LaTeX FOR BEGINNERS:
WRITING MATH WITHOUT IMAGES

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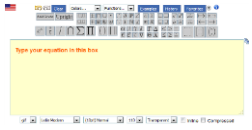
ONLINE LaTeX EQUATION EDITORS
SO YOU CAN FOLLOW ALONG …

www.codecogs.com/latex/eqneditor.php

- templates and palettes



arachnoid.com/latex/

- three renderers and drop-down menus

WHAT IS LaTeX?

LaTeX is a document markup language for TeX that was developed by Leslie Lamport in 1985

- TeX is a typesetting system developed by Donald Knuth in 1978
- LaTeX is designed to be a page layout language that achieves quality typographic output
- LaTeX inherits the ability of TeX to work with complex mathematical text

Euler's Identity: e^{i \pi} + 1 = 0

$$e^{i\pi} + 1 = 0$$


Lamport


Knuth

WHY SHOULD I USE LaTeX?

LaTeX is widely used in the technical publishing industry

Text entry (not templates and palettes) can speed up writing

LaTeX is used by MathJax (for displaying math online)

MathPlayer can screen-read MathJax, thus ADA-compliant
Demo: http://www.milefoot.com/about/presentations/speakingMath.mp4

Several Learning Management Systems allow LaTeX input
(Desire2Learn, Canvas, Blackboard)

SOME LaTeX DISPLAY CHARACTERISTICS

Different packages
Math folks will want to include amsmath

Different environments
Text mode vs. math mode
Inline math vs. display math

Different renderers
Arachnoid has 3: Codecogs, MathJax, Google Chart API
MathJax has 3: HTML-CSS, MathML, SVG

Implication: Things may not display exactly as you thought, always test LaTeX to verify

RESERVED SYMBOLS

Symbols	Purpose	If you really wanted that symbol …
{ or }	Invisible grouping symbols	\{ or \}
_ or ^	Subscript or superscript	\ _ or \^
%	Comment	\%
$	Delimiter for inline math	\$
&	Alignment point or next entry in an array or a matrix	\&
#		\#
~	Nonbreakable space	\sim
\	Control character (what follows will specify a different rendering)	\backslash or \setminus

BASIC OPERATIONS

Want: $6+7-4\times18\div3^2=5$

LaTeX: 6 + 7 - 4 \times 18 \div 3 ^ 2 = 5

Used: \times for multiplying
\div for dividing
^ for exponent (23rd power needs ^{23})

Also: \cdot is also available for multiplication

INEQUALITIES AND NEW LINES

Want: $3<x\le5$
$8>y\ge4$
$z\ne2$

LaTeX: 3 < x \le 5 \\ 8 > y \ge 4 \\ z \ne 2

Used: \\ for a new line
\le for "less than or equal"
\ge for "greater than or equal"
\ne for "not equal"

FRACTIONS

Want: $\frac{2}{3}+\frac{41}{x}+\frac{1+\frac{2}{x}}{3+\frac{4}{5}}$

LaTeX: \frac23 + \frac{41}{x}
+ \frac{ 1 + \dfrac2x}{3+\dfrac45}

Used: \frac for fractions
\dfrac for "display-style" fractions when inline

Also: \tfrac for inline-style fractions in display math

PERCENTS AND REPEATERS

Want: $15.2\overline{7}\% \approx \frac{3}{20}$

LaTeX: `15.2\overline{7} \% \approx \frac{3}{20}`

Used:
- `\overline` for the repeating bar
- `\%` for the percent sign
- `\approx` for the approximately equal sign

RADICALS

Want: $\sqrt{5x} \pm \sqrt[3]{78 + \sqrt{6}}$

LaTeX: `\sqrt{5x} \pm \sqrt[3]{78 + \sqrt{6}}`

Used:
- `\sqrt{ }` for square root
- `\sqrt[ ]{ }` for other radicals
- `\pm` for "plus or minus"

QUADRATIC FORMULA?

Want:

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

LaTeX:

```
ax^2 + bx + c = 0 \\
x = \frac{-b \pm \sqrt{ b^2 - 4ac}}{2a}
```

FUNCTIONS AND GROUPING

Want: $(f \circ g)(x) = 3\left(\frac{|x|}{4} + 5\right) - \left|\frac{|x|}{4}\right|$

LaTeX:
```
(f \circ g )(x) = 3 \left( \frac{|x|}{4} + 5 \right)
- \left| \frac{|x|}{4} \right|
```

Used:
\circ for function composition
\left(and \right) for stretchy parentheses
\left| and \right| for stretchy absolute values

Also:
\left[and \right] for stretchy brackets
\left\{ and \right\} for stretchy braces
\left. and \right. for a one-sided stretchy grouping
\| for a norm (double vertical lines)

PIECEWISE DEFINED FUNCTIONS

Want: $f(x) = \begin{cases} x^2, & \text{if } x \le 0 \\ 0, & \text{otherwise} \end{cases}$

LaTeX:
```
f(x) =
\begin{cases}
   x^2,  & \text{if } x \le 0  \\
   0,  & \text{otherwise}
\end{cases}
```

Used:
\begin{cases} and \end{cases} for formatting
& to begin condition
\text{ } for text inside math mode (note spacing)

ALIGNING EQUATIONS

Want:
$$x + 3 = \sqrt{x+5}$$
$$x^2 + 6x + 9 = x + 5$$
$$x^2 + 5x + 4 = 0$$

LaTeX:
```
\begin{align*}
   x+3 &= \sqrt{x+5} \\
   x^2 + 6x + 9 &= x + 5 \\
   x^2 + 5x + 4 &= 0
\end{align*}
```

Used:
\begin{align*} and \end{align*} for formatting
& to identify the alignment point

Also:
omit * for automatic equation numbering
\begin{alignat}{4} for more control

MATRICES

Want: $\begin{pmatrix} 12 & 34 \\ 5 & 6 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{cases} 12x + 34y \\ 5x + 6y \end{cases}$

LaTeX:
```
\begin{pmatrix} 12 & 34 \\ 5 & 6 \end{pmatrix}
\begin{pmatrix} x \\ y \end{pmatrix}
= \left\{ \begin{array}{l} 12x + 34y \\ 5x + 6y
\end{array} \right.
```

Used: \begin and \end to mark blocks
{pmatrix} for a matrix with parentheses
{array} for an array with unlike delimiters
{l} to align left, similarly {c} or {r}

Also: {vmatrix}, {bmatrix}, {Bmatrix}, {matrix} for matrices with vertical lines, brackets, braces, and none

LINEAR PROGRAMMING?

Want:

$$\begin{aligned} &\text{Maximize } P = 40x + 75y \\ &\text{subject to the constraints} \\ &5x + 10y \le 600 \\ &4x + 3y \le 240 \\ &x \ge 0 \\ &y \ge 0 \end{aligned}$$

LaTeX:
```
\text{Maximize } P=40x+75y \\
\text{subject to the constraints} \\
\begin{align*}
   5x+10y &\le 600 \\ 4x + 3y &\le 240 \\
   x &\ge 0 \\ y &\ge 0
\end{align*}
```

PERMUTATIONS AND COMBINATIONS

Want: $\binom{10}{4} = {}_{15}P_2 = 210$

LaTeX:
```
\binom{10}{4} = { }_{15} P_2 = 210
```

Used: \binom for binomial coefficent
_n P_r for permutation
the empty group { } for a leading subscript

Also: _n C_r for combination

GEOMETRY AND SPACING

Want: $\angle A \cong \angle BOC, \quad \triangle BOC \sim \triangle DEF$
$a \parallel b, \quad c \perp d$

LaTeX:
```
\angle A \cong \angle BOC , \quad
\triangle ABC \sim \triangle DEF \\
a \parallel b ,\quad c \perp d
```

Used:
- \angle for angle, \triangle for triangle
- \cong for congruent, \sim for similar
- \parallel for parallel (not \|, for meaning & spacing)
- \perp for perpendicular
- \quad for extra space (1 em)

Also: for smaller spacing, use \; , \> , or \,

TRIGONOMETRY

Want: $\sin\frac{\pi}{4} = \sin 45^\circ = \frac{\sqrt{2}}{2}$

LaTeX:
```
\sin \frac{\pi}{4} = \sin 45^\circ = \frac{\sqrt{2}}{2}
```

Used:
- \sin for sine
- \pi for π (\Pi for a capital Π)
- ^\circ for the degree symbol

Also: \cos, \tan, \cot, \sec, \csc for the other trig functions
\alpha, \Alpha, etc. for the other Greek letters

INVERSE TRIG FUNCTIONS

Want: $\sin^{-1} x + \arctan y + \operatorname{arcsec} z$

LaTeX:
```
\sin^{-1} x + \arctan y + \operatorname{arcsec} z
```

Used:
- \sin^{-1} works for all 6 functions
- \arctan works for the basic 3 functions
- \operatorname{ … } for an unknown function

DEMOIVRE'S THEOREM?

Want: $$z^n = r^n\left(\cos n\theta + i\sin n\theta\right) = r^n \operatorname{cis}\theta$$

LaTeX:
```
\begin{align*}
    z^n &= r^n (\cos n \theta + i \sin n \theta)  \\
    &= r^n \operatorname{cis} n \theta
\end{align*}
```

LIMITS

Want: $$e = \lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$$

LaTeX:
```
e = \lim \limits_{n \to \infty}
\left( 1 + \frac1n \right )^n
```

Used:
- \lim for limit
- \limits for avoiding subscript style of notation
- \to for arrow
- \infty for infinity

DERIVATIVES

Want: $$\frac{\partial}{\partial x}\left(3x^2y\right)+\frac{d}{dy}\left(5y^2\right)=6xy+10y$$

LaTeX:
```
\frac{\partial}{\partial x} (3x^2 y)
+ \frac{d}{dy}(5y^2)=6xy + 10y
```

Used:
- \frac{d}{dx} for derivative
- \partial for ∂ symbol

INTEGRALS

Want: $\int_3^6 \frac{1}{x}\,dx = \ln 2$

LaTeX: `\int _3^6 \frac1x \, dx = \ln 2`

Used: `\int` for integral
`\,` for extra space before dx

Also: `\iint` and `\iiint` for double and triple integrals
`\oint` for a closed path integral

POWER SERIES

Want: $\sin x = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} x^{2n+1} = x - \frac{x^3}{6} + \ldots$

LaTeX:
```
\sin x = \displaystyle \sum_{n=0} ^\infty
\frac{(-1)^n}{(2n+1)!} x^{2n+1}
= x - \dfrac{x^3}{6} + \dots
```

Used: `\sum` for summation
`\displaystyle` for limits above and below
`\dots` for ellipsis

Also: `\prod` for product
`\cdots` or `\ldots` for centered or low ellipsis

DEFINITE INTEGRAL AS A RIEMANN SUM?

Want: $\int_a^b f(x)\,dx = \lim_{\|\Delta\|\to 0} \sum_{i=1}^{n} f(c_i)\Delta x_i$

LaTeX:
```
\int_a^b f(x)\, dx
= \lim \limits_{ \| \Delta \| \to 0}
\displaystyle \sum _{i=1}^n  f(c_i) \Delta x_i
```

QUANTIFIERS

Want: $\forall x \in \mathbb{N} \quad \exists y \in \mathbb{R} \quad xy = 5$

LaTeX:
```
\forall x \in \mathbb{N} \quad
\exists y \in \mathbb{R} \quad xy=5
```

Used:
- \forall and \exists for quantifiers
- \mathbb{ } for "blackboard bold" of special sets
- \in for "is an element of"

SETS

Want: $(-3,1] \cap [-2,5) \subseteq \mathbb{R}^+ \cup [-3,0] \subset \mathbb{C}$

LaTeX:
```
(-3,1] \cap [-2,5) \subseteq
\mathbb{R}^+ \cup [-3,0] \subset \mathbb{C}
```

Used:
- \cap for intersections
- \cup for unions
- \subset for proper subsets
- \subseteq for subsets

SOME OTHER REFERENCES

LaTeX (the official site)
http://www.latex-project.org/

The Comprehensive LaTeX Symbol List (over 5000 symbols)
http://ctan.sharelatex.com/tex-archive/info/symbols/comprehensive/symbols-a4.pdf

The LaTeX Guide, at the Art of Problem Solving
http://www.artofproblemsolving.com/Wiki/index.php/LaTeX

LaTeX, at Wikibooks
http://en.wikibooks.org/wiki/LaTeX

This presentation
http://www.milefoot.com/about/presentations/LaTeX.pdf

LaTeX for Beginners: Writing Math Without Images

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Some online LaTeX editors: www.codecogs.com/latex/eqneditor.php
arachnoid.com/latex/

Mathematics	LaTeX
$6+7-4\times18\div3^2=5$	6 + 7 - 4 \times 18 \div 3^2 = 5
$3<x\le5$ $8>y\ge4$ $z\ne2$	3 < x \le 5 \\ 8 > y \ge 4 \\ z \ne 2
$\frac{2}{3}+\frac{41}{x}+\frac{1+\frac{2}{x}}{3+\frac{4}{5}}$	\frac23 + \frac{41}{x} + \frac{1 + \dfrac2x}{3 + \dfrac45}
$15.2\overline{7}\% \approx \frac{3}{20}$	15.2\overline{7}\% \approx \frac{3}{20}
$\sqrt{5x}\pm\sqrt[3]{78+\sqrt{6}}$	\sqrt{5x} \pm \sqrt[3]{78 + \sqrt{6}}
$ax^2+bx+c=0$ $x=\frac{-b\pm\sqrt{b^2-4ac}}{2a}$	
$(f\circ g)(x)=3\left(\frac{\lvert x\rvert}{4}+5\right)-\left\lvert\frac{\lvert x\rvert}{4}\right\rvert$	(f \circ g)(x) = 3 \left(\frac{|x|}{4} + 5 \right) - \left| \frac{|x|}{4} \right|
$f(x)=\begin{cases}x^2, & \text{if } x\le0\\ 0, & \text{otherwise}\end{cases}$	f(x) = \begin{cases} x^2, & \text{if } x \le 0 \\ 0, & \text{otherwise} \end{cases}
$x+3=\sqrt{x+5}$ $x^2+6x+9=x+5$ $x^2+5x+4=0$	\begin{align*} x+3 &= \sqrt{x+5} \\ x^2 + 6x + 9 &= x + 5 \\ x^2 + 5x + 4 &= 0 \end{align*}
$\begin{pmatrix}12 & 34\\ 5 & 6\end{pmatrix}\begin{pmatrix}x\\ y\end{pmatrix}=\begin{cases}12x+34y\\ 5x+6y\end{cases}$	\begin{pmatrix} 12 & 34 \\ 5 & 6 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \left\{ \begin{array}{l} 12x + 34y \\ 5x + 6y \end{array} \right.

Maximize $P = 40x + 75y$ subject to the constraints $5x + 10y \le 600$ $4x + 3y \le 240$ $x \ge 0$ $y \ge 0$	
$\binom{10}{4} = {}_{15}P_2 = 210$	\binom{10}{4} = { }_{15} P_2 = 210
$\angle A \cong \angle BOC, \quad \triangle BOC \sim \triangle DEF$ $a \parallel b, \quad c \perp d$	\angle A \cong \angle BOC , \quad \triangle ABC \sim \triangle DEF \\ a \parallel b ,\quad c \perp d
$\sin\frac{\pi}{4} = \sin 45^\circ = \frac{\sqrt{2}}{2}$	\sin \frac{\pi}{4} = \sin 45^\circ = \frac{\sqrt{2}}{2}
$\sin^{-1} x + \arctan y + \operatorname{arcsec} z$	\sin^{-1} x + \arctan y + \operatorname{arcsec} z
$z^n = r^n\left(\cos n\theta + i \sin n\theta\right)$ $= r^n \operatorname{cis}\theta$	
$e = \lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$	e = \lim \limits_{n \to \infty} \left(1 + \frac1n \right)^n
$\frac{\partial}{\partial x}\left(3x^2y\right) + \frac{d}{dy}\left(5y^2\right) = 6xy + 10y$	\frac{\partial}{\partial x} (3x^2 y) + \frac{d}{dy}(5y^2)=6xy + 10y
$\int_3^6 \frac{1}{x}\,dx = \ln 2$	\int _3^6 \frac1x \, dx = \ln 2
$\sin x = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} x^{2n+1} = x - \frac{x^3}{6} + \dots$	\sin x = \displaystyle \sum_{n=0} ^\infty \frac{(-1)^n}{(2n+1)!} x^{2n+1} = x - \dfrac{x^3}{6} + \dots
$\int_a^b f(x)\,dx = \lim_{\|\Delta\|\to 0} \sum_{i=1}^{n} f(c_i)\Delta x_i$	
$\forall x \in \mathbb{N} \quad \exists y \in \mathbb{R} \quad xy = 5$	\forall x \in \mathbb{N} \quad \exists y \in \mathbb{R} \quad xy=5
$(-3,1] \cap [-2,5) \subseteq \mathbb{R}^+ \cup [-3,0] \subset \mathbb{C}$	(-3,1] \cap [-2,5) \subseteq \mathbb{R}^+ \cup [-3,0] \subset \mathbb{C}

This presentation: www.milefoot.com/about/presentations/LaTeX.pdf