

Acronyms

Notation	Description
AC	Alternating Current
DC	Direct Current
EMI	Electromagnetic Interference
GCD	Greatest Common Divisor
LCM	Least Common Multiple
MCU	Microcontroller Unit
MOSFET	Metal-Oxide-Semiconductor Field-Effect Transistor
MRI	Magnetic Resonance Imaging
RVS	Reduced Voltage Switching
SMPS	Switched-Mode Power Supply
SNR	Signal-to-Noise Ratio

Glossary

Notation	Description
HIGH	Logic high voltage level
LOW	Logic low voltage level
SPICE	Electronic circuit simulator

1 Introduction

The progress of imaging internal organs has advanced significantly during the 20th century. Three major technologies used are X-ray, Magnetic Resonance Imaging (MRI), and ultrasound. Each of the technologies have distinct advantages and disadvantages in biomedical imaging, thus are still relevant for modern medicine. With x-rays, an important drawback is that patients are exposed to ionizing radiation [1], [4], [5], [7] [3], [6] This template complies with the DTU Design Guide <https://www.designguide.dtu.dk/>. DTU holds all rights to the design program including all copyrights. It is intended for two-sided printing. The `\cleardoublepage` command can be used to ensure that new sections and the table of contents begins on a right-hand page. The back page always ends as an odd page. [2]

All document settings have been collected in `Setup/Settings.tex`. These are global settings, meaning the settings will affect the whole document. Defining the title for example will change the title on the front page, the copyright page, and the footer. A watermark can be enabled or disabled in `Setup/Preamble.tex`. You can edit the watermark to display draft, review, approve, confidential, or anything else. By default, the watermark is printed on top of the document's contents and has a transparent gray color. Here I am just testing the synchronization functionality of Overleaf and Github. Now, that the first synchronization finished successfully, I want to test that the reverse direction process is also functional. Hopefully, this will end up on Overleaf.

1.1 This is a section

Every chapter is numbered and the sections inherit the chapter number followed by a dot and a section number. Figures, equations, tables, etc. also inherit the chapter numbering.

1.1.1 This is a sub section

Sub-sections are also numbered. In general, try not to use a deep hierarchy of sub-sections (`\paragraph{}` and the like). The document will become segmented, which will make the document appear less coherent.

This is a sub sub section

And those are not numbered. It is possible to adjust the deep hierarchy of numbering sections in `Setup/Settings.tex`.

The front and back cover has been made to replicate the examples in the design guide <https://www.designguide.dtu.dk/#stnd-printmedia>. The name of department heading is omitted because it is located in the top right corner (no need to write it twice). Take a look at <https://www.inside.dtu.dk/en/medarbejder/om-dtu-campus-og-bygninger/kommunikation-og-design/skabeloner/rapporter> if you want to make your cover separately.

Citing is done with the `biblatex` package [3]. Cross referencing (figures, tables, etc.) is taken care by the `cleveref` package. Just insert the name of the label in `\cref{}` and it will automatically format the cross-reference. For example, writing the `cleveref` command `\cref{fig:groupedcolumn}` will output "fig. 3.3". Using `\Cref{}` will capitalize the first letter and `\crefrange{ }{ }` will make a reference range. An example: Figure 3.2 is an example of a stacked bar chart and figs. 3.1 to 3.3 are three consecutive figures.

1.2 Font and symbols test

Symbols can be written directly in the document, meaning that there is no need for special commands to write special characters. I love to write special characters like æøå inside my T_EX document. Also á, à, ü, û, ë, ê, î, ï could be nice. So what about the “£” character. What about ř é ő † ‡ ü | œ ‘ @ ö ä ñ í Š š † … ç ñ ‡ û à “ č ” [] ’. Some dashes - – —, and the latex form - – —

This is a font test
Arial Regular

MRI, Signal-to-Noise Ratio (SNR), Switched-Mode Power Supply (SMPS), Reduced Voltage Switching (RVS), Alternating Current (AC), Direct Current (DC), Electromagnetic Interference (EMI), Greatest Common Divisor (GCD), Least Common Multiple (LCM)
HIGH, LOW, SPICE

I want to talk about SPICE, HIGH and LOW. These are all DC and AC electric principles. I want to mention that Metal-Oxide-Semiconductor Field-Effect Transistor devices can be called MOSFET.

1.3 Tikz Test

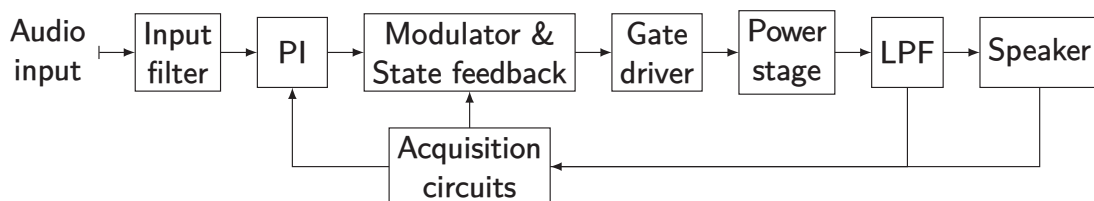






































Figure 1.1: Simple overview of the system

I like to talk about logic systems and their binary states. Such as HIGH and LOW. These are also important in SPICE simulation systems.

I like to explain abbreviations such as MOSFET. This abbreviation stands for Metal-Oxide-Semiconductor Field-Effect Transistor. I like this paper [11]. Two datasheets [8], [9]

2 Colours

The design guide define 3 primary colours (dtured, white and black) and 10 secondary colours <https://www.designguide.dtu.dk/#stnd-colours>. Below are codes for the various colour modes. RGB is used for web and Office Programmes. CMYK is used for print. HTML is used for HTML-coding. If you know anything about colour codes you might notice that the RGB codes are ranging from 0-1 instead of the usual 0-255.

color	rgb	cmyk	HTML
dtured	 0.77 0 0.05	 <u>0</u> 0.91 0.72 0.23	 C4000D
white	 1 1 1	 0 0 0 0	 FFFFFFFF
black	 0 0 0	 0 0 0 1	 000000
blue	 0.12 0.24 1	 <u>0.88</u> 0.76 0 0	 1F3DFF
brightgreen	 0.31 1 0.34	 <u>0.69</u> 0 0.66 0	 4FFF57
navyblue	 0 0 0.4	 <u>1</u> 0.9 0 0.6	 000066
yellow	 0.95 0.83 0.18	 <u>0.05</u> 0.17 0.82 0	 F2D42E
orange	 1 0.35 0.14	 0 0.65 0.86 0	 FF5924
pink	 1 0.65 0.74	 0 0.35 0.26 0	 FFA6BD
red	 1 0.14 0.35	 0 0.86 0.65 0	 FF2459
green	 0 0.78 0	 <u>0.89</u> 0.05 1 0.17	 00C700
purple	 0.33 0.04 1	 <u>0.67</u> 0.96 0 0	 540AFF

The default colour mode for this template is cmyk. The current colour model is cmyk which is also illustrated by the underlined numbers in the colour test table above. If you which to change the colour model to rgb go to Setup/Settings.tex and change `targetcolourmodel` to rgb. In Setup/Settings.tex it is also possible to change the background colour of the front and back page. The colours are primarily used for diagrams (the plotcyclelist DTU) and the front and back page.

Lighter colours can be achieved as written in the \LaTeX code below. For example to get a tint of 50% you would write `colourname!50`.

Normal dtured 80% dtured 70% dtured 60% dtured 50% dtured

For more information about colours in \LaTeX read the `xcolor` manual. I want to use the MCU [10] for the MCU part of the project. Microcontroller Unit (MCU)

3 Examples of figures, tables, equations and listings

In the following a bunch of examples of figures and tables have been made. There are advantages to using `tikZ` diagrams over excel diagrams. 1) the font and font size perfectly matches the document 2) the styling and colours are pre-defined to follow the design guide 3) the plots uses vector graphics which reduces the file size, reduces the compile time and looks sharp when zooming in. The possibilities are endless, look at the `pgfplots` gallery for inspiration: <http://pgfplots.sourceforge.net/gallery.html>. However there are still cases where I would recommend to insert a plot as a picture. For example if the plot contains a lot of data: a line graph with 1000 points takes a long time to compile.

Some tips if you want good looking diagrams or graphs which will be inserted as pictures (e.g. in a figure environment with `\includegraphics`): The main font is Arial. Use DTU colours as described in chapter 2. Use high quality pictures. Try to scale the diagram (picture) so the text size of the axis legends match the text size in this document.

Remember to change the label of your figures so there are no duplicate labels. A label should be placed below a caption or after a heading (fx after a `\chapter`).

3.1 Graphs and charts

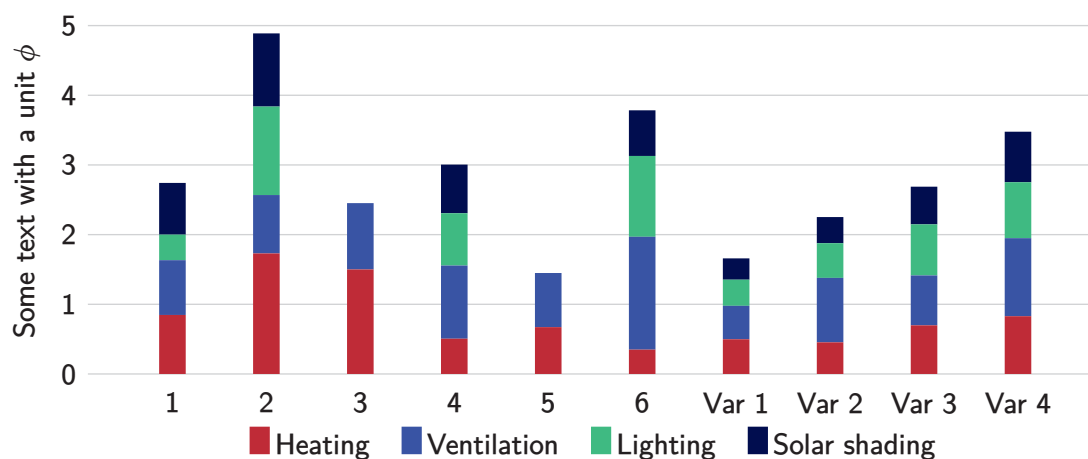


Figure 3.1: Stacked column chart

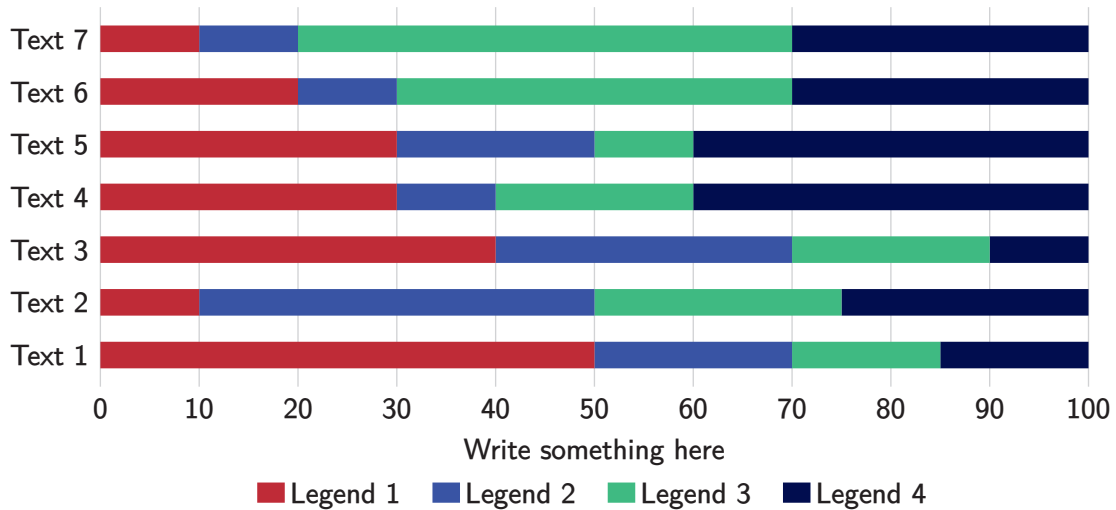


Figure 3.2: Stacked bar chart

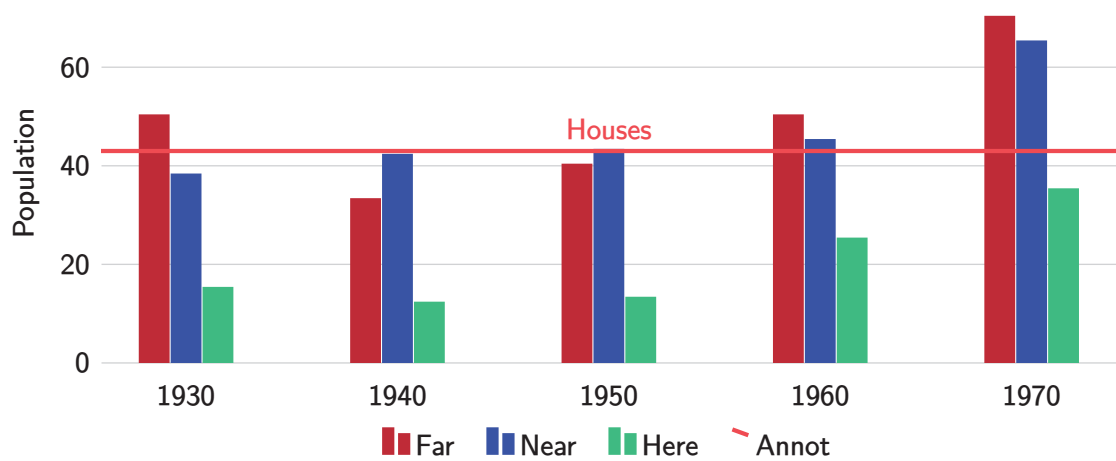


Figure 3.3: Grouped column chart

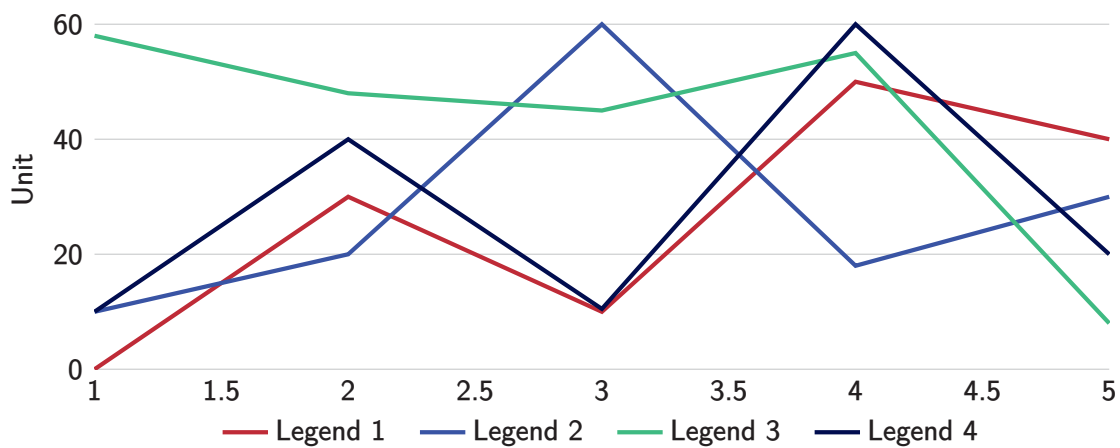


Figure 3.4: Line graph

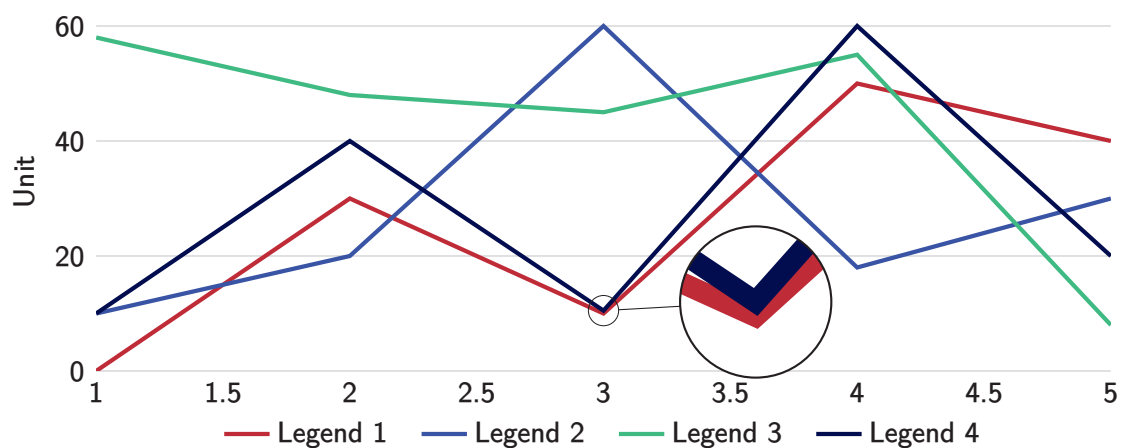


Figure 3.5: Line graph with magnifying glass

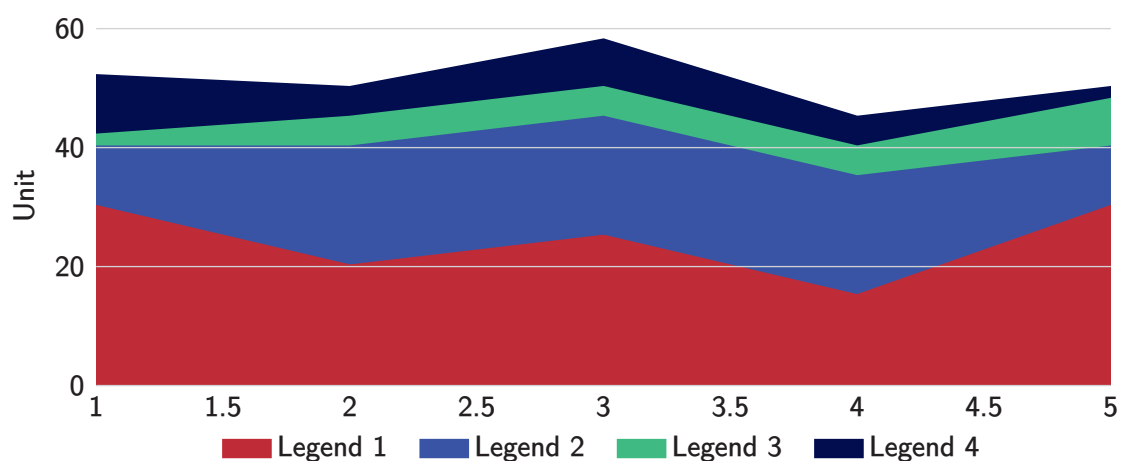


Figure 3.6: Area graph

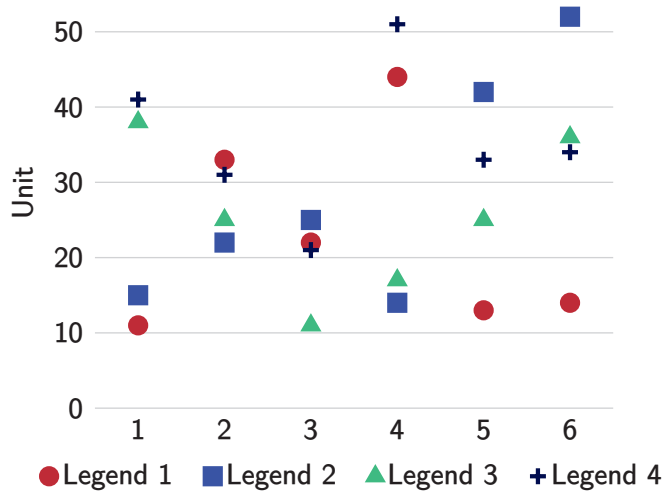


Figure 3.7: Scatter plot

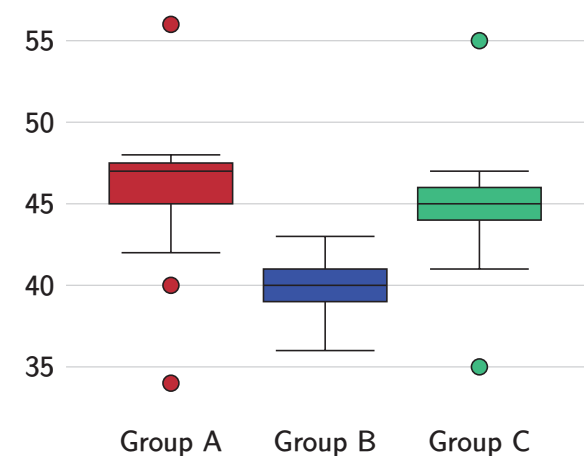


Figure 3.8: Boxplot

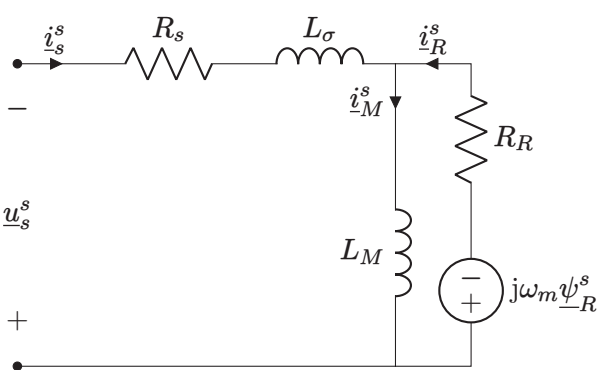


Figure 3.9: The nodes short, V, R and L are presented here, but there a lot more

3.2 Tables and figures

Table 3.1: This is a booktabs table

Animal	Description	Price (\$)
Gnat	per gram	13.65
	each	0.01
Gnu	stuffed	92.50
Emu	stuffed	33.33
Armadillo	frozen	8.99

Booktabs tables don't use any vertical lines. Only horizontal lines are used. Table 3.1 begins with a `\toprule`, ends with a `\bottomrule` with `\midrule` in between. The table has 3 columns formatted as `@{}l1S@{}`. `@{}` is cropping the horizontal lines of the table to fit the content (removes column spacing at the left and right edges). `l` aligns the column to the left and `S` aligns the column according to the decimal point (`siunitx` package). You can of course also use `r` to align right or `c` to center the contents of the column.

Table 3.2: Wrongly formatted table

	Voltage V	Current A	Power W
Transformer input	234.4	0.50	117.4
Transformer output	25.86	2.72	70.3
Efficiency			60%

Table 3.3: Correctly formatted table

	Voltage V	Current A	Power W
Transformer input	234.4	0.50	117.4
Transformer output	25.86	2.72	70.3
Efficiency			60 %

Table 3.2 and table 3.3 have the same contents but there are some subtle differences in formatting which makes table 3.3 the superior table of the two. The most obvious change is removing the midrule between the transformer input and output rows. The efficiency row is the odd man out and a midrule has been used to emphasise the difference between the transformer rows and the efficiency row. The delimiters in the voltage, current and power columns are aligned. The horizontal lines (rules) fits to the content and instead of protruding. The spacing between 60 and the percentage sign is correctly adjusted.



Figure 3.10: Just a normal figure



(a) A subfigure



(b) A subfigure

Figure 3.11: A figure with two subfigures



(a) A subfigure



(b) A subfigure



(c) A subfigure



(d) A subfigure

Figure 3.12: A figure with four subfigures

Referring to the figure as a whole fig. 3.12 or to an individual sub figure fig. 3.12a is done the normal way with `\cref{}` commands.

3.3 Equations

In-line math is easy. Anything surrounded by dollar signs becomes a math field. Here is an example: $f(x) = 2x - 1$. Also anything inside the “`\begin{equation}`” and “`\end{equation}`” environment is also a math field. Examples are shown below.

All equations use the default latex font. Some might say it looks weird with a serif font for equations and a sans-serif font for the body text. However, it is very unpractical to change the math font in latex which is the exactly the reason why this has not been done. One benefit of the serif style math font is the clear distinction between symbols (variables) and units.

On the subject of units, those are all taken care of by the `\siunitx` package. Whenever there is a number followed by a unit one should write `\SI{number}{unit}`. Note this command is case sensitive. If a unit should follow a variable use the command `\si{unit}` (also case sensitive).

The ideal gas law is shown in eq. (3.1).

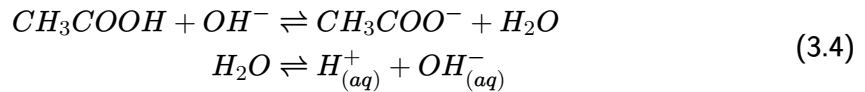
$$p \cdot V = n \cdot R \cdot T \quad (3.1)$$

$$\frac{\partial}{\partial t} \int_0^\delta U dy = -\delta \frac{1}{\rho} \frac{\partial P}{\partial x} - U_f(t)^2 \quad (3.2)$$

$$d_{step} = \sqrt{\frac{\delta}{\frac{dw}{dp_v}} \cdot t} = \sqrt{\frac{1.0 \times 10^{-11} \text{ kg}/(\text{m s Pa})}{\frac{5.4 \text{ kg}/\text{m}^3}{233.82 \text{ Pa}}} \cdot 7200 \text{ s}} = 0.001766 \text{ m} = 1.766 \text{ mm} \quad (3.3)$$

$$x = \text{x}, \text{x}, \text{x}, x_{1234}^{1234} \cdot \text{hello} * \text{hello world} \cdot \text{equation without number}$$

Notice how the `aligned` environment can be used to align the equilibrium arrows in eq. (3.4). Only one equation number is generated using this method. Alternatively if you want an equation number for each line see eqs. (3.5) to (3.6).



$$f(x) = 1 + x - 3x^2 \quad (3.5)$$

$$g(x) + y = 3x - \frac{1}{2}x^3 \quad (3.6)$$

3.4 Listings (code)

Listing 3.1 is a nicely formatted block of code. A listing will automatically continue on the next page if it encounters a page break. Many different programming languages can be highlighted. Check the listings package documentation for a list of supported programming languages.

```
1 %% Monte Carlo simulation, estimation of pi
2 m=1E7;
3
4 x=rand(m,1);
5 y=rand(m,1);
6
7 g = x.^2+y.^2-1;
8
9 %dots outside
10 Pf = sum((g)<=0)/m
11
12 pi = 4*Pf
```

Listing 3.1: Monte Carlo simulation to estimate the value of π

Bibliography

- [1] K. K. Shung, R. A. Sigelmann, and J. M. Reid, "Scattering of ultrasound by blood," *IEEE Transactions on Biomedical Engineering*, pp. 460–467, 6 November 1976, ISSN: 0018-9294. DOI: 10.1109/TBME.1976.324604. [Online]. Available: <http://ieeexplore.ieee.org/document/4121084/>.
- [2] J. A. Jensen, "An analysis of pulsed wave ultrasound systems for blood velocity estimation," *Acoustical Imaging*, L. T. Piero and Masotti, Eds., pp. 377–384, 1996. DOI: 10.1007/978-1-4419-8772-3_61. [Online]. Available: http://link.springer.com/10.1007/978-1-4419-8772-3_61.
- [3] J. A. Jensen, *Linear description of ultrasound imaging systems: Notes for the International Summer School on Advanced Ultrasound Imaging at the Technical University of Denmark*. Technical University of Denmark, Department of Electrical Engineering, 1999. [Online]. Available: <https://orbit.dtu.dk/en/publications/linear-description-of-ultrasound-imaging-systems-notes-for-the-in>.
- [4] J. A. Jensen, "Algorithms for estimating blood velocities using ultrasound," *Ultrasonics*, vol. 38, pp. 358–362, 1–8 March 2000, ISSN: 0041624X. DOI: 10.1016/S0041-624X(99)00127-4. [Online]. Available: <https://linkinghub.elsevier.com/retrieve/pii/S0041624X99001274>.
- [5] J. A. Jensen, *Estimation of Blood Velocities Using Ultrasound: A Signal Processing Approach*, Third Edition. Department of Electrical Engineering, Technical University of Denmark, August 2013, ISBN: 9780521464840.
- [6] T. L. Szabo, *Diagnostic Ultrasound Imaging: Inside Out*, Second Edition. Elsevier, 2014, ISBN: 9780123964878. DOI: 10.1016/C2011-0-07261-7. [Online]. Available: <https://linkinghub.elsevier.com/retrieve/pii/C20110072617>.
- [7] K. K. Shung, *Diagnostic Ultrasound: Imaging and Blood Flow Measurements*, Second Edition. CRC Press, December 2015, ISBN: 978-1-4665-8264-4.
- [8] AD8332 Ultralow Noise VGAs with Preamplifier and Programmable R_{IN} , May 2016. [Online]. Available: https://www.analog.com/media/en/technical-documentation/data-sheets/AD8331_8332_8334.pdf.
- [9] AD8333 DC to 50 MHz, Dual I/Q Demodulator and Phase Shifter, May 2016. [Online]. Available: <https://www.analog.com/media/en/technical-documentation/data-sheets/AD8333.pdf>.
- [10] STM32F411xE High-performance access line, Arm Cortex-M4 core with DSP and FPU, 512 Kbytes of Flash memory, 100 MHz CPU, ART Accelerator, December 2017. [Online]. Available: <https://www.st.com/resource/en/datasheet/stm32f411re.pdf>.
- [11] M. Omura, R. Nagaoka, K. Yagi, K. Yoshida, T. Yamaguchi, and H. Hasegawa, "Characterization of blood mimicking fluid with ultrafast ultrasonic and optical image velocimeters," *Japanese Journal of Applied Physics*, vol. 61, Jul. 2022, ISSN: 0021-4922. DOI: 10.35848/1347-4065/ac4ea9. [Online]. Available: <https://iopscience.iop.org/article/10.35848/1347-4065/ac4ea9>.