# List of mathematical symbols

This is a **list of mathematical symbols** used in all branches of mathematics to express a formula or to represent a constant.

Some symbols used widely in mathematics.

A mathematical concept is independent of the symbol chosen to represent it. For many of the symbols below, the symbol is usually synonymous with the corresponding concept (ultimately an arbitrary choice made as a result of the cumulative history of mathematics), but in some situations, a different convention may be used. For example, depending on context, the triple bar "≡" may represent congruence or a definition. However, in mathematical logic, numerical equality is sometimes represented by "≡" instead of "=", with the latter representing equality of well-formed formulas. In short, convention dictates the meaning.

Each symbol is shown both in HTML, whose display depends on the browser's access to an appropriate font installed on the particular device, and typeset as an image using TeX.

## Contents



## Guide

This list is organized by symbol type and is intended to facilitate finding an unfamiliar symbol by its visual appearance. For a related list organized by mathematical topic, see List of mathematical symbols by subject. That list also includes LaTeX and HTML markup, and Unicode code points for each symbol (note that this article doesn't have the latter two, but they could certainly be added).

There is a Wikibooks guide for using maths in LaTeX,[1] and a comprehensive LaTeX symbol list.[2] It is also possible to check to see if a Unicode code point is available as a LaTeX command, or vice versa.[3] Also note that where there is no LaTeX command natively available for a particular symbol (although there may be options that require adding packages), the symbol could be added via other options, such as setting the document up to support Unicode,[4] and entering the character in a variety of ways (e.g. copying and pasting, keyboard shortcuts, the \unicode{<insertcodepoint>} command[5]) as well as other options[6] and extensive additional information.[7][8].

- **Basic symbols:** Symbols widely used in mathematics. More advanced meanings are included with some symbols listed here.
- **Symbols based on equality :** Symbols derived from or similar to the equal sign "=", including double-headed arrows. These symbols are often associated with an equivalence relation.
- **Symbols that point left or right:** Symbols, such as "<" and ">", that appear to point to one side or another.
- **Brackets:** Symbols that are placed on either side of a variable or expression, such as $|x|$.
- **Other non-letter symbols:** Symbols that do not fall in any of the other categories.
- **Letter-based symbols:** Many mathematical symbols are based on, or closely resemble, a letter in some alphabet. This section includes such symbols, including symbols that resemble upside-down letters. Many letters have conventional meanings in various branches of mathematics and physics. These are not listed here. The See also section, below, has several lists of such usages.
  - **Letter modifiers:** Symbols that can be placed on or next to any letter to modify the letter's meaning.
  - **Symbols based on Latin letters**, including those symbols that resemble or contain an X.
  - **Symbols based on Hebrew or Greek letters** e.g. א, ב, δ, Δ, π, Π, σ, Σ, Φ. *Note:* symbols resembling Λ are grouped with V under Latin letters.
- **Variations:** Usage in languages written right-to-left.

## Basic symbols

| Symbol in HTML | Symbol in TeX | Name | Read as | Category | Explanation | Examples |
|---|---|---|---|---|---|---|
| + | $+$ | addition | plus; add | arithmetic | $2 + 7$ means the sum of $2$ and $7$. | $2 + 7 = 9$ |
| | | disjoint union | the disjoint union of ... and ... | set theory | $A_1 + A_2$ means the disjoint union of sets $A_1$ and $A_2$. | $A_1 = \{3, 4, 5, 6\} \land A_2 = \{7, 8, 9, 10\} \Rightarrow$ <br> $A_1 + A_2 = \{(3, 1), (4, 1), (5, 1), (6, 1), (7, 2), (8, 2), (9, 2), (10, 2)\}$ |
| − | $-$ | subtraction | minus; take; subtract | arithmetic | $36 - 11$ means the subtraction of $11$ from $36$. | $36 - 11 = 25$ |
| | | negative sign | negative; minus; the opposite of | arithmetic | $-3$ means the additive inverse of the number $3$. | $-(-5) = 5$ |
| | | set-theoretic complement | minus; without | set theory | $A - B$ means the set that contains all the elements of $A$ that are not in $B$. <br> ($\setminus$ *can also be used for set-theoretic complement as described below.*) | $\{1, 2, 4\} - \{1, 3, 4\} = \{2\}$ |
| ± | $\pm$ <br> \pm | plus-minus | plus or minus | arithmetic | $6 \pm 3$ means both $6 + 3$ and $6 - 3$. | The equation $x = 5 \pm \sqrt{4}$, has two solutions, $x = 7$ and $x = 3$. |
| | | plus-minus | plus or minus | measurement | $10 \pm 2$ or equivalently $10 \pm 20\%$ means the range from $10 - 2$ to $10 + 2$. | If $a = 100 \pm 1$ mm, then $a \geq 99$ mm and $a \leq 101$ mm. |
| ∓ | $\mp$ <br> \mp | minus-plus | minus or plus | arithmetic | $6 \pm (3 \mp 5)$ means $6 + (3 - 5)$ and $6 - (3 + 5)$. | Used paired with ± to mean the opposite <br> $\cos(x \pm y) = \cos(x)\cos(y) \mp \sin(x)\sin(y)$. |
| × <br> · <br> · | $\times$ <br> \times <br> $\cdot$ <br> \cdot | multiplication | times; multiplied by | arithmetic | $3 \times 4$ or $3 \cdot 4$ means the multiplication of $3$ by $4$. | $7 \cdot 8 = 56$ |
| | | dot product scalar product | dot | linear algebra vector algebra | $\mathbf{u} \cdot \mathbf{v}$ means the dot product of vectors $\mathbf{u}$ and $\mathbf{v}$ | $(1, 2, 5) \cdot (3, 4, -1) = 6$ |
| | | cross product vector product | cross | linear algebra vector algebra | $\mathbf{u} \times \mathbf{v}$ means the cross product of vectors $\mathbf{u}$ and $\mathbf{v}$ | $(1, 2, 5) \times (3, 4, -1) = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 1 & 2 & 5 \\ 3 & 4 & -1 \end{vmatrix} = (-22, 16, -2)$ |
| | | placeholder | (silent) | functional analysis | A · means a placeholder for an argument of a function. Indicates the functional nature of an expression without assigning a specific symbol for an argument. | $\lvert \cdot \rvert$ |
| ÷ <br> ⁄ | $\div$ <br> \div <br> $/$ | division (Obelus) | divided by; over | arithmetic | $6 \div 3$ or $6 / 3$ means the division of $6$ by $3$. | $2 \div 4 = 0.5$ <br> $12 / 4 = 3$ |
| | | quotient group | mod | group theory | $G / H$ means the quotient of group $G$ modulo its subgroup $H$. | $\{0, a, 2a, b, b + a, b + 2a\} / \{0, b\} = \{\{0, b\}, \{a, b + a\}, \{2a, b + 2a\}\}$ |
| | | quotient set | mod | set theory | $A/\sim$ means the set of all $\sim$ equivalence classes in $A$. | If we define $\sim$ by $x \sim y \Leftrightarrow x - y \in \mathbb{Z}$, then <br> $\mathbb{R}/\sim = \{x + n : n \in \mathbb{Z}, x \in [0,1)\}$. |
| √ | $\surd$ <br> \surd <br> $\sqrt{x}$ <br> \sqrt{x} | square root (radical symbol) | the (principal) square root of | real numbers | $\sqrt{x}$ means the nonnegative number whose square is $x$. | $\sqrt{4} = 2$ |
| | | complex square root | | | If $z = r\exp(i\varphi)$ is represented in polar coordinates with $-\pi < \varphi \leq \pi$, then $\sqrt{z} = \sqrt{r}\exp(i\varphi/2)$. | $\sqrt{-1} = i$ |

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| | | the (complex) square root of<br>complex numbers | | |
| ∑ | $\sum$<br>`\sum` | summation<br>sum over ... from ... to ... of<br>calculus | $\sum_{k=1}^{n} a_k$ means $a_1 + a_2 + \cdots + a_n$. | $\sum_{k=1}^{4} k^2 = 1^2 + 2^2 + 3^2 + 4^2 = 1 + 4 + 9 + 16 = 30$ |
| ∫ | $\int$<br>`\int` | indefinite integral or antiderivative<br>indefinite integral of - OR - the antiderivative of<br>calculus | $\int f(x)\, dx$ means a function whose derivative is $f$. | $\int x^2 dx = \frac{x^3}{3} + C$ |
| | | definite integral<br>integral from ... to ... of ... with respect to<br>calculus | $\int_a^b f(x)\, dx$ means the signed area between the $x$-axis and the graph of the function $f$ between $x = a$ and $x = b$. | $\int_a^b x^2\, dx = \frac{b^3 - a^3}{3}$ |
| | | line integral<br>line/ path/ curve/ integral of ... along ...<br>calculus | $\int_C f\, ds$ means the integral of $f$ along the curve $C$, $\int_a^b f(\mathbf{r}(t))\, \|\mathbf{r}'(t)\|\, dt$, where $\mathbf{r}$ is a parametrization of $C$. (If the curve is closed, the symbol $\oint$ may be used instead, as described below.) | |
| ∮ | $\oint$<br>`\oint` | Contour integral; closed line integral<br>contour integral of<br>calculus | Similar to the integral, but used to denote a single integration over a closed curve or loop. It is sometimes used in physics texts involving equations regarding Gauss's Law, and while these formulas involve a closed surface integral, the representations describe only the first integration of the volume over the enclosing surface. Instances where the latter requires simultaneous double integration, the symbol $\oiint$ would be more appropriate. A third related symbol is the closed volume integral, denoted by the symbol $\oiiint$.<br>The contour integral can also frequently be found with a subscript capital letter C, $\oint_C$, denoting that a closed loop integral is, in fact, around a contour $C$, or sometimes dually appropriately, a circle $C$. In representations of Gauss's Law, a subscript capital S, $\oint_S$, is used to denote that the integration is over a closed surface. | If $C$ is a Jordan curve about 0, then $\oint_C \frac{1}{z}\, dz = 2\pi i$. |
| …<br>⋯<br>⋮<br>⋰<br>⋱ | $\ldots$<br>`\ldots`<br>$\cdots$<br>`\cdots`<br>$\vdots$<br>`\vdots`<br>$\ddots$<br>`\ddots` | ellipsis<br>and so forth<br>everywhere | Indicates omitted values from a pattern. | 1/2 + 1/4 + 1/8 + 1/16 + ⋯ = 1 |
| ∴ | $\therefore$<br>`\therefore` | therefore<br>therefore; so; hence<br>everywhere | Sometimes used in proofs before logical consequences. | All humans are mortal. Socrates is a human. ∴ Socrates is mortal. |
| ∵ | $\because$<br>`\because` | because<br>because; since<br>everywhere | Sometimes used in proofs before reasoning. | 11 is prime ∵ it has no positive integer factors other than itself and one. |
| ! | ! | factorial<br>factorial<br>combinatorics | $n!$ means the product $1 \times 2 \times \cdots \times n$. | $4! = 1 \times 2 \times 3 \times 4 = 24$ |
| | | logical | The statement !*A* is true if and only if *A* is false. | !(!*A*) ⇔ *A* |

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| | | negation<br>not<br>propositional logic | A slash placed through another operator is the same as "!" placed in front.<br><br>(*The symbol* ! *is primarily from computer science. It is avoided in mathematical texts, where the notation* ¬*A is preferred.*) | *x* ≠ *y* ⇔ !(*x* = *y*) |
| ¬<br><br>~ | ¬<br>\neg<br><br>∼ | logical negation<br>not<br>propositional logic | The statement ¬*A* is true if and only if *A* is false.<br><br>A slash placed through another operator is the same as "¬" placed in front.<br><br>(*The symbol ~ has many other uses, so* ¬ *or the slash notation is preferred. Computer scientists will often use* ! *but this is avoided in mathematical texts.*) | ¬(¬*A*) ⇔ *A*<br>*x* ≠ *y* ⇔ ¬(*x* = *y*) |
| ∝ | ∝<br>\propto | proportionality<br>is proportional to;<br>varies as<br>everywhere | *y* ∝ *x* means that *y* = *kx* for some constant *k*. | if *y* = 2*x*, then *y* ∝ *x*. |
| ∞ | ∞<br>\infty | infinity<br>infinity<br>numbers | ∞ is an element of the extended number line that is greater than all real numbers; it often occurs in limits. | $\lim_{x\to 0} \frac{1}{\lvert x\rvert} = \infty$ |
| ■<br><br>□<br><br>■<br><br>█<br><br>▸ | ■<br>\blacksquare<br><br>□<br>\Box<br><br>▶<br>\blacktriangleright | end of proof<br>QED;<br>tombstone;<br>Halmos finality symbol<br>everywhere | Used to mark the end of a proof.<br><br>(*May also be written* Q.E.D.) | |

## Symbols based on equality

| Symbol in HTML | Symbol in TeX | Name / Read as / Category | Explanation | Examples |
|---|---|---|---|---|
| = | $=$ | equality<br>is equal to; equals<br>everywhere | $x = y$ means $x$ and $y$ represent the same thing or value. | $2 = 2$<br>$1 + 1 = 2$<br>$36 - 5 = 31$ |
| ≠ | $\neq$<br>`\ne, \neq` | inequality<br>is not equal to; does not equal<br>everywhere | $x \neq y$ means that $x$ and $y$ do not represent the same thing or value.<br>(*The forms !=, /= or <> are generally used in programming languages where ease of typing and use of ASCII text is preferred.*) | $2 + 2 \neq 5$<br>$36 - 5 \neq 30$ |
| ≈ | $\approx$<br>`\approx` | approximately equal<br>is approximately equal to<br>everywhere | x ≈ y means x is approximately equal to y.<br>*This may also be written ≃, ≅, ~, ♎ (Libra Symbol), or ≒.* | π ≈ 3.14159 |
| | | isomorphism<br>is isomorphic to<br>group theory | G ≈ H means that group G is isomorphic (structurally identical) to group H.<br>(*≅ can also be used for isomorphic, as described below.*) | $Q_8 / C_2 \approx V$ |
| ~ | $\sim$<br>`\sim` | probability distribution<br>has distribution<br>statistics | X ~ D, means the random variable X has the probability distribution D. | X ~ N(0,1), the standard normal distribution |
| | | row equivalence<br>is row equivalent to<br>matrix theory | A ~ B means that B can be generated by using a series of elementary row operations on A | $\begin{bmatrix}1 & 2\\2 & 4\end{bmatrix} \sim \begin{bmatrix}1 & 2\\0 & 0\end{bmatrix}$ |
| | | same order of magnitude<br>roughly similar; poorly approximates; is on the order of<br>approximation theory | m ~ n means the quantities m and n have the same order of magnitude, or general size.<br>(*Note that ~ is used for an approximation that is poor, otherwise use ≈ .*) | 2 ~ 5<br>8 × 9 ~ 100<br>but $\pi^2 \approx 10$ |
| | | similarity<br>is similar to[9]<br>geometry | △ABC ~ △DEF means triangle ABC is similar to (has the same shape) triangle DEF. | |
| | | asymptotically equivalent<br>is asymptotically equivalent to<br>asymptotic analysis | f ~ g means $\lim_{n\to\infty} \frac{f(n)}{g(n)} = 1$. | x ~ x+1 |
| | | equivalence relation<br>are in the same equivalence class<br>everywhere | a ~ b means $b \in [a]$ (and equivalently $a \in [b]$). | 1 ~ 5 mod 4 |
| =:<br>:=<br>≡<br>:⇔<br>≜<br>$\stackrel{\mathrm{def}}{=}$<br>≐ | $=:$<br>$:=$<br>$\equiv$<br>`\equiv`<br>$:\Leftrightarrow$<br>`:\Leftrightarrow`<br>$\triangleq$<br>`\triangleq`<br>$\stackrel{\mathrm{def}}{=}$<br>`\stackrel{\mathrm{def}}{=}` | definition<br>is defined as; is equal by definition to<br>everywhere | In definitions, the symbol "=" is preferred over "≡" or ":=". (*see § Writing style in mathematics*)<br>x := y, y =: x or x ≡ y means x is defined to be another name for y, under certain assumptions taken in context.<br>(*Some writers use ≡ to mean congruence*).<br>P :⇔ Q means P is defined to be logically equivalent to Q. | $\cosh x \triangleq \frac{e^x + e^{-x}}{2}$<br>$[a, b] \stackrel{\mathrm{def}}{=} a \cdot b - b \cdot a$ |

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| | ≝<br>`\overset{\underset{\mathrm{def}}{}}{=}`<br>≐<br>`\doteq` | | | |
| ≅ | ≅<br>`\cong` | congruence<br>is congruent to<br>geometry | △ABC ≅ △DEF means triangle ABC is congruent to (has the same measurements as) triangle DEF. | |
| | | isomorphic<br>is isomorphic to<br>abstract algebra | $G \cong H$ means that group $G$ is isomorphic (structurally identical) to group $H$.<br>(*≈ can also be used for isomorphic, as described above.*) | $V \cong C_2 \times C_2$ |
| ≡ | ≡<br>`\equiv` | congruence relation<br>... is congruent to ... modulo ...<br>modular arithmetic | $a \equiv b \pmod{n}$ means $a - b$ is divisible by $n$ | 5 ≡ 2 (mod 3) |
| | | identical equality<br>is identically equivalent to<br>mathematical analysis | $f \equiv g$ for two functions $f$, $g$, means $f(x) = g(x)$ for all $x$.[10] | |
| ⇔<br>↔ | ⇔<br>`\Leftrightarrow`<br>⟺<br>`\iff`<br>↔<br>`\leftrightarrow` | material equivalence<br>if and only if; iff<br>propositional logic | $A \Leftrightarrow B$ means $A$ is true if $B$ is true and $A$ is false if $B$ is false. | $x + 5 = y + 2 \Leftrightarrow x + 3 = y$ |
| :=<br>=: | :=<br>=: | Assignment<br>is defined to be<br>everywhere | $A := b$ means $A$ is defined to have the value $b$. | Let $a := 3$, then...<br>$f(x) := x + 3$ |

## Symbols that point left or right

| Symbol in HTML | Symbol in TeX | Name<br>Read as<br>Category | Explanation | Examples |
|---|---|---|---|---|
| < > | $<$ $>$ | strict inequality<br>is less than, is greater than<br>order theory | $x<y$ means $x$ is less than $y$.<br>$x>y$ means $x$ is greater than $y$. | $3<4$<br>$5>4$ |
| | | proper subgroup<br>is a proper subgroup of<br>group theory | $H<G$ means $H$ is a proper subgroup of $G$. | $5\mathbf{Z}<\mathbf{Z}$<br>$\mathbf{A}_3<\mathbf{S}_3$ |
| ≪ ≫ | $\ll$ $\gg$<br>\ll<br>\gg | significant (strict) inequality<br>is much less than, is much greater than<br>order theory | $x \ll y$ means x is much less than y.<br>$x \gg y$ means x is much greater than y. | $0.003 \ll 1000000$ |
| | | asymptotic comparison<br>is of smaller order than, is of greater order than<br>analytic number theory | $f \ll g$ means the growth of f is asymptotically bounded by g.<br>(*This is I. M. Vinogradov's notation. Another notation is the Big O notation, which looks like* $f = \mathrm{O}(g)$.) | $x \ll e^x$ |
| | | absolute continuity<br>is absolutely continuous with respect to<br>measure theory | $\mu \ll \nu$ means that $\mu$ is absolutely continuous with respect to $\nu$, *i.e.*, whenever $\nu(A)=0$, we have $\mu(A)=0$. | If $c$ is the counting measure on $[0,1]$ and $\mu$ is the Lebesgue measure, then $\mu \ll c$. |
| ≤ ≥ | $\le$ $\ge$<br>\le<br>\ge | inequality<br>is less than or equal to, is greater than or equal to<br>order theory | $x \le y$ means x is less than or equal to y.<br>$x \ge y$ means x is greater than or equal to y.<br>(*The forms <= and >= are generally used in programming languages, where ease of typing and use of ASCII text is preferred.*)<br>(*≦ and ≧ are also used by some writers to mean the same thing as ≤ and ≥, but this usage seems to be less common.*) | $3 \le 4$ and $5 \le 5$<br>$5 \ge 4$ and $5 \ge 5$ |
| | | subgroup<br>is a subgroup of<br>group theory | $H \le G$ means H is a subgroup of G. | $\mathrm{Z} \le \mathrm{Z}$<br>$\mathrm{A}_3 \le \mathrm{S}_3$ |
| | | reduction<br>is reducible to<br>computational complexity theory | $A \le B$ means the problem A can be reduced to the problem B. Subscripts can be added to the ≤ to indicate what kind of reduction. | If<br>$\exists f \in F \,.\, \forall x \in \mathbb{N} \,.\, x \in A \Leftrightarrow f(x) \in B$<br>then<br>$A \le_F B$ |
| ≦ ≧ | $\leqq$ $\geqq$<br>\leqq<br>\geqq | congruence relation<br>... is less than ... is greater than ...<br>modular arithmetic | | $10a \equiv 5 \pmod 5$ for $1 \leqq a \leqq 10$ |
| | | vector inequality<br>... is less than or equal... is greater than or equal...<br>order theory | $x \leqq y$ means that each component of vector x is less than or equal to each corresponding component of vector y.<br>$x \geqq y$ means that each component of vector x is greater than or equal to each corresponding component of vector y.<br>*It is important to note that* $x \leqq y$ *remains true if every element is equal. However, if the operator is changed,* $x \le y$ *is true if and only if* $x \neq y$ *is also true.* | |
| ≺ ≻ | $\prec$ $\succ$<br>\prec<br>\succ | Karp reduction<br>is Karp reducible to; is polynomial-time many-one reducible to<br>computational complexity theory | $L_1 \prec L_2$ means that the problem $L_1$ is Karp reducible to $L_2$.[11] | If $L_1 \prec L_2$ and $L_2 \in \mathbf{P}$, then $L_1 \in \mathbf{P}$. |
| | | Nondominated order<br>is nondominated by<br>Multi-objective optimization | $P \prec Q$ means that the element P is nondominated by element Q.[12] | If $P_1 \prec Q_2$ then $\forall_i P_i \leq Q_i \land \exists P_i < Q_i$ |
| ◅ ▻ | $\triangleleft$ $\triangleright$<br>\triangleleft<br>\triangleright | normal subgroup<br>is a normal subgroup of<br>group theory | $N \triangleleft G$ means that N is a normal subgroup of group G. | $Z(G) \triangleleft G$ |
| | | ideal | $I \triangleleft R$ means that I is an ideal of ring R. | $(2) \triangleleft \mathrm{Z}$ |

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| ◁<br>▷ | | is an ideal of<br>ring theory | | |
| | | antijoin<br>the antijoin of<br>relational algebra | $R \rhd S$ means the antijoin of the relations *R* and *S*, the tuples in *R* for which there is not a tuple in *S* that is equal on their common attribute names. | $R \triangleright S = R - R \ltimes S$ |
| ⇒<br>→<br>⊃ | ⇒<br>→<br>⊃<br>\Rightarrow<br>\rightarrow<br>\supset | material implication<br>implies; if ... then<br>propositional logic, Heyting algebra | *A* ⇒ *B* means if *A* is true then *B* is also true; if *A* is false then nothing is said about *B*.<br>(*→ may mean the same as ⇒, or it may have the meaning for functions given below.*)<br>(*⊃ may mean the same as ⇒,*[13] *or it may have the meaning for superset given below.*) | $x = 6 \Rightarrow x^2 - 5 = 36 - 5 = 31$ is true, but $x^2 - 5 = 36 - 5 = 31 \Rightarrow x = 6$ is in general false (since *x* could be −6). |
| ⊆<br>⊂ | ⊆<br>⊂<br>\subseteq<br>\subset | subset<br>is a subset of<br>set theory | (subset) $A \subseteq B$ means every element of *A* is also an element of *B*.[14]<br>(proper subset) $A \subset B$ means $A \subseteq B$ but $A \neq B$.<br>(*Some writers use the symbol ⊂ as if it were the same as ⊆.*) | $(A \cap B) \subseteq A$<br>$\mathbb{N} \subset \mathbb{Q}$<br>$\mathbb{Q} \subset \mathbb{R}$ |
| ⊇<br>⊃ | ⊇<br>⊃<br>\supseteq<br>\supset | superset<br>is a superset of<br>set theory | $A \supseteq B$ means every element of *B* is also an element of *A*.<br>$A \supset B$ means $A \supseteq B$ but $A \neq B$.<br>(*Some writers use the symbol ⊃ as if it were the same as ⊇.*) | $(A \cup B) \supseteq B$<br>$\mathbb{R} \supset \mathbb{Q}$ |
| ⋐ | \Subset | compact embedding<br>is compactly contained in<br>set theory | $A \Subset B$ means the closure of *A* is a compact subset of *B*. | $\mathbb{Q} \cap (0,1) \Subset [0,5]$ |
| → | →<br>\to | function arrow<br>from ... to<br>set theory, type theory | $f\colon X \to Y$ means the function *f* maps the set *X* into the set *Y*. | Let $f\colon \mathbb{Z} \to \mathbb{N} \cup \{0\}$ be defined by $f(x) := x^2$. |
| ↦ | ↦<br>\mapsto | function arrow<br>maps to<br>set theory | $f\colon a \mapsto b$ means the function *f* maps the element *a* to the element *b*. | Let $f\colon x \mapsto x + 1$ (the successor function). |
| ← | ←<br>\leftarrow | Converse implication<br>.. if ..<br>logic | $a \leftarrow b$ means that for the propositions *a* and *b*, if *b* implies *a*, then *a* is the converse implication of *b.a* to the element *b*. This reads as "a if b", or "not b without a". It is not to be confused with the assignment operator in computer science. | |
| <:<br><· | <:<br><· | subtype<br>is a subtype of<br>type theory | $T_1 <: T_2$ means that $T_1$ is a subtype of $T_2$. | If $S <: T$ and $T <: U$ then $S <: U$ (transitivity). |
| | | cover<br>is covered by<br>order theory | $x <\!\!\cdot\ y$ means that *x* is covered by *y*. | $\{1, 8\} <\!\!\cdot \{1, 3, 8\}$ among the subsets of $\{1, 2, ..., 10\}$ ordered by containment. |
| ⊨ | ⊨<br>\vDash | entailment<br>entails<br>model theory | $A \vDash B$ means the sentence *A* entails the sentence *B*, that is in every model in which *A* is true, *B* is also true. | $A \vDash A \vee \neg A$ |
| ⊢ | ⊢<br>\vdash | inference<br>infers; is derived from<br>propositional logic, predicate logic | $x \vdash y$ means *y* is derivable from *x*. | $A \to B \vdash \neg B \to \neg A$ |
| | | partition<br>is a partition of<br>number theory | $p \vdash n$ means that *p* is a partition of *n*. | $(4,3,1,1) \vdash 9$, $\sum_{\lambda \vdash n} (f_\lambda)^2 = n!$ |
| ⟨\| | ⟨\|<br>\langle | bra vector<br>the bra ...; the dual of ...<br>Dirac notation | ⟨*φ*\| means the dual of the vector \|*φ*⟩, a linear functional which maps a ket \|*ψ*⟩ onto the inner product ⟨*φ*\|*ψ*⟩. | |
| \|⟩ | \|⟩<br>\rangle | ket vector<br>the ket ...; the vector ...<br>Dirac notation | \|*φ*⟩ means the vector with label *φ*, which is in a Hilbert space. | A qubit's state can be represented as *α*\|0⟩+ *β*\|1⟩, where *α* and *β* are complex numbers s.t. $\|\alpha\|^2 + \|\beta\|^2 = 1$. |

# Brackets

| Symbol in HTML | Symbol in TeX | Name<br>Read as<br>Category | Explanation | Examples |
|---|---|---|---|---|
| | $\binom{}{}$<br>`{\ \choose\ }` | combination; binomial coefficient<br>*n* choose *k*<br>combinatorics | $\binom{n}{k} = \frac{n!/(n-k)!}{k!} = \frac{(n-k+1)\cdots(n-2)\cdot(n-1)\cdot n}{k!}$<br>means (in the case of *n* = positive integer) the number of combinations of *k* elements drawn from a set of *n* elements.<br>(*This may also be written as* C(*n*, *k*), C(*n*; *k*), ${}_nC_k$, ${}^n\mathbf{C}_k$, or $\left\langle \begin{matrix} n \\ k \end{matrix} \right\rangle$.) | $\binom{36}{5} = \frac{36!/(36-5)!}{5!} = \frac{32\cdot 33\cdot 34\cdot 35\cdot 36}{1\cdot 2\cdot 3\cdot 4\cdot 5} = 376992$<br>$\binom{.5}{7} = \frac{-5.5\cdot -4.5\cdot -3.5\cdot -2.5\cdot -1.5\cdot -.5\cdot .5}{1\cdot 2\cdot 3\cdot 4\cdot 5\cdot 6\cdot 7}$ |
| | $\left(\!\!\binom{}{}\!\!\right)$<br>`\left(\!\!{\ \choose\ }\!\!\right)` | multiset coefficient<br>*u* multichoose *k*<br>combinatorics | $\left(\!\!\binom{u}{k}\!\!\right) = \binom{u+k-1}{k} = \frac{(u+k-1)!/(u-1)!}{k!}$<br>(when *u* is positive integer)<br>means reverse or rising binomial coefficient. | $\left(\!\!\binom{-5.5}{7}\!\!\right) = \frac{-5.5\cdot -4.5\cdot -3.5\cdot -2.5\cdot -1.5\cdot -.5\cdot .5}{1\cdot 2\cdot 3\cdot 4\cdot 5\cdot 6\cdot 7} = ($ |
| | $\left\{\begin{array}{lr}\ldots \\ \ldots\end{array}\right.$<br>`\left\{ \begin{array}{lr} \ldots \\ \ldots \end{array}\right.` | piecewise-defined function; pattern matching; Switch statement<br>is defined as ... if ..., or as ... if ...; match ... with<br>everywhere | $f(x) = \begin{cases} a, & \text{if } p(x) \\ b, & \text{if } q(x) \end{cases}$ means the function *f(x)* is defined as *a* if the condition *p(x)* holds, or as *b* if the condition *q(x)* holds.<br>(The body of a piecewise-defined function can have any finite number (not only just two) expression-condition pairs.)<br>This symbol is also used in type theory for pattern matching the constructor of the value of an algebraic type. For example $g(n) = \mathbf{match}\ n\ \mathbf{with} \begin{cases} x & \to a \\ y & \to b \end{cases}$ does pattern matching on the function's arguments and means that *g(x)* is defined as *a*, and *g(y)* is defined as *b*.<br>(A pattern matching can have any finite number (not only just two) pattern-expression pairs.) | $\lvert x\rvert = \begin{cases} x, & \text{if } x \geq 0 \\ -x, & \text{if } x < 0 \end{cases}$<br>$a + b = \mathbf{match}\ b\ \mathbf{with} \begin{cases} 0 & \to a \\ Sn & \to S(a+n) \end{cases}$ |
| \|...\| | $\lvert\ldots\rvert$<br>`\| \ldots \| \!\,` | absolute value; modulus<br>absolute value of; modulus of<br>numbers | \|*x*\| means the distance along the real line (or across the complex plane) between *x* and zero. | \|3\| = 3<br>\|–5\| = \|5\| = 5<br>\| *i* \| = 1<br>\| 3 + 4*i* \| = 5 |
| | | Euclidean norm or Euclidean length or magnitude<br>Euclidean norm of<br>geometry | \|**x**\| means the (Euclidean) length of vector **x**. | For **x** = (3,–4)<br>$\lvert\mathbf{x}\rvert = \sqrt{3^2 + (-4)^2} = 5$ |
| | | determinant<br>determinant of<br>matrix theory | \|*A*\| means the determinant of the matrix *A* | $\begin{vmatrix} 1 & 2 \\ 2 & 9 \end{vmatrix} = 5$ |
| | | cardinality<br>cardinality of; size of; order of<br>set theory | \|*X*\| means the cardinality of the set *X*.<br>(*# may be used instead as described below.*) | \|{3, 5, 7, 9}\| = 4. |
| ‖...‖ | $\lVert\ldots\rVert$<br>`\| \ldots \| \!\,` | norm<br>norm of; length of<br>linear algebra | ‖ *x* ‖ means the norm of the element *x* of a normed vector space.[15] | ‖ *x* + *y* ‖ ≤ ‖ *x* ‖ + ‖ *y* ‖ |
| | | nearest integer function<br>nearest integer to<br>numbers | ‖*x*‖ means the nearest integer to *x*.<br>(*This may also be written* [*x*], ⌊*x*⌉, nint(*x*) *or* Round(*x*).) | ‖1‖ = 1, ‖1.6‖ = 2, ‖−2.4‖ = −2, ‖3.49‖ = 3 |
| { , } | $\{\ ,\!\ \}$<br>`{\{\ ,\!\ \}} \!\,` | set brackets<br>the set of ...<br>set theory | {*a*,*b*,*c*} means the set consisting of *a*, *b*, and *c*.[16] | ℕ = { 1, 2, 3, ... } |
| { : }<br>{ \| }<br>{ ; } | $\{\ :\ \}$<br>`\{\ :\ \} \!\,`<br>$\{\ \mid\ \}$<br>`\{\ \|\ \} \!\,`<br>$\{\ ;\ \}$<br>`\{\ ;\ \} \!\,` | set builder notation<br>the set of ... such that<br>set theory | {*x* : *P*(*x*)} means the set of all *x* for which *P*(*x*) is true.[16] {*x* \| *P*(*x*)} is the same as {*x* : *P*(*x*)}. | {*n* ∈ ℕ : $n^2$ < 20} = { 1, 2, 3, 4 } |
| ⌊...⌋ | $\lfloor\ldots\rfloor$ | floor | ⌊*x*⌋ means the floor of *x*, i.e. the largest integer less than or | ⌊4⌋ = 4, ⌊2.1⌋ = 2, ⌊2.9⌋ = 2, ⌊−2.6⌋ = −3 |

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| | ⌊…⌋<br>\lfloor \ldots \rfloor \!\, | floor; greatest integer; entier<br>numbers | equal to *x*.<br>(*This may also be written* [*x*], floor(*x*) *or* int(*x*).) | |
| ⌈…⌉ | ⌈…⌉<br>\lceil \ldots \rceil \!\, | ceiling<br>ceiling<br>numbers | ⌈*x*⌉ means the ceiling of *x*, i.e. the smallest integer greater than or equal to *x*.<br>(*This may also be written* ceil(*x*) *or* ceiling(*x*).) | ⌈4⌉ = 4, ⌈2.1⌉ = 3, ⌈2.9⌉ = 3, ⌈−2.6⌉ = −2 |
| ⌊…⌉ | ⌊…⌉<br>\lfloor \ldots \rceil \!\, | nearest integer function<br>nearest integer to<br>numbers | ⌊*x*⌉ means the nearest integer to *x*.<br>(*This may also be written* [*x*], $\Vert x \Vert$, nint(*x*) *or* Round(*x*).) | ⌊2⌉ = 2, ⌊2.6⌉ = 3, ⌊−3.4⌉ = −3, ⌊4.49⌉ = 4 |
| [ : ] | [ : ]<br>[\ :\ ] \!\, | degree of a field extension<br>the degree of<br>field theory | [*K* : *F*] means the degree of the extension *K* : *F*. | [ℚ(√2) : ℚ] = 2<br>[ℂ : ℝ] = 2<br>[ℝ : ℚ] = ∞ |
| [ ]<br>[ , ]<br>[ , , ] | [ ]<br>[\ ] \!\,<br>[ , ]<br>[\ ,\ ] \!\,<br>[ , , ] | equivalence class<br>the equivalence class of<br>abstract algebra | [*a*] means the equivalence class of *a*, i.e. {*x* : *x* ~ *a*}, where ~ is an equivalence relation.<br>$[a]_R$ means the same, but with *R* as the equivalence relation. | Let *a* ~ *b* be true iff *a* ≡ *b* (mod 5).<br>Then [2] = {..., −8, −3, 2, 7, ...}. |
| | | floor<br>floor; greatest integer; entier<br>numbers | [*x*] means the floor of *x*, i.e. the largest integer less than or equal to *x*.<br>(*This may also be written* ⌊*x*⌋, floor(*x*) *or* int(*x*). *Not to be confused with the nearest integer function, as described below.*) | [3] = 3, [3.5] = 3, [3.99] = 3, [−3.7] = −4 |
| | | nearest integer function<br>nearest integer to<br>numbers | [*x*] means the nearest integer to *x*.<br>(*This may also be written* ⌊*x*⌉, $\Vert x \Vert$, nint(*x*) *or* Round(*x*). *Not to be confused with the floor function, as described above.*) | [2] = 2, [2.6] = 3, [−3.4] = −3, [4.49] = 4 |
| | | Iverson bracket<br>1 if true, 0 otherwise<br>propositional logic | [*S*] maps a true statement *S* to 1 and a false statement *S* to 0. | [0=5]=0, [7>0]=1, [2 ∈ {2,3,4}]=1, [5 ∈ {2,3,4}]=0 |
| | | image<br>image of ... under ...<br>everywhere | *f*[*X*] means { *f*(*x*) : *x* ∈ *X* }, the image of the function *f* under the set *X* ⊆ dom(*f*).<br>(*This may also be written as f*(*X*) *if there is no risk of confusing the image of f under X with the function application f of X. Another notation is* Im *f, the image of f under its domain.*) | $\sin[\mathbb{R}] = [-1, 1]$ |
| | | closed interval<br>closed interval<br>order theory | $[a,b] = \{x \in \mathbb{R} : a \leq x \leq b\}$. | 0 and 1/2 are in the interval [0,1]. |
| | | commutator<br>the commutator of<br>group theory, ring theory | [*g*, *h*] = $g^{-1}h^{-1}gh$ (or $ghg^{-1}h^{-1}$), if *g*, *h* ∈ *G* (a group).<br>[*a*, *b*] = *ab* − *ba*, if *a*, *b* ∈ *R* (a ring or commutative algebra). | $x^y$ = *x*[*x*, *y*] (group theory).<br>[*AB*, *C*] = *A*[*B*, *C*] + [*A*, *C*]*B* (ring theory). |
| | | triple scalar product<br>the triple scalar product of<br>vector calculus | [**a**, **b**, **c**] = **a** × **b** · **c**, the scalar product of **a** × **b** with **c**. | [**a**, **b**, **c**] = [**b**, **c**, **a**] = [**c**, **a**, **b**]. |
| ( )<br>( , ) | ( )<br>(\ ) \!\,<br>( , )<br>(\ ,\ ) \!\, | function application<br>of<br>set theory | *f*(*x*) means the value of the function *f* at the element *x*. | If *f*(*x*) := $x^2$ − 5, then *f*(6) = $6^2$ − 5 = 36 − 5=31. |
| | | image<br>image of ... under ...<br>everywhere | *f*(*X*) means { *f*(*x*) : *x* ∈ *X* }, the image of the function *f* under the set *X* ⊆ dom(*f*).<br>(*This may also be written as f*[*X*] *if there is a risk of confusing the image of f under X with the function application f of X. Another notation is* Im *f, the image of f under its domain.*) | $\sin(\mathbb{R}) = [-1, 1]$ |
| | | precedence grouping<br>parentheses<br>everywhere | Perform the operations inside the parentheses first. | (8/4)/2 = 2/2 = 1, but 8/(4/2) = 8/2 = 4. |

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| | | tuple<br>tuple; *n*-tuple; ordered pair/triple/etc; row vector; sequence<br>everywhere | An ordered list (or sequence, or horizontal vector, or row vector) of values.<br>(*Note that the notation* (*a*,*b*) *is ambiguous: it could be an ordered pair or an open interval. Set theorists and computer scientists often use angle brackets* ⟨ ⟩ *instead of parentheses.*) | (*a*, *b*) is an ordered pair (or 2-tuple).<br>(*a*, *b*, *c*) is an ordered triple (or 3-tuple).<br>( ) is the empty tuple (or 0-tuple). |
| | | highest common factor<br>highest common factor; greatest common divisor; hcf; gcd<br>number theory | (*a*, *b*) means the highest common factor of *a* and *b*.<br>(*This may also be written* hcf(*a*, *b*) *or* gcd(*a*, *b*).) | (3, 7) = 1 (they are coprime); (15, 25) = 5. |
| ( , )<br>] , [ | ( , )<br>`(\ ,\ ) \!\,(\ ,\ ) \!\,`<br>] , [<br>`]\ ,\ [ \!\,]` | open interval<br>open interval<br>order theory | $(a,b) = \{x \in \mathbb{R} : a < x < b\}$.<br>(*Note that the notation* (*a*,*b*) *is ambiguous: it could be an ordered pair or an open interval. The notation* ]*a*,*b*[ *can be used instead.*) | 4 is not in the interval (4, 18).<br>(0, +∞) equals the set of positive real numbers. |
| ( , ]<br>] , ] | ( , ]<br>`(\ ,\ ] \!\,`<br>] , ]<br>`\ ,\ ] \!\,]` | left-open interval<br>half-open interval; left-open interval<br>order theory | $(a,b] = \{x \in \mathbb{R} : a < x \leq b\}$. | (−1, 7] and (−∞, −1] |
| [ , )<br>[ , [ | [ , )<br>`[\ ,\ ) \!\,`<br>[ , [<br>`[\ ,\ [ \!\,` | right-open interval<br>half-open interval; right-open interval<br>order theory | $[a,b) = \{x \in \mathbb{R} : a \leq x < b\}$. | [4, 18) and [1, +∞) |
| ⟨⟩<br>⟨,⟩ | ⟨ ⟩<br>`\langle\ \rangle \!\,`<br>⟨ , ⟩<br>`\langle\ ,\ \rangle \!\,` | inner product<br>inner product of<br>linear algebra | ⟨*u*,*v*⟩ means the inner product of *u* and *v*, where *u* and *v* are members of an inner product space.<br>*Note that the notation* ⟨*u*, *v*⟩ *may be ambiguous: it could mean the inner product or the linear span.*<br>*There are many variants of the notation, such as* $\langle u \mid v \rangle$ *and* $(u \mid v)$, *which are described below. For spatial vectors, the dot product notation, x* · *y is common. For matrices, the colon notation A* : *B may be used. As* ⟨ *and* ⟩ *can be hard to type, the more "keyboard friendly" forms* < *and* > *are sometimes seen. These are avoided in mathematical texts.* | The standard inner product between two vectors *x* = (2, 3) and *y*<br>⟨x, y⟩ = 2 × −1 + 3 × 5 = 13 |
| | | average<br>average of<br>statistics | let S be a subset of N for example, $\langle S \rangle$ represents the average of all the elements in S. | for a time series :*g*(*t*) (*t* = 1, 2,...)<br>we can define the structure functions $S_q(\tau)$:<br>$S_q = \langle \lvert g(t+\tau) - g(t) \rvert^q \rangle_t$ |
| | | expectation value<br>the expectation value of<br>probability theory | For a single discrete variable $x$ of a function $f(x)$, the expectation value of $f(x)$ is defined as $\langle f(x) \rangle = \sum_x f(x)P(x)$, and for a single continuous variable the expectation value of $f(x)$ is defined as $\langle f(x) \rangle = \int_x f(x)P(x)$; where $P(x)$ is the PDF of the variable $x$.[17] | |
| | | linear span<br>(linear) span of; linear hull of<br>linear algebra | ⟨*S*⟩ means the span of *S* ⊆ *V*. That is, it is the intersection of all subspaces of *V* which contain *S*.<br>$\langle u_1, u_2, \ldots \rangle$ is shorthand for $\langle \{u_1, u_2, \ldots\} \rangle$.<br>*Note that the notation* ⟨*u*, *v*⟩ *may be ambiguous: it could mean the inner product or the linear span.*<br>*The span of S may also be written as* Sp(*S*). | $\left\langle \begin{pmatrix}1\\0\\0\end{pmatrix}, \begin{pmatrix}0\\1\\0\end{pmatrix}, \begin{pmatrix}0\\0\\1\end{pmatrix} \right\rangle = \mathbb{R}^3$. |
| | | subgroup generated by a set<br>the subgroup generated by<br>group theory | $\langle S \rangle$ means the smallest subgroup of *G* (where *S* ⊆ *G*, a group) containing every element of *S*.<br>$\langle g_1, g_2, \ldots \rangle$ is shorthand for $\langle \{g_1, g_2, \ldots\} \rangle$. | In $S_3$, $\langle (1\ 2) \rangle = \{id,\ (1\ 2)\}$ and $\langle (1\ 2\ 3) \rangle = \{id,\ (1\ 2\ 3), (1\ 3$ |
| | | tuple | An ordered list (or sequence, or horizontal vector, or row vector) of values. | $\langle a, b \rangle$ is an ordered pair (or 2-tuple). |

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| | | tuple; *n*-tuple; ordered pair/triple/etc; row vector; sequence<br>everywhere | (*The notation* (*a*,*b*) *is often used as well.*) | $\langle a, b, c\rangle$ is an ordered triple (or 3-tuple).<br>⟨⟩ is the empty tuple (or 0-tuple). |
| ⟨\|⟩<br>(\|) | ⟨ \| ⟩<br>`\langle\ |\ \rangle \!\,`<br>( \| )<br>`(\ |\ ) \!\,` | inner product<br>inner product of<br>linear algebra | ⟨*u* \| *v*⟩ means the inner product of *u* and *v*, where *u* and *v* are members of an inner product space.[18] (*u* \| *v*) means the same.<br>*Another variant of the notation is* ⟨*u*, *v*⟩ *which is described above. For spatial vectors, the dot product notation, x · y is common. For matrices, the colon notation A : B may be used. As* ⟨ *and* ⟩ *can be hard to type, the more "keyboard friendly" forms* < *and* > *are sometimes seen. These are avoided in mathematical texts.* | |

## Other non-letter symbols

| Symbol in HTML | Symbol in TeX | Name<br>Read as<br>Category | Explanation | Examples |
|---|---|---|---|---|
| ∗ | $\ast$<br>`\ast or *` | convolution<br>convolution; convolved with<br>functional analysis | $f*g$ means the convolution of $f$ and $g$.<br>*(Different than f*g, which means the product of g with the complex conjugate of f, as described below.)*<br>*(Can also be written in text as f ∗ g.)* | $(f*g)(t)=\int_0^t f(\tau)g(t-\tau)\,d\tau.$ |
| | | Hodge star operator<br>Hodge star; Hodge dual<br>linear algebra | $*v$ means the Hodge dual of a vector $v$. If $v$ is a $k$-vector within an $n$-dimensional oriented quadratic space, then $*v$ is an $(n-k)$-vector. | If $\{e_i\}$ are the standard basis vectors of $\mathbb{R}^5$, $*(e_1\wedge e_2\wedge e_3)=e_4\wedge e_5$ |
| * | $^*$<br>`^\ast or ^*` | complex conjugate<br>conjugate<br>complex numbers | $z^*$ means the complex conjugate of $z$.<br>($\bar{z}$ *can also be used for the conjugate of z, as described below.*) | $(3+4i)^*=3-4i.$ |
| | | group of units<br>the group of units of<br>ring theory | $R^*$ consists of the set of units of the ring $R$, along with the operation of multiplication.<br>*This may also be written* $R^\times$ *as described above, or* U($R$). | $(\mathbb{Z}/5\mathbb{Z})^*=\{[1],[2],[3],[4]\}$<br>$\cong \mathrm{C}_4$ |
| | | hyperreal numbers<br>the (set of) hyperreals<br>non-standard analysis | $^*\mathbf{R}$ means the set of hyperreal numbers. Other sets can be used in place of **R**. | $^*\mathbf{N}$ is the hypernatural numbers. |
| | | Kleene star<br>Kleene star<br>computer science, mathematical logic | Corresponds to the usage of * in regular expressions. If ∑ is a set of strings, then ∑* is the set of all strings that can be created by concatenating members of ∑. The same string can be used multiple times, and the empty string is also a member of ∑*. | If ∑ = ('a', 'b', 'c') then ∑* includes '', 'a', 'ab', 'aba', 'abac', etc. The full set cannot be enumerated here since it is countably infinite, but each individual string must have finite length. |
| ∝ | $\propto$<br>`\propto \!\,` | proportionality<br>is proportional to; varies as<br>everywhere | $y \propto x$ means that $y = kx$ for some constant $k$. | if $y = 2x$, then $y \propto x$. |
| | | Karp reduction[19]<br>is Karp reducible to; is polynomial-time many-one reducible to<br>computational complexity theory | $A \propto B$ means the problem $A$ can be polynomially reduced to the problem $B$. | If $L_1 \propto L_2$ and $L_2 \in \mathbf{P}$, then $L_1 \in \mathbf{P}$. |
| \ | $\setminus$<br>`\setminus` | set-theoretic complement<br>minus; without; throw out; not<br>set theory | $A \setminus B$ means the set that contains all those elements of $A$ that are not in $B$.[14]<br>(**−** *can also be used for set-theoretic complement as described above.*) | {1,2,3,4} \ {3,4,5,6} = {1,2} |
| \| | \| | conditional event<br>given<br>probability | P($A$\|$B$) means the probability of the event $A$ occurring given that $B$ occurs. | if X is a uniformly random day of the year P(X is 25 \| X is in May) = 1/31 |
| | | restriction<br>restriction of ... to ...; restricted to<br>set theory | $f|_A$ means the function $f$ is restricted to the set $A$, that is, it is the function with domain $A \cap \mathrm{dom}(f)$ that agrees with $f$. | The function $f : \mathbf{R} \to \mathbf{R}$ defined by $f(x) = x^2$ is not injective, but $f|_{\mathbf{R}^+}$ is injective. |
| | | such that<br>such that; so that<br>everywhere | \| means "such that", see ":" (*described below*). | S = {(x,y) \| 0 < y < f(x)}<br>The set of (x,y) such that y is greater than 0 and less than f(x). |
| \|<br>∤ | $\mid$<br>`\mid`<br>$\nmid$<br>`\nmid` | divisor, divides<br>divides<br>number theory | $a \mid b$ means $a$ divides $b$.<br>$a \nmid b$ means $a$ does not divide $b$.<br>(*The symbol* \| *can be difficult to type, and its negation is rare, so a regular but slightly shorter vertical bar* \| *character is often used instead.*) | Since 15 = 3 × 5, it is true that 3 \| 15 and 5 \| 15. |
| | \|\| | exact | $p^a \parallel n$ means $p^a$ exactly divides $n$ (i.e. $p^a$ | $2^3 \parallel 360$. |

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| $\mid\mid$ | \mid\mid | divisibility<br>exactly divides<br>number theory | divides $n$ but $p^{a+1}$ does not). | |
| $\parallel$<br>∦<br>⋕ | $\parallel$<br>\\|<br>Requires the viewer to support Unicode: \unicode{x2225}, \unicode{x2226}, and \unicode{x22D5}.<br>\mathrel{\rlap{\,\parallel}} requires \setmathfont{MathJax}.[20] | parallel<br>is parallel to<br>geometry | $x \parallel y$ means $x$ is parallel to $y$.<br>$x \nparallel y$ means $x$ is not parallel to $y$.<br>$x$ ⋕ $y$ means $x$ is equal and parallel to $y$.<br><br>(*The symbol ∥ can be difficult to type, and its negation is rare, so two regular but slightly longer vertical bar \|\| characters are often used instead.*) | If $l \parallel m$ and $m \perp n$ then $l \perp n$. |
| | | incomparability<br>is incomparable to<br>order theory | $x \parallel y$ means $x$ is incomparable to $y$. | {1,2} ∥ {2,3} under set containment. |
| # | #<br>\sharp | cardinality<br>cardinality of; size of; order of<br>set theory | #$X$ means the cardinality of the set $X$.<br><br>(\|...\| *may be used instead as described above.*) | #{4, 6, 8} = 3 |
| | | connected sum<br>connected sum of; knot sum of; knot composition of<br>topology, knot theory | $A$#$B$ is the connected sum of the manifolds $A$ and $B$. If $A$ and $B$ are knots, then this denotes the knot sum, which has a slightly stronger condition. | $A$#$S^m$ is homeomorphic to $A$, for any manifold $A$, and the sphere $S^m$. |
| | | primorial<br>primorial<br>number theory | $n$# is product of all prime numbers less than or equal to $n$. | 12# = 2 × 3 × 5 × 7 × 11 = 2310 |
| : | : | such that<br>such that; so that<br>everywhere | : means "such that", and is used in proofs and the set-builder notation (*described below*). | $\exists\, n \in \mathbb{N}$: $n$ is even. |
| | | field extension<br>extends; over<br>field theory | $K : F$ means the field $K$ extends the field $F$.<br><br>*This may also be written as $K \geq F$.* | $\mathbb{R} : \mathbb{Q}$ |
| | | inner product of matrices<br>inner product of<br>linear algebra | $A : B$ means the Frobenius inner product of the matrices $A$ and $B$.<br><br>*The general inner product is denoted by ⟨u, v⟩, ⟨u \| v⟩ or (u \| v), as described below. For spatial vectors, the dot product notation, x·y is common.* See also bra–ket notation. | $A:B=\sum_{i,j} A_{ij}B_{ij}$ |
| | | index of a subgroup<br>index of subgroup<br>group theory | The index of a subgroup $H$ in a group $G$ is the "relative size" of $H$ in $G$: equivalently, the number of "copies" (cosets) of $H$ that fill up $G$ | $\|G:H\|=\frac{\|G\|}{\|H\|}$ |
| | | division<br>divided by over<br>everywhere | $A : B$ means the division of $A$ with $B$ (dividing $A$ by $B$) | 10 : 2 = 5 |
| ⋮ | ⋮<br>\vdots \!\, | vertical ellipsis<br>vertical ellipsis<br>everywhere | Denotes that certain constants and terms are missing out (e.g. for clarity) and that only the important terms are being listed. | $P(r,t)=\chi\vdots E(r,t_1)E(r,t_2)E(r,t_3)$ |
| ≀ | ≀<br>\wr \!\, | wreath product<br>wreath product of ... by ...<br>group theory | $A \wr H$ means the wreath product of the group $A$ by the group $H$.<br><br>*This may also be written $A$ wr $H$.* | $\mathbf{S}_n \wr \mathbf{Z}_2$ is isomorphic to the automorphism group of the complete bipartite graph on ($n$,$n$) vertices. |
| ↯<br>※<br>⇒⇐ | \blitza<br>\lightning: requires \usepackage{stmaryd}.[21]<br>\smashtimes requires \usepackage{unicode-math} and \setmathfont{XITS Math} or another Open Type Math Font.[22]<br><br>⇒⇐[2]<br>\Rightarrow\Leftarrow<br><br>⊥[2]<br>\bot | downwards zigzag arrow<br>contradiction; this contradicts that<br>everywhere | Denotes that contradictory statements have been inferred. For clarity, the exact point of contradiction can be appended. | x + 4 = x − 3 ※<br><br>Statement: Every finite, non-empty, ordered set has a largest element. Otherwise, let's assume that $X$ is a finite, non-empty, ordered set with no largest element. Then, for some $x_1 \in X$, there exists an $x_2 \in X$ with $x_1 < x_2$, but then there's also an $x_3 \in X$ with $x_2 < x_3$, and so on. Thus, $x_1, x_2, x_3, \ldots$ are distinct elements in $X$. ↯ $X$ is finite. |

| | | | | |
|---|---|---|---|---|
| | ↮[2] `\nleftrightarrow` `\textreferencemark`[2] `Contradiction!`[2] | | | |
| ⊕ ⊻ | ⊕ `\oplus \!\,` ⊻ `\veebar \!\,` | exclusive or; xor; propositional logic, Boolean algebra | The statement $A \oplus B$ is true when either A or B, but not both, are true. $A \veebar B$ means the same. | $(\neg A) \oplus A$ is always true, $A \oplus A$ is always false. |
| | | direct sum; direct sum of; abstract algebra | The direct sum is a special way of combining several objects into one general object. (*The bun symbol ⊕, or the coproduct symbol* ∐*,* is used; ⊻ is only for logic.) | Most commonly, for vector spaces *U*, *V*, and *W*, the following consequence is used: $U = V \oplus W \Leftrightarrow (U = V + W) \wedge (V \cap W = \{0\})$ |
| ⦾ | ⦾ `{~\wedge\!\!\!\!\!\!\!\;\bigcirc~}` | Kulkarni–Nomizu product; Kulkarni–Nomizu product; tensor algebra | Derived from the tensor product of two symmetric type (0,2) tensors; it has the algebraic symmetries of the Riemann tensor. $f = g \owedge h$ has components $f_{\alpha\beta\gamma\delta} = g_{\alpha\gamma}h_{\beta\delta} + g_{\beta\delta}h_{\alpha\gamma} - g_{\alpha\delta}h_{\beta\gamma} - g_{\beta\gamma}h_{\alpha\delta}$. | |
| □ | □ `\Box \!\` | D'Alembertian; wave operator; non-Euclidean Laplacian; vector calculus | It is the generalisation of the Laplace operator in the sense that it is the differential operator which is invariant under the isometry group of the underlying space and it reduces to the Laplace operator if restricted to time independent functions. | $\Box = \frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \frac{\partial^2}{\partial x^2} - \frac{\partial^2}{\partial y^2} - \frac{\partial^2}{\partial z^2}$ |

# Letter-based symbols

*Includes upside-down letters.*

## Letter modifiers

Also called diacritics.

| Symbol in HTML | Symbol in TeX | Name / Read as / Category | Explanation | Examples |
|---|---|---|---|---|
| $\overline{a}$ | $\bar{a}$ `\bar{a}` | mean<br>overbar; ... bar<br>statistics | $\bar{x}$ (often read as "x bar") is the mean (average value of $x_i$). | $x = \{1, 2, 3, 4, 5\}; \bar{x} = 3$. |
| | | finite sequence, tuple<br>finite sequence, tuple<br>model theory | $\overline{a}$ means the finite sequence/tuple $(a_1, a_2, \ldots, a_n)$.. | $\overline{a} := (a_1, a_2, \ldots, a_n)$. |
| | | algebraic closure<br>algebraic closure of<br>field theory | $\overline{F}$ is the algebraic closure of the field *F*. | The field of algebraic numbers is sometimes denoted as $\overline{\mathbb{Q}}$ because it is the algebraic closure of the rational numbers $\mathbb{Q}$. |
| | | complex conjugate<br>conjugate<br>complex numbers | $\overline{z}$ means the complex conjugate of *z*.<br><br>($z^*$ *can also be used for the conjugate of z, as described above.*) | $\overline{3 + 4i} = 3 - 4i$. |
| | | topological closure<br>(topological) closure of<br>topology | $\overline{S}$ is the topological closure of the set *S*.<br><br>*This may also be denoted as* cl(*S*) *or* Cl(*S*). | In the space of the real numbers, $\overline{\mathbb{Q}} = \mathbb{R}$ (the rational numbers are dense in the real numbers). |
| $\overrightharpoonup{a}$ | $\overset{\rightharpoonup}{a}$ `\overset{\rightharpoonup}{a}` | vector<br>harpoon<br>linear algebra | | |
| â | $\hat{a}$ `\hat a` | unit vector<br>hat<br>geometry | $\mathbf{\hat{a}}$ (pronounced "a hat") is the normalized version of vector $\mathbf{a}$, having length 1. | |
| | | estimator<br>estimator for<br>statistics | $\hat{\theta}$ is the estimator or the estimate for the parameter $\theta$. | The estimator $\hat{\mu} = \frac{\sum_i x_i}{n}$ produces a sample estimate $\hat{\mu}(\mathbf{x})$ for the mean $\mu$. |
| ′ | $'$ `'` | derivative<br>... prime; derivative of<br>calculus | *f* ′(*x*) means the derivative of the function *f* at the point *x*, i.e., the slope of the tangent to *f* at *x*.<br><br>(*The single-quote character* ' *is sometimes used instead, especially in ASCII text.*) | If *f*(*x*) := $x^2$, then *f* ′(*x*) = 2*x*. |
| • | $\dot{\,}$ `\dot{\,}` | derivative<br>... dot; time derivative of<br>calculus | $\dot{x}$ means the derivative of *x* with respect to time. That is $\dot{x}(t) = \frac{\partial}{\partial t} x(t)$. | If *x*(*t*) := $t^2$, then $\dot{x}(t) = 2t$. |

## Symbols based on Latin letters

| Symbol in HTML | Symbol in TeX | Name<br>Read as<br>Category | Explanation | Examples |
|---|---|---|---|---|
| ∀ | $\forall$<br>`\forall` | universal quantification<br>for all;<br>for any;<br>for each;<br>for every<br>predicate logic | ∀ $x$, $P(x)$ means $P(x)$ is true for all $x$. | $\forall\ n \in \mathbb{N}, n^2 \geq n.$ |
| 𝔹<br>**B** | $\mathbb{B}$<br>`\mathbb{B}`<br>$\mathbf{B}$<br>`\mathbf{B}` | boolean domain<br>B;<br>the (set of) boolean values;<br>the (set of) truth values;<br>set theory, boolean algebra | 𝔹 means either {0, 1}, {false, true}, {F, T}, or $\{\bot, \top\}$. | $(\neg False) \in \mathbb{B}$ |
| ℂ<br>**C** | $\mathbb{C}$<br>`\mathbb{C}`<br>$\mathbf{C}$<br>`\mathbf{C}` | complex numbers<br>C;<br>the (set of) complex numbers<br>numbers | ℂ means $\{a + b\ i : a,b \in \mathbb{R}\}$. | $i \in \mathbb{C}$ |
| 𝔠 | $\mathfrak{c}$<br>`\mathfrak c` | cardinality of the continuum<br>cardinality of the continuum;<br>c;<br>cardinality of the real numbers<br>set theory | The cardinality of ℝ is denoted by $\lvert\mathbb{R}\rvert$ or by the symbol 𝔠 (a lowercase Fraktur letter C). | $\mathfrak{c} = \beth_1$ |
| ∂ | $\partial$<br>`\partial` | partial derivative<br>partial;<br>d<br>calculus | $\partial f/\partial x_i$ means the partial derivative of $f$ with respect to $x_i$, where $f$ is a function on $(x_1, ..., x_n)$. | If $f(x,y) := x^2y$, then $\partial f/\partial x = 2xy$, |
| | | boundary<br>boundary of<br>topology | $\partial M$ means the boundary of $M$ | $\partial\{x : \lVert x\rVert \leq 2\} = \{x : \lVert x\rVert = 2\}$ |
| | | degree of a polynomial<br>degree of<br>algebra | $\partial f$ means the degree of the polynomial $f$.<br>(*This may also be written* deg *f*.) | $\partial(x^2 - 1) = 2$ |
| 𝔼<br>E | $\mathbb{E}$<br>`\mathbb E`<br>$\mathrm{E}$<br>`\mathrm{E}` | expected value<br>expected value<br>probability theory | the value of a random variable one would "expect" to find if one could repeat the random variable process an infinite number of times and take the average of the values obtained | $\mathbb{E}[X] = \dfrac{x_1p_1 + x_2p_2 + \cdots + x_kp_k}{p_1 + p_2 + \cdots + p_k}$ |
| ∃ | $\exists$<br>`\exists` | existential quantification<br>there exists;<br>there is;<br>there are<br>predicate logic | ∃ $x$: $P(x)$ means there is at least one $x$ such that $P(x)$ is true. | ∃ $n \in \mathbb{N}$: $n$ is even. |
| ∃! | $\exists!$<br>`\exists!` | uniqueness quantification<br>there exists exactly one<br>predicate logic | ∃! $x$: $P(x)$ means there is exactly one $x$ such that $P(x)$ is true. | ∃! $n \in \mathbb{N}$: $n + 5 = 2n$. |
| ∈<br>∉ | $\in$<br>`\in`<br>$\notin$<br>`\notin` | set membership<br>is an element of;<br>is not an element of<br>everywhere, set theory | $a \in S$ means $a$ is an element of the set $S$;[16] $a \notin S$ means $a$ is not an element of $S$.[16] | $(1/2)^{-1} \in \mathbb{N}$<br>$2^{-1} \notin \mathbb{N}$ |
| ∌ | $\not\ni$<br>`\not\ni` | set membership<br>does not contain as an element<br>set theory | $S \not\ni e$ means the same thing as $e \notin S$, where $S$ is a set and $e$ is not an element of $S$. | |
| ∋ | $\ni$<br>`\ni` | such that symbol<br>such that<br>mathematical logic | often abbreviated as "s.t."; : and \| are also used to abbreviate "such that". The use of ∋ goes back to early mathematical logic and its usage in this sense is declining. The symbol ∍ ("back epsilon") is sometimes specifically used for "such that" to avoid confusion with set membership. | Choose $x \ni 2 \mid x$ and $3 \mid x$. (Here \| is used in the sense of "divides".) |
| | | set membership<br>contains as an element<br>set theory | $S \ni e$ means the same thing as $e \in S$, where $S$ is a set and $e$ is an element of $S$. | |
| 𝔽 | $\mathbb{F}$<br>`\mathbb{F}` | Galois field<br>Galois field, or finite field<br>Field (mathematics) theory | $\mathbb{F}_{p^n}$, for any prime p and integer n, is the unique finite field with order $p^n$, often written $\mathrm{GF}(p^n)$, and sometimes also known as $\mathbf{Z}/p\mathbf{Z}$, $\mathbb{Z}/p\mathbb{Z}$, or $\mathbb{Z}_p$, although this last notation is ambiguous. | $(\mathbb{F}_{2^{255}-19})^2$ is $\mathrm{GF}(2^{255}-19)^2$, the finite field in whose quadratic extension the popular elliptic curve Curve25519 is computed. |
| ℍ<br>**H** | $\mathbb{H}$<br>`\mathbb{H}`<br>$\mathbf{H}$<br>`\mathbf{H}` | quaternions or Hamiltonian quaternions<br>H;<br>the (set of) quaternions<br>numbers | ℍ means $\{a + b\ \mathbf{i} + c\ \mathbf{j} + d\ \mathbf{k} : a,b,c,d \in \mathbb{R}\}$. | |
| 𝕀 | $\mathbb{I}$<br>`\mathbb{I}` | Indicator function<br>the indicator of<br>Boolean algebra | The indicator function of a subset $A$ of a set $X$ is a function $\mathbf{1}_A \colon X \to \{0,1\}$ defined as : | |

| | | | | |
|---|---|---|---|---|
| $\mathbf{I}$ | $\mathbf{I}$<br>`\mathbf{I}` | | $\mathbf{1}_A(x) := \begin{cases} 1 & \text{if } x \in A, \\ 0 & \text{if } x \notin A. \end{cases}$<br>Note that the indicator function is also sometimes denoted $\mathbf{1}$. | |
| $\mathbb{N}$<br>$\mathbf{N}$ | $\mathbb{N}$<br>`\mathbb{N}`<br>$\mathbf{N}$<br>`\mathbf{N}` | natural numbers<br>the (set of) natural numbers<br>numbers | **N** means either { 0, 1, 2, 3, ...} or { 1, 2, 3, ...}.<br>*The choice depends on the area of mathematics being studied; e.g. number theorists prefer the latter; analysts, set theorists and computer scientists prefer the former. To avoid confusion, always check an author's definition of* **N**.<br>*Set theorists often use the notation ω (for least infinite ordinal) to denote the set of natural numbers (including zero), along with the standard ordering relation ≤.* | $\mathbb{N}$ = {\|*a*\| : *a* ∈ $\mathbb{Z}$} **or** $\mathbb{N}$ = {\|*a*\| > 0: *a* ∈ $\mathbb{Z}$} |
| ∘<br>⊙ | ∘<br>`\circ`<br>⊙[23][24]<br>`\odot` | Hadamard product<br>entrywise product, elementwise product, circled dot<br>linear algebra | For two matrices (or vectors) of the same dimensions $A, B \in \mathbb{R}^{m\times n}$ the Hadamard product is a matrix of the same dimensions $A \circ B \in \mathbb{R}^{m\times n}$ with elements given by $(A \circ B)_{i,j} = (A \odot B)_{i,j} = (A)_{i,j} \cdot (B)_{i,j}$. | $\begin{bmatrix} 1 & 2 \\ 2 & 4 \end{bmatrix} \circ \begin{bmatrix} 1 & 2 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 2 & 4 \end{bmatrix} \odot \begin{bmatrix} 1 & 2 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 4 \\ 0 & 0 \end{bmatrix}$ |
| ∘ | ∘<br>`\circ` | function composition<br>composed with<br>set theory | $f \circ g$ is the function such that $(f \circ g)(x) = f(g(x))$.[25] | if $f(x) := 2x$, and $g(x) := x + 3$, then $(f \circ g)(x) = 2(x + 3)$. |
| O | $O$<br>`O` | Big O notation<br>big-oh of<br>Computational complexity theory | The Big O notation describes the limiting behavior of a function, when the argument tends towards a particular value or infinity. | If $f(x) = 6x^4 - 2x^3 + 5$ and $g(x) = x^4$, then $f(x) = O(g(x))$ as $x \to \infty$ |
| ∅<br>{ } | ∅<br>`\emptyset`<br>$\varnothing$<br>`\varnothing`<br>{}<br>`\{\}` | empty set<br>the empty set null set<br>set theory | ∅ means the set with no elements.[16] { } means the same. | $\{n \in \mathbb{N} : 1 < n^2 < 4\} = \emptyset$ |
| $\mathbb{P}$<br>$\mathbf{P}$ | $\mathbb{P}$<br>`\mathbb{P}`<br>$\mathbf{P}$<br>`\mathbf{P}` | set of primes<br>P;<br>the set of prime numbers<br>arithmetic | $\mathbb{P}$ is often used to denote the set of prime numbers. | $2 \in \mathbb{P}, 3 \in \mathbb{P}, 8 \notin \mathbb{P}$ |
| | | projective space<br>P;<br>the projective space;<br>the projective line;<br>the projective plane<br>topology | $\mathbb{P}$ means a space with a point at infinity. | $\mathbb{P}^1, \mathbb{P}^2$ |
| | | polynomials<br>the space of all possible polynomials<br>vector space | $\mathbb{P}$ means $a_n x^n + a_{n-1}x^{n-1} ... a_1 x + a_0$<br>$\mathbb{P}_n$ means the space of all polynomials of degree less than or equal to $n$ | $2x^3 - 3x^2 + 2 \in \mathbb{P}_3$ |
| | | probability<br>the probability of<br>probability theory | $\mathbb{P}(X)$ means the probability of the event $X$ occurring.<br>*This may also be written as* P($X$), Pr($X$), P[$X$] or Pr[$X$]. | If a fair coin is flipped, $\mathbb{P}$(Heads) = $\mathbb{P}$(Tails) = 0.5. |
| | | Power set<br>the Power set of<br>Powerset | Given a set $S$, the power set of $S$ is the set of all subsets of the set $S$. The power set of $S$0 is denoted by P($S$). | The power set P({0, 1, 2}) is the set of all subsets of {0, 1, 2}. Hence,<br>P({0, 1, 2}) = {∅, {0}, {1}, {2}, {0, 1}, {0, 2}, {1, 2}, {0, 1, 2} }. |
| $\mathbb{Q}$<br>$\mathbf{Q}$ | $\mathbb{Q}$<br>`\mathbb{Q}`<br>$\mathbf{Q}$<br>`\mathbf{Q}` | rational numbers<br>Q;<br>the (set of) rational numbers;<br>the rationals<br>numbers | $\mathbb{Q}$ means {$p/q$ : $p \in \mathbb{Z}$, $q \in \mathbb{N}$}. | 3.14000... ∈ $\mathbb{Q}$<br>π ∉ $\mathbb{Q}$ |
| $\mathbb{Q}_p$<br>$\mathbf{Q}_p$ | $\mathbb{Q}_p$<br>`\mathbb{Q}_p`<br>$\mathbf{Q}_p$<br>`\mathbf{Q}_p` | p-adic numbers<br>the (set of) p-adic numbers;<br>the p-adics<br>numbers | $\mathbb{Q}$ means {$p/q$ : $p \in \mathbb{Z}$, $q \in \mathbb{N}$}. | |
| $\mathbb{R}$<br>$\mathbf{R}$ | $\mathbb{R}$<br>`\mathbb{R}`<br>$\mathbf{R}$<br>`\mathbf{R}` | real numbers<br>R;<br>the (set of) real numbers;<br>the reals<br>numbers | $\mathbb{R}$ means the set of real numbers. | π ∈ $\mathbb{R}$<br>√(−1) ∉ $\mathbb{R}$ |
| † | †<br>`{}^\dagger` | conjugate transpose<br>conjugate transpose;<br>adjoint;<br>Hermitian<br>adjoint/conjugate/transpose/dagger<br>matrix operations | $A^\dagger$ means the transpose of the complex conjugate of $A$.[26]<br>*This may also be written* $A^{*\mathsf{T}}$, $A^{\mathsf{T}*}$, $A^*$, $\overline{A}^{\mathsf{T}}$ *or* $\overline{A^{\mathsf{T}}}$. | If $A = (a_{ij})$ then $A^\dagger = (\overline{a_{ji}})$. |
| | | transpose | | |

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|---|---|---|---|---|
| T | $^{\mathsf{T}}$<br>`{}^{\mathsf{T}}` | transpose<br>matrix operations | $A^{\mathsf{T}}$ means $A$, but with its rows swapped for columns.<br>*This may also be written $A'$, $A^t$ or $A^{tr}$.* | If $A = (a_{ij})$ then $A^{\mathsf{T}} = (a_{ji})$. |
| ⊤ | ⊤<br>`\top` | top element<br>the top element<br>lattice theory | ⊤ means the largest element of a lattice. | ∀$x$ : $x$ ∧ ⊤ = x |
| | | top type<br>the top type; top<br>type theory | ⊤ means the top or universal type; every type in the type system of interest is a subtype of top. | ∀ types $T$, $T$ <: ⊤ |
| ⊥ | ⊥<br>`\bot` | perpendicular<br>is perpendicular to<br>geometry | $x \perp y$ means $x$ is perpendicular to $y$; or more generally $x$ is orthogonal to $y$. | If $l \perp m$ and $m \perp n$ in the plane, then $l \parallel n$. |
| | | orthogonal complement<br>orthogonal/ perpendicular complement of;<br>perp<br>linear algebra | $W^{\perp}$ means the orthogonal complement of $W$ (where $W$ is a subspace of the inner product space $V$), the set of all vectors in $V$ orthogonal to every vector in $W$. | Within $\mathbb{R}^3$, $(\mathbb{R}^2)^{\perp} \cong \mathbb{R}$. |
| | | coprime<br>is coprime to<br>number theory | $x \perp y$ means $x$ has no factor greater than 1 in common with $y$. | 34 ⊥ 55 |
| | | independent<br>is independent of<br>probability | $A \perp B$ means $A$ is an event whose probability is independent of event $B$. The double perpendicular symbol (⫫) is also commonly used for the purpose of denoting this, for instance: $A \perp\!\!\!\perp B$ (In LaTeX, the command is: "A \perp\!\!\!\perp B".) | If $A \perp B$, then P($A$\|$B$) = P($A$). |
| | | bottom element<br>the bottom element<br>lattice theory | ⊥ means the smallest element of a lattice. | ∀$x$ : $x$ ∨ ⊥ = x |
| | | bottom type<br>the bottom type;<br>bot<br>type theory | ⊥ means the bottom type (a.k.a. the zero type or empty type); bottom is the subtype of every type in the type system. | ∀ types $T$, ⊥ <: $T$ |
| | | comparability<br>is comparable to<br>order theory | $x \perp y$ means that $x$ is comparable to $y$. | {$e$, $\pi$} ⊥ {1, 2, $e$, 3, $\pi$} under set containment. |
| $\mathbb{U}$<br>**U** | $\mathbb{U}$<br>`\mathbb{U}`<br>$\mathbf{U}$<br>`\mathbf{U}` | all numbers being considered<br>U;<br>the universal set;<br>the set of all numbers;<br>all numbers considered<br>set theory | $\mathbb{U}$ means "the set of all elements being considered."<br>It may represent all numbers both real and complex, or any subset of these—hence the term "universal". | $\mathbb{U}$ = {$\mathbb{R}$,$\mathbb{C}$} includes all numbers.<br>If instead, $\mathbb{U}$ = {$\mathbb{Z}$,$\mathbb{C}$}, then π ∉ $\mathbb{U}$. |
| ∪ | ∪<br>`\cup` | set-theoretic union<br>the union of ... or ...;<br>union<br>set theory | $A \cup B$ means the set of those elements which are either in $A$, or in $B$, or in both.[14] | $A \subseteq B \Leftrightarrow (A \cup B) = B$ |
| ∩ | ∩<br>`\cap` | set-theoretic intersection<br>intersected with;<br>intersect<br>set theory | $A \cap B$ means the set that contains all those elements that $A$ and $B$ have in common.[14] | $\{x \in \mathbb{R} : x^2 = 1\} \cap \mathbb{N} = \{1\}$ |
| ∨ | ∨<br>`\lor` | logical disjunction or **join** in a lattice<br>or;<br>max;<br>join<br>propositional logic, lattice theory | The statement $A \lor B$ is true if $A$ or $B$ (or both) are true; if both are false, the statement is false.<br>For functions $A$(x) and $B$(x), $A$(x) ∨ $B$(x) is used to mean max(A(x), B(x)). | $n \geq 4 \lor n \leq 2 \Leftrightarrow n \neq 3$ when $n$ is a natural number. |
| ∧ | ∧<br>`\land`<br>`(logical and)`<br>∧<br>`\wedge`<br>`(wedge product)` | logical conjunction or meet in a lattice<br>and;<br>min;<br>meet<br>propositional logic, lattice theory | The statement $A \land B$ is true if $A$ and $B$ are both true; else it is false.<br>For functions $A$(x) and $B$(x), $A$(x) ∧ $B$(x) is used to mean min(A(x), B(x)). | $n < 4 \land n > 2 \Leftrightarrow n = 3$ when $n$ is a natural number. |
| | | wedge product<br>wedge product;<br>exterior product<br>exterior algebra | $u \wedge v$ means the wedge product of any multivectors $u$ and $v$. In three-dimensional Euclidean space the wedge product and the cross product of two vectors are each other's Hodge dual. | $\boldsymbol{u} \wedge \boldsymbol{v} = *(\boldsymbol{u} \times \boldsymbol{v}) \;\text{ if } \boldsymbol{u}, \boldsymbol{v} \in \mathbb{R}^3$ |
| × | ×<br>`\times` | multiplication<br>times;<br>multiplied by<br>arithmetic | 3 × 4 means the multiplication of 3 by 4.<br>(*The symbol * is generally used in programming languages, where ease of typing and use of ASCII text is preferred.*) | 7 × 8 = 56 |
| | | Cartesian product<br>the Cartesian product of ... and ...;<br>the direct product of ... and ...<br>set theory | $X \times Y$ means the set of all ordered pairs with the first element of each pair selected from X and the second element selected from Y. | {1,2} × {3,4} = {(1,3),(1,4),(2,3),(2,4)} |
| | | cross product<br>cross<br>linear algebra | **u** × **v** means the cross product of vectors **u** and **v** | (1,2,5) × (3,4,−1) =<br>(−22, 16, − 2) |
| | | group of units | | |

| | | | | |
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| | | the group of units of<br>ring theory | $R^\times$ consists of the set of units of the ring $R$, along with the operation of multiplication.<br><br>*This may also be written $R^*$ as described below, or* U($R$). | $(\mathbb{Z}/5\mathbb{Z})^\times = \{[1],[2],[3],[4]\}$<br>$\cong \mathrm{C}_4$ |
| $\otimes$ | $\otimes$<br>`\otimes` | tensor product, tensor product of modules<br>tensor product of<br>linear algebra | $V \otimes U$ means the tensor product of $V$ and $U$.[27]<br>$V \otimes_R U$ means the tensor product of modules $V$ and $U$ over the ring $R$. | {1, 2, 3, 4} ⊗ {1, 1, 2} =<br>{{1, 1, 2}, {2, 2, 4}, {3, 3, 6}, {4, 4, 8}} |
| $\ltimes$<br><br>$\rtimes$ | $\ltimes$<br>`\ltimes`<br><br>$\rtimes$<br>`\rtimes` | semidirect product<br>the semidirect product of<br>group theory | $N \rtimes_\varphi H$ is the semidirect product of $N$ (a normal subgroup) and $H$ (a subgroup), with respect to φ. Also, if $G = N \rtimes_\varphi H$, then $G$ is said to split over $N$.<br><br>(⋊ *may also be written the other way round, as* ⋉, *or as* ×.) | $D_{2n} \cong \mathrm{C}_n \rtimes \mathrm{C}_2$ |
| | | semijoin<br>the semijoin of<br>relational algebra | $R \ltimes S$ is the semijoin of the relations $R$ and $S$, the set of all tuples in $R$ for which there is a tuple in $S$ that is equal on their common attribute names. | $R \ltimes S = \Pi_{a_1,\ldots,a_n}(R \bowtie S)$ |
| $\bowtie$ | $\bowtie$<br>`\bowtie` | natural join<br>the natural join of<br>relational algebra | $R \bowtie S$ is the natural join of the relations $R$ and $S$, the set of all combinations of tuples in $R$ and $S$ that are equal on their common attribute names. | |
| $\mathbb{Z}$<br><br>$\mathbf{Z}$ | $\mathbb{Z}$<br>`\mathbb{Z}`<br><br>$\mathbf{Z}$<br>`\mathbf{Z}` | integers<br>the (set of) integers<br>numbers | $\mathbb{Z}$ means {..., −3, −2, −1, 0, 1, 2, 3, ...}.<br>$\mathbb{Z}^+$ or $\mathbb{Z}^>$ means {1, 2, 3, ...} .<br>$\mathbb{Z}^\geq$ means {0, 1, 2, 3, ...} .<br>$\mathbb{Z}^*$ is used by some authors to mean {0, 1, 2, 3, ...}[28] and others to mean {... -2, -1, 1, 2, 3, ... }[29] . | $\mathbb{Z} = \{p, -p : p \in \mathbb{N} \cup \{0\}\}$ |
| $\mathbb{Z}_n$<br><br>$\mathbb{Z}_p$<br><br>$\mathbf{Z}_n$<br><br>$\mathbf{Z}_p$ | $\mathbb{Z}_n$<br>`\mathbb{Z}_n`<br><br>$\mathbb{Z}_p$<br>`\mathbb{Z}_p` | integers mod $n$<br>the (set of) integers modulo $n$<br>numbers | $\mathbb{Z}_n$ means {[0], [1], [2], ...[$n$−1]} with addition and multiplication modulo $n$.<br><br>*Note that any letter may be used instead of n, such as p. To avoid confusion with p-adic numbers, use* $\mathbb{Z}/p\mathbb{Z}$ *or* $\mathbb{Z}/(p)$ *instead.* | $\mathbb{Z}_3$ = {[0], [1], [2]} |
| | $\mathbf{Z}_n$<br>`\mathbf{Z}_n`<br><br>$\mathbf{Z}_p$ | $p$-adic integers<br>the (set of) $p$-adic integers<br>numbers | *Note that any letter may be used instead of p, such as n or l.* | |

## Symbols based on Hebrew or Greek letters

| Symbol in HTML | Symbol in TeX | Name<br>Read as<br>Category | Explanation | Examples |
|---|---|---|---|---|
| ℵ | $\aleph$<br>\aleph | aleph number<br>aleph<br>set theory | $\aleph_\alpha$ represents an infinite cardinality (specifically, the *α*-th one, where *α* is an ordinal). | $\vert\mathbb{N}\vert = \aleph_0$, which is called aleph-null. |
| ℶ | $\beth$<br>\beth | beth number<br>beth<br>set theory | $\beth_\alpha$ represents an infinite cardinality (similar to ℵ, but ℶ does not necessarily index all of the numbers indexed by ℵ. ). | $\beth_1 = \vert P(\mathbb{N})\vert = 2^{\aleph_0}.$ |
| Γ | $\Gamma$<br>\Gamma | Gamma function<br>Gamma function<br>combinatorics | $\Gamma(z) = \int_0^\infty x^{z-1}e^{-x}\,dx, \qquad \Re(z) > 0\,.$ | : $\begin{aligned}\Gamma(1) &= \int_0^\infty x^{1-1}e^{-x}\,dx \\ &= \Big[-e^{-x}\Big]_0^\infty \\ &= \lim_{x\to\infty}(-e^{-x}) - (-e^{-0}) \\ &= 0 - (-1) \\ &= 1.\end{aligned}$ |
| δ | $\delta$<br>\delta | Dirac delta function<br>Dirac delta of<br>hyperfunction | $\delta(x) = \begin{cases}\infty, & x = 0 \\ 0, & x \neq 0\end{cases}$ | *δ*(*x*) |
| | | Kronecker delta<br>Kronecker delta of<br>hyperfunction | $\delta_{ij} = \begin{cases}1, & i = j \\ 0, & i \neq j\end{cases}$ | $\delta_{ij}$ |
| | | Functional derivative<br>Functional derivative of<br>Differential operators | $\begin{aligned}\left\langle \frac{\delta F[\varphi(x)]}{\delta\varphi(x)}, f(x)\right\rangle &= \int \frac{\delta F[\varphi(x)]}{\delta\varphi(x')} f(x')dx' \\ &= \lim_{\varepsilon\to 0}\frac{F[\varphi(x)+\varepsilon f(x)] - F[\varphi(x)]}{\varepsilon} \\ &= \left.\frac{d}{d\epsilon}F[\varphi+\epsilon f]\right\vert_{\epsilon=0}.\end{aligned}$ | $\frac{\delta V(r)}{\delta\rho(r')} = \frac{1}{4\pi\epsilon_0\lvert r - r'\rvert}$ |
| ∆<br><br>⊖<br><br>⊕ | $\vartriangle$<br>\vartriangle<br><br>$\ominus$<br>\ominus<br><br>$\oplus$<br>\oplus | symmetric difference<br>symmetric difference<br>set theory | *A* ∆ *B* (or *A* ⊖ *B*) means the set of elements in exactly one of *A* or *B*.<br><br>(*Not to be confused with delta*, Δ, *described below.*) | {1,5,6,8} ∆ {2,5,8} = {1,2,6}<br><br>{3,4,5,6} ⊖ {1,2,5,6} = {1,2,3,4} |
| Δ | $\Delta$<br>\Delta | delta<br>delta; change in<br>calculus | Δ*x* means a (non-infinitesimal) change in *x*.<br><br>(*If the change becomes infinitesimal*, δ *and even* d *are used instead. Not to be confused with the symmetric difference, written* ∆, *above.*) | $\frac{\Delta y}{\Delta x}$ is the gradient of a straight line. |
| | | Laplacian<br>Laplace operator<br>vector calculus | The Laplace operator is a second order differential operator in n-dimensional Euclidean space | If *f* is a twice-differentiable real-valued function, then the Laplacian of *f* is defined by $\Delta f = \nabla^2 f = \nabla \cdot \nabla f$ |
| ∇ | $\nabla$<br>\nabla | gradient<br>del; nabla; gradient of<br>vector calculus | $\nabla f(x_1, \ldots, x_n)$ is the vector of partial derivatives $(\partial f / \partial x_1, \ldots, \partial f / \partial x_n)$. | If $f(x,y,z) := 3xy + z^2$, then $\nabla f = (3y, 3x, 2z)$ |
| | | divergence<br>del dot; divergence of<br>vector calculus | $\nabla\cdot\vec{v} = \frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{\partial v_z}{\partial z}$ | If $\vec{v} := 3xy\mathbf{i} + y^2z\mathbf{j} + 5\mathbf{k}$, then $\nabla\cdot\vec{v} = 3y + 2yz$. |
| | | curl<br>curl of<br>vector calculus | $\begin{aligned}\nabla\times\vec{v} = &\left(\frac{\partial v_z}{\partial y} - \frac{\partial v_y}{\partial z}\right)\mathbf{i} \\ &+ \left(\frac{\partial v_x}{\partial z} - \frac{\partial v_z}{\partial x}\right)\mathbf{j} + \left(\frac{\partial v_y}{\partial x} - \frac{\partial v_x}{\partial y}\right)\mathbf{k}\end{aligned}$ | If $\vec{v} := 3xy\mathbf{i} + y^2z\mathbf{j} + 5\mathbf{k}$, then $\nabla\times\vec{v} = -y^2\mathbf{i} - 3x\mathbf{k}$. |
| π | $\pi$<br>\pi | Pi<br>pi; 3.1415926...; ≈355÷113<br>mathematical constant | Used in various formulas involving circles; *π* is equivalent to the amount of area a circle would take up in a square of equal width with an area of 4 square units, roughly 3.14159. It is also the ratio of the circumference to the diameter of a circle. | A = πR$^2$ = 314.16 → R = 10 |
| | | prime-counting function<br>prime-counting | $\pi(x)$ counts the number of prime numbers less than or equal to $x$. | $\pi(10) = 4$ |

| | | | | |
|---|---|---|---|---|
| | | function of number theory | | |
| | | projection<br>Projection of relational algebra | $\pi_{a_1,\ldots,a_n}(R)$ restricts $R$ to the $\{a_1,\ldots,a_n\}$ attribute set. | $\pi_{\text{Age,Weight}}(\text{Person})$ |
| | | Homotopy group<br>the *n*th Homotopy group of Homotopy theory | $\pi_n(X)$ consists of homotopy equivalence classes of base point preserving maps from an n-dimensional sphere (with base point) into the pointed space X. | $\pi_i(S^4) = \pi_i(S^7) \oplus \pi_{i-1}(S^3)$ |
| ∏ | $\prod$<br>`\prod` | product<br>product over ... from ... to ... of arithmetic | $\prod_{k=1}^{n} a_k$ means $a_1 a_2 \ldots a_n$. | $\prod_{k=1}^{4}(k+2) = (1+2)(2+2)(3+2)(4+2) = 3 \times 4 \times 5 \times 6 = 360$ |
| | | Cartesian product<br>the Cartesian product of; the direct product of set theory | $\prod_{i=0}^{n} Y_i$ means the set of all (n+1)-tuples<br>($y_0$, ..., $y_n$). | $\prod_{n=1}^{3} \mathbb{R} = \mathbb{R} \times \mathbb{R} \times \mathbb{R} = \mathbb{R}^3$ |
| ∐ | $\coprod$<br>`\coprod` | coproduct<br>coproduct over ... from ... to ... of category theory | A general construction which subsumes the disjoint union of sets and of topological spaces, the free product of groups, and the direct sum of modules and vector spaces. The coproduct of a family of objects is essentially the "least specific" object to which each object in the family admits a morphism. | |
| σ | $\sigma$<br>`\sigma` | selection<br>Selection of relational algebra | The selection $\sigma_{a\theta b}(R)$ selects all those tuples in $R$ for which $\theta$ holds between the $a$ and the $b$ attribute. The selection $\sigma_{a\theta v}(R)$ selects all those tuples in $R$ for which $\theta$ holds between the $a$ attribute and the value $v$. | $\sigma_{\text{Age}\geq 34}(\text{Person})$<br>$\sigma_{\text{Age}=\text{Weight}}(\text{Person})$ |
| ∑ | $\sum$<br>`\sum` | summation<br>sum over ... from ... to ... of arithmetic | $\sum_{k=1}^{n} a_k$ means $a_1 + a_2 + \cdots + a_n$. | $\sum_{k=1}^{4} k^2 = 1^2 + 2^2 + 3^2 + 4^2 = 1 + 4 + 9 + 16 = 30$ |

## Variations

In mathematics written in Persian or Arabic, some symbols may be reversed to make right-to-left writing and reading easier.[30]

## See also

- Greek letters used in mathematics, science, and engineering
- List of letters used in mathematics and science
- List of common physics notations
- Diacritic
- ISO 31-11 (Mathematical signs and symbols for use in physical sciences and technology)
- Latin letters used in mathematics
- List of mathematical abbreviations
- List of mathematical symbols by subject
- Mathematical Alphanumeric Symbols (Unicode block)
- Mathematical constants and functions
- Mathematical notation
- Mathematical operators and symbols in Unicode
- Notation in probability and statistics
- Physical constants
- Table of logic symbols
- Table of mathematical symbols by introduction date
- Typographical conventions in mathematical formulae
- APL syntax and symbols

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## External links

- Jeff Miller: *Earliest Uses of Various Mathematical Symbols* (http://jeff560.tripod.com/mathsym.html)
- Numericana: *Scientific Symbols and Icons* (http://www.numericana.com/answer/symbol.htm)
- GIF and PNG Images for Math Symbols (http://us.metamath.org/symbols/symbols.html)
- Mathematical Symbols in Unicode (https://web.archive.org/web/20070117015443/http://tlt.psu.edu/suggestions/international/bylanguage/math.html)

Some Unicode charts of mathematical operators and symbols:

- Index of Unicode symbols (https://www.unicode.org/charts/#symbols)
- Range 2100–214F: Unicode Letterlike Symbols (https://www.unicode.org/charts/PDF/U2100.pdf)
- Range 2190–21FF: Unicode Arrows (https://www.unicode.org/charts/PDF/U2190.pdf)
- Range 2200–22FF: Unicode Mathematical Operators (https://www.unicode.org/charts/PDF/U2200.pdf)
- Range 27C0–27EF: Unicode Miscellaneous Mathematical Symbols–A (https://www.unicode.org/charts/PDF/U27C0.pdf)
- Range 2980–29FF: Unicode Miscellaneous Mathematical Symbols–B (https://www.unicode.org/charts/PDF/U2980.pdf)
- Range 2A00–2AFF: Unicode Supplementary Mathematical Operators (https://www.unicode.org/charts/PDF/U2A00.pdf)

Some Unicode cross-references:

- Short list of commonly used LaTeX symbols (http://www.artofproblemsolving.com/Wiki/index.php/LaTeX:Symbols) and Comprehensive LaTeX Symbol List (https://web.archive.org/web/20090323063515/http://mirrors.med.harvard.edu/ctan/info/symbols/comprehensive/)
- MathML Characters (http://www.robinlionheart.com/stds/html4/entities-mathml) - sorts out Unicode, HTML and MathML/TeX names on one page
- Unicode values and MathML names (http://www.w3.org/TR/REC-MathML/chap6/bycodes.html)
- Unicode values and Postscript names (http://svn.ghostscript.com/ghostscript/branches/gs-db/Resource/Decoding/Unicode) from the source code for Ghostscript