An Introduction to LaTeX

June 22, 2017

LaTeXis a document preparation language.

- 1977: Donald Knuth (Stanford University) developed typesetting system TeX.
- 1980: Leslie Lamport extends TeX to Lamport's TeX (short LaTeX)
- 1993: progression to LaTeX2_ϵ

Compared to traditional (offline) letterpress printing TeX is the typesetter and LaTeX is the layout designer.

WYSIWYG vs. WYSIWYW

Here I briefly want to discuss pros and cons of these two different approaches to document preparation.

WYSIWYG is short for "What You See Is What You Get". This describes the behavior of modern word processing software, such as *Microsoft Word*, *Apple Pages*, or *OpenOffice Writer* (and also their presentation parts PowerPoint, Keynote, Presentation?).

"What You See Is What You Want" (WYSIWYW), on the other hand, describes markup languages such as *HTML*, *Markdown*, and of course LaTeX.

LaTeX

WYSIWYG (Word, Pages, . . .)

Pros:

- Immediate feedback on form and content
- one step to final document (never leave the program)
- Rich/Fancy user interface
- “Fool-proof”

Cons:

- Slow, resource consuming
- Slow browsability for long documents
- Document structuring complicated
- Formatting is a mess
- Formatting not reproducible (Version incompatibility)
- Not editable everywhere
- Formatting and content need to be edited at the same time

LaTeX

WYSIWYW (LaTeX, Markdown, . . .)

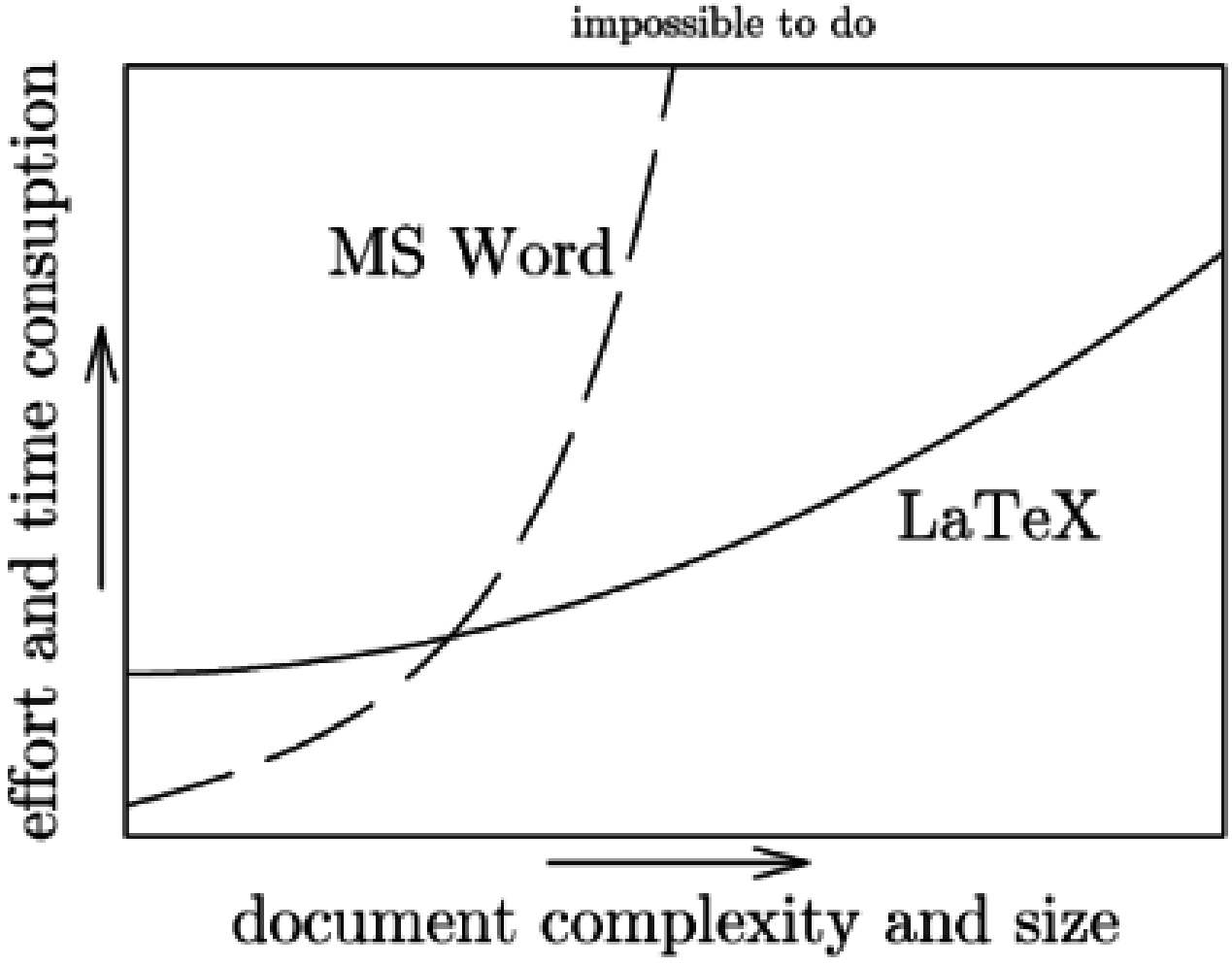
Pros:

- simple, text-based files
- separation of content and layout
- template-based reproducible formatting
- consistent behavior everywhere
- multiple output formats
- mathematical typesetting

Cons:

- Not very intuitive at first
- steep learning curve
- needs additional translation step to final document

WYSIWYG vs. WYSIWYW



Availability

LaTeXis available for all operating systems.

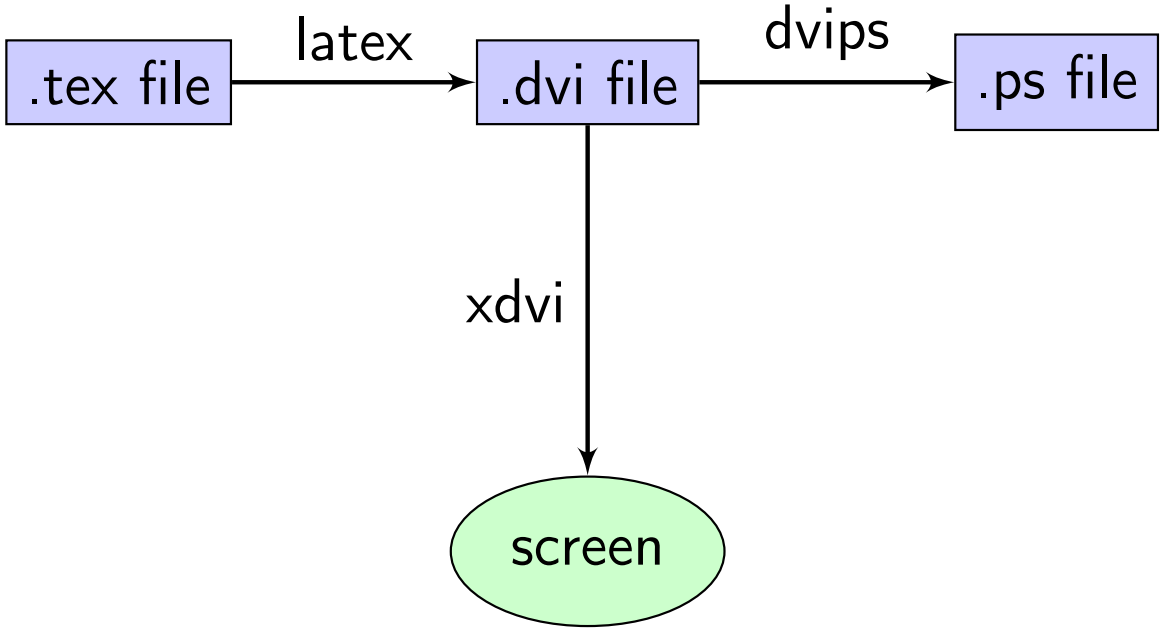
MiKTeX (`www.miktex.org`) is the best version for Windows. Comes with an automated installer that takes care of everything.
TeXLive (`www.tug.org/texlive`) is the best version for Unix (that includes OS X and Linux). This is already installed in your virtual machines.
MacTeX (`www.tug.org/mactex`) is a specialized version of TeXLive for OS X.

Since .tex files are completely text based, you can basically use every editor you like.
But there are some LaTeX-specific editors that have syntax highlighting and help with the translation (compilation) process.
For Windows there is **TeXnicCenter** (`www.texniccenter.org`) which works seamlessly with MikTeX.
TeXmaker (`www.xm1math.net/texmaker`) works on Windows, MacOSX, and Linux.
Installed inside your virtual machines is another great editor named **Kile**.

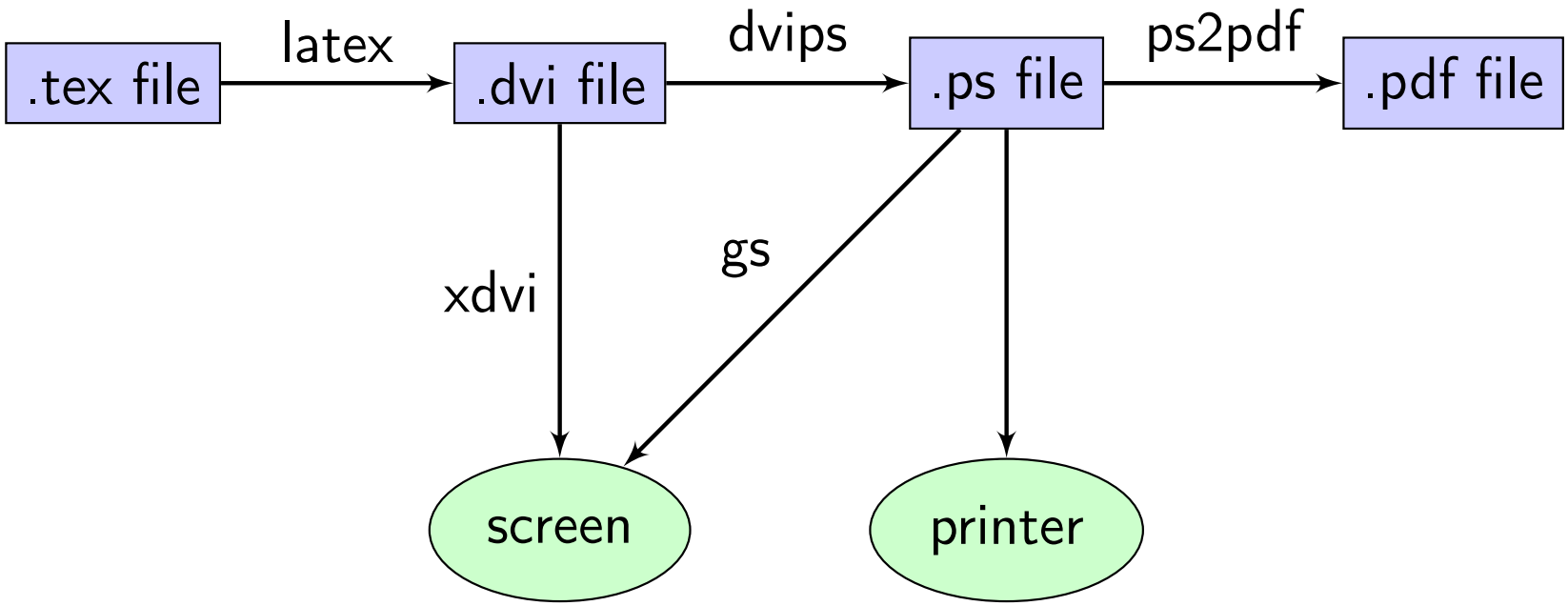
LaTeX workflow

LaTeX workflow

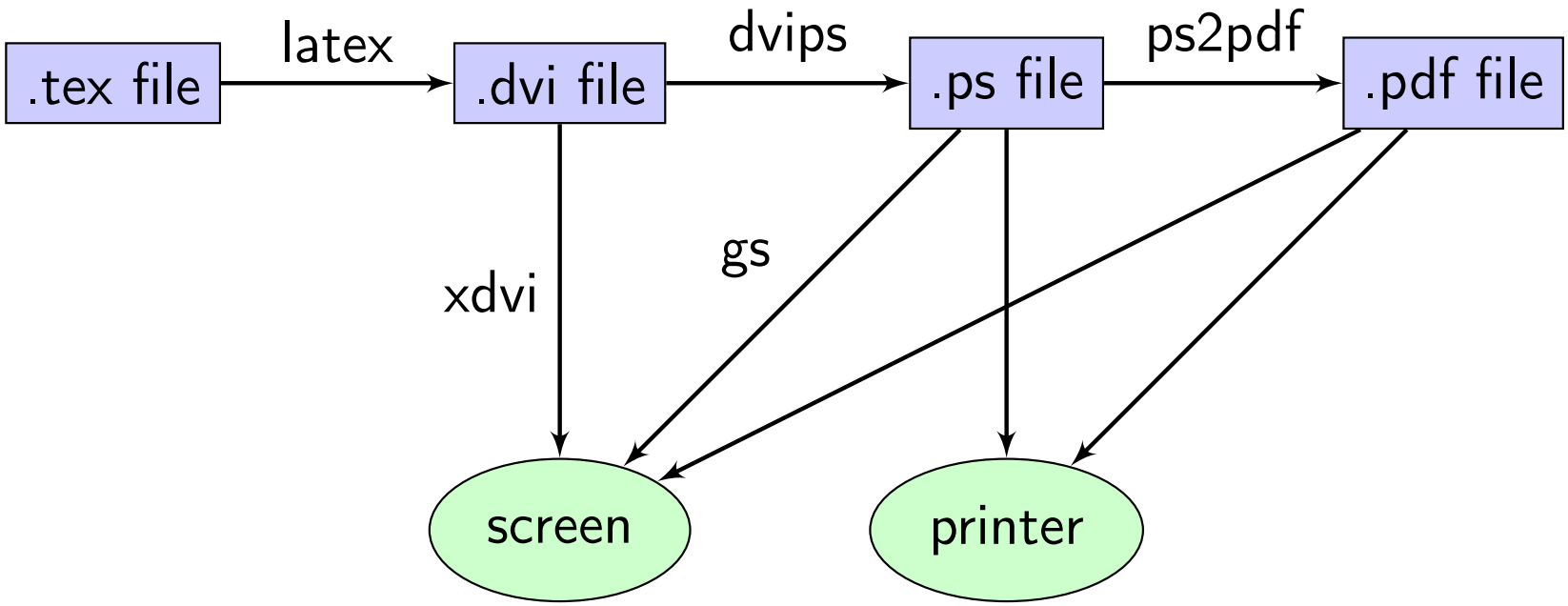
LaTeX workflow



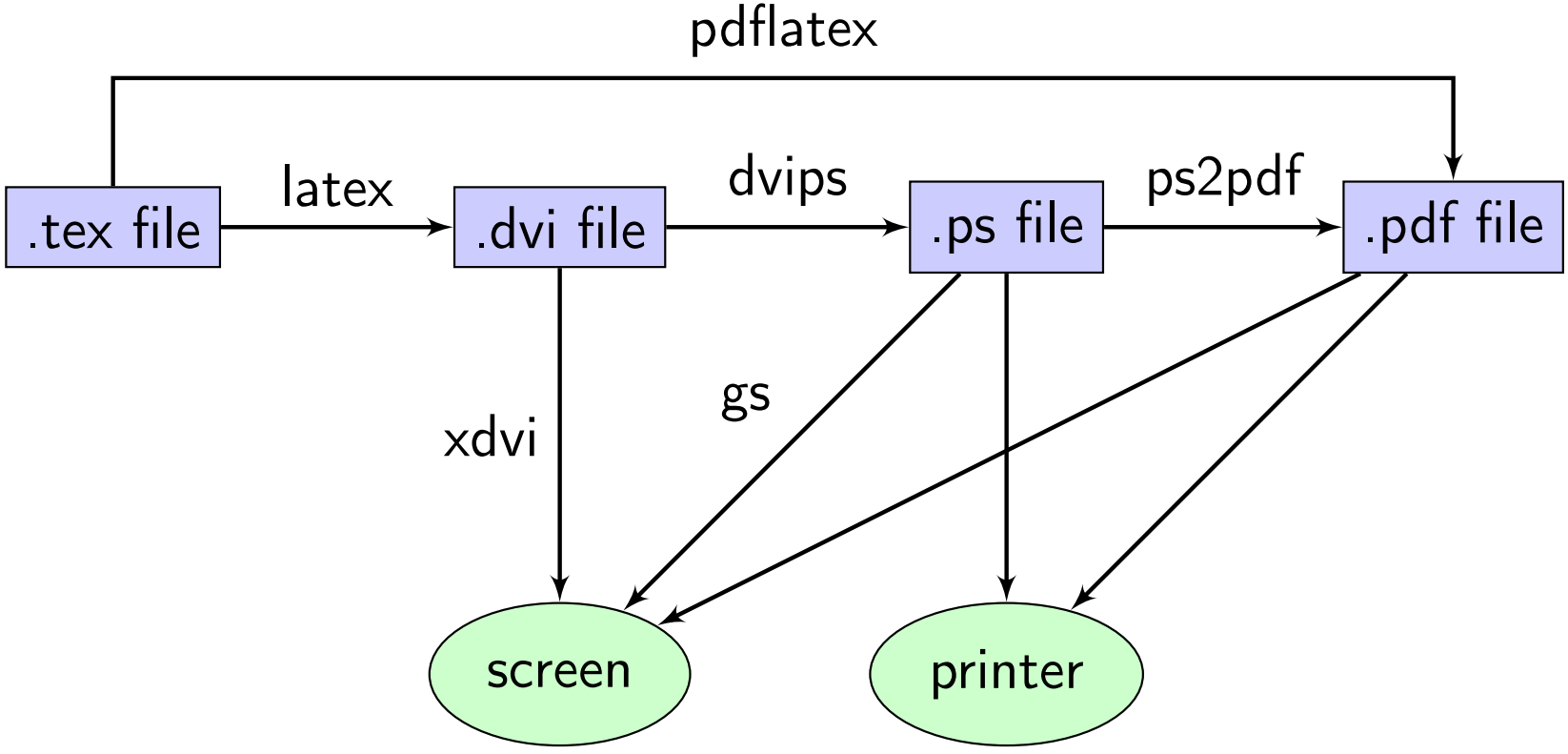
LaTeX workflow



LaTeX workflow



LaTeX workflow



Your very first document

The simplest possible example looks something like this:

```
\documentclass{article}
\begin{document}
This is my first TeX document.
\end{document}
```

Now let us translate this example into a PDF file and look at it!
(first.tex)

Basic document layout

- A `.tex`-file always has a *preamble* and a *document* part.
- The `document` environment **must** be defined
- Commands begin with a backslash `\`
- Environments have a *begin* and an *end* tag

Document classes

The very first line of every LaTeX document is `\documentclass[options]{class}`.

- Classes
  - `book` or `scrbook` for books, obviously
  - `report` or `scrreprt` for long documents
  - `article` or `scracrtcl` for short to medium long documents
  - `letter` or `scrlttr2` for letters
  - `beamer` for presentations like this one
- Options (assorted samples)
  - `11pt`, `12pt`, ... - sets the main font size
  - `twoside` - sets up two sided documents (page numbering etc.)
  - `twocolumn` - two column documents, such as scientific papers
  - `a4paper`, `usletter` - paper format

Packages

LaTeXis modular and extensible. To import modules or *packages* you write `\usepackage[options]{package}` in the *preamble*.
A few very useful packages are:

- `graphicx` - support for `.PNG`, `.JPG`, `.PDF`, `.EPS`, etc. figures
- `tabular`, `longtable`, `tabularx` - support for tables
- `float` - flexible placement of figures and tables
- `natbib` - bibliography with numerous style sheets
- `inputenc` - support UTF-8 input
- `amsmath`, `amssymb` - math symbols
- `siunitx` - numbers and units

If you do not use options, you can import multiple packages at once using `\usepackage{natbib, float, graphicx}`.

Depending on the `documentclass` you have several commands available to structure your document.

- `\section{name}`
- `\subsection{name}`
- `\subsubsection{name}`
- `\paragraph{name}`
- `\subparagraph{name}`

The document classes `book` and `report` also support `\part{name}` and `\chapter{name}`.

Metadata

You can assign values to special variables, that LaTeX can use to create title pages.

```
\author{John Doe}
\title{John Doe's view of the world}
\date{June, 2015}

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

Now let see how this looks like! (second.tex and third.tex)

With LaTeX it is almost too easy to create other meta content in your document.
You can create a **table of contents** using the `\tableofcontents` command in the beginning of your document. This will create a table of contents using the chapter and section names with the correct page numbers.
Similarly you can create a **list of the figures** used in your document or a **list of all tables** and put them in the appendix. This is accomplished by the commands `\listoffigures` and `\listoftables`, respectively.

Font sizes

\tiny \scriptsize \footnotesize \small \normalsize \large

\Large \LARGE \huge \Huge

Use examples:

```
{\scriptsize This text will be fairly small}.
{\LARGE Nobody will miss this!}
```

This text will be fairly small.

Nobody will miss this!

Font families and styles

There are 3 basic font families roman (`\textrm{}`), sans serif (`\textsf{}`), and typewriter (`\texttt{}`).

The 3 mainly used font styles are **bold text** (`\textbf{}`), *italic text* (`\textit`), and SMALL CAPS (`\textsc{}`).

Of course you can change the global font. There are packages that allow you to use True Type fonts.

Lists and enumerations

To create bullet point lists you can use the `itemize` environment. For example:

- first
- second
  - first nested
  - second nested
- third

And here is the source code:

```
\begin{itemize}
  \item first
  \item second
    \begin{itemize}
        \item first nested
        \item second nested
    \end{itemize}
    \item third
\end{itemize}
```

Lists and enumerations

Creating a number list is just as easy. Here we just change the environment from `itemize` to `enumerate` and the result is the following.

For example:

1. first
2. second
    2.1 first nested
    2.2 second nested
3. third

And here is the source code:

```
\begin{enumerate}
  \item first
  \item second
    \begin{enumerate}
        \item first nested
        \item second nested
    \end{enumerate}
    \item third
\end{enumerate}
```

Figures

With the `graphicx` package you can embed pictures or graphs in your document.
The packages provides the `figure` environment and the `includegraphics` command.

```
\documentclass{article}
\usepackage{graphicx}
\begin{document}
\begin{figure}
  \includegraphics[width=\textwidth]{images/flower.jpg}
  \caption{A beautiful flower.}
\end{figure}
\end{document}
```

Other options for the `includegraphics` command are: `height`, `angle`, `scale`. You can also write specific lengths in arbitrary units such as `in`, `cm`, `pt`.

When using the `float` package, you have some influence of the positioning of your figure inside your document. You can put an option after opening the `figure` environment like this:

```
\begin{figure}[h!]
```

Valid options for figure placement are:

- `h` (here) - same location
- `t` (top) - top of the page
- `b` (bottom) - bottom of the page
- `p` (page) - on an extra page
- `!` (override) - will force the specified location
- `H` - even stricter than using h!

Manual vs. automatic line breaking

One of the great strengths of LaTeX is how it handles line breaks in long texts. It will take care of hyphenating words, while using as much space of the line as possible. However, you have of course full control over everything.
Newlines are ignored in LaTeX. But you can force a manual linebreak with `\newline`.
A manual page break can be accomplished via `\newpage`.

A new paragraph is used automatically after two newlines (press Return twice) or manually with `\par`. Where appropriate (in the specific document classes), paragraphs will be indented. You can force no indentation for a new paragraph with `\par\noindent`.

Footnotes

Handling footnotes can sometimes be a hassle in other programs. In LaTeX it just another simple command and the compiler[1] takes care of everything. As you can see, it even works here[2].
The command is, of course, just named `\footnote{}`. Here is the source code of the example above:

```
As you can see, it even works here\footnote{The \texttt{beamer} class}.
```

[1] Program that translates source code into the desired output.
[2] The `beamer` class

Tables

There are several packages for tables in LaTeX . The simplest one is `table`. Here is an example of a simple table and the corresponding source code.

Table: Caption for the table.

1	2 ‖ 3
a	b ‖ c

```
\begin{table}[h!]
  \begin{center}
    \caption{Caption for the table.}
    \begin{tabular}{l|c||r}
      \toprule
      1 & 2 & 3\\
      \midrule
      a & b & c\\
      \bottomrule
    \end{tabular}
  \end{center}
\end{table}
```

The `table` environment allows to add a caption and the positioning of the table within the document similar to a figure.
The actual data of the table is inside the `tabular` environment.
The layout of the table is given by the argument after the begin tag of the environment.

```
\begin{tabular}{l|c||r}
```

Above code creates a 3 column table, where the first column's data is aligned left, the second column is centered and the third column is aligned to the right. The pipes (|) are the lines that separate the columns. In the actual data ampersands (&) are used to separate columns and the newline shortcut (\\) separates the rows. Lines between rows can be drawn using `\hline`.

Labels and references

Another great power of LaTeX is how it deals with references in the document. To all important environments, `equation`, `figure`, and `table` you can assign a label (`\label{name}`). And you can refer (`\ref{name}`) to that label later in your document. LaTeX then automatically inserts the right number of the given equation or figure. This is even updated when the order changes, or you add more equations.

```
\begin{equation}
  \label{eq:newton2nd}
  F = ma
\end{equation}
``Lex II: Mutationem motus proportionalem esse vi motrici impressae,
et fieri secundum lineam rectam qua vis illa imprimitur.''
The above sentence is Newton's second law of motion,
as described by Equation (\ref{eq:newton2nd}).
```

$$F = ma \tag{1}$$

"Lex II: Mutationem motus proportionalem esse vi motrici impressae, et fieri secundum lineam rectam qua vis illa imprimitur." The above sentence is Newton's second law of motion, as described by Equation 1.

Environments for equations and inline math

If you want to write mathematical equations inside a function, just like this example $f(x) = x^2 + c$, you use the inline math environment denoted by the actual equation surrounded by dollar signs: `$f(x)=x^2+c$`. To typeset numbered single line equations there is the `equation` environment.

$$E = mc^2 \tag{2}$$

```
\begin{equation}
  E = mc^2
\end{equation}
```

Adding an asterisk to the environment, i.e. `equation*`, will suppress the numbering.

$$E = mc^2$$

Another environment for typesetting multiple equations is `align`. This allows you to put multiple equations in one environment and align them using the ampersand symbol. Single equations are again separated by a linebreak \\.

```
\begin{align}
 2x_1 + 4x_2 + 7 x_3 &= 5\\
 9x_2 + 7x_3 &= b
\end{align}
```

$$2x_1 + 4x_2 + 7x_3 = 5 \tag{3}$$

$$9x_2 + 7x_3 = b \tag{4}$$

LaTeX

A few useful math typesetting examples

- Arithmetic operations $a + b$, $a - b$, $-a$, a/b, and ab are just typed as expected.

```
$a+b$, $a-b$, $-a$, $a/b$, $a b$
```

- To use a symbol for multiplication, you can either use $a \cdot b$ or $a \times b$.

```
$a \cdot b$, or $a \times b$
```

- To typeset fractions you can use the `\frac` command.

$$\frac{1 + 2x}{x + y + xy} \tag{5}$$

```
\begin{equation}
  \frac{1 + 2x}{x + y + xy}
\end{equation}
```

A few useful math typesetting examples

- Subscripts are typed with _ (underscore)
  For example: a_1 (`$a_1$`) or x_i (`$x_i$`).
  Now let us try more than one symbol as subscript:
  `$a_10$` results in a_10.
  Now what?
  Brackets to the rescue!
  `$a_{10}` will give the expected result a_{10}.
- Superscripts are typed using the ^ (caret) character
  For example: x^2 (`$x^2$`).
  You can even combine them:
  `$a^{i_{1}}$` will produce a^{i_1}.

Using the *right* brackets.

```
\begin{equation}
  a \cdot [ \frac{1 + 2x}{x + y + xy}) \cdot (x+z) ]
\end{equation}
```

$$a \cdot [(\frac{1 + 2x}{x + y + xy}) \cdot (x + z)] \tag{6}$$

```
\begin{equation}
  a \cdot \left[ \left(\frac{1 + 2x}{x + y + xy}\right) \cdot
          \left(x+z\right) \right]
\end{equation}
```

$$a \cdot \left[\left(\frac{1 + 2x}{x + y + xy} \right) \cdot (x + z) \right] \tag{7}$$

LaTeX

A few useful math typesetting examples

- Sums:

$$\sum_{n=0}^{\infty} a_n = a_0 + a_1 + a_2 + \cdots .$$

```
\begin{equation*}
  \sum_{n=0}^\infty a_n = a_0 + a_1 + a_2 + \cdots .
\end{equation*}
```

- Integrals:

$$\int_a^b f(x)dx = F(b) - F(a)$$

```
\begin{equation*}
  \int_a^b f(x) dx = F(b) - F(a)
\end{equation*}
```

LaTeX

A few useful math typesetting examples

- Products:

$$Z_N(T) = 2^N \prod_{i=1}^{N-1} \cosh(\beta J_i)$$

```
\begin{equation*}
  Z_N(T) = 2^N\prod_{i=1}^{N-1} \cosh (\beta J_i)
\end{equation*}
```

LaTeX

Some math symbols

$\hat{a}$	`\hat{a}`	$\dot{a}$	`\dot{a}`
$\check{a}$	`\check{a}`	$\ddot{a}$	`\ddot{a}`
$\tilde{a}$	`\tilde{a}`	$\breve{a}$	`\breve{a}`
$\acute{a}$	`\acute{a}`	$\bar{a}$	`\bar{a}`
$\grave{a}$	`\grave{a}`	$\vec{a}$	`\vec{a}`

LaTeX

Some math symbols

α	\alpha	ν	\nu
β	\beta	ξ	\xi
γ	\gamma	o	o
δ	\delta	π	\pi
ϵ	\epsilon	ρ	\rho
ζ	\zeta	σ	\sigma
η	\eta	τ	\tau
θ	\theta	υ	\upsilon
ι	\iota	ϕ	\phi
κ	\kappa	χ	\chi
λ	\lambda	ψ	\psi
μ	\mu	ω	\omega

LaTeX

Some math symbols

ε	\varepsilon	ς	\varsigma
ϑ	\vartheta	φ	\varphi
ϱ	\varrho		
Γ	\Gamma	Σ	\Sigma
Δ	\Delta	Υ	\Upsilon
Θ	\Theta	Φ	\Phi
Λ	\Lambda	Ψ	\Psi
Ξ	\Xi	Ω	\Omega
Π	\Pi		

LaTeX

Some math symbols

$\pm$	\pm	$\cap$	\cap
$\mp$	\mp	$\cup$	\cup
$\setminus$	\setminus	$\uplus$	\uplus
$\cdot$	\cdot	$\sqcap$	\sqcap
$\times$	\times	$\sqcup$	\sqcup
$*$	\ast	$\triangleleft$	\triangleleft
$\star$	\star	$\triangleright$	\triangleright
$\diamond$	\diamond	$\wr$	\wr
$\circ$	\circ	$\bigcirc$	\bigcirc
$\bullet$	\bullet	$\bigtriangleup$	\bigtriangleup
$\div$	\div	$\bigtriangledown$	\bigtriangledown
$\lhd$	\lhd	$\rhd$	\rhd
$\vee$	\vee	$\odot$	\odot
$\wedge$	\wedge	$\dagger$	\dagger
$\oplus$	\oplus	$\ddagger$	\ddagger
$\ominus$	\ominus	$\amalg$	\amalg
$\otimes$	\otimes	$\unlhd$	\unlhd
$\oslash$	\oslash	$\unrhd$	\unrhd

LaTeX

Some math symbols

$\leq$	\leq	$\geq$	\geq
$\prec$	\prec	$\succ$	\succ
$\preceq$	\preceq	$\succeq$	\succeq
$\ll$	\ll	$\gg$	\gg
$\subset$	\subset	$\supset$	\supset
$\subseteq$	\subseteq	$\supseteq$	\supseteq
$\sqsubset$	\sqsubset	$\sqsupset$	\sqsupset
$\sqsubseteq$	\sqsubseteq	$\sqsupseteq$	\sqsupseteq
$\in$	\in	$\ni$	\ni
$\vdash$	\vdash	$\dashv$	\dashv
$\smile$	\smile	$\mid$	\mid
$\frown$	\frown	$\parallel$	\parallel
$\neq$	\neq	$\perp$	\perp
$\equiv$	\equiv	$\cong$	\cong
$\sim$	\sim	$\bowtie$	\bowtie
$\simeq$	\simeq	$\propto$	\propto
$\asymp$	\asymp	$\models$	\models
$\approx$	\approx	$\doteq$	\doteq
		$\Join$	\Join

LaTeX

Math delimiters

(	(	)	)
[	[	]	]
{	\{	}	\}
⌊	\lfloor	⌋	\rfloor
⌈	\lceil	⌉	\rceil
⟨	\langle	⟩	\rangle
|	\vert	‖	\Vert
/	/	\	\backslash

LaTeX

Arrow symbols (math mode)

$\leftarrow$	\leftarrow	$\longleftarrow$	\longleftarrow
$\Leftarrow$	\Leftarrow	$\Longleftarrow$	\Longleftarrow
$\rightarrow$	\rightarrow	$\longrightarrow$	\longrightarrow
$\Rightarrow$	\Rightarrow	$\Longrightarrow$	\Longrightarrow
$\leftrightarrow$	\leftrightarrow	$\longleftrightarrow$	\longleftrightarrow
$\Leftrightarrow$	\Leftrightarrow	$\Longleftrightarrow$	\Longleftrightarrow
$\mapsto$	\mapsto	$\longmapsto$	\longmapsto
$\hookleftarrow$	\hookleftarrow	$\hookrightarrow$	\hookrightarrow
$\leftharpoonup$	\leftharpoonup	$\rightharpoonup$	\rightharpoonup
$\leftharpoondown$	\leftharpoondown	$\rightharpoondown$	\rightharpoondown
$\rightleftharpoons$	\rightleftharpoons	$\leadsto$	\leadsto
$\uparrow$	\uparrow	$\Updownarrow$	\Updownarrow
$\Uparrow$	\Uparrow	$\nearrow$	\nearrow
$\downarrow$	\downarrow	$\searrow$	\searrow
$\Downarrow$	\Downarrow	$\swarrow$	\swarrow
$\updownarrow$	\updownarrow	$\nwarrow$	\nwarrow

LaTeX

Even more symbols

$\aleph$	\aleph	$\prime$	\prime
$\hbar$	\hbar	$\emptyset$	\emptyset
$\imath$	\imath	∇	\nabla
$\jmath$	\jmath	$\surd$	\surd
ℓ	\ell	$\top$	\top
$\wp$	\wp	$\bot$	\bot
$\Re$	\Re	$\|$	|
$\Im$	\Im	$\angle$	\angle
∂	\partial	$\triangle$	\triangle
∞	\infty	$\backslash$	\backslash
$\Diamond$	\Diamond	$\Diamond$	\Diamond
$\forall$	\forall	$\sharp$	\B
$\exists$	\exists	$\clubsuit$	\clubsuit
$\neg$	\neg	$\diamondsuit$	\diamondsuit
$\flat$	\flat	$\heartsuit$	\heartsuit
$\natural$	\natural	$\spadesuit$	\spadesuit
$\mho$	\mho		

Function names in math mode

```
\arccos  \csc  \ker     \min
\arcsin  \deg  \lg      \Pr
\arctan  \det  \lim     \sec
\arg     \dim  \liminf  \sin
\cos     \exp  \limsup  \sinh
\cosh    \gcd  \ln      \sup
\cot     \hom  \log     \tan
\coth    \inf  \max     \tanh
```

```
Compare $sin^2x+cos^2x=1$ with $\sin^2x+\cos^2x=1$.
```

Result: Compare $sin^2x + cos^2x = 1$ with $\sin^2 x + \cos^2 x = 1$.

Physical quantities

The value of a quantity is given by the product of a number and its unit.

Example

A pressure p of 24,381 MPa.

No math environment

Pressure p of 24,381 MPa

```
Pressure $p$ of 24,381\,MPa
```

With math environment and problems

$$p = 24,381\,MPa$$

```
p = 24,381\,MPa
```

Correct math environment version

$$p = 24,381\,\text{MPa}$$

```
p = 24,381\,\text{MPa}
```

New commands from the `siunitx` package

- `\SI{}{}`
- `\num{}`
- `\si{}`
- `\SIrange{}{}{}`
- `\numrange{}{}`
- `\ang{;;}`

Examples

24.381 MPa	`\SI{24,381}{MPa}`
24.381	`\num{24,381}`
MPa	`\si{MPa}`
1 *to* 8	`\numrange{1}{8}`
2 kg … 7 kg	`\SIrange[range-phrase=\dots]{2}{7}{kg}`
4°31′10″	`\ang{4;31;10}`
24 µm	`\SI{24}{\micro\meter}`
$24.381\,765\,41 \times 10^4$	`\num{24,38176541e4}`
m Pa	`\si{m.Pa}`
$p = 24.381$ MPa	`p=\SI{24,381}{MPa}`

More examples (fractions with `xfrac` package)

$\mathrm{g\,mol^{-1}}$	`\si{\gram\per\mole}`
$\frac{\mathrm{g}}{\mathrm{mol}}$	`\si[per-mode=fraction]{\gram\per\mole}`
g/mol	`\si[per-mode=fraction,fraction-function=\sfrac]{\gram\per\mole}`
$\mathrm{g/mol}$	`\si[per-mode=symbol]{\gram\per\mole}`
$100\,\mathrm{m\,s^{-2}}$	`\SI{100}{\meter\per\square\second}`
$10\,\mathrm{m^2}$	`\SI{10}{\meter\squared}`
$20\,\mathrm{m^2}$	`\SI{20}{\square\meter}`

More examples - number separation symbols

12,34	`\num[output-decimal-marker={,}]{12,34}`
1 234 567.89	`\num{1234567,89}`
1234567.89	`\num[group-separator={}]{1234567,89}`
1.234.567,89	`\num[group-separator={.},output-decimal-marker={,}]{1234567,89}`