

An introduction to L^AT_EX

Workshop

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Presentation contains slides by Marko Boon and Jan Willem Knopper



Part I

L^AT_EX basics



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L^AT_EX basics



L^AT_EX basics

Question

What is the goal of this workshop?

Answer

That after doing this workshop you will have enough knowledge about L^AT_EX to format the typical mathematical things that are being used in Computing Science homework assignments.

Or at least you know which package documentation you should read. . .

L^AT_EX basics (2)

Because I don't know for sure that you know the real basics of L^AT_EX I included some slides created by Marko Boon and Jan Willem Knopper, both related to the Eindhoven University of Technology.

Their full set of slides is available at

<http://www.win.tue.nl/~marko/latex/>



Introduction

3/82

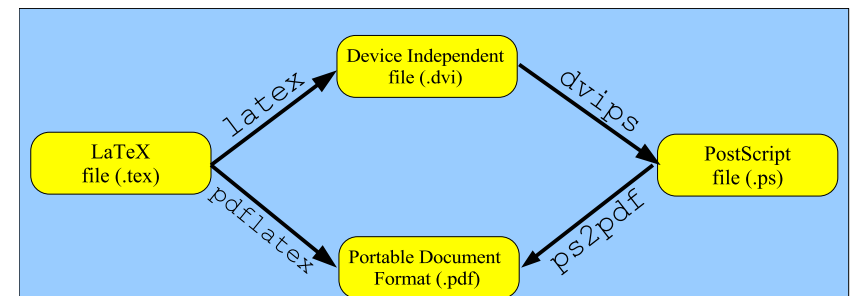
L^AT_EX is a document preparation system. It is widely used in the fields of mathematics and natural sciences, but also spreading to many other disciplines.

- L^AT_EX is a set of markup commands used with the powerful typesetting program T_EX.
- totally open software system, free of charge.
- maintained by the L^AT_EX3 Project group. Hundreds of user contributions.
- platform independent.

L^AT_EX is no word processor! L^AT_EX stimulates placing emphasis on content (logical markup) instead of appearance (typographical markup).

Introduction

9/82



The \LaTeX language

- \LaTeX commands always start with a backslash: `\`
- required command arguments are placed between curly brackets: `{ }`
- optional command arguments are placed between brackets: `[]`
- comments start with a percentage symbol: `%`
- \LaTeX takes care of the spacing between words and paragraphs (just like HTML).
- the commands `\begin{ }` and `\end{ }` create environments.

A .tex file

```
\documentclass[options]{document_class}

% preamble

\begin{document}

% document

\end{document}
```

A .tex file: intro.tex

```
\documentclass[12pt]{article}
\usepackage[english]{babel}

\begin{document}
\section{Introduction}
```

LaTeX is a document preparation system used to create documents of high quality typography.

It is mostly used in the fields of mathematics and natural sciences, but can in fact be used for any type of publication.

```
\end{document}
```

Part II

Go to work!

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Learn by doing

The best way to learn \LaTeX is by doing.

So the rest of this slideshow basically contains some assignments that you will have to try. . .



A1: Getting names in a list

Make a small document that lists the following names in a list with bullets:

- Axel van Abkoude
- Wilrick Bakker
- Maarten Berenschot
- Famke van den Boom
- Julian van der Horst



A1: Getting names in a list (2)

That was easy (I hope. . .)

Now try to add a list that has these names in it:

- David Cacín Brouwer
- Ad'ka Minichová
- Felix Mölder
- Yasin Tavşan
- Pāvels Vznudzajevs
- Anda Zāle



A1: Getting names in a list (3)

There are basically two approaches to get this right:

- Either you use something like:
 - `A\v{d}ka Minichov\'{a}` to get Ad'ka Minichová, and
 - `Felix M\''{o}lder` to get Felix Mölder
- or you add some special packages to allow for UTF8 symbols in your input file:

```
\usepackage[T1]{fontenc}
```

```
\usepackage[utf8]{inputenc}
```

Note that if you only use the second package, some names are correct, but Ad'ka's name is still wrong!

Remark

If you want to know more about this, read the page

https://en.wikibooks.org/wiki/LaTeX/Special_Characters.



A1: Getting names in a list (4)

Now that you know how to get names showing up properly, it is time to create an attendance list that meets some requirements:

- The list should fit on two pages of A4.
- It is shown in three columns.
- Even 'Marthijn van den Nieuwenhuizen' should fit on a single line within a column.

In order to help you, all students are in the file as `\student{Gijs Kopmeiners}`, so what you should do is to modify the definition of the command `\student` in such a way that you get a nice box in front of the name.



A1: Getting names in a list (5)

Remarks:

- Use the `multicol` package to get three columns.
- Use the `amssymb` package to get the `\Box` command.
- If 'Jordy Aaldering' is not left aligned, set the paragraph indentation to zero `\parindent=0em`. Probably using `\noindent` also works.
- If the lines are not wide enough, add a `textwidth=...` to the geometry declaration.
- If it doesn't fit on two pages, add a `textheight=...` to the geometry declaration.



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A2: Prettyprinting code (2)

Consider this interesting C++ program:

```
#include<stdio.h>
#include<iostream>
// A comment
int main(void)
{
    printf("Hello World\n");
    return 0;
}
```

Make a small document that includes this code in such a way that it is typeset as if it was written with a type writer. . .

A2: Prettyprinting code

As a Computing Science student you probably will write some code every now and then.

But how to put this into L^AT_EX documents?



A2: Prettyprinting code (3)

The main idea is that L^AT_EX has a so-called ‘verbatim’ mode, which basically shows what you typed, without actually executing possible commands that are in the text.

For short pieces of code you typically write `\verb+Verbatim+` to get Verbatim, whereas the `+` symbol serves as the opening and closing scope identifier. It doesn’t need to be a `+`, just use something that is not in your text!

For longer pieces of code you typically use the environment

```
\begin{verbatim}
...
\end{verbatim}
```



A2: Prettyprinting code (4)

But wouldn't it be nice if \LaTeX could show you things like:

- Line numbers every three lines,
- keywords in blue,
- text strings in red,
- comments in green and
- preprocessor directives in magenta?

```
1 #include<stdio.h>
  #include<iostream>
  // A comment
4 int main(void)
  {
    printf("Hello World\n");
7   return 0;
  }
```

The listings and the xcolor package can help you with this!



A2: Prettyprinting code (5)

Remarks:

- Using `\usepackage{xcolor}` gives you a lot of predefined colors.
- Using `\lstset{...}` you can set all kinds of options for your piece of code:

```
\lstset{language=C++,
        numbers=left,
        stepnumber=3,
        basicstyle=\ttfamily,
        keywordstyle=\color{blue}\ttfamily,
        stringstyle=\color{red}\ttfamily,
        commentstyle=\color{green}\ttfamily,
        morecomment=[1][\color{magenta}]{\#}
}
```

- Do you understand what every line does?



A2: Prettyprinting code (6)

Note that there are more packages that help you with verbatim inside your document:

- verbatim
- verbatimbox
- moreverb
- fancyvrb

Some of these have also commands for including files as verbatim.



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A3: Truth tables

The book we use for the course **Mathematical Structures** uses T and F as truth values.

p	q	$p \wedge q$	$\neg(p \wedge q)$	$\neg p$	$\neg q$	$\neg p \vee \neg q$
T	T	T	F	F	F	F
T	F	F	T	F	T	T
F	T	F	T	T	F	T
F	F	F	T	T	T	T

But what if I use a different book next year that uses 1 and 0?

How can I prevent that I have to recreate all my truth tables?

By using \LaTeX 's `\newcommand{...}` and `\renewcommand{...}` constructions.

Try it!



A3: Truth tables (3)

That was easy (I hope...)

But can we (you!) also change the table in such a way that all T's show up in a green cell like this:

p	q	$p \wedge q$	$\neg(p \wedge q)$	$\neg p$	$\neg q$	$\neg p \vee \neg q$
1	1	1	0	0	0	0
1	0	0	1	0	1	1
0	1	0	1	1	0	1
0	0	0	1	1	1	1

Use the packages `xcolor` and `colortbl`!



A3: Truth tables (2)

The current book wants upright T and F inside math mode.

This can be accomplished by:

```
\newcommand{\Tt}{\ensuremath{\mathrm T}}
\newcommand{\Ff}{\ensuremath{\mathrm F}}
```

Btw, what do you think `\ensuremath{...}` does?

Now changing to 1 and 0 is as easy as modifying these two definitions into:

```
\newcommand{\Tt}{1}
\newcommand{\Ff}{0}
```

And if you want to use both versions within one document you can use

```
\renewcommand{\Tt}{1}
\renewcommand{\Ff}{0}
```



A3: Truth tables (4)

Did you encounter problems with the background color being put on top of the lines?

This is usually caused by the viewers: try to zoom to a different level and see if the problem remains.

But now that we are talking about the lines, can you modify the table in such a way that you get exactly these lines:

p	q	$p \wedge q$	$\neg(p \wedge q)$	$\neg p$	$\neg q$	$\neg p \vee \neg q$
T	T	T	F	F	F	F
T	F	F	T	F	T	T
F	T	F	T	T	F	T
F	F	F	T	T	T	T



A3: Truth tables (5)

Do you also think that the lines are too close to the text?

Then use `\renewcommand{\arraystretch}{...}` with a well chosen decimal value to make it look better:

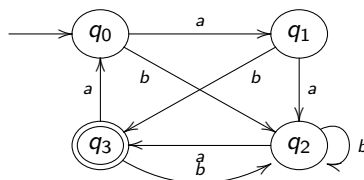
p	q	$p \wedge q$	$\neg(p \wedge q)$	$\neg p$	$\neg q$	$\neg p \vee \neg q$
T	T	T	F	F	F	F
T	F	F	T	F	T	T
F	T	F	T	T	F	T
F	F	F	T	T	T	T



A4: Finite automata

For the course 'Languages and automata' you probably have to draw some ... automata!

If you have no clue yet what such an automaton is, don't worry, it will be explained in that course. For now it suffices to know that it is something like the diagram below, where the circles represent **states** and the arrows represent **transitions**. A circle with a double round is a final state and the circle with this dangling incoming arrow on the top left is the initial state.



This diagram was created with `\xymatrix`, part of the package `xy`.



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A4: Finite automata (2)

So how does it work?

Basically, the argument of `\xymatrix` is a ... matrix!

In this matrix (or grid) the coefficients are given by the states (or nodes) and for each coefficient it is written which outgoing arrows it has.

$\rightarrow [r]$	$q_0 \rightarrow [rr] \rightarrow [drr]$	$q_1 \rightarrow [d] \rightarrow [dll]$
	$q_3 \rightarrow [u] \rightarrow [rr]$	$q_2 \rightarrow [ll] \rightarrow [(ur, dr)]$

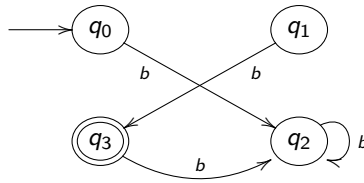
The direction of the transitions is determined by the `[d1l]` or `[(ur, dr)]`. The first one means 'go one down and two to the left'; the second one means 'make a loop starting from up right position to down right position'

Note that the empty column is used to separate q_0 and q_1 a bit more.

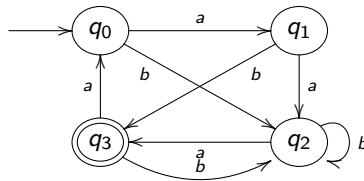


A4: Finite automata (3)

Can you add the missing transitions to get from



to



?



A4: Finite automata (4)

The full code for this diagram is given by:

```

\[\
\xymatrix{
\ar[r]
& \node{q_0} \ar[rr]^a \ar[dr]_<<<<\{b\}
& \\
& \node{q_1} \ar[d]^a \ar[dl]_<<<<\{b\}
& \\
& \fnode{q_3} \ar[u]^a \ar@/_0.5cm/[rr]^b
& \\
& \node{q_2} \ar[ll]^a \ar@(ur,dr)_b
& }
\]

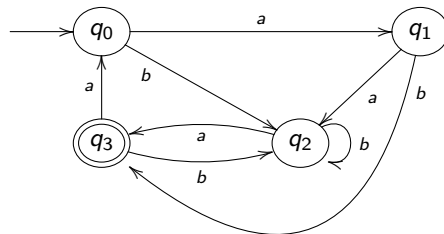
```

Note that '_', '^' and '<<<<' are used for the positioning of the labels.



A4: Finite automata (5)

I think that the arrows between q_2 and q_3 are too close to each other, and the label of the b should be on the other side. And I also don't like the crossing arrows in the middle, because in this situation it is not needed. Can you manage to change the code to get this diagram instead?



A4: Finite automata (6)

Remarks:

- The grid needs to be extended.
- Node q_1 needs to be moved, which implies that all directions of incoming transitions of q_1 also need to be modified.
- Some straight lines need to be replaced by curved lines.
 - Note that it can be a hassle to find values that give a nice looking diagram!



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A5: Parse trees (2)

This package `tikz` is a very complex package for drawing diagrams in \LaTeX , and I only know a few things.

Fortunately, there is a large set of examples available on the Internet where you can compare source and output, and hopefully modify the source in such a way that you get your preferred output.

The parse trees that I use, really look like trees in the source:

- They start with a node that acts as root,
- and recursively, underneath each node that is not a leaf, a list of subnodes (children) is given.

The layout and positioning of these nodes is typically organized by setting style parameters in a `tikzset` command.

A5: Parse trees

In **Mathematical Structures** we have created the parse tree for the formula

$$\neg(p \leftrightarrow q \wedge r \leftrightarrow s \vee t)$$

on the whiteboard.

But how to do that in \LaTeX ?

I use the package `tikz` for that.



A5: Parse trees (3)

```
\tikzset{
  treenode/.style = {
    align=center,
    inner sep=0pt,
    text centered,
    font=\sffamily},
  arn_n/.style = {
    anchor=center,
    thick,
    treenode,
    circle,
    font=\sffamily\bfseries,
    draw=black,
    fill=white,
    minimum size=1.5em
  }
}
```



A5: Parse trees (4)

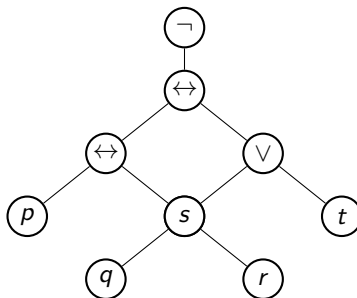
```
\begin{tikzpicture}[-,
>=stealth',
level/.style={
sibling distance = 3cm, % This parameter can be used to place the nodes
% further apart horizontally.
level distance = 1.2cm % This parameter can be used to place the nodes
% further apart vertically.
},
scale=0.7]
\node [arn_n] {$\neg$} % We start with the root (operator)
% The arn_n is specified to use a specific set that is defined above in
% \tikzset.
% This root operator is unary so it has one child.
child { node [arn_n] {$\leftrightarrow$}
child { node [arn_n] {$\leftrightarrow$}
child { node [arn_n] {$\lor$}
}
}
}
;
\end{tikzpicture}
```

A5: Parse trees (5)

Now try to adapt the given parse tree into the proper one for the formula

$$\neg(p \leftrightarrow q \wedge r \leftrightarrow s \vee t)$$

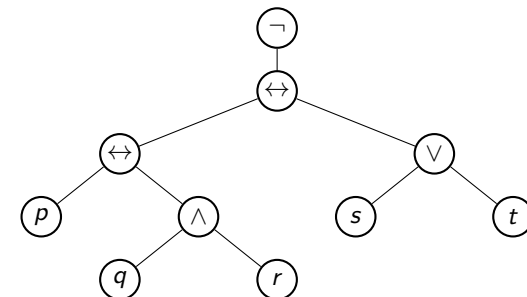
A5: Parse trees (6)



So the result is not really satisfactory...

A5: Parse trees (7)

Can you fix it in such a way that it looks like this:



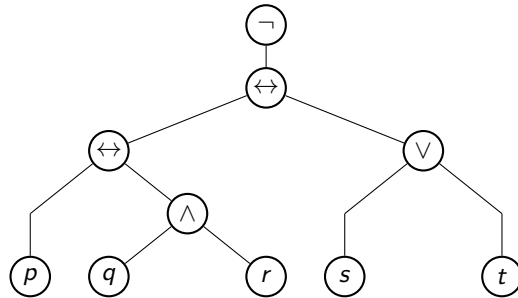
A5: Parse trees (8)

During the lecture, we started bottom up and had all the leaves, the atomic propositions, aligned horizontally.

Can you modify the tree in such a way that this works?

I couldn't without abandoning the 'node' and 'child' system that tikz provides.

The best thing I could do was:



Can you do this as well with reasonably simple modifications?

A6: Including images

If you are not able to create such parse trees within a reasonable amount, it might be wiser to simply include a picture that contains a scan of your hand made parse tree.

But how to include pictures?

Basically, you only need a few lines of code for that:

```
\usepackage{graphicx}

\begin{document}

\includegraphics{filename.png}

\end{document}
```

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A6: Including images (2)

However, usually you have to add several options to get what you want.

```
\begin{center}
\includegraphics[scale=0.5,angle=-45]{net.jpg}
\end{center}
```



This package also lets you rotate text!

A6: Including images (3)

Can you make a document where the picture is included in such a way that you give it a number and caption and refer to it?

And please make sure that the picture appears on the top of a page!

Experiment with the `figure` environment.

And you may also need the commands `\label`, `\caption`, `\ref`. and `\pageref`.



A6: Including images (5)

So it is not that difficult to put pictures somewhere between blocks of text. But can you also wrap text around them?

Yes, it is possible using the package `wrapfig`, but is usually quite tricky to get a reasonable result.



A6: Including images (4)

But what if you only want to use a part of your picture?



Try to do this with the `trim` or `viewport` options.

Both use a bounding box with four values, but the meaning of the values is different. Try it out!



A6: Including images (6)

The next page is created with this code:

```
\begin{multicols}{2}
\begin{wrapfigure}{R}{0.15\textwidth}
\centering
\includegraphics[width=0.10\textwidth]{net.jpg}
\caption{\label{fig:net}No}
\end{wrapfigure}
\lipsum[75]

\columnbreak

\begin{wrapfigure}{L}{0.15\textwidth}
\centering
\includegraphics[width=0.10\textwidth]{tabak_yad.jpg}
\caption{\label{fig:tabak}Tabacco — Poison}
\end{wrapfigure}
\lipsum[66]

\end{multicols}
```

Note that the random text is created using the package `lipsum`.



A6: Including images (7)

Pellentesque
interdum sapien sed
nulla. Proin tincidunt.
Aliquam volutpat est
vel massa. Sed dolor
lacus, imperdiet non,
ornare non, commodo
eu, neque. Integer
pretium semper justo.
Proin risus. Nullam id quam. Nam
neque. Duis vitae wisi ullamcorper
diam congue ultricies. Quisque
ligula. Mauris vehicula.



Figure: No



Figure:
Tabacco –
Poison

Nunc sed pede.
Praesent vitae lectus.
Praesent neque
justo, vehicula eget,
interdum id, facilisis
et, nibh. Phasellus
at purus et libero
lacinia dictum. Fusce
aliquet. Nulla eu ante
placerat leo semper
dictum. Mauris metus. Curabitur
lobortis. Curabitur sollicitudin
hendrerit nunc. Donec ultrices
lacus id ipsum.



A7: Thalia's logo

Now that you know how to include images, it should be easy to include Thalia's logo as an image.

But can you also include it as a Tangram?

I could not find a real `tangram` package, but somebody called `Loop Space` put a helpful post on <https://tex.stackexchange.com/questions/407449/typesetting-tangram-figures-in-latex>.



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A7: Thalia's logo (2)

Some examples:



These diagrams have been created with a package that was already mentioned before in this workshop, namely ...?

`tikz`

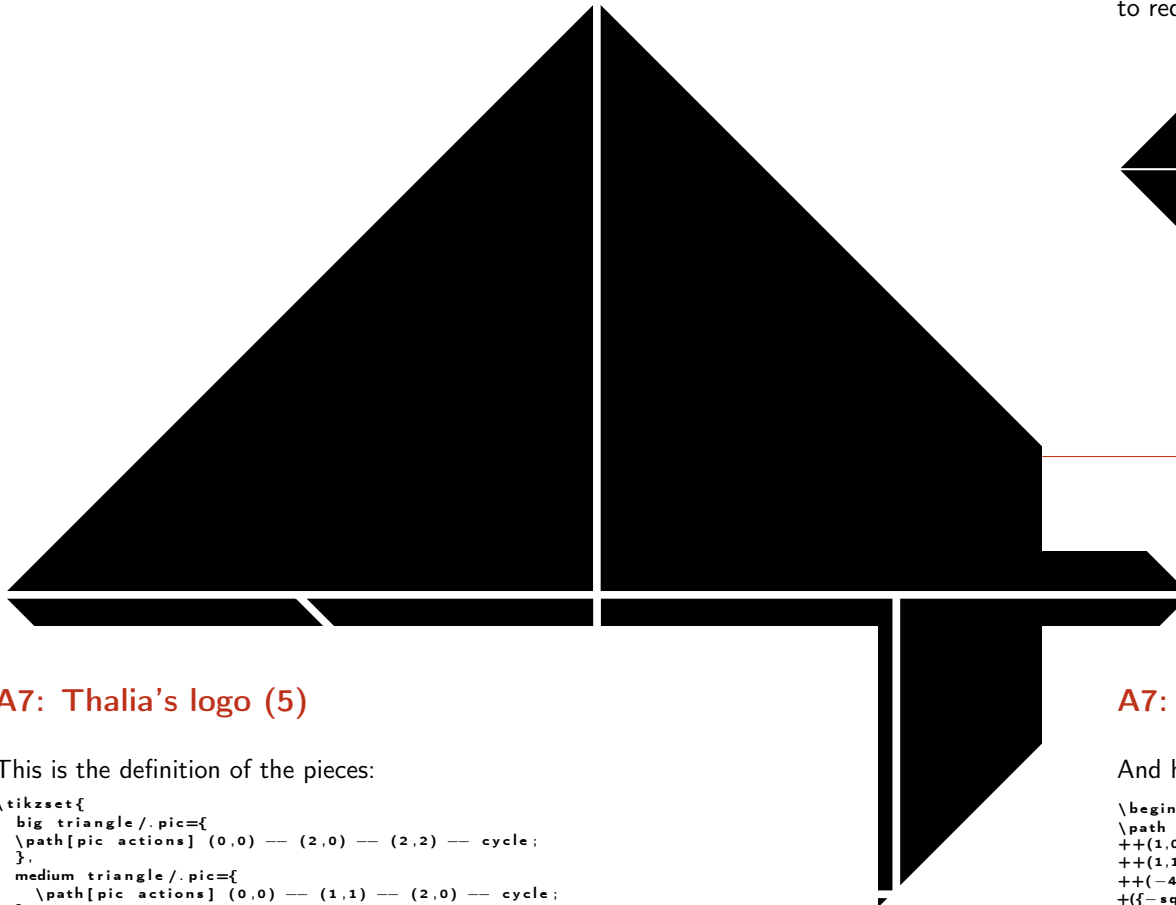
It first defines all the pieces in a `tikzset` definition.

And these pieces are used within a `tikzpicture` environment.



A7: Thalia's logo (3)

Another example on full size:



A7: Thalia's logo (5)

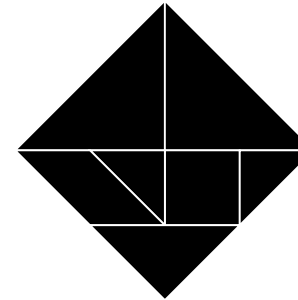
This is the definition of the pieces:

```
\tikzset{
  big_triangle/.pic={
    \path[pic actions] (0,0) -- (2,0) -- (2,2) -- cycle;
  },
  medium_triangle/.pic={
    \path[pic actions] (0,0) -- (1,1) -- (2,0) -- cycle;
  },
  square/.pic={
    \path[pic actions] (0,0) -- (1,0) -- (1,1) -- (0,1) -- cycle;
  },
  small_triangle/.pic={
    \path[pic actions] (0,0) -- (1,0) -- (1,1) -- cycle;
  },
  parallelogram/.pic={
    \path[pic actions] (0,0) -- (1,0) -- (2,1) -- (1,1) -- cycle;
  }
}

\tikzset{
  tangram_puzzle/.style={ fill=black, draw=black },
  tangram_solution/.style={ fill=black, draw=white, line width=1mm },
  tangram/.style={ transform shape,
    %tangram_puzzle
    tangram_solution
  }
}
```

A7: Thalia's logo (4)

Use a nice command from the `graphicx` package (or is it from `tikz`?) to reduce it to a reasonable size:



A7: Thalia's logo (6)

And here is an example:

```
\begin{tikzpicture}[scale=3.5]
\path (0,-1) pic[tangram] {small_triangle}
++(1,0) pic[tangram] {square}
++(1,1) pic[tangram, rotate=-45, yscale=-1] {big_triangle}
++(-45:2) pic[tangram, rotate=-135] {big_triangle}
+({-sqrt(2)},0) pic[tangram, rotate=-135] {parallelogram}
+(-2,{-2*sqrt(2)}) pic[tangram] {medium_triangle}
++(2,1) pic[tangram, rotate=-90] {small_triangle}
;
\end{tikzpicture}
```



Can you use this example to create Thalia's logo?

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A8: Matrices (2)

If it was the first one, then you can easily create it with either default \LaTeX , or with the `amsmath` package.

```
\[
\left( \begin{array}{cc}
a_{11} & a_{12} \\
a_{21} & a_{22}
\end{array} \right)
```

```
\[
\begin{pmatrix}
a_{11} & a_{12} \\
a_{21} & a_{22}
\end{pmatrix}
```

A8: Matrices

I assume Bart will show you some matrices in his course [Matrix Calculation](#).

But what do they look like?

$$\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \quad \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad \left\{ \begin{array}{cc} a_{11} & a_{12} \\ a_{21} & a_{22} \end{array} \right\} \quad \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} \quad \left\| \begin{array}{cc} a_{11} & a_{12} \\ a_{21} & a_{22} \end{array} \right\|$$

I hope the first one...



A8: Matrices (3)

The second version is easier, but the first version provides more functionalities, like having lines in it:

$$\left(\begin{array}{cc|c} a_{11} & a_{12} & \\ \hline a_{21} & a_{22} & \end{array} \right)$$

```
\[
\left( \begin{array}{cc|c}
a_{11} & a_{12} & \\ \hline
a_{21} & a_{22} & 
\end{array} \right)
```



A8: Matrices (4)

And what about these?

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad \left\{ \begin{array}{cc} a_{11} & a_{12} \\ a_{21} & a_{22} \end{array} \right\} \quad \left| \begin{array}{cc} a_{11} & a_{12} \\ a_{21} & a_{22} \end{array} \right| \quad \left\| \begin{array}{cc} a_{11} & a_{12} \\ a_{21} & a_{22} \end{array} \right\|$$

Use `bmatrix`, `Bmatrix`, `vmatrix` and `Vmatrix` respectively.



A8: Matrices (5)

If you want to find the inverse of a matrix, you typically have to do Gauss Jordan elimination on this matrix:

$$\left(\begin{array}{ccc|ccc} a_{11} & a_{12} & a_{13} & 1 & 0 & 0 \\ a_{21} & a_{22} & a_{23} & 0 & 1 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 1 \end{array} \right)$$

Do you know how to create it?



A8: Matrices (6)

That was easy (I hope...)

But can you also do it with a dashed line?

$$\left(\begin{array}{ccc|ccc} a_{11} & a_{12} & a_{13} & 1 & 0 & 0 \\ a_{21} & a_{22} & a_{23} & 0 & 1 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 1 \end{array} \right)$$

The trick is to use package `arydshln`, which provides dashed lines in arrays.

```
\usepackage{arydshln}
\[
\left( \begin{array}{ccc|ccc}
a_{11} & a_{12} & a_{13} & 1 & 0 & 0 \\
a_{21} & a_{22} & a_{23} & 0 & 1 & 0 \\
a_{31} & a_{32} & a_{33} & 0 & 0 & 1
\end{array} \right)
\]
```

A8: Matrices (7)

Now try to create this one yourself:

$$\left(\begin{array}{ccc|ccc} a_{11} & a_{12} & a_{13} & 1 & 0 & 0 \\ a_{21} & a_{22} & a_{23} & 0 & 1 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 1 \end{array} \right)$$



A8: Matrices (8)

If you thought that this short horizontal line is ugly: please do something about it!

Do you recall the magical command to get more vertical space inside arrays and tabulars?

$$\left(\begin{array}{ccc|cc} a_{11} & a_{12} & a_{13} & 1 & 0 & 0 \\ a_{21} & a_{22} & a_{23} & 0 & 1 & 0 \\ \hline a_{31} & a_{32} & a_{33} & 0 & 0 & 1 \end{array} \right)$$

A8: Matrices (9)

A bit more tricky is this incidence matrices I used in the Combinatorics course:

$$\begin{array}{c} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \end{array} \begin{array}{cccccc} e_1 & e_2 & e_3 & e_4 & e_5 & e_6 \\ \left(\begin{array}{cccccc} 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 \\ 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 \end{array} \right) \end{array}$$

How can you create the headings above and on the left in such a way that they are well aligned with the columns and the rows?

It may help to use a package called `blkarray`...



Overview

Learn by doing

Listing names

Including source code

Truth tables

Automata

Parse trees

Including images

Thalia's logo

Matrices

A9: Mathematical formulas

For this part I again included some slides from Boon and Knopper.



9 Mathematical formulas

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In a text:

For a rectangular triangle, we know from *Pythagoras' theorem* that $a^2 + b^2 = c^2$ where a and b are the length of two sides adjoining the straight angle while c is the length of the side opposite the straight angle.

Compare this with:

For a rectangular triangle, we know from *Pythagoras' theorem* that $a^2+b^2=c^2$ where a and b are the length of two sides adjoining the straight angle while c is the length of the side opposite the straight angle.

Mathematical formulas are created as follows:

```
We get : $a^2+b^2=c^2$, $a^{13}$, $b_3$ or $b_{13}$
```

results in

We get: $a^2 + b^2 = c^2, a^{13}, b_3$ or b_{13}

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Mathematical formulas are created as follows:

```
We get  
\[  
  a^2+b^2=c^2, a^{13}, b_3 \mbox{ or } b_{13}  
\]
```

results in

We get $a^2 + b^2 = c^2, a^{13}, b_3$ or b_{13}

We can also number our equations:

```
We get  
\begin{equation} \label{one}  
  a^2+b^2=c^2, a^{13}, b_3 \mbox{ or } b_{13}  
\end{equation}
```

results in

We get $a^2 + b^2 = c^2, a^{13}, b_3$ or b_{13} (1)

We can also have multiple equations:

```
\begin{eqnarray}
x & = & r\sin \varphi \quad \text{\label{11}} \\
y & = & r\cos \varphi \quad \text{\nonumber} \\
z & = & z \quad \text{\label{33}}
\end{eqnarray}
```

$$x = r \sin \varphi \quad (2)$$

$$y = r \cos \varphi$$

$$z = z \quad (3)$$

or without numbers:

```
\begin{eqnarray*}
x & = & r\sin \varphi \quad \text{\ll[-0.2cm]} \\
y & = & r\cos \varphi \\
z & = & z \\
\end{eqnarray*}
```

$$x = r \sin \varphi$$

$$y = r \cos \varphi$$

$$z = z$$

Obviously we can do more:

```
\frac{n}{n+p^2} \int_0^\infty \sqrt[n]{x^n - \sin y} \, dx
```

$$\frac{n}{n+p^2} \int_0^\infty \sqrt[n]{x^n - \sin y} \, dx$$

On the other hand:

```
\[
\frac{n}{n+p^2} \int_0^\infty \sqrt[n]{x^n - \sin y} \, dx
\]
```

$$\frac{n}{n+p^2} \int_0^\infty \sqrt[n]{x^n - \sin y} \, dx$$

and finally:

```
$\displaystyle \frac{n}{n+p^2} \int_0^\infty \sqrt[n]{x^n - \sin y} \, dx$
```

$$\frac{n}{n+p^2} \int_0^\infty \sqrt[n]{x^n - \sin y} \, dx$$

Dots

```
$x_1, \dots, x_n$ or $x_1+\dots+x_n$ versus  
$x_1, \ldots, x_n$ or $x_1+ \cdots + x_n$
```

x_1, \dots, x_n or $x_1 + \dots + x_n$ versus x_1, \dots, x_n or $x_1 + \cdots + x_n$

Functions

```
$\sin x, \; \sin x, \; \mbox{sin} x$
```

$\sin x, \sin x, \sin x$

Symbols

\hat{a} <code>\hat{a}</code>	\acute{a} <code>\acute{a}</code>	\bar{a} <code>\bar{a}</code>	\dot{a} <code>\dot{a}</code>	\breve{a} <code>\breve{a}</code>
\check{a} <code>\check{a}</code>	\grave{a} <code>\grave{a}</code>	\vec{a} <code>\vec{a}</code>	\ddot{a} <code>\ddot{a}</code>	\tilde{a} <code>\tilde{a}</code>

Table 8.1: Math mode accents (available in L^AT_EX)

α <code>\alpha</code>	β <code>\beta</code>	γ <code>\gamma</code>	δ <code>\delta</code>	ϵ <code>\epsilon</code>
ε <code>\varepsilon</code>	ζ <code>\zeta</code>	η <code>\eta</code>	θ <code>\theta</code>	ϑ <code>\vartheta</code>
ι <code>\iota</code>	κ <code>\kappa</code>	λ <code>\lambda</code>	μ <code>\mu</code>	ν <code>\nu</code>
ξ <code>\xi</code>	\omicron <code>\omicron</code>	π <code>\pi</code>	ϖ <code>\varpi</code>	ρ <code>\rho</code>
ϱ <code>\varrho</code>	σ <code>\sigma</code>	ς <code>\varsigma</code>	τ <code>\tau</code>	υ <code>\upsilon</code>
ϕ <code>\phi</code>	φ <code>\varphi</code>	χ <code>\chi</code>	ψ <code>\psi</code>	ω <code>\omega</code>
Γ <code>\Gamma</code>	Δ <code>\Delta</code>	Θ <code>\Theta</code>	Λ <code>\Lambda</code>	Ξ <code>\Xi</code>
Π <code>\Pi</code>	Σ <code>\Sigma</code>	Υ <code>\Upsilon</code>	Φ <code>\Phi</code>	Ψ <code>\Psi</code>
Ω <code>\Omega</code>				

Table 8.2: Greek letters (available in L^AT_EX)

Symbols

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\pm	<code>\pm</code>	\cap	<code>\cap</code>	\diamond	<code>\diamond</code>	\oplus	<code>\oplus</code>
\mp	<code>\mp</code>	\cup	<code>\cup</code>	\triangle	<code>\bigtriangleup</code>	\ominus	<code>\ominus</code>
\times	<code>\times</code>	\uplus	<code>\uplus</code>	∇	<code>\bigtriangledown</code>	\otimes	<code>\otimes</code>
\div	<code>\div</code>	\sqcap	<code>\sqcap</code>	\triangleleft	<code>\triangleleft</code>	\oslash	<code>\oslash</code>
$*$	<code>\ast</code>	\sqcup	<code>\sqcup</code>	\triangleright	<code>\triangleright</code>	\odot	<code>\odot</code>
\star	<code>\star</code>	\vee	<code>\vee</code>	\triangleleft^a	<code>\lhd^a</code>	\bigcirc	<code>\bigcirc</code>
\circ	<code>\circ</code>	\wedge	<code>\wedge</code>	\triangleright^a	<code>\rhd^a</code>	\dagger	<code>\dagger</code>
\bullet	<code>\bullet</code>	\setminus	<code>\setminus</code>	\triangleleft^a	<code>\unlhd^a</code>	\ddagger	<code>\ddagger</code>
\cdot	<code>\cdot</code>	\wr	<code>\wr</code>	\triangleright^a	<code>\unrhd^a</code>	\amalg	<code>\amalg</code>

^a Not predefined in NFSS. Use the latexsym or amssymb package.

Table 8.3: Binary operation symbols (available in L^AT_EX)

\leq	<code>\leq</code>	\geq	<code>\geq</code>	\equiv	<code>\equiv</code>	\models	<code>\models</code>	\prec	<code>\prec</code>
\succ	<code>\succ</code>	\sim	<code>\sim</code>	\perp	<code>\perp</code>	\preceq	<code>\preceq</code>	\succcurlyeq	<code>\succcurlyeq</code>
\simeq	<code>\simeq</code>	\mid	<code>\mid</code>	\ll	<code>\ll</code>	\gg	<code>\gg</code>	\asymp	<code>\asymp</code>
\parallel	<code>\parallel</code>	\subset	<code>\subset</code>	\supset	<code>\supset</code>	\approx	<code>\approx</code>	\bowtie	<code>\bowtie</code>
\subseteq	<code>\subseteq</code>	\supseteq	<code>\supseteq</code>	\cong	<code>\cong</code>	\Join	<code>\Join</code>	\sqsubset	<code>\sqsubset</code>
\sqsupset	<code>\sqsupset</code>	\neq	<code>\neq</code>	\smile	<code>\smile</code>	\sqsubseteq	<code>\sqsubseteq</code>	\sqsupseteq	<code>\sqsupseteq</code>
\doteq	<code>\doteq</code>	\frown	<code>\frown</code>	\in	<code>\in</code>	\ni	<code>\ni</code>	\propto	<code>\propto</code>
$=$	<code>=</code>	\vdash	<code>\vdash</code>	\dashv	<code>\dashv</code>	$<$	<code><</code>	$>$	<code>></code>

Table 8.4: Relation symbols (available in L^AT_EX)

Symbols

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\leftarrow	<code>\leftarrow</code>	\longleftarrow	<code>\longleftarrow</code>	\uparrow	<code>\uparrow</code>
\Leftarrow	<code>\Leftarrow</code>	\Longleftarrow	<code>\Longleftarrow</code>	\Uparrow	<code>\Uparrow</code>
\rightarrow	<code>\rightarrow</code>	\longrightarrow	<code>\longrightarrow</code>	\downarrow	<code>\downarrow</code>
\Rightarrow	<code>\Rightarrow</code>	\Longrightarrow	<code>\Longrightarrow</code>	\Downarrow	<code>\Downarrow</code>
\leftrightarrow	<code>\leftrightarrow</code>	\longleftrightarrow	<code>\longleftrightarrow</code>	\updownarrow	<code>\updownarrow</code>
\Leftrightarrow	<code>\Leftrightarrow</code>	\Longleftrightarrow	<code>\Longleftrightarrow</code>	\Updownarrow	<code>\Updownarrow</code>
\mapsto	<code>\mapsto</code>	\longmapsto	<code>\longmapsto</code>	\nearrow	<code>\nearrow</code>
\hookrightarrow	<code>\hookrightarrow</code>	\hookrightarrow	<code>\hookrightarrow</code>	\searrow	<code>\searrow</code>
\leftharpoonup	<code>\leftharpoonup</code>	\rightharpoonup	<code>\rightharpoonup</code>	\swarrow	<code>\swarrow</code>
\leftharpoondown	<code>\leftharpoondown</code>	\rightharpoondown	<code>\rightharpoondown</code>	\nwarrow	<code>\nwarrow</code>

Table 8.5: Arrow symbols (available in L^AT_EX)

\ldots	<code>\ldots</code>	\cdots	<code>\cdots</code>	\vdots	<code>\vdots</code>	\ddots	<code>\ddots</code>	\aleph	<code>\aleph</code>
\prime	<code>\prime</code>	\forall	<code>\forall</code>	∞	<code>\infty</code>	\hbar	<code>\hbar</code>	\emptyset	<code>\emptyset</code>
\exists	<code>\exists</code>	∇	<code>\nabla</code>	\surd	<code>\surd</code>	\Box	<code>\Box</code>	\triangle	<code>\triangle</code>
\Diamond	<code>\Diamond</code>	\imath	<code>\imath</code>	\jmath	<code>\jmath</code>	ℓ	<code>\ell</code>	\neg	<code>\neg</code>
\top	<code>\top</code>	\flat	<code>\flat</code>	\natural	<code>\natural</code>	\sharp	<code>\sharp</code>	\wp	<code>\wp</code>
\bot	<code>\bot</code>	\clubsuit	<code>\clubsuit</code>	\diamondsuit	<code>\diamondsuit</code>	\heartsuit	<code>\heartsuit</code>	\spadesuit	<code>\spadesuit</code>
\mho	<code>\mho</code>	\Re	<code>\Re</code>	\Im	<code>\Im</code>	\angle	<code>\angle</code>	∂	<code>\partial</code>

^a Not predefined in NFSS. Use the latexsym or amssymb package.

Table 8.6: Miscellaneous symbols (available in L^AT_EX)

Symbols

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\sum	<code>\sum</code>	\prod	<code>\prod</code>	\coprod	<code>\coprod</code>	\int	<code>\int</code>	\oint	<code>\oint</code>
\bigcap	<code>\bigcap</code>	\bigcup	<code>\bigcup</code>	\bigsqcup	<code>\bigsqcup</code>	\bigvee	<code>\bigvee</code>	\bigwedge	<code>\bigwedge</code>
\bigodot	<code>\bigodot</code>	\bigotimes	<code>\bigotimes</code>	\bigoplus	<code>\bigoplus</code>	\biguplus	<code>\biguplus</code>		

Table 8.7: Variable-sized symbols (available in L^AT_EX)

\arccos	<code>\arccos</code>	\cos	<code>\cos</code>	\csc	<code>\csc</code>	\exp	<code>\exp</code>	\ker	<code>\ker</code>	\limsup	<code>\limsup</code>	\min	<code>\min</code>	\sinh	<code>\sinh</code>
\arcsin	<code>\arcsin</code>	\cosh	<code>\cosh</code>	\deg	<code>\deg</code>	\gcd	<code>\gcd</code>	\lg	<code>\lg</code>	\ln	<code>\ln</code>	\Pr	<code>\Pr</code>	\sup	<code>\sup</code>
\arctan	<code>\arctan</code>	\cot	<code>\cot</code>	\det	<code>\det</code>	\hom	<code>\hom</code>	\lim	<code>\lim</code>	\log	<code>\log</code>	\sec	<code>\sec</code>	\tan	<code>\tan</code>
\arg	<code>\arg</code>	\coth	<code>\coth</code>	\dim	<code>\dim</code>	\inf	<code>\inf</code>	\liminf	<code>\liminf</code>	\max	<code>\max</code>	\sin	<code>\sin</code>	\tanh	<code>\tanh</code>

Table 8.8: Log-like symbols (available in L^AT_EX)

\uparrow	<code>\uparrow</code>	\Uparrow	<code>\Uparrow</code>	\downarrow	<code>\downarrow</code>	\Downarrow	<code>\Downarrow</code>
$\{$	<code>\{</code>	$\}$	<code>\}</code>	\updownarrow	<code>\updownarrow</code>	\Updownarrow	<code>\Updownarrow</code>
\lfloor	<code>\lfloor</code>	\rfloor	<code>\rfloor</code>	\lceil	<code>\lceil</code>	\rceil	<code>\rceil</code>
\langle	<code>\langle</code>	\rangle	<code>\rangle</code>	$/$	<code>/</code>	\backslash	<code>\backslash</code>
$ $	<code> </code>	$\ $	<code>\ </code>				

Table 8.9: Delimiters (available in L^AT_EX)

Symbols

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Several packages exist that extend the number of available symbols:

`\usepackage{amssymb}`

Symbols

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\leq	<code>\leqq</code>	\leq	<code>\leqslant</code>	\leq	<code>\eqslantless</code>
\lesssim	<code>\lessim</code>	\approx	<code>\lessapprox</code>	\approx	<code>\approxeq</code>
\lessdot	<code>\lessdot</code>	\lll	<code>\lll</code>	\lessgtr	<code>\lessgtr</code>
\lesseqgtr	<code>\lesseqgtr</code>	\lesseqqgtr	<code>\lesseqqgtr</code>	\doteqdot	<code>\doteqdot</code>
\risingdotseq	<code>\risingdotseq</code>	\fallingdotseq	<code>\fallingdotseq</code>	\backsimeq	<code>\backsimeq</code>
\backsimeq	<code>\backsimeq</code>	\subseteq	<code>\subseteq</code>	\subsetneq	<code>\subsetneq</code>
\sqsubset	<code>\sqsubset</code>	\preccurlyeq	<code>\preccurlyeq</code>	\curlyeqprec	<code>\curlyeqprec</code>
\precsim	<code>\precsim</code>	\precapprox	<code>\precapprox</code>	\vartriangleleft	<code>\vartriangleleft</code>
\trianglelefteq	<code>\trianglelefteq</code>	\vdash	<code>\vdash</code>	\Vdash	<code>\Vdash</code>
\smallsmile	<code>\smallsmile</code>	\smallfrown	<code>\smallfrown</code>	\bumpeq	<code>\bumpeq</code>
\Bumpeq	<code>\Bumpeq</code>	\geq	<code>\geq</code>	\geqslant	<code>\geqslant</code>
\eqslantgtr	<code>\eqslantgtr</code>	\gtrsim	<code>\gtrsim</code>	\gtrapprox	<code>\gtrapprox</code>
\gtrdot	<code>\gtrdot</code>	\ggg	<code>\ggg</code>	\gtrless	<code>\gtrless</code>
\gtreqless	<code>\gtreqless</code>	\gtreqqless	<code>\gtreqqless</code>	\eqcirc	<code>\eqcirc</code>
\circeq	<code>\circeq</code>	\triangleq	<code>\triangleq</code>	\thicksim	<code>\thicksim</code>
\thickapprox	<code>\thickapprox</code>	\supseteq	<code>\supseteq</code>	\supsetneq	<code>\supsetneq</code>
\sqsupset	<code>\sqsupset</code>	\succcurlyeq	<code>\succcurlyeq</code>	\curlyeqsucc	<code>\curlyeqsucc</code>
\succsim	<code>\succsim</code>	\succapprox	<code>\succapprox</code>	\vartriangleright	<code>\vartriangleright</code>
\trianglerighteq	<code>\trianglerighteq</code>	\dashv	<code>\dashv</code>	\shortmid	<code>\shortmid</code>
\shortparallel	<code>\shortparallel</code>	\between	<code>\between</code>	\pitchfork	<code>\pitchfork</code>
\varpropto	<code>\varpropto</code>	\blacktriangleleft	<code>\blacktriangleleft</code>	\therefore	<code>\therefore</code>
\backepsilon	<code>\backepsilon</code>	\blacktriangleright	<code>\blacktriangleright</code>	\because	<code>\because</code>

Table 8.16: AMS binary relations (available with amssymb package)

Brackets

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```
\displaystyle (\frac{n}{\frac{n}{n+p}+1})
+ \left( \frac{n}{\frac{n}{n+p}+1} \right)
```

$$\left(\frac{n}{\frac{n}{n+p}+1} \right) + \left(\frac{n}{\frac{n}{n+p}+1} \right)$$

Brackets

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```
\left\{ T^{t^2} \right\} \hspace{1cm}
\left( \frac{\sin x}{1+\sin^2 x} \right)
```

$$\left\{ T^{t^2} \right\} \left(\frac{\sin x}{1+\sin^2 x} \right)$$

Arrays in mathematics

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```
\left( \begin{array}{c|c}
a_{11} & a_{12} \\ \hline
a_{21} & a_{22} \end{array} \right)
```

$$\left(\begin{array}{c|c} a_{11} & a_{12} \\ \hline a_{21} & a_{22} \end{array} \right)$$

Fonts in mathematics

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```
\mathrm{\sin x + \phi^2}$
\mathtt{\sin x + \phi^2}$
\mathbf{\sin x + \phi^2}$
\mathsf{\sin x + \phi^2}$
\mathit{\sin x + \phi^2}$
\mathcal{\sin x + \phi^2}$
```

$\sin x + \phi^2$
 $\sin x + \phi^2$
 $\sin x + \phi^2$
 $\sin x + \phi^2$
 $\sin x + \phi^2$
 $\sin x + \phi^G$

Fonts in mathematics

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```
\boldmath $x+\phi$
\mathbf{x+\phi}$
```

$x + \phi$
 $x + \phi$

Fonts in mathematics

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```
\boldmath $x+\phi$
\boldmath x+\phi$
```

$x + \phi$
 $x + \phi$

Fonts in mathematics

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Using `\usepackage{bm}` we can create bold symbols:

```
\boldmath $x+\phi$
\bm{x}+\bm{\phi}$
```

$x + \phi$
 $x + \phi$

Font size in mathematics

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```
{\small $x+\phi$}  
{\large $x+\phi$}
```

$x + \phi$
 $x + \phi$

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```
{ $x + {\scriptstyle \phi} +  
{\scriptscriptstyle \phi} $ }
```

$x + \phi + \phi$

10 The amsmath package

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A major extension to standard mathematics is provided by the amsmath package:

```
\usepackage{amsmath}
```

An example:

```
\numberwithin{equation}{section}
```

The amsmath package

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```
$x(t) = \begin{cases} 1 & t=0 \\ 0 & t \neq 0 \end{cases} \\ \binom{n}{m} \\ \displaystyle \binom{n}{m}
```

$$x(t) = \begin{cases} 1 & t = 0 \\ 0 & t \neq 0 \end{cases} \quad \binom{n}{m} \quad \binom{n}{m}$$

```

 $\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \iint\limits_V f(x,y,z) dx dy dz$ 

```

$$\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \iint\limits_V f(x,y,z) dx dy dz$$

```

\begin{equation}
\begin{aligned}
x(t) &= \sin t \\
y(t) &= \cos t
\end{aligned}
\end{equation}

```

$$\begin{aligned} x(t) &= \sin t \\ y(t) &= \cos t \end{aligned} \quad (4)$$

A9: Mathematical formulas (2)

Boon and Knopper had one interesting page with mathematical formulas on it.

Will you be able to recreate this page yourself?

Computer Modern Fonts (L^AT_EX default)

First some large operators both in text: $\iiint_{\mathbb{Q}} f(x,y,z) dx dy dz$ and $\prod_{\gamma \in \Gamma_{\tilde{C}}} \partial(\tilde{X}_{\gamma})$; and also on display:

$$\iiint_{\mathbb{Q}} f(w,x,y,z) dw dx dy dz \leq \oint_{\partial \mathbb{Q}} f' \left(\max \left\{ \frac{\|w\|}{|w^2+x^2|}, \frac{\|z\|}{|y^2+z^2|}, \frac{\|w \oplus z\|}{\|x \oplus y\|} \right\} \right) \approx \bigcup_{\mathbb{Q} \in \tilde{\mathbb{Q}}} \left[f^* \left(\frac{\int \mathbb{Q}(t)}{\sqrt{1-t^2}} \right) \right]_{t=\alpha}^{t=\vartheta} \quad (1)$$

For x in the open interval $] -1, 1[$ the infinite sum in Equation (2) is convergent; however, this does not hold throughout the closed interval $[-1, 1]$.

$$(1-x)^{-k} = 1 + \sum_{j=1}^{\infty} (-1)^j \begin{Bmatrix} k \\ j \end{Bmatrix} x^j \quad \text{for } k \in \mathbb{N}; k \neq 0. \quad (2)$$

Part III

Questions

Questions

I have shown quite a few tricks that may help you with your \LaTeX career, but maybe you already have some questions about other issues that I did not address?

If so, then this is the moment to ask me. . .

