# Typesetting Math with OpTEX

Version 01

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This document is a brief summary about typesetting math. It describes TEX, Plain TEX and OpTEX features concerned to math. The first two types of features are documented in TEXbook in chapters 16, 17 and 18, but it is summarized here in short again in order to give a complete guide about math typesetting for OpTEX users.

The OpTEX features which differs from standard TEX or Plain TEX are documented with the red triangle at the margin (like in this paragraph). Reader can simply distinguish between “standard” features (given by TEX or Plain TEX) and new OpTEX features.

There are more types of extensions: eTEX, luaTEX, Unicode math and OpTEX macros. The appropriate label (eTEX, LuaTEX, Unicode, OpTEX) is appended to the red triangle to inform you about the extension type. Nevertheless, OpTEX user doesn't have to worry about it, all extensions are available if Unicode Math font is loaded (e.g., by the command `\fonfam[lmfonts]`). See section 1.3.3 in OpTEX documentation about loading Unicode math fonts.

# 1 Basics structure of math formulas

## 1.1 General rules and terminology

The in-line math (in the paragraph) is created by `$`⟨*math list*⟩`$`. The display math (standalone line between paragraphs) is created by `$$`⟨*math list*⟩`$$`. More than one line can be here if appropriate macro is used. In-line math is processed in a TeX group in *in-line math mode*. The display math is processed in a TeX group in *display math mode*. Spaces are ignored in math modes.

The ⟨*math list*⟩ is a sequence of *math atoms* and *other materials*. The math atoms are *single math objects* or composed math atoms.

- The single math object is a single character to be printed in math mode like `x`, `+`, `\int`.
- The math atom is constructed in genereal by `{`⟨*mat list 1*⟩`}^{`⟨*math list 2*⟩`}_{`⟨*math list 3*⟩`}`. It consists from *nucleus* ⟨*math list 1*⟩, exponent ⟨*math list 2*⟩ and subscript ⟨*math list 3*⟩. Each part of the atom should be empty. If the mentioned ⟨*math list*⟩ consist only from a single math object then we need not to use brackets, for example `x^2` is a math atom with `x` in nucleus, `2` in exponent and with empty subscript. Or `a_{i,j}` is a math atom with `a` in nucleus, empty exponent and `i,j` in subscript. The constructors for exponent `^` and for subscript `_` can be used in arbitrary order followed by the nucleus, for example `z_1^{x+y}` it the same math atom as `z^{x+y}_1`. The single math objects not followed by `^` nor `_` are considered as math atoms with this object in nucleus and with empty exponent and subscript (this is very common case). TeX assigns the *class* for each math atom, see section 1.2.
- Other material can be TeX box or glue (space) or `\kern` or `\vrule` etc.

Example: The `Z = \int_\Omega x^{2y} + z\, dx` generates $Z = \int_\Omega x^{2y} + z\,dx$ and it is ⟨*math list*⟩ which consists from:

- `Z` is math atom with empty exponent and subscript, class: Ord,
- `=` is math atom with empty exponent and subscript, class: Rel,
- `\int_\Omega` is math atom with empty exponent and with subscript `\Omega`, class: Op,
- `x^{2y}` is math atom with exponent `2y` and empty subscript, class: Ord,
  - `2` is math atom with empty exponent and subscript, class: Ord,
  - `y` is math atom with empty exponent and subscript, class: Ord,
- `+` is math atom with empty exponent and subscript, class: Bin,
- `z` is math atom with empty exponent and subscript, class: Ord,
- `\,` is other material, the glue (space) in this case,
- `d` is math atom with empty exponent and subscript, class: Ord,
- `x`is math atom with empty exponent and subscript, class: Ord.

## 1.2 Classes of math atoms

TeX assigns *a class* for each math atom.[1] This data type is used when TeX decides about horizontal spaces between atoms in the output. (Note that spaces in the input are ignored.) For example, `$xy$` prints two atoms without space between them but `$x+y$` is printed with small spaces around the `+` binary operator. Compare: $xy$ and $x + y$.

The class is assigned depending on the nucleus of the atom. If the nucleus is not single math object, i.e. it is constructed by `{`⟨*math list*⟩`}` with braces then the atom has its class Ord. If the nucleus is single math object constructed without braces then the class of the atom depends on this single math object. Each single math object must be declared in TeX with its default class. The following table lists the classes with typical examples. Full set of all math objects used in math typesetting is listed in the section 1.10 with their default classes.

[1] Using terminology of TeXbook, each single math object has its *class* but the math atom has its *kind* derived from this class. I use only one word for both meanings in this document.

| | Class | Meaning | Example |
|---|---|---|---|
| 0 | Ord | ordinary object | variables, digits, $x, \mathbb{R}, \Gamma, 0, 1$ |
| 1 | Op | big opertator | $\sum, \int, \bigcup$ |
| 2 | Bin | binary operator | $+, \times, -, \pm, \cup$ |
| 3 | Rel | reations | $=, \neq, \leq, \supseteq, \gtrsim$ |
| 4 | Open | opening bracket | $\{, (, [, \langle$ |
| 5 | Close | closing bracket | $\}, ), ], \rangle$ |
| 6 | Punct | punctuation | comma |
| | Inner | left-right | `\left...\right` outputs, see section 1.5 |

There are three space types used by the algorithm for horizontal spacing in the math formulas.

- Thin space: `\thinmuskip` primitive register, `\,` macro. Used around Op atoms.
- Medium space: `\medmuskip` primitive register, `\>` macro. Used around Bin atoms.
- Thick space: `\thickmusip` primitive register, `\;` macro. Used around Rel atoms.

Ord atoms are printed without spaces between them. The spaces are not cummulated, so the rules about spaces mentioned above is only rough idea. The exact rule for horizontal spaces is given for each pairs of atoms in the table here. The symbol 0 means no space, 1 thin space, 2 medium space and 3 means thick space.

| Left atom \ Right atom | Ord | Op | Bin | Rel | Open | Close | Punct | Inner |
|---|---|---|---|---|---|---|---|---|
| Ord | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 |
| Op | 1 | 1 | | 3 | 0 | 0 | 0 | 1 |
| Bin | 2 | 2 | | | 2 | | | 2 |
| Rel | 3 | 3 | | 0 | 3 | 0 | 0 | 3 |
| Open | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| Close | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 |
| Punct | 1 | 1 | | 1 | 1 | 1 | 1 | 1 |
| Inner | 1 | 1 | 2 | 3 | 1 | 0 | 1 | 1 |

The Bin atom is automaticaly transformed to the Ord atom if no atom precedes or if Op, Bin, Rel, Open or Punct atom precedes. And it is transformed to the Ord atom if Rel, Close or Punct atom follows. This corresponds to the empty cells in the table. Why such behavior? Compare “$0 - 1$” and “$-1$”. The Bin atom in the second case behaves like Ord atom because it is *unary minus*. There is no space between unary minus and one.

All medium spaces and thick spaces and some thin spaces from this table are omitted if the ⟨*math list*⟩ is processed in script or scriptscript styles (smaller size). See section 1.3 about math styles.

You can overwrite the default class derived from the nucleus of the atom by TeX primitives `\mathord`, `\mathop`, `\mathbin`, `\mathrel`, `\mathopen`, `\mathclose`, `\mathpunct` and `\mathinner`. They can precede a nucleus of the atom and they set the class of the atom. For example, `x \mathrel+ y` behaves like `x = y` in spacing point of view but + is printed. Another example: `\mathop{\rm lim} z` creates the atom `lim` in roman font of class Op. So, the thin space is inserted between lim and $z$.

There are more special kinds of math atoms: fractions, math accents, radicals. They are constructed by special way (see next sections) but they behaves like Ord atom in the horizontal spacing algorithm.

## 1.3 Math styles

When a formula (or a sub-formula) is processed by TeX then one from four styles is active: display style ($D$), text style ($T$), script style ($S$) or scriptscript style ($SS$).

The $T$ style is started in in-line math mode `$...$` and the $D$ style is started in display math mode `$$...$$`. The first level of exponents or subscripts is processed in $S$ style and the second and more levels of exponents or indexes are processed in $SS$ style. There are special rules for math styles when fractions are constructed, see section 1.4.

The $D$ and $T$ style uses basic font size, $S$ uses smaller font size (typically 70 %) and $SS$ style uses more smaller font size (typically 50 %). Next levels of “more smaller fonts” are not used due to classical typographic rules.

The nucleus of Op atoms (big operators, $\sum$, $\int$, etc.) have typically bigger versions of the character shape for $D$ style than for $T$ style. So, there are four sizes for such math objects: one size for each math style. All other math objects (with non Op class) are printed only in three sizes: The sizes for $T$ and $D$ styles are equal.

The Op atom puts its exponent and subscript above and below the nucleus in $D$ style but right to the nucleus in other styles:

`\sum_{i=1}^\infty` gives $\displaystyle\sum_{i=1}^\infty$ in $D$ style and $\textstyle\sum_{i=1}^\infty$ in $T$ style.

This default behavior of the Op atom can be modified by placing `\limits` or `\nolimits` or `\displaylimits` TeX primitive just after the Op nucleus before the constructors of exponent and/or index. The `\nolimits` puts exponent and subscript right to the nucleus (regardless of the current style) and `\limits` puts these objects above and below the nucleus (regardless of the current style). There can be more such primitives in a queue (due to a macro expansion, for instance). Then the last primitive in the queue wins. If the last primitive is `\displaylimits` then default behavior is processed regardless there are `\limits` or `\nolimits` before it.

`\sum\nolimits_{i=1}^\infty` gives $\displaystyle\sum\nolimits_{i=1}^\infty$ in $D$ style and $\textstyle\sum_{i=1}^\infty$ in $T$ style.

Atoms of all other classes have their exponents and/or subscripts only right to their nucleus without any exception.

The primitives `\displaystyle`, `\textstyle`, `\scriptstyle` and `\scriptscriptstyle` set the given style regardless the default rules. For example, you can create a formula in in-line math mode and in $D$ style by `$\displaystyle` ⟨*fomula*⟩`$` or a formula in display mode and $T$ style can be printed by `$$\textstyle` ⟨*fomrula*⟩`$$`.

If the subformula is placed below something (below a rule from root symbol, below a fraction rule), then the processed style $D, T, S$ or $SS$ is *cramped*. The exponents are positioned slightly lower than in non-cramped style.

Several macros need to know what math style is currently processed (for example they need to draw something in an appropriate size). But it not possible simply due to the syntax of fractions (section 1.4). This syntax requires to process all math lists in two steps: the first step expands all macros and creates structured data of processed math list. The second step reads the output of the first step, switches between math styles and creates definitive output. So, macros (working in first step) cannot know the current math style because it is set only in the second step. TeX supports the primitive `\matchchioce{`⟨*D*⟩`}{`⟨*T*⟩`}{`⟨*S*⟩`}{`⟨*SS*⟩`}` which prepares four math lists in the first step and only one of these four lists are used in the second step. We can put different macros into each of the four parameters of `\mathchoice`. Plain TeX supports the macro `\mathpalette` which gives a more comfortable interface of `\mathchoice` to macro programmer.

We describe another interface for creating macros depending on current style. You can use `\mathstyles{`⟨*math list*⟩`}`. It behaves like `{`⟨*math list*⟩`}`, moreover, you can use following commands inside such ⟨*math list*⟩: ◀ OpTeX

- The macro `\currstyle`. It expands to `\displaystyle`, `\textstyle`, `\scriptstyle` or `\scriptscriptstyle` depending on the current math style when the `\mathstyles` was opened.
- The `\dobystyle{`⟨*D*⟩`}{`⟨*T*⟩`}{`⟨*S*⟩`}{`⟨*SS*⟩`}` is expandable macro. It expands its parameter ⟨*D*⟩, ⟨*T*⟩, ⟨*S*⟩ or ⟨*SS*⟩ depending on the current math style when `\mathstyles` was opened.
- The value of the `\stylenum` register is 0, 1, 2 or 3 depending on the current math style when `\mathstyles` was opened.

Example of usage of `\mathstyles`:

```
\def\mysymbol{\mathbin\mathstyles
   {\kern1pt\vrule height\mysymbolA width\mysymbolA\kern1pt}}
\def\mysymbolA{\dobystyle{5pt}{5pt}{3.5pt}{2.5pt}}
Test: $a\mysymbol b_{c \mysymbol d}$ or $a\mysymbol b\over c$.
```

This example gives Test: $a \blacksquare b_{c\blacksquare d}$ or $\frac{a\blacksquare b}{c}$.

The `\mathstyles` macro mentioned above uses TEX primitive `\mathchoice`, so it creates four math lists and only one is used. It may take more computer time in special cases. LuaTEX supports the `\mathstyle` primitive (no "s" at the end of this control sequence) which expands to values 0 to 7 depending on the current style: $D, D', T, T', S, S', SS, SS'$ (where $X'$ means cramped variant of the style). This primitive does not use `\mathchoice` but it simply ignores the fraction syntax, so `$a\mysymbol b\over c$` cannot work if `\mysymbol` is defined using the `\mathstyle` primitive. See section 7.3.1 of LuaTEX documentation for more information. ◀ LuaTEX

## 1.4 Fractions

The fraction can be constructed by `{`⟨*numerator*⟩`\over`⟨*denominator*⟩`}`. If the fraction is only single object in the whole math mode (between dollars), you need not to use the outer braces, so you can write `$1\over2$` to get $\frac{1}{2}$.

The ⟨*numerator*⟩ and ⟨*denominator*⟩ are printed in "smaller" math style than current math style. More exactly the following schema is used. $D$: $\frac{T}{T'}$, $T$: $\frac{S}{S'}$, $S$: $\frac{SS}{SS'}$, $SS$: $\frac{SS}{SS'}$. For example

`{a+b \over c}` is printed as $\displaystyle\frac{a+b}{c}$ in $D$ style and as $\textstyle\frac{a+b}{c}$ in $T$ style.

The LaTEX macro `\frac{`⟨*numerator*⟩`}{`⟨*denominator*⟩`}` is not supported in Plain TEX nor in OpTEX but you can define such macro if you want.

The syntax with `\over` is more preferred because it is more human readable notation. You can write the fraction in the same manner as you can read it. You can compare: `$1\over2$` (one over two) with `$\frac12$` (frac twelve).

Besides the `\over` primitive, there are analogical TEX primitives which create "generalized" fractions. The result is similar as `{`⟨*above*⟩`\over` ⟨*below*⟩`}` but there is something extra:

- `{`⟨*above*⟩`\atop` ⟨*below*⟩`}` does `{`⟨*above*⟩`\over`⟨*below*⟩`}` but without the fractional rule.
- `{`⟨*above*⟩`\above`⟨*dimen*⟩⟨*below*⟩`}` creates fractional rule with ⟨*dimen*⟩ thickness.
- `{`⟨*above*⟩`\overwithdelims`⟨*delim-l*⟩⟨*delim-r*⟩⟨*below*⟩`}` adds the ⟨*delim-l*⟩ left to the fraction and the ⟨*delim-r*⟩ right to the fraction.
- `{`⟨*above*⟩`\atopwithdelims`⟨*delim-l*⟩⟨*delim-r*⟩⟨*below*⟩`}` is analogical to `\overwithdelims` but without fractional rule.
- `{`⟨*above*⟩`\abovewithdelims`⟨*delim-l*⟩⟨*delim-r*⟩⟨*dimen*⟩⟨*below*⟩`}` behaves as `\overwithdelims` but the fractional rule has ⟨*dimen*⟩ thickness.

The `\...withdelims` variants read ⟨*delim-l*⟩ and ⟨*delim-r*⟩, they must be declared as *math delimiter* in TEX. They are vertically scalable math objects, typically brackets. See section 1.5 for more information about math delimiters. Example:

`{n \atopwithdelims() k}` creates $\displaystyle\binom{n}{k}$ in $D$ style and $\textstyle\binom{n}{k}$ in $T$ style.

The `\choose` macro is defined by `\def\choose{\atopwithdelims()}`, so the user can write `{n\choose k}` in order to get binomial coefficients.

## 1.5 Vertically scalable objects: math delimiters

The vertically scalable objects are called *delimiters*. For example, all types of brackets are declared as delimiters. This means that you can use a bracket in arbitrary vertical size.[2]

[2] This is not exactly true, because traditional typography says that they cannot be scaled continuously but by visible steps. This means that there is a sequence of increasing brackets in the font, reader must see a difference between each two sizes of brackets.

The following objects are declared as delimiters (i.e. vertically scalable):

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| source: | `(` | `)` | `[` | `]` | `\{` | `\}` | `/` | `\backslash` | `\langle` | `\rangle` | `\|` | `\\|` |
| output: | ( | ) | [ | ] | $\{$ | $\}$ | / | $\backslash$ | $\langle$ | $\rangle$ | $\vert$ | $\Vert$ |

| | | | | |
|---|---|---|---|---|
| source: | `\lfloor` | `\rfloor` | `\lceil` | `\rceil` |
| output: | $\lfloor$ | $\rfloor$ | $\lceil$ | $\rceil$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| source: | `\uparrow` | `\Uparrow` | `\dowarrow` | `\Downarrow` | `\updownarrow` | `\Updownarrow` |
| output: | $\uparrow$ | $\Uparrow$ | $\downarrow$ | $\Downarrow$ | $\updownarrow$ | $\Updownarrow$ |

If you are able to produce the characters ⟨, ⟩,[3] ⌊, ⌋, ... ↕, ⇕ directly in your text editor then you can use these Unicode characters in your source instead of control sequences `\langle`, `\rangle`, `\lfloor`, `\rfloor` ... `\updownarrow`, `\Updownarrow`. For many users (including me), there is more simple to type `\lfloor` than to find how to create the ⌊ character in my text editor. Note that there exist text editors (Emacs, for example) enabling you to type `\lfloor` and this control sequence is immediately converted to the ⌊ Unicode character. Your source looks pretty and you can use classical TeX sequences. ◀ Unicode

There are more delimiters, but it heavily depends on loaded Unicode Math font. For example, this document is printed in `latinmodern-math` font and there are six more delimiters `\lBrack` ⟦, `\rBrack` ⟧, `\lAngle` ⟪, `\rAngle` ⟫, `\lgroup` ⟮, `\rgroup` ⟯. See section 1.10 for table of all Unicode symbols for math typesetting. ◀ Unicode

Arbitrary tall formula can be surrounded by a pair of delimiters using `\left` and `\right` TeX primitives: `\left`⟨*delim*⟩ ⟨*formula*⟩ `\right`⟨*delim*⟩. The delimiters are scaled to the height and depth of the ⟨*formula*⟩ and vertically centered to the *math axis*.[4] Example:

`+ \left\{ \sum _{i=1}^\infty x_i \right)` gives $+\left\{\sum_{i=1}^\infty x_i\right).$

The pair `\left`⟨*delim*⟩ ⟨*formula*⟩ `\right`⟨*delim*⟩ creates the formula in a TeX group. Such group can be nested with another groups. Each `\left` must have its `\right` counterpart at the same group level. If you don't want to create visible delimiter, use dot instead ⟨*delim*⟩. Example:

`\left. \int_0^t e^{x^2}\,dx\, \right|_{t=42}` gives $\left.\int_0^t e^{x^2}\,dx\,\right|_{t=42}$

You can use `\middle`⟨*delim*⟩ inside the ⟨*formula*⟩ which is surrounded by `\left...\right`. Then the given ⟨*delim*⟩ is scaled to the same size like their `\left` and `\right` counterparts. ◀ eTeX

When a delimiter is used without `\left` nor `\right` prefix, then it is the Open, Close, Ord or Bin atom by its natural meaning: $(, [, \{, \ldots, \lfloor, \lceil$ are Open atoms, $], ], \}, \ldots, \rfloor, \rceil$ are Close atoms, $/, \backslash, |, \Vert$ are Ord atoms and $\uparrow, \Uparrow, \ldots, \Updownarrow$ are Bin atoms. You can overwrite this default setting, for example `\mathclose(`. If delimiters are used with `\left` and `\right` prefixes then `\left`⟨*delim*⟩ behaves like Open atom, `\right`⟨*delim*⟩ behaves like Close atom and the math list `\left`⟨*delim*⟩⟨*formula*⟩`\right`⟨*delim*⟩ is encapsulated as a single Inner atom. The `\middle`⟨*delim*⟩ behaves like Open atom at its left side and like Close atom at its right side.

The sequence of increasing delimiters can be printed by the following macros:

`(` $\to ($, `\big(` $\to \big($, `\Big(` $\to \Big($, `\bigg(` $\to \bigg($, `\Bigg(` $\to \Bigg($.

[3] Do not confuse $<, >$ and $\langle, \rangle$. The first pair are Rel atoms with meaning "less than" or "greater than", but the second pair are special types of brackets. They are not directly available at computer keyboards without using a keyboard macro.

[4] Math axis is a horizontal line passing through the center of symbols $+$ and $-$. All vertically scalable objects are vertically centered with respect to this axis.

The `\Bigg`$\langle$*delim*$\rangle$ is not maximal size of the bracket. Try `\left(\vbox to5cm{}\right.`, for example. You can see that the font "cheats" from certain sizes, because there are not all infinity number of sizes of brackets drawn in the font, of course.

The `\big`$\langle$*delim*$\rangle$ creates Ord atom. We need to create Open atom for opening bracket and Close atom for closing bracket more often. Then we can use macros `\bigl`$\langle$*delim*$\rangle$, `\Bigl`$\langle$*delim*$\rangle$, `\biggl`$\langle$*delim*$\rangle$, `\Biggl`$\langle$*delim*$\rangle$ for creating Open atoms and `\bigr`$\langle$*delim*$\rangle$, `\Bigr`$\langle$*delim*$\rangle$, `\biggr`$\langle$*delim*$\rangle$, `\Biggr`$\langle$*delim*$\rangle$ for creating Close atoms. Unfortunately, the source is not too attractive when more sizes of brackets are used, but typographic traditions say that we have to distinguish brackets by the size in math mode if they are in equal types:

`\Bigl( f\bigl( 2(x+y) + z\bigr) \Bigr)'` gives $\Bigl(f\bigl(2(x+y)+z\bigr)\Bigr)'$.

## 1.6 Horizontally scalable objects: math accents

Arbitrary wide formula can be covered by *scalable math accent*. Example:

`\overrightarrow {a+b+c+d+e+f}` gives $\overrightarrow{a+b+c+d+e+f}$.

The usage is: control sequence of selected math accent followed by `{`$\langle$*math list*$\rangle$`}`.

Standard scalable math accents are: `\overline` $\overline{abc}$, `\overbrace` $\overbrace{abc}$, `\overrightarrow` $\overrightarrow{abc}$, `\overleftarrow` $\overleftarrow{abc}$, `\underline` $\underline{abc}$, `\underbrace` $\underbrace{abc}$.

A Op atom is created. The exponents and subscripts are centered above and below the nucleus of this atom (regardless of the current style). Example:

`\overbrace {b\cdot b\cdot b \cdots b}^{k\times}` gives $\overbrace{b\cdot b\cdot b\cdots b}^{k\times}$

There are scalable accents with limited maximum width: `\widehat` $\widehat{abc}$ and `\widetilde` $\widetilde{abc}$. If the formula is wider than the font is able to cover then widest variant from the font is used and it is horizontally centered.

There are more scalable accents in Unicode math fonts: `\overparen` $\overparen{abc}$, `\underparen` $\underparen{abc}$, `\overbracket` $\overbracket{abc}$, `\underbracket` $\underbracket{abc}$, `\overleftrightarrow` $\overleftrightarrow{abc}$, `\overleftharpoon` $\overleftharpoon{abc}$, `\overrightharpoon` $\overrightharpoon{abc}$, ◀ Unicode

## 1.7 Fixed math accents

Fixed math accents can be applied to single math object or to the `{`$\langle$*math list*$\rangle$`}`. The accent is centered (with respect of slanting axis) and the result is a nucleus of Ord atom. For example `\dot x` gives $\dot{x}$. The list of fixed math accents follows: `\acute x` $\acute{x}$, `\bar x` $\bar{x}$, `\breve x` $\breve{x}$, `\check x` $\check{x}$, `\dot x` $\dot{x}$, `\ddot x` $\ddot{x}$, `\grave x` $\grave{x}$, `\hat x` $\hat{x}$, `\vec x` $\vec{x}$, `\tilde x` $\tilde{x}$.

The additional fixed accents depends on used Unicode math font. The `latinmodern-math` supports: `\ovhook x` $\ovhook{x}$, `\ocirc x` $\mathring{x}$, `\leftharpoonaccent x` $\leftharpoonaccent{x}$, `\rightharpoonaccent x` $\rightharpoonaccent{x}$, `\dddot x` $\dddot{x}$, `\ddddot x` $\ddddot{x}$, `\widebridgeabove x` $\widebridgeabove{x}$, `\asteraccent x` $\asteraccent{x}$. ◀ Unicode

There exist one special math accent `'` (single quote, ASCII 39) which can be appended after a symbol like this: `f'` and it creates $f'$ (typical meaning is the derivation of the given function). You can put more such accents, for example `g'''` gives $g'''$.

## 1.8 Roots

There is a macro `\sqrt{`$\langle$*math list*$\rangle$`}` to create square root. For example:

`\sqrt{\sqrt{\sqrt{x+1}+1}+1}` gives $\sqrt{\sqrt{\sqrt{x+1}+1}+1}$

The $n$-th root is created by the macro `\root` $\langle n\rangle$`\of{`$\langle$*math list*$\rangle$`}`. For example `\root k+1\of x` gives $\sqrt[k+1]{x}$.

## 1.9 Math alphabets

Letters $a \ldots z$, $A \ldots Z$ and $\alpha \ldots \omega$ are printed in italic in math mode. This follows the traditional typographic rule. All other math symbols, digits and uppercase Greek letters must be upright.[5] These rules are independent of the current variant of surrounding text font.

If we want to use the letters or digits in another than this default shape, then we can use *math alphabet selectors*: `\mit`, `\rm`, `\it`, `\bf`, `\cal`. OpTEX supports more such selectors `\script`, `\frak`, `\bbchar`, `\bi`, see section 1.3.3 in the OpTEX documentation. The math selectors have local validity in the group. ◀ OpTEX

The control sequences `\rm`, `\it`, `\bf`, and `\bi` act as variant selectors of fonts in non-math mode (text mode) and they act as math alphabet selectors in math mode. This "overlaying" concept is given by Plain TEX. Example: math operators lim, sin, cos, log, etc. must be printed unslanted. We are using `\lim`, `\sin`, `\cos`, `\log` etc. in math mode in order to comply this typographic convention. For example `\sin` is defined as:

```
\def\sin {\mathop{\rm sin}\nolimits}
```

The `\rm` is used here as math alphabet selector, no variant selector of text fonts.

The list of all predefined `\rm`-like math operators follows: `\arccos`, `\arcsin`, `\arctan`, `\arg`, `\cos`, `\cosh`, `\cot`, `\coth`, `\deg`. `\det`, `\dim`, `\exp`, `\gcd`, `\hom`, `\inf`, `\ker`, `\lg`, `\lim`, `\liminf`, `\limsup`, `\ln`, `\log`, `\max`, `\min`, `\Pr`, `\scs`, `\sin`, `\sinh`, `\sup`, `\tan`, `\tanh`, You can define another such operator analogically.

Unicode font can include the following math alphabets: ◀ Unicode

```
\_rmvariables      % upright letters A-Z, a-z
\_bfvariables      % bold letters A-Z, a-z
\_itvariables      % italic letters A-Z, a-z
\_bivariables      % bold italic letters A-Z, a-z
\_calvariables     % calligraphic letters A-Z, a-z
\_bcalvariables    % calligraphic letters A-Z, a-z
\_frakvariables    % fraktur A-Z, a-z
\_bfrakvariables   % bold fraktur A-Z, a-z
\_sansvaraibales   % sans serif letters A-Z, a-z
\_bsansvaraibales  % bold sans serif letters A-Z, a-z
\_isansvaraibales  % slanted sans serif letters A-Z, a-z
\_bisansvaraibales % bold slanted sans serif letters A-Z, a-z
\_ttvariables      % monospace, typewriter letters A-Z, a-z
\_bbvariables      % double struck A-Z, a-z
\_rmdigits         % upright digits 0..9
\_bfdigits         % bold digits 0..9
\_sansdigits       % sans serif digits 0..9
\_bsansdigits      % bold sans serif digits 0..9
\_ttdigits         % monospace typewriter digits 0..9
\_bbdigits         % double-struck digits 0..9
\_rmgreek          % upright Greek letters \alpha-\omega
\_itgreek          % slanted Greek letters \alpha-\omega
\_bfgreek          % bold Greek letters \alpha-\omega
\_bigreek          % bold italic Greek letters \alpha-\omega
\_bsansgreek       % bold sans serif Greek letters \alpha-\omega
\_bisansgreek      % bold slanted snas serif Greek letters \alpha-\omega
\_itGreek          % slanted Greek letters \Alpha-\Omega
\_bfGreek          % bold Greek letters \Alpha-\Omega
\_biGreek          % bold italic Greek letters \Alpha-\Omega
\_bsansGreek       % bold sans serif Greek letters \Alpha-\Omega
\_bisansGreek      % bold slanted snas serif Greek letters \Alpha-\Omega
```

Not all Unicode math fonts include all math alphabets listed here. Typically, the lowercase letters of calligraphic shape and all letters of bold calligraphic shape are missing.

[5] French typographic convention says that uppercase Greek letters have to be in italic too. Use `\_itGreek` declaration in this case.

OpTEX defines internal math alphabet selectors as mentioned in the previous listing of math alphabets and sets as default: ◀ OpTEX

```
\_itvariables \_rmdigits \_itgreek \_rmGreek
```

Moreover, it defines the alphabet selectors at user level (see section 1.3.3 of the OpTEX manual). For example

```
\def\rm {\_tryload\_tenrm \_inmath{\_rmavariables \_rmdigits}}
```

The first part `\_tryload\_tenrm` is applicable for text fonts and the `\_inmath` part is processed only in math mode and sets the math alphabets. You can see the file `unimath-codes.opm` where all user level selectors are defined. You can redefine them. For example, OpTEX defines `\bf` as a math alphabet selector which selects sans serif bold in math. This is common notation for vectors, tensors and matrices. If you dislike this, then you can define: ◀ OpTEX

```
\def\bf {\_tryloadbf\_tenbf \_inmath{\_bfvariables\_bfdigits\_bfgreek\_bfGreek}}
```

## 1.10 List of single math objects

All single math objects are listed in the `unimath-table.opm` or `unicode-math-table.tex` file. You can look into this file. The codes, TEX sequences, classes and comments for all possible math codes are here. Maybe, your Unicode math font which is loaded, does not support all these codes. You can try all codes of currently loaded font by ◀ Unicode ◀ OpTEX

```
\input print-unimath.opm
```

The `unimath-table` is printed with characters available in loaded font. If the character is unsupported by the font then the slot is empty and only TEX sequence and the class of the code is printed in the table. For example, this document loads `latimodern-math.otf` font. And the result from `\input print-unimath.opm` looks like the following ten pages. ◀ OpTEX

Codes U+00000 … U+10000

| | | |
|---|---|---|
| ! | Close | \mathexclam |
| # | Ord | \mathoctothorpe |
| $ | Ord | \mathdollar |
| % | Ord | \mathpercent |
| & | Ord | \mathampersand |
| ( | Open | \lparen |
| ) | Close | \rparen |
| + | Bin | \mathplus |
| , | Punct | \mathcomma |
| . | Ord | \mathperiod |
| / | Ord | \mathslash |
| : | Punct | \mathcolon |
| ; | Punct | \mathsemicolon |
| < | Rel | \less |
| = | Rel | \equal |
| > | Rel | \greater |
| ? | Ord | \mathquestion |
| @ | Ord | \mathatsign |
| [ | Open | \lbrack |
| \ | Ord | \backslash |
| ] | Close | \rbrack |
| { | Open | \lbrace |
| $\vert$ | Fence | \vert |
| } | Close | \rbrace |
| £ | Ord | \mathsterling |
| ¥ | Ord | \mathyen |
| § | Ord | \mathsection |
| ¬ | Ord | \neg=\lnot |
| ± | Bin | \pm |
| ¶ | Ord | \mathparagraph |
| · | Bin | \cdotp |
| × | Bin | \times |
| | Alph | \matheth=\eth |
| ÷ | Bin | \div |
| | Ord | \Zbar |
| ` | Acc | \grave |
| ´ | Acc | \acute |
| ˆ | Acc | \hat |
| ˆ | Accw | \widehat |
| ˜ | Acc | \tilde |
| ˜ | Accw | \widetilde |
| ¯ | Acc | \bar |
| ¯ | Acc | \overbar |
| | Accw | \wideoverbar |
| ˘ | Acc | \breve |
| | Accw | \widebreve |
| ˙ | Acc | \dot |
| ¨ | Acc | \ddot |
| ̉ | Acc | \ovhook |
| ˚ | Acc | \ocirc=\mathring |
| ˇ | Acc | \check |
| | Accw | \widecheck |
| | Acc | \candra |
| | Acc | \oturnedcomma |
| | Acc | \ocommatopright |
| | Acc | \droang |
| | AccBw | \wideutilde |
| | AccBw | \mathunderbar |
| | AccO | \notaccent |
| | AccBw | \underleftrightarrow |
| Α | Alph | \mupAlpha |
| Β | Alph | \mupBeta |
| Γ | Alph | \mupGamma |
| Δ | Alph | \mupDelta |
| Ε | Alph | \mupEpsilon |
| Ζ | Alph | \mupZeta |
| Η | Alph | \mupEta |
| Θ | Alph | \mupTheta |
| Ι | Alph | \mupIota |
| Κ | Alph | \mupKappa |
| Λ | Alph | \mupLambda |
| Μ | Alph | \mupMu |
| Ν | Alph | \mupNu |
| Ξ | Alph | \mupXi |
| Ο | Alph | \mupOmicron |
| Π | Alph | \mupPi |
| Ρ | Alph | \mupRho |
| Σ | Alph | \mupSigma |
| Τ | Alph | \mupTau |
| | Alph | \mupUpsilon |
| Φ | Alph | \mupPhi |
| Χ | Alph | \mupChi |
| Ψ | Alph | \mupPsi |
| Ω | Alph | \mupOmega |
| α | Alph | \mupalpha |
| β | Alph | \mupbeta |
| γ | Alph | \mupgamma |
| δ | Alph | \mupdelta |
| ε | Alph | \mupvarepsilon |
| ζ | Alph | \mupzeta |
| η | Alph | \mupeta |
| θ | Alph | \muptheta |
| ι | Alph | \mupiota |
| κ | Alph | \mupkappa |
| λ | Alph | \muplambda |
| μ | Alph | \mupmu |
| ν | Alph | \mupnu |
| ξ | Alph | \mupxi |
| ο | Alph | \mupomicron |
| π | Alph | \muppi |
| ρ | Alph | \muprho |
| | Alph | \mupvarsigma |
| σ | Alph | \mupsigma |
| τ | Alph | \muptau |
| υ | Alph | \mupupsilon |

| | | |
|---|---|---|
| φ | Alph | \mupvarphi |
| χ | Alph | \mupchi |
| ψ | Alph | \muppsi |
| ω | Alph | \mupomega |
| ϑ | Alph | \mupvartheta |
| ϕ | Alph | \mupphi |
| ϖ | Alph | \mupvarpi |
| | Alph | \upDigamma |
| | Alph | \updigamma |
| ϰ | Alph | \mupvarkappa |
| ϱ | Alph | \mupvarrho |
| ϴ | Alph | \mupvarTheta |
| ϵ | Alph | \mupepsilon |
| | Ord | \upbackepsilon=\backepsilon |
| ‐ | Alph | \mathhyphen |
| | Ord | \horizbar |
| ‖ | Fence | \Vert |
| | Ord | \twolowline |
| † | Bin | \dagger |
| ‡ | Bin | \ddagger |
| • | Bin | \smblkcircle=\bullet |
| | Ord | \enleadertwodots |
| … | Ord | \unicodeellipsis |
| ′ | Ord | \prime |
| ″ | Ord | \dprime |
| ‴ | Ord | \trprime |
| ‵ | Ord | \backprime |
| ‶ | Ord | \backdprime |
| ‷ | Ord | \backtrprime |
| | Ord | \caretinsert |
| | Ord | \Exclam |
| | Bin | \tieconcat |
| | Ord | \hyphenbullet |
| ⁄ | Bin | \fracslash |
| | Ord | \Question |
| | Rel | \closure |
| ⁗ | Ord | \qprime |
| | Ord | \euro |
| ⃐ | Acc | \leftharpoonaccent |
| ⃐ | Accw | \overleftharpoon |
| ⃑ | Acc | \rightharpoonaccent |
| ⃑ | Accw | \overrightharpoon |
| ⃒ | Acc | \vertoverlay |
| ⃖ | Accw | \overleftarrow |
| ⃗ | Accw | \overrightarrow |
| ⃗ | Acc | \vec |
| ⃛ | Acc | \dddot |
| ⃜ | Acc | \ddddot |
| | Ord | \enclosecircle |
| | Ord | \enclosesquare |
| | Ord | \enclosediamond |
| ⃡ | Accw | \overleftrightarrow |
| | Ord | \enclosetriangle |
| | Acc | \annuity |
| | AccB | \threeunderdot |
| ⃩ | Acc | \widebridgeabove |
| | AccBw | \underrightharpoondown |
| | AccBw | \underleftharpoondown |
| | AccBw | \underleftarrow |
| | AccBw | \underrightarrow |
| ⃰ | Acc | \asteraccent |
| ℂ | Alph | \BbbC |
| ℇ | Ord | \Eulerconst |
| | Alph | \mscrg |
| ℋ | Alph | \mscrH |
| ℌ | Alph | \mfrakH |
| ℍ | Alph | \BbbH |
| ℎ | Ord | \Planckconst |
| ℏ | Alph | \hslash=\hbar |
| ℐ | Alph | \mscrI |
| ℑ | Alph | \Im |
| ℒ | Alph | \mscrL |
| ℓ | Alph | \ell |
| ℕ | Alph | \BbbN |
| ℘ | Alph | \wp |
| ℙ | Alph | \BbbP |
| ℚ | Alph | \BbbQ |
| ℛ | Alph | \mscrR |
| ℜ | Alph | \Re |
| ℝ | Alph | \BbbR |
| ℤ | Alph | \BbbZ |
| ℧ | Ord | \mho |
| ℨ | Alph | \mfrakZ |
| | Alph | \turnediota |
| Å | Alph | \Angstrom |
| ℬ | Alph | \mscrB |
| ℭ | Alph | \mfrakC |
| | Alph | \mscre |
| ℰ | Alph | \mscrE |
| ℱ | Alph | \mscrF |
| | Ord | \Finv |
| ℳ | Alph | \mscrM |
| | Alph | \mscro |
| ℵ | Alph | \aleph |
| ℶ | Alph | \beth |
| ℷ | Alph | \gimel |
| ℸ | Alph | \daleth |
| ℼ | Ord | \Bbbpi |
| ℽ | Alph | \Bbbgamma |
| ℾ | Alph | \BbbGamma |
| ℿ | Alph | \BbbPi |
| ⅀ | Op | \Bbbsum |
| | Ord | \Game |
| | Ord | \sansLturned |
| | Ord | \sansLmirrored |
| | Ord | \Yup |
| ⅅ | Ord | \mitBbbD |
| ⅆ | Ord | \mitBbbd |
| ⅇ | Ord | \mitBbbe |
| ⅈ | Ord | \mitBbbi |
| ⅉ | Ord | \mitBbbj |
| | Ord | \PropertyLine |
| | Bin | \upand |
| ← | Rel | \leftarrow=\gets |
| ↑ | Rel | \uparrow |
| → | Rel | \rightarrow=\to |
| ↓ | Rel | \downarrow |
| ↔ | Rel | \leftrightarrow |
| ↕ | Rel | \updownarrow |
| ↖ | Rel | \nwarrow |
| ↗ | Rel | \nearrow |
| ↘ | Rel | \searrow |
| ↙ | Rel | \swarrow |
| ↚ | Rel | \nleftarrow |
| ↛ | Rel | \nrightarrow |
| | Rel | \leftwavearrow |
| | Rel | \rightwavearrow |
| ↞ | Rel | \twoheadleftarrow |
| ↟ | Rel | \twoheaduparrow |
| ↠ | Rel | \twoheadrightarrow |
| ↡ | Rel | \twoheaddownarrow |
| ↢ | Rel | \leftarrowtail |
| ↣ | Rel | \rightarrowtail |
| ↤ | Rel | \mapsfrom |
| ↥ | Rel | \mapsup |
| ↦ | Rel | \mapsto |
| ↧ | Rel | \mapsdown |
| | Ord | \updownarrowbar |
| ↩ | Rel | \hookleftarrow |
| ↪ | Rel | \hookrightarrow |
| ↫ | Rel | \looparrowleft |
| ↬ | Rel | \looparrowright |
| ↭ | Rel | \leftrightsquigarrow |
| ↮ | Rel | \nleftrightarrow |
| | Rel | \downzigzagarrow |
| ↰ | Rel | \Lsh |
| ↱ | Rel | \Rsh |
| ↲ | Rel | \Ldsh |
| ↳ | Rel | \Rdsh |
| | Ord | \linefeed |
| | Ord | \carriagereturn |
| ↶ | Rel | \curvearrowleft |
| ↷ | Rel | \curvearrowright |
| | Ord | \barovernorthwestarrow |
| | Ord | \barleftarrowrightarrowbar |
| ↺ | Ord | \acwopencirclearrow |
| ↻ | Ord | \cwopencirclearrow |
| ↼ | Rel | \leftharpoonup |
| ↽ | Rel | \leftharpoondown |
| ↾ | Rel | \upharpoonright |
| ↿ | Rel | \upharpoonleft |
| ⇀ | Rel | \rightharpoonup |
| ⇁ | Rel | \rightharpoondown |
| ⇂ | Rel | \downharpoonright |
| ⇃ | Rel | \downharpoonleft |
| ⇄ | Rel | \rightleftarrows |
| ⇅ | Rel | \updownarrows |
| ⇆ | Rel | \leftrightarrows |
| ⇇ | Rel | \leftleftarrows |
| ⇈ | Rel | \upuparrows |
| ⇉ | Rel | \rightrightarrows |
| ⇊ | Rel | \downdownarrows |
| ⇋ | Rel | \leftrightharpoons |
| ⇌ | Rel | \rightleftharpoons |
| ⇍ | Rel | \nLeftarrow |
| ⇎ | Rel | \nLeftrightarrow |
| ⇏ | Rel | \nRightarrow |
| ⇐ | Rel | \Leftarrow |
| ⇑ | Rel | \Uparrow |
| ⇒ | Rel | \Rightarrow |
| ⇓ | Rel | \Downarrow |
| ⇔ | Rel | \Leftrightarrow |
| ⇕ | Rel | \Updownarrow |
| ⇖ | Rel | \Nwarrow |
| ⇗ | Rel | \Nearrow |
| ⇘ | Rel | \Searrow |
| ⇙ | Rel | \Swarrow |
| ⇚ | Rel | \Lleftarrow |
| ⇛ | Rel | \Rrightarrow |
| ⇜ | Rel | \leftsquigarrow |
| ⇝ | Rel | \rightsquigarrow |
| | Ord | \nHuparrow |
| | Ord | \nHdownarrow |
| | Ord | \leftdasharrow |
| | Ord | \updasharrow |
| | Ord | \rightdasharrow |
| | Ord | \downdasharrow |
| | Rel | \barleftarrow |
| | Rel | \rightarrowbar |
| ⇦ | Ord | \leftwhitearrow |
| ⇧ | Ord | \upwhitearrow |
| ⇨ | Ord | \rightwhitearrow |
| ⇩ | Ord | \downwhitearrow |
| | Ord | \whitearrowupfrombar |
| | Rel | \circleonrightarrow |
| ⇵ | Rel | \downuparrows |
| ⇶ | Rel | \rightthreearrows |
| | Rel | \nvleftarrow |
| | Rel | \nvrightarrow |
| | Rel | \nvleftrightarrow |
| | Rel | \nVleftarrow |
| | Rel | \nVrightarrow |
| | Rel | \nVleftrightarrow |
| | Rel | \leftarrowtriangle |
| | Rel | \rightarrowtriangle |
| | Rel | \leftrightarrowtriangle |
| ∀ | Ord | \forall |
| ∁ | Ord | \complement |
| ∂ | Alph | \partial |
| ∃ | Ord | \exists |
| ∄ | Ord | \nexists |
| ∅ | Ord | \varnothing=\emptyset |
| ∆ | Ord | \increment |
| ∇ | Alph | \nabla |
| ∈ | Rel | \in |
| ∉ | Rel | \notin |
| ∊ | Rel | \smallin |
| ∋ | Rel | \ni=\owns |
| ∌ | Rel | \nni |
| ∍ | Rel | \smallni |
| ∎ | Ord | \QED |

| | | |
|---|---|---|
| ∏ | Op | \prod |
| ∐ | Op | \coprod |
| ∑ | Op | \sum |
| − | Bin | \minus |
| ∓ | Bin | \mp |
| ∔ | Bin | \dotplus |
| ∕ | Bin | \divslash |
| ∖ | Bin | \smallsetminus |
| ∗ | Bin | \ast |
| ∘ | Bin | \vysmwhtcircle=\circ |
| ∙ | Bin | \vysmblkcircle |
| √ | Open | \sqrt |
| √ | Ord | \surd |
| | Open | \cuberoot |
| | Open | \fourthroot |
| ∝ | Rel | \propto |
| ∞ | Ord | \infty |
| ∟ | Ord | \rightangle |
| ∠ | Ord | \angle |
| ∡ | Ord | \measuredangle |
| ∢ | Ord | \sphericalangle |
| ∣ | Rel | \mid |
| ∤ | Rel | \nmid |
| ∥ | Rel | \parallel |
| ∦ | Rel | \nparallel |
| ∧ | Bin | \wedge=\land |
| ∨ | Bin | \vee=\lor |
| ∩ | Bin | \cap |
| ∪ | Bin | \cup |
| ∫ | Op | \int |
| ∬ | Op | \iint |
| ∭ | Op | \iiint |
| ∮ | Op | \oint |
| ∯ | Op | \oiint |
| ∰ | Op | \oiiint |
| ∱ | Op | \intclockwise |
| ∲ | Op | \varointclockwise |
| ∳ | Op | \ointctrclockwise |
| ∴ | Ord | \therefore |
| ∵ | Ord | \because |
| ∶ | Rel | \mathratio |
| ∷ | Rel | \Colon |
| ∸ | Bin | \dotminus |
| ∹ | Rel | \dashcolon |
| ∺ | Rel | \dotsminusdots |
| ∻ | Rel | \kernelcontraction |
| ∼ | Rel | \sim |
| ∽ | Rel | \backsim |
| ∾ | Bin | \invlazys |
| ∿ | Ord | \sinewave |
| ≀ | Bin | \wr |
| ≁ | Rel | \nsim |
| ≂ | Rel | \eqsim |
| ≃ | Rel | \simeq |
| ≄ | Rel | \nsime |
| ≃ | Rel | \sime |
| ≄ | Rel | \nsimeq |
| ≅ | Rel | \cong |
| ≆ | Rel | \simneqq |
| ≇ | Rel | \ncong |
| ≈ | Rel | \approx |
| ≉ | Rel | \napprox |
| ≊ | Rel | \approxeq |
| ≋ | Rel | \approxident |
| ≌ | Rel | \backcong |
| ≍ | Rel | \asymp |
| ≎ | Rel | \Bumpeq |
| ≏ | Rel | \bumpeq |
| ≐ | Rel | \doteq |
| ≑ | Rel | \Doteq |
| ≒ | Rel | \fallingdotseq |
| ≓ | Rel | \risingdotseq |
| ≔ | Rel | \coloneq |
| ≕ | Rel | \eqcolon |
| ≖ | Rel | \eqcirc |
| ≗ | Rel | \circeq |
| ≘ | Rel | \arceq |
| ≙ | Rel | \wedgeq |
| ≚ | Rel | \veeeq |
| ≛ | Rel | \stareq |
| ≜ | Rel | \triangleq |
| ≝ | Rel | \eqdef |
| ≞ | Rel | \measeq |
| ≟ | Rel | \questeq |
| ≠ | Rel | \ne=\neq |
| ≡ | Rel | \equiv |
| ≢ | Rel | \nequiv |
| ≣ | Rel | \Equiv |
| ≤ | Rel | \leq=\le |
| ≥ | Rel | \geq=\ge |
| ≦ | Rel | \leqq |
| ≧ | Rel | \geqq |
| ≨ | Rel | \lneqq |
| ≩ | Rel | \gneqq |
| ≪ | Rel | \ll |
| ≫ | Rel | \gg |
| ≬ | Rel | \between |
| ≭ | Rel | \nasymp |
| ≮ | Rel | \nless |
| ≯ | Rel | \ngtr |
| ≰ | Rel | \nleq |
| ≱ | Rel | \ngeq |
| ≲ | Rel | \lesssim |
| ≳ | Rel | \gtrsim |
| ≴ | Rel | \nlesssim |
| ≵ | Rel | \ngtrsim |
| ≶ | Rel | \lessgtr |
| ≷ | Rel | \gtrless |
| ≸ | Rel | \nlessgtr |
| ≹ | Rel | \ngtrless |
| ≺ | Rel | \prec |
| ≻ | Rel | \succ |
| ≼ | Rel | \preccurlyeq |
| ≽ | Rel | \succcurlyeq |
| ≾ | Rel | \precsim |
| ≿ | Rel | \succsim |
| ⊀ | Rel | \nprec |
| ⊁ | Rel | \nsucc |
| ⊂ | Rel | \subset |
| ⊃ | Rel | \supset |
| ⊄ | Rel | \nsubset |
| ⊅ | Rel | \nsupset |
| ⊆ | Rel | \subseteq |
| ⊇ | Rel | \supseteq |
| ⊈ | Rel | \nsubseteq |
| ⊉ | Rel | \nsupseteq |
| ⊊ | Rel | \subsetneq |
| ⊋ | Rel | \supsetneq |
| ⊌ | Bin | \cupleftarrow |
| ⊍ | Bin | \cupdot |
| ⊎ | Bin | \uplus |
| ⊏ | Rel | \sqsubset |
| ⊐ | Rel | \sqsupset |
| ⊑ | Rel | \sqsubseteq |
| ⊒ | Rel | \sqsupseteq |
| ⊓ | Bin | \sqcap |
| ⊔ | Bin | \sqcup |
| ⊕ | Bin | \oplus |
| ⊖ | Bin | \ominus |
| ⊗ | Bin | \otimes |
| ⊘ | Bin | \oslash |
| ⊙ | Bin | \odot |
| ⊚ | Bin | \circledcirc |
| ⊛ | Bin | \circledast |
| ⊜ | Bin | \circledequal |
| ⊝ | Bin | \circleddash |
| ⊞ | Bin | \boxplus |
| ⊟ | Bin | \boxminus |
| ⊠ | Bin | \boxtimes |
| ⊡ | Bin | \boxdot |
| ⊢ | Rel | \vdash |
| ⊣ | Rel | \dashv |
| ⊤ | Ord | \top |
| ⊥ | Ord | \bot |
| ⊦ | Rel | \assert |
| ⊧ | Rel | \models |
| ⊨ | Rel | \vDash |
| ⊩ | Rel | \Vdash |
| ⊪ | Rel | \Vvdash |
| ⊫ | Rel | \VDash |
| ⊬ | Rel | \nvdash |
| ⊭ | Rel | \nvDash |
| ⊮ | Rel | \nVdash |
| ⊯ | Rel | \nVDash |
| | Rel | \prurel |
| | Rel | \scurel |
| ⊲ | Rel | \vartriangleleft |
| ⊳ | Rel | \vartriangleright |
| ⊴ | Rel | \trianglelefteq |
| ⊵ | Rel | \trianglerighteq |
| ⊶ | Rel | \origof |
| ⊷ | Rel | \imageof |
| ⊸ | Rel | \multimap |
| ⊹ | Ord | \hermitmatrix |
| ⊺ | Bin | \intercal |
| ⊻ | Bin | \veebar |
| ⊼ | Bin | \barwedge |
| ⊽ | Bin | \barvee |
| ⊾ | Ord | \measuredrightangle |
| ⊿ | Ord | \varlrtriangle |
| ⋀ | Op | \bigwedge |
| ⋁ | Op | \bigvee |
| ⋂ | Op | \bigcap |
| ⋃ | Op | \bigcup |
| ⋄ | Bin | \smwhtdiamond=\diamond |
| ⋅ | Bin | \cdot |
| ⋆ | Bin | \star |
| ⋇ | Bin | \divideontimes |
| ⋈ | Rel | \bowtie |
| ⋉ | Bin | \ltimes |
| ⋊ | Bin | \rtimes |
| ⋋ | Bin | \leftthreetimes |
| ⋌ | Bin | \rightthreetimes |
| ⋍ | Rel | \backsimeq |
| ⋎ | Bin | \curlyvee |
| ⋏ | Bin | \curlywedge |
| ⋐ | Rel | \Subset |
| ⋑ | Rel | \Supset |
| ⋒ | Bin | \Cap |
| ⋓ | Bin | \Cup |
| | Rel | \pitchfork |
| ⋕ | Rel | \equalparallel |
| ⋖ | Rel | \lessdot |
| ⋗ | Rel | \gtrdot |
| ⋘ | Rel | \lll |
| ⋙ | Rel | \ggg |
| ⋚ | Rel | \lesseqgtr |
| ⋛ | Rel | \gtreqless |
| ⋜ | Rel | \eqless |
| ⋝ | Rel | \eqgtr |
| ⋞ | Rel | \curlyeqprec |
| ⋟ | Rel | \curlyeqsucc |
| ⋠ | Rel | \npreccurlyeq |
| ⋡ | Rel | \nsucccurlyeq |
| ⋢ | Rel | \nsqsubseteq |
| ⋣ | Rel | \nsqsupseteq |
| ⋤ | Rel | \sqsubsetneq |
| ⋥ | Rel | \sqsupsetneq |
| ⋦ | Rel | \lnsim |
| ⋧ | Rel | \gnsim |
| ⋨ | Rel | \precnsim |
| ⋩ | Rel | \succnsim |
| ⋪ | Rel | \nvartriangleleft |
| ⋫ | Rel | \nvartriangleright |
| ⋬ | Rel | \ntrianglelefteq |
| ⋭ | Rel | \ntrianglerighteq |
| ⋮ | Rel | \unicodevdots |
| ⋯ | Ord | \unicodecdots |
| ⋰ | Rel | \unicodeadots |
| ⋱ | Rel | \unicodeddots |
| | Rel | \disin |

| | | |
|---|---|---|
| | Rel | \varisins |
| | Rel | \isins |
| | Rel | \isindot |
| | Rel | \varisinobar |
| | Rel | \isinobar |
| | Rel | \isinvb |
| | Rel | \isinE |
| | Rel | \nisd |
| | Rel | \varnis |
| | Rel | \nis |
| | Rel | \varniobar |
| | Rel | \niobar |
| | Rel | \bagmember |
| ⌀ | Ord | \diameter |
| | Ord | \house |
| ⌅ | Bin | \varbarwedge |
| ⌆ | Bin | \vardoublebarwedge |
| ⌈ | Open | \lceil |
| ⌉ | Close | \rceil |
| ⌊ | Open | \lfloor |
| ⌋ | Close | \rfloor |
| ⌐ | Ord | \invnot |
| | Ord | \sqlozenge |
| | Ord | \profline |
| | Ord | \profsurf |
| | Ord | \viewdata |
| ⌙ | Ord | \turnednot |
| ⌜ | Open | \ulcorner |
| ⌝ | Close | \urcorner |
| ⌞ | Open | \llcorner |
| ⌟ | Close | \lrcorner |
| | Ord | \inttop |
| | Ord | \intbottom |
| ⌢ | Rel | \frown |
| ⌣ | Rel | \smile |
| | Ord | \varhexagonlrbonds |
| | Ord | \conictaper |
| | Ord | \topbot |
| | Bin | \obar |
| | Rel | \APLnotslash |
| | Ord | \APLnotbackslash |
| | Ord | \APLboxupcaret |
| | Ord | \APLboxquestion |
| | Ord | \rangledownzigzagarrow |
| | Ord | \hexagon |
| | Ord | \lparenuend |
| | Ord | \lparenextender |
| | Ord | \lparenlend |
| | Ord | \rparenuend |
| | Ord | \rparenextender |
| | Ord | \rparenlend |
| | Ord | \lbrackuend |
| | Ord | \lbrackextender |
| | Ord | \lbracklend |
| | Ord | \rbrackuend |
| | Ord | \rbrackextender |
| | Ord | \rbracklend |
| | Ord | \lbraceuend |
| | Ord | \lbracemid |
| | Ord | \lbracelend |
| | Ord | \vbraceextender |
| | Ord | \rbraceuend |
| | Ord | \rbracemid |
| | Ord | \rbracelend |
| | Ord | \intextender |
| | Ord | \harrowextender |
| | Open | \lmoustache |
| | Close | \rmoustache |
| | Ord | \sumtop |
| | Ord | \sumbottom |
| ⎴ | Over | \overbracket |
| ⎵ | Under | \underbracket |
| | Ord | \bbrktbrk |
| | Ord | \sqrtbottom |
| | Ord | \lvboxline |
| | Ord | \rvboxline |
| | Ord | \varcarriagereturn |

| | | |
|---|---|---|
| ⏜ | Over | \overparen |
| ⏝ | Under | \underparen |
| ⏞ | Over | \overbrace |
| ⏟ | Under | \underbrace |
| | Ord | \obrbrak |
| | Ord | \ubrbrak |
| | Ord | \trapezium |
| | Ord | \benzenr |
| | Ord | \strns |
| | Ord | \fltns |
| | Ord | \accurrent |
| | Ord | \elinters |
| | Ord | \blanksymbol |
| | Ord | \mathvisiblespace |
| | Ord | \bdtriplevdash |
| | Ord | \blockuphalf |
| | Ord | \blocklowhalf |
| | Ord | \blockfull |
| | Ord | \blocklefthalf |
| | Ord | \blockrighthalf |
| | Ord | \blockqtrshaded |
| | Ord | \blockhalfshaded |
| | Ord | \blockthreeqtrshaded |
| ■ | Ord | \mdlgblksquare |
| □ | Ord | \mdlgwhtsquare |
| | Ord | \squoval |
| | Ord | \blackinwhitesquare |
| | Ord | \squarehfill |
| | Ord | \squarevfill |
| | Ord | \squarehvfill |
| | Ord | \squarenwsefill |
| | Ord | \squareneswfill |
| | Ord | \squarecrossfill |
| ▪ | Ord | \smblksquare |
| ▫ | Ord | \smwhtsquare |
| | Ord | \hrectangleblack |
| ▭ | Ord | \hrectangle |
| | Ord | \vrectangleblack |
| | Ord | \vrectangle |
| | Ord | \parallelogramblack |
| | Ord | \parallelogram |
| ▲ | Ord | \bigblacktriangleup |
| △ | Bin | \bigtriangleup |
| | Ord | \blacktriangle |
| | Rel | \vartriangle |
| ▶ | Ord | \blacktriangleright |
| ▷ | Bin | \triangleright |
| | Ord | \smallblacktriangleright |
| | Ord | \smalltriangleright |
| | Ord | \blackpointerright |
| | Ord | \whitepointerright |
| ▼ | Ord | \bigblacktriangledown |
| ▽ | Ord | \bigtriangledown |
| | Ord | \blacktriangledown |
| | Ord | \triangledown |
| ◀ | Ord | \blacktriangleleft |
| ◁ | Bin | \triangleleft |
| | Ord | \smallblacktriangleleft |
| | Ord | \smalltriangleleft |
| | Ord | \blackpointerleft |
| | Ord | \whitepointerleft |
| | Ord | \mdlgblkdiamond |
| | Ord | \mdlgwhtdiamond |
| | Ord | \blackinwhitediamond |
| | Ord | \fisheye |
| ◊ | Ord | \mdlgwhtlozenge |
| ○ | Bin | \mdlgwhtcircle=\bigcirc |
| | Ord | \dottedcircle |
| | Ord | \circlevertfill |
| | Ord | \bullseye |
| ● | Ord | \mdlgblkcircle |
| | Ord | \circlelefthalfblack |
| | Ord | \circlerighthalfblack |
| | Ord | \circlebottomhalfblack |
| | Ord | \circletophalfblack |
| | Ord | \circleurquadblack |
| | Ord | \blackcircleulquadwhite |

| | | |
|---|---|---|
| | Ord | \blacklefthalfcircle |
| | Ord | \blackrighthalfcircle |
| | Ord | \inversebullet |
| | Ord | \inversewhitecircle |
| | Ord | \invwhiteupperhalfcircle |
| | Ord | \invwhitelowerhalfcircle |
| | Ord | \ularc |
| | Ord | \urarc |
| | Ord | \lrarc |
| | Ord | \llarc |
| | Ord | \topsemicircle |
| | Ord | \botsemicircle |
| | Ord | \lrblacktriangle |
| | Ord | \llblacktriangle |
| | Ord | \ulblacktriangle |
| | Ord | \urblacktriangle |
| ◦ | Ord | \smwhtcircle |
| | Ord | \squareleftblack |
| | Ord | \squarerightblack |
| | Ord | \squareulblack |
| | Ord | \squarelrblack |
| | Bin | \boxbar |
| | Ord | \trianglecdot |
| | Ord | \triangleleftblack |
| | Ord | \trianglerightblack |
| ◯ | Ord | \lgwhtcircle |
| | Ord | \squareulquad |
| | Ord | \squarellquad |
| | Ord | \squarelrquad |
| | Ord | \squareurquad |
| | Ord | \circleulquad |
| | Ord | \circlellquad |
| | Ord | \circlelrquad |
| | Ord | \circleurquad |
| | Ord | \ultriangle |
| | Ord | \urtriangle |
| | Ord | \lltriangle |
| | Ord | \mdwhtsquare |
| | Ord | \mdblksquare |
| | Ord | \mdsmwhtsquare |
| | Ord | \mdsmblksquare |
| | Ord | \lrtriangle |
| | Ord | \bigstar |
| | Ord | \bigwhitestar |
| | Ord | \astrosun |
| | Ord | \danger |
| | Ord | \blacksmiley |
| | Ord | \sun |
| | Ord | \rightmoon |
| | Ord | \leftmoon |
| | Ord | \female |
| | Ord | \male |
| ♠ | Ord | \spadesuit |
| ♡ | Ord | \heartsuit |
| ♢ | Ord | \diamondsuit |
| ♣ | Ord | \clubsuit |
| ♤ | Ord | \varspadesuit |
| ♥ | Ord | \varheartsuit |
| ♦ | Ord | \vardiamondsuit |
| ♧ | Ord | \varclubsuit |
| | Ord | \quarternote |
| | Ord | \eighthnote |
| | Ord | \twonotes |
| ♭ | Ord | \flat |
| ♮ | Ord | \natural |
| ♯ | Ord | \sharp |
| | Ord | \acidfree |
| | Ord | \dicei |
| | Ord | \diceii |
| | Ord | \diceiii |
| | Ord | \diceiv |
| | Ord | \dicev |
| | Ord | \dicevi |
| | Ord | \circledrightdot |
| | Ord | \circledtwodots |
| | Ord | \blackcircledrightdot |
| | Ord | \blackcircledtwodots |

| | | |
|---|---|---|
| | Ord | \Hermaphrodite |
| | Ord | \mdwhtcircle |
| | Ord | \mdblkcircle |
| | Ord | \mdsmwhtcircle |
| | Ord | \neuter |
| ✓ | Ord | \checkmark |
| ✠ | Ord | \maltese |
| | Ord | \circledstar |
| | Ord | \varstar |
| | Ord | \dingasterisk |
| | Open | \lbrbrak |
| | Close | \rbrbrak |
| | Ord | \draftingarrow |
| | Ord | \threedangle |
| | Ord | \whiteinwhitetriangle |
| ⊥ | Rel | \perp |
| | Ord | \subsetcirc |
| | Ord | \supsetcirc |
| | Open | \lbag |
| | Close | \rbag |
| | Bin | \veedot |
| | Rel | \bsolhsub |
| | Rel | \suphsol |
| | Open | \longdivision |
| | Ord | \diamondcdot |
| | Bin | \wedgedot |
| | Rel | \upin |
| | Rel | \pullback |
| | Rel | \pushout |
| | Op | \leftouterjoin |
| | Op | \rightouterjoin |
| | Op | \fullouterjoin |
| ⟘ | Op | \bigbot |
| ⟙ | Op | \bigtop |
| ⟚ | Rel | \DashVDash |
| ⟛ | Rel | \dashVdash |
| ⟜ | Rel | \multimapinv |
| ⟝ | Rel | \vlongdash |
| ⟞ | Rel | \longdashv |
| | Rel | \cirbot |
| ⟠ | Bin | \lozengeminus |
| ⟡ | Bin | \concavediamond |
| ⟢ | Bin | \concavediamondtickleft |
| ⟣ | Bin | \concavediamondtickright |
| | Bin | \whitesquaretickleft |
| | Bin | \whitesquaretickright |
| ⟦ | Open | \lBrack |
| ⟧ | Close | \rBrack |
| ⟨ | Open | \langle |
| ⟩ | Close | \rangle |
| ⟪ | Open | \lAngle |
| ⟫ | Close | \rAngle |
| | Open | \Lbrbrak |
| | Close | \Rbrbrak |
| ⟮ | Open | \lgroup |
| ⟯ | Close | \rgroup |
| | Rel | \UUparrow |
| | Rel | \DDownarrow |
| | Rel | \acwgapcirclearrow |
| | Rel | \cwgapcirclearrow |
| ⟴ | Rel | \rightarrowonoplus |
| ⟵ | Rel | \longleftarrow |
| ⟶ | Rel | \longrightarrow |
| ⟷ | Rel | \longleftrightarrow |
| ⟸ | Rel | \Longleftarrow |
| ⟹ | Rel | \Longrightarrow |
| ⟺ | Rel | \Longleftrightarrow |
| ⟻ | Rel | \longmapsfrom |
| ⟼ | Rel | \longmapsto |
| ⟽ | Rel | \Longmapsfrom |
| ⟾ | Rel | \Longmapsto |
| ⟿ | Rel | \longrightsquigarrow |
| | Rel | \nvtwoheadrightarrow |
| | Rel | \nVtwoheadrightarrow |
| | Rel | \nvLeftarrow |
| | Rel | \nvRightarrow |
| | Rel | \nvLeftrightarrow |
| | Rel | \twoheadmapsto |
| ⤆ | Rel | \Mapsfrom |
| ⤇ | Rel | \Mapsto |
| | Rel | \downarrowbarred |
| | Rel | \uparrowbarred |
| | Rel | \Uuparrow |
| | Rel | \Ddownarrow |
| | Rel | \leftbkarrow |
| | Rel | \rightbkarrow |
| | Rel | \leftdbkarrow |
| | Rel | \dbkarrow=\dbkarow |
| | Rel | \drbkarrow=\drbkarow |
| | Rel | \rightdotarrow |
| | Rel | \baruparrow |
| | Rel | \downarrowbar |
| | Rel | \nvrightarrowtail |
| | Rel | \nVrightarrowtail |
| | Rel | \twoheadrightarrowtail |
| | Rel | \nvtwoheadrightarrowtail |
| | Rel | \nVtwoheadrightarrowtail |
| | Rel | \lefttail |
| | Rel | \righttail |
| | Rel | \leftdbltail |
| | Rel | \rightdbltail |
| | Rel | \diamondleftarrow |
| | Rel | \rightarrowdiamond |
| | Rel | \diamondleftarrowbar |
| | Rel | \barrightarrowdiamond |
| | Rel | \nwsearrow |
| | Rel | \neswarrow |
| | Rel | \hknwarrow |
| | Rel | \hknearrow |
| | Rel | \hksearrow=\hksearow |
| | Rel | \hkswarrow=\hkswarow |
| | Rel | \tona |
| | Rel | \toea |
| | Rel | \tosa |
| | Rel | \towa |
| | Ord | \rdiagovfdiag |
| | Ord | \fdiagovrdiag |
| | Ord | \seovnearrow |
| | Ord | \neovsearrow |
| | Ord | \fdiagovnearrow |
| | Ord | \rdiagovsearrow |
| | Ord | \neovnwarrow |
| | Ord | \nwovnearrow |
| | Rel | \rightcurvedarrow |
| | Ord | \uprightcurvearrow |
| | Ord | \downrightcurvedarrow |
| | Rel | \leftdowncurvedarrow |
| | Rel | \rightdowncurvedarrow |
| | Rel | \cwrightarcarrow |
| | Rel | \acwleftarcarrow |
| | Rel | \acwoverarcarrow |
| | Rel | \acwunderarcarrow |
| | Rel | \curvearrowrightminus |
| | Rel | \curvearrowleftplus |
| | Rel | \cwundercurvearrow |
| | Rel | \ccwundercurvearrow |
| | Rel | \acwcirclearrow |
| | Rel | \cwcirclearrow |
| | Rel | \rightarrowshortleftarrow |
| | Rel | \leftarrowshortrightarrow |
| | Rel | \shortrightarrowleftarrow |
| | Rel | \rightarrowplus |
| | Rel | \leftarrowplus |
| | Rel | \rightarrowx |
| | Rel | \leftrightarrowcircle |
| | Rel | \twoheaduparrowcircle |
| | Rel | \leftrightharpoonupdown |
| | Rel | \leftrightharpoondownup |
| | Rel | \updownharpoonrightleft |
| | Rel | \updownharpoonleftright |
| | Rel | \leftrightharpoonupup |
| | Rel | \updownharpoonrightright |
| | Rel | \leftrightharpoondowndown |
| | Rel | \updownharpoonleftleft |
| | Rel | \barleftharpoonup |
| | Rel | \rightharpoonupbar |
| | Rel | \barupharpoonright |
| | Rel | \downharpoonrightbar |
| | Rel | \barleftharpoondown |
| | Rel | \rightharpoondownbar |
| | Rel | \barupharpoonleft |
| | Rel | \downharpoonleftbar |
| | Rel | \leftharpoonupbar |
| | Rel | \barrightharpoonup |
| | Rel | \upharpoonrightbar |
| | Rel | \bardownharpoonright |
| | Rel | \leftharpoondownbar |
| | Rel | \barrightharpoondown |
| | Rel | \upharpoonleftbar |
| | Rel | \bardownharpoonleft |
| | Rel | \leftharpoonsupdown |
| | Rel | \upharpoonsleftright |
| | Rel | \rightharpoonsupdown |
| | Rel | \downharpoonsleftright |
| | Rel | \leftrightharpoonsup |
| | Rel | \leftrightharpoonsdown |
| | Rel | \rightleftharpoonsup |
| | Rel | \rightleftharpoonsdown |
| | Rel | \leftharpoonupdash |
| | Rel | \dashleftharpoondown |
| | Rel | \rightharpoonupdash |
| | Rel | \dashrightharpoondown |
| | Rel | \updownharpoonsleftright |
| | Rel | \downupharpoonsleftright |
| | Rel | \rightimply |
| | Rel | \equalrightarrow |
| | Rel | \similarrightarrow |
| | Rel | \leftarrowsimilar |
| | Rel | \rightarrowsimilar |
| | Rel | \rightarrowapprox |
| | Rel | \ltlarr |
| | Rel | \leftarrowless |
| | Rel | \gtrarr |
| | Rel | \subrarr |
| | Rel | \leftarrowsubset |
| | Rel | \suplarr |
| | Rel | \leftfishtail |
| | Rel | \rightfishtail |
| | Rel | \upfishtail |
| | Rel | \downfishtail |
| | Fence | \Vvert |
| | Ord | \mdsmblkcircle |
| | Rel | \typecolon |
| | Open | \lBrace |
| | Close | \rBrace |
| | Open | \lParen |
| | Close | \rParen |
| | Open | \llparenthesis |
| | Close | \rrparenthesis |
| | Open | \llangle |
| | Close | \rrangle |
| | Open | \lbrackubar |
| | Close | \rbrackubar |
| | Open | \lbrackultick |
| | Close | \rbracklrtick |
| | Open | \lbracklltick |
| | Close | \rbrackurtick |
| | Open | \langledot |
| | Close | \rangledot |
| | Open | \lparenless |
| | Close | \rparengtr |
| | Open | \Lparengtr |
| | Close | \Rparenless |
| | Open | \lblkbrbrak |
| | Close | \rblkbrbrak |
| | Ord | \fourvdots |
| | Ord | \vzigzag |
| | Ord | \measuredangleleft |
| | Ord | \rightanglesqr |
| | Ord | \rightanglemdot |
| | Ord | \angles |

| | | |
|---|---|---|
| | Ord | \angdnr |
| | Ord | \gtlpar |
| | Ord | \sphericalangleup |
| | Ord | \turnangle |
| | Ord | \revangle |
| | Ord | \angleubar |
| | Ord | \revangleubar |
| | Ord | \wideangledown |
| | Ord | \wideangleup |
| | Ord | \measanglerutone |
| | Ord | \measanglelutonw |
| | Ord | \measanglerdtose |
| | Ord | \measangleldtosw |
| | Ord | \measangleurtone |
| | Ord | \measangleultonw |
| | Ord | \measangledrtose |
| | Ord | \measangledltosw |
| | Ord | \revemptyset |
| | Ord | \emptysetobar |
| | Ord | \emptysetocirc |
| | Ord | \emptysetoarr |
| | Ord | \emptysetoarrl |
| | Bin | \circlehbar |
| | Bin | \circledvert |
| | Bin | \circledparallel |
| | Bin | \obslash |
| | Bin | \operp |
| | Ord | \obot |
| | Ord | \olcross |
| | Ord | \odotslashdot |
| | Ord | \uparrowoncircle |
| | Ord | \circledwhitebullet |
| | Ord | \circledbullet |
| | Bin | \olessthan |
| | Bin | \ogreaterthan |
| | Ord | \cirscir |
| | Ord | \cirE |
| | Bin | \boxdiag |
| | Bin | \boxbslash |
| | Bin | \boxast |
| | Bin | \boxcircle |
| | Bin | \boxbox |
| | Ord | \boxonbox |
| | Ord | \triangleodot |
| | Ord | \triangleubar |
| | Ord | \triangles |
| | Bin | \triangleserifs |
| | Rel | \rtriltri |
| | Rel | \ltrivb |
| | Rel | \vbrtri |
| | Rel | \lfbowtie |
| | Rel | \rfbowtie |
| | Rel | \fbowtie |
| | Rel | \lftimes |
| | Rel | \rftimes |
| | Bin | \hourglass |
| | Bin | \blackhourglass |
| | Open | \lvzigzag |
| | Close | \rvzigzag |
| | Open | \Lvzigzag |
| | Close | \Rvzigzag |
| | Ord | \iinfin |
| | Ord | \tieinfty |
| | Ord | \nvinfty |
| | Rel | \dualmap |
| | Ord | \laplac |
| | Rel | \lrtriangleeq |
| | Bin | \shuffle |
| | Rel | \eparsl |
| | Rel | \smeparsl |
| | Rel | \eqvparsl |
| | Rel | \gleichstark |
| | Ord | \thermod |
| | Ord | \downtriangleleftblack |
| | Ord | \downtrianglerightblack |
| | Ord | \blackdiamonddownarrow |
| | Bin | \mdlgblklozenge |

| | | |
|---|---|---|
| | Ord | \circledownarrow |
| | Ord | \blackcircledownarrow |
| | Ord | \errbarsquare |
| | Ord | \errbarblacksquare |
| | Ord | \errbardiamond |
| | Ord | \errbarblackdiamond |
| | Ord | \errbarcircle |
| | Ord | \errbarblackcircle |
| | Rel | \ruledelayed |
| $\setminus$ | Bin | \setminus |
| | Bin | \dsol |
| | Bin | \rsolbar |
| | Op | \xsol |
| | Op | \xbsol |
| | Bin | \doubleplus |
| | Bin | \tripleplus |
| | Open | \lcurvyangle |
| | Close | \rcurvyangle |
| | Bin | \tplus |
| | Bin | \tminus |
| $\bigodot$ | Op | \bigodot |
| $\bigoplus$ | Op | \bigoplus |
| $\bigotimes$ | Op | \bigotimes |
| ⨃ | Op | \bigcupdot |
| $\biguplus$ | Op | \biguplus |
| ⨅ | Op | \bigsqcap |
| $\bigsqcup$ | Op | \bigsqcup |
| | Op | \conjquant |
| | Op | \disjquant |
| ⨉ | Op | \bigtimes |
| | Op | \modtwosum |
| | Op | \sumint |
| $\iiiint$ | Op | \iiiint |
| | Op | \intbar |
| | Op | \intBar |
| | Op | \fint |
| | Op | \cirfnint |
| ⨑ | Op | \awint |
| | Op | \rppolint |
| | Op | \scpolint |
| | Op | \npolint |
| | Op | \pointint |
| | Op | \sqint |
| | Op | \intlarhk |
| | Op | \intx |
| | Op | \intcap |
| | Op | \intcup |
| | Op | \upint |
| | Op | \lowint |
| | Op | \Join |
| | Op | \bigtriangleleft |
| | Op | \zcmp |
| | Op | \zpipe |
| | Op | \zproject |
| | Bin | \ringplus |
| | Bin | \plushat |
| | Bin | \simplus |
| | Bin | \plusdot |
| | Bin | \plussim |
| | Bin | \plussubtwo |
| | Bin | \plustrif |
| | Bin | \commaminus |
| | Bin | \minusdot |
| | Bin | \minusfdots |
| | Bin | \minusrdots |
| | Bin | \opluslhrim |
| | Bin | \oplusrhrim |
| ⨯ | Bin | \vectimes |
| | Bin | \dottimes |
| | Bin | \timesbar |
| | Bin | \btimes |
| | Bin | \smashtimes |
| | Bin | \otimeslhrim |
| | Bin | \otimesrhrim |
| | Bin | \otimeshat |
| | Bin | \Otimes |
| | Bin | \odiv |

| | | |
|---|---|---|
| | Bin | \triangleplus |
| | Bin | \triangleminus |
| | Bin | \triangletimes |
| | Bin | \intprod |
| | Bin | \intprodr |
| | Bin | \fcmp |
| $\amalg$ | Bin | \amalg |
| | Bin | \capdot |
| | Bin | \uminus |
| | Bin | \barcup |
| | Bin | \barcap |
| | Bin | \capwedge |
| | Bin | \cupvee |
| | Bin | \cupovercap |
| | Bin | \capovercup |
| | Bin | \cupbarcap |
| | Bin | \capbarcup |
| | Bin | \twocups |
| | Bin | \twocaps |
| | Bin | \closedvarcup |
| | Bin | \closedvarcap |
| | Bin | \Sqcap |
| | Bin | \Sqcup |
| | Bin | \closedvarcupsmashprod |
| | Bin | \wedgeodot |
| | Bin | \veeodot |
| | Bin | \Wedge |
| | Bin | \Vee |
| | Bin | \wedgeonwedge |
| | Bin | \veeonvee |
| | Bin | \bigslopedvee |
| | Bin | \bigslopedwedge |
| | Rel | \veeonwedge |
| | Bin | \wedgemidvert |
| | Bin | \veemidvert |
| | Bin | \midbarwedge |
| | Bin | \midbarvee |
| | Bin | \doublebarwedge |
| | Bin | \wedgebar |
| | Bin | \wedgedoublebar |
| | Bin | \varveebar |
| | Bin | \doublebarvee |
| | Bin | \veedoublebar |
| | Bin | \dsub |
| | Bin | \rsub |
| | Rel | \eqdot |
| | Rel | \dotequiv |
| | Rel | \equivVert |
| | Rel | \equivVvert |
| | Rel | \dotsim |
| | Rel | \simrdots |
| | Rel | \simminussim |
| | Rel | \congdot |
| | Rel | \asteq |
| | Rel | \hatapprox |
| | Rel | \approxeqq |
| | Bin | \eqqplus |
| | Bin | \pluseqq |
| | Rel | \eqqsim |
| | Rel | \Coloneq |
| | Rel | \eqeq |
| | Rel | \eqeqeq |
| | Rel | \ddotseq |
| | Rel | \equivDD |
| | Rel | \ltcir |
| | Rel | \gtcir |
| | Rel | \ltquest |
| | Rel | \gtquest |
| $\leqslant$ | Rel | \leqslant |
| $\geqslant$ | Rel | \geqslant |
| | Rel | \lesdot |
| | Rel | \gesdot |
| | Rel | \lesdoto |
| | Rel | \gesdoto |
| | Rel | \lesdotor |
| | Rel | \gesdotol |
| $\lessapprox$ | Rel | \lessapprox |

| | | |
|---|---|---|
| ⪆ | Rel | \gtrapprox |
| ⪇ | Rel | \lneq |
| ⪈ | Rel | \gneq |
| ⪉ | Rel | \lnapprox |
| ⪊ | Rel | \gnapprox |
| ⪋ | Rel | \lesseqqgtr |
| ⪌ | Rel | \gtreqqless |
| | Rel | \lsime |
| | Rel | \gsime |
| | Rel | \lsimg |
| | Rel | \gsiml |
| | Rel | \lgE |
| | Rel | \glE |
| | Rel | \lesges |
| | Rel | \gesles |
| ⪕ | Rel | \eqslantless |
| ⪖ | Rel | \eqslantgtr |
| | Rel | \elsdot |
| | Rel | \egsdot |
| | Rel | \eqqless |
| | Rel | \eqqgtr |
| | Rel | \eqqslantless |
| | Rel | \eqqslantgtr |
| | Rel | \simless |
| | Rel | \simgtr |
| | Rel | \simlE |
| | Rel | \simgE |
| | Rel | \Lt |
| | Rel | \Gt |
| | Rel | \partialmeetcontraction |
| | Rel | \glj |
| | Rel | \gla |
| | Rel | \ltcc |
| | Rel | \gtcc |
| | Rel | \lescc |
| | Rel | \gescc |
| | Rel | \smt |
| | Rel | \lat |
| | Rel | \smte |
| | Rel | \late |
| | Rel | \bumpeqq |
| ⪯ | Rel | \preceq |
| ⪰ | Rel | \succeq |
| | Rel | \precneq |
| | Rel | \succneq |
| | Rel | \preceqq |
| | Rel | \succeqq |
| | Rel | \precneqq |
| | Rel | \succneqq |
| | Rel | \precapprox |
| | Rel | \succapprox |
| | Rel | \precnapprox |
| | Rel | \succnapprox |
| | Rel | \Prec |
| | Rel | \Succ |
| | Rel | \subsetdot |
| | Rel | \supsetdot |
| | Rel | \subsetplus |
| | Rel | \supsetplus |
| | Rel | \submult |
| | Rel | \supmult |
| | Rel | \subedot |
| | Rel | \supedot |
| | Rel | \subseteqq |
| | Rel | \supseteqq |
| | Rel | \subsim |
| | Rel | \supsim |
| | Rel | \subsetapprox |
| | Rel | \supsetapprox |
| | Rel | \subsetneqq |
| | Rel | \supsetneqq |
| | Rel | \lsqhook |
| | Rel | \rsqhook |
| | Rel | \csub |
| | Rel | \csup |
| | Rel | \csube |
| | Rel | \csupe |
| | Rel | \subsup |
| | Rel | \supsub |
| | Rel | \subsub |
| | Rel | \supsup |
| | Rel | \suphsub |
| | Rel | \supdsub |
| | Rel | \forkv |
| | Rel | \topfork |
| | Rel | \mlcp |
| | Rel | \forks |
| | Rel | \forksnot |
| | Rel | \shortlefttack |
| | Rel | \shortdowntack |
| | Rel | \shortuptack |
| | Ord | \perps |
| | Rel | \vDdash |
| | Rel | \dashV |
| | Rel | \Dashv |
| | Rel | \DashV |
| | Rel | \varVdash |
| | Rel | \Barv |
| | Rel | \vBar |
| | Rel | \vBarv |
| | Rel | \barV |
| | Rel | \Vbar |
| | Rel | \Not |
| | Rel | \bNot |
| | Rel | \revnmid |
| | Rel | \cirmid |
| | Rel | \midcir |
| | Ord | \topcir |
| | Rel | \nhpar |
| | Rel | \parsim |
| | Bin | \interleave |
| | Bin | \nhVvert |
| | Bin | \threedotcolon |
| | Rel | \lllnest |
| | Rel | \gggnest |
| | Rel | \leqqslant |
| | Rel | \geqqslant |
| | Bin | \trslash |
| | Op | \biginterleave |
| | Bin | \sslash |
| | Bin | \talloblong |
| | Op | \bigtalloblong |
| | Ord | \squaretopblack |
| | Ord | \squarebotblack |
| | Ord | \squareurblack |
| | Ord | \squarellblack |
| | Ord | \diamondleftblack |
| | Ord | \diamondrightblack |
| | Ord | \diamondtopblack |
| | Ord | \diamondbotblack |
| | Ord | \dottedsquare |
| | Ord | \lgblksquare |
| | Ord | \lgwhtsquare |
| | Ord | \vysmblksquare |
| | Ord | \vysmwhtsquare |
| | Ord | \pentagonblack |
| | Ord | \pentagon |
| | Ord | \varhexagon |
| | Ord | \varhexagonblack |
| | Ord | \hexagonblack |
| | Ord | \lgblkcircle |
| | Ord | \mdblkdiamond |
| | Ord | \mdwhtdiamond |
| | Ord | \mdblklozenge |
| | Ord | \mdwhtlozenge |
| | Ord | \smblkdiamond |
| | Ord | \smblklozenge |
| | Ord | \smwhtlozenge |
| | Ord | \blkhorzoval |
| | Ord | \whthorzoval |
| | Ord | \blkvertoval |
| | Ord | \whtvertoval |
| | Rel | \circleonleftarrow |
| ⬱ | Rel | \leftthreearrows |
| | Rel | \leftarrowonoplus |
| ⬳ | Rel | \longleftsquigarrow |
| | Rel | \nvtwoheadleftarrow |
| | Rel | \nVtwoheadleftarrow |
| | Rel | \twoheadmapsfrom |
| | Rel | \twoheadleftdbkarrow |
| | Rel | \leftdotarrow |
| | Rel | \nvleftarrowtail |
| | Rel | \nVleftarrowtail |
| | Rel | \twoheadleftarrowtail |
| | Rel | \nvtwoheadleftarrowtail |
| | Rel | \nVtwoheadleftarrowtail |
| | Rel | \leftarrowx |
| | Rel | \leftcurvedarrow |
| | Rel | \equalleftarrow |
| | Rel | \bsimilarleftarrow |
| | Rel | \leftarrowbackapprox |
| | Rel | \rightarrowgtr |
| | Rel | \rightarrowsupset |
| | Rel | \LLeftarrow |
| | Rel | \RRightarrow |
| | Rel | \bsimilarrightarrow |
| | Rel | \rightarrowbackapprox |
| | Rel | \similarleftarrow |
| | Rel | \leftarrowapprox |
| | Rel | \leftarrowbsimilar |
| | Rel | \rightarrowbsimilar |
| | Ord | \medwhitestar |
| | Ord | \medblackstar |
| | Ord | \smwhitestar |
| | Ord | \rightpentagonblack |
| | Ord | \rightpentagon |
| | Ord | \postalmark |
| | Ord | \hzigzag |

Codes U+10001 … U+1EEF1

| | | |
|---|---|---|
| **A** | Alph | \mbfA |
| **B** | Alph | \mbfB |
| **C** | Alph | \mbfC |
| **D** | Alph | \mbfD |
| **E** | Alph | \mbfE |
| **F** | Alph | \mbfF |
| **G** | Alph | \mbfG |
| **H** | Alph | \mbfH |
| **I** | Alph | \mbfI |
| **J** | Alph | \mbfJ |
| **K** | Alph | \mbfK |
| **L** | Alph | \mbfL |
| **M** | Alph | \mbfM |
| **N** | Alph | \mbfN |
| **O** | Alph | \mbfO |
| **P** | Alph | \mbfP |
| **Q** | Alph | \mbfQ |
| **R** | Alph | \mbfR |
| **S** | Alph | \mbfS |
| **T** | Alph | \mbfT |
| **U** | Alph | \mbfU |
| **V** | Alph | \mbfV |
| **W** | Alph | \mbfW |
| **X** | Alph | \mbfX |
| **Y** | Alph | \mbfY |
| **Z** | Alph | \mbfZ |
| **a** | Alph | \mbfa |
| **b** | Alph | \mbfb |
| **c** | Alph | \mbfc |
| **d** | Alph | \mbfd |
| **e** | Alph | \mbfe |
| **f** | Alph | \mbff |
| **g** | Alph | \mbfg |
| **h** | Alph | \mbfh |
| **i** | Alph | \mbfi |
| **j** | Alph | \mbfj |
| **k** | Alph | \mbfk |
| **l** | Alph | \mbfl |
| **m** | Alph | \mbfm |
| **n** | Alph | \mbfn |
| **o** | Alph | \mbfo |
| **p** | Alph | \mbfp |
| **q** | Alph | \mbfq |
| **r** | Alph | \mbfr |

| | | |
|---|---|---|
| 𝐬 | Alph | \mbfs |
| 𝐭 | Alph | \mbft |
| 𝐮 | Alph | \mbfu |
| 𝐯 | Alph | \mbfv |
| 𝐰 | Alph | \mbfw |
| 𝐱 | Alph | \mbfx |
| 𝐲 | Alph | \mbfy |
| 𝐳 | Alph | \mbfz |
| 𝐴 | Alph | \mitA |
| 𝐵 | Alph | \mitB |
| 𝐶 | Alph | \mitC |
| 𝐷 | Alph | \mitD |
| 𝐸 | Alph | \mitE |
| 𝐹 | Alph | \mitF |
| 𝐺 | Alph | \mitG |
| 𝐻 | Alph | \mitH |
| 𝐼 | Alph | \mitI |
| 𝐽 | Alph | \mitJ |
| 𝐾 | Alph | \mitK |
| 𝐿 | Alph | \mitL |
| 𝑀 | Alph | \mitM |
| 𝑁 | Alph | \mitN |
| 𝑂 | Alph | \mitO |
| 𝑃 | Alph | \mitP |
| 𝑄 | Alph | \mitQ |
| 𝑅 | Alph | \mitR |
| 𝑆 | Alph | \mitS |
| 𝑇 | Alph | \mitT |
| 𝑈 | Alph | \mitU |
| 𝑉 | Alph | \mitV |
| 𝑊 | Alph | \mitW |
| 𝑋 | Alph | \mitX |
| 𝑌 | Alph | \mitY |
| 𝑍 | Alph | \mitZ |
| 𝑎 | Alph | \mita |
| 𝑏 | Alph | \mitb |
| 𝑐 | Alph | \mitc |
| 𝑑 | Alph | \mitd |
| 𝑒 | Alph | \mite |
| 𝑓 | Alph | \mitf |
| 𝑔 | Alph | \mitg |
| 𝑖 | Alph | \miti |
| 𝑗 | Alph | \mitj |
| 𝑘 | Alph | \mitk |
| 𝑙 | Alph | \mitl |
| 𝑚 | Alph | \mitm |
| 𝑛 | Alph | \mitn |
| 𝑜 | Alph | \mito |
| 𝑝 | Alph | \mitp |
| 𝑞 | Alph | \mitq |
| 𝑟 | Alph | \mitr |
| 𝑠 | Alph | \mits |
| 𝑡 | Alph | \mitt |
| 𝑢 | Alph | \mitu |
| 𝑣 | Alph | \mitv |
| 𝑤 | Alph | \mitw |
| 𝑥 | Alph | \mitx |
| 𝑦 | Alph | \mity |
| 𝑧 | Alph | \mitz |
| 𝑨 | Alph | \mbfitA |
| 𝑩 | Alph | \mbfitB |
| 𝑪 | Alph | \mbfitC |
| 𝑫 | Alph | \mbfitD |
| 𝑬 | Alph | \mbfitE |
| 𝑭 | Alph | \mbfitF |
| 𝑮 | Alph | \mbfitG |
| 𝑯 | Alph | \mbfitH |
| 𝑰 | Alph | \mbfitI |
| 𝑱 | Alph | \mbfitJ |
| 𝑲 | Alph | \mbfitK |
| 𝑳 | Alph | \mbfitL |
| 𝑴 | Alph | \mbfitM |
| 𝑵 | Alph | \mbfitN |
| 𝑶 | Alph | \mbfitO |
| 𝑷 | Alph | \mbfitP |
| 𝑸 | Alph | \mbfitQ |
| 𝑹 | Alph | \mbfitR |
| 𝑺 | Alph | \mbfitS |
| 𝑻 | Alph | \mbfitT |
| 𝑼 | Alph | \mbfitU |
| 𝑽 | Alph | \mbfitV |
| 𝑾 | Alph | \mbfitW |
| 𝑿 | Alph | \mbfitX |
| 𝒀 | Alph | \mbfitY |
| 𝒁 | Alph | \mbfitZ |
| 𝒂 | Alph | \mbfita |
| 𝒃 | Alph | \mbfitb |
| 𝒄 | Alph | \mbfitc |
| 𝒅 | Alph | \mbfitd |
| 𝒆 | Alph | \mbfite |
| 𝒇 | Alph | \mbfitf |
| 𝒈 | Alph | \mbfitg |
| 𝒉 | Alph | \mbfith |
| 𝒊 | Alph | \mbfiti |
| 𝒋 | Alph | \mbfitj |
| 𝒌 | Alph | \mbfitk |
| 𝒍 | Alph | \mbfitl |
| 𝒎 | Alph | \mbfitm |
| 𝒏 | Alph | \mbfitn |
| 𝒐 | Alph | \mbfito |
| 𝒑 | Alph | \mbfitp |
| 𝒒 | Alph | \mbfitq |
| 𝒓 | Alph | \mbfitr |
| 𝒔 | Alph | \mbfits |
| 𝒕 | Alph | \mbfitt |
| 𝒖 | Alph | \mbfitu |
| 𝒗 | Alph | \mbfitv |
| 𝒘 | Alph | \mbfitw |
| 𝒙 | Alph | \mbfitx |
| 𝒚 | Alph | \mbfity |
| 𝒛 | Alph | \mbfitz |
| 𝒜 | Alph | \mscrA |
| 𝒞 | Alph | \mscrC |
| 𝒟 | Alph | \mscrD |
| 𝒢 | Alph | \mscrG |
| 𝒥 | Alph | \mscrJ |
| 𝒦 | Alph | \mscrK |
| 𝒩 | Alph | \mscrN |
| 𝒪 | Alph | \mscrO |
| 𝒫 | Alph | \mscrP |
| 𝒬 | Alph | \mscrQ |
| 𝒮 | Alph | \mscrS |
| 𝒯 | Alph | \mscrT |
| 𝒰 | Alph | \mscrU |
| 𝒱 | Alph | \mscrV |
| 𝒲 | Alph | \mscrW |
| 𝒳 | Alph | \mscrX |
| 𝒴 | Alph | \mscrY |
| 𝒵 | Alph | \mscrZ |
| | Alph | \mscra |
| | Alph | \mscrb |
| | Alph | \mscrc |
| | Alph | \mscrd |
| | Alph | \mscrf |
| | Alph | \mscrh |
| | Alph | \mscri |
| | Alph | \mscrj |
| | Alph | \mscrk |
| | Alph | \mscrl |
| | Alph | \mscrm |
| | Alph | \mscrn |
| | Alph | \mscrp |
| | Alph | \mscrq |
| | Alph | \mscrr |
| | Alph | \mscrs |
| | Alph | \mscrt |
| | Alph | \mscru |
| | Alph | \mscrv |
| | Alph | \mscrw |
| | Alph | \mscrx |
| | Alph | \mscry |
| | Alph | \mscrz |
| 𝓐 | Alph | \mbfscrA |
| 𝓑 | Alph | \mbfscrB |
| 𝓒 | Alph | \mbfscrC |
| 𝓓 | Alph | \mbfscrD |
| 𝓔 | Alph | \mbfscrE |
| 𝓕 | Alph | \mbfscrF |
| 𝓖 | Alph | \mbfscrG |
| 𝓗 | Alph | \mbfscrH |
| 𝓘 | Alph | \mbfscrI |
| 𝓙 | Alph | \mbfscrJ |
| 𝓚 | Alph | \mbfscrK |
| 𝓛 | Alph | \mbfscrL |
| 𝓜 | Alph | \mbfscrM |
| 𝓝 | Alph | \mbfscrN |
| 𝓞 | Alph | \mbfscrO |
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| 𝓠 | Alph | \mbfscrQ |
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| 𝓥 | Alph | \mbfscrV |
| 𝓦 | Alph | \mbfscrW |
| 𝓧 | Alph | \mbfscrX |
| 𝓨 | Alph | \mbfscrY |
| 𝓩 | Alph | \mbfscrZ |
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| | Alph | \mbfscrb |
| | Alph | \mbfscrc |
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| | Alph | \mbfscrw |
| | Alph | \mbfscrx |
| | Alph | \mbfscry |
| | Alph | \mbfscrz |
| 𝔄 | Alph | \mfrakA |
| 𝔅 | Alph | \mfrakB |
| 𝔇 | Alph | \mfrakD |
| 𝔈 | Alph | \mfrakE |
| 𝔉 | Alph | \mfrakF |
| 𝔊 | Alph | \mfrakG |
| 𝔍 | Alph | \mfrakJ |
| 𝔎 | Alph | \mfrakK |
| 𝔏 | Alph | \mfrakL |
| 𝔐 | Alph | \mfrakM |
| 𝔑 | Alph | \mfrakN |
| 𝔒 | Alph | \mfrakO |
| 𝔓 | Alph | \mfrakP |
| 𝔔 | Alph | \mfrakQ |
| 𝔖 | Alph | \mfrakS |
| 𝔗 | Alph | \mfrakT |
| 𝔘 | Alph | \mfrakU |
| 𝔙 | Alph | \mfrakV |
| 𝔚 | Alph | \mfrakW |
| 𝔛 | Alph | \mfrakX |
| 𝔜 | Alph | \mfrakY |
| 𝔞 | Alph | \mfraka |
| 𝔟 | Alph | \mfrakb |
| 𝔠 | Alph | \mfrakc |
| 𝔡 | Alph | \mfrakd |
| 𝔢 | Alph | \mfrake |
| 𝔣 | Alph | \mfrakf |
| 𝔤 | Alph | \mfrakg |
| 𝔥 | Alph | \mfrakh |
| 𝔦 | Alph | \mfraki |
| 𝔧 | Alph | \mfrakj |
| 𝔨 | Alph | \mfrakk |
| 𝔩 | Alph | \mfrakl |
| 𝔪 | Alph | \mfrakm |
| 𝔫 | Alph | \mfrakn |
| 𝔬 | Alph | \mfrako |
| 𝔭 | Alph | \mfrakp |
| 𝔮 | Alph | \mfrakq |
| 𝔯 | Alph | \mfrakr |
| 𝔰 | Alph | \mfraks |
| 𝔱 | Alph | \mfrakt |
| 𝔲 | Alph | \mfraku |
| 𝔳 | Alph | \mfrakv |
| 𝔴 | Alph | \mfrakw |
| 𝔵 | Alph | \mfrakx |
| 𝔶 | Alph | \mfraky |
| 𝔷 | Alph | \mfrakz |
| 𝔸 | Alph | \BbbA |
| 𝔹 | Alph | \BbbB |
| 𝔻 | Alph | \BbbD |
| 𝔼 | Alph | \BbbE |
| 𝔽 | Alph | \BbbF |
| 𝔾 | Alph | \BbbG |
| 𝕀 | Alph | \BbbI |
| 𝕁 | Alph | \BbbJ |
| 𝕂 | Alph | \BbbK |
| 𝕃 | Alph | \BbbL |
| 𝕄 | Alph | \BbbM |
| 𝕆 | Alph | \BbbO |
| 𝕊 | Alph | \BbbS |
| 𝕋 | Alph | \BbbT |
| 𝕌 | Alph | \BbbU |
| 𝕍 | Alph | \BbbV |
| 𝕎 | Alph | \BbbW |
| 𝕏 | Alph | \BbbX |
| 𝕐 | Alph | \BbbY |
| 𝕒 | Alph | \Bbba |
| 𝕓 | Alph | \Bbbb |
| 𝕔 | Alph | \Bbbc |
| 𝕕 | Alph | \Bbbd |
| 𝕖 | Alph | \Bbbe |
| 𝕗 | Alph | \Bbbf |
| 𝕘 | Alph | \Bbbg |
| 𝕙 | Alph | \Bbbh |
| 𝕚 | Alph | \Bbbi |
| 𝕛 | Alph | \Bbbj |
| 𝕜 | Alph | \Bbbk |
| 𝕝 | Alph | \Bbbl |
| 𝕞 | Alph | \Bbbm |
| 𝕟 | Alph | \Bbbn |
| 𝕠 | Alph | \Bbbo |
| 𝕡 | Alph | \Bbbp |
| 𝕢 | Alph | \Bbbq |
| 𝕣 | Alph | \Bbbr |
| 𝕤 | Alph | \Bbbs |
| 𝕥 | Alph | \Bbbt |
| 𝕦 | Alph | \Bbbu |
| 𝕧 | Alph | \Bbbv |
| 𝕨 | Alph | \Bbbw |
| 𝕩 | Alph | \Bbbx |
| 𝕪 | Alph | \Bbby |
| 𝕫 | Alph | \Bbbz |
| 𝕬 | Alph | \mbffrakA |
| 𝕭 | Alph | \mbffrakB |
| 𝕮 | Alph | \mbffrakC |
| 𝕯 | Alph | \mbffrakD |
| 𝕰 | Alph | \mbffrakE |
| 𝕱 | Alph | \mbffrakF |
| 𝕲 | Alph | \mbffrakG |
| 𝕳 | Alph | \mbffrakH |
| 𝕴 | Alph | \mbffrakI |
| 𝕵 | Alph | \mbffrakJ |
| 𝕶 | Alph | \mbffrakK |
| 𝕷 | Alph | \mbffrakL |

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|---|---|---|
| 𝕸 | Alph | \mbffrakM |
| 𝕹 | Alph | \mbffrakN |
| 𝕺 | Alph | \mbffrakO |
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| 𝚭 | Alph | \mbfZeta |

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| $\mbfNu$ | Alph | \mbfNu |
| $\mbfXi$ | Alph | \mbfXi |
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| $\mbfitphi$ | Alph | \mbfitphi |
| $\mbfitvarrho$ | Alph | \mbfitvarrho |
| $\mbfitvarpi$ | Alph | \mbfitvarpi |
| $\mbfsansAlpha$ | Alph | \mbfsansAlpha |
| $\mbfsansBeta$ | Alph | \mbfsansBeta |
| $\mbfsansGamma$ | Alph | \mbfsansGamma |
| $\mbfsansDelta$ | Alph | \mbfsansDelta |
| $\mbfsansEpsilon$ | Alph | \mbfsansEpsilon |
| $\mbfsansZeta$ | Alph | \mbfsansZeta |
| $\mbfsansEta$ | Alph | \mbfsansEta |
| $\mbfsansTheta$ | Alph | \mbfsansTheta |
| $\mbfsansIota$ | Alph | \mbfsansIota |
| $\mbfsansKappa$ | Alph | \mbfsansKappa |
| $\mbfsansLambda$ | Alph | \mbfsansLambda |
| $\mbfsansMu$ | Alph | \mbfsansMu |
| $\mbfsansNu$ | Alph | \mbfsansNu |
| $\mbfsansXi$ | Alph | \mbfsansXi |
| $\mbfsansOmicron$ | Alph | \mbfsansOmicron |
| $\mbfsansPi$ | Alph | \mbfsansPi |
| $\mbfsansRho$ | Alph | \mbfsansRho |
| $\mbfsansvarTheta$ | Alph | \mbfsansvarTheta |
| $\mbfsansSigma$ | Alph | \mbfsansSigma |
| $\mbfsansTau$ | Alph | \mbfsansTau |
| $\mbfsansUpsilon$ | Alph | \mbfsansUpsilon |
| $\mbfsansPhi$ | Alph | \mbfsansPhi |
| $\mbfsansChi$ | Alph | \mbfsansChi |
| $\mbfsansPsi$ | Alph | \mbfsansPsi |
| $\mbfsansOmega$ | Alph | \mbfsansOmega |
| $\mbfsansnabla$ | Alph | \mbfsansnabla |
| $\mbfsansalpha$ | Alph | \mbfsansalpha |
| $\mbfsansbeta$ | Alph | \mbfsansbeta |
| $\mbfsansgamma$ | Alph | \mbfsansgamma |
| $\mbfsansdelta$ | Alph | \mbfsansdelta |
| $\mbfsansvarepsilon$ | Alph | \mbfsansvarepsilon |
| $\mbfsanszeta$ | Alph | \mbfsanszeta |
| $\mbfsanseta$ | Alph | \mbfsanseta |
| $\mbfsanstheta$ | Alph | \mbfsanstheta |
| $\mbfsansiota$ | Alph | \mbfsansiota |
| $\mbfsanskappa$ | Alph | \mbfsanskappa |
| $\mbfsanslambda$ | Alph | \mbfsanslambda |
| $\mbfsansmu$ | Alph | \mbfsansmu |
| $\mbfsansnu$ | Alph | \mbfsansnu |
| $\mbfsansxi$ | Alph | \mbfsansxi |
| $\mbfsansomicron$ | Alph | \mbfsansomicron |
| $\mbfsanspi$ | Alph | \mbfsanspi |
| $\mbfsansrho$ | Alph | \mbfsansrho |
| $\mbfsansvarsigma$ | Alph | \mbfsansvarsigma |
| $\mbfsanssigma$ | Alph | \mbfsanssigma |
| $\mbfsanstau$ | Alph | \mbfsanstau |
| $\mbfsansupsilon$ | Alph | \mbfsansupsilon |
| $\mbfsansvarphi$ | Alph | \mbfsansvarphi |
| $\mbfsanschi$ | Alph | \mbfsanschi |
| $\mbfsanspsi$ | Alph | \mbfsanspsi |
| $\mbfsansomega$ | Alph | \mbfsansomega |
| $\mbfsanspartial$ | Alph | \mbfsanspartial |
| $\mbfsansepsilon$ | Alph | \mbfsansepsilon |
| $\mbfsansvartheta$ | Alph | \mbfsansvartheta |
| $\mbfsansvarkappa$ | Alph | \mbfsansvarkappa |
| $\mbfsansphi$ | Alph | \mbfsansphi |
| $\mbfsansvarrho$ | Alph | \mbfsansvarrho |
| $\mbfsansvarpi$ | Alph | \mbfsansvarpi |
| $\mbfitsansAlpha$ | Alph | \mbfitsansAlpha |
| $\mbfitsansBeta$ | Alph | \mbfitsansBeta |
| $\mbfitsansGamma$ | Alph | \mbfitsansGamma |
| $\mbfitsansDelta$ | Alph | \mbfitsansDelta |
| $\mbfitsansEpsilon$ | Alph | \mbfitsansEpsilon |
| $\mbfitsansZeta$ | Alph | \mbfitsansZeta |
| $\mbfitsansEta$ | Alph | \mbfitsansEta |
| $\mbfitsansTheta$ | Alph | \mbfitsansTheta |
| $\mbfitsansIota$ | Alph | \mbfitsansIota |
| $\mbfitsansKappa$ | Alph | \mbfitsansKappa |
| $\mbfitsansLambda$ | Alph | \mbfitsansLambda |
| $\mbfitsansMu$ | Alph | \mbfitsansMu |
| $\mbfitsansNu$ | Alph | \mbfitsansNu |
| $\mbfitsansXi$ | Alph | \mbfitsansXi |
| $\mbfitsansOmicron$ | Alph | \mbfitsansOmicron |
| $\mbfitsansPi$ | Alph | \mbfitsansPi |
| $\mbfitsansRho$ | Alph | \mbfitsansRho |
| $\mbfitsansvarTheta$ | Alph | \mbfitsansvarTheta |
| $\mbfitsansSigma$ | Alph | \mbfitsansSigma |
| $\mbfitsansTau$ | Alph | \mbfitsansTau |
| $\mbfitsansUpsilon$ | Alph | \mbfitsansUpsilon |
| $\mbfitsansPhi$ | Alph | \mbfitsansPhi |
| $\mbfitsansChi$ | Alph | \mbfitsansChi |
| $\mbfitsansPsi$ | Alph | \mbfitsansPsi |
| $\mbfitsansOmega$ | Alph | \mbfitsansOmega |
| $\mbfitsansnabla$ | Alph | \mbfitsansnabla |
| $\mbfitsansalpha$ | Alph | \mbfitsansalpha |
| $\mbfitsansbeta$ | Alph | \mbfitsansbeta |
| $\mbfitsansgamma$ | Alph | \mbfitsansgamma |
| $\mbfitsansdelta$ | Alph | \mbfitsansdelta |
| $\mbfitsansvarepsilon$ | Alph | \mbfitsansvarepsilon |
| $\mbfitsanszeta$ | Alph | \mbfitsanszeta |
| $\mbfitsanseta$ | Alph | \mbfitsanseta |
| $\mbfitsanstheta$ | Alph | \mbfitsanstheta |
| $\mbfitsansiota$ | Alph | \mbfitsansiota |
| $\mbfitsanskappa$ | Alph | \mbfitsanskappa |
| $\mbfitsanslambda$ | Alph | \mbfitsanslambda |
| $\mbfitsansmu$ | Alph | \mbfitsansmu |
| $\mbfitsansnu$ | Alph | \mbfitsansnu |
| $\mbfitsansxi$ | Alph | \mbfitsansxi |
| $\mbfitsansomicron$ | Alph | \mbfitsansomicron |
| $\mbfitsanspi$ | Alph | \mbfitsanspi |
| $\mbfitsansrho$ | Alph | \mbfitsansrho |
| $\mbfitsansvarsigma$ | Alph | \mbfitsansvarsigma |
| $\mbfitsanssigma$ | Alph | \mbfitsanssigma |
| $\mbfitsanstau$ | Alph | \mbfitsanstau |
| $\mbfitsansupsilon$ | Alph | \mbfitsansupsilon |
| $\mbfitsansvarphi$ | Alph | \mbfitsansvarphi |
| $\mbfitsanschi$ | Alph | \mbfitsanschi |
| $\mbfitsanspsi$ | Alph | \mbfitsanspsi |
| $\mbfitsansomega$ | Alph | \mbfitsansomega |
| $\mbfitsanspartial$ | Alph | \mbfitsanspartial |
| $\mbfitsansepsilon$ | Alph | \mbfitsansepsilon |
| $\mbfitsansvartheta$ | Alph | \mbfitsansvartheta |
| $\mbfitsansvarkappa$ | Alph | \mbfitsansvarkappa |
| $\mbfitsansphi$ | Alph | \mbfitsansphi |
| $\mbfitsansvarrho$ | Alph | \mbfitsansvarrho |
| $\mbfitsansvarpi$ | Alph | \mbfitsansvarpi |
| | Alph | \mbfDigamma |
| | Alph | \mbfdigamma |
| $\mbfzero$ | Ord | \mbfzero |
| $\mbfone$ | Ord | \mbfone |
| $\mbftwo$ | Ord | \mbftwo |
| $\mbfthree$ | Ord | \mbfthree |
| $\mbffour$ | Ord | \mbffour |
| $\mbffive$ | Ord | \mbffive |
| $\mbfsix$ | Ord | \mbfsix |
| $\mbfseven$ | Ord | \mbfseven |
| $\mbfeight$ | Ord | \mbfeight |
| $\mbfnine$ | Ord | \mbfnine |
| $\Bbbzero$ | Ord | \Bbbzero |
| $\Bbbone$ | Ord | \Bbbone |
| $\Bbbtwo$ | Ord | \Bbbtwo |
| $\Bbbthree$ | Ord | \Bbbthree |
| $\Bbbfour$ | Ord | \Bbbfour |
| $\Bbbfive$ | Ord | \Bbbfive |
| $\Bbbsix$ | Ord | \Bbbsix |
| $\Bbbseven$ | Ord | \Bbbseven |
| $\Bbbeight$ | Ord | \Bbbeight |
| $\Bbbnine$ | Ord | \Bbbnine |
| $\msanszero$ | Ord | \msanszero |
| $\msansone$ | Ord | \msansone |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Ord | `\msanstwo` | **0** | Ord | `\mbfsanszero` | **8** | Ord | `\mbfsanseight` | 6 | Ord | `\mttsix` |
| 3 | Ord | `\msansthree` | **1** | Ord | `\mbfsansone` | **9** | Ord | `\mbfsansnine` | 7 | Ord | `\mttseven` |
| 4 | Ord | `\msansfour` | **2** | Ord | `\mbfsanstwo` | 0 | Ord | `\mttzero` | 8 | Ord | `\mtteight` |
| 5 | Ord | `\msansfive` | **3** | Ord | `\mbfsansthree` | 1 | Ord | `\mttone` | 9 | Ord | `\mttnine` |
| 6 | Ord | `\msanssix` | **4** | Ord | `\mbfsansfour` | 2 | Ord | `\mtttwo` | | Op | `\arabicmaj` |
| 7 | Ord | `\msansseven` | **5** | Ord | `\mbfsansfive` | 3 | Ord | `\mttthree` | | Op | `\arabichad` |
| 8 | Ord | `\msanseight` | **6** | Ord | `\mbfsanssix` | 4 | Ord | `\mttfour` | | | |
| 9 | Ord | `\msansnine` | **7** | Ord | `\mbfsansseven` | 5 | Ord | `\mttfive` | | | |

It isn't very comfortable to find something in the previous table if you know the shape. You can try the online web tool Detexify. You can draw the symbol here and the suggestion of TeX sequence is printed.

The generic TeX sequences for the Greek letters can be used: `\alpha` $\alpha$, `\beta` $\beta$, `\gamma` $\gamma$, `\delta` $\delta$, `\varepsilon` $\varepsilon$, `\zeta` $\zeta$, `\eta` $\eta$, `\theta` $\theta$, `\iota` $\iota$, `\kappa` $\kappa$, `\lambda` $\lambda$, `\mu` $\mu$, `\nu` $\nu$, `\xi` $\xi$, `\omicron` $o$, `\pi` $\pi$, `\rho` $\rho$, `\varsigma` $\varsigma$, `\sigma` $\sigma$, `\tau` $\tau$, `\upsilon` $\upsilon$, `\varphi` $\varphi$, `\chi` $\chi$, `\psi` $\psi$, `\omega` $\omega$, `\vardelta` $\partial$, `\epsilon` $\epsilon$, `\vartheta` $\vartheta$, `\varkappa` $\varkappa$, `\phi` $\phi$, `\varrho` $\varrho$, `\varpi` $\varpi$ and `\Alpha` A, `\Beta` B, `\Gamma` $\Gamma$, `\Delta` $\Delta$, `\Epsilon` E, `\Zeta` Z, `\Eta` H, `\Theta` $\Theta$, `\Iota` I, `\Kappa` K, `\Lambda` $\Lambda$, `\Mu` M, `\Nu` N, `\Xi` $\Xi$, `\Omicron` O, `\Pi` $\Pi$, `\Rho` P, `\Sigma` $\Sigma$, `\Tau` T, `\Upsilon` $\Upsilon$, `\Phi` $\Phi$, `\Chi` X, `\Psi` $\Psi$, `\Omega` $\Omega$.

The variant of Greek letters in the output (upright, italic, bold, bold sans serif, etc.) written by the sequences `\alpha`, `\beta` etc. depends on the math alphabet selected by `\_itgreek`, `\_rmgreek`, etc. selectors. The user-level selectors `\bf` and `\bi` set `\_bsansgreek` and `\_bisansgreek`, so `{\bi\delta}` produces $\boldsymbol{\delta}$. ◀ OpTeX

All characters available in the math font can be accessed by TeX control sequence or by direct using the Unicode character in the document source. Example: ◀ Unicode

```
$$
   \sum_{k=0}^\infty e^{(\alpha+i\beta_k)} =
   e^\alpha \sum_{k=0}^\infty e^{i\beta_k} =
   e^\alpha \sum_{k=0}^\infty (\cos\beta_k + i\sin\beta_k).
$$
```

or

```
$$
   ∑_{k=0}^∞ e^{(α + iβ_k)} = e^α ∑_{k=0}^∞ e^{iβ_k}
                            = e^α ∑_{k=0}^∞ (\cos β_k + i\sin β_k).
$$
```

both gives the same result:

$$\sum_{k=0}^{\infty} e^{(\alpha+i\beta_k)} = e^\alpha \sum_{k=0}^{\infty} e^{i\beta_k} = e^\alpha \sum_{k=0}^{\infty} (\cos\beta_k + i\sin\beta_k).$$

# 2 Other specialities

## 2.1 The `\not` prefix

You can apply `\not` to the following math object. The slash / is overprinted such math object, for example `$a \not= b$` gives $a \neq b$.

If there exist a direct Unicode character for negation of a relation symbol (for example `\ne` creates $\neq$ directly as a character U+2260) then `\not`⟨*char*⟩ expands to appropriate Unicode character. For example `\not=` expands to `\ne` or `\not\in` expands to `\notin`. If such character does not exist then the centered / is overprinted over the next character. ◀ OpTeX

## 2.2 The `\buildrel` macro: text over relation

The macro `\buildrel` ⟨*text*⟩`\over` ⟨*relation*⟩ creates a new atom Rel with the ⟨*relation*⟩ and with the smaller ⟨*text*⟩ above this ⟨*relation*⟩. Example: `$M \buildrel\rm def\over= X\cup Y$` gives $M \buildrel\rm def\over= X\cup Y$.

## 2.3 Spaces

Spaces between atoms are created automatically as were mentioned in section 1.2. But sometimes you have to help TeX to create appropriate space. You can use following macros:

- `\,` is *thin space* used around Op atoms, after comma, etc.: $|\,|$,
- `\!` is negative thin space,
- `\>` is *medium space* used around Bin atoms: $|\>|$,
- `\;` is *thick space* used around Rel atoms: $|\;|$,
- `\quad` is *em space*: $|\quad|$,
- `\qquad` is *double em space*: $|\qquad|$.

Of course, you can use *direct space* `\␣` which is TeX primitive and gives interword space: $|\ |$ or you can use `\hskip` ⟨*value*⟩ to put arbitrary space.

The space size of `\,`, `\!` resp. `\>`, resp. `\;` is given by `\thinmuskip`, resp. `\medmuskip`, resp. `\thickmuskip` values. You can see in the `plain.tex` file that these default values differ very little in their basic size but there is no stretchability/shrinkability in the `\,` space, there is small stretchability in the `\>` space and more stretchability in the `\;` space.

The registers `\thinmuskip`, `\medmuskip` and `\thickmuskip` store so called *mu values* given by math unit `mu`. It is 1/18 em and this unit depends on the current font size used in the math formula ($S$ or $SS$ styles use smaller font size, the `mu` unit is smaller here). You can use `\muskip` instead `\hskip` or `\mukern` instead `\kern` if you want to use this special mu unit. It is allowed only in math mode.

The `\quad` and `\qquad` spaces have fixed width and they can be used in text mode too. (OpTeX allows to use `\,` in text mode too). Use `\quad` or `\qquad` if you want to separate more formulas created in single math mode. Examples of typical usage of spaces:

```
$$ \alpha\,(x+y), \qquad \int_a^b \!\! f(x)\,{\rm d}x, \qquad \Gamma_{\!i}. $$
```

$$\alpha\,(x+y), \qquad \int_a^b \!\! f(x)\,{\rm d}x, \qquad \Gamma_{\!i}.$$

## 2.4 Texts in math mode

If you write `$Hello world!$` (i.e. Hello world in math mode), then you get $Hello world!$. It is interpreted as product of variables $H$ and $e$ and $l^2$ and $o$ etc., followed by the symbol ! used for factorial. The non-ASCII letters (with accents) don't work at all because they are never used as symbols for variables. Spaces are ignored.

If you want to write a short text in the math mode, then you can use `\hbox{`⟨*text*⟩`}`. The `\hbox` primitive initializes text mode regardless of the "outer mode". Example:

```
$$ \sum_{n=0}^\infty (-1)^n a_n \hbox{ converges, if $a_n\searrow 0$.} $$
```

$$\sum_{n=0}^\infty (-1)^n a_n \hbox{ converges, if } a_n\searrow 0.$$

Note the space before the word "converges". The space before `\hbox` is irrelevant. Second notice: the example shows the text mode inside math mode and the in-line math mode inside this text mode. The same result can be produced by:

```
$$ \sum_{n=0}^\infty (-1)^n a_n \hbox{ converges, if } a_n\searrow 0. $$
```

The difference can be visible if the formula $a_n \searrow 0$ includes a fraction, for example $\frac12 a_n \searrow 0$. The first example prints the fraction in the text style and the second example prints it in the display style.

The disadvantage of `\hbox` is that it starts in the text mode independently of the current style, but we want to use smaller font in $S$ or $SS$ styles. You can use `\mathbox{`⟨*text*⟩`}` in such situations. This macro behaves like `\hbox` but the text is appropriately smaller in $S$ and $SS$ styles. Example: ◀ OpTEX

`{\mathbox{cena}\over\mathbox{výkon}}` gives $\displaystyle{\hbox{cena}\over\hbox{výkon}}$ in $D$ style and $\textstyle{\hbox{cena}\over\hbox{výkon}}$ in $T$ style.

Note that $\frac{cena}{výkon}$ means $\frac{price}{performance}$ and you can write `$\rm price\over performance$` when you are using only words without spaces and accented letters. But phrases with spaces or accented letters should be printed in text mode using `\hbox` or `\mathbox`.

## 2.5 `\vcenter`

The `\vcenter` primitive behaves like `\vbox`, but it can be used only in math mode and its result is vertically centered to the math axis. For example, matrices, are created by tables in `\vcenter`.

All big objects in math formula is centered to math axis and the baseline is ignored. In the following example we create a new big math operator by `\vcenter`:

```
$$
  \def\myop#1{\mathop{\vcenter{\frame{\vbox to2em{\vss\hbox{ $#1$ }\vss}}}}}
  F(x) = \myop{x(i)}_{i=1}^\infty
$$
```

$$F(x) = \mathop{\boxed{x(i)}}_{i=1}^{\infty}$$

## 2.6 Three dots

You can write `$1,2,\dots,n$` to get $1,2,\dots,n$. The `\dots` macro puts thin space between dots and after the last dot, so the five object: comma, dots, comma are exactly equidistant.

Typographic conventions say that you have to use the repeating symbol before and after three dots (comma in previous example) and the three dots should be at baseline, if the repeating symbol is at baseline. Or they should be at math axis, if the repeating symbol is at math axis. We have to use `\cdots` instead `\dots` in second case. Example:

`a_1, a_2, \dots, a_n, \quad a_1 + a_2 + \cdots + a_n` $\quad a_1, a_2, \dots, a_n, \quad a_1 + a_2 + \cdots + a_n$

There are `\vdots` $\vdots$, `\ddots` $\ddots$ and `\adots` $⋰$ which can be used in matrices.

Three dots like the output of the `\dots` macro are present as a single character in fonts too. This character is called ellipsis. Font designers typically suggest this character with smaller spaces between dots than we need in math mode. So the rule about equidistant “comma, three dots, comma” is not met when this character is used. You can try `$1,2,\unicodeellipsis, n$` and `$1+2+\unicodecdots + n$`. You get $1,2,…,n$ and $1+2+⋯+n$. If you feel that this is better, then you can set: `\let\dots=\unicodeellipsis \let\cdots=\unicodecdots`. ◀ Unicode

The Unicode fonts includes compact variants `\unicodevdots` ⋮, `\unicodeddots` ⋱ and `\unicodeadots` ⋰ too.

## 2.7 Phantoms and `\smash`

The `\phantom{`⟨*math list*⟩`}` macro creates an invisible subformula equal to the formula generated by ⟨*math list*⟩. It has its size, so it can interfere with surrounding visible subformulas. This macro is very useful for aligning with special requirements. Examples are shown in sections 3.1 and 4.4.

The `\vphantom{`⟨*math list*⟩`}` has only its vertical size (i.e. its height and depth), the width is zero. The `\hphantom{`⟨*math list*⟩`}` has only its width.

The `\smash{`⟨*math list*⟩`}` is the opposite of `\vphantom`. It creates visible subformula but it has only its width. Its height and depth are zero.

The result of these macros is the nucleus of an Ord atom. You can use `\mathop`, `\mathbin`, etc. primitives to change this class. For example `$a\mathrel{\phantom{=}}b$` creates the same formula as $a = b$ with the same distance from $a$ to $b$ but without the equal sign: $a \mathrel{\phantom{=}} b$.

These macros work in the text mode too. Then their argument is the ⟨*horizontal list*⟩.

# 3 Structured objects

## 3.1 Matrices

The macro `\matrix{`⟨*data*⟩`}` creates a vertically centered table of items. The ⟨*data*⟩ includes ⟨*items*⟩ separated by `&` and rows are separated by `\cr`. The number of columns and rows are unlimited. Columns are printed centered and separated by the `\quad` space. The vertically scalable brackets around the table are not printed. You can use `\pmatrix{`⟨*data*⟩`}` instead `\matrix{`⟨*data*⟩`}`: the vertically scalable parentheses () are inserted around the table. Examples:

```
$$
  {\bf A} = \pmatrix{a_{1,1} & a_{1,2} & \cdots & a_{1,n} \cr
                     a_{2,1} & a_{2,2} & \cdots & a_{2,n} \cr
                     \vdots  & \vdots  & \ddots & \vdots  \cr
                     a_{m,1} & a_{m,2} & \cdots & a_{m,n} },
$$
```

$$\mathbf{A} = \begin{pmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,n} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m,1} & a_{m,2} & \cdots & a_{m,n} \end{pmatrix},$$

or:

```
\def\qmatrix[#1]{\left[\matrix{#1}\right]}
$$
  \qmatrix[a&b&c\cr d&e&f\cr g&h&i] \cdot \qmatrix[x_1\cr x_2\cr x_3]
  = \qmatrix[b_1\cr b_2\cr b_3].
$$
```

$$\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}.$$

If you need to aling the columns by another way than to center, then you can use phantom. Compare:

```
$$
  \pmatrix{ 1 & -1 & 0  \cr
            0 &  2 & 13 \cr
           -3 &  0 & 5 }     \quad \hbox{or} \quad
  \def\0{\phantom0} \def\+{\phantom+}
  \pmatrix { \+1 &  -1 & \00 \cr
             \+0 & \+2 &  13 \cr
              -3 & \+0 & \05 }
$$
```

$$\begin{pmatrix} 1 & -1 & 0 \\ 0 & 2 & 13 \\ -3 & 0 & 5 \end{pmatrix} \quad \text{or} \quad \begin{pmatrix} \phantom{+}1 & -1 & \phantom{0}0 \\ \phantom{+}0 & \phantom{+}2 & 13 \\ -3 & \phantom{+}0 & \phantom{0}5 \end{pmatrix}$$

Another option to set right aligned matrix is setting the `\lmfil`: Its value is used at left side in each `\matrix` item. The right side is set directly to `\hfil`. ◀ OpTEX

```
$$
  \lmfil={\hfill}  % left matrix filler = \hfill
  \pmatrix{ 1 & -1 & 0 \cr 0 & 2 & 13 \cr -3 & 0 & 5 }
$$
```

If you want to draw a vertical line inside the matrix, you can use `\adef|` as in the following example: ◀ OpTEX

```
$$
  \adef|{\kern-.2em&\strut\vrule&\kern-.2em}
  \def\+{\phantom+}
  \pmatrix{1 & 2 & 3 | 0 \cr 4 & 5 & 6 | 1 \cr 7 & 8 & 9 | 2 } \sim
  \pmatrix{1 & \+2 & \+3 | 0 \cr 0 & -3 & -6 | 1 \cr 0 & -6 & -12 | 2} \sim
  \pmatrix{1 & 2 & 3 | 0 \cr 0 & 1 & 2 | -1/3 \cr 0 & 0 & 0 | 1 }
$$
```

$$\left(\begin{array}{ccc|c} 1 & 2 & 3 & 0 \\ 4 & 5 & 6 & 1 \\ 7 & 8 & 9 & 2 \end{array}\right) \sim \left(\begin{array}{ccc|c} 1 & \phantom{+}2 & \phantom{+}3 & 0 \\ 0 & -3 & -6 & 1 \\ 0 & -6 & -12 & 2 \end{array}\right) \sim \left(\begin{array}{ccc|c} 1 & 2 & 3 & 0 \\ 0 & 1 & 2 & -1/3 \\ 0 & 0 & 0 & 1 \end{array}\right)$$

If you want to put something before opening bracket in the matrix, you can use another `\matrix`. Example:

```
$$
  \adef|{\kern-.2em&\strut\vrule&\kern-.2em}
  \def\+{\phantom+}
  \def\r{{\bf r}}
  \pmatrix{1 & 2 & 3 | 0 \cr 4 & 5 & 6 | 1 \cr 7 & 8 & 9 | 2 } \ \sim \
  \matrix{\cr 2.\r - 4\cdot 1.\r: \cr 3.\r -7\cdot 1.\r: }
  \pmatrix{1 & \+2 & \+3 | 0 \cr 0 & -3 & -6 | 1 \cr 0 & -6 & -12 | 2}
$$
```

$$\left(\begin{array}{ccc|c} 1 & 2 & 3 & 0 \\ 4 & 5 & 6 & 1 \\ 7 & 8 & 9 & 2 \end{array}\right) \ \sim \ \begin{matrix} \\ 2.\mathbf{r} - 4\cdot 1.\mathbf{r}: \\ 3.\mathbf{r} - 7\cdot 1.\mathbf{r}: \end{matrix} \left(\begin{array}{ccc|c} 1 & \phantom{+}2 & \phantom{+}3 & 0 \\ 0 & -3 & -6 & 1 \\ 0 & -6 & -12 & 2 \end{array}\right)$$

Plain TEX defines the `\bordermatrix` macro which allows you to create a top row above the brackets and left column before the opening bracket. TEXbook shows the following example:

```
$$
  M = \bordermatrix{ &C&I&C'\cr
                    C&1&0&0 \cr I&1-b&0 \cr C'&0&a&1-a }
$$
```

$$M = \begin{array}{c} \\ C \\ I \\ C' \end{array} \!\!\begin{array}{c} \begin{matrix} C & \quad I & \quad C' \end{matrix} \\ \begin{pmatrix} 1 & 0 & 0 \\ 1-b & 0 & \\ 0 & a & 1-a \end{pmatrix} \end{array}$$

The `\matrix` macro used in $D$ style creates all its items in $T$ style. If you are using the `\matrix` macro in $T$ style or $S$ style (but not in fractions nor another matrices) then the resulting table is appropriately smaller and all its items are processed in $S$ style. If you are using `\matrix` in $SS$ style then the items are in $SS$ style too. The following example shows one-column matrix in script style: ◀ OpTEX

`\sum_{\matrix{i\in M\cr j\in N\cr k\in P}} x_{i,j,k}` creates: $\sum_{\substack{i\in M\\ j\in N\\ k\in P}} x_{i,j,k}$

## 3.2 Cases

The `\cases` macro can be used as in the following example:

```
$$
  f(x) = \cases{        1       & for $x\le 0$, \cr
                 100-x\over 100 & when $0 < x \le 100$, \cr
                        0       & in other cases. }
$$
```

$$f(x) = \begin{cases} 1 & \text{for } x \le 0, \\ \frac{100-x}{100} & \text{when } 0 < x \le 100, \\ 0 & \text{in other cases.} \end{cases}$$

The `\cases` macro behaves like a special `\matrix` with two left aligned columns and with left vertically scaled brace {. First column is processed in math mode and $T$ style, second column is processed in text mode. We have to use `$...$` in the second column if there is a math material.

# 4 Lines in display mode

## 4.1 General principles

The `$$`⟨*formula*⟩`$$` finalizes previous paragraph, prints centered ⟨*formula*⟩ on single line with a vertical space above and below and opens next paragraph with no indentation.

From TEX's point of view, the text above plus `$$`⟨*formula*⟩`$$` plus text below is single paragraph interrupted by display ⟨*formula*⟩. If there is no text above (i.e. the opening `$$` are in vertical mode), then the internal `\noindent` is processed first and empty line above ⟨*formula*⟩ is created. Thus, it is definitely bad idea to open display mode in vertical mode: never put empty line before `$$`⟨*formula*⟩`$$`. On the other hand, the empty line just after `$$`⟨*formula*⟩`$$` says that the paragraph is finalized by the ⟨*formula*⟩ and the next text (after the empty line) opens next paragraph with indentation. Summary:

- "Text above `$$`⟨*formula*⟩`$$` text below": the ⟨*formula*⟩ interrupts the paragraph with "Text above" and "text below". The "text below" is without indentation.
- "Text above `$$`⟨*formula*⟩`$$` empty line Text below": the "Text below" opens new paragraph with indentation.
- "Empty line `$$`⟨*formula*⟩`$$`" is bad practice.

In contrast with the paragraph breaking, there is no built-in algorithm for breaking display ⟨*formula*⟩ to more lines. If the ⟨*formula*⟩ is too wide then overfull `\hbox` occurs and human must decide about splitting the ⟨*formula*⟩ to more lines. The macros `\displaylines` and `\eqalign` are intended to such task, see sections 4.3 and 4.4.

On the other hand, the in-line math ⟨*formula*⟩, i.e. the `$`⟨*formula*⟩`$` in a paragraph, can be broken after a Bin atom (with penalty `\binoppenalty`) or after a Rel atom (with penalty `\relpenalty`). If you don't want to break such formula at a specific place then use `\nobreak`, for example `$a+\nobreak b$`. If you want never to break such formulas then you can set `\binoppenalty=10000`, `\relpenalty=10000`. (Default values are 700 and 500.)

## 4.2 References to display lines

The `$$`⟨*formula*⟩`\eqno`⟨*mark*⟩`$$` prints centered ⟨*formula*⟩ and the ⟨*mark*⟩ at right margin. The `$$`⟨*formula*⟩`\leqno`⟨*mark*⟩`$$` prints centered ⟨*formula*⟩ and the ⟨*mark*⟩ at left margin. Examples:

```
$$ a^2 + b^2 = c^2  \eqno (1) $$
```

$$a^2 + b^2 = c^2 \tag{1}$$

```
$$ a^2 + b^2 = c^2  \leqno \rm Py $$
```

Py $$a^2 + b^2 = c^2$$

The ⟨*mark*⟩ is processed in math mode and $T$ style. If you want to put a text here then you have to use `\rm` ⟨*text*⟩ or `\hbox{`⟨*text*⟩`}`.

The auto-generated ⟨*mark*⟩ can be created by `$$`⟨*formula*⟩`\eqmark$$`. The ⟨*label*⟩ previously declared by `\label[`⟨*label*⟩`]` can be used. Then it is associated to such auto-generated ⟨*mark*⟩ and you can write a reference in the form `see equation~\ref[`⟨*label*⟩`]`. You can write `\eqmark[`⟨*label*⟩`]` instead of `\label[`⟨*label*⟩`]...\eqmark`. See the OpTeX manual, section 1.4.3. ◀ OpTeX

## 4.3 The `\displaylines` macro

This macro creates more horizontally centered formulas in one display mode. The syntax is

```
$$ \displaylines{
   ⟨formula⟩ \cr
   ⟨formula⟩ \cr
   ... \cr
   ⟨formula⟩
} $$
```

Usage of `\displaylines` is more prefered than doing more display modes just behind each other. Example:

```
$$ \displaylines{
   (3x^3 + 4x^2 + 5x + 6) \cdot (x^6 + x^2 + 5) = \cr
   = 3x^9 + 4x^8 + 5x^7 + 6x^6 + 3x^5 + 4x^4 + 20x^3 + 26x^2 + 25x + 30.
} $$
```

$$(3x^3 + 4x^2 + 5x + 6) \cdot (x^6 + x^2 + 5) =$$
$$= 3x^9 + 4x^8 + 5x^7 + 6x^6 + 3x^5 + 4x^4 + 20x^3 + 26x^2 + 25x + 30.$$

The output from `\displaylines` macro is breakable to more pages because the lines are not encapsulated in one box. The macro uses a special feature of `\halign` primitive. The disadvantage is that you cannot use `\eqno` nor `\leqno` nor `\eqmark`.

OpTeX provides alternative form: `\displaylines to`⟨*dimen*⟩ `{`⟨*data*⟩`}`. Then the centered formulas are encapsulated in a `\vcenter` box of width ⟨*dimen*⟩ and usage of `\eqno` or `\leqno` or `\eqmark` is allowed. The individual lines have the form `\hbox to`⟨*dimen*⟩ and formulas are centered using `\hss` from both sides. This means that you can set arbitrary ⟨*dimen*⟩ without visual change of the formulas. Use smaller ⟨*dimen*⟩ value than `\hsize` (or `\displaywidth`[6]) if you want to center formulas with `\eqno` appended. The internal TeX rule says: the formula with `\eqno` (or `\leqno`) is centered if its width is less or equal `\displaywidth-4`⟨*mark-width*⟩. So ◀ OpTeX

```
$$ \displaylines to\hsize-8em {⟨formula⟩\cr⟨formula⟩}\eqno (1) $$
```

does global centering, because size of `(1)` is less than 2 em. You can do more experiments with this example, for example `\diplaylines to\hsize{...}` puts the `\eqno` mark to the next line in the display environment. Read TeXbook or TeXbook naruby, where the precise explanation about such positioning is.

You can use "`\displaylines to`⟨*dimen*⟩" for more applications. For example, you can put more "`\displaylines to`⟨*dimen*⟩" in single display mode, one next to second in order to creating more centered columns with formulas; the width of such columns are controlled by the ⟨*dimen*⟩ parameter. Or, you can give an exception for first and last formula: ◀ OpTeX

```
$$\displaylines to 10cm {⟨formula⟩\hfill \cr
                         ⟨formula⟩\cr
                         ⟨formula⟩\cr
                         \hfill ⟨formula⟩}
$$
```

[6] `\displaywith` = `\hsize` in most cases but it is real display width when `\parshape` or `\hangindent` is used.

The example above gives similar result as the LaTeX `multline` environment:

$$
\begin{aligned}
&(3x^3 + 4x^2 + 5x + 6) \cdot (x^6 + x^2 + 5) = \\
&\qquad = 3x^9 + 3x^5 + 15x^3 + 4x^8 + 4x^4 + 20x^2 + 5x^7 + 5x^3 + 25x + 6x^6 + 6x^2 + 30 = \\
&\qquad\qquad = 3x^9 + 4x^8 + 5x^7 + 6x^6 + 3x^5 + 4x^4 + 20x^3 + 26x^2 + 25x + 30.
\end{aligned}
$$

## 4.4 The `\eqalign` macro

The usage is:

```
$$ \eqalign { ⟨left-side⟩ & ⟨right-side⟩ \cr
              ⟨left-side⟩ & ⟨right-side⟩ \cr
              ... \cr
              ⟨left-side⟩ & ⟨right-side⟩
} $$
```

The `\vcenter` box is created with two columns, left column is right aligned and right column is left aligned. Example:

```
$$ \eqalign{
     x + 2y + 3z &= 600 \cr
    12x + y - 3z &= 7 \cr
     4x - y + 5z &= -5 \cr
} $$
```

$$
\begin{aligned}
x + 2y + 3z &= 600 \\
12x + y - 3z &= 7 \\
4x - y + 5z &= -5
\end{aligned}
$$

The tab "`&`" should be used just before a relation, i.e. `&=` is right, `=&` is wrong. All lines are aligned to the used tab.

Maybe you want more precise alignment in the example above. You can use `\phantom`:

```
$$ \def\1{\phantom1} \def\+{\phantom+}
   \eqalign{
      x +   2y + 3z &=  600 \cr
    12x + \1y - 3z &= \+7 \cr
     4x - \1y + 5z &=  -5 \cr
} $$
```

$$
\begin{aligned}
x + 2y + 3z &= 600 \\
12x + \phantom{1}y - 3z &= \phantom{+}7 \\
4x - \phantom{1}y + 5z &= -5
\end{aligned}
$$

Another typical usage of the `\eqalign` macro:

```
$$ \eqalign{
  p(x)\,q(x) &= (3x^3 + 4x^2 + 5x + 6) \cdot (x^6 + x^2 + 5) = \cr
             &= 3x^9 + 4x^8 + 5x^7 + 6x^6 + 3x^5 + 4x^4 + 20x^3 + 26x^2 + 25x + 30.
} $$
```

$$
\begin{aligned}
p(x)\,q(x) &= (3x^3 + 4x^2 + 5x + 6) \cdot (x^6 + x^2 + 5) = \\
&= 3x^9 + 4x^8 + 5x^7 + 6x^6 + 3x^5 + 4x^4 + 20x^3 + 26x^2 + 25x + 30.
\end{aligned}
$$

In OpTeX, the `\eqalign` macro is more flexible. You can set the `\baselineskip` value by the `\eqlines` parameter and math style by the `\eqstyle` parameter. For example, you need to put the system of "equations" as an subscript of sum operator: ◀ OpTeX

```
$$
  \sum_{\eqlines{\baselineskip=.7\baselineskip}\eqstyle{\scriptstyle}\eqalign{
                  i &\in A   \cr
          \quad  j &\in B\cup C  \cr
                  m &\in C }}
   i + j + m
$$
```

$$\sum_{\substack{i\in A\\ j\in B\cup C\\ m\in C}} i+j+m$$

You can write more equation systems one next second: ◀ OpTEX

```
$$\eqalign{
     x + y + z &= 1     &&  a + b + c &= -1 \cr
         u + v &= 20    &&      f + g &= -20 \cr
             i &= j
}$$
```

You can use the third column for centered equations without aligning point. For example:

```
$$ \left( \eqspace=0pt \eqalign{&& ⟨first equation⟩\cr
                                 && ⟨second equation⟩} \right) $$
```

The `\eqspace` is additional space used in the third column to separate equation systems one next second.

OpTEX extensions summary: ◀ OpTEX

- `\eqlines` and `\eqstyle` set baselineskip and math style of the formulas.
- `\eqalign` allows more than two columns: First column is right aligned (no space). Second is left aligned (no space). Third column (if used) is centered with `\eqspace/2` at left and right boundary of the column. Fourth is the same as first. Fifth is the same as second etc. The number of columns which can be used in `\eqalign` is unlimited.

## 4.5 The `\eqalign` macro with references

You can give common mark to whole equation system by `$$\eqalign{`⟨*data*⟩`}\eqno` ⟨*mark*⟩`$$`. If you want to give marks to individual lines of the equation system, then you can use another macro: `\eqalignno`. The usage is similar as `\eqalign` but the third column (if used) is intended to the equation mark. Example:

```
$$ \eqalignno{
    x + 2y + 3z &= 600 & \rm(A) \cr
   12x + y - 3z &= 7   & \rm(B) \cr
    4x - y + 5z &= -5  & \rm(C) \cr
} $$
```

$$\begin{aligned} x+2y+3z&=600 \qquad &\text{(A)}\\ 12x+y-3z&=7 &\text{(B)}\\ 4x-y+5z&=-5 &\text{(C)}\end{aligned}$$

The `\leqalignno` macro is similar as `\eqalignno` but the marks are at the left margin. The OpTEX extensions of `\eqalign` are not available in `\eqalignno` nor `\leqalignno` macros.

You can use auto-generated marks by `\eqmark` macro: `$$\eqalign{`⟨*data*⟩`}\eqmark$$` or: ◀ OpTEX

```
$$ \eqalignno{
    x + 2y + 3z &= 600 & \eqmark[A] \cr
   12x + y - 3z &= 7   & \eqmark[B] \cr
    4x - y + 5z &= -5  & \eqmark[C] \cr
} $$
```

# 5 Concept of loading math fonts

## 5.1 Math families

TeX is able to use more than one math font in math mode. This was a necessity in old days when only 128-characters fonts existed. Each math font used in math mode has its *math family* represented by a number. Math family is a collection of three (almost) equal fonts in three sizes: first for `\textstyle` and `\displaystyle`, second for `\scriptstyle` and third for `\scriptscriptstyle`.

When Unicode math font is loaded then it includes all three optical sizes and all characters needed for typeseting math formula. Theoretically, we can use only one math family with this single font. But more math families (i.e. more fonts in math mode) is still possible. You can combine characters from more fonts (Unicode fonts and old TFM fonts together) in one math formula. ◀ Unicode

OpTeX loads the specified Unicode math font into math family 1. The math families 2 and 3 are reserved for specific TeXnical reasons, family 4 is used for `\script` font and families 5, 6, 7, etc. can be used by user for loading more fonts. The default macro for loading math fonts looks like: ◀ OpTeX

```
\_def\_normalunimath{%
    \_loadumathfamily 1 {\_unimathfont}{} % Base Unicode math font
    \_loadmathfamily  4 rsfs              % \script (old TFM font)
    \_setunimathdimens   % set dimen parameters used in math formulas internally
}%
\let\_normalmath=\_normalunimath % this is done when Unicode math is initialized
```

Whenever OpTeX needs to resize math fonts (for example in footnotes or titles), it calls the `\_normalmath` macro in order to reload all math families to desired size. If you want to add a next font, you can add `\_loadunimathfamily` ⟨*family*⟩ `{`⟨*Unicode-font*⟩`}{`⟨*features*⟩`}` or `\_loadmathfamily` ⟨*family*⟩ ⟨*TFM-font*⟩ into the `\_normalmath` macro. The example in section 5.3 shows how to do it.

## 5.2 Two variants of math fonts: normal and bold

All math formulas in the whole document need only one Unicode font (or only one collection of math fonts as mentioned in section 5.1). But this is not really true if titles are in bold font. If a math formula is present in such a bold title then all characters of this formula must be bolder. For example "normal" variables must be in bold italic in titles, symbols like `+ =` must be bold and "normal bold" letters (e.g., indicating vectors in math formula) must be extra bold in titles. It means that all fonts from collection of math fonts must be bolder. We need second collection of math fonts with bolder shape. Unfortunately, it is not always available.

If you have bold variant of used Unicode math font, then you can use `\loadboldmath` command, for example: ◀ OpTeX

```
\loadmath     {[xitsmath-regular]}
\loadboldmath {[xitsmath-bold]} \to {[xitsmath-regular]}
```

OpTeX uses `\_normalmath` macro for loading collection of math fonts in "normal" cases and `\_boldmath` macro for bold titles. The font declared by `\loadboldmath` is used in second case. But if the bold variant of the font is not available (this is unfortunately more typical), then OpTeX uses faked bold of basic Unicode math font (the `embolden` internal font feature is used). So, the default `\_boldmath` macro defined by OpTeX looks like:

```
\_def\_boldunimath{%
   \_ifx\_unimathboldfont \_undefined
      \_loadumathfamily 1 {\_unimathfont}{embolden=1.7;} % Base faked bold
   \_else
      \_loadumathfamily 1 {\_unimathboldfont}{} % Base real bold font
```

```
      \_fi
      \_loadmathfamily 4 rsfs  % rsfs in not in bold, unfortunately
      \_setunimathdimens
   }%
   \let\_boldmath=\_boldunimath % this is done when Unicode math is initialized
```

## 5.3 Example of using additional math font

The font `bbold10.tfm` includes double stroked characters, for example double stroked plus, double stroked Greek letters and digits. Try to run `pdftex testfont`, then answer to the question about name of the font: `bbold10` and then type command `\table\end`. The `testfont.pdf` is printed with the table of characters of this font. Most of these characters cannot be found in Unicode math fonts.

We show an example how to add this font to the collection of used math fonts. We can re-define the `\_normalmath` macro by: ◀ OpTEX

```
\addto\_normalmath {\_loadmathfamily 5 bbold }

\_regtfm bbold 0 bbold5 5.5 bbold6 6.5 bbold7 7.5 bbold8 8.5 bbold9
               9.5 bbold10 11.1 bbold12 15 bbold17 * % using all bbold*.tfm
\_normalmath  % reload the math fonts collection
```

The string "`bbold`" is declared by `\_regtfm` as a collection of all `bbold*.tfm` fonts, the optical sizes are supported.

Finally, we must to declare new TEX sequences for accessing the characters from the new font, for example:

```
\Umathchardef \bbplus 2 5 "2B
\Umathchardef \bble   3 5 "3C
\Umathchardef \bbge   3 5 "3E
```

The `\Umathchardef` TEX primitive declares new TEX sequence used in math typesetting. First parameter is class number (2 means Bin, 3 means Rel, see the table in the section 1.2). Second parameter is math family number. It is 5, see the redefinition of the `\_normalmath` macro above. Third parameter is the slot in the font. Now you can try to use these characters:

`a \bbplus b \bbge c` gives $a ⧺ b \geqslant c$.

Maybe, you want to declare a special math selector which can be used as `$\bball a+b>c$` in order to get $\mathbb{a} ⧺ \mathbb{b} \geqslant \mathbb{c}$. Then you can define:

```
\def\bball {\bbchar \Umathcodenum `+ \bbplus
                    \Umathcodenum `> \bbge
                    \Umathcodenum `< \bble }
```

If you want to add all double stroked Greek letters into `\bball` selector, then you can do something like this:

```
\def\setbbgreek #1 {\tmpnum=#1\xargs\setbbgreekA}
\def\setbbgreekA #1{\Umathcode \_ea`#1 0 5 \tmpnum \advance\tmpnum by1 }

\addto\bball {%
   \setbbgreek "0B \alpha \beta \gamma \delta \epsilon \zeta \eta
                   \theta \iota \kappa \lambda \mu \nu \xi \pi \rho \sigma
                   \tau \upsilon \phi \chi ;
   \setbbgreek "7F \omega ;
   \setbbgreek "00 \Gamma \Delta \Theta \Lambda \Xi \Pi \Sigma \Upsilon
                   \Phi \Psi \Omega ; }
```

The `\Umathcode` ⟨*input-code*⟩ ⟨*class*⟩ ⟨*family*⟩ ⟨*font-slot*⟩ primitive is used here. The control sequences `\alpha`, `\beta`, `\gamma` etc. are macros which expand to the Unicode character of appropriate (non-math) Greek letter. We set the Umathcode to such character, for example `\Umathcode `α 0 5 "0B` is processed.

The bold variant of the font `bbold*.tfm` is not available, unfortunately. We have to settle for normal version of the font in the `\_boldmath` macro:

```
\addto \_boldmath {\_loadmathfamily 5 bbold }
```