LaTeX Math for Undergrads

Rule One Any mathematics at all, even a single character, gets 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{mathtools,amssymb,amsthm} % imports amsmath

\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 in `$\mathcal{A}$`.

$$\mathcal{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$$

Get script letters, such as $\mathscr{P}$ from `$\mathscr{P}$`, by putting `\usepackage{mathrsfs}` in the preamble.

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`
$\notin$	`\notin`	$\aleph$	`\aleph`	$\setminus$	`\setminus`

Negate an operator, as in $\not\subset$, with `\not\subset`. Get the set complement A^{c} with `A^{\mathsf{c}}` (or $A^{\complement}$ with `A^{\complement}`, or $\overline{A}$ with `\overline{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{..}`).

$$\underbrace{x+y}_{|A|}$$ `\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 with `London, Paris, \ldots{}\,.` then 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`	$\liminf$	`\liminf`
$\ln$	`\ln`	$\arg$	`\arg`	$\limsup$	`\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`	$\ast$	`\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`	$\checkmark$	`\checkmark`

Use `a\mid b` for the divides relation, $a \mid b$, and `a\nmid b` for the negation, $a \nmid b$. Also use `\mid` to get set builder notation $\{a\in S\mid a\text{ is odd}\}$, with `\{a\in S\mid\text{$a$ is odd}\}`.

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.

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`

Fences

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

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

$$\Big[\sum_{k=0}^n e^{k^2}\Big]$$ `\Big[\sum_{k=0}^n e^{k^2}\Big]`

To have them grow with the enclosed formula, use `\left` and `\right` (although sometimes `\big`, etc., are necessary).

$$\left\langle i,2^{2^i}\right\rangle$$ `\left\langle i,2^{2^i}\right\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 `\left.` or `\right.` on the other side.

$$\left.\frac{df}{dx}\right|_{x_0}$$ `\left.\frac{df}{dx}\right|_{x_0}`

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 an array with fences. With a `pmatrix` environment, you need not specify column alignments.

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

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

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

Spacing in mathematics Improve $\sqrt{2}x$ to $\sqrt{2}\,x$ with a thin space, as in `\sqrt{2}\,x`. Slightly wider are `\:` and `\;` (the three are in ratio $3:4:5$). Get the improvement of $n/\log n$ instead of $n/\!\log n$ by using a negative thin space, as in `n/\!\log n`. Bigger spaces are: `\quad` for $\rightarrow\quad\leftarrow$, and `\qquad` for $\rightarrow\qquad\leftarrow$, which are useful between parts of a display. Get arbitrary space as in `\hspace*{0.5cm}`.

Displayed equations The `equation*` environment puts an equation on a separate line.

$$S=k\cdot\lg W$$

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

You can break into multiple lines.

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

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

Align equations using `align*`

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

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

(the left or right side of an alignment can be empty). For each environment, get a numbered version by dropping the asterisk from the name.

Calculus examples The last three here are display style.

$f\colon\mathbb{R}\to\mathbb{R}$ `f\colon\mathbb{R}\to\mathbb{R}`

$9.8~\text{m}/\text{s}^2$ `9.8~\text{m}/\text{s}^2`

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

$\int x^2\,dx=x^3/3+C$ `\int x^2\,dx=x^3/3+C`

$\nabla=\boldsymbol{i}\frac{d}{dx}+\boldsymbol{j}\frac{d}{dy}+\boldsymbol{k}\frac{d}{dz}$ `\nabla=\boldsymbol{i}\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 $a\equiv b\pod m$ 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 require the inline version with `\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

$\sigma^2=\sqrt{\,\sum (x_i-\mu)^2/N}$ `\sigma^2=\sqrt{\,\sum (x_i-\mu)^2/N}`

$E(X)=\mu_X=\sum (x_i-P(x_i))$ `E(X)=\mu_X=\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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