

L^AT_EX 2_ε Workshop

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How do you write a document?

Appearance
before structure



**“WYSWYG”
worse at both**

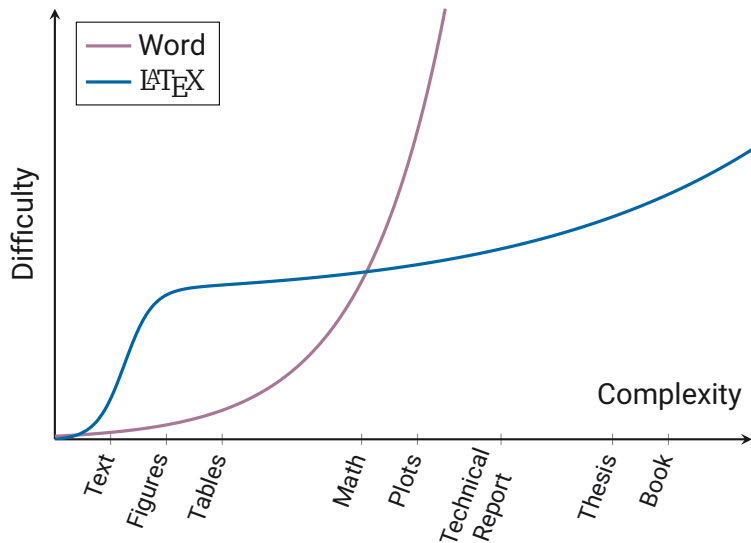


Structure before
appearance

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



Why engineers should know \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 ρ :

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

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

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

Example

Things in green boxes are examples

Tip

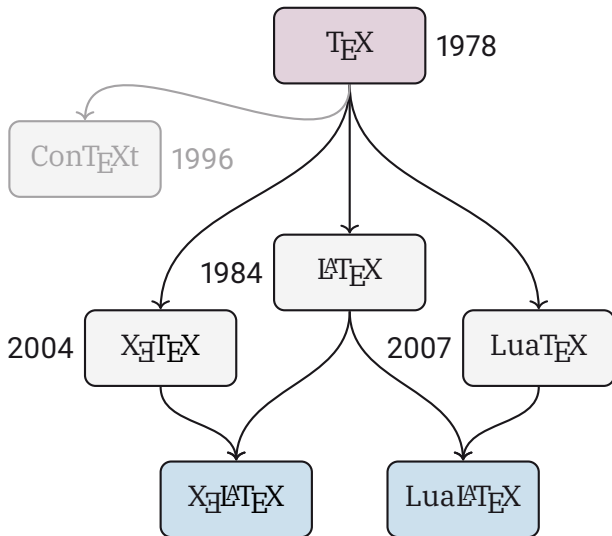
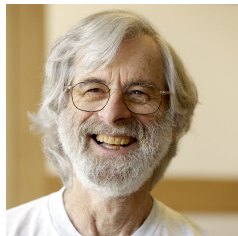
Things in red boxes are tips or extras

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 | İ | 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_EX, what should you use?



A: Use X_YL^AT_EX, it has UTF-8 support! (ä, ü, ô, ...)

Table of Contents

- 1 Fundamentals
- 2 Basics
- 3 Mathematics
- 4 Bibliography management
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Commands aka Macros

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

```
\documentclass[a4paper]{article}
```

```
\LaTeX{}
```

```
\newpage
```

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^AT_EX changes the style of the quotation mark according to the language (for ex “–”, «–», ...).

- 1 This is an incorrect way to have a "quoted word".
- 2 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

```
1 \documentclass[a4paper]{article}
2
3 % preamble
4 \title{A very simple document}
5 \author{Naoki Pross}
6 \date{\today}
7
8 % content
9 \begin{document}
10
11 \maketitle
12 ...
13
14 \end{document}
```

Spacing and newlines

In general

\LaTeX does not care too much about whitespace

```
1 I can put           however many spaces      here.
2 However if I leave   an empty   line, like  this
3
4 LaTeX will in indent this sentence because
5 it is a new paragraph.
```

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

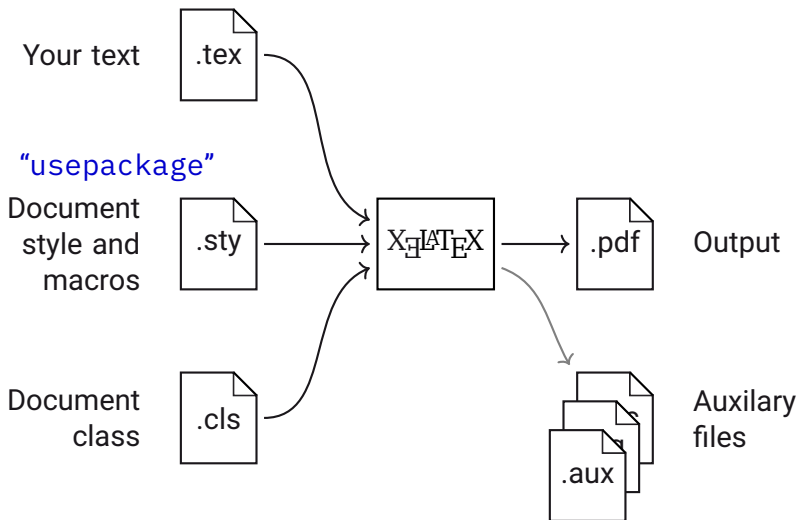
LaTeX will in indent this sentence because it is a new paragraph.

What is CTAN

The Comprehensive T_EX Archive Network is a set of Internet sites around the world that offer T_EX-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)

```
1 \documentclass{thesis}
2
3 \usepackage{tex/mystyle}
4 \usepackage{tex/docmacros}
5 % preamble ...
6
7 \begin{document}
8   \maketitle
9   \tableofcontents
10
11   \include{chapters/intro}
12   \include{chapters/purpose}
13   % ...
14 \end{document}
```

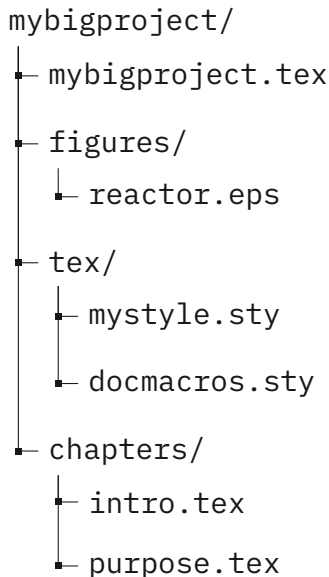


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Headings

Numbered sections:

```
1 \part{}  
2 \chapter{}  
3 \section{}  
4 \subsection{}  
5 \subsubsection{}  
6 \paragraph{}  
7 \subparagraph{}
```

Unnumbered sections:

```
1 \section*{}  
2 \subsection*{}  
3 \subsubsection*{}
```

Pro Tip

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

Emphasis, Bold, Italic, ...

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

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

Lists

```
1 \begin{itemize}
2   \item Tomatoes
3   \item Peppers
4   \item Broccoli
5 \end{itemize}
```

Itemize

- Tomatoes
- Peppers
- Broccoli

```
1 \begin{enumerate}
2   \item Discover coffee
3   \item Get addicted
4   \item Congratulations
5 \end{enumerate}
```

Enumerate

- 1 Discover coffee
- 2 Get addicted
- 3 Congratulations

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

Description

```
1 \begin{description}
2   \item[Programmer] A person who is paid to
      professionally scream at a computer.
3
4   \item[Manager] A person who appears to know how
      all tasks should be accomplished but can't
      actually do any of those tasks themselves.
5 \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 ¹ | Place exactly here (may look very ugly) |

Pro tip

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

¹Requires the "float" package, i.e. `"\usepackage{float}"`

Tables and tabular

```
1 \begin{table}[h]
2   \caption{Not up to date numbers\label{tab:covid}}
3   \begin{tabular}{l r r}
4     \toprule
5     Country      & Infected & Deaths \\
6     \midrule
7     China        & 80'652 & 3'070 \\
8     South Korea  & 7'041  & 44 \\
9     Italy        & 5'833  & 233 \\
10    \bottomrule
11  \end{tabular}
12 \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

```
1 \begin{figure}[h]
2   % center stuff
3   \centering
4
5   % to include a picture, use eps, pdf, dvi
6   % preamble: \usepackage{graphicx}
7   \includegraphics[width = 5cm]{path/to/picture}
8   % or if you have some TikZ code
9   \input{path/to/tikz/code}
10
11   \caption{
12     A meaningful caption for my picture.
13     \label{fig:meaningful-name}
14   }
15 \end{figure}
```

Figures

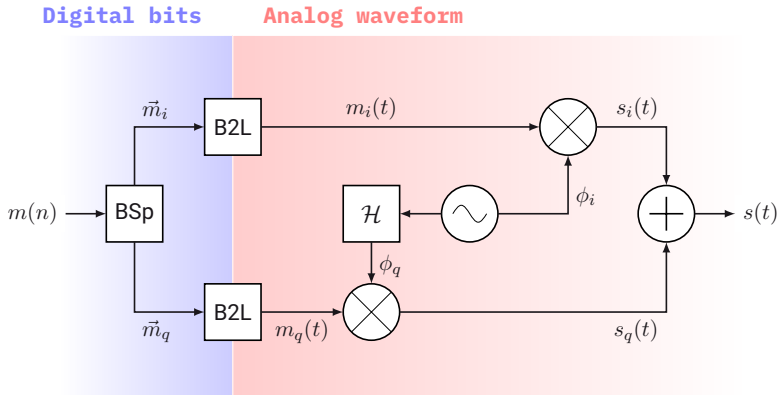


Figure 1: Block diagram of a QAM Modulator.

Cross-References I: Parts of text

```
1 \section{Introduction}  
2 ... will be discussed in \S \ref{sec:nvstokes} ...  
3  
4 \section{Stokes equation} \label{sec:nvstokes}
```

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.

Cross-References II: Floatings

```
1 \begin{figure} % or table
2   \includegraphics{...}
3   \caption{
4     A stereographic projection.
5     \label{fig:projection}
6   }
7 \end{figure}
8
9 ... as shown in figure \ref{fig:projection} ...
```

Pro Tip

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

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Math environments

| Environment | \LaTeX | \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> | — | — |

²Don't use them in \LaTeX . **For real: don't use them.**

Example

```
1 The Pythagoran Theorem states that for a right
  triangle with sides \((a,b,c)\) there is the
  relation:
2 \[
3   c^2 = a^2 + b^2.
4 \]
```

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

```
1 \[
2   \text{normal} % normal text
3   \mathrm{R}    % roman
4   \mathit{R}    % italic
5   \mathbf{R}    % bold
6   \mathsf{R}    % sans-serif
7   \mathtt{R}    % typewriter
8   \mathbb{R}    % blackboard bold
9   \mathcal{R}   % calligraphy
10  \mathfrak{R}  % fraktur
11 \]
```

normal R R \mathbf{R} R \mathtt{R} \mathbb{R} \mathcal{R} \mathfrak{R}

Sub- and Superscript

Hats and underscores

```
1 \[  
2 c = \sqrt{a^2 + b^2 - 2ab \cos( \alpha_{ab} )}  
3 \]
```

Cosine theorem

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

Sum and Integral

```
1 \[
2   % math community meme
3   \sum_{k = 1}^{\infty} k = - \frac{1}{12}
4   \hspace{1.5cm}
5
6   % fourier transform
7   F(\omega) = \int\limits_{-\infty}^{\infty}
8     f(t) e^{-i\omega t} \mathrm{d}t
9 \]
```

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

```
1 \[  
2   \mathbf{J} = \begin{pmatrix}  
3     0 & 1 \\  
4     1 & 0 \\  
5   \end{pmatrix}  
6 \]
```

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

```
1 Equation \eqref{eqn:schroedinger} is the
   Schrödinger Equation that describes the
   evolution of a quantum state  $(\psi)$ .
2
3 \begin{equation} \label{eqn:schroedinger}
4   i\hbar \partial_t \psi =
5   - \frac{\hbar^2}{2m} \partial_x^2 \psi + V\psi
6 \end{equation}
```

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

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

Alignment

```
1 \begin{align*} % numbered when without *  
2   \nabla \cdot \vec{F}(1,1)  
3   &= \partial_x F_x + \partial_y F_y \\\br/>4   &= 2x + 3y^4 \\\br/>5   &= 2 + 3 \\\br/>6   &= 5  
7 \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

```
1 Maxwell's equations in their integral form are:
2 \begin{subequations}
3   \begin{align}
4     \oint_{\partial S} \mathbf{E} \cdot d\mathbf{l} = -\frac{d}{dt} \int_S \mathbf{B} \cdot d\mathbf{s},
5   \end{align}
6 \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!

- 1 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}.

- 1 \begin{thebibliography}{9} % widest label
- 2 % manually set up MLA style
- 3 \bibitem{unabomber} Kaczynski, Theodore.
- 4 \textit{''Industrial Society and Its Future.''}
5 The Washington Post, 19 Sept. 1995.
- 6 \end{thebibliography}

External bibliography (Better)

Put in the preamble:

```
1 %% Citations
2 \usepackage[
3     backend = biber, % or bibtex (older)
4     style = ieee, % or any other
5 ]{biblatex}
6
7 \addbibresource{MyDocument.bib}
```

and then

```
1 \begin{document}
2 % use \cite{..} commands ...
3 \printbibliography
4 \end{document}
```

BibTeX files: Example I

```
1 @article{Alimohammad2009,  
2   title      = {Compact Rayleigh and Rician fading  
3   simulator based on random walk processes},  
4   author     = {Alimohammad, A. and Fard, S.F. and  
5   Cockburn, B.F. and Schlegel, C.},  
6   journal    = {IET Commun.},  
7   publisher  = {Institution of Engineering and  
8   Technology (IET)},  
9   volume     = {3},  
10  number     = {8},  
11  pages      = {1333},  
12  year       = {2009},  
13  language   = {en}  
14 }
```

BibTeX files: Example II

```
1 @book{Griffith,  
2   title      = {Introduction to Electrodynamics,  
3     Fourth Edition},  
4   author     = {Griffiths, David J.},  
5   year       = {2017},  
6   publisher  = {Cambridge University Press; 4th  
7     edition},  
8   isbn       = {978-1108420419}  
9 }
```

and many more

```
1 @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:

```
1 \usepackage{lstlistings}
2
3 % define a style
4 \lstdefinestyle{samplestyle}{
5   belowcaptionskip=\baselineskip,
6   breaklines=true,
7   frame=none,
8   inputencoding=utf8,
9   % margin
10  xleftmargin=\parindent,
11  % numbers
12  numbers=left,
13  numbersep=5pt,
14  numberstyle=\ttfamily\footnotesize\color{hsr-
    black40},
```


Source code listings I: Settings (cont.)

```
15 % background
16 backgroundcolor=\color{hsr-lightgrey20},
17 % default language:
18 language=[LaTeX]TeX,
19 showstringspaces=false,
20 % font
21 basicstyle=\ttfamily\small,
22 identifierstyle=\color{hsr-black},
23 keywordstyle=\color{hsr-blue},
24 commentstyle=\color{hsr-black40},
25 stringstyle=\color{hsr-mauve80},
26 }
27
28 % use the style
29 \lstset{style=samplestyle, escapechar='}
```

Source code listings II: Usage

Finally in your document:

```
1 \begin{lstlisting}[  
2   language = python,  
3   caption = {  
4     FIR filter in python. \label{lst:py-fir}  
5   }]  
6 import numpy as np  
7  
8 def tap(c, tau, f):  
9     return np.exp(2j * np.pi * f * tau)  
10  
11 f = np.logspace(5, 9, samples = 500)  
12 multipath = tap(.8, 500e-9, f) + tap(.4, 300e-9, f)  
13 \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.

```
1 import numpy as np
2
3 def tap(c, tau, f):
4     return np.exp(2j * np.pi * f * tau)
5
6 f = np.logspace(5, 9, samples = 500)
7 multipath = tap(.8, 500e-9, f) + tap(.4, 300e-9, f)
```


Plots

Makefiles (yes)

Using it practice / Real examples

- See README file in this workshop's repository
github.com/OpenHSR/LaTeX-Workshop
- Documents I wrote in \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

THE END

It was a lot, I know.