

Introduction to L^AT_EX for Helping Manage the Complexity of Your Dissertation and More

 Dr. Daniel R. Herber

 Colorado State University – Department of Systems Engineering
 daniel.herber@colostate.edu

November 3, 2023; Fort Collins, CO, USA



→ Outline

1. Introduction to \LaTeX
2. Basics of \LaTeX
3. Overleaf
4. Discussion
 - Advantages
 - Challenges
5. Resources



①

Introduction to L^AT_EX

→ L^AT_EX Introduction

- L^AT_EX is a document preparation system for high-quality typesetting
- L^AT_EX itself is *free* software (with many free, freemium, and paid supporting products)

I will initially liken L^AT_EX vs. Word to Python vs. Excel; both have their uses, but once you know the commands and tools in Python, there are tasks you will only do through Python code.

Have a Conversation First

If you find what you see in the presentation interesting and want to pursue it in your own work, be sure to have a conversation with your advisor and collaborators first (and with insights from Section 4). The research is more important than how it is written up!

→ How Does It Work? (1): Describe What It Is

- You write most of your document content in `plain text` with **commands** that describe its structure and meaning
- A `latex` program processes your *content* (text, commands, images, and more) to produce a beautifully formatted document

The `\textbf{rain}` in Spain
falls `\textit{mainly}` on
the plain.

latex →

The **rain** in Spain falls *mainly*
on the plain.

- Use commands to primarily describe *what it is*, not how it looks

→ A Minimal Example

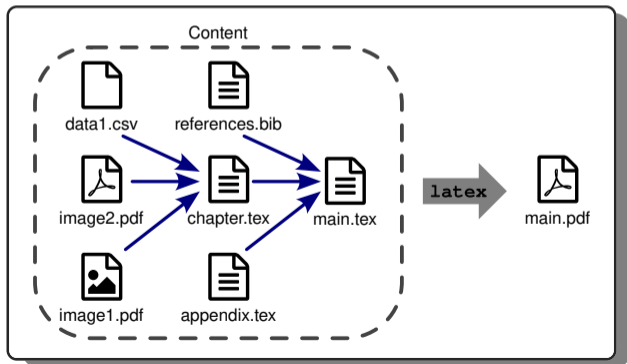
- A minimal \LaTeX document (within a file with extension `.tex`):

```
\documentclass{article}
\begin{document}
% a useful comment
The \textbf{rain} in Spain falls \textit{mainly} on the plain.
\end{document}
```

- **Commands** start with a *backslash* `\`
- Every document starts with a `\documentclass` command
- The *argument* in curly braces `{ }` indicates what kind of document we are creating: an **article**
- A percent sign `%` starts a *comment* — will ignore the rest of the line

→ How Does It Work? (2): Compiling Content Together

- Multiple files can be part of your *content*, including files with text and commands (`.tex`), figures (`.pdf`, `.png`, `.jpg`), references (`.bib`), and data (`.csv`)
- Utilize `\input` and `\include` for composing `.tex` files
- These files are then *compiled* together to make the formatted document (typically a `.pdf` file)



②

Basics of L^AT_EX

→ Environments (1): Different Equation Contexts

- **equation** is an *environment* — a context
- A **command** can produce different output in different contexts

We can write

```
$$\Omega = \sum_{k=1}^n \omega_k$
```

in text, or we can write:

```
\begin{equation}
```

```
  \Omega = \sum_{k=1}^n \omega_k
```

```
\end{equation}
```

to display it.

We can write $\Omega = \sum_{k=1}^n \omega_k$ in text, or we can write:

$$\Omega = \sum_{k=1}^n \omega_k \quad (2)$$

to display it.

- Note how the Σ is bigger in the **equation** environment, and how the subscripts and superscripts change position, even though we used the same commands

→ Environments (2): Lists

- The `\begin` and `\end` commands are used to create many different environments
- The `itemize` and `enumerate` environments generate lists

```
\begin{itemize} % for bullet points  
\item Biscuits  
\item Tea  
\end{itemize}
```

- Biscuits
- Tea

```
\begin{enumerate} % for numbers  
\item Biscuits  
\item Tea  
\end{enumerate}
```

1. Biscuits
2. Tea

→ Packages

- All of the commands and environments we've used so far are built into \LaTeX
- *Packages* are libraries of extra commands and environments
- There are thousands of freely available packages (see Slides 32 and 33)
- We have to load each of the packages we want to use with a `\usepackage` command in the *preamble*
- Example — **fontawesome**¹ provides 634 web-related icons

```
\documentclass{article}
\usepackage{fontawesome} % preamble
\begin{document}
% now we can use commands from fontawesome here...
\end{document}
```

Now for some icons:

```
\faThumbsOUp{} \faTag{} \faSmileO{}
```



¹ ctan.org/pkg/fontawesome

→ Structured Documents

- The default **commands** for document structuring are: `\title`, `\author`, `\date`, `\maketitle`, `\section`, `\subsection`, and `\subsubsection`
- Use the **abstract** environment to make an abstract
- `\chapter` is available in some classes

```

\documentclass{article}
\begin{document}
\title{The Title}
\author{A. Author}
\date{\today}
\maketitle
\begin{abstract}
Abstract goes here...
\end{abstract}
\section{Section}
Content \ldots
\subsection{Subsection}
\subsubsection{Subsubsection}
More content \ldots
\section*{Unnumbered Section}
\end{document}

```

The Title

A. Author

October 31, 2023

Abstract

Abstract goes here...

1 Section

Content ...

1.1 Subsection

1.1.1 Subsubsection

More content ...

Unnumbered Section

→ Labels and Cross-References

- Use `\label` and `\ref` for cross-referencing and automatic numbering
- Works with sections (and variants), equations, figures, tables, lists, etc.

```

\documentclass{article}
\begin{document}
\section{Introduction}
\label{sec:intro}
This is Section \ref{sec:intro},
but Section \ref{sec:method} \ldots
\section{Method}
\label{sec:method} % defines a label
\begin{equation}
\label{eq:euler} % defines a label
e^{i\pi} + 1 = 0
\end{equation}
By Eq. (\ref{eq:euler}), \ldots
\end{document}

```

1 Introduction

This is Section 1, but Section 2...

2 Method

By Eq. (1), ...

$$e^{i\pi} + 1 = 0$$

(1)

→ Figures

- Requires the **graphicx** package¹, which provides `\includegraphics`
- Supported graphics formats including `.pdf`, `.eps`, `.png`, and `.jpg`
- The `figure` environment is a kind of *float* — \LaTeX will mostly decide where the figure will go (it can “float”)

```

\documentclass{article}
\usepackage{graphicx}
\begin{document}

Figure \ref{fig:logo} shows \ldots

\begin{figure}
\centering % center the figure
\includegraphics[height=1in]{csu-logo}
\caption{\label{fig:logo}Go Rams!}
\end{figure}

\end{document}

```



Figure 1: Go Rams!

Figure 1 shows ...

¹ ctan.org/pkg/graphicx

→ References with bib_TE_X(1): Creating the Database

- Put your references in a `.bib` file in the bib_TE_X database format
- There are many available *entry* types with specific *fields* that can be populated
- Each entry in the `.bib` file has a *key* that you can use to reference it in the document — `Call2022b` for the article entry below

```
@article{Call2022b,  
  author   = {Call, Daniel R. and Herber, Daniel R.},  
  title    = {Applicability of the diffusion of innovation theory to  
  accelerate model-based systems engineering adoption},  
  journal  = {Systems Engineering},  
  volume   = {25},  
  number   = {6},  
  pages    = {574--583},  
  month    = nov,  
  year     = {2022},  
  doi      = {10.1002/sys.21638},  
}
```

- Most reference managers can create an (initial) bib_TE_X entry (see Slide 31 for more info)

→ References with bibT_EX(2): Including Citations

- Can automatically format your in-text citations and generate a list of references with many standard styles available
- Use `\cite` in the text when you want to include a citation
- Include `\bibliography` at the end, and specify a `\bibliographystyle`

```

\documentclass{article}
\begin{document}

Reference \cite{Call2022b} is
a cool paper. We also cite
a great book \cite{Borky2019-EMBSE}.

% reference style
\bibliographystyle{ieeetr}

% reference list with a .bib file
\bibliography{bib-example}

\end{document}

```

Reference [1] is a cool paper. We also cite a great book [2].

References

- [1] D. R. Call and D. R. Herber, "Applicability of the diffusion of innovation theory to accelerate model-based systems engineering adoption," *Systems Engineering*, vol. 25, pp. 574-583, Nov. 2022.
- [2] J. M. Borky and T. H. Bradley, *Effective Model-Based Systems Engineering*. Springer, 2019.

→ More Document Structuring and Custom Commands

- Add the `\tableofcontents` command to generate a table of contents from the `\section` and its variants
- Also consider `\listoffigures` and `\listoftables`
- You can also define your own commands with `\newcommand` for uniform, repeatable, and updatable tasks

```
\newcommand{\myformat}[1]{%
\textcolor{red}{#1}}

\myformat{The equation} has
my formatting applied:
\myformat{$x^2 + y^2 = z^2$}
```

The equation has my formatting applied: $x^2 + y^2 = z^2$

- Basic format is `\newcommand{command}[arguments]{definition}`

→ [Read Later!] Basic Spacing and Whitespace

- For the most part, you can just type your text normally:

```
Words are separated by one or more spaces.
```

```
Paragraphs are separated by one or more blank lines.
```

Words are separated by one or more spaces.

Paragraphs are separated by one or more blank lines.

- Space in the source file is collapsed in the output:

```
The rain in Spain % a comment  
falls mainly on the plain.
```

The rain in Spain falls mainly on the plain.

→ [Read Later!] Quotation Marks and Special Characters

- For quotation marks, use backticks ``` on the left and apostrophes `'` on the right:

Single quotes: ``text``.

Double quotes: ```text```.

Single quotes: `'text'`.

Double quotes: `"text"`.

- Some common characters have special meanings, including `%` percent sign, `#` hash (pound/sharp) sign, `&` ampersand, and `$` dollar sign
- If you just type these, you'll get an error
- If you want one to appear in the output document, you have to *escape* it by preceding it with a backslash:

`\$\%\&\#!`

`$%&#!`

→ [Read Later!] Tables

- Use the `tabular` environment from the `tabularx` package¹
- The argument specifies column alignment — `left`, `right`, `right`
- It also specifies vertical lines with `|`; use `\hline` for horizontal lines
- Use an ampersand `&` to separate columns and a double backslash `\\` to start a new row
- The `table` environment is also a kind of float

```

\begin{table}
\caption{\label{tab:items}My table.}
\begin{tabular}{l|r|r} \hline \hline
Item & Qty & Unit \ $ \\ \hline
Widget & 1 & 199.99 \\
Gadget & 2 & 399.99 \\
Cable & 3 & 19.99 \\ \hline \hline
\end{tabular}
\end{table}

```

Table `\ref{tab:items}` is a float `\ldots`

Table 1: My table.

Item	Qty	Unit \$
Widget	1	199.99
Gadget	2	399.99
Cable	3	19.99


Table 1 is a float ...

¹ ctan.org/pkg/tabularx

③

Overleaf

→ Overleaf

- Overleaf ( www.overleaf.com) is a website for writing documents in \LaTeX
- It compiles your \LaTeX automatically to show you the results with no setup needed — get instant access with a Web browser
- Collaboration made easy with sharing, viewing collaborators' cursors and edits in real-time, comments/reply in the document, and built-in chat
- Synchronizes changes from all authors transparently, so everyone always has the latest version
- Autocomplete for **commands** generally and `\includegraphics`, `\input`, `\ref`, and `\cite` inputs based on your project
- Visual Editor for less code and more visual editing
- Other features as well¹

¹  www.overleaf.com/about/features-overview

→ Learning Materials


- Homepage of the Overleaf knowledge base is a great resource¹
 - How do I use Overleaf?²
 - Creating a document in Overleaf³
 - Learn LaTeX in 30 minutes with Overleaf⁴
- Many videos on this topic⁵
- Additional general learning materials in Section 5

¹  www.overleaf.com/learn

²  www.overleaf.com/learn/how-to/How_do_I_use_Overleaf%3F

³  www.overleaf.com/learn/how-to/Creating_a_document_in_Overleaf

⁴  www.overleaf.com/learn/latex/Learn_LaTeX_in_30_minutes

⁵  www.youtube.com/results?search_query=overleaf

→ CSU Thesis/Dissertation L^AT_EX Template on Overleaf

- This read-only Overleaf document is based on the one provided by the Graduate School¹ with additional project structure and L^AT_EX content to help you get started
- Conforms to their formatting guidelines²; you *just* add the content!
- Examples on Mountain Scholar using this template below³

```
\centering  
\qrcode[height=1.2in,  
]{https://www.overleaf.com/read/pfmyndbspfdk}
```



- This code snippet utilizes the `qrcode` package⁴ (you can click it)

¹ github.com/idfah/csuthesis ² graduateschool.colostate.edu/thesis-dissertation ³ hdl.handle.net/10217/235652, hdl.handle.net/10217/235332, hdl.handle.net/10217/234210, hdl.handle.net/10217/233718 ⁴ ctan.org/pkg/qrcode

④

Discussion

→ Advantages (1): Content First and Modularity

- *Content First* — let \LaTeX focus on formatting, you can focus on the content
 - Everything can be done in the text editor; limited clicking through menus
 - Can holistically modify presentation/organization later with commands
 - Use comments to add working content as you go, maintain multiple options, and keep older wording
- *Modularity* — organize your research effort as you see fit
 - Utilize `\input` and `\include` to manage the complexity of a 100+ page dissertation with multiple `.tex` files (as illustrated on Slide 7)
 - Leverage comments to focus on only a part (e.g., a single chapter)
 - Different contributors can better find individual files and can have ownership over specific inputs
 - Organize files (e.g., images) and methods to generate them; no moving files around to create your document

→ Advantages (2): Reusability and Consistency

- *Reusability* — use things more than once
 - Natural to reuse packages and custom commands but also reuse content and equations in a different context (e.g., a conference paper vs. presentation)
 - A single `.bib` reference database for different products with one line change to `\bibliographystyle` (as shown on Slide 15)
 - Overleaf supports reusing files from other projects¹
- *Consistency* — more confidence that content is uniform and up-to-date
 - Natural consequence of letting \LaTeX handle most of the formatting
 - Many templates for conformity with formatting guidelines (see Slide 34); you can define your own for your research group/organization
 - Cross-references always up-to-date (as shown on Slide 12)

¹ [www.overleaf.com/learn/how-to/Can_I_share_files_\(e.g....bib_and_some_graphics\)_across_my_projects%3F](https://www.overleaf.com/learn/how-to/Can_I_share_files_(e.g....bib_and_some_graphics)_across_my_projects%3F)

→ Advantages (3): Automation and Efficiency

- *Automation* — make \LaTeX work for you
 - Create custom commands (as shown on Slide 16) once and use as needed (for both formatting and content)
 - Leverage packages to do things for you like create QR codes and load `.csv` data (see Section 5 for more examples)
 - Change the formatting of all similar environments in one go
- *Efficiency* — do things faster
 - A “flatten” toolset with limited time navigating through menus (faster once you know the commands)
 - Many of the points already mentioned

→ Advantages (4): Collaboration

- *Collaboration* — existing and new ways to collaborate and review
 - Annotating the outputted `.pdf` is still an option
 - Traditional \LaTeX approaches include comments and formatting commands (see example below)
 - Works well with general version control (e.g., Git)
 - Overleaf works like Google Docs or Microsoft 365 Online with real-time viewing of a collaborators' cursors and edits¹, comments/reply in the document's margin, and built-in chat

```
\newcommand{\xdrh}[1]{\color{red}*#1}
% DRH: I made this change
The \textbf{rain} in \xdrh{Spain
falls \textit{mainly}} on
the plain
```

The **rain** in **Spain falls mainly*
on the plain

¹ Also a premium feature for real-time track changes and accept/reject each individual change

→ Challenges (1): Learning Curve, Errors, and Collaboration

- *Learning Curve* — as with any new process, there is certainly some upfront learning effort to be effective
 - Lots of resources to help in Section 5
- *Errors* — potentially (cryptic) errors that prevent any output (see Slide 29)
- *Collaboration* — even with the points made on the previous slide, it can still be challenging for unfamiliar collaborators
 - It can be very frustrating to not be able to provide or see your feedback
 - Again, please consider the statement on Slide 3

→ Challenges (2): Grammar, Spellcheck, and Moving Images

- *Grammar and Spellcheck* — due to the use of **commands** and other non-traditional “non-content”, there are sometimes issues providing good spellcheck and grammar suggestions
 - Many \LaTeX -centric editors know there are **commands** so still can provide good spellcheck
 - Tools like Grammarly¹ work within Overleaf, but are not perfect
 - Another option is to copy the formatted text in the outputted **.pdf** into another program for review
- *Moving Images* — quite challenging to directly include moving image files (e.g., **.gif**) and video in the **.pdf** output

¹  app.grammarly.com/

→ Handling Errors

- \LaTeX can get confused when it is trying to compile your document
- If it does, it stops with an error, which you must fix before it will produce any output
- For example, if you misspell `\emph` as `\meph`, \LaTeX will stop with an “undefined control sequence” error, because “meph” is not one of the **commands** it knows
- List of common errors below¹

Advice on Errors

1. Don't panic! Errors happen
2. Fix them as soon as they arise — if what you just typed caused an error, you can start your debugging there
3. If there are multiple errors, start with the first one — the cause may even be above it
4. Compile often






¹  www.overleaf.com/learn/latex/Errors

5

Resources

→ More Learning Resources

- Several large parts of these slides were based on an excellent *Interactive Introduction to L^AT_EX* by John D. Lees-Miller¹
- *The Overleaf Learn Wiki* — hosts lots of tutorials and reference material²
- *The L^AT_EX Wikibook* — excellent tutorials and reference material³
- *Overleaf Examples* — searchable examples of powerful L^AT_EX packages and techniques in use⁴
- *T_EX Stack Exchange* — ask questions and get excellent answers⁵
- *L^AT_EX Community* — a large online forum⁶
- *Comprehensive T_EX Archive Network (CTAN)* — over four thousand packages plus documentation⁷
- *The L^AT_EX Companion* — a great book by Frank Mittelbach with Ulrike Fischer
- *The Not So Short Introduction to L^AT_EX* — another great book⁸
- Google will usually get you to one of the above

¹  github.com/jdleesmiller/latex-course ²  www.overleaf.com/learn ³  en.wikibooks.org/wiki/LaTeX
⁴  www.overleaf.com/latex/examples ⁵  tex.stackexchange.com ⁶  latex.org/forum ⁷  ctan.org
⁸  tobi.oetiker.ch/lshort/lshort.pdf











→ Bibliography Resources

- List of bibT_EX entry types and fields¹ and styles²
- Standalone tools for generating bibT_EX entries from a DOI, URL, ISBN, arXiv, etc. include zotero**ib**³, crosscite⁴, and bibtex.com⁵
- Reference managers that work well with bibT_EX and/or Overleaf include JabRef⁶ and Zotero⁷
- Packages for enhanced bibliographic facilities in L^AT_EX:
 - **natbib**: additional features such as author-year citations⁸
 - **biblatex**: a modern, more powerful package for bibliographies⁹; used in the modified CSU dissertation template on Slide 22

¹  www.bibtex.com/format ²  www.bibtex.com/styles ³  zbib.org ⁴  citation.crosscite.org ⁵  www.bibtex.com/converters ⁶  www.jabref.org ⁷  www.zotero.org ⁸  ctan.org/pkg/natbib ⁹  ctan.org/pkg/biblatex

→ Some Basic Packages

- **hyperref**: hypertext links in the document from cross-referencing commands¹
- **amsmath**, **amssymb**, **amsthm**: essential for mathematical typesetting in \LaTeX ²
- **mathtools**: mathematical tools to use with **amsmath**³
- **listings**: display stylized source code⁴
- **xcolor**: color extensions for eight color models and ways to create tints, shades, tones, and mixes of arbitrary colors⁵
- **bm**: better bold math symbols⁶
- **longtable**: allow tables to flow over page boundaries⁷
- **pdfpages**: inclusion of external multi-page PDF documents⁸
- **cite**: compressed, sorted lists of numerical citations⁹
- **latex-tools**: collection of (variously) simple tools, including some of the packages above¹⁰

¹  ctan.org/pkg/hyperref ²  ctan.org/pkg/amsmath ³  ctan.org/pkg/mathtools ⁴  ctan.org/pkg/listings
⁵  ctan.org/pkg/xcolor ⁶  ctan.org/pkg/bm ⁷  ctan.org/pkg/longtable ⁸  ctan.org/pkg/pdfpages
⁹  ctan.org/pkg/cite ¹⁰  ctan.org/pkg/latex-tools

→ Some Advanced Packages

- **beamer**: for presentations (like this one!)¹
- **nicematrix**: improved matrices and tables²
- **booktabs**: better tables³
- **csvsimple**: processing of files with comma separated values (CSV)⁴
- **tcolorbox**: colored and framed textboxes with a heading line⁵
- **tikz**: make amazing graphics, but quite complicated⁶
- **glossaries**: create glossaries and lists of acronyms⁷
- **enumitem**: control layout of itemize, enumerate, description⁸
- **algorithm2e**: floating algorithm environment with algorithmic keywords⁹
- **microtype**: better interword spacing, kerning, and more¹⁰
- **catchfilebetween tags**: extracted portion of text delimited by strings; useful for responses¹¹

¹  ctan.org/pkg/beamer ²  ctan.org/pkg/nicematrix ³  ctan.org/pkg/booktabs ⁴  ctan.org/pkg/csvsimple
⁵  ctan.org/pkg/tcolorbox ⁶  ctan.org/pkg/tikz ⁷  ctan.org/pkg/glossaries
⁸  ctan.org/pkg/enumitem ⁹  ctan.org/pkg/algorithm2e ¹⁰  ctan.org/pkg/microtype ¹¹  ctan.org/pkg/catchfilebetween tags

→ Templates

- Many but not all professional organizations have \LaTeX templates for conference and journal submissions
 - **Official:** IEEE¹, AIAA², ASME³, Wiley⁴, Elsevier⁵, Springer⁶, MDPI⁷, ASCE⁸, NREL⁹
 - **Unofficial** (or not officially supported): SAE¹⁰, INCOSE¹¹
- Templates for things like a resume, CV, cover letter, posters, presentations, etc. on Overleaf¹²

¹ www.ieee.org/conferences/publishing/templates.html, www.overleaf.com/gallery/tagged/ieee-official

² www.aiaa.org/events-learning/events/Technical-Presenter-Resources, www.overleaf.com/project/65428c4f5ee74287b9bd2cb3

³ www.asme.org/publications-submissions/proceedings/author-guidelines/elements-of-a-paper/author-templates, ctan.org/pkg/asmecconf, www.asme.org/publications-submissions/journals/information-for-authors/overleaf

⁴ authorservices.wiley.com/author-resources/Journal-Authors/Prepare/new-journal-design.html, www.overleaf.com/latex/templates?q=wiley

⁵ beta.elsevier.com/researcher/author/policies-and-guidelines/latex-instructions, www.overleaf.com/latex/templates?q=elsevier

⁶ preview.springer.com/gp/livingreviews/latex-templates, www.springernature.com/gp/authors/campaigns/latex-author-support, www.overleaf.com/latex/templates?q=springer

⁷ www.mdpi.com/authors/latex, www.overleaf.com/latex/templates/mdpi-article-template/fcpwsspzfzsp

⁸ ascelibrary.org/author-center/journal#latex-guide ⁹ github.com/NREL/latex_editing ¹⁰ volunteers.sae.org/authors/techpaperfaq.pdf

¹¹ www.overleaf.com/latex/templates?q=sae ¹¹ HRG template coming soon

¹² www.overleaf.com/latex/examples

→ Installing L^AT_EX on Your Own Machine

- To run L^AT_EX on your own computer, you'll want to use a L^AT_EX *distribution* — includes a `latex` program and (typically) several thousand packages
- Two popular distributions are MikT_EX¹ and T_EX Live²
- You'll also want a text editor with L^AT_EX support — see link below³ for a list of (many) options

¹  miktex.org ²  tug.org/texlive ³  en.wikipedia.org/wiki/Comparison_of_TeX_editors

→ Inkscape and TeXText for \LaTeX Vector Images

- Inkscape¹ is a great, free vector image editor that works great in \LaTeX workflows
 - Lossless editing of `.svg` and `.pdf` images
 - Exports to `.pdf` and `.eps` lossless formats
- TeXText² extension allows you to add and re-edit \LaTeX generated elements to your drawing

¹  inkscape.org ²  texttext.github.io/texttext


Thanks!




Introduction to \LaTeX for Helping Manage the Complexity of Your
Dissertation and More

 Dr. Daniel R. Herber

 Colorado State University

 daniel.herber@colostate.edu

Slides (QR code above):

 www.engr.colostate.edu/~drherber/files/latex-introduction.pdf

→ XKCD Comic 1301: File Extensions

