An introduction to LaTeX

Workshop

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Presentation contains slides by Marko Boon and Jan Willem Knopper

iCIS | Digital Security
Radboud University

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LaTeX basics

Question

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

LaTeX basics

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Answer
That after doing this workshop you will have enough knowledge about LaTeX 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. . .

LaTeX basics (2)

Because I don't know for sure that you know the real basics of LaTeX 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/

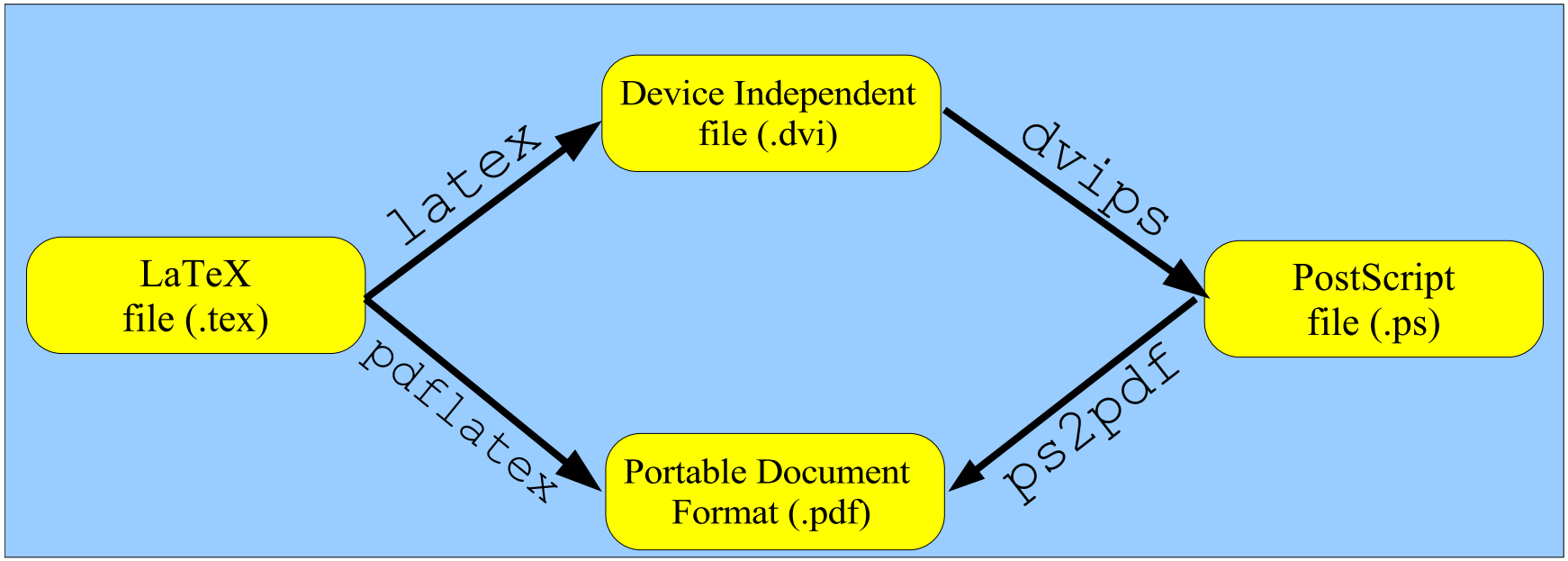
Introduction

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

- LaTeX is a set of markup commands used with the powerful typesetting program TeX.
- totally open software system, free of charge.
- maintained by the LaTeX3 Project group. Hundreds of user contributions.
- platform independent.

LaTeX is no word processor! LaTeX stimulates placing emphasis on **content** (logical markup) instead of **appearance** (typographical markup).

Introduction



Introduction

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...

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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
- Aďka Minichová
- Felix Mölder
- Yasin Tavşan
- Pāvels Vznuzdajevs
- 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 Aďka 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 Aďka'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

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

But how to put this into LaTeX documents?

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 (3)

The main idea is that LaTeX 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>
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       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=[l][\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

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

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

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

Try it!

A3: Truth tables (2)

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

This can be accomplished by:

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\newcommand{\Tt}{\ensuremath{\mathrm T}}
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Now changing to 1 and 0 is as easy as modifying these two definitions into:

```
\newcommand{\Tt}{1}
\newcommand{\Ff}{0}
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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 (3)

That was easy (I hope...)

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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

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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`!

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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
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A3: Truth tables (5)

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

A3: Truth tables (5)

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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
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A4: Finite automata

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

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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.

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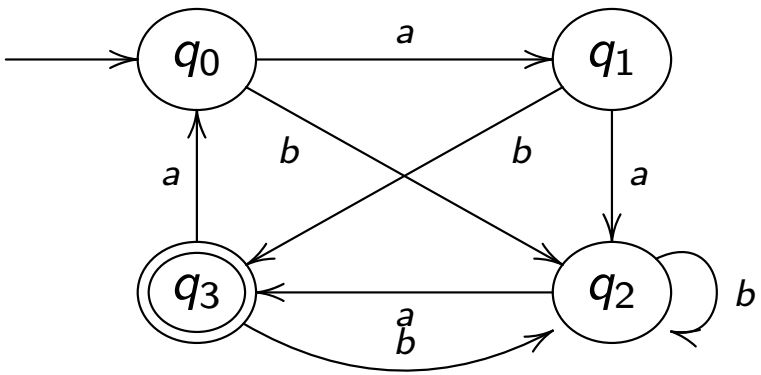

This diagram was created with `\xymatrix`, part of the package `xy`.

A4: Finite automata (2)

So how does it work?

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

A4: Finite automata (2)

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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.

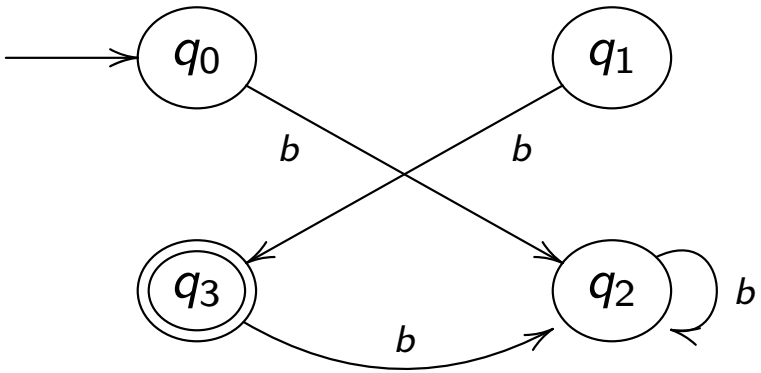
$\to [r]$	$q_0 \to [rr] \to [drr]$		$q_1 \to [d] \to [dll]$
	$q_3 \to [u] \to [rr]$		$q_2 \to [ll] \to [(ur, dr)]$

The direction of the transitions is determined by the `[dll]` 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'

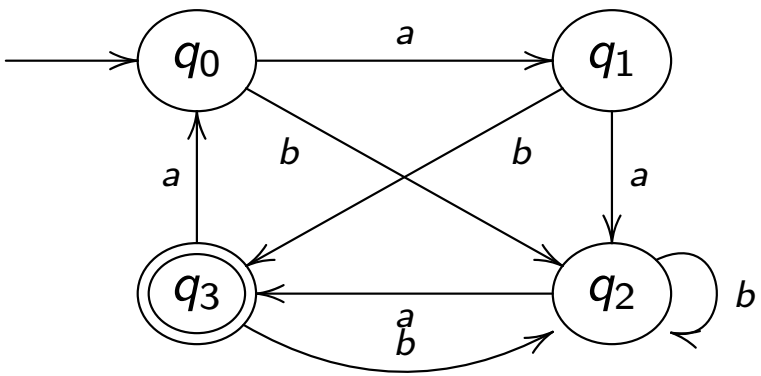
Note that the empty column is used to separate q_0 and q_1 a bit more.

A4: Finite automata (3)

Can you add the missing transitions to get from



to



?

A4: Finite automata (4)

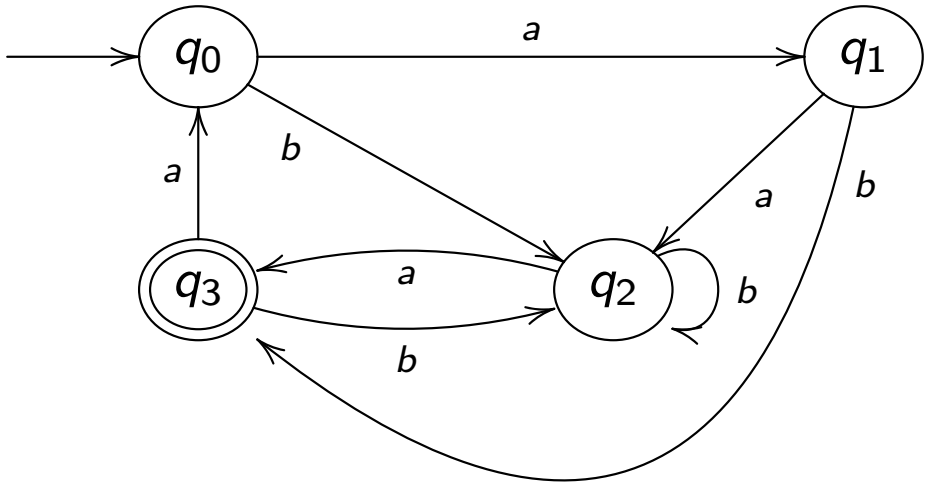
The full code for this diagram is given by:

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

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

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?

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

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But how to do that in LaTeX?

I use the package `tikz` for that.

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.

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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 (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)

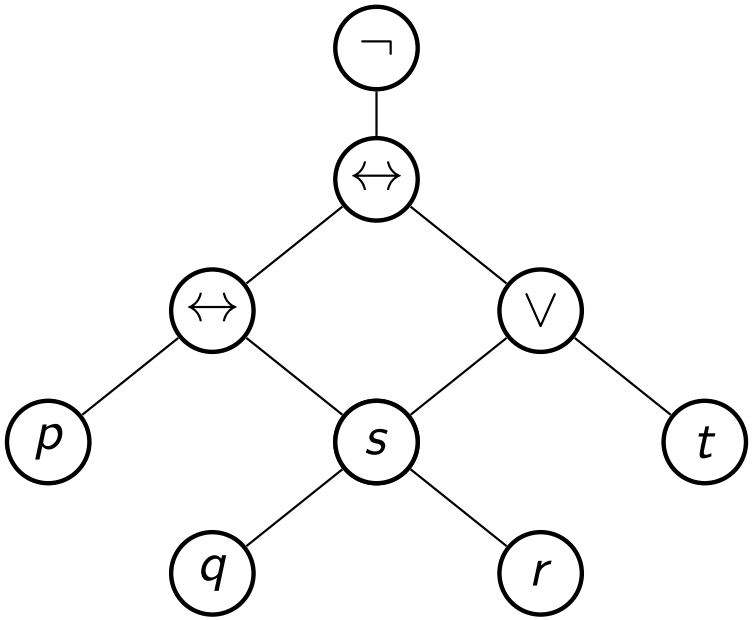
```
\begin{tikzpicture}[-,
  >=stealth',
   level/.style={
     sibling distance = 3cm, % This parameter can be used to place the nodes
                             % further apart horizontally.
     level distance = 1.2cm % This parameter can be used to place the nodes
                            % 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

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

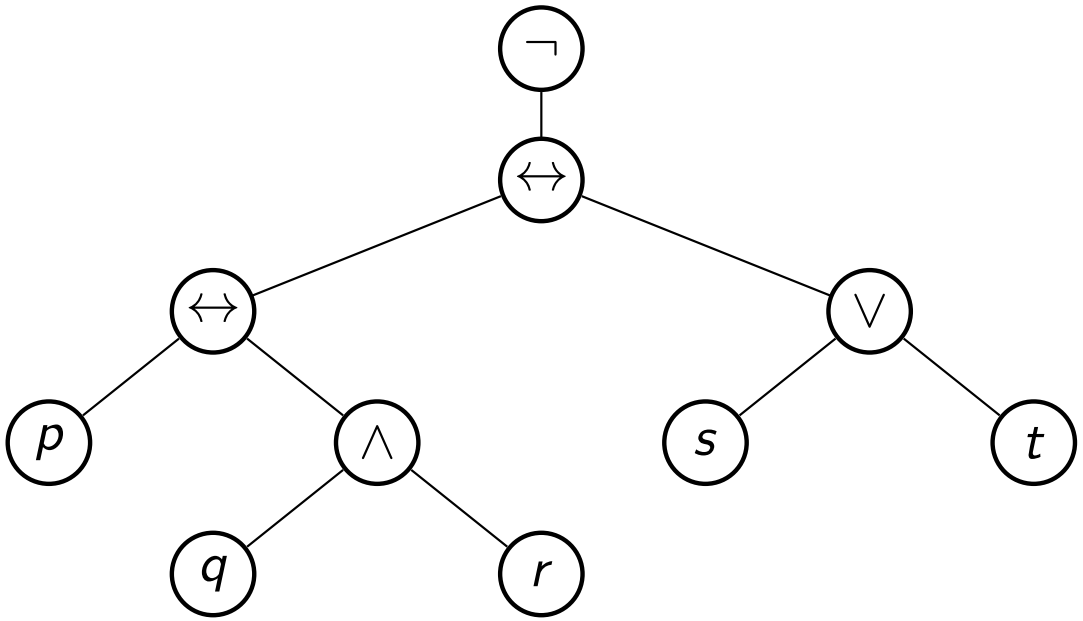
A5: Parse trees (6)



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?

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

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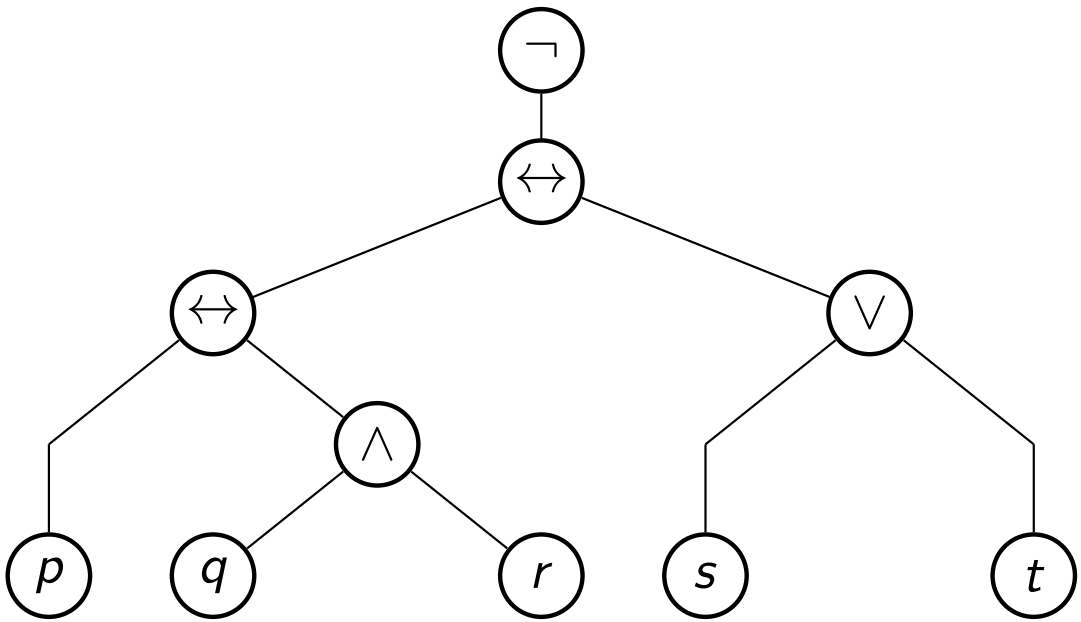
Can you modify the tree in such a way that this works?

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?

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A6: Including images

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But how to include pictures?

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}
```

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!

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Experiment with the `figure` environment.

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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 (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 (5)

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

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 (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.

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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?

A7: Thalia's logo

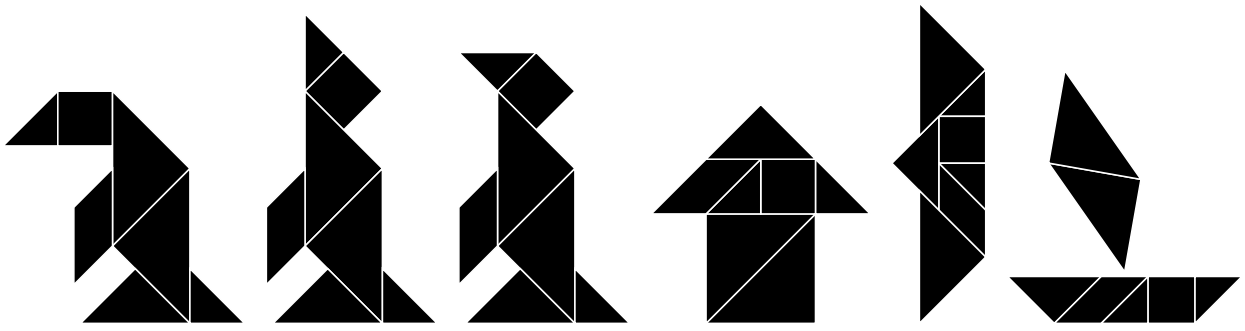
Now that you know how to include images, it should be easy to include Thalia's logo as an image.

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`.

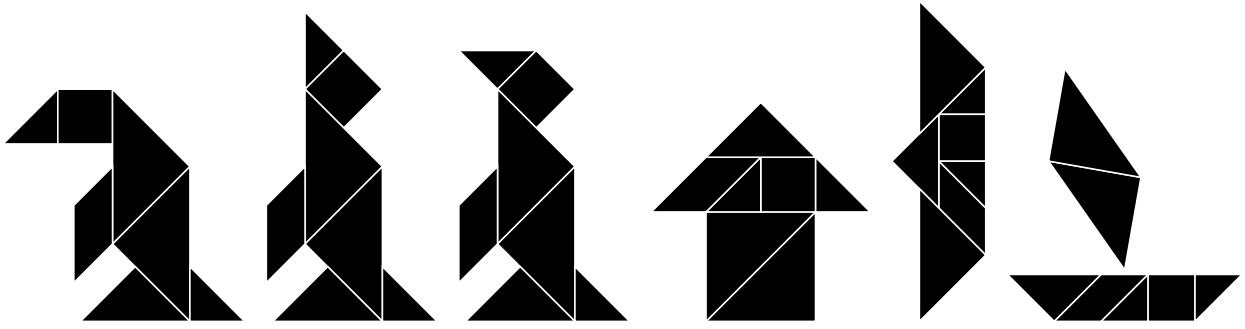
A7: Thalia's logo (2)

Some examples:



A7: Thalia's logo (2)

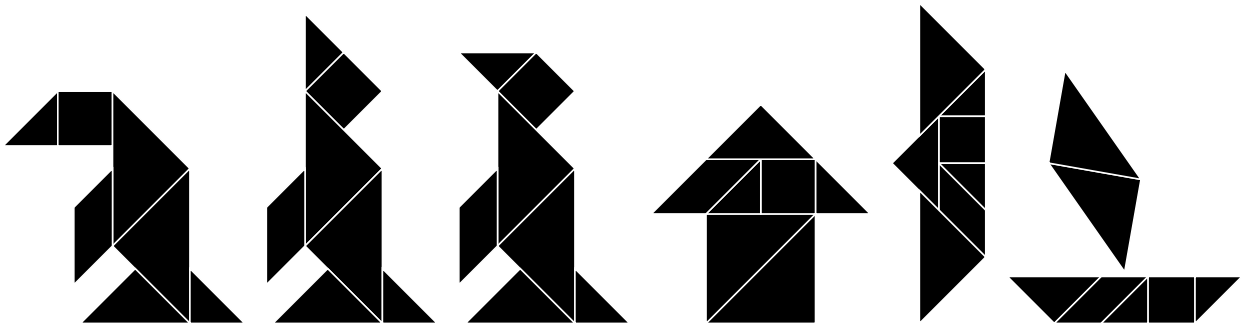
Some examples:



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

A7: Thalia's logo (2)

Some examples:



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

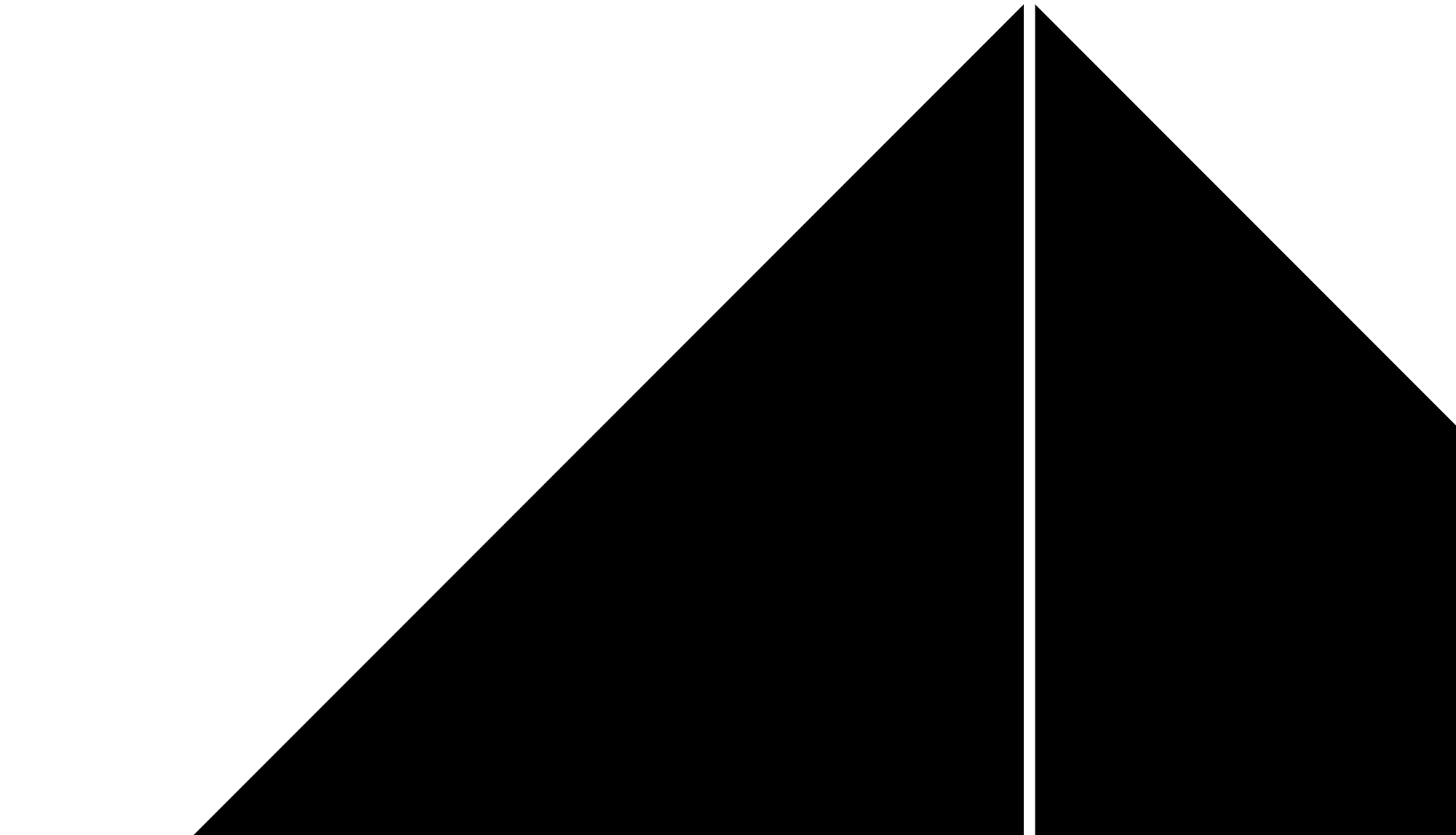
`tikz`

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

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

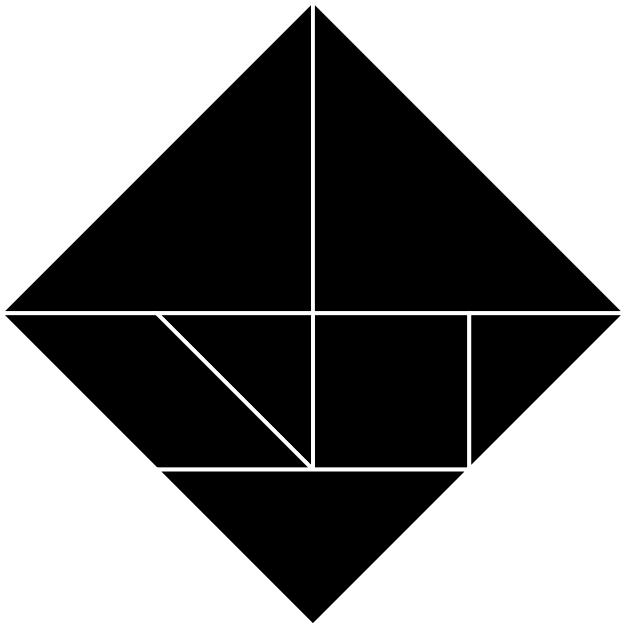
A7: Thalia's logo (3)

Another example on full size:



A7: Thalia's logo (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 (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 (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

I assume Bart will show you some matrices in his course Matrix Calculation.

But what do they look like?

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I assume Bart will show you some matrices in his course Matrix Calculation.

But what do they look like?

$$\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \quad \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad \begin{Bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Bmatrix} \quad \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} \quad \begin{Vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Vmatrix}$$

A8: Matrices

I assume Bart will show you some matrices in his course Matrix Calculation.

But what do they look like?

$$\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \quad \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad \begin{Bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Bmatrix} \quad \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} \quad \begin{Vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Vmatrix}$$

I hope the first one...

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 (3)

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

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

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

A8: Matrices (4)

And what about these?

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad \begin{Bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Bmatrix} \quad \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} \quad \begin{Vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Vmatrix}$$

A8: Matrices (4)

And what about these?

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad \begin{Bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Bmatrix} \quad \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} \quad \begin{Vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Vmatrix}$$

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?

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

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}
\[
\left( \begin{array}{ccc;{2pt/2pt}ccc}
a_{11} & a_{12} & a_{13} & 1 & 0 & 0\\
a_{21} & a_{22} & a_{23} & 0 & 1 & 0\\
a_{31} & a_{32} & a_{33} & 0 & 0 & 1
\end{array} \right)
\]
```

A8: Matrices (7)

Now try to create this one yourself:

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

A8: Matrices (8)

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

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?

$$\left(\begin{array}{ccc:ccc} a_{11} & a_{12} & a_{13} & 1 & 0 & 0 \\ \cline{4-6} a_{21} & a_{22} & a_{23} & 0 & 1 & 0 \\ \hdashline a_{31} & a_{32} & a_{33} & 0 & 0 & 1 \end{array}\right)$$

A8: Matrices (9)

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

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

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?

A8: Matrices (9)

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

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

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`...

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A9: Mathematical formulas

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

9 Mathematical formulas

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 $b_1 3$

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

$$a^2 + b^2 = c^2, a^{13}, b_3 \text{ or } b_13$$

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

$$a^2 + b^2 = c^2, a^{13}, b_3 \text{ or } b_13 \tag{1}$$

We can also have multiple equations:

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

$$x = r \sin \varphi \tag{2}$$
$$y = r \cos \varphi$$
$$z = z \tag{3}$$

or without numbers:

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

$$
\begin{aligned}
x &= r \sin \varphi \\
y &= r \cos \varphi \\
z &= z
\end{aligned}
$$

Obviously we can do more:

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

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

On the other hand:

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

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

and finally:

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

$$\displaystyle \frac{n}{n+p^2} \int_0^\infty \sqrt[n]{x^n-\sin y}\; \textrm{d}x$$

Dots


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

$x_1, ..., x_n$ or $x_1 + ... + x_n$ versus $x_1, \ldots, x_n$ or $x_1 + \cdots + x_n$

Functions


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

$\sin x,\ sinx,\ \mathrm{sin}x$

Symbols

$\hat{a}$	\hat{a}	$\acute{a}$	\acute{a}	$\bar{a}$	\bar{a}	$\dot{a}$	\dot{a}	$\breve{a}$	\breve{a}
$\check{a}$	\check{a}	$\grave{a}$	\grave{a}	$\vec{a}$	\vec{a}	$\ddot{a}$	\ddot{a}	$\tilde{a}$	\tilde{a}

Table 8.1: Math mode accents (available in LaTeX)

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

Table 8.2: Greek letters (available in LaTeX)

Symbols

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

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

Table 8.3: Binary operation symbols (available in LaTeX)

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

Table 8.4: Relation symbols (available in LaTeX)

Symbols

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

Table 8.5: Arrow symbols (available in LaTeX)

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

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

Table 8.6: Miscellaneous symbols (available in LaTeX)

Symbols

$\sum$	\sum	$\prod$	\prod	$\coprod$	\coprod	$\int$	\int	$\oint$	\oint
$\bigcap$	\bigcap	$\bigcup$	\bigcup	$\bigsqcup$	\bigsqcup	$\bigvee$	\bigvee	$\bigwedge$	\bigwedge
$\bigodot$	\bigodot	$\bigotimes$	\bigotimes	$\bigoplus$	\bigoplus	$\biguplus$	\biguplus		

Table 8.7: Variable-sized symbols (available in LaTeX)

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

Table 8.8: Log-like symbols (available in LaTeX)

$\uparrow$	\uparrow	$\Uparrow$	\Uparrow	$\downarrow$	\downarrow	$\Downarrow$	\Downarrow
$\{$	\{	$\}$	\}	$\updownarrow$	\updownarrow	$\Updownarrow$	\Updownarrow
$\lfloor$	\lfloor	$\rfloor$	\rfloor	$\lceil$	\lceil	$\rceil$	\rceil
$\langle$	\langle	$\rangle$	\rangle	/	/	$\backslash$	\backslash
$\vert$	|	$\Vert$	\\|				

Table 8.9: Delimiters (available in LaTeX)

Symbols

Several packages exist that extend the number of available symbols:

```
\usepackage{amssymb}
```

Symbols

$\leqq$	\leqq	$\leqslant$	\leqslant	$\eqslantless$	\eqslantless
$\lesssim$	\lesssim	$\lessapprox$	\lessapprox	$\approxeq$	\approxeq
$\lessdot$	\lessdot	$\lll$	\lll,\llless	$\lessgtr$	\lessgtr
$\lesseqgtr$	\lesseqgtr	$\lesseqqgtr$	\lesseqqgtr	$\doteqdot$	\doteqdot,\Doteq
$\risingdotseq$	\risingdotseq	$\fallingdotseq$	\fallingdotseq	$\backsim$	\backsim
$\backsimeq$	\backsimeq	$\subseteqq$	\subseteqq	$\Subset$	\Subset
$\sqsubset$	\sqsubset	$\preccurlyeq$	\preccurlyeq	$\curlyeqprec$	\curlyeqprec
$\precsim$	\precsim	$\precapprox$	\precapprox	$\vartriangleleft$	\vartriangleleft
$\trianglelefteq$	\trianglelefteq	$\vDash$	\vDash	$\Vvdash$	\Vvdash
$\smallsmile$	\smallsmile	$\smallfrown$	\smallfrown	$\bumpeq$	\bumpeq
$\Bumpeq$	\Bumpeq	$\geqq$	\geqq	$\geqslant$	\geqslant
$\eqslantgtr$	\eqslantgtr	$\gtrsim$	\gtrsim	$\gtrapprox$	\gtrapprox
$\gtrdot$	\gtrdot	$\ggg$	\ggg,\gggtr	$\gtrless$	\gtrless
$\gtreqless$	\gtreqless	$\gtreqqless$	\gtreqqless	$\eqcirc$	\eqcirc
$\circeq$	\circeq	$\triangleq$	\triangleq	$\thicksim$	\thicksim
$\thickapprox$	\thickapprox	$\supseteqq$	\supseteqq	$\Supset$	\Supset
$\sqsupset$	\sqsupset	$\succcurlyeq$	\succcurlyeq	$\curlyeqsucc$	\curlyeqsucc
$\succsim$	\succsim	$\succapprox$	\succapprox	$\vartriangleright$	\vartriangleright
$\trianglerighteq$	\trianglerighteq	$\Vdash$	\Vdash	$\shortmid$	\shortmid
$\shortparallel$	\shortparallel	$\between$	\between	$\pitchfork$	\pitchfork
$\varpropto$	\varpropto	$\blacktriangleleft$	\blacktriangleleft	$\therefore$	\therefore
$\backepsilon$	\backepsilon	$\blacktriangleright$	\blacktriangleright	$\because$	\because

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

Brackets


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

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

Brackets


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

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

Arrays in mathematics


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

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

Fonts in mathematics


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

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

Fonts in mathematics


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

$\boldsymbol{x+\phi}$

$\mathbf{x+\phi}$

Fonts in mathematics


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

$\boldsymbol{x + \phi}$
$x + \phi$

Fonts in mathematics

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

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

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

Font size in mathematics


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

$x + \phi$

$x + \phi$

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

$x + \phi + \phi$

10 The amsmath package

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

```
\usepackage{amsmath}
```

An example:

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

The amsmath package


```
$x(t) = \begin{cases}
   1 & t=0 \\
   0 & t\neq 0
\end{cases}\hspace{2cm}
\binom{n}{m}\hspace{1cm}
\displaystyle \binom{n}{m}$
```

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

The amsmath package


```
$\begin{pmatrix}
   a_{11} & a_{12} \\ a_{21} & a_{22}
\end{pmatrix}\quad
\boxed{\iiint_{V}\, f(x,y,z)\,
    \textrm{d}x\textrm{d}y\textrm{d}z}
$
```

$$\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \quad \boxed{\iiint_V f(x, y, z)\, \mathrm{d}x\mathrm{d}y\mathrm{d}z}$$

The amsmath package


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

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

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 (LaTeX default)

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

$$\iiiint_{\mathbf{Q}} f(w,x,y,z)\,dw\,dx\,dy\,dz \leq \oint_{\partial\mathbf{Q}} f'\left(\max\left\{\frac{\|w\|}{|w^2+x^2|};\frac{\|z\|}{|y^2+z^2|};\frac{\|w\oplus z\|}{\|x\oplus y\|}\right\}\right)$$
$$\approx\!\!\preceq \biguplus_{\mathbb{Q}\in\bar{\mathbf{Q}}}\left[f^*\left(\frac{\int\mathbb{Q}(t)\Big]}{\sqrt{1-t^2}}\right)\right]_{t=\alpha}^{t=\vartheta} \tag{1}$$

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 $[-1,1]$.

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

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?

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...