KU LEUVEN

Introduction to LaTeX

mathematics

Contents

Math mode

- Inside a document:
  - text is set in *text mode*.
  - formulas are typeset in *math mode*.
    - Uses math italic font
    - Uses different spacing, ignoring all but explicit spaces
- Math typesetting includes:
  - mathematical expressions and formulas:
    - digits, variables, operations and operators, mathematical symbols,
    - names of mathematical functions;
  - superscribing or subscribing of text;
  - Greek letters;
  - various special characters/symbols.

AMS-math

- LaTeX provides a very large number of math symbols.
- The amsmath package, (American Mathematical Society) adds to LaTeX extra features related to math typesetting.
  - Advisable to use this package when a lot of mathematics are in your document.
    ```
    \usepackage{mathtools}
    \usepackage{mathsymb}
    ```
  - `mathtools` is an extention of `amsmath`. amsmath is a broad set of tools for typesetting equations. mathtools extends the amsmath functions to provide additional formatting options and to clean up some of the more common problems with math typesetting.
- https://en.wikibooks.org/wiki/LaTeX/Mathematics
- https://ctan.mirrors.hoobly.com/info/short-math-guide/short-math-guide.pdf

equations

- Equations can be included in 2 ways:
  - in-line mode (within a text paragraph):
    - delineated by `$ $`
    - delineated by `\( \)`
    - delineated by `\begin{math} \end{math}`
  - Display mode: will be centered and in their own line of text.
    - Unnumbered `\[ \]`
    - Unnumbered `\begin{displaymath} \end{displaymath}`
    - Unnumbered `$$ $$` (not advisable)
    - Numbered `\begin{equation} \end{equation}`
- *File: demo_math_equation.tex*


```
%demo_math01
Formulas can be in-lined as
$\vec{\alpha_{i}} | = 0.5$ and
appear
in the middle of the text. It has
already been shown that $a_{n+1} = 2
\times a_n$. We can thus conclude
that $\frac{a_n}{a_0} = 2^n$.
Summation notation, as in
$\sum_{k=1}^n 2^k$, looks
slightly different when it occurs
within a line of text (in-line).
Contrast this appearance with the
display
\[
\sum_{k=1}^n 2^k.
\]

Alternatively formulas can be put
as a separate line
\[ \gamma = \frac{2.56}{34^{4}} \]

The third option for equations is a
numbered equation such as

\begin{equation}
x = \left\{ \begin{array}{l}
\sum_{x=25}^{357} x \\
                                243
\end{array} \right.
\end{equation}
```

1 Mathematics

The well known Pythagorean theorem $x^2 + y^2 = z^2$ was proved to be invalid for other exponents. Meaning the next equation has no integer solutions:

$$x^n + y^n = z^n$$

Formulas ... can be in-lined as $|\vec{\alpha_i}| = 0.5$ and appear in the middle of the text. It has already been shown that $a_{n+1} = 2 \times a_n$. We can thus conclude that $\frac{a_n}{a_0} = 2^n$. Summation notation, as in $\sum_{k=1}^{n} 2^k$, looks slightly different when it occurs within a line of text (in-line). Contrast this appearance with the display

$$\sum_{k=1}^{n} 2^k.$$

Alternatively formulas can be put as a separate line

$$\gamma = \frac{2.56}{34^4}$$

The third option for equations is a numbered equation such as

$$x = \left\{ \begin{array}{l} \sum_{x=25}^{357} x \\ 243 \end{array} \right. \quad (1)$$

TEX is spelled as $\tau\epsilon\chi$.
100 m^2 area
my sweet♡
H_2SO_4

$$thisistextinmathmode \quad (2)$$

$$\text{this is mbox text in math mode} \quad (3)$$

$$sin(f(x)) = x^2 \quad (4)$$

$$\sin(f(x)) = x^2 \quad (5)$$

Building blocks of a formula

- Arithmetic
- Delimiters
- Binomial coefficients
- Ellipses
- Operators
- Text
- Math accents
- Matrices

Based on: Practical LaTeX, by George Grätzer

Arithmetics

- Write the operators in a natural way
  - `+ - /`
  - For multiplication use `\cdot` or `\times`
- Fractions use \frac
  - `$\frac{numerator}{denominator}$,`
- Subscripts and superscripts:
  - Carets (^) indicate superscripts, `$X^2$`
  - Underscores (_) indicate subscripts, `$X_1$.`
  - When the sub/superscript contains more than one character, it is enclosed in braces, `$X^{n+1}$.`
- *File: demo_math_arithmetics*

Binomial, Delimiter

- Binomial coefficients are typeset with the `\binom` command
  `\binom{a}{b + c}`
- Brackets around a tall object in math mode do not look right with normal sized brackets:
  `\[(\frac{1}{1 + x})\]`
- Use the command to resize dynamically
  `\left`*Delimiter* `\right`*Delimiter*

  $(\frac{1}{1+x})$

  `\[\left(\frac{1}{1+x}\right)\]`

  $\left(\frac{1}{1+x}\right)$

Invisible delimiter

- Use `\right.` or `\left.` for an invisible delimiter

```
\[
f(x) = \left\{
\begin{array}{cl}
0 & x \leq 0 \\
1 & x > 0
\end{array}
\right.
\]
```

$$f(x) = \left\{ \begin{array}{cl} 0 & x \leq 0 \\ 1 & x > 0 \end{array} \right.$$

Controlling size of the brackets

- Control the size of the brackets manually:
  - `\big`
  - `\Big`
  - `\bigg`
  - `\Bigg`
- *File: demo_math_delimiter.tex*

cases environment

- The environment builds the curly bracket, and you simply write what is to the right of it, starting a new line with the standard line break command.
- *File: demo_cases.tex*

```
\begin{equation}
    \delta_{ij} =
    \begin{cases}
        1 \quad \mathrm{if}\ i = j \\
        0 \quad \mathrm{if}\ i \neq j
    \end{cases}
\end{equation}
```

Integrals, operators

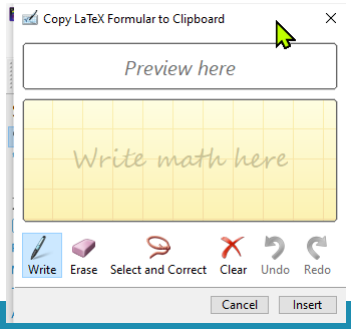
- Sums and integrals:
  - Sum: `\sum` (different from the \Sigma symbol).
  - Product: `\prod`
  - Integrals: `\int`
  - Size is adjusted automatically according to the equation
  - Lower and upper limits are specified as subscripts and superscripts:
- Limits:
  - `\lim` produces the “lim” symbol
- *File: demo_math_calculus.tex*

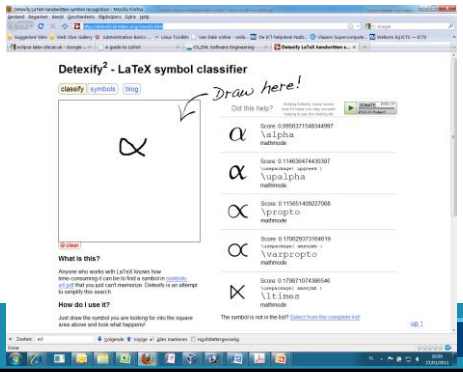
Text and math accents

- Math Text:
  - Text in math mode is in italics
  - This can be avoided for certain functions by typing the following: `\sin, \cos, \log, \ln, \exp`, etc.
  - Regular text within equations in display mode is specified with `\text (amsmath)` command (this command also keeps text together - `\mbox` can also be used)
- Math accents
  - `$\bar{a}$`
  - `$\hat{a}$`
  - `$\tilde{a}$`
  - `$\vec{a}$`
- *File: demo_math_text.tex*

Symbols

- Check https://www.ctan.org/tex-archive/info/symbols/comprehensive/
- Use detexify (http://detexify.kirelabs.org/classify.html)
- Help in the (La)tekst editor (TeXstudio Math Assistant)





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Some Mathematical Symbols

$\aleph$	\aleph	$\prime$	\prime	$\forall$	\forall
$\hbar$	\hbar	$\emptyset$	\emptyset	$\exists$	\exists
$\imath$	\imath	∇	\nabla	$\neg$	\neg
$\jmath$	\jmath	$\surd$	\surd	$\flat$	\flat
ℓ	\ell	$\top$	\top	$\natural$	\natural
$\wp$	\wp	$\bot$	\bot	$\sharp$	\sharp
$\Re$	\Re	$\|$	|	$\clubsuit$	\clubsuit
$\Im$	\Im	$\angle$	\angle	$\diamondsuit$	\diamondsuit
∂	\partial	$\triangle$	\triangle	$\heartsuit$	\heartsuit
∞	\infty	$\backslash$	\backslash	$\spadesuit$	\spadesuit

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Greek Letters

α	\alpha	ι	\iota	ρ	\rho
β	\beta	κ	\kappa	σ	\sigma
γ	\gamma	λ	\lambda	τ	\tau
δ	\delta	μ	\mu	υ	\upsilon
ϵ	\epsilon	ν	\nu	ϕ	\phi
ζ	\zeta	ξ	\xi	χ	\chi
η	\eta	o	o	ψ	\psi
θ	\theta	π	\pi	ω	\omega

ϵ	\epsilon	ε	\varepsilon
θ	\theta	ϑ	\vartheta
π	\pi	ϖ	\varpi
ρ	\rho	ϱ	\varrho
σ	\sigma	ς	\varsigma
ϕ	\phi	φ	\varphi

Hands-on

$$\frac{\sqrt{2+z^2}}{\sqrt[3]{a}+5}$$

$\alpha, \beta, \Gamma, \epsilon, \varepsilon, \tau$
$\exp(i\theta) = \cos\theta + i\sin\theta$

$$\lim_{\theta\to\pi}\sum_{i=1}^{n}\theta^i\sin\theta$$

$\lim_{b\to\infty}\int_a^b f(x)$

$$\lim_{b\to\infty}\int_a^b f(x)$$

$$\left(\frac{1}{1+x}\right)$$

Write a file (math_handson_1.tex) expressing the above mathematical formulas.

Matrices / arrays

- The most basic way to create matrices is by entering the matrix environment while in math mode.(amsmath needed)

```
\[
\begin{matrix}
a & b & c\\
d & e & f\\
g & h & i
\end{matrix}
\]
```

- `&` symbols will align, and `\\` will drop to the next line
- `pmatrix and bmatrix` will put parentheses
- *File: demo_math_matrix.tex*

Matrices / arrays

- typeset arrays use `array` environment (default LaTeX environment)
- Similar to `matrix` environment, offers some control (cfr text tables)
  - Specify alignment
  - `l` align to the left, `c` align each to the center, and `r` align to the right
  - use delimiters to get brackets
- *File: demo_math_array.tex*

```
\[ \begin{array}{cc}
0 & 1\\
2 & 3
\end{array}
\]
```

Matrices / arrays

- Dots in an array:
  - `\ldots`: horizontal
  - `\vdots`: vertical
  - `\ddots`: diagonal

$$\mathbf{X} = \begin{pmatrix} x_{11} & x_{12} & \dots \\ x_{21} & x_{22} & \dots \\ \vdots & \vdots & \ddots \end{pmatrix}$$

Aligning equations

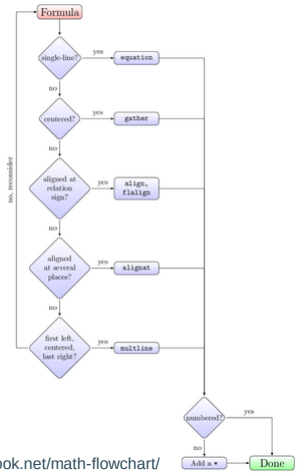
- The *amsmath* package provides options for displaying equations
- Split an equation
  - In the `split` environment
- For equations longer than a line use the `multline` environment. Insert \\ to set the break.
- Align several equations vertically, with the `align` environment
- *File: demo_math_aligneqn.tex*

- Based on https://www.overleaf.com/learn/latex/Aligning_equations_with_amsmath

Aligning equations

- https://en.wikibooks.org/wiki/LaTeX/Advanced_Mathematics#Other_environments

`multline`	First line is left-aligned, last line is right-aligned, all others are centered.
`gather`	Each line is centered.
`align`	Use & to mark a symbol where the formulas shall be aligned.
`split`	Similar to align, but within another math environment, thus unnumbered



https://latex-cookbook.net/math-flowchart/

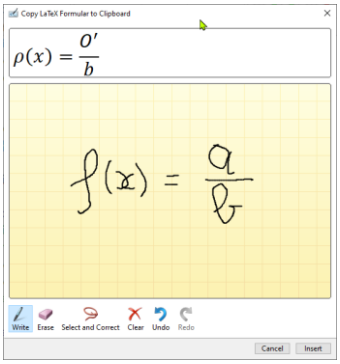
Math spacing

- Commands to adjust spacing between symbols in a formula
- Based on https://www.overleaf.com/learn/latex/Spacing_in_math_mode

LATEX code	Description
\quad	space equal to size of a capital M (= 18 mu)
\,	3/18 of \quad (= 3 mu)
\:	4/18 of \quad (= 4 mu)
\;	5/18 of \quad (= 5 mu)
\!	-3/18 of \quad (= -3 mu)
\ (space after backslash!)	equivalent of space in normal text
\qquad	twice of \quad (= 36 mu)

Equations help

- TeXstudio



- Web:
  - https://equplus.net/
  - http://rogercortesi.com/eqn/index.php
  - http://www.tlhiv.org/ltxpreview/
  - https://www.codecogs.com/latex/eqneditor.php?lang=en-en

Tips

- No blank lines are permitted in a formula.
- LaTeX ignores spaces in math