can be used alongside the text and in a mathematical display style using `\frac { } { }` (Example 4.7). Fractions can also be forced into text or display mode using `\tfrac { } { }` and `\dfrac { } { }`, respectively (Example 4.8). Examples 4.9 and 4.10 demonstrate how LaTeX can handle even complex expressions.

Example 4.7: Fractions

$$f(x) = \frac{1}{x^2}$$

Example 4.8: Fractions with Different Display Styles

Inline Mode: $f(x) = \frac{1}{2}x^2 = \frac{1}{2}x^2 = \frac{1}{2}x^2$
Display Mode:

$$f(x) = \frac{1}{2}x^2 = \frac{1}{2}x^2 = \frac{1}{2}x^2$$

Example 4.9: Fractions and binomials

The binomial coefficient is defined by:

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}$$

Example 4.10: Complicated Fractions

$$\frac{1+\frac{a}{b}}{1+\frac{1}{1+\frac{1}{a}}} + \frac{1}{\sum_{k=0}^{\frac{a-b}{a}} k^{\frac{1}{2}}}$$

4.2.4 Matrices

Matrices are also nicely rendered in LaTeX (Examples 4.11 and 4.12).

Example 4.11: Identity Matrix

$$I = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Example 4.12: Matrix

$$A = \begin{bmatrix} a_1 & a_2 & a_3 & a_4 \\ b_1 & b_2 & b_3 & b_4 \\ c_1 & c_2 & c_3 & c_4 \end{bmatrix}$$

4.3 Reactions

LaTeX can also reactions such as the enzyme-mediated biochemical reaction described by Michaelis-Menten kinetics (Example 4.13). See Section 6 for information on citing a work.

Example 4.13: Enzyme Kinetics

Michaelis-Menten kinetics [1] describe enzyme-mediated biochemical reaction, i.e.

$$\mathrm{E} + \mathrm{S} \underset{\mathrm{k_{-1}}}{\overset{\mathrm{k_1}}{\rightleftharpoons}} \mathrm{ES} \xrightarrow{\mathrm{k_2}} \mathrm{E} + \mathrm{P}$$

where E is an enzyme, S is a substrate, ES is an enzyme-substrate complex and P is a product.

References

[1] Leonor Michaelis and Maude L Menten. "The kinetics of the inversion effect". In: *Biochem. Z* 49 (1913), pp. 333–369.

5 Including Figures

Including figures will be slightly different depending on how the document is being edited and compiled. The simplest way to include an image is using the `\includegraphics{···}` command, where the location + name + extension of the image are specified (Example 5.1. To change the size of the image, you can specify the width, height, or scale (Example 5.2). It is usually desirable to add a caption and label to a figure so that it can be referenced later (Example 5.3). See Activity 8 to add a figure to your document using Overleaf.

Example 5.1: Inserting Figures/Graphics

Include Figure:
`\includegraphics{exampleImage.png}`

Example 5.2: Changing the Figure Size

Set the scale to be half the original scale :
`\includegraphics[scale = 0.5]{exampleImage.png}`

Example 5.3: Inserting Figures Using the Figure Environment

Include Figure with caption and label:

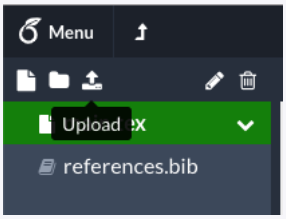
```
\begin{figure}[h]
      \centering
     \includegraphics{exampleImage.png}
      \caption{My example image caption.}
      \label{fig:myFigLabel}
\end{figure}
```

Reference this figure later in the body using the command:

```
\ref{fig:myFigLabel}
```

Activity 8: Include Figure in Overleaf

1. Load an image into Overleaf (See Below)



2. Include an image using only `\includegraphics{···}` as in Example 5.1.
3. Resize your image (Example 5.2).
4. Include your image using the figure environment (Example 5.3).
5. Reference your image (Example 5.3).

6 Including Bibliography/References

There are three main bibliography management packages: bibtex, natbib (a package for use with bibtex) and biblatex. This document uses biblatex, but other packages may be better depending on your reference manager (Mendeley, EndNote, JabRef) and how you're editing / compiling your .tex documents (Overleaf, Local GUI LaTeX editor/compiler, Local command line).

In general, including references requires a bibliography file with all entries in a standard bibtex syntax (See: references.bib and Figure 3). It is possible to copy the bibtex syntax from google scholar (Figure 4), however reference managers such as Mendeley and EndNote can also create the LaTeX bibliography file.

To cite a specific entry, type `\cite{···}` with the keyword corresponding to that entry. In Figures 3 and 4, the work that should be cited ('Nonlinear dynamics and chaos" by Steven Strogatz), has the keyword `strogatz2018nonlinear`, and is cited using the command: `\cite{strogatz2018nonlinear}`.

```
@book{strogatz2018nonlinear,
  title={Nonlinear dynamics and chaos: with applications to physics, biology, chemistry, and engineering},
  author={Strogatz, Steven H},
  year={2018},
  publisher={CRC Press}
}
```

Figure 3: BibTeX entry for "Nonlinear dynamics and chaos" by Steven Strogatz. The bibtex key is `strogatz2018nonlinear`

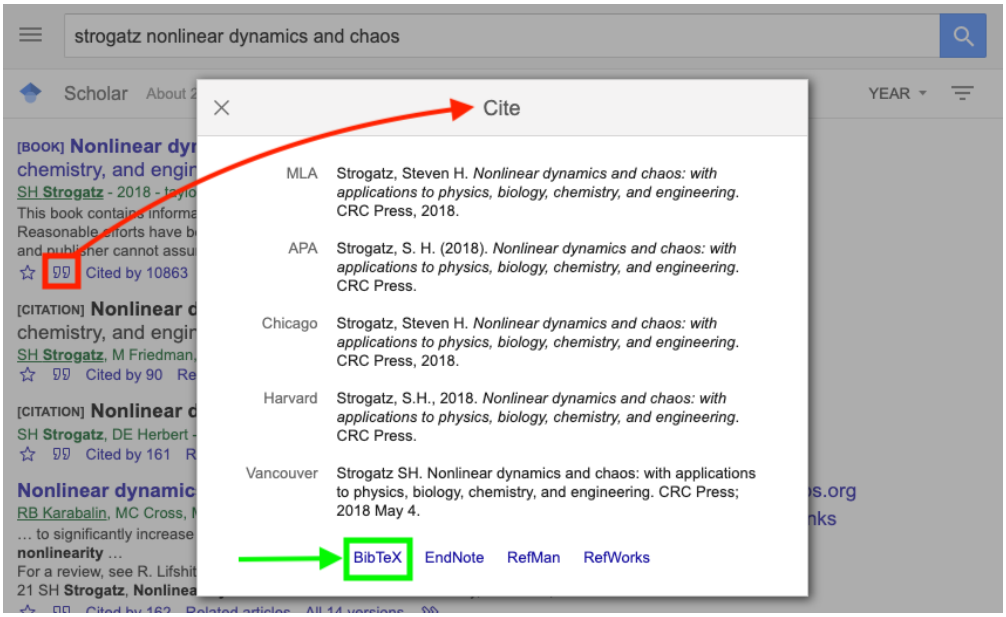


Figure 4: Google Scholar Citation of 'Nonlinear dynamics and chaos" by Steven Strogatz. Clicking BibTeX will link you to Figure 3

In Example 4.13, the work cited ("The kinetics of the inversion effect" by Leonor Michaelis and Maude L Menten), had the keyword `michaelis1913kinetics`, and was cited using the command: `\cite{michaelis1913kinetics}`. Print a list of the references used with the command `\printbibliography` (Example 4.13).