Introduction to LaTeX (Part 3)

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

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Contents

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*}
```

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

We have the following \documentclass options:

fleqn Displayed formulas will be flushed left

leqno Equation number on the left

```
\documentclass[11pt,a4paper,fleqn]{article}
```

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


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

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

$\hat{a}$	\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	$\bigtriangledown$	\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
$\vert$	|	$\Vert$	\\|				

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


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

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

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


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

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

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}
```

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

11 Define your own commands


```
\newcommand{\xytwo}{x_{\mathbf{y}}^2}
\newcommand{\xy}[1]{x_{\mathbf{y}}^{#1}}
```

```
$\xytwo \hspace*{1cm} \xy{3}$
```

$x_{\mathbf{y}}^2 \qquad x_{\mathbf{y}}^3$

Define your own commands


```
\renewcommand{\xy}[1][2]{x_{\mathbf{y}}^{#1}}
```

```
$\xy \hspace*{1cm} \xy[3]$
```

$x_{\mathbf{y}}^{2}$ $x_{\mathbf{y}}^{3}$

Define your own commands


```
\providecommand{\xy}[1][2]{x_{\mathbf{y}}^{#1}}
```

```
$\xy \hspace*{1cm} \xy[3]$
```

$x_{\mathbf{y}}^{2}$ $x_{\mathbf{y}}^{3}$

When using the package `amsmath` we can also define new functions:

```
\DeclareMathOperator{\sinc}{sinc}
$\sinc x$, $\sin x$
```

$\operatorname{sinc} x$, $\sin x$

When using the package `amsmath` we can also define new functions:

```
\DeclareMathOperator*{\supp}{supp}
$\sinc^2 x$, $\supp_{t\rightarrow\infty} x(t)$
```

$\sinc^2 x$, $\supp_{t\rightarrow\infty} x(t)$

Adopting standard LaTeX is often more involved:

```
\makeatletter
\renewcommand{\thesection}
      {Appendix \@Alph\c@section}
\makeatother

\renewcommand{\theenumi}
      {[\textit{\roman{enumi}}]}
\renewcommand{\labelenumi}
      {\textbf{(\roman{enumi})}}
```

```
\begin{enumerate}
\item \label{one} One
\item Two
\end{enumerate}
See \ref{one}
```

(i) One

(ii) Two

See [*i*]

12 Theorem, proposition, lemma

Preamble:

```
\newtheorem{theorem}{Theorem}[section]
\newtheorem{lemma}[theorem]{Lemma}
\newtheorem{definition}{Definition}
```

Text:

```
\begin{theorem} \label{Two}
  Tada
\end{theorem}
```

Theorem 12.1 Tada

Definition 1 Todo

Lemma 12.2 Todo

```
\usepackage{theorem}

{\theorembodyfont{\upshape}
 \theoremheaderfont{\slshape\bfseries}
 \theoremstyle{break}
   \newtheorem{remark}{Remark}}
```

Remark 1
Tidi