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Creating content using RStudio Server

manual

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Introduction

Once upon a time, a student asked me to help him in R. i had no experience with R, however i gave it a chance. i installed RStudio Server. Months passed after my first use until i needed it for my stuff. i was studying statistics in a university and our teacher wanted us to create our solutions using a spreadsheet program. i saw that using R, i could learn more useful stuff and moved on RStudio Server. i learnt to create output using *bookdown* which is a library that can be used for creating websites or e-books while including calculations and graphs. As *bookdown* has a steap learning curve, i want to elaborate it here. Template strings are marked with angle brackets.

For me, regarding cross-references, the following things are important:

1. It must be possible to cross-reference between files.
2. R code in one file must be accessible in another file.
3. Citations in table captions using `kableStyling` must be possible.

Currently, *bookdown* supports all of them.

we can see the workflow of from the written markdown to the ready output on the figure 1.

```
include_external_graphics("rmd/workflow.png")  # 1
```

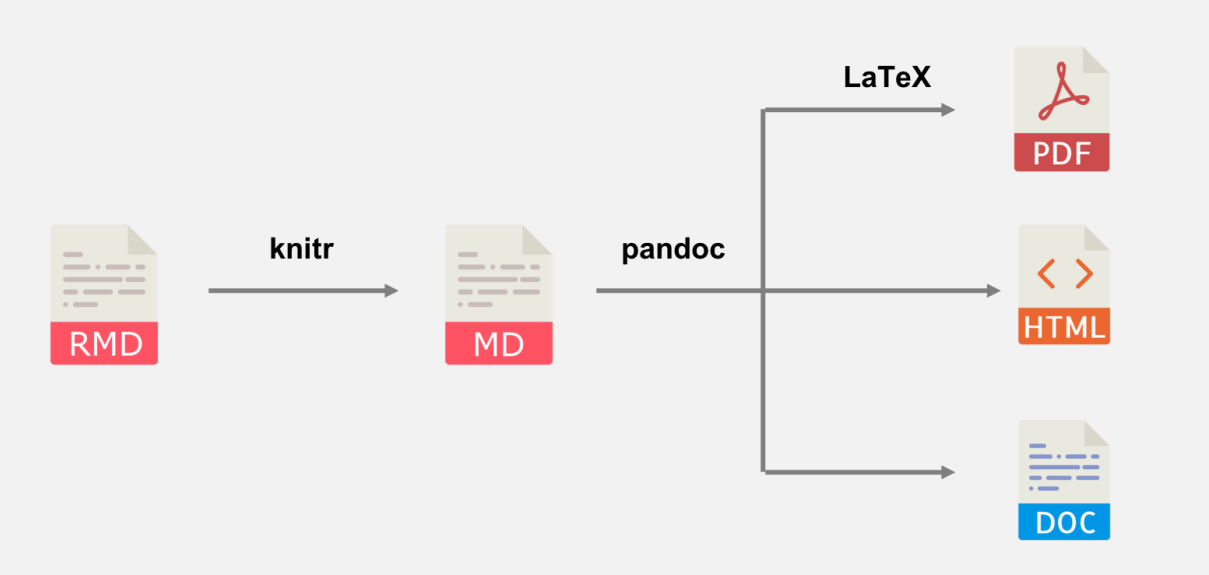


Figure 1: The workflow from the written markdown to the ready output using *bookdown*[1].

Chapter 1

Setup of the project

1.1 Getting the project files

After creating many projects using *bookdown*, i was ready to turn a project into a template. In order to turn a repository to a template, i went to GitHub, entered my project, chose *Settings* and checked *Template repository*. For a new project, i went to *New repository* and chose my template as *Repository template*. Another way to do the latter thing is to go to the main page of the template repository and click *Use this template*.

For projects inside an organisation, the project must be set to public in order to not having to use a password for cloning: *Settings -> General -> Danger Zone -> Change visibility*.

In RStudio Server, i created the new project: *File -> New Project... -> Version Control -> Git*, entered the HTTPS version of *Uniform Resource Locator* (URL) of my template repository for *Repository URL* and clicked *Create Project*.

RStudio Server doesn't rename the project metadata file *.*Rproj* automatically. i did the rename manually and reopened the project: *File -> Open Project...*.

1.2 Automated actions

For automation the user-based actions after the user has an account, i created a script that should be run if the manual set-up is too overwhelming:

```
~/rstudio-projects/create-project.sh --project <subdomain> --user <user>
 ↪  # 1
                                                                    ↪  #
                                                                    ↪  2
```

This is the content of that file written in BouShell Command Language[2] using[3]:

```
#!/bin/bash
 ↪  # 1
programname=$0
 ↪  # 2



usage() {
 ↪  # 4
    echo ""
     ↪  # 5
    echo "This program automates creating a new RStudio Server project."
     ↪  # 6
    echo ""
     ↪  # 7
    echo "usage: $programname --project string --user string[
     ↪  --existing]"
     ↪  # 8
```

```
9       echo ""
        ↪ # 9
10      echo "  --project string   name of the project"
        ↪ # 10
11      echo "                          (example: loodusteaduste-klubi)"
        ↪ # 11
12      echo "  --user string            the user in GitHub"
        ↪ # 12
13      echo "                          (example: Tome-Kit)"
        ↪ # 13
14      echo "  --existing         Is it an old project instead of a
        ↪ brand-new one?"
        ↪ # 14
15      echo ""
        ↪ # 15
16  }
    ↪ # 16
17
18  die() {
    ↪ # 18
19      printf "Script failed: %s\n\n" "$1"
        ↪ # 19
20      exit 1
        ↪ # 20
21  }
    ↪ # 21
22
23  while [ $# -gt 0 ]; do
    ↪ # 23
```

```
24      if [[ $1 == "--help" ]]; then
        ↪ # 24
25          usage
            ↪ # 25
26          exit 0
            ↪ # 26
27      elif [[ $1 == "--"* ]]; then
        ↪ # 27
28          v="${1/--/}"
            ↪ # 28
29          declare "$v"="$2"
            ↪ # 29
30      shift
        ↪ # 30
31      fi
        ↪ # 31
32      shift
        ↪ # 32
33  done
    ↪ # 33
34
35  if [[ -z $project ]]; then
    ↪ # 35
36      usage
        ↪ # 36
37      die "The name of the project is missing."
        ↪ # 37
38  elif [[ -z $user ]]; then
    ↪ # 38
39      usage
        ↪ # 39
```

```
40      die "The name of the user in GitHub is missing."
        ↪  # 40
41  fi
    ↪  # 41
42
43  folder_of_project="/home/kalmer/rstudio-projects/$project"
    ↪  # 43
44  git clone https://github.com/$user/$project $folder_of_project
    ↪  # 44
45
46  tee ~/.ssh/github.com/$project > /dev/null <<EOF
    ↪  # 46
47  Host github.com-$project
    ↪  # 47
48    HostName github.com
    ↪  # 48
49    User git
    ↪  # 49
50    IdentityFile ~/.ssh/$project
    ↪  # 50
51  EOF
    ↪  # 51
52
    ↪  # 52
53  configuration_file_for_git="$folder_of_project/.git/config"
    ↪  # 53
54  sed -i "s/https:\/\//git@/" $configuration_file_for_git
    ↪  # 54
```

```
55 sed -i "s/github.com\//github.com-$project:/" $configuration_file_for_git
   ↪ # 55
56
   ↪ # 56
57 if [[ ! -z $existing ]]; then
   ↪ # 57
58     ssh-keygen -N '' -f ~/.ssh/$project -q
   ↪ # 58
59
   ↪ # 59
60     ## Configuration of the content
   ↪ # 60
61
   ↪ # 61
62     name_of_original_project="manual-for-rstudio"
   ↪ # 62
63     sed_for_renaming_project="s/$name_of_original_project/$project/"
   ↪ # 63
64
   ↪ # 64
65     path_to_bookdown_yml="$folder_of_project/_bookdown.yml"
   ↪ # 65
66     echo $sed_for_renaming_project
   ↪ # 66
67     sed -i $sed_for_renaming_project $path_to_bookdown_yml
   ↪ # 67
68
   ↪ # 68
69     sed -i "/\"rmd\//d" $path_to_bookdown_yml
   ↪ # 69
70     rm $folder_of_project/rmd/*
   ↪ # 70
```

```
71      rm $folder_of_project/washing-cycles.csv
    ↪  # 71
72
    ↪  # 72
73      path_to_output_yml="$folder_of_project/_output.yml"
    ↪  # 73
74      sed -i "s/piiskop/$user/" $path_to_output_yml
    ↪  # 74
75      sed -i $sed_for_renaming_project $path_to_output_yml
    ↪  # 75
76
    ↪  # 76
77      sed -i $sed_for_renaming_project $folder_of_project/js.js
    ↪  # 77
78  fi
    ↪  # 78
79
    ↪  # 79
80  ## Web output
    ↪  # 80
81
    ↪  # 81
82  configuration_file="/etc/nginx/sites-available/$project.ons.ee"
    ↪  # 82
83  sudo cp /etc/nginx/sites-available/manual-for-rstudio.ons.ee
    ↪  $configuration_file
    ↪  # 83
84  sudo sed -i "s/manual-for-rstudio/$project/g" $configuration_file
    ↪  # 84
85  sudo ln -s $configuration_file "/etc/nginx/sites-enabled/$project.ons.ee"
    ↪  # 85
86  sudo systemctl reload nginx
    ↪  # 86
```

```
87
    ↪ # 87
```

On the line 64 of the previous script, there is `sed` command which can be used for deleting unnecessary lines[4]. The command on the particular line deletes all the lines from the file *_bookdown.yml* in the project folder that contain the text *"rmd/"* because the files in the folder *rmd* are project-specific.

1.3 User-based actions

The following actions must be performed for every editor of the repository.

For a new user:

```
1 sudo adduser <username>  # 1
2                          # 2
```

If instead of `adduser` the command `useradd` would be used then the password and home folder must be set manually.

In order to push into the remote repository i need to create a key that can be used to unlock the lock to the repository in GitHub. i let to generate the key:

```
1 ssh-keygen  # 1
2             # 2
```

This command first generates the following output:

> Generating public/private rsa key pair.
> Enter file in which to save the key (/home//.ssh/id_rsa):

As i have many projects in GitHub i need to have many keys as one key can't be used for many projects. Therefore, i also write a new file name

for the key:

```
/home/<username>/.ssh/<name-of-project>
```

If instead of the full path only the file name would be set then that file would be created into the home folder and for further actions with Secure Shell (SSH) its folder must be created manually.

The content of the newly created public key must be copied into GitHub for the named project as deploying the key by also allowing write access. i also have to inform my server about the connections of the newly created key by adding the following lines into *~/.ssh/config*:

```
Host github.com-<name-of-project>
 HostName github.com
 User git
 IdentityFile ~/.ssh/<name-of-project>
```

So far, *git* has no information on the newly cloned project about it's credentials. i need to tell it this information in order to be able to push my changes into the remote repository by changing the file *.git/config* inside my project's folder by setting a new value for *url*:

```
url = git@github.com-<name-of-project>:<username-in-github>/<name-of-project>.git
```

From now on, it's possible to edit the newly created project and push its changes into GitHub.

Inside RStudio Server, i want to make some changes right at the beginning before the first building as it's a new project. One of them is to change the name of the output file in *_bookdown.yml*:

```
book_filename: "<name-of-project>"
```

The same filename must be entered into *js.js*:

```
  createLink(div, "book-print", "<name-of-project>.pdf", "View printable
↪  book");  # 1

↪  # 2
```

```
3
↪ # 3
```

i might want to delete all the files inside *rmd* subfolder and their references in `rmd_files`:

```
rmd_files: [
  "index.Rmd",
  "references.Rmd"
]
```

Samuti tasub koheselt muuta faili *README.md* sisu projektile vastavaks.

i need to update the repository Uniform Resource Locator (URL) in *_output.yml* for `bookdown::bs4_book`:

```
repo: https://github.com/<username-in-github>/<name-of-project>
```

Chapter 2

Configuration

2.1 Mandatory files

The project has the following mandatory files:

1. *<name-of-project>.Rproj*,
2. *_bookdown.yml*,
3. *_output.yml*,
4. *.git*,
5. *.gitignore*,
6. *README.md*,
7. *default.latex*,
8. *index.Rmd*,
9. *js.html*,
10. *js.js*,
11. *preamble.TEX*,
12. *references.Rmd*, and
13. *references.bib*,
14. *style.css*.

i explain the purpose and content of each file.

2.2 *project.Rproj*

This is the project metadata file for RStudio Server.

2.3 *_bookdown.yml*

This file is used because in *index.Rmd,* the value for `site` is `bookdown::bookdown_site`.

Inside the file *_bookdown.yml,* the following settings are:

```
book_filename: "<name-of-project>"
```

This was set already in the setup phase. Once i give RStudio Server the command *Build Book* it creates the output Portable Document Format (PDF) file with the given name for `book_filename` by adding the file extension *.pdf*

inside the subfolder *_book*. If i stop the build process then the auxiliary file must be deleted or any further build would fail.

```
new_session: false
```

For multi-chaptered or -sectioned outputs, every chapter or section is meant to be in a separate R markdown (Rmd) file. In order to be reference parts from one Rmd file to another Rmd file, the value for `new_session` must be `false`. Otherwise, a new session will be created for every file and referencing between the files isn't possible.

```
delete_merged_file: true
```

During building, all the included Rmd files will be merged into one Rmd file that will be used for generating TEX file. That merged Rmd file is usually unnecessary, so i let RStudio Server delete it automatically.

```
language:
  label:
    fig: 'Joonis '
```

If the language is Estonian then for web output the word *Figure* below each figure must be translated manually.

```
rmd_files: [
  "index.Rmd",
  <<rmd/...,>>
  "references.Rmd"
]
```

`rmd_files` contains the list of involved Rmd files. There must be involved *index.Rmd* as only that file can have `site` which is necessary for generating anything at all. *references.Rmd* contains references and usually, i have references, so i include the file. If `rmd_files` isn't present then all the files whose name doesn't start by _ will be included sorted according to their names. With `rmd_files`, i can also set the order of files.

2.4 *_output.yml*

2.4.1 Introduction

This file is used because in *index.Rmd*, the value for `site` is `bookdown::bookdown_site`.

Inside the file *_output.yml*, the output types can be set. i only use two of them: a web format `bs4_book` and a print format

`pdf_book`.

2.4.2 `bookdown::bs4_book`

The following settings are for `bookdown::bs4_book`:

```
css: style.css
```

In *style.css*, it's possible to restyle the website.

```
  includes:
    in_header: js.html
```

i don't like if i lead the user from my site away once they click a link to an external site on my bibliography page. Therefore, i wrote a program in ECMAScript that adds `target = "_blank"` to every `a` in the bibliography after the whole page is loaded. i put the script into the file *js.js* as i want to keep scripts written in different languages in separate files. Then, i created the file *js.html* that reads the content of *js.js*. i want the script tag to be put into `head` - therefore `in_header`.

```
repo: https://github.com/<username-in-github>/<name-of-project>
```

The repository will be linked in three places. In the left column, there's the link for the main page of the repository. In the right column, there are two links regarding to the repo. The upper one refers the repo page of the current page and the lower link leads to the repo page where the current page can be edited. In GitHub, discussions can take place.

2.4.3 `bookdown::pdf_book`

The following settings are for `bookdown::pdf_book`:

```
  includes:
    in_header: preamble.tex
```

As the default LaTeX template file is *default.tex*, i don't want to change that and instead, offer additions and modifications through `includes`. In the file whose name is given - *preamble.tex*, the additions and modifications can be made.

```
  keep_tex: yes
```

As PDF-file is generated according to TeX file, it's sometimes useful to see what TeX file consists of.

```
  latex_engine: xelatex
```

Actually, it's the format, not engine, one out of three available in *bookdown*. It allegedly has the best language and font support and is recent[5]. The other current format is *lualatex* which doesn't work with chinese characters and while beign extendable and therefore, slow.

```
  template: default.latex
```

In order to make everything work, it's useful to use the default template downloaded from *pandoc*'s repository[6]. Modifications can be done in *preamble.tex* or as `extra_dependencies`. i never edit *default.latex*.

2.5 *.git*

This folder is for *git* configuration regarding to this project.

2.6 *.gitignore*

This file contains the list of files *git* should ignore.

2.7 *README.md*

This file contains the human-friendly metainformation about the project.

2.8 *default.latex*

This is the default LaTeXtemplate downloaded from[6].

2.9 *index.Rmd*

2.9.1 Introduction

This file must contain the site generator information in the metadata section and can contain other metadata there. In addition, it serves as the holder of common functions and commands and contains an introduction as if the number of Rmd files and first-level headings don’t match, a warning will be given.

2.9.2 Metadata

The optional metadata can be the following:

`colorlinks: TRUE`

i want that the user sees what part of the text is a link.

`author: "<the name of the author>"`

The author's name will be displayed in the footer of the web output.

`description: "<description of the project>"`

`lang: <two-letter lowercase language code>`

Language is important for hyphenation. A known bug is that the word *mõistmisel* will be hyphenated incorrectly[7].

```
include-before:
    - \input{title-page.tex}
```

As the default template does not correspond to all the needs set in Tallinn University, i use an extra template for the title page that i command to include before the rest. Please pay attention that the header is not allowed to contain `title` because the default title page would be displayed otherwise as well. Therefore, i need the following line:

```
1 title: "`r if (knitr::is_latex_output()) { '' } else { 'Manual for
  ↪  creating content<br/>using<br/>RStudio Server' }`"  # 1
2
  ↪  # 2
```

For every linebreak, `<br/>` has to be used.

`documentclass: <the document class>`

There are five document classes. i use mainly `article` if i want to create a short lab report which doesn't have chapters but sections that flow after each other from page to page. Here, i use `book` because it's a book that has chapters whereas each chapter begins on a new page.

`papersize: <paper format>`

This can be set for instance to `a4`.

`geometry: top=<top>cm, right=<right>cm, bottom=<bottom>cm, left=<left>cm`

`geometry` takes the values for margins from the given directions in centimeters.

`classoption: <options for the document class separated by commas>`

These are the options for the document class. i want my text to be mainly in one column, therefore `onecolumn` and printed on both sides - therefore `twoside`.

`linestretch: <line height: how many lines>`

`fontsize: <size of the font in points>pt`

```
mainfont: DejaVu Serif  # 1
                        # 2
```

`CJKmainfont: Droid Sans Fallback`

`CJKmainfont` has to be set in order to show Chinese characters.

`bibliography: [references.bib]`

This is the reference to the bibliography file.

`csl: apa-numeric-superscript-brackets.csl`

This is the reference to the style of American Psychological Association. i decided to use the numeric style as it is more compact.

`link-citations: yes`

i want the references inside the text to be linked to the appropriate reference list items.

`lof: yes`

i want the list of figures to be displayed.

```
lot: yes
```

i want the list of tables to be displayed not the logo of the Polish airlines company that we can see on the background as Kim Wilde was delivering a concert in Sopot in 1988[8].

2.9.3 *knitr*

knitr on R'i teek, mis teeb Rmd failist md faili[9]. i've made the following setting for that:

```
collapse = TRUE  # 1
                 # 2
```

i want the result of running the source code to be printed into the same box instead of a separate box after the source code box[10].

```
echo = TRUE  # 1
             # 2
```

i want the source code to be displayed.

i want the code chunks to have line numbers displayed although it only works for print output:

```
attr.source = '.numberLines'  # 1
                              # 2
```

Next, `librarian` is being loaded because i don't want to check manually if a particular package exists.

There are the definitions of three helper functions for:

1. including graphics,
2. creating tables,
3. rendering the LaTeX string universal regarding to the output format,
4. rendering a text bold as there are different approaches regarding to the output mode and the main font because of the need for displaying emojis isn't able to display anything in bold[11],
5. rendering text that have emojis by switching the font to *Symbola* only for that part. *Symbola* must be the emoji font for having both Chinese characters as emojis displayed. If that font isn't present in the system, it can be installed[12]:

```
sudo apt install fonts-symbola  # 1
                                # 2
```

It is important that all the parts of the same type look similar, so it is essential to use this function for all the external references outside presentations. we could use

the font *Symbola* for everything however it does not support bold or italic text.

There's also a set of commands for using units.

2.9.4 Content

Finally, there can be entered the introductionary content.

Commenting should take place according to the rules of roxygen2[13].

2.10 *favicon.ico*

This is the custom browser icon file referenced in *js.html* as seen in the listing 2.1 on the page 33[14].

```
1
2 <link rel="shortcut icon" href="
    favicon.ico" />
```

Listing 2.1: An example of how to reference the custom browser icon file.

2.11 *js.html*

This file just includes the necessary ECMAScript script and can be used to include other ECMAScript scripts in the header of the webpage. It is basically a part of the metadata part of the web page.

2.12 *js.js*

This file contains ECMAScript script that must be included in the header of the webpage. The link for the Portable-Document-Format-(PDF)file must be changed here. In this file, the file names for the presentation(s) must be set if there are some presentations available.

2.13 *preamble.TEX*

This file contains LaTeXinclusions for PDF output that doesn't exist in *default.latex*.

The decimal separator can be specified in `output-decimal-marker`:

```
1 \sisetup{
  ↪  # 1
2   input-decimal-markers = {.,},
  ↪  # 2
3   output-decimal-marker = {.},
  ↪  # 3
4   separate-uncertainty,
  ↪  # 4
```

```
  separate-uncertainty-units =
  ↪ repeat  # 5
}
  ↪ # 6

  ↪ # 7
```

2.14 *references.Rmd*

This file is meant for containing the list of references.

2.15 *references.bib*

This is the bibliography file.

2.16 *style.css*

This file contains the styling for the web version that's not included by default.

2.17 *title-page.tex*

This is the template for the title page and should be adopted according to the needs of the project.

2.18 Troubleshooting

If shit hits the fan and there are overwhelming many conflicts to solve then it is easier to perform a hard reset[15]:

```
git reset --hard <identifier of
  ↪ the commit>  # 1
git push -f
  ↪ # 2

  ↪ # 3
```

More shit can hit the fan, especially if tha ability of using RStudio fails totally[16]. I am not sure why that happened to me twice already but probably because of an interrupted build process. Once I relogged in I could not use anything on that tab. RStudio's tab ate read-only memory up to 11 GB and crashed. That happened every time. Last time, the solution was to suspend all the sessions[17]:

```
sudo rstudio-server suspend-all  #
  ↪ 1
                                 #
  ↪ 2
```

Chapter 3

R markdown

3.1 Headings

Every chapter should have a first-level heading marked by #. A second-level heading has two of #, a third-level heading three of them and so on until six. Here's how to write a first-level heading followed by a second-level heading:

```
# <first-level heading>


## <second-level heading>
```

The caption for references must be unnumbered so i did with the corresponding command:

```
# References {.unnumbered}  # 1
                            # 2
```

The latter result can be achieved using a shorter form:

```
# References {-}  # 1
                  # 2
```

3.2 Paragraphs

Paragraphs are separated by two line-breaks:

```
<one paragraph>   # 1
                  # 2
<next paragraph>  # 3
                  # 4
```

3.3 Italics

Text can be turned to italics using asterisks around it:

```
*<text in italics>*
```

<text in italics>

3.4 Superscript

```
2^2^  # 1
      # 2
```

2^2

3.5 Color

```
render_color(color = "008000",
 ↪  text = "10 \\cdot V")  # 1

 ↪  # 2
```

This text is *colored*.

3.6 Code

3.6.1 As a block

Code blocks can be marked by three ticks following by braces containing metadata. The first metadata is the language. i've used so far `r` and `bash`:

```
```{bash eval = FALSE}  # 1
ssh-keygen             # 2
                       # 3
```                    # 4
                       # 5
```

i keep an empty line at the end of the code block content because if i want to use a keyboard shortcut for commenting out it only works if the last line is empty.

If the language is LaTeX or LaTeX then the language must not only be in lowercase but have a preceding =[18]:

```
```{=latex eval = FALSE}  # 1
\onecolumn               # 2
                         # 3
```                      # 4
                         # 5
```

There are some options that can be used for code blocks or chunks in addition to them mentioned in the general configuration part:

`eval` Shall the code be executed or not or what lines of the code should be executed?

If i want to show a code-block without rendering it, i use a `verbatim` block as a wrapper around it:

```
````{verbatim label =
 ↪  "onecolumn-example", lang =
 ↪  "latex"}  # 1
```{=latex eval = FALSE}
 ↪  # 2
```
```
```

````
\onecolumn
 ↪  # 3

 ↪  # 4
```
 ↪  # 5

 ↪  # 6
````
 ↪ # 7

 ↪ # 8
````

For `verbatim` to work, it has to have at least one more backtick than the outermost inner block[19].

3.6.2 Inline

The inline code must be between ticks:

```
i show how to display `<inline
 ↪  code>`.  # 1

 ↪  # 2
```

i show how to display `<inline code>`.

3.7 Quoting

For quoting, i use > at the beginning of each line of the quote.

```
> <the quoted text>  # 1
                     # 2
```

> <the quoted text>

It's also possible to do a multi-line quote by adding two spaces at the end of each line which means a line break[20]:

```
> <first line of the quote>    # 1
<second line of the quote>     # 2
                               # 3
```

> <first line of the quote>
> <second line of the quote>

Another way of multiline quoting is to inclue > in front of each row:

```
> <first line of the quote>    # 1
<second line of the quote>     # 2
>                              # 3
> <fourth line of the quote>   # 4
                               # 5
```

> <first line of the quote>
> <second line of the quote>

> <fourth line of the
> quote>

A quote with the author:

```
> All on konstantne. Siis ma...
  Midagi läheb sealt läbi, aga
  siis peab mõtlema, mis, mis
  kurat sealt läbi läheb.  # 1

  # 2
`r librarian::shelf(c("tufte"));
  tufte::quote_footer('--- Tõnu
  Laas')`
  # 3
```

> All on konstantne. Siis ma... Midagi läheb sealt läbi, aga siis peab mõtlema, mis, mis kurat sealt läbi läheb.
>
> — Tõnu Laas

3.8 Escaping

If a character must be escaped then a backslash can be used right in front of it (example (1)).

(1)	`*\**`	*

The following additional characters must be escaped:

1. _,
2. @,
3. &.

If the number is an ordinal then in Estonian, there is a period after the scalar which the parser recognizes as the period for a list element. For that not happen, the period must be preceded by a backslash (example (2)).

(2)	`1961\. a sätestati...`	1961. a sätestati...

3.9 Non-breaking space

In the example (3), the name will be broken if it does not fit into the line.

(3)

```
The name of one of my companies out of many is MTÜ Eesti Kõrgkoolitennise
↪ Liit.  # 1

↪ # 2
```

The name of one of my companies out of many is MTÜ Eesti Kõrgkoolitennise Liit.

In the example (4), the name will not be broken if it does not fit into the line using ` `[21].

(4)

```
The name of one of my companies out of many is
↪ MTÜ Eesti Kõrgkoolitennise Liit.  # 1

↪ # 2
```

The name of one of my companies out of many is
MTÜ Eesti Kõrgkoolitennise Liit.

In the example (5), the name will not be broken if it does not fit into the line using `\`[22].

(5)

```
The name of one of my companies out of many is MTÜ\ Eesti\
↪ Kõrgkoolitennise\ Liit.  # 1

↪ # 2
```

The name of one of my companies out of many is
MTÜ Eesti Kõrgkoolitennise Liit.

Non-breaking spaces do not work with *multicols*.

3.10 Referencing

3.10.1 Common reference

A target for a common reference:

```
[]{#<label-for-target>}
```

A link for a common target:

```
[<link text>](#<label-for-target>)
```

3.10.2 External reference

3.10.2.1 Preparation and common use cases

For having an external reference, i put its *BibTEX* block into *references.bib*. i seldom create it manually. Instead, i use the help of MyBib[23] where i *Start a new project* for every project, *Add Citation*, *Download References* as *BibTEX*, copy the lastly added reference from the downloaded file into *references.bib* so that the items there are listed alphabetically. Another such helper is BibGuru[24].

As there's a problem to display emojis and they appear seldom then i only use the emoji-able font *Symbola* that can't italics nor bold only for strings that contain emojis. External references can contain them. This is why all the external references will be rendered using *Symbola*. For that, i created a function called `render_with_emojis` that can't handle references directly but over inner reference because of the corresponding *bookdown* restriction. Therefore, for every record in the list of external references, i also created an inner reference into the end of the file *references.Rmd* like this:

```
(ref:<identifier-of-inner-reference-in-snake-case>)
  @<identifier-of-external-reference-as-is>  # 1

  # 2
```

The identifier of the inner reference isn't allowed to contain underscores. Between every inner reference, at least one empty line must be.

For inline referencing, wherever i wanted to have a reference to that reference record i called `render_with_emojis` and fed it with a value for `text` as the identifier of the internal reference in parenthesis if the reference is direct and in double parenthesis if indirect:

```
i use MyBib `r render_with_emojis("((ref:<identifier-of-inner-reference-in-snake-case>))")`. # 1

# 2
`r render_with_emojis("(ref:<identifier-of-inner-reference-in-snake-case>)")` automates creating references.  # 3

# 4
```

As i am using numeric referencing now, the identifier is not textual, so i use the short version for referencing whereas the identifier is the one in the BIB-file as `render_with_emojis` does not do the job in this case:

```
i use MyBib [@<identifier-of-inner-reference-in-snake-case>]. # 1

# 2
@<identifier-of-inner-reference-in-snake-case> automates creating references.  # 3

# 4
```

If the exact location in the source is necessary to refer to then it can be added to the reference part in the short version by separating it from the identifier with a comma and preceding it with *p.* which is short for *page* or *pages*. One can also use the corresponding short in another language. For minutes in a video, the short could be *min*. The rule:

```
i use MyBib [@<identifier-of-inner-reference-in-snake-case>(p. <range>)]. # 1

# 2
```

```
@<identifier-of-inner-reference-in-snake-case>(p. <range>) automates creating references.  # 3


# 4
```

For example:

A surprising piece of data is this[25(p. 6)].

CRC Handbook of Chemistry and Physics, 95th Edition[25(p. 6)] represents some suprising pieces of data.

We can use a comma instead of parentheses for the page range however that would confuse the reader as in the output commas a also used to separate multiple references.

3.10.2.2 Multiple references

Multiple references can be used with a semicolon[26]:

```
I use the help of bibliography generators [@a1970_; @noauthor_undated_tf].  # 1


# 2
```

I use the help of bibliography generators[23,24].

3.10.2.3 Reference in the caption

Referencing in the caption works just fine if the figure is upright. If the figure is at a different angle the whole caption must be written out as a reference before[27]:

```
Joonisel \@ref(fig:cities) leheküljel `r render_pageref(reference =
↪  "fig:cities")` on näidatud gravitatsioonist põhjustatud kiirendus eri
↪  piirkondades Maal.  # 1

↪  # 2
(ref:caption-for-cities) Gravitatsioonist põhjustatud kiirendus eri Maa
↪  paigus[@elert_2019_glenn].
↪  # 3

↪  # 4
```{r label = "cities", echo = FALSE, fig.cap =
↪  "(ref:caption-for-cities)", echo = FALSE, out.extra="angle = 90",
↪  out.width=".92\\textheight"}                # 5
include_external_graphics("rmd/g.png")
↪  # 6

↪  # 7
```
↪ # 8

↪ # 9
```

Joonisel 2 leheküljel 47 on näidatud gravitatsioonist põhjustatud kiirendus eri piirkondades Maal.

3.11 Tables

```
Võrdlen tabelis \@ref(tab:base-10-base-1) kümnendsüsteemi arve
↪  ühendsüsteemi arvudega.  # 1

↪  # 2
```

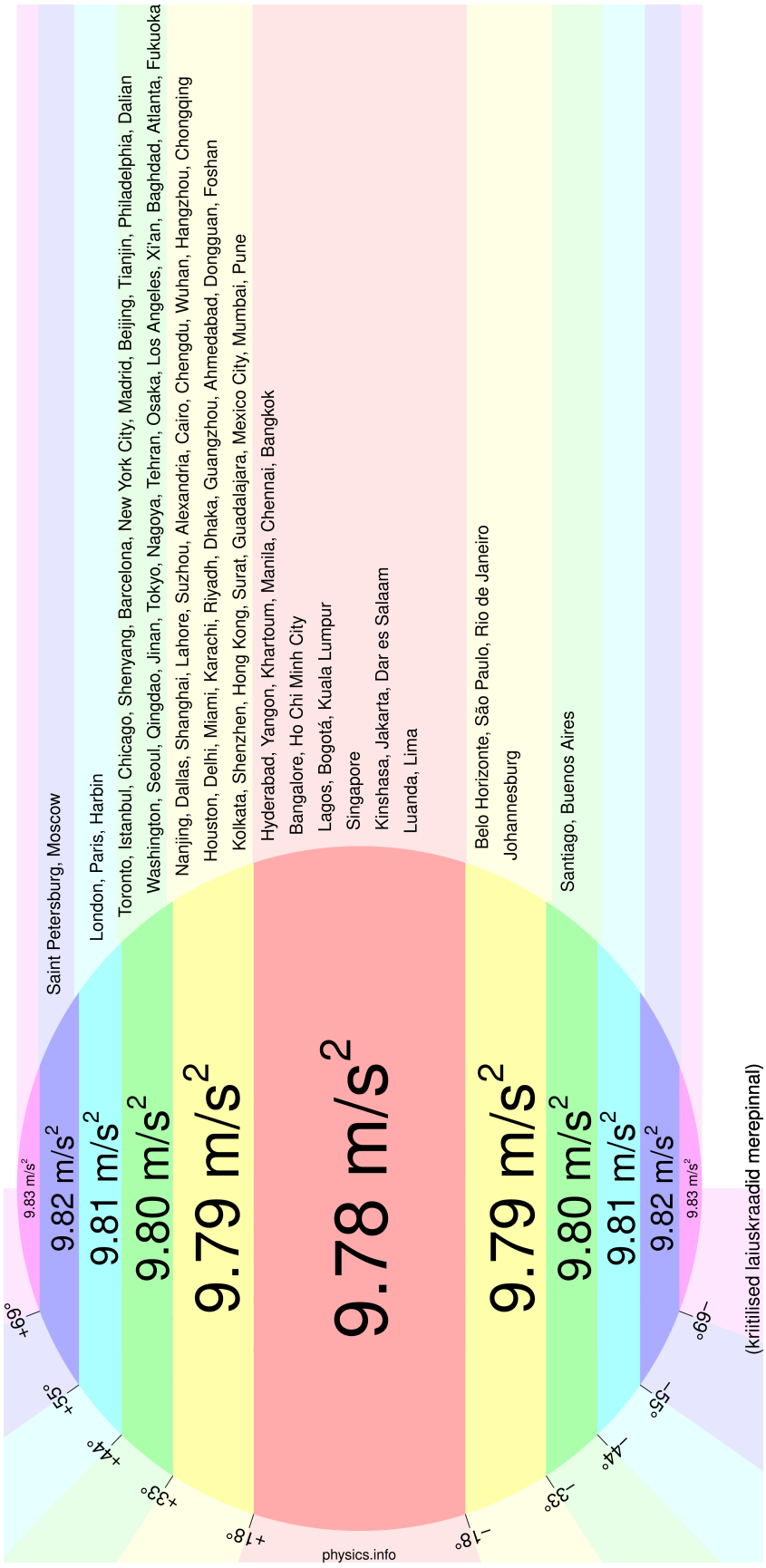


Figure 2: Gravitatsioonist põhjustatud kiirendus eri Maa paigus[28].

```
| Baas 10 | Baas 1 |
↪ # 3
|---------|--------|
↪ # 4
| 1       | 1      |
↪ # 5
| 2       | 11     |
↪ # 6
| 3       | 111    |
↪ # 7
| 4       | 1111   |
↪ # 8

↪ # 9
: (\#tab:base-10-base-1) Kümnendsüsteemi ja ühendsüsteemi arvud
↪ # 10

↪ # 11
```

Võrdlen tabelis 3.1 kümnendsüsteemi arve ühendsüsteemi arvudega.

Table 3.1: Kümnendsüsteemi ja ühendsüsteemi arvud.

Baas 10	Baas 1
1	1
2	11
3	111
4	1111

```
Kolmendsüsteemis on kasutuses kolm võimalikku erinevat numbrit, nt 0, 1
↪ ja 2. Võrdlen tabelis \@ref(tab:bases-10-2-3) eri baaside arve.  # 1

↪ # 2
```

```
| Baas 10 | Baas 2 | Baas 3 |
# 3
|--------:|-------:|-------:|
# 4
|       0 |      0 |      0 |
# 5
|       1 |      1 |      1 |
# 6
|       2 |     10 |      2 |
# 7
|       3 |     11 |     10 |
# 8
|       4 |    100 |     11 |
# 9
|       5 |    101 |     12 |
# 10
|       6 |    110 |     20 |
# 11
|       7 |    111 |     21 |
# 12
|       8 |   1000 |     22 |
# 13
|       9 |   1001 |    100 |
# 14

# 15
: (\#tab:bases-10-2-3)Kümnend-, kahend- ja kolmendsüsteemi arvud
# 16

# 17
```

Kolmendsüsteemis on kasutuses kolm võimalikku erinevat numbrit, nt 0, 1

ja 2. Võrdlen tabelis 3.2 eri baaside arve.

Table 3.2: Kümnend-, kahend- ja kolmendsüsteemi arvud.

Baas 10	Baas 2	Baas 3
0	0	0
1	1	1
2	10	2
3	11	10
4	100	11
5	101	12
6	110	20
7	111	21
8	1000	22
9	1001	100

```
| Second bit | First bit |  # 1
|:----------:|:---------:|  # 2
|     0      |     0     |  # 3
|     0      |     1     |  # 4
|     1      |     0     |  # 5
|     1      |     1     |  # 6

                           # 7
: (\#tab:base-2)For representing a larger number, more bits on the left are needed. 0 and 1 can still be displayed using two bits while the second bit having 0-s. Once the first bit is full the second bit starts with 1 and the first bit starts over  # 8
```

```
9
    ↪ # 9
10  Taken from the table \@ref(tab:base-2) there are four combinations
    ↪ altogether possible using two bits.
    ↪ # 10
11
    ↪ # 11
```

Taken from the table 3.3 there are four combinations altogether possible using two bits.

Table 3.3: For representing a larger number, more bits on the left are needed. 0 and 1 can still be displayed using two bits while the second bit having 0-s. Once the first bit is full the second bit starts with 1 and the first bit starts over

Second bit	First bit
0	0
0	1
1	0
1	1

3.12 Equations

Equations can be inserted in math mode, id est between double bug signs if in a block or single bug signes if inline:

```
1 $$\frac{t_\text{d}}{}$$  # 1
2                          # 2
```

$$\frac{t_\text{d}}{}$$

```
The same equation inline: $\frac{t_\text{d}}{}$.  # 1
                                                  # 2
```

The same equation inline: $\frac{t_\text{d}}{}$.

3.13 Lists

In the example (6), a comment between two list items ends the list and starts a new one[29]. This way, it is possible to create a non-continuous list.

(6) A list with holes:

```
7. Korrutage \qty{4,079e2}{\m} \qty{0,057e-1}{\m}'ga, võttes arvesse
 ↪  olulisi numbreid.                                # 1

 ↪  # 2
<!-- -->
 ↪  # 3

 ↪  # 4
9. Väikeste nurkade $u$ korral on $\mathrm{sin}(u)$ arvväärtus
 ↪  ligikaudu sama, mis $\mathrm{tan}(u)$ arvväärtus.  # 5
Leia suurim nurk, mille puhul siinus ja tangens langevad kokku kahe
 ↪  tüvenumbri piires.                                # 6

 ↪  # 7
```

7. Korrutage $4.079 \times 10^{2}\,\mathrm{m}$ $0.057 \times 10^{-1}\,\mathrm{m}$'ga, võttes arvesse olulisi numbreid.

9. Väikeste nurkade u korral on $\sin(u)$ arvväärtus ligikaudu sama, mis $\tan(u)$ arvväärtus. Leia suurim nurk, mille puhul siinus ja tangens langevad kokku kahe tüvenumbri piires.

In the example (7), the list is continuous no matter what identifier is in front of the second item.

(7) A continuous list:

```
7. Korrutage \qty{4,079e2}{\m} \qty{0,057e-1}{\m}'ga, võttes arvesse olulisi numbreid.  # 1

# 2
9. Väikeste nurkade $u$ korral on $\mathrm{sin}(u)$ arvväärtus ligikaudu sama, mis $\mathrm{tan}(u)$ arvväärtus.  # 3
Leia suurim nurk, mille puhul siinus ja tangens langevad kokku kahe tüvenumbri piires.  # 4

# 5
```

7. Korrutage $4.079 \times 10^2\,\mathrm{m}$ $0.057 \times 10^{-1}\,\mathrm{m}$'ga, võttes arvesse olulisi numbreid.

8. Väikeste nurkade u korral on $\sin(u)$ arvväärtus ligikaudu sama, mis $\tan(u)$ arvväärtus. Leia suurim nurk, mille puhul siinus ja tangens langevad kokku kahe tüvenumbri piires.

3.14 Examples

Examples can be made as seen in the example (8)[29].

(8) An example of an example:

```
In the example (@examples-example), it is possible to see an
↪  example.  # 1

↪  # 2
(@examples-example) This is an example.
↪  # 3

↪  # 4
```

In the example (9), it is possible to see an example.

(9) This is an example.

3.15 Exercises[27]

```
::: {.exercise #dynamics-task-20240303-1 name="Kolme vektori suurus ja suund."}
Tee kindlaks kolme vektori
$$\overrightarrow{\bf{V}_1} = 4,0 \hat{\bf{i}} - 8,0 \hat{\bf{j}},$$
$$\overrightarrow{\bf{V}_2} = \hat{\bf{i}} + \hat{\bf{j}} \text{ ja}$$
$$\overrightarrow{\bf{V}_3} = -2,0\hat{\bf{i}} + 4,0\hat{\bf{j}}$$
suurus ja suund!

Tee kindlaks $\overrightarrow{\bf{V}_1} - \overrightarrow{\bf{V}_2} + \overrightarrow{\bf{V}_3}$.
:::
```

Exercise 3.1 (Kolme vektori suurus ja suund.)**.** Tee kindlaks kolme vektori

$$\overrightarrow{\mathbf{V_1}} = 4,0\hat{\mathbf{i}} - 8,0\hat{\mathbf{j}},$$

$$\overrightarrow{\mathbf{V_2}} = \hat{\mathbf{i}} + \hat{\mathbf{j}} \text{ ja}$$

$$\overrightarrow{\mathbf{V_3}} = -2,0\hat{\mathbf{i}} + 4,0\hat{\mathbf{j}}$$

suurus ja suund!

Tee kindlaks $\overrightarrow{\mathbf{V_1}} - \overrightarrow{\mathbf{V_2}} + \overrightarrow{\mathbf{V_3}}$.

3.16 Captions

Captions of figures, exercises, examples etc can be changed by adding the specific translations into *_bookdown.yml* (10).

(10)

```
language:             # 1
  label:              # 2
    exr: 'Ülesanne '  # 3
    fig: 'Joonis '    # 4
                      # 5
```

Chapter 4

LaTeX

4.1 Testing

If the Portable Document Format file would not be produced and it is cumbersome to figure out the error based on the log file then one can use *pdflatex* for testing the intermediate TEX-file as shown in (11)[30].

(11) Usage of *pdflatex*.

```
pdflatex <name-of-file>.tex  # 1
                             # 2
```

4.2 Layout

4.2.1 Page Orientation

```
\begin{landscape}
 ↪  # 1

 ↪  # 2
Here is anything but figures that needs to be displayed in landscape
 ↪  mode.  # 3

 ↪  # 4
```

```
\end{landscape}
 ↪  # 5

 ↪  # 6
```

```
librarian::shelf(c(                                 # 1
  "formatdown"                                      # 2
))                                                  # 3
numbers <- c(123.456, 2e-6, 5e8, 0.23)              # 4
format_power_numbers <- format_power(numbers)  # 5
## Warning in format_power(numbers): `format_power()` is deprecated. Use
 ↪  `format_numbers()`
##               which offers additional arguments and access to package
 ↪  options.
format_power_numbers_digits <- format_power(numbers, format = "sci",
 ↪  digits = 2, omit_power=NULL)  # 1
## Warning in format_power(numbers, format = "sci", digits = 2,
 ↪  omit_power = NULL): `format_power()` is deprecated. Use
 ↪  `format_numbers()`
##               which offers additional arguments and access to package
 ↪  options.
format_power_numbers_digits  # 1
## [1] "$\\small 1.2 \\times 10^{2}$"  "$\\small 2.0 \\times 10^{-6}$"
## [3] "$\\small 5.0 \\times 10^{8}$"  "$\\small 2.3 \\times 10^{-1}$"
```

Here is anything but figures that needs to be displayed in the landscape mode.

4.2.2 Justifying text

By default, the text is justified on both edges. For a better readability, we can use left-justifying by telling the specific commands in *preamble.tex* as shown in the listing 4.1 on the page 62[31, lk 62].

```
1 \usepackage{ragged2e}
2 \RaggedRight
```

Listing 4.1: An example of how to left-justify elements on the page.

The example (12) shows how to center items[31(p. 64)].

(12) `\begin{center}centered item\end{center}` 👉 centered item

4.3 List of tables and figures

Normally, the caption for a list of tables and a list of figures is shown no matter whether tables or figures exist. i found a solution for only displaying a list if there's an item available for that[32]. That code is in *preamble.TEX* under the corresponding caption as a comment. Using the package *xassoccnt* triggers the warning:

> Warning: Package xassoccnt Warning: Warning: Package "calc" is loaded – this is not Warning: (xassoccnt) recommended for xassoccnt Warning: (xassoccnt)

calc is being called directly from *default.LATEX* and as i don't want to modify the contents of *default.LATEX*, i have to live with the warning.

4.4 Reference to a page

If a referenced equation, figure, table or other item is on a different page, i also reference the page number:

```
`r render_pageref(reference = "fig:workflow")`  # 1
                                                # 2
```

... on the page 12.

This only works for the print output as there are no pages on a webpage.

4.5 The non-math LaTeX string

```
`r render_nonmath_LaTeX_string_universal("\\LaTeX{}")`    # 1
                                                          # 2
```

LaTeX

4.6 Spacing

4.6.1 Space after macro

Using a macro without braces at the end removes the possible spacing from after it in PDF[33(p. 181)]:

```
`r render_nonmath_LaTeX_string_universal("\\LaTeX{}")` <text after space>
↪  # 1

↪  # 2
`r render_nonmath_LaTeX_string_universal("\\LaTeX")` <text after space>
↪  # 3

↪  # 4
```

LaTeX <text after space>

LaTeX<text after space>

4.6.2 Horizontal fill

For a horizontal fill, `hfill` can be used[34]:

```
Harku      # 1
\hfill     # 2
2022-2023  # 3
           # 4
```

Harku 2022-2023

4.6.3 Vertical fill

For a vertical fill, `vfill` can be used:

```
Harku      # 1
\vfill     # 2
2022-2023  # 3
           # 4
```

Harku

4.7 Columns

If i want the following text to be in two columns i write:

```
\twocolumn    # 1
              # 2
```

i'm just writing some text that will be placed in two columns because it's easier to read if the text is in two columns.

If i want the following text to be in one column, i write:

```
\onecolumn    # 1
              # 2
```

I am just writing some text that will be placed in one column because it can contain a figure or equation that does not fit in a narrower column.

This way, the columns are not balanced. If I want balanced columns, I have to use the package `multicol`[35] by referencing it in *preamble.tex* as seen in the listing 4.2 on the page 69.

```
\usepackage{multicol}
\setlength{\columnseprule}{1pt}
```

Listing 4.2: An example of how to reference the package `multicol` and configure its use.

```
                                    # 1
\begin{multicols}{2}                # 2
- titaandioksiid: \ce{TiO2};        # 3
                                    # 4
- ränitetrakloriid: \ce{SiCl4};     # 5
                                    # 6
- süsinikdisulfiid: \ce{CS2};       # 7
                                    # 8
- vääveltetrafluoriid: \ce{SF4};    # 9
                                   # 10
- liitiumsulfiid: \ce{Li2S};       # 11
                                   # 12
- antimonpentafluoriid: \ce{SbF5}; # 13
                                   # 14
- dilämmastikpentooksiid: \ce{N2O5}; # 15
                                   # 16
- joodheptafluoriid: \ce{IF7}.     # 17
\end{multicols}                     # 18
                                    # 19
```

- titaandioksiid: TiO_2;
- ränitetrakloriid: $SiCl_4$;
- süsinikdisulfiid: CS_2;
- vääveltetrafluoriid: SF_4;
- liitiumsulfiid: Li_2S;
- antimonpentafluoriid: SbF_5;
- dilämmastikpentooksiid: N_2O_5;
- joodheptafluoriid: IF_7.

It is possible to influence where the column breakes and throught that it is also possible to move the contents onto the next page as seen in the listing 4.3 on the page 70.

```
\begin{multicols}{2}
- titaandioksiid: \ce{TiO2};

- ränitetrakloriid: \ce{SiCl4};

- süsinikdisulfiid: \ce{CS2};

- vääveltetrafluoriid: \ce{SF4};

\vfill\null
\columnbreak

- liitiumsulfiid: \ce{Li2S};

- antimonpentafluoriid: \ce{SbF5};

- dilämmastikpentooksiid: \ce{N2O
    5};

- joodheptafluoriid: \ce{IF7}.
\end{multicols}
```

Listing 4.3: An example with the column break.

- titaandioksiid: TiO_2;
- ränitetrakloriid: $SiCl_4$;
- süsinikdisulfiid: CS_2;
- vääveltetrafluoriid: SF_4;
- liitiumsulfiid: Li_2S;
- antimonpentafluoriid: SbF_5;
- dilämmastikpentooksiid: N_2O_5;
- joodheptafluoriid: IF_7.

`\begin{multicols}{2}` does not allow markdown's sharp symbol. In order to tolerate captions inside a multi-column environment, the command must be redefined and used as a command without any parameters (example (13) with the listing 4.4 on the page 71)[36].

(13)

```
\multicolsbegin
### Head
\multicolsend
```

Listing 4.4: An example of tolerating markdown in a multicolumn environment.

4.7.1 Head

`multicols` does not show figures.

The example (14) with the listing 4.5 on the page 71 shows how to decorate the vertical line between the columns[37(p. 7)].

(14)

```
\multicolsbegin
\SetMCRule{custom-pattern={\
   faHandPointRight}{0pt}{0pt},
   color=gray}
This is just a sample text.
\multicolsend
```

This is just a sample text.

Listing 4.5: An example of decorating the rule.

It is not possible to have tables created by `print_table` in a multicolumn environment[38]:

> ! Package longtable Error: longtable not in 1-column mode.

4.8 No hyphenation

After the following command, no hyphenation takes place:

```
\hyphenpenalty=10000    # 1
                        # 2
```

4.9 Chinese characters

In order to display Chinese characters an appropriate main and mono font must be set in *preamble.TEX*.[39] lists suitable fonts, for example:

```
1 \setCJKmonofont{Noto Sans Mono CJK SC}    # 1
2                                           # 2
```

That font wasn't available in my system, so i installed it:

```
1 sudo apt install fonts-noto-cjk    # 1
2                                    # 2
```

After that, i was looking for Chinese fonts:

```
1 fc-list :lang=zh    # 1
2                     # 2
```

That resulted with:

> /usr/share/fonts/opentype/noto/NotoSerifCJK-Bold.ttc: Noto Serif CJK SC:style=Bold
> /usr/share/fonts/opentype/noto/NotoSerifCJK-Bold.ttc: Noto Serif CJK TC:style=Bold
> /usr/share/fonts/opentype/noto/NotoSerifCJK-Bold.ttc: Noto Serif CJK JP:style=Bold
> /usr/share/fonts/opentype/noto/NotoSerifCJK-Bold.ttc: Noto Serif CJK KR:style=Bold
> /usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: Noto Sans CJK JP:style=Regular
> /usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: Noto Sans CJK HK:style=Regular
> /usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: Noto Sans CJK KR:style=Regular
> /usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: Noto

Sans CJK SC:style=Regular
/usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: Noto
Sans CJK TC:style=Regular
/usr/share/fonts/opentype/noto/NotoSerifCJK-Regular.ttc: Noto
Serif CJK SC:style=Regular
/usr/share/fonts/opentype/noto/NotoSerifCJK-Regular.ttc: Noto
Serif CJK TC:style=Regular
/usr/share/fonts/opentype/noto/NotoSerifCJK-Regular.ttc: Noto
Serif CJK JP:style=Regular
/usr/share/fonts/opentype/noto/NotoSerifCJK-Regular.ttc: Noto
Serif CJK KR:style=Regular
/usr/share/fonts/truetype/droid/DroidSansFallbackFull.ttf: Droid
Sans Fallback:style=Regular
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto
Sans Mono CJK TC:style=Bold
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto
Sans Mono CJK SC:style=Bold
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto
Sans Mono CJK KR:style=Bold
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto
Sans Mono CJK HK:style=Bold
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto
Sans Mono CJK JP:style=Bold
/usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: **Noto**
Sans Mono CJK SC:style=Regular
/usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: Noto Sans
Mono CJK TC:style=Regular
/usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: Noto Sans
Mono CJK HK:style=Regular
/usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: Noto Sans
Mono CJK KR:style=Regular
/usr/share/fonts/opentype/noto/NotoSansCJK-Regular.ttc: Noto Sans

Mono CJK JP:style=Regular
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto Sans CJK JP:style=Bold
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto Sans CJK KR:style=Bold
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto Sans CJK HK:style=Bold
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto Sans CJK TC:style=Bold
/usr/share/fonts/opentype/noto/NotoSansCJK-Bold.ttc: Noto Sans CJK SC:style=Bold

where i chose `render_font(text = "Noto Sans Mono CJK SC")` from, the way as pointed out in[40].

4.10 Units

For units, there's the package *siunitx* that only works for PDF output. As it does some automation i like to use it. It keeps the spacing between the scalar and its unit smaller than around it. However, there's no working implementation for *MathJax* that translates between LaTeX and HyperText Markup Language (HTML).

The examples (15-22) show how to use a quantity consisting out of a scalar and unit.

(15) `\qty{5}{\percent} \ce{K2Cr2O7}` 👉 $5\,\%\ \mathrm{K_2Cr_2O_7}$

(16) `\qty{120}{\degree}` 👉 $120\,^\circ$

(17) `\qty{40.5}{\cm}.` 👉 $40.5\,\mathrm{cm}$.

(18) `\qty{1}{\ml}.` 👉 $1\,\mathrm{mL}$.

(19) `\qty{14417}{\Hz}.` 👉 $14\,417\,\mathrm{Hz}$.

(20) `Kuusnurkset alfat saab konverteerida mehhaaniliselt beetaks ja beeta taastub alfaks, kui seda kuumutada kõrgemal temperatuuril kui $\qty{1273,15}{\K}$.` 👉 Kuusnurkset alfat saab konverteerida mehhaaniliselt beetaks ja beeta taastub alfaks, kui seda kuumutada kõrgemal temperatuuril kui $1273{,}15\,\mathrm{K}$.

(21) `Lisasime katseklaasi ~$\qty{0,05}{\g}$ lahustatavat ainet (spaatli/pipeti otsatäis).` 👉 Lisasime katseklaasi $\sim 0{,}05\,\mathrm{g}$ lahustatavat ainet (spaatli/pipeti otsatäis).

(22) `Miks katsetes 3.4 ja 3.5 lahuse värvus ei muutunud (vähemalt $\qty{1}{\min}$ kestel)?` 👉 Miks katsetes 3.4 ja 3.5 lahuse värvus ei muutunud (vähemalt $1\,\mathrm{min}$ kestel)?

The example (23) shows additionally how to display just a scalar.

(23)
```
Juhendis on esitatud,
et selle aine molaarne
ekstinktsioonitegur
lainepikkuse $\qty{330}{\nm}$
juures on $\num{34300}$.
```
👉 Juhendis on esitatud, et selle aine molaarne ekstinktsioonitegur lainepikkuse $330\,\mathrm{nm}$ juures on $34\,300$.

The example (24) shows how to show the quantity the qualitative way.

(24)
```
\num{5}-\unit{\percent}
\ce{CuSO4} lahust.
```
👉 $5\text{-}\%$ $CuSO_4$ lahust.

The example (25) shows how to use a numeric product as a measurement.

(25)
```
Minu näites tahan
ma teada kataloogis
*~/eclipse-workspace/test2*
asuva faili
*children-computers.jpg*
omadusi. Näeme, et
selle faili tihedus on
$\numproduct{96 x 96}$ dpi
ja mõõdud on $\numproduct{668
x 371}$ px.
```
👉 Minu näites tahan ma teada kataloogis *~/eclipse-workspace/test2* asuva faili *children-computers.jpg* omadusi. Näeme, et selle faili tihedus on 96×96 dpi ja mõõdud on 668×371 px.

The examples (26-27) show (additionally) how to use a quantity range.

(26)
```
Standardtasu, kui
pole ahvatlevamat
ettepanekut, on $\num{40}
\frac{\epsilon}{\unit{\hour}}$
ja tavaliselt tegutseme
$\qty{1.5}{\hour}$
järjest tehes iga tund
$\qtyrange{5}{15}{\min}$
silmadele ja mõistusele
pause.
```
👉
Standardtasu, kui pole ahvatlevamat ettepanekut, on $40\frac{\epsilon}{\mathrm{h}}$ ja tavaliselt tegutseme $1.5\,\mathrm{h}$ järjest tehes iga tund $5\,\mathrm{min}$ to $15\,\mathrm{min}$ silmadele ja mõistusele pause.

(27)
```
Alkoholi olemasolu
puhul muutub kroomisegu
oranž värvus
$\qtyrange{2}{3}{\second}$
kestel roheliseks.
```
👉
Alkoholi olemasolu puhul muutub kroomisegu oranž värvus $2\,\mathrm{s}$ to $3\,\mathrm{s}$ kestel roheliseks.

Some units have subunits on different floors (examples (28-30)).

(28) `\unit{\mole\per\cubic\meter}.` $\mathrm{mol\,m^{-3}}$.

(29) `\unit{\kg\per\mol}.`

(30)
```
õpetaja siiski ütles,
et ühik oli hoopis
$\unit{\l\per\mol\per\cm}$.
```
👉
$\mathrm{kg\,mol^{-1}}$.

õpetaja siiski ütles, et ühik oli hoopis $\mathrm{L\,mol^{-1}\,cm^{-1}}$.

The example (31) additionally shows how to incorporate measurement uncertainty.

(31)
```
$\qty{56,08 \pm
0,07}{\degreeCelsius}$.
```
👉
$56.08(7)\,^{\circ}\mathrm{C}$.

For including R's values for `qty`, they need to be converted into characters as shown in the example (32).

(32) Valguse kiirus vaakumis[41(p. 127)].

```
speed_of_light_in_vacuum <- 299792458  # 1
```

```
\begin{align}                                                    # 1
c = \qty{`r as.character(speed_of_light_in_vacuum)`}{\m\per\s}   # 2
(\#eq:speed-of-light-in-vacuum)                                  # 3
\end{align}                                                      # 4
                                                                 # 5
```

$$c = 299\,792\,458\,\mathrm{m\,s^{-1}} \tag{4.1}$$

Some quantities are not present in `siunitx`, for instance the short for year in Estonian - "a".

The example (33) shows how the decimal point if the unit is 0 and it is the smallest unit is not retained[42].

(33) Pean valmistama $510\,\mathrm{g}$ vesilahust, mis sisaldab 5.45 massiprotsenti K_2NO_3.

Pean valmistama $510\,\mathrm{g}$ vesilahust, mis sisaldab 5.45 massiprotsenti K_2NO_3.

The example (34) shows how to retain the decimal point if the unit is 0 and it is the smallest unit.

(34) Pean valmistama $510.\,\mathrm{g}$ vesilahust, mis sisaldab 5.45 massiprotsenti K_2NO_3.

Pean valmistama $510.\,\mathrm{g}$ vesilahust, mis sisaldab 5.45 massiprotsenti K_2NO_3.

4.11 Equations

4.11.1 Introduction

Equations can be used in math mode, id est either between `$` or `\[` and `\]`. i prefer the bug signs.

4.11.2 Text

In order to display the text in roman, i use `\text`:

```
\text{d}  # 1
          # 2
```

$$\text{d}$$

4.11.3 Subscript

Subscript can be used with _:

```
t_\text{d}  # 1
            # 2
```

$$t_{\text{d}}$$

4.11.4 Superscript

```
10^3  # 1
      # 2
```

$$10^3$$

4.11.5 Vector

For one-letter-vectors:

```
\vec{F}  # 1
         # 2
```

$$\vec{F}$$

For multiple-letter-vectors:

```
\overrightarrow{\frac{E \cdot Q}{\mathrm{d}(s)}}  # 1
                                                  # 2
```

$$\overrightarrow{\frac{E \cdot Q}{\mathrm{d}(s)}}$$

4.11.6 Multiplication

i like to use the dot for a comma. If there are decimals inside the equation according to rules of System Internationale des Unités cross must be used instead of dot:

```
C_i \times (t + 273.15)^{i - 9}  # 1
                                 # 2
```

$$C_i \times (t + 273.15)^{i-9}$$

Otherwise, a center dot is a better solution as cross symbolises vector multiplication as well:

```
m \cdot \vec{a}  # 1
                 # 2
```

$$m \cdot \vec{a}$$

4.11.7 Fraction

`\frac` regulates the height of the expression, so that an inline expression has the height of the text line and a block expression has a higher height[43, lk 122]. `\tfrac` always renders the expression to have the height of the inline text. `\dfrac` always renders the expression to have a higher and better readable height. The examples can be seen in the code block 4.6 on the page 82.

```
Rõhu valem muutumatu massi korral
    on $\frac{m \cdot a}{A}$ ehk $\
    dfrac{m \cdot a}{A}$ ehk $\
    tfrac{m \cdot a}{A}$.

\begin{align}
\frac{m \cdot a}{A}\leavevmode\\
\dfrac{m \cdot a}{A}\leavevmode\\
\tfrac{m \cdot a}{A}
\end{align}
```

Listing 4.6: An example of how to display fractions.

Rõhu valem muutumatu massi korral on $\frac{m \cdot a}{A}$ ehk $\dfrac{m \cdot a}{A}$ ehk $\tfrac{m \cdot a}{A}$.

$$\frac{m \cdot a}{A} \tag{4.2}$$

$$\dfrac{m \cdot a}{A} \tag{4.3}$$

$$\tfrac{m \cdot a}{A} \tag{4.4}$$

4.11.8 Functions

As functions must be written in roman then:

```
$\mathrm{ln}(T)$  # 1
                  # 2
```

$$\mathrm{ln}(T)$$

4.11.9 Sum

```
\sum_{i := 8}^{n}{C_i}  # 1
                        # 2
```

$$\sum_{i:=8}^{n} C_i$$

4.11.10 Aligning

It's reasonable to align all the tables:

```
\begin{align}
 ↪  # 1
\frac{R_{sisemine}}{(R + R_{sisemine})^2} &= 0, R \nequal R_{sisemine}
 ↪  (\#eq:extrema-of-eta-R-initial)\leavevmode\\   # 2
R_{sisemine} &= 0
 ↪  # 3
(\#eq:extrema-of-eta-R)
 ↪  # 4
\end{align}
 ↪  # 5

 ↪  # 6
```

$$\frac{R_{sisemine}}{(R + R_{sisemine})^2} = 0, R \neq R_{sisemine} \tag{4.5}$$

$$R_{sisemine} = 0 \tag{4.6}$$

Here, \\ and line break means a real line break.

Additional labels must be placed in the end of the corresponding row just

before the double slashes before the line break. Additional labels are displayed on the web page however not linked.

Referencing an equation is also visible in the equation (4.5):

```
\@ref(eq:extrema-of-eta-R-initial)  # 1
                                    # 2
```

Empty lines aren’t allowed.

4.11.11 Calculus

```
\partial{H}  # 1
             # 2
```

$$\partial H$$

4.11.12 Cancelling

```
\begin{align}  # 1
`r if (knitr::is_html_output()) { "\\require{cancel}" }`\frac{\frac{\mathrm{\frac{L^2 \cdot \cancel{M}}{T^2}}}{\mathrm{\cancel{N}} \cdot \Theta}}{\mathrm{\frac{\cancel{M}}{\cancel{N}}}} = \frac{\mathrm{L^2}}{\mathrm{T^2} \cdot \Theta},  # 2 (\#eq:dimensional-analysis-for-specific-gas-constant)  # 3
\end{align}  # 4

  # 5
```

$$\frac{\frac{\mathrm{L}^2 \cdot \cancel{\mathrm{M}}}{\mathrm{T}^2}}{\frac{\cancel{\mathrm{N}} \cdot \Theta}{\cancel{\mathrm{N}}}} = \frac{\mathrm{L}^2}{\mathrm{T}^2 \cdot \Theta}, \tag{4.7}$$

4.11.13 Underbrace

```
\underbrace{c_p \cdot (T_\text{out} - T_\text{d})}_{\text{mõistlik soojuskadu õhus}}  # 1

  # 2
```

$$\underbrace{c_p \cdot (T_\text{out} - T_\text{d})}_{\text{mõistlik soojuskadu õhus}}$$

4.11.14 Integral

```
\int{\overrightarrow{\frac{E \cdot Q}{\mathrm{d}(s)}}} \cdot \mathrm{d}(s).  # 1

                                                                             # 2
```

$$\int \overrightarrow{\frac{E \cdot Q}{\mathrm{d}(s)}} \cdot \mathrm{d}(s).$$

4.11.15 Percent

```
\%.  # 1
     # 2
```

$$\%.$$

4.11.16 Comparison

```
p \ll .05.  # 1
            # 2
```

$$p \ll .05.$$

4.11.17 Greek letters

```
$$\Delta, \epsilon, \eta, \nu.$$  # 1
                                  # 2
```

$$\Delta, \epsilon, \eta, \nu.$$

4.11.18 Matrices

Avaldisena (4.8) leheküljel 88 on esitatud kolme vektori ristkorrutis[25(lk A-7)], [44].

$$\vec{V}_1 \times (\vec{V}_2 \times \vec{V}_3) = \vec{V}_1 \times \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ V_{2;x} & V_{2;y} & V_{2;z} \\ V_{3;x} & V_{3;y} & V_{3;z} \end{vmatrix} \tag{4.8}$$

4.11.19 Proportionality

The symbol for proportionality is $\propto$ and it can be used as shown in the listing 4.7 on the page 88[33, lk 151].

```
$F_\mathrm{D} \propto v^2$
```

Listing 4.7: Is proportional to.

$F_\mathrm{D} \propto v^2$

4.11.20 Mean

The command for the mean symbol is `\overline` and it can be used as shown in the listing 4.8 on the page 88[33, lk 164].

```
$\overline{\frac{days}{year}}$
```

Listing 4.8: Mean.

$\overline{\frac{days}{year}}$

4.12 Text

4.12.1 Non-breaking space

Without a non-breaking space:

```
Joonistan Lewise skeemi, millele on märgitud ainult elektronid, mitte
↪ elemendi sümbol.  # 1

↪ # 2
```

Joonistan Lewise skeemi, millele on märgitud ainult elektronid, mitte elemendi sümbol.

With a non-breaking space[45]:

```
Joonistan Lewise skeemi, millele on märgitud ainult elektronid, mitte
↪ elemendi\nobreakspace{}sümbol.  # 1

↪ # 2
```

Joonistan Lewise skeemi, millele on märgitud ainult elektronid, mitte elemendi sümbol.

4.12.2 Colour

```
$$\color{red}{\text{Augusti psühhomeetriga}}.$$  # 1
                                                 # 2
```

$$\color{red}{\text{Augusti psühhomeetriga}}.$$

4.12.3 Size

```
$$\huge{\text{Augusti psühhomeetriga}}$$  # 1
                                          # 2
```

Augusti psühhomeetriga

4.12.4 Typewriter

Inline code can be written using `\texttt` as seen in the code block 4.9 on the page 90[33, lk 23].

```
An example of how to reference the
   package \texttt{multicol} and
   configure its use.
```

Listing 4.9: An example of how to display inline code.

An example of how to reference the package `multicol` and configure its use.

4.12.5 Code blocks

Code blocks can be written using the package `listings`[46] that can be configured in *preamble.tex* as seen in the listing 4.10 on the page 91.

```
\usepackage{listings}
\lstloadlanguages{TeX}
\definecolor{codegreen}{rgb}{0,0.6,0}
\definecolor{codegray}{rgb}{0.5,0.5,0.5}
\definecolor{codepurple}{rgb}{0.58,0,0.82}
\definecolor{backcolour}{rgb}{0.95,0.95,0.92}
\lstdefinestyle{mystyle}{
  backgroundcolor=\color{backcolour},
  commentstyle=\color{codegreen},
  keywordstyle=\color{magenta},
  numberstyle=\tiny\color{codegray},
  stringstyle=\color{codepurple},
  basicstyle=\ttfamily\footnotesize,
  breakatwhitespace=false,
  breaklines=true,
  captionpos=b,
  keepspaces=true,
  numbers=left,
  numbersep=5pt,
  showspaces=true,
  showstringspaces=true,
  showtabs=true,
  tabsize=2
}
\lstset{style=mystyle}
```

Listing 4.10: An example of how to reference the package `listings` and configure its use.

An example with `listings` is shown in the listing 4.11 on the page 92.

```
\begin{lstlisting}[label=lst:itemize, language=TeX, caption=An example of a code listing of a list with checkboxes.]
Märgista omadus, kui see on keemiline:

\begin{itemize}
    \item[\Square] hõbedast esemed tuhmuvad;
    \item[\Square] rubiinide punane värvus on tingitud kroomiioonide
      olemasolust;
    \item[\Square] etanooli keemistemperatuur on 78°C.
\end{itemize}
\end{lstlisting}
```

Listing 4.11: An example for a code listing.

```
Märgista omadus, kui see on keemiline:

\begin{itemize}
    \item[\Square] hõbedast esemed tuhmuvad;
    \item[\Square] rubiinide punane värvus on tingitud kroomiioonide
      olemasolust;
    \item[\Square] etanooli keemistemperatuur on 78°C.
\end{itemize}
```

Listing 4.12: An example of a code listing of a list with checkboxes.

The latter example has been created by nesting `lstlisting` inside a new environment created extra for that as it is not possible to show `\begin{lstlisting}` inside another `\begin{lstlisting}`. The new environment must be created in *preamble.tex* as seen in the listing 4.13 on the page 92[45].

```
\lstnewenvironment{TeXlstlisting}[2]{
    \lstset{
        caption=#1,
        label=#2,
        language=[LaTeX]TeX
    }
}{}
```

Listing 4.13: An example of how to create a new environment for `lstlisting`.

The usage of this new environment can be seen in the listing 4.14 on the page 93.

```
\begin{TeXlstlisting}{An example for a code listing.}{lst:lstlisting}
...
\end{TeXlstlisting}
```

Listing 4.14: An example of how to use `TeXlstlisting`.

4.12.6 Line breaks

An example of how to force a line break is shown in the listing 4.15 on the page 93[31, lk 271].

```
\color{green}{5}\ce{Na}\color{green
   }{\ce{Cl}}\ce{O2} + \color{blue
   }{4}\ce{H}\color{blue}{\ce{Cl}}
    \ce{->}\leavevmode\\
\color{blue}{\ce{4Cl}}\ce{O2} + \
   color{green}{5}\ce{Na}\color{
   green}{\ce{Cl}} + \ce{2H2O}
```

Listing 4.15: An example of how to break lines.

$$5NaClO_2 + 4HCl \longrightarrow 4\,ClO_2 + 5NaCl + 2\,H_2O$$

4.12.7 Symbols

The examples (35-36) show how to use some symbols as text[47(lk 186)]. The package *fontawesome5* is needed for them.

(35) `\faHandPointRight`

(36) `\faHandPointDown`

4.12.8 Superscript

The example (38) with the listing 5.1 on the page 144 shows how to use a superscript outside the math mode[48].

4.13 Chemistry

4.13.1 Chemical symbols

For using the package *mhchem*, it has to be installed[49]:

```
sudo apt install texlive-science  # 1
                                  # 2
```

After that, *mchem* can be used:

```
`r if (knitr::is_html_output()) { "\\require{mhchem}" }`\ce{N_2}  # 1
                                                                  # 2
```

$$N_2$$

```
Puidu ja arheoloogiliste proovide dateerimiseks kasutatakse
 ↪  $\ce{^{14}C}$'d, mille poolestusaeg on 5715 a.  # 1

 ↪  # 2
```

Puidu ja arheoloogiliste proovide dateerimiseks kasutatakse ^{14}C'd, mille poolestusaeg on 5715 a.

The use with an arrow is shown in the equation

```
\begin{align}
 ↪  # 1
\color{green}{5}\ce{Na}\color{green}{\ce{Cl}}\ce{O2} +
 ↪  \color{blue}{4}\ce{H}\color{blue}{\ce{Cl}} \ce{->}\leavevmode\\  # 2
\color{blue}{\ce{4Cl}}\ce{O2} +
 ↪  \color{green}{5}\ce{Na}\color{green}{\ce{Cl}} + \ce{2H2O}
 ↪  # 3
(\#eq:ce-with-arrow)
 ↪  # 4
```

```
\end{align}
    # 5

    # 6
```

$$5NaClO_2 + 4HCl \longrightarrow \tag{4.9}$$

$$4\,ClO_2 + 5NaCl + 2\,H_2O \tag{4.10}$$

```
Aldehüüd on redutseerija ja redutseerib komplekseeritud vask(II)iooni  #
    1
vask(I)oksiidiks:                                                       #
    2
                                                                        #
    3
$$\ce{2Cu^2+}_\text{complexed}\ce{+2[OH]- + 2e- -> Cu2O + H2O}.$$       #
    4
                                                                        #
    5
```

Aldehüüd on redutseerija ja redutseerib komplekseeritud vask(II)iooni vask(I)oksiidiks:

$$2\,Cu^{2+}_{\text{complexed}} + 2\,OH^- + 2\,e^- \longrightarrow Cu_2O + H_2O.$$

4.13.2 Electron configuration

For automatically displaying electron configuration, one can use the package *elements*[50].

Electron configuration for carbon which is the sixth element in the periodic system of chemical elements:

```
\elconf{6}  # 1
            # 2
```

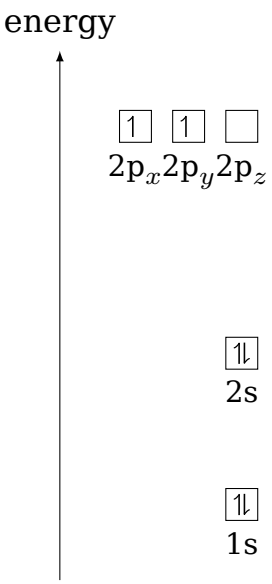
$1s^2 2s^2 2p^2$

4.13.3 Orbital energy level diagram

For generating orbital energy level diagrams, one can use the package *modiagram*[51]. It only works up to the second energy level.

This is how to display an orbital energy levels diagram for carbon:

```
                                          # 1
\begin{modiagram}[style = square, labels]  # 2
    \atom{left}{1s, 2s, 2p = {; up, up}}   # 3
    \EnergyAxis[title]                     # 4
\end{modiagram}                            # 5
                                          # 6
```



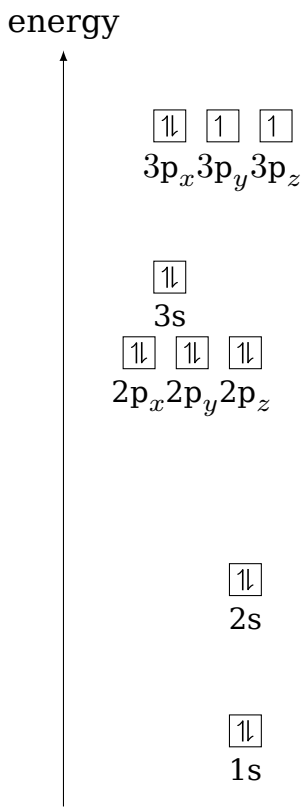
It's still possible to hack in the third levels' s- and p-levels but not further levels as seen for sulfur:

```

↪  # 1
```

```
\begin{modiagram}[style = square, labels]
    # 2
    \atom{left}{1s, 2s, 2p}
    # 3
    \AO{s}[label = {3s}]{6; pair}
    # 4
    \AO{p}[label[x] = $3\mathrm{p}_x$, label[y] =
    $3\mathrm{p}_y$,label[z]= $3\mathrm{p}_z$]{8; pair, up, up}  # 5
    \EnergyAxis[title]
    # 6
\end{modiagram}
    # 7

    # 8
```



4.13.4 Lewis dot diagram

For generating Lewis dot diagrams, one can use the package *chemfig*[52].

This is how to display the Lewis dot diagram for sulfur using angles:

```
\Charge{0 = \:, 90 = \:, 180 = \., 270 = \.}{S}  # 1
                                                 # 2
```

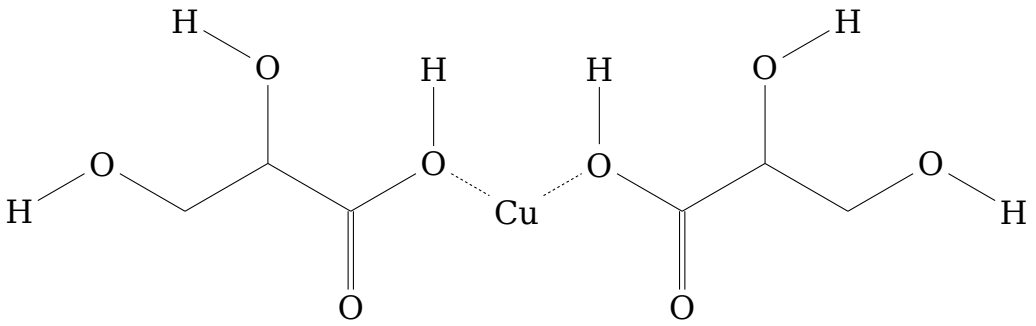
S:

4.13.5 Molecular schemas

chemfig is useful for drawing molecular schemas as seen in the schema (4.11) on the page 99.

```
\begin{align}                                    # 1
\chemfig{                                        # 2
    H-[:30]                                      # 3
    O-[:-30]                                     # 4
    -[:30](-[:90]O-[:150]H)                      # 5
    -[:-30](=[:-90]O)                            # 6
    -[:30]                                       # 7
    O(-[:90]H)                                   # 8
    -[:-30,,,,dash pattern=on 1pt off 1pt]       # 9
    Cu-[:30,,,,dash pattern=on 1pt off 1pt]      # 10
    O(-[:90]H)                                   # 11
    -[:-30](=[:-90]O)                            # 12
    -[:30](-[:90]O-[:30]H)                       # 13
    -[:-30]                                      # 14
    -[:30]                                       # 15
    O-[:-30]                                     # 16
    H                                            # 17
}                                                # 18
(\#eq:copper-glycerate)                          # 19
```

```
\end{align}                                    # 20
                                               # 21
[@pubchem_copper].                             # 22
                                               # 23
```



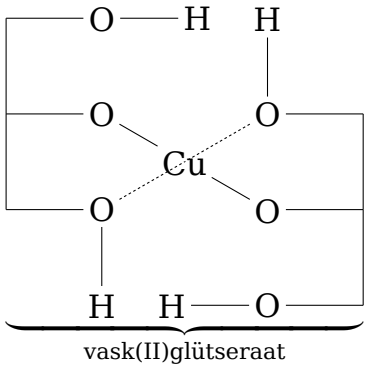
(4.11)

[53].

A more complicated molecular diagram is represented as the schema (4.12) on the page 100.

```
\begin{align}
 ↪ # 1
\chemfig{
 ↪ # 2
\underbrace{\chemfig{H-[:180]O-[:180]-[:-90](-[:-90]-O(-[:30,,,,dash
 ↪ pattern=on 1pt off
 ↪ 1pt])-[:-90]H)-O-[:-30]Cu-[:-30]O-(-[:90]-[:180]O(-[:-150,,,,dash
 ↪ pattern=on 1pt off
 ↪ 1pt])-[:90]H)-[:-90]-[:180]O-[:180]H}}_\text{vask(II)glütseraat}.  #
 ↪ 3
(\#eq:Cu-II-glycerate)
 ↪ # 4
\end{align}
 ↪ # 5

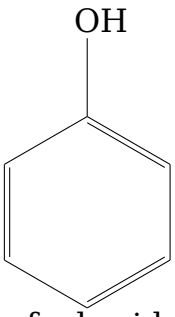
 ↪ # 6
```



. (4.12)

```
Vesi ja hüdroksübenseen (fenool [@haynes_2014_crc, p. 3-446],
↪ $\chemfig{*6(-=-=(-OH)-=)}\qquad$ [@haynes_2014_crc, p. 3-447],
↪ tsükloalkeen) omavahel ei lahustu, sest hüdrofoobseid süsinikke on
↪ võrdlemisi palju.  # 1

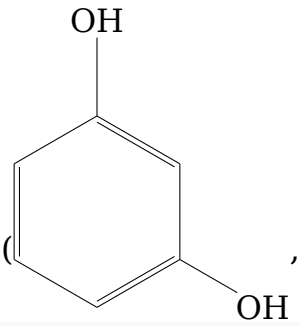
↪ # 2
```

Vesi ja hüdroksübenseen (fenool[25(pp. 3–446)], 

[25(pp. 3–447)], tsükloalkeen) omavahel ei lahustu, sest hüdrofoobseid süsinikke on võrdlemisi palju.

```
1,3-benseendiool ($\chemfig{*6(-=(-\ce{OH})-=(-\ce{OH})-=)}$, resortsiin
↪ `r render_with_emojis(text = "(ref:haynes-2014-crc), p. 3-480")`).  #
↪ 1

↪ # 2
```

1,3-benseendiool (

, resortsiin[25(pp. 3–480)]).

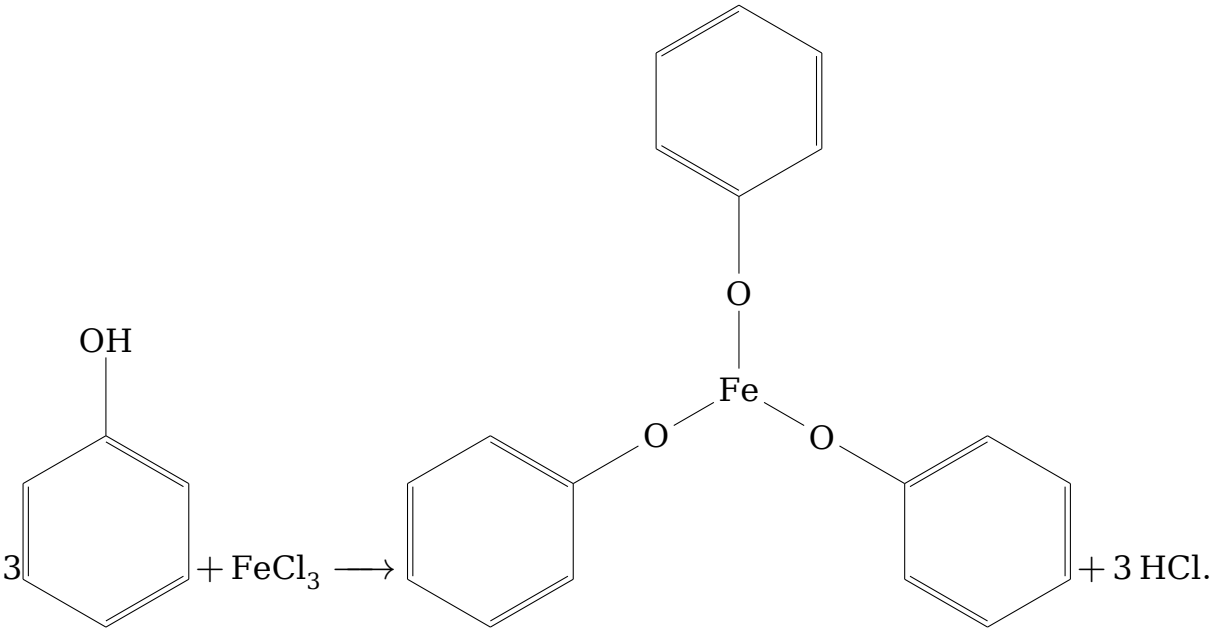
```
Hüdroksübenseen reageeris raudkloriidiga niimoodi:
 ↪ # 1

 ↪ # 2
$$\ce{3} \chemfig{*6(-=-=(-\ce{OH})-=)} \ce{+ FeCl3 ->}
 ↪ # 3
\chemfig{
 ↪ # 4

 ↪ *6(-=-(-O-[:30]Fe(-[:90]O(-[:90]*6(-=-=-=)))-[:-30]O-[:-30]*6(-=-=-=))=-=)
 ↪ # 5
}
 ↪ # 6
\ce{+ 3HCl}.$$
 ↪ # 7

 ↪ # 8
```

Hüdroksübenseen reageeris raudkloriidiga niimoodi:


OH
3
+ FeCl3
O
Fe
O
O
+ 3 HCl.

4.14 Physics

Current diagrams are only shown in the print form. For a current diagram, i need to add the following line into *preamble.tex*:

```
\usepackage{circuitikz}  # 1
                         # 2
```

```

 # 1
\begin{figure}
 # 2
\begin{circuitikz}[european]
 # 3
   \draw
 # 4
   (0, 0)  to[dcvsource, l = $E$,
 v_ = $r$] (0, 2)
 # 5
           to[ammeter] (2, 2)
 # 6
           to[vR, l = $R$, *-*]
 (2, 0) -- (0, 0);
 # 7
   \draw
 # 8
       (2, 2)  to[voltmeter] (4,
 2) -- (4, 0) -- (2, 0)
 # 9
   ;
 # 10
\end{circuitikz}
 # 11
  \caption{Skeem, mille järgi
 toimetasime.}
 \label{fig:schema}   # 12
\end{figure}
 # 13


 # 14
```

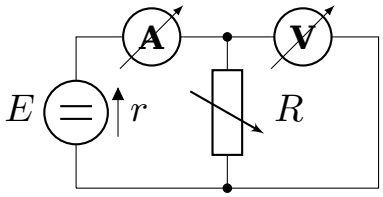


Figure 3: Skeem, mille järgi toimetasime.

4.15 New page

The following snippet is the code for a page break:

```
\newpage  # 1
          # 2
```

If the new page must be empty then the following code snippet is useful:

```
\newpage    # 1
\mbox{}     # 2
\pagebreak  # 3
            # 4
```

4.16 Blanks

For scaffolding, one needs to have these rows in *preamble.tex*[54]:

```
% for fill-in-the-gaps-tests                                          # 1
\newlength{\blankwidth}                                               # 2
\newcommand{\blank}[1]{%                                              # 3
    \ifmmode\settowidth{\blankwidth}{\ensuremath{{#1}{#1}{#1}}}%  # 4
    \else\settowidth{\blankwidth}{{#1}{#1}{#1}}%                      # 5
    \fi                                                               # 6
    \makebox[\blankwidth]{\dotfill}}                                  # 7
                                                                      # 8
```

Then, you can use `blank`:

```
Täna on 2023-12-12 ja mina olen \blank{10. Trubilko, Vladislav}.  # 1
                                                                  # 2
```

The output looks like:

Täna on 2023-12-12 ja mina olen

.....

4.17 Lists

For creating tasks for pupils, sometimes checkboxes are needed. For that, there is `itemize`[55]. The example (37) with `itemize` is shown in the listing 4.16 on the page 106. Form elements need the package *wasysym*[47(p. 187)].

(37)

```
Märgista omadus, kui see on keemiline:

\begin{itemize}
  \item[\Square] hõbedast esemed tuhmuvad;
  \item[\Square] rubiinide punane värvus on tingitud kroomiioonide olemasolust;
  \item[\Square] etanooli keemistemperatuur on 78°C.
\end{itemize}
```

Listing 4.16: An Example for a list with checkboxes.

Märgista omadus, kui see on keemiline:

- □ hõbedast esemed tuhmuvad;
- □ rubiinide punane värvus on tingitud kroomiioonide olemasolust;
- □ etanooli keemistemperatuur on 78°C.

Chapter 5

R

5.1 Assignment

For assigning a value to a variable, i use <- unless the variable is a parameter or an argument - then i use =:

```
variable <- "value"                                    # 1
                                                       # 2
name_of_function <- function(parameter = "value") {    # 3
                                                       # 4
}                                                      # 5
```

5.2 Debugging

5.2.1 Printing out a value

```
print(2)  # 1
## [1] 2
```

5.2.2 Datatype

For figuring out the datatype[56]:

```
class(2)  # 1
## [1] "numeric"
```

5.2.3 Datatype and value

```
str(2)  # 1
##  num 2
```

5.2.4 Is the value not set?

```
is.null(variable)  # 1
## [1] FALSE
```

5.2.5 Stopping execution

```
stop("error message")  # 1
                       # 2
```

5.3 Numbers

5.3.1 Converting a string to a number

```
number = "3"  # 1
str(number)   # 2
##  chr "3"
                                    # 1
numeric_number <- as.numeric(number)  # 2
str(numeric_number)                   # 3
##  num 3
```

5.3.2 Sequencing

```
seq(0, 14, 2)  # 1
## [1]  0  2  4  6  8 10 12 14
```

5.3.3 Rounding

5.3.3.1 Normal rounding

```
round(123.456, digits = 1)  # 1
## [1] 123.5
round(122.5)  # 1
## [1] 122
round(123.5)  # 1
## [1] 124
```

5.3.3.2 Significant digits

For printing only significant digits, there's the function `signif` which takes two parameters: the initial number `x` and the number of significant digits `digits`:

```
number <- 123.456                                                  # 1
                                                                   # 2
number_with_significant_digits <- signif(x = number, digits = 4)   # 3
print(number_with_significant_digits)                              # 4
## [1] 123.5
```

5.3.3.3 Prefixes

For formatting with prefixes, one can use the function *format_SI*[57] from the package *BAAQMD/strtools*[58]:

```
number <- c(1234.56, 0.123456)  # 1
librarian::shelf(c(             # 2
  "strtools"                    # 3
))                              # 4
format_SI(number)               # 5
## [1] "1k"   "123m"
format_SI(number, fixed=TRUE)  # 1
## [1] "1k" "0k"
format_SI(number, engineering=TRUE)  # 1
## [1] "1.234560000k" "0.000123456k"
format_SI(number, digits=2)  # 1
## [1] "1.23k"   "123.46m"
```

5.3.3.4 Powers and units

For using powers and units, there is the package *formatdown*[59]:

```
librarian::shelf(c(                             # 1
  "formatdown"                                  # 2
))                                              # 3
numbers <- c(123.456, 2e-6, 5e8, 0.23)          # 4
format_power_numbers <- format_power(numbers)  # 5
## Warning in format_power(numbers): `format_power()` is deprecated. Use
 ↪  `format_numbers()`
##               which offers additional arguments and access to package
 ↪  options.
format_power_numbers_digits <- format_power(numbers, digits = 2)  # 1
## Warning in format_power(numbers, digits = 2): `format_power()` is
 ↪  deprecated. Use `format_numbers()`
##               which offers additional arguments and access to package
 ↪  options.
format_power_numbers_sci <- format_power(numbers, format="sci")  # 1
```

```
## Warning in format_power(numbers, format = "sci"): `format_power()` is
↪  deprecated. Use `format_numbers()`
##                which offers additional arguments and access to package
↪  options.
format_power_numbers_omit <- format_power(numbers, omit_power = c(-6,
↪  -6))  # 1
## Warning in format_power(numbers, omit_power = c(-6, -6)):
↪  `format_power()` is deprecated. Use `format_numbers()`
##                which offers additional arguments and access to package
↪  options.
format_power_numbers_set <- format_power(numbers, set_power = 5)  # 1
## Warning in format_power(numbers, set_power = 5): `format_power()` is
↪  deprecated. Use `format_numbers()`
##                which offers additional arguments and access to package
↪  options.
units(numbers) <- "kg m-3"                                        # 1
format_units_numbers <- format_units(x=numbers, unit="g l-1")  # 2
## Warning in format_units(x = numbers, unit = "g l-1"):
↪  `format_units()` is deprecated. Use `format_numbers()`
##                which offers additional arguments and access to package
↪  options.
```

$123.5, 2.000 \times 10^{-6}, 500.0 \times 10^{6}, 0.2300$

$120, 2.0 \times 10^{-6}, 500 \times 10^{6}, 0.23$

$123.5, 2.000 \times 10^{-6}, 5.000 \times 10^{8}, 0.2300$

$123.5 \times 10^{0}, 0.000002000, 500.0 \times 10^{6}, 230.0 \times 10^{-3}$

$123.5, 0.00000000002000 \times 10^{5}, 5000 \times 10^{5}, 0.2300$

123.456000 [g/L], 0.000002 [g/L], 500000000.000000 [g/L], 0.230000 [g/L]

5.4 Time

5.4.1 Converting to time

```
string_of_time = "2020.7.08 16:43:59"  # 1
str(string_of_time)                    # 2
##  chr "2020.7.08 16:43:59"



librarian::shelf(c(
 ↪  # 2
  "lubridate"
   ↪  # 3
))
 ↪  # 4


string_of_time_as_time <- parse_date_time(string_of_time, c("%Y.%m.%d
 ↪  %H:%M", "%m.%d.%Y %H:%M", "%Y.%m.%d %H:%M:%S"))  # 6
str(string_of_time_as_time)
 ↪  # 7
##  POSIXct[1:1], format: "2020-07-08 16:43:59"
```

[60].

5.4.2 Parts of time

For *ms,* the package *lubridate* is needed. This function extracts the minutes and seconds.

```
time <- "2:53"           # 1
parsed_time <- ms(time)  # 2
print(parsed_time)       # 3
## [1] "2M 53S"
```

The time in the last minute is $53\,\mathrm{s}$.

```
s <- as.numeric(parsed_time)  # 1
```

The time is $173\,\mathrm{s}$.

5.5 Array

5.5.1 Creation

An array can be created using the function `c`:

```
array <- c("value_1", "value_2")  # 1
print(array)                      # 2
## [1] "value_1" "value_2"
```

5.5.2 Referencing position

Referencing a position inside the array takes place using brackets whereas the first position has the index `1`:

```
value_at_position_2 <- array[2]  # 1
print(value_at_position_2)       # 2
## [1] "value_2"
                        # 1
array[2] <- "value_3"   # 2
print(array)            # 3
## [1] "value_1" "value_3"
```

5.5.3 Multidimensional

Arrays with the same length can be connected into `data.frame`:

```
array_2 <- c("value_3", "value_4")          # 1
data_frame <- data.frame(array, array_2)    # 2
print(data_frame)                           # 3
##     array array_2
## 1 value_1 value_3
## 2 value_3 value_4
```

5.5.4 Column names

A `data.frame` can have column names:

```
colnames(data_frame) <- c(  # 1
  "array",                  # 2
  "array 2"                 # 3
)                           # 4
                            # 5
print(data_frame)           # 6
##     array array 2
## 1 value_1 value_3
## 2 value_3 value_4
```

5.5.5 Adding column[61]

```
data_frame_with_array_2 <- cbind(data_frame, array_2)  # 1
                                                       # 2
print(data_frame_with_array_2)                         # 3
##     array array 2 array_2
## 1 value_1 value_3 value_3
## 2 value_3 value_4 value_4
```

5.5.6 Row names

```
rownames(data_frame) <- c(  # 1
  "Caption of first row",   # 2
  "Caption of second row"   # 3
)                           # 4
                            # 5
print(data_frame)           # 6
##                          array array 2
## Caption of first row  value_1 value_3
## Caption of second row value_3 value_4
```

5.5.7 Importing data

Data can be imported from a text file into a data frame:

```
CO2_in_air <- read.table("co2_brw_surface-insitu_1_ccgg_DailyData.txt",
↪  header = TRUE, sep = "", dec = ".")  # 1

```

Data can also be imported from a comma-separated-values-(CSV-)file into a data frame:

```
washing_cycles <- read.table("washing-cycles.csv", header = TRUE, sep =
↪  ",", dec = ".")  # 1
```

5.5.8 Printing first rows

```
print(head(washing_cycles))  # 1
##              Algus Kestus Temperatuur Pöördeid.min      Kava
 ↪  Veenäit.enne
## 1 2018.12.24 19:05   0:29          40         1000  lühikava
 ↪  NA
## 2 2018.12.24 23:03   0:29          30         1000  lühikava
 ↪  NA
## 3  2018.12.24 0:27   1:54          40         1000  segakiud
 ↪  NA
## 4 2018.12.26 14:30   0:47          30          800  käsipesu
 ↪  NA
## 5 2018.12.26 23:35   0:47          40          800 villapesu
 ↪  NA
## 6  2018.12.27 0:58   0:29          30         1000  lühikava
 ↪  279.396
##   Veenäit.pärast Veekulu..l. kWh
## 1                           NA 0.5
## 2                           NA 0.2
## 3                           NA 0.4
## 4                           NA 0.4
## 5                           NA 0.4
## 6        279.428         3.2 0.3
```

5.5.9 Editing the look of a cell

```
librarian::shelf("kableExtra")                                  # 1
coloured_cell <- cell_spec(data_frame[, 2], color = "red")  # 2
```

[62].

5.5.10 Editing the content

```
librarian::shelf("dplyr")                   # 1
mutate(data_frame, "array 2" = "mutated")  # 2
##                           array array 2
## Caption of first row  value_1 mutated
## Caption of second row value_3 mutated
```

[63].

5.5.11 Size

```
length(data_frame)  # 1
## [1] 2
                  # 1
nrow(data_frame)  # 2
## [1] 2
```

5.5.12 Looping

```
                                      # 1
for (index in 1:length(data_frame)) {  # 2
  print(data_frame[index])             # 3
}                                      # 4
##                           array
## Caption of first row  value_1
## Caption of second row value_3
##                         array 2
## Caption of first row  value_3
## Caption of second row value_4
```

5.5.13 Referencing by column name

```
print(data_frame$`array 2`)  # 1
## [1] "value_3" "value_4"
```

[64]

5.5.14 Subsetting

As `washing_cycles` also contains records with missing data i want them removed:

```
washing_cycles_with_full_records <- subset(washing_cycles,
    !is.na(`Veenäit.enne`) & "" != `Veenäit.pärast` &
    !is.na(`Veekulu..l.`) & !is.na(`kWh`))  # 2


print(head(washing_cycles_with_full_records))
    # 4
##               Algus Kestus Temperatuur Pöördeid.min       Kava
    Veenäit.enne
## 6   2018.12.27 0:58   0:29          30         1000   lühikava
    279.396
## 7  2018.12.27 19:32   0:44          30         1000   lühikava
    279.439
## 9   2019.1.12 15:13   1:54          30         1000 sünteetika
    280.071
## 10   2019.2.7 12:46   0:29          30         1000   lühikava
    281.189
## 11  2019.2.16 21:56   0:29          30         1000   lühikava
    281.522
## 12  2019.2.20 17:10   0:47          40          800  villapesu
    281.698
##        Veenäit.pärast Veekulu..l. kWh
## 6              279.428         3.2 0.3
## 7              279.459         2.0 0.1
```

```
## 9  280.13400000000001         6.3 1.5
## 10 281.21499999999997         2.6 0.4
## 11 281.54899999999998         2.7 0.3
## 12           281.745         4.7 0.9
```

[65]

This was how to remove incomplete records by manually setting the columns that contain empty records. There is a move convenient method to do that without specifying columns:

```
washing_cycles_with_full_records <-
 ↪  washing_cycles[complete.cases(washing_cycles), ]  # 1
```

[64]

I only want to see the data in the column `Kava`:

```
program_in_washing_cycles <- subset(washing_cycles_with_full_records,
 ↪  select = `Kava`)  # 1


print(head(program_in_washing_cycles))
 ↪  # 3
##          Kava
## 6    lühikava
## 7    lühikava
## 9  sünteetika
## 10   lühikava
## 11   lühikava
## 12  villapesu
```

I only want to see cycles from the rows 2 to 4 in the second column:

```
print(washing_cycles_with_full_records[2:4, 2])  # 1
## [1] "0:44" "1:54" "0:29"
```

I want the last 216 rows to be removed:

```
number_of_rows_in_washing_cycles_with_full_records <-
 ↪  nrow(washing_cycles_with_full_records)                              # 1
data_frame_of_washing_cycles_with_full_records_without_last_records <-
 ↪  washing_cycles_with_full_records[                 # 2
  -c((number_of_rows_in_washing_cycles_with_full_records -
   ↪  215):number_of_rows_in_washing_cycles_with_full_records), ]  # 3
print(data_frame_of_washing_cycles_with_full_records_without_last_records)
 ↪  # 4
##              Algus Kestus Temperatuur Pöördeid.min       Kava
 ↪  Veenäit.enne
## 6  2018.12.27 0:58   0:29          30         1000   lühikava
 ↪  279.396
## 7 2018.12.27 19:32   0:44          30         1000   lühikava
 ↪  279.439
## 9  2019.1.12 15:13   1:54          30         1000 sünteetika
 ↪  280.071
##       Veenäit.pärast Veekulu..l. kWh
## 6              279.428         3.2 0.3
## 7              279.459         2.0 0.1
## 9 280.13400000000001         6.3 1.5
```

I only want to see hot cycles:

```
hot_cycles <- subset(washing_cycles_with_full_records, `Temperatuur` >
 ↪  40)  # 1
print(hot_cycles)
 ↪  # 2
##                  Algus  Kestus Temperatuur Pöördeid.min
 ↪  Kava
```

```
## 23      2019.4.19 15:13    2:10          60         1000
    ↪ beebi
## 34       2019.7.6 16:05    1:54          60         1000
    ↪ sünteetika
## 38      2019.7.10 13:30    1:54          60         1000
    ↪ segakiud
## 65      2019.9.28 19:41    1:54          60         1000
    ↪ segakiud, hygiene+
## 68      2019.9.29 16:39    2:10          90          400
    ↪ autoclean
## 184 2020.11.15 19:19:59 1:54:59          60         1000
    ↪ segakiud, hygiene+
## 203  2021.2.12 19:09:59 2:49:00          90         1300
    ↪ Kochwäsche
## 206  2021.2.16 18:31:59 1:54:59          60         1000  sünteetika
    ↪ + hygiene+
## 320 11.12.2021 15:24:59 1:54:59          60         1000
    ↪ segu, hygiene+
## 340 12.10.2021 23:22:00 2:49:00          90         1300
    ↪ keedupesu, hygiene+
## 393  3.20.2022 14:42:00 2:59:00          90         1300 keedupesu,
    ↪ lisaloputus
## 425  6.24.2022 14:10:59 4:00:59          60         1300   puuvill,
    ↪ lisaloputus
## 427  6.24.2022 17:48:59 2:04:00          60         1000      segu,
    ↪ lisaloputus
## 439  7.17.2022 15:33:00 2:59:00          90          400
    ↪ keedupesu
##     Veenäit.enne     Veenäit.pärast Veekulu..l. kWh
## 23       284.498 284.53699999999998         3.9 2.3
## 34       287.732 287.80200000000002         7.0 1.0
## 38       288.129 288.20600000000002         7.7 2.3
```

```
## 65       292.237 292.30799999999999         7.1 0.9
## 68       292.478 292.49799999999999         2.0 0.5
## 184      316.293 316.31200000000001         1.9 0.4
## 203      321.112 321.17500000000001         6.3 3.7
## 206      321.487 321.52199999999999         3.5 0.6
## 320      341.609 341.67599999999999         6.7 0.9
## 340      344.372 344.41000000000003         3.8 1.2
## 393      352.388 352.42599999999999         3.8 0.9
## 425      358.710 358.73599999999999         2.6 1.4
## 427      358.805 358.82999999999998         2.5 0.4
## 439      360.281              360.31         2.9 0.9
```

I only want to see the indices of the cycles at the temperature of $313.15 \times$ K:

```
which(washing_cycles_with_full_records[3] == 40)  # 1
##  [1]   6   9  13  14  16  18  23  25  29  38  44  48  52  56  66  73
 ↪  80  89  91
## [20]  93  98 102 112 113 118 120 123 126 150 153 162 167 169 172 174
 ↪  176 180 181
## [39] 182 186 187 191 193 197 198 202 203 206 207 208 212 214 215 217
```

5.5.15 Sorting

Displaying the indices of the descending sorted values of a vector:

```
librarian::shelf("dplyr")
 ↪  # 1
desc(as.matrix(subset(head(washing_cycles_with_full_records), select =
 ↪  `Kava`)))  # 2
## [1] -1 -1 -5 -1 -1 -6
```

[66(pp. 7, 21)].

Sorting values in ascending order according to the program:

```
head(arrange(washing_cycles_with_full_records, `Kava`))  # 1
##                 Algus  Kestus Temperatuur Pöördeid.min
 ↪  Kava
## 1  2021.2.12 19:09:59 2:49:00          90         1300
 ↪  Kochwäsche
## 2  7.13.2022 18:17:59 0:59:00          30          800
 ↪  Trainers
## 3     2019.9.29 16:39    2:10          90          400
 ↪  autoclean
## 4     2019.4.19 15:13    2:10          60         1000
 ↪  beebi
## 5  7.17.2022 15:33:00 2:59:00          90          400
 ↪  keedupesu
## 6 12.10.2021 23:22:00 2:49:00          90         1300 keedupesu,
 ↪  hygiene+
##   Veenäit.enne     Veenäit.pärast Veekulu..l. kWh
## 1      321.112 321.17500000000001         6.3 3.7
## 2      359.990            360.005         1.5 0.2
## 3      292.478 292.49799999999999         2.0 0.5
## 4      284.498 284.53699999999998         3.9 2.3
## 5      360.281             360.31         2.9 0.9
## 6      344.372 344.41000000000003         3.8 1.2
```

5.5.16 Totals

```
librarian::shelf("janitor")
 ↪  # 1
adorn_totals(dat = head(subset(x = washing_cycles_with_full_records,
 ↪  select = c(`Algus`, `Veekulu..l.`))), where = "row", fill = "", na.rm
 ↪  = TRUE, name = "Kokku", c(`Veekulu..l.`))  # 2
```

```
##             Algus Veekulu..l.
##   2018.12.27 0:58         3.2
##  2018.12.27 19:32         2.0
##   2019.1.12 15:13         6.3
##    2019.2.7 12:46         2.6
##   2019.2.16 21:56         2.7
##   2019.2.20 17:10         4.7
##             Kokku        21.5
```

[67].

5.5.17 Mean

Mean row-wise can be calculated using `rowMeans()`[68].

```
t_1 <- c(7.508, 4.452, 3.434, 2.978, 2.752)       # 1
t_2 <- c(7.775, 4.515, 3.434, 2.978, 2.752)       # 2
t_3 <- c(7.685, 4.47, 3.603, 2.992, 2.732)        # 3


data_frame_of_mass_time <- data.frame(            # 5
  t_1,                                            # 6
  t_2,                                            # 7
  t_3                                             # 8
)                                                 # 9


rowMeans(x = data_frame_of_mass_time[, c(1:3)])   # 11
## [1] 7.656000 4.479000 3.490333 2.982667 2.745333
```

5.6 Functions

Functions can be made using the keyword `function`:

```
add <- function(first, second, digits = 2) {  # 1
  return(signif(first + second, digits = digits))  # 2
}                                                  # 3


add(first = 123, second = 456) # using the default value 2 for digits  # 5
## [1] 580


sum <- add(first = 123, second = 456, digits = 1)  # 2
                                                   #
```

It is not possible to assign an argument with the same name as the parameter[69]. In the example above, the value for `first` could not be `first` although there might be an external variable `first`, id est `first = first` is not allowed. I

have to use different names.

5.7 Square root

A square root can be calculated using the function `sqrt()`:

```
input_for_square_root <- 4 # 1
square_root <- sqrt(input_for_square_root) # 2
```

The square root of 4 is 2.

5.8 Derivation

```
initial_function <- "x^3 + x^2" # 1
functionToUse <- parse(text = initial_function) # 2


librarian::shelf(c( # 4
  "Ryacas" # 5
)) # 6

derivative = D(functionToUse, "x") # 8
string_of_derivative <- deparse(derivative) # 9
```

The derivative of $x^3 + x^2$ is $3 * x^2 + 2 * x$.

```
equality <- paste(string_of_derivative, "== 0") # 1
print(equality) # 2
## [1] "3 * x^2 + 2 * x == 0"
print(paste("Solve(", equality, ", x)", sep = "")) # 1
## [1] "Solve(3 * x^2 + 2 * x == 0, x)"
print(y_rmvars(paste("Solve(", equality, ", x)", sep = ""))) # 1
## [1] "((Solve(3 * x^2 + 2 * x == 0, x)) /:: { _lhs == _rhs <- rhs })"
critical_places <- yac_str(y_rmvars(paste("Solve(", equality, ", x)", sep = ""))) # 1
print(critical_places) # 2
## [1] "{0,(-2)/3}"
critical_places_as_r <- as_r(critical_places) # 1
```

```
print(critical_places_as_r)
 ↪  # 2
## [1] "0"      "(-2)/3"
critical_solution_1 <-
 ↪  (critical_places_as_r[1])  # 1
critical_solution_2 <-
 ↪  critical_places_as_r[2]    # 2
```

The critical solutions of $x^3 + x^2$ are 0 and (-2)/3.

5.9 Comments

Comments can be done with `#`:

```
print(sum) # printing out the
 ↪  value of sum  # 1
## [1] 600
```

5.10 Strings

Strings can be written using either apostrophes or quotation marks.

For substituting something inside a string, `gsub` can be used[70]:

```
gsub("_", "\\_", array, fixed =
 ↪  TRUE)  # 1
## [1] "value\\_1" "value\\_3"
```

Here, in order to preserve a backslash, it has to be escaped as otherwise, it escapes the underscore. If I would turn off `fixed`, the function would work like with regular expressions.

5.11 Branching

```
ifelse(is.na(NA), "Not Available",
 ↪  "Available")  # 1
## [1] "Not Available"
```

5.12 Table

5.12.1 A user-friendly look

A table that is not just in R code but designed and all can be created using `kable` and `kableExtra`[71]. I have built a wrapper function `print_table` for that purpose so that I do not have to rewrite some general things from table to table. An example table is 5.1 on the page 130.

```
omega <- c(932.0058, 827.2861, 733.0383, 628.3185, 523.5988, 418.8790,
 ↪  314.1593)                    # 1
omega_P <- c(0.03966657, 0.04155546, 0.05073632, 0.05411874, 0.05817764,
 ↪  0.03878509, 0.01811760)  # 2



data_frame_of_precession <- data.frame(
 ↪  # 4
  omega,
 ↪  # 5
  omega_P
 ↪  # 6
)
 ↪  # 7



colnames(data_frame_of_precession) <- c(
 ↪  # 9
  "$\\frac{\\omega}{\\unit{\\per\\s}}$",
   ↪  # 10
  "$\\frac{\\omega_\\text{P}}{\\unit{\\per\\s}}$"
   ↪  # 11
```

```
12 )
    ↪  # 12
13
14 print_table(
    ↪  # 14
15   table = data_frame_of_precession,
      ↪  # 15
16   caption = "Pretsessiooni nurkkiiruse sõltuvus güroskoobi
      ↪  nurkkiirusest."                          # 16
17 )
    ↪  # 17
```

Table 5.1: Pretsessiooni nurkkiiruse sõltuvus güroskoobi nurkkiirusest.

$\frac{\omega}{\mathrm{s}^{-1}}$	$\frac{\omega_\mathrm{p}}{\mathrm{s}^{-1}}$
932.01	0.04
827.29	0.04
733.04	0.05
628.32	0.05
523.60	0.06
418.88	0.04
314.16	0.02

5.12.2 Untolerated symbols

I have to pay attention that there can't be any underscores inside the table unless they are part of an equation. They can be escaped using `gsub` and the result is shown as the table 5.2 on the page 131.

```
print_table(
  # 1
  table = sapply(data_frame, function(value) gsub("_", "\\_", value,
    fixed = TRUE)),  # 2
  caption = "Caption."
    # 3
)
  # 4
```

Table 5.2: Caption.

array	array 2
value_1	value_3
value_3	value_4

Inside the table, backslashes must be escaped.

5.12.3 Number of digits after comma

Tables 5.3 on the page 133 and 5.4 on the page 133 are for comparing the number of digits after comma. The table 5.3 has the default number of digits and the table 5.4 has another number of digits in every number after comma.

```
water_report <- head(subset(x = washing_cycles_with_full_records, select
  = c(`Algus`, `Veenäit.enne`, `Veenäit.pärast`)))  # 1


librarian::shelf(c(
  # 3
  'dplyr'
    # 4
```

```
))  # 5


water_report <- water_report %>%  # 7
  mutate(`Veenäit.pärast` = as.numeric(`Veenäit.pärast`))  # 8


colnames(water_report) <- c(  # 10
  "Start",  # 11
  "$\\mathrm{\\frac{\\text{Used water before}}{\\mathrm{m^3}}}$",  # 12
  "$\\mathrm{\\frac{\\text{Used water after}}{\\mathrm{m^3}}}$"  # 13
)  # 14


print_table(  # 16
  table = water_report,  # 17
  caption = "Water report with numbers with up to two digits after comma."  # 18
)  # 19
```

Table 5.3: Water report with numbers with up to two digits after comma.

	Start	Used water before m^3	Used water after m^3
6	2018.12.27 0:58	279.40	279.43
7	2018.12.27 19:32	279.44	279.46
9	2019.1.12 15:13	280.07	280.13
10	2019.2.7 12:46	281.19	281.21
11	2019.2.16 21:56	281.52	281.55
12	2019.2.20 17:10	281.70	281.74

[66(p. 38) to 42].

```
1 print_table(
  ↪  # 1
2   table = water_report,
    ↪  # 2
3   caption = "Water report with numbers with up to four digits after
    ↪  comma.",  # 3
4   digits = 4
    ↪  # 4
5 )
  ↪  # 5
```

Table 5.4: Water report with numbers with up to four digits after comma.

	Start	Used water before m^3	Used water after m^3
6	2018.12.27 0:58	279.396	279.428
7	2018.12.27 19:32	279.439	279.459
9	2019.1.12 15:13	280.071	280.134
10	2019.2.7 12:46	281.189	281.215

(continued ...)

Table 5.4: Water report with numbers with up to four digits after comma. *(Continued…)*

	Start	Used water before m^3	Used water after m^3
11	2019.2.16 21:56	281.522	281.549
12	2019.2.20 17:10	281.698	281.745

5.12.4 Additional header

It's also possible for the table to have an additional header whose columns span over multiple columns in the first header[72] (the table 5.5 on the page 134):

```
print_table(                                          # 1
  table = water_report,                               # 2
  caption = "Water report with additional header.",   # 3
  additional_header = c("Spanned header" = 4)         # 4
)                                                     # 5
```

Table 5.5: Water report with additional header.

	Spanned header		
	Start	Used water before m^3	Used water after m^3
6	2018.12.27 0:58	279.40	279.43
7	2018.12.27 19:32	279.44	279.46
9	2019.1.12 15:13	280.07	280.13
10	2019.2.7 12:46	281.19	281.21
11	2019.2.16 21:56	281.52	281.55
12	2019.2.20 17:10	281.70	281.74

5.12.5 Look

It's possible to change the look of a row (the table 5.6 on the page 135):

```
print_table(                                    # 1
  table = water_report,                         # 2
  caption = "Water report with coloured row."   # 3
) %>%                                           # 4
  row_spec(2, color = "teal")                   # 5
```

Table 5.6: Water report with coloured row.

	Start	Used water before m^3	Used water after m^3
6	2018.12.27 0:58	279.40	279.43
7	2018.12.27 19:32	279.44	279.46
9	2019.1.12 15:13	280.07	280.13
10	2019.2.7 12:46	281.19	281.21
11	2019.2.16 21:56	281.52	281.55
12	2019.2.20 17:10	281.70	281.74

Here, %>% means piping.

And it's possible to change the look of a column (the table 5.7 on the page 135):

```
print_table(                                    # 1
  table = water_report,                         # 2
  caption = "Water report with wider column."   # 3
) %>%                                           # 4
  column_spec(1, width = "16em")                # 5
```

Table 5.7: Water report with wider column.

	Start	Used water before m^3	Used water after m^3
6	2018.12.27 0:58	279.40	279.43
7	2018.12.27 19:32	279.44	279.46

(continued ...)

Table 5.7: Water report with wider column. *(Continued...)*

	Start	Used water before m^3	Used water after m^3
9	2019.1.12 15:13	280.07	280.13
10	2019.2.7 12:46	281.19	281.21
11	2019.2.16 21:56	281.52	281.55
12	2019.2.20 17:10	281.70	281.74

5.12.6 Landscape

If the table is too wide to fit the portrait format, it can be displayed in the landscape mode (the table 5.8 on the page 137):

```
print_table(                                  # 1
  table = water_report,                       # 2
  caption = "Water report as landscape."      # 3
) %>%                                         # 4
  landscape()                                 # 5
```

Table 5.8: Water report as landscape.

	Start	Used water before m^3	Used water after m^3
6	2018.12.27 0:58	279.40	279.43
7	2018.12.27 19:32	279.44	279.46
9	2019.1.12 15:13	280.07	280.13
10	2019.2.7 12:46	281.19	281.21
11	2019.2.16 21:56	281.52	281.55
12	2019.2.20 17:10	281.70	281.74

5.12.7 Footnotes

Linked footnotes don't work with `kable`. Footnotes can be created like this (the table 5.9 on the page 138):

```
                                                                    # 1
DATA_FRAME_OF_COMPARISON <- data.frame(                             # 2
  0.3                                                               # 3
)                                                                   # 4
                                                                    # 5
colnames(DATA_FRAME_OF_COMPARISON) <- c(                            # 6
  paste("$\\frac{T_\\text{dew}}{}$", footnote_marker_number(1))     # 7
)                                                                   # 8
                                                                    # 9
print_table(                                                       # 10
  table = DATA_FRAME_OF_COMPARISON,                                # 11
  caption = "Water report with a footnote.",                       # 12
  footnotes = c(                                                   # 13
    "juhendi tabel 5.1" # 1                                        # 14
  )                                                                # 15
)                                                                  # 16
```

Table 5.9: Water report with a footnote.

T_{dew} [1]
0.3

[1] juhendi tabel 5.1

`threeparttable` must be set to `TRUE` for just in case the footnote is too long for the width of the paper[73].

5.12.8 Transposing

By default, I feed one-dimensional arrays to data frame and the values of these arrays will be displayed from top to down. If I want them to be displayed from left to right, I have to transform the table (the table 5.10 on the page 139):

```
                                                                    # 1
DATA_FRAME_OF_COMPARISON <- data.frame(                             # 2
  0.3                                                               # 3
)                                                                   # 4
                                                                    # 5
rownames(DATA_FRAME_OF_COMPARISON) <- c(                            # 6
  "\"Pasco\" ilmajaam"                                              # 7
)                                                                   # 8
                                                                    # 9
colnames(DATA_FRAME_OF_COMPARISON) <- c(                            # 10
  paste("$\\frac{T_\\text{dew}}{}$", footnote_marker_number(1))     # 11
)                                                                   # 12
                                                                    # 13
print_table(                                                        # 14
  DATA_FRAME_OF_COMPARISON,                                         # 15
  caption = "Table with rows and columns exchanged.",               # 16
  do_i_transpose = TRUE                                             # 17
)                                                                   # 18
```

Table 5.10: Table with rows and columns exchanged.

	”Pasco” ilmajaam
$\frac{T_{\text{dew}}}{}$ [1]	0.3

5.12.9 Coloring according to values

It is possible to automatically show the values growing by different colors using the function `spec_color` of `kableExtra` as seen in the table 5.11 leheküljel 143.

```
Li <- c(
  # 1
  4.5e-1, # acetate
    # 2
  1.81, # bromide
    # 3
  1.30e-2 # carbonate
    # 4
)
  # 5



Na <- c(
  # 7
  5.04e-1, # acetate
    # 8
  9.46e-1, # bromide
    # 9
  3.07e-2 # carbonate
    # 10
)
  # 11



K <- c(
  # 13
```

```
  2.69, # acetate
   ↪  # 14
  6.78e-1, # bromide
   ↪  # 15
  1.11 # carbonate
   ↪  # 16
)
 ↪  # 17

solubility <- data.frame(
 ↪  # 19
  Li,
 ↪  # 20
  Na,
 ↪  # 21
  K
 ↪  # 22
)
 ↪  # 23


colnames(solubility) <- c(
 ↪  # 25
  "\\ce{Li+}",
   ↪  # 26
  "\\ce{Na+}",
   ↪  # 27
  "\\ce{K+}"
   ↪  # 28
```

```
29 )
    ↪ # 29
30 rownames(solubility) <- c(
    ↪ # 30
31   "\\ce{[CH3CO2]-}",
      ↪ # 31
32   "\\ce{Br-}",
      ↪ # 32
33   "\\ce{[CO3]^2-}"
      ↪ # 33
34 )
    ↪ # 34
35 librarian::shelf(c(
    ↪ # 35
36   "dplyr"
      ↪ # 36
37 ))
    ↪ # 37
38 solubility <- mutate_all(.tbl=solubility, ~cell_spec(.x,
    ↪ color=spec_color(.x), font_size = spec_font_size(.x)))  # 38
39 print_table(table=solubility, caption="Kilogrammi ühendi lahustuvus vees
    ↪ kilogrammi vee kohta[25, lk 4-43-4-114]. If the value of the solubility is
    ↪ unknown then the solubility is marked as follows: slightly soluble:
    ↪ $1\,\mathrm{kg\,kg^{-1}}$, soluble: $0.1\,\mathrm{kg\,kg^{-1}}$, very soluble: $0.01\,\mathrm{kg\,kg^{-1}}$.")
    ↪ # 39
```

Table 5.11: Kilogrammi ühendi lahustuvus vees kilogrammi vee kohta[25, lk 4-43-4-114]. If the value of the solubility is unknown then the solubility is marked as follows: slightly soluble: $1\,\mathrm{kg\,kg^{-1}}$, soluble: $0.1\,\mathrm{kg\,kg^{-1}}$, very soluble: $0.01\,\mathrm{kg\,kg^{-1}}$.

	Li^+	Na^+	K^+
$[CH_3CO_2]^-$	0.45	0.504	2.69
Br^-	1.81	0.946	0.678
$[CO_3]^{2-}$	0.013	0.0307	1.11

5.12.10 Line breaks

The example (38) shows how to deal with line breaks inside a table[74].

(38)

```
intro_redox_reactions_25<- data.frame(
  linebreak(c(
    "\\blank{ränitetrakloriid}",
    "\\blank{tinaoksiid}",
    "\\blank{vanaadiumpentoksiid}",
    "\\blank{booroksiid}"
  ))
)

rownames(intro_redox_reactions_25) <- linebreak(c(
  "\\blank{1}\\textbf{\\ce{Si\\textsuperscript{\\blank{4+}}}\\ce{Cl4(l)}
 +}\\blank{2} \\ce{H2(g)}\n \\ce{ ->}\\blank{1}\\ce{ Si(s) +}\\blank{2}\\
 ce{ HCl(g)}",
  "\\blank{1}\\textbf{\\ce{Sn\\textsuperscript{\\blank{4+}}}\\ce{O2(s)}
 +}\\blank{1}\\ce{ C(s)}\n \\ce{ ->[\\qty{1,2e3}{\\degreeCelsius}]}\\
 blank{1}\\ce{ Sn(l) +}\\blank{1}\\ce{ CO2}",
  "\\blank{1}\\textbf{\\ce{V2\\textsuperscript{\\blank{5+}}}\\ce{O5 (s)}
 +}\\blank{5}\\ce{ Ca (l)}\n \\ce{->[\\Delta]}\\blank{2}\\ce{ V (s) +}\\
 blank{5}\\ce{ CaO (s)}",
  "\\blank{1}\\textbf{\\ce{B2\\textsuperscript{\\blank{3+}}}\\ce{O3(s)}
 +}\\blank{3}\\ce{ Mg(s)}\n \\ce{ ->}\\blank{2}\\ce{ B(s) +}\\blank{3}\\
 ce{ MgO(s)}"
))

colnames(intro_redox_reactions_25) <- c(
  "Nimetus"
)

print_table(table = intro_redox_reactions_25, caption = "
 Oksüdatsiooniastme määramine ja võrrandi kujundamine.")
```

Listing 5.1: An example of how to have line breaks inside a table.

Table 5.12: Oksüdatsiooniastme määramine ja võrrandi kujundamine.

	Nimetus
$\ldots . \mathbf{Si} \cdots\cdots \mathbf{Cl_4(l)} + \ldots . \ \mathrm{H_2(g)}$ $\longrightarrow \ldots . \mathrm{Si(s)} + \ldots . \mathrm{HCl(g)}$	.....
$\ldots . \mathbf{Sn} \cdots\cdots \mathbf{O_2(s)} + \ldots . \mathrm{C(s)}$ $\xrightarrow{1.2 \times 10^3\,^\circ\mathrm{C}} \ldots . \mathrm{Sn(l)} + \ldots . \mathrm{CO_2}$	.....
$\ldots . \mathbf{V_2} \cdots\cdots \mathbf{O_5\ (s)} + \ldots . \mathrm{Ca\ (l)}$ $\xrightarrow{\Delta} \ldots . \mathrm{V\ (s)} + \ldots . \mathrm{CaO\ (s)}$	.....
$\ldots . \mathbf{B_2} \cdots\cdots \mathbf{O_3(s)} + \ldots . \mathrm{Mg(s)}$ $\longrightarrow \ldots . \mathrm{B(s)} + \ldots . \mathrm{MgO(s)}$	.....

5.13 Exponents and logarithms

$$e^1$$

```
exp(1)  # 1
## [1] 2.718282
```

$$\ln(e)$$

```
log(exp(1))  # 1
## [1] 1
```

5.14 Plotting

5.14.1 One graph

An example of plotting data is putting data points to the plot - visible on the figure 4 on the page 148. The packages:

`ggplot2` for plotting[75]

`latex2exp` for using LaTeXstrings in labels

The parameters:

`data` the data table

`aes` the function that describes axis

`x` data array for *x* axis

`y` data array for *y* axis

`geom_point` the function for plotting data points

`shape` the shape of points

`size` the size of points

`color` the border color

`fill` the fill color

`labs` the function for creating labels for axis

`TeX` the function for converting LaTeXstrings in labels

```
1
2 librarian::shelf(c(
  ↪  # 2
3   "Cairo",
    ↪  # 3
4   "ggplot2",
    ↪  # 4
5   "latex2exp"
    ↪  # 5
```

```
))  # 6


ggplot(data = washing_cycles_with_full_records, aes(x = `Temperatuur`, y = `Pöördeid.min`)) + geom_point(shape = 23, color = "#008000", fill = "#ff6600", size = 3) +  # 8
  labs(x = TeX("$\\frac{\\textit{t}}{^\\circ C}$"), y = TeX("$\\frac{\\textit{f}}{min}$"))  # 9
```

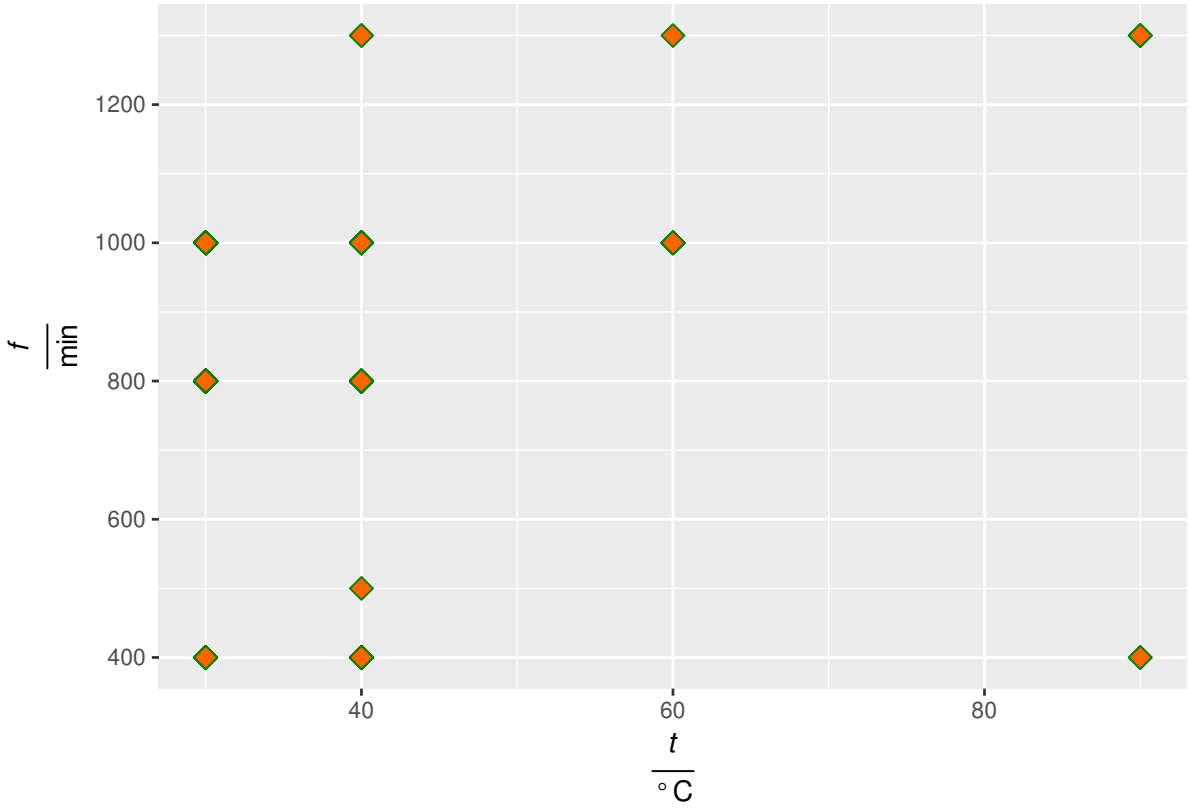


Figure 4: Washing cycles.

In order to use Unicode characters like the degree symbol, we need the library `Cairo` and the corresponding `dev`[76].

5.14.2 Additional data point

A single additional data point can be added using `geom_point` (figure 5 on the page 150)[77].

```
librarian::shelf(c(
  "Cairo",
  "ggplot2",
  "latex2exp"
))

ggplot(data = washing_cycles_with_full_records, aes(x = `Temperatuur`, y = `Pöördeid.min`)) +
  geom_point(shape = 23, color = "#008000", fill = "#ff6600", size = 3) +
  geom_point(aes(x = 75, y = 900), shape = 23, size = 3) +
  labs(x = TeX("$\\frac{\\textit{t}}{^\\circ C}$"), y = TeX("$\\frac{\\textit{f}}{min}$"))
## Warning in geom_point(aes(x = 75, y = 900), shape = 23, size = 3): All aesthetics have length 1, but the data has 219
## rows.
## i Please consider using `annotate()` or provide
```

```
##   this layer with data containing a single row.
```

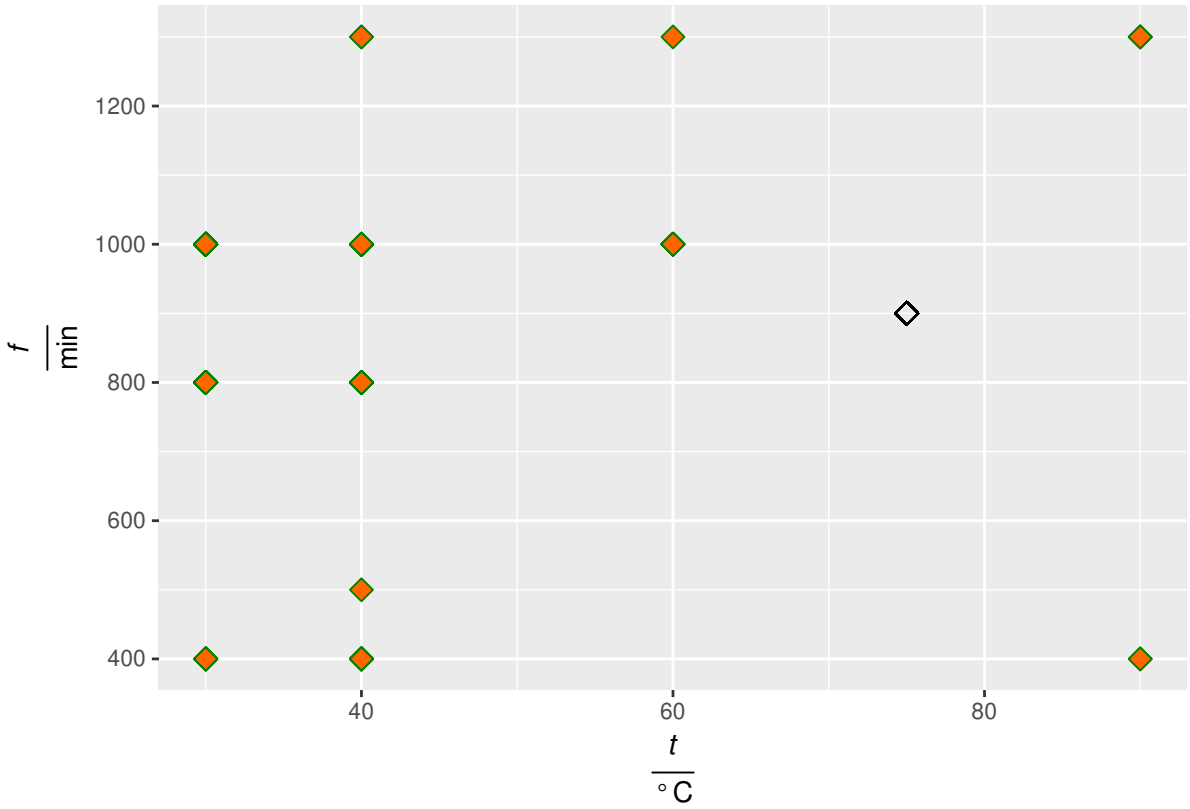


Figure 5: Additional data point.

5.14.3 Multiple graphs

Multiple graphs can be displayed on a same figure as seen on the figure 6 on the page 153.

```
librarian::shelf(c(
  # 1
  "lubridate"
    # 2
))
  # 3

```

```
washing_cycles_with_full_records <- washing_cycles_with_full_records %>%  # 5
  mutate(`Algus` = parse_date_time(x =  washing_cycles_with_full_records$Algus, orders = c(  # 6
  "%Y-%m-%d %H",  # 7
  "%Y.%m.%d %H:%M",  # 8
  "%Y.%m.%d %H:%M:%S",  # 9
  "%m.%d.%Y %H:%M",  # 10
  "%m.%d.%Y %H:%M:%S"  # 11
))) %>%  # 12
   mutate(`veekulu_dal` =  (as.numeric(washing_cycles_with_full_records$Veenäit.pärast) -  washing_cycles_with_full_records$Veenäit.enne) * 100)  # 13



min_time = min(washing_cycles_with_full_records$Algus)  # 15
max_time = max(washing_cycles_with_full_records$Algus)  # 16



librarian::shelf(c(  # 18
```

```
19   "ggplot2",
     ↪  # 19
20   "latex2exp"
     ↪  # 20
21 ))
   ↪  # 21
22
23 ggplot(data = washing_cycles_with_full_records, mapping = aes(x =
   ↪  `Algus`, y = `veekulu_dal`)) +
   ↪  # 23
24   geom_point(shape = 23, color = "#008000", fill = "#008000", size = 3) +
     ↪  # 24
25   labs(x = "Algus", y = TeX("$\\frac{\\textit{V} \\times 10^2}{m^3}$")) +
     ↪  # 25
26   geom_point(mapping = aes(x = `Algus`, y = `kWh`), color = "#ff6600",
     ↪  fill = "#ff6600", shape = 24, size = 3)  +
     ↪  # 26
27   scale_y_continuous(sec.axis = sec_axis(~., name =
     ↪  TeX("\\frac{\\textit{W}}{kWh}"))) +
     ↪  # 27
28   theme(
     ↪  # 28
29     axis.title.y = element_text(colour = "#008000"),
       ↪  # 29
30     axis.text.y = element_text(colour = "#008000"),
       ↪  # 30
31     axis.ticks.y = element_line(colour = "#008000"),
       ↪  # 31
32     axis.title.y.right = element_text(colour = "#ff6600"),
       ↪  # 32
```

```
33      axis.ticks.y.right = element_line(colour = "#ff6600"),
        ↪  # 33
34      axis.text.y.right = element_text(colour = "#ff6600")
        ↪  # 34
35    )
    ↪  # 35
```

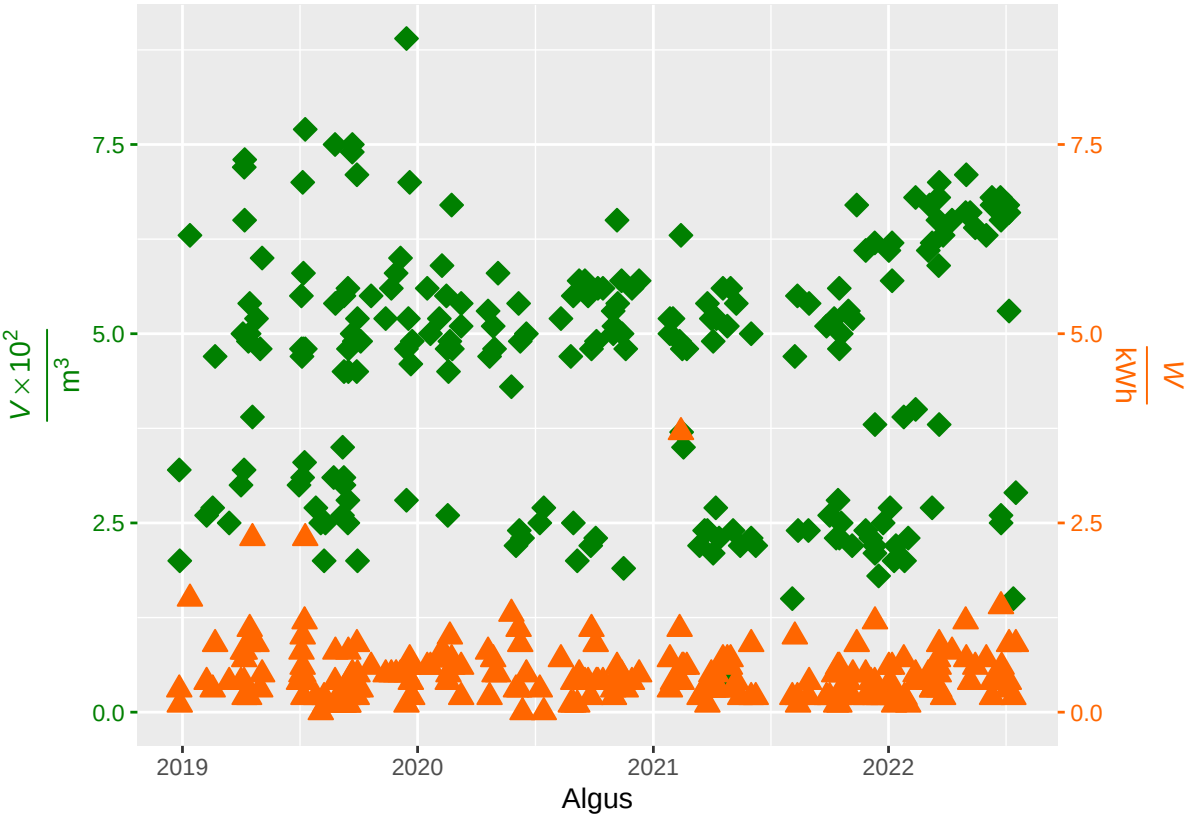


Figure 6: Water and electricity consumption between 2018-12-27 00:58:00 and 2022-07-17 15:33:00 .

5.14.4 Trend line

On the figure 7 on the page 155.

```
1  ggplot(data = washing_cycles_with_full_records, aes(x = `Temperatuur`, y
   ↪  = `Pöördeid.min`)) + geom_point(shape = 23, color = "#008000", fill =
   ↪  "#ff6600", size = 3) +  # 1
2    labs(x = TeX("$\\frac{\\textit{t}}{\\degree C}$"), y =
     ↪  TeX("$\\frac{\\textit{f}}{min}$")) +
     ↪  # 2
```

```
  geom_smooth()
    # 3
## `geom_smooth()` using method = 'loess' and formula
## = 'y ~ x'
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
  parametric,
## : pseudoinverse used at 29.7
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
  parametric,
## : neighborhood radius 10.3
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
  parametric,
## : reciprocal condition number 2.4663e-30
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric =
  parametric,
## : There are other near singularities as well. 100
## Warning in predLoess(object$y, object$x, newx = if (is.null(newdata))
  object$x
## else if (is.data.frame(newdata))
## as.matrix(model.frame(delete.response(terms(object)), : pseudoinverse
  used at
## 29.7
## Warning in predLoess(object$y, object$x, newx = if (is.null(newdata))
  object$x
## else if (is.data.frame(newdata))
## as.matrix(model.frame(delete.response(terms(object)), : neighborhood
  radius
## 10.3
## Warning in predLoess(object$y, object$x, newx = if (is.null(newdata))
  object$x
## else if (is.data.frame(newdata))
## as.matrix(model.frame(delete.response(terms(object)), : reciprocal
  condition
```

```
## number 2.4663e-30
## Warning in predLoess(object$y, object$x, newx = if (is.null(newdata))
    object$x
## else if (is.data.frame(newdata))
## as.matrix(model.frame(delete.response(terms(object)), : There are
    other near
## singularities as well. 100
```

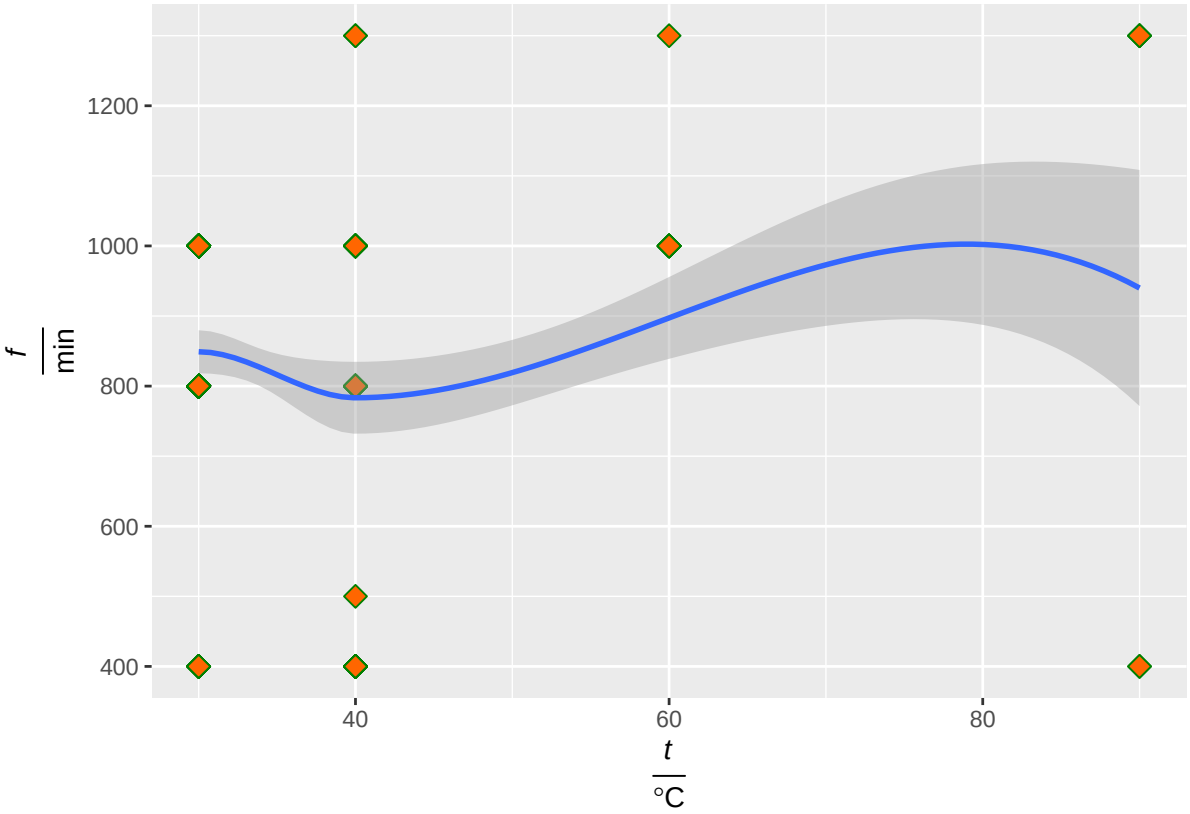


Figure 7: Graph with a trend line.

5.14.5 Regression and correlation

The figure 8 on the page 157 represents the correlation between the water and electricity consumption between 2018-12-27 00:58:00 and 2022-07-17 15:33:00. The plot displays the smooth regression line[78] and the correlation coefficient. There are also the data about the regression. Both labels have been positioned vertically.

For `ggpubr`, the dependency `nloptr` must be installed directly in *Ubuntu*[79]:

```
sudo apt-get install libnlopt-dev  # 1
                                   # 2
```

```
librarian::shelf(c(
 ↪  # 1
  "ggplot2",
   ↪  # 2
  "ggpmisc", #for stat_poly_line
   ↪  # 3
  "ggpubr", # for stat_regline_equation
   ↪  # 4
  "latex2exp"
   ↪  # 5
))
 ↪  # 6


if (!decimal_separator_period) { # for stat_regline_equation and
 ↪  stat_cor
 ↪  # 8
  options(OutDec = ".")
   ↪  # 9
}
 ↪  # 10
ggplot(data = washing_cycles_with_full_records, mapping = aes(x =
 ↪  `Veekulu..l.`, y = `kWh`)) +
 ↪  # 11
  geom_point(shape = 23, color = "#ff6600", fill = "#ff6600", size = 3) +
   ↪  # 12
  labs(x = TeX("$\\frac{\\textit{V}}{m^3}$"), y =
   ↪  TeX("$\\frac{\\textit{W}}{kWh}$")) +
   ↪  # 13
```

```
  stat_poly_line() +                                                    # 14
  stat_regline_equation(mapping = aes(x = `Veekulu..l.`, y = `kWh`, label = paste(after_stat(eq.label), after_stat(rr.label), after_stat(adj.rr.label), sep = "~~~~")), color = "#ff6600", label.y = 3) +  # 15
  stat_cor(aes(x = `Veekulu..l.`, y = `kWh`), color = "#ff6600", label.y = 2.5)  # 16
```

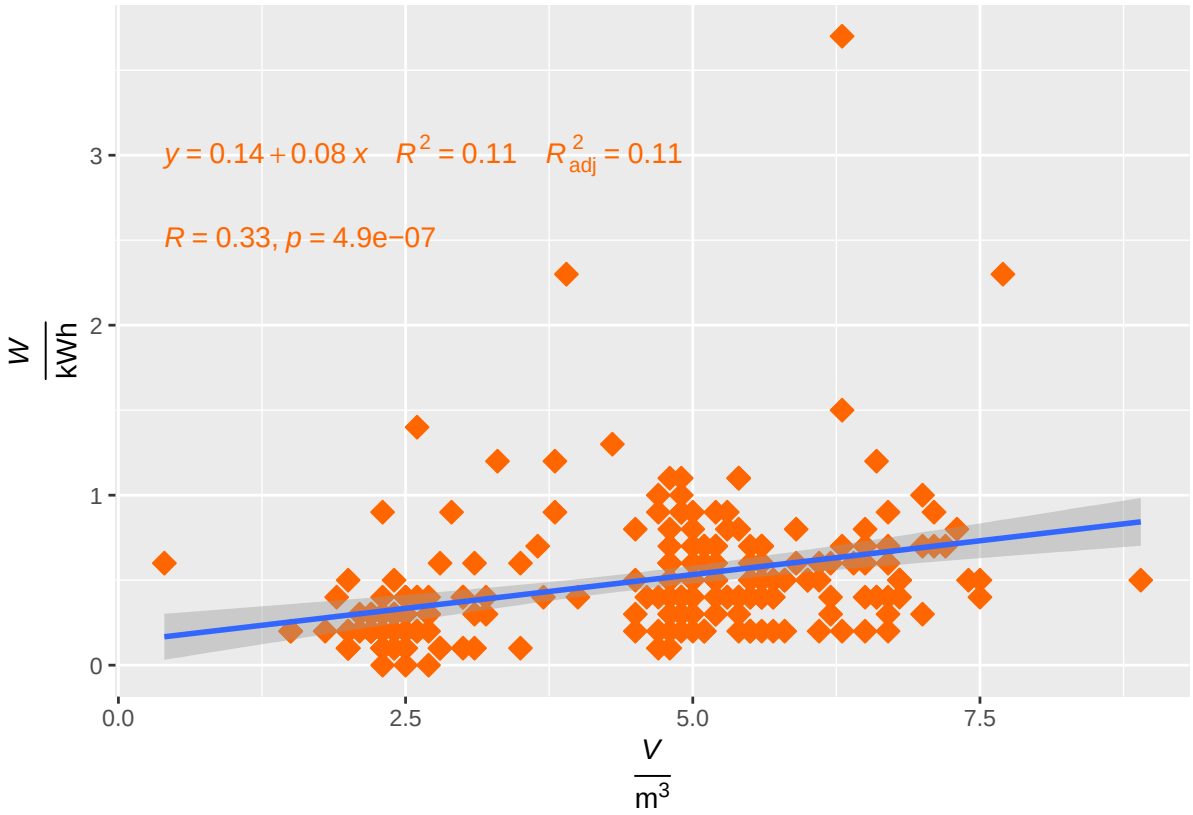


Figure 8: Correlation between the water and electricity consumption between 2018-12-27 00:58:00 and 2022-07-17 15:33:00 .

```
if (!decimal_separator_period) {  # 1
  options(OutDec = ",")           # 2
}                                 # 3
```

It is possible to use different kind of trend lines as seen on the figure 9 on

the page 160:

```
omega <- c(932.0058, 827.2861, 733.0383, 628.3185, 523.5988)  # 1
h <- c(303.44868, 239.08893, 187.71603, 137.91380,  95.77349)  # 2

                                                                # 3
data_frame_of_precession_with_height_without_outliers <- data.frame(  # 4
  omega,  # 5
  h  # 6
)  # 7

                                                                # 8
color_of_height <- "#ff00ff"  # 9
color_x <- "#008000"  # 10

                                                                # 11
ggplot(  # 12
  data <- data_frame_of_precession_with_height_without_outliers,  # 13
  mapping <- aes(x = omega, y = h)  # 14
```

```
15 ) +
   ↪  # 15
16   geom_point(shape = 23, size = 1) +
      ↪  # 16
17   labs(x = TeX("$\\frac{\\omega}{\\frac{1}{s}}$"), y =
      ↪  TeX("$\\frac{h}{m}$")) +  # 17
18   theme(
      ↪  # 18
19     axis.title.x = element_text(colour = color_x),
        ↪  # 19
20     axis.text.x = element_text(colour = color_x),
        ↪  # 20
21     axis.ticks.x = element_line(colour = color_x),
        ↪  # 21
22     axis.title.y = element_text(colour = color_of_height),
        ↪  # 22
23     axis.text.y = element_text(colour = color_of_height),
        ↪  # 23
24     axis.ticks.y = element_line(colour = color_of_height)
        ↪  # 24
25   ) +
   ↪  # 25
26   stat_poly_line(formula = y ~ poly(x, 2))
      ↪  # 26
```

5.14.6 Error bars

The figure 10 on the page 162 represents the water and electricity consumption between 2018-12-27 00:58:00 and 2022-07-17 15:33:00 with errorbars.

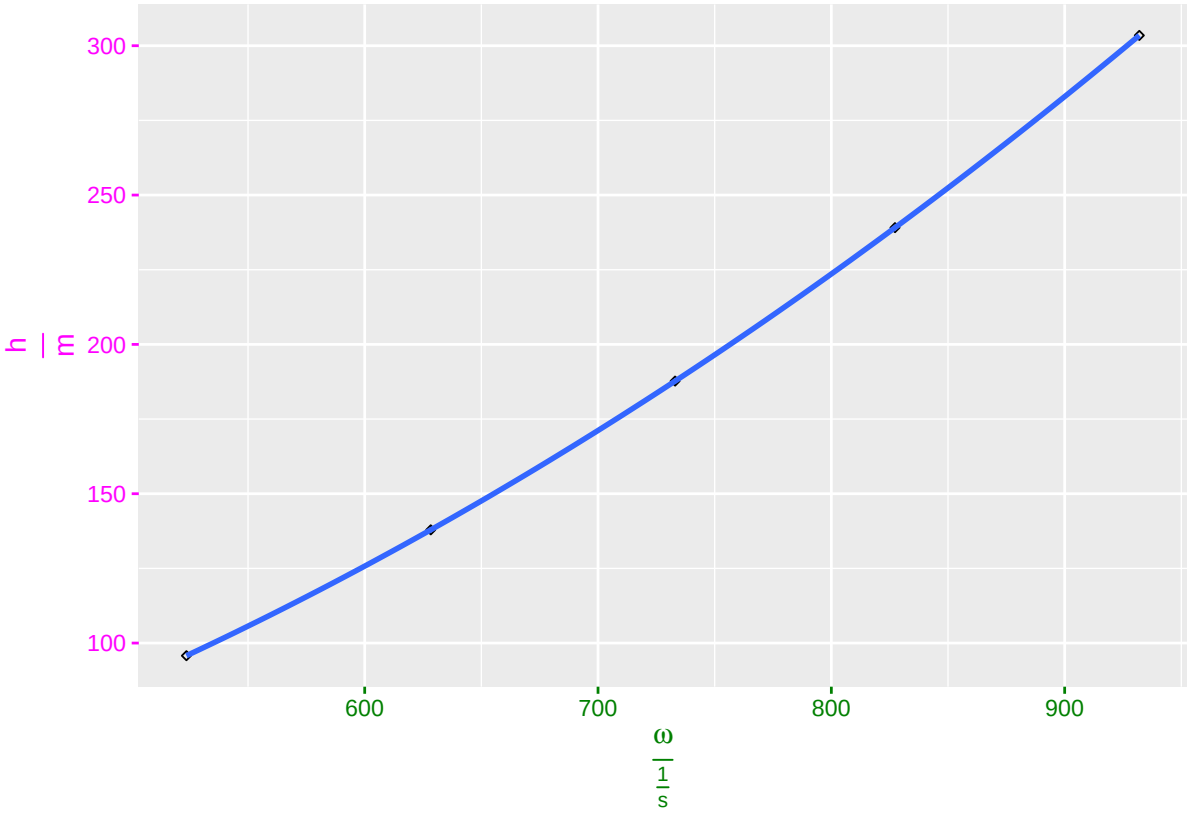


Figure 9: Polynomial trend line with the degree 2.

```
librarian::shelf(c(
  # 2
  "ggplot2",
    # 3
  "latex2exp"
    # 4
))
  # 5



margin_of_V <- 1e-3 / 2 * 2 * 1e2
  # 7
```

```
8  margin_of_W <- .1 / 2
   ↪  # 8
9
10 color_x <- "#008000"
   ↪  # 10
11 color_y <- "#ff6600"
   ↪  # 11
12
13 ggplot(data = washing_cycles_with_full_records, mapping = aes(x =
   ↪  `veekulu_dal`, y = `kWh`)) +
   ↪  # 13
14   geom_point(shape = 23, size = 1) +
      ↪  # 14
15   labs(x = TeX("$\\frac{\\textit{V} \\times 10^2}{m^3}$"), y =
      ↪  TeX("$\\frac{\\textit{W}}{kWh}$")) +
      ↪  # 15
16   geom_errorbarh(aes(xmin = `veekulu_dal` - margin_of_V, xmax =
      ↪  `veekulu_dal` + margin_of_V, y = `kWh`), color = color_x) +
      ↪  # 16
17   geom_errorbar(aes(x = `veekulu_dal`, ymin = `kWh` - margin_of_W, ymax =
      ↪  `kWh` + margin_of_W), color = color_y) +
      ↪  # 17
18   theme(axis.title.x = element_text(colour = color_x), axis.text.x =
      ↪  element_text(colour = color_x), axis.ticks.x = element_line(colour
      ↪  = color_x), axis.title.y = element_text(colour = color_y),
      ↪  axis.text.y = element_text(colour = color_y), axis.ticks.y =
      ↪  element_line(colour = color_y))  # 18
```

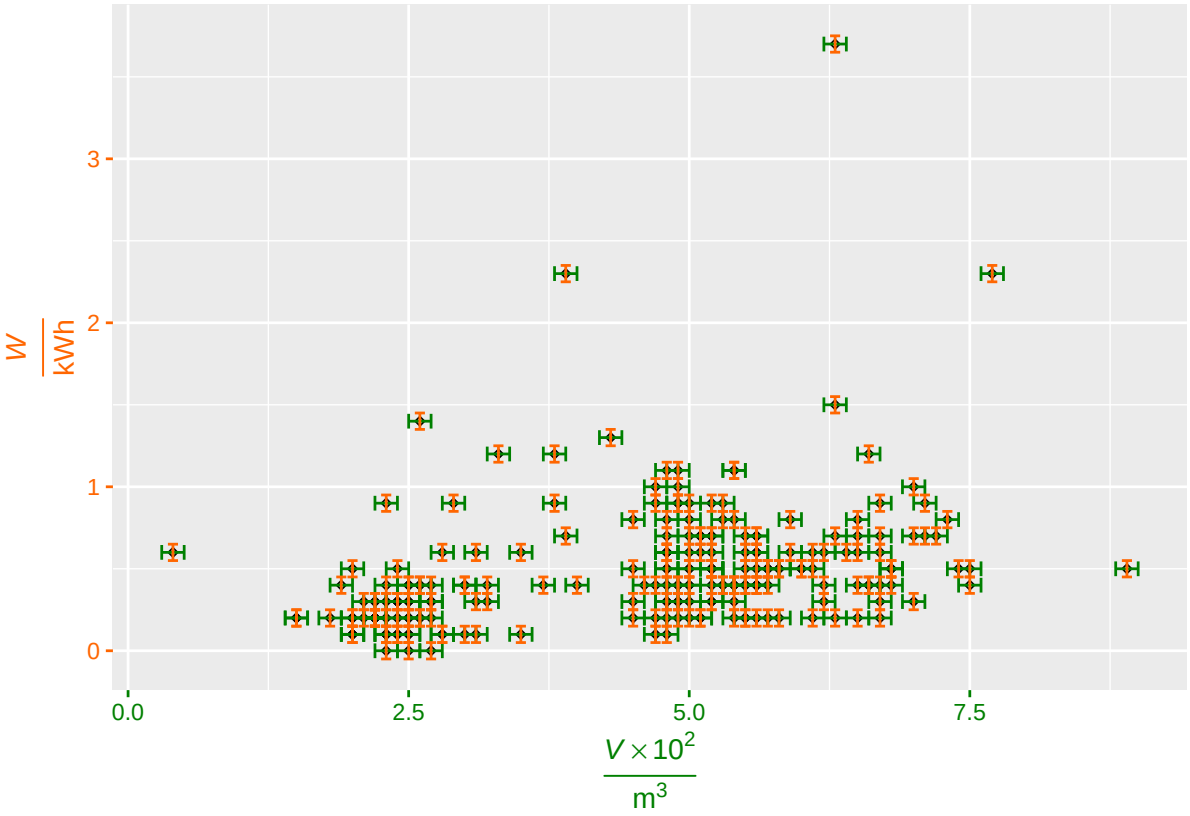


Figure 10: Water and electricity consumption between 2018-12-27 00:58:00 and 2022-07-17 15:33:00 with errobars.

Joonisel 11 leheküljel 167 on esitatud valgustugevuse mõõtmise tulemused keskväärtuse ja mõõtemääramatustega: mustaga on tähistatud A-, oranžiga B1-, roosaga B2-tüüpi ja rohelisega kogu mõõtemääramatus[80]. Sellelt jooniselt näeme, kui palju mingit tüüpi mõõtemääramatus antud juhul mõju avaldab.

```
librarian::shelf(c(
  # 1
  "ggplot2",
    # 2
  "latex2exp"
    # 3
))
  # 4
color_x <- "#008000"
  # 5
illuminance <- c(923, 905, 593, 587)
  # 6
illuminance_data_frame = data.frame(illuminance)
  # 7
illuminance_mean <- mean(illuminance)
  # 8
illuminance_se <- as.numeric(mean_se(illuminance)["ymax"] -
  illuminance_mean)
  # 9
illuminance_size <- length(illuminance)
  # 10
illuminance_size_less_1 <- illuminance_size - 1
  # 11
librarian::shelf(c(
  # 12
  "distributions3"
    # 13
```

```
14 ))
    ↪ # 14
15 studentTDistribution = StudentsT(df = illuminance_size_less_1)
    ↪ # 15
16 alpha <- 0.05
    ↪ # 16
17 probability_for_Student <- 1 - alpha / 2
    ↪ # 17
18 caliper_number_student = quantile(studentTDistribution,
    ↪ probability_for_Student)
    ↪ # 18
19 illuminance_uncertainty_A <- caliper_number_student * illuminance_se
    ↪ # 19
20
21 precision_ratio <- .05
    ↪ # 21
22 number_of_least_sigfig = 10
    ↪ # 22
23 student_inf <- quantile(StudentsT(df = Inf), probability_for_Student)
    ↪ # 23
24 illuminance_uncertainty_B_1 <- student_inf * (illuminance_mean *
    ↪ precision_ratio + number_of_least_sigfig) / 3
    ↪ # 24
25
26 illuminance_smallest_unit <- 1
    ↪ # 26
27 probability <- 1 - alpha
    ↪ # 27
```

```
28
29 illuminance_uncertainty_B_2 <- probability * illuminance_smallest_unit /
   ↪ 2
   ↪ # 29
30
31 illuminance_uncertainty <- sqrt(illuminance_uncertainty_A^2 +
   ↪ illuminance_uncertainty_B_1^2 + illuminance_uncertainty_B_2^2)
   ↪ # 31
32
33 ggplot(data = illuminance_data_frame, mapping = aes(x = `illuminance`, y
   ↪ = 0)) +
   ↪ # 33
34   geom_point(shape = 23, size = 1) +
      ↪ # 34
35   geom_point(aes(x = illuminance_mean, y = 0), shape = 23, size = 2,
      ↪ color = color_x) +
      ↪ # 35
36   labs(x = TeX("$\\frac{\\textit{q}}{lx}$")) +
      ↪ # 36
37   geom_errorbarh(aes(xmin = illuminance_mean - illuminance_uncertainty,
      ↪ xmax = illuminance_mean + illuminance_uncertainty), color =
      ↪ color_x) +                          # 37
38   geom_errorbarh(aes(xmin = illuminance_mean - illuminance_uncertainty_A,
      ↪ xmax = illuminance_mean + illuminance_uncertainty_A), height = .1)
      ↪ +                           # 38
39   geom_errorbarh(aes(xmin = illuminance_mean -
      ↪ illuminance_uncertainty_B_1, xmax = illuminance_mean +
      ↪ illuminance_uncertainty_B_1), color = "#ff6600", height = .2) +  #
      ↪ 39
```

```
40   geom_errorbarh(aes(xmin = illuminance_mean -
      ↪  illuminance_uncertainty_B_2, xmax = illuminance_mean +
      ↪  illuminance_uncertainty_B_2), color = "#ff66ff", height = .4) +  #
      ↪  40
41   theme(
      ↪  # 41
42     axis.title.x = element_text(colour = color_x),
        ↪  # 42
43     axis.text.x = element_text(colour = color_x),
        ↪  # 43
44     axis.ticks.x = element_line(colour = color_x),
        ↪  # 44
45     axis.title.y=element_blank(),
        ↪  # 45
46     axis.text.y=element_blank(),
        ↪  # 46
47     axis.ticks.y=element_blank()
        ↪  # 47
48   )
    ↪  # 48
49 ## Warning in geom_point(aes(x = illuminance_mean, y = 0), shape = 23,
    ↪  size = 2, : All aesthetics have length 1, but the data has 4
50 ## rows.
51 ## i Please consider using `annotate()` or provide
52 ##   this layer with data containing a single row.
```

5.14.7 Accuracy

Joonisel 12 leheküljel 170 on esitatud mõõdetud keskväärtus koos mõõtemääramatusega graafiliselt.

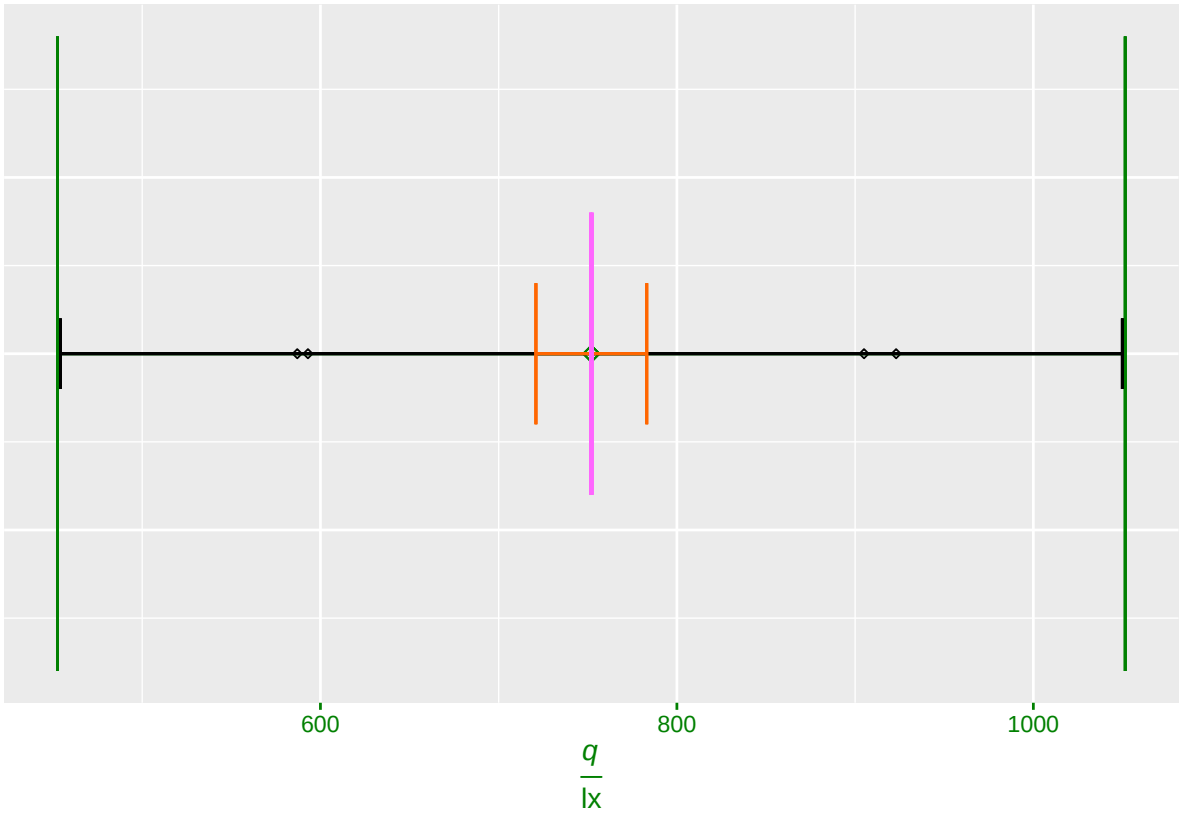


Figure 11: Valgustugevus koos keskmise valgustugevuse ja mõõtemääramatustega.

```
librarian::shelf(c(
  # 1
  "ggplot2",
    # 2
  "latex2exp"
    # 3
))
  # 4



color_x <- "#008000"
  # 6
ruler_smallest_unit <- .5
  # 7
ruler_relation = 4000 / 400
  # 8
ruler_smallest_unit_actual <- ruler_smallest_unit * ruler_relation
  # 9
ruler_x <- 42
  # 10
ruler_x_actual <- ruler_x * ruler_relation
  # 11
ruler_data_frame <- data.frame(ruler_x_actual)
  # 12



plot <- ggplot(data = ruler_data_frame, mapping = aes(x =
  `ruler_x_actual`, y = 0)) +
  # 14
  geom_point(shape = 23, size = 1) +
    # 15
```

```
  labs(x = TeX("$\\frac{\\textit{q}}{m}$")) +
   ↪ # 16
  geom_errorbarh(aes(xmin = `ruler_x_actual` -
   ↪ ruler_smallest_unit_actual, xmax = `ruler_x_actual` +
   ↪ ruler_smallest_unit_actual), color = color_x) +  # 17
  theme(
   ↪ # 18
    axis.title.x = element_text(colour = color_x),
     ↪ # 19
    axis.text.x = element_text(colour = color_x),
     ↪ # 20
    axis.ticks.x = element_line(colour = color_x),
     ↪ # 21
    axis.title.y=element_blank(),
     ↪ # 22
    axis.text.y=element_blank(),
     ↪ # 23
    axis.ticks.y=element_blank()
     ↪ # 24
  )
 ↪ # 25


plot
 ↪ # 27
```

The figure 13 on the page 171 shows how to specify the accuracy of the numbers on axis[34].

```
plot +                                          # 1
  scale_x_continuous(                           # 2
```

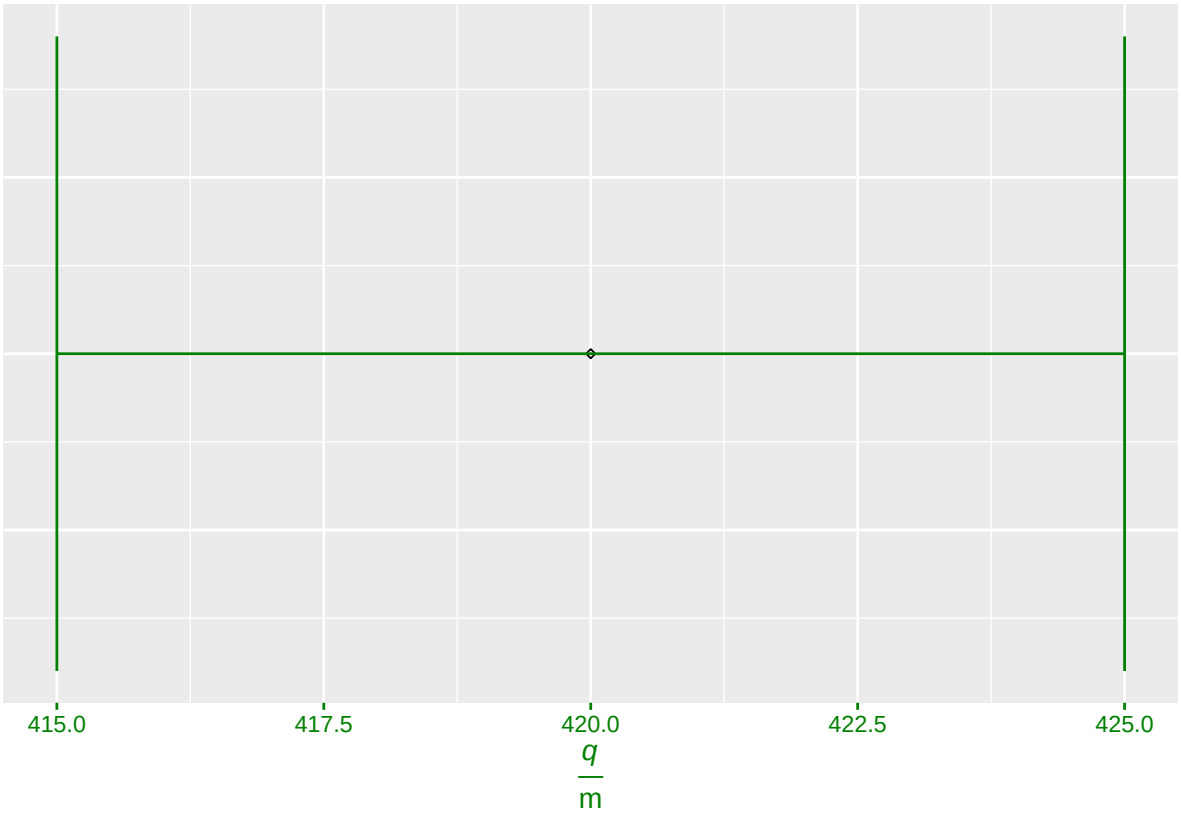


Figure 12: Kahe kontrollpunkti omavaheline kaugus mõõtemääramatusega.

```
    labels = scales::label_number(accuracy = 1)  # 3
  )                                              # 4
```

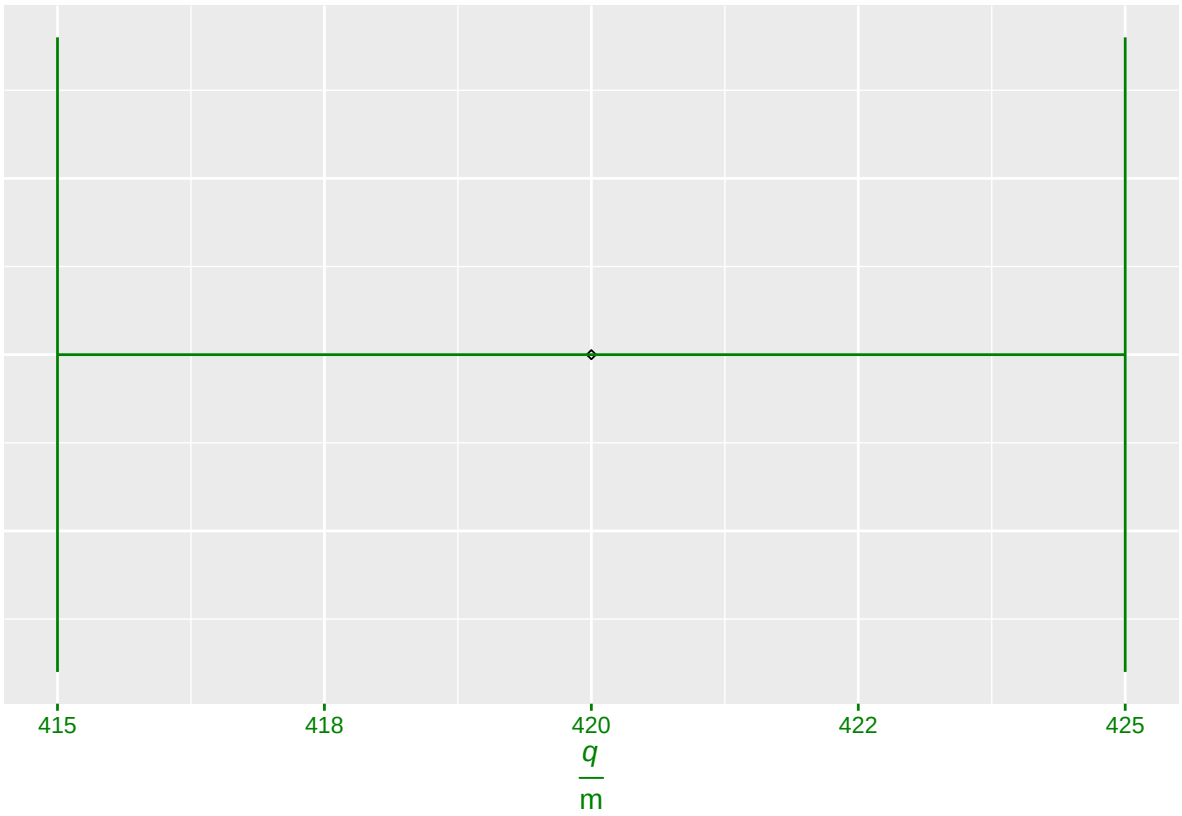


Figure 13: With specified accuracy.

5.15 Regression model[81]

```
angular_acceleration <- c(5.902952, 17.246897, 28.401369, 38.892302,
↪  45.907424)  # 1
torque <- c(0.001153365, 0.002174215, 0.003190228, 0.004201956,
↪  0.005009516)     # 2
formula = torque ~ angular_acceleration
↪  # 3
model = lm(formula = formula)
↪  # 4

```

```
b <- model$coefficients[1]  # 6
k <- model$coefficients[2]  # 7
```

```
Regressioonisirge tõus on \qty{`r as.character(signif(x = k, digits = 3))`}{\kg\m\squared} ja see näitab inertsimomenti. Vabaliige on \qty{`r as.character(signif(x = b, digits = 3))`}{\N\m} ja see näitab hõõrdejõu momenti.  # 1

  # 2
```

Regressioonisirge tõus on $9.55 \times 10^{-5}\,\mathrm{kg\,m^2}$ ja see näitab inertsimomenti. Vabaliige on $0.000\,542\,\mathrm{N\,m}$ ja see näitab hõõrdejõu momenti.

5.16 Correlation

In order to get the values of the result of a correlation analysis, one can use `cor`[82].

```
cor(                                                  # 1
  washing_cycles_with_full_records$`Veekulu..l.`,     # 2
  washing_cycles_with_full_records$`kWh`,             # 3
  method = 'pearson'                                  # 4
)                                                     # 5
## [1] 0.3320582
```

5.17 Linearizing

Lasen joonestada pretsessiooninurkkiiruse sõltuvuse graafiku rootori osakeste nurkkiirusest (joonis 14 leheküljel 175).

```
librarian::shelf(c(
  # 1
  "ggplot2",
    # 2
  "latex2exp"
    # 3
))
  # 4



color_x <- "#008000"
  # 6
color_y <- "#ff6600"
  # 7



number_of_rows_in_data_frame_of_precession <-
  nrow(data_frame_of_precession)
  # 9
data_frame_of_precession_without_outliers <-
  data_frame_of_precession[-c((number_of_rows_in_data_frame_of_precession
  - 1):number_of_rows_in_data_frame_of_precession), ]  # 10



ggplot(
  # 12
  data <- data_frame_of_precession_without_outliers,
  # 13
  mapping <- aes(x = `$\\frac{\\omega}{\\unit{\\per\\s}}$`, y =
  `$\\frac{\\omega_\\text{P}}{\\unit{\\per\\s}}$`)
  # 14
```

```
15 ) +
    # 15
16   geom_point(shape = 23, size = 1) +
      # 16
17   labs(x = TeX("$\\frac{\\omega}{\\frac{1}{s}}$"), y =
      TeX("$\\frac{\\omega_P}{\\frac{1}{s}}$")) +
      # 17
18   theme(
      # 18
19     axis.title.x = element_text(colour = color_x),
        # 19
20     axis.text.x = element_text(colour = color_x),
        # 20
21     axis.ticks.x = element_line(colour = color_x),
        # 21
22     axis.title.y = element_text(colour = color_y),
        # 22
23     axis.text.y = element_text(colour = color_y),
        # 23
24     axis.ticks.y = element_line(colour = color_y)
        # 24
25   )
    # 25
```

Teooria seosega (5.1) leheküljel 174 ennustab pöördvõrdelist sõltuvust.

$$\omega_{\mathrm{P}} = \frac{\left(\left(\overrightarrow{r_{\text{balancer; final}}} - \overrightarrow{r_{\text{balancer; initial}}}\right)\right) \times \overrightarrow{F_{\text{balancer}}}}{I \cdot \vec{\omega}}. \tag{5.1}$$

Joonisel 14 leheküljel 175 olev graafik lineariseeritud kujul[83] on esitatud joonisel 15 leheküljel 177.

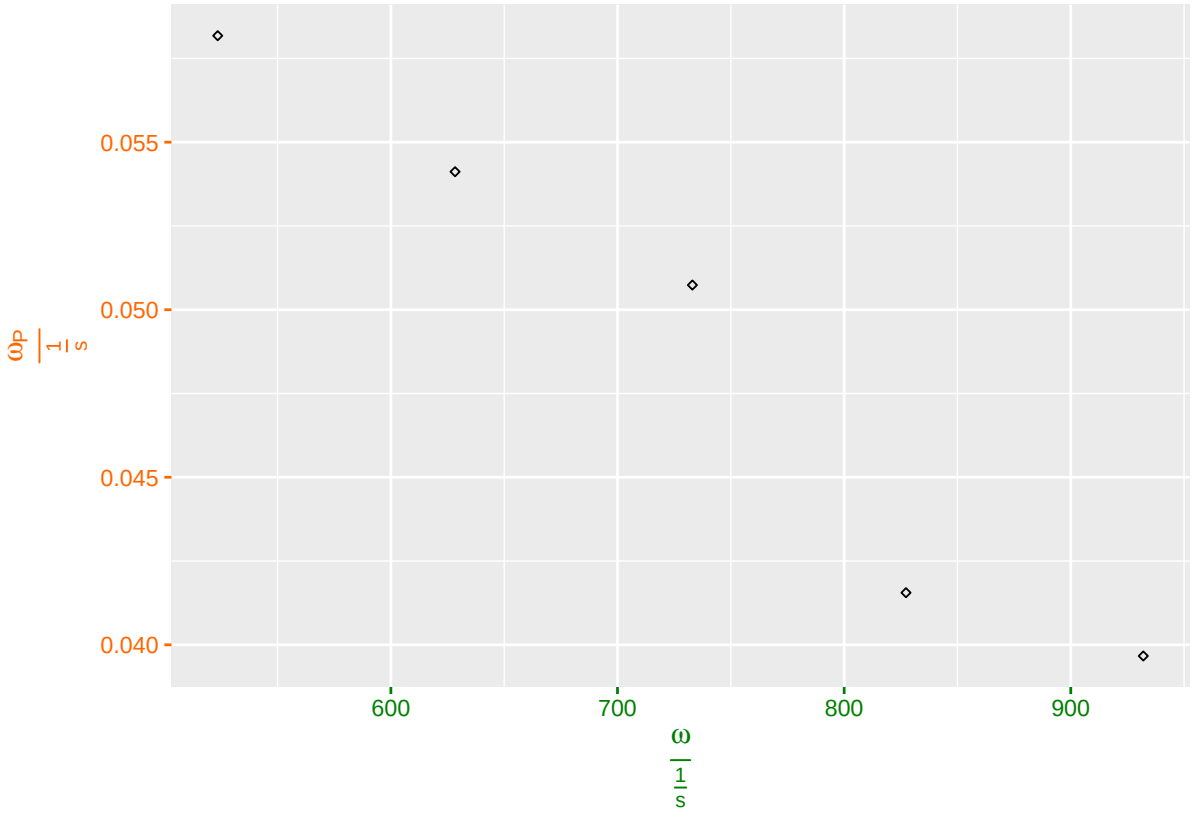


Figure 14: Pretsessiooninurkkiiruse sõltuvus rootori osakeste nurkkiirusest.

```
data_frame_of_precession_without_outliers_linearized <- mutate(.data =
↪  data_frame_of_precession_without_outliers, linearized_omega = 1 /
↪  `$\\frac{\\omega}{\\unit{\\per\\s}}$`, .keep = "unused", .after =
↪  `$\\frac{\\omega}{\\unit{\\per\\s}}$`)  # 1
colnames(data_frame_of_precession_without_outliers_linearized) <- c(
↪  # 2
  "$\\frac{\\frac{1}{\\omega}}{\\unit{\\s}}$",
   ↪  # 3
  "$\\frac{\\omega_\\text{P}}{\\unit{\\per\\s}}$"
   ↪  # 4
)
↪  # 5


ggplot(
↪  # 7
  data <- data_frame_of_precession_without_outliers_linearized,
↪  # 8
  mapping <- aes(x = `$\\frac{\\frac{1}{\\omega}}{\\unit{\\s}}$`, y =
↪  `$\\frac{\\omega_\\text{P}}{\\unit{\\per\\s}}$`)
↪  # 9
) +
↪  # 10
  geom_point(shape = 23, size = 1) +
   ↪  # 11
  labs(x = TeX("$\\frac{\\frac{1}{\\omega}}{s}$"), y =
   ↪  TeX("$\\frac{\\omega_P}{\\frac{1}{s}}$")) +
   ↪  # 12
  theme(
   ↪  # 13
    axis.title.x = element_text(colour = color_x),
     ↪  # 14
```

```
    axis.text.x = element_text(colour = color_x),  # 15
    axis.ticks.x = element_line(colour = color_x),  # 16
    axis.title.y = element_text(colour = color_y),  # 17
    axis.text.y = element_text(colour = color_y),  # 18
    axis.ticks.y = element_line(colour = color_y)  # 19
  )  # 20
```

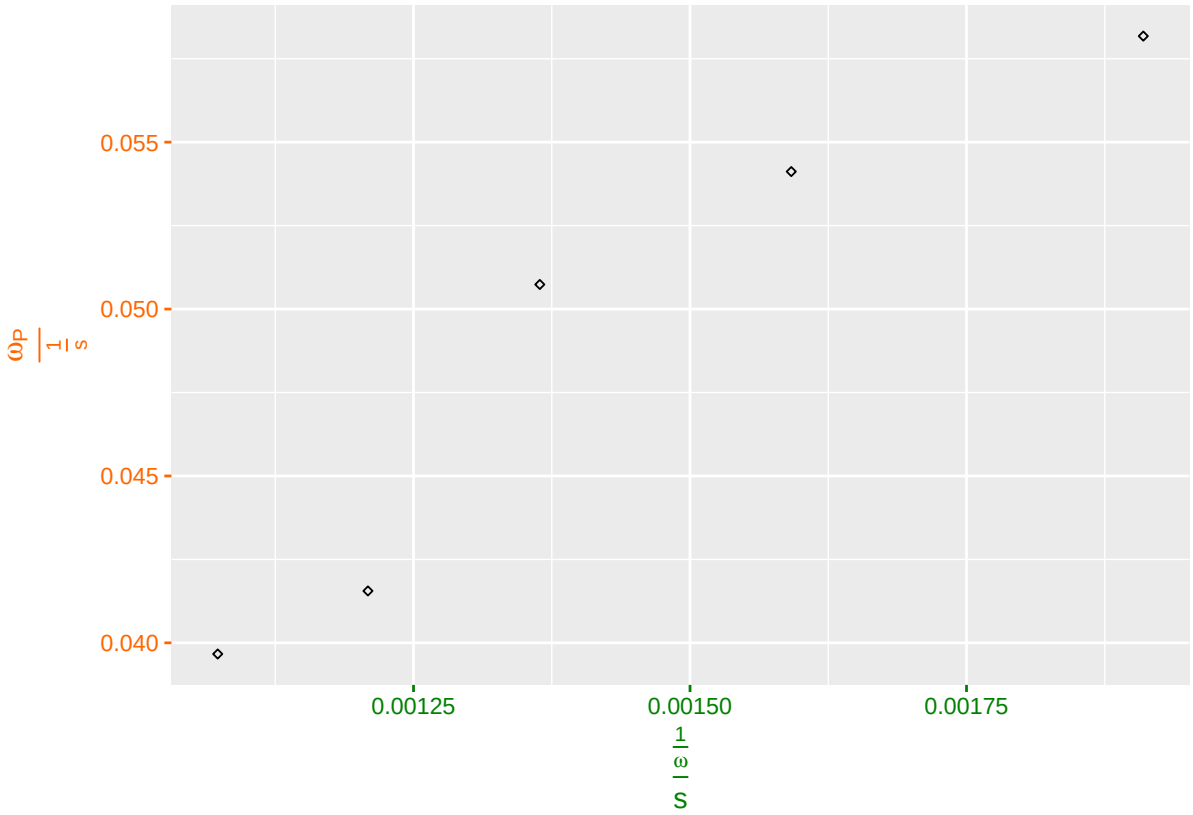


Figure 15: Lineariseeritud nurkkiiruste graafik. Propelleri nurkkiiruse asemel on esitatud selle pöördväärtus, mis näitab, mitu sekundit ühe radiaani läbimine kestis.

5.18 Embedding

Including works for web output[84]:

```
if (knitr::is_html_output()) {
  # 1

  knitr::include_url("https://learningapps.org/view409713")
  # 2
}
  # 3

  # 4
```

5.19 Figures

5.19.1 Displaying a figure

For figures, i created a wrapper function `include_external_graphics()` for `knitr`'s `include_graphics()` because natively, `include_graphics()` doesn't support all the necessary file types:

```
1 ```{r label = "<label of figure>", echo=FALSE, fig.cap = "<caption of
  ↪  figure>"}  # 1
2 include_external_graphics("<path-to-image-file>")
  ↪  # 2
3
  ↪  # 3
4 ```
  ↪  # 4
5
  ↪  # 5
```

For this code chunk, i use the label and the following options:

label the label that can be referenced must not include underscores but can include dashes

fig.cap the caption of the figure. This must be present in order to reference it.

Other options are possible:

fig.align i set it to have the value `center` if i want the image to reside in center

fig.fullheight i set it to `TRUE` if the image would be printed out smaller otherwise

out.width the width. Sometimes, the image is too wide for the page. Here, i set the width to be .92 of the height of the text part on the page as that image is rotated at a right angle: `.92\\textheight`

out.height sometimes, especially images with full size tend to be still a bit too large, so i set this parameter to have a value like `96%`

out.extra: for instance to turn the image with `angle` that has a value in degrees

5.19.2 Referencing a figure

Referencing a figure takes place using `\@ref(fig:<label of figure>)`.

As an example, i refer to the figure 16.

```
1 include_external_graphics("rmd/workflow.png")  # 1
```

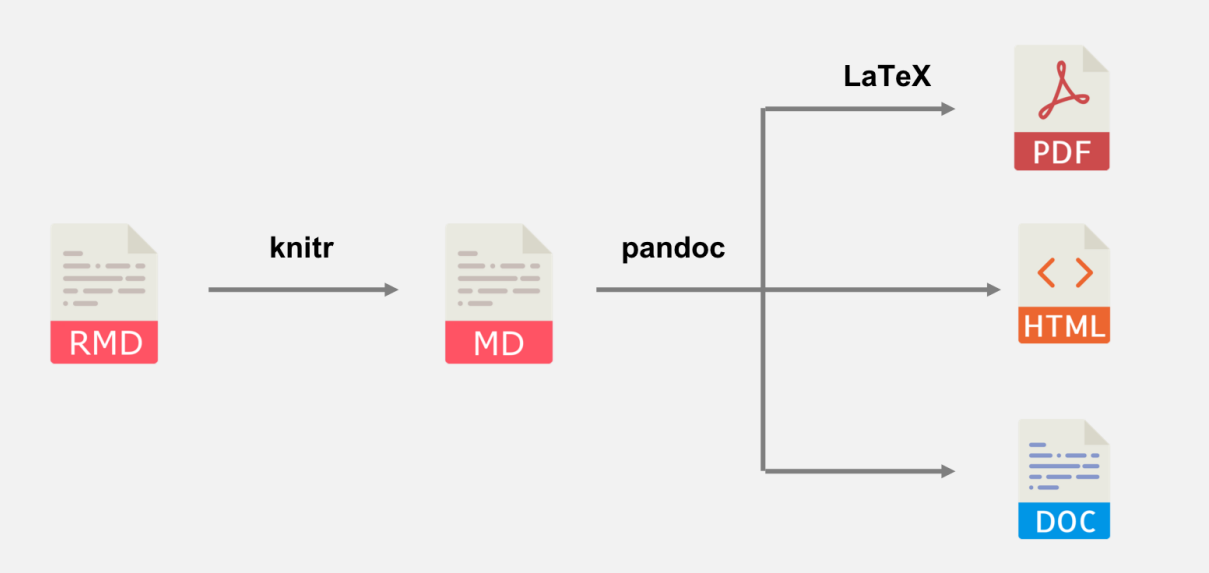


Figure 16: The workflow from the written markdown to the ready output using *bookdown*.

5.19.3 Involving an external reference in the figure caption

If i want to include an external reference inside the figure caption, i had to use the function `render_with_emojis` inside the caption:

```
1
 ↪  # 1
2 ```{r label = "workflow", fig.cap = paste("The workflow from the written
 ↪  markdown to the ready output using *bookdown*",
 ↪  render_with_emojis("((ref:riederer-21))"), ".", sep = "")}  # 2
3 include_external_graphics("rmd/workflow.png")
 ↪  # 3
4
 ↪  # 4
5 ```
 ↪  # 5
6
 ↪  # 6
```

This is also obsolete because of numeric referencing.

```
1 include_external_graphics("rmd/workflow.png")  # 1
```

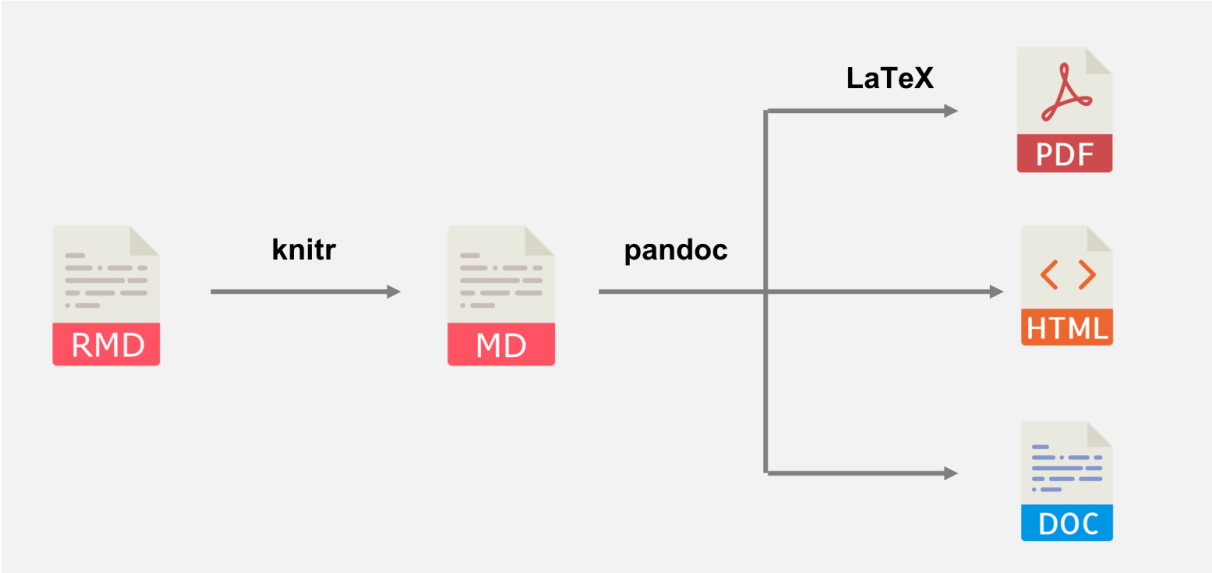


Figure 17: The workflow from the written markdown to the ready output using *bookdown*((ref:riederer-21)).

Here, the function `paste` comes handy. `paste` glues strings together that can be fed into that function. The last parameter is `sep` which can be used

to set the separator between the strings. Currently, i told the function to use an empty string as a separator.

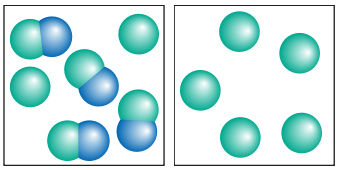
5.19.4 Subfigures

Sometimes, it would be wasting having each figure below each other if they are narrow. In such a case, I want the images to be side by side. For that, I need to involve *subfig* as a dependency for the print output[85]:

```
bookdown::pdf_book:              # 1
  extra_dependencies: "subfig"   # 2
                                 # 3
```

Pildil 18 leheküljel 182 kujutatud konteinerid sisaldavad kas segu, ühte ühendit, ühte elementi või nende kombinatsiooni. Sinised sfäärid tähistavad ühe elemendi aatomeid, rohelised sfäärid teise elemendi aatomeid.

```
include_external_graphics("rmd/alused-kordamine-ühendid-segu-element.svg")
 ↪  # 1
include_external_graphics("rmd/alused-ühendid-element.svg")
 ↪  # 2
```



(a) Elements, compounds, and a mixture.

(b) Only elements.

Figure 18: Konteinerid.

As you see, there is no spacing between subfigures. I have not found a solution for that.

5.20 Quick-response code[86]

The example (39) with the listing 5.2 on the page 183 and the figure19 on the page 183 shows how to generate a quick-response code[87,88].

(39)

```
librarian::shelf(c(
  "qrcode"
))
code <- qr_code(x="https://e-koolikott.ee/et/oppematerjal/19850-2-1-Dunaamika/229902#229903-Newtoni-kolmas-seadus", ecl="H")
plot(code)
```

Listing 5.2: An example of how to generate a quick-response code.

Figure 19: Newtoni kolmas seadus - viide.

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