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Introduction to LaTeX

mathematics

Contents

- Math mode
- Basic math building blocks
- Arrays
- Aligning equations

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{amsmath}`
  - `mathtools` is an extention of `amsmath`. amsmath is a broad set of tools for typesetting equations, and is widely used. mathtools extends the amsmath functions to provide additional formatting options and to clean up some of the more common problems with math typesetting.
- http://en.wikibooks.org/wiki/LaTeX/Mathematics

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 $$ $$
    - 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

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

$\TeX$ is spelled as $\tau\epsilon\chi$.
100 m^2 area
my sweet$\heartsuit$
H$_2$SO$_4$

$$thisistextinmathmode \tag{2}$$

$$\text{this is mbox text in math mode} \tag{3}$$

$$sin(f(x)) = x^2 \tag{4}$$

$$\sin(f(x)) = x^2 \tag{5}$$

Building blocks of a formula

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

Based on: Practical LaTeX, by George Grätzer

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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*

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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
  `\leftDelimiter \rightDelimiter`

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

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

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

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
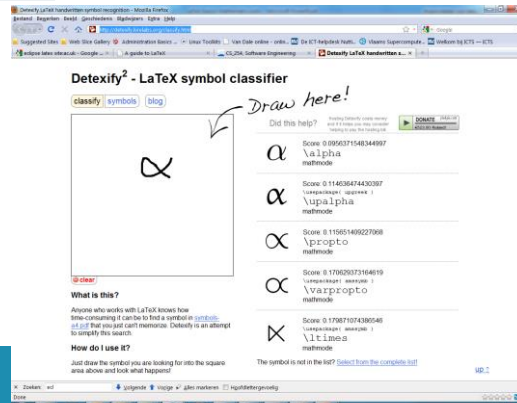- *File: demo_math_calculus.tex*

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.
  - Other text within equations is specified with an `\mbox` or `\text` `(amsmath)` command (this command also keeps text together)
- Math accents
  - `$\bar{a}$`
  - `$\hat{a}$`
  - `$\tilde{a}$`
  - `$\vec{a}$`
- *File: demo_math_text.tex*

Symbols

- Check http://www.ctan.org/tex-archive/info/symbols/comprehensive/
- Use detexify
  http://detexify.kirelabs.org/classify.html

Some Mathematical Symbols

ℵ	\aleph	′	\prime	∀	\forall
ℏ	\hbar	∅	\emptyset	∃	\exists
ı	\imath	∇	\nabla	¬	\neg
ȷ	\jmath	√	\surd	♭	\flat
ℓ	\ell	⊤	\top	♮	\natural
℘	\wp	⊥	\bot	♯	\sharp
ℜ	\Re	‖	|	♣	\clubsuit
ℑ	\Im	∠	\angle	♢	\diamondsuit
∂	\partial	△	\triangle	♡	\heartsuit
∞	\infty	\	\backslash	♠	\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

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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.

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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

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

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

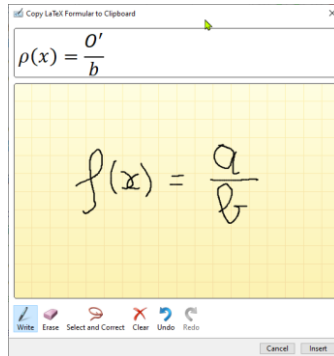|	
multline	First line is left-aligned, last line is right-aligned, all others are centered.
gather	Each line is centered.
align	Use & to mark a symbol where the formulas shall be aligned.
split	Similar to align, but within another math environment, thus unnumbered

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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)

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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