

# Document title

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*Lorem ipsum dolor sit amet, consectetur adipiscing elit. Aenean ut elit odio.*

*Donec fermentum tellus neque, vitae fringilla orci pretium vitae. Fusce maximus  
finibus facilisis. Donec ut ullamcorper turpis. Donec ut porta ipsum. Nullam cursus  
mauris a sapien ornare pulvinar. Aenean malesuada molestie erat quis mattis.*

*Praesent scelerisque posuere faucibus.*

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2022-09-06



Universität Hamburg  
DER FORSCHUNG | DER LEHRE | DER BILDUNG

**FAKULTÄT**  
**FÜR MATHEMATIK, INFORMATIK**  
**UND NATURWISSENSCHAFTEN**

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# 1 Introduction

## 1.1 YAML header

Configure the YAML header including the following elements:

- **title**: Title
- **subtitle**: Subtitle; remove option completely if you don't need a subtitle.
- **author**: Here you can list various author's names including their affiliation(s) and the email of the corresponding author.
- **date**: A date
- **abstract**: The abstract will be shown right after the title in smaller font size.
- **logo1** and **logo2**: path of the logos that will be displayed on the bottom left and right of title page (after the front cover).
- **language**: If language is NOT English refer to the file `custom_lang.yml` for automatic text in German. If the document language is another one, adjust this file.
- **bibliography**: A path to the bibliography file to use for references (BibTeX `.bib` file). The current file includes 3 dummy references; either insert your references into this file or replace the file with your own.
- **csl**: The style is provided in the 'sage-harvard.csl' file, which adopts the [SAGE Harvard](#) reference style. Just leave the file as it is.
- **format - pdf**: In this template many of the Quarto options for Word output are listed in the YAML header. If you want to know more about these settings I recommend the [PDF format reference](#) for a complete list of available options. For instance, you can adjust the figure and table references with `fig-title`, `tbl-title`, `fig-prefix`, and `tbl-prefix`.
  - **template-partials**: these 3 files are required for the layout of the front cover and title page.
  - **include-in-header**: The file 'styles/in-header.tex' determines the overall layout of the document.
  - Custom options:
    - `cover-bg-image`: path of the image on the cover page.
    - `cover-page-color`: background color of the cover page (provided as hex color code).
    - `cover-text-color`: color of the header on the cover page (provided as hex color code).
    - `cover-fade-effect`: if 'true' (default), the background color will overlay the image and fade away from top to bottom. If 'false' the image will overlay the background color.
- **execute**: Global options for customizing output from executed code are specified within this execute key.
- **fig-align**: Global settings for figure positioning. For other settings see the [PDF format reference](#).

The default font for this template is ‘Helvetica’ but can be replaced with the University’s own font style ‘TheSansUHH’. If you are associated with the UHH you are allowed to use this font. You can choose the font in the template when running the function, e.g., `UHHformats::create_quarto_doc(dirname = "your_pdf_report", template = "pdf_report", font = "TheSansUHH")`.

## 1.2 Code blocks

Code blocks in Quarto documents are treated in similar way as in Markdown documents. One important difference is that code chunk options (in Quarto also called ‘cell level options’) are typically included in special comments using `#|` at the top of code chunks rather than within the line that begins the chunk:

Please note that individual words are separated with a hyphen, not a dot, followed by a colon, not an equal sign as in R Markdown documents. Quarto uses this approach to both better accommodate longer options like `fig-cap`, `fig-subcap`, and `fig-alt` as well as to make it straightforward to edit chunk options within more structured editors that don’t have an easy way to edit chunk metadata (e.g. most traditional notebook UIs).

However, if you prefer it is still possible to include chunk options on the first line (e.g. “`{r, echo = FALSE}`”) as in R Markdown documents.

## 1.3 Callout blocks

Quarto provides five different types of callouts that are an excellent way to draw extra attention to certain concepts.

### Note

The color and icon will be different depending upon the type that you select. You can choose between: `note`, `warning`, `important`, `tip`, and `caution`.

### Tip With Caption

This is an example of a callout with a caption.

## 2 Methods

### 2.1 Cross-references

External images and R figures can be referenced with `@fig-label`, where ‘label’ is the name of the code chunk. These label names should not contain underscores to separate words, use hyphens here instead. Note that figures need to have a caption to be numbered and for cross-referencing, The caption is also set in the chunk option with `#| fig-cap: "Your caption"`.

Tables require similarly a label and table caption for cross-referencing. But here, the cross-reference contains the prefix ‘tbl’: `@tbl-label`.

Cross-references to individual sections can simply be made with the prefix ‘sec’ and by adding a ‘`{#sec-identifier}`’ to any heading.

This is for example a cross-reference to Table 3.2 in Section 3.2 and a cross-reference to Fig. 3.1 in Section 3.3.

To create a reference-able code block, add a `#lst-identifier` along with a `lst-cap` attribute inside the curly braces (see code chunk example Listing 2.1). Note that the indication of the programming language requires for this static code block a dot set before the ‘r’.

---

#### **Listing 2.1** Example for a referenceable code block

---

4+4

---

### 2.2 Mathematical equations

Use mathematics as usual with the dollar sign \$ at the beginning and end of the equation; either in **inline mode** with one dollar sign such as  $E = mc^2$  or in **display mode** with two dollar signs:

$$E = mc^2$$

Important to note: do not leave a space between the ‘\$’ and your mathematical notation.

Alternatively, you can use LaTeX for more control and when equations are more complicated. LaTeX equations are also automatically numbered if you define a label within the equation environment, which is useful if you have many equations and want to cross-reference them. The equation label needs to be written with ‘`#eq:label`’ before the end of the equation (see Equation 2.1):

$$\bar{X} = \frac{\sum_{i=1}^n X_i}{n} \tag{2.1}$$

Formulas and corresponding explanations should be integrated into the sentence and, thus, end with a comma or period. Here comes an example:

If the random variable  $Y$  follows a standard normal distribution, i.e.  $Y \sim N(0, 1)$ , its density function can be described with

$$f_Y(y) = \varphi(y) \stackrel{\text{def}}{=} \frac{1}{\sqrt{2\pi}} \exp \left\{ -\frac{y^2}{2} \right\}, \quad y \in \mathbb{R}. \quad (2.2)$$

$\pi$  represents the circle number or Ludolph's number. The function

$$F_Y(y) = \Phi(y) \stackrel{\text{def}}{=} \int_{-\infty}^y \varphi(x) dx, \quad y \in \mathbb{R} \quad (2.3)$$

represents then the distribution function of Equation 2.2.

The numbering of equations, as in Equation 2.2, should only be done if they are referred to in the rest of the text. Especially if there are many equations in the thesis, the use of LaTeX seems to make more sense.

## 2.3 Images

Quarto includes several features aimed at making it easier to work with figures and subfigures, as well as for laying out panels that contain multiple figures, tables, or other content.



**Figure 2.1:** Single image of Iris setosa with URL link but no cross-reference.

For instance, if you have several figures that appear as a group, you can create a figure div to enclose them (see Fig. 2.2 and Fig. 2.3).

The layout attribute enables the creation of much more complex layouts. Fig. 2.7 provides an example with a common figure caption and one identifier for all three.



**Figure 2.2:** Iris versicolor



**Figure 2.3:** Iris virginica



**Figure 2.4:** Iris setosa



**Figure 2.5:** Iris versicolor



**Figure 2.6:** Iris virginica

**Figure 2.7:** Custom layout of images

# 3 Results

## 3.1 R output

R output is typically shown in the monospace font (here an example with the `mtcars` dataset in the subfolder `data/`):

mpg	cyl	disp	hp
Min. :10.40	Min. :4.000	Min. : 71.1	Min. : 52.0
1st Qu.:15.43	1st Qu.:4.000	1st Qu.:120.8	1st Qu.: 96.5
Median :19.20	Median :6.000	Median :196.3	Median :123.0
Mean :20.09	Mean :6.188	Mean :230.7	Mean :146.7
3rd Qu.:22.80	3rd Qu.:8.000	3rd Qu.:326.0	3rd Qu.:180.0
Max. :33.90	Max. :8.000	Max. :472.0	Max. :335.0

## 3.2 Tables

Here is a simple table based on Markdown Syntax (Table 3.1).

**Table 3.1:** My Caption

A	New	Table
left-aligned	center-aligned	right-aligned
\$123	\$456	\$789
<i>italics</i>	<del>strikethrough</del>	<b>boldface</b>

### 3.2.1 Using the `knitr` package

Table 3.2 is an example of using `knitr::kable()` to generate the table.

**Table 3.2:** This is a table produced with `knitr::kable()`.

	mpg	cyl	disp	hp	drat	wt
Mazda RX4	21.0	6	160	110	3.90	2.620
Mazda RX4 Wag	21.0	6	160	110	3.90	2.875
Datsun 710	22.8	4	108	93	3.85	2.320
Hornet 4 Drive	21.4	6	258	110	3.08	3.215
Hornet Sportabout	18.7	8	360	175	3.15	3.440

### 3.2.2 The `xtable` package

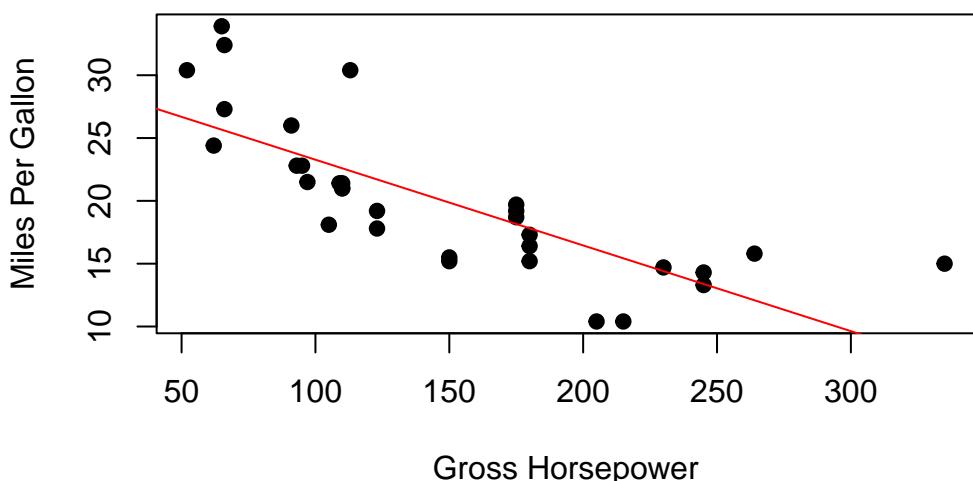
Another useful package for tables for PDF output is `xtable`. The following code will produce an example table if the `xtable` package is installed. Note that you need to add the chunk option `results = "asis"` inside `{r}` otherwise the PDF will contain the `\LaTeX` code of the table!

**Table 3.3:** A table made with `xtable`.

	mpg	cyl	disp	hp	drat	wt
Mazda RX4	21.00	6	160.00	110	3.90	2.62
Mazda RX4 Wag	21.00	6	160.00	110	3.90	2.88
Datsun 710	22.80	4	108.00	93	3.85	2.32
Hornet 4 Drive	21.40	6	258.00	110	3.08	3.21
Hornet Sportabout	18.70	8	360.00	175	3.15	3.44

## 3.3 Figures

A base graphics scatterplot (Fig. 3.1).

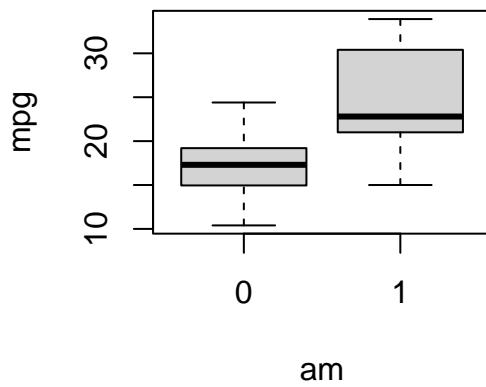


**Figure 3.1:** Relationship between horsepower and fuel economy.

Here for comparison a boxplot with a different image height (Fig. 3.2).

## 3.4 Diagrams

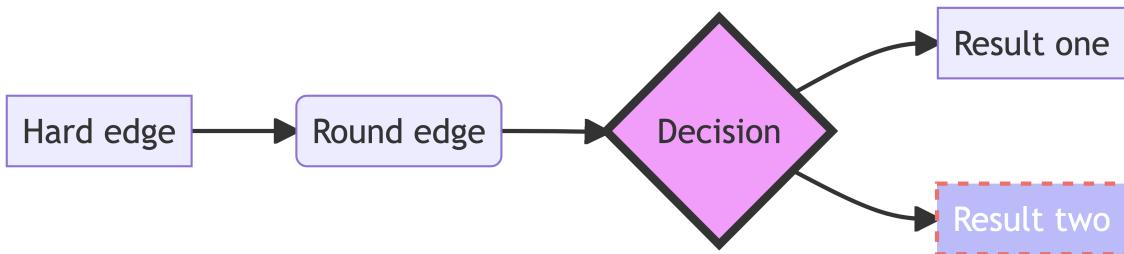
Quarto has native support for embedding *Mermaid* and *Graphviz* diagrams. This enables you to create flowcharts, sequence diagrams, state diagrams, gnatt charts, and more using a plain text syntax inspired by markdown.



**Figure 3.2:** Fuel differences between transmission types (0 = automatic, 1 = manual).

### 3.4.1 Mermaid

Mermaid is a Javascript based diagramming and charting tool that uses Markdown-inspired text definitions and a renderer to create and modify complex diagrams (see Fig. 3.3).



**Figure 3.3:** Simple flowchart based on the JS-tool Mermaid.

**i Note**

Cell level options are here indicated with %%| instead of #|!

Useful links:

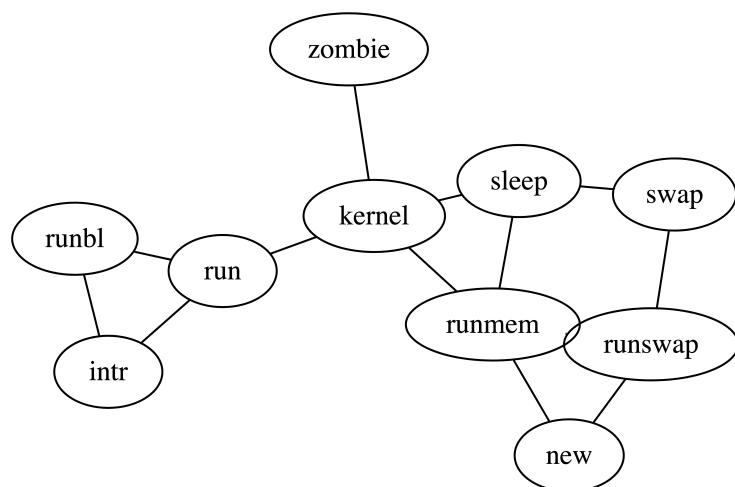
- <https://mermaid-js.github.io/mermaid/#/>
- <https://mermaid.live>

### 3.4.2 Graphviz

The [Graphviz](#) layout programs take descriptions of graphs in a simple text language and make diagrams in useful formats. Graphviz has many useful features for concrete diagrams, such as options for colors, fonts, tabular node layouts, line styles, hyperlinks, and custom shapes (see Fig. 3.4).

**i Note**

Cell level options are here indicated with //|!



**Figure 3.4:** An example for a diagram made with Graphviz.

# 4 Adding citations and bibliography

Link a `.bib` document via the YAML header, and the bibliography will be printed at the end. The default bibliography style is provided in the `sage-harvard.csl` file (do not delete), which adopts the [SAGE Harvard](#) reference style.

References can be cited directly within the document using the Quarto equivalent of the L<sup>A</sup>T<sub>E</sub>X citation system `[@key]`, where key is the citation key in the first line of the entry in the `.csl` file. Example: (Taylor and Green, 1937). To cite multiple entries, separate the keys by semicolons (e.g., (Kamm, 2000; Knupp, 1999)). You can also write in-text citations, as follows: Taylor and Green (1937) say this and that.

There is also the package `citr` which I highly recommend: `citr` provides functions and an RStudio add-in to search a BibTeX-file to create and insert formatted Markdown citations into the current document. If you are using the reference manager [Zotero](#) the add-in can access your reference database directly.

## 4.1 Software

If you want to include a paragraph on the software used, here is some example text/code to get the current R and package versions. The code to create a separate bibliography file named ‘packages.bib’ with all package references has already been added at the beginning of this script (code chunk ‘generate-package-refs’).

All analyses were performed using the statistical software R (version 4.1.2) (R Core Team, 2021). This thesis, including tables, was generated using the R packages ‘rmarkdown’ (version 2.14) (Allaire et al., 2022), and ‘knitr’ (version 1.39) (Xie, 2022).

## 4.2 Examples for footnotes

Here is a footnote reference<sup>1</sup>, and another<sup>2</sup>.

---

<sup>1</sup>Here is the footnote.

<sup>2</sup>Here's one with multiple blocks.

Subsequent paragraphs are indented to show that they belong to the previous footnote.

```
{ some.code }
```

The whole paragraph can be indented, or just the first line. In this way, multi-paragraph footnotes work like multi-paragraph list items.

## 5 References

- Allaire J, Xie Y, McPherson J, et al. (2022) *Rmarkdown: Dynamic Documents for r*. Available at: <https://CRAN.R-project.org/package=rmarkdown>.
- Kamm J (2000) *Evaluation of the Sedov-von Neumann-Taylor blast wave solution*. Technical Report LA-UR-00-6055. Los Alamos National Laboratory.
- Knupp P (1999) Winslow smoothing on two-dimensional unstructured meshes. *Eng Comput* 15: 263–268.
- R Core Team (2021) *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. Available at: <https://www.R-project.org/>.
- Taylor G and Green A (1937) Mechanism of the production of small eddies from large ones. *P Roy Soc Lond A Mat* 158(895): 499–521.
- Xie Y (2022) *Knitr: A General-Purpose Package for Dynamic Report Generation in r*. Available at: <https://yihui.org/knitr/>.

## Acknowledgments

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Aenean ut elit odio. Donec fermentum tellus neque, vitae fringilla orci pretium vitae. Fusce maximus finibus facilisis. Donec ut ullamcorper turpis.