

# L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> Workshop

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# How do you write a document?

Appearance  
before structure



**“WYSWYG”  
worse at both**

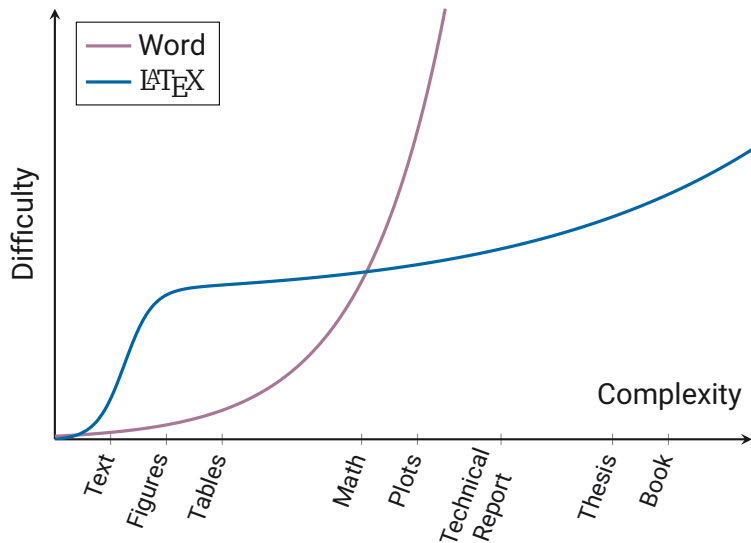


Structure before  
appearance

$\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X } 2_{\epsilon}$



# Why engineers should know $\text{\LaTeX}$



# Goal: Learn to typeset something like this

The last equality follows by observing that  $(\Omega \setminus B_R(\mathbf{r}_0)) \cap B_R(\mathbf{r}_0) = \emptyset$ , and the argument above. The RHS is the electric flux generated by a charged sphere, and so:

$$\Phi(R) = \frac{Q(R)}{\varepsilon_0} = \frac{1}{\varepsilon_0} \int_{B_R(\mathbf{r}_0)} \rho(\mathbf{r}') \, d\mathbf{r}' = \frac{1}{\varepsilon_0} \rho(\mathbf{r}'_c) |B_R(\mathbf{r}_0)| \quad \text{with } r'_c \in B_R(\mathbf{r}_0)$$

Where the last equality follows by the mean value theorem for integrals. Finally for the Squeeze theorem and the continuity of  $\rho$ :

$$\nabla \cdot \mathbf{E}_0(\mathbf{r}_0) = \lim_{R \rightarrow 0} \frac{\Phi(R)}{|B_R(\mathbf{r}_0)|} = \frac{\rho(\mathbf{r}_0)}{\varepsilon_0}$$

## 7.2 Deriving Coulomb's law from Gauss's law

Strictly speaking, Coulomb's law cannot be derived from Gauss's law alone, since Gauss's law does not give any information regarding the curl of  $\mathbf{E}$  (see Helmholtz decomposition and Faraday's law). However, Coulomb's law can be proven from Gauss's law if it is assumed, in addition, that the electric field from a point charge is spherically symmetric (this assumption, like Coulomb's law itself, is exactly true if the charge is stationary, and approximately true if the charge is in motion).

# About this presentation

## Content

- $\text{\LaTeX}$  is *learn by doing*
- Will be mostly examples
- Sorry for the crowded slides

## Example

Things in green boxes are examples

## Tip

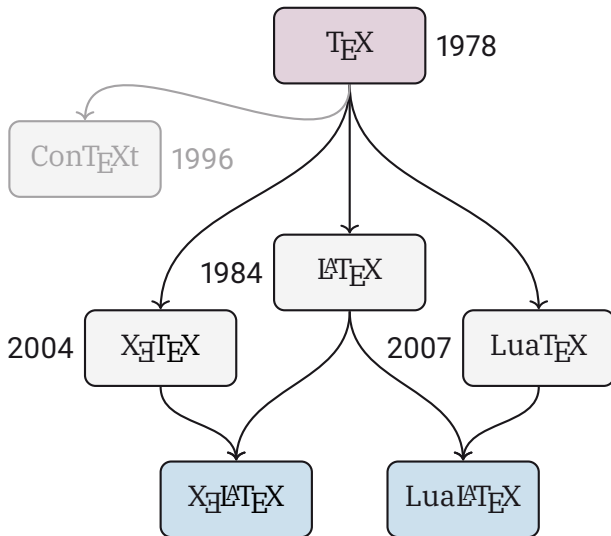
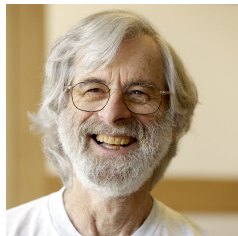
Things in red boxes are tips or extras

# Do yourself a favor

## Use the International US Keyboard Layout

~	! 1	@ 2	# 3	\$ 4	£ 5	% 6	^ 7	& 8	* 9	( 0	) 1	+ 2	÷ 3	← Backspace													
Tab ↵	Q	Å	W	Ä	E	É	R	T	Þ	Y	Û	Ü	Í	Í	O	Ó	P	Ö	{	}	[	«	»	]	\		~
Caps Lock ⬆	A	Å	S	Š	D	Đ	F	G	H	J	K	L	Ø	:	°	"	"	:	¶	'	'	↶	↷	↶	↷	↶	↷
Shift ⬆	Z	Æ	X	C	¢	V	B	N	Ñ	M	<	Ç	>	?	Shift ⬆												
Ctrl	Win Key	Alt											Alt Gr	Win Key	Menu	Ctrl											

# History of T<sub>E</sub>X, what should you use?



A: Use X<sub>Ǝ</sub>L<sup>A</sup>T<sub>E</sub>X, it has UTF-8 support! (ä, ü, ô, ...)

# Table of Contents

**1** Fundamentals

2 Basics

3 Mathematics

4 Bibliography management

5 Extras



# Commands aka Macros

*\command* [*options*] {*parameters*}

```
\documentclass{article}
```

```
\LaTeX{}
```

```
\usepackage[a4paper]{geometry}
```

# Special characters

## Reserverd characters

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

## Replacement macros

```
\# \$ \% \^{} \& \_ \{ \}  
\textasciitilde{}  
\textbackslash{}
```

# Accents and Unicode

## Accents

If you use `pdflatex` you cannot use unicode!  
That means no `ä`, `ú`, `ò`, `ô`, `å`, `ě`, .... You will need to use

`\"a`, `\'u`, `\'o`, `\^o`, ...

instead.

## Tip

If you compile with `xelatex` or `lualatex` you will not have this problem!

# Quotation marks

L<sup>A</sup>T<sub>E</sub>X changes the style of the quotation mark according to the language (for ex “–”, «–», ...).

This is an incorrect way to have a “quoted word”.  
This is the correct way to have a ‘‘quoted word’’.

This is an incorrect way to have a “quoted word”.  
This is the correct way to have a “quoted word”.

To have “quotation marks”, *do not* use " (shift + 2).  
Use 2 grave accents ‘ and two apostrophes ’.

# Environments

```
\begin{environment} [options]
```

```
...
```

```
\end{environment}
```

```
\begin{document}    \end{document}
```

```
\begin{quote}    \end{quote}
```

```
\begin{math}    \end{math}
```

# Document structure

```
\documentclass[a4paper]{article}  
  
% preamble  
\title{A very simple document}  
\author{Naoki Pross}  
\date{\today}  
  
% content  
\begin{document}  
  
\maketitle  
...  
  
\end{document}
```

# Spacing and newlines

## In general

$\text{\LaTeX}$  does not care too much about whitespace

```
I can put          however many spaces      here.  
However if I leave  an empty   line, like  this
```

```
LaTeX will in indent this sentence because  
it is a new paragraph.
```

I can put however many spaces here. However if I leave an empty line, like this.

LaTeX will in indent this sentence because it is a new paragraph.

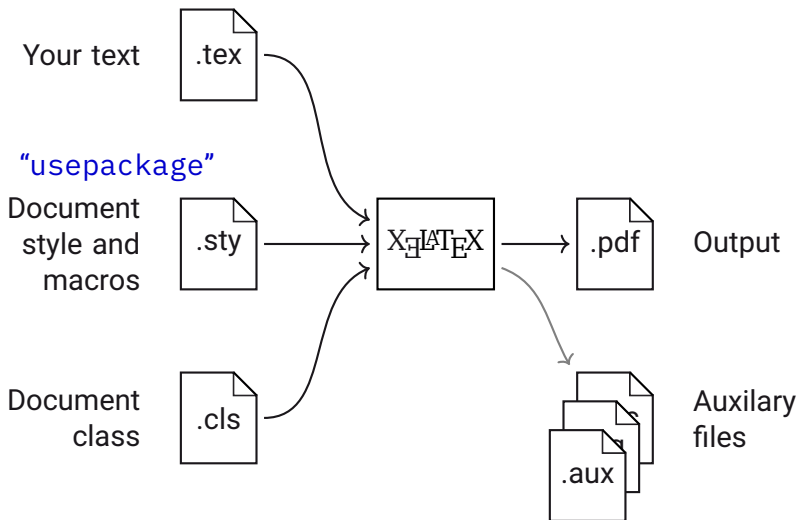
## What is CTAN

The Comprehensive T<sub>E</sub>X Archive Network is a set of Internet sites around the world that offer T<sub>E</sub>X-related material for download.

Wow, that doesn't mean anything. Just go to <https://ctan.org>



# Typesetting (aka “compilation”)



# Very big projects (like a thesis or a book)

```
\documentclass{thesis}

\usepackage{tex/mystyle}
\usepackage{tex/docmacros}
% preamble ...

\begin{document}
  \maketitle
  \tableofcontents

  \include{chapters/intro}
  \include{chapters/purpose}
  % ...
\end{document}
```

```
mybigproject/
├─ mybigproject.tex
├─ figures/
│   └─ reactor.eps
├─ tex/
│   ├── mystyle.sty
│   └─ docmacros.sty
└─ chapters/
    ├── intro.tex
    └─ purpose.tex
```

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# Headings

Numbered sections:

```
\part{}  
\chapter{}  
\section{}  
\subsection{}  
\subsubsection{}  
\paragraph{}  
\subparagraph{}
```

Unnumbered sections:

```
\section*{}  
\subsection*{}  
\subsubsection*{}
```

## Pro Tip

You can customize what these commands do with the `titlesec` package.

# Emphasis, Bold, Italic, ...

```
This is \emph{emphasized}.  
You may, but should not, also use  
\textbf{Bold},           % \bfseries  
\textit{Italic},         % \itshape  
\textsc{SmallCaps},      % \scshape  
\textsl{Slanted},        % \slshape  
\textsf{Sans-Serif},     % \sffamily  
\textrm{Roman},          % \rmfamily  
\texttt{Typewriter}.     % \ttfamily
```

This is *emphasized*. You may also use **Bold**, *Italic*, SMALLCAPS, *Slanted*, Sans-Serif, Roman, Typewriter.

# Lists

```
\begin{itemize}  
  \item Tomatoes  
  \item Peppers  
  \item Broccoli  
\end{itemize}
```

## Itemize

- Tomatoes
- Peppers
- Broccoli

```
\begin{enumerate}  
  \item Discover coffee  
  \item Get addicted  
  \item Congratulations  
\end{enumerate}
```

## Enumerate

- 1 Discover coffee
- 2 Get addicted
- 3 Congratulations

You can customize itemize, enumerate, description with the enumitem package.

# Description

```
\begin{description}  
  \item[Programmer] A person who is paid to  
    professionally scream at a computer.  
  
  \item[Manager] A person who appears to know how  
    all tasks should be accomplished but can't  
    actually do any of those tasks themselves.  
\end{description}
```

**Programmer** A person who is paid to professionally scream at a computer.

**Manager** A person who appears to know how all tasks should be accomplished but can't actually do any of those tasks themselves.

# Floating elements

Table 1: Floats placing permissions

Specifier	Permission
h	Place around here
t	At the top of the page
b	At the bottom of the page
p	On a special page containing only floats
!	"I don't care if it will be ugly"
H <sup>1</sup>	Place <b>exactly here</b> (may look very ugly)

## Pro tip

The algorithm is very good, it's better not give a specifier at all.

<sup>1</sup>Requires the "float" package, i.e. `"\usepackage{float}"`



# Tables and tabular

```
\begin{table}[h]
  \caption{Not up to date numbers\label{tab:covid}}
  \begin{tabular}{l r r}
    \toprule
    Country      & Infected & Deaths \\
    \midrule
    China        & 80'652 & 3'070 \\
    South Korea  & 7'041  & 44 \\
    Italy        & 5'833  & 233 \\
    \bottomrule
  \end{tabular}
\end{table}
```

## Pro Tip

Add “`\usepackage{booktabs}`” to use rulers. Do not use vertical rulers.

## Example Table

Table 2: Not up to date numbers

Country	Infected	Deaths
China	80'652	3'070
South Korea	7'041	44
Italy	5'833	233

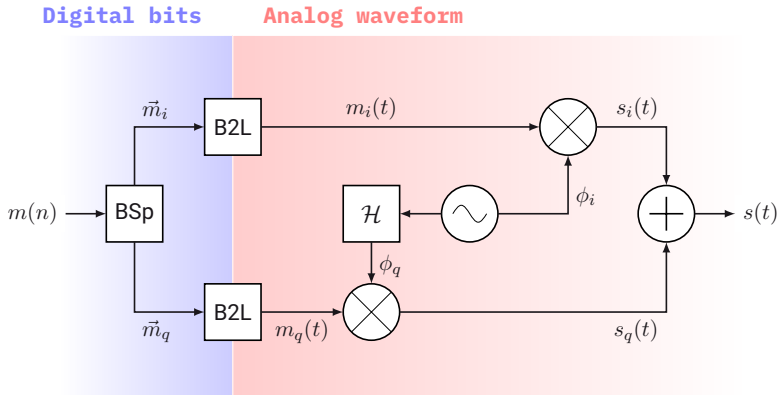
# Figures

```
\begin{figure}[h]
  % center stuff
  \centering

  % to include a picture, use eps, pdf, dvi
  % preamble: \usepackage{graphicx}
  \includegraphics[width = 5cm]{path/to/picture}
  % or if you have some TikZ code
  \input{path/to/tikz/code}

  \caption{
    A meaningful caption for my picture.
    \label{fig:meaningful-name}
  }
\end{figure}
```

# Figures



**Figure 1:** Block diagram of a QAM Modulator.

# Cross-References I: Floatings

```
\begin{figure} % or table
  \includegraphics{...}
  \caption{
    A stereographic projection.
    \label{fig:projection}
  }
\end{figure}

... as shown in figure \ref{fig:projection} ...
```

## Pro Tip

Put `\label` inside of `\caption`!

# Cross-References II: Parts of text

```
\section{Introduction}  
... will be discussed in \S \ref{sec:vstokes} ...  
  
\section{Stokes equation} \label{sec:vstokes}
```

## Document

### 1 Introduction

... will be discussed in §4 ...

### 4 Stokes Equation

...

## Pro Tip

Use prefixes such as `sec:`, `fig:`, `tab:`, `bib:`, `eqn:` to avoid mistakes.

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# Math environments

Environment	$\text{\LaTeX}$	$\text{\TeX}^2$
<code>math</code>	<code>\( ... \)</code>	<code>\$ ... \$</code>
<code>displaymath</code>	<code>\[ ... \]</code>	<code>\$\$ ... \$\$</code>
<code>equation</code>	—	—
<code>align</code>	—	—
<code>gather</code>	—	—

---

<sup>2</sup>Don't use them in  $\text{\LaTeX}$ . **For real: don't use them.**



# Example

The Pythagorean Theorem states that for a right triangle with sides  $(a,b,c)$  there is the relation:

$$\begin{aligned} &[ \\ & \quad c^2 = a^2 + b^2. \\ &] \end{aligned}$$

The Pythagorean Theorem states that for a right triangle with sides  $a, b, c$  there is the relation:

$$c^2 = a^2 + b^2.$$

# Math styles

With the packages `amsmath`, `amssymb`

```
\[
  \text{normal} % normal text
  \mathrm{R}    % roman
  \mathit{R}    % italic
  \mathbf{R}    % bold
  \mathsf{R}    % sans-serif
  \mathtt{R}    % typewriter
  \mathbb{R}    % blackboard bold
  \mathcal{R}   % calligraphy
  \mathfrak{R}  % fraktur
\]
```

normal    $\mathrm{R}$     $\mathit{R}$     $\mathbf{R}$     $\mathtt{R}$     $\mathbb{R}$     $\mathcal{R}$     $\mathfrak{R}$

# Sub- and Superscript

Hats and underscores

```
\[  
c = \sqrt{a^2 + b^2 - 2ab \cos( \alpha_{ab} )}  
\]
```

Cosine theorem

$$c = \sqrt{a^2 + b^2 - 2ab \cos(\alpha_{ab})}$$

# Sum and Integral

```
\[
% math community meme
\sum_{k = 1}^{\infty} k = - \frac{1}{12}
\hspace{1.5cm}

% fourier transform
F(\omega) = \int\limits_{-\infty}^{\infty}
  f(t) e^{-i\omega t} \mathrm{d}t
\]
```

Limits are similar with:  $\lim_{t \rightarrow a}$

$$\sum_{k=1}^{\infty} k = -\frac{1}{12}$$

$$F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt$$

# Matrices with amsmath

```
\[  
  \mathbf{J} = \begin{pmatrix}  
    0 & 1 \\  
    1 & 0  
  \end{pmatrix}  
\]
```

## The complex matrix

$$\mathbf{J} = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \quad \mathbf{R}_\phi = e^{\phi \mathbf{J}}$$

There are also `bmatrix`, `vmatrix`, `Bmatrix`, `Vmatrix`.

# Cross-References III: Equations

Equation `\eqref{eqn:schroedinger}` is the Schrödinger Equation that describes the evolution of a quantum state `\(\psi\)`.

```
\begin{equation} \label{eqn:schroedinger}
  i\hbar \partial_t \psi =
    - \frac{\hbar^2}{2m} \partial_x^2 \psi + V\psi
\end{equation}
```

Equation (1) is the Schrödinger equation that describes the evolution of a quantum state  $\psi$ .

$$i\hbar \partial_t \psi = -\frac{\hbar^2}{2m} \partial_x^2 \psi + V\psi \quad (1)$$

# Alignment

```
\begin{align*} % numbered when without *  
  \nabla \cdot \vec{F}(1,1)  
    &= \partial_x F_x + \partial_y F_y \\\br/>    &= 2x + 3y^4 \\\br/>    &= 2 + 3 \\\br/>    &= 5  
\end{align*}
```

$$\begin{aligned}\nabla \cdot \vec{F}(1,1) &= \partial_x F_x + \partial_y F_y \\ &= 2x + 3y^4 \\ &= 2 + 3 \\ &= 5\end{aligned}$$

# Subequations

Maxwell's equations in their integral form are:

```
\begin{subequations}
  \begin{align}
    \oint_{\partial S} \mathbf{E} \cdot d\mathbf{l} &= -\frac{d}{dt} \int_S \mathbf{B} \cdot d\mathbf{s} \dots
  \end{align}
\end{subequations}
```

Maxwell's equations in their integral form are:

$$\oint_{\partial S} \mathbf{E} \cdot d\mathbf{l} = -\frac{d}{dt} \int_S \mathbf{B} \cdot d\mathbf{s}, \quad (2a)$$

$$\oint_{\partial S} \mathbf{H} \cdot d\mathbf{l} = \int_S (\mathbf{J} + \partial_t \mathbf{D}) \cdot d\mathbf{s}, \quad (2b)$$

$$\oint_{\partial V} \mathbf{D} \cdot d\mathbf{s} = \int_V \rho \, dv, \quad (2c)$$

$$\oint_{\partial V} \mathbf{B} \cdot d\mathbf{s} = 0. \quad (2d)$$



Learn by doing: try to typeset these

$$x_{t+1} = kx_t(1 - x_t)$$

$$H = - \sum_{x \in \mathbb{X}} p(x) \log p(x)$$

$$\mathcal{L}^{-1}\{F\} = \lim_{T \rightarrow \infty} \frac{1}{2\pi i} \int_{\gamma - iT}^{\gamma + iT} e^{st} F(s) \, ds$$

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# The Bibliography

Only for **very short** bibliographies!

The industrial-technological society cannot be reformed in such a way as to prevent it from progressively narrowing down the sphere of human freedom\cite{unabomber}.

```
\begin{thebibliography}{9} % widest label
% manually set up MLA style
\bibitem{unabomber} Kaczynski, Theodore.
  \textit{''Industrial Society and Its Future.''}
  The Washington Post, 19 Sept. 1995.
\end{thebibliography}
```

# External bibliography (Better)

Put in the preamble:

```
%% Citations
\usepackage[
  backend = biber, % or bibtex (older)
  style = ieee, % or any other
]{biblatex}

\addbibresource{MyDocument.bib}
```

and then

```
\begin{document}
% use \cite{..} commands ...
\printbibliography
\end{document}
```

# BibTeX files: Example I

```
@article{Alimohammad2009,  
  title = {Compact Rayleigh and Rician fading ..},  
  author = {Alimohammad, A. and Fard, ...},  
  journal = {IET Commun.},  
  publisher = {Institution of Engineering and ...},  
  volume = {3},  
  number = {8},  
  pages = {1333},  
  year = {2009},  
  language = {en}  
}
```

# BibTeX files: Example II

```
@book{Griffith,  
  title = {Introduction to Electrodynamics ...},  
  author = {Griffiths, David J.},  
  year = {2017},  
  publisher = {Cambridge University Press; ...},  
  isbn = {978-1108420419}  
}
```

and many more

```
@article @book @collectedbook @conference  
  @electronic @ieeetrans @inbook  
  @incollectedbook @incollection @injournal  
  @inproceedings @manual @mastersthesis @misc  
  @patent @periodical @phdthesis @preamble  
  @proceedings @standard @string @techreport  
  @unpublished
```

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# Source code listings I: Settings

This presentation uses:

```
\usepackage{lstlistings}

% define a style
\lstdefinestyle{samplestyle}{
  belowcaptionskip=\baselineskip,
  breaklines=true,
  frame=none,
  inputencoding=utf8,
  % margin
  xleftmargin=\parindent,
  % numbers
  numbers=left,
  numbersep=5pt,
  ...
}

% use the style
\lstset{style=samplestyle, escapechar='}
```



## Source code listings II: Usage

Finally in your document:

```
\begin{lstlisting}[  
  language = python,  
  caption = {  
    FIR filter in python.  
  },  
  label = {lst:py-fir}]  
import numpy as np  
  
def tap(c, tau, f):  
    return np.exp(2j * np.pi * f * tau)  
  
f = np.logspace(5, 9, samples = 500)  
multipath = tap(.8, 500e-9, f) + tap(.4, 300e-9, f)  
\end{lstlisting}
```

lstlistings is pretty good, but there is also minted as alternative. minted requires python to be installed.

## Source code listings II: Usage (cont.)

Listing 1: FIR filter in python.

```
import numpy as np

def tap(c, tau, f):
    return np.exp(2j * np.pi * f * tau)

f = np.logspace(5, 9, samples=500)
multipath = tap(.8, 500e-9, f) + tap(.4, 300e-9, f)
```

# Real examples

- See README file in this workshop's repository  
`github.com/OpenHSR/LaTeX-Workshop`
- Documents I wrote in  $\text{\LaTeX}$ 
  - `github.com/HSR-Stud/VorlageZF`
  - `github.com/NaoPross/DigDes`
  - `github.com/NaoPross/FuVar`
  - `git.thearcway.org/naopross/hsr`
- My semester thesis (see under doc/thesis)  
`github.com/NaoPross/Fading`
- Books Prof. Dr. Müller wrote
  - `github.com/AndreasFMueller/SeminarMatrizen`
  - `github.com/AndreasFMueller/SeminarNumerik`
- Another real book  
`github.com/hmemcpy/milewski-ctfp-pdf`

# THE END

It was a lot, I know.