LaTeX Math for Undergrads

Rule One Any mathematics at all, even a single character, goes in a mathematical setting. Thus, for "the value of x is 7" enter '`the value of \( x \) is \( 7 \)`'.

Template Your document should contain at least this.

```
\documentclass{article}
\usepackage{amsmath, amssymb, amsthm}
\usepackage[utf8]{inputenc}

\begin{document}
  --document body here--
\end{document}
```

Common constructs

x^2	`x^2`	$\sqrt{2}$, $\sqrt[n]{3}$	`\sqrt{2}`, `\sqrt[n]{3}`
$x_{i,j}$	`x_{i,j}`	$\frac{2}{3}$, $2/3$	`\frac{2}{3}`, `2/3`

Calligraphic letters Use as `\( \mathcal{A} \)`.

$$\mathcal{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$$

Greek

α	`\alpha`	ξ, Ξ	`\xi`, `\Xi`
β	`\beta`	o	o
γ, Γ	`\gamma`, `\Gamma`	π, Π	`\pi`, `\Pi`
δ, Δ	`\delta`, `\Delta`	ϖ	`\varpi`
ϵ	`\epsilon`	ρ	`\rho`
ε	`\varepsilon`	ϱ	`\varrho`
ζ	`\zeta`	σ, Σ	`\sigma`, `\Sigma`
η	`\eta`	ς	`\varsigma`
θ Θ	`\theta`, `\Theta`	τ	`\tau`
ϑ	`\vartheta`	υ, Υ	`\upsilon`, `\Upsilon`
ι	`\iota`	ϕ, Φ	`\phi`, `\Phi`
κ	`\kappa`	φ	`\varphi`
λ Λ	`\lambda`, `\Lambda`	χ	`\chi`
μ	`\mu`	ψ, Ψ	`\psi`, `\Psi`
ν	`\nu`	ω, Ω	`\omega`, `\Omega`

Sets and logic

$\cup$	`\cup`	$\mathbb{R}$	`\mathbb{R}`	$\forall$	`\forall`
$\cap$	`\cap`	$\mathbb{Z}$	`\mathbb{Z}`	$\exists$	`\exists`
$\subset$	`\subset`	$\mathbb{Q}$	`\mathbb{Q}`	$\neg$	`\neg`
$\subseteq$	`\subseteq`	$\mathbb{N}$	`\mathbb{N}`	$\vee$	`\vee`
$\supset$	`\supset`	$\mathbb{C}$	`\mathbb{C}`	$\wedge$	`\wedge`
$\supseteq$	`\supseteq`	$\varnothing$	`\varnothing`	$\vdash$	`\vdash`
$\in$	`\in`	$\emptyset$	`\emptyset`	$\models$	`\models`
$\ni$	`\ni`	$\aleph$	`\aleph`	$\Rightarrow$	`\Rightarrow`
$\notin$	`\notin`	$\setminus$	`\setminus`	$\nRightarrow$	`\nRightarrow`
$\notin$	`\not\in`	$\equiv$	`\equiv`		

Negate an operator, as in $\not\subset$, with `\not\subset`. For the set complement, get A^c with `A^{\mathsf{c}}`, get $A^{\complement}$ with `A^{\complement}`, or get $\bar{A}$ with `\bar{A}`.

Decorations

f'	`f'`	$\dot{a}$	`\dot{a}`	$\tilde{x}$	`\tilde{x}`
f''	`f''`	$\ddot{a}$	`\ddot{a}`	$\bar{x}$	`\bar{x}`
Σ^*	`\Sigma^{*}`	$\hat{x}$	`\hat{x}`	$\vec{x}$	`\vec{x}`

If the decorated letter is i or j then some decorations need `\imath` or `\jmath`, as in `\vec{\imath}`. Some authors use boldface for vectors: `\boldsymbol{x}`.

Entering `\overline{x+y}` produces $\overline{x+y}$, and `\widehat{x+y}` gives $\widehat{x+y}$. Comment on an expression as here (there is also `\overbrace{..}`).

$$\underbrace{x+y}_{|A|} \quad \texttt{\underbrace\{x+y\}\_\{|A|\}}$$

Dots Use low dots in a list $\{0, 1, 2, \ldots\}$, entered as `\{0,1,2,\,\ldots\}`. (If you use `\ldots` in plain text as `London, Paris, \ldots{}\,.` note the thinspace `\,` before the period.) Use centered dots in a sum or product $1 + \cdots + 100$, entered as `1+\cdots+100`. You can also get vertical dots `\vdots` and diagonal dots `\ddots`.

Roman names Enter `\tan(x)`, with a backslash, instead of `tan(x)`. These get the same treatment.

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

Other symbols

$<$	`<`	$\angle$	`\angle`	$\cdot$	`\cdot`
$\leq$	`\leq`	$\measuredangle$	`\measuredangle`	$\pm$	`\pm`
$>$	`>`	ℓ	`\ell`	$\mp$	`\mp`
$\geq$	`\geq`	$\parallel$	`\parallel`	$\times$	`\times`
$\neq$	`\neq`	$45°$	`45^{\circ}`	$\div$	`\div`
$\ll$	`\ll`	$\cong$	`\cong`	$*$	`\ast`
$\gg$	`\gg`	$\ncong$	`\ncong`	$\mid$	`\mid`
$\approx$	`\approx`	$\sim$	`\sim`	$\nmid$	`\nmid`
$\asymp$	`\asymp`	$\simeq$	`\simeq`	$n!$	`n!`
$\equiv$	`\equiv`	$\nsim$	`\nsim`	∂	`\partial`
$\prec$	`\prec`	$\oplus$	`\oplus`	∇	`\nabla`
$\preceq$	`\preceq`	$\ominus$	`\ominus`	$\hbar$	`\hbar`
$\succ$	`\succ`	$\odot$	`\odot`	$\circ$	`\circ`
$\succeq$	`\succeq`	$\otimes$	`\otimes`	$\star$	`\star`
$\propto$	`\propto`	$\oslash$	`\oslash`	$\surd$	`\surd`
$\doteq$	`\doteq`	$\upharpoonright$	`\upharpoonright`	✓	`\checkmark`

Enter `a|b` for the divides relation $a|b$. Use `\mid` as in `\{a\in S\mid\text{\(a=0\) or \(a\) is odd}\}` for the set $\{a \in S \mid a = 0 \text{ or } a \text{ is odd}\}$.

Variable-sized operators The summation $\sum_{j=0}^{3} j^2$ `\sum_{j=0}^3 j^2` and the integral $\int_{x=0}^{3} x^2\,dx$ `\int_{x=0}^3 x^2\,dx` expand when displayed.

$$\sum_{j=0}^{3} j^2 \qquad \int_{x=0}^{3} x^2\,dx$$

These do the same.

$\int$	`\int`	$\iiint$	`\iiint`	$\bigcup$	`\bigcup`
$\iint$	`\iint`	$\oint$	`\oint`	$\bigcap$	`\bigcap`

Arrows

$\rightarrow$	\rightarrow, \to	$\mapsto$	\mapsto
$\nrightarrow$	\nrightarrow	$\longmapsto$	\longmapsto
$\longrightarrow$	\longrightarrow	$\leftarrow$	\leftarrow
$\Rightarrow$	\Rightarrow	$\leftrightarrow$	\leftrightarrow
$\nRightarrow$	\nRightarrow	$\downarrow$	\downarrow
$\Longrightarrow$	\Longrightarrow	$\uparrow$	\uparrow
$\leadsto$	\leadsto	$\updownarrow$	\updownarrow

The right arrows in the first column have matching left arrows, such as `\nleftarrow`, and there are some other matches for down arrows, etc.

Fences

( )	()	$\langle\,\rangle$	\langle\rangle	$\vert\,\vert$	| |
[ ]	[]	$\lfloor\,\rfloor$	\lfloor\rfloor	$\Vert\,\Vert$	\\| \\|
{ }	\{\}	$\lceil\,\rceil$	\lceil\rceil		

They will grow with the enclosed formula using `\left` and `\right`.

$$\left\langle i, 2^{2^i} \right\rangle \quad \texttt{\textbackslash left\textbackslash langle i,2\^{}\{2\^{}i\}\textbackslash right\textbackslash rangle}$$

Every `\left` must match a `\right` and they must end on the same line in the output. For a one-sided fence put a period `\left.` or `\right.` on the other side.

$$\left.\frac{df}{dx}\right|_{x_0} \quad \texttt{\textbackslash left.\textbackslash frac\{df\}\{dx\}\textbackslash right\|\_\{x\_0\}}$$

Fix the size with `\big`, `\Big`, `\bigg`, or `\Bigg`.

$$\Big[\sum_{k=0}^{n} e^{k^2}\Big] \quad \texttt{\textbackslash Big[\textbackslash sum\_\{k=0\}\^{}n e\^{}\{k\^{}2\}\textbackslash Big]}$$

Arrays, Matrices

Make an array of mathematical text as you make a table of plain text.

$$\begin{array}{rcl} 0 & \leftrightarrow & 0 \\ 1 & \leftrightarrow & 1 \\ 2 & \leftrightarrow & 4 \\ \vdots & & \vdots \end{array}$$

```
\begin{array}{rcl}
  0 &\leftrightarrow &0 \\
  1 &\leftrightarrow &1 \\
  2 &\leftrightarrow &4 \\
  \vdots &  &\vdots
\end{array}
```

Definition by cases is an array with two columns.

$$f_n = \begin{cases} a & \text{if } n=0 \\ r\cdot f_{n-1} & \text{else} \end{cases}$$

```
f_n=
\begin{cases}
 a      &\text{if \(n=0\)} \\
 r\cdot f_{n-1} &\text{else}
\end{cases}
```

A matrix is another array variant. With this abbreviation you need not specify that columns are centered.

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

```
\begin{pmatrix}
  a  &b \\
  c  &d
\end{pmatrix}
```

For the determinant use `|A|` inline and `vmatrix` in display.

Spacing in mathematics

$\rightarrow\!\leftarrow$	\,	$\rightarrow\quad\leftarrow$	\quad
$\rightarrow\!\leftarrow$	\:	$\rightarrow\qquad\leftarrow$	\qquad
$\rightarrow\!\leftarrow$	\;	$\rightarrow\!\!\!\leftarrow$	\!

The left column spaces are in ratio 3 : 4 : 5. The last in the right column is a negative space, opposite to `\,`. Get arbitrary space as in `\hspace{0.5cm}`.

Displayed equations

Put equations on a separate line with the `equation*` environment.

$$S = k \log W$$

```
\begin{equation*}
  S=k\log W
\end{equation*}
```

You can break into multiple lines.

$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \cdots$$

```
\begin{multline*}
  \sin (x)=x-\frac{x^3}{3!} \\
      +\frac{x^5}{5!}-\cdots
\end{multline*}
```

Align using the `align*` environment

$$\begin{aligned} \nabla\cdot\boldsymbol{D} &= \rho \\ \nabla\cdot\boldsymbol{B} &= 0 \end{aligned}$$

```
\begin{align*}
  \nabla\cdot\boldsymbol{D} &= \rho \\
  \nabla\cdot\boldsymbol{B} &= 0
\end{align*}
```

(you can have an empty left or right side of the alignment). For each environment, get a numbered version by omitting the asterisk, as with `align` in place of `align*`.

Calculus examples

The last three here are display style.

$$f\colon \mathbb{R} \to \mathbb{R} \quad \texttt{f\textbackslash colon\textbackslash mathbb\{R\}\textbackslash to\textbackslash mathbb\{R\}}$$

$$9.8\ \mathrm{m/s^2} \quad \texttt{9.8\~{}\textbackslash text\{m\}/\textbackslash text\{s\}\^{}2}$$

$$\lim_{h\to 0}\frac{f(x+h)-f(x)}{h} \quad \texttt{\textbackslash lim\_\{h\textbackslash to 0\}\textbackslash frac\{f(x+h)-f(x)\}\{h\}}$$

$$\int x^2\,dx = x^3/3 + C \quad \texttt{\textbackslash int x\^{}2\textbackslash,dx=x\^{}3/3+C}$$

$$\nabla = \boldsymbol{i}\frac{d}{dx} + \boldsymbol{j}\frac{d}{dy} + \boldsymbol{k}\frac{d}{dz} \quad \texttt{\textbackslash nabla=\textbackslash boldsymbol\{i\}\textbackslash frac\{d\}\{dx\}+}\cdots$$

Discrete mathematics examples

There are four modulo forms: $m \bmod n$ is from `m\bmod n`, and $a \equiv b \pmod m$ is from `a\equiv b\pmod m`, and $a \equiv b \mod m$ is from `a\equiv b\mod m`, and $a \equiv b\ (m)$ is from `a\equiv b\pod m`.

For combinations the binomial symbol $\binom{n}{k}$ is from `\binom{n}{k}`. This resizes to be bigger in a display (to require the display version use `\dbinom{n}{k}` and for the inline version use `\tbinom{n}{k}`).

For permutations use $n^{\underline{r}}$ from `n^{\underline{r}}` (some authors use $P(n,r)$, or ${}_nP_r$ from `{}_nP_r`).

Statistics examples

$$\sigma^2 = \sqrt{\textstyle\sum(x_i-\mu)^2/N} \quad \texttt{\textbackslash sigma\^{}2=\textbackslash sqrt\{\textbackslash sum (x\_i-\textbackslash mu)\^{}2/N\}}$$

$$E(X) = \mu_X = \textstyle\sum(x_i - P(x_i)) \quad \texttt{E(X)=\textbackslash mu\_X=\textbackslash sum (x\_i-P(x\_i))}$$

The probability density of the normal distribution

$$\frac{1}{\sqrt{2\sigma^2\pi}}\,e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

comes from this.

```
\frac{1}{sqrt{2\sigma^2\pi}}
  \,e^{-\frac{(x-\mu)^2}{2\sigma^2}}!.
```

For more See also the Comprehensive LaTeX Symbols List at `mirror.ctan.org/info/symbols/comprehensive` and DeTeXify at `detexify.kirelabs.org/classify.html`.

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