

# L<sup>A</sup>T<sub>E</sub>X Math Mode

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## Math Mode

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L<sup>A</sup>T<sub>E</sub>X has a special mode for formatting mathematical formulas. In addition to displaying complicated mathematical notations, this mode allows the use of:

- Subscripts and superscripts
- Greek letters and various special symbols

Thus, math mode is also useful for some nonmathematical text:

The CH<sub>3</sub>COOH was irradiated with  $\alpha$ -rays while at a temperature of 350°C.

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## Types of Math Mode

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1. *Text math mode* (`\begin{math}... \end{math}`): the formula appears in the middle of running text (e.g.  $x^2 + y^2$ ).
2. *Display math mode* (`\begin{displaymath}... \end{displaymath}`): the formula is set off on its own line.

$$\int_0^{\infty} \frac{\sin x}{x} = \frac{\pi}{2}.$$

A special type of this mode is *equation mode* (`\begin{equation}... \end{equation}`), in which the formula is numbered for reference purposes (1):

$$H : I \rightarrow \pi_k(GL_{2n}(\mathbb{C})), H_t = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}^t \cdot \begin{pmatrix} 1 & 0 \\ 0 & B \end{pmatrix} \cdot \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}^t \quad (1)$$

Long or tall formulae should ordinarily be displayed.

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## Using Math Mode

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There are several shorthand techniques of using math mode.

- For text math mode, use  $\$ \dots \$$  or  $\langle \dots \rangle$ .
- For display math mode, use  $\$ \$ \dots \$ \$$  or  $\langle \dots \rangle$ .

It is important to make sure that the way you end math mode matches the way you started it. For example,

```
\begin{math} math stuff $
```

**will not work.**

## Example

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```
For  $a \in A = \mathcal{O}_{V,W}$ , let  
 $\text{ord}_V(a) = l_A(A/(a))$   
denote the length of  $A/(a)$   
as an  $A$ -module: we extend this as  
 $\text{ord}_V\left(\frac{a}{b}\right)$   
 $= \text{ord}_V(a) - \text{ord}_V(b)$ . Then,  
for  $r \in R(W_i)$   
 $\text{div}(r) = \sum_{\substack{V \\ \subset W \\ \text{codim}(V) = 1}} \text{ord}_V(r)[V]$ 
```

For  $a \in A = \mathcal{O}_{V,W}$ , let

$$\text{ord}_V(a) = l_A(A/(a))$$

denote the length of  $A/(a)$  as an  $A$ -  
module: we extend this as

$$\text{ord}_V\left(\frac{a}{b}\right) = \text{ord}_V(a) - \text{ord}_V(b).$$

Then, for  $r \in R(W_i)$ , we construct the  
divisor

$$\text{div}(r) = \sum_{\substack{V \subset W \\ \text{codim}(V) = 1}} \text{ord}_V(r)[V].$$

## Typing Mathematical Expressions

- Numbers, Roman variable names, and most symbols of basic arithmetic may be typed directly:

If  $a + 2 = 4 + b$  and  
 $2(3b - a) = 43$ ,  
then  $b = 47/4$ .

If $a + 2 = 4 + b$ and $2(3b - a) = 43$ , then $b = 47/4$ .
--

- Spaces are generally ignored in math mode:  $abc+def$  and  $a b c + d e f$  both make  $abc + def$ .

## Typefaces in Math Mode

Letters typed in math mode are set in an italic type, as is conventional for Roman variables ( $x$ , etc.).

But do not use this as a quick way to italicize ordinary text! Words typed in math mode look *reallyfreakin'ugly* (that was  $\$really\ freakin'\ ugly$ ). Use `\emph{...}` instead.

For  $\sin$ ,  $\cos$ ,  $\lim$ , and other notations written in upright type, use commands `\sin`, `\cos`, `\lim`, and so forth.

## Super- and Subscripts

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To get a superscript, use  $\text{\^{\{text\}}$ . To get a subscript, use  $\text{\_{\{text\}}$ .

Both a subscript and a superscript can be placed on the same expression.

To get a ' (prime), use ' repeated as many times as needed.

Examples:

Command	Result	Command	Result
$\text{\^{\{b\}}$	$a^b$	$\text{\^{\{b + c\}}$	$a^{b+c}$
$\text{\prime}$	$a'$	$\text{\prime\prime}$	$a''$
$\text{\_{\{b\}}$	$a_b$	$\text{\_{\{b + c\}}$	$a_{b+c}$
$\text{\_{\{0\}}^{\{n+1\}}$	$a_0^{n+1}$	$\text{\^{\{n+1\}}_{\{0\}}$	$a_0^{n+1}$
$\text{\^{\{y\}}^{\{z\}}$	$x^{y^z}$	$\text{\_{\{b_{\{c\}}\}}$	$a_{b_c}$

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## Nonmath Uses of Math Mode

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Subscripts and superscripts are often useful in chemical formulae and temperature values.

Text	Result
$\text{\text{\$}_{\{3\}}\text{\$COOH}$	$\text{CH}_3\text{COOH}$
$180\text{\^{\{\\circ\}}\text{\$C}$	$180^\circ\text{C}$
$\text{\^{\{238\}}_{\{92\}}\text{\$U}$	${}^{238}_{92}\text{U}$

Notice that subscripts and superscripts may be attached to nothing (as in  $\text{\_{\{3\}}\text{\$}$  in the formula for acetic acid above).

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## Variables and Symbols in Math Mode

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Greek letters: for lowercase, use `\lettername` in math mode (`$$\gamma$`  $\rightarrow \gamma$ ). Some uppercase letters can be obtained by `\Lettername` (`$$\Gamma$`  $\rightarrow \Gamma$ ).

Assignment 1: Open `math.tex` in your `examples` directory, and typeset the following sentence into the body of the document.

If  $f(\omega) = \omega - e \log \omega$  then  $f'(\omega) = 1 - e/\omega$  and  $e^{f(\omega)} = \Omega(1)$  in positive  $\omega$ .

## Assignment 1 solution

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If `$f(\omega) = \omega - e \log \omega$` then `$f'(\omega) = 1 - e/\omega$` and `$e^{f(\omega)} = \Omega(1)$` in positive `$$\omega$`.

If  $f(\omega) = \omega - e \log \omega$  then  $f'(\omega) = 1 - e/\omega$  and  $e^{f(\omega)} = \Omega(1)$  in positive  $\omega$ .

## Fractions and Roots

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Fraction: use `\frac{numerator}{denominator}` (`\frac{3}{5}` →  $\frac{3}{5}$ ).  
(In text math mode, the slashed forms n/d usually look better.)

Square root: use `\sqrt{...}` (`\sqrt{3x + 5}` →  $\sqrt{3x + 5}$ ).

$n^{\text{th}}$  power root: use `\sqrt[n]{...}` (`\sqrt[3]{x}` →  $\sqrt[3]{x}$ ).

Assignment 2: Typeset the equation

$$\frac{1}{1 + \sqrt[3]{2} + \sqrt[3]{4}} = \sqrt[3]{2} - 1 \quad (2)$$

Note that it is numbered.

## Assignment 2 solution

---

```
\begin{equation}
\frac{1}{1 + \sqrt[3]{2}
+ \sqrt[3]{4}} =
\sqrt[3]{2} - 1
\end{equation}
```

$$\frac{1}{1 + \sqrt[3]{2} + \sqrt[3]{4}} = \sqrt[3]{2} - 1 \quad (3)$$

## Common Mathematical Functions

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Most common mathematical functions and operators have corresponding commands which are just names of the functions:

- Summation ( $\Sigma$ ), product ( $\Pi$ ), and integral ( $\int$ ) signs are given by `\sum`, `\prod`, and `\int` respectively.
- `\lim`, `\log`, `\sin`, `\cos`, `\tan`, `\sec`, `\csc`, `\cot` yield proper formatting of these common functions.

Command	Result
<code>\log (3x + 5)</code>	$\log(3x + 5)$
<code>\cos (5x + x^2)</code>	$\cos(5x + x^2)$
<code>\sin^{2} (4x + 7)</code>	$\sin^2(4x + 7)$

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## Common Mathematical Symbols

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Most common mathematical symbols have corresponding commands related to the symbol name or symbol appearance.

Command	Result	Command	Result
<code>\in</code>	$\in$	<code>\nabla</code>	$\nabla$
<code>\cap, \cup</code>	$\cap, \cup$	<code>\subset, \supset</code>	$\subset, \supset$
<code>\geq, \leq</code>	$\geq, \leq$	<code>\ldots, \cdots</code>	$\dots, \cdots$

To negate  $=$  and  $\in$ , use `\neq` and `\notin`. Other symbols can be negated using the `\not` command: `\not\leq`  $\rightarrow \not\leq$ , `\not>`  $\rightarrow \not>$ .

Assignment 3: Typeset the following.

If  $A, B \subset \Gamma$  then  $(\Gamma - A \cup B) \subset (\Gamma - A \cap B)$ .

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## Assignment 3 solution

---

If  $A, B \subset \Gamma$  then  
 $(\Gamma - A \cup B) \subset$   
 $(\Gamma - A \cap B)$ .

If  $A, B \subset \Gamma$  then  $(\Gamma - A \cup B) \subset (\Gamma - A \cap B)$ .

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## Bounded Sums and Such

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Sums, products, integrals, and the like often have written upper and lower bounds. These can be indicated using  $_$  for the lower bound and  $^$  for the upper bound:

$\sum_{i=-N}^N$   
 $\sum_{j \geq 0}$   
 $\frac{1}{i^2 + j^3}$

$$\sum_{i=-N}^N \sum_{j \geq 0} \frac{1}{i^2 + j^3}$$

To best display unions and intersections that are bounded, use  $\bigcup$  and  $\bigcap$  instead of  $\cup$  and  $\cap$ .

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## Sum, Integral, Limit Examples

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In text:

$$\backslash\text{sum}_{i=1}^{\infty} i^{-2} \qquad \sum_{i=1}^{\infty} i^{-2}$$

$$\backslash\text{int}_{3}^{2x} y \backslash, dy \qquad \int_3^{2x} y dy$$

$$\backslash\text{lim}_{n \to \infty} \backslash\text{frac}\{1\}\{n\} \qquad \lim_{n \rightarrow \infty} \frac{1}{n}$$

In displays:

$$\backslash\text{sum}_{i=1}^{\infty} i^{-2} \qquad \sum_{i=1}^{\infty} i^{-2}$$

$$\backslash\text{int}_{3}^{2x} y \backslash, dy \qquad \int_3^{2x} y dy$$

$$\backslash\text{lim}_{n \to \infty} \backslash\text{frac}\{1\}\{n\} \qquad \lim_{n \rightarrow \infty} \frac{1}{n}$$

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## Union and Intersection Examples

---

In text:

$$\backslash\text{bigcap}_{i=0}^{\infty} U_i \qquad \bigcap_{i=0}^{\infty} U_i$$

$$\backslash\text{bigcup}_{k=3}^n \{1, 2, \backslash\text{ldots}, k\} \qquad \bigcup_{k=3}^n \{1, 2, \dots, k\}$$

In displays:

$$\backslash\text{bigcap}_{i=0}^{\infty} U_i \qquad \bigcap_{i=0}^{\infty} U_i$$

$$\backslash\text{bigcup}_{k=3}^n \{1, 2, \backslash\text{ldots}, k\} \qquad \bigcup_{k=3}^n \{1, 2, \dots, k\}$$

$$(\bigcup_i U_i) \backslash\text{cup} (\bigcup_i V_i) \qquad \left(\bigcup_i U_i\right) \cup \left(\bigcup_i V_i\right)$$

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## Assignment 7—Integrals, roots, exponents

Typeset the following equations:

$$\lim_{\min\{x,y\} \rightarrow \infty} \frac{x+y}{x^2+y^2} = 0 \quad (4)$$

$$\int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi} \quad (5)$$

## Assignment 7 solution

```
\begin{equation}
\lim_{\min\{x,y\} \to \infty}
\frac{x+y}{x^2+y^2} = 0
\end{equation}
\begin{equation}
\int_{-\infty}^{\infty}
e^{-x^2} dx = \sqrt{\pi}
\end{equation}
```

$$\lim_{\min\{x,y\} \rightarrow \infty} \frac{x+y}{x^2+y^2} = 0 \quad (5)$$

$$\int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi} \quad (6)$$

## Mathematical fonts

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- Various fonts can be used to create unique mathematical symbols:

Bold	<code>\mathbf{x}</code>	$\mathbf{x}$
Calligraphic	<code>\mathcal{A}</code>	$\mathcal{A}$
Blackboard bold	<code>\mathbb{Z}</code>	$\mathbb{Z}$
Script	<code>\mathscr{O}</code>	$\mathscr{O}$

Assignment 8: Typeset the following equation.

$$\mathbb{R}^s \supset \mathbf{I}$$

Note: the “I” is bold.

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## Assignment 8 solution

---

```
\begin{displaymath}
\mathbb{R}^s \supset \mathbf{I}
\end{displaymath}
```

$$\mathbb{R}^s \supset \mathbf{I}$$

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## Common Error Messages

! Missing \$ inserted.

<inserted text>

\$

1.8

?

You have forgotten to end math mode. The line number after the “1.” (in this case “8”) is the first line at which  $\text{\LaTeX}$  has realized that you have forgotten to end math mode; it is usually the end of the paragraph the error is in.

Common cause: Forgetting to put a  $\backslash$  before a  $\%$ .

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## Common Error Messages

! Missing \$ inserted.

<inserted text>

\$

1.6 30<sup>^</sup>

$\backslash$ circ

?

You have used a command (in this case  $\wedge$ ) which  $\text{\LaTeX}$  knows belongs only in math mode. The line number given is the location of the command in question.

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## Common Error Messages

```
! LaTeX Error: \begin{displaymath} on input line 8 ended by
\end{document}.
```

See the LaTeX manual or LaTeX Companion for explanation.

Type H <return> for immediate help.

...

```
1.10 \end{document}
```

?

You have forgotten to end display math mode. The line number on which math mode began is listed (in this case, "input line 8").

## Common Error Messages

```
! LaTeX Error: \mathbb allowed only in math mode.
```

See the LaTeX manual or LaTeX Companion for explanation.

Type H <return> for immediate help.

...

```
1.6 \mathbb
      {stuff}
```

?

The command in question (in this case `\mathbb`) is only allowed in math mode and you have tried to use it outside of math mode.