# Mathematical typefaces in TeX documents

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## Abstract

This paper discusses free math fonts that can be used by TeX to harmonize with desired text typefaces. It has been written with a user of plain TeX in mind but the pivotal issues discussed are common to other friends of TeX, e.g., LaTeX. A technique for changing text and math fonts in TeX is given. Then the paper discusses the lack of math fonts compared to text fonts in TeX. It is followed by some deliberation on some aspects of complete sets of math fonts. The term "math mode" includes both TeX's in-line and display math modes, unless stated otherwise.

## 1. Changing math fonts

Changing the text font in TeX is quite simple. For example, the command `\font\myfont=cmss10` will assign the font `cmss10` to the control word `\myfont`. However, this does not work when assigning fonts to be used in math mode. TeX uses fonts from one or more of the sixteen *font families* to typeset mathematical characters. Each font family consists of three fonts — textfont, scriptfont, and scriptscriptfont.

In plain TeX, by default, most of the mathematical characters come from family 0 (*roman*), family 1 (*math italic*), family 2 (*math symbol*), and family 3 (*math extension*); TeX expects these families to be fixed. There are characters in math mode that come from other font families, e.g., **x** in $f(\mathbf{x})$ is from family 6 (`\bffam`). In all, plain TeX uses 8 families (0–7). To thoroughly change the typeface/type family of a document generated by plain TeX, it is required to change the fonts in 7 of those font families; one of the eight families is for the typewriter typeface.

The following code changes the type family in a TeX document from Computer Modern (default) to Charter. The fonts used in the code are free and included in most TeX distributions. This method works well with other formats based on plain TeX, e.g., AMS-TeX, XeTeX (not XeLaTeX), Eplain, etc. With LaTeX, the given method does not work.

```
% Family 0 (Roman)
\font\tenrm=mdbchr7t at10pt
\font\sevenrm=mdbchr7t at7pt
\font\fiverm=mdbchr7t at5pt
\textfont0=\tenrm
\scriptfont0=\sevenrm
\scriptscriptfont0=\fiverm
\def\rm{\fam=0 \tenrm}
%
% Family 1 (Math italic)
\font\teni=mdbchri7m at10pt
\font\seveni=mdbchri7m at7pt
\font\fivei=mdbchri7m at5pt
\textfont1=\teni
\scriptfont1=\seveni
\scriptscriptfont1=\fivei
\def\mit{\fam=1}
%
% Family 2 (Math symbols)
\font\tensy=md-chr7y at10pt
\font\sevensy=md-chr7y at7pt
\font\fivesy=md-chr7y at5pt
\textfont2=\tensy
\scriptfont2=\sevensy
\scriptscriptfont2=\fivesy
\def\cal{\fam=2}
%
% Family 3 (Math extension)
\font\tenex=mdbchr7v at10pt
\font\sevenex=mdbchr7v at7pt
\font\fiveex=mdbchr7v at5pt
\textfont3=\tenex
\scriptfont3=\sevenex
\scriptscriptfont3=\fiveex
%
% Family 4 (Italic text)
\font\tenit=mdbchri7t at10pt
\font\sevenit=mdbchri7t at7pt
\font\fiveit=mdbchri7t at5pt
\textfont\itfam=\tenit
\scriptfont\itfam=\sevenit
\scriptscriptfont\itfam=\fiveit
\def\it{\fam=\itfam \tenit}
%
% Family 5 (Slanted text)
\font\tensl=mdbchro7t at10pt
\font\sevensl=mdbchro7t at7pt
\font\fivesl=mdbchro7t at5pt
\textfont\slfam=\tensl
\scriptfont\slfam=\sevensl
\scriptscriptfont\slfam=\fivesl
\def\sl{\fam=\slfam \tensl}
%
% Family 6 (Bold text)
\font\tenbf=mdbchb7t at10pt
\font\sevenbf=mdbchb7t at7pt
\font\fivebf=mdbchb7t at5pt
\textfont\bffam=\tenbf
\scriptfont\bffam=\sevenbf
\scriptscriptfont\bffam=\fivebf
```

```
\def\bf{\fam=\bffam \tenbf}
%
% Family 7 (Typewriter)
\font\tentt=cmtt10
\font\seventt=cmtt10 at7pt
\font\fivett=cmtt10 at5pt
\textfont\ttfam=\tentt
\scriptfont\ttfam=\seventt
\scriptscriptfont\ttfam=\fivett
\def\tt{\fam=\ttfam \tentt}
%
\rm   % Sets normal roman font
```

Another way to change the fonts is to use the control word `\newfam` [1]. The technique is similar to the one illustrated above. The macro `\newfam` allows the user to form new font families under new assigned names.

## 2. Available math fonts

TEX can change the math typefaces only if the fonts to do that are available. Today's TEX distributions include hundreds of fonts to change the typeface for text, but this is not the case with math. We can find hundreds of readily available free fonts offering the roman, *italic*, *slanted*, and **bold** typeface variants, but the fonts for creating specific math typefaces are not even in tens. The problem is the lack of fonts that are included in font families 1, 2, and 3 — *math italic*, *math symbol*, and *math extension* fonts. Given below is some math and text in different typefaces, typeset using free fonts available in major TEX distributions like TEX Live 2009 and MiKTEX 2.8.

Computer Modern

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty}\frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Charter

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty}\frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Utopia

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty}\frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Century

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty}\frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Palatino

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty}\frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Times

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty}\frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Bookman

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty}\frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Antykwa Toruńska

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty}\frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Iwona

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty} \frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Kurier

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty} \frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Arev

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty} \frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Computer Modern Bright

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty} \frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Concrete

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty} \frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Kepler

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

$$\lim_{k\to\infty} \frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Euler

$$f(x,y) = (x+y)^{(2x)^{y^{x+2y^3}}}$$

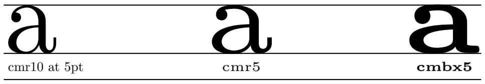
$$\lim_{k\to\infty} \frac{1}{2\pi}\int_T \sigma_{n_k}(t)e^{-ijt}dt = \lim_{k\to\infty}\left(1-\frac{|j|}{n_k+1}\right)c_j$$

Mathematical typesetting in TeX is more complex than text typesetting, and so is the making of math fonts compared to text fonts. Though aesthetic appreciation is subjective, most of us would agree that inter-character spacing, kerning, scripts and scriptscripts look better in Computer Modern and Euler. Here we are not talking about the design features like the contours that shape the characters or the lightness of a type family, but the fine tuning that the font offers. All the fonts used above are vector fonts, and only Computer Modern and Euler offer separate math italic and math symbol fonts at 10pt, 7pt, and 5pt. The math italic of Computer Modern is different than the normal italic of the same, the former being a bit extended. The 5pt size of Computer Modern is not 10pt scaled to 5pt; it is a separate font designed specifically for 5pt size, and this feature enhances math typesetting.

In $e^{ijt}$ of Bookman, which uses math italic from Antonis Tsolomitis' Kerkis package, $ij$ looks like a '$y$ with two dots'. This is confusing and in italic text it is a blemish on the look of words like *bijection*. It can be seen that the space setting in Kerkis is in need of improvement. In $|j|$, the *descender* (the foot of the $j$) cuts the vertical bar. We can improve such shortcomings manually but such alterations will be tedious and font specific — a change of font might then produce ugly results due to bad spacing. Another option is to include such tuning in the font metric information, making the process of adjustment automatic and transferable. Another alternative is to have a separate math italic font, that has its own glyphs which match the normal italic without being mere copies, which would be advantageous. After trimming the *terminal* (leg) of $i$ of `kmath8r` (Kerkis math italic) we can get an individual glyph for math italic, which goes with the text italic but it is not a duplication. A separate math italic in Kerkis with well-chosen font metric parameters would solve most problems without the need of manual tuning. Nevertheless, some cases will always exist (especially for diehard typographers) where some manual fine-tuning would be required to produce desired results.

In the given examples, some interesting details to note are:

1. Inter-character spacing, with special attention to the spacing between scriptsize (7pt) and scriptscriptsize (5pt) glyphs, respectively.
2. The readability of smaller glyphs — scriptsize and scriptscriptsize. As discussed earlier, 5pt of Computer Modern or Euler is not 10pt scaled to 5pt. Typically, a font at 10pt scaled to 5pt has the same height as the original 5pt but the latter is wider with thicker strokes. True or original 5pt is not an extended version of 10pt scaled to 5pt either. Shown below are respective typefaces magnified to 40pt for illustration. Note the difference in the shape and stroke thickness.

   At smaller sizes it is easier to read wider and thicker types. This is the philosophy behind designing separate 7pt and 5pt fonts. These typefaces, when used in scriptsize or scriptscriptsize, match better in weight with the main text: compared with the main text, they do not seem as light as the scaled down versions.
3. Whether math symbols, Greek letters, and delimiters go with the type family. Evenness of typographic *color*. This $(\Delta + \Gamma)$ blends better with the main text than $(\Delta + \Gamma)$ or $(\Delta + \Gamma)$. The glyphs in math symbol and extension fonts should be in harmony with the text font glyphs.

Typography is an art used by many but valued by few, and practised by fewer. Moreover, in the realm of typography, mathematics is underprivileged. There are many reasons for this, the main cause being that the majority of the world never uses or only sporadically uses specialized mathematical typesetting features. Another reason is that most of the mathematicians, scientists, students, . . . , who typeset mathematics, are more focussed on the content than its presentation — it suffices for them that at least and at most it works! The present typesetting algorithms of TeX suggest that typesetting mathematics is more demanding than typesetting text. TeX requires text fonts to have at least 7 `\fontdimen` parameters, whereas math symbol fonts should have at least 22 `\fontdimen` parameters and math extension fonts require at least 13 `\fontdimen` parameters. Availability of a separate math italic font is an advantage but as it is not usable as a text italic, and text italics are what most users need, there is not a huge demand for it.

## 3. Requirements of math fonts

The TeX world would certainly enjoy having more math fonts that have at least all the features of the legendary Computer Modern fonts. In the world of typography, two developments have been very popular — Unicode and OpenType. Is TeX ready for it? The development of XeTeX, LuaTeX, Latin Modern and TeX Gyre fonts is promising. However, this is only in the field of text typesetting. To my knowledge, none of the present TeX engines support Unicode math or any TeX fonts have OpenType math fonts.

OpenType text fonts from Adobe, like the *Pro* series, have set new heights of typographic elegance. For example, the *Warnock Pro* font family from Adobe offers 2 styles: roman and italic, in 4 weights: light, normal, semibold, and bold, in 4 optical sizes: caption, normal, subheading, and display. Amongst many other features, there is support for small caps and oldstyle figures too. Fake slanted faces, which are almost as true as real slanted when the slant is less than 0.2, can be obtained using the OpenType *slant* tag. There are some TeX fonts, like *Kpfonts*, that have light weight variants.

As Unicode is becoming the de facto encoding standard, TeX needs to gear up to accept it in a “standardized” way. Another wonderful addition would be the wholehearted acceptance of OpenType format. This would enhance TeX’s communication with the non-TeX world. Opinions on these two recommendations might differ and only with time will we see what the future holds for us. We refrain from mentioning more on these topics.

At the glyph level, we can reckon a few features that TeX math fonts should offer. They should have:

1. At least three sizes (5pt, 7pt, 10pt).
2. Separate math italics suited for math and harmonious with text.
3. A complete set of math symbols and extension characters that are at least as many as offered by the AMS fonts collection. Missing glyphs are a massive disappointment and marks of unreliability.
4. The symbols and math extension characters should coordinate with the text and math letters and numbers. Balance of serifs, stroke weight, and x-height are a few considerations.
5. Availability of Script, Fraktur (lower and upper case), Blackboard fonts. It would be nice to

have more than one script glyph per character to meet special requirements.

6. All glyphs of a type family should complement each other. With proper spacing, they should give similar typographic *color* to text and math. The use of *virtual fonts*, though inviting, should be avoided.
7. All glyphs should have normal and bold variants. A semibold variant would be welcomed.
8. For slides and posters, some complete sans serif type families would be appreciated.

This list can be enlarged as refinement has no limits. It should be kept in mind that font design is an extremely demanding task. At the user level it is better to have a few sets of fonts that are well-designed and complete than having many which are incomplete. A typeset page should convey information with clarity and according to context. Academic book publishing has its own requirements, slide display has its own, and so on. Good typography does justice to all.

We have mentioned earlier in this section that it is required of TEX to adapt itself to popular font formats like OpenType. A common font design platform would allow TEX font designers to reach even non-TEXnicians — this would make their work valued by more which means greater effort.

## 4. Conclusion

The birth of TEX was a revolution in typesetting. Though in text typesetting today, after decades, TEX faces competition from some commercial software applications, in math typesetting it is still far ahead of the competition. Let's make our TEX, which is the best, even better!

TEX users are thankful to TEX font designers and contributors for their involvement and support. In this paper some suggestions were given, e.g., provision of original 5pt, 7pt, and 10pt sizes. Any design and effort, no matter how rudimentary, deserves its due respect. It is hoped that the words of this paper spoke with and for encouragement.

As TEX is free, so does it call for free fonts. Though it is feasible, at least in text, to use almost any font with TEX, free fonts are the real requirement of TEX. And beautiful free fonts with complete math support in the best format encoded with elegance is what TEX deserves.

## References

[1] D. E. Knuth. *The TEXbook*. Addison-Wesley Pub. Co., Reading, Mass., 1986.

[2] A. R. Dhawan. "Macros to Change Text & Math fonts in TEX: 19 Beautiful Variants," CTAN, August 2009. `http://mirror.ctan.org/macros/plain/contrib/font-change/doc/`

[3] R. Bringhurst. *The Elements of Typographic Style*. Hartley & Marks, Publishers, 3rd edition, 2004.

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