

Just Another Introduction to L^AT_EX: A (Very) Short Course

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Introduction to this Short Course

Purpose. The aim of this document is to serve as a set of guided lessons in creating L^AT_EX documents and to serve as an example of the kind of documents that can be produced with the L^AT_EX family of tools. It is not and does not aim to be comprehensive.

About. This document was originally prepared by the author during his tenure as **the starlab** fellow for the incoming graduate student cohort in the Political Science department at the University of Rochester. Previous versions of the short course and the corresponding materials are available at **the starlab**'s website (<http://www.rochester.edu/college/psc/thestarlab/>). This document began as an adaptation of Arthur Spirling's version. It's current version may or may not have diverged considerably.

In addition to the supplemental files used for the various exercises included in this version, all files required to create this document are available at <https://github.com/olmjo/LaTeX-Intro>.

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Comments. If you have any comments, questions, or concerns regarding this document please contact Jonathan Olmsted jpolmsted@gmail.com.

Contents

I	An Introduction to Using \LaTeX	4
1	What is \LaTeX (lay-teck) or LaTeX, but not latex or Latex?	4
2	Why Would You Use \LaTeX ?	4
3	How Does \LaTeX Work?	5
4	Exercise: Your First Document	7
II	Basic Content in LaTeX	10
5	\LaTeX 's Interpretation of Plain Text	10
6	.tex Input File Structure	12
7	Output File Structure	15
8	Environments	15
9	Error Debugging	15
10	Solving Problems and Getting Help	16
III	Creating Full Documents in \LaTeX	17
11	Starting Point	17
12	Fonts	18
13	List Environments	19
14	Metadata: titles, dates, authors, abstracts	19
15	Fancy (and not Fancy) Headers	20
IV	Including Mathematics in \LaTeX Documents	22
16	Additional Packages	22
17	Math Modes	22
18	Superscripts and Subscripts	24

19 Operators	24
20 Greek Letters	25
21 Other Letter-y Things	25
22 Special Text-like Mathematical Expressions	25
23 Delimiters	26
24 Accents	26
25 Assignment!	27

Part I

An Introduction to Using L^AT_EX

1 What is L^AT_EX (lay-teck) or LaTeX, but not latex or Latex?

- L^AT_EX is an open, document-preparation system used by many students, academics, and publishers whose content involves technical topics or complex structure (*e.g.* math professors, engineers, you).
- L^AT_EX is a kind of markup language. This means L^AT_EX files explicitly articulate both the *content* and the *structure*. Other markup languages include HTML, XML and Markdown. If you go to the New York Times webpage (www.nytimes.com) and view the HTML source for the main page it will look (incredibly) different from how that web page is rendered by your browser.¹ The web page is written in the HTML markup language, but then a separate program renders the page. The main point here is that “creation” and “consumption” are conceptually distinct. LaTeX is much more similar to HTML source than it is to a word processor (*e.g.* MS Word, OpenOffice Writer, Google Documents). When you work with a L^AT_EX file, you describe how the file should look, but this is not displayed for you in real-time.

2 Why Would You Use L^AT_EX?

L^AT_EX has a number of distinct advantages:

- A L^AT_EX document can be very pleasing to the eye without the need for any customization.
- When your focus is on producing content, but are neither a publisher nor a graphic designer, L^AT_EX lets you focus on the content: L^AT_EX separates content from appearance.
- L^AT_EX’s ability to incorporate math is un-rivaled.
- You will never get locked out from the fruits of your intellectual labor because of licenses or old software. The software is open and the files you create are “flat text” files. If someone has a computer, they can read your L^AT_EX files.
- Also, because it relies on plain text files, collaboration among multiple contributors to a single project can be managed *much* more readily.
- The markup code for L^AT_EX math is one of the canonical ways of representing math in plain-text environments (*e.g.* email, instant messaging).

¹In the Google Chrome browser you can view source by navigating to the “Tools” menu item and choosing “View Source”.

3 How Does L^AT_EX Work?

The process of creating a L^AT_EX document is quite different from creating one in a word processor. There is, undeniably, a learning curve.

Although most of the technical details can safely be ignored, some understanding of the different components comprising a functioning L^AT_EX workflow is helpful at the outset. And, understanding how pieces fit together makes asking for help much easier. A basic representation of the workflow is given in Figure 1.

The basic steps to creating a document are:

1. Have an idea!
2. Create a plain text document containing the content in a text editor. These plain text files are typically given a file extension of `.tex`.
3. Process the plain text document with the L^AT_EX “program”.
4. L^AT_EX pulls in any additional files that are asked for—but they have to be asked for—and creates, among other files, the document you will print or email. Most of the time, this is a PDF file.
5. View the result/rendering of your L^AT_EX document by opening the PDF file.
6. Be happy.

Notice that this is different from the word processor workflow. In that case, Steps 2, 4, and 5 are basically integrated. Step 3 is unnecessary. Step 6 may or may not happen.

What now follows is some more explanation of the kind of software will be needed for each step.

Step 2 You could use any number of other text editors. Many Windows users like WinEdt or Sublime. Other options include nerdier text editors like Emacs. It’s best to find a text editor with well-documented L^AT_EX integration. This will facilitate the next steps after you write your file.

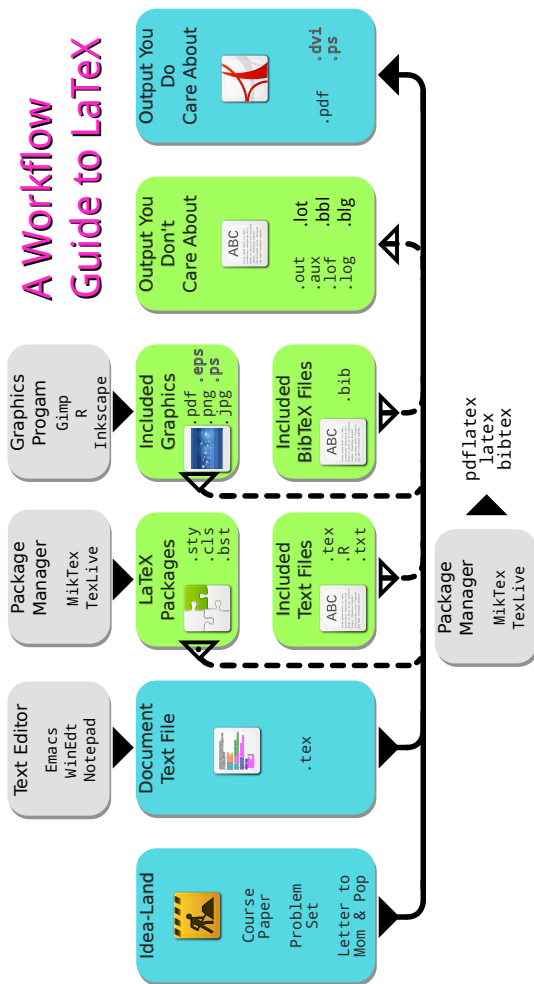
We typically denote L^AT_EX files with the `.tex` file extension. Although it isn’t necessary in some cases, most software and operating systems will make your life easier if you are willing to name L^AT_EX files what they expect you to name them.

Step 3 If you have chosen your text editor well, you can achieve this from within that program. For example, WinEdt has a button you can just click to process your `.tex` file.

Also, L^AT_EX-ing your document can proceed through one of two different branches. I will focus on the `pdflatex` branch and not the `latex` branch. `pdflatex` will convert your `.tex` file into a `.pdf` document. Included images must be `.jpg`, `.png`, `.pdf`, or `.svg` files. These inputs and PDF output are far more common now, so that is the focus here.

Step 4 Sometimes markup in the L^AT_EX file will require contributed packages which tell the L^AT_EX how the content should be rendered. This is one of the critical benefits of using a system like L^AT_EX: you can utilize functionality that many other people have already provided rather than re-invent it or do without.

However, making sure these packages are placed in the right spot on your system and up-to-date can be involved and opaque to the newcomer. L^AT_EX package managers simplify this. On Window

Figure 1: Example L^AT_EX Workflow

An example workflow using L^AT_EX to produce the output you care about. Blue regions represent the components you will focus on the most on a daily basis. Grey regions represent the software that will help you get from start to finish. Green regions represent intermediate or sometimes option files that are less focal.

machines, MikTeX is often used. By and large, you can and should ignore this fact in the beginning of your L^AT_EX experience. What is important is to realize the following:

L^AT_EX \neq a text editor \neq a package manager (e.g., MikTeX).

Step 5 Once you have a PDF file, you can view it in your preferred PDF viewer like Adobe Reader. A well-chosen text editor will make this viewing easy, too.

Step 6 No software necessary.

4 Exercise: Your First Document

1. Go to https://github.com/olmjo/LaTeX-Intro/tree/master/Extra_Materials.
2. Save the file `FakeFile.tex` to your desktop.
3. Open this file in your text editor.
4. Run `pdflatex` on the `.tex` file and view it.
5. Notice how many ancillary files this process creates.

The contents of this file are as follows:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%                                PREAMBLE                                %%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%                                CLASS                                %%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

\documentclass[11pt,letterpaper]{article}

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%                                PACKAGES                                %%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

\usepackage{graphicx}

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%                                SETTINGS                                %%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

\pagestyle{plain}

\author{}
\title{Questions and Answers}
\date{\today}

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%                                CONTENT                                %%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```



```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  
  
\begin{document}  
  
\maketitle  
  
\section{Hello World.}  
Hello, right back at you. Also, not a question.  
  
\section{What is this?}  
This is a document.  
  
\section{Why is this?}  
Buttons were pushed, naturally. Come back later.  
  
\section{No, but \textit{why} is this?}  
That's deep!  
  
\end{document}
```

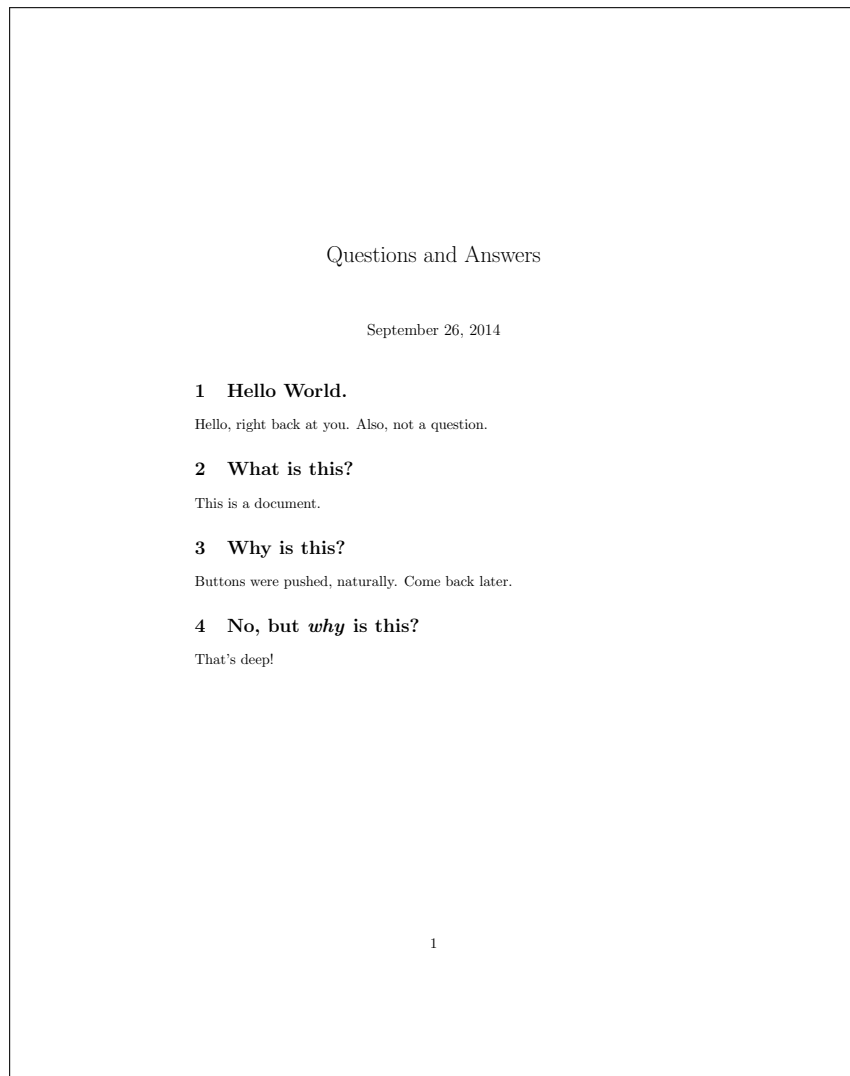
```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

Listing 1: FakeFile.tex

The resultant PDF file should look like Figure 2.

You have successfully created your first \LaTeX document and simultaneously learned to always keep \LaTeX files/projects in separate directories because the output will create clutter.

Figure 2: `FakeFile.pdf` Output




This figure shows the PDF output created by the input \LaTeX file `FakeFile.tex`.

Part II

Basic Content in LaTeX

5 L^AT_EX's Interpretation of Plain Text

- The entire `.tex` file you write will contain only characters on your keyboard. That means, somehow, the characters on your keyboard you need to represent: `a`, `A`, `α`, `ℤ`, `à`, `Å`, `ₐ`, and `Ä`.
- The file that you write will be composed entirely of the characters in Table 1. This is true no

matter what kind of crazy symbols are ultimately included, such as .

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
0	1	2	3	4	5	6	7	8	9																
!	@	#	\$	%	^	&	*	()	_	+														
{	}	[]		\	~	:	'	"	<	,	>	.	?	/										

Table 1: Characters To Use in `.tex` Files

Special Characters

- The following characters are reserved or *special*:

%	#	\$	^	&	_	{	}	~	\
---	---	----	---	---	---	---	---	---	---

Table 2: Special Characters in `.tex` Files

- By special, we mean that each of these characters in the L^AT_EX file doesn't represent itself in your output file. If you type “%” into your text editor and build your output, you will not get a percent sign.
- In order to generate these symbols in your *output* you need to use special representations. Although detailed descriptions of these symbols is beyond the purpose of this section, accept the following brief comments:

Character	Purpose
%	used for including comments and preventing L ^A T _E X from interpreting file contents
#	used to define L ^A T _E X commands (or macros)
\$	used to start L ^A T _E X math mode
^	used for superscripts in math mode
_	used for subscripts in math mode
&	used for alignment in L ^A T _E X math and tables
{ }	used to pass arguments to L ^A T _E X commands
~	used to represent a special kind of whitespace
\	used to start every L ^A T _E X command

Table 3: Purpose of Special Characters

Commands

- Using L^AT_EX efficiently often requires one be familiar with various L^AT_EX commands (or macros). In general, this comes only with practice. Commands start with a “\” and they are case-sensitive. Commands can be used to generate particular glyphs (think shapes on the page) or alter the content in some way.
- One command is “\LaTeX{ }” which produces “L^AT_EX”. Similarly, “\textbf{election}” produces “**election**”.
- You’ll never learn a significant proportion of all the L^AT_EX commands that people use. However, you’ll eventually memorize the ones you use over and over and know how to look up the rest.
- The mandatory arguments to a command are passed inside curly braces and the option arguments to a macro are passed inside square brackets. The result is something like

```
\command[optional1=1, optional2=2]{mandatory=Always}
```

where the (optional) argument `optional1` is being passed the value 1, the (optional) argument `optional2` is being passed the value 2, and the (mandatory) argument `mandatory` is passed the value “Always”.

Whitespace and Spacing

- 2 or more carriage returns, “\”, and “\linebreak” break lines
- “~” is a non-breaking space
- “\par” will create a new paragraph for the succeeding text, regardless of surrounding whitespace
- “\linebreak” and “\pagebreak” are appropriately named

- multiple consecutive spaces are interpreted as one

So,

```
And in the naked light I saw \\ Ten thousand people, maybe more.

    People talking without speaking, \\
    People~hearing~without~listening,

People writing
songs that voices never share \par And no one dared

Disturb      the      sound      of      silence.
```

```
And in the naked light I saw
Ten thousand people, maybe more.
People talking without speaking,
People hearing without listening,
People writing songs that voices never share
And no one dared
Disturb the sound of silence.
```

6 .tex Input File Structure

- L^AT_EX .tex files have a particular structure. If the file you attempt to compile has an error, your document will either fail to be produced or it will not be compiled in accordance with your intentions.
- First, you must declare the *document class*:

```
\documentclass[letterpaper, 10pt]{article}
```

or

```
\documentclass[12pt]{letter}
```

and this is part of the *preamble*. For most purposes, **article** is sufficient.

- Second, the remainder of the preamble contains explicit calls to outside packages if you require their functionality, the creation of new macros, and setting document properties. After the `\documentclass` command we might see the following lines:

```
\usepackage{fancyhdr}

\pagestyle{fancy}
\cfoot{\thepage}
\title{A Document}
```

which provides the functionality from the `fancyhdr` package, sets the “`pagestyle`” to “`fancy`”, places the page number in the center of the footer, and sets the title to “A Document”.

This is also part of the *preamble*.

- Third, the main content is typed within the “`document`” environment, as in:

```
\begin{document}

%% place content here

\end{document}
```

- Lastly, any characters occurring after the close of the `document` environment will be ignored by L^AT_EX. This includes special characters and commands.

In its entirety, we might have the following `.tex` file:

```
\documentclass[12pt]{article}

\title{An Essay about a Guy Named Rob}

\begin{document}

\maketitle

Rob is a cheery chap whose trumpeted lips are sometimes chapped.

%% note to self: add some additional character development

\end{document}

$ breaking \ rules # $ without }any{ effect
```

Listing 2: `fakefile2.tex`

Go ahead and
compile this
document after you
type it out.

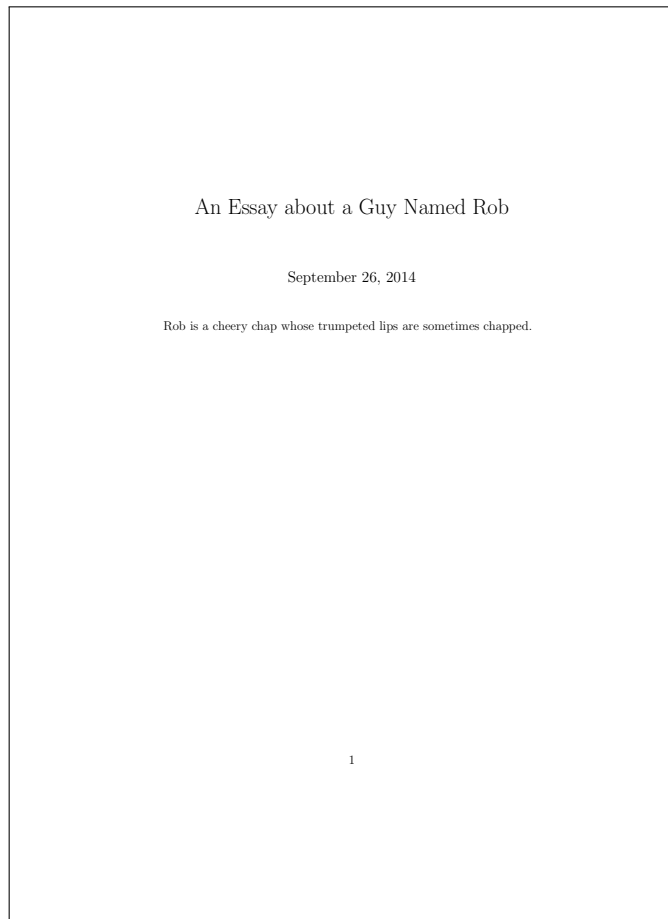


Figure 3: Output from Example Input: `fakefile2.tex`

7 Output File Structure

Headings

- L^AT_EX accepts the definition of a document hierarchy and displays headings appropriately. The *article* class accepts the following headings whose order indicates how far down they are in the order: `\part{}`, `\section{}`, `\subsection{}`, `\subsubsection{}`, `\paragraph{}`, and `\subparagraph{}`. If an “*” is placed after the name as in “`\part*{}`” then the heading will not be numbered and will not be included in the table of contents, if it exists. Otherwise it will be numbered and included in the table of contents. The one mandatory argument is the text of the heading.
- Any headings after the `\appendix` command will be altered to reflect that they do not belong to the main body of the text and, rather, the appendix.

Add a section and a subsection* heading to your document. Name them after your two favorite colors. Compile the document.

8 Environments

- All of the content that will be displayed in your final document is contained in at least one environment. Environments are contexts which affect how the content is rendered and interpreted. Environments are indicated by the `\begin{env}` and `\end{env}` commands. We have already seen the `document` environment.
- We will discuss various environments (and there are many) during the remainder of the week, but the basics are all the same. If you begin an environment, you must end it. When nesting environments, the most recently opened environment must be closed before an earlier environment can be closed.
- The `enumerate` environment creates ordered lists. The `itemize` environment creates unordered lists. The `table` environment is used to encapsulate table-like content.

The insertion might look like

```
\begin{tiny}
‘‘Stellaaaaaaaaa!’’
\end{tiny}
```

At the end of your content begin and end a “tiny” environment. Inside this environment type your favorite thing to shout. Use proper latex quotes (i.e. “...” and not "..."). Compile the document.

9 Error Debugging

You will, invariably, make errors. However, you’ll probably never be the first person to make any particular error. The four most common errors are

1. you type a command incorrectly
2. you forget to `\usepackage` the package that supplies a command which L^AT_EX interprets as if you typed a command incorrectly
3. you don’t `\end{env}` what you `\begin{env}` or you abuse the order of nested environments

4. you have un-balanced braces/parenthesis/brackets depending on what \LaTeX is looking for.

Place the `tiny` environment inside a `center` environment. Now, change one of the `\begin` commands to `\benign`. Compile it. This is not benign! Look at the error message. Correct this mistake and swap the two `end` statements. Compile the document now. Look at the error message.

10 Solving Problems and Getting Help

- Don't panic.
- Check the usual suspects.
- Google a description of your problem in addition to "latex ctan." Including "latex" without "ctan" is a bad, bad, bad, bad, bad idea!
- Comment out potential sources of the problem until you identify it. Slowly add things back in until you have removed only the offending portion. Can this be fixed?
- Consult one of the many great \LaTeX sites out there.²
- Ask a friend!

²Google either "latex ctan wikibook" or "latex comprehensive symbol". These two are great.

Part III

Creating Full Documents in L^AT_EX

11 Starting Point

- This tutorial builds off of the previous one which introduced L^AT_EX commands.
- By the end of the last tutorial we had working documents with environments and headings that were quite pleasing to the eye.
- We will quickly create a very basic document to pick up where we left off.
- Open WinEdt and create a new L^AT_EX *.tex file where you would like it.
- Create a basic document with the following code and check that it compiles.

```
\documentclass{article}

% This is just a comment.
\begin{document}

\section{The Content}

\subsection{Short Content}

\subsection{Long Content}

\appendix

\section{Some Book-keeping}

\end{document}
```

- Go ahead and download the two dummy text files from www.rochester.edu/college/gradstudents/jolmsted/teaching/LaTeX/. Place these two files inside the same directory as your new L^AT_EX .tex file.
- As it stands, our compiled document is quite bare. Add the following L^AT_EX commands:
 - Add `\input{./loremipsum_short.txt}` on a new line directly after `\section{Short Content}`. As long as the downloaded file was placed in the appropriate place, you can safely ignore what this command does.
 - Add `\input{./loremipsum.txt}` on a new line directly after `\section{Long Content}`. Enter this line, again, on a new line. As long as the downloaded file was placed in the appropriate place, you can safely ignore what this command does.
- Compile this document again.

12 Fonts

In L^AT_EX we can make some very basic changes to the font in with ease. These changes can be made with one of two approaches. The *environment* approach or the *command* approach. In the first, whatever font we change will be inside an environment. In the second, whatever font we change will be the mandatory argument to a command.

Font Styles

When consider **bold face** or SMALL CAPS, we are changing font styles. The basic and most common changes are here:

Style	Environment	Command
normal/default	<code>\begin{textnormal} ... \end{textnormal}</code>	<code>\textnormal{...}</code>
bold	<code>\begin{bf} ... \end{bf}</code>	<code>\textbf{...}</code>
<i>italics</i>	<code>\begin{it} ... \end{it}</code>	<code>\textit{...}</code>
SMALLCAPS	<code>\begin{sc} ... \end{sc}</code>	<code>\textsc{...}</code>
<u>underline</u>	<code>:- (</code>	<code>\underline{...}</code>
Roman	<code>\begin{textrm} ... \end{textrm}</code>	<code>\textrm{...}</code>
Sans Serif	<code>\begin{textsf} ... \end{textsf}</code>	<code>\textsf{...}</code>
teletype	<code>\begin{tt} ... \end{tt}</code>	<code>\texttt{...}</code>

- Place the `\input` command under the “Short Content” section inside a font style environment of your choice. Compile the document.
- Before this environment, but under the “Short Content” section type and complete the following sentence: “If I had a boat, I’d ...”.
- Change the style of the font for that sentence and only that sentence by using the command approach. This time, choose a different style from the environment change you made above.

Sizes

Style	Environment	Command
tiny	<code>\begin{tiny} ... \end{tiny}</code>	<code>\tiny{...}</code>
scriptsize	<code>\begin{scriptsize} ... \end{scriptsize}</code>	<code>\scriptsize{...}</code>
footnotesize	<code>\begin{footnotesize} ... \end{footnotesize}</code>	<code>\footnotesize{...}</code>
small	<code>\begin{small} ... \end{small}</code>	<code>\small{...}</code>
normalsize	<code>\begin{normalsize} ... \end{normalsize}</code>	<code>\normalsize{...}</code>
large	<code>\begin{large} ... \end{large}</code>	<code>\large{...}</code>
Large	<code>\begin{Large} ... \end{Large}</code>	<code>\Large{...}</code>
LARGE	<code>\begin{LARGE} ... \end{LARGE}</code>	<code>\LARGE{...}</code>
huge	<code>\begin{huge} ... \end{huge}</code>	<code>\huge{...}</code>
Huge	<code>\begin{Huge} ... \end{Huge}</code>	<code>\Huge{...}</code>

- Place the `\input` under the “Long Content” inside a font size environment of your choice, but choose a size that is small than the normal size. Compile your document.

13 List Environments

There are three main list environments that you will use: `itemize`, `enumerate`, and `description`.

itemize The `itemize` environment allows you to make bullet-ed lists without conveying any order. These can be nested to create any structure desired. However, complex nesting often results in user-mistakes.

enumerate The `enumerate` environment allows you to make numbered lists which convey a precise order. The number is automatic. These can be nested to create any structure desired and the “numbering” system used at each level reflects how far in the tree the entry is.

description The `description` environment is slightly different. In fact, I am using it here. Instead of each entry being marked with an automatic bullet or number, the user must provide the “term” being described.

- For either `itemize` or `enumerate` your code looks like this, where “environment” is swapped out for the correct environment:

```
\begin{environment}
\item An item
\item Another item
\item Still more items!
\end{environment}
```

- For the `description` environment your code is slightly different:

```
\begin{description}
\item[An item] description 1
\item[Another item] description 2
\item[Still more items!] description 3
\end{description}
```

- Create a list in the “Some Book-keeping” section. In this list you should have two items—two of your favorite books. If you are using the `description` environment include the author’s name as the description if you know it. In this case, make sure the book title is in square brackets.

14 Metadata: titles, dates, authors, abstracts

`\maketitle`

- Although our content is already impressively long, the document is lacking all metadata. To address this we will formally introduce the `\maketitle` command
- In the preamble of the file (that is, before `\begin{document}`, but after `\documentclass`), enter the following code:

```
\title{My First Opus}
\date{\today}
\author{Kevin Clarke}
```

- Compile the document. Does anything change?
- Now, add `\maketitle` directly after `\begin{document}`, but on a new line.
- Compile again.
- Comment out the line with the `\date` directive. Re-compile. What happens?
- Uncomment that same line, delete the directive's single mandatory argument and compile. What happens?
- In order to use the `\maketitle` command, a title must be defined. The author and date, however are optional.

`\thanks`

- Kevin is a humble man and acknowledges the contribution that non-Kevin entities play in his success. To add this to the title we use `\thanks`.
- Include the following line at the end of “Clarke” within the author directive as part of the mandatory argument: `\thanks{The author thanks Rochester winters for being sufficiently ridiculous that everyone is forced to stay inside and work.}`
- You can use `thanks` to include institution information or contact information, too.

`titlepage`

- Because this opus is so substantial, it can be overwhelming to assault the reader with content on the first page. In this case, we'd like to have just a title page.
- Place the `\maketitle` directive in an environment by the name of `titlepage`

`abstract`

- Even with a title, we might want to convey the content of our document in more detail.
- In this case, we'd use an abstract.
- After `\maketitle` but within the `titlepage` environment, create a new environment (which is completely nested) called `abstract`. Within the `abstract` environment, write two sentences about what we have covered in this tutorial, so far. Include the word `LATEX`, properly typeset.
- Compile the document.

15 Fancy (and not Fancy) Headers

- By default, the only content in the header or footer of our document is the page number.
- We can change this by using a package called `fancyhdr`.
- Tell `LATEX` to use this package? What is the command? Where does it go?

- In the header, also include `\pagestyle{plain}`. Compile the document. What changes?
- Now use `\pagestyle{fancy}`, instead. Compile the document. What changes?
- You can change the contents of the headers and footers by using commands of the form `\rfoot{}` for `r`, `l`, and `c`; and for `foot` and `head`.
- Place the state or non-US country in which you were born somewhere in the footer. Compile the document.
- Notice that the first page, the title page, has no header. Even when we use fancy headers and get the pretty content on that first inch of the page, any page with `\maketitle` is unchanged, by default. We can change this by including `\thispagestyle{fancy}` immediately after `\maketitle`.

Part IV

Including Mathematics in L^AT_EX Documents

16 Additional Packages

- In order to avoid a lot of redundant and complicated code, it is helpful to load two particular packages each time you create a document with mathematics in it.
- A bare-bones document requires only a `\documentclass{}` line, followed by the `\begin{document}` and `\end{document}` lines.
- We will now add `\usepackage{amsmath, amsthm, amssymb, amsfonts}` to the *preamble* of the document. This tells L^AT_EX to recognize certain commands defined in these packages.
- We'll never use most of the functionality they add, but we'll often use some of it!
- Create the following empty L^AT_EX document in WinEdt in which we'll practice mathematical commands.

```
\documentclass{article}

\usepackage{amsmath, amsthm, amssymb, amsfonts}

% This is just a comment.

\begin{document}

\end{document}
```

17 Math Modes

- In order to display mathematical content in L^AT_EX, we will use a new set of commands that we wouldn't need for, say, writing a letter. However, L^AT_EX doesn't allow you to issue these commands just anywhere.
- Rather, you need to be either in math mode or in a mathematical *environment* where the math mode is implied.
- There are two math modes which don't utilize special *environments*: *in-line* math and *display math*.
- These two are analogous to the way we include quotes in our own written work.

In-line Sometimes the quotes are treated like any other text and printed in the same sized font without any special indentation.

Display Sometimes the quotes begin on new lines, are indented, and quite distinct from the other text.

- As a note, some commands and characters can only be entered in math mode. However, many, like the word “computer” can be entered in normal mode and math mode. Yet, if you think “computer” is different from “*computer*”, then you must beware which mode you use.
- After this section, it will be assumed that all math command sequence are typed in math mode. Otherwise, they will almost always fail. The math mode openings and closings are omitted.

In-line Math

- The *in-line* math mode is opened by typing a single dollar sign (\$) and then closed by typing a single dollar sign.
- The content is placed in between the two \$ symbols.
- When we type `$55/i = \pi^{-0.3}$`, we get $55/i = \pi^{-0.3}$. Any lines immediately following the in-line text are entirely unaffected, including this one. And this one, too.

Display Math

- The *display* math mode is opened by typing `\[` and closed by typing `\]`. Another approach is to use double dollar signs as in the in-line mode (`$$... $$`). However, the square bracket approach is considered “better”.
- Again, the content to be displayed in the math mode is placed between the opening and closing key sequences.
- Now, when we type `\[55/i = \pi^{-0.3}\]`, we get

$$55/i = \pi^{-0.3},$$

which is the same as when we type `$$55/i = \pi^{-0.3}$$` and we get

$$55/i = \pi^{-0.3}.$$

- Clearly the appearance of the *display* math is different from the *in-line* math. However, sometimes the differences go beyond indentation and size. Both $\int_0^\infty \sum_{n=1}^\infty \frac{1}{n} dx$ and

$$\int_0^\infty \sum_{n=1}^\infty \frac{1}{n} dx$$

have the same math mode code, but they are placed in the two different modes. In this examples, the limits of integration are the most obvious difference in how these expressions are rendered.

18 Superscripts and Subscripts

- To add a superscript to an expression use a hat, “ \wedge ”, after the term with the exponent. So, X^3 gives X^3 .
- If your exponent has more than one character to be rendered in the case of X^{3+y} , then we must surround the entire exponent in *curly braces* ($\{ \}$). For this previous expression we’d type $X^{\{3+y\}}$. In this sense, the *curly braces* group terms. When in doubt, use curly braces to set the scope of your exponent. Had we omitted the curly braces, we’d see $X^3 + y$ which is quite different.
- The principle for subscripting is identical, but we use the underscore, “ $_$ ”, instead. Typing $X_{\{3+y\}}$ gives X_{3+y} .
- Super- and subscripting can be recursive. However, one must be very careful with braces in this case. We can typeset e^{x_i} with $e^{\{x_{\{i\}}\}}$. Now, the braces around the i term are optional. Remove them, what happens to the rendering? Remove the braces around the x_i term. Compile the document. What happens to the rendering?
- Both superscripts and subscripts can be used simultaneously. In Social Choice, we often care about the median voter’s preference, denoted x_i^m . This can be achieved with either $x_{\{i\}}^m$ or $x_{\{i\}^m}$. The latter is more typing, but forces you to be explicit about the scope which tends to reduce the number of errors.

19 Operators

$+$	\bigcup	\sim
$=$	\bigcap	\approx
$-$	\forall	\Leftrightarrow
$/$	\exists	\leftrightarrow
$<$	\subset	\Leftarrow
$>$	\subseteq	\leftarrow
\leq	\subsetneq	\Rightarrow
\geq	\supset	\rightarrow
\vee	\supseteq	$/$
\wedge	\supsetneq	\neg
\bigvee	\int	\div
\bigwedge	\sum	∞
\cup	\prod	\emptyset
\cap	∂	\in

20 Greek Letters

- Greek letters are uncomfortably common in the work we do, so you will get used to including them in your documents.
- Although there are neither ζ nor χ keys on your keyboard, we can include these symbols in the math environment in a very intuitive way. Type `\name-of-letter` or `\Name-of-letter` for the lower-case and upper-case version of the Greek letter.
- So, `\delta` and `\Delta` give δ and Δ , respectively.
- Not every letter has a special upper-case version provided. Although `\beta` gives β `\Beta` is undefined.
- Not every letter has a special character, regardless of case. For example, the Greek omicron is just like the Roman ‘o’, so `o` gives o which will be sufficient.
- With Greek letters a particular issue arises often, although it isn’t specific to Greek letters. \LaTeX commands do not need a leading space before the `\`. Yet, they do need a trailing space so that \LaTeX knows the name of the command is over. So, `X\beta` ($X\beta$) is rendered identically to `X \beta` ($X\beta$) because \LaTeX has its own way of interpreting whitespace. However, `X\beta + \epsilon` ($X\beta + \epsilon$) works whereas `X \beta + \epsilon` will not because `\beta +` is an undefined control sequence (i.e. we just made up that command).

21 Other Letter-y Things

Sometimes we need to present change the presentation of standard letters or symbols in math mode. Here are several common examples. The way these work is that whatever symbols are to have their face changed are passed to these commands as arguments. Notice how the “math” faces remove white space

Modification	Command	Example	Common Uses
Normal Math Face	—	$ABCXY$	most maths
Roman Face	<code>\textrm{}</code>	$ABC\,XY$	text within equation
Bold Math Face	<code>\mathbf{}</code>	\mathbf{ABCXY}	vectors and matrices
Blackboard Math	<code>\mathbb{}</code>	\mathbb{ABCXY}	special sets of numbers
Calligraphic Math	<code>\mathcal{}</code>	\mathcal{ABCXY}	arbitrary sets

22 Special Text-like Mathematical Expressions

Certain functions, operators, and constructs pop up in math frequently which are basically abbreviates for words. The cosine function—as in $\cos(\pi) = 1$ —and the limit of an expression—as in $\lim_{x \rightarrow \infty} \frac{1}{x}$ —are two such examples. If we just typed `\cos` (\cos) or `\lim` (\lim) we get results quite different. An incomplete list of the expressions for which the control sequences are defined is below.

<code>det \det</code>	<code>min \min</code>	<code>cos \cos</code>	<code>exp \exp</code>
<code>lim \lim</code>	<code>inf \inf</code>	<code>sin \sin</code>	<code>Pr \Pr</code>
<code>max \max</code>	<code>sup \sup</code>	<code>tan \tan</code>	<code>arg \arg</code>

23 Delimiters

Many times, we need to express groupings through the use of delimiters. For example, $(100 - 100)^{100}$ is quite different than $100 - 100^{100}$. For parentheses we can just enter `(x)`. For curly braces we enter `{x}`. And, lastly, for square brackets we use `[x]`. These produce (x) , $\{x\}$, and $[x]$, respectively. In longer expressions, though, the results can look funny. In

$$[\sum_{x=1}^3\{(\int_0^x(e^y dy))\}],$$

the size of the delimiters is off. However, in

$$\left[\sum_{x=1}^3\left\{\left(\int_0^x(e^y dy)\right)\right\}\right],$$

the problems seem to be gone. If we type `\left(`, `\left\{`, or `\left[` and close the expression off with the appropriate `\right)`, `\right\}`, or `\right]`, the sizes are determined by the size of the internal expression as opposed to being constant.

24 Accents

Often times we need to modify slightly a character to denote that the construct has slightly changed. For example, we want

- not the true parameter β but the estimate $\hat{\beta}$,
- not the random variable y , but the sample mean \bar{y} , or
- not the singleton x , but a vector \vec{x} .

A partial list of these accents is below.

<code>á \acute{a}</code>	<code>é \dot{e}</code>	<code>ĩ \tilde{\imath}</code>
<code>̄b \bar{b}</code>	<code>̈f \ddot{f}</code>	<code>→j \vec{j}</code>
<code>ċ \breve{c}</code>	<code>ğ \grave{g}</code>	<code>xyz \widehat{xyz}</code>
<code>đ \check{d}</code>	<code>ĥ \hat{h}</code>	<code>xyz \widetilde{xyz}</code>

25 Assignment!

Questions

Write L^AT_EX code for the following expressions. Confirm that your compiled document matches these.

1.

$$\neg((T \vee F) \wedge F) \vee (T)$$

2.

$$e^{ix} = \cos x + i \sin x$$

3.

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \epsilon_i$$

4.

$$\left(\sum_{x=1}^{\infty} (1/x) \right) - \left(\sum_{x=1}^{\infty} (1/x)^2 \right)$$

Answers

1.

$$\neg((T \vee F) \wedge F) \vee (T)$$

2.

$$e^{ix} = \cos x + i \sin x$$

3.

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \epsilon_i$$

4.

$$\left(\sum_{x=1}^{\infty} (1/x) \right) - \left(\sum_{x=1}^{\infty} (1/x)^2 \right)$$