Introduction to the Typesetting System LaTeX

day two

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Contents

Part VII

Bibliographies

Bibliography

- Bibliography contains a list of used sources and possibly further literature.
- Different citation styles depending on the field of study.
- (Rough) appearance of the bibliography is determined by the document class.
- Two methods for creating the bibliography:
    1. Manual method with the thebibliography environment.
    2. Automatic method with BibTeX/biber.

Manual Method

Specific syntax for setting the bibliography:

- Environment \begin{thebibliography}{⟨*Number*⟩}
- Listing of works using \bibitem{⟨*Key*⟩} ⟨*Text*⟩
- Citing a work with \cite{⟨*Key(s)*⟩} or \cite[⟨*Page*⟩]{⟨*Key*⟩}

```
\begin{thebibliography}{9}
 \bibitem{frankfurt05} Harry G. Frankfurt:
   \textit{On Bullshit}, Princeton University Press,
   Princeton, New Jersey, 2005.
\end{thebibliography}
```

- Manual creation (and sorting) of the bibliography is very cumbersome.
- Entries not easily reusable.
- ⟹ Program biber takes over sorting and management of entries.

BibTeX/biber Idea

- Entries exist as text files (.bib) in a predefined syntax.
- Reference in the document with \cite{mittelbach2004}
- Program biber automatically adds referenced source to bibliography.
- Appearance of the reference and bibliography entries can be configured in various ways.
- Access to a large number of available references.

The .bib File

Different bib items for different document types:

- @article
- @book
- @mvbook
- @inbook
- @suppbook

- @collection
- @manual
- @online
- @patent
- @periodical

- @proceedings
- @thesis
- @unpublished
- …

Each item has various mandatory and optional fields.

Syntax of an Entry

```
@⟨Item-Type⟩{⟨Ref-Key⟩,
    ⟨Field⟩    = {⟨Value⟩},
    ⟨Field⟩    = {⟨Value⟩},
}
```

The .bib File

- Usage is unintuitive.
- Graphical interfaces make life easier.
  e. g., JabRef, BibSonomy, Citavi, EndNote, Mendeley, Zotero, …
- Direct online search e. g., at UB or Google Scholar

Syntax of an Entry

```
@⟨Item-Type⟩{⟨Ref-Key⟩,
    ⟨Field⟩    = {⟨Value⟩},
    ⟨Field⟩    = {⟨Value⟩},
}
```

Creating the Bibliography

in the document

```
\usepackage[style=authoryear]{biblatex}
\addbibresource{bibfile.bib}
\begin{document}
  Text  ... \parencite{Tolkien54} ... text.
  \printbibliography
\end{document}
```

in the .bib file

```
@book{Tolkien54,
  author    ={Tolkien, John R. R.},
  title     ={The Lord of the Rings},
  publisher ={Allen \& Unwin},
  place     ={London},
  year      ={1954},
}
```

Citation and Bibliography Styles

- biblatex supports many predefined styles:
- \usepackage[style=⟨*Style*⟩]{biblatex}

numeric	Standard style	[1, 2, 4, 3, 7]
numeric-comp	Compact version of numeric	[1-4, 7]
alphabetic	Abbreviations of author and year	[Jon95] [JW86]
authoryear	Author-year style	Jones 1995
authoryear-ibid	Multiple citations on one page are abbreviated with *ibid.*	

- Bibliography style is adapted to the citation style.
- Can be changed with citestyle= and bibstyle=.

Citing

\textcite{⟨*key*⟩} generates reference in the text: van Mises (1962)
\Textcite{⟨*key*⟩} generates reference at the beginning of the sentence: Van Mises (1962)
\parencite{⟨*key*⟩} generates reference in parentheses: (van Mises 1962)

Optional arguments:
\parencite[⟨*Text before*⟩][⟨*Text after*⟩]{⟨*key*⟩}
\parencite[⟨*Text after*⟩]{⟨*key*⟩}

Assignment

Create a .bib file with some entries and try to reference them in a document.
Generate your document and bibliography by calling LuaLATEX, biber, and LuaLATEX.

Typesetting Mathematics

Inline and Display Mode

Inline Mode

- Formulas appearing directly in the text flow
- Short formulas, mentioning variables
- Elements do not exceed the line height
- Limits are set *beside* integrals, sums, and products

Display Mode

- Emphasizes important formulas
- Represents long calculations
- Complex formulas
- Multiply indexed quantities
- Nested fractions
- ...

Inline and Display Mode

Inline Math: $E = mc^2$ is known by every child, but hardly anyone can make more sense of it than with $\int_{-\infty}^{\infty} \sum_{n=1}^{5} dx$, where this formula simply makes no sense, but shows how limits look in TeX typesetting. **Inline Math with Displaystyle:** $E = mc^2$ is known by every child, but hardly anyone can make more sense of it than with $\displaystyle\int_{-\infty}^{\infty} \sum_{n=1}^{5} dx$, where this formula simply makes no sense, but shows how limits look in TeX typesetting. **Display Math:** $E = mc^2$ is known by every child, but hardly anyone can make more sense of it than with

$$\int_{-\infty}^{\infty} \sum_{n=1}^{5} dx,$$

where this second formula simply makes no sense, but shows how limits look in TeX typesetting.

Inline and Display Mode

Inline Mode

`$⟨Formula⟩$`

```
The function $K(x)$ models $K$ depending
on $x$.
```

The function $K(x)$ models K depending on x.

Display Mode

```
\begin{equation}
 ⟨Formula⟩
\end{equation}
```

```
\begin{equation}
  K(x) = c \cdot x^{-a}
\end{equation}
```

$$K(x) = c \cdot x^{-a} \qquad (1)$$

Multi-line Formulas

A series of equations aligned and arranged with respect to each other, for example used for:

- Derivations
- Summaries
- Comparison of formulas

`align` environment from the `amsmath` package.

```
\begin{align}
a &= b, &
c &= d,\\
abc &= d \\
&= r
\end{align}
```

$$a = b, \qquad c = d, \qquad (2)$$
$$abc = d \qquad (3)$$
$$= r \qquad (4)$$

without numbering: {align*}

Variables and Numbers

- Variables are set in italics: a: a
- Font depends on the document class!
  (Grotesque, Serifs, etc.)
- Digits are automatically set correctly: 12.2 instead of 12.2

Package siunitx allows typesetting of quantities and units

```
\num{3.14159+-0.00001} \\
\SI{95}{\kilo\joule} \\
\si{\milli\meter}
```

```
3.141 59(1)
95 kJ
mm
```

(works in math mode and text mode)

Superscripts and Subscripts

- Characters with special meaning: ^ and _
- Superscript: a^b $\qquad a^b$
- Subscript: a_b $\qquad a_b$
- Grouping is possible: a^{bc}, a_{bc} $\qquad a_{bc}$
- Combination is possible: a_b^c $\qquad a_b^c$
- Without preceding character: ^{235}U $\qquad ^{235}U$
- Nesting only with grouping:

  a_{b_{c_{d_{e_{f^g}}}}}^{h^{i^{j_k}}}
  $\qquad a_{b_{c_{d_{e_{f g}}}}}^{h^{i^{j k}}}$

  a_b_c produces an error!

Operators

Operator names are set upright and are predefined

- Correct: $\sin(x)$ Incorrect: $sin(x)$

```
$\sin(x) \cos(y) \tan(2\pi) \lim \arctan$
```

$\sin(x) \cos(y) \tan(2\pi) \lim \arctan$

- Package amsopn provides many definitions:

```
\arccos \arcsin \arg \cos \cot \coth \deg \det
\exp \gcd \inf \injlim \lg \lim \limsup \ln
\max \min \projlim \sec \sinh \sup \tanh
```

Brackets

Bracketing large expressions can be problematic:

```
\[ (
  \frac{\int^a x dx}{\sum_{n=1} x}
) \]
```

$$(\frac{\int^a xdx}{\sum_{n=1} x})$$

Better:

```
\[ \left(
  \frac{\int^a x dx}{\sum_{n=1} x}
\right) \]
```

$$\left(\frac{\int^a xdx}{\sum_{n=1} x}\right)$$

Brackets

- \left and \right before everything that stretches
- \left(\right] also works
- \left. \right) provides adapted right bracket
- Superscripts and subscripts are adjusted:

```
\begin{displaymath}
  \left. \int_a^b f(x) \mathrm dx \right\vert_a^b
  \qquad
  \left\{ \int_a^b f(x) \mathrm dx \right]
\end{displaymath}
```

$$\int_a^b f(x)\mathrm{d}x \Bigg|_a^b \qquad \left\{\int_a^b f(x)\mathrm{d}x\right]$$

Limits

- Specify limits using \limits
- Multi-line limits with \atop

```
\[
  \int_a^b
  \int\limits_a^b
  \sum_{n=1}^\infty
  \prod_{n = 1 \atop m = 2}
\]
```

$$\int_a^b \int\limits_a^b \sum_{n=1}^\infty \prod_{n=1 \atop m=2}$$

Special Characters

- Many characters are accessible by their names,
- as well as Greek uppercase and lowercase letters

```
\begin{align*}
  \nabla \square \\
  \partial \infty \\
  \pm \mp \\
  \alpha \beta \gamma \\
  \rho \varrho \\
  \kappa \varkappa \\
  \epsilon \varepsilon \\
  \theta \vartheta \\
   A B \Gamma
\end{align*}
```

$$\nabla \square$$
$$\partial \infty$$
$$\pm \mp$$
$$\alpha \beta \gamma$$
$$\rho \varrho$$
$$\kappa \varkappa$$
$$\epsilon \varepsilon$$
$$\theta \vartheta$$
$$A B \Gamma$$

If you are looking for a symbol:
texdoc maths-symbols symbols-a4 or Detexify

Roots

```
\[
  \sqrt{a_{n_{m_p}}}
  \quad
  \sqrt[3]{a}
\]
```

$$\sqrt{a_{n_{m_p}}} \quad \sqrt[3]{a}$$

- Roots with deep descenders are unsightly

$\implies$ \smash[⟨t. b⟩]{⟨Formula⟩}

```
\[
  \sqrt{a_{n_{m_p}}}
  \quad
  \sqrt{
    \smash[b]{
      a_{n_{m_p}}
    }
  }
\]
```

$$\sqrt{a_{n_{m_p}}} \quad \sqrt{a_{n_{m_p}}}$$

Matrices

```
\[
  \begin{matrix}
    a_{11} & a_{12}\\
    a_{21} & a_{22}
  \end{matrix}
\]
```

$$
\begin{matrix}
a_{11} & a_{12}\\
a_{21} & a_{22}
\end{matrix}
$$

```
\[
  \left(
    \begin{matrix}
      a_{11} & a_{12}\\
      a_{21} & a_{22}
    \end{matrix}
  \right)
\]
```

$$
\left(
\begin{matrix}
a_{11} & a_{12}\\
a_{21} & a_{22}
\end{matrix}
\right)
$$

Matrices

Package amsmath defines additional matrix environments:

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

pmatrix

$$\begin{Vmatrix} a & b \\ c & d \end{Vmatrix}$$

Vmatrix

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix}$$

vmatrix

$$\begin{Bmatrix} a & b \\ c & d \end{Bmatrix}$$

Bmatrix

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

bmatrix

$$\begin{smallmatrix} a & b \\ c & d \end{smallmatrix}$$

smallmatrix

Package cases provides numbering of case constructs:

```
\begin{numcases}{E = mc^2}
  m \neq 0 & massless particles\\
  m < 0 & antiparticles (?)\\
  m > 0 & normal particles
\end{numcases}
```

$$E = mc^2 \begin{cases} m \neq 0 & \text{massless particles} & (5) \\ m < 0 & \text{antiparticles (?)} & (6) \\ m > 0 & \text{normal particles} & (7) \end{cases}$$

Application

Assignment

Try to recreate the following example.

The Maxwell equations represent the relationship between the electric field $\vec{E}$ and the magnetic field $\vec{B}$:

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0} \qquad\qquad \vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad\qquad \vec{\nabla} \times \vec{B} = \mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t}$$

Formula 8 adds all a_i weighted by c_i.
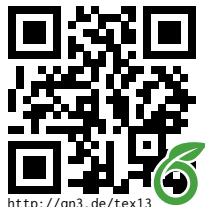
$$\sum_{i=1}^{n} c_i \cdot a_i \tag{8}$$

Part IX

Tables

Table Environment: tabular

\begin{tabular}{⟨*Column Specification*⟩}

```
\begin{tabular}{llr}
first & second & third entry \\
new line & & with two entries \\
third & line
\end{tabular}
```

first	second	third entry
new line		with two entries
third	line	

Column Types

l left-aligned column

c centered column

r right-aligned column

| vertical line between columns

|| double line between columns

p⟨*Width*⟩ column with fixed width

*n⟨*short*⟩ repeat ⟨*short*⟩ *n* times, e. g., *{3}{p{4cm}|}

tabular

```
\begin{tabular}{l|c||r|p{2cm}|c|}
left & center & right & four & five\\\hline\hline
left & center & & & a exceptionally long fourth column that breaks\\\hline
& & & &
\end{tabular}
```

left	center	right	four	five
left	center		a exceptionally long fourth column that breaks	

Different Column Widths

- Package tabularray offers various design options for tables.
- classic usage: \begin{tblr}{⟨*column definitions*⟩} \end{tblr}
- extended input options:
  \begin{tblr}{colspec={⟨*column definitions*⟩}, ⟨*additional options*⟩}
    ⟨*table content*⟩
  \end{tblr}

Table with `tabularray`

```
\begin{tblr}{
    columns = {wd=2cm, halign=c},
    row{2-3} = {font=\itshape},
    vlines, hlines,
  }
  Alpha  & Beta  & Gamma  & Delta \\
  Epsilon & Zeta  & Eta    & Theta \\
  Iota    & Kappa & Lambda & Mu    \\
\end{tblr}
```

Alpha	Beta	Gamma	Delta
Epsilon	*Zeta*	*Eta*	*Theta*
Iota	*Kappa*	*Lambda*	*Mu*

Different Column Widths

New column type:

X[⟨*Factor*⟩,⟨*Type*⟩] (left-aligned) column with variable width

Available width is evenly distributed among all X-columns:

```
\begin{tblr}{|l|l|r|}
 a a & b b & c c
\end{tblr}
```

| a a | b b | c c | |

```
\begin{tblr}{|l|X|r|}
 a a & b b & c c
\end{tblr}
```

| a a | b b | c c |

```
\begin{tblr}{|X[1]|X[2]|X[3]|}
 a a & b b & c c
\end{tblr}
```

| a a | b b | c c |

Rows can be broken with { \\ } if the cell content is enclosed:

```
\begin{tblr}{|X[r]|X[2,c]|X|}
 a a & {b b\\b b} & c c
\end{tblr}
```

| a a | b b
b b | c c |

Vertical Alignment

Row types h, m, and b{⟨*Height*⟩} align content at the head, center, and foot of the row, respectively.

```
\begin{tblr}{ colspec={l|c|r}, rowspec={h{8mm}|m{12mm}|f{8mm}} }
  aa        & bb       & {cc\\ccc} \\
  aa        & {bb\\bbb} & cc        \\
  {aa\\aaa} & bb       & cc        \\
\end{tblr}
```

aa	bb	cc
		ccc
aa	bb bbb	cc
aa aaa	bb	cc

Cells Spanning Multiple Columns/Rows

\SetCell[r=⟨*Rows*⟩,c=⟨*Columns*⟩]{⟨*Alignment*⟩} enlarges current cell

```
\begin{tblr}{|c|c|c|c|c|}
\hline
  \SetCell[r=2]{c} 2 Rows
  & \SetCell[c=2]{c} 2 Columns
  & & \SetCell[r=2,c=2]{c} 2 Rows 2 Cols &
\\
\hline
  & 2b & 2c & & \\
\hline
3a & 3b & 3c & 3d & 3e \\
\hline
\end{tblr}
```

2 Rows	2 Columns		2 Rows 2 Cols	
	2b	2c		
3a	3b	3c	3d	3e

Colored Tables

```
\begin{tblr}{
  row{odd} = {bg=azure8},
  column{1} = {bg=azure4},
  row{1} = {
    bg=azure3, fg=white,
    font=\bfseries,
  },
}
  Alpha & Beta & Gamma & Delta \\
  Epsilon & Zeta & Eta & Theta \\
  Iota & Kappa & Lambda & Mu \\
  Nu & Xi & Omicron & Pi \\
  Rho & Sigma & Tau & Ypsilon \\
\end{tblr}
```

Alpha	Beta	Gamma	Delta
Epsilon	Zeta	Eta	Theta
Iota	Kappa	Lambda	Mu
Nu	Xi	Omicron	Pi
Rho	Sigma	Tau	Ypsilon

In addition to tabularray, the xcolor package must be loaded.

Math in Tables

X[$/$$] automatically starts inline/display math mode throughout the column

S automatically aligns at the decimal point
requires \UseTblrLibrary{siunitx}
Text must be marked with guard

```
\begin{tblr}{
  hlines,vlines,
  colspec={X[$]X[$$]SS[table-format=1.5]},
  row{1} = {guard},
}
  a·b·c  & a·b·c  & Numbers & Numbers \\
  \frac12 & \frac12 & 111     & 0.00001 \\
  \frac34 & \frac34 &   2.1   & 0.0001  \\
  \frac56 & \frac56 & 33.11   & 0.001   \\
\end{tblr}
```

$a \cdot b \cdot c$	$a \cdot b \cdot c$	Numbers	Numbers
$\frac{1}{2}$	$\dfrac{1}{2}$	111	0.000 01
$\frac{3}{4}$	$\dfrac{3}{4}$	2.1	0.0001
$\frac{5}{6}$	$\dfrac{5}{6}$	33.11	0.001

Questionable Layout

- Package booktabs (Simon Fear) for high-quality tables
- when using tabularray: \UseTblrLibrary{booktabs}
- Recommendations from the package:

"

1. *Never, ever use vertical rules.*
2. *Never use double rules.*
3. *Put the units in the column heading (not in the body of the table).*
4. *Always precede a decimal point by a digit; thus* 0.1 *not just* .1.
5. *Do not use "ditto" signs or any other such convention to repeat a previous value. In many circumstances a blank will serve just as well. If it won't, then repeat the value.* booktabs documentation

"

Without booktabs

```
\begin{tabular}{||l|lr||} \hline
  Mosquitoes     & Grams      & \$13.65 \\ \cline{2-3}
           & per          & .01 \\ \hline
  Wildebeest        & stuffed & 92.50 \\ \cline{1-1} \cline{3-3}
  Emu        &                & 33.33 \\ \hline
  Armadillo & frozen   & 8.99 \\ \hline
\end{tabular}
```

Mosquitoes	Grams	$13.65
	per	.01
Wildebeest	stuffed	92.50
Emu		33.33
Armadillo	frozen	8.99

With booktabs

```
\begin{tblr}{llS[table-format=3.2]} \toprule
  \SetCell[c=2]{c} Item & & \\ \cmidrule[r]{1-2}
  Animal      & Description & {{{Price (\$)}}}\\ \midrule
  Mosquito    & per Gram   & 13.65 \\
            & per Piece   & 0.01 \\
  Wildebeest      & stuffed  & 92.50 \\
  Emu       & stuffed  & 33.33 \\
  Armadillo & frozen     & 8.99 \\ \bottomrule
\end{tblr}
```

Item		
Animal	Description	Price ($)
Mosquito	per Gram	13.65
	per Piece	0.01
Wildebeest	stuffed	92.50
Emu	stuffed	33.33
Armadillo	frozen	8.99

Useful for Dealing with Tables ...

- tabularray libraries integrate existing packages into tblr syntax
  Load with \UseTblrLibrary{⟨*library*⟩} (see documentation)
    - amsmath use table functions e. g., in matrices
    - booktabs set *beautiful* tables
    - diagbox split first cell diagonally
    - siunitx align data in tables at decimal point
- longtblr environment allows tables with footnotes and page breaks

- Practical Online Tool: Tables Generator
  https://www.tablesgenerator.com/

Application

Assignment

Create a table with the following table header in a floating environment. Add a caption (\caption).

Serial No.	Item	Quantity	Description
1	Pencil	13	absolute premium quality, especially sharp, hand-painted, grade HB
2	...		

Part X

Extensive Documents

Organization

- Drawback of TeX: Long documents become unwieldy
- Advantage of TeX: Parts of the document can be outsourced to external files
- Enables smart organization and management of a document

Organization

- One main file as a blank skeleton
- One header file (possibly additional file(s) for specific command definitions)
- Contents in a subfolder
- Figures and other materials in further subfolders

```
main/
    mainfile.tex
    header.tex
    contents/
        chapter1.tex
        chapter2.tex
        appendix1.tex
    images/
        image1.png
        image2.jpg
```
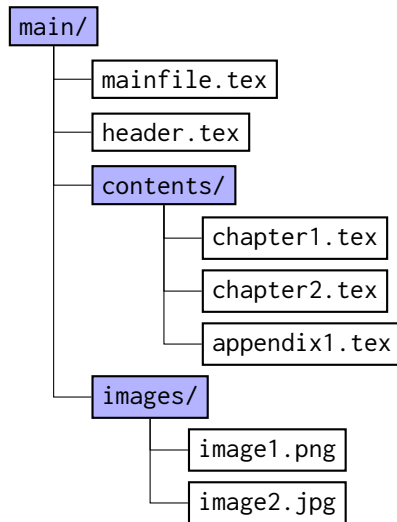
- \input and \include insert external files at the specified location
- TₑX "jumps" out of the current document, reads elsewhere, and jumps back
- TₑX version: \input simply reads the code as if it belonged to the main document
- LATₑX version: \include creates its own .aux file (useful when .aux is needed)
- \includeonly{a.tex,b.tex} in the preamble allows only the specified files for \include
- \excludeonly{b.tex,c.tex} does *not* allow the specified files for \include (requires excludeonly package)

Root Document

- After division, only the main document must be compiled
⇒ Constant switching between documents
- Good editors take care of the work:
    - Definition of main documents possible
    - Automatically compiles the associated main document

TEXworks	Setting *magic comments:*
TEXshop	%␣!TEX␣root␣=␣⟨*Main document*⟩
TEXstudio	

```
% !TEX root = ../Thesis.tex
% !TEX program = lualatex
% !TEX encoding = utf8
% !TEX spellcheck = en_US
```

Overleaf	Menu → Main Document
Many IDEs	Setting a "project main file"

Example Main Document

```
\input{header}

\includeonly{chapter1}
\excludeonly{appendix} % requires excludeonly package!

\begin{document}
\include{chapter1}
\include{chapter2}
...
\appendix
\include{appendix}
\end{document}
```

$\Rightarrow$ Only chapter1 is set here, appendix is explicitly never included.

- Page layout
- Fonts (body text, headings)
- Formatting of equations
- ...
- everything before \begin{document}

Front Matter

- Contains everything up to the first content page
- Includes author, title, etc.
- with KOMA: Document option `titlepage=true/false` sets own pages or a title head
- Environment `\begin{titlepage}` sets a freely designable title page
- Command `\maketitle` sets predefined front matter
- Specifications of `\title`, `\author`, `\extratitle` etc. necessary and possible

Title Commands in the KOMA Bundle

```
\documentclass{scrbook}
\begin{document}
\titlehead{\Large University of Smartville}
\subject{Master's Thesis}
\title{Risk Management in the Era of Social Media}
\subtitle{Design of Interactive Apps for Banks and
Insurance Companies}
\author{cand. stup. Ian Imprécis}
\date{February 30, 2024}
\publishers{Supervised by Prof. Dr. Smartypants}
\dedication{For my Mom.}

\maketitle
\end{document}
```

\maketitle (in the Beamer Class)

```
\title{Risk Management in the Era of Social Media}
\subtitle{Design of Interactive Apps for Banks and
Insurance Companies}
\author{cand. stup. Ian Imprécis}
\date{30. Februar 2024}

\maketitle
```

Risk Management in the Era of Social Media
Design of Interactive Apps for Banks and Insurance Companies

cand. stup. Ian Imprécis

30. Februar 2024

Abstract

- Environment abstract exists for a brief summary of the document
- Several abstracts possible (e. g., English/German etc.)

```
\begin{abstract}
Here comes a brief summary of the
content \dots
\end{abstract}

And here the actual document starts
\dots
```

<div>

Abstract

Here comes a brief summary of the content ...

And here the actual document starts ...

</div>

The abstract environment is not available in the scrbook/book class.

- Lists compile structured elements
- Essentially, anything can be included in its own list
- Common lists:
  - Table of contents   `\tableofcontents`
  - List of figures   `\listoffigures`
  - List of tables   `\listoftables`
- Inclusion of lists in the table of contents: `\setuptoc{toc}{totoc}`

Footnotes, Marginal Notes

Additional text that does not fit into the main document/text flow

- Footnotes   \footnote{}
- Floating margin note   \marginpar
- Margin note (Package marginnote)   \marginnote

Package footmisc offers various options to customize the appearance of footnotes

Quotations

There are dedicated environments for quotations:

- quote for short quotations
- quotation for longer quotations
- verse for poems

Package csquotes adjusts finer points of quotation marks for non-English text.

```
\begin{quote}
alea iacta est \hfill\textit{Caesar}
\end{quote}
```

References

- Elements can be labeled with \label{}
- Possible elements are headings (sections etc.), table, figure, formulas, …
- Referencing with \ref{} or \cref (Package cleveref)

Links in the Document
hyperref

- Package hyperref makes references clickable in the PDF
- \ref and \cite are automatically linked
- URLs can be specified with \url{}
- Named links with \href{}{}

To avoid problems, load hyperref as the last package!

```
\url{http://xkcd.com}\\
\href{mailto:mail@latexkurs.de}{\huge\
Letter}
```

```
http://xkcd.com
⊠
```

Front Matter

- Command \frontmatter switches to Roman page numbers
- \mainmatter to normal numbering
- \backmatter to appendix
  in other document classes: only \appendix
- Numbering starts anew
  (dependent on document class A, B, C, ...)
- Sections in the appendix as usual with \chapter, \section, etc.

```
\frontmatter
\mainmatter
\backmatter
```

Application

Assignment

Add the following elements to your document:

- Title page
- Table of contents
- List of figures
- List of tables
- Appendix

Diagrams

Diagrams

- A diagram is a graphical representation of data, facts, or information.
- Information should be the primary focus.
- Diagrams should fit into the document:
    - appropriate dimensions
    - labeling in the same font style

Recommendation for diagrams in LaTeX: `pgfplots`

pgfplots

Configuration using \pgfplotsset{⟨*options*⟩}. The package author recommends specifying the current version for future compatibility.

```
\usepackage{pgfplots}
\pgfplotsset{compat=1.18}
```

pgfplots is based on TikZ/PGF and therefore is within a tikzpicture environment:

```
\begin{tikzpicture}
  \begin{axis}
    ...
  \end{axis}
\end{tikzpicture}
```
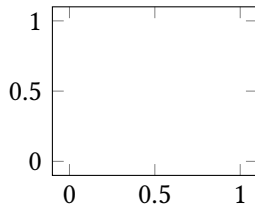
Types of Axes

Various types of axes available:

```
\begin{⟨axis type⟩}[⟨options⟩]
  ⟨content⟩
\end{⟨axis type⟩}
```

axis	linear coordinate axes
semilogyaxis	linear x-axis, logarithmic y-axis
semilogxaxis	logarithmic x-axis, linear y-axis
loglogaxis	both axes logarithmic
polaraxis	polar coordinates[*]
smithchart	Smith chart[†]
ternaryaxis	ternary diagram[‡]

---

[*]with \usepgfplotslibrary{polar}
[†]with \usepgfplotslibrary{smithchart}
[‡]with \usepgfplotslibrary{ternary}

Adding Data

```
\addplot [⟨options⟩] {⟨input data⟩};
\addplot+[⟨options⟩] {⟨input data⟩};
```

```
\begin{tikzpicture}
  \begin{axis}
    \addplot{sin deg(x)};
  \end{axis}
\end{tikzpicture}
```

Coordinate Input
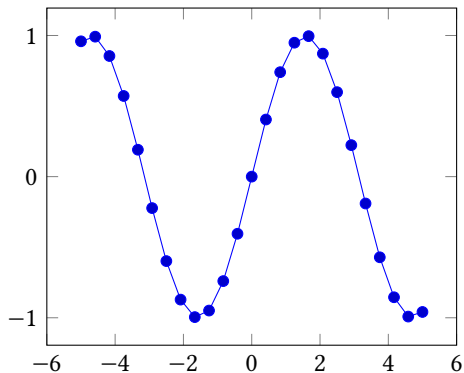
\addplot [⟨*options*⟩] coordinates {⟨*coordinates*⟩};

```
\begin{tikzpicture}
  \begin{loglogaxis}
    \addplot+[smooth]
     coordinates {
       (769, 1.6227e-04)
       (1793, 4.4425e-05)
       (4097, 1.2071e-05)
       (9217, 3.2610e-06)
       (2.2e5, 2.1E-6)
       (1e6, 0.00003341)
       (2.3e7, 0.00131415)
     };
  \end{loglogaxis}
\end{tikzpicture}
```

Data Tables

\addplot [⟨*options*⟩] table [⟨*column selection*⟩] {⟨*table*⟩};
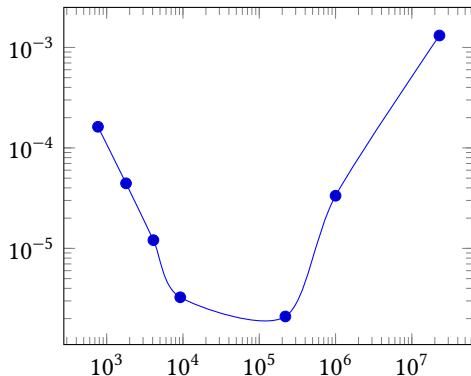
```
\begin{tikzpicture}
  \begin{axis}
    \addplot table [
      only marks,
    ] {
      x    y    myvalue
      0.5  0.2  0.25
      0.2  0.1  1.5
      0.7  0.6  0.75
      0.35 0.4  0.125
      0.65 0.1  2
    };
  \end{axis}
\end{tikzpicture}
```

Data in External Files

`\addplot [⟨options⟩] table [⟨column selection⟩] {⟨file path⟩};`
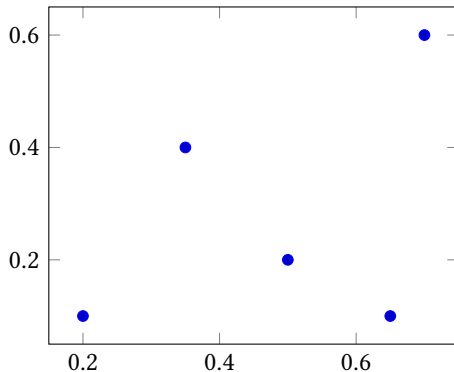
```
\begin{tikzpicture}
  \begin{axis}
    \addplot [no markers]
      table
      [x=time, y=values]
      {data.dat};
  \end{axis}
\end{tikzpicture}
```
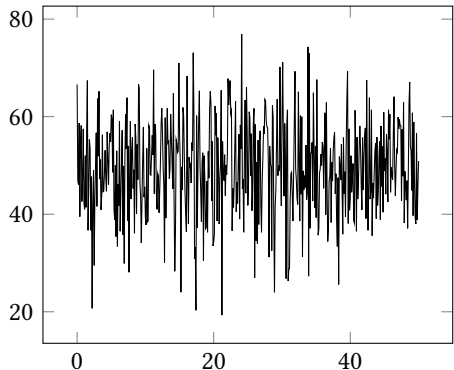

Package pgfplotstable allows post-processing of existing tables (e.g., inserting a trendline).

Labels

Key	Values	Function
title	Text	Title above the diagram
x/ylabel	any text	Label of the x- or y-axis
x/ymin/max	value	limits axis to range
mark	*, x, +, o, ...	customize coordinate markers
x/ytick	list	explicitly specify coordinate ticks
minor tick num	number	number of minor ticks
grid	major, minor	display gridlines in the background

Legends

\addlegendentry{⟨*description*⟩}

```
\begin{tikzpicture}
\begin{axis}
  \addplot[smooth,mark=*,blue]
coordinates {
    (0,2) (1,3) (3,1)
  };
  \addlegendentry{Case 1}
  \addplot[smooth,color=red,mark=x]
coordinates {
    (0,0) (1,1) (2,1) (3,2)
  };
  \addlegendentry{Case 2}
\end{axis}
\end{tikzpicture}
```
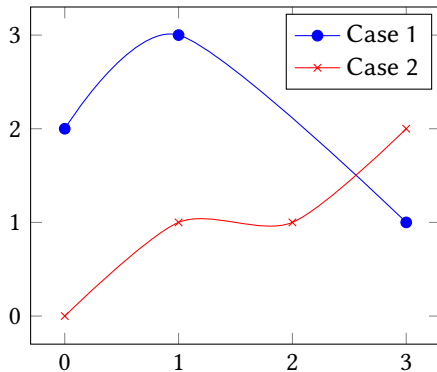
Axis Placement

axis y line=⟨*placement*⟩, axis x line=⟨*placement*⟩

```
\begin{tikzpicture}
\begin{axis}[
minor tick num=3,
axis y line=center,
axis x line=middle,
xlabel=$x$,ylabel=$\sin x$
]
\addplot[smooth,blue,mark=none,
domain=-5:5,samples=40]
{sin(deg(x))};
\end{axis}
\end{tikzpicture}
```
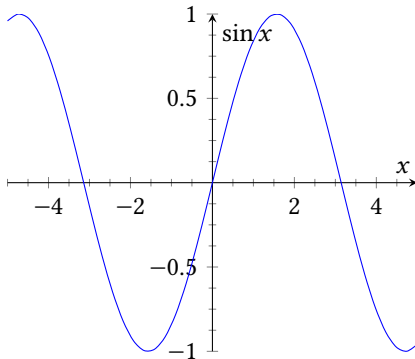
Error Bars

Errors can be set using the options error bars/⟨key⟩=⟨value⟩.

```
\begin{tikzpicture}
\begin{axis}
 \addplot+[
  error bars/y dir=both,
  error bars/y fixed relative=.1,
 ] table [x=x,y=y]
 {x      y
  32     32
  64     64
  128    128
 };
\end{axis}
\end{tikzpicture}
```
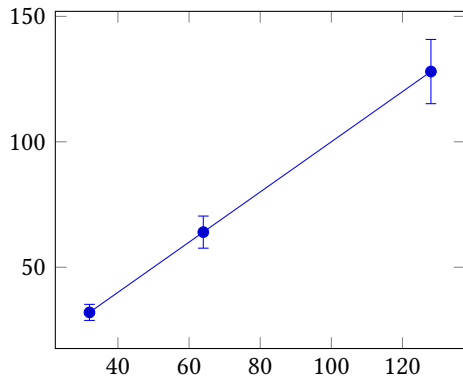
Error Bars

Individual errors can be specified with +- (symmetric) or += and -= (asymmetric):
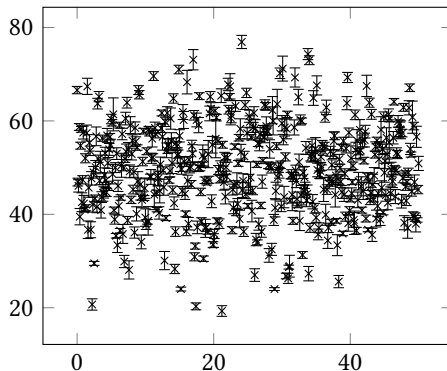
```
\begin{tikzpicture}
\begin{axis}
  \addplot+[
    error bars/.cd,
    x dir=both,
    x explicit,
    y dir=both,
    y explicit,
  ] coordinates {
    (1,1) += (0.4,0.2)
          -= (0.1,0.1)
    (3,2) -= (1,0)
    (4,5) +- (0.3,0.2)
  };
\end{axis}
\end{tikzpicture}
```
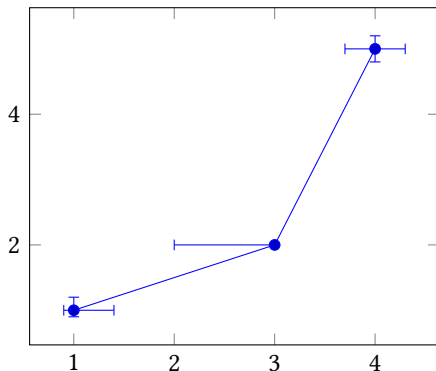
Error Bars

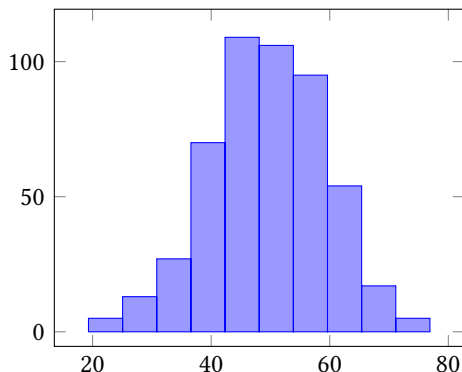Errors can also come from a table:

```
\begin{tikzpicture}
  \begin{axis}
    \addplot [only marks, mark=x,
    error bars/.cd,
    y dir=both, y explicit,]
      table
      [x=time, y=values, y error=error]
      {data.dat};
  \end{axis}
\end{tikzpicture}
```

Histograms

Histograms with option hist={⟨*histogram options*⟩}

```
\begin{tikzpicture}
  \begin{axis}
    \addplot+[
      fill=blue!40!white,
      mark={},
      hist={
        data=y,
        bins=10
      }
    ] table {data.dat};
  \end{axis}
\end{tikzpicture}
```
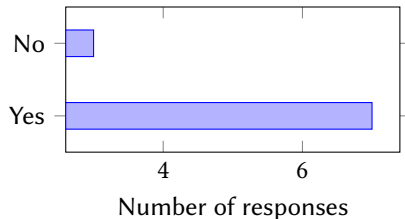

Interesting options:
cumulative for cumulative histogram
density normalized to 1

Bar Charts

Option xbar creates horizontal bar chart, ybar creates vertical bar chart

```
\begin{tikzpicture}
\begin{axis}[
 xbar,
 width=6cm, height=3.5cm,
 enlarge y limits=0.5,
 xlabel={Number of responses},
 symbolic y coords={Yes,No},
 ytick=data,
]
 \addplot coordinates
  {(3,No) (7,Yes)};
\end{axis}
\end{tikzpicture}
```


Number of responses

Bar Charts

Option xbar creates horizontal bar chart, ybar creates vertical bar chart

```
\begin{tikzpicture}
\begin{axis}[
 ybar,enlargelimits=0.15,
 symbolic x coords={a,b,c},xtick={a,b,c
},
]
 \addplot coordinates
 {(a,40) (b,50) (c,70)};
 \addplot coordinates
 {(a,43) (b,45) (c,65)};
 \

addplot coordinates
 {(a,13) (b,25) (c,35)};
\end{axis}
\end{tikzpicture}
```
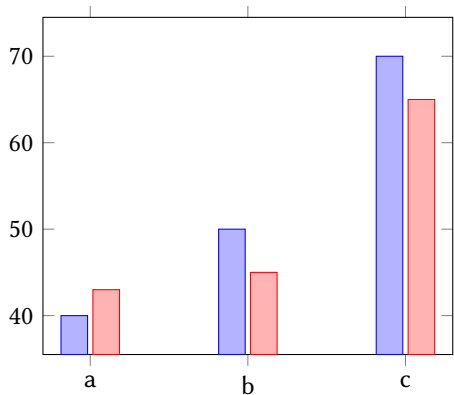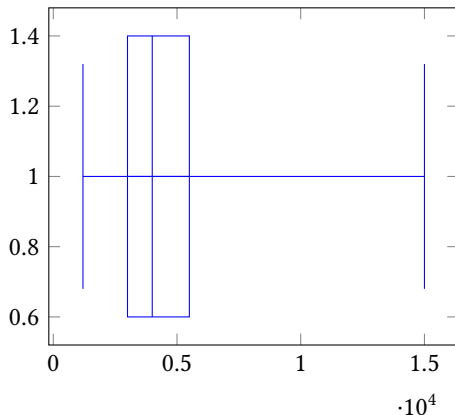
Boxplots

\usepgfplotslibrary{statistics} allows generation of boxplots:
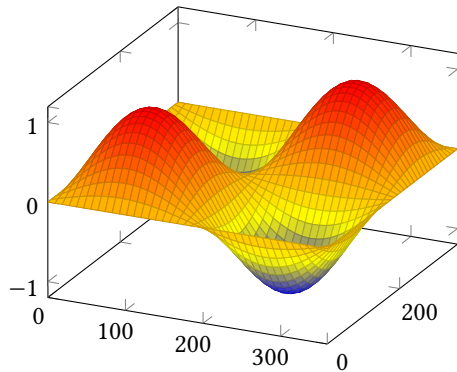
```
\begin{tikzpicture}
  \begin{axis}
    \addplot+[
    boxplot prepared={
      median=4000,
      upper quartile=5500,
      lower quartile=3000,
      upper whisker=1200,
      lower whisker=15000,
    } ] coordinates {};
  \end{axis}
\end{tikzpicture}
```

3D Plots

\addplot3 [⟨*options*⟩] {⟨*input data*⟩};

```
\begin{tikzpicture}
  \begin{axis}
    \addplot3[
      surf,
      domain=0:360,
      samples=40,
    ]
    {sin(x)*sin(y)};
  \end{axis}
\end{tikzpicture}
```

Further Reading I

📄 Herbert Voß.
"Math mode."
texdoc mathmode

📄 American Mathematical Society.
"User's Guide for the amsmath Package."
texdoc amsmath

📄 Jianrui Lyu.
"Tabularray. Typeset Tabulars and Arrays with LaTeX3."
texdoc tabularray

📄 Simon Fear.
"Publication quality tables in LaTeX."
texdoc booktabs

Further Reading II

📕 Herbert Voß.
"Die wissenschaftliche Arbeit mit LaTeX. unter Verwendung von LuaTeX, KOMA-Script und Biber/BibLaTeX."
Lehmanns Media, 2018.

📕 Markus Kohm.
"KOMA-Script."
texdoc koma-script
2023.

📄 Christian Feuersänger.
"Manual for Package pgfplots."
texdoc pgfplots

Teaching Evaluation

Link: evasys.uni-mannheim.de
TAN: UKFED

Happy T_EXing