

Thesis Title

Bachelor Thesis
John Smith

Thesis Title

Bachelor Thesis

Bearbeitung:	John Smith
Matrikelnummer:	1234567
Abgabetermin:	01.01.1900

Aufgabenstellung:	Prof. Dr. Stefan Brunthaler
Zweitprüfer:	Prof. Dr. Max Mustermann
Betreuung:	M.Sc. Max Mustermann

Kurzfassung

Es muss immer eine Kurzfassung auf Deutsch geben (unabhängig davon, ob man die Abschlussarbeit in Englisch verfasst). Die Kurzfassung ist der s.g. "Abstract". Das ist eine kurze Zusammenfassung der Arbeit, welche nicht länger als eine Seite sein darf.

Abstract

If you are writing your thesis in English, you also need to provide an English Abstract. Content-wise it should be the same as the German. Also, it should not be longer than one page.

If you happen to write in German, you can safely omit the English Abstract.

Contents

Kurzfassung	iii
Abstract	v
Contents	vii
1 Introduction	1
2 Background	3
3 Related Work	5
4 Design	7
5 Implementation	9
6 Evaluation	11
7 Conclusion	13
7.1 Future Work	13
7.2 Summary	13
8 L^AT_EX Guide and Examples	15
8.1 Welcome	15
8.2 Learning L ^A T _E X	15
8.2.1 A (not so short) Introduction to L ^A T _E X	15
8.2.2 A Short Math Guide for L ^A T _E X	16
8.2.3 Common L ^A T _E X Math Symbols	16
8.2.4 L ^A T _E X on a Mac	16
8.3 Getting Started with this Template	16
8.3.1 About this Template	16
8.4 What this Template Includes	17
8.4.1 Folders	17
8.4.2 Files	17
8.5 Filling in Your Information in the <code>main.tex</code> and <code>settings.tex</code> Files . .	17
8.6 Thesis Features and Conventions	18
8.6.1 Printing Format	18
8.6.2 References	18
A Note on <code>bibtex</code>	19
8.6.3 Tables	19
8.6.4 Figures	19
8.6.5 Typesetting mathematics	21
8.7 Sectioning and Subsectioning	22
8.8 Source Code Listings	22

8.9	Acronyms	23
8.10	Lists and Enumerations	23
8.11	Referencing	23
8.12	In Closing	24
9	Chapter Title Here	25
9.1	Main Section 1	25
9.1.1	Subsection 1	25
9.1.2	Subsection 2	25
9.2	Main Section 2	25
A	Frequently Asked Questions	27
A.1	How do I change the colors of links?	27
	Bibliography	29
	List of Figures	31
	List of Tables	33
	List of Code Examples	35
	List of Abbreviations	37

Chapter 1

Introduction

Chapter 2

Background

Chapter 3

Related Work

Chapter 4

Design

Chapter 5

Implementation

Chapter 6

Evaluation

Chapter 7

Conclusion

7.1 Future Work

7.2 Summary

Chapter 8

L^AT_EX Guide and Examples

8.1 Welcome

Welcome to this L^AT_EX Thesis Template, a nicely looking and easy to use template for writing a thesis using the L^AT_EX typesetting system.

If you are writing a thesis (or will be in the future) and its subject is technical or mathematical (though it doesn't have to be), then creating it in L^AT_EX is highly recommended as a way to make sure you can just get down to the essential writing without having to worry over formatting or wasting time arguing with your word processor.

L^AT_EX is easily able to professionally typeset documents that run to hundreds or thousands of pages long. With simple mark-up commands, it automatically sets out the table of contents, margins, page headers and footers and keeps the formatting consistent. One of its main strengths is the way it can easily typeset mathematics, even *heavy* mathematics. Even if those equations are the most horribly twisted and most difficult mathematical problems that can only be solved on a super-computer, you can at least count on L^AT_EX to make them look good.

8.2 Learning L^AT_EX

L^AT_EX is not a WYSIWYG (What You See is What You Get) program, unlike word processors such as Microsoft Word or Apple's Pages. Instead, a document written for L^AT_EX is actually a simple, plain text file that contains *no formatting*. You tell L^AT_EX how you want the formatting in the finished document by writing in simple commands amongst the text, for example, if I want to use *italic text for emphasis*, I write the `\emph{text}` command and put the text I want in italics in between the curly braces. This means that L^AT_EX is a "mark-up" language, very much like HTML.

8.2.1 A (not so short) Introduction to L^AT_EX

If you are new to L^AT_EX, there is a very good eBook – freely available online as a PDF file – called, "The Not So Short Introduction to L^AT_EX". The book's title is typically shortened to just *lshort*. You can download the latest version (as it is occasionally updated) from here: <http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf>

It is also available in several other languages. Find yours from the list on this page: <http://www.ctan.org/tex-archive/info/lshort/>

Making the effort now means you're not stuck learning the system when what you *really* need to be doing is writing your thesis.

8.2.2 A Short Math Guide for \LaTeX

If you are writing a technical or mathematical thesis, then you may want to read the document by the AMS (American Mathematical Society) called, “A Short Math Guide for \LaTeX ”. It can be found online here: <http://www.ams.org/tex/amslatex.html> under the “Additional Documentation” section towards the bottom of the page.

8.2.3 Common \LaTeX Math Symbols

There are a multitude of mathematical symbols available for \LaTeX and it would take a great effort to learn the commands for them all. The most common ones you are likely to use are shown on this page: <http://www.sunilpatel.co.uk/latex-type/latex-math-symbols/>

You can use this page as a reference or crib sheet, the symbols are rendered as large, high quality images so you can quickly find the \LaTeX command for the symbol you need.

8.2.4 \LaTeX on a Mac

The \LaTeX distribution is available for many systems including Windows, Linux and Mac OS X. The package for OS X is called MacTeX and it contains all the applications you need – bundled together and pre-customized – for a fully working \LaTeX environment and work flow.

MacTeX includes a custom dedicated \LaTeX editor called TeXShop for writing your ‘.tex’ files and BibDesk: a program to manage your references and create your bibliography section just as easily as managing songs and creating playlists in iTunes.

8.3 Getting Started with this Template

If you are familiar with \LaTeX , then you should explore the directory structure of the template and then proceed to place your own information into the `main.tex` and `settings.tex` files.

If you are new to \LaTeX it is recommended that you carry on reading through the rest of the information in this document, as it contains useful examples that you can borrow while writing your thesis, and thus save valuable time.

8.3.1 About this Template

This \LaTeX Thesis Template is originally based and created around a \LaTeX style file created by Steve R. Gunn from the University of Southampton (UK), department of Electronics and Computer Science. You can find his original thesis style file at his site, here: <http://www.ecs.soton.ac.uk/~srg/softwaretools/document/templates/>

Steve’s `ecsthesis.cls` was then taken by Sunil Patel who modified it by creating a skeleton framework and folder structure to place the thesis files in. The resulting template can be found on Sunil’s site here: <http://www.sunilpatel.co.uk/thesis-template>

Sunil’s template was made available through <http://www.LaTeXTemplates.com> where it was modified many times based on user requests and questions. Version 2.0 and onwards of this template represents a major modification to Sunil’s template

and is, in fact, hardly recognisable. The work to make version 2.0 possible was carried out by [Vel](#) and Johannes Böttcher.

Subsequently, Vasil Sarafov from Munich's Computer Systems Research Laboratory (<https://ucsr1.de>), Department of Informatics, University of the Bundeswehr Munich, forked the template from <http://www.LaTeXTemplates.com> and heavily modified it to satisfy the university's requirements. Some parts of version 2.0 can still be found in the `style.cls` code. However, large portions of the code has been overhauled.

8.4 What this Template Includes

8.4.1 Folders

This template comes as a single zip file that expands out to several files and folders. The folder names are mostly self-explanatory:

root – the root directory contains almost everything: settings, styles, chapters, appendices.

figures – this folder contains all figures for the thesis.

build – this folder is created automatically when you build the \LaTeX source code using the `Makefile`. The build process will put there all intermediate files, and finally will obtain `main.pdf` – the compiled pdf document.

8.4.2 Files

Included are also several files, most of them are plain text and you can see their contents in a text editor:

lit.bib – this is an important file that contains all the bibliographic information and references that you will be citing in the thesis for use with BibTeX. You can write it manually, but there are reference manager programs available that will create and manage it for you. Bibliographies in \LaTeX are a large subject and you may need to read about BibTeX before starting with this. Many modern reference managers will allow you to export your references in BibTeX format which greatly eases the amount of work you have to do.

style.cls – this is an important file. It is the class file that tells \LaTeX how to format the thesis. You generally will not need to modify it (i.e. you can safely ignore it).

main.pdf – this is your beautifully typeset thesis (in the PDF file format) created by \LaTeX . It is supplied in the PDF with the template and after you compile the template you should get an identical version.

main.tex – this is the core source file that defines your thesis. It includes everything else and tells \LaTeX how to produce your thesis as a PDF file. It is heavily commented so you can read exactly what each line of code does and why it is there.

settings.tex – self-explanatory. This file is included by `main.tex`.

8.5 Filling in Your Information in the `main.tex` and `settings.tex` Files

You will need to personalise the thesis template and make it your own by filling in your own information. This is done by editing the `main.tex` and `settings.tex` files in a text editor or your favourite \LaTeX environment.

Fill out the information about yourself, and your thesis (e.g. its title).

When you have done this, save the file and recompile with `make`.

8.6 Thesis Features and Conventions

To get the best out of this template, there are a few conventions that you may want to follow.

One of the most important (and most difficult) things to keep track of in such a long document as a thesis is consistency. Using certain conventions and ways of doing things (such as using a Todo list) makes the job easier. Of course, all of these are optional and you can adopt your own method.

8.6.1 Printing Format

This thesis template is designed for double sided printing (i.e. content on the front and back of pages) as most theses are printed and bound this way. Switching to one sided printing is as simple as uncommenting the *oneside* option of the `documentclass` command at the top of the `settings.tex` file.

The text is set to 11 point by default with single line spacing, again, you can tune the text size and spacing should you want or need to using the options at the very start of `settings.tex`. The spacing can be changed similarly by replacing the *singlespacing* with *onehalfspacing* or *doublespacing*.

The paper size used in the template is A4, which is the standard size in Germany (and whole of Europe).

8.6.2 References

The `biblatex` package is used to format the bibliography and inserts references such as this one (Hawthorn, Weber, and Scholten, 2001). The options used in the `settings.tex` file mean that the in-text citations of references are formatted with the author(s) listed with the date of the publication. Multiple references are separated by semicolons (e.g. (Wieman and Hollberg, 1991; Hawthorn, Weber, and Scholten, 2001)) and references with more than three authors only show the first author with *et al.* indicating there are more authors (e.g. (Arnold et al., 1998)). This is done automatically for you. To see how you use references, have a look at the `guide.tex` source file, which is rendered below. Many reference managers allow you to simply drag the reference into the document as you type.

Scientific references should come *before* the punctuation mark if there is one (such as a comma or period). The same goes for footnotes¹. You can change this but the most important thing is to keep the convention consistent throughout the thesis. Footnotes themselves should be full, descriptive sentences (beginning with a capital letter and ending with a full stop). The APA6 states: "Footnote numbers should be superscripted, [...], following any punctuation mark except a dash." The Chicago manual of style states: "A note number should be placed at the end of a sentence or clause. The number follows any punctuation mark except the dash, which it precedes. It follows a closing parenthesis."

The bibliography is typeset with references listed in alphabetical order by the first author's last name. This is similar to the APA referencing style. To see how L^AT_EX typesets the bibliography, have a look at the very end of this document (or just click on the reference number links in in-text citations).

¹Such as this footnote, here down at the bottom of the page.

Groups	Treatment X	Treatment Y
1	0.2	0.8
2	0.17	0.7
3	0.24	0.75
4	0.68	0.3

Table 8.1: The effects of treatments X and Y on the four groups studied.

A Note on bibtex

The bibtex backend used in the template by default does not correctly handle unicode character encoding (i.e. "international" characters). You may see a warning about this in the compilation log and, if your references contain unicode characters, they may not show up correctly or at all. The solution to this is to use the biber backend instead of the outdated bibtex backend. This is done by finding this in `settings.tex`: `backend=bibtex` and changing it to `backend=biber`. You will then need to delete all auxiliary BibTeX files and navigate to the template directory in your terminal (command prompt). Once there, simply type `biber main` and `biber` will compile your bibliography. You can then compile `main.tex` as normal and your bibliography will be updated. An alternative is to set up your LaTeX editor to compile with biber instead of bibtex, see [here](#) for how to do this for various editors.

8.6.3 Tables

Tables are an important way of displaying your results, below is an example table which was generated with this code:

```
\begin{table}
\centering
\begin{tabular}{l l l}
\toprule
\thead{Groups} & \thead{Treatment X} & \thead{Treatment Y} \\
\midrule
1 & 0.2 & 0.8\\
2 & 0.17 & 0.7\\
3 & 0.24 & 0.75\\
4 & 0.68 & 0.3\\
\bottomrule
\end{tabular}
\end{table}
\caption{The effects of treatments X and Y on the four groups studied.}
\label{tab:treatments}
```

You can reference tables with `\ref{<label>}` where the label is defined within the table environment. Alternatively, you can use `\Cref{<label>}`, which will also include the object's type: Table [8.1](#).

8.6.4 Figures

There will hopefully be many figures in your thesis (that should be placed in the *Figures* folder). The way to insert figures into your thesis is to use a code template like this:

```
\begin{figure}
\centering
\includegraphics{figures/electron}
\decoRule
\caption[An Electron]{An electron (artist's impression).}
\label{fig:Electron}
\end{figure}
```

Also look in the source file. Putting this code into the source file produces the picture of the electron that you can see in the figure below.



Figure 8.1: An electron (artist's impression).

Sometimes figures don't always appear where you write them in the source. The placement depends on how much space there is on the page for the figure. Sometimes there is not enough room to fit a figure directly where it should go (in relation to the text) and so \LaTeX puts it at the top of the next page. Positioning figures is the job of \LaTeX and so you should only worry about making them look good!

Figures usually should have captions just in case you need to refer to them (such as in Figure 8.1). The `\caption` command contains two parts, the first part, inside the square brackets is the title that will appear in the *List of Figures*, and so should be short. The second part in the curly brackets should contain the longer and more descriptive caption text.

The `\decoRule` command is optional and simply puts an aesthetic horizontal line below the image. If you do this for one image, do it for all of them.

\LaTeX is capable of using images in pdf, jpg and png format. However, you should generally aim for high-quality vector images (e.g., pdf, or svg), as lower-resolution figures look bad when printed.

Here is another example for an image (cf. Figure 8.2), which has been reduced to fit better on the page:



Figure 8.2: A scaled representation of an electron.

The code used to render this scaled image is as follows (mind the width parameter passed to `\includegraphics`):

```
\begin{figure}[th]
\centering
\includegraphics[width=0.4\columnwidth]{figures/electron}
\decoRule
\caption[A Scaled Electron]{A scaled representation of an electron.}
\label{fig:scaled-electron}
\end{figure}
```

The next example uses `\minipage` to put two images side by side (cf. Figure 8.3):



Figure 8.3: A divided, side-by-side image

8.6.5 Typesetting mathematics

If your thesis is going to contain heavy mathematical content, \LaTeX can render them without any problems.

The “Not So Short Introduction to \LaTeX ” (available on [CTAN](#)) should tell you everything you need to know for most cases of typesetting mathematics. If you need more information, a much more thorough mathematical guide is available from the AMS called, “A Short Math Guide to \LaTeX ” and can be downloaded from: <ftp://ftp.ams.org/pub/tex/doc/amsmath/short-math-guide.pdf>

There are many different \LaTeX symbols to remember, luckily you can find the most common symbols in [The Comprehensive \$\text{\LaTeX}\$ Symbol List](#).

You can write an equation, which is automatically given an equation number by \LaTeX like this:

```
\begin{equation}
```

```
E = mc^{2}
\label{eqn:Einstein}
\end{equation}
```

This will produce Einstein’s famous energy-matter equivalence equation:

$$E = mc^2 \tag{8.1}$$

All equations you write (which are not in the middle of paragraph text) are automatically given equation numbers by *L^AT_EX*. If you don’t want a particular equation numbered, use the unnumbered form:

```
\[ a^{2}=4 \]
```

which will render to

$$a^2 = 4$$

8.7 Sectioning and Subsectioning

You should break your thesis up into nice, bite-sized sections and subsections. *L^AT_EX* automatically builds a Table of Contents by looking at all the `\chapter{}`, `\section{}` and `\subsection{}` commands you write in the source.

The Table of Contents should only list the sections to three (3) levels. A `\chapter{}` is level zero (0). A `\section{}` is level one (1) and so a `\subsection{}` is level two (2). In your thesis it is likely that you will even use a `\subsubsection{}`, which is level three (3). The depth to which the Table of Contents is formatted is set within `style.cls`. If you need this changed, you can do it in `main.tex`.

If you want a chapter, section, or subsection to be skipped from the Table of Contents, you can append an asterisk, like so: `\chapter*{}`, `\section*{}`, and `\subsection*{}`.

8.8 Source Code Listings

You can add source code snippets, like on Listing 8.1, Listing 8.2, and Listing 8.3 on the facing page, using the `\begin{listing}[...]` environment. The documentation for this package is at <https://mirror.physik.tu-berlin.de/pub/CTAN/macros/latex/contrib/listings/listings.pdf>.

```
1 int main(int argc, char **argv) {
2     int x = 0;
3     scanf("%d", &x);
4     printf("%d\n", x);
5     /* some comment */
6     return 0;
7 }
```

Listing 8.1: C code snippet

```
1 class A:
2     def __init__(x):
3         self.x = x
4
5 if __name__ == "__main__":
6     # another comment
7     print("Hello World!")
```

Listing 8.2: Python code snippet


```
1 #!/bin/sh
2 echo 'starting'
3 find . -type f -name '*.bin'
4 echo 'finished'
5 exit 0
```

Listing 8.3: Code snippet in POSIX shell

8.9 Acronyms

You can use acronyms like this: The Central Processing Unit (**CPU**) is something very important (with `\ac{}`). Generally, a computer does not have multiple **CPUs** (with `\acp{}` for the plural form). If you want, you can restate the acronym as if it were mentioned for the first time, like so: Central Processing Unit (**CPU**) (with `\acf{}`).

The documentation for this package includes more examples and describes all usage patterns. You can find it here: <https://mirror.funkfreundelandshut.de/latex/macros/latex/contrib/acronym/acronym.pdf>.

8.10 Lists and Enumerations

This is a classic enumeration with one entry per line, done with `\begin{enumerate}`:

- (1) First item;
- (2) Second item;
- (3) Third item.

This is an inline enumeration with the `\begin{enumerate*}` environment: (1) first item, (2) second item, and (3) third item.

This is a classic list with one entry per line via `\begin{itemize}`:

- First item;
- Second item;
- Third item.

This is an inline list of items using `\begin{itemize*}`: • First item; • Second item; • Third item.

8.11 Referencing

With this template you have three ways how to reference labeled entities (i.e., figures, tables, listings, etc.):

- (1) `\ref{}` prints only the entity's id: [8.1](#)
- (2) `\Cref{}` automatically prints the entity's type followed by its id: Figure [8.1](#)
- (3) `\Vref{}` automatically adds text to describe where the entity is located, so that the reader can find it more easily: Figure [8.1](#) on page [20](#).

8.12 In Closing

You have reached the end of this mini-guide.

The easy work of setting up the structure and framework has been taken care of for you. It's now your job to fill it out! Don't forget to also delete/comment out whatever you don't need.

Good luck and have lots of fun!

Chapter 9

Chapter Title Here

9.1 Main Section 1

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Aliquam ultricies lacinia euismod. Nam tempus risus in dolor rhoncus in interdum enim tincidunt. Donec vel nunc neque. In condimentum ullamcorper quam non consequat. Fusce sagittis tempor feugiat. Fusce magna erat, molestie eu convallis ut, tempus sed arcu. Quisque molestie, ante a tincidunt ullamcorper, sapien enim dignissim lacus, in semper nibh erat lobortis purus. Integer dapibus ligula ac risus convallis pellentesque.

9.1.1 Subsection 1

Nunc posuere quam at lectus tristique eu ultrices augue venenatis. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Aliquam erat volutpat. Vivamus sodales tortor eget quam adipiscing in vulputate ante ullamcorper. Sed eros ante, lacinia et sollicitudin et, aliquam sit amet augue. In hac habitasse platea dictumst.

9.1.2 Subsection 2

Morbi rutrum odio eget arcu adipiscing sodales. Aenean et purus a est pulvinar pellentesque. Cras in elit neque, quis varius elit. Phasellus fringilla, nibh eu tempus venenatis, dolor elit posuere quam, quis adipiscing urna leo nec orci. Sed nec nulla auctor odio aliquet consequat. Ut nec nulla in ante ullamcorper aliquam at sed dolor. Phasellus fermentum magna in augue gravida cursus. Cras sed pretium lorem. Pellentesque eget ornare odio. Proin accumsan, massa viverra cursus pharetra, ipsum nisi lobortis velit, a malesuada dolor lorem eu neque.

9.2 Main Section 2

Sed ullamcorper quam eu nisl interdum at interdum enim egestas. Aliquam placerat justo sed lectus lobortis ut porta nisl porttitor. Vestibulum mi dolor, lacinia molestie gravida at, tempus vitae ligula. Donec eget quam sapien, in viverra eros. Donec pellentesque justo a massa fringilla non vestibulum metus vestibulum. Vestibulum in orci quis felis tempor lacinia. Vivamus ornare ultrices facilisis. Ut hendrerit volutpat vulputate. Morbi condimentum venenatis augue, id porta ipsum vulputate in. Curabitur luctus tempus justo. Vestibulum risus lectus, adipiscing nec condimentum quis, condimentum nec nisl. Aliquam dictum sagittis velit sed iaculis. Morbi tristique augue sit amet nulla pulvinar id facilisis ligula mollis. Nam elit libero, tincidunt ut aliquam at, molestie in quam. Aenean rhoncus vehicula hendrerit.

Appendix A

Frequently Asked Questions

A.1 How do I change the colors of links?

The color of links can be changed to your liking using:

```
\hypersetup{urlcolor=red}, or  
\hypersetup{citecolor=green}, or  
\hypersetup{allcolor=blue}.
```

If you want to completely hide the links, you can use:

```
\hypersetup{allcolors=.}, or even better:  
\hypersetup{hidelinks}.
```

If you want to have obvious links in the PDF but not the printed text, use:

```
\hypersetup{colorlinks=false}.
```


Bibliography

- Arnold, A. S. et al. (Mar. 1998). "A Simple Extended-Cavity Diode Laser". In: *Review of Scientific Instruments* 69.3, pp. 1236–1239. URL: <http://link.aip.org/link/?RSI/69/1236/1>.
- Hawthorn, C. J., K. P. Weber, and R. E. Scholten (Dec. 2001). "Littrow Configuration Tunable External Cavity Diode Laser with Fixed Direction Output Beam". In: *Review of Scientific Instruments* 72.12, pp. 4477–4479. URL: <http://link.aip.org/link/?RSI/72/4477/1>.
- Wieman, Carl E. and Leo Hollberg (Jan. 1991). "Using Diode Lasers for Atomic Physics". In: *Review of Scientific Instruments* 62.1, pp. 1–20. URL: <http://link.aip.org/link/?RSI/62/1/1>.

List of Figures

8.1	An Electron	20
8.2	A Scaled Electron	21
8.3	A divided, side-by-side image	21

List of Tables

8.1 The effects of treatments X and Y on the four groups studied. 19

List of Code Examples

- 8.1 C code snippet 22
- 8.2 Python code snippet 22
- 8.3 Code snippet in POSIX shell 23

List of Abbreviations

KB Kilobyte

MB Megabyte

GB Gigabyte

TB Terabyte

BB Basic Block

CFG Control-flow Graph

HDD Hard Disk Drive

SSD Solid-state Drive

USB Universal Serial Bus

RAM Random-access Memory

AST Abstract Syntax Tree

CPU Central Processing Unit

Hiermit versichere ich, dass die vorliegende Arbeit selbständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt wurden.

Ferner habe ich vom Merkblatt über die Verwendung von Bachelorarbeit Kenntnis genommen und räume das einfache Nutzungsrecht an meiner Bachelorarbeit der Universität der Bundeswehr München ein.

Neubiberg, den 01.01.1900

(Unterschrift des Kandidaten)