
Math alphabets and the `mathalfa` package

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Abstract

This is both a survey of existing math alphabets and a brief description of a unified method of calling them via the package `mathalfa`.

1 Introduction

For the purposes of this article, a math alphabet is one normally selected in math mode using the \LaTeX macros `\mathcal`, `\mathscr`, `\mathbb`, `\mathfrak`, or their bold counterparts `\mathbcal`, `\mathbscr`, `\mathbbb` and `\mathbfrak`.

Regular and bold weights of a math calligraphic font are built into Computer Modern, occupying the upper case letter slots in the `cm[b]sy` family. The *fraktur* and *blackboard bold* alphabets were (I believe) introduced with the AMS fonts, and the `mathrsfs` package introduced the term `\mathscr` in order to provide a script font with more elaborate shapes, as is customary in a number of areas in math and physics, in addition to an ordinary calligraphic alphabet. The Unicode specification lists the fonts under *Mathematical Alphanumeric Symbols* (U1D400–U1D7FF), though a number of special, commonly used glyphs fall under the heading *Letterlike Symbols* (U2100–U214F). The Unicode names for the alphabets are:

MATHEMATICAL SCRIPT:

a.k.a. script, swash, calligraphic.

MATHEMATICAL DOUBLE-STRUCK:

a.k.a. double-struck, blackboard bold, openface.

MATHEMATICAL FRAKTUR:

a.k.a. *fraktur*, *blackletter*, *gothic*.

2 `Mathalfa`

The `mathalfa` package in most cases bypasses the usual font-loading mechanisms for these math alphabets and substitutes its own, allowing it to use common terminology and, in all cases, allow arbitrary scaling. (Many \LaTeX packages that load fonts have not been modified since the days when Metafont was the predominant font format, and it was desirable to restrict the set of sizes at which the bitmaps were generated, thus limiting the possibility of fine scaling.) In a number of cases, the original math alphabet fonts were never set up with the metrics appropriate for math mode, leading to awkward placement of accents and subscripts, and inappropriate spacing. This package corrects such deficiencies by supplying virtual fonts with my preferences for those metrics following, by and large, the appearance of `mtpro2` (*MathTime Pro II*).

The line

```
\usepackage[showoptions]{mathalfa}
```

throws an error and shows all alphabet names understood by the package. As an example, to load Zapf Chancery scaled up by 15% as the output of `\mathcal` and Fourier Double-Struck scaled down by 4% as the output of `\mathbb`, you enter

```
\usepackage[cal=zapfc,calscaled=1.15,
             bb=fourier,bbscaled=.96]
             {mathalfa}
```

after loading other math packages. You may also set as options

```
frak=...[,frakscaled=...],
scr=...[,scrscaled=...],
```

to enable the macros

```
\mathfrak
\mathbfrak % if there is a bold fraktur
\mathscr
\mathbscr  % if there is a bold script
```

The names available for the alphabets are listed separately below by type. Any *Mathematical Script* name may serve as a target for both `cal` and `scr`. In all cases, if a bold version is available, then the corresponding bold variant is also defined.

The `mathalfa` package does not provide the PostScript fonts required for activating all its options. The metrics and virtual fonts are publicly available, but are useless without the `.pfb` files which you must acquire. See the `mathalfa` documentation for detailed descriptions of sources.

2.1 **BOONDOX**

The `boondox` package is a reworking of the STIX calligraphic, *fraktur* and double-struck alphabets with virtual fonts and metrics suitable for math mode. (In the USA, *the boondocks* and *the sticks* are essentially synonymous.) When the \LaTeX support files for the STIX fonts are made public, the `boondox` package will most likely become obsolete except to those who may prefer its metrics.

2.2 **ESSTIX**

The other relatively unknown font package here is `esstix`, an unfinished math font collection produced by Elsevier, never officially released and subsequently donated to the STIX consortium, serving as a precursor to their STIX font family. The ESSTIX collection is now under the same license as the STIX collection — the liberal SIL Open Font License, version 1.1. Though STIX regards the ESSTIX collection as deprecated, the math alphabets it contains have some unique elements which, in my opinion, should not be

allowed to become extinct. The ESSTIX fonts and support files are now available from CTAN and have become part of T_EX Live.

The ESSTIX fonts in their original forms may be loaded via `mathalfa` using the option `esstix`, but there is now an updated version of the ESSTIX calligraphic font. The metrics are identical to the original fonts, but the font has been modified in several respects (using `FontForge`) so that it now validates properly following modifications to repair font outline points and the font `BlueScale` parameter.

In addition, a bold version has been created, following modifications to a small number of glyphs to prevent outline self-intersections. (The original was quite light, rather of book weight, and the bold is more correctly a demi-bold.) ESSTIX calligraphic and its update, dubbed `DutchCal`, are visually almost identical at regular weight, though the latter is hinted better and is the only one shown in the samples below.

3 Mathematical script

The following choices are available for `cal` and `scr`, listed according to general appearance.

UPRIGHT:

```
euler    % euscript
mtc      % MathTime Curly (commercial)
```

RESTRAINED:

```
cm       % Computer Modern Math Italic (cmmi)
lucida   % From Lucida New Math (commercial)
zapfc    % Adobe Zapf Chancery (or URW clone)
mma      % Mathematica fonts
```

EMBELLISHED:

```
mt       % MathTime (commercial)
rsfso    % based on rsfs, much less sloped
mathpi   % Adobe Mathematical Pi (commercial)
esstix   % ESSTIX-thirteen
dutchcal % modification of ESSTIX13
boondoxo % based on boondox, less sloped
```

HEAVILY SLOPED:

```
rsfs     % Ralph Smith Formal Script
boondox  % SCRIPT alphabet from stix fonts
```

Script font samples follow in the above order.

3.1 Upright

`euler` (Euler script):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`euler` (Euler script-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`mtc` (MathTime Pro 2 Curly script):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

3.2 Restrained

`cm` (CM calligraphic, `cmsy`):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`cm` (CM calligraphic-bold, `cmbsty`):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`zapfc` (Zapf Chancery):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`lucida` (Lucida calligraphic):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`lucida` (Lucida calligraphic-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`mma` (Mathematica script):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`mma` (Mathematica script-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

3.3 Embellished

`mt` (MathTime Pro 2 script):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`mt` (MathTime Pro 2 script-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`mathpi` (Mathpi script):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`dutchcal` (DutchCal):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`dutchcal` (DutchCal-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`rsfso` (RSFS oblique):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`boondoxo` (BOONDOX calligraphic oblique):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

`boondoxo` (BOONDOX calligraphic oblique-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

3.4 Heavily sloped

boondox (BOONDOX calligraphic):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

boondox (BOONDOX calligraphic-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

rsfs (RSFS standard):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

3.5 Notes

- Lucida fonts generally need to be reduced in scale to match other math and text fonts.
- Zapf Chancery needs to be scaled up by 15% or so. This font is not ideally suited for use as a math alphabet due to the disparate heights and depths and the long tails on some glyphs. Use with care.
- The calligraphic fonts break down into four natural groups:
 - (i) the upright styled Euler and Curly;
 - (ii) the rather restrained CM, Lucida, Zapf Chancery, ESSTIX and mma;
 - (iii) the moderately sloped but more embellished Mathpi, MathTime (borderline case), rsfs and boondoxo;
 - (iv) the heavily sloped rsfs and the slightly less sloped boondox.

My preference, if not using euler or lucida for math, would be to set `\mathcal` to one from group (ii) and `\mathscr` to one from group (iii).

4 Mathematical double-struck

Double-struck font samples follow.

4.1 Normal weight

BLACKBOARD BOLD (WITH SERIFS):

ams (AMS bb):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

math (MathTime Pro 2 Holey Roman):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

pazo (Mathpazo bb):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

BLACKBOARD BOLD (SANS SERIF):

lucida (Lucida bb):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

mathpi (Mathpi bb):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

mt (MathTime Pro 2 bb):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

mma (Mathematica bb):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

fourier (Fourier bb):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

esstix (ESSTIX bb):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

boondox (BOONDOX bb):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

4.2 Bold weight

BLACKBOARD BOLD (WITH SERIFS):

math (MathTime Pro 2 Holey Roman-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

BLACKBOARD BOLD (SANS SERIF):

mt (MathTime Pro 2-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

mma (Mathematica bb-bold):

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

boondox (BOONDOX bb-bold):

C D H N P Q R Z (few glyphs available)

4.3 Notes

- Blackboard bold can look poor on the screen in many cases. Perhaps the thin parallel lines in the figures are a challenge to anti-aliasing mechanisms, at some resolutions. For example, here is the result of a screenshot from my 94 dpi LCD screen of a fragment containing ams double-struck E at 153%, magnified by a factor of 4.

E^μ{f}

The glyph displays unevenly, and appears to be of a weight different to its neighbors. In my experience, blackboard bold is the most problematic alphabet for screen rendering, and AMS bb and Holey Roman bb are the most likely to show up as a bit ghostly (gray and indistinct) on the screen compared to other math glyphs. Both

seem to be formed by removing the interiors of glyphs from a bold serifed font. MathTime Pro 2 Holey Roman-bold is a much better fit to most math fonts of weight heavier than Computer Modern. Other such hollowed-out fonts which are occasionally used as a double-struck font, such as Caslon OpenFace and Goudy Hand-Tooled, have to my eye either a similar problem, or have insufficient hollowing-out to distinguish them from an ordinary bold font.

- Fourier, Mathpi, esstix and boondox bb appear to be very close in style, with Mathpi bb a bit less sharp. These are geometric shapes, and because of screen-rendering issues, you may find that the font rendered there appears asymmetric even though there is no problem on paper, at least for resolutions over 300 dpi.
- Mathpazo bb and Mathematica bb have a heavier appearance and should work well with fonts other than Computer Modern, but the uneven weights of their strokes can lead to unsightly screen artifacts.
- In my opinion, for best appearance on screen and on paper, the best-looking blackboard bold glyphs (matching the weights of fonts heavier than Computer Modern) are (i) BOONDOX bb-bold; (ii) MathTime Pro 2 Holey Roman-bold. In both cases, there is no ghostly appearance, but in case (i), the glyph selection is limited.

5 Mathematical fraktur

Fraktur font samples follow, arranged in order of blackness.

esstix (ESSTIX fraktur):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

mathpi (Mathpi fraktur):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

mt (MathTime Pro 2 fraktur):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

euler (Euler fraktur):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

lucida (Lucida fraktur):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

mma (Mathematica fraktur):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

boondox (BOONDOX fraktur):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

euler (Euler fraktur-bold):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

mma (Mathematica fraktur-bold):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

mt (MathTime Pro 2 fraktur-bold):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

boondox (BOONDOX fraktur-bold):

\mathfrak{A} \mathfrak{B} \mathfrak{C} \mathfrak{D} \mathfrak{E} \mathfrak{F} \mathfrak{G} \mathfrak{H} \mathfrak{I} \mathfrak{J} \mathfrak{K} \mathfrak{L} \mathfrak{M}
 \mathfrak{N} \mathfrak{O} \mathfrak{P} \mathfrak{Q} \mathfrak{R} \mathfrak{S} \mathfrak{T} \mathfrak{U} \mathfrak{V} \mathfrak{W} \mathfrak{X} \mathfrak{Y} \mathfrak{Z}

5.1 Notes

- While mma is easy to read, I find it less attractive than other fraktur faces as it seems to have random variations in heights and depths, and seems overly dark. Some of these comments might also apply to lucida.
- lucida fraktur is one of the most idiosyncratic of the fraktur fonts, seeming to be considerably more influenced by Duc de Berry than by traditional fraktur sources.
- boondox fraktur is very attractive, but a bit heavy for all but the blackest text fonts (Times, Arno Pro, Lucida), while esstix is a bit too light for all but fonts like Computer Modern and Goudy Old Style.

6 A tool for making virtual fonts

TeX does not make it easy to take a text font (e.g., a script font) and construct from it a virtual font suitable for use in math mode, with accents properly positioned, width adjusted to match other math glyphs, and subscripts properly placed. The tool I used to do this in several cases is TeXFontUtility, available for Mac OS X as TeXFontUtility.dmg from <http://math.ucsd.edu/~msharp>. The program is specific to Mac OS X, but the output may be used in any L^AT_EX installation.

With this tool, the math metrics can be adjusted visually. For example, adjusting the left and right side-bearings, subscript position and accent position for the glyph A of boondox script is simply a matter of selecting and dragging the line segments (the hat for the accent) to your personal tastes. See figure 1.

This tool has many other uses, most importantly, serving as a graphical interface to fontinst for purposes such as substituting an italic alphabet for the math italic glyphs in a virtual font based on mtpro2

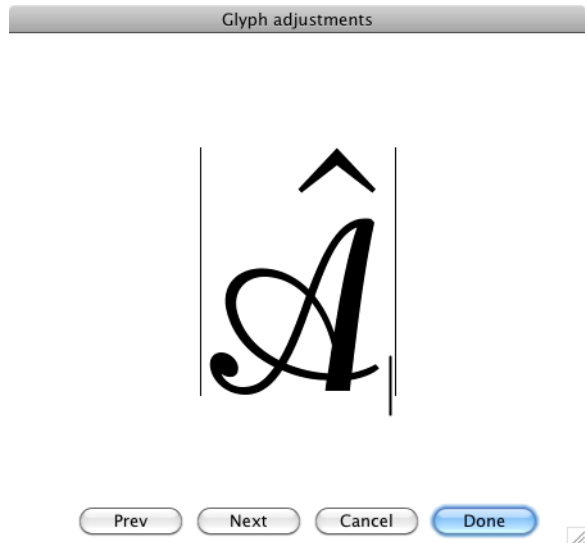


Figure 1: Adjusting a glyph in TeXFontUtility.

(and making the appropriate visual adjustments to the metrics for math mode), and diagnosing common errors made in adding packages to \TeX Live. All the “frankenfonts” in the file `mathsamples.pdf` mentioned below were created using this program.

7 In conclusion

- Several of the packages described above are advertised as suitable companions for Times, a rather heavy font that is not generally considered the best choice for book text. (It was designed for newspaper use, where it would remain legible even after the ink soaked unevenly into cheap newsprint paper, and was compact enough for the narrow columns.) Nonetheless, there is a high variance in the weights of those companions. For example, both `boondox` fraktur and `mt` fraktur were designed for Times, and there is a great difference between their weights. In my opinion, this means that the issue of matching math alphabet weight to text font weight is not critical, and there are many examples of successful use of the `mtpro2` fonts with text fonts having a multiplicity of weights. For examples, see the file `mathsamples.pdf` at <http://math.ucsd.edu/~msharpe/>.
- If your interest in math fonts goes beyond the basic level (e.g., you are writing a book or lecture notes with mathematical content), you should look into the commercial products Lucida from

<http://www.tug.org/lucida> and MathTime Pro 2 from <http://pctex.com>. Both are high quality products, and are excellent values for the prices. Even if you only use small pieces of the collections, these are much better buys than most commercial text fonts.

- The Mathematica fonts are not of very high quality as a collection (i.e., not suitable for professional use as they stand), but they have some excellent components. In particular, the calligraphic font may be turned into a good target for `\mathcal` after its metrics have been fine-tuned. You are missing out on some good stuff if you don’t install this free collection. Sadly, Jens-Peer Kuska, the theoretical physicist who devised the \LaTeX support files for these fonts, died before his time in 2009, and it seems unlikely that they will be revised in the near future.
- The `rsfs` package is not well-suited to `\mathcal`, being much too slanted. The best options for `\mathcal` are, in my opinion, `rsfso`, `dutchcal`, `boondoxo` and `mt`, the latter requiring the (non-free) `mtpro2` collection.
- If you own the `mtpro2` collection, look into the ‘curly’ script font, which seems useful, though a bit heavy.
- It is questionable whether there is value in the Mathpi fonts given that each of its constituents may be approximated closely by free alternatives, and the fonts can be tricky to install.
- The `boondox` calligraphic font is quite handsome. I prefer it to be less sloped, along the lines of `rsfso`. This is provided by the option `boondoxo`, which uses virtual fonts sloped much like `rsfso`.
- It is possible to produce a candidate for a math script font starting from any script text font, but it is very difficult to locate suitable text script fonts. The most frequent problem is long tails on some glyphs. Another is that the glyphs can be over-elaborate, more suited to a wedding invitation than a scientific publication.

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