User's Guide to AMSFonts Version 2.2d

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Standard distributions of TEX ordinarily come with all the fonts specified in `plain.tex`, and they may also come with a number of additional fonts intended for use with LATEX. Additional fonts designed for use in mathematics and defined in $\mathcal{AMS}$-TEX are not always included among such font collections. For this reason, the American Mathematical Society has compiled a collection, known as AMSFonts, which contains fonts of symbols and several alphabets corresponding to symbols and alphabets used in AMS publications, including electronic journals and the MathSci online database.

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1. Contents of the AMSFonts collection

The AMSFonts collection contains the METAFONT sources, `.tfm` files and bitmaps for the following fonts, in the sizes indicated:

- The Euler family, all but `euex` in 5, 6, 7, 8, 9, and 10 point:
  - Fraktur (German), medium-weight and bold (`eufm` and `eufb`)
  - "roman" cursive, medium-weight and bold (`eurm` and `eurb`)
  - script, medium-weight and bold (`eusm` and `eusb`)
  - Euler-compatible extension font (`euex`), in 7, 8, 9, and 10 point
- Additional sizes of some Computer Modern math fonts (the 10-point fonts are included in standard TEX distributions):
  - bold math italic (`cmmib`), in 5, 6, 7, 8, and 9 point
  - bold math symbols (`cmbsy`), in 5, 6, 7, 8, and 9 point
  - math extension font (`cmex`), in 7, 8, and 9 point

- Extra math symbols, in 5, 6, 7, 8, 9, and 10 point:
  - first series, medium-weight (`msam`)
  - second series, including Blackboard Bold, medium-weight (`msbm`)
- Cyrillic, developed at the University of Washington
  - lightface (`wncyr`), in 5, 6, 7, 8, 9, and 10 point
  - bold (`wncyb`), in 5, 6, 7, 8, 9, and 10 point
  - italic (`wncyi`), in 5, 6, 7, 8, 9, and 10 point
  - caps and small caps (`wncysc`), in 10 point
  - sans serif (`wncyss`), in 8, 9, and 10 point
  - virtual font property list (`.vpl`) files to enable the use of these fonts with alternate encodings and transliteration schemes
- Computer Modern caps and small caps (`cmcsc`), in 8 and 9 point (the 10-point font is included in standard TEX distributions)
- The "dummy font", used in $\mathcal{AMS}$-TEX for syntax checking, which consists only of metrics (`dummy.tfm`), no character shapes
- Packages for using these fonts with LATEX:
  - `amsfonts`, a package for using the fonts `msam`, `msbm`, and `eufm` in LATEX
  - `amssymb`, a package for defining en masse (instead of selectively) command names for all the math symbols in the fonts `msam` and `msbm`
  - `eucal`, a package for using the Euler script font `eusm`
  - `cmmib57`, a package for adapting the font definitions for `cmmib` and `cmbsy` to scale from sizes 5,7,10 instead of sizes 5,6,7,8,9,10 when the Y&Y/Blue Sky PostScript outline fonts are used
  - `*.fd`, font definition files

  For details, see Section 3 on using AMSFonts with LATEX.
- Macro files for using these fonts with plain TEX:
  - `amssym.tex`, a file defining names for the symbols in fonts `msam` and `msbm`
  - `amssym.def`, a file that loads the fonts `msam`, `msbm` and `eufm` and defines some control sequences required by `amssym.tex`
  - `cyracc.def`, a file containing definitions needed for proper access to characters in the cyrillic fonts
- Documentation files:
  - `amsfndoc.tex`, the source file for this User's Guide
  - `amsfndoc.cyr`, the source file for the table showing cyrillic input conventions, input by `amsfndoc.tex`
  - `amsfndoc.fnt`, the source file for the tables of the principal 10-point fonts in the AMSFonts collection, input by `amsfndoc.tex`; this file may also be TEXed by itself
  - `amsfndoc.def`, the macros used to format this User's Guide
  - `amsfndoc.ins`, the source file for the appendixes to this User's Guide, input by `amsfndoc.tex`; this file may also be TEXed by itself
  - `amsfonts.faq`, a file of Frequently Asked Questions about AMSFonts
  - `amsfonts.bug`, a chronicle of bug fixes and list of known bugs still outstanding

Each font at a particular size is provided in seven standard TEX magnifications, magsteps 0 through 5, including magstephalf (except the *Textures*/Macintosh package, which includes only magnifications 0 and 1; see the installation instructions).

The philosophy under which the Euler fonts were implemented was different from that used for Computer Modern, and the result is a lower degree of "metaness". For that reason, the appearance of these fonts is not very good at small sizes when output on low-resolution devices, in particular on screens. Even so, the fonts are included in AMSFonts in all the sizes and magnifications offered, on the assumption that the printed output will be prepared on a device of higher resolution (at least 300dpi) where this effect will not be noticeable.

Font charts are given in Appendix D.

1.1. Font naming conventions

Developers of fonts for use with TEX, at least those using METAFONT, generally try to make the names distinctive, so that a user will know the origin of the font by the font name. For most of the fonts in the AMSFonts collection, the first two letters identify the font source, as follows:

- "`cm`": These fonts are based directly on the specifications for Knuth's Computer Modern fonts, as described in Volume E of *Computers & Typesetting* [DEK86E].
- "`eu`": These are members of the Euler family, described below.
- "`ms`": These fonts of math symbols were developed by or under the direction of the AMS staff.
- "`wn`": These cyrillic fonts were developed at or under the direction of the University of Washington Humanities and Arts Computing Center, and are distributed with their permission.

The font called `dummy` is a special case; it was developed as part of the Stanford University TEX Project, and follows no particular naming convention.

For information on Computer Modern fonts other than those specifically named here, and on other fonts in general, the newsgroup `comp.text.tex` is a good source. For some other suggestions, see Appendix C, **For further information**.

2. History of these fonts

When the AMS began using TEX to produce its publications, the available complement of symbols was found to be inadequate. Several alphabets used extensively as symbols were not available either. While development of the symbols could be undertaken by in-house personnel, using the existing TEX symbol font as a model, the creation of new Fraktur and script alphabets required the assistance of someone with experience in font design.

2.1. Euler

With Donald Knuth's assistance and encouragement, Hermann Zapf, one of the premier font designers of this century, was commissioned to create designs for Fraktur and script, and for a somewhat experimental, upright cursive alphabet that would represent a mathematician's handwriting on a blackboard and that could be used in place of italic. The designs that resulted were named Euler, in honor of Leonhard Euler, a prominent mathematician of the eighteenth century. Zapf's designs were rendered in METAFONT code by graduate students at Stanford, working under Knuth's direction; the process by which the METAFONT fonts were implemented is described in a report by David Siegel [DRS85]. The Euler fonts were designed to be used as math symbols; they are not intended for setting running text.

The Fraktur face of the Euler family has been used in production by the AMS since it became available. However, no extensive test or use had been made of the script or cursive until Knuth decided that they should be used in a textbook, *Concrete Mathematics*, written by him and two co-authors [GKP88]. During the course of preparing that book, a number of errors, particularly in spacing parameters affecting the placement of sub- and superscripts, were discovered. All these errors have been corrected in the medium-weight versions of the Euler fonts (almost no boldface symbols were used in *Concrete Mathematics*). Knuth also noticed that the style of some symbols in the Computer Modern extension font, in particular the integral sign, was too slanted to be attractive with Euler, and consequently he prepared a new (partial) extension font for use with Euler. Knuth described his experience with the Euler fonts in a *TUGboat* article [DEK89]. In the article he also identified the macros he used and where they can be obtained.

The Euler fonts are sparsely populated; only the alphabetic locations are filled in most instances (see the font charts in Appendix D for specifics). For this reason, when processing the file for this User's Guide, and in particular the font charts, warnings about "Missing characters" are not a cause for concern.

2.2. Additional Computer Modern fonts for use in math

Only the 10-point size of the Computer Modern bold math italic (which includes Greek), symbol, and math extension fonts are included in standard distributions of TEX. Since these symbols are often needed in mathematics, other sizes have been constructed, using the principles demonstrated in Knuth's *Computer Modern Typefaces* [DEK86E], and included in the AMSFonts collection.

2.3. Symbols

Two fonts of "extra" symbols are included in the AMSFonts collection. These are named `msam` and `msbm`, and have been implemented in "new" METAFONT (MF84); they replace earlier fonts (named `msxm` and `msym`) that were defined in old METAFONT (MF79). These fonts contain symbols needed in the publishing program of the AMS, including the MathSci online database, and include the uppercase letters of an alphabet known as Blackboard Bold ($\mathbb{A}, \ldots, \mathbb{Z}$).

2.4. Cyrillic

Titles of books reviewed in *Mathematical Reviews* are traditionally rendered in their original language. For books published in Russian or other Slavic languages, this frequently requires use of the cyrillic alphabet. A cyrillic font was developed at AMS using METAFONT79 with the `am` fonts as a model. This font was organized in a manner suitable for use with the transliteration scheme adopted by *MR* in 1980, and contained only those letters which appear in current mathematical literature. In particular, this meant that the letters dropped from the Russian alphabet after the Revolution of 1917, and some letters used in non-Slavic languages now rendered in cyrillic (such as Azerbaijani, from which no mathematical literature is currently reviewed in *MR*) were absent.

In 1988, the Humanities and Arts Computing Center of the University of Washington undertook a font development project for support of scholars in Slavic languages. The fonts developed through this project include several different font layouts. One layout is based on that of the original AMS cyrillic augmented with 'й' (cyrillic short 'i'), 'ё' (umlauted 'e'), and several pre-Revolutionary letters. The fonts with the AMS layout are included in the AMSFonts collection with the permission of the University of Washington developers. "Virtual property list" (`.vpl`) files are also included in the collection to support several other layouts; these can be found in the `cyr-alt` area, and are accomanied by a `README` file with further information.

The cyrillic fonts are based on Computer Modern letter shapes. Type styles include ordinary upright, bold (based on CM bold extended), caps and small caps, italic, and upright sans serif. The principal text fonts (upright, italic and boldface) are present in sizes from 5 through 10 point; sans serif is in sizes 8, 9 and 10 point; caps and small caps are in 10 point only. See also Appendix B for information on a PostScript (Type 1) version of the cyrillic fonts, in particular concerning the sizes provided in that format.

2.5. Caps/small caps

The font `cmcsc10` is referenced in `plain.tex` and should be included in all standard TEX distributions. However, Knuth did not generate this font in any other sizes. The AMSFonts collection includes 8 and 9-point sizes, generated according to the same principles as other CM fonts of these sizes.

2.6. Dummy font

The dummy font contains no ligature or kerning information, and all dimensions and parameter values are set to zero. This is a pseudo-font, which has only general font metrics and no characters. No `.pk` or `.gf` files are needed for this font; it is provided only in `.tfm` and `.mf` form.

The dummy font is used in $\mathcal{AMS}$-TEX to implement "syntax checking". (Syntax checking is activated by the `\printoptions` command as described in *The Joy of TEX* [MDS86].) In this mode, the dummy font replaces all the usual "printing" fonts, so that TEX never accumulates any text to be set, and never tries

to write out a page, but in the process of reading the input file, checks all control sequences for syntactic correctness. In this mode, an input file will be processed perhaps 30 percent faster than if it were actually being set. However, some errors and conditions are not detected during a syntax check; in particular, overfull boxes cannot be detected until setting actually occurs.

2.6. PostScript (Type 1) implementation of AMSFonts

The AMSFonts are available in Type 1 outline form as an alternative to the bitmap images generated by METAFONT. The Type 1 files are not part of the regular AMSFonts distribution, but can be obtained at no charge from the AMS server. For details, see Appendix B.

3. How to use AMSFonts with LaTeX

3.1. General

These instructions are for current LaTeX (version 2ε, dated January 1995 or later). If you have version 2.09 of LaTeX, dated 1993 or earlier, you must upgrade to current LaTeX. Earlier versions of LaTeX are no longer supported for AMSFonts; however, the LaTeX compatibility mode will usually allow documents prepared for version 2.09 to be processed with the current version.

To use the AMSFonts collection with LaTeX you choose from an assortment of LaTeX "packages" that provide various kinds of access to the fonts, calling the packages that you need in a given document through standard LaTeX `\usepackage` statements. For example, the statement

```
\usepackage{amsfonts}
```

calls in the `amsfonts` package, which provides blackboard bold and Fraktur letters and selective access to the math symbol fonts `msam` and `msbm`.

These packages are currently available:

- `amsfonts` – for blackboard bold letters, Fraktur letters, and miscellaneous symbols
- `amssymb` – superset of the `amsfonts` package, defines the full set of symbol names for the `msam` and `msbm` fonts
- `eufrak` – for Fraktur letters; redundant if `amsfonts` is used
- `eucal` – Makes `\mathcal` use Euler script instead of the usual Computer Modern calligraphic alphabet
- `euscript` – old name of the `eucal` package, now obsolete but included for convenience in printing pre-existing documents

All of the above packages have a '`psamsfonts`' option that should be used if and only if your copy of the AMSFonts collection is the Y&Y/Blue Sky Research PostScript version. In that version, the font files are not provided in all the sizes (5,6,7,8,9,10), but only in sizes 5,7,10, with sizes 6,8,9 produced by interpolation. In practice it's easy to tell if you need to use the `psamsfonts` option: you'll get an error message about a missing `.tfm` file:

```
! Font \U/AMSa/m/n/9=msam9 not loadable: Metric (TFM) file not found.
```

where the mentioned font name is one of the AMS font names (`msam`, `msbm`, `eufm`, etc.), and the font size is 6, 8, or 9. If this happens to you, look at your `\usepackage` statements and change

`\usepackage{amssymb}` to `\usepackage[psamsfonts]{amssymb}`

or

`\usepackage{eucal}` to `\usepackage[psamsfonts]{eucal}`

and so forth.

If you are using an AMS document class (`amsart`, `amsbook`, `amsproc`) or an AMS author package, apply the option `[psamsfonts]` to `\documentclass` as well.

> **Warning:** Adding the option `[psamsfonts]` to an existing file may result in changed line and page breaks, owing to the fact that sizes 6, 8, and 9 are produced by interpolation.

Use of the PostScript AMSFonts is explicitly marked in individual documents because the interpolation process used produces character metrics that are not identical with those of the noninterpolated font files for the corresponding sizes. If these discrepancies were simply ignored, *there would be no warning* of unexpected changes in line or page breaks that might occur in documents exchanged between colleagues. As it is, if you find it necessary to add or remove the `psamsfonts` option in order to print a colleague's document, you are free to go ahead and do so, but the fact that you must make that change should be understood as a reminder that a small possibility of changed line breaks or page breaks does exist.

A package `cmmib57` provides analogous font definitions for the fonts `cmmib` and `cmbsy` (yes, both in the same package, despite the name), for those users who have the Y&Y/Blue Sky Research PostScript versions of those fonts. Typical usage is:

```
\documentclass{article}
\usepackage{cmmib57}
```

3.2. Computer Modern bold math italic and symbols

The package `amsbsy` (part of the $\mathcal{AMS}$-LaTeX distribution) defines two commands to obtain bold symbols:

- `\boldsymbol` – for bold numbers and other nonalphabetic symbols, as well as bold Greek letters, which cannot be made bold via the `\mathbf` command, and bold math italic letters
- `\pmb` – "poor man's bold", which overlays multiple copies of the same symbol with slight offsets, for cases where `\boldsymbol` does not work, e.g., a bold font is not available

`\boldsymbol` can also be used to obtain bold letters from the Euler fonts.

These commands are valid in math mode only. For example,

```
$$\boldsymbol{\beta} \pmb{\boxdot}
\boldsymbol{\Omega} \boldsymbol+ \pmb{\mathbb{R}}$$
```

(Since this User's Guide is not prepared with LaTeX, getting output for this expression is left as an exercise to the user.)

3.3. Blackboard bold letters (uppercase only)

The `amsfonts` package defines a "math alphabet" command `\mathbb` for printing letters of the blackboard bold alphabet that resides in the `msbm` font. This alphabet is restricted to uppercase only (no lowercase, no numerals). The suggested method for defining a `\R` command to print a blackboard bold R is as follows:

```
\usepackage{amsfonts}
\newcommand{\R}{\mathbb{R}}
```

3.4. Extra math symbols

The `amssymb` package defines math symbol commands for all the extra math symbols in the `msam` and `msbm` fonts, as listed in the table in Section 7. Thus if you want to use the `\blacktriangle` ▲ and `\nsubseteq` ⊈ symbols, the easiest way is to put the statement

```
\usepackage{amssymb}
```

in the preamble of your document.

If you want more selective access to the math symbols in those fonts you can use the `amsfonts` package instead and define math symbol commands individually using LaTeX's `\DeclareMathSymbol` (cf. [LFG] or [GMS94]):

```
\usepackage{amsfonts}
\DeclareMathSymbol{\blacktriangle}{\mathord}{AMSa}{"4E}
\DeclareMathSymbol{\nsubseteq}{\mathrel}{AMSb}{"2A}
```

This alternative might be useful to you if adding the `amssymb` package to your document leads to an error message of the form

```
! TeX capacity exceeded, sorry (hash size=3000)
```

This could happen if you have an older version of TeX with a relatively low limit on the number of commands that can be defined in a single document. (But in that case, note that there may be configuration options for increasing that limit; check the documentation for your TeX system.)

Since `\DeclareMathSymbol` is used in the `amssymb` package, the definitions for particular symbols can be borrowed from there (file `amssymb.sty`). Alternatively, the values can be obtained from the tables in Section 7.2, as follows:

- First digit identifies font:
  - 1 AMSa
  - 2 AMSb
- Second digit identifies class:
  - 0 `\mathord`
  - 2 `\mathbin`
  - 3 `\mathrel`
- Third and fourth digits identify (hex) location in font.

3.5. Euler Fraktur letters

A math alphabet command `\mathfrak` for using Fraktur letters such as $\mathfrak{A}\ \mathfrak{m}\ \mathfrak{g}\ \mathfrak{H}$ in math can be obtained by using any of the packages `amssymb`, `amsfonts`, or `eufrak`.

3.6. Euler script letters (uppercase only)

The main purpose of the `eucal` package is to change LATEX's `\mathcal` command so that it produces Euler script instead of Computer Modern calligraphic letters:

CM calligraphic: $\mathcal{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$
Euler script: $\mathcal{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$

There is also an option `mathscr` for the `eucal` package that causes Euler script to be associated to a `\mathscr` command, leaving the `\mathcal` command unaffected. This imitates the behavior of the predecessor package `euscript`.

3.7. University of Washington Cyrillic fonts

There is no AMS package for LATEX at the present time to support the use of Cyrillic languages in LATEX documents with the `wncy*` fonts. Producing a proper Cyrillic package involves rather difficult questions of input and output encodings, for which it would be useful to rely on general mechanisms provided by LATEX.

If you require these fonts, you can consult the LATEX documentation [LFG], [L94] and use directly the commands described there, such as `\DeclareFontFamily`, `\DeclareFontShape`, and `\symbol`. A scheme for accessing letters that don't correspond to the 26-letter Latin alphabet will be needed; the file `cyracc.def` can be used as a starting point.

4. How to use AMSFonts with $\mathcal{AMS}$-TEX

In *The Joy of TEX*, Michael Spivak describes various fonts that are used in mathematics in addition to the fonts provided with the standard distributions of TEX. Two references in particular are of interest with respect to AMSFonts: the section **Fonts in math mode** in Chapter 19, and Appendix G, **Further fonts**. The first describes the use of letters from alphabets, including Fraktur, and the second, mostly nonalphabetic symbols.

Instructions for using the fonts of the AMSFonts collection with $\mathcal{AMS}$-TEX are also given in the *User's Guide to $\mathcal{AMS}$-TEX Version 2.2* [AMS01] and in Appendix G of editions of *The Joy of TEX* [MDS90] dated 1990 or later.

Additional fonts to be used with $\mathcal{AMS}$-TEX should be specified at the top of the document input file, in what is known as the "preamble". The arrangement of commands at the top of an input file is the following:

```
\input amstex
\documentstyle{...}
⟨preamble commands⟩
```

$\mathcal{A}\mathcal{M}\mathcal{S}$-TEX provides a simple method for accessing most of the fonts in the AMSFonts collection. The two extra symbol fonts and Euler Fraktur are loaded automatically by the preprint style (`amsppt.sty`). If you are using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX, but not the preprint style, the method used to load these fonts and define the associated symbol names depends on how many symbols will be needed. If a lot of the symbols will be needed, or you aren't worried about memory space and just want to do what is easiest, all three fonts will be loaded and the symbol names defined if you type the command `\UseAMSsymbols` in the preamble. This will load the file `amssym.tex`, in which all the symbol names (more than 200 of them) are defined. If only a few symbols from these fonts are needed, the commands `\loadmsam`, `\loadmsbm`, and `\loadeufm` will load the medium-weight versions of the two extra symbol fonts and Euler Fraktur respectively. The command `\newsymbol` can then be used to define just those symbols that are needed; its use is described in Section 7, **Using the extra symbols**.*

Two sizes of fonts, suitable for body text and for passages requiring smaller type (e.g. abstracts and footnotes), are incorporated in the preprint style `amsppt.sty`. These are accessed through the control sequences `\tenpoint` and `\eightpoint`, which are ordinarily referred to only by higher-level commands that identify the kind of text being input (e.g. `\title`, `\abstract`, `\footnote`). Most fonts in the AMSFonts collection have `\load...` instructions defined in $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX and will be accessed properly for use with the preprint style when the `\load` instructions are included in the preamble of the document input. If you are not using the preprint style, you can use the font definitions in `amsppt.sty` as a model.

If you are using the PostScript version of the AMSFonts developed by Y&Y/Blue Sky Research, only selected sizes (5, 7 and 10) are provided, and the other sizes are produced by interpolation. With the $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX preprint style, use the command `\PSAMSFonts`, placed after the `\documentstyle` line and before `\topmatter` and `\document`, to access these fonts correctly. Papers and monographs submitted to the AMS for publication are required to use this command.

> **Warning:** Adding the command `\PSAMSFonts` to an existing file may result in changed line and page breaks, owing to the fact that sizes 6, 8, and 9 are produced by interpolation.

4.1. Euler

The Euler fonts are defined only in math mode, in sizes appropriate for text and two orders of sub- and superscripts. They can be activated by invoking the proper `\load` instructions before the `\documentstyle` command, in the preamble of a

* Additional fonts from the AMSFonts collection can be accessed easily in $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX. However, users should be aware that TEX limits the number of math mode font families to 16, of which 11 are predefined in $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX. Only those additional families should be activated that will actually be used in a document, to avoid exceeding the limit.

paper in which the fonts are to be used. (The medium-weight Fraktur font is activated automatically by the preprint style.) The Euler fonts can be activated by the following commands:

`\loadeufm`	Euler Fraktur medium (automatic with the preprint style)
`\loadeufb`	Euler Fraktur bold
`\loadeurm`	Euler cursive medium
`\loadeurb`	Euler cursive bold
`\loadeusm`	Euler script medium
`\loadeusb`	Euler script bold

After the `eufm` font has been loaded, the medium-weight Fraktur letters can be produced by typing `\frak` followed by the desired letter. For example, `$\frak g \frak A$` yields $\mathfrak{g}\mathfrak{A}$. $\mathcal{AMS}$-TEX 2.1 also defines `\eufm`, `\eufb`, `\eurm`, `\eurb`, `\eusm` and `\eusb`.

4.2. Computer Modern bold math italic and symbols

The Computer Modern bold math italic (`cmmib`) and bold math symbol (`cmbsy`) fonts can both be loaded in $\mathcal{AMS}$-TEX by the command `\loadbold`; there are no predefined commands to load them separately. `\loadbold` must be invoked in the preamble of the document input file.

A rather elaborate mechanism has been defined in $\mathcal{AMS}$-TEX to simplify access to bold letters and symbols, in math mode only. Three control sequences are available, each of which affects a particular class of characters:

`\bold`	for a single letter or numeral
`\boldkey`	for other symbols that appear on the keyboard
`\boldsymbol`	for a symbol specified by a single control sequence

These facilities are described in more detail in the *User's Guide to $\mathcal{AMS}$-TEX Version 2.2* [AMS01] and editions of *Joy* published in 1990 or later [MDS90].

4.3. Computer Modern math extension font

Smaller sizes of the math extension font are appropriate for use in text smaller than ten-point and in sub- and superscripts. They are provided automatically for these environments in the preprint style. If you are not using the preprint style, you can use the font definitions in either `amsppt.sty` or Appendix E of *The TEXbook* [DEK86A] as a model.

4.4. Extra symbols

The medium-weight versions of the two extra symbol fonts are available automatically, including all the symbol names, if you are using the preprint style or if you have specified `\input amssym`. If you wish to load these fonts separately, use the appropriate control sequence `\loadmsam` or `\loadmsbm` in the preamble of your document. If you load the fonts separately, a few symbols will be defined when one of the fonts is loaded, but most must be defined using the `\newsymbol` command before they can be used. See Section 7, **Using the extra symbols**, for information on both the symbol names and on using `\newsymbol` to define them.

4.5. Cyrillic

Cyrillic is not referred to in the $\mathcal{AMS}$-TEX files as distributed. The cyrillic fonts included in AMSFonts are intended for use mainly in text, not as symbols in math. Detailed instructions for loading and using cyrillic appear below in Section 6, **Using cyrillic**.

4.6. Caps/small caps

Caps/small caps are loaded automatically by the $\mathcal{AMS}$-TEX preprint style for use in ten-point and eight-point text. If you are not using the preprint style, you can use the font definitions in either `amsppt.sty` or Appendix E of *The TEXbook* [DEK86A] as a model.

4.7. Dummy font

No special action is needed to use the dummy font with $\mathcal{AMS}$-TEX. It is already built into the syntax checking procedure.

5. How to use AMSFonts with plain TEX or other macro packages

If you are not using LATEX or $\mathcal{AMS}$-TEX then there are too many variables for us to provide much specific guidance. It will be necessary to assume that you either have some experience with TEX macros or have a TEXnician available to help you. However, some general guidelines may be helpful.

Two models for defining fonts should be accessible to most users:

- Appendix E of *The TEXbook* contains size-specific font definitions for `\tenpoint`, `\ninepoint` and `\eightpoint` that permit size-switching, including support of mathematics.
- `amsppt.sty`, the file of macros supporting the $\mathcal{AMS}$-TEX preprint style, contains similar font definitions, `\tenpoint` and `\eightpoint`.

The font-size-switching facilities of LATEX are not recommended as a model because they include many features (such as loading fonts on demand) that make them too complex to be copied easily for uses outside of LATEX except by someone with substantial TEX expertise.

Before attempting to load all available fonts into every TEX job, determine (if you can) how many fonts can be accommodated by the implementation of TEX you are using. It is generally a good idea to load seldom-used fonts selectively.

5.1. Euler

The following commands will load the medium-weight Euler Fraktur font, and can be used as a model for accessing the other Euler fonts.

```
\font\teneufm=eufm10
\font\seveneufm=eufm7
\font\fiveeufm=eufm5
```

```
\newfam\eufmfam
\textfont\eufmfam=\teneufm
\scriptfont\eufmfam=\seveneufm
\scriptscriptfont\eufmfam=\fiveeufm
\def\eufm#1{{\fam\eufmfam\relax#1}}
```

Individual letters in the Euler fonts are accessible by the ordinary letters on your keyboard, once the font has been loaded and named by a control sequence equivalent to `\eufm`.

The medium-weight Fraktur font, `eufm`, can also be loaded by `\input amssym.def`; this loads the two extra symbol fonts as well.

5.2. Computer Modern bold math italic and symbols

The `cmmib` and `cmbsy` fonts can be loaded and made accessible to math in ten-point environments by the following code:

```
\font\tencmmib=cmmib10  \skewchar\tencmmib='177
\font\sevencmmib=cmmib7 \skewchar\sevencmmib='177
\font\fivecmmib=cmmib5  \skewchar\fivecmmib='177
\newfam\cmmibfam
\textfont\cmmibfam=\tencmmib \scriptfont\cmmibfam=\sevencmmib
 \scriptscriptfont\cmmibfam=\fivecmmib

\font\tencmbsy=cmbsy10  \skewchar\tencmbsy='60
\font\sevencmbsy=cmbsy7 \skewchar\sevencmbsy='60
\font\fivecmbsy=cmbsy5  \skewchar\fivecmbsy='60
\newfam\cmbsyfam
\textfont\cmbsyfam=\tencmbsy \scriptfont\cmbsyfam=\sevencmbsy
 \scriptscriptfont\cmbsyfam=\fivecmbsy
```

The TEX primitive `\mathchar` must be used to access individual characters from a font in math mode. `\mathchar`, like the `\char` primitive, requires that you know the position in the font of the character you are accessing. However, `\mathchar` also requires that you specify the "class" and the family of the math character being accessed. See Chapter 17 of *The TEXbook* for more details on the use of `\mathchar`, as well as `\mathchardef`, which will allow you to define your own macro names for individual characters in these fonts.

> **Note:** The file `amssym.def` contains a convenient macro, `\hexnumber@`, to determine the family number of the font being accessed through `\mathchar`. For example, the `\mathchar` statement to properly access the bold alpha in the `cmmib` font would be:
>
> ```
> \mathchar"0\hexnumber@\cmmibfam0B
> ```

5.3. Computer Modern math extension font

The 10-point `cmex` font is loaded by `plain.tex`. To install the 7-point size appropriate for sub- and superscripts in a ten-point math environment, include the following code in your file:

```
\font\sevenex=cmex7
\scriptfont3=\sevenex \scriptscriptfont3=\sevenex
```

To use other sizes implies the use of switchable-size fonts, which may be implemented according to the models cited at the beginning of this section.

5.4. Extra symbols

Detailed instructions for accessing the `msam` and `msbm` fonts are given in Section 7, **Using the extra symbols**.

5.5. Cyrillic

See Section 6, **Using cyrillic**, for instructions.

5.6. Caps/small caps

The 10-point `cmcsc` font is loaded by `plain.tex`. To use the smaller versions implies the use of switchable-size fonts, which may be implemented according to the models cited at the beginning of this section.

5.7. Dummy font

The dummy font was designed to be used for syntax checking. The general technique is described in Appendix D of *The TEXbook*, p. 401. This has been implemented in the file `amstex.tex`, which can be used as a model.

6. Using cyrillic

The cyrillic fonts in the AMSFonts collection have been designed so that input using the transliteration conventions of *Mathematical Reviews* will be converted directly to cyrillic text. Other transliteration schemes exist, as well as methods for keying directly from the keyboard to access cyrillic characters. We have included two sets of virtual fonts in this distribution, which provide access to the characters of the cyrillic fonts through the KOI-8 or Alternativnyj Variant (AV) encodings. At the present time macro support is provided only for the *Mathematical Reviews* transliteration scheme; to use one of the other encodings, you must seek support from other sources. Also, the instructions in this section are unsuitable for LaTeX; they apply only to $\mathcal{AMS}$-TeX, plain TeX, and other macro packages that use plain TeX font loading methods.

The following cyrillic fonts are included:

`wncyr` (upright), in sizes 5, 6, 7, 8, 9, and 10 point

`wncyb` (bold), in the same range of sizes as `wncyr`

`wncyi` (italic), in the same range of sizes as `wncyr`

`wncysc` (caps and small caps), in size 10 point

`wncyss` (upright sans serif), in sizes 8, 9, and 10 point

(The Y&Y/Blue Sky PostScript collection contains only 10-point outlines. Other sizes must be obtained by scaling.)

The file `cyracc.def`, which is included in the AMSFonts collection, must be input to any document using the cyrillic fonts as defined with the AMS layout. Since the cyrillic alphabet contains more letters than the roman alphabet, some cyrillic letters are accessed by combinations of roman letters, accented letters, or control sequences. `cyracc.def` contains the definitions of these accents and control sequences. If this file is not input, some cyrillic letters will be inaccessible.

6.1. Making cyrillic available to a document

If you are using plain TEX, include the following instructions near the top of the document input file to make the 10-point cyrillic font available for use in text (see below for cyrillic in math):

```
\input cyracc.def
\font\tencyr=wncyr10
\def\cyr{\tencyr\cyracc}
```

If you require cyrillic text in more than one size, you must take a different approach in defining `\cyr`. An appropriate model appears in Appendix E of *The TEXbook* [DEK86A], pages 414–15. The definition of `\cyr` should be incorporated into size-specific macros such as `\tenpoint` and `\eightpoint` similarly to what is done there for `\bf`. Don't forget to include the command `\cyracc` in the definition.

If you are using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX and the preprint style, include the following instructions in the preamble of your document input file to make cyrillic available in 10-point and 8-point text:

```
\input cyracc.def
\catcode`\@=11
\font@\tencyr=wncyr10
\font@\eightcyr=wncyr8
\catcode`\@=13
\addto\tenpoint{\def\cyr{\tencyr\cyracc}}
\addto\eightpoint{\def\cyr{\eightcyr\cyracc}}
```

(The `\font@` command not only loads the fonts, but also makes them behave properly during syntax checking.) If you are not using the preprint style, you can use the font definitions in either `amsppt.sty` or *The TEXbook* Appendix E as a model.

The macro definitions in `cyracc.def` govern the behavior of cyrillic-specific control sequences, including accents, in cyrillic and noncyrillic text. Definitions governing noncyrillic text are activated as soon as `cyracc.def` is `\input`. This will permit text input according to the scheme shown in Figure 1 to be typeset in transliterated form, according to the *MR* conventions. To produce actual cyrillic

text, enclose the cyrillic input in a group that begins with the instruction `\cyr` *inside* the group, as

```
... {\cyr ...} ...
```

Enclosing in braces both the `\cyr` and the text to be set in cyrillic type (in the same way that an italic phrase would be indicated in a roman text) is particularly important for two reasons. First, like `\it`, `\cyr` must be explicitly terminated to return to roman text. And second, unlike `\it`, the special cyrillic control sequences invoked by `\cyracc` are interpreted differently by TEX depending on whether they are in a cyrillic or a noncyrillic environment. The "cyrillic" interpretation is not turned off simply by invoking `\rm`. Failure to follow this practice will yield gibberish.

6.2. Cyrillic input

The table in Figure 1 follows the alphabetical order of the table published in the 1983 MR author index. The three paired columns contain: (1) Cyrillic; (2) Input; (3) Transliteration.

The letters in the Cyrillic columns will appear in the typeset output when the corresponding codes from the Input columns are used in the `{\cyr ...}` context described above. The roman letters in the Transliteration columns will appear in the output when the corresponding codes from the Input columns are used in a noncyrillic environment, i.e., have not been preceded by `\cyr`.

Several points should be noted here.

- Input codes for uppercase cyrillic which consist of more than one letter, e.g. `Zh` ↦ Ж, can also be input in all caps, e.g. `ZH` ↦ Ж, if the context is entirely in caps.
- Particular care is necessary when the letter t ↦ т is followed by s ↦ с. The control sequence `\cydot` ("cyrillic dot") is provided as a separator to keep those letters distinct: `t\cydot s` (t·s) ↦ тс. Otherwise, they will be combined as ts ↦ ц.

  The t·s pair appears, for example, in the word `sovet\cydot ski\u\i` (sovet·skiĭ) ↦ советский and is not uncommon in the suffix of reflexive verbs, e.g. `nakhodyat\cydot sya` (nakhodyat·sya) ↦ находятся.
- Because there is not a one-to-one correspondence between cyrillic and roman letters, some cyrillic letters have been placed in locations where a roman letter does not have a cyrillic counterpart. A user who is aware of this fact may be able to detect input keying that does not conform to the recommendations shown in Figure 1, and correct it more easily than otherwise. The following nonstandard assignments have been made:

  `c` ↦ ц; `h` ↦ х; `q` ↦ ч; `w` ↦ щ; `x` ↦ ш.
- Some very strange effects can occur in cyrillic text hyphenated by the default English hyphenation rules; in particular, a cyrillic letter input as a group of letters can be decomposed. (Most multiple-letter input groups are converted to a single cyrillic letter by way of TEX's ligaturing mechanism.) For example, `shch` ↦ щ might, in especially unlucky circumstances, be decomposed as с-хч,

FIGURE 1. Input conventions for AMS cyrillic

Cyrillic	Input		Translit.		Cyrillic	Input		Translit.	
А а	`A`	`a`	A	a	Р р	`R`	`r`	R	r
Б б	`B`	`b`	B	b	С с	`S`	`s`	S	s
В в	`V`	`v`	V	v	Т т	`T`	`t`	T	t
Г г	`G`	`g`	G	g	Ћ ћ	`\'C`	`\'c`	Ć	ć
Д д	`D`	`d`	D	d	Ќ ќ	`\'K`	`\'k`	Ќ	ќ
Ђ ђ	`Dj`	`dj`	Dj	dj	У у	`U`	`u`	U	u
Ѓ ѓ	`\'G`	`\'g`	Ǵ	ǵ	Ў ў	`\u U`	`\u u`	Ŭ	ŭ
Е е	`E`	`e`	E	e	Ф ф	`F`	`f`	F	f
Ё ё	`\"E`	`\"e`	Ë	ë	Х х	`Kh`	`kh`	Kh	kh
Є є	`\=E`	`\=e`	Ē	ē	Ц ц	`Ts`	`ts`	Ts	ts
Ж ж	`Zh`	`zh`	Zh	zh	Ч ч	`Ch`	`ch`	Ch	ch
З з	`Z`	`z`	Z	z	Џ џ	`\Dzh`	`\dzh`	Dzh·	dzh·
И и	`I`	`i`	I	i	Ш ш	`Sh`	`sh`	Sh	sh
І і	`\=I`	`\=\i`	Ī	ī	Щ щ	`Shch`	`shch`	Shch	shch
Ї ї	`\"I`	`\"\i`	Ï	ï	Ъ ъ	`\Cdprime`	`\cdprime`	‟	‟
Ј ј	`J`	`j`	J	j	Ы ы	`Y`	`y`	Y	y
Й й	`\u I`	`\u\i`	Ĭ	ĭ	Ь ь	`\Cprime`	`\cprime`	′	′
К к	`K`	`k`	K	k	Э э	`\‘E`	`\‘e`	È	è
Л л	`L`	`l`	L	l	Ю ю	`Yu`	`yu`	Yu	yu
Љ љ	`Lj`	`lj`	Lj	lj	Я я	`Ya`	`ya`	Ya	ya
М м	`M`	`m`	M	m	S s	`\Dz`	`\dz`	Dz	dz
Н н	`N`	`n`	N	n	№	`N0`		N0	
Њ њ	`Nj`	`nj`	Nj	nj	«	`<`		¡	
О о	`O`	`o`	O	o	»	`>`		¿	
П п	`P`	`p`	P	p		`\cydot`		·	

ш-ч or 7-х. In other words, if there is any chance that cyrillic text might fall into a position where hyphenation could occur, the results should be checked very carefully, and discretionary hyphens used as appropriate.

- Hyphenation patterns do not exist for the AMS cyrillic font when the input conventions shown here are used. Furthermore, it is probably impracticable to attempt to develop such rules, since the rules to recognize control sequences and complicated ligatures, both used extensively by the AMS cyrillic input conventions, are not easily specified to TEX's hyphenation mechanism. Another approach to hyphenation, requiring some changes to the cyrillic `.tfm` files, has been described by Dimitri Vulis in a *TUGboat* article [DLV89].

6.3. Cyrillic in math

Although the cyrillic fonts are intended for use as text, individual letters are sometimes requested in math; for example, Ш may be used to represent the Shafarevich group. When cyrillic is needed in math mode, replace the definition of `\cyr` shown previously (which will work only for text) by the following instructions (which will support the use of cyrillic in both text and math):

```
\newfam\cyrfam
\font\tencyr=wncyr10
\font\sevencyr=wncyr7
\font\fivecyr=wncyr5
\def\cyr{\fam\cyrfam\tencyr\cyracc}
\textfont\cyrfam=\tencyr \scriptfont\cyrfam=\sevencyr
  \scriptscriptfont\cyrfam=\fivecyr
```

If only the 10-point cyrillic font has been accessed, the references to `\sevencyr` and `\fivecyr` can be changed to `\tencyr` to save memory. When using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX and the preprint style, use `\font@` instead of `\font`, remembering to change the `\catcode` of the `@` appropriately, and embed the font family specifications in `\addto\tenpoint`, as shown above.

If other base text sizes are used besides ten point, the suggestions given above in Section 6.1, **Making cyrillic available**, apply here as well.

7. Using the extra symbols

Most users of the extra symbol fonts will probably want to make them accessible to their TEX jobs with the least possible fuss. For $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX users, these fonts are available automatically with the preprint style, and other methods of loading them for use with $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX are described above. To load these fonts with LATEX or $\mathcal{A}\mathcal{M}\mathcal{S}$-LATEX, see Section 3.4, **Extra math symbols**.

If you are not using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX or LATEX, the easiest method of loading these fonts and defining the control sequences for accessing the symbols is to place the command

```
\input amssym.tex
```

at the top of your input file. This will load the fonts `msam`, `msbm`, and `eufm` in sizes 10, 7, and 5 point, suitable for use in ordinary ten-point math environments, and define the names of all the symbols in these fonts. However, this assigns more than 200 control sequence names, so if you are limited for space, an alternative method may be preferred.

If you type just `\input amssym.def` (or `\usepackage{amsfonts}` for LATEX), the fonts will be loaded, but only the names of the few special symbols listed below will be defined.

First there are four symbols that are normally used outside of math mode:

✓	`\checkmark`	®	`\circledR`
✠	`\maltese`	¥	`\yen`

These symbols, like ¶, §, †, and ‡, can also be used in math mode; they will change sizes correctly in subscripts and superscripts.

Next are four symbols that are "delimiters" (although there are no larger versions obtainable with `\left` and `\right`), so they must be used in math mode:

⌜ `\ulcorner` ⌝ `\urcorner`

⌞ `\llcorner` ⌟ `\lrcorner`

Finally, two dashed arrows are constructed from symbols in this family (note that one of them has two names; it can be accessed by either one):

⇢ `\dashrightarrow`, `\dasharrow` ⇠ `\dashleftarrow`

The Blackboard Bold letters $\mathbb{A}, \ldots, \mathbb{Z}$ can be accessed by typing (in math mode) `\Bbb A`, ...,`\Bbb Z` in plain TEX or $\mathcal{AMS}$-TEX, or `\mathbb{A}`, ...,`\mathbb{Z}` in LATEX.

Wider versions of the `plain.tex` `\widehat` and `\widetilde` are now available.

Letters in the `eufm` font can be accessed (in math mode) by typing, for example, `\frak A \frak g` to get $\mathfrak{Ag}$ (`\mathfrak{Ag}` in LATEX). For the other Euler fonts, see the various "Euler" subsections under the sections for different macro packages (LATEX, $\mathcal{AMS}$-TEX, plain TEX).

7.1. The `\newsymbol` command ($\mathcal{AMS}$-TEX or plain TEX)

All other symbols of the `msam` and `msbm` fonts must be named by control sequences so that they can be used (in math mode only) when the fonts are loaded. If you are very short on space for control sequence names, and need only a few of these symbols, you can omit the loading of `amssym.tex` and instead assign only the names you will need by using the command `\newsymbol` for each symbol you need, to create a control sequence that will properly produce that symbol. The control sequence can be either the "standard" name, as listed below, or one of your own choosing.

The list of symbols below shows for each symbol the symbol itself, a four-character "ID", and the "standard" name of the symbol. (The first character of the ID identifies the font family in which a symbol resides. Symbols from the `msam` family have `1` as the first character; symbols from the `msbm` family have `2` as the first character.) For example, the symbol $\nleqslant$ appears as

$\nleqslant$ `230A \nleqslant`

To produce a control sequence with this name, the instruction

```
\newsymbol\nleqslant 230A
```

appears in the file `amssym.tex`. This same instruction can be typed by a user who is not using the $\mathcal{AMS}$-TEX preprint style and has chosen not to load all the symbols, and thereafter the control sequence `\nleqslant` will produce the symbol $\nleqslant$ (in math mode), and will act properly as a "binary relation".

A few symbols in these fonts replace symbols defined in `plain.tex` by combinations of symbols available in the Computer Modern fonts. These are `\angle` ($\angle$) and `\hbar` ($\hbar$) from the group "Miscellaneous symbols", and

`\rightleftharpoons` (⇌) from the group "Arrows" below. The new symbols will change sizes correctly in subscripts and superscripts, provided that you are using appropriate redefinitions. In order to use `\newsymbol` to replace an existing definition, the name must first be "undefined". Here are the lines you must put in your file if you are not using the $\mathcal{AMS}$-TEX preprint style or `\input amssym` (which perform the redefinition automatically):

```
\undefine\angle
\newsymbol\angle 105C
\undefine\hbar
\newsymbol\hbar 207E
\undefine\rightleftharpoons
\newsymbol\rightleftharpoons 130A
```

These symbols are flagged in the tables below with a "(U)", as a reminder that they must be undefined.

7.2. The extra symbols

Note in the tables that some symbols are shown with two names; in such a case, either one can be used to access the symbol.

- **Lowercase Greek letters**

ϝ	207A	\digamma	ϰ	207B	\varkappa

- **Hebrew letters**

ב	2069	\beth	ג	206A	\gimel
ד	206B	\daleth			

- **Miscellaneous symbols**

ℏ	207E	\hbar (U)	‵	1038	\backprime
ℏ	207D	\hslash	∅	203F	\varnothing
△	134D	\vartriangle	▲	104E	\blacktriangle
▽	104F	\triangledown	▼	1048	\blacktriangledown
□	1003	\square	■	1004	\blacksquare
◊	1006	\lozenge	⧫	1007	\blacklozenge
Ⓢ	1073	\circledS	★	1046	\bigstar
∠	105C	\angle (U)	◁	105E	\sphericalangle
∡	105D	\measuredangle			
∄	2040	\nexists	∁	107B	\complement
℧	2066	\mho	ð	2067	\eth
ⅎ	2060	\Finv	⟋	201E	\diagup
⅁	2061	\Game	⟍	201F	\diagdown
𝕜	207C	\Bbbk			

- **Binary operators**

$\dot{+}$	1275	\dotplus	$\ltimes$	226E	\ltimes
$\smallsetminus$	2272	\smallsetminus	$\rtimes$	226F	\rtimes
$\Cap$	1265	\Cap, \doublecap	$\leftthreetimes$	1268	\leftthreetimes
$\Cup$	1264	\Cup, \doublecup	$\rightthreetimes$	1269	\rightthreetimes
$\barwedge$	125A	\barwedge	$\curlywedge$	1266	\curlywedge
$\veebar$	1259	\veebar	$\curlyvee$	1267	\curlyvee
$\doublebarwedge$	125B	\doublebarwedge			
$\boxminus$	120C	\boxminus	$\circleddash$	127F	\circleddash
$\boxtimes$	1202	\boxtimes	$\circledast$	127E	\circledast
$\boxdot$	1200	\boxdot	$\circledcirc$	127D	\circledcirc
$\boxplus$	1201	\boxplus	$\centerdot$	1205	\centerdot
$\divideontimes$	223E	\divideontimes	$\intercal$	127C	\intercal

- **Binary relations**

$\leqq$	1335	\leqq	$\geqq$	133D	\geqq
$\leqslant$	1336	\leqslant	$\geqslant$	133E	\geqslant
$\eqslantless$	1330	\eqslantless	$\eqslantgtr$	1331	\eqslantgtr
$\lesssim$	132E	\lesssim	$\gtrsim$	1326	\gtrsim
$\lessapprox$	132F	\lessapprox	$\gtrapprox$	1327	\gtrapprox
$\approxeq$	2375	\approxeq	$\eqsim$	2368	\eqsim
$\lessdot$	236C	\lessdot	$\gtrdot$	236D	\gtrdot
$\lll$	136E	\lll, \llless	$\ggg$	136F	\ggg, \gggtr
$\lessgtr$	1337	\lessgtr	$\gtrless$	133F	\gtrless
$\lesseqgtr$	1351	\lesseqgtr	$\gtreqless$	1352	\gtreqless
$\lesseqqgtr$	1353	\lesseqqgtr	$\gtreqqless$	1354	\gtreqqless
$\doteqdot$	132B	\doteqdot, \Doteq	$\eqcirc$	1350	\eqcirc
$\risingdotseq$	133A	\risingdotseq	$\circeq$	1324	\circeq
$\fallingdotseq$	133B	\fallingdotseq	$\trianglelefteq$	132C	\trianglelefteq
$\backsim$	1376	\backsim	$\thicksim$	2373	\thicksim
$\backsimeq$	1377	\backsimeq	$\thickapprox$	2374	\thickapprox
$\subseteqq$	136A	\subseteqq	$\supseteqq$	136B	\supseteqq
$\Subset$	1362	\Subset	$\Supset$	1363	\Supset
$\sqsubset$	1340	\sqsubset	$\sqsupset$	1341	\sqsupset
$\preccurlyeq$	1334	\preccurlyeq	$\succcurlyeq$	133C	\succcurlyeq
$\curlyeqprec$	1332	\curlyeqprec	$\curlyeqsucc$	1333	\curlyeqsucc
$\precsim$	132D	\precsim	$\succsim$	1325	\succsim
$\precapprox$	2377	\precapprox	$\succapprox$	2376	\succapprox
$\vartriangleleft$	1343	\vartriangleleft	$\vartriangleright$	1342	\vartriangleright
$\trianglelefteq$	1345	\trianglelefteq	$\trianglerighteq$	1344	\trianglerighteq
$\vDash$	130F	\vDash	$\Vdash$	130D	\Vdash
$\Vvdash$	130E	\Vvdash			
$\smallsmile$	1360	\smallsmile	$\shortmid$	2370	\shortmid
$\smallfrown$	1361	\smallfrown	$\shortparallel$	2371	\shortparallel
$\bumpeq$	136C	\bumpeq	$\between$	1347	\between
$\Bumpeq$	136D	\Bumpeq	$\pitchfork$	1374	\pitchfork

∝	135F	\varpropto	϶	237F	\backepsilon
◀	134A	\blacktriangleleft	▶	1349	\blacktriangleright
∴	1329	\therefore	∵	132A	\because

- **Negated relations**

≮	2304	\nless	≯	2305	\ngtr
≰	2302	\nleq	≱	2303	\ngeq
⩽̸	230A	\nleqslant	⩾̸	230B	\ngeqslant
≦̸	2314	\nleqq	≧̸	2315	\ngeqq
⪇	230C	\lneq	⪈	230D	\gneq
≨	2308	\lneqq	≩	2309	\gneqq
≨	2300	\lvertneqq	≩	2301	\gvertneqq
⋦	2312	\lnsim	⋧	2313	\gnsim
⪉	231A	\lnapprox	⪊	231B	\gnapprox
⊀	2306	\nprec	⊁	2307	\nsucc
⪯̸	230E	\npreceq	⪰̸	230F	\nsucceq
⋨	2316	\precneqq	⋩	2317	\succneqq
⋨	2310	\precnsim	⋩	2311	\succnsim
⪹	2318	\precnapprox	⪺	2319	\succnapprox
≁	231C	\nsim	≇	231D	\ncong
∤	232E	\nshortmid	∦	232F	\nshortparallel
∤	232D	\nmid	∦	232C	\nparallel
⊬	2330	\nvdash	⊭	2332	\nvDash
⊮	2331	\nVdash	⊯	2333	\nVDash
⋪	2336	\ntriangleleft	⋫	2337	\ntriangleright
⋬	2335	\ntrianglelefteq	⋭	2334	\ntrianglerighteq
⊄	232A	\nsubseteq	⊅	232B	\nsupseteq
⊈	2322	\nsubseteqq	⊉	2323	\nsupseteqq
⊊	2328	\subsetneq	⊋	2329	\supsetneq
⊊	2320	\varsubsetneq	⊋	2321	\varsupsetneq
⫋	2324	\subsetneqq	⫌	2325	\supsetneqq
⫋	2326	\varsubsetneqq	⫌	2327	\varsupsetneqq

- **Arrows**

⇇	1312	\leftleftarrows	⇉	1313	\rightrightarrows
⇆	131C	\leftrightarrows	⇄	131D	\rightleftarrows
⇚	1357	\Lleftarrow	⇛	1356	\Rrightarrow
↞	1311	\twoheadleftarrow	↠	1310	\twoheadrightarrow
↢	131B	\leftarrowtail	↣	131A	\rightarrowtail
↫	1322	\looparrowleft	↬	1323	\looparrowright
⇋	130B	\leftrightharpoons	⇌	130A	\rightleftharpoons (U)
↶	2378	\curvearrowleft	↷	2379	\curvearrowright
↺	1309	\circlearrowleft	↻	1308	\circlearrowright
↰	131E	\Lsh	↱	131F	\Rsh
⇈	1314	\upuparrows	⇊	1315	\downdownarrows
↿	1318	\upharpoonleft	↾	1316	\upharpoonright, \restriction

⇃	1319	\downharpoonleft	⇂	1317	\downharpoonright
⊸	1328	\multimap	⇝	1320	\rightsquigarrow
⇜⇝	1321	\leftrightsquigarrow			

- **Negated arrows**

↚	2338	\nleftarrow	↛	2339	\nrightarrow
⇍	233A	\nLeftarrow	⇏	233B	\nRightarrow
↮	233D	\nleftrightarrow	⇎	233C	\nLeftrightarrow

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Appendix A
Installation Procedures

A.1. Introduction

"AMSFonts" is a collection of fonts that supplement the basic Computer Modern fonts, for use with the TEX typesetting system. These fonts were originally intended for use with the $\mathcal{AMS}$-TEX or $\mathcal{AMS}$-LATEX macro packages, but they can also be used with plain TEX or LATEX, independently of the AMS formatting packages.

AMSFonts can be used with any full implementation of TEX. Many TEX distributions include the AMSFonts; check the documentation that came with the TEX distribution you are using. When a new version of AMSFonts is released, all distributors are notified, so if your TEX system is up to date, it is likely that you don't need to do anything at all.

Most current TEX installations are organized according to the TEX Directory Structure (TDS). This is a tree structure whose root is identified as something like `/usr/local/share/texmf` or `c:\sw\texmf`. In the following instructions, we will use the name `TEXMF` to identify the root directory of a TDS or similar structure. (For detailed documentation of the TDS, see the report at

`http://www.ctan.org/tex-archive/tds/standard/tds/`

for a browsable version, or the file `tds.pdf` in the same area if you prefer a copy formatted for printing.)

When installing a new release of the AMSFonts, you may want to first back up your old version, if you have existing documents that use it. Although new releases are intended to be backward compatible, a backup provides insurance in case something goes wrong.

A.2. Location of AMSFonts files in a TDS tree

Files in the AMSFonts distribution fall into several categories: `.tfm` (metric) files, macro files for use with TEX, source files, documentation, and raster image (`.pk`) files. The following list shows the files in the current distribution, along with their recommended locations in a TDS tree.

```
TEXMF/
  fonts/source/
    ams/
      README
      amsfonts.lst
      cmextra/
        cmbsy*.mf     (5 files)
        cmcsc*.mf     (2 files)
        cmex*.mf      (3 files)
        cmmib*.mf     (5 files)
```

```
    cyrillic/
      cyr*.mf       (9 files)
      serb*.mf      (2 files)
      wncy*.mf      (22 files)
    euler/
      ebigop.mf
      eubase.mf
      euex*.mf      (4 files)
      eufb*.mf      (7 files)
      eufm*.mf      (7 files)
      eurb*.mf      (7 files)
      eurm*.mf      (7 files)
      eusb*.mf      (7 files)
      eusm*.mf      (7 files)
  public/misc/
    dummy.mf
fonts/pk/
    ⟨device resolution⟩/          (not included in bundled collection)
fonts/tfm/
  ams/
    cmextra/
    cyrillic/
    euler/
    symbols/
  public/misc/
    dummy.tfm
tex/latex/amsfonts/
  amsdtx.cls
  amsfonts.sty
  amssymb.sty
  cmmib7.sty

tex/plain/amsfonts/
  amssym.def
  amssym.tex
  cyracc.def
source/fonts/amsfonts/
  amsfndoc.tex
  amsfndoc.def
  amsfndoc.cyr
  amsfndoc.fnt
  amsfndoc.ins
    cyr-alt/
      README
      wkcy*.vpl     (5 files)
      wlcy*.vpl     (5 files)
      wvcy*.vpl     (5 files)
    symbols/
      amsy*.mf      (2 files)
      *symbols.mf   (2 files)
      msam*.mf      (6 files)
      msbm*.mf      (6 files)
      xb*.mf        (3 files)
    eucal.sty
    eufrak.sty
    euscript.sty
    ueu*.fd         (8 files)
    ums*.fd         (4 files)
  doc/ams/amsfonts/
    amsfndoc.ps
    amsfonts.bug
    amsfonts.faq
  source/latex/amsfonts/
    amsfonts.dtx
    amsfonts.fdd
    amsfonts.ins
    amssymb.dtx
    cmmib57.dtx
    eufrak.dtx
    euscript.dtx
```

The AMSFonts distribution can be retrieved in bundled form from the AMS web site, e.g., as a `.zip`, `.tar` or `.hqx` file. In this form, the files are already arranged according to the TDS structure. The `.pk` files are not included in the main bundle; they are bundled separately, by output device resolution or by platform. To install the main bundle, place the bundled file into a convenient directory and unpack it using the `TEXMF` directory as the "Extract to" target. Some examples:

WinZip:	Click on "Extract" and then in the "Extract to" box, enter `\sw\texmf` (or whatever `TEXMF` is on your system)
gzip:	`gzip -dc amsfonts-all-but-pk-files.tgz | (cd TEXMF; tar xvf -)`
unzip:	`unzip amsfonts-all-but-pk-files.zip -d TEXMF`

The bundled file may be deleted after unpacking.

A.3. Installing the `.pk` files

Many modern TEX installations incorporate a feature called MakeTeXPk that creates a `.pk` file only when it has actually been requested by a job. Check the documentation that came with your system; if MakeTeXPk is available, you may choose to omit installing any `.pk` files, but let the system generate them on demand.

Alternatively, if you are using a PostScript output device, you will probably want to use Postscript (Type 1) outline files rather than `.pk` files. Type 1 versions of the AMSFonts are available separately from the AMS web site,

`http://www.ams.org/tex/amsfonts.html`

The fonts in the Type 1 collection do not include all sizes; for details, see the appropriate section of the *AMSFonts 2.2d User's Guide* and the documentation that comes with the collection.

If you do decide you want to install the `.pk` files from the AMS server, consult the TDS tree shown above to identify the proper location.

The amount of disk space required for installation of the AMSFonts depends on the resolution of your output device and on which families of fonts you choose to install. There are five families of fonts, and you may choose to install any or all of these families. Also, you may choose to install all magnifications or only magnifications 100%, 109.5% and 120% (TEX magsteps 0, $\frac{1}{2}$ and 1). For a more complete description of these families and magnifications, please see the appropriate sections of the *AMSFonts 2.2d User's Guide*.

The following table lists all the families and the disk space required for their installation. Before you begin the installation, decide which fonts and which magnifications you will choose, and make sure that you have enough disk space available.

Approximate Disk Space Required for AMSFonts Installation

		Extra CM	Euler Fraktur	Other Euler	Extra Symbols	Cyrillic	All Fonts
118dpi	100% thru 120%	200K	150K	350K	150K	250K	1100K
	all mags	550K	350K	850K	450K	750K	2950K
180dpi	100% thru 120%	250K	150K	350K	200K	300K	1250K
	all mags	750K	450K	950K	650K	1000K	3800K
240dpi	100% thru 120%	300K	150K	350K	250K	400K	1450K
	all mags	900K	500K	1000K	800K	1200K	4400K
300dpi	100% thru 120%	350K	200K	450K	350K	500K	1850K
	all mags	1100K	700K	1300K	1000K	1500K	5600K
400dpi	100% thru 120%	450K	250K	500K	400K	550K	2150K
	all mags	1450K	825K	1625K	1250K	1850K	7000K
600dpi	100% thru 120%	650K	325K	600K	500K	725K	2800K
	all mags	2000K	1150K	2150K	1750K	2650K	9700K

A.4. What if your TEX system isn't in a TDS tree?

If your TEX system is arranged in some other way, you must consult the user documentation for guidance. The hints that follow are just that—hints. If your TEX system documentation recommends something different, you should follow that procedure.

We recommend placing AMSFonts files into distinct subdirectories or folders, to simplify installation of future versions.

First, determine where TEX will look for its files. The AMSFonts collection contains not only fonts, but also support for their use with plain TEX and LATEX. Look first for files listed in the tree above; if you find them, you should simply install the new versions in the same areas. If you don't find them, some more specific hints follow.

To install plain TEX support files, look on your system for the file `plain.tex`; the files listed above under `tex/plain/amsfonts/` should go into (a subarea of) that area.

To install LATEX support files, look for the file `article.sty`; the files listed above under `tex/latex/amsfonts/` should go into (a subarea of) that area.

To install the `.tfm` files, look for the file `cmr10.tfm`.

Raster image files may or may not have `pk` in the file extension, depending on the system. These files are used by the output device drivers, not by TEX itself. Consult the documentation for your drivers to see where they look for `.pk` files. In the AMSFonts distribution, the directories are labeled `\amsfonts\dpiXXX`, where `XXX` is the resolution of the output device multiplied by the magnification (for example, for a 300dpi printer, `XXX` would be `300` for a font at 100% or `360` for a font at 120%). Unix users will have to rename the `.pk` files in each directory to the extension `.XXXpk`, where `XXX` is the number in the directory `dpiXXX` in which

the file is located. Once all the files have been renamed, they can be placed all together in the directory where your drivers will find them.

A.5. Font definition files for LaTeX

Warning: If your version of LaTeX 2_ε is earlier than December 1996, *and* if your operating system and TeX implementation both refer to filenames in a case-sensitive manner, the `.fd` files you need are not included in the bundled AMSFonts distribution; you will need to retrieve them explicitly from the AMS FTP server, at

`ftp://ftp.ams.org/pub/tex/amsfonts/latex/obsolete/`

This warning may apply to users of Unix systems; it does not generally apply to users of Windows or DOS.

A better option, which we recommend strongly, is to update your version of LaTeX; the case-sensitive `.fd` filenames were made obsolete with the December 1996 release of LaTeX, so if you are still using an older version, it is overdue for update.

A.6. Additional note for all users of AMSFonts

The device driver with which you are using these fonts may have a font table that needs to be updated in order for the driver to recognize the fonts. In order to use AMSFonts with any software that uses such a table, you must enter the names of each of the fonts in the AMSFonts package and the effective resolutions at which you have them installed. The file `amsfonts.lst`, which appears at the same level in the TDS tree as the `README` file, contains a list of all of the font names and all of the resolutions contained in the distribution. You may have to alter the format of this file to make it conform to your driver's needs or to reflect installation of only some of the fonts, but it provides you with the necessary data. See the documentation for your device driver to see what format is required. If your device driver does not depend on such a table, this step is not necessary.

A.7. Note for users of *Textures* on Macintosh

The AMSFonts distribution for *Textures* is different from what has been described above; the fonts are distributed in several different suitcase files rather than in a TDS tree. This distribution is bundled in the file

`/pub/macintosh/amsfonts2-2.hqx`

which is available from the AMS FTP server or web site.

Appendix B
Using the PostScript (Type 1) AMSFonts

The AMSFonts were reimplemented in Type 1 outline form jointly by Blue Sky Research and Y&Y, and made freely available for general use through a consortium of scientific publishers. These Type 1 fonts are not part of the main AMSFonts distribution, but are available separately from the AMS web site:

`http://www.ams.org/tex/type1-fonts.html`

The web page contains a more detailed history of these fonts than is given here.

This collection can also be found on CTAN (the Comprehensive TEX Archive Network), at

`http://www.ctan.org/tex-archive/amsfonts/ps-type1/`

The CTAN entry is mirrored directly from the AMS server.

The symbols and fonts of mathematical alphabets in the Type 1 collection are provided only in sizes 5, 7, and 10 point, with additional sizes produced by interpolation. To accommodate this reduced set of sizes, a "PS AMS fonts" option is provided with both LATEX and $\mathcal{AMS}$-TEX; see the relevant sections of this guide for details. Papers and monographs submitted to the AMS for publication are required to use this option.

> **Warning:** Adding the "PS AMS fonts" option to an existing file may result in changed line and page breaks, owing to the fact that sizes 6, 8, and 9 are produced by interpolation.

The Type 1 cyrillic fonts are provided only in 10 point. The "PS AMS fonts" option does not apply to cyrillic at the present time.

Some output device drivers (e.g., `dvips`) require a "map" file to identify Type 1 fonts; for details, see the documentation for your device driver.

If you are using the Type 1 AMSFonts, you may wish to rename the `.tfm` files for the intermediate sizes—6, 8, and 9 point for the math fonts and all sizes but 10 point for the cyrillic—so that TEX won't find them. This will insure that the bitmaps aren't used inadvertently, or created on demand by systems that use the MakeTeXPk facility.

Appendix C
For further information

The AMSFonts collection was implemented and packaged by the Society's Publications Technical Group. Questions or suggestions for improvements should be directed to that group at the following address:

Publications Technical Group
American Mathematical Society
P. O. Box 6248
Providence, RI 02940

Phone: 800-321-4AMS (4267) or 401-455-4080
Internet: `tech-support@ams.org`

Questions or comments concerning *Textures* can be directed to:

Blue Sky Research
516 Southeast Morrison
Portland, OR 97204

Phone: 800-622-8398 or 503-222-9571
Internet: `help@bluesky.com`

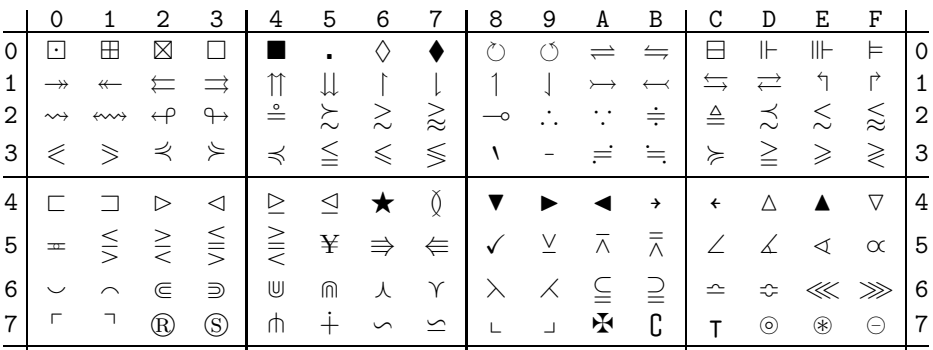
The Internet newsgroup `comp.text.tex` is an excellent source of general information about anything related to TEX, and fonts are no exception. The newsgroup and its archives can be accessed at `http://groups.google.com/`.

The TEX Resources pages at the AMS web site (`http://www.ams.org/tex/`) contain pointers to additional sources of TEX-related information, including answers to Frequently Asked Questions (FAQ).

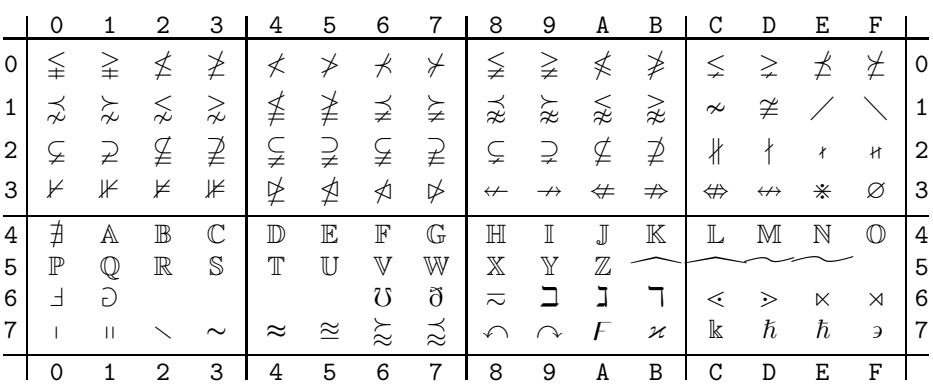
Appendix D
Font charts

Note: Row and column numbers are hexadecimal.

Extra symbols, group 1, medium weight – `msam10`



Extra symbols, group 2, medium weight – `msbm10`



Euler Fraktur medium weight – `eufm10`

Euler cursive (roman) medium weight – `eurm10`

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	Γ	Δ	Θ	Λ	Ξ	Π	Σ	Υ	Φ	Ψ	Ω	α	β	γ	δ	ϵ	0
1	ζ	η	θ	ι	κ	λ	μ	ν	ξ	π	ρ	σ	τ	υ	ϕ	χ	1
2	ψ	ω	ε	ϑ	ϖ			φ									2
3	0	1	2	3	4	5	6	7	8	9	.	,	<	/	>		3
4	∂	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	4
5	P	Q	R	S	T	U	V	W	X	Y	Z						5
6	ℓ	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	6
7	p	q	r	s	t	u	v	w	x	y	z	ı	ȷ	℘			7
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

Euler script medium weight – `eusm10`

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	−																0
1									~								1
2																	2
3											¬		ℜ	ℑ			3
4	ℵ	𝒜	ℬ	𝒞	𝒟	ℰ	ℱ	𝒢	ℋ	ℐ	𝒥	𝒦	ℒ	ℳ	𝒩	𝒪	4
5	𝒫	𝒬	ℛ	𝒮	𝒯	𝒰	𝒱	𝒲	𝒳	𝒴	𝒵				∧	∨	5
6							{	}			|				\		6
7									§								7
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

Euler-compatible extension font – `euex10`

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0									{	}	{	}	{	}	{	}	0
1									↼	↽	⇀	⇁					1
2	←	→	↑	↓	↔	↗	↘		⇐	⇒	⇑	⇓	⇔	↖	↙		2
3		∞							⎛	⎞	⎝	⎠	⎧	⎫	⎪		3
4									∮	∯							4
5	∑	∏	∫						∑	∏	∫						5
6	⨋	⨌											↕	⇕			6
7											⏜	⏝	⏜	⏝			7
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

Cyrillic, medium weight – `wncyr10`

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	Њ	Љ	Ц	Э	І	Є	Ъ	Ћ	њ	љ	ц	э	і	є	ђ	ћ	0
1	Ю	Ж	Й	Ё	Ѵ	Ѳ	S	Я	ю	ж	й	ё	ѵ	ѳ	s	я	1
2	¨	!	”	Ѣ	˘	%	´	’	(	)	*	ѣ	,	-	.	/	2
3	0	1	2	3	4	5	6	7	8	9	:	;	«	ı	»	?	3
4	ˇ	А	Б	Ц	Д	Е	Ф	Г	Х	И	J	К	Л	М	Н	О	4
5	П	Ч	Р	С	Т	У	В	Щ	Ш	Ы	З	[	“	]	Ь	Ъ	5
6	‘	а	б	ц	д	е	ф	г	х	и	j	к	л	м	н	о	6
7	п	ч	р	с	т	у	в	щ	ш	ы	з	–	—	№	ь	ъ	7
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

Italic Cyrillic, medium weight – `wncyi10`

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	*Њ*	*Љ*	*Ц*	*Э*	*І*	*Є*	*Ъ*	*Ћ*	*њ*	*љ*	*ц*	*э*	*і*	*є*	*ђ*	*ћ*	0
1	*Ю*	*Ж*	*Й*	*Ё*	*Ѵ*	*Ѳ*	*S*	*Я*	*ю*	*ж*	*й*	*ё*	*ѵ*	*ѳ*	*s*	*я*	1
2	¨	*!*	”	*Ѣ*	˘	*%*	´	’	*(*	*)*	*	*ѣ*	,	-	.	/	2
3	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*:*	*;*	«	*ı*	»	*?*	3
4	ˇ	*А*	*Б*	*Ц*	*Д*	*Е*	*Ф*	*Г*	*Х*	*И*	*J*	*К*	*Л*	*М*	*Н*	*О*	4
5	*П*	*Ч*	*Р*	*С*	*Т*	*У*	*В*	*Щ*	*Ш*	*Ы*	*З*	*[*	“	*]*	*Ь*	*Ъ*	5
6	‘	*а*	*б*	*ц*	*д*	*е*	*ф*	*г*	*х*	*и*	*j*	*к*	*л*	*м*	*н*	*о*	6
7	*п*	*ч*	*р*	*с*	*т*	*у*	*в*	*щ*	*ш*	*ы*	*з*	–	—	№	*ь*	*ъ*	7
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

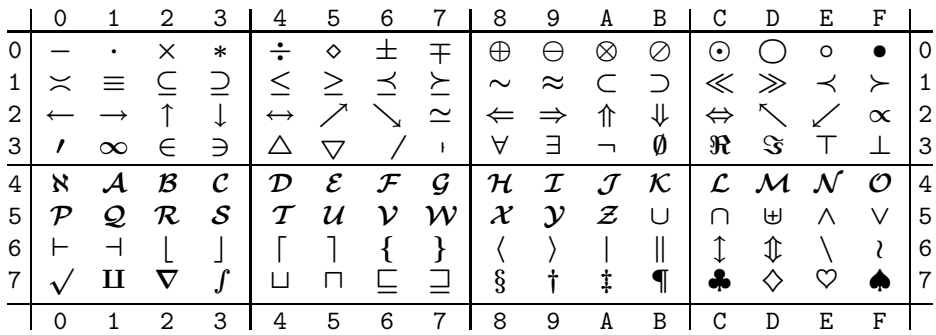
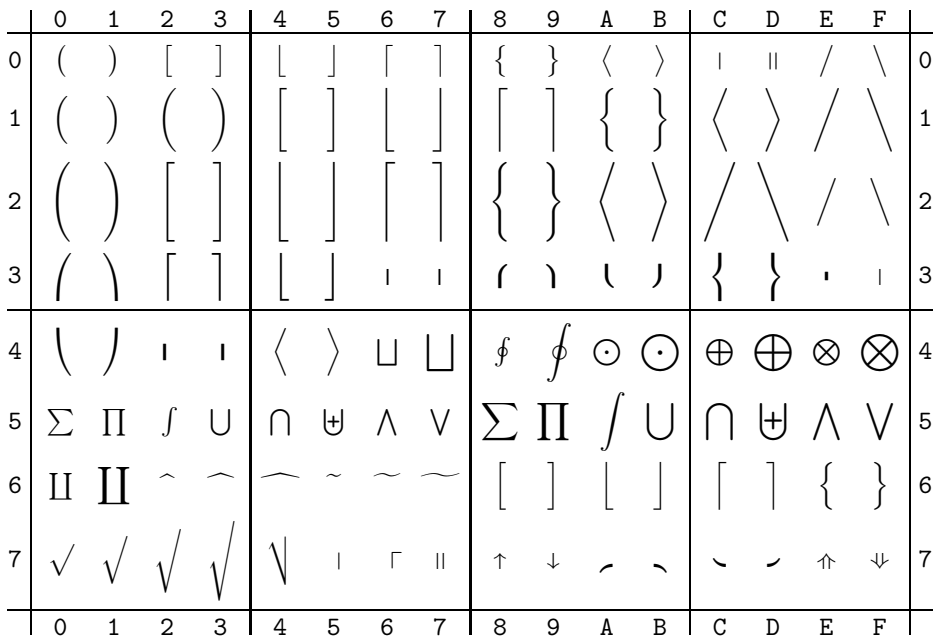
Computer Modern caps and small caps – `cmcsc10`

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	Γ	Δ	Θ	Λ	Ξ	Π	Σ	Υ	Φ	Ψ	Ω	↑	↓	'	¡	¿	0
1	ı	ȷ	`	´	˘	ˇ	¯	°	¸	SS	Æ	Œ	Ø	Æ	Œ	Ø	1
2	˙	!	”	#	$	%	&	’	(	)	*	+	,	-	.	/	2
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?	3
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	4
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	“	]	^	·	5
6	‘	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	6
7	p	q	r	s	t	u	v	w	x	y	z	–	—	”	~	¨	7
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

Computer Modern bold math italic – `cmmib10`

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	$\boldsymbol{\Gamma}$	$\boldsymbol{\Delta}$	$\boldsymbol{\Theta}$	$\boldsymbol{\Lambda}$	$\boldsymbol{\Xi}$	$\boldsymbol{\Pi}$	$\boldsymbol{\Sigma}$	$\boldsymbol{\Upsilon}$	$\boldsymbol{\Phi}$	$\boldsymbol{\Psi}$	$\boldsymbol{\Omega}$	$\boldsymbol{\alpha}$	$\boldsymbol{\beta}$	$\boldsymbol{\gamma}$	$\boldsymbol{\delta}$	$\boldsymbol{\epsilon}$	0
1	$\boldsymbol{\zeta}$	$\boldsymbol{\eta}$	$\boldsymbol{\theta}$	$\boldsymbol{\iota}$	$\boldsymbol{\kappa}$	$\boldsymbol{\lambda}$	$\boldsymbol{\mu}$	$\boldsymbol{\nu}$	$\boldsymbol{\xi}$	$\boldsymbol{\pi}$	$\boldsymbol{\rho}$	$\boldsymbol{\sigma}$	$\boldsymbol{\tau}$	$\boldsymbol{\upsilon}$	$\boldsymbol{\phi}$	$\boldsymbol{\chi}$	1
2	$\boldsymbol{\psi}$	$\boldsymbol{\omega}$	$\boldsymbol{\varepsilon}$	$\boldsymbol{\vartheta}$	$\boldsymbol{\varpi}$	$\boldsymbol{\varrho}$	$\boldsymbol{\varsigma}$	$\boldsymbol{\varphi}$	$\boldsymbol{\leftharpoonup}$	$\boldsymbol{\leftharpoondown}$	$\boldsymbol{\rightharpoonup}$	$\boldsymbol{\rightharpoondown}$	‘	’	$\boldsymbol{\triangleright}$	$\boldsymbol{\triangleleft}$	2
3	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	.	,	<	/	>	$\star$	3
4	$\boldsymbol{\partial}$	$\boldsymbol{A}$	$\boldsymbol{B}$	$\boldsymbol{C}$	$\boldsymbol{D}$	$\boldsymbol{E}$	$\boldsymbol{F}$	$\boldsymbol{G}$	$\boldsymbol{H}$	$\boldsymbol{I}$	$\boldsymbol{J}$	$\boldsymbol{K}$	$\boldsymbol{L}$	$\boldsymbol{M}$	$\boldsymbol{N}$	$\boldsymbol{O}$	4
5	$\boldsymbol{P}$	$\boldsymbol{Q}$	$\boldsymbol{R}$	$\boldsymbol{S}$	$\boldsymbol{T}$	$\boldsymbol{U}$	$\boldsymbol{V}$	$\boldsymbol{W}$	$\boldsymbol{X}$	$\boldsymbol{Y}$	$\boldsymbol{Z}$	$\flat$	$\natural$	$\sharp$	$\smile$	$\frown$	5
6	$\boldsymbol{\ell}$	$\boldsymbol{a}$	$\boldsymbol{b}$	$\boldsymbol{c}$	$\boldsymbol{d}$	$\boldsymbol{e}$	$\boldsymbol{f}$	$\boldsymbol{g}$	$\boldsymbol{h}$	$\boldsymbol{i}$	$\boldsymbol{j}$	$\boldsymbol{k}$	$\boldsymbol{l}$	$\boldsymbol{m}$	$\boldsymbol{n}$	$\boldsymbol{o}$	6
7	$\boldsymbol{p}$	$\boldsymbol{q}$	$\boldsymbol{r}$	$\boldsymbol{s}$	$\boldsymbol{t}$	$\boldsymbol{u}$	$\boldsymbol{v}$	$\boldsymbol{w}$	$\boldsymbol{x}$	$\boldsymbol{y}$	$\boldsymbol{z}$	$\boldsymbol{\imath}$	$\boldsymbol{\jmath}$	$\wp$	$\vec{}$	$\frown$	7
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

Computer Modern bold math symbols – `cmbsy10`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