# Comprehensive List of Tokens

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## 1 Tokens by Syntax Usage

### 1.1 Constants

| Name | Symbol | Code | Description |
|---|---|---|---|
| Pi | $\pi$ | `#p`, `#pi` | |
| Natural Exponential Base | e | `#e` | Euler's/Napier's Number, "e", etc. |
| Euler-Mascheroni Constant | $\gamma$ | `#gamma` | |
| Imaginary Unit | $i$ | `#i` | $\sqrt{-1}$ |
| Infinity | $\infty$ | `#infinity`, `infinity` | |
| True | $\mathbf{T}$ | `#T`, `#t`, `#true`, `true` | |
| False | $\mathbf{F}$ | `#F`, `#f`, `#false`, `false` | |
| Natural Numbers | $\mathbb{N}$ | `#N` | |
| Integer Ring | $\mathbb{Z}$ | `#Z` | |
| Rational Field | $\mathbb{Q}$ | `#Q` | |
| Real Field | $\mathbb{R}$ | `#R` | |
| Complex Field | $\mathbb{C}$ | `#C` | |
| Quaternion Ring | $\mathbb{H}$ | `#H` | Hamilton numbers |
| Octonion Algebra | $\mathbb{O}$ | `#O` | Cayley numbers, Type "Oh". |
| Universal Set | $\mathbb{U}$ | `#U` | |
| Empty Set | $\emptyset$ | `#empty`, `{}` | |
| Zero Vector | $\vec{0}$ | `#v0` | |
| $x$ Unit Vector | $\hat{\imath}$ | `#vi` | |
| $y$ Unit Vector | $\hat{\jmath}$ | `#vj` | |
| $z$ Unit Vector | $\hat{k}$ | `#vk` | |
| Zero Matrix | $\mathbb{0}$ | `#0` | Type "zero". |
| Unit Matrix | $\mathbb{I}$ | `#1` | |

## 1.2 Unary Operators

| Name | Symbol | Code | Description |
|---|---|---|---|
| Positive | $+a$ | `+a` | |
| Negative | $-a$ | `-a` | |
| Positive/Negative | $\pm a$ | `&pm a` | |
| Natural Exponential | $\exp(a)$ | `exp(a)` | |
| Natural Logarithm | $\ln(a)$ | `ln(a)` | |
| Square Root | $\sqrt{a}$ | `sqrt(a)` | |
| Factorial | $n!$ | `n!` | |
| Logical Negation | $\neg p$ | `not p`, `~p`, `!p` | |
| Differential | $\mathrm{d}x$ | `&d x` | |
| Partial Differential | $\partial x$ | `&pd x` | |
| Prime | $f'$ | `f'` | |
| Dot derivative | $\dot{x}$ | `x.` | Multiple dots are automatically grouped. |
| Vector | $\vec{u}$ | `&v u` | |
| Unit Vector | $\hat{u}$ | `&u u` | |

## 1.3 Binary Operators

| Name | Symbol | Code | Description |
|---|---|---|---|
| Addition | $a + b$ | `a+b` | |
| Subtraction | $a - b$ | `a-b` | |
| Plus/Minus | $a \pm b$ | `a &pm b` | |
| Multiplication | $a \cdot b$ | `a*b` | |
| Division | $\frac{a}{b}$ | `a/b` | |
| Modulus | $a \pmod n$ | `a%n`, `a mod n` | |
| Exponentiation | $a^b$ | `a^b`, `a**b` | |
| Logarithm with Base | $\log_b a$ | `log(a, b)` | |
| $n$th Root | $\sqrt[n]{a}$ | `root(a, n)` | |
| Subscript | $a_b$ | `a &_ b` | Indexing |
| Superscript | $a^b$ | `a &^ b` | Indexing |
| Set Union | $a \cup b$ | `a union b` | |
| Set Intersection | $a \cap b$ | `a intersect b` | |
| Set Difference | $a \setminus b$ | `a \ b` | |
| Biconditional | $p \longleftrightarrow q$ | `p iff q`, `p <-> q` | |
| Conditional | $p \to q$ | `p implies q`, `p -> q` | |
| Conjunction | $p \wedge q$ | `p and q`, `p && q` | Logical AND |
| Disjunction | $p \vee q$ | `p or q`, `p \|\| q` | Logical OR |
| Exclusion | $p \oplus q$ | `p xor q` | Logical XOR |
| Such That | $p : q$, $p \mid q$ | `p : q`, `p \| q` | Used with set builder and quantifiers |
| Dot Product | $\vec{u} \cdot \vec{v}$ | `&v u &. &v v` | |
| Cross Product | $\vec{u} \times \vec{v}$ | `&v u &x &v v` | |
| Function Composition | $f \circ g$ | `f @ g` | |

## 1.4 Relations

| Name | Symbol | Code | Description |
|---|---|---|---|
| Equal | $=$ | `=`, `==` | |
| Not Equal | $\neq$ | `!=`, `/=`, `<>` | |
| Less than | $<$ | `<` | |
| Greater than | $>$ | `>` | |
| Less than or Equal to | $\leq$ | `<=` | |
| Greater than or Equal to | $\geq$ | `>=` | |
| Subset | $\subseteq$ | `subset` | |
| Superset | $\supseteq$ | `superset`, `supset` | |
| Proper Subset | $\subset$ | `propersubset`, `propsubset`, `psubset` | |
| Proper Superset | $\supset$ | `propersuperset`, `propsuperset`, `psuperset` `propersupset`, `propsupset`, `psupset` | |
| Inclusion | $\in$ | `in` | |
| Equivalent | $\equiv$ | `===`, `equiv` | |
| Not Equivalent | $\not\equiv$ | `!==`, `/==`, `nequiv` | |

## 1.5 Delimiters

| Name | Symbol | Code | Description |
|---|---|---|---|
| Such That | $p : q$, $p \mid q$ | `p : q`, `p \| q` | Used with set builder and quantifiers |
| Parentheses | $(\ )$ | `( )` | Order of operation |
| Square Brackets | $[\ ]$ | `[ ]` | Lists |
| Curly Braces | $\{\ \}$ | `{ }` | Set Notation |
| Angle Brackets | $\langle\ \rangle$ | `< >`, `<: :>` | Vectors |
| Vertical Bars | $\|\ \|$ | `\| \|`, `\|: :\|` | Absolute value, length, determinant, norm |
| Double Bars | $\|\|\ \|\|$ | `\|\| \|\|`, `\|\|: :\|\|` | Length or norm |
| Subscript | $a_b$ | `a &_ b` | Indexing |
| Superscript | $a^b$ | `a &^ b` | Indexing |
| Open Interval | $(a, b)$ | `(:a,b:)` | Exclusive Range Delimiters |
| Closed Interval | $[a, b]$ | `[:a,b:]` | Inclusive Range Delimiters |
| Half-Open Interval | $[a, b)$ | `[:a,b:)` | Mixed Range Delimiters |

Note that some delimiters have more than one format either with or without colons. Namely, absolute value can be written as `| ... |` or `|: ... :|`, norm can be written as `|| ... ||` or `||: ... :||`, and vector literals can be surrounded by either `< ... >` or `<: ... :>`. Of the listed alternate delimiters, those without colons are *context-aware* in that they have different meanings and therefore cannot be automatically matched by the Lexer. Additionally, if an expression opened with one type of delimiter, it must be closed with the same type (i.e. context-aware vs. specialized).

## 1.6 Functions

| Name | Symbol | Code | Description |
|---|---|---|---|
| Trig | $\sin(\theta)$, ... | `sin(theta)`, ... | Also cos, tan, cot, sec, csc |
| Inverse Trig | $\arcsin(x)$, ... | `arcsin(x)`, ... | Also arccos, arctan, arccot, arcsec, arccsc |
| Hyperbolic Trig | $\sinh(\lambda)$, ... | `sinh(lambda)`, ... | Also cosh, tanh, coth, sech, csch |
| Inv. Hyp. Trig | $\operatorname{arcsinh}(x)$, ... | `arcsinh(x)`, ... | Also arccosh, arctanh, arccoth, arcsech, arccsch |
| Absolute Value | $\lvert a \rvert$ | `abs(a)` | |
| Square Root | $\sqrt{a}$ | `sqrt(a)` | |
| $n$th Root | $\sqrt[n]{a}$ | `root(a, n)` | |
| Natural Exponential | $\exp(a)$ | `exp(a)` | |
| Natural Logarithm | $\ln(a)$ | `ln(a)` | |
| Logarithm & Base | $\log_b a$ | `log(a, b)` | |
| Limit | $\lim_{x \to a} f(x)$ | `lim(f(x), a, x)` | |
| | | `limit(f(x), x, a)` | |
| Derivative | $\frac{\mathrm{d}}{\mathrm{d}x}(f(x))$ | `diff(f(x), x)` | |
| Partial Derivative | $\frac{\partial}{\partial x}(f(x,y))$ | `pdiff(f(x,y), x)` | |
| Indefinite Integral | $\int f(x)\,\mathrm{d}x$ | `int(f(x),x)` | |
| Definite Integral | $\int_a^b f(x)\,\mathrm{d}x$ | `int(f(x),x,a,b)` | |
| Sum Over Set | $\sum_i n_i$ | `sum(n&_i, i)` | Can also be used with relations |
| Sum Over Range | $\sum_{n=a}^{b} n_i$ | `sum(n&_i,i,a,b)` | |
| Product Over Set | $\prod_i n_i$ | `prod(n&_i, i)` | Can also be used with relations |
| | | `product(n&_i,i,a,b)` | |
| Product Over Range | $\prod_{n=a}^{b} n_i$ | `prod(n&_i,i,a,b)` | |
| | | `product(n&_i,i,a,b)` | |
| Universal Quantifier | $\forall x P(x)$ | `forall x : P(x)` | "For all"; chain nested quantifiers with `;` |
| Existential Quantifier | $\exists x P(x)$ | `exists x : P(x)` | "There exists" |
| Unique Quantifier | $\exists! x P(x)$ | `unique x : P(x)` | "There exists a unique" |