

L^AT_EX 2_ε Workshop

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How do you write a document?

Appearance
before structure



**“WYSWYG”
worse at both**

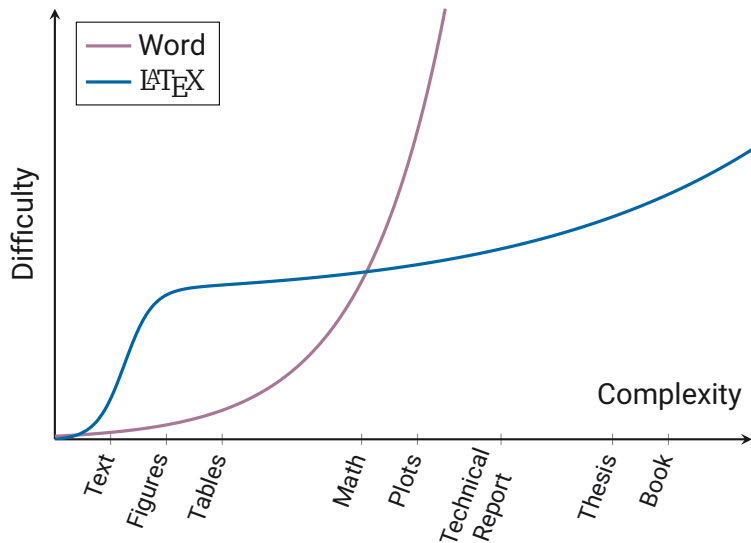


Structure before
appearance

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



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

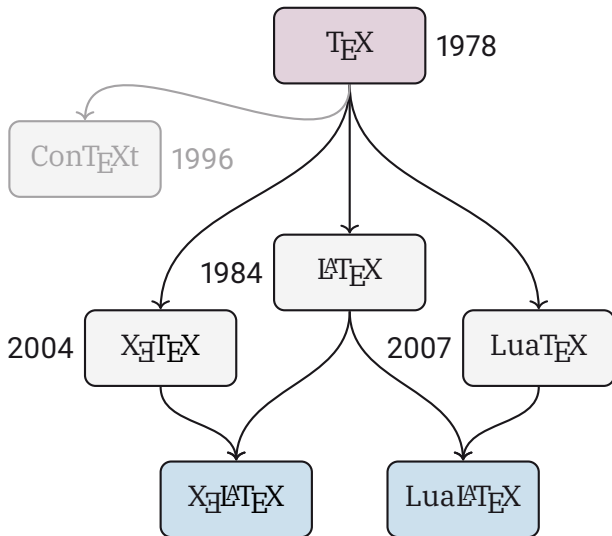
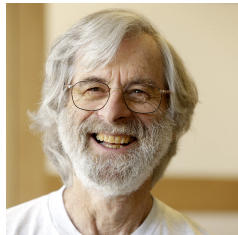
Things in red boxes are tips or extras

Do yourself a favor

Use the International US Keyboard Layout

~ '	! 1 i	@ 2 2	# 3 3	\$ £ 4 ¤	% 5 €	^ 6 ¼	& 7 ½	* 8 ¾	() 9 '	0 ' 0 '	- ¥ = ×	← Backspace
Tab ↔	Q Ä	W Å	E É	R ®	T Þ	Y Ü	U Ú	I Í	O Ó	P Ö	{ } [«] » \	! ;
Caps Lock ⇧	A Á	S Š	D Đ	F	G	H	J	K	L Ø	: ° ; ¶	" " ' '	Enter ↵
Shift ⇧	Z Æ	X	C ¢ ©	V	B	N Ñ	M μ	< Ç ,	> .	? / ¿	Shift ⇧	
Ctrl	Win Key	Alt							Alt Gr	Win Key	Menu	Ctrl

History of T_EX, what should you use?



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

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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^AT_EX 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

\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.

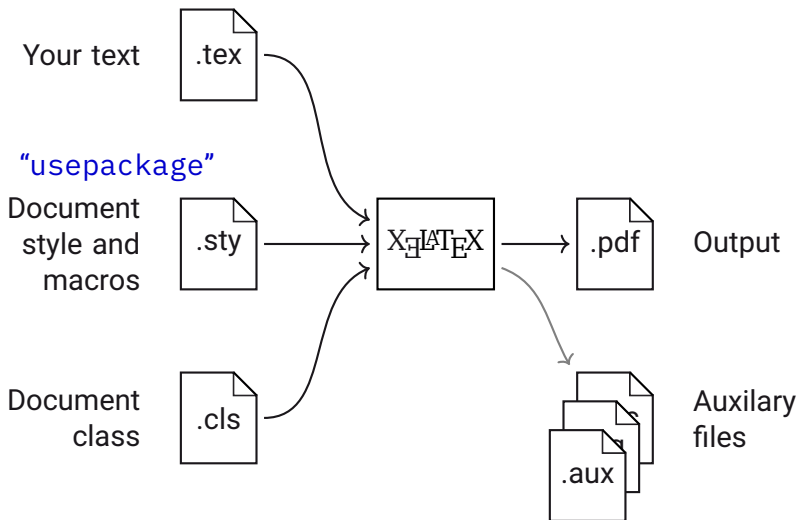
LaTeX will in indent this sentence because it is a new paragraph.

What is CTAN

The Comprehensive T_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)

```
\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 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

```
\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

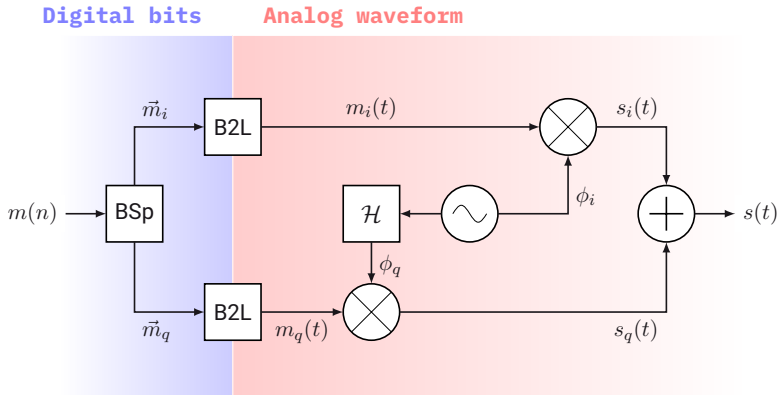


Figure 1: Block diagram of a QAM Modulator.

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	\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

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 R 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: $\lim_{t \rightarrow a}$

$$\sum_{k=1}^{\infty} k = -\frac{1}{12} \qquad F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt$$

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 ψ .

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

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 progresively 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)
```

TikZ = TikZ ist kein Zeichenprogramm

```
\usepackage{tikz}  
\usetikzlibrary{calc, positioning, ...}
```

```
\begin{figure}  
  \centering  
  \begin{tikzpicture}[  
    % global settings / styles  
  ]  
  
    % drawing commands  
  
  \end{tikzpicture}  
  \caption{... \label{fig:...}}  
\end{figure}
```

Basics

- `\coordinate (name)at (x,y);`
- `\node[options] (name)at (x,y){label};`
- `\draw[options] commands;`
- `\fill[options] commands;`

Drawing commands

- Line (A) -- (B)
- Horiz. then vert. line (A) -| (B)
- Vert. then horiz. line (A) |- (B)
- Quadratic Bézier (A).. controls (P)and (Q).. (B)
- Advanced curve (A) to[options] (B)
- Nodes `node[options] (name){label}`
- Shapes (A)rectangle (B), (A)circle (2cm)

TikZ III: Basic example

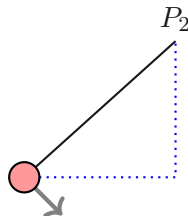
```
\begin{tikzpicture}
  \coordinate (O) at (0,0);
  \coordinate (A) at (2cm,18mm);
  % no units = cm

  \draw[thick] (O) -- (A);
  \draw[thick, dotted, blue]
    (O) -| (A);

  \draw[ultra thick, ->, gray]
    (O) -- ++(5mm, -5mm);

  \fill[thick, draw = black,
    fill = red!40] (O) circle (2mm);

  \node[above] at (A) {\(P_2\)};
\end{tikzpicture}
```



TikZ IV: Example with nodes

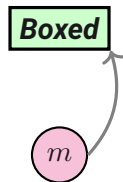
```
\node (A) at (0,0) {A node};

\node[
  rectangle, very thick,
  draw = black, fill = green!20,
  font = \bfseries\slshape,
  % positioning library
  below = 5mm of A,
] (B) {Boxed};

\node[
  circle, thick,
  draw = black, fill = magenta!20,
  below = 1cm of B,
] (C) {\(m\)};

\draw[very thick, gray, ->]
  (C.east) to[bend right] (B.south east)
  ;
```

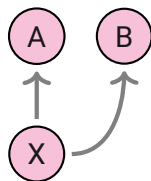
A node



TikZ V: Matrix and scope

```
\matrix (M) [ % node with table of nodes
  row sep = 8mm,
  column sep = 4mm,
  nodes = {
    circle, thick,
    draw = black,
    fill = magenta!30,
    outer sep = 1mm,
  },
] {
  \node (A) {A}; & \node (B) {B}; \\
  \node (X) {X}; & \\
};

\begin{scope}[ultra thick, gray, ->]
  \draw (X) -- (A);
  \draw (X) to[out = 0, in = -90] (B);
\end{scope}
```



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`
- Another real book
`github.com/hmemcpy/milewski-ctfp-pdf`

THE END

It was a lot, I know.