\LaTeX\ and Friends
Mathematics

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

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ucc
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:
  - \texttt{amscls} AMS document class and theorem package.
  - \texttt{amsmath} Extension package.
    - Makes math writing easier and improves quality.
Provided Packages

\texttt{amsmath} Environments for displayed equations and more.
\texttt{amstext} A \texttt{text} command for typesetting text in formula.
\texttt{amsopn} \texttt{\DeclareMathOperator} for “operator names”.
  \begin{itemize}
    \item The operators are typeset like \texttt{\sin} and \texttt{\lim}.
  \end{itemize}
\texttt{amsthm} Extensions of \texttt{\newtheorem} command.
  \begin{itemize}
    \item Also provides \texttt{proof} environment.
  \end{itemize}
\texttt{amscd} Environment for simple commutative diagrams.
\texttt{amsfonts} Extra fonts including blackboard boldface (A, B, ...).
\texttt{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.
The Binomial Theorem states
\[
\sum_{i=0}^{n} \binom{n}{i} a^i b^{n-i} = (a + b)^{n}.
\]
Substituting 1 for \(a\) and 1 for \(b\) gives us
\[
\sum_{i=0}^{n} \binom{n}{i} = 2^n.
\]
Superscripts

- The superscript operator (^) creates a superscript.
- $\langle expr \rangle ^ {\langle sup \rangle}$ makes $\langle sup \rangle$ a superscript of $\langle expr \rangle$.
  - So $x^2 + 2 \times + 1$ 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.
- $\langle expr \rangle_{\langle sub \rangle}$ makes $\langle sub \rangle$ a subscript of $\langle expr \rangle$.
  - So to get $f_{n+2} = f_{n+1} + f_n$ you need
  
  $f_{n + 2} = f_{n + 1} + f_n$. 
Subscripts and superscripts may be nested and combined.

$〈expr〉_{〈sub〉}^{〈sup〉}$ is the same as $〈expr〉^{〈sup〉}_{〈sub〉}$.

Both give you $〈expr〉^{〈sup〉}_{〈sub〉}$.
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 $\pi$

regular $\alpha (\alpha), \beta (\beta), \gamma (\gamma),$ ....

additional italic $\varepsilon (\varepsilon), \vartheta (\vartheta), \varrho (\varrho),$ ....

old number $\digamma (\digamma).$
# Lowercase Greek Letters

<table>
<thead>
<tr>
<th>Greek Letter</th>
<th>Standard commands</th>
<th>Greek Letter</th>
<th>Standard commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha)</td>
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<td>(\varsigma)</td>
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<td>(\varpi)</td>
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</tbody>
</table>

### \textit{AMS-\LaTeX} provided commands

<table>
<thead>
<tr>
<th>Greek Letter</th>
<th>\AMS-L\TeX provided commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\varepsilon)</td>
<td>(\varepsilon) (\varkappa) (\varrho) (\varpi) (\vartheta) (\varsigma) (\varpi)</td>
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<tr>
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</tr>
<tr>
<td>(\varsigma)</td>
<td>(\varsigma)</td>
</tr>
</tbody>
</table>

\(F\) \(\digamma\)
Uppercase Greek Letters: Easy as Π

regular \Gamma, \Delta, \Theta, ....
italic \varGamma, \varDelta, \varTheta, ....
# Uppercase Greek Letters

<table>
<thead>
<tr>
<th>Uppercase Greek Letters</th>
<th>Standard commands</th>
<th>\AMS-LaTeX\ provided commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Γ \Gamma</td>
<td>Ξ \Xi</td>
<td>Φ \Phi</td>
</tr>
<tr>
<td>Δ \Delta</td>
<td>Π \Pi</td>
<td>Ψ \Psi</td>
</tr>
<tr>
<td>Θ \Theta</td>
<td>Σ \Sigma</td>
<td>Ω \Omega</td>
</tr>
<tr>
<td>Λ \Lambda</td>
<td>Υ \Upsilon</td>
<td></td>
</tr>
</tbody>
</table>

\AMS-LaTeX\ provided commands:

| Γ \varGamma             | Ξ \varXi           | Φ \varPhi                      |
| Δ \varDelta             | Π \varPi           | Ψ \varPsi                      |
| Θ \varTheta             | Σ \varSigma        | Ω \varOmega                    |
| Λ \varLambda            | Υ \varUpsilon      |                               |
Display Math

- The \texttt{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 following is the Binomial Theorem:
\begin{equation}
\sum_{i=0}^{n} \binom{n}{i} a^i b^{n-i} = (a+b)^n .
\end{equation}

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 \\
& \quad + f + g + h \\
& > 0 , .
\end{split}
\end{equation*}

**\LaTeX** Output

\[
a = b + c + d \\
\quad + f + g + h \\
> 0 .
\]
The align Environment

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

Use `align` for equation groups with alignment.
Each row is numbered separately.
To turn off numbering of current equation: use `\nonumber`.
The \texttt{align} Environment (Output)

\begin{align*}
F(z) &= \sum_{n=0}^{\infty} f_n z^n \\
&= z + \sum_{n=2}^{\infty} (f_{n-1} + f_{n-2}) z^n \\
&= z + F(z)/z + F(z)/z^2 \\
&= z/(1 - z - z^2).
\end{align*}

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

\[ F(z) = \sum_{n=0}^{\infty} f_n z^n \]
The \texttt{align} Environment (Input)

\begin{align}
\label{eq:one}
F(z) & = \sum_{n=0}^{\infty} f_n z^n \\
\label{eq:two}
& = z + \sum_{n=2}^{\infty} (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\footnote{(\ref{eq:one})},\footnote{(\ref{eq:two})}, and\footnote{(\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**

\[a_0 = b_0, \quad b_0 = c_0, \quad c_0 = d_0, \quad (5)\]
\[a_1 = b_1, \quad b_1 = c_1, \quad c_1 = d_1, \quad (6)\]
\[a_2 = b_2, \quad b_2 = c_2, \quad c_2 = d_2. \quad (7)\]
\begin{align*}
x_0 & = 0 , \\
x_1 & = 1 , \\
\text{and} \\
x_2 & = 2 .
\end{align*}

and

\[ x_0 = 0 , \]
\[ x_1 = 1 , \]
\[ x_2 = 2 . \]
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**

\[
I = \begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{bmatrix}.
\]
\LaTeX{} also has an `eqnarray` environment.

- For multiple equations with horizontal alignment.
- In short: *Don’t use it!*
Sometimes you need plain text in mathematical formulae. \( {\text{	extsc{AMS-}}\LaTeX}\) provides special-purpose \texttt{text} command.

\texttt{LaTeX} Input

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

\texttt{LaTeX} Output

final grade = ca + 5 \times exam.
Delimiters

- Every now and then \LaTeX{} needs a bit of help.
- For example, $f(2^{2^{2^2}}_{2^2})$ gives $f(2^{2^{2^{2^2}}}_{2^{2^2}})$.
- Use \texttt{\left} and \texttt{\right} to scale the size of the parentheses.
- Then $f\left(2^{2^{2^2}}_{2^2}\right)$ gives $f\left(2^{2^{2^{2^2}}}_{2^{2^2}}\right)$. 
\( n! = \begin{cases} 
1 & \text{if } 0 \leq n \leq 1, \\
n \times (n - 1)! & \text{otherwise}. 
\end{cases} \)
Yer $\left,\ Yer \right, \ldots$

**LaTeX Output**

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

**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.

\texttt{LaTeX} Input

\begin{verbatim}
Simplifying
$[ (a + b)^2
- (a - b)^2 ]^2$
gives us $16 a^2 b^2$.
\end{verbatim}

\texttt{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 + \ldots \right. \\
  & \qquad \left. + 3 \right) .
\end{align*}

\texttt{\LaTeX} Output

\[ f = g \left( 3^3 + \ldots \\
  + 3 \right) . \]
Delimiters on Different Lines

The \texttt{\textbackslash vphantom} Trick

\textbf{LATEX Input}

\begin{align*}
  f & = g\left( 3^3 + \ldots \right. \\
  \quad & \left. + 3 \texttt{\textbackslash vphantom}\{3^3\} \right) \,.
\end{align*}

\textbf{LATEX Output}

\[ f = g \left( 3^3 + \ldots \right. \\
  \quad \left. + 3 \right) \,.
\]
Overloading

- Some symbols are used for different purposes: overloading.
- For example, $|$ is used as left and right delimiter in $|·|$.  
- \texttt{AMS-\LaTeX} provides new commands for delimiters.
- Delimiters scale with \texttt{\left} and \texttt{\right}.
Typesetting ‘Non-delimiting’ Bars

\textbf{\LaTeX} Input

The even digits are given by
\begin{align*}
\{2n \in \mathbb{N} \mid 0 \leq n \leq 4\}.
\end{align*}

\textbf{\LaTeX} Output

The even digits are given by \{2n \in \mathbb{N} \mid 0 \leq n \leq 4\}.
More Variable-sized Bars

\[
\{ \left\lfloor \text{\textbackslash left} \right\rfloor \text{x} \ \left\lceil \text{\textbackslash right} \right\rceil \}
\]

- Absolute-values and similar: \( |x| \).

\[
\{ \left\lfloor \text{\textbackslash lVert} \text{x} \ \text{\textbackslash rVert} \right\rceil \}
\]

- Norms: \( \|x\| \).
Evaluation

**LaTeX Input**

\[
\left. f(x) \right|_{x=0} = 0 .
\]

**LaTeX Output**

\[ f(x) \bigg|_{x=0} = 0 . \]
Don’t Try This at Home

Say no to $\langle 1,2,3 \rangle$!

\LaTeX\ Output

Say no to $< 1, 2, 3 >$!
Let $F(z)$ be the ordinary generating function of $\langle t_0, t_1, \ldots \rangle$. Then $zF(z)$ is the ordinary generating function of $\langle 0, t_0, t_1, \ldots \rangle$. 
Floors and Ceilings

**\LaTeX** Input

Let \(x\) be any real number. By definition
\[
i \leq \lfloor x \rfloor \leq x \leq \lceil x \rceil \leq I
\]
for all integers \(i\) and \(I\) such that
\[
i \leq x \leq I.
\]

**\LaTeX** Output

Let \(x\) be any real number. By definition \(i \leq \lfloor x \rfloor \leq x \leq \lceil x \rceil \leq I\) for all integers \(i\) and \(I\) such that \(i \leq x \leq I\).
Variable-sized Delimiter Commands

<table>
<thead>
<tr>
<th>Standard</th>
<th>amsmath</th>
</tr>
</thead>
<tbody>
<tr>
<td>{ }</td>
<td>| \rangle</td>
</tr>
<tr>
<td>\lceil \rfloor \langle</td>
<td>\uparrow \downarrow \updownarrow</td>
</tr>
<tr>
<td>\Downarrow \Uparrow</td>
<td>( )</td>
</tr>
<tr>
<td>[ ] | | | / \backslash</td>
<td></td>
</tr>
</tbody>
</table>
Fractions

- Ordinary fractions are typeset using the command `\frac`.
- To get \( \frac{\langle\text{num}\rangle}{\langle\text{den}\rangle} \) you use `\frac{\langle\text{num}\rangle}{\langle\text{den}\rangle}`.
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: \texttt{amsmath}

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

\texttt{LAT\TeX Input}

\[
\sqrt{2} - 1 = \cfrac{1}{2 + \cfrac{1}{2 + \cfrac{1}{2 + \ldots}}}.
\]

\texttt{LAT\TeX Output}

\[
\sqrt{2} - 1 = \frac{1}{\frac{1}{2 + \frac{1}{2 + \cdots}}}.
\]
According to folklore Gauss proved that
\[
\sum_{i=0}^{n} i = n(n+1)/2.
\]
Delimited Sums

Notice Upper and Lower Index Placement

\textbf{LaTeX Input}

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

\textbf{LaTeX Output}

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

\textbf{LaTeX Input}

According to folklore Gauss proved that $\left[ \sum_{i=0}^{n} i = n(n + 1)/2 \right]$.

\textbf{LaTeX Output}

According to folklore Gauss proved that

$$\sum_{i=0}^{n} i = n(n + 1)/2.$$
Overriding the Style for Lower and Upper Limits

**LaTeX Input**

\[
\textstyle \sum_{n=0}^{\infty} 2^{-n} = 2.
\]

**LaTeX Output**

\[\sum_{n=0}^{\infty} 2^{-n} = 2.\]
### Other Variable-sized Operators

<table>
<thead>
<tr>
<th>Standard</th>
<th>\AMS-LATEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\sum)</td>
<td>(\iint)</td>
</tr>
<tr>
<td>(\prod)</td>
<td>(\iiint)</td>
</tr>
<tr>
<td>(\bigoplus)</td>
<td>(\iiiint)</td>
</tr>
<tr>
<td>(\bigotimes)</td>
<td>(\idotsint)</td>
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<tr>
<td>(\bigodot)</td>
<td></td>
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<tr>
<td>(\bigcap)</td>
<td></td>
</tr>
<tr>
<td>(\bigcup)</td>
<td></td>
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<tr>
<td>(\bigwedge)</td>
<td></td>
</tr>
<tr>
<td>(\bigvee)</td>
<td></td>
</tr>
<tr>
<td>(\coprod)</td>
<td></td>
</tr>
</tbody>
</table>

**AMS-LaTeX**
Multi-Line Limits with the \texttt{\substack} Command

\textbf{\LaTeX Input}

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

\textbf{\LaTeX Output}

\[
\sum_{i \text{ odd} \atop 0 \leq i \leq n} \binom{n}{i} = 2^n - \sum_{i \text{ even} \atop 0 \leq i \leq n} \binom{n}{i}.
\]
Complex Limits with the `subarray` Environment

**\LaTeX** Input

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

**\LaTeX** Output

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

\[
\sum_{i \text{ odd} \atop 0 \leq i \leq n} \binom{n}{i} = 2^n - \sum_{i \text{ even} \atop 0 \leq i \leq n} \binom{n}{i}.
\]
### Log-like Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>arccos</td>
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</tr>
<tr>
<td>arcsin</td>
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<td>arctan</td>
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<td>arg</td>
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<tr>
<td>det</td>
<td>\ln</td>
</tr>
<tr>
<td>ln</td>
<td>\ln</td>
</tr>
</tbody>
</table>
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: \texttt{mod}

<table>
<thead>
<tr>
<th>Command</th>
<th>Expression</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>\bmod</td>
<td>$\gcd( 5, 3 ) = \gcd( 3, 5 \bmod 3)$</td>
<td>$\gcd(5, 3) = \gcd(3, 5 \mod 3)$</td>
</tr>
<tr>
<td>\mod</td>
<td>$2 \equiv 5 \mod 3$</td>
<td>$2 \equiv 5 \mod 3$</td>
</tr>
<tr>
<td>\pmod</td>
<td>$2 \equiv 5 \pmod 3$</td>
<td>$2 \equiv 5 \pmod 3$</td>
</tr>
<tr>
<td>\pod</td>
<td>$2 \equiv 5 \pod 3$</td>
<td>$2 \equiv 5 (3)$</td>
</tr>
</tbody>
</table>
Integration

\textbf{\LaTeX \ Input}

\[
\int_{a}^{b} 3 x^2 \, dx = \left. x^3 \right|_{a}^{b} = b^3 - a^3 .
\]

\textbf{\LaTeX \ Output}

\[
\int_{a}^{b} 3 x^2 \, dx = \left. x^3 \right|_{a}^{b} = b^3 - a^3 .
\]
# Multiple Integral Signs

| \[ \int \] | \[ \iint \] | \[ \iiint \] | \[ \iiiint \] |
| \[ \idotsint \] |
Differentiation

- Differentiations are typeset using $\frac{\text{d} u}{\text{d} x}$.
- You get $\frac{\text{d} u}{\text{d} x}$ with $\frac{\text{d} u}{\text{d} x}$.
- You get $\frac{\text{d}^2 u}{\text{d} x^2}$ with $\frac{\text{d}^2 u}{\text{d} x^2}$. 
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 $\sqrt[3]{27}$ by any Other Name Smell as Sweet?

\texttt{\LaTeX} Input

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

\texttt{\LaTeX} Output

... $\sqrt[3]{27} = 3$. 
Roots: \texttt{\textbackslash leftroot} and \texttt{\textbackslash uproot}

\texttt{\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?

\texttt{\LaTeX} Output

We all agree that \( \beta \sqrt[\beta]{k} \) is equal to \( \beta \sqrt[\beta]{k} \). But why are they different in type?
Changing the Type Style

\[ \texttt{\textit{italic} + abc^2} \]
\[ \texttt{\textsc{italic} + abc^2}. \]

\[ \texttt{\textsc{roman} + abc^2} \]
\[ \texttt{\textbf{roman} + abc^2}. \]

\[ \texttt{\textsf{sans serif} + abc^2} \]
\[ \texttt{\textsf{sans serif} + abc^2}. \]

\[ \texttt{\texttt{teletype} + abc^2} \]
\[ \texttt{\texttt{teletype} + abc^2}. \]

\[ \texttt{\textsc{CALLIGRAPHIC}} \]
\[ \texttt{CALLIGRAPHIC}. \]
### Operator Symbols

<table>
<thead>
<tr>
<th>\amalg</th>
<th>\diamond</th>
<th>\sqcap</th>
</tr>
</thead>
<tbody>
<tr>
<td>\ast</td>
<td>\div</td>
<td>\sqcup</td>
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<tr>
<td>\bigcirc</td>
<td>\lhd</td>
<td>\star</td>
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<tr>
<td>\bigtriangleup</td>
<td>\odot</td>
<td>\triangleleft</td>
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<td>\ominus</td>
<td>\triangleright</td>
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<tr>
<td>\cap</td>
<td>\oplus</td>
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<td>\oslash</td>
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<td>\cup</td>
<td>\pm</td>
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</tr>
<tr>
<td>\dagger</td>
<td>\rhd</td>
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</tr>
<tr>
<td>\ddagger</td>
<td>\setminus</td>
<td>\wr</td>
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</tbody>
</table>
## Relation Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Command</th>
</tr>
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<tbody>
<tr>
<td>&lt;</td>
<td>\langle \ll</td>
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<tr>
<td>&gt;</td>
<td>\mid</td>
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<td>\approx</td>
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<table>
<thead>
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<td>\ll</td>
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<tr>
<td>\vdash</td>
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</tr>
</tbody>
</table>
## Additional Relation Symbols

\[ \approx \quad \text{\approx} \quad \text{\approx} \]
\[ \approxeq \quad \backepsilon \quad \fallingdotseq \]
\[ \backsim \quad \multiimap \quad \succcurlyeq \]
\[ \backsimeq \quad \pitchfork \quad \therefore \]
\[ \because \quad \precapprox \quad \approx \]
\[ \between \quad \preccurlyeq \quad \sim \]
\[ \bumpeq \quad \preccsim \quad \bumpeq \]
\[ \bumpeq \quad \precapprox \quad \approx \]
\[ \backepsilon \quad \fallingdotseq \quad \succcurlyeq \]
\[ \backsimeq \quad \pitchfork \quad \therefore \]
\[ \because \quad \precapprox \quad \approx \]
\[ \between \quad \preccurlyeq \quad \sim \]
\[ \bumpeq \quad \preccsim \quad \bumpeq \]
\[ \bumpeq \quad \precapprox \quad \approx \]
Fixed-size Arrows

\downarrow \Downarrow
\uparrow \Uparrow
\updownarrow \Updownarrow
\leftarrow \Leftarrow
\rightarrow \Rightarrow
\longleftarrow \Longleftarrow
\longrightarrow \Longrightarrow
\leftrightarrow \Leftrightarrow
\longleftrightarrow \Longleftrightarrow
\mapsto \hookleftarrow
\longmapsto \hookrightarrow
\leftharpoonup \nearrow
\leftharpoondown \searrow
\rightharpoonup \swarrow
\rightharpoondown \nwarrow
### Extensible Arrows: \texttt{amsmath}

<table>
<thead>
<tr>
<th>Extensible Arrows</th>
<th>\texttt{amsmath}</th>
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</thead>
<tbody>
<tr>
<td>$\xleftarrow{e}$</td>
<td>$\xleftarrow{[o]{e}}$</td>
</tr>
<tr>
<td>$\xrightarrow{e}$</td>
<td>$\xrightarrow{[o]{e}}$</td>
</tr>
<tr>
<td>$\underleftarrow{e}$</td>
<td>$\underrightarrow{e}$</td>
</tr>
<tr>
<td>$\overleftrightarrow{e}$</td>
<td>$\underleftrightarrow{e}$</td>
</tr>
</tbody>
</table>
Extensible Arrows: \texttt{mathtools} (No Option)

\begin{align*}
\leftarrow & \quad \xleftleftharpoons{e} \\
\uparrow & \quad \xleftharpoonup{e} \\
\leftarrow & \quad \xleftharpoonup{e} \\
\leftarrow & \quad \xhookleftarrow{e} \\
\leftarrow & \quad \xLeftarrow{e} \\
\leftarrow & \quad \xmapsto{e}
\end{align*}
Extensible Arrows: `mathtools (With Option)`

\[
\begin{array}{c c}
\xleftrightharpoons[0]{e} & \xrightleftharpoons[0]{e} \\
\xleftharpoondown[0]{e} & \xrightharpoondown[0]{e} \\
\leftharpoonup[0]{e} & \rightharpoonup[0]{e} \\
\xleftrightarrow[0]{e} & \xRightarrow[0]{e} \\
\xhookleftarrow[0]{e} & \xhookrightarrow[0]{e} \\
\Leftarrow[0]{e} & \Rightarrow[0]{e} \\
\mapsto[0]{e} & \mapsto[0]{e}
\end{array}
\]
## Miscellaneous Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Command</th>
<th>Symbol</th>
<th>Command</th>
<th>Symbol</th>
<th>Command</th>
<th>Symbol</th>
<th>Command</th>
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</thead>
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<td>♮</td>
<td>\natural</td>
<td>∃</td>
<td>\exists</td>
<td>ℍ</td>
<td>\imath</td>
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<td>Ⅎ</td>
<td>\mho</td>
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<td>\diamondsuit</td>
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<td>\bot</td>
<td>♠</td>
<td>\spadesuit</td>
<td>∂</td>
<td>\partial</td>
<td>∞</td>
<td>\infty</td>
</tr>
<tr>
<td>□</td>
<td>\Box</td>
<td>ℑ</td>
<td>\Im</td>
<td>⊴</td>
<td>\triangledown</td>
<td>♩</td>
<td>\heartsuit</td>
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<td>\clubsuit</td>
<td>ℙ</td>
<td>\wp</td>
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<td>\flat</td>
<td>\Re</td>
<td>\Re</td>
</tr>
<tr>
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<td>\diamondsuit</td>
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<tr>
<td>⬄</td>
<td>\texttt{Im}</td>
<td>∂</td>
<td>\partial</td>
<td>\prime</td>
<td>\prime</td>
<td>\top</td>
<td>\top</td>
</tr>
</tbody>
</table>
Dotless $i$ and $j$

**\LaTeX** Input

Some people write

\[ \hat{i} \text{ and } \hat{j} \]

but \[ \hat{\imath} \text{ and } \hat{\jmath} \]

is better.

**\LaTeX** Output

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

- Defines \langle command\rangle for symbol \langle sym\rangle.
- \langle sym\rangle is typeset with proper spacing and uniform style.
Example

**\LaTeX** Input

\begin{verbatim}
\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}
\end{verbatim}

**\LaTeX** Output

... Note that $1 \mathrm{op} 2 = 3$ does not look pretty. However, $1 \op 2 = 3$
looks good.
Declaring Your own Operators (Continued)

Operators with Limit Positions

\texttt{\LaTeX} Input
\begin{verbatim}
\DeclareMathOperator*{\Lim}{Lim}
\end{verbatim}

\texttt{\LaTeX} Input
\begin{verbatim}
$\lim_{x \to 0} \frac{x^2}{x} = 0$....
\end{verbatim}

\texttt{\LaTeX} Output
\begin{verbatim}
... \lim_{x \to 0} \frac{x^2}{x} = 0. ...
\end{verbatim}
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 $\int f \, dx$, versus, $\int dx f$, ....
Arrays and Matrices: \texttt{array}

\texttt{LaTeX} Input

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

\texttt{LaTeX} Output

$$
\begin{pmatrix}
  x & y & z \\
  2a & 3b & 4c \\
  \alpha & \beta
\end{pmatrix}
$$
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: \((1 \ 2 \ 3)\).
- `bmatrix`: Square brackets as delimiters: \([1 \ 2 \ 3]\).
- `Bmatrix`: Braces as delimiters: \(\{1 \ 2 \ 3\}\).
- `vmatrix`: Vertical bars as delimiters: \(|1 \ 2 \ 3|\).
- `Vmatrix`: Double vertical bars as delimiters: \(\|1 \ 2 \ 3\|\).
- `matrix`: No delimiters: \(1 \ 2 \ 3\).
AMS-\LaTeX{} also provides a `smallmatrix` environment.

Delimiters should be typeset with `\bigl` and `\bigr`.

\[
\begin{smallmatrix}
...
\end{smallmatrix}
\]
Small Matrices

\textbf{\LaTeX\ Input}

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

\textbf{\LaTeX\ Output}

... The linear transformation \( \langle x, y \rangle \mapsto \langle 2x + y, y \rangle \) is written as follows: 
\[
\begin{bmatrix}
\dot{2} & 1 \\
0 & 1
\end{bmatrix}
\begin{bmatrix}
x \\
y
\end{bmatrix}.
\]
# Accents and Decorations

## Fixed-size Decorations

<table>
<thead>
<tr>
<th>Sample</th>
<th>LaTeX</th>
</tr>
</thead>
<tbody>
<tr>
<td>\dot{x}</td>
<td>\acute{x}</td>
</tr>
<tr>
<td>\ddot{x}</td>
<td>\grave{x}</td>
</tr>
<tr>
<td>\dddot{x}</td>
<td>\hat{x}</td>
</tr>
<tr>
<td>\mathring{x}</td>
<td>\tilde{x}</td>
</tr>
<tr>
<td>\check{x}</td>
<td>\vec{x}</td>
</tr>
<tr>
<td>\breve{x}</td>
<td>\underline{x}</td>
</tr>
</tbody>
</table>

## Extensible Decorations

<table>
<thead>
<tr>
<th>Sample</th>
<th>LaTeX</th>
</tr>
</thead>
<tbody>
<tr>
<td>\overleftarrow{e}</td>
<td>\overline{e}</td>
</tr>
<tr>
<td>\overrightarrow{e}</td>
<td>\widetilde{e}</td>
</tr>
<tr>
<td>\overleftrightarrow{e}</td>
<td>\widehat{e}</td>
</tr>
<tr>
<td>\underleftarrow{e}</td>
<td>\underbar{e}</td>
</tr>
<tr>
<td>\underleftrightarrow{e}</td>
<td>\underline{e}</td>
</tr>
<tr>
<td>\underrightarrow{e}</td>
<td>\underline{e}</td>
</tr>
</tbody>
</table>
Braces

\[ \overbrace{u} \quad \underbrace{u} \]

\[ \overbrace{u} \quad \underbrace{u} \]

\[ \overbrace{u} \quad \underbrace{u} \]
Braces (Continued)

\[
x^k = \underbrace{1 \times x \times x \times \cdots \times x}_{k \text{ times } \times x}.
\]
Case-based Definitions: Cases

\[
\begin{cases}
  1 & \text{if } n = 0; \\
  (n-1)! \times n & \text{if } n > 0.
\end{cases}
\]
Case-based Definitions: Iversonians

\textbf{\LaTeX} Input

... We define

\[ n! = [ n = 0 ] + ( n - 1 ) \times n \times [ n > 0 ]. \]

\textbf{\LaTeX} Output

... We define \( n! = [ n = 0 ] + ( n - 1 )! \times n \times [ n > 0 ] \). ...
Function Definitions

\textbf{LaTeX Input}

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

\textbf{LaTeX Output}

The successor function, \( s : \mathbb{N} \to \mathbb{N} \), 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

**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

\textbf{\LaTeX} Output

\textbf{Theorem 2.1.3} (Fermat’s Last Theorem). \textit{Let }n\textit{ be any integer greater than 2, then the equation }a^n + b^n = c^n\textit{ has no solutions in positive integers }a, b, \text{ and } c.\textit{ }

\begin{itemize}
  \item \textbf{heading} Describes the rôle of the environment.
  \item \textbf{number} Numbers the environment (optional).
  \item \textbf{body} The meat.
  \item \textbf{name} Names it (optional).
\end{itemize}

\begin{itemize}
  \item Captures essence of body.
  \item Used to refer to environment by name.
\end{itemize}
Theorems: Ingredients

\textbf{LaTeX Output}

\textbf{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 \( c. \)

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Theorems: Ingredients

\textbf{\LaTeX\ Output}

\textbf{Theorem 2.1.3} (Fermat’s Last Theorem). \textit{Let }\textit{n} \textit{be any integer greater than 2, then the equation }a^n + b^n = c^n \textit{has no solutions in positive integers }a, b, \textit{and }c.\textit{ }

\textbf{heading} Describes the rôle of the environment.

\begin{itemize}
  \item Usually, Theorem, Lemma, Definition, ....
\end{itemize}

\textbf{number} Numbers the environment (optional).

\begin{itemize}
  \item body The meat.
\end{itemize}

\textbf{name} Names it (optional).

\begin{itemize}
  \item Captures essence of body.
  \item Used to refer to environment by name.
\end{itemize}
Theorems: Ingredients

**ŁATeX** 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.
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.
Existing Theorem Styles (Numbering)

Numbering Depends on Style

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Existing Theorem Styles (Numbering)

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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.
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Existing Theorem Styles (Numbering)

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- 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.
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 \texttt{\textbackslash theoremstyle}.
- Command takes the label of the style as its argument.
- Initially, the current style is \texttt{plain}. 
Defining the Next Environment

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

\texttt{\LaTeX} Usage

\begin{verbatim}
\newtheorem{〈env〉}[〈old〉]{〈heading〉}
\end{verbatim}

- Defines new environment \texttt{〈env〉} with heading \texttt{〈heading〉}.
- New environment shares numbering with \texttt{〈old〉}.
Defining Environments With Option
Option as Last Argument

\newtheorem{〈env〉}{〈heading〉}[〈unit〉]

- Defines environment \texttt{〈env〉} with heading \texttt{〈heading〉}.
- Here \texttt{〈unit〉} is the name of a sectional unit.
- Starts new numbering sequence that depends on \texttt{〈unit〉}. 
Example

\texttt{\LaTeX\ Usage}

\begin{verbatim}
\usepackage{amsmath}
\usepackage{amsthm}

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

% Set environment style to definition.
\theoremstyle{definition}
% Define environment \texttt{def} for definitions.
% Share numbering with \texttt{thm} environment.
\newtheorem{def}[thm]{Definition}
\end{verbatim}
Defining New Styles

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

\textbf{LaTeX Input}

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

\textbf{LaTeX Output}

Challenge.

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

$$5^2 = 25 = 9 + 16 = 3^2 + 4^2.$$
Dot-like Symbols

Low dots \( n(n - 1) \ldots (1) \)

Centred dots \( x_1 + \cdots + x_n \)

Diagonal dots In arrays and matrices. \( \ddots \)

Vertical dots In arrays and matrices. \( \vdots \)
Pedantic Dots (amsmath)

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

**\LaTeX** Input

\begin{verbatim}
\ldots \text{Then we have series}
\quad A_1, A_2, \ldots,
\text{regional sum}
\quad A_1 + A_2 + \ldots,
\text{orthogonal product}
\quad A_1 A_2 \ldots,
\text{and infinite integral}
\quad \int_{A_1} \int_{A_2} \ldots.
\end{verbatim}

**\LaTeX** Output

...Then we have series $A_1, A_2, \ldots$, regional sum $A_1 + A_2 + \ldots$, orthogonal product $A_1 A_2 \ldots$, and infinite integral

\[
\int_{A_1} \int_{A_2} \ldots.
\]
Linebreaks in Ordinary Math

Not after Commas

\textbf{LaTeX Usage}

\begin{verbatim}
for $x = f( a, b )$, $f( b, c )$, \\
or $f( b, c )$.
\end{verbatim}

\textbf{Don’t Try This at Home}

\begin{verbatim}
for $x = f( a, b ), f( b, c )$, \\
or $f( b, c )$.
\end{verbatim}

\textbf{Don’t Try This at Home}

\begin{verbatim}
Let $x, y$, and $z$ be real numbers.
\end{verbatim}

\textbf{LaTeX Usage}

\begin{verbatim}
Let $x$, $y$, and $z$ be real numbers.
\end{verbatim}
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 −):

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

- Insert linebreak after multiplicative operators (× or /):

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

**LaTeX Usage**

\[
\sum_{n} g_{n - m} z^n, \quad \text{integer } m \geq 0.
\]

**LaTeX Usage**

\[
\sum_{n} (g_{n - m} z^n), \quad \text{integer } m \geq 0.
\]
Physical Units

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

**\LaTeX** Usage

\[
g = 9.8, \text{m}/\text{s}^2
\]

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

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

**\LaTeX** Usage

\[
\text{The natural numbers, } \mathbb{N}, \text{ are defined}
\]
\[
\mathbb{N} = \{ 0, 1, 2, \ldots \}.
\]

- For guarded sets you insert extra thin space.

**\LaTeX** Usage

\[
\text{The even numbers, } \mathbb{E}, \text{ are defined}
\]
\[
\mathbb{E} = \left\{ \begin{array}{c}
2 n \mid n \in \mathbb{N}
\end{array} \right\}.
\]
# Horizontal Spacing Commands

<table>
<thead>
<tr>
<th>Positive Spacing</th>
<th>\texttt{\textbackslash hphantom}</th>
<th>Negative Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>,</td>
<td>\texttt{\textbackslash hphantom{M}}</td>
<td>!</td>
</tr>
<tr>
<td>\texttt{\textbackslash thinspace}</td>
<td>M</td>
<td>\texttt{\textbackslash negthinspace}</td>
</tr>
<tr>
<td>\texttt{\textbackslash medspace}</td>
<td>\texttt{\textbackslash hphantom{z^n}}</td>
<td>\texttt{\textbackslash negmedspace}</td>
</tr>
<tr>
<td>\texttt{\textbackslash negmedspace}</td>
<td>z^n</td>
<td>\texttt{\textbackslash negthickspace}</td>
</tr>
<tr>
<td>\texttt{\textbackslash negthickspace}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\quad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>\qquad</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMS</td>
<td>American Mathematical Society</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>APL</td>
<td>A Programming Language</td>
</tr>
<tr>
<td>CTAN</td>
<td>Comprehensive (\text{T}\text{E}X) Archive Network</td>
</tr>
<tr>
<td>CD</td>
<td>Compact Disk</td>
</tr>
<tr>
<td>FAQ</td>
<td>Frequently Asked Question</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>IDE</td>
<td>Integrated Development Environment</td>
</tr>
<tr>
<td>ISBN</td>
<td>International Standard Book Number</td>
</tr>
<tr>
<td>OS</td>
<td>Operating System</td>
</tr>
<tr>
<td>SI</td>
<td>Système International d’Unités/International System of Units</td>
</tr>
<tr>
<td>TUG</td>
<td>(\text{T}\text{E}X) Users Group</td>
</tr>
<tr>
<td>URL</td>
<td>Uniform Resource Locator</td>
</tr>
<tr>
<td>WYSIWYG</td>
<td>What You See Is What You Get</td>
</tr>
</tbody>
</table>
About this Document

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