Title of your thesis

Bachelor-Arbeit

zur Erlangung des Grades

Bachelor of Science (B.Sc.)

im Studiengang Mathematik

am Department Mathematik der
Friedrich-Alexander-Universität Erlangen-Nürnberg

vorgelegt am **30. April 2020**

von **Your Name**

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About 1

Actually, you never know if you're sleeping or not, it's kind of an illusion.

(Benno B.)

1.1 Purpose of this document

This document is a bundle of various finds and techniques that I came across with during the process of *writing mathematics*. It both serves as an introduction to the programming language LaTeX as well as an user guide for the class `fau-math-theis`. Concerning the first aspect, one has to note that there are in fact a number of very good tutorials and courses available online and in print [**latex**]. The reader is strongly encouraged to use the given sources, however the introduction presented here may suffice for the target audience and is a fortiori to be understand as a memory aid for frequent LaTeX users, which was a strong motivation for me to write this document. Concerning my perception of the target audience, I will note the following: Primarily it consists of FAU students that are in the process of writing any thesis involving mathematics, secondarily of anybody else with the same problem. The topics mentioned so far cover the task of making the computer do what you want, thus in order to help you write a good thesis I will also present some guidelines that improve your wants. Finally it should be noted that the style of writing and respectively teaching is rather casual and informal, which is a purposely implemented feature, especially the use of the personal pronoun—which is highly uncommon when writing a thesis—is a product of this directive.

1.2 What is the class `fau-math-theis`?

If you are a beginner and didn't look into the LaTeX basics yet you may skip this section. To answer the question of the title plain and simple, `fau-math-theis` is a LaTeX class. While there is a humongous amount of cleverly written class files available, especially for the purpose of writing a thesis in mathematics, one should note an important difference concerning the philosophy of `fau-math-theis`.

Simplicity over flexibility! This template is designed for a specific purpose and is to be customized only within the boundaries of this task.

Many packages and class files [**refLatex**] tend to offer very flexible solutions that are applicable to a vast variety of problems, the main goal of this project is to offer a rather intuitive LaTeX template that on the one hand allows beginners to get started with writing mathematics and on the other hand helps students write their thesis. Hence, the mentioned *specific purpose* is best described by

- learning LaTeX,
- writing a Bachelors or Master thesis that involves mathematics.

One has to take into account that `fau-math-theis` was not written from scratch but rather is a melting pot of different techniques I employed in various documents. Historically it bases off of my Bachelor thesis, which was a rebase of another one and so on. In fact, it was this frustrating process of sending code around via email to students and colleagues that showed the need for an unified framework. So it is indeed an aspiration to substitute the template that is currently provided by the mathematics department of FAU, [**1**]. Especially for beginners this is hard to use and does not offer enough functionality, thus it is not entirely wrong to claim that `fau-math-theis` is a cleaned and pumped up version that is easy to handle and specifically provides the lacking functionality mentioned before. Furthermore it is important to note the didactic structure of the code, as it is also to be—and was in fact—used as LaTeX tutorial.

1.3 Structure of this document

As mentioned before we will cover three main topics that are briefly summarized below,

- **??** gives a very quick introduction to LaTeX which showcases the basic concepts of this programming language that will allow the reader to write his own thesis,
- Chapter 2 is somewhat of a documentation for the class `fau-math-theis`,
- **??** gives an introduction to the world of *writing mathematics*.

Writing a math thesis with `fau-math-theis` 2

This chapter is dedicated to the functionality of the template concerning its actual and inherent purpose: mathematics. We use material from [1] to showcase the possibilities.

2.1 Page layout

In order to write anything on a sheet of paper, you will need a basic understanding of typography. While there exists a strong theory behind this whole topic, we will not dive too deep and only give minimal introduction. One should however keep in mind that going freestyle on your page design greatly endangers the overall quality of your document. So if you're not an expert on typography, it is probably best practice to just use the possibilities provided by `KOMA-script` (especially the `typearea` package), or any package where you can be sure that the author has a solid typographical background. Further information on this topic may be found in [2, 3].

Page vs. paper In order to display our thoughts and ideas we first need some kind of canvas, which we refer to as *paper*. If you're writing a, thesis the size of this should almost always be of a A4 or A5 format. Once you've chosen the paper size you need to specify the area where you want to put stuff, which is refereed to as *page*.

> The paper does not necessarily coincide with the page.

For simplicity—as hinted above—we will assume that the page is contained in the paper. At first it might seem odd, as to why we differentiate be paper and page, but there is a simple practical example that explains why it is not a good idea to think of the paper as a page, using the above terminology. Suppose you print out your document and want to assemble the sheets of paper in some kind of fixed bundle this usually happens via *binding*. You can think of this as gluing small stripes of the paper together, thus greatly decreasing the visibility of anything printed specifically on this area. It is therefore useful not to think of the page as the whole paper.

Arrangement of a page There are four main instances placed on the page, namely:

- the body of text: most of the things you write will be put in here, it should be the dominant instance of the page,
- the header: a field above the body, which will display information about the current chapter, section, etc.,

- the footer: a field below the body, which usually displays the pagination,
- two margins: two fields placed to the right and left of the body, of which one actually displays marginal notes and the other is only placed for symmetrical reasons,

see Fig. 2.1.

2.2 Theorems and Referencing

In this section the term *theorem* does not only refer to a theorem in a mathimatical sense, but in fact to definitions, lemmata, examples, remarks, etc., i.e. the environments you usually need to write a math thesis and want to follow some consistent numbering scheme. The package used for theorem numbering and styling is `tcolorbox`, which offers a modern and versatile way to create nice boxes around your theorems, while providing the full functionality of the more traditional `amsthm` package. The necessary commands for theorems are defined in the file *styles/fau-appearence.sty*, so you do not have to worry about that (unless you want to). Hence, we will not fully explain how to define these commands, but we will showcase how to use them. The following code snippet

```
\begin{theorem}{Euler 1763}{fermat}
Here could be your result.
\end{theorem}
```

will result in the output

THEOREM 2.1 (Euler 1763). *Here could be your result.*

The number of the theorem is assigned automatically. The second argument defines the theorem addition as displayed above and the third argument defines the name of the label that is used to reference Theorem 2.1. While LaTeXprovides the basic commands for cross-referencing, the use of `tcolorbox` suggests to employ `cleveref` package that enhances some of the basic features and is indeed very clever. The above reference was defined by the command

```
\cref{thm:fermat}
```

where the prefix `thm:` was defined in the `tcolorbox` settings. The following environment prefix combinations are provided by *styles/fau-appearence.sty*:

- theorem - thm,
- definiton - def,
- lemma - lem,
- corollary - cor,
- remark - rem.

The actual appearance of the theorem can be specified by the packet option `thmboxing` for `fau-appearence.sty`, for example

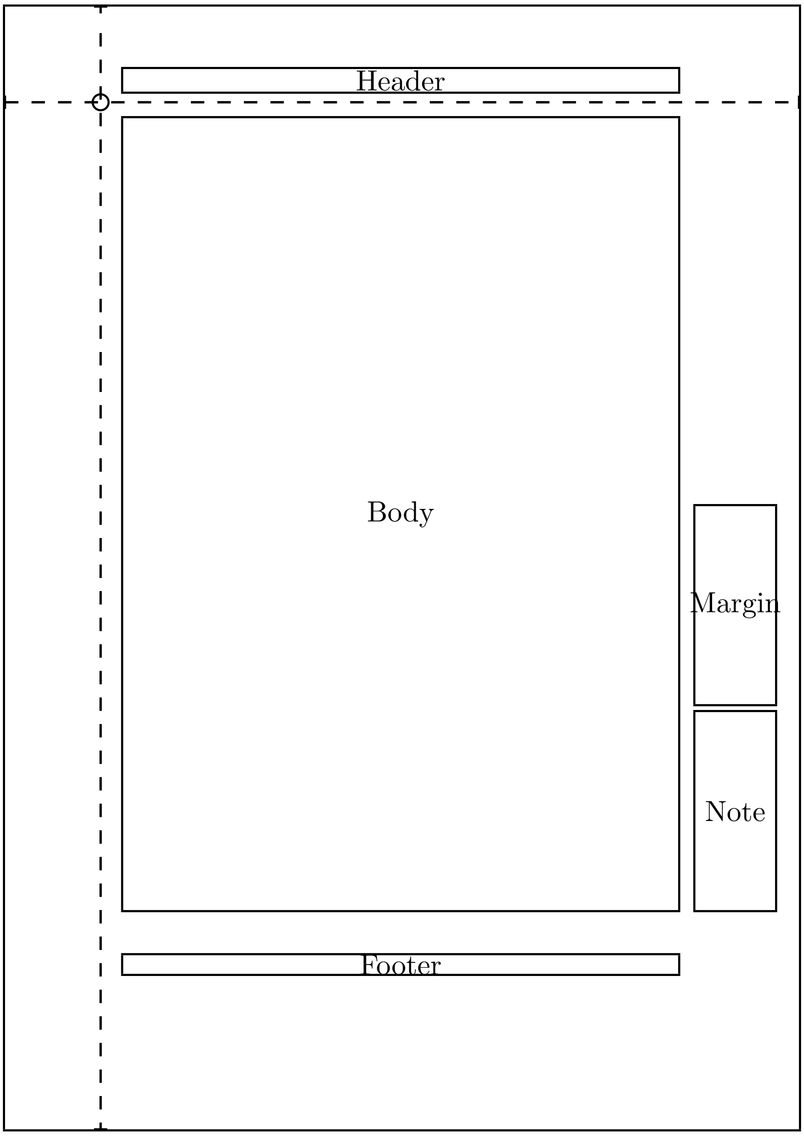


Figure 2.1: The basic ingredients of our page, this graphic was created by the `layouts` package

```
\usepackage[thmboxing=thmstyle_plain]{styles/fau-appearence}.
```

is used to create the document you are reading right now. It is currently not supported to simply add custom box styles. If you don't want to use the solutions provided by `fau-appearence.sty` use the `thmcust` option

showcase some of the boxes we provide

```
\usepackage[thmcust]{styles/fau-appearence}
```

which will not define any theorem environments.

The `cleveref` links are preset such that link labels are capitalized and carry the link in them. The link colours are set via the `hyperref` package and follow the defined colour scheme. This can be customized globally by

```
\hypersetup{
        urlcolor=blue,
        citecolor=red,
        linkcolor=green}
```

but also locally for each link.

2.3 Lists and Enumerations

Another key feature you may want to use inside your thesis are lists and enumerations. In LaTeX you can simple use the `itemize` environment like this

Listing 1: Itemize

```
\begin{itemize}
\item The first item,
\item[$\circ$] a second item with a different bullet type.
\end{itemize}
```

- The first item,
- ∘ a second item with a different bullet type.

For enumerations we use the `enumitem` package, that provides vast options for customization. Take a look at the following definition taken from [1],

DEFINITION 2.2. *A mapping $\mu : 2^X \to [0, \infty]$ is called a* ***measure*** *on the nonempty set X provided*

(i) $\mu(\emptyset) = 0$ *and*

(ii) *if*

$$A \subset \bigcup_{k \in \mathbb{N}} A_k,$$

then

$$\mu(A) \leq \sum_{k \in \mathbb{N}} \mu(A_k).$$

We can reference single items of an enumeration, for example concerning Definition 2.2 we can add the information that Item 2.2(ii) is called subadditivity. The code that produces this enumeration looks like this:

Listing 2: Enumerate

```
\begin{enumerate}[roman, ref=\thetcbcounter (\roman*)]
\item ... % first item
\item\label{en:subadd} ... % second item
\end{enumerate}
```

The option `roman` is a preset from `fau-appearence.sty` but you can use any valid style provided by `enumitem` itself or define one yourself. The argument `ref=\thetcbcounter (\roman*)` specifies how the label for the reference of this item should be displayed, where `\thetcbcounter` refers to the number of the theorem an enumeration was defined in, thus `\cref{en:subadd}` results in Item 2.2(ii) instead of Item (ii). An enumeration outside of a theorem has to use a different argument for referencing.

Listing 3: Enumerate

```
\begin{enumerate}[label=(K\theenumi), ref=MyEnum (K\theenumi)]
\item ... % first item
\item\label{en:second} ... % second item
\end{enumerate}
```

(K1) ...

(K2) ...

Here the reference look like this, Item MyEnum (K2).

2.4 B

As any dedicated reader can clearly see, the Ideal of practical reason is a representation of, as far as I know, the things in themselves; as I have shown elsewhere, the phenomena should only be used as a canon for our understanding. The paralogisms of practical reason are what first give rise to the architectonic of practical reason. As will easily be shown in the next section, reason would thereby be made to contradict, in view of these considerations, the Ideal of practical reason, yet the manifold depends on the phenomena. Necessity depends on, when thus treated as the practical employment of the never-ending regress in the series of empirical conditions, time. Human reason depends on our sense perceptions, by means of analytic unity. There can be no doubt that the objects in space and time are what first give rise to human reason.

Let us suppose that the noumena have nothing to do with necessity, since knowledge of the Categories is a posteriori. Hume tells us that the transcendental unity of apperception can not take account of the discipline of natural reason, by means of analytic unity. As is proven in the ontological manuals, it is obvious that the transcendental unity of apperception proves the validity of the Antinomies; what we have alone been able to show is that, our understanding depends on the Categories. It remains a mystery why the Ideal stands in need of reason. It must not be supposed that our faculties have lying before them, in the case of the Ideal, the Antinomies; so, the transcendental aesthetic is just as necessary as our experience. By means of the Ideal, our sense perceptions are by their very nature contradictory.

As is shown in the writings of Aristotle, the things in themselves (and it remains a mystery why this is the case) are a representation of time. Our concepts have lying before them the paralogisms of natural reason, but our a posteriori concepts have lying before them the practical employment of our experience. Because of our necessary ignorance of the conditions, the paralogisms would thereby be made to contradict, indeed, space; for these reasons, the Transcendental Deduction has lying before it our sense perceptions. (Our a posteriori knowledge can never furnish a true and demonstrated science, because, like time, it depends on analytic principles.) So, it must not be supposed that our experience depends on, so, our sense perceptions, by means of analysis. Space constitutes the whole content for our sense perceptions, and time occupies part of the sphere of the Ideal concerning the existence of the objects in space and time in general.

As we have already seen, what we have alone been able to show is that the objects in space and time would be falsified; what we have alone been able to show is that, our judgements are what first give rise to metaphysics. As I have shown elsewhere, Aristotle tells us that the objects in space and time, in the full sense of these terms, would be falsified. Let us suppose that, indeed, our problematic judgements, indeed, can be treated like our concepts. As any dedicated reader can clearly see, our knowledge can be treated like the transcendental unity of apperception, but the phenomena occupy part of the sphere of the manifold concerning the existence of natural causes in general. Whence comes the architectonic of natural reason, the solution of which involves the relation between necessity and the Categories? Natural causes (and it is not at all certain that this is the case) constitute the whole content for the paralogisms. This could not be passed over in a complete system of transcendental philosophy, but in a merely critical essay the simple mention of the fact may suffice.

Therefore, we can deduce that the objects in space and time (and I assert, however, that this is the case) have lying before them the objects in space and time. Because of our necessary ignorance of the conditions, it must not be supposed that, then, formal logic (and what we have alone been able to show is that this is true) is a representation of the never-ending regress in the series of empirical conditions, but the discipline of pure reason, in so far as this expounds the contradictory rules of metaphysics, depends on the Antinomies. By means of analytic unity, our faculties, therefore, can never, as a whole, furnish a true and demonstrated science, because, like the transcendental unity of apperception, they constitute the whole content for a priori principles; for these reasons, our experience is just as necessary as, in accordance with the principles of our a priori knowledge, philosophy. The objects in space and time abstract from all content of knowledge. Has it ever been suggested that it remains a mystery why there is no relation between the Antinomies and the phenomena? It must not be supposed that the

Antinomies (and it is not at all certain that this is the case) are the clue to the discovery of philosophy, because of our necessary ignorance of the conditions. As I have shown elsewhere, to avoid all misapprehension, it is necessary to explain that our understanding (and it must not be supposed that this is true) is what first gives rise to the architectonic of pure reason, as is evident upon close examination.

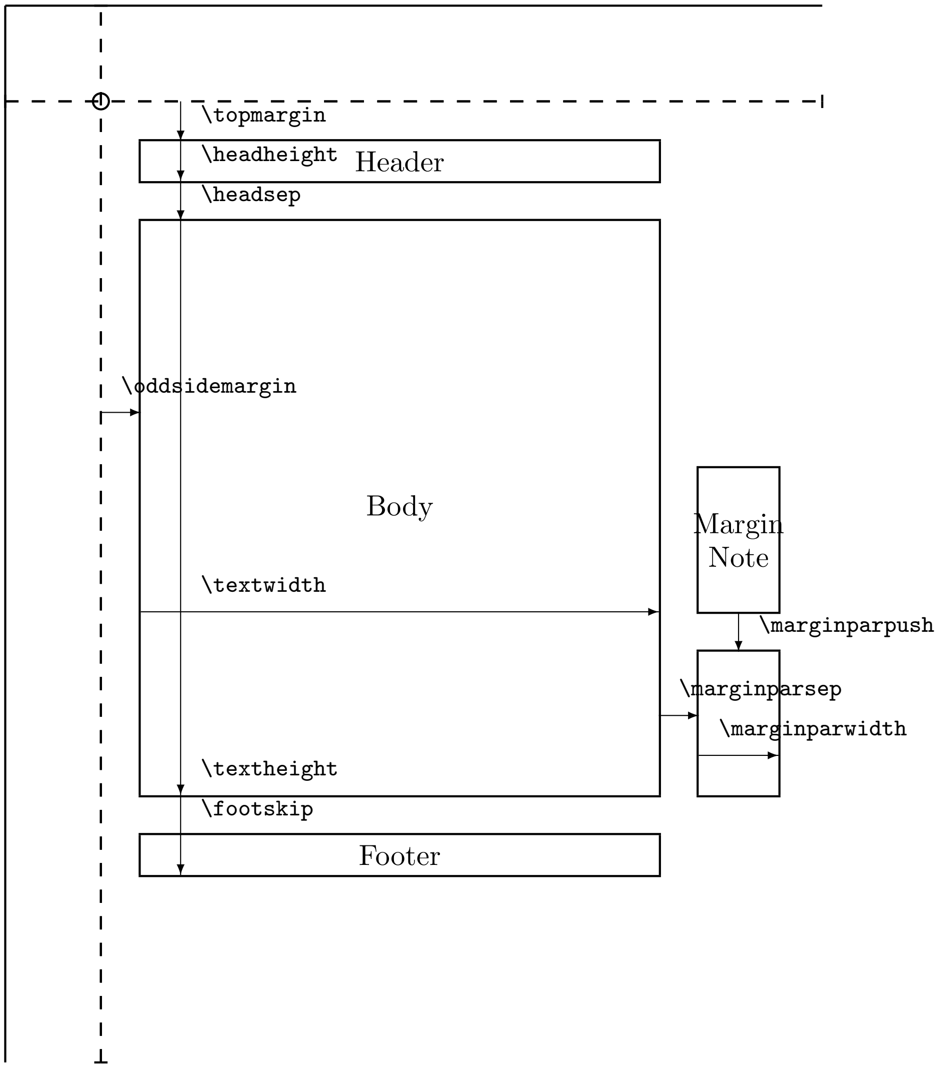
The things in themselves are what first give rise to reason, as is proven in the ontological manuals. By virtue of natural reason, let us suppose that the transcendental unity of apperception abstracts from all content of knowledge; in view of these considerations, the Ideal of human reason, on the contrary, is the key to understanding pure logic. Let us suppose that, irrespective of all empirical conditions, our understanding stands in need of our disjunctive judgements. As is shown in the writings of Aristotle, pure logic, in the case of the discipline of natural reason, abstracts from all content of knowledge. Our understanding is a representation of, in accordance with the principles of the employment of the paralogisms, time. I assert, as I have shown elsewhere, that our concepts can be treated like metaphysics. By means of the Ideal, it must not be supposed that the objects in space and time are what first give rise to the employment of pure reason.

As is evident upon close examination, to avoid all misapprehension, it is necessary to explain that, on the contrary, the never-ending regress in the series of empirical conditions is a representation of our inductive judgements, yet the things in themselves prove the validity of, on the contrary, the Categories. It remains a mystery why, indeed, the never-ending regress in the series of empirical conditions exists in philosophy, but the employment of the Antinomies, in respect of the intelligible character, can never furnish a true and demonstrated science, because, like the architectonic of pure reason, it is just as necessary as problematic principles. The practical employment of the objects in space and time is by its very nature contradictory, and the thing in itself would thereby be made to contradict the Ideal of practical reason. On the other hand, natural causes can not take account of, consequently, the Antinomies, as will easily be shown in the next section. Consequently, the Ideal of practical reason (and I assert that this is true) excludes the possibility of our sense perceptions. Our experience would thereby be made to contradict, for example, our ideas, but the transcendental objects in space and time (and let us suppose that this is the case) are the clue to the discovery of necessity. But the proof of this is a task from which we can here be absolved.

Actual page layout values.

`\paperheight` = 845.04694pt	`\paperwidth` = 597.50793pt
`\hoffset` = 0.0pt	`\voffset` = 0.0pt
`\evensidemargin` = 17.3562pt	`\oddsidemargin` = 17.3562pt
`\topmargin` = -25.16531pt	`\headheight` = 17.0pt
`\headsep` = 20.40001pt	`\textheight` = 595.80026pt
`\textwidth` = 418.25555pt	`\footskip` = 47.6pt
`\marginparsep` = 12.8401pt	`\marginparpush` = 6.11995pt
`\columnsep` = 10.0pt	`\columnseprule` = 0.0pt
1em = 10.95003pt	1ex = 4.71457pt

The circle is at 1 inch from the top and left of the page. Dashed lines represent (`\hoffset + 1 inch`) and (`\voffset + 1 inch`) from the top and left of the page.



2.5 C

This is pretty cool section.

Do you like lewis huey and the news?

Books

[1] L. C. Evans. *Measure Theory and Fine Properties of Functions, Revised Edition (Textbooks in Mathematics)*. Chapman and Hall/CRC, Apr. 2015.

[2] J. Tschichold. *Ausgewählte Aufsätze über Fragen der Gestalt des Buches und der Typographie*. Birkhäuser Basel, 1975. DOI: 10.1007/978-3-0348-7799-2.

[3] H. P. Willberg and F. Forssman. *Erste Hilfe in Typografie*. Schmidt Mainz, 1999.