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Universität  
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Bachelor Thesis

**Investigation of Synergy Effects  
in Complex Systems**

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# Abstract

Describe the contents of the thesis here. Present briefly the starting point and motivation of the work, and which goals the work pursues. Identify the (research) gap. Then describe the methods used and the results achieved or contributions made.



# Foreword

You can optionally add a foreword to your thesis.



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# 1. Introduction

This document serves as a template for your thesis. At the same time, it contains important information that will help you to make it easier for you to write your thesis.

Provide a general introduction to the topic of your thesis here.

## 1.1. Objectives

Describe the objectives of your work here

## 1.2. Overview

Chapter 2 contains information on how you should should prepare the content of your thesis. In Chapter 3 you can find a short introduction to the packages you may need for this work. Chapter 4 completes the document.

Describe here how you will proceed in the following chapters proceed to achieve the objectives defined above.



## 2. Remarks on the Content

- Scope of the thesis:

**Bachelor thesis** 25-35 pages

**Master thesis** 50-60 pages

Pure text only, all indices, title pages etc. not included. These figures are only rough guidance values, depending on the topic, it is possible to deviate from these values. It is therefore essential that you discuss the actual length target with your supervisor! Keep in mind that writing short, **concise**, yet **comprehensive** is harder and more valuable than producing a lot of text with repetitions.

- Be sure to consider [Kes07] for your literature research.
- Your final thesis is a scientific work that must also meet appropriate quality requirements.
  - Do not use colloquial terms.
  - Be sure to back up any statements you make with appropriate arguments or literature references.
  - Perform a spell check before submitting. A good tool for this is for example **aspell**, which is also provided for use in editors such as Emacs is also intended for use.
- This book [GD09] is another great resource for improving your writing style in English, in particular for non-native speakers of English.



## 3. Short Introduction to L<sup>A</sup>T<sub>E</sub>X

### 3.1. Table of Contents

Organize your work by using chapters (`\chapter`), sections (`\section`), and subsections (`\subsection` and `\subsubsection`). If these are not sufficient, you can also use paragraphs (`\paragraph`). In the template provided here, up to the the outline level `subsection` the outline numbers are numbers are automatically generated and the corresponding entries end up in the table of contents. If you do not want this at certain places use the `*` form of the command.

### 3.2. Text Composition

L<sup>A</sup>T<sub>E</sub>X offers several ways to structure a text. The following sections explain the use of bullets, tables, and images.

#### 3.2.1. Lists

L<sup>A</sup>T<sub>E</sub>X has three kinds of lists. Probably the most widely used is the `itemize` environment:

- This is the first bullet point.
- Another bullet point.
- Lists can consist of longer or multiline texts. L<sup>A</sup>T<sub>E</sub>X takes care of the current layout the same way as for normal text.

For enumerated lists the `enumerate` environment can be used:

1. Single bullet points are only set with `\item`.
2. The enumeration will be generated automatically by L<sup>A</sup>T<sub>E</sub>X .
3. Lists can be nested:
  - Here with an unnumbered list.

If you want to explain multiple terms the `description`-environment can be used:

**Usage** Descriptions are set like all other enumerations, with the term being describe in brackets right after `\item`.

**Text markup** You can highlight text with `\textXX` in **bold**, *cursive* or SMALL CAPS. For simple highlighting, you can use the `\emph` command.

**Document class** The first command of a L<sup>A</sup>T<sub>E</sub>X-Dokuments defines the document class, i.e., the template. For example, this document, uses the class `sikthesis` (`\documentclass{sikthesis}`). You can pass the document class an optional argument [`draft`] to create a draft of the document (this will compile much faster, which can be useful during writing). Images are then displayed only as empty frames, and L<sup>A</sup>T<sub>E</sub>X marks issues in the margin, e.g., if there are still problems with pagination or overlong text. These problems can generally be solved by slightly rewording the text.

### 3.2.2. Tables

A table can be generated in L<sup>A</sup>T<sub>E</sub>X using the `tabular` environment:

Row 1	2nd cell	long text that is automatically wrapped
Row 2	2nd cell	short text

Tables can also be embedded in `table` environments. L<sup>A</sup>T<sub>E</sub>X then places these tables *floatingly*. Such tables can then also be provided with a `\caption` and referenced in the text (see the 3.1 table). If the `\caption` text is very long, it is recommended to add a short text to the macro for the table listing as an optional argument. `\caption[Text for table listing]{Caption}`.

Row 1	2nd cell	long text that is automatically wrapped
Row 2	2nd cell	short text

Table 3.1.: Example for a floating table. Always provide an informative caption.

### 3.2.3. Figures

As with tables, graphics should be placed in a flowing manner, so that L<sup>A</sup>T<sub>E</sub>X takes care of their placement as much as possible. Figure 3.1 shows an example of such an image.

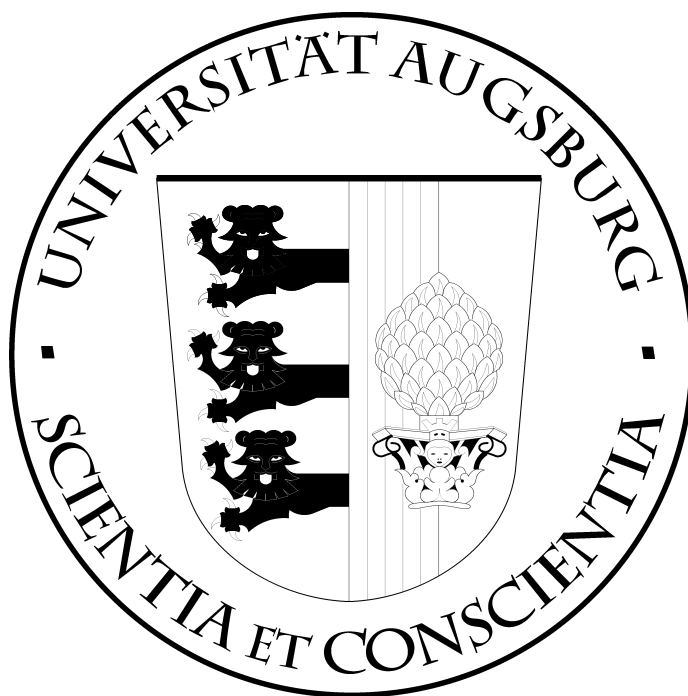


Figure 3.1.: Example for a figure, 60% text width, the width can be configured as well, e.g., 6cm.

If possible, use the `TikZ` package to create diagrams. Specify the description of the graphic directly in the `TeX` code. This ensures in particular that captions in the graphic have the same typeface as the text of your work. An example of such a figure can be found in the figures 3.2 and 3.3. These figures also show how to create two graphics using `minipage` environments side by side. Another useful environment to achieve this is `subfigure`.

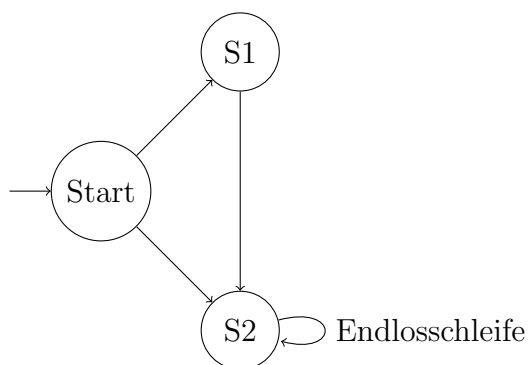


Figure 3.2.: TikZfigure 1

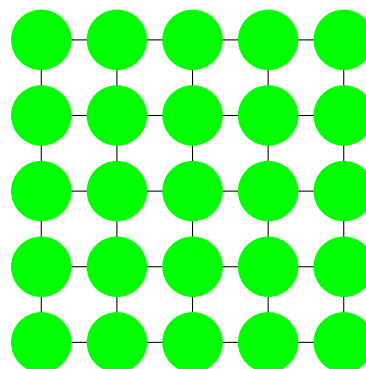


Figure 3.3.: TikZfigure 2

To create diagrams you can use the `pgfplots` package, which is based on `TikZ` and `PGF`. For examples see the figures 3.4 and 3.5.

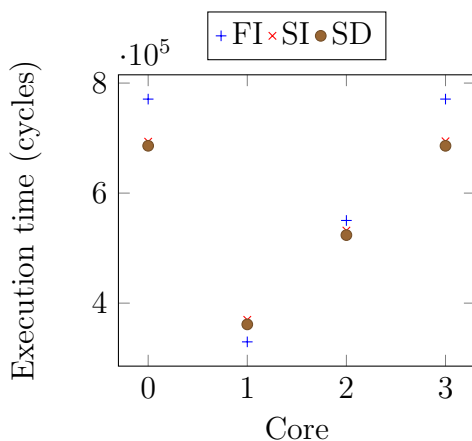


Figure 3.4.: pgf diagram 1

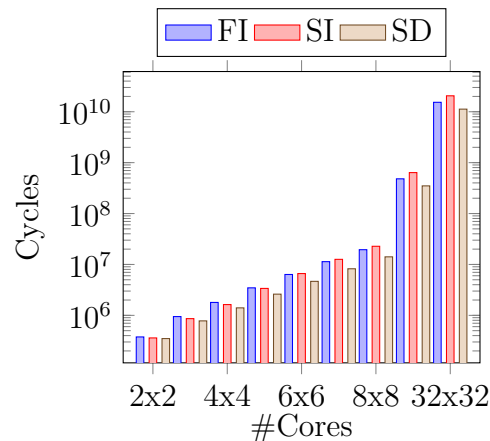


Figure 3.5.: pgf diagram 2

### 3.3. Mathematical Symbols

Mathematical formulas in texts are marked by \$ signs, e.g.  $E = mc^2$ . Separate formulas are set in the following way:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

If you want to enumerate formulas use the `equation` environment:

$$F(x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^x \exp\left(-\frac{(t-\mu)^2}{2\sigma^2}\right) dt \quad (3.1)$$

The formula can now be referenced in the text using `\eqref`: Equation (3.1).

Please note that in mathematical mode, L<sup>A</sup>T<sub>E</sub>X regards each character as own variable. The character string *size* is therefore set as the product of the variables *s*, *i*, *z* and *e* (the multiplication sign is usually not specified). If you want to use a variable with a longer name instead, set this with `\mathit{...}`, e.g. *size*. If you look closely, you will see that in this case the character spacing is set differently.

### 3.4. External References

Literature references are managed using BibTeX. For this purpose the references are stored in a file of their own (e.g. `thesis.bib`) and provided with abbreviations. These can then be referenced in the text. Note that you now have to “translate” your document twice. Between the two `latex` or `pdflatex` calls you must call `bibtex`. More information on this and on using L<sup>A</sup>T<sub>E</sub>X in general can be found in [Kop00] and online.



Here is an example for an internet reference [Hei] and one for a reference with multiple authors [LL73].

## 3.5. Helpers

The following packages are a great help when working with L<sup>A</sup>T<sub>E</sub>X to write your thesis:

**acro** allows you to conveniently use abbreviations without having to track them yourself. You do not have to keep track whether they have already been used in a particular place. Using `\DeclareAcronym{id}{short=...,long=...}` in the document preamble, you can define the acronyms. In the text the acronym is then used by means of `\ac{id}`. The first time it is used, the long name is generated, as for example in “operating system (OS),” for later use only the the abbreviation is output, e.g., “OS.” You can generate a list of all existing acronyms with `\printacronyms`.

**todonotes** are helpful for the ongoing work on the document. They can be used to create marginal notes, e.g., for later editing. This package can also be used to create placeholder graphics like the one in Figure 3.1. Using `\todotoc` you can get a list of all existing todo notes.

Yes, the quotes are set correctly in English like this. :)

Example  
todo note



## 4. Conclusion and Outlook

In the conclusion, you summarize your most important findings and contribution. It is generally a good idea to keep this short, e.g., 1 page for conclusions and 1-2 pages for an outlook (“What should be done next?”). But make sure to check these recommendations with your supervisor.



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# List of Tables

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# Bibliography

- [GD09] Hilary Glasman-Deal. *Science research writing for non-native speakers of English*. World Scientific, 2009.
- [Hei] *Heise online*. Abgerufen am 22.02.2022. URL: <http://www.heise.de/>.
- [Kes07] Srinivasan Keshav. “How to Read a Paper”. In: *SIGCOMM Computer Communication Review* 37.3 (July 2007), pp. 83–84. ISSN: 0146-4833. DOI: 10.1145/1273445.1273458. URL: <http://doi.acm.org/10.1145/1273445.1273458>.
- [Kop00] Helmut Kopka. *L<sup>A</sup>T<sub>E</sub>X, Band 1*. Addison-Wesley Verlag, 2000.
- [LL73] Chung Laung Liu and James W. Layland. “Scheduling Algorithms for Multiprogramming in a Hard-Real-Time Environment”. In: *Journal of the ACM* 20.1 (Jan. 1973), pp. 46–61. ISSN: 0004-5411. DOI: 10.1145/321738.321743. URL: <http://doi.acm.org/10.1145/321738.321743>.



# **A. Appendix Chapter**

If you want to include information in your paper that is only marginally relevant to the understanding of your work, create an appendix for this purpose.

## **A.1. foo**

## **A.2. bar**



## **B. Second Appendix Chapter**

