

Experimental Unicode mathematical typesetting: The unicode-math package

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<http://github.com/wspr/unicode-math>

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Abstract

This document describes the unicode-math package, which is intended as an implementation of Unicode maths for \LaTeX using the \XeTeX and \LuaTeX typesetting engines. With this package, changing maths fonts is as easy as changing text fonts — and there are more and more maths fonts appearing now. Maths input can also be simplified with Unicode since literal glyphs may be entered instead of control sequences in your document source.

The package provides support for both \XeTeX and \LuaTeX . The different engines provide differing levels of support for Unicode maths. Please let us know of any troubles.

Alongside this documentation file, you should be able to find a minimal example demonstrating the use of the package, ‘unimath-example.ltx’. It also comes with a separate document, ‘unimath-symbols.pdf’, containing a complete listing of mathematical symbols defined by unicode-math, including comparisons between different fonts.

Finally, while the STIX fonts may be used with this package, accessing their alphabets in their ‘private user area’ is not yet supported. (Of these additional alphabets there is a separate caligraphic design distinct to the script design already included.) Better support for the STIX fonts is planned for an upcoming revision of the package after any problems have been ironed out with the initial version.

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1 Introduction

This document describes the unicode-math package, which is an *experimental* implementation of a macro to Unicode glyph encoding for mathematical characters.

Users who desire to specify maths alphabets only (Greek and Latin letters, and Arabic numerals) may wish to use Andrew Moschou’s mathspec package instead. (X_YTeX-only at time of writing.)

2 Acknowledgements

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3 Getting started

Load unicode-math as a regular L^ATeX package. It should be loaded after any other maths or font-related package in case it needs to overwrite their definitions. Here’s an example using the filename syntax to load the TeX Gyre Pagella Math font: (this works for both X_YL^ATeX and LuaL^ATeX)

```
\usepackage{amsmath} % if desired
\usepackage{unicode-math}
\setmathfont{texgyrepagella-math.otf}
```

Once the package is loaded, traditional TFM-based maths fonts are no longer supported; you can only switch to a different OpenType maths font using the `\setmathfont` command. If you do not load an OpenType maths font before `\begin{document}`, Latin Modern Math (see above) will be loaded automatically.

3.1 New commands

L^ATeX, since the first version of L^ATeX 2_ε, changed the math group selection from, say, `{\bf x}` to `\mathbf{x}`. It introduced commands such as `\mathbf}`, `\mathit}`, `\mathsf}`, `\mathtt}` and `\mathcal}`, besides `\mathnormal}`. This was not only done to maintain the analogy with `\textbf}`, `\textit}` and so on, but with the precise purpose of loading the needed math groups (or math families) on demand and not allocating them if not required by the document.

The introduction of unicode-math posed new problems. For instance, there is a big difference between say `fit` as an operator name in boldface type and the product of three boldface variables. With legacy \TeX engines, `\mathbf{fit}` would use a ligature and the same would happen with the input `\mathbf{f}\mathbf{i}\mathbf{t}`. For the latter case, the user should probably use `\mathbf{f\!/}`.

However, there is another important point from a *conceptual* point of view. A boldface variable name should be printed using the *math font*, whereas a boldface operator name should be printed using the *text font*. OpenType math fonts make this distinction feasible, because they contain several math alphabets. Of course a boldface text ‘x’ will not differ much (or at all) from a boldface math ‘x’, but this is not the point: they *should* be considered different, because the former is U+0078 in Unicode, the latter is U+1D431.

It was clear that *two* different commands are needed: one for using text boldface in math, one for using math boldface. Only the document’s author can know whether one or the other is needed. The decision was to split off the two meanings with a command like `\mathbf` for the boldface text font in math and a command like `\symbf` (for the bold math font).

The five new symbol font commands that behave in this way are: `\symup`, `\symit`, `\symbf`, `\symsf`, and `\symit`. These commands switch to single-letter mathematical symbols (generally within the same OpenType font).

The legacy `\math.` commands switch to text fonts that are set up to behave correctly in mathematics, and should be used for multi-letter identifiers. These could be denoted ‘text math alphabets’; further details are discussed in section §4.4. Additional similar ‘text math alphabet’ commands can be defined using the `\setmathfontface` command discussed in section §4.4. To control the behaviour of the default text math alphabet commands to behave in a backwards-compatible mode, see the package options described in section §4.4.2.

In addition, unicode-math also provides a number of commands (such as `\symcal`) to select specific ‘symbol alphabets’ within the unicode maths font, with usage, e.g., `\symcal{G}` $\rightarrow \mathcal{G}$. The full listing is shown in Table 1. For backwards compatibility, many of these are also defined with ‘familiar’ synonyms such as `\mathcal`. However, where possible the ‘sym’ prefix commands should be preferred, as certain synonyms may become deprecated in time. The `\symliteral` command is described in section §5.1.

3.2 Package options

Package options may be set when the package is loaded or at any later stage with the `\unimathsetup` command. Therefore, the following two examples are equivalent:

```
\usepackage[math-style=TeX]{unicode-math}
% OR
\usepackage{unicode-math}
\unimathsetup{math-style=TeX}
```

Note, however, that some package options affect how maths is initialised and

Table 1: New unicode-math commands which overlap with legacy math commands. For new documents the sym versions are recommended.

Command	Synonym	Command	Synonym
<code>\symnormal</code>	<code>\mathnormal</code>		
<code>\symliteral</code>			
		<code>\ymbfsf</code>	<code>\mathbfsf</code>
		<code>\ymbfup</code>	<code>\mathbfup</code>
		<code>\ymbfit</code>	<code>\mathbfit</code>
<code>\ymbb</code>	<code>\mathbb</code>		
<code>\ymbbit</code>	<code>\mathbbbit</code>		
<code>\symcal</code>	<code>\mathcal</code>	<code>\ymbfcal</code>	<code>\mathbfcal</code>
<code>\symscr</code>	<code>\mathscr</code>	<code>\ymbfscr</code>	<code>\mathbfscr</code>
<code>\symfrac</code>	<code>\mathfrac</code>	<code>\ymbffrak</code>	<code>\mathbffrak</code>
<code>\symsfup</code>	<code>\mathsfup</code>	<code>\ymbfsfup</code>	<code>\mathbfsfup</code>
<code>\symsfit</code>	<code>\mathsfit</code>	<code>\ymbfsfit</code>	<code>\mathbfsfit</code>

Table 2: Package options.

Option	Description	See...
<code>math-style</code>	Style of letters	§5.1
<code>bold-style</code>	Style of bold letters	§5.2
<code>sans-style</code>	Style of sans serif letters	§5.3
<code>nabla</code>	Style of the nabla symbol	§5.5.1
<code>partial</code>	Style of the partial symbol	§5.5.2
<code>colon</code>	Behaviour of <code>\colon</code>	§5.5.5
<code>slash-delimiter</code>	Glyph to use for ‘stretchy’ slash	§5.5.6

changing an option such as `math-style` will not take effect until a new maths font is set up.

Package options may *also* be used when declaring new maths fonts, passed via options to the `\setmathfont` command. Therefore, the following two examples are equivalent:

```
\unimathsetup{math-style=TeX}
\setmathfont{texgyrepagella-math.otf}
% OR
\setmathfont{texgyrepagella-math.otf}[math-style=TeX]
```

A summary list of package options is shown in [table 2](#). See following sections for more information.

Table 3: Maths font options.

Option	Description	See...
range	Style of letters	section §4.1
script-font	Font to use for sub- and super-scripts	section §4.2
script-features	Font features for sub- and super-scripts	section §4.2
sscript-font	Font to use for nested sub- and super-scripts	section §4.2
sscript-features	Font features for nested sub- and super-scripts	section §4.2

4 Unicode maths font setup

In the ideal case, a single Unicode font will contain all maths glyphs we need. The file `unicode-math-table.tex` (based on Barbara Beeton’s `stix` table) provides the mapping between Unicode maths glyphs and macro names (all 3298 — or however many — of them!). A single command

$$\setmathfont{\langle font\ name\rangle}[\langle font\ features\rangle]$$

implements this for every every symbol and alphabetic variant. That means x to x , ξ to ξ , \leq to \leq , etc., \mathscr{H} to \mathscr{H} and so on, all for Unicode glyphs within a single font.

This package deals well with Unicode characters for maths input. This includes using literal Greek letters in formulae, resolving to upright or italic depending on preference.

Font features specific to `unicode-math` are shown in table 3. Package options (see table 2) may also be used. Other `fontspec` features are also valid.

4.1 Using multiple fonts

There will probably be few cases where a single Unicode maths font suffices (simply due to glyph coverage). The `stix` font comes to mind as a possible exception. It will therefore be necessary to delegate specific Unicode ranges of glyphs to separate fonts:

$$\setmathfont{\langle font\ name\rangle}[range=\langle unicode\ range\rangle,\langle font\ features\rangle]$$

where $\langle unicode\ range\rangle$ is a comma-separated list of Unicode slot numbers and ranges such as `{"27D0"-"27EB","27FF","295B"-"297F"}`. Note that \TeX ’s syntax for accessing the slot number of a character, such as `\+`, will also work here. Only numerical slots can be used in ranged declarations.

You may also use the macro for accessing the glyph, such as `range=\int`, or whole collection of symbols with the same math type, such as `range=\mathopen`, or complete math styles such as `range=\sybbb` (or just `range=bb`).

4.1.1 Control over alphabet ranges

As discussed earlier, Unicode mathematics consists of a number of ‘alphabet styles’ within a single font. In `unicode-math`, these ranges are indicated with the following (hopefully self-explanatory) labels:

up, it, bb, bbit, scr, cal, bfc, frac, tt, sfup, sfit,
bfup, bfit, bfscr, bffrac, bbsfup, bbsfit

Fonts can be selected (for predefined ranges only) using the following syntax, in which case all other maths font setup remains untouched:

- [range=bb] to use the font for ‘bb’ letters only.
- [range=bbsfit/{greek,Greek}] for Greek lowercase and uppercase only (also with latin, Latin, num as possible options for Latin lower-/upper-case and numbers, resp.).
- [range=up->sfup] to map to different output styles.

A common request is to load numerals only from a specific font. This can be achieved with an option such as range=up/{num}.

Note that ‘meta-styles’ such as ‘bf’ and ‘sf’ are not included in the list above since they are context dependent. Use [range=bfup] and [range=bfit] to effect changes to the particular ranges selected by ‘bf’ (and similarly for ‘sf’).

If a particular math style is not defined in the font, we fall back onto the lower-base plane (i.e., ‘upright’) glyphs. Therefore, to use an ASCII-encoded fractur font, for example, write

```
\setmathfont{SomeFrakturFont}[range=frac]
```

and because the math plane fractur glyphs will be missing, unicode-math will know to use the ASCII ones instead. If necessary this behaviour can be forced with [range=frac->up], since the ‘up’ range corresponds to ASCII letters.

Users of the impressive Minion Math fonts (commercial) may use remapping to access the bold glyphs using:

```
\setmathfont{MinionMath-Regular.otf}
\setmathfont{MinionMath-Bold.otf}[range={bfup->up,bfit->it}]
```

To set up the complete range of optical sizes for these fonts, a font declaration such as the following may be used: (adjust may be desired according to the font size of the document)

```
\setmathfont{Minion Math}[
SizeFeatures = {
  {Size = -6.01, Font = MinionMath-Tiny},
  {Size = 6.01-8.41, Font = MinionMath-Capt},
  {Size = 8.41-13.01, Font = MinionMath-Regular},
  {Size = 13.01-19.91, Font = MinionMath-Subh},
  {Size = 19.91-, Font = MinionMath-Disp}
}]

\setmathfont{Minion Math}[range = {bfup->up,bfit->it},
SizeFeatures = {
  {Size = -6.01, Font = MinionMath-BoldTiny},
  {Size = 6.01-8.41, Font = MinionMath-BoldCapt},
```



```
{Size = 8.41-13.01, Font = MinionMath-Bold},
{Size = 13.01-19.91, Font = MinionMath-BoldSubh},
{Size = 19.91-,      Font = MinionMath-BoldDisp}
}]
```

4.2 Script and scriptscript fonts/features

Cambria Math uses OpenType font features to activate smaller optical sizes for scriptsize and scriptscriptsize symbols (the B and C , respectively, in A_{B_C}). Other typefaces (such as Minion Math) may use entirely separate font files.

The features `script-font` and `sscript-font` allow alternate fonts to be selected for the script and scriptscript sizes, and `script-features` and `sscript-features` to apply different OpenType features to them.

By default `script-features` is defined as `Style=MathScript` and `sscript-features` is `Style=MathScriptScript`. These correspond to the two levels of OpenType’s `ssty` feature tag. If the (s)script-features options are specified manually, you must additionally specify the `Style` options as above.

4.3 Maths ‘versions’

L^AT_EX uses a concept known as ‘maths versions’ to switch math fonts mid-document. This is useful because it is more efficient than loading a complete maths font from scratch every time—especially with thousands of glyphs in the case of Unicode maths! The canonical example for maths versions is to select a ‘bold’ maths font which might be suitable for section headings, say. (Not everyone agrees with this typesetting choice, though; be careful.)

To select a new maths font in a particular version, use the syntax

```
\setmathfont{<font name>}[version=<version name>,<font features>]
```

and to switch between maths versions mid-document use the standard L^AT_EX command `\mathversion{<version name>}`.

Note there are currently open issues regarding the interaction between the version and the range features, so please proceed with caution.

4.4 Legacy maths ‘alphabet’ commands

L^AT_EX traditionally uses `\DeclareMathAlphabet` and `\SetMathAlphabet` to define document commands such as `\mathit`, `\mathbf`, and so on. While these commands can still be used, `unicode-math` defines a wrapper command to assist with the creation of new such maths alphabet commands. This command is known as `\setmathface` in symmetry with `fontspec`’s `\newfontface` command; it takes syntax:

```
\setmathfontface<command>{<font name>}[<font features>]
```

```
\setmathfontface<command>{<font name>}[version=<version name>,<font features>]
```

For example, if you want to define a new legacy maths alphabet font `\mathittt`:

```
\setmathfontface\mathittt{texgyrecursor-italic.otf}
```

Table 4: Maths text font configuration options. Note that `\mathup` and `\mathrm` are aliases of each other and cannot be configured separately.

Defaults (from ‘text’ font)	From ‘maths symbols’
<code>\mathrm=text</code>	<code>\mathrm=sym</code>
<code>\mathup=text*</code>	<code>\mathup=sym*</code>
<code>\mathit=text</code>	<code>\mathit=sym</code>
<code>\mathsf=text</code>	<code>\mathsf=sym</code>
<code>\mathbf=text</code>	<code>\mathbf=sym</code>
<code>\mathtt=text</code>	<code>\mathtt=sym</code>

```
...
 $\mathit{ttt}\{foo\} = \mathit{ttt}\{a\} + \mathit{ttt}\{b\}$ 
```

4.4.1 Default ‘text math’ fonts

The five ‘text math’ fonts, discussed above, are: `\mathrm`, `\mathbf`, `\mathit`, `\mathsf`, and `\mathtt`. These commands are also defined with their original definition under synonyms `\mathtextrm`, `\mathtextbf`, and so on. (These definitions hold regardless of package option, in case you need to be sure.)

When selecting document fonts using `fontspec` commands such as `\setmainfont`, `unicode-math` inserts some additional code into `fontspec` that keeps the current default fonts ‘in sync’ with their corresponding `\mathrm` commands, etc.

For example, in standard L^AT_EX, `\mathsf` doesn’t change even if the main document font is changed using `\renewcommand\sfddefault{...}`. With `unicode-math` loaded, after writing `\setsansfont{Helvetica}`, `\mathsf` will now be set in Helvetica.

If the `\mathsf` font is set explicitly at any time in the preamble, this ‘auto-following’ does not occur. The legacy math font switches can be defined either with commands defined by `fontspec` (`\setmathrm`, `\setmathsf`, etc.) or using the more general `\setmathfontface\mathsf` interface defined by `unicode-math`.

4.4.2 Replacing ‘text math’ fonts by symbols

For certain types of documents that use legacy input syntax, it may be preferable to have `\mathbf` behave as if it were `\symbol` en masse (et cetera respectively). A series of package options (table 4) are provided to facilitate switching the definition of `\mathXYZ` for the five legacy text math font definitions.

For example, if in a particular document `\mathbf` is used only for choosing symbols of vectors and matrices, a dedicated symbol font (`\symbol`) will produce better spacing and will better match the main math font. In that case loading `unicode-math` with the `\mathbf=sym` will achieve the desired result.

4.4.3 Operator font

L^AT_EX defines an internal command `\operator@font` for typesetting elements such as `\sin` and `\cos`. This font is selected from the legacy operators NFSS ‘MathAlphabet’, which is no longer relevant in the context of unicode-math. By default, the `\operator@font` command is defined to switch to the `\mathrm` font. You may now change these using the command:

```
\setoperatorfont\mathit
```

Or, to select a unicode-math range:

```
\setoperatorfont\symscr
```

For example, after the latter above, `\sin x` will produce ‘*sin x*’.

5 Maths input

X_YL^AT_EX’s Unicode support allows maths input through two methods. Like classical T_EX, macros such as `\alpha`, `\sum`, `\pm`, `\leq`, and so on, provide verbose access to the entire repertoire of characters defined by Unicode. The literal characters themselves may be used instead, for more readable input files.

5.1 Math ‘style’

Classically, T_EX uses italic lowercase Greek letters and *upright* uppercase Greek letters for variables in mathematics. This is contrary to the ISO standards of using italic forms for both upper- and lowercase. Furthermore, in various historical contexts, often associated with French typesetting, it was common to use upright uppercase *Latin* letters as well as upright upper- and lowercase Greek, but italic lowercase latin. Finally, it is not unknown to use upright letters for all characters, as seen in the Euler fonts.

The unicode-math package accommodates these possibilities with the option `math-style` that takes one of four (case sensitive) arguments: `TeX`, `ISO`, `french`, or `upright`.¹ The `math-style` options’ effects are shown in brief in table 5.

The philosophy behind the interface to the mathematical symbols lies in L^AT_EX’s attempt of separating content and formatting. Because input source text may come from a variety of places, the upright and ‘mathematical’ italic Latin and Greek alphabets are *unified* from the point of view of having a specified meaning in the source text. That is, to get a mathematical ‘*x*’, either the ASCII (‘keyboard’) letter `x` may be typed, or the actual Unicode character may be used. Similarly for Greek letters. The upright or italic forms are then chosen based on the `math-style` package option.

If glyphs are desired that do not map as per the package option (for example, an upright ‘*g*’ is desired but typing `g` yields ‘*g*’), *markup* is required to specify

¹Interface inspired by Walter Schmidt’s `lucimatx` package.

Table 5: Effects of the `math-style` package option.

Package option	Example	
	Latin	Greek
<code>math-style=ISO</code>	(a, z, B, X)	$(\alpha, \beta, \Gamma, \Xi)$
<code>math-style=TeX</code>	(a, z, B, X)	$(\alpha, \beta, \Gamma, \Xi)$
<code>math-style=french</code>	(a, z, B, X)	$(\alpha, \beta, \Gamma, \Xi)$
<code>math-style=upright</code>	(a, z, B, X)	$(\alpha, \beta, \Gamma, \Xi)$

this; to follow from the example: `\symup{g}`. Maths style commands such as `\symup` are detailed later.

For compatibility and consistency, however, `upright` and `italic` Greek letters can be ‘forced’ using `up` or `it` prefixes before their names. For example, `\Gamma` will give an upright or italic Gamma depending on the `math-style`, but `\upGamma` and `\itGamma` will always give upright or italic Gammas, respectively.

‘Literal’ interface Some may not like this convention of normalising their input. For them, an upright `x` is an upright ‘`x`’ and that’s that. (This will be the case when obtaining source text from copy/pasting PDF or Microsoft Word documents, for example.) For these users, the `literal` option to `math-style` will effect this behaviour. The `\symliteral{<syms>}` command can also be used, regardless of package setting, to force the style to match the literal input characters. This is a ‘mirror’ to `\symnormal{<syms>}` (also alias `\mathnormal`) which ‘resets’ the character mapping in its argument to that originally set up through package options.

‘Full-width’ letters Unicode contains ‘full-width’ versions of ASCII from `U+FF01`. The numerals and latin letters in this range are defined by `unicode-math` to map to their standard ASCII counterparts, which are then controlled by the relevant `math-style` setting. Other full-width symbols are not currently included but can be if there is sufficient need or desire.

5.2 Bold style

Similar as in the previous section, ISO standards differ somewhat to \TeX ’s conventions (and classical typesetting) for ‘boldness’ in mathematics. In the past, it has been customary to use bold *upright* letters to denote things like vectors and matrices. For example, $\mathbf{M} = (M_x, M_y, M_z)$. Presumably, this was due to the relatively scarcity of bold italic fonts in the pre-digital typesetting era. It has been suggested by some that *italic* bold symbols should be used nowadays instead, but this practise is certainly not widespread.

Bold Greek letters have simply been bold variant glyphs of their regular weight, as in $\boldsymbol{\xi} = (\xi_r, \xi_\phi, \xi_\theta)$. Confusingly, the syntax in \LaTeX traditionally has been different for obtaining ‘normal’ bold symbols in Latin and Greek: `\mathbf` in Latin and Greek: `\mathbf` in the former (‘ \mathbf{M} ’), and `\bm` (or `\boldsymbol`, deprecated) in the latter (‘ $\boldsymbol{\xi}$ ’).

Table 6: Effects of the bold-style package option.

Package option	Example	
	Latin	Greek
<code>bold-style=ISO</code>	(a, z, B, X)	$(\alpha, \beta, \Gamma, \Xi)$
<code>bold-style=TeX</code>	$(\mathbf{a}, \mathbf{z}, \mathbf{B}, \mathbf{X})$	$(\alpha, \beta, \Gamma, \Xi)$
<code>bold-style=upright</code>	$(\mathbf{a}, \mathbf{z}, \mathbf{B}, \mathbf{X})$	$(\alpha, \beta, \Gamma, \Xi)$

In unicode-math, the `\symbf` command works directly with both Greek and Latin maths characters and depending on package option either switches to upright for Latin letters (`bold-style=TeX`) as well or keeps them italic (`bold-style=ISO`). To match the package options for non-bold characters, with option `bold-style=upright` all bold characters are upright, and `bold-style=literal` does not change the upright/italic shape of the letter. The bold-style options' effects are shown in brief in table 6.

Upright and italic bold mathematical letters input as direct Unicode characters are normalised with the same rules. For example, with `bold-style=TeX`, a literal bold italic latin character will be typeset upright.

Note that `bold-style` is independent of `math-style`, although if the former is not specified then matching defaults are chosen based on the latter.

5.3 Sans serif style

Unicode contains upright and italic, medium and bold mathematical style characters. These may be explicitly selected with the `\symsfup`, `\symsfit`, `\symbfsfup`, and `\symbfsfit` commands discussed in section §5.4.

How should the generic `\symsf` behave? Unlike bold, sans serif is used much more sparingly in mathematics. I've seen recommendations to typeset tensors in sans serif italic or sans serif italic bold (e.g., examples in the `isomath` and `mattens` packages). But L^AT_EX's `\mathsf` is *upright* sans serif.

Therefore, the package options `[sans-style=upright]` and `[sans-style=italic]` control the behaviour of `\symsf`. The upright style sets up the command to use upright sans serif, including Greek; the italic style switches to using italic in both Latin and Greek. In other words, this option simply changes the meaning of `\symsf` to either `\symsfup` or `\symsfit`, respectively. Please let me know if more granular control is necessary here.

There is also a `[sans-style=literal]` setting, set automatically with `[math-style=literal]`, which retains the uprightness of the input characters used when selecting the sans serif output.

5.3.1 What about bold sans serif?

While you might want your bold upright and your sans serif italic, I don't believe you'd also want your bold sans serif upright (etc.). Therefore, bold sans serif fol-

Table 7: Mathematical styles defined in Unicode. Black dots indicate an style exists in the font specified; blue dots indicate shapes that should always be taken from the upright font even in the italic style. See main text for description of `\mathbbi`.

Font				Alphabet		
Style	Shape	Series	Switch	Latin	Greek	Numerals
Serif	Upright	Normal	<code>\symup</code>	•	•	•
		Bold	<code>\symbfup</code>	•	•	•
	Italic	Normal	<code>\symit</code>	•	•	•
		Bold	<code>\symbfit</code>	•	•	•
Sans serif	Upright	Normal	<code>\symsfup</code>	•		•
	Italic	Normal	<code>\symsfit</code>	•		•
	Upright	Bold	<code>\sybfsfup</code>	•	•	•
	Italic	Bold	<code>\sybfsfit</code>	•	•	•
Typewriter	Upright	Normal	<code>\symtt</code>	•		•
Double-struck	Upright	Normal	<code>\sybbb</code>	•		•
	Italic	Normal	<code>\sybbbit</code>	•		
Script	Upright	Normal	<code>\symscr</code>	•		
		Bold	<code>\sybfscr</code>	•		
Fraktur	Upright	Normal	<code>\symfrak</code>	•		
		Bold	<code>\sybfrac</code>	•		

lows from the setting for sans serif; it is completely independent of the setting for bold.

In other words, `\sybfsf` is either `\sybfsfup` or `\sybfsfit` based on `[sans-style=upright]` or `[sans-style=italic]`, respectively. And `[sans-style = literal]` causes `\sybfsf` to retain the same italic or upright shape as the input, and turns it bold sans serif.

N.B.: there is no medium-weight sans serif Greek range in Unicode. Therefore, `\symsf{\alpha}` does not make sense (it produces ‘ α ’), while `\sybfsf{\alpha}` gives ‘ α ’ or ‘ α ’ according to the `sans-style`.

5.4 All (the rest) of the mathematical styles

Unicode contains separate codepoints for most if not all variations of style shape one may wish to use in mathematical notation. The complete list is shown in table 7. Some of these have been covered in the previous sections.

The math font switching commands do not nest; therefore if you want sans serif bold, you must write `\sybfsf{...}` rather than `\sybf{\symsf{...}}`. This may change in the future.

5.4.1 Scope of the functionality of the `\sym..` commands

The `\sym..` commands are designed to affect only the follow sets of input letters: numerals (0–9), Latin (a – z , A – Z), Greek (α – ω , A – Ω), and the `\partial` and `\nabla` symbols (∂ , ∇). These are the only symbols for which Unicode defines separate codepoints with varying mathematical style.

There is currently no scope for including other symbols in the `\sym..` commands, such as writing `\symbf{\int}` for a bold integral symbol. Therefore the commands provided by `unicode-math` should not be compared to those provided by the `bm` package.

5.4.2 Double-struck

The double-struck style (also known as ‘blackboard bold’) consists of upright Latin letters $\{a-z, A-Z\}$, numerals $0-9$, summation symbol Σ , and four Greek letters only: $\{ \Upsilon \Pi \Gamma \Pi \}$.

While `\symbb{\sum}` does produce a double-struck summation symbol, its limits aren’t properly aligned. Therefore, either the literal character or the control sequence `\Bbbsum` are recommended instead.

There are also five Latin *italic* double-struck letters: $Ddeijj$. These can be accessed (if not with their literal characters or control sequences) with the `\mathbbi` style switch, but note that only those five letters will give the expected output.

5.4.3 Caligraphic vs. Script variants

The Unicode maths encoding contains a style for ‘Script’ letters, and while by default `\mathcal` and `\mathscr` are synonyms, there are some situations when a separate ‘Caligraphic’ style is needed as well.

If a font contains alternate glyphs for a separat caligraphic style, they can be selected explicitly as shown below. This feature is currently only supported by the XITS Math font, where the caligraphic letters are accessed with the same glyph slots as the script letters but with the first stylistic set feature (`ss01`) applied.

```
\setmathfont{xits-math.otf}[range={cal,bfcal},StylisticSet=1]
```

An example is shown below.

The Script style (`\mathscr`) in XITS Math is: $ABCXYZ$

The Caligraphic style (`\mathcal`) in XITS Math is: $ABCXYZ$

5.5 Miscellanea

5.5.1 Nabla

The symbol ∇ comes in the six forms shown in table 8. We want an individual option to specify whether we want upright or italic nabla by default (when either upright or italic nabla is used in the source). \TeX classically uses an upright nabla, and iso standards agree with this convention. The package options `nabla=upright`

Table 8: The various forms of nabla.

Description		Glyph
Upright	Serif	∇
	Bold serif	∇
	Bold sans	∇
Italic	Serif	∇
	Bold serif	∇
	Bold sans	∇

Table 9: The partial differential.

Description		Glyph
Regular	Upright	∂
	Italic	∂
Bold	Upright	∂
	Italic	∂
Sans bold	Upright	∂
	Italic	∂

(default) and `nabla=italic` switch between the two choices, and `nabla=literal` respects the shape of the input character. `nabla=literal` is activated automatically after `math-style=literal`.

These settings are then inherited through `\symbf`; `\symit` and `\symup` can be used to force the shape of the nabla one way or the other.

5.5.2 Partial

The same logic as for nabla applies to the symbols `u+2202` partial differential and `u+10715` math italic partial differential. However, in practice these symbols are often designed identically in an italic style.

If the font you are using supports it, use the `partial=upright` or `partial=italic` (default) package options to specify which one you would like, or `partial=literal` to have the same character used in the output as was used for the input. `partial=literal` is activated following `math-style=literal`.

See table 9 for the variations on the partial differential symbol.

5.5.3 Primes

Primes (x') may be input in several ways. You may use any combination the ASCII straight quote (') or the Unicode prime `u+2032` ('); when multiple primes occur next to each other, they chain together to form double, triple, or quadruple primes if the font contains pre-drawn glyphs. The individual prime glyphs are accessed, as usual, with the `\prime` command, and the double-, triple-, and quadruple-prime glyphs are available with `\dprime`, `\trprime`, and `\qprime`, respectively.

If the font does not contain the pre-drawn glyphs or more than four primes are used, the single prime glyph is used multiple times with a negative kern to get the spacing right. There is no user interface to adjust this negative kern yet (because I haven't decided what it should look like); if you need to, write something like this:

```
\ExplSyntaxOn
\muskip_gset:Nn \g_@@_primekern_muskip { -\thinmuskip/2 }
\ExplSyntaxOff
```


Table 10: Slashes and backslashes.

Slot	Name	Glyph	Command
U+002F	SOLIDUS	/	\slash
U+2044	FRACTION SLASH	/	\fracslash
U+2215	DIVISION SLASH	/	\divslash
U+29F8	BIG SOLIDUS	/	\xsol
U+005C	REVERSE SOLIDUS	\	\backslash
U+2216	SET MINUS	\	\smallsetminus
U+29F5	REVERSE SOLIDUS OPERATOR	\	\setminus
U+29F9	BIG REVERSE SOLIDUS	\	\xbsol

The package option `colon=literal` forces ASCII input ‘:’ to be printed as `\mathcolon` instead.

5.5.6 Slashes and backslashes

There are several slash-like symbols defined in Unicode. The complete list is shown in table 10.

In regular \LaTeX we can write `\left\slash...\right\backslash` and so on and obtain extensible delimiter-like symbols. Not all of the Unicode slashes are suitable for this (and do not have the font support to do it).

Slash Of U+2044 fraction slash, TR25 says that it is:

...used to build up simple fractions in running text...however parsers of mathematical texts should be prepared to handle fraction slash when it is received from other sources.

U+2215 division slash should be used when division is represented without a built-up fraction; $\pi \approx 22/7$, for example.

U+29F8 big solidus is a ‘big operator’ (like \sum).

Backslash The U+005C reverse solidus character `\backslash` is used for denoting double cosets: $A \backslash B$. (So I’m led to believe.) It may be used as a ‘stretchy’ delimiter if supported by the font.

MathML uses U+2216 set minus like this: $A \setminus B$.² The \LaTeX command name `\smallsetminus` is used for backwards compatibility.

Presumably, U+29F5 reverse solidus operator is intended to be used in a similar way, but it could also (perhaps?) be used to represent ‘inverse division’: $\pi \approx 7 \setminus 22$.³ The \LaTeX name for this character is `\setminus`.

Finally, U+29F9 big reverse solidus is a ‘big operator’ (like \sum).

²§4.4.5.11 <http://www.w3.org/TR/MathML3/>

³This is valid syntax in the Octave and Matlab programming languages, in which it means matrix inverse pre-multiplication. I.e., $A \setminus B \equiv A^{-1}B$.

How to use all of these things Unfortunately, font support for the above characters/glyphs is rather inconsistent. In Cambria Math, the only slash that grows (say when writing

$$\left[\begin{array}{cc} a & b \\ c & d \end{array} \right] \bigg/ \left[\begin{array}{cc} 1 & 1 \\ 1 & 0 \end{array} \right])$$

is the `FRACTION SLASH`, which we just established above is sort of only supposed to be used in text.

Of the above characters, the following are allowed to be used after `\left`, `\middle`, and `\right`:

- `\fracslash`;
- `\slash`; and,
- `\backslash` (the only reverse slash).

However, we assume that there is only *one* stretchy slash in the font; this is assumed by default to be `U+002F` solidus. Writing `\left/` or `\left\slash` or `\left\fracslash` will all result in the same stretchy delimiter being used.

The delimiter used can be changed with the `slash-delimiter` package option. Allowed values are `ascii`, `frac`, and `div`, corresponding to the respective Unicode slots.

For example: as mentioned above, Cambria Math’s stretchy slash is `U+2044` fraction slash. When using Cambria Math, then `unicode-math` should be loaded with the `slash-delimiter=frac` option. (This should be a font option rather than a package option, but it will change soon.)

5.5.7 Behaviour of hyphens in mathematics

Unicode defines the following related characters:

- `U+002D`hyphen-minus
- `U+02212`minus sign
- `U+02010`hyphen (`\mathhyphen`)

The first two of these characters in the input will all behave as the binary operator ‘minus sign’. The third is defined by `unicode-math` as a ‘math letter’ for constructions like $\mathbb{R} \bmod \text{Mod}$ ($\mathbb{R} \bmod$). If more control is needed surrounding these symbols, additional options can be added to the package; please get in touch if this is the case for you.

5.5.8 Growing and non-growing accents

There are a few accents for which TEX has both non-growing and growing versions. Among these are `\hat` and `\tilde`; the corresponding growing versions are called `\widehat` and `\widetilde`, respectively.

Older versions of \XeTeX and \LuaTeX did not support this distinction, however, and *all* accents there were growing automatically. (I.e., \hat and \widehat are equivalent.) As of \LuaTeX v0.65 and \XeTeX v0.9998, these wide/non-wide commands will again behave in their expected manner.

5.5.9 Negations and the \not command

The \not command in classic \LaTeX 2_ε was a mathematical slash modifying glyph that allowed for ‘negating’ maths symbols where pre-built glyphs were not available. While Unicode encodes a slot for this modifying slash, it is only well-supported in \LuaTeX and not in \XeTeX .

To provide more flexibility, the unicode-math package defines \not to search for a predefined ‘negated’ definitions for its argument and use that if available. This method can be used for fine-tuning in cases where spacing needs to be adjusted.

A ‘negated definition’ is any symbol command prefixed by either \n or \not . For example, unicode-math by default defines both \leftarrow (\leftarrow) and \nleftarrow (\nleftarrow).

To define custom negated definitions for either symbols (e.g., \not=) or commands (e.g., \not\equal), use the $\text{\NewNotCommand}\{\langle symbol \text{ or } cmd \rangle\}\{\langle definition \rangle\}$ command. Its usage is as follows:

```
 $\text{\NewNegationCommand}\{=\}\{\text{\neq}\}$ 
 $\text{\NewNegationCommand}\{\text{\equal}\}\{\text{\neq}\}$ 
```

If the command has already been defined, an error will result and $\text{\RenewNegationCommand}$ can be used to overwrite the original definition.

5.5.10 Pre-drawn fraction characters

Pre-drawn fractions U+00BC–U+00BE, U+2150–U+215E are not suitable for use in mathematics output. However, they can be useful as input characters to abbreviate common fractions.

$\frac{1}{4}$ $\frac{1}{2}$ $\frac{3}{4}$ $\frac{0}{3}$ $\frac{1}{7}$ $\frac{1}{9}$ $\frac{1}{10}$ $\frac{1}{3}$ $\frac{2}{3}$ $\frac{1}{5}$ $\frac{2}{5}$ $\frac{3}{5}$ $\frac{4}{5}$ $\frac{1}{6}$ $\frac{5}{6}$ $\frac{1}{8}$ $\frac{3}{8}$ $\frac{5}{8}$ $\frac{7}{8}$

For example, instead of writing ‘ $\text{\tfrac{12}{x}}$ ’, you may consider it more readable to have ‘ $\frac{12}{x}$ ’ in the source instead.

If the \tfrac command exists (i.e., if amsmath is loaded or you have specially defined \tfrac for this purpose), it will be used to typeset the fractions. If not, regular \frac will be used. The command to use (\tfrac or \frac) can be forced either way with the package option $\text{active-fraction=small}$ or $\text{active-fraction=normalsize}$, respectively.

5.5.11 Circles

Unicode defines a large number of different types of circles for a variety of mathematical purposes. There are thirteen alone just considering the all white and all black ones, shown in table 11.

Slot	Command	Glyph	Glyph	Command	Slot
U+00B7	<code>\cdotp</code>	·			
U+22C5	<code>\cdot</code>	·			
U+2219	<code>\vysmblkcircle</code>	•	◦	<code>\vysmwhtcircle</code>	U+2218
U+2022	<code>\smbkcircle</code>	•	◦	<code>\smwhtcircle</code>	U+25E6
U+2981	<code>\mdsmbkcircle</code>	●	◦	<code>\mdsmwhtcircle</code>	U+26AC
U+26AB	<code>\mdblkcircle</code>	●	◯	<code>\mdwhtcircle</code>	U+26AA
U+25CF	<code>\mdlgblkcircle</code>	●	◯	<code>\mdlgwhtcircle</code>	U+25CB
U+2B24	<code>\lgblkcircle</code>	●	◯	<code>\lgwhtcircle</code>	U+25EF

Table 11: Filled and hollow Unicode circles.

Slot	Command	Glyph	Class
U+25B5	<code>\vartriangle</code>	△	binary
U+25B3	<code>\bigtriangleup</code>	△	binary
U+25B3	<code>\triangle</code>	△	ordinary
U+2206	<code>\increment</code>	△	ordinary
U+0394	<code>\mathup\Delta</code>	Δ	ordinary

Table 12: Different upwards pointing triangles.

L^AT_EX defines considerably fewer: `\circ` and `\bigcirc` for white; `\bullet` for black. This package maps those commands to `\vysmwhtcircle`, `\mdlgwhtcircle`, and `\smbkcircle`, respectively.

5.5.12 Triangles

While there aren’t as many different sizes of triangle as there are circle, there’s some important distinctions to make between a few similar characters. See table 12 for the full summary.

These triangles all have different intended meanings. Note for backwards compatibility with T_EX, U+25B3 has *two* different mappings in unicode-math. `\bigtriangleup` is intended as a binary operator whereas `\triangle` is intended to be used as a letter-like symbol.

But you’re better off if you’re using the latter form to indicate an increment to use the glyph intended for this purpose, U+2206: Δx .

Finally, given that \triangle and Δ are provided for you already, it is better off to only use upright Greek Delta Δ if you’re actually using it as a symbolic entity such as a variable on its own.

6 *Advanced*

6.1 *Warning messages*

This package can produce a number of informational messages to try and inform the user when something might be going wrong due to package conflicts or something else. As an experimental feature, these can be turned off on an individual basis with the package option `warnings-off` which takes a comma-separated list of warnings to suppress. A warning will give you its name when printed on the console output; e.g.,

```
* unicode-math warning: "mathtools-colon"
*
* ... <warning message> ...
```

This warning could be suppressed by loading the package as follows:

```
\usepackage[warnings-off={mathtools-colon}]{unicode-math}
```

6.2 *Programmer's interface*

(Tentative and under construction.) If you are writing some code that needs to know the current maths style (`\mathbf`, `\mathit`, etc.), you can query the variable `\l_@@_mathstyle_t1`. It will contain the maths style without the leading ‘math’ string; for example, `\symbf { \show \l_@@_mathstyle_t1 }` will produce ‘bf’.

A *STIX table data extraction*

The source for the $\text{T}_{\text{E}}\text{X}$ names for the very large number of mathematical glyphs are provided via Barbara Beeton’s table file for the `stix` project (ams.org/STIX). A version is located at <http://www.ams.org/STIX/bnb/stix-tbl.asc> but check <http://www.ams.org/STIX/> for more up-to-date info.

This table is converted into a form suitable for reading by $\text{T}_{\text{E}}\text{X}$. A single file is produced containing all (more than 3298) symbols. Future optimisations might include generating various (possibly overlapping) subsets so not all definitions must be read just to redefine a small range of symbols. Performance for now seems to be acceptable without such measures.

This file is currently developed outside this DTX file. It will be incorporated when the final version is ready. (I know this is not how things are supposed to work!)

B *Documenting maths support in the NFSS*

In the following, $\langle \text{NFSS decl.} \rangle$ stands for something like $\{\text{T1}\}\{\text{lmr}\}\{\text{m}\}\{\text{n}\}$.

Maths symbol fonts Fonts for symbols: $\propto, \leq, \rightarrow$

`\DeclareSymbolFont{<name>}\langle \text{NFSS decl.} \rangle`

Declares a named maths font such as operators from which symbols are defined with `\DeclareMathSymbol`.

Maths alphabet fonts Fonts for $ABC-xyz, \mathfrak{ABC}-\mathcal{XYZ}$, etc.

`\DeclareMathAlphabet{<cmd>}\langle \text{NFSS decl.} \rangle`

For commands such as `\mathbf`, accessed through maths mode that are unaffected by the current text font, and which are used for alphabetic symbols in the `ASCII` range.

`\DeclareSymbolFontAlphabet{<cmd>}\{<name>\}`

Alternative (and optimisation) for `\DeclareMathAlphabet` if a single font is being used for both alphabetic characters (as above) and symbols.

Maths ‘versions’ Different maths weights can be defined with the following, switched in text with the `\mathversion{<maths version>}` command.

`\SetSymbolFont{<name>}\{<maths version>\}\langle \text{NFSS decl.} \rangle`

`\SetMathAlphabet{<cmd>}\{<maths version>\}\langle \text{NFSS decl.} \rangle`

Maths symbols Symbol definitions in maths for both characters (=) and macros (`\eqdef`): `\DeclareMathSymbol{<symbol>}\{<type>\}\{<named font>\}\{<slot>\}` This is the macro that actually defines which font each symbol comes from and how they behave.

Delimiters and radicals use wrappers around $\text{T}_{\text{E}}\text{X}$ ’s `\delimiter/\radical` primitives, which are re-designed in $\text{X}_{\text{Y}}\text{T}_{\text{E}}\text{X}$. The syntax used in $\text{L}_{\text{A}}\text{T}_{\text{E}}\text{X}$ ’s NFSS is therefore not so relevant here.

Delimiters A special class of maths symbol which enlarge themselves in certain contexts.

```
\DeclareMathDelimiter{<symbol>}{<type>}{<sym.font>}{<slot>}{<sym.font>}{<slot>}
```

Radicals Similar to delimiters (`\DeclareMathRadical` takes the same syntax) but behave ‘weirdly’.

In those cases, glyph slots in *two* symbol fonts are required; one for the small (‘regular’) case, the other for situations when the glyph is larger. This is not the case in \LaTeX .

Accents are not included yet.

Summary For symbols, something like:

```
\def\DeclareMathSymbol#1#2#3#4{
  \global\mathchardef#1"\mathchar@type#2
  \expandafter\hexnumber@\csname sym#2\endcsname
  {\hexnumber@{\count\z@}\hexnumber@{\count\tw@}}}
```

For characters, something like:

```
\def\DeclareMathSymbol#1#2#3#4{
  \global\mathcode`#1"\mathchar@type#2
  \expandafter\hexnumber@\csname sym#2\endcsname
  {\hexnumber@{\count\z@}\hexnumber@{\count\tw@}}}
```


C Legacy $\text{T}_{\text{E}}\text{X}$ font dimensions

Text fonts		Maths font, $\backslash\text{fam}2$		Maths font, $\backslash\text{fam}3$	
ϕ_1	slant per pt	σ_5	x height	ζ_8	default rule thickness
ϕ_2	interword space	σ_6	quad	ζ_9	big op spacing1
ϕ_3	interword stretch	σ_8	num1	ζ_{10}	big op spacing2
ϕ_4	interword shrink	σ_9	num2	ζ_{11}	big op spacing3
ϕ_5	x-height	σ_{10}	num3	ζ_{12}	big op spacing4
ϕ_6	quad width	σ_{11}	denom1	ζ_{13}	big op spacing5
ϕ_7	extra space	σ_{12}	denom2		
ϕ_8	cap height ($\text{X}_{\text{E}}\text{T}_{\text{E}}\text{X}$ only)	σ_{13}	sup1		
		σ_{14}	sup2		
		σ_{15}	sup3		
		σ_{16}	sub1		
		σ_{17}	sub2		
		σ_{18}	sup drop		
		σ_{19}	sub drop		
		σ_{20}	delim1		
		σ_{21}	delim2		
		σ_{22}	axis height		

D $\text{X}_{\text{E}}\text{T}_{\text{E}}\text{X}$ math font dimensions

These are the extended $\backslash\text{fontdimen}$ s available for suitable fonts in $\text{X}_{\text{E}}\text{T}_{\text{E}}\text{X}$. Note that $\text{LuaT}_{\text{E}}\text{X}$ takes an alternative route, and this package will eventually provide a wrapper interface to the two (I hope).

$\backslash\text{fontdimen}$	Dimension name	Description
10	<code>SCRIPTPERCENTSCALEDOWN</code>	Percentage of scaling down for script level 1. Suggested value: 80%.
11	<code>SCRIPTSCRIPTPERCENTSCALEDOWN</code>	Percentage of scaling down for script level 2 (ScriptScript). Suggested value: 60%.
12	<code>DELIMITEDSUBFORMULAMINHEIGHT</code>	Minimum height required for a delimited expression to be treated as a subformula. Suggested value: normal line height \times 1.5.
13	<code>DISPLAYOPERATORMINHEIGHT</code>	Minimum height of n-ary operators (such as integral and summation) for formulas in display mode.

\fontdimen	Dimension name	Description
14	MATHLEADING	White space to be left between math formulas to ensure proper line spacing. For example, for applications that treat line gap as a part of line ascender, formulas with ink going above (os2.sTypoAscender + os2.sTypoLineGap – MathLeading) or with ink going below os2.sTypoDescender will result in increasing line height.
15	AxisHEIGHT	Axis height of the font.
16	ACCENTBASEHEIGHT	Maximum (ink) height of accent base that does not require raising the accents. Suggested: x-height of the font (os2.sxHeight) plus any possible overshots.
17	FLATTENEDACCENTBASE-HEIGHT	Maximum (ink) height of accent base that does not require flattening the accents. Suggested: cap height of the font (os2.sCapHeight).
18	SUBSCRIPTSHIFTDOWN	The standard shift down applied to subscript elements. Positive for moving in the downward direction. Suggested: os2.ySubscriptYOffset.
19	SUBSCRIPTTOPMAX	Maximum allowed height of the (ink) top of subscripts that does not require moving subscripts further down. Suggested: $\frac{1}{5}$ x-height.
20	SUBSCRIPTBASELINEDROPMIN	Minimum allowed drop of the baseline of subscripts relative to the (ink) bottom of the base. Checked for bases that are treated as a box or extended shape. Positive for subscript baseline dropped below the base bottom.
21	SUPERSCRIPSHIFTUP	Standard shift up applied to superscript elements. Suggested: os2.ySuperscriptYOffset.
22	SUPERSCRIPSHIFTUPCRAMPED	Standard shift of superscripts relative to the base, in cramped style.
23	SUPERSCRIPBOTTOMMIN	Minimum allowed height of the (ink) bottom of superscripts that does not require moving subscripts further up. Suggested: $\frac{1}{4}$ x-height.

\fontdimen	Dimension name	Description
24	SUPERSCRIPTBASELINEDROP-MAX	Maximum allowed drop of the baseline of superscripts relative to the (ink) top of the base. Checked for bases that are treated as a box or extended shape. Positive for superscript baseline below the base top.
25	SUBSUPERSCRIPGAPMIN	Minimum gap between the superscript and subscript ink. Suggested: 4×default rule thickness.
26	SUPERSCRIPBTOMMAX-WITHSUBSCRIPT	The maximum level to which the (ink) bottom of superscript can be pushed to increase the gap between superscript and subscript, before subscript starts being moved down. Suggested: /5 x-height.
27	SPACEAFTERSCRIPT	Extra white space to be added after each subscript and superscript. Suggested: 0.5pt for a 12 pt font.
28	UPPERLIMITGAPMIN	Minimum gap between the (ink) bottom of the upper limit, and the (ink) top of the base operator.
29	UPPERLIMITBASELINERISEMIN	Minimum distance between baseline of upper limit and (ink) top of the base operator.
30	LOWERLIMITGAPMIN	Minimum gap between (ink) top of the lower limit, and (ink) bottom of the base operator.
31	LOWERLIMITBASELINEDROP-MIN	Minimum distance between baseline of the lower limit and (ink) bottom of the base operator.
32	STACKTOPSHIFTUP	Standard shift up applied to the top element of a stack.
33	STACKTOPDISPLAYSTYLESHIFT-UP	Standard shift up applied to the top element of a stack in display style.
34	STACKBOTTOMSHIFTDOWN	Standard shift down applied to the bottom element of a stack. Positive for moving in the downward direction.
35	STACKBOTTOMDISPLAYSTYLE-SHIFTDOWN	Standard shift down applied to the bottom element of a stack in display style. Positive for moving in the downward direction.
36	STACKGAPMIN	Minimum gap between (ink) bottom of the top element of a stack, and the (ink) top of the bottom element. Suggested: 3×default rule thickness.

\fontdimen	Dimension name	Description
37	STACKDISPLAYSTYLEGAPMIN	Minimum gap between (ink) bottom of the top element of a stack, and the (ink) top of the bottom element in display style. Suggested: 7×default rule thickness.
38	STRETCHSTACKTOPSHIFTUP	Standard shift up applied to the top element of the stretch stack.
39	STRETCHSTACKBOTTOMSHIFT-DOWN	Standard shift down applied to the bottom element of the stretch stack. Positive for moving in the downward direction.
40	STRETCHSTACKGAPABOVEMIN	Minimum gap between the ink of the stretched element, and the (ink) bottom of the element above. Suggested: UpperLimitGapMin
41	STRETCHSTACKGAPBELOWMIN	Minimum gap between the ink of the stretched element, and the (ink) top of the element below. Suggested: LowerLimitGapMin.
42	FRACTIONNUMERATORSHIFTUP	Standard shift up applied to the numerator.
43	FRACTIONNUMERATOR-DISPLAYSTYLESHIFTUP	Standard shift up applied to the numerator in display style. Suggested: StackTopDisplayStyleShiftUp.
44	FRACTIONDENOMINATORSHIFT-DOWN	Standard shift down applied to the denominator. Positive for moving in the downward direction.
45	FRACTIONDENOMINATOR-DISPLAYSTYLESHIFTDOWN	Standard shift down applied to the denominator in display style. Positive for moving in the downward direction. Suggested: StackBottomDisplayStyleShiftDown.
46	FRACTIONNUMERATORGAP-MIN	Minimum tolerated gap between the (ink) bottom of the numerator and the ink of the fraction bar. Suggested: default rule thickness
47	FRACTIONNUMDISPLAYSTYLE-GAPMIN	Minimum tolerated gap between the (ink) bottom of the numerator and the ink of the fraction bar in display style. Suggested: 3×default rule thickness.
48	FRACTIONRULETHICKNESS	Thickness of the fraction bar. Suggested: default rule thickness.

\fontdimen	Dimension name	Description
49	FRACTIONDENOMINATORGAP-MIN	Minimum tolerated gap between the (ink) top of the denominator and the ink of the fraction bar. Suggested: default rule thickness
50	FRACTIONDENOMDISPLAY-STYLEGAPMIN	Minimum tolerated gap between the (ink) top of the denominator and the ink of the fraction bar in display style. Suggested: 3×default rule thickness.
51	SKEWEDFRACTION-HORIZONTALGAP	Horizontal distance between the top and bottom elements of a skewed fraction.
52	SKEWEDFRACTIONVERTICAL-GAP	Vertical distance between the ink of the top and bottom elements of a skewed fraction.
53	OVERBARVERTICALGAP	Distance between the overbar and the (ink) top of the base. Suggested: 3×default rule thickness.
54	OVERBARRULETHICKNESS	Thickness of overbar. Suggested: default rule thickness.
55	OVERBAREXTRAASCENDER	Extra white space reserved above the overbar. Suggested: default rule thickness.
56	UNDERBARVERTICALGAP	Distance between underbar and (ink) bottom of the base. Suggested: 3×default rule thickness.
57	UNDERBARRULETHICKNESS	Thickness of underbar. Suggested: default rule thickness.
58	UNDERBAREXTRADESCENDER	Extra white space reserved below the underbar. Always positive. Suggested: default rule thickness.
59	RADICALVERTICALGAP	Space between the (ink) top of the expression and the bar over it. Suggested: 1¼ default rule thickness.
60	RADICALDISPLAYSTYLE-VERTICALGAP	Space between the (ink) top of the expression and the bar over it. Suggested: default rule thickness + ¼ x-height.
61	RADICALRULETHICKNESS	Thickness of the radical rule. This is the thickness of the rule in designed or constructed radical signs. Suggested: default rule thickness.
62	RADICALEXTRAASCENDER	Extra white space reserved above the radical. Suggested: RadicalRuleThickness.

\fontdimen	Dimension name	Description
63	RADICALKERNBEFOREDEGREE	Extra horizontal kern before the degree of a radical, if such is present. Suggested: 5/18 of em.
64	RADICALKERNAFTERDEGREE	Negative kern after the degree of a radical, if such is present. Suggested: -10/18 of em.
65	RADICALDEGREEBOTTOM- RAISEPERCENT	Height of the bottom of the radical degree, if such is present, in proportion to the ascender of the radical sign. Suggested: 60%.