



Utrecht University

Graduate School of
Natural Sciences

Welcome

to the workshop

**LaTeX Basics: How to use LaTeX
for group projects**

GSNS Intro \LaTeX -course

The basics of \LaTeX

TeXnicie

A-Eskwadraat

February 9, 2021



Table of contents

- 1 Introduction to \LaTeX
- 2 Building blocks of \LaTeX
- 3 Mathematical notation
- 4 Advanced constructions



Basics

- The *author* writes a manuscript for his book;
- The *graphic designer* creates the lay-out (columnwidth, font, spacings of headers etc.);
- The *typesetter* sets the manuscript according to the instructions.

In \LaTeX :

- \LaTeX is the graphic designer and the typesetter.
- You are only the author!
- You direct \LaTeX using commands in the editor.



Example Paper

github.com/scheinerman/SampleMathPaper

A Sample Mathematics Paper

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May 13, 2005

Abstract

This is a sample L^AT_EX paper; its purpose is to show the basics of setting up a paper and important features of L^AT_EX. It can also be used for assignments or other short notes.

1 Introduction

This is a simple L^AT_EX document designed to illustrate the basics of typesetting a paper. The ideas shown here can be adapted for a more informal document, such as a homework assignment.

This document is created from various source files, the most important of which is named `paper.tex`. By reading `paper.tex` along side the typeset output, the diligent reader should be able to deduce how various parts of L^AT_EX work. Indeed, you cannot understand everything that we did in this paper without looking at the source file. For example, how did we type L^AT_EX?

Remember that L^AT_EX is a markup language and not a what-you-see-is-what-you-get word processor.

Good luck.





Example

Summary (page 2)

1 Mizera – Status of Intersection Theory and Feynman Integrals

A short overview referring to multiple different papers and giving a general idea of ‘intersection theory’.

- 1 We want to calculate an S -matrix, $S = \mathbf{1} + iT$; T gives matrix between incoming and outgoing momenta.
- Consider two-to-two scattering:

$$T_{12 \rightarrow 34} = \delta^4(p_1 + p_2 - p_3 - p_4) \mathcal{T}_{12 \rightarrow 34}(s, t, p_i^2, m^2, \dots),$$

where $s = (p_1 + p_2)^2$, $t = (p_1 - p_3)^2$ are Mandelstam variables.

- What are the (analytical) properties of $\mathcal{T}_{12 \rightarrow 34}$ as function of the (generally complex) variables s, t, p_i^2, m, \dots ? (The space spanned by these variables is the *Kinematic space*.)
- We want to calculate loops γ in said Kinematic space, to learn about branch cuts etc.
- Need simplifications: only perturbation theory, $4 - 2\epsilon$ dimensional regularisation, scalar Feynman diagrams (generic Feynman can be reduced to sum of scalar Feynman).
- Example: 4-point 1-loop diagrams with no masses:

$$I_{n_1 n_2 n_3 n_4}(s, t) = \int_{\Gamma} \frac{d^{4-2\epsilon} \ell}{[\ell^2]^{n_1} [(\ell + p_1)^2]^{n_2} [(\ell + p_1 + p_2)^2]^{n_3} [(\ell + p_4)^2]^{n_4}},$$

where Γ is an integration contour with the right causality conditions and n_i are integers to distinguish box, triangle and bubble diagrams by which propagators appear.

- There is a topological invariant integer χ , such that for χ different Feynman integrals (e.g. $\chi = 3$, $I_{1111}, I_{1110}, I_{1010}$) and for (s_*, t_*) fixed, we can find a $\chi \times \chi$ -matrix φ such that for any path γ from (s_*, t_*) to (s, t) we have

$$(I_{1111}, I_{1110}, I_{1010})^\top(s, t) = \mathcal{P}e^{\int_{\gamma} \varphi} (I_{1111}, I_{1110}, I_{1010})^\top(s_*, t_*) =: \mathcal{P}e^{\int_{\gamma} \varphi} |\Phi\rangle.$$

Here \mathcal{P} denotes the path-ordered exponential.



When would you use \LaTeX ?

Advantages

- Professional layout.
- Easy mathematical formula editing.
- Simple commands for complex structures like footnotes, references, table of contents and bibliographies.
- \LaTeX forces authors to write well structured documents.
- \LaTeX is free.



When would you use \LaTeX ?

Disadvantages

- Not really suited for graphic design.
- It is not WYSIWYG (what you see is what you get), like e.g. Word.
- Less intuitive than Word.

Everything is possible in \LaTeX ; the bigger the deviation from normal, the harder it is.



Processing

Procedure

It is not *WYSIWYG* software, so:

- You write (flat) text with commands for layout in a \LaTeX editor.
- \LaTeX places the text and produces a PDF as output.



Example

\LaTeX code

Example

```
\documentclass[a5paper]{article}
\title{\LaTeX cursus A-Eskwadraat}
\author{\TeX nicie}
\date{November 14, 2016}
\begin{document}
\maketitle
\section{Important title}
Lorem ipsum ...
\end{document}
```

Example

L^AT_EX code

Example

```
\documentclass[a5paper]{article}
\title{\LaTeX cursus A-Eskwadraat}
\author{\TeX nicie}
\date{November 14, 2016}
\begin{document}
\maketitle
\section{Important title}
Lorem ipsum ...
\end{document}
```

PDF output

L^AT_EX cursus A-Eskwadraat

T_EXnicie

November 14, 2016

1 Important Title

Lorem ipsum ...

Structure of a \LaTeX -file

A \LaTeX -file always has the following structure:

\LaTeX

```
\documentclass{article}
```

```
\begin{document}
```

This is a really tiny document,
isn't it?

```
\end{document}
```

Meaning

class-definition

preamble, commands which are valid through
the whole document.

start of the actual document

the document

end of the document

\LaTeX will generate the following: This is a really tiny document, isn't it?

Title and date

In order to automatically generate a title on the front page you need to place two commands in the preamble:

```
\title{Report on Recent Advancements in X}  
\author{Students Y and Z}
```

Optionally, one can specify a date:

```
\date{January 28th, 2021}
```

Finally, place the following command direct after the beginning of your document.

```
\maketitle
```

If you do not include a date, L^AT_EX will use the date at which you generated the PDF-file.

Headings

Headings mark the start of a section or chapter.

The usual commands are:

- `\section{<name>}`
- `\subsection{<name>}`
- `\subsubsection{<name>}`

You might also encounter:

- `\chapter{<name>}`
- `\paragraph{<name>}`



Table of contents

Using the mentioned (sub)*sections, you can generate a table of contents with one command:

```
\tableofcontents
```

Near the end of the document, you might find:

```
\appendix
```

The `\appendix` command marks the start of the appendices. All sections after this command are indicated in another style.

Paragraphs

Paragraphs

Of course you want to structure your text in paragraphs:

- for **flat text** just write everything successively;
- **paragraphs** are made by including white-space or `\par`.

If you really want something else

- `\\` forces a **line cut**;
- `\bigbreak` gives vertical white-space;
- `\newpage` enforces a new page;
- `\clearpage` enforces a new page, but first places all tables and figures.

You should minimise the use of above commands in your text!

Accents

Standard pdf- \LaTeX can only handle flat text and certain symbols. In order to use accents, the accent has to be written in front of the letter:

Signs

ó	ò	ö	ô	õ
\'o	\`o	\"o	\^o	\~o

You will most likely need the above for names or words borrowed from another language.

“A naïve man was eating a crème brûlée during the El Niño.”



Symbols

The following symbols all have a special meaning in L^AT_EX. In order to print them as text you will need a special command:

symbol	command
--------	---------

\$	<code>\\$</code>
----	------------------

%	<code>\%</code>
---	-----------------

{	<code>\{</code>
---	-----------------

-	<code>\-</code>
---	-----------------

,	<code>\,</code>
---	-----------------

symbol	command
--------	---------

#	<code>\#</code>
---	-----------------

&	<code>\&</code>
---	---------------------

}	<code>\}</code>
---	-----------------

\	<code>\textbackslash</code>
---	-----------------------------

,	<code>,</code>
---	----------------



Exercise 1

Look at the following code.

- 1 Who is the author?
- 2 What date will be used in the PDF?
- 3 Which entries would be in the table of contents?
- 4 Can you guess what the % sign does?

```

\documentclass{article}

\title{Algebraic Geometry and Feynman Diagrams}
\author{Pepijn de Maat}

\begin{document}

\maketitle
% Maybe I should add a Table of Contents
\clearpage

\section{Introduction} %TODG
This subject is very important for TO DO reasons.

\paragraph{Physical Relevance}
TO DO, something with Cern.

\paragraph{Historical Interest}
TO DO, was there any?

\end{document}

```

Listings

\LaTeX has three different listings:

- A plain list.
- 1. A numbered list.

Description A list with no predefined ‘bulletpoints’

These listings are produced by the environments `itemize`, `enumerate` and `description`.



Example

Itemize

Example

```
...  
\begin{itemize}  
\item Mathematics  
\item Theoretical Physics  
\item Experimental Physics  
\item Climate Physics  
\item Chemistry  
\end{itemize}  
...
```

PDF output

- Mathematics
- Theoretical Physics
- Experimental Physics
- Climate Physics
- Chemistry

The `enumerate` environment has the same syntax.

Example

Description

Example

```
...  
\begin{description}  
\item[a] Introduction  
\item[aa] Remarks on Previous Version  
\item[ab] Historical Relevance  
\item[b] Preliminaries  
\item[Cats] Felis catus  
\item[Dogs] Canis familiaris  
\end{description}  
...
```

PDF output

```
a Introduction  
aa Remarks on Previous Version  
ab Historical Relevance  
b Preliminaries  
Cats Felis catus  
Dogs Canis familiaris
```

Packages

L^AT_EX itself is only a basic framework, and for many things you need packages. We recommend the following:

babel The Babel package manages typographical rules such as line breaks for many different languages. The default language is 'US English'. (LuaL^AT_EX: use **Polyglossia** instead.)

graphicx The Graphicx package vastly simplifies including images in your output.

geometry The Geometry package allows you to change the margins and size of your document.

You can import a package with `\usepackage[optional]{package}`.

E.g.: `\usepackage[English]{babel}`, `\usepackage[margin=24mm]{geometry}`,
`\usepackage{graphicx}`.

Exercise 2 and a short break

Make exercise 2 on the exercise sheet:

Try to recreate the given page in \LaTeX . It is an article document using the things you have learned above.

This is also a short break. It is no problem if you don't finish the exercise, but try to at least have a compiling document with a title.



Mathmode

So far we have worked in *text mode*.

Mathematical formulas and signs are made in *math mode*.

Text mode and math mode use separate commands, which will not work in the other.



Two types: inline and display math

Inline math mode:

Example

This sentence uses inline math like $a^2 + b^2 = c^2$ or $\oint_C B \cdot dl = \mu_0 \sum_{i=\text{encl}} I_i$. This works well for small formulas.

Display math mode:

Example

Here we see display math, which is more fitting for large or important formulas.

$$a^2 + b^2 = c^2, \quad \oint_C B \cdot dl = \mu_0 \sum_{i=\text{encl}} I_i$$

Opening math mode

In order to open math mode, you need one of the following commands:

Inline math

- $\langle \dots \rangle$
- $\$ \dots \$$

Display math

- $[\dots]$
- $\$ \$ \dots \$ \$$

The basics

The basic operations works as you might expect, e.g. `$4 + 5 - 3 * 6 / 9 = 7$` gives $4 + 5 - 3 * 6 / 9 = 7$.

For multiplication: use `2×3` or `$2 \cdot 3$` for 2×3 respectively $2 \cdot 3$.



Subscript and superscript

Relative placing (sub- and superscript):

The hat (^) and the dash (_).

- One argument, surrounded by brackets {...}.
- Or no brackets, then only the next character is taken into account.

Example

x_n	<code>\$x_n\$</code>
e^{tA}	<code>\$e^{\{tA\}}\$</code>
$3^r d$	<code>\$3^rd\$</code>

Common commands

Most mathematical symbols which are not on the keyboard are given by an abbreviation of their name (as it is pronounced).

Example (Vertical combinations)

<code>\frac{⟨num⟩}{⟨denom⟩}</code>	$\frac{1}{137}$	<code>\frac{1}{137}</code>
<code>\binom{⟨high⟩}{⟨low⟩}</code>	$\binom{n}{p}$	<code>\binom{n}{p}</code>
<code>\sqrt[⟨power⟩]{⟨number⟩}</code>	$\sqrt[3]{512}$	<code>\sqrt[3]{512}</code>

Example (Sine, cosine, etc.)

<code>\sin⟨number⟩</code>	$\sin 60^\circ$	<code>\sin 60^\circ</code>
<code>\cos(⟨number⟩)</code>	$\cos(\pi/3)$	<code>\cos(\pi/3)</code>
<code>\log⟨number⟩</code>	$\log 2i$	<code>\log 2i</code>

Greek

Example

$$\frac{\hbar^2 \nabla^2}{2m} \psi(r) + \frac{1}{4\pi\epsilon_0 r} \psi(r) = E \psi(r)$$

```


$$\frac{\hbar^2 \nabla^2}{2m} \psi(r) + \frac{1}{4 \pi \epsilon_0 r} \psi(r) = E \psi(r)$$


```

Greek characters: `\theta` (θ).

Greek capitals: `\Phi` (Φ).

Nicer Greek characters: `\varepsilon` (ε).

N.B. Not all characters can be made nicer.

Different variants of a character: `\hbar` (\hbar), `\ell` (ℓ).



Summations, integrals and products

Integrals, sums and product absorb the sub- and superscript when in display math:

Example

$$\sum_{n=0}^{\infty} \int_0^1 \frac{1}{n!} A^n t^n dt$$

`$$\sum_{n=0}^{\infty} \int_0^1 \frac{1}{n!} A^n t^n dt $$`



Symbols

\LaTeX has many, many mathematical symbols. You can find them here:

- Complete list at CTAN:
<http://www.ctan.org/tex-archive/info/symbols/comprehensive/>.
- Drawing a symbol yourself: <https://detexify.kirelabs.org/>
- Other problems:
 - <http://duckduckgo.com/>
 - <http://www.google.com/>
 - <http://www.bing.com/>
 - <http://www.yahoo.com/>
 - <http://yandex.com/>
 - <https://search.creativecommons.org/>
 - <https://swisscows.com/>



Brackets (left and right)

Pairs of vertical symbols can be enlarged automatically using `\left` en `\right` right in front of the symbol.

Example

Ugly:

$$\left(\frac{1}{2}\right)$$

```
(\frac{1}{2})
```

Beautiful:

$$\left(\frac{1}{2}\right)$$

```
\left( \frac{1}{2} \right)
```

Only a left bracket? Place a dot/period after `\right`.

```
\left\{ ... \right. → { \frac{1}{\omega}
```



White space

White spacings are neglected in math mode. You can force white spacings using:

<code>\!</code>		<code>\pi\!\varphi</code>	$\pi\varphi$
		<code>\pi \varphi</code>	$\pi\varphi$
<code>\,</code>		<code>\pi\,\varphi</code>	$\pi\varphi$
<code>\quad</code>		<code>\pi\quad\varphi</code>	$\pi\varphi$
<code>\qquad</code>		<code>\pi\qquad\varphi</code>	$\pi\varphi$



The American Mathematical Society provides a number of packages for working with mathematical formulae. This project includes the following packages:

- amsmath** The basis of most mathematical editing, used many times in these slides.
- amssymb** Additional symbols like \therefore , \beth and \mathcal{U} , as well as the most important math fonts.
- amsfonts** Provides more additional font types. (Try also the packages **eufrak** and **eucal**).
- amsthm** Support for defining environments for definitions, theorems, exercises and so on.



Advanced *math mode*-environments

align Displays multiple vertically aligned numbered equations.

equation A 'better' version of

`$$... $$` which also adds a number at the end of the line.

No numbering: place a star (*) after the environment.

Example: `\begin{equation*} ... \end{equation*}`.

You can add a row of text within the **align** environment using `\intertext`.



Advanced *math mode*-environments (example)

Example

$$a = b + c$$

$$a + 2b = c$$

(1)

```
\begin{align}
a &= b+c\\
```

(2)

```
a+2b &= c
\end{align}
```

$$2x + 3 = 0$$

Hence:

$$x = -\frac{3}{2}$$

```
\begin{align*}
2x + 3 &= 0 \\
\intertext{Hence:}
x &= -\frac{3}{2}
\end{align*}
```

Exercise 3

For the final exercise, reconstruct the following formulas in the document of Exercise 2.

$$\int_{-\infty}^{\infty} e^{ax^2} = \sqrt{\frac{\pi}{a}}$$
$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \kappa T_{\mu\nu}$$

(This formula uses the Lambda and the mu, nu and kappa from Greek.)

Your formulas might look slightly different since this presentation uses a non-standard math font.



Questions and closing remarks

The solutions for the exercises as well as a cheat-sheet can be found on the site or in this Team.

To learn more, e.g. about images, see an online manual. Examples:

- Wikibooks: en.wikibooks.org/wiki/LaTeX
- Overleaf Learn: overleaf.com/learn

If you have any questions you can reach us via mail; hektex@a-eskwadraat.nl.



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Are there any questions?

