AMSFonts Version 2.1 — User's Guide June 1991

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 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 the MathSci online database.

> **Warning:** The fonts in this collection are suitable for use with AMS-TEX Version 2.0+, but are not compatible with earlier versions of AMS-TEX. If you are using an older version of AMS-TEX and are intending to use fonts from this Version 2.1 collection, you should obtain a new version of AMS-TEX, if you haven't already done so. Similarly, earlier versions of this collection are not compatible with AMS-TEX Version 2.0+.

Contents of this document

Contents of the AMSFonts collection

The AMSFonts collection contains 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 (the 10-point font is included in standard TEX distributions)
- 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
- 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 AMS-TEX for syntax checking, exists only as metrics (`DUMMY.TFM`)
- Other files needed to use these fonts:
  - `AMSSYM.TEX`, a file defining 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
- Other useful files:
  - `USERDOC.TEX`, the source file for this User's Guide
  - `USERDOC.CYR`, the source file for the table showing cyrillic input conventions, input by `USERDOC.TEX`
  - `USERDOC.FNT`, the source file for the tables of the principal 10-point fonts in the AMSFonts collection, input by `USERDOC.TEX`; this file may also be TEXed by itself
  - `USERDOC.DEF`, the macros used to format this User's Guide

Each font at a particular size is provided in seven standard TEX magnifications, magsteps 0 through 5, including magstephalf. The AMSFonts package for the IBM PC and compatibles includes all magnifications. For use with *Textures* on the Macintosh, the Standard AMSfonts package includes only magsteps 0 and 1; the Extended AMSFonts package includes all seven magnifications. All instances of every font have been newly generated for this release of the AMSFonts collection.

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.

Figure 1 shows the layouts for the 10-point fonts listed above. Where both medium-weight and bold versions are listed, only the medium-weight layout is shown. The bold fonts have the same layout as the corresponding medium-weight versions.

Figure 1a. Layouts of the AMSFonts — Euler

Note: The charts shown in this figure were set with the 10-point versions of the indicated fonts, then photographically reduced.

Charts to appear here:

Euler: EUFM10, EURM10, EUSM10, EUEX10

Figure 1b. Layouts of the AMSFonts — Computer Modern bold math; extra symbols

Charts to appear here:

Symbols: MSAM10, MSBM10

Computer Modern bold math: CMMIB10, CMBSY10

Figure 1c. Layouts of the AMSFonts — Computer Modern math extension; caps/small caps; cyrillic

Charts to appear here:

Math extension: CMEX10

Caps/small caps: CMCSC10

Cyrillic: WNCYR10, WNCYI10

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.

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 CM fonts other than those specifically named here, and on other fonts in general, the TEX Users Group is the best source. For TUG's address, see the section **For further information**.

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.

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 symbols; they are not intended for setting running text.

The Fraktur face of the Euler family has been used by the AMS for several years in its production. 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 new 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 has described his experience with the Euler fonts in a *TUGboat* article [DEK89]. In the article he also identifies the macros he used and where they can be obtained.

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.

Symbols

Two fonts of "extra" symbols are included in the AMSFonts collection. These are named MSAM and MSBM, and have been newly 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 ($\mathbb{A}, \ldots, \mathbb{Z}$).

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'), 'ë' (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. For information on cyrillic fonts with other layouts, see the section **For 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.

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.

Dummy font

This is a pseudo-font, which exists only as a set of metrics. Mainframe TEX distributions contain this font in "property list" (`.PL`) format, a human-readable file that contains everything in the corresponding `.TFM` file. (Transformation between `.PL` and `.TFM` formats can be accomplished by the programs `PLtoTF` and `TFtoPL`; for convenience, the AMSFonts collection includes the file `DUMMY.TFM`.) Specifically, the dummy font contains no ligature or kerning information, and all dimensions and parameter values are set to zero.

The dummy font is used in $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-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 will not be detected until setting actually occurs.

How to use AMSFonts 2.1 with $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX 2.0+

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 20, and Appendix F, **Further fonts**. The first describes the use of letters from alphabets, including Fraktur, and the second, mostly nonalphabetic symbols.

> **Warning:** This information is effective as of $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX version 2.0+, June 1991 and the 2nd edition of *The Joy of TEX* [MDS90]. The handling of non-`PLAIN` fonts in earlier versions is different from what is described here. If you have an earlier version of $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX, it is highly recommended that you obtain $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX Version 2.0+, which is available from AMS and most TEX distributors.

Instructions for using the fonts of the AMSFonts collection with $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX are also given in the *User's Guide to $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX Version 2.1* [AMS91] and in Appendix F of editions of *The Joy of TEX* [MDS90] dated 1990 or later.

Additional fonts to be used with $\mathcal{A}\mathcal{M}\mathcal{S}$-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
⟨preamble commands⟩
\documentstyle{...}
```

$\mathcal{A}\mathcal{M}\mathcal{S}$-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 below, in the section **Installing and using the extra symbols**.

> **Warning:** 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.

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.

> **Warning:** Editions of *Joy* prior to 1990 describe an obsolete method of accessing these fonts. The directions given in Appendix F of these older editions are superseded by the `\load...` instructions cited here for Euler, bold math italic, and symbol fonts.

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 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 $\mathfrak{g}\mathfrak{A}$. $\mathcal{A}\!\mathcal{M}\!\mathcal{S}$-TEX 2.1 also defines `\eufm`, `\eufb`, `\eurm`, `\eurb`, `\eusm` and `\eusb`

Computer Modern bold math italic and symbols

The Computer Modern bold math italic (CMMIB) and bold math symbol (CMBSY) fonts can both be loaded 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 $\mathcal{A}\!\mathcal{M}\!\mathcal{S}$-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 $\mathcal{A}\!\mathcal{M}\!\mathcal{S}$-TEX Version 2.1 [AMS91] and editions of *Joy* published in 1990 or later [MDS90].

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.

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 the section **Installing and using the extra symbols** for information on both the symbol names and on using `\newsymbol` to define them.

Cyrillic

Cyrillic is not referred to in the $\mathcal{A}_\mathcal{M}\mathcal{S}$-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 the section **Installing and using cyrillic**.

Caps/small caps

Caps/small caps are loaded automatically by the $\mathcal{A}_\mathcal{M}\mathcal{S}$-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.

Dummy font

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

How to use AMSFonts 2.1 without $\mathcal{A}_\mathcal{M}\mathcal{S}$-TEX

For the most part, it is assumed that anyone using AMSFonts without $\mathcal{A}_\mathcal{M}\mathcal{S}$-TEX has some experience with TEX macros or has a friendly relationship with a TEXnician. Since all applications seem to refer to fonts in different ways, no assumptions are made about how any "average" user is going to use these fonts. 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 $\mathcal{A}_\mathcal{M}\mathcal{S}$-TEX preprint style, contains similar font definitions, `\tenpoint` and `\eightpoint`.

Extensive size-switching font facilities are also present in LATEX, but these cannot easily be copied for uses outside of LATEX.

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.

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.

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
```

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.

Extra symbols

Detailed instructions for accessing the MSAM and MSBM fonts are given in the section **Installing and using the extra symbols**.

Cyrillic

See the section **Installing and using cyrillic** for instructions.

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.

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.

Installing and 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. 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 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.

Making cyrillic available to a document

If you are not using $\mathcal{AMS}$-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 $\mathcal{AMS}$-TEX and the preprint style, the following instructions should be included 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 2 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.

Cyrillic input

The table in Figure 2 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 2, 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, ш-ч or 7-х. In other words, if there is any chance that cyrillic text might fall

Figure 2. 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	Ḱ	ḱ
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	Ѕ	ѕ	\Dz	\dz	Dz	dz
Н	н	N	n	N	n	№		NO		N0	
Њ	њ	Nj	nj	Nj	nj	«		<		¡	
О	о	O	o	O	o	»		>		¿	
П	п	P	p	P	p			\cydot		·	

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].

Cyrillic in math

Although the cyrillic fonts are intended for use as text, the need occasionally arises to use one or two letters in math; for example, Ш may be used to represent the Shafarevich group. When cyrillic must also be made available to math mode, the following instructions (which will support the use of cyrillic in both text and math) should replace the definition of `\cyr` shown previously (which will work only for text):

```
\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=\sevencyr
```

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 AMS-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 under **Making cyrillic available** apply here as well.

Installing and 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 AMS-TEX users, these fonts are available automatically with the preprint style, and other methods of loading them for use with AMS-TEX are described above.

If you are not using AMS-TEX, the easiest method of loading these fonts and defining the control sequences for accessing the symbols is to place the commands

```
\input amssym.def
\input amssym
```

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 amssmy.def`, 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, and 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:

$\ulcorner$	`\ulcorner`	$\urcorner$	`\urcorner`
$\llcorner$	`\llcorner`	$\lrcorner$	`\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):

$\dashrightarrow$	`\dashrightarrow`, `\dasharrow`	$\dashleftarrow$	`\dashleftarrow`

The Blackboard Bold letters $\mathbb{A}, \ldots, \mathbb{Z}$ can be accessed by typing (in math mode) `\Bbb A`,. . . ,`\Bbb Z`.

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 $\mathfrak{A}\mathfrak{g}$.

The `\newsymbol` command

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 $\mathcal{A}\mathcal{M}\mathcal{S}$-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` ($\rightleftharpoons$) 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 $\mathcal{A}\!\mathcal{M}\!\mathcal{S}$-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.

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**

$\digamma$	207A	`\digamma`	$\varkappa$	207B	`\varkappa`

- **Hebrew letters**

$\beth$	2069	`\beth`	$\gimel$	206A	`\gimel`
$\daleth$	206B	`\daleth`			

- **Miscellaneous symbols**

$\hbar$	207E	`\hbar` (U)	$\backprime$	1038	`\backprime`
$\hslash$	207D	`\hslash`	$\varnothing$	203F	`\varnothing`
$\vartriangle$	134D	`\vartriangle`	$\blacktriangle$	104E	`\blacktriangle`
$\triangledown$	104F	`\triangledown`	$\blacktriangledown$	1048	`\blacktriangledown`
$\square$	1003	`\square`	$\blacksquare$	1004	`\blacksquare`
$\lozenge$	1006	`\lozenge`	$\blacklozenge$	1007	`\blacklozenge`
$\circledS$	1073	`\circledS`	$\bigstar$	1046	`\bigstar`
$\angle$	105C	`\angle` (U)	$\sphericalangle$	105E	`\sphericalangle`
$\measuredangle$	105D	`\measuredangle`			
$\nexists$	2040	`\nexists`	$\complement$	107B	`\complement`
$\mho$	2066	`\mho`	$\eth$	2067	`\eth`
$\Finv$	2060	`\Finv`	$\diagup$	231E	`\diagup`
$\Game$	2061	`\Game`	$\diagdown$	231F	`\diagdown`
$\Bbbk$	207C	`\Bbbk`			

- **Binary operators**

$\dotplus$	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			
$\lessdot$	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	$\triangleq$	132C	\triangleq
$\backsim$	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

$\varpropto$	135F	`\varpropto`	$\backepsilon$	237F	`\backepsilon`
$\blacktriangleleft$	134A	`\blacktriangleleft`	$\blacktriangleright$	1349	`\blacktriangleright`
$\therefore$	1329	`\therefore`	$\because$	132A	`\because`

- **Negated relations**

$\nless$	2304	`\nless`	$\ngtr$	2305	`\ngtr`
$\nleq$	2302	`\nleq`	$\ngeq$	2303	`\ngeq`
$\nleqslant$	230A	`\nleqslant`	$\ngeqslant$	230B	`\ngeqslant`
$\nleqq$	2314	`\nleqq`	$\ngeqq$	2315	`\ngeqq`
$\lneq$	230C	`\lneq`	$\gneq$	230D	`\gneq`
$\lneqq$	2308	`\lneqq`	$\gneqq$	2309	`\gneqq`
$\lvertneqq$	2300	`\lvertneqq`	$\gvertneqq$	2301	`\gvertneqq`
$\lnsim$	2312	`\lnsim`	$\gnsim$	2313	`\gnsim`
$\lnapprox$	231A	`\lnapprox`	$\gnapprox$	231B	`\gnapprox`
$\nprec$	2306	`\nprec`	$\nsucc$	2307	`\nsucc`
$\npreceq$	230E	`\npreceq`	$\nsucceq$	230F	`\nsucceq`
$\precneqq$	2316	`\precneqq`	$\succneqq$	2317	`\succneqq`
$\precnsim$	2310	`\precnsim`	$\succnsim$	2311	`\succnsim`
$\precnapprox$	2318	`\precnapprox`	$\succnapprox$	2319	`\succnapprox`
$\nsim$	231C	`\nsim`	$\ncong$	231D	`\ncong`
$\nshortmid$	232E	`\nshortmid`	$\nshortparallel$	232F	`\nshortparallel`
$\nmid$	232D	`\nmid`	$\nparallel$	232C	`\nparallel`
$\nvdash$	2330	`\nvdash`	$\nvDash$	2332	`\nvDash`
$\nVdash$	2331	`\nVdash`	$\nVDash$	2333	`\nVDash`
$\ntriangleleft$	2336	`\ntriangleleft`	$\ntriangleright$	2337	`\ntriangleright`
$\ntrianglelefteq$	2335	`\ntrianglelefteq`	$\ntrianglerighteq$	2334	`\ntrianglerighteq`
$\nsubseteq$	232A	`\nsubseteq`	$\nsupseteq$	232B	`\nsupseteq`
$\nsubseteqq$	2322	`\nsubseteqq`	$\nsupseteqq$	2323	`\nsupseteqq`
$\subsetneq$	2328	`\subsetneq`	$\supsetneq$	2329	`\supsetneq`
$\varsubsetneq$	2320	`\varsubsetneq`	$\varsupsetneq$	2321	`\varsupsetneq`
$\subsetneqq$	2324	`\subsetneqq`	$\supsetneqq$	2325	`\supsetneqq`
$\varsubsetneqq$	2326	`\varsubsetneqq`	$\varsupsetneqq$	2327	`\varsupsetneqq`

- **Arrows**

$\leftleftarrows$	1312	`\leftleftarrows`	$\rightrightarrows$	1313	`\rightrightarrows`
$\leftrightarrows$	131C	`\leftrightarrows`	$\rightleftarrows$	131D	`\rightleftarrows`
$\Lleftarrow$	1357	`\Lleftarrow`	$\Rrightarrow$	1356	`\Rrightarrow`
$\twoheadleftarrow$	1311	`\twoheadleftarrow`	$\twoheadrightarrow$	1310	`\twoheadrightarrow`
$\leftarrowtail$	131B	`\leftarrowtail`	$\rightarrowtail$	131A	`\rightarrowtail`
$\looparrowleft$	1322	`\looparrowleft`	$\looparrowright$	1323	`\looparrowright`
$\leftrightharpoons$	130B	`\leftrightharpoons`	$\rightleftharpoons$	130A	`\rightleftharpoons` (U)
$\curvearrowleft$	2378	`\curvearrowleft`	$\curvearrowright$	2379	`\curvearrowright`
$\circlearrowleft$	1309	`\circlearrowleft`	$\circlearrowright$	1308	`\circlearrowright`
$\Lsh$	131E	`\Lsh`	$\Rsh$	131F	`\Rsh`
$\upuparrows$	1314	`\upuparrows`	$\downdownarrows$	1315	`\downdownarrows`
$\upharpoonleft$	1318	`\upharpoonleft`	$\upharpoonright$	1316	`\upharpoonright`, `\restriction`

$\downharpoonleft$	1319	`\downharpoonleft`	$\downharpoonright$	1317	`\downharpoonright`
$\multimap$	1328	`\multimap`	$\rightsquigarrow$	1320	`\rightsquigarrow`
$\leftrightsquigarrow$	1321	`\leftrightsquigarrow`			

- **Negated arrows**

$\nleftarrow$	2320	`\leftarrow`	$\nrightarrow$	2339	`\nrightarrow`
$\nLeftarrow$	233A	`\nLeftarrow`	$\nRightarrow$	233B	`\nRightarrow`
$\nleftrightarrow$	233D	`\nleftrightarrow`	$\nLeftrightarrow$	233C	`\nLeftrightarrow`

For further information

The AMSFonts collection was implemented and packaged by the Technical Support Group in the American Mathematical Society's Composition Services Department. Questions or suggestions for improvements should be directed to that group at the following address:

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

Phone: 800-321-4AMS or 401-455-4080
Internet: Tech-Support@Math.AMS.com

The cyrillic fonts included in the AMSFonts collection were developed at the Humanities and Arts Computing Center of the University of Washington. Questions regarding these cyrillic fonts should be directed to:

Director
Humanities and Arts Computing Center
DR-10
University of Washington
Seattle, WA 98195

Phone: 206-543-4218

The TEX Users Group is a good source of general information about fonts for use with TEX. Inquiries can be directed to:

TEX Users Group
P. O. Box 9506
Providence, RI 02940-9506

Phone: 401-751-7760
Internet: TUG@Math.AMS.com

Obtaining the METAFONT source files

The AMSFonts collection has been prepared for a number of different resolutions suitable for use on what the AMS staff has determined to be the most popular devices currently being used to prepare TEX output. More such devices continue to appear, many of them with characteristics different from the devices that are currently supported.

Users of unsupported devices who have access to an operating version of METAFONT and have some experience with generating METAFONT fonts are encouraged to contact the manager of the Society's Composition Services Department to arrange to obtain the METAFONT source files. Some restrictions will apply; details will be provided when the sources are requested.

METAFONT source files for the cyrillic fonts in the AMSFonts collection can be obtained either from the Society or directly from the University of Washington. The sources available from Washington also include other fonts in different layouts. Information can be obtained from the director of the Academic Computing Center at the address given above.

References

[AMS91] *User's Guide to AMS-TEX Version 2.1, January 1991*, American Mathematical Society, Providence, RI, 1991; distributed with AMS-TEX Version 2.1.

[DEK86A] Donald E. Knuth, *The TEXbook*, Volume A of *Computers & Typesetting*, Addison-Wesley Publishing Co., Reading, 1986.

[DEK86E] ———, *Computer Modern Typefaces*, Volume E of *Computers & Typesetting*, Addison-Wesley Publishing Co., Reading, 1986.

[DEK89] ———, "Typesetting Concrete Mathematics," *TUGboat* **10** (1989), no. 1, 31–36; erratum, *TUGboat* **10** (1989), no. 3, 342.

[DLV89] Dimitri Vulis, "Notes on Russian TEX," *TUGboat* **10** (1989), no. 3, 332–36.

[DRS86] David R Siegel, *The Euler Project at Stanford*, Computer Science Department, Stanford University, 1985.

[GKP88] Ronald L. Graham, Donald E. Knuth, and Oren Patashnik, *Concrete Mathematics*, Addison-Wesley Publishing Co., Reading, 1988.

[MDS86] M. D. Spivak, *The Joy of TEX*, American Mathematical Society, Providence, 1986.

[MDS90] ———, *The Joy of TEX*, 2^{nd} (revised) edition, American Mathematical Society, Providence, 1990 (to appear).

Font charts to be used in Figure 1

	´0	´1	´2	´3	´4	´5	´6	´7	
´00x	$\mathfrak{d}$	$\mathfrak{d}$	$\mathfrak{f}$	$\mathfrak{f}$	$\mathfrak{g}$	$\mathfrak{k}$	$\mathfrak{t}$	$\mathfrak{u}$	″0x
´01x									
´02x			‘	’					″1x
´03x									
´04x		!					&	'	″2x
´05x	(	)	*	+	,	–	.	/	
´06x	0	1	2	3	4	5	6	7	″3x
´07x	8	9	:	;		=		?	
´10x		$\mathfrak{A}$	$\mathfrak{B}$	$\mathfrak{C}$	$\mathfrak{D}$	$\mathfrak{E}$	$\mathfrak{F}$	$\mathfrak{G}$	″4x
´11x	$\mathfrak{H}$	$\mathfrak{I}$	$\mathfrak{J}$	$\mathfrak{K}$	$\mathfrak{L}$	$\mathfrak{M}$	$\mathfrak{N}$	$\mathfrak{O}$	
´12x	$\mathfrak{P}$	$\mathfrak{Q}$	$\mathfrak{R}$	$\mathfrak{S}$	$\mathfrak{T}$	$\mathfrak{U}$	$\mathfrak{V}$	$\mathfrak{W}$	″5x
´13x	$\mathfrak{X}$	$\mathfrak{Y}$	$\mathfrak{Z}$	[		]	^		
´14x		$\mathfrak{a}$	$\mathfrak{b}$	$\mathfrak{c}$	$\mathfrak{d}$	$\mathfrak{e}$	$\mathfrak{f}$	$\mathfrak{g}$	″6x
´15x	$\mathfrak{h}$	$\mathfrak{i}$	$\mathfrak{j}$	$\mathfrak{k}$	$\mathfrak{l}$	$\mathfrak{m}$	$\mathfrak{n}$	$\mathfrak{o}$	
´16x	$\mathfrak{p}$	$\mathfrak{q}$	$\mathfrak{r}$	$\mathfrak{s}$	$\mathfrak{t}$	$\mathfrak{u}$	$\mathfrak{v}$	$\mathfrak{w}$	″7x
´17x	$\mathfrak{x}$	$\mathfrak{y}$	$\mathfrak{z}$			"		1	
	″8	″9	″A	″B	″C	″D	″E	″F	

Euler Fraktur medium weight – `eufm10`

	´0	´1	´2	´3	´4	´5	´6	´7	
´00x	Γ	Δ	Θ	Λ	Ξ	Π	Σ	Υ	″0x
´01x	Φ	Ψ	Ω	α	β	γ	δ	ϵ	
´02x	ζ	η	θ	ι	κ	λ	μ	ν	″1x
´03x	ξ	π	ρ	σ	τ	υ	ϕ	χ	
´04x	ψ	ω	ε	ϑ	ϖ			φ	″2x
´05x									
´06x	0	1	2	3	4	5	6	7	″3x
´07x	8	9	.	,	$<$	/	$>$		
´10x	∂	A	B	C	D	E	F	G	″4x
´11x	H	I	J	K	L	M	N	O	
´12x	P	Q	R	S	T	U	V	W	″5x
´13x	X	Y	Z						
´14x	ℓ	a	b	c	d	e	f	g	″6x
´15x	h	i	j	k	l	m	n	o	
´16x	p	q	r	s	t	u	v	w	″7x
´17x	x	y	z	$\imath$	$\jmath$	$\wp$			
	″8	″9	″A	″B	″C	″D	″E	″F	

Euler cursive (roman) medium weight – `eurm10`

	´0	´1	´2	´3	´4	´5	´6	´7	
´00x	—								″0x
´01x									
´02x									″1x
´03x	~								
´04x									″2x
´05x									
´06x									″3x
´07x			$\neg$		$\Re$	$\Im$			
´10x	$\aleph$	$\mathcal{A}$	$\mathcal{B}$	$\mathcal{C}$	$\mathcal{D}$	$\mathcal{E}$	$\mathcal{F}$	$\mathcal{G}$	″4x
´11x	$\mathcal{H}$	$\mathcal{I}$	$\mathcal{J}$	$\mathcal{K}$	$\mathcal{L}$	$\mathcal{M}$	$\mathcal{N}$	$\mathcal{O}$	
´12x	$\mathcal{P}$	$\mathcal{Q}$	$\mathcal{R}$	$\mathcal{S}$	$\mathcal{T}$	$\mathcal{U}$	$\mathcal{V}$	$\mathcal{W}$	″5x
´13x	$\mathcal{X}$	$\mathcal{Y}$	$\mathcal{Z}$				$\wedge$	$\vee$	
´14x							$\{$	$\}$	″6x
´15x			$\vert$				$\backslash$		
´16x									″7x
´17x	§								
	″8	″9	″A	″B	″C	″D	″E	″F	

Euler script medium weight – `eusm10`

	´0	´1	´2	´3	´4	´5	´6	´7	
´00x									″0x
´01x	$\{$	$\}$	$\big\{$	$\big\}$	$\Big\{$	$\Big\}$	$\bigg\{$	$\bigg\}$	
´02x									″1x
´03x	$\leftharpoonup$	$\leftharpoondown$	$\rightharpoonup$	$\rightharpoondown$					
´04x	$\leftarrow$	$\rightarrow$	$\uparrow$	$\downarrow$	$\leftrightarrow$	$\nearrow$	$\searrow$		″2x
´05x	$\Leftarrow$	$\Rightarrow$	$\Uparrow$	$\Downarrow$	$\Leftrightarrow$	$\nwarrow$	$\swarrow$		
´06x		∞							″3x
´07x	⎧	⎫	⎩	⎭	⎨	⎬	⎪		
´10x									″4x
´11x	$\oint$	$\displaystyle\oint$							
´12x	$\sum$	$\prod$	$\int$						″5x
´13x	$\displaystyle\sum$	$\displaystyle\prod$	$\displaystyle\int$						
´14x	$\coprod$	$\displaystyle\coprod$							″6x
´15x					$\updownarrow$	$\Updownarrow$			
´16x									″7x
´17x									
	″8	″9	″A	″B	″C	″D	″E	″F	

Euler-compatible extension font – `euex10`

	´0	´1	´2	´3	´4	´5	´6	´7	
´00x	Γ	Δ	Θ	Λ	Ξ	Π	Σ	Υ	″0x
´01x	Φ	Ψ	Ω	α	β	γ	δ	ϵ	
´02x	ζ	η	θ	ι	κ	λ	μ	ν	″1x
´03x	ξ	π	ρ	σ	τ	υ	ϕ	χ	
´04x	ψ	ω	ε	ϑ	ϖ	ϱ	ς	φ	″2x
´05x	$\leftharpoonup$	$\leftharpoondown$	$\rightharpoonup$	$\rightharpoondown$	‘	’	$\triangleright$	$\triangleleft$	
´06x	0	1	2	3	4	5	6	7	″3x
´07x	8	9	.	,	$<$	$/$	$>$	$\star$	
´10x	∂	A	B	C	D	E	F	G	″4x
´11x	H	I	J	K	L	M	N	O	
´12x	P	Q	R	S	T	U	V	W	″5x
´13x	X	Y	Z	$\flat$	$\natural$	$\sharp$	$\smile$	$\frown$	
´14x	ℓ	a	b	c	d	e	f	g	″6x
´15x	h	i	j	k	l	m	n	o	
´16x	p	q	r	s	t	u	v	w	″7x
´17x	x	y	z	$\imath$	$\jmath$	$\wp$	$\vec{}$	$\frown$	
	″8	″9	″A	″B	″C	″D	″E	″F	

Computer Modern bold math italic – `cmmib10`

	´0	´1	´2	´3	´4	´5	´6	´7	
´00x	$-$	$\cdot$	$\times$	$\ast$	$\div$	$\diamond$	$\pm$	$\mp$	″0x
´01x	$\oplus$	$\ominus$	$\otimes$	$\oslash$	$\odot$	$\bigcirc$	$\circ$	$\bullet$	
´02x	$\asymp$	$\equiv$	$\subseteq$	$\supseteq$	$\leq$	$\geq$	$\preceq$	$\succeq$	″1x
´03x	$\sim$	$\approx$	$\subset$	$\supset$	$\ll$	$\gg$	$\prec$	$\succ$	
´04x	$\leftarrow$	$\rightarrow$	$\uparrow$	$\downarrow$	$\leftrightarrow$	$\nearrow$	$\searrow$	$\simeq$	″2x
´05x	$\Leftarrow$	$\Rightarrow$	$\Uparrow$	$\Downarrow$	$\Leftrightarrow$	$\nwarrow$	$\swarrow$	$\propto$	
´06x	$\prime$	∞	$\in$	$\ni$	$\bigtriangleup$	$\bigtriangledown$	$\not$	$\mapstochar$	″3x
´07x	$\forall$	$\exists$	$\neg$	$\emptyset$	$\Re$	$\Im$	$\top$	$\bot$	
´10x	$\aleph$	$\mathcal{A}$	$\mathcal{B}$	$\mathcal{C}$	$\mathcal{D}$	$\mathcal{E}$	$\mathcal{F}$	$\mathcal{G}$	″4x
´11x	$\mathcal{H}$	$\mathcal{I}$	$\mathcal{J}$	$\mathcal{K}$	$\mathcal{L}$	$\mathcal{M}$	$\mathcal{N}$	$\mathcal{O}$	
´12x	$\mathcal{P}$	$\mathcal{Q}$	$\mathcal{R}$	$\mathcal{S}$	$\mathcal{T}$	$\mathcal{U}$	$\mathcal{V}$	$\mathcal{W}$	″5x
´13x	$\mathcal{X}$	$\mathcal{Y}$	$\mathcal{Z}$	$\cup$	$\cap$	$\uplus$	$\wedge$	$\vee$	
´14x	$\vdash$	$\dashv$	$\lfloor$	$\rfloor$	$\lceil$	$\rceil$	$\{$	$\}$	″6x
´15x	$\langle$	$\rangle$	$\vert$	$\Vert$	$\updownarrow$	$\Updownarrow$	$\backslash$	$\wr$	
´16x	$\surd$	$\amalg$	∇	$\int$	$\sqcup$	$\sqcap$	$\sqsubseteq$	$\sqsupseteq$	″7x
´17x	$\S$	$\dagger$	$\ddagger$	$\P$	$\clubsuit$	$\diamondsuit$	$\heartsuit$	$\spadesuit$	
	″8	″9	″A	″B	″C	″D	″E	″F	

Computer Modern bold math symbols – `cmbsy10`

	'0	'1	'2	'3	'4	'5	'6	'7	
'00x	$\boxdot$	$\boxplus$	$\boxtimes$	$\square$	$\blacksquare$	$\centerdot$	$\lozenge$	$\blacklozenge$	"0x
'01x	$\circlearrowright$	$\circlearrowleft$	$\rightleftharpoons$	$\leftrightharpoons$	$\boxminus$	$\Vdash$	$\Vvdash$	$\vDash$	
'02x	$\twoheadrightarrow$	$\twoheadleftarrow$	$\leftleftarrows$	$\rightrightarrows$	$\upuparrows$	$\downdownarrows$	$\upharpoonright$	$\downharpoonright$	"1x
'03x	$\upharpoonleft$	$\downharpoonleft$	$\rightarrowtail$	$\leftarrowtail$	$\leftrightarrows$	$\rightleftarrows$	$\Lsh$	$\Rsh$	
'04x	$\rightsquigarrow$	$\leftrightsquigarrow$	$\looparrowleft$	$\looparrowright$	$\circeq$	$\succsim$	$\gtrsim$	$\gtrapprox$	"2x
'05x	$\multimap$	$\therefore$	$\because$	$\doteqdot$	$\triangleq$	$\precsim$	$\lesssim$	$\lessapprox$	
'06x	$\eqslantless$	$\eqslantgtr$	$\curlyeqprec$	$\curlyeqsucc$	$\preccurlyeq$	$\leqq$	$\leqslant$	$\lessgtr$	"3x
'07x	$\backprime$	–	$\risingdotseq$	$\fallingdotseq$	$\succcurlyeq$	$\geqq$	$\geqslant$	$\gtrless$	
'10x	$\sqsubset$	$\sqsupset$	$\vartriangleright$	$\vartriangleleft$	$\trianglerighteq$	$\trianglelefteq$	$\bigstar$	$\between$	"4x
'11x	$\blacktriangledown$	$\blacktriangleright$	$\blacktriangleleft$	$\rightarrow$	$\leftarrow$	$\vartriangle$	$\blacktriangle$	$\triangledown$	
'12x	$\eqcirc$	$\lesseqgtr$	$\gtreqless$	$\lesseqqgtr$	$\gtreqqless$	$\yen$	$\Rrightarrow$	$\Lleftarrow$	"5x
'13x	$\checkmark$	$\veebar$	$\barwedge$	$\doublebarwedge$	$\angle$	$\measuredangle$	$\sphericalangle$	$\varpropto$	
'14x	$\smallsmile$	$\smallfrown$	$\Subset$	$\Supset$	$\Cup$	$\Cap$	$\curlywedge$	$\curlyvee$	"6x
'15x	$\leftthreetimes$	$\rightthreetimes$	$\subseteqq$	$\supseteqq$	$\bumpeq$	$\Bumpeq$	$\lll$	$\ggg$	
'16x	$\ulcorner$	$\urcorner$	$\circledR$	$\circledS$	$\pitchfork$	$\dotplus$	$\backsim$	$\backsimeq$	"7x
'17x	$\llcorner$	$\lrcorner$	$\maltese$	$\complement$	$\intercal$	$\circledcirc$	$\circledast$	$\circleddash$	
	"8	"9	"A	"B	"C	"D	"E	"F	

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

	'0	'1	'2	'3	'4	'5	'6	'7	
'00x	$\lvertneqq$	$\gvertneqq$	$\nleq$	$\ngeq$	$\nless$	$\ngtr$	$\nprec$	$\nsucc$	"0x
'01x	$\lneqq$	$\gneqq$	$\nleqslant$	$\ngeqslant$	$\lneq$	$\gneq$	$\npreceq$	$\nsucceq$	
'02x	$\precnsim$	$\succnsim$	$\lnsim$	$\gnsim$	$\nleqq$	$\ngeqq$	$\precneqq$	$\succneqq$	"1x
'03x	$\precnapprox$	$\succnapprox$	$\lnapprox$	$\gnapprox$	$\nsim$	$\ncong$	$\diagup$	$\diagdown$	
'04x	$\varsubsetneq$	$\varsupsetneq$	$\nsubseteqq$	$\nsupseteqq$	$\subsetneqq$	$\supsetneqq$	$\varsubsetneqq$	$\varsupsetneqq$	"2x
'05x	$\subsetneq$	$\supsetneq$	$\nsubseteq$	$\nsupseteq$	$\nparallel$	$\nmid$	$\nshortmid$	$\nshortparallel$	
'06x	$\nvdash$	$\nVdash$	$\nvDash$	$\nVDash$	$\ntrianglerighteq$	$\ntrianglelefteq$	$\ntriangleleft$	$\ntriangleright$	"3x
'07x	$\nleftarrow$	$\nrightarrow$	$\nLeftarrow$	$\nRightarrow$	$\nLeftrightarrow$	$\nleftrightarrow$	$\divideontimes$	$\varnothing$	
'10x	$\nexists$	$\mathbb{A}$	$\mathbb{B}$	$\mathbb{C}$	$\mathbb{D}$	$\mathbb{E}$	$\mathbb{F}$	$\mathbb{G}$	"4x
'11x	$\mathbb{H}$	$\mathbb{I}$	$\mathbb{J}$	$\mathbb{K}$	$\mathbb{L}$	$\mathbb{M}$	$\mathbb{N}$	$\mathbb{O}$	
'12x	$\mathbb{P}$	$\mathbb{Q}$	$\mathbb{R}$	$\mathbb{S}$	$\mathbb{T}$	$\mathbb{U}$	$\mathbb{V}$	$\mathbb{W}$	"5x
'13x	$\mathbb{X}$	$\mathbb{Y}$	$\mathbb{Z}$	$\widehat{\ }$	$\widehat{\qquad}$	$\widetilde{\ }$	$\widetilde{\qquad}$		
'14x	$\Finv$	$\Game$					$\mho$	$\eth$	"6x
'15x	$\eqsim$	$\beth$	$\gimel$	$\daleth$	$\lessdot$	$\gtrdot$	$\ltimes$	$\rtimes$	
'16x	$\shortmid$	$\shortparallel$	$\smallsetminus$	$\thicksim$	$\thickapprox$	$\approxeq$	$\succapprox$	$\precapprox$	"7x
'17x	$\curvearrowleft$	$\curvearrowright$	$\digamma$	$\varkappa$	$\Bbbk$	$\hslash$	$\hbar$	$\backepsilon$	
	"8	"9	"A	"B	"C	"D	"E	"F	

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

	'0	*'1*	*'2*	*'3*	*'4*	*'5*	*'6*	*'7*	
'00x	(	)	[	]	⌊	⌋	⌈	⌉	"0x
'01x	{	}	⟨	⟩	∣	‖	/	\	
'02x	(	)	(	)	[	]	⌊	⌋	"1x
'03x	⌈	⌉	{	}	⟨	⟩	/	\	
'04x	(	)	[	]	⌊	⌋	⌈	⌉	"2x
'05x	{	}	⟨	⟩	/	\	/	\	
'06x	⎛	⎞	⎡	⎤	⎣	⎦	⎢	⎥	"3x
'07x	⎧	⎫	⎩	⎭	⎨	⎬	⎪	∣	
'10x	⎝	⎠	⎜	⎟	⟨	⟩	⊔	⊔	"4x
'11x	∮	∮	⊙	⊙	⊕	⊕	⊗	⊗	
'12x	∑	∏	∫	⋃	⋂	⊎	⋀	⋁	"5x
'13x	∑	∏	∫	⋃	⋂	⊎	⋀	⋁	
'14x	∐	∐	^	^	^	~	~	~	"6x
'15x	[	]	⌊	⌋	⌈	⌉	{	}	
'16x	√	√	√	√	⎷	∣	┌	‖	"7x
'17x	↑	↓	◜	◝	◟	◞	⇑	⇓	
	"8	"9	"A	"B	"C	"D	"E	"F	

Computer Modern math extension font – `cmex10`

	´0	´1	´2	´3	´4	´5	´6	´7	
´00x	Γ	Δ	Θ	Λ	Ξ	Π	Σ	Υ	″0x
´01x	Φ	Ψ	Ω	↑	↓	'	¡	¿	
´02x	I	J	`	´	ˇ	˘	¯	˚	″1x
´03x	¸	ss	æ	œ	ø	Æ	Œ	Ø	
´04x	-	!	”	#	$	%	&	’	″2x
´05x	(	)	*	+	,	-	.	/	
´06x	0	1	2	3	4	5	6	7	″3x
´07x	8	9	:	;	<	=	>	?	
´10x	@	A	B	C	D	E	F	G	″4x
´11x	H	I	J	K	L	M	N	O	
´12x	P	Q	R	S	T	U	V	W	″5x
´13x	X	Y	Z	[	“	]	ˆ	˙	
´14x	‘	A	B	C	D	E	F	G	″6x
´15x	H	I	J	K	L	M	N	O	
´16x	P	Q	R	S	T	U	V	W	″7x
´17x	X	Y	Z	–	—	˝	˜	¨	
	″8	″9	″A	″B	″C	″D	″E	″F	

Computer Modern caps and small caps – `cmcsc10`

	´0	´1	´2	´3	´4	´5	´6	´7	
´00x	Њ	Љ	Џ	Э	І	Є	Ђ	Ћ	″0x
´01x	њ	љ	џ	э	і	є	ђ	ћ	
´02x	Ю	Ж	Й	Ё	Ѵ	Ѳ	Ѕ	Я	″1x
´03x	ю	ж	й	ё	ѵ	ѳ	ѕ	я	
´04x	¨	!	”	Ѣ	˘	%	´	’	″2x
´05x	(	)	*	ѣ	,	-	.	/	
´06x	0	1	2	3	4	5	6	7	″3x
´07x	8	9	:	;	«	ı	»	?	
´10x	˘	А	Б	Ц	Д	Е	Ф	Г	″4x
´11x	Х	И	Ј	К	Л	М	Н	О	
´12x	П	Ч	Р	С	Т	У	В	Щ	″5x
´13x	Ш	Ы	З	[	“	]	Ь	Ъ	
´14x	‘	а	б	ц	д	е	ф	г	″6x
´15x	х	и	ј	к	л	м	н	о	
´16x	п	ч	р	с	т	у	в	щ	″7x
´17x	ш	ы	з	–	—	№	ь	ъ	
	″8	″9	″A	″B	″C	″D	″E	″F	

Cyrillic, medium weight – `wncyr10`

	´0	´1	´2	´3	´4	´5	´6	´7	
´00x	Њ	Љ	Џ	Э	І	Є	Ђ	Ћ	″0x
´01x	њ	љ	џ	э	і	є	ђ	ћ	
´02x	Ю	Ж̇	Й	Ё	Ѵ	Ѳ	Ѕ	Я	″1x
´03x	ю	ж	й	ё	ѵ	ѳ	ѕ	я	
´04x	¨	!	”	Ѣ	˘	%	´	’	″2x
´05x	(	)	*	ѣ	,	-	.	/	
´06x	0	1	2	3	4	5	6	7	″3x
´07x	8	9	:	;	«	ı	»	?	
´10x	˘	А	Б	Ц	Д	Е	Ф	Г	″4x
´11x	Х	И	Ј	К	Л	М	Н	О	
´12x	П	Ч	Р	С	Т	У	В	Щ	″5x
´13x	Ш	Ы	З	[	“	]	Ь	Ъ	
´14x	‘	а	б	ц	д	е	ф	г	″6x
´15x	х	и	ј	к	л	м	н	о	
´16x	п	ч	р	с	т	у	в	щ	″7x
´17x	ш	ы	з	–	—	№	ь	ъ	
	″8	″9	″A	″B	″C	″D	″E	″F	

Italic Cyrillic, medium weight – `wncyi10`