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# List of mathematical symbols

A **mathematical symbol** is a figure or a combination of figures that is used to represent a mathematical object, an action on mathematical objects, a relation between mathematical objects, or for structuring the other symbols that occur in a formula. As formulas are entierely constitued with symbols of various types, many symbols are needed for expressing all mathematics.

The most basic symbols are the decimal digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9), and the letters of the Latin alphabet. The decimal digits are used for representing numbers through the Hindu–Arabic numeral system. Historically, upper-case letters were used for representing points in geometry, and lower-case letters were used for variables and constants. Letters are used for representing many other sort of mathematical objects. As the number of these sorts has dramatically increased in modern mathematics, the Greek alphabet and some Hebrew letters are also used. In mathematical formulas, the standard typeface is italic type for Latin letters and lower-case Greek letters, and upright type for upper case Greek letters. For having more symbols, other typefaces are also used, mainly boldface $\mathbf{a}, \mathbf{A}, \mathbf{b}, \mathbf{B}, \ldots$, script typeface $\mathcal{A}, \mathcal{B}, \ldots$ (the lower-case script face is rarely used because of the possible confusion with the standard face), German fraktur $\mathfrak{a}, \mathfrak{A}, \mathfrak{b}, \mathfrak{B}, \ldots$, and blackboard bold $\mathbb{N}, \mathbb{Z}, \mathbb{R}, \mathbb{C}$ (the other letters are rarely used in this face, or their use is controversial).

The use of letters as symbols for variables and numerical constants is not described in this article. For these uses, see Variable (mathematics) and Constant (mathematics).

Letters are not sufficient for the need of mathematicians, and many other symbols are used. Some take their origin in punctuation marks and diacritics traditionally used in typography. Other, such as $+$ and $=$, have been specially designed for mathematics, often by deforming some letters, such as $\in$ or $\forall$.

Most symbols have two printed versions. They can be displayed as Unicode characters, or in LaTeX format. With the Unicode version, using search engines and copy-pasting is easier. On the other hand, the LaTeX rendering is generally much better (more aesthetic). Therefore, in this article, the Unicode version of the symbols is used (when possible) for labelling their entry, and the LaTex version is used in their description. So, for finding how to type a symbol in LaTeX, it suffices to look at the source of the article.

## Contents



## Arithmetic operators

+

1. Denotes addition and is read as *plus*; for example, $3+2$.
2. Sometimes used instead of $\sqcup$ for a disjoint union of sets.

−

1. Denotes subtraction and is read as *minus*; for example, $3-2$.
2. Denotes the additive inverse and is read as *the opposite of*; for example, $-2$.
3. Also used in place of $\setminus$ for denoting the set-theoretic complement; see \ in § Set theory.

×

1. In elementary arithmetic, denotes multiplication, and is read as *times*; for example $3 \times 2$.
2. In geometry and linear algebra, denotes the cross product.
3. In set theory and category theory, denotes the Cartesian product and the direct product. See also × in § Set theory.

·

1. Denotes multiplication and is read as *times*; for example $3 \cdot 2$.
2. In geometry and linear algebra, denotes the dot product.

3. Placeholder used for replacing an indeterminate element. For example, "the absolute value is denoted $|\cdot|$" is clearer than saying that it is denoted as $|\ |$.

±

1. Denotes denotes either a plus sign or a minus sign
2. Denotes the range of values that a measured quatity may have; for example, $10 \pm 2$ denotes a unknown value that lies between 8 and 12.

∓

Used paired with $\pm$, denotes the opposite sign, that is $+$ if $\pm$ is $-$, and $-$ if $\pm$ is $+$.

÷

Widely used for denoting division in anglophone countries, it is no longer in common use in mathematics and its use is "not recommended".[1] In some countries, it can indicate subtraction.

/

1. Denotes division and is read as *divided by* or *over*. Often replaced by a horizontal bar. For example $3\,/\,2$ or $\frac{3}{2}$.
2. Denotes a quotient structure. For example quotient set, quotient group, quotient category, etc.
3. In number theory and field theory, $F/E$ denotes a field extension, where $F$ is an extension field of the field $E$.
4. In probability theory, denotes a conditional probability. For example, $P(A/B)$ denotes the probability of $A$, given that $B$ occurs.

√

Denotes square root and is read as *square root of*. Rarely used in modern mathematics without an horizontal bar delimiting the width of its argument (see the next item). For example $\surd 2$.

$\sqrt{\ }$

1. Denotes square root and is read as *square root of*. For example $\sqrt{3+2}$.
2. With an integer greater than 2 as a left superscript, denotes a $n$th root. For example $\sqrt[3]{2}$.

## Equality, equivalence and similarity

=

1. Denotes equality.
2. Used for naming a mathematical object in a sentence like "let $x = E$", where $E$ is an expression. On a blackbord and in some mathematical texts, this may be abbreviated as $x \stackrel{\text{def}}{=} E$. This is related with the concept of assignment in computer science, which is variously denoted (depending on the used programming language) $=, :=, ==, \leftarrow, \ldots$

≠

Denotes inequality and means "not equal".

≈

Means "is approximatively equal to". For example, $\pi \approx 3.1415$.

~

1. Between two numbers, either it is used in place of $\approx$ for meaning "approximatively equal", or it means "has the same order of magnitude as".
2. Denotes the asymptotic equivalence of two functions or sequences.
3. Often used for denoting other types of similarity, for example, matrix similarity or similarity of geometric shapes.
4. Standard notation for an equivalence relation.

≡

1. Denotes an identity, that is an equality that is true whichever values are given to the variables occurring in it.
2. In number theory, and more specifically in modular arithmetic, denotes the congruence modulo an integer.

≅

1. May denote an isomorphism between two mathematical structures, and is read as "is isomorphic to".
2. In geometry, may denote the congruence of two geometric shapes (that is the equality up to a displacement), and is read "is congruent to".

## Comparison

<

1. Strict inequality between two numbers; means and is read as "less than".
2. Commonly used for denoting any strict order.
3. Between two groups, may mean that the first one is a proper subgroup of the second one.

>

1. Strict inequality between two numbers; means and is read as "greater than".
2. Commonly used for denoting any strict order.
3. Between two groups, may mean that the second one is a proper subgroup of the first one.

≤

1. Means "less than or equal to". That is, whichever $A$ and $B$ are, $A \leq B$ is equivalent with $A < B$ or $A = B$.
2. Between two groups, may mean that the first one is a subgroup of the second one.

≥

1. Means "greater than or equal to". That is, whichever $A$ and $B$ are, $A \geq B$ is equivalent with $A > B$ or $A = B$.
2. Between two groups, may mean that the second one is a subgroup of the first one.

≪ , ≫

1. Mean "much less than" and "much greater than". Generally, *much* is not formally defined, but means that the lesser quantity can be neglected with respect to the other. This is generally the case when the lesser quantity is smaller than the other by one or several orders of magnitude.
2. In measure theory, $\mu \ll \nu$ means that the measure $\mu$ is absolutely continuous with respect to the measure $\nu$.

≦

1. A rarely used synonym of $\leq$. Despite the easy confusion with $\leqq$, some authors use it with a different meaning.

≺ , ≻

Often used for denoting an order or, more generally, a preorder, when it would be confusing or not convenient to use $<$ and $>$.

## Set theory

∅

Denotes the empty set, and is more often written $\emptyset$. Using set builder notation, it may also be denoted $\{\}$.

∈

Denotes set membership, and is read "in" or "belongs to". That is, $x \in S$ means that $x$ is an element of the set $S$.

∉

Means "not in". That is, $x \notin S$ means $\neg(x \in S)$.

⊂

Denotes set inclusion. However two slightly different definitions are common. It seems that the first one is more commonly used in recent texts, since it allows often avoiding case distinction.
1. $A \subset B$ may mean that $A$ is a subset of $B$, and is possibly equal to $B$; that is, every element of $A$ belongs to $B$; in formula, $\forall x,\, x \in A \Rightarrow x \in B.$
2. $A \subset B$ may mean that $A$ is a proper subset of $B$, that is the two sets are different, and every element of $A$ belongs to $B$; in formula, $A \neq B \wedge \forall x,\, x \in A \Rightarrow x \in B.$

⊆

$A \subseteq B$ means that $A$ is a subset of $B$. Used for emphasizing that equality is possible, or when the second definition is used for $A \subset B.$

⊊

$A \subsetneq B$ means that $A$ is a proper subset of $B$. Used for emphasizing that $A \neq B,$ or when the first definition is used for $A \subset B.$

⊃ , ⊇ , ⊋

The same as the preceding ones with the operands reverted. For example, $B \supset A$ is equivalent with $A \subset B.$

∪

Denotes set-theoretic union, that is, $A \cup B$ is the set formed by the elements of $A$ and $B$ together. That is, $A \cup B = \{x \mid (x \in A) \vee (x \in B)\}.$

∩

Denotes set-theoretic intersection, that is, $A \cap B$ is the set formed by the elements of both $A$ and $B$. That is, $A \cap B = \{x \mid (x \in A) \wedge (x \in B)\}.$

\

Denotes set difference; that is, $A \setminus B$ is the set formed by the elements of $A$ that are not in $B$. Sometimes, $A - B$ is used instead; see – in § Arithmetic operators.

∁

1. With a subscript, denotes a set complement: that is, if $B \subseteq A$, then $\complement_A B = A \setminus B.$
2. Without a subscript, denotes the absolute complement; that is, $\complement A = \complement_U A,$ where $U$ is a set implicitely defined by the context, which contains all sets under consideration. This set $U$ is sometimes called the universe of discourse.

×

See also × in § Arithmetic operators.
1. Denotes the Cartesian product of two sets. That is, $A \times B$ is the set formed by all pairs of an element of $A$ and an element of $B$.
2. Denotes the direct product of two mathematical structures of the same type, which is the Cartesian product of the underlying sets, equipped with a structure of the same type. For example, direct product of rings, direct product of topological spaces.
3. In category theory, denotes the direct product (often called simply *product*) of two objects, which is a generalization of the preceding concepts of product.

⊔

Denotes the disjoint union. That is, if $A$ and $B$ are two sets, $A \sqcup B = A \cup C,$ where $C$ is a set formed by the elements of $B$ renamed for not belonging to $A$.

∐

1. Alternative of ⊔ for denoting disjoint union.
2. Denotes the coproduct of mathematical structures or of objects in a category.

## Basic logic

Several logical symbols are widely used in all mathematics, and are listed here. For symbols that are used only in mathematical logic, or are rarely used, see List of logic symbols.

¬

Denotes logical negation, and is read as "not". If $E$ is a logical predicate, $\neg E$ is the predicate that evaluates to *true* if and only if $E$ evaluates to *false*. For clarity, it is often replaced by the word "not". In programming languages and some mathematical texts, it is often replaced by "~" or "!", which are easier to type on a keyboard.

∨

1. Denotes the logical or and is read as "or". If $E$ and $F$ are logical predicates, $E \vee F$ is true if either $E$, $F$, or both are true. It is often replaced by the word "or" or the symbol "&".
2. In lattice theory, denotes the join or least upper bound operation.
3. In topology, denotes the wedge sum of two pointed spaces.

∧

1. Denotes the logical and and is read as "and". If $E$ and $F$ are logical predicates, $E \wedge F$ is true if $E$ and $F$ are both true. It is often replaced by the word "and".
2. In lattice theory, denotes the meet or greatest lower bound operation.
3. In multilinear algebra, geometry, and multivariable calculus denotes the wedge product or the exterior product.

∀

1. Denotes universal quantification and is read "for all". If $E$ is a logical predicate, $\forall x E$ means that $E$ is true for all possible values of the variable $x$.
2. Often used improperly in plain text as an abbreviation of "for all" or "for every".

∃

1. Denotes existential quantification and is read "there exists ... such that". If $E$ is a logical predicate, $\exists xE$ means that there exists at least one value of $x$ for which $E$ is true.
2. Often used improperly in plain text as an abbreviation of "there exists".

$\exists!$

Denotes uniqueness quantification, that is, $\exists!xP$ means "there exists exactly one $x$ such that $P$ (is true)". In other words, $\exists!xP(x)$ is an abbreviation of $\exists x\,(P(x)\,\wedge\neg\exists y\,(P(y)\wedge y\neq x))$.

$\Rightarrow$

1. Denotes material conditional, and is read as "implies". If $P$ and $Q$ are logical predicates, $P\Rightarrow Q$ means that if $P$ is true, then $Q$ is also true. Thus, $P\Rightarrow Q$ is logically equivalent with $Q\vee\neg P$.
2. Often used improperly in plain text as an abbreviation of "implies".

$\Leftrightarrow$

1. Denotes logical equivalence, and is read "is equivalent to" or "if and only if. If $P$ and $Q$ are logical predicates, $P\Leftrightarrow Q$ is thus an abbreviation of $(P\Rightarrow Q)\wedge(Q\Rightarrow P)$, or of $(P\wedge Q)\vee(\neg P\wedge\neg Q)$.
2. Often used improperly in plain text as an abbreviation of "if and only if".

## Operators acting on functions or sequences

$\sum$

1. Denotes the sum of a finite number of terms, which are determined by underscripts and superscripts such as in $\sum_{i=1}^{n} i^2$ or $\sum_{0<i<j<n}^{n} j-i$
2. Denotes a series and, if the series is convergent, the sum of the series. For example $\sum_{i=0}^{\infty}\frac{x^i}{i!}=e^i$.

$\int$

1. Without a subscript, denotes an antiderivative. For example, $\int x^2dx=\frac{x^3}{3}+C$.
2. With a subscript and a superscript, denotes a definite integral, For example, $\int_a^b x^2dx=\frac{b^3-a^3}{3}$.
3. With a subscript that denotes a curve, denotes a line integral. For example, $\int_C f=\int_a^b f(r(t))r'(t)dt$, if $r$ is a parametrization of the curve $C$, from $a$ to $b$.

$\oint$

Often used, typically in physics, instead of $\int$ for line integrals over a closed curve.

$\iint$, $\oiint$

Similar to $\int$ and $\oint$ for surface integrals.

## Infinite numbers

$\infty$

1. The symbol is read as infinity. As an upper bound of a summation, an infinite product, an integral, etc., means that the computation is unlimited. Similarly, $-\infty$ in a lower bound means that the computation is not limited toward negative values.
2. $-\infty$ and $+\infty$ are the generalized numbers that are added to the real line for forming the extended real line
3. $\infty$ is the generalized number that is added to the real line for forming the projectively extended real line.

$\mathfrak{c}$

$\mathfrak{c}$ denotes the cardinality of the continuum, which is the cardinality of the set of real numbers.

$\aleph$

With an ordinal $i$ as a subscript, denotes the $i$th aleph number, that is the $i$th infinite cardinal. For example, $\aleph_0$ is the smallest infinite cardinal, that is, the cardinal of the natural numbers.

$\beth$

With an ordinal $i$ as a subscript, denotes the $i$th beth number. For example, $\beth_0$ is the cardinal of the natural numbers, and $\beth_1$ is the cardinal of the continuum.

$\omega$

1. Denotes the first limit ordinal. It is also denoted $\omega_0$ and can be identified with the ordered set of the natural numbers.
2. With an ordinal $i$ as a subscript, denotes the $i$th limit ordinal that has a cardinality greater than that of all preceding ordinals.
3. In computer science, denotes the (unknown) greatest lower bound for the exponent of the computational complexity of matrix multiplication.
4. Written as a function of another function, it is used for comparing the asymptotic growth of two functions. See Big O notation § Related asymptotic notations.
5. In number theory, may denote the prime omega function. That is, $\omega(n)$ is the number of distinct prime factors of the integer $n$.

## Abbreviation of English phrases and logical punctuation

In this section, the symbols that are listed are used as some sort of punctuation marks in mathematics reasoning, or as abbreviations of English phrases. They are generally not used inside a formula. Some were used in classical logic for indicating the logical dependence between sentences written in plain English. Except for the first one, they are normally not used in printed mathematical texts since, for readability, it is generally recommended to have at least one word between two formulas. However, they are still used on a black board for indicating relationships between formulas.

■ , □

Used for marking the end of a proof and separating it from the current text. The initialism Q.E.D. or QED (*quod erat demonstrandum*) is often used for the same purpose, either in its upper-case form or in lower case.

$\therefore$

Abbreviation of "therefore". Placed between two assertions, it means that the first one implies the second one. For example: "All humans are mortal. Socrates is a human. $\therefore$ Socrates is mortal."

$\because$

Abbreviation of "because" or "since". Placed between two assertions, it means that the first one is implied by the second one. For example: "$11$ is prime ∵ it has no positive integer factors other than itself and one."

∋

1. Abbreviation of "such that". For example $x \ni x > 3$ is normally printed "$x$ such that $x > 3$.
2. Sometimes used for reverting the operands of $\in$; that is, $S \ni x$ has the same meaning as $x \in S$. See ∈ in § Set theory.

∝

Abbreviation of "is proportional to"

## Miscellaneous

| Symbol in HTML | Symbol in TeX | Name<br>Read as<br>Category | Explanation | Examples |
|---|---|---|---|---|
| ! | ! | factorial<br>factorial<br>combinatorics | $n!$ means the product $1 \times 2 \times \cdots \times n$. | $4! = 1 \times 2 \times 3 \times 4 = 24$ |
| → | $\to$<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 $f(x) := x^2$. |
| ↦ | $\mapsto$<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). |
| ← | $\leftarrow$<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. | |
| ⟨\| | $\langle\,\vert$<br>\langle | bra vector<br>the bra ...; the dual of ...<br>Dirac notation | $\langle\varphi\vert$ means the dual of the vector $\vert\varphi\rangle$, a linear functional which maps a ket $\vert\psi\rangle$ onto the inner product $\langle\varphi\vert\psi\rangle$. | |
| \|⟩ | $\vert\,\rangle$<br>\rangle | ket vector<br>the ket ...; the vector ...<br>Dirac notation | $\vert\varphi\rangle$ means the vector with label $\varphi$, which is in a Hilbert space. | A qubit's state can be represented as $\alpha\vert 0\rangle + \beta\vert 1\rangle$, where $\alpha$ and $\beta$ are complex numbers s.t. $\vert\alpha\vert^2 + \vert\beta\vert^2 = 1$. |

## Brackets

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

| | | | | |
|---|---|---|---|---|
| ⌊...⌋ | \lfloor \ldots \rfloor \!\, | floor;<br>greatest integer;<br>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*], \|\|*x*\|\|, nint(*x*) *or* Round(*x*).) | ⌊2⌉ = 2, ⌊2.6⌉ = 3, ⌊−3.4⌉ = −3, ⌊4.49⌉ = 4, ⌊4.5⌉ = 5 |
| [ : ] | [ : ]<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;<br>greatest integer;<br>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*⌉, \|\|*x*\|\|, 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. |

| | | | | |
|---|---|---|---|---|
| | | 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 ⟨u* **\|** *v⟩ and (u* **\|** *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>$S_q=\langle\|g(t+\tau)-g(t)\|^q\rangle_t$ |
| | | 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 $x$.[4] | |
| | | 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>⟨$u_1$, $u_2$, ...⟩ is shorthand for ⟨{$u_1$, $u_2$, ...}⟩.<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*). | $\left\langle\left(\begin{smallmatrix}1\\0\\0\end{smallmatrix}\right),\left(\begin{smallmatrix}0\\1\\0\end{smallmatrix}\right),\left(\begin{smallmatrix}0\\0\\1\end{smallmatrix}\right)\right\rangle=\mathbb{R}^3$. |
| | | 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>$\langle g_1,g_2,\dots\rangle$ is shorthand for $\langle\{g_1,g_2,\dots\}\rangle$. | In $S_3$, $\langle(1\ 2)\rangle=\{id,\ (1\ 2)\}$ and $\langle(1\ 2\ 3)\rangle=\{id,\ (1\ 2\ 3),(1\ 3\ 2$ |
| | | tuple | An ordered list (or sequence, or horizontal vector, or row | |

| | | | | |
|---|---|---|---|---|
| | | tuple; *n*-tuple; ordered pair/triple/etc; row vector; sequence<br>everywhere | vector) of values.<br>(*The notation* (*a*,*b*) *is often used as well.*) | $\langle a, b\rangle$ is an ordered pair (or 2-tuple).<br>$\langle a, b, c\rangle$ is an ordered triple (or 3-tuple).<br>$\langle\rangle$ is the empty tuple (or 0-tuple). |
| $\langle\vert\rangle$<br>$(\vert)$ | ⟨ \| ⟩<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.[5] (*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

<table>
<tr><th>Symbol<br>in HTML</th><th>Symbol<br>in TeX</th><th>Name<br>Read as<br>Category</th><th>Explanation</th><th>Examples</th></tr>
<tr><td rowspan="2">∗</td><td rowspan="2">∗<br>\ast or *</td><td>convolution<br>convolution; convolved with<br>functional analysis</td><td>$f*g$ means the convolution of $f$ and $g$. (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.)</td><td>$(f*g)(t)=\int_0^t f(\tau)g(t-\tau)\,d\tau.$</td></tr>
<tr><td>Hodge star operator<br>Hodge star; Hodge dual<br>linear algebra</td><td>$*v$ 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.</td><td>If $\{e_i\}$ are the standard basis vectors of $\mathbb{R}^5$, $*(e_1\wedge e_2\wedge e_3)=e_4\wedge e_5$</td></tr>
<tr><td rowspan="4">*</td><td rowspan="4">*<br>^\ast or ^*</td><td>complex conjugate<br>conjugate<br>complex numbers</td><td>$z^*$ means the complex conjugate of $z$.<br>($\bar{z}$ can also be used for the conjugate of z, as described below.)</td><td>$(3+4i)^*=3-4i.$</td></tr>
<tr><td>group of units<br>the group of units of<br>ring theory</td><td>$R^*$ 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($R$).</td><td>$(\mathbb{Z}/5\mathbb{Z})^*=\{[1],[2],[3],[4]\}\cong \mathrm{C}_4$</td></tr>
<tr><td>hyperreal numbers<br>the (set of) hyperreals<br>non-standard analysis</td><td>$^*\mathbf{R}$ means the set of hyperreal numbers. Other sets can be used in place of $\mathbf{R}$.</td><td>$^*\mathbf{N}$ is the hypernatural numbers.</td></tr>
<tr><td>Kleene star<br>Kleene star<br>computer science, mathematical logic</td><td>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 ∑*.</td><td>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.</td></tr>
<tr><td rowspan="3">|</td><td rowspan="3">|</td><td>conditional event<br>given<br>probability</td><td>P($A$|$B$) means the probability of the event $A$ occurring given that $B$ occurs.</td><td>if X is a uniformly random day of the year P(X is 25 | X is in May) = 1/31</td></tr>
<tr><td>restriction<br>restriction of ... to ...; restricted to<br>set theory</td><td>$f|_A$ 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 $f$.</td><td>The function $f:\mathbf{R}\to\mathbf{R}$ defined by $f(x)=x^2$ is not injective, but $f|_{\mathbf{R}^+}$ is injective.</td></tr>
<tr><td>such that<br>such that; so that<br>everywhere</td><td>| means "such that", see ":" (described below).</td><td>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).</td></tr>
<tr><td>∣<br>∤</td><td>∣<br>\mid<br>∤<br>\nmid</td><td>divisor, divides<br>divides<br>number theory</td><td>$a \mid b$ 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.)</td><td>Since 15 = 3 × 5, it is true that 3 ∣ 15 and 5 ∣ 15.</td></tr>
<tr><td>||</td><td>||<br>\mid\mid</td><td>exact divisibility<br>exactly divides<br>number theory</td><td>$p^a \mid\mid n$ means $p^a$ exactly divides $n$ (i.e. $p^a$ divides $n$ but $p^{a+1}$ does not).</td><td>$2^3 \mid\mid 360$.</td></tr>
<tr><td rowspan="2">∥<br>∦<br>⋕</td><td rowspan="2">∥<br>\|<br>Requires the viewer to support Unicode: \unicode{x2225}, \unicode{x2226}, and \unicode{x22D5}. \mathrel{\rlap{\,\parallel}} requires \setmathfont{MathJax}.[6]</td><td>parallel<br>is parallel to<br>geometry</td><td>$x \parallel y$ 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>(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.)</td><td>If $l \parallel m$ and $m \perp n$ then $l \perp n$.</td></tr>
<tr><td>incomparability<br>is incomparable to<br>order theory</td><td>$x \parallel y$ means $x$ is incomparable to $y$.</td><td>{1,2} ∥ {2,3} under set containment.</td></tr>
<tr><td rowspan="2">#</td><td rowspan="2">#<br>\sharp</td><td>cardinality<br>cardinality of; size of; order of<br>set theory</td><td>#$X$ means the cardinality of the set $X$.<br>(|...| may be used instead as described above.)</td><td>#{4, 6, 8} = 3</td></tr>
<tr><td>connected sum<br>connected sum of; knot sum of;</td><td>$A\#B$ 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.</td><td>$A\#S^m$ is homeomorphic to $A$, for any manifold $A$, and the sphere $S^m$.</td></tr>
</table>

| | | | | |
|---|---|---|---|---|
| | | knot composition of<br>topology, knot theory | | |
| | | 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*). | ∃ $n \in \mathbb{N}$: $n$ 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 $A_{\text{wr}} H$.* | $\mathrm{S}_n \wr \mathrm{Z}_2$ is isomorphic to the automorphism group of the complete bipartite graph on ($n$,$n$) vertices. |
| ⊕<br><br>⊻ | ⊕<br>`\oplus \!\,`<br><br>⊻<br>`\veebar \!\,` | exclusive or<br>xor<br>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. | (¬$A$) ⊕ $A$ is always true, $A \oplus A$ is always false. |
| | | direct sum<br>direct sum of<br>abstract algebra | The direct sum is a special way of combining several objects into one general object.<br><br>(*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:<br>$U = V \oplus W \Leftrightarrow (U = V + W) \wedge (V \cap W = \{0\})$ |
| □ | □<br>`\Box \!\` | D'Alembertian; wave operator<br>non-Euclidean Laplacian<br>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<br>Read as<br>Category | Explanation | Examples |
|---|---|---|---|---|
| $\bar{a}$ | $\bar{a}$<br>`\bar{a}, \overline{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). |
| $\overset{\rightharpoonup}{a}$ | $\overset{\rightharpoonup}{a}$<br>`\overset{\rightharpoonup}{a}` | vector<br>harpoon<br>linear algebra | | |
| â | $\hat{a}$<br>`\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 $\mu$. |
| ′ | $'$<br>`'` | 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*. |
| • | $\dot{\,}$<br>`\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 |
|---|---|---|---|---|
| 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 | $\mathbb{B}$ 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 | $\mathbb{C}$ means $\{a + b\ i : a,b \in \mathbb{R}\}$. | $i \in \mathbb{C}$ |
| ∂ | $\partial$<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 $M$ | $\partial\{x : \|\|x\|\| \le 2\} = \{x : \|\|x\|\| = 2\}$ |
| | | 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 | $\mathbb{E}[X] = \dfrac{x_1p_1 + x_2p_2 + \cdots + x_kp_k}{p_1 + p_2 + \cdots + p_k}$ |
| 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. | $\left(\mathbb{F}_{2^{255}-19}\right)^2$ 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 | $\mathbb{H}$ means $\{a + b\,\mathbf{i} + c\,\mathbf{j} + d\,\mathbf{k} : a,b,c,d \in \mathbb{R}\}$. | |
| 𝕀<br>**I** | $\mathbb{I}$<br>`\mathbb{I}`<br>$\mathbf{I}$<br>`\mathbf{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 :<br>$\mathbf{1}_A(x) := \begin{cases} 1 & \text{if } x \in A, \\ 0 & \text{if } x \notin A. \end{cases}$<br>Note that the indicator function is also sometimes denoted $\mathbf{1}$. | |
| ℕ<br>**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* ≤. | $\mathbb{N} = \{\|a\| : a \in \mathbb{Z}\}$ **or** $\mathbb{N} = \{\|a\| > 0: a \in \mathbb{Z}\}$ |
| ○<br>⊙ | $\circ$<br>`\circ`<br>$\odot$[7][8]<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 $(A \circ B)_{i,j} = (A \odot B)_{i,j} = (A)_{i,j} \cdot (B)_{i,j}$. | $\begin{bmatrix}1 & 2\\2 & 4\end{bmatrix} \circ \begin{bmatrix}1 & 2\\0 & 0\end{bmatrix} = \begin{bmatrix}1 & 2\\2 & 4\end{bmatrix} \odot \begin{bmatrix}1 & 2\\0 & 0\end{bmatrix} = \begin{bmatrix}1 & 4\\0 & 0\end{bmatrix}$ |
| ∘ | $\circ$<br>`\circ` | function composition<br>composed with<br>set theory | $f \circ g$ is the function such that $(f \circ g)(x) = f(g(x))$.[9] | 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<br>$f(x) = O(g(x))$ **as** $x \to \infty$ |
| ℙ<br>**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. | $\mathbb{P}^1, \mathbb{P}^2$ |

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| | | polynomials<br>the space of all possible polynomials<br>vector space | $\mathbb{P}$ means $a_nx^n + a_{n-1}x^{n-1}...a_1x+a_0$<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$0 is<br>denoted by P($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... $\in \mathbb{Q}$<br>$\pi \notin \mathbb{Q}$ |
| $\mathbb{Q}_p$<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. | $\pi \in \mathbb{R}$<br>$\sqrt{(-1)} \notin \mathbb{R}$ |
| † | $\dagger$<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 $A$.[10]<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 $A^\dagger = (\overline{a_{ji}})$. |
| T | $\mathsf{T}$<br>`{}^{\mathsf{T}}` | transpose<br>transpose<br>matrix operations | $A^{\mathsf{T}}$ means $A$, but with its rows swapped for columns.<br>*This may also be written* $A'$, $A^{\mathsf{t}}$ *or* $A^{\mathsf{tr}}$. | If $A = (a_{ij})$ then $A^{\mathsf{T}} = (a_{ji})$. |
| ⊤ | $\top$<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 $T$, $T$ <: ⊤ |
| | | Tautology<br>top, verum<br>propositional logic, Boolean algebra | The statement ⊤ is unconditionally true. | $A$ ⇒ ⊤ is always true. |
| ⊥ | $\bot$<br>`\bot` | Contradiction<br>bottom, falsum, falsity<br>propositional logic, Boolean algebra | The statement ⊥ is unconditionally false. | ⊥ ⇒ $A$ is always true. |
| | | 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. |

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|---|---|---|---|---|
| $\mathbb{U}$<br>$\mathbf{U}$ | $\mathbb{U}$ `\mathbb{U}`<br>$\mathbf{U}$ `\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." 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 $\pi \notin \mathbb{U}$. |
| $\otimes$ | $\otimes$ `\otimes` | tensor product, tensor product of modules<br>tensor product of<br>linear algebra | $V \otimes U$ means the tensor product of $V$ and $U$.[11]<br>$V \otimes_R U$ means the tensor product of modules $V$ and $U$ over the ring $R$. | $\{1, 2, 3, 4\} \otimes \{1, 1, 2\} =$<br>$\{\{1, 1, 2\}, \{2, 2, 4\}, \{3, 3, 6\}, \{4, 4, 8\}\}$ |
| $\ltimes$<br>$\rtimes$ | $\ltimes$ `\ltimes`<br>$\rtimes$ `\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>(⋊ *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. | $R \ltimes S = \Pi_{a_1,\ldots,a_n}(R \bowtie S)$ |
| $\bowtie$ | $\bowtie$ `\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>$\mathbf{Z}$ | $\mathbb{Z}$ `\mathbb{Z}`<br>$\mathbf{Z}$ `\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 $\{0, 1, 2, 3, ...\}$[12] and others to mean $\{... -2, -1, 1, 2, 3, ... \}$.[13] | $\mathbb{Z} = \{p, −p : p \in \mathbb{N} \cup \{0\}\}$ |
| $\mathbb{Z}_n$<br>$\mathbb{Z}_p$<br>$\mathbf{Z}_n$<br>$\mathbf{Z}_p$ | $\mathbb{Z}_n$ `\mathbb{Z}_n`<br>$\mathbb{Z}_p$ `\mathbb{Z}_p`<br>$\mathbf{Z}_n$ `\mathbf{Z}_n`<br>$\mathbf{Z}_p$ | 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>*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.* | $\mathbb{Z}_3 = \{[0], [1], [2]\}$ |
| | | *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 |
|---|---|---|---|---|
| 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 | $\begin{aligned}\left\langle\frac{\delta F[\varphi(x)]}{\delta\varphi(x)},f(x)\right\rangle&=\int\frac{\delta F[\varphi(x)]}{\delta\varphi(x')}f(x')dx'\\&=\lim_{\varepsilon\to 0}\frac{F[\varphi(x)+\varepsilon f(x)]-F[\varphi(x)]}{\varepsilon}\\&=\frac{d}{d\epsilon}F[\varphi+\epsilon f]\Big\vert_{\epsilon=0}.\end{aligned}$ | $\frac{\delta V(r)}{\delta\rho(r')}=\frac{1}{4\pi\epsilon_0\lvert r-r'\rvert}$ |
| ∆<br>⊖<br>⊕ | ∆<br>\vartriangle<br>⊖<br>\ominus<br>⊕<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 | ∇*f* ($x_1$, ..., $x_n$) is the vector of partial derivatives (∂*f* / ∂$x_1$, ..., ∂*f* / ∂$x_n$). | If *f* (*x*,*y*,*z*) := 3*xy* + *z*², then ∇*f* = (3*y*, 3*x*, 2*z*) |
| | | 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 | $\nabla\times\vec v=\left(\frac{\partial v_z}{\partial y}-\frac{\partial v_y}{\partial z}\right)\mathbf{i}+\left(\frac{\partial v_x}{\partial z}-\frac{\partial v_z}{\partial x}\right)\mathbf{j}+\left(\frac{\partial v_y}{\partial x}-\frac{\partial v_x}{\partial y}\right)\mathbf{k}$ | 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 = πR² = 314.16 → R = 10 |
| | | prime-counting function<br>prime-counting function of<br>number theory | $\pi(x)$ counts the number of prime numbers less than or equal to $x$ . | $\pi(10)=4$ |
| | | projection<br>Projection of<br>relational algebra | $\pi_{a_1,\ldots,a_n}(R)$ restricts $R$ to the $\{a_1,\ldots,a_n\}$ attribute set. | $\pi_{\text{Age,Weight}}(\text{Person})$ |

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|---|---|---|---|---|
| | | Homotopy group<br>the *n*th Homotopy group of<br>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. | $\pi_i(S^4) = \pi_i(S^7) \oplus \pi_{i-1}(S^3)$ |
| $\prod$ | $\prod$<br>\prod | product<br>product over ... from ... to ... of<br>arithmetic | $\prod_{k=1}^{n} a_k$ means $a_1 a_2 \dots a_n$. | $\prod_{k=1}^{4}(k+2) = (1+2)(2+2)(3+2)(4+2) = 3 \times 4 \times 5 \times 6 = 360$ |
| | | Cartesian product<br>the Cartesian product of; the direct product of<br>set theory | $\prod_{i=0}^{n} Y_i$ means the set of all (n+1)-tuples<br>$(y_0, \ldots, y_n)$. | $\prod_{n=1}^{3} \mathbb{R} = \mathbb{R} \times \mathbb{R} \times \mathbb{R} = \mathbb{R}^3$ |
| σ | $\sigma$<br>\sigma | standard deviation<br>population standard deviation<br>statistics | A measure of spread or variation of a set of values in a sample population set. | $\sigma = \sqrt{\frac{\Sigma(x_i - \mu)^2}{N}}$ |

## Variations

In mathematics written in Persian or Arabic, some symbols may be reversed to make right-to-left writing and reading easier.[14]

## See also

- List of mathematical symbols (Unicode and LaTeX)
  - List of mathematical symbols by subject
  - List of logic symbols
- Mathematical Alphanumeric Symbols (Unicode block)
  - Mathematical constants and functions
  - Table of mathematical symbols by introduction date
- List of Unicode characters
  - Blackboard bold#Usage
  - Letterlike Symbols
  - Unicode block
- Lists of Mathematical operators and symbols ***in Unicode***
  - Mathematical Operators and Supplemental Mathematical Operators
  - Miscellaneous Math Symbols: A, B, Technical
  - Arrow (symbol) and Miscellaneous Symbols and Arrows and arrow symbols (https://coolsymbol.com/arrow-symbols-arrow-signs.html)
  - ISO 31-11 (Mathematical signs and symbols for use in physical sciences and technology)
  - Number Forms
  - Geometric Shapes
- Diacritic
- Language of mathematics
- Typographical conventions and common meanings of symbols:
  - APL syntax and symbols
  - Greek letters used in mathematics, science, and engineering
  - Latin letters used in mathematics
  - List of common physics notations
  - List of letters used in mathematics and science
  - List of mathematical abbreviations
  - Mathematical notation
  - Notation in probability and statistics
  - Physical constants
  - Typographical conventions in mathematical formulae

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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)
- Detexify: LaTeX Handwriting Recognition Tool (https://detexify.kirelabs.org/classify.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 (https://web.archive.org/web/20141105143723/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 (https://web.archive.org/web/20140222144828/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 (https://web.archive.org/web/20141126074509/http://svn.ghostscript.com/ghostscript/branches/gs-db/Resource/Decoding/Unicode) from the source code for Ghostscript

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