CSE 3112
Technical Writing and Presentation
Winter 2018-2019

LaTeX Math and Equations

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Contents

- Inline math
- Displayed
- Equations
- Fractions
- Matrices
- Scaling of Parentheses, Brackets etc.

Inserting Equations-Inline math

Enter math mode with an opening and closing dollar sign $.

```
This formula $f(x) = x^2$ is an example.
```

Output equation: This formula $f(x) = x^2$ is an example.

Inserting Equations-Displayed

Enter math mode with an opening with **\[** and closing **/]** .

typed as

```
\[
   \lim_{x \to a} f(x)
\]
```

the displayed version:

$$\lim_{x \to a} f(x)$$

Math-Superscripts

Scripts	Produces-O/P
a) $ 2x^3 $	$2x^3$
b) $$ 2x^3 $$	Newline $2x^3$ Newline
c) $$ 2x^34 $$	$2x^34$
d) $$ 2x^{34} $$	$2x^{34}$
e) $$ 2x^{3x+4} $$	$2x^{3x+4}$

Math-Subscripts

Scripts	Produces-O/P
a) $ 2x_3 $	$2x_3$
b) $$ 2x_3 $$	Newline $2x^3$ Newline
c) $$ 2x_34 $$	$2x_34$
d) $$ 2x_{34} $$	$2x_{34}$
e) $$ {2x_1}_2 $$	$2x_{12}$

More Detailed Examples

```
\[ a_1^2 + a_2^2 = a_3^2 \]
```

$$a_1^2 + a_2^2 = a_3^2$$

```
\[ x^{2 \alpha} - 1 = y_{ij} + y_{ij}  \]
```

$$x^{2\alpha} - 1 = y_{ij} + y_{ij}$$

```
\[ (a^n)^{r+s} = a^{nr+ns}  \]
```

$$(a^n)^{r+s} = a^{nr+ns}$$

Math - Greek letter

αA	`\alpha A`	νN	`\nu N`
βB	`\beta B`	$\xi \Xi$	`\xi\Xi`
$\gamma \Gamma$	`\gamma \Gamma`	oO	`o O`
$\delta \Delta$	`\delta \Delta`	$\pi \Pi$	`\pi \Pi`
$\epsilon \varepsilon E$	`\epsilon \varepsilon E`	$\rho \varrho P$	`\rho\varrho P`
ζZ	`\zeta Z`	$\sigma \Sigma$	`\sigma \Sigma`
ηH	`\eta H`	τT	`\tau T`
$\theta \vartheta \Theta$	`\theta \vartheta \Theta`	$\upsilon \Upsilon$	`\upsilon \Upsilon`
ιI	`\iota I`	$\phi \varphi \Phi$	`\phi \varphi \Phi`
κK	`\kappa K`	χX	`\chi X`
$\lambda \Lambda$	`\lambda \Lambda`	$\psi \Psi$	`\psi \Psi`
μM	`\mu M`	$\omega \Omega$	`\omega \Omega`

Text Spacing Commands

Short form:	Full form:	Size:	Short form:	Full form:
\,	\thinspace	␣	\!	\negthinspace
\:	\medspace	␣		\negmedspace
\;	\thickspace	␣		\negthickspace
	\quad	␣␣		
	\qquad	␣␣␣␣		

The \medspace, \thickspace, \negmedspace, and \negthickspace commands require the amsmath package.

Arrows

$\leftarrow$	\leftarrow	$\Leftarrow$	\Leftarrow
$\rightarrow$	\rightarrow	$\Rightarrow$	\Rightarrow
$\leftrightarrow$	\leftrightarrow	$\rightleftharpoons$	\rightleftharpoons
$\uparrow$	\uparrow	$\downarrow$	\downarrow
$\Uparrow$	\Uparrow	$\Downarrow$	\Downarrow
$\Leftrightarrow$	\Leftrightarrow	$\Updownarrow$	\Updownarrow
$\mapsto$	\mapsto	$\longmapsto$	\longmapsto
$\nearrow$	\nearrow	$\searrow$	\searrow
$\swarrow$	\swarrow	$\nwarrow$	\nwarrow
$\leftharpoonup$	\leftharpoonup	$\rightharpoonup$	\rightharpoonup
$\leftharpoondown$	\leftharpoondown	$\rightharpoondown$	\rightharpoondown

Miscellaneous Symbols

∞	\infty	$\forall$	\forall
$\Re$	\Re	$\Im$	\Im
∇	\nabla	$\exists$	\exists
∂	\partial	$\nexists$	\nexists
$\emptyset$	\emptyset	$\varnothing$	\varnothing
$\wp$	\wp	$\complement$	\complement
$\neg$	\neg	$\cdots$	\cdots
$\square$	\square	$\surd$	\surd
$\blacksquare$	\blacksquare	$\triangle$	\triangle

Binary Operation/Relation Symbols

$\times$	\times	$\times$	\times
$\div$	\div	$\cap$	\cap
$\cup$	\cup	$\neq$	\neq
$\leq$	\leq	$\geq$	\geq
$\in$	\in	$\perp$	\perp
$\notin$	\notin	$\subset$	\subset
$\simeq$	\simeq	$\approx$	\approx
$\wedge$	\wedge	$\vee$	\vee
$\oplus$	\oplus	$\otimes$	\otimes
$\Box$	\Box	$\boxtimes$	\boxtimes
$\equiv$	\equiv	$\cong$	\cong

Trigonometric Functions

Name	Symbol	Command
Sine	$\sin x$	\sin x
Cosine	$\cos x$	\cos x
Tangent	$\tan x$	\tan x
Cotangent	$\cot x$	\cot x
Secant	$\sec x$	\sec x
Cosecant	$\csc x$	\csc x

Log Function

Scripts	Produces-O/P
$ \log{x} $	$\log x$
$ \log_a{b} $	$\log_a b$
$ \ln {x} $	ln x

Square Roots

$$\sqrt{y^2}$$ produces:

$$\sqrt{y^2}$$

$$\sqrt[x]{y^2}$$ produces:

$$\sqrt[x]{y^2}$$

Scripts	Produces-O/P
$$ \sqrt{2} $$	$\sqrt{2}$
$$ \sqrt[3]{2} $$	$\sqrt[3]{2}$
$$ \sqrt{x^2+y^2}$$	$\sqrt{x^2+y^2}$
$$ \sqrt{1+\sqrt(x)}$$	$\sqrt{1+\sqrt{x}}$

Fractions

Scripts	Produces-O/P
$\frac{2}{3}$	$\frac{2}{3}$
$\displaystyle{\frac{2}{3}$	$\frac{2}{3}$
$$ \frac{x}{x^2+x+1} $$	$$\frac{x}{x^2+x+1}$$
$$ \frac{\sqrt{x+1}} {\sqrt{x-1}}	$$\frac{\sqrt{x+1}}{\sqrt{x-1}}$$
$$ \frac{1} {1+\frac{1}{x}} $$	$$\frac{1}{1+\frac{1}{x}}$$

Sums

- The command \sum inserts a sum symbol;

```
$$\sum_{x=1}^5 y^z$$ produces:
```

$$\sum_{x=1}^{5} y^z$$

Integrals

Name	Symbol	Command
Indefinite integral	$\int f(x)dx$	\int f(x) dx
Definite integral	$\int_a^b f(x)x$	\int_a^b f(x) x
Domain integral	$\int_D f(x)dx$	\int_D f(x) dx
Double integral	$\iint f(x,y)dxdy$	\iint f(x,y) dx dy
Triple integral	$\iiint f(x,y,z)dxdydz$	\iiint f(x,y,z) dx dy dz
Closed curve integral	$\oint_C Fds$	\oint_C F ds

Binomial Coefficients

```
\usepackage{amsmath}
```

```
\[
    \binom{n}{k} = \frac{n!}{k!(n-k)!}
\]
```

The binomial coefficient is defined by the next expression:

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}$$

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And of course this command can be included in the normal
text flow \(\binom{n}{k}\).
```

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$$\binom{n}{k} = \frac{n!}{k!(n-k)!}$$

And of course this command can be included in the normal text flow $\binom{n}{k}$.

Brackets

S.N.	Scripts	Output
01	$$ (x+1) $$	(x+1)
02	$$ 3[2+(x+1)] $$	3[2+(x+1)]
03	$$ \{ a, b, c \} $$	{ a, b, c }
04	$$ \$ 12.55 $$	$12.55
05	$$ 3\left(\frac{2}{5} \right) $$	$3\left(\frac{2}{5}\right)$
06	$$ 3\left[\frac{2}{5} \right] $$	$3\left[\frac{2}{5}\right]$

Brackets Con…

S.N.	Scripts	Output
07	$$ 3\left\{\frac{2}{5} \right\} $$	$3\left\{\frac{2}{5}\right\}$
08	$$ \|x\| $$	$\|x\|$
09	$$ \left\|\frac{x}{x+1} \right \| $$	$\left\|\frac{x}{x+1}\right\|$
10	$$ \left \{ x^2 \right.$$	$\{x^2$
11	$$ \left|\frac{dy}{dx}\right|	$\left\|\frac{dy}{dx}\right\|_{x=1}$
12	$$ \left.\frac{dy}{dx}\right|	$\frac{dy}{dx}\Big\|_{x=1}$

Example - Math

```
\begin{center}
{\large
$$ y=\frac{a^3+2c_{x}}{1+\sqrt{b_{x}}} $$ \\
\vspace{0.2in}
```

$$y = \frac{a^3 + 2c_x}{1 + \sqrt{b_x}}$$

```
$$ Q=\sum_{i=1}^{j}\int_{\mu}^{\infty}f(x_{j})dx $$ \\
\vspace{0.2in}
```

$$Q = \sum_{i=1}^{j} \int_{\mu}^{\infty} f(x_j) dx$$

```
$$ \Psi = \oint_{- \infty}^{\infty}f_{xy}({\frac{\partial
Qx}{\partial Qy}})^{\Im_{\pi}^ \prime} $$ \\ }
```

$$\Psi = \oint_{-\infty}^{\infty} f_{xy} (\frac{\partial Qx}{\partial Qy})^{\Im_{\pi}^{\prime}}$$

Additional operators

LaTeX markup	Renders as
`\prod_{i=1}^n`	$\prod_{i=1}^{n}$
`\cup_{i=1}^n`	$\bigcup_{i=1}^{n}$
`\cap_{i=1}^n`	$\bigcap_{i=1}^{n}$
`\oint_{i=1}^n`	$\oint_{i=1}^{n}$
`\coprod_{i=1}^n`	$\coprod_{i=1}^{n}$

There are also a **bigcup** and **bigcap** commands similar to **cup** and **cap** but larger for larger expressions.

Inline and Displayed Comparisons

Type:	Inline	Displayed	Type:	Inline	Displayed
`\prod_{i=1}^{n}`	$\prod_{i=1}^{n}$	$\displaystyle\prod_{i=1}^{n}$	`\coprod_{i=1}^{n}`	$\coprod_{i=1}^{n}$	$\displaystyle\coprod_{i=1}^{n}$
`\bigcap_{i=1}^{n}`	$\bigcap_{i=1}^{n}$	$\displaystyle\bigcap_{i=1}^{n}$	`\bigcup_{i=1}^{n}`	$\bigcup_{i=1}^{n}$	$\displaystyle\bigcup_{i=1}^{n}$
`\bigwedge_{i=1}^{n}`	$\bigwedge_{i=1}^{n}$	$\displaystyle\bigwedge_{i=1}^{n}$	`\bigvee_{i=1}^{n}`	$\bigvee_{i=1}^{n}$	$\displaystyle\bigvee_{i=1}^{n}$
`\bigsqcup_{i=1}^{n}`	$\bigsqcup_{i=1}^{n}$	$\displaystyle\bigsqcup_{i=1}^{n}$	`\biguplus_{i=1}^{n}`	$\biguplus_{i=1}^{n}$	$\displaystyle\biguplus_{i=1}^{n}$
`\bigotimes_{i=1}^{n}`	$\bigotimes_{i=1}^{n}$	$\displaystyle\bigotimes_{i=1}^{n}$	`\bigoplus_{i=1}^{n}`	$\bigoplus_{i=1}^{n}$	$\displaystyle\bigoplus_{i=1}^{n}$
`\bigodot_{i=1}^{n}`	$\bigodot_{i=1}^{n}$	$\displaystyle\bigodot_{i=1}^{n}$	`\sum_{i=1}^{n}`	$\sum_{i=1}^{n}$	$\displaystyle\sum_{i=1}^{n}$

Write code to produce the following equations:

$$e = mc^2 \tag{6.1}$$

$$\pi = \frac{c}{d} \tag{6.2}$$

$$\frac{d}{dx}e^x = e^x \tag{6.3}$$

$$\frac{d}{dx}\int_0^\infty f(s)ds = f(x) \tag{6.4}$$

$$f(x) = \sum_i = 0^\infty \frac{f^{(i)}(0)}{i!}x^i \tag{6.5}$$

$$x = \sqrt{\frac{x_i}{z}y} \tag{6.6}$$

Limits

```
Testing notation for limits

\[
\lim_{h \rightarrow 0 } \frac{f(x+h)-f(x)}{h}
\]

This operator changes when used alongside
text \( \lim_{x \rightarrow h} (x-h) \).
```

Testing notation for limits

$$\lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$$

This operator changes when used alongside text $\lim_{x \to h}(x - h)$.

Aligning Equations

```
\begin{equation} \label{eq1}
\begin{split}
A &= \frac{\pi r^2}{2} \\
  &= \frac{1}{2} \pi r^2
\end{split}
\end{equation}
```

$$\begin{aligned} A &= \frac{\pi r^2}{2} \\ &= \frac{1}{2}\pi r^2 \end{aligned} \tag{1}$$

Including the amsmath Package

```
\usepackage{amsmath}
```

```
\begin{equation} \label{eu_eqn}
e^{\pi i} + 1 = 0
\end{equation}

The beautiful equation \ref{eu_eqn} is known as the Euler equation
```

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

The beautiful equation 1 is known as the Euler equation

Displaying Long Multiple Line Equations

```
\begin{multline*}
p(x) = 3x^6 + 14x^5y + 590x^4y^2 + 19x^3y^3\\
- 12x^2y^4 - 12xy^5 + 2y^6 - a^3b^3
\end{multline*}
```

$$p(x) = 3x^6 + 14x^5y + 590x^4y^2 + 19x^3y^3 - 12x^2y^4 - 12xy^5 + 2y^6 - a^3b^3$$

Aligning several equations

```
\begin{align*}
2x - 5y &=  8 \\
3x + 9y &=  -12
\end{align*}
```

$$2x - 5y = 8$$
$$3x + 9y = -12$$

```
\begin{align*}
x&=y          &  w &=z                  &  a&=b+c\\
2x&=-y        &  3w&=\frac{1}{2}z       &  a&=b\\
-4 + 5x&=2+y  &  w+2&=-1+w              &  ab&=cb
\end{align*}
```

$$x = y \qquad w = z \qquad a = b + c$$
$$2x = -y \qquad 3w = \frac{1}{2}z \qquad a = b$$
$$-4 + 5x = 2 + y \qquad w + 2 = -1 + w \qquad ab = cb$$

Grouping and Centering Equations

```
\begin{gather*}
2x - 5y =  8 \\
3x^2 + 9y =  3a + c
\end{gather*}
```

$$2x - 5y = 8$$
$$3x^2 + 9y = 3a + c$$

Spacing in Math Mode

```
Assume we have the next sets
\[
S = \{ z \in \mathbb{C}\, |\, |z| < 1 \} \quad \textrm{and} \quad
S_2=\partial{S}
\]
```

Assume we have the next sets

$$S = \{z \in \mathbb{C} \,|\, |z| < 1\} \quad \text{and} \quad S_2 = \partial S$$

Spacing Depends on Command

```
\begin{align*}
f(x) =& x^2\! +3x\! +2 \\
f(x) =& x^2+3x+2 \\
f(x) =& x^2\, +3x\, +2 \\
f(x) =& x^2\: +3x\: +2 \\
f(x) =& x^2\; +3x\; +2 \\
f(x) =& x^2\ +3x\ +2 \\
f(x) =& x^2\quad +3x\quad +2 \\
f(x) =& x^2\qquad +3x\qquad +2
\end{align*}
```

Spacing Depends on Command

Spaces in mathematical mode.

$$f(x) =x^2+3x+2$$
$$f(x) =x^2 + 3x + 2$$
$$f(x) =x^2 \ + 3x \ + 2$$
$$f(x) =x^2 \ + 3x \ + 2$$
$$f(x) =x^2 \ + 3x \ + 2$$
$$f(x) =x^2 \ + 3x \ + 2$$
$$f(x) =x^2 \quad + 3x \quad + 2$$
$$f(x) =x^2 \qquad + 3x \qquad + 2$$

Spacing Depends on Command

LaTeX code	Description
\quad	space equal to the current font size (= 18 mu)
\,	3/18 of \quad (= 3 mu)
\:	4/18 of \quad (= 4 mu)
\;	5/18 of \quad (= 5 mu)
\!	-3/18 of \quad (= -3 mu)
\ (space after backslash!)	equivalent of space in normal text
\qquad	twice of \quad (= 36 mu)

Operators spacing

```
\begin{align*}
3ax+4by=5cz\\
3ax<4by+5cz
\end{align*}
```

$$3ax + 4by = 5cz$$
$$3ax < 4by + 5cz$$

- `\thinmuskip` (by default it is equal to 3 mu)
- `\medmuskip` (by default it is equal to 4 mu)
- `\thickmuskip` (by default it is equal to 5 mu)

- For relational operators, such as < , > and =, LATEX establishes \thickmuskip space.
- For binary operators such as +, - and x, the \medmuskip space is set.
- The difference is almost unnoticeable.

User-defined binary and relational operators

```
\begin{align*}
34x^2a \mathbin{\#} 13bc \\
34x^2a \mathrel{\#} 13bc
\end{align*}
```

$$34x^2a \# 13bc$$
$$34x^2a \# 13bc$$

The previous example sets a particular spacing before and after # by using \mathrel (relational) and \mathbin (binary) commands

Display Style in Math Mode

```
In-line maths elements can be set with a different style: \(f(x) = \displaystyle
\frac{1}{1+x}\). The same is true the other way around:

\begin{eqnarray*}
\begin{eqnarray*}
f(x) = \sum_{i=0}^{n} \frac{a_i}{1+x} \\
\textstyle f(x) = \textstyle \sum_{i=0}^{n} \frac{a_i}{1+x} \\
\scriptstyle f(x) = \scriptstyle \sum_{i=0}^{n} \frac{a_i}{1+x} \\
\scriptscriptstyle f(x) = \scriptscriptstyle \sum_{i=0}^{n} \frac{a_i}{1+x}
\end{eqnarray*}
\end{eqnarray*}
```

In-line maths elements can be set with a different style: $f(x) = \displaystyle\frac{1}{1+x}$. The same is true the other way around:

$$f(x) = \sum_{i=0}^{n} \frac{a_i}{1+x}$$

$$f(x) = \textstyle\sum_{i=0}^{n} \frac{a_i}{1+x}$$

$$f(x) = \scriptstyle\sum_{i=0}^{n} \frac{a_i}{1+x}$$

$$f(x) = \scriptscriptstyle\sum_{i=0}^{n} \frac{a_i}{1+x}$$

Capital Letters-Font Typefaces

```
\begin{align*}
RQSZ \\
\mathcal{RQSZ} \\
\mathfrak{RQSZ} \\
\mathbb{RQSZ}
\end{align*}
```

$$RQSZ$$
$$\mathcal{RQSZ}$$
$$\mathfrak{RQSZ}$$
$$\mathbb{RQSZ}$$

This example shows Calligraphic, Fraktur and Blackboard bold typefaces.
To display the R in blackboard bold typeface $\mathbb{R}$ will do the trick.

Other Mathematical Fonts

```
\begin{align*}
3x^2 \in R \subset Q \\
\mathnormal{3x^2 \in R \subset Q} \\
\mathrm{3x^2 \in R \subset Q} \\
\mathit{3x^2 \in R \subset Q} \\
\mathbf{3x^2 \in R \subset Q} \\
\mathsf{3x^2 \in R \subset Q} \\
\mathtt{3x^2 \in R \subset Q}
\end{align*}
```

$$3x^2 \in R \subset Q$$

$$3x^2 \in R \subset Q$$

$$3\mathrm{x}^2 \in \mathrm{R} \subset \mathrm{Q}$$

$$3x^2 \in R \subset Q$$

$$\mathbf{3x^2 \in R \subset Q}$$

$$3\mathsf{x}^2 \in \mathsf{R} \subset \mathsf{Q}$$

$$3\mathtt{x}^2 \in \mathtt{R} \subset \mathtt{Q}$$

In this case, not only letters but all characters change its appearance, for example :

$\mathit{3x^2}$

italicises the entire expression.

Other Mathematical Fonts

TABLE 213: Math Alphabets

Font sample	Generating command	Required package
ABCdef123	`\mathrm{ABCdef123}`	*none*
ABCdef123	`\mathit{ABCdef123}`	*none*
ABCdef123	`\mathnormal{ABCdef123}`	*none*
$\mathcal{ABC}$	`\mathcal{ABC}`	*none*
$\mathscr{ABC}$	`\mathscr{ABC}`	mathrsfs
or	`\mathcal{ABC}`	calrsfs
$\mathcal{ABC}$	`\mathcal{ABC}`	euscript with the mathcal option
or	`\mathscr{ABC}`	euscript with the mathscr option
$\mathpzc{ABCdef123}$	`\mathpzc{ABCdef123}`	*none*; manually defined*
$\mathbb{ABC}$	`\mathbb{ABC}`	amsfonts,§ amssymb, txfonts, or pxfonts
$\varmathbb{ABC}$	`\varmathbb{ABC}`	txfonts or pxfonts
$\mathbb{ABCdef123}$	`\mathbb{ABCdef123}`	bbold or mathbbol†
$\mathbb{ABCdef123}$	`\mathbb{ABCdef123}`	mbboard†
$\mathbbm{ABCdef12}$	`\mathbbm{ABCdef12}`	bbm
$\mathbbmss{ABCdef12}$	`\mathbbmss{ABCdef12}`	bbm
$\mathbbmtt{ABCdef12}$	`\mathbbmtt{ABCdef12}`	bbm
$\mathds{ABC1}$	`\mathds{ABC1}`	dsfont
$\mathds{ABC1}$	`\mathds{ABC1}`	dsfont with the sans option
$\symA\symB\symC$	`\symA\symB\symC`	china2e‡
$\mathfrak{ABCdef123}$	`\mathfrak{ABCdef123}`	eufrak
$\textfrak{ABCdef123}$	`\textfrak{ABCdef123}`	yfonts¶
$\textswab{ABCdef123}$	`\textswab{ABCdef123}`	yfonts¶
$\textgoth{ABCdef123}$	`\textgoth{ABCdef123}`	yfonts¶