LaTeX and Friends
Mathematics

http://csweb.ucc.ie/~dongen/LAF/LAF.html

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UCC

$\mathcal{AMS}$-LaTeX

- $\mathcal{AMS}$-LaTeX is a useful platform for typesetting mathematics.
- Supported by the American Mathematical Society (AMS).
- Provides useful extensions to LaTeX.
- The distribution has two main parts:

  `amscls` AMS document class and theorem package.

  `amsmath` Extension package.

  - Makes math writing easier and improves quality.

Provided Packages

amsmath Environments for displayed equations and more.

amstext A `\text` command for typesetting text in formula.

amsopn `\DeclareMathOperator` for “operator names”.

- The operators are typeset like `\sin` and `\lim`.

amsthm Extensions of `\newtheorem` command.

- Also provides `proof` environment.

amscd Environment for simple commutative diagrams.

amsfonts Extra fonts including blackboard boldface ($\mathbb{A}$, $\mathbb{B}$, ...).

amssymb Lots of extra symbols.

LaTeX's Typesetting Modes

text	Typeset as basic text.
ordinary math	Typeset as math in the running text.
display math	Typeset as math in display.

Text → $ → Ordinary Math → $ → Text

LaTeX Input

```
The Binomial Theorem states
$\sum^{n}_{i=0}
 \binom{n}{i} a^{i} b^{n-i} = (a + b)^{n}$.
Substituting $1$ for $a$
 and $1$ for $b$ gives us
$\sum^{n}_{i=0}
 \binom{n}{i} = 2^{n}$.
```

LaTeX Output

The Binomial Theorem states $\sum^{n}_{i=0} \binom{n}{i} a^{i} b^{n-i} = (a + b)^{n}$. Substituting 1 for a and 1 for b gives us $\sum^{n}_{i=0} \binom{n}{i} = 2^{n}$.

Superscripts

- The superscript operator (`^`) creates a superscript.
- `$`⟨expr⟩`^`⟨sup⟩`$` makes ⟨sup⟩ a superscript of ⟨expr⟩.
  - So `$x^2 + 2 x + 1$` gives you $x^2 + 2x + 1$.
- Grouping works as usual.
  - So to typeset e^{a+b} you need braces: `$e^{a+b}$`.

Subscripts

- The subscript operator (_) creates a subscript.
- $⟨expr⟩_⟨sub⟩$ makes ⟨sub⟩ a subscript of ⟨expr⟩.
  - So to get $f_{n+2} = f_{n+1} + f_n$ you need

    ```
    $f_{n + 2} = f_{n + 1} + f_n$.
    ```

Mixing Subscripts and Superscripts

- Subscripts and superscripts may be nested and combined.
- $⟨expr⟩_⟨sub⟩^⟨sup⟩$ is the same as $⟨expr⟩^⟨sup⟩_⟨sub⟩$.
- Both give you $\langle\mathtt{expr}\rangle_{\langle\mathtt{sub}\rangle}^{\langle\mathtt{sup}\rangle}$.

Avoid Su*scripts

simplicity Keep the number of subscripts and superscripts low:

- Simpler notation;
- Greater transparency.

readability The resulting expression is easier to parse.

spacing Fewer inconsistencies in interline spacing.

Lower Case Greek Letters: Easy as π

regular	`\alpha` (α), `\beta` (β), `\gamma` (γ), ...
additional italic	`\varepsilon` (ε), `\vartheta` (ϑ), `\varrho` (ϱ), ...
old number	`\digamma` ($\digamma$).

Lowercase Greek Letters

				Standard commands	
α	`\alpha`	ι	`\iota`	τ	`\tau`
β	`\beta`	κ	`\kappa`	υ	`\upsilon`
γ	`\gamma`	λ	`\lambda`	ϕ	`\phi`
δ	`\delta`	μ	`\mu`	χ	`\chi`
ϵ	`\epsilon`	ν	`\nu`	ρ	`\rho`
ζ	`\zeta`	ξ	`\xi`	ψ	`\psi`
η	`\eta`	ø	`\o`	σ	`\sigma`
θ	`\theta`	π	`\pi`	ω	`\omega`
				AMS-LaTeX provided commands	
ε	`\varepsilon`	$\varkappa$	`\varkappa`	ϱ	`\varrho`
φ	`\varphi`	ϑ	`\vartheta`	ϖ	`\varpi`
ς	`\varsigma`				
$\digamma$	`\digamma`				

Uppercase Greek Letters: Easy as Π

regular `\Gamma` (Γ), `\Delta` (Δ), `\Theta` (Θ), ...
italic `\varGamma` ($\varGamma$), `\varDelta` ($\varDelta$), `\varTheta` ($\varTheta$), ...

Uppercase Greek Letters

				Standard commands	
Γ	\Gamma	Ξ	\Xi	Φ	\Phi
Δ	\Delta	Π	\Pi	Ψ	\Psi
Θ	\Theta	Σ	\Sigma	Ω	\Omega
Λ	\Lambda	Υ	\Upsilon		
				AMS-LaTeX provided commands	
$\varGamma$	\varGamma	$\varXi$	\varXi	$\varPhi$	\varPhi
$\varDelta$	\varDelta	$\varPi$	\varPi	$\varPsi$	\varPsi
$\varTheta$	\varTheta	$\varSigma$	\varSigma	$\varOmega$	\varOmega
$\varLambda$	\varLambda	$\varUpsilon$	\varUpsilon		

Display Math

- The `amsmath` package provides display math environments.
- Provides starred and unstarred versions.
- Some environments allow alignment in multi-line expressions.
  - The alignment positions are specified with &.
  - Line breaks are specified with \\.

Starred versus Unstarred Environments

- Unstarred versions of the environment produce labels:
- Starred versions of the environment do not produce labels:
  - `equation*`, `align*`, ...
- Avoid the unstarred version unless text refers to the label.

The equation Environment

LaTeX Input

```
The following is the Binomial Theorem:
\begin{equation}
 \label{eq:Binomial}
 \sum^{n}_{i=0} \binom{n}{i}a^{i}b^{n-i} = (a+b)^{n}\,.
\end{equation}
Substituting $1$ for~$a$ and $1$ for~$b$
 in~(\ref{eq:Binomial}) ...
```

LaTeX Output

The following is the Binomial Theorem:

$$\sum^{n}_{i=0} \binom{n}{i}a^{i}b^{n-i} = (a+b)^{n}\,. \tag{1}$$

Substituting 1 for a and 1 for b in (1) gives us $\sum_{i=0}^{n} \binom{n}{i} = 2^n$.

Splitting a Single Equation

LaTeX Input

```
\begin{equation*}
\begin{split}
 a & = b + c + d         \\
   & \qquad + f + g + h \\
   & > 0\,.
\end{split}
\end{equation*}
```

LaTeX Output

$$\begin{split} a &= b + c + d \\ &\qquad + f + g + h \\ &> 0\,. \end{split}$$

The `align` Environment

- Use `align` for equation groups with alignment.
- Each row is numbered separately.
- To turn off numbering of current equation: use `\nonumber`.

The align Environment (Output)

LaTeX Output

$$F(z) = \sum_{n=0}^{\infty} f_n z^n \tag{2}$$

$$= z + \sum_{n=2}^{\infty} (f_{n-1} + f_{n-2}) z^n \tag{3}$$

$$= z + F(z)/z + F(z)/z^2 \tag{4}$$

$$= z/(1 - z - z^2) .$$

Here the last equation is obtained from (2), (3), and (4) by transitivity of equality and by solving for $F(z)$.

The align Environment (Input)

LaTeX Input

```
\begin{align}
   \label{eq:one}
F( z ) & = \sum^\infty_{n=0} f_n z^n               \\
   \label{eq:two}
       & = z + \sum^\infty_{n=2}(f_{n-1}+f_{n-2}) z^n \\
   \label{eq:three}
       & = z + F( z )/z + F( z )/z^2              \\
   \nonumber
       & = z / (1 - z - z^2)                      \,.
\end{align}
Here the last equation is obtained from~(\ref{eq:one}),
 (\ref{eq:two}), and~(\ref{eq:three}) by transitivity
 of equality and by solving for~$F( z )$.
```

The align Environment: Multiple Columns

LaTeX Input

```
\begin{align}
  a_0 & = b_0\,, & b_0 & = c_0\,, & c_0 & = d_0\,,\\
  a_1 & = b_1\,, & b_1 & = c_1\,, & c_1 & = d_1\,,\\
  a_2 & = b_2\,, & b_2 & = c_2\,, & c_2 & = d_2\,.
\end{align}
```

LaTeX Output

$$a_0 = b_0\,, \qquad b_0 = c_0\,, \qquad c_0 = d_0\,, \tag{5}$$
$$a_1 = b_1\,, \qquad b_1 = c_1\,, \qquad c_1 = d_1\,, \tag{6}$$
$$a_2 = b_2\,, \qquad b_2 = c_2\,, \qquad c_2 = d_2\,. \tag{7}$$

LaTeX Usage

```
\begin{align*}
   x_0 & = 0\,, \\
   x_1 & = 1\,, \\
\shortintertext{and}
   x_2 & = 2\,.
\end{align*}
```

LaTeX Output

$$x_0 = 0\,,$$
$$x_1 = 1\,,$$

and

$$x_2 = 2\,.$$

Low-level Alignment Building Blocks

LaTeX Input

```
\begin{equation*}
   I = \left[
       \begin{aligned}
           1 && 0 && 0 \\
           0 && 1 && 0 \\
           0 && 0 && 1
       \end{aligned}
       \right]\,.
\end{equation*}
```

LaTeX Output

$$I = \left[\begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}\right]\,.$$

The eqnarray Environment

- LaTeX also has an eqnarray environment.
- For multiple equations with horizontal alignment.
- In short: *Don't use it!*

Text in Formulae

- Sometimes you need plain text in mathematical formulae.
- $\mathcal{A}\mathcal{M}\mathcal{S}$-LaTeX provides special-purpose `\text` command.

LaTeX Input

```
\[ \text{final grade} =
   \text{\textsc{ca}} +
 5 \times \text{exam}\,. \]
```

LaTeX Output

$$\text{final grade} = \text{\textsc{ca}} + 5 \times \text{exam}\,.$$

Delimiters

- Every now and then LaTeX needs a bit of help.
- For example, `$f( 2^{2^{2^2}}_{2_{2_2}} )$` gives

$$f(2^{2^{2^2}}_{2_{2_2}}).$$

- Use `\left` and `\right` to scale the size of the parentheses.
- Then `$f\left(2^{2^{2^2}}_{2_{2_2}}\right)$` gives

$$f\left(2^{2^{2^2}}_{2_{2_2}}\right).$$

Yer `\left`, Yer `\right`, ...

LaTeX Output

$$n! = \begin{cases} 1 & \text{if } 0 \leq n \leq 1\,, \\ n \times (n-1)! & \text{otherwise}\,. \end{cases}$$

Yer \left, Yer \right, ...

LaTeX Output

$$n! = \left\{ \begin{aligned} & 1 && \text{if $0 \leq n \leq 1$}\,, \\ & n \times (n-1)! && \text{otherwise}\,. \end{aligned} \right.$$

LaTeX Input

```
\[ n! =
   \left\{
      \begin{aligned}
         & 1             && \text{if $0 \leq n \leq 1$}\,,
      \\ & n \times (n-1)! && \text{otherwise}\,.
     \end{aligned}
   \right.
\]
```

Nested Delimiters

- Common to use square brackets outside parentheses.
- This should work especially well in inline math mode.

LaTeX Input

```
Simplifying
 $[ (a + b)^{2}
  - (a - b)^{2} ]^{2}$
gives us $16 a^{2} b^{2}$.
```

LaTeX Output

Simplifying $[(a+b)^2 - (a-b)^2]^2$ gives us $16a^2b^2$.

Delimiters on Different Lines

How Not To ...

Don't Try This at Home

```
\begin{align*}
   f & = g\left( 3^{3^{3}}
       + ...\right.
   \\& \qquad \left. + 3 \right)\,.
\end{align*}
```

LaTeX Output

$$f = g\left(3^{3^{3}} + \dots\right.$$
$$\qquad \left. + 3\right)\,.$$

Delimiters on Different Lines

The \vphantom Trick

LaTeX Input

```
\begin{align*}
   f & = g\left( 3^{3^{3}}
       + ...\right.
   \\& \qquad \left.
       + 3 \vphantom{3^{3^{3}}}
       \right)\,.
\end{align*}
```

LaTeX Output

$$\begin{aligned} f &= g\left(3^{3^{3}} + \ldots\right. \\ &\qquad \left. + 3 \vphantom{3^{3^{3}}} \right)\,. \end{aligned}$$

Overloading

- Some symbols are used for different purposes: overloading.
  - For example, $|$ is used as left and right delimiter in $|\cdot|$.
- $\mathcal{AMS}$-LaTeX provides new commands for delimiters.
- Delimiters scale with `\left` and `\right`.

Typesetting 'Non-delimiting' Bars

LaTeX Input

```
The even digits are
 given by
$\{\, 2 n \in \mathbb{N}
   \,\vert\,
      0 \leq n \leq 4 \,\}$.
```

LaTeX Output

The even digits are given by $\{\, 2n \in \mathbb{N} \,\vert\, 0 \leq n \leq 4 \,\}$.

More Variable-sized Bars

- `$\left\lvert x \right\rvert$`
  - Absolute-values and similar: $\left\lvert x \right\rvert$.
- `$\left\lVert x \right\rVert$`
  - Norms: $\left\lVert x \right\rVert$.

Evaluation

LaTeX Input

```
\[\left. f( x )
  \right \rvert_{x=0} = 0\,.
\]
```

LaTeX Output

$$\left. f(x) \right\rvert_{x=0} = 0\,.$$

Know thy TEX

Don't Try This at Home

```
Say no to $<1,2,3>$!
```

LATEX Output

Say no to $< 1, 2, 3 >$!

Know thy TEX

LATEX Input

```
Let $F( z )$ be the ordinary generating function of
 $\left\langle t_0,t_1, \ldots \right\rangle$.
Then $z F( z )$ is the ordinary
 generating function of
 $\left\langle 0,t_0,t_1, \ldots \right\rangle$.
```

LATEX Output

Let $F(z)$ be the ordinary generating function of $\left\langle t_0, t_1, \ldots \right\rangle$. Then $zF(z)$ is the ordinary generating function of $\left\langle 0, t_0, t_1, \ldots \right\rangle$.

Floors and Ceilings

LaTeX Input

```
Let $x$ be any real number.
By definition
$i \leq \left\lfloor x \right\rfloor
   \leq x
   \leq \left\lceil x \right\rceil
   \leq I$
 for all integers $i$ and $I$ such that
 $i \leq x \leq I$.
```

LaTeX Output

Let x be any real number. By definition $i \leq \left\lfloor x \right\rfloor \leq x \leq \left\lceil x \right\rceil \leq I$ for all integers i and I such that $i \leq x \leq I$.

Variable-sized Delimiter Commands

<table>
<tr><th colspan="6">Standard</th></tr>
<tr><td>$\{$</td><td>\{</td><td>$\}$</td><td>\}</td><td>$\langle$</td><td>\langle</td></tr>
<tr><td>$\lceil$</td><td>\lceil</td><td>$\lfloor$</td><td>\lfloor</td><td>$\rangle$</td><td>\rangle</td></tr>
<tr><td>$\rceil$</td><td>\rceil</td><td>$\rfloor$</td><td>\rfloor</td><td>$\uparrow$</td><td>\uparrow</td></tr>
<tr><td>$\Downarrow$</td><td>\Downarrow</td><td>$\updownarrow$</td><td>\updownarrow</td><td>$\downarrow$</td><td>\downarrow</td></tr>
<tr><td>$\Uparrow$</td><td>\Uparrow</td><td>$\Updownarrow$</td><td>\Updownarrow</td><td>$($</td><td>(</td></tr>
<tr><td>$[$</td><td>[</td><td>$|$</td><td>|</td><td>$)$</td><td>)</td></tr>
<tr><td>$]$</td><td>]</td><td>$\|$</td><td>\|</td><td>$/$</td><td>/</td></tr>
<tr><td>$\backslash$</td><td>\backslash</td><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="6">amsmath</th></tr>
<tr><td>$\lvert$</td><td>\lvert</td><td>$\rvert$</td><td>\rvert</td><td></td><td></td></tr>
<tr><td>$\lVert$</td><td>\lVert</td><td>$\rVert$</td><td>\rVert</td><td></td><td></td></tr>
</table>

Fractions

- Ordinary fractions are typeset using the command `\frac`.
- To get $\frac{\langle\texttt{num}\rangle}{\langle\texttt{den}\rangle}$ you use `\frac{⟨num⟩}{⟨den⟩}`.

Use Fractions with Discretion

- Fractions in ordinary math mode may affect the interline spacing.
- Use n/d if n and d are “simple.”
- If $d \neq 0$, consider using $d \times f = n$ instead of $f = \frac{n}{d}$.

Continued Fractions: amsmath

- Continued fractions are typeset with the command \cfrac.
- Has optional argument (l or r) for placement of numerator.

LaTeX Input

```
\[ \sqrt{2} - 1
 = \cfrac{1}{2 +
   \cfrac{1}{2 +
   \dotsb}}}\,. \]
```

LaTeX Output

$$\sqrt{2} - 1 = \cfrac{1}{2 + \cfrac{1}{2 + \dotsb}}\,.$$

Typesetting Delimited Sums

LaTeX Input

```
According to folklore Gauss proved that
 \[ \sum^{n}_{i=0} i=n(n+1)/2\,. \]
```

LaTeX Output

According to folklore Gauss proved that

$$\sum^{n}_{i=0} i=n(n+1)/2\,.$$

Delimited Sums

Notice Upper and Lower Index Placement

LaTeX Input

```
According to folklore Gauss proved that $\sum^{n}_{i=0} i=n(n+1)/2$.
```

LaTeX Output

According to folklore Gauss proved that $\sum^{n}_{i=0} i=n(n+1)/2$.

LaTeX Input

```
According to folklore Gauss proved that \[\sum^{n}_{i=0} i=n(n+1)/2\,.\]
```

LaTeX Output

According to folklore Gauss proved that

$$\sum^{n}_{i=0} i=n(n+1)/2\,.$$

Overriding the Style for Lower and Upper Limits

LaTeX Input

```
\[ \textstyle
   \sum^\infty_{n=0}
         2^{-n} = 2\,. \]
```

LaTeX Output

$$\textstyle \sum^\infty_{n=0} 2^{-n} = 2\,.$$

Other Variable-sized Operators

					Standard
$\sum$	\sum	$\int$	\int	$\bigcap$	\bigcap
$\prod$	\prod	$\oint$	\oint	$\bigcup$	\bigcup
$\bigoplus$	\bigoplus	$\bigsqcup$	\bigsqcup	$\bigwedge$	\bigwedge
$\bigotimes$	\bigotimes	$\coprod$	\coprod	$\bigvee$	\bigvee
$\bigodot$	\bigodot	$\biguplus$	\biguplus		
					$\mathcal{A}\mathcal{M}\mathcal{S}$-LaTeX
$\iint$	\iint	$\iiint$	\iiint	$\iiiint$	\iiiint
$\idotsint$	\idotsint				

Multi-Line Limits with the \substack Command

LaTeX Input

```
\[ \sum_{\substack{\text{$i$ odd}}
                  \\0 \leq i\leq n}}
       \binom{n}{i}
 = 2^n -
   \sum_{\substack{\text{$i$ even}
                  \\0\leq i\leq n}}
       \binom{n}{i}\,. \]
```

LaTeX Output

$$\sum_{\substack{\text{i odd}\\0 \leq i\leq n}} \binom{n}{i} = 2^n - \sum_{\substack{\text{i even}\\0\leq i\leq n}} \binom{n}{i}\,.$$

Complex Limits with the subarray Environment

LaTeX Input

```
\[ \sum_{\begin{subarray}{l}
            i \text{ odd}\\
            0 \leq i \leq n
         \end{subarray}}
       \binom{n}{i}
 = 2^n -
   \sum_{\begin{subarray}{c}
            i \text{ even}\\
            0 \leq i \leq n
         \end{subarray}}\,.
       \binom{n}{i}  \]
```

LaTeX Output

$$\sum_{\begin{subarray}{l} i \text{ odd}\\ 0 \leq i \leq n \end{subarray}} \binom{n}{i} = 2^n - \sum_{\begin{subarray}{c} i \text{ even}\\ 0 \leq i \leq n \end{subarray}} \binom{n}{i}\,.$$

Complex Limits with the subarray Environment

LaTeX Input

```
\[ \sum_{\begin{subarray}{l}
           i \text{␣odd}\\
           0 \leq i \leq n
         \end{subarray}}
       \binom{n}{i}
 = 2^n -
   \sum_{\begin{subarray}{c}
           i \text{␣even}\\
           0 \leq i \leq n
         \end{subarray}}\,.
       \binom{n}{i}  \]
```

LaTeX Output

$$\sum_{\begin{subarray}{l} i \text{␣odd}\\ 0 \leq i \leq n \end{subarray}} \binom{n}{i} = 2^n - \sum_{\begin{subarray}{c} i \text{␣even}\\ 0 \leq i \leq n \end{subarray}} \binom{n}{i}\,.$$

Log-like Functions

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

Subscripts, Superscripts, and Limit Arguments

LaTeX Input

```
\[ \lim_{x \to 0}
       \frac{x^{2}}
            {x} = 0\,. \]
```

LaTeX Output

$$\lim_{x \to 0} \frac{x^{2}}{x} = 0\,.$$

More Overloaded Symbols: mod

Command	Expression	Result
`\bmod`	`$\gcd( 5, 3 ) = \gcd( 3, 5 \bmod 3 )$`	$\gcd(5, 3) = \gcd(3, 5 \bmod 3)$
`\mod`	`$2 \equiv 5 \mod 3$`	$2 \equiv 5 \mod 3$
`\pmod`	`$2 \equiv 5 \pmod 3$`	$2 \equiv 5 \pmod 3$
`\pod`	`$2 \equiv 5 \pod 3$`	$2 \equiv 5 \pod 3$

Integration

LaTeX Input

```
\[ \int^{b}_{a} 3 x^{2}\,d x
 = \left. x^{3} \right\rvert^{b}_{a}
 = b^{3} - a^{3}\,. \]
```

LaTeX Output

$$\int^{b}_{a} 3 x^{2}\,d x = \left. x^{3} \right\rvert^{b}_{a} = b^{3} - a^{3}\,.$$

Multiple Integral Signs

amsmath

$\int$	\int	$\iint$	\iint
$\iiint$	\iiint	$\iiiint$	\iiiint
$\idotsint$	\idotsint		

esint

$\int$	\int	$\iint$	\iint
$\iiint$	\iiintop	$\iiiint$	\iiiintop
$\sqint$	\sqint	$\sqiint$	\sqiint
$\ointctrclockwise$	\ointctrclockwise	$\ointclockwise$	\ointclockwise
$\landupint$	\landupint	$\landdownint$	\landdownint
$\fint$	\fint	$\dotsint$	\dotsintop
$\oint$	\ointop	$\oiint$	\oiintop
$\varointctrclockwise$	\varointctrclockwise	$\varointclockwise$	\varointclockwise
$\varoiint$	\varoiint		

Differentiation

- Differentiations are typeset using `\frac`.
- You get $\frac{du}{dx}$ with `\frac{d u}{d x}`.
- You get $\frac{d^2 u}{dx^2}$ with `\frac{d^{2} u}{d x^{2}}`.

Differentiation

LaTeX Input

```
Let $z = x^{2} + x y$, then
\[ \frac{\partial z}
        {\partial x}
   = 2x + y\,. \]
```

LaTeX Output

Let $z = x^2 + xy$, then

$$\frac{\partial z}{\partial x} = 2x + y\,.$$

Roots

LaTeX Input

```
... $\sqrt{2} \approx 1.414213562$.
```

LaTeX Output

... $\sqrt{2} \approx 1.414213562$.

A Root is a Root

Would $\sqrt[3]{}$ by any Other Name Smell as Sweet?

LaTeX Input

```
... $\sqrt[3]{27} = 3$.
```

LaTeX Output

… $\sqrt[3]{27} = 3$.

Roots: \leftroot and \uproot

LaTeX Input

```
We all agree that
$\sqrt[\beta]{k}$
 is equal to
$\sqrt[\leftroot{-2}\uproot{2}\beta]{k}$.
But why are they different in type?
```

LaTeX Output

We all agree that $\sqrt[\beta]{k}$ is equal to $\sqrt[\leftroot{-2}\uproot{2}\beta]{k}$. But why are they different in type?

Changing the Type Style

```
$\mathit{italic + abc^2}$
```
$\mathit{italic + abc^2}$.

```
$\mathrm{roman + abc^2}$
```
$\mathrm{roman + abc^2}$.

```
$\mathbf{bold + abc^2}$
```
$\mathbf{bold + abc^2}$.

```
$\mathsf{sans serif + abc^2}$
```
$\mathsf{sans serif + abc^2}$.

```
$\mathtt{teletype + abc^2}$
```
$\mathtt{teletype + abc^2}$.

```
$\mathcal{CALLIGRAPHIC}$
```
$\mathcal{CALLIGRAPHIC}$.

Operator Symbols

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

Relation Symbols

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

Additional Relation Symbols

$\approxeq$	\approxeq	$\eqcirc$	\eqcirc	$\succapprox$	\succapprox
$\backepsilon$	\backepsilon	$\fallingdotseq$	\fallingdotseq	$\succcurlyeq$	\succcurlyeq
$\backsim$	\backsim	$\multimap$	\multimap	$\succsim$	\succsim
$\backsimeq$	\backsimeq	$\pitchfork$	\pitchfork	$\therefore$	\therefore
$\because$	\because	$\precapprox$	\precapprox	$\thickapprox$	\thickapprox
$\between$	\between	$\preccurlyeq$	\preccurlyeq	$\thicksim$	\thicksim
$\Bumpeq$	\Bumpeq	$\precsim$	\precsim	$\varpropto$	\varpropto
$\bumpeq$	\bumpeq	$\risingdotseq$	\risingdotseq	$\Vdash$	\Vdash
$\circeq$	\circeq	$\shortmid$	\shortmid	$\vDash$	\vDash
$\curlyeqprec$	\curlyeqprec	$\shortparallel$	\shortparallel	$\Vvdash$	\Vvdash
$\curlyeqsucc$	\curlyeqsucc	$\smallfrown$	\smallfrown	$\doteqdot$	\doteqdot
$\smallsmile$	\smallsmile				

Fixed-size Arrows

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

Extensible Arrows: amsmath

$\xleftarrow{e}$	`\xleftarrow{e}`	$\xleftarrow[o]{e}$	`\xleftarrow[o]{e}`
$\xrightarrow{e}$	`\xrightarrow{e}`	$\xrightarrow[o]{e}$	`\xrightarrow[o]{e}`
$\underleftarrow{e}$	`\underleftarrow{e}`	$\underrightarrow{e}$	`\underrightarrow{e}`
$\overleftrightarrow{e}$	`\overleftrightarrow{e}`	$\underleftrightarrow{e}$	`\underleftrightarrow{e}`

Extensible Arrows: mathtools (No Option)

$\xleftrightharpoons{e}$	\xleftrightharpoons{e}	$\xrightleftharpoons{e}$	\xrightleftharpoons{e}
$\xleftharpoondown{e}$	\xleftharpoondown{e}	$\xrightharpoondown{e}$	\xrightharpoondown{e}
$\xleftharpoonup{e}$	\xleftharpoonup{e}	$\xrightharpoonup{e}$	\xrightharpoonup{e}
$\xleftrightarrow{e}$	\xleftrightarrow{e}	$\xLeftrightarrow{e}$	\xLeftrightarrow{e}
$\xhookleftarrow{e}$	\xhookleftarrow{e}	$\xhookrightarrow{e}$	\xhookrightarrow{e}
$\xLeftarrow{e}$	\xLeftarrow{e}	$\xRightarrow{e}$	\xRightarrow{e}
$\xmapsto{e}$	\xmapsto{e}		

Extensible Arrows: mathtools (With Option)

$\xleftrightharpoons[o]{e}$	\xleftrightharpoons[o]{e}	$\xrightleftharpoons[o]{e}$	\xrightleftharpoons[o]{e}
$\xleftharpoondown[o]{e}$	\xleftharpoondown[o]{e}	$\xrightharpoondown[o]{e}$	\xrightharpoondown[o]{e}
$\xleftharpoonup[o]{e}$	\xleftharpoonup[o]{e}	$\xrightharpoonup[o]{e}$	\xrightharpoonup[o]{e}
$\xleftrightarrow[o]{e}$	\xleftrightarrow[o]{e}	$\xLeftrightarrow[o]{e}$	\xLeftrightarrow[o]{e}
$\xhookleftarrow[o]{e}$	\xhookleftarrow[o]{e}	$\xhookrightarrow[o]{e}$	\xhookrightarrow[o]{e}
$\xLeftarrow[o]{e}$	\xLeftarrow[o]{e}	$\xRightarrow[o]{e}$	\xRightarrow[o]{e}
$\xmapsto[o]{e}$	\xmapsto[o]{e}		

Miscellaneous Symbols

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

Dotless $\imath$ and $\jmath$

LaTeX Input

```
Some people write
 $\hat{i}$ and $\hat{j}$
 but $\hat{\imath}$ and
 $\hat{\jmath}$ is better.
```

LaTeX Output

Some people write $\hat{i}$ and $\hat{j}$ but $\hat{\imath}$ and $\hat{\jmath}$ is better.

Functions and Operators

- The `amsmath` package lets you define your own operators.
- Ensures proper typesetting in uniform and consistent style.
- Gives full control over positioning of sub- and superscripts.

\DeclareMathOperator

\DeclareMathOperator{⟨command⟩}{⟨sym⟩}

- Defines ⟨command⟩ for symbol ⟨sym⟩.
- ⟨sym⟩ is typeset with proper spacing and uniform style.

Example

LaTeX Input

```
\documentclass{article}
\usepackage{amsmath}
\DeclareMathOperator\op{op}
\begin{document}
  ... Note that
  $1 \mathrm{op} 2 = 3$
  does not look pretty.
  However, $1 \op 2 = 3$
  looks good.
\end{document}
```

LaTeX Output

… Note that $1 \mathrm{op} 2 = 3$ does not look pretty. However, $1 \operatorname{op} 2 = 3$ looks good.

Declaring Your own Operators (Continued)

Operators with Limit Positions

LaTeX Input

```
\DeclareMathOperator*\Lim{Lim}
```

LaTeX Input

```
$\Lim_{x \to 0}
     \frac{x^{2}}{x} = 0$....
```

LaTeX Output

... $\mathrm{Lim}_{x\to 0} \frac{x^2}{x} = 0$. ...

COntent Oriented LaTeX: the `cool` Package

- Provides commands for consistently typesetting symbols.
- Provides easy commands for typesetting complex matrices.
- Provides commands for consistent typesetting expressions.
  - Inverse trigonometric functions $\arcsin x$ versus $\sin^{-1} x$.
  - Derivatives $\frac{d}{dx}f$ versus $\frac{df}{dx}$.
  - Printing of certain functions and polynomials
  - Integrals $\int f\, dx$, versus $\int f \mathrm{d}x$, versus, $\int dx\, f$, ...

Arrays and Matrices: array

LaTeX Input

```
\[ \left(
   \begin{array}{c}
      \left\lvert
      \begin{array}{lrc}
            x &   y &   z
         \\ 2 a & 3 b & 4 c
      \end{array}
      \right\rvert
      \\ \alpha
      \\ \beta
   \end{array}
   \right) \]
```

LaTeX Output

$$\left(\begin{array}{c}\left\lvert\begin{array}{lrc} x & y & z \\ 2a & 3b & 4c \end{array}\right\rvert \\ \alpha \\ \beta \end{array}\right)$$

Matrices

- The `amsmath` package provides six environments for matrices.
- All commands are for display math mode.
- Not possible to specify horizontal alignment.
- Ten columns by default: alignment to the centre.

`pmatrix` Parentheses as delimiters: $\begin{pmatrix} 1 & 2 & 3 \end{pmatrix}$.
`bmatrix` Square brackets as delimiters: $\begin{bmatrix} 1 & 2 & 3 \end{bmatrix}$.
`Bmatrix` Braces as delimiters: $\begin{Bmatrix} 1 & 2 & 3 \end{Bmatrix}$.
`vmatrix` Vertical bars as delimiters: $\begin{vmatrix} 1 & 2 & 3 \end{vmatrix}$.
`Vmatrix` Double vertical bars as delimiters: $\begin{Vmatrix} 1 & 2 & 3 \end{Vmatrix}$.
`matrix` No delimiters: $\begin{matrix} 1 & 2 & 3 \end{matrix}$.

Small Matrices

- $\mathcal{A}\mathcal{M}\mathcal{S}$-LaTeX also provides a `smallmatrix` environment.
- Delimiters should be typeset with `\bigl` and `\bigr`.
- ```
  $\bigl[\begin{smallmatrix} ...
          \end{smallmatrix}
   \bigr]$.
  ```
  ```

Small Matrices

$\LaTeX$ Input

```
... The linear transformation
$\langle\,x,y\,\rangle
 \mapsto
 \langle\,2x + y, y\,\rangle$
is written as follows:
$\bigl[\begin{smallmatrix}
   2&1 \\ 0&1
 \end{smallmatrix}\bigr]
 \bigl[\begin{smallmatrix}
   x   \\ y
 \end{smallmatrix}\bigr]$.
```

$\LaTeX$ Output

... The linear transformation $\langle\,x,y\,\rangle \mapsto \langle\,2x + y, y\,\rangle$ is written as follows: $\bigl[\begin{smallmatrix} 2&1 \\ 0&1 \end{smallmatrix}\bigr] \bigl[\begin{smallmatrix} x \\ y \end{smallmatrix}\bigr]$.

Accents and Decorations

Fixed-size Decorations			
$\dot{x}$	`\dot{x}`	$\acute{x}$	`\acute{x}`
$\ddot{x}$	`\ddot{x}`	$\grave{x}$	`\grave{x}`
$\dddot{x}$	`\dddot{x}`	$\hat{x}$	`\hat{x}`
$\ddddot{x}$	`\ddddot{x}`	$\tilde{x}$	`\tilde{x}`
$\mathring{x}$	`\mathring{x}`	$\bar{x}$	`\bar{x}`
$\check{x}$	`\check{x}`	$\vec{x}$	`\vec{x}`
$\breve{x}$	`\breve{x}`		
Extensible Decorations			
$\overleftarrow{e}$	`\overleftarrow{e}`	$\overline{e}$	`\overline{e}`
$\overrightarrow{e}$	`\overrightarrow{e}`	$\widetilde{e}$	`\widetilde{e}`
$\overleftrightarrow{e}$	`\overleftrightarrow{e}`	$\widehat{e}$	`\widehat{e}`
$\underleftarrow{e}$	`\underleftarrow{e}`	$\underbar{e}$	`\underbar{e}`
$\underleftrightarrow{e}$	`\underleftrightarrow{e}`	$\underline{e}$	`\underline{e}`
$\underrightarrow{e}$	`\underrightarrow{e}`		

Braces

$\overbrace{u}^{o}$	`\overbrace{u}^{o}`	$\overbrace{u}$	`\overbrace{u}`
$\underbrace{o}_{u}$	`\underbrace{o}_{u}`	$\underbrace{o}$	`\underbrace{o}`

Braces (Continued)

LaTeX Input

```
\[ x^{k} =
   \underbrace
      {1 \times x
       \times x \times
       \dotsb \times x}
     _{\text{$k$~times
             $\times x$}} \,. \]
```

LaTeX Output

$$x^{k} = \underbrace{1 \times x \times x \times \dotsb \times x}_{\text{k~times $\times x$}} \,.$$

Case-based Definitions: Cases

LaTeX Input

```
\[ n! = \begin{cases}
          1                  & \text{if $n = 0$}\,; \\
          (n-1) ! \times n & \text{if $n > 0$}\,.
        \end{cases}  \]
```

LaTeX Output

$$n! = \begin{cases} 1 & \text{if } n = 0\,; \\ (n-1)! \times n & \text{if } n > 0\,. \end{cases}$$

Case-based Definitions: Iversonians

LaTeX Input

```
… We define
 $n! = [\,n = 0\,] +
  (n-1) ! \times n
  \times [\,n > 0\,]$. …
```

LaTeX Output

… We define $n! = [\,n = 0\,] + (n-1)! \times n \times [\,n > 0\,]$. …

Function Definitions

LaTeX Input

```
The successor function,
 $s \colon \mathbb{N}
    \to    \mathbb{N}$,
 is defined as follows:
\[ s( n ) \mapsto n+1 \,. \]
```

LaTeX Output

The successor function, $s\colon \mathbb{N} \to \mathbb{N}$, is defined as follows:

$$s(n) \mapsto n+1\,.$$

Theorems

- Writing theorems, lemmas, and friends is easy with `amsthm`.
- Package ensures consistent numbering and appearance.
  - A `proof` environment;
  - Styles for theorem-like environments;
  - Commands for defining new theorem-like styles; and
  - Commands for defining new theorem-like environments.

Theorems: Ingredients

LaTeX Output

Theorem 2.1.3 (Fermat's Last Theorem). *Let n be any integer greater than 2, then the equation* $a^n + b^n = c^n$ *has no solutions in positive integers a, b, and c.*

heading Describes the rôle of the environment.
- Usually, Theorem, Lemma, Definition, ...

number Numbers the environment (optional).

body The meat.

name Names it (optional).
- Captures essence of body.
- Used to refer to environment by name.

Theorems: Ingredients

LaTeX Output

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Theorems: Ingredients

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Theorem 2.1.3 (Fermat's Last Theorem). *Let n be any integer greater than 2, then the equation $a^n + b^n = c^n$ has no solutions in positive integers a, b, and c.*

heading: Describes the rôle of the environment.
- Usually, Theorem, Lemma, Definition, ...

number: Numbers the environment (optional).

body: The meat.

name: Names it (optional).
- Captures essence of body.
- Used to refer to environment by name.

Existing Theorem Styles (Typesetting)

`plain` Usually associated with: Theorem, Lemma, Corollary, Proposition, Conjecture, Criterion, and Algorithm.

LaTeX Output

Theorem 1.1 (Fermat's Last Theorem). *Let n be any integer greater than 2, then the equation* $a^n + b^n = c^n$ *has no solutions in positive integers a, b, and c.*

`definition` Usually associated with: Definition, Condition, Problem, and Example.

LaTeX Output

Definition 1.2 (Ceiling). The *ceiling* of real number, r, is the smallest integer, i, such that $r \leq i$.

`remark` Usually associated with: Remark, Note, Notation, Claim, Summary, Acknowledgement, Case, and Conclusion.

LaTeX Output

Tip 1.3 (Tip). Don't do this at home.

Existing Theorem Styles (Numbering)

Numbering Depends on Style

- Numbering may or may not depend on the sectional unit.

  independent numbering Theorem 1, Theorem 2, ...

  dependent numbering Theorem 1.1, Theorem 1.2, ...

- Different environments may or may not share number sequences.

  with sharing Theorem 1, Lemma 2, Theorem 3, and so on, but not Theorem 2.

  without sharing Theorem 1, Lemma 1, Theorem 2, and so on.

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independent numbering	Theorem 1, Theorem 2, ...
dependent numbering	Theorem 1.1, Theorem 1.2, ...

- Different environments may or may not share number sequences.

with sharing	Theorem 1, Lemma 2, Theorem 3, and so on, but not Theorem 2.
without sharing	Theorem 1, Lemma 1, Theorem 2, and so on.

Defining New Environments

- Defining new theorem-like environment styles is done in two stages.
  1. Set the current style;
  2. Define the environments.
- New environments are typeset in the current style.

Defining the Current Style

- Defining the current style is done with `\theoremstyle`.
- Command takes the label of the style as its argument.
- Initially, the current style is `plain`.

Defining the Next Environment

- The next environment is defined with `\newtheorem`.
- Environments are typeset according to current style.
- Numbering depends on `\newtheorem`.

Defining Environments *Without* Option

LaTeX Usage

```
\newtheorem{⟨env⟩}{⟨heading⟩}
```

- Defines environment ⟨env⟩ with heading ⟨heading⟩.
- Environment is started with new numbering sequence.

Defining Environments *With* Option

Option as Second Argument

LaTeX Usage

```
\newtheorem{⟨env⟩}[⟨old⟩]{⟨heading⟩}
```

- Defines new environment ⟨env⟩ with heading {⟨heading⟩}.
- New environment shares numbering with ⟨old⟩.

Defining Environments *With* Option

Option as Last Argument

LaTeX Usage

`\newtheorem{⟨env⟩}{⟨heading⟩}[⟨unit⟩]`

- Defines environment ⟨env⟩ with heading ⟨heading⟩.
- Here ⟨unit⟩ is the name of a sectional unit.
- Starts new numbering sequence that depends on ⟨unit⟩.

Example

LaTeX Usage

```
\usepackage{amsmath}
\usepackage{amsthm}

% Current environment style is plain.
%% Define environment thm for theorems.
\newtheorem{thm}{Theorem}
%% Define environment lemma for lemmas.
%% Share numbering with thm environment.
\newtheorem{lemma}[thm]{Lemma}

% Set environment style to definition.
\theoremstyle{definition}
%% Define environment def for definitions.
%% Share numbering with thm environment.
\newtheorem{def}[thm]{Definition}
```

Defining New Styles

- `\newtheoremstyle` defines a new theorem-like style.
- Gives you ultimate control.
- Usually predefined styles suffice.
  - (`plain`, `definition`, and `remark`.)

Proofs

LaTeX Input

```
\begin{proof}[Challenge]
The following proves that
$5^{2} = 3^{2} + 4^{2}$:
\[ 5^2 = 25 = 9 + 16
       = 3^2 + 4^2\,.
   \qedhere \]
\end{proof}
```

LaTeX Output

Challenge.

The following proves that $3^2 + 4^2 = 5^2$:

$$5^2 = 25 = 9 + 16 = 3^2 + 4^2\,. \qquad \square$$

Dot-like Symbols

Low dots `$n(n-1)\ldots(1)$`: $n(n-1)\ldots(1)$

Centred dots `$x_{1}+\cdots+x_{n}$`: $x_{1}+\cdots+x_{n}$

Diagonal dots In arrays and matrices. `\ddots`: $\ddots$

Vertical dots In arrays and matrices. `\vdots`: $\vdots$

Pedantic Dots (`amsmath`)

- Dots with commas: `\dotsc`
- Dots with binary operators: `\dotsb`
- multiplication dots: `\dotsm`
- Dots with integrals: `\dotsi`
- other dots: `\dotso`

Example

LaTeX Input

```
\ldots Then we have series
  $A_1, A_2, \dotsc$,
regional sum
  $A_1 + A_2 + \dotsb$,
orthogonal product
  $A_1 A_2 \dotsm$,
and infinite integral
  \[  \int_{A_1}
    \!\int_{A_2}
      \dotsi\,.\]
```

LaTeX Output

…Then we have series $A_1, A_2, \dotsc$, regional sum $A_1 + A_2 + \dotsb$, orthogonal product $A_1 A_2 \dotsm$, and infinite integral

$$\int_{A_1} \!\int_{A_2} \dotsi\,.$$

Linebreaks in Ordinary Math

Not after Commas

LATEX Usage

```
for $x = f( a, b )$, $f( b, c )$,
 or~$f( b, c )$.
```

Don't Try This at Home

```
for $x = f( a, b ), f( b, c )$,
 or $f( b, c )$.
```

Don't Try This at Home

```
Let $x, y$, and $z$ be real numbers.
```

LATEX Usage

```
Let $x$, $y$, and $z$ be real numbers.
```

Linebreaks in Display Math

- (Always insert a thin space (`\,`) before final punctuation symbol.)
- Indent line after linebreak by a qquad.
- Insert linebreaks before additive operators (+ or −):

LaTeX Usage

```
\begin{align*}
 f( x ) & = a + b + c + d \\
        & \qquad + e + f + g\,.
\end{align*}
```

- Insert linebreak *after* multiplicative operators ($\times$ or /):

LaTeX Usage

```
\begin{align*}
 f( x ) & = a \times b \times c \times d \times\\
        & \qquad e \times f \times g\,.
\end{align*}
```

The `breqn` Package

- Automates some non-trivial linebreaking.

Conditions

- In ordinary math mode put extra space for conditions.

LaTeX Usage

```
The Fibonacci numbers satisfy
 $F_{n} = F_{n - 1} + F_{n - 2}$, \ $n \geq 2$.
```

- Better turn it into a proper sentence.

LaTeX Usage

```
The Fibonacci numbers satisfy
 $F_{n} = F_{n - 1} + F_{n - 2}$, for~$n \geq 2$.
```

Conditions

- In display math separate formula and conditions using qquad.

LaTeX Usage

```
\[ z^{m} G( z ) = \sum_{n} g_{n - m} z^{n}\,,
   \qquad\text{integer $m \geq 0$}\,. \]
```

LaTeX Usage

```
\[ z^{m} G( z ) = \sum_{n} g_{n - m} z^{n}
   \qquad\text{(integer $m \geq 0$)}\,. \]
```

Physical Units

- Physical units should be typeset in roman.
- Insert thin space between numbers and name of unit.

LaTeX Usage

```
$g = 9.8\,\mathrm{m}/\mathrm{s}^{2}$
```

- The siunitx package provides support for typesetting units.
  - Using the package you write \SI{9.8}{\metre\per\second\squared}.
  - This gives you $9.8\,\mathrm{m\,s^{-2}}$ as standard, or
  - $9.8\,\mathrm{m/s^2}$ by setting per=slash with the \sisetup macro.

Sets

- For ordinary sets there is no need for extra spacing.

LaTeX Usage

```
The natural numbers, $\mathbb{N}$, are defined
 $\mathbb{N} = \{ 0, 1, 2, \ldots \}$.
```

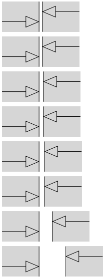
- For guarded sets you insert extra thin space.

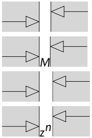
LaTeX Usage

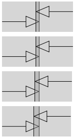
```
The even numbers, $E$, are defined
 $E = \left\{\, 2 n \,:\, n \in \mathbb{N} \,\right\}$.
```

Horizontal Spacing Commands

Positive Spacing		\hphantom		Negative Spacing	
`\,`		`\hphantom{M}`		`\!`	
`\thinspace`		`M`		`\negthinspace`	
`\:`		`\hphantom{z^n}`		`\negmedspace`	
`\medspace`		`z^n`		`\negthickspace`	
`\;`					
`\thickspace`					
`\quad`					
`\qquad`					







Bibliography

Acronyms and Abbreviations

AMS	American Mathematical Society
API	Application Programming Interface
APL	A Programming Language
CTAN	Comprehensive TEX Archive Network
CD	Compact Disk
FAQ	Frequently Asked Question
GUI	Graphical User Interface
IDE	Integrated Development Environment
ISBN	International Standard Book Number
OS	Operating System
SI	Système International d'Unités/International System of Units
TUG	TEX Users Group
URL	Uniform Resource Locator
WYSIWYG	What You See Is What You Get

About this Document

- This document was created with `pdflatex`.
- The LaTeX document class is `beamer`.