User's Guide to $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX

Version 2.1
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User's Guide to $\mathcal{AMS}$-TEX Version 2.1

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1. Overview

$\mathcal{AMS}$-TEX is a macro package for TEX, designed to simplify the input of mathematical material and format the output according to preset style specifications. Although the American Mathematical Society holds the copyright for $\mathcal{AMS}$-TEX, its use is not restricted, but is encouraged for the preparation of manuscripts intended for publication both in the Society's books and journals, and also in other mathematical literature. In recognition of the copyright, the Society requests that published documents prepared with $\mathcal{AMS}$-TEX include an acknowledgment of its use. The suggested forms for acknowledgments are given in the section **Other Things You Ought to Know**.

Version 2.0 of $\mathcal{AMS}$-TEX contained numerous minor improvements and bug fixes, as well as some major changes involving additional fonts. This User's Guide describes all the new and changed features and how to use them, with further additions and revisions pertaining to version 2.1. Topics are grouped by type, and then presented in roughly the same order as they appear in *The Joy of TEX*.

This User's Guide assumes that you already have a copy of *The Joy of TEX*. It contains references to specific sections that won't help you much if you don't have a copy. It also assumes for the most part that you will be using the "preprint style," a set of macros that provides features specific to the formatting of a document, such as headings, page numbers, and the like. If you are planning to use the preprint style, you will also need to have a copy of AMSFonts Version 2.1. *The Joy of TEX* and AMSFonts 2.1 are available from the American Mathematical Society and other distributors.

Typeset by $\mathcal{AMS}$-TEX

Files Comprising the $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX Version 2.1 package

The following files are contained in the $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX Version 2.1 package distributed by the American Mathematical Society:

`AMSTEX.TEX`	the $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX Version 2.1 macros
`AMSSYM.TEX`	macros defining the symbols in fonts `msam` and `msbm`
`AMSPPT.STY`	the preprint style for $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX Version 2.1
`AMSPPT.DOC`	technical documentation for `AMSPPT.STY`
`AMSGUIDE.TEX`	the source file for this User's Guide
`AMSPPT1.TEX`	a backward compatibility file for use with documents already completed using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX versions earlier than 2.0
`JOYERR.TEX`	errata to *The Joy of TEX* (first edition)
`*.TFM`	TFM files for AMSFonts Version 2.1
`AMSTEX.INI`	Used in creating format files
`AMSTEX.BAT`	DOS installations only

The file `AMSPPT.DOC` is an ASCII file, and is not intended to be processed with TEX. This documentation file is arranged in the same order as the macro file that it describes, and explains the intent and mechanics of the macros in detail. A separate file (`AMSTEX.DOC`), documenting the file `AMSTEX.TEX`, is available on request.

In addition, other files are used during installation from diskettes. For instructions on installing the $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX macros and preprint style, see Appendixes B and C. These appendixes describe the installation process for two common systems: PCTEX on an IBM PC or compatible, and *Textures* on a Macintosh. They also give suggestions for installation on other systems.

General Description of Changes

$\mathcal{A}\mathcal{M}\mathcal{S}$-TEX 2.0+, the preprint style, and their technical documentation are the result of a joint effort begun by Michael Spivak and extended by the Composition Technical Support group of the American Mathematical Society.

In version 2.0 of $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX, the following changes were made:

(1) All known bugs were eliminated.
(2) Messages were added identifying the current versions of `AMSTEX.TEX` and `AMSPPT.STY`, to be displayed on your terminal screen and in the log file.
(3) Some error and help messages were changed for the sake of clarity or to provide more information.
(4) Refinements were made to conserve memory space.
(5) The CM versions of the Computer Modern fonts were substituted for the older AM versions.
(6) Support for additional fonts was added.
    (a) `AMSTEX.TEX` provides the mechanism for accessing the Euler and extra symbol fonts of the AMSFonts collection.
    (b) The preprint style assumes that fonts `msam`, `msbm`, and `eufm` are installed and available.
(7) Changes were made to the preprint style to make it conform more closely to the style of AMS publications, in particular, the *Journal of the American Mathematical Society*.

   (a) Running heads were made automatic; they can be suppressed if desired.
   (b) Additional elements are recognized in both the top matter and the body of a document, and the input syntax was regularized.
   (c) Footnotes were changed to have normal indentation.[1]
   (d) The style of the references was changed considerably.
(8) The ability to produce roman-numeral page numbers using the plain TEX convention (negative `\pageno`) was added.
(9) In the preprint style, mathematics-oriented hyphenation exceptions were added. (These follow American, not British, rules.)
(10) An option was added in the preprint style that allows documents to be formatted as chapters of a monograph rather than as separate papers.
(11) Finally, some optional formatting features requested by $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX users were added to the preprint style.

In version 2.1, the following changes were made:

(1) `\curraddr` and `\rom` were added.
(2) Additional error conditions were identified and supplied with more informative messages.
(3) A sporadic line-breaking problem in the preprint style references section was remedied.
(4) Some bugs introduced into the preprint style during the version 2.0 changes were found and eliminated.
(5) Use of the Euler fonts other than medium Euler Fraktur was made more convenient.
(6) The ability to use multiple `\thanks` commands was added.
(7) The installation instructions were revised and augmented.
(8) The backward compatibility file `AMSPPT1.TEX` was added.

This User's Guide

This User's Guide has been prepared using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX Version 2.1 with the preprint style. Some changes have been made: font and dimension settings have been reset, the macros for headings have been redefined to produce a result more suited to documentation, and some *ad hoc* macros have been defined to simplify the presentation of particular information. However, in general, this document and the file from which it was produced illustrate the general appearance and input for a preprint with running heads. Printing the output of TEX for this Guide requires AMSFonts Version 2.0 or later (users of AMSFonts Version 2.0 are strongly encouraged to upgrade to Version 2.1).

2. Formatting Features

Formatting documents prepared with $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX is accomplished by a "style file." The features described here are part of the preprint style. The $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX

[1] Like this.

preprint style, Version 2.1, will format an input file in a manner suitable for a paper in a journal, unless the style of a `\Monograph` is explicitly selected. Unless noted otherwise, the journal style is the style described below.

Top Matter

Some commands affect the appearance of a whole document. Such commands should go at the top of your input file, right after the `\documentstyle` line and before the `\topmatter` line. This area will be referred to as the "preamble." Commands that should be in the preamble include `\define`, `\TagsOnRight` and the like, `\NoPageNumbers`, `\NoRunningHeads`, `\Monograph`, `\pagewidth`, `\pageheight`, `\pageno`, and commands that load fonts. The preamble is relevant to any document, whether paper or monograph.

The beginning of an $\mathcal{AMS}$-TEX file should look something like this:

```
\input amstex
\documentstyle{...}

⟨preamble commands, such as \define, \pageno, \Monograph,
    \NoRunningHeads, \loadbold, etc.⟩

\topmatter
\title...\endtitle                  ⎫
\author...\endauthor                ⎪
\affil...\endaffil                  ⎪
\address...\endaddress              ⎪
\curraddr...\endcurraddr            ⎪
\email...\endemail                  ⎪
\dedicatory...\enddedicatory        ⎬
\date...\enddate                    ⎪
\thanks...\endthanks                ⎪
\translator...\endtranslator        ⎪
\keywords...\endkeywords            ⎪
\subjclass...\endsubjclass          ⎪
\abstract...\endabstract            ⎭
\endtopmatter
\document
```

If any `\end...` tag is omitted (or misspelled), an error message will appear at `\endtopmatter` or at the next blank line: for example, if you misspell `\endtitle`, the message will be something like "`! Paragraph ended before \title was complete.`" If you omit `\endtopmatter`, there won't be any error message, but none of the topmatter material will print.

If you have documents that were prepared for versions of $\mathcal{AMS}$-TEX earlier than version 2.0, you may find the file `amsppt1.tex` useful. By including the line `\input amsppt1` immediately after the `\documentstyle` line, the topmatter commands and the sectioning commands that changed in form will work in the original way. Other than that, there should be few incompatibility problems with previous versions. Note: The use of `amsppt1.tex` is discouraged except for processing preexisting files.

For multi-line titles, affiliations, authors, or dedications (basically everywhere that lines are centered individually rather than being set in paragraphs), line breaks are obtained by using `\\`. In other parts of the topmatter, which are set in paragraph form, line breaks are obtained by `\linebreak`.

The title will be set in uppercase. To turn off the automatic uppercasing, use the `\nofrills` option: `\title\nofrills...\endtitle`.

Electronic mail addresses can be keyed using `\email` ... `\endemail`. Every `\email` address must be preceded by a regular `\address`, otherwise the e-mail address will not print. Multiple `\email` addresses may be used, but each `\email` ... `\endemail` must be paired with the `\address` of the same author. The `\email` address will be printed at the end of the paper, as "*E-mail address:* ⟨*net-address*⟩," following the address with which it is paired.

Normally, the address given in `\address` is the address of the author at the time the research was being done; if the author's address at the time of publication is different, the current address should be given in `\curraddr`. This should be entered between `\address` and `\email` in the document file. Like `\email`, multiple `\curraddr`'s can be used, if each one is keyed after the `\address` of the author to which it pertains. If it is not preceded by an `\address`, the current address will not print.

The `\dedicatory` command is used for such things as "Dedicated to Professor X on the occasion of his eightieth birthday." The dedication will appear in italics, before the abstract.

The `\thanks` command is provided for acknowledgments of grant support and other kinds of support for the author's research, or other general information not covered by one of the predefined tags such as `\keywords` or `\subjclass`. The information will be printed as an unnumbered footnote at the bottom of the first page. Like `\address`, `\thanks` can be used more than once.

In case a paper has not only an author but a translator, `\translator` is provided. This information will be printed at the end of the paper in eight-point roman, as "Translated by" followed by the translator's name in uppercase.

The information for `\keywords` and `\subjclass` appears as unnumbered footnotes at the foot of the first page, as in AMS journals. In a monograph chapter they will not print at all, since they should be handled separately, as part of the front matter for the monograph.

The abstract heading "Abstract." appears in caps and small caps, in the same size (eight point) as the abstract itself.

A simple table of contents setup is available. Tables of contents are typed in the topmatter along with everything else (except for monographs—see the section **Book Formatting** below), using `\toc...\endtoc`.

```
\toc
\specialhead...\endspecialhead
\head...\endhead
\subhead...\endsubhead
\subsubhead...\endsubsubhead
\endtoc
```

The syntax of the parts is identical to the syntax used for headings within the

document (see the sections **Headings** and **Book Formatting** below), so that for those who wish to do so and have a capable text editor, the table of contents can be constructed by extracting the relevant lines from the main text.[2]

Page numbers aren't usually appropriate for the short table of contents that might appear in a journal article, but if desired, page numbers can be entered in a manner similar to that for a monograph; see the section **Book Formatting** below.

The hanging indentation within a table of contents for `\head` and `\subhead` is preset to accommodate numbers of the form "1." and "1.1." respectively; the amount of indentation can be adjusted by using `\widestnumber`:

```
\toc
\widestnumber\head{10}
\widestnumber\subhead{10.1}
...
```

This can be done more than once within different sections of the table of contents, if desired.

If the "section number" of a `\head` happens to be something like "Appendix" (as actually happens in this User's Guide), a pair of empty braces should be entered before it, as follows:

```
\head {} Appendix. Sample bibliography input ...\endhead
```

Insertion of `{}` followed by a space at the beginning of the heading text will cause the entire entry to be set flush left as a unit.

If you are preparing a monograph, the format and content of the top matter will be different. See the section below on **Book Formatting** for details.

Headings

There are four levels of headings (not counting `\title`'s):

```
\specialhead...\endspecialhead
\head...\endhead
\subhead...\endsubhead
\subsubhead...\endsubsubhead
```

The heading of this section was typed as

```
\head 2. Formatting Features
\endhead
```

And the subheading for this subsection was typed as

```
\subhead Headings\endsubhead
```

Ordinarily, subheadings in the preprint style are run into the text, but for this User's Guide, the style varies slightly.

`\specialhead` is for long articles that need extra divisions at a level above the `\head` level. In the preprint style `\specialhead` uses boldface type and is set ragged

[2]But note that the original line breaks in multi-line headings would not be appropriate for the table of contents, so you'd want to remove any `\\`'s that might be present.

right; \head is small caps, centered; \subhead is boldface, flush left, run in with the following text; and \subsubhead is italic, indented as for an ordinary paragraph, and run into the text.

Explicit line breaks are obtained by a \\ in a \head or a \specialhead, but for \subhead and \subsubhead, which are part of their paragraph, just use \linebreak as you would in normal paragraphed text.

If you are preparing a monograph, the styles of headings will be different. See the section below on **Book Formatting** for details.

Theorems and Proofs

In addition to the usual proclamations and demonstrations, mathematicians may pose other kinds of propositions, which editors may prefer to see presented in different styles. The following have been provided in the preprint style.

```
\definition...\enddefinition
\example...\endexample
\remark...\endremark
```

In the preprint style \definition and \example have the spacing and heading font of \proclaim, but are in roman. \remark resembles \demo except that extra space added at the end of a proof by \enddemo is not added by \endremark.

In accordance with the style of the *Journal of the American Mathematical Society*, the labels on \proclaim's and similar constructions are now printed in boldface type (\bf). However, unlike the *Journal of the American Mathematical Society*, the preprint style uses slanted type (\sl) for the text of a \proclaim, rather than italic. (Most American Mathematical Society publications currently use Times Roman fonts, for which no slanted form was designed.)

It is conventional in mathematical publishing to use roman, upright numbers and punctuation even in the midst of italic text, to avoid visual conflicts with numbers and punctuation in adjacent math formulas. Since dedicated "mathematical text italic" fonts containing roman numbers and punctuation are not currently available, the amsppt preprint style provides a command \rom to be applied inside theorems and other stretches of italic text, to give the desired results. For example, to produce

Proposition 2.5. *Let $S_1, \dots, S_m$ be the components of a J-holomorphic cusp-curve S and suppose that each component S_i is (a multiple covering of) a regular curve and that Assumption* (1.4a) *is satisfied. ...*

you would use \rom in the following places:

```
each component $S_i$ is \rom(a multiple covering of\rom) a
regular curve and that Assumption \rom{(1.4a)} is satisfied
```

As you can see, \rom is used like the math font command \roman: it applies to the next single character or the next group enclosed in braces.

Other Devices

For a list produced by \roster, the amount of indentation can be adjusted to accommodate wide item numbers. Just before beginning the \roster, type,

for example, `\widestnumber\item{(viii)}`. This adjustment is temporary. The default will be reinstated by `\endroster`.

The command `\cite` produces a reference citation in roman type, within square brackets: [21].

A structure `\block...\endblock` is provided for quotations. It is intended for use in the middle of a paragraph to quote an extract from another source.

Book Formatting

If you are preparing a monograph, several features are available in the preprint style that will make your output look like chapters rather than individual papers.

First of all, you must signal your intentions by typing `\Monograph` in the preamble, right after the `\documentstyle` line.

A typical topmatter section for a monograph chapter would be typed like this:

```
\documentstyle{amsppt}
\Monograph
\topmatter
\title\chapter{4} Matrix Algebras\endtitle
\endtopmatter
```

which produces a chapter heading that looks like this:

CHAPTER IV

MATRIX ALGEBRAS

Notice that the number is converted automatically to roman numerals and the word "CHAPTER" is added. For a chapter title that needs a different sort of treatment, `\nofrills` can be used:

```
\topmatter
\title\chapter\nofrills{APPENDIX D} The Poisson Integral\endtitle
\endtopmatter
```

This produces

APPENDIX D

THE POISSON INTEGRAL

The replacement `\chapter` text will appear exactly as typed.

Finally, for things like a preface or introduction which have no pretitle text at all, omit the `\chapter` command:

```
\topmatter
\title Preface\endtitle
\endtopmatter
```

In monographs, the table of contents is usually treated as a separate chapter. Start by typing the title "Contents" as for a preface or introduction, and then use

the \toc...\endtoc structure as the body of the document (rather than putting it in the topmatter, as you would for a journal article).

```
\topmatter
\title Contents\endtitle
\endtopmatter

\document
\toc
\title Preface\page{vii}\endtitle
\title\chapter{1} Matrix Algebras\page{1}\endtitle
\head {} Continuous complex-valued functions\page{1}\endhead
...
\title Bibliography\page{307}\endtitle
\endtoc
\enddocument
```

The chapter titles listed in the table of contents are typed in the same way as in actual use. To get page numbers in the table of contents, use \page as shown, just before the ending of an element. This option is available for all levels of headings.

In a monograph using the preprint style, the chapter title is used for the left running head and the text of section headings (from \head) appears as the right running head. It's not uncommon for the text of a heading to be too long to fit in the running head width; in such a case use \rightheadtext to specify a shortened form of the heading for use in the running heads:

```
\head Fourier coefficients of continuous periodic functions
of bounded entropy norm\endhead
\rightheadtext{Fourier coefficients of periodic functions}
```

This should follow immediately after the \head, to ensure that both take effect on the same page. If the chapter title is too long to fit as a running head, a shortened form can be supplied in a similar way with \leftheadtext immediately after the \title. See also the section **Running Heads**.

The style for a chapter of a monograph differs in some particulars from the style for a paper. The text of a \head will be boldface instead of small caps; headings of theorems, propositions, definitions, remarks, etc. will be small caps instead of boldface, and indented rather than flush left.

Inserts with Captions

Figures, tables, and some other kinds of objects are often handled as inserts. These objects may be prepared separately from the main document and pasted in, in which case space must be left for them. These objects usually have captions; a caption may be positioned above (for a table) or below (for a figure).

An insert may be specified for the top or "middle" of a page, i.e., right where the input for the insert occurs in the text. These are typed as \topinsert and \midinsert respectively. Furthermore, a caption may be placed at the top or the bottom of the insert, using the tags \topcaption and \botcaption respectively.

The general structure used to specify an insert with a caption at the top is:

```
\topinsert  or  \midinsert
\captionwidth{⟨dimen⟩}  (optional)
\topcaption{⟨caption label⟩}
 ⟨optional caption text⟩
\endcaption
\vspace{⟨dimen⟩}  or  ⟨optional code for the insertion body⟩
\endinsert
```

Here the notation ⟨*dimen*⟩ means a valid TEX dimension as described in the **Dimensions** section of *The Joy of TEX*. If a bottom caption was desired, `\topcaption` would be replaced by `\botcaption`, and the `\vspace` command (or the optional code for the insertion body) would be moved before the `\botcaption` macro.

The `\vspace{`⟨*dimen*⟩`}` option would be used to leave blank space for an object to be pasted into place. The value of the ⟨*dimen*⟩ should be the exact height of the object to be pasted in, because extra space around the object and the caption are dependent on the document style, and will be provided automatically.

The `\captionwidth{`⟨*dimen*⟩`}` option may be used to override the default caption width specified by the document style.

The ⟨*caption label*⟩ is something like "Figure 1" or "Table 2a." Do not type any final punctuation; it will be provided. The caption label will be set in caps and small caps.

The ⟨*optional caption text*⟩ is any descriptive text that may be desired. The preprint style will set this in roman. Even if there is no text, the `\endcaption` tag must be present.

If you choose to include the TEX code for a figure, table, or other captioned object in the input, then omit the `\vspace` command and type the code where appropriate (before `\botcaption` or after the `\endcaption` of `\topcaption`).

Sometimes a table is small enough that it is not necessary to put it in an insert. If the caption is to appear above it, input can be typed as follows:

```
\topcaption{⟨caption label⟩}
 ⟨optional caption text⟩
\endcaption
 ⟨code for the table body⟩
```

The form of the input would be the following if the caption is to appear below:

```
 ⟨code for the table body⟩
\botcaption{⟨caption label⟩}
 ⟨optional caption text⟩
\endcaption
```

To avoid page-breaking problems, this form of "insertion" should be used only for very small objects.

Page Numbers

If you are using the preprint style, page numbers will appear in the running heads, at the outside margin, except for the first page, where the running head will be omitted and the page number will be centered at the bottom of the page.

If you wish to omit page numbers, type `\NoPageNumbers` at the beginning of the document (after the `\documentstyle` line). The running head text will remain; see also **Running Heads**.

You can get roman numeral page numbers, e.g. for a table of contents or preface, using the normal TEX convention of `\pageno` plus a negative number.

Page Size

In the preprint style, the default page width is 30pc, and the default height is 47.5pc. You can change the size of the page by typing

```
\pagewidth{⟨dimen⟩}
\pageheight{⟨dimen⟩}
```

using suitable ⟨*dimen*⟩s, where by this notation we mean a valid TEX dimension as described in the **Dimensions** section of *The Joy of TEX*.

QED

In the preprint style, `\qed` gives an open box '□', separated from what precedes it by a quad of space.

Running Heads

If you are using the preprint style, running heads similar to those in *Joy* will appear, with text in the center and page numbers to the outside. (On the first page, as usual, the running head is omitted, and the page number is placed at the bottom.)

If you do nothing to define the text of the running heads, the author's name will be used on the left-hand and the title on the right-hand pages. (This is the style for papers; for monographs, see below.) If you want some other values, say a shortened title, you can redefine the text to appear on left- and right-hand pages by typing

```
\leftheadtext{⟨left running head text⟩}
\rightheadtext{⟨right running head text⟩}
```

These instructions can appear anywhere after the `\documentstyle` command, but the most common place to use them is immediately after a `\title` or `\author` or `\head` to override the automatic running head text. If `\rightheadtext` or `\leftheadtext` is specified above the topmatter, `\title` and `\author` will not override them.

If you are doing a monograph rather than a journal article, and use the `\Monograph` switch, it affects the running heads as follows: The chapter title appears in the left-hand running heads, and the text of the current section heading (from `\head`) appears in the right-hand running heads. In chapters that don't contain any `\head`'s—for example, a foreword—both the left- and right-hand running heads will contain the chapter title.

By default, running heads will be uppercase. This is a frill that can be turned off by `\nofrills`, e.g.,

```
\rightheadtext\nofrills{Text of Running Head}
```

If for some reason you don't want running heads at all, type `\NoRunningHeads` at the beginning of the document (after the `\documentstyle` line). When running

heads are omitted, page numbers will appear centered at the bottom of the page. (And even those can be turned off using `\NoPageNumbers`.)

In a monograph, if you don't want the text from the section `\head`'s to appear in the running heads you must redefine the internal command, `\headmark`, that is used by `\head` to set the right-hand running head. To do this, put the following line in your document file, after `\Monograph` and before `\topmatter`:

```
\redefine\headmark#1{}
```

(where the `#1` is an argument number as explained in *Joy*, in the description of `\define` and related commands).

Tables

There are no special macros to support the creation of tables in $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX. Plain TEX's `\settabs` command and `\halign` can also be used (see *The TEXbook* for documentation of their usage). More sophisticated table macro packages are available from other sources. See also the section **Inserts with Captions** above.

Bibliographies

The references section of a paper begins with `\Refs` and must have `\endRefs` at the end. Each entry in the references begins with `\ref` and ends with `\endref`. The individual elements between `\ref` and `\endref` can be specified in any order. However, following `\ref` is usually a number or other label identifying the particular reference. This label is produced using `\key`. The format of the labels is determined by the current *references style*, which is set by the `\refstyle` command. The preprint documentstyle provides three reference styles denoted A, B, and C, corresponding to letter labels, no labels, and arabic numbers respectively. The form of the `\cite` and `\key` commands for each style, and the output they produce, is as follows:

`\refstyle{A}`		`\refstyle{B}`		`\refstyle{C}`	
`\cite{DK}`	[DK]	`\cite{Smith 1989}`	[Smith 1989]	`\cite{19}`	[19]
`\key DK`	[DK]	(no key)	(no label)	`\key 19`	19.

The `\refstyle` command is normally placed in the preamble of a document.

The references are set with hanging indentation. The amount of indentation is preset to accommodate the most common case, two-digit numbers. It can be increased (or decreased) by specifying the widest label used in the references. For example,

```
\widestnumber\key{GHMR} % refstyle A
\widestnumber\key{999} % refstyle C --- 3 digits
```

will increase the indentation to accommodate the key [GHMR], or a three-digit number, respectively. You could also specify `\widestnumber\key{9}` to reduce the indentation from two digits' worth to one, if your bibliography has fewer than ten entries. As the examples show, you do not include square brackets, periods, font commands, or other such formatting when using `\widestnumber`. The indentation will be adjusted for these things automatically.

For consecutive references by the same author(s), `\by` is used for the first reference, with the author name(s) given in full, and `\bysame` is used for subsequent ones—just the command `\bysame` without repetition of the name(s). The horizontal line produced by `\bysame` has a fixed length of three ems.

Two variations, `\ed` and `\eds`, are provided for entering editor names, as with `\page` and `\pages`, because the note "ed." or "eds." is part of the automatic formatting. If `\by` is absent, the editor name(s) will be used in place of the author name.

For a proceedings volume, the place and date of the meeting can be recorded in the `\procinfo` field. Parentheses will be added.

There are two options for miscellaneous notes at the end of a reference, `\finalinfo` and `\miscnote`. `\miscnote` differs only by automatically adding parentheses; it would typically be used for a note such as "(preprint)" or "(submitted)" or "(to appear)". Because it's fairly common, the latter has its own command `\toappear` that is equivalent to `\miscnote to appear`.

`\lang` is used to indicate the original language for papers where bibliographic information has been translated or there is some other reason to believe that the original language cannot be correctly identified from information in the reference.

Sometimes several references are combined into one—for example, parts of a long paper that have been published separately. Another type of compound reference is a work cited both in the original and in translation. There are commands `\moreref` and `\transl` to handle such situations. After `\moreref` and `\transl`, any of the normal reference tags can be used again.

`\moreref` is used for citing, e.g., "part II" of an article; the `\moreref` command is followed by the desired additional tags and data. For example:

```
...\moreref\paper\rom{II}
\jour Comm. Pure Appl. Math. \vol 36
\yr 1983 \pages 571--594\endref
```

When using `\transl`, a note that describes the translation is normally entered between `\transl` and the next tag. The tags and data for the translated work then follow. For example:

```
...\transl English transl. \publ Birkh\"auser
\publaddr Basel \yr 1985 \endref
```

Automatic punctuation will be omitted if the pertinent field was included but left blank. Otherwise, the command `\nofrills` can be used to keep automatic punctuation from appearing. For example, `\bookinfo\nofrills...` suppresses the comma or other punctuation that would normally be added at the end of the `\bookinfo` information. `\nofrills` also suppresses other automatic formatting such as the word "eds." for `\eds`, the word "vol." for book volumes, or the parentheses around the year for journal articles. The ending period of a reference can be suppressed with `\finalinfo\nofrills`.

Some examples will illustrate the use of these tags. See Appendix A for samples of input and output. See also Appendix C of *The Joy of TEX* (first edition: Appendix B) for more information on references.

3. Mathematical Constructions

Wide Accents in Math Mode

In version 2.0+ of the AMSFonts, there are wider versions of the `\widehat` and `\widetilde` accents; they appear on lines (5) and (6):

(1)	`$\hat x, \tilde x$`	$\hat{x}, \tilde{x}$
(2)	`$\widehat x, \widetilde x$`	$\widehat{x}, \widetilde{x}$
(3)	`$\widehat{xy}, \widetilde{xy}$`	$\widehat{xy}, \widetilde{xy}$
(4)	`$\widehat{xyz}, \widetilde{xyz}$`	$\widehat{xyz}, \widetilde{xyz}$
(5)	`$\widehat{xyzu}, \widetilde{xyzu}$`	$\widehat{xyzu}, \widetilde{xyzu}$
(6)	`$\widehat{xyzuv}, \widetilde{xyzuv}$`	$\widehat{xyzuv}, \widetilde{xyzuv}$

These wider accents are in the `msbm` family. If `msbm` has been loaded, `\widehat` and `\widetilde` will automatically select these wider versions when required; otherwise, the characters on line (4) will be the largest available. If you are using the preprint style, `msbm` is loaded automatically; otherwise, see the section entitled **Fonts** for instructions on loading it.

4. Fonts

Additional fonts for $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX

A number of fonts were created for use with $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX 2.0+, both Computer Modern fonts in sizes not previously available and new fonts of alphabets and symbols intended to be used for mathematical notation. These fonts are in the collection AMSFonts Version 2.1. They must be installed on your computer before you can use $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX's preprint style or otherwise refer to them. Note that AMSFonts Version 2.1 cannot be used with versions of $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX earlier than Version 2.0, and $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX Version 2.1 cannot be used with versions of AMSFonts earlier than Version 2.0 (users of AMSFonts Version 2.0 are strongly encouraged to upgrade to Version 2.1).

Several of these fonts are loaded automatically by the preprint style and others can be loaded on demand. The fonts available and the commands used to load them are described below.

Fonts loaded with the preprint style. Several fonts are loaded automatically for general use.

- `cmcsc8` is a new size of the Computer Modern small caps font.
- `cmex8` and `cmex7` are new sizes of the Computer Modern math extension font. `cmex8` is used by the preprint style in abstracts and other eight-point environments; `cmex7` is used for all sub- and superscripts.

Math fonts loaded with the preprint style.

- `msam` and `msbm` contain extra symbols. The symbols and the names that will produce them are shown in the section **Symbol Names** below. If you are not using the preprint style, each can be loaded separately by `\loadmsam` or `\loadmsbm` as appropriate.

– `eufm` is the medium-weight Euler Fraktur (German) font. It can also be loaded by `\loadeufm` if the preprint style is not being used.

Math fonts loaded by `\loadbold`. See the sections below on **Bold Characters in Math Mode** and **Bold Greek Letters** for details on accessing particular characters in these fonts.

– `cmmib` is Computer Modern bold math italic. It also contains bold Greek.
– `cmbsy` contains Computer Modern bold math symbols.

Additional Euler fonts, for use in math, loaded by `\loadeu...`.

– `eufb` is bold Fraktur (`\loadeufb`).
– `eusm` is medium-weight script (`\loadeusm`).
– `eusb` is bold script (`\loadeusb`).
– `eurm` is medium-weight "cursive roman" (`\loadeurm`).
– `eurb` is bold "cursive roman" (`\loadeurb`).

Considerations and warnings. The commands to load these font files should be typed in the preamble area between the `\documentstyle{...}` line and the `\topmatter`. Each `\load...` command loads the pertinent fonts (including subscript sizes), assigns a "math family" for them, and defines a math font command. The names of the commands are the same as the font names: `\eufm`, `\eufb`, `\eusm`, `\eusb`, `\eurm`, and `\eurb`. These are used in the same way as `\roman` or `\bold`, e.g., `\eufb{M}` or `\eufb M`. $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX also defines a couple of synonyms, `\frak` and `\goth`, for `\eufm` (medium Euler Fraktur).

TEX can accommodate only sixteen font families in math mode; eight are already defined by plain TEX before $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX begins, and the preprint style loads three more (`msam`, `msbm`, and `eufm`), for a total of eleven. For this reason, you should load additional fonts with care, requesting only those you know for certain you will need.

All the fonts described here, and some others as well, are included in the collection AMSFonts Version 2.1, which is available from the AMS and other distributors. The math fonts mentioned here are all supplied in sizes from five through ten point, suitable for use in mathematical text.

Bold Characters in Math Mode

Bold letters are obtained by `\bold` as described in *Joy*. In addition, bold symbols, italic, and lowercase Greek can be obtained once `\loadbold` appears in the file (this requires version 2.0+ of $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX and AMSFonts). Two control sequences are used for different kinds of bold symbols:

`\boldkey`	for symbols that actually appear on the keyboard
`\boldsymbol`	for symbols specified by a single control sequence

For example,

```
$\bold x \boldsymbol\in \boldsymbol\varGamma$
```

gives

$$\mathbf{x} \in \boldsymbol{\Gamma}$$

[and `$\boldsymbol\lbrack a \boldsymbol\rbrack$` gives $[a]$, if you need to use `\lbrack` and `\rbrack` instead of the `[` and `]` keys].

More precisely, `\boldkey` can be used in math formulas in the following combinations:

- With any of the symbols

  `+ - = < > ( ) [ ] | / * . , : ; ! ?`

  to give

  $$+ - = < > ( ) [ ] | / * . , : ; ! ?$$

  But `\bold` cannot be used to get bold versions of these symbols. `$\bold+$` will give only the ordinary +, etc.

  The bold + and − will be binary operators, like the ordinary + and − symbols; the bold = will be a binary relation, like the ordinary =, etc.

- With letters:

`$\boldkey a$, ..., $\boldkey z$`	$\boldsymbol{a}, \ldots, \boldsymbol{z}$
`$\boldkey A$, ..., $\boldkey Z$`	$\boldsymbol{A}, \ldots, \boldsymbol{Z}$

  Notice that these are ***bold math italic*** letters, as opposed to the bold text letters $\mathbf{a}, \ldots, \mathbf{z}$, $\mathbf{A}, \ldots, \mathbf{Z}$ that you get by using `\bold` in math mode.

- With numbers:

`$\boldkey 0$, ..., $\boldkey 9$`	$\boldsymbol{0}, \ldots, \boldsymbol{9}$

  However, these combinations simply give the same numerals that you get with `$\bold0$`, ... , `$\bold9$`.

The `\boldsymbol` construction can be used in any of the following combinations:

- With uppercase and lowercase Greek letters

`$\boldsymbol\Gamma$, ..., $\boldsymbol\Omega$`	$\boldsymbol{\Gamma}, \ldots, \boldsymbol{\Omega}$
`$\boldsymbol\varGamma$, ..., $\boldsymbol\varOmega$`	$\boldsymbol{\varGamma}, \ldots, \boldsymbol{\varOmega}$
`$\boldsymbol\alpha$, ..., $\boldsymbol\omega$`	$\boldsymbol{\alpha}, \ldots, \boldsymbol{\omega}$

  In versions of $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX earlier than 2.0, bold unslanted uppercase Greek letters $\mathbf{\Gamma}, \ldots, \mathbf{\Omega}$ were specified by `\boldGamma`, ... , `\boldOmega`; these control sequences have now disappeared.

- For convenience, `\boldsymbol` may also be followed by a letter (but not by a number or other character), giving the same result as `\boldkey`.

- You can also apply `\boldsymbol` to all the other standard symbols that are specified by single control sequences. For example, to get bold primes:

`$\boldsymbol\prime$`	$\boldsymbol{\prime}$
`$\boldsymbol A^{\boldsymbol\prime}$`	$\boldsymbol{A^{\prime}}$

  (But `\boldsymbol'`, using the shorthand notation for `\prime`, won't work.)

- You can apply `\boldsymbol` to "delimiters," such as

```
$\boldsymbol\{ ... \boldsymbol\}$                    {...}
$\boldsymbol\langle ... \boldsymbol\rangle$          ⟨...⟩
$|, \boldkey|, \||, \boldsymbol\||$                  |, |, ‖, ‖
$\vert, \boldsymbol\vert, \Vert, \boldsymbol\Vert$   |, |, ‖, ‖
```

However, you can't use `\boldsymbol` after `\left` and `\right`. In particular, typing `\left\boldsymbol| ... \right\boldsymbol|` will produce only error messages.

- Certain symbols on the bold fonts can't be accessed at all via `\boldkey` or `\boldsymbol`: These include bold versions $\boldsymbol{\mathcal{A}}$, ... , $\boldsymbol{\mathcal{Z}}$ of the "calligraphic letters" $\mathcal{A}$, ... , $\mathcal{Z}$ that you type as `\Cal A`, ... , `\Cal Z`, and bold versions $\mathbf{0}$, ... , $\mathbf{9}$ of the oldstyle numbers 0, ... , 9 that you get with `\oldnos`. If you really need to have these symbols, you will have to enlist the aid of a TEXnician, or use `\pmb`.

Fraktur Font

The German Fraktur font, which is designed for use only in math mode, can be made available by typing `\loadeufm` in the preamble area of your paper. If you are using the preprint style, medium-weight Fraktur is loaded automatically. To produce a Fraktur letter, type

```
$\frak g$                                  𝔤
$\frak A$, \dots, $\frak Z$                𝔄, ... , 𝔷
```

Blackboard Bold

$\mathcal{AMS}$-TEX has a "blackboard bold" font, `\Bbb`. Like `\Cal`, it will work only in math mode, and only when applied to uppercase letters. This alphabet is part of the `msbm` font, and can be made available by typing `\loadmsbm` at the top of your file. (It is loaded automatically with the preprint style.)

```
$\Bbb A, \Bbb C, \Bbb R$, etc.             𝔸, ℂ, ℝ, etc.
```

Poor Man's Bold

$\mathcal{AMS}$-TEX now has boldface versions of most math symbols. However, if you need only one or two bold symbols and have run out of TEX capacity for new fonts or font families, you can always get a poor man's bold version of bold with `\pmb`, as described in *Joy*.

Bold Greek Letters

Bold Greek letters, both lowercase and uppercase, can be obtained by using the `\boldsymbol` construction, as described in **Bold Characters in Math Mode**. The upright uppercase bold Greek letters are part of the ordinary bold font and therefore extra font loading commands do not need to be used in order to get them. However, the lowercase and slanted uppercase bold Greek letters are not loaded automatically, so you must specify `\loadbold` before using them.

5. Symbol Names

The symbols in the `msam` and `msbm` fonts have been assigned "standard" control sequence names as shown below. All the symbol names are loaded automatically by the preprint style; if you are not using the preprint style, the command `\UseAMSsymbols` will have the same effect. This will add about 200 new control sequences to TEX's internal table. If you are short on space, or need only a few of the symbols, you can use a different approach to access just the ones you need. See the section **The `\newsymbol` command** below.

Special Symbols and Blackboard Bold Letters

Certain symbols from the `msam` family can be specified by control sequences that will be defined as soon as the command `\loadmsam` has appeared in the file.

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`	⌝	`\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 $\mathbb{A}, \ldots, \mathbb{Z}$ appear in the `msbm` family. Once `\loadmsbm` has appeared in the file, they can be typed (in math mode) as `\Bbb A`, ... , `\Bbb Z`.

The `msbm` family also contains wider versions of the `\widehat` and `\widetilde` as described in Chapter 20, "Wide accents in math mode."

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. This can be done all at once by typing the instruction `\UseAMSsymbols`, which will load in the file `AMSSYM.TEX`. This instruction is included in the preprint style, so the names are assigned automatically, which requires over 200 control sequences.

If you are very short on space for control sequence names, and need only a few of these symbols, you can omit `\UseAMSsymbols`. Instead, assign only the names you will need by using a new $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX control sequence `\newsymbol` to create a control sequence that will properly produce this 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 preprint style and has chosen not to load all the symbol names by `\UseAMSsymbols`. 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 (and *Joy*, Appendix F). 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 preprint style or `\UseAMSsymbols` (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 cases, 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)	$\backprime$	2038	`\backprime`
$\hslash$	207D	`\hslash`	$\varnothing$	203F	`\varnothing`
$\vartriangle$	234D	`\vartriangle`	$\blacktriangle$	204E	`\blacktriangle`
$\triangledown$	204F	`\triangledown`	$\blacktriangledown$	2048	`\blacktriangledown`
$\square$	2003	`\square`	$\blacksquare$	2004	`\blacksquare`
$\lozenge$	2006	`\lozenge`	$\blacklozenge$	2007	`\blacklozenge`

Ⓢ 2073 \circledS
∠ 205C \angle (U)
∡ 205D \measuredangle
∄ 2040 \nexists
℧ 2066 \mho
⅁ 2061 \Game
𝕜 207C \Bbbk
★ 2046 \bigstar
◁ 205E \sphericalangle
∁ 207B \complement
ð 2067 \eth
╱ 231E \diagup
╲ 231F \diagdown

• **Binary operators**

∔ 2275 \dotplus
∖ 2272 \smallsetminus
⋒ 2265 \Cap, \doublecap
⋓ 2264 \Cup, \doublecup
⊼ 225A \barwedge
⊻ 2259 \veebar
⩞ 225B \doublebarwedge
⊟ 220C \boxminus
⊠ 2202 \boxtimes
⊡ 2200 \boxdot
⊞ 2201 \boxplus
⋇ 223E \divideontimes
⋉ 226E \ltimes
⋊ 226F \rtimes
⋋ 2268 \leftthreetimes
⋌ 2269 \rightthreetimes
⋏ 2266 \curlywedge
⋎ 2267 \curlyvee
⊖ 227F \circleddash
⊛ 227E \circledast
⊚ 227D \circledcirc
· 2205 \centerdot
⊺ 227C \intercal

• **Binary relations**

≦ 2335 \leqq
≦ 2336 \leqslant
⪕ 2330 \eqslantless
≲ 232E \lesssim
≲ 232F \lessapprox
≊ 2375 \approxeq
⋖ 236C \lessdot
⋘ 236E \lll, \llless
≶ 2337 \lessgtr
⋚ 2351 \lesseqgtr
⋚ 2353 \lesseqqgtr
≑ 232B \doteqdot, \Doteq
≓ 233A \risingdotseq
≒ 233B \fallingdotseq
∽ 2376 \backsim
⋍ 2377 \backsimeq
⫅ 236A \subseteqq
⋐ 2362 \Subset
⊏ 2340 \sqsubset
≼ 2334 \preccurlyeq
⋞ 2332 \curlyeqprec
≾ 232D \precsim
≧ 233D \geqq
⩾ 233E \geqslant
⪖ 2331 \eqslantgtr
≳ 2326 \gtrsim
≳ 2327 \gtrapprox
⋗ 236D \gtrdot
⋙ 236F \ggg, \gggtr
≷ 233F \gtrless
⋛ 2352 \gtreqless
⋛ 2354 \gtreqqless
≗ 2350 \eqcirc
≗ 2324 \circeq
≜ 232C \triangleq
∼ 2373 \thicksim
≈ 2374 \thickapprox
⫆ 236B \supseteqq
⋑ 2363 \Supset
⊐ 2341 \sqsupset
≽ 233C \succcurlyeq
⋟ 2333 \curlyeqsucc
≿ 2325 \succsim

$\precapprox$	2377	\precapprox	$\succapprox$	2376	\succapprox
$\vartriangleleft$	2343	\vartriangleleft	$\vartriangleright$	2342	\vartriangleright
$\trianglelefteq$	2345	\trianglelefteq	$\trianglerighteq$	2344	\trianglerighteq
$\vDash$	230F	\vDash	$\Vdash$	230D	\Vdash
$\Vvdash$	230E	\Vvdash			
$\smallsmile$	2360	\smallsmile	$\shortmid$	2370	\shortmid
$\smallfrown$	2361	\smallfrown	$\shortparallel$	2371	\shortparallel
$\bumpeq$	236C	\bumpeq	$\between$	2347	\between
$\Bumpeq$	236D	\Bumpeq	$\pitchfork$	2374	\pitchfork
$\varpropto$	235F	\varpropto	$\backepsilon$	237F	\backepsilon
$\blacktriangleleft$	234A	\blacktriangleleft	$\blacktriangleright$	2349	\blacktriangleright
$\therefore$	2329	\therefore	$\because$	232A	\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**

$\leftleftarrows$	2312	\leftleftarrows	$\rightrightarrows$	2313	\rightrightarrows
$\leftrightarrows$	231C	\leftrightarrows	$\rightleftarrows$	231D	\rightleftarrows
$\Lleftarrow$	2357	\Lleftarrow	$\Rrightarrow$	2356	\Rrightarrow

$\twoheadleftarrow$	2311	\twoheadleftarrow	$\twoheadrightarrow$	2310	\twoheadrightarrow
$\leftarrowtail$	231B	\leftarrowtail	$\rightarrowtail$	231A	\rightarrowtail
$\looparrowleft$	2322	\looparrowleft	$\looparrowright$	2323	\looparrowright
$\leftrightharpoons$	230B	\leftrightharpoons	$\rightleftharpoons$	230A	\rightleftharpoons (U)
$\curvearrowleft$	2378	\curvearrowleft	$\curvearrowright$	2379	\curvearrowright
$\circlearrowleft$	2309	\circlearrowleft	$\circlearrowright$	2308	\circlearrowright
$\Lsh$	231E	\Lsh	$\Rsh$	231F	\Rsh
$\upuparrows$	2314	\upuparrows	$\downdownarrows$	2315	\downdownarrows
$\upharpoonleft$	2318	\upharpoonleft	$\upharpoonright$	2316	\upharpoonright, \restriction
$\downharpoonleft$	2319	\downharpoonleft			
$\multimap$	2328	\multimap	$\downharpoonright$	2317	\downharpoonright
$\leftrightsquigarrow$	2321	\leftrightsquigarrow	$\rightsquigarrow$	2320	\rightsquigarrow

- **Negated arrows**

$\nleftarrow$	2338	\nleftarrow	$\nrightarrow$	2339	\nrightarrow
$\nLeftarrow$	233A	\nLeftarrow	$\nRightarrow$	233B	\nRightarrow
$\nleftrightarrow$	233D	\nleftrightarrow	$\nLeftrightarrow$	233C	\nLeftrightarrow

6. Other Things You Ought to Know

Errata to *The Joy of TEX* prior to $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX 2.0

The file JOYERR.TEX contains the full list of errata for the first edition of *The Joy of TEX*, for versions of $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX earlier than version 2.0. A user who desires a typeset copy of this file may run it through TEX and print out the .dvi file. This will require Version 2.0+ of $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX and AMSPPT.STY, and also AMSFonts Version 2.0+ (users of AMSFonts Version 2.0 are strongly encouraged to upgrade to Version 2.1).

Acknowledging the Use of $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX

The following are suggested as appropriate statements of acknowledgment that $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX has been used to format a document for publication.

A single paper should include the following at the bottom of the first page:

> Typeset by $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX

(This notation is provided automatically by the $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX preprint style.)

If an entire journal or book is prepared with $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX, the following statement should appear on its copyright page:

> This [journal/book] was typeset by $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX, the TEX macro system of the American Mathematical Society.

If only selected papers in a journal or book are set with $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX, these papers should be identified as shown above, and the following should appear on the copyright page:

> $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX is the TEX macro system of the American Mathematical Society.

7. Getting Help

If you should find any bugs in the macros or documentation, send a Problem Report to:

Technical Support Department
American Mathematical Society
P. O. Box 6248
Providence, RI 02940
Phone: 800-321-4AMS or 401-455-4080
Internet: tech-support@Math.AMS.org

A Problem Report should contain the following information:

(1) version of `AMSTEX.TEX` and of `AMSPPT.STY` with which the problem occurred;
(2) a detailed description of the problem, including the input code for one or more examples that illustrate the problem;
(3) a log file of a TEX session showing the problem.

References

Knuth, Donald E. *The TEXbook*. Reading: Addison Wesley, 1986.

Spivak, Michael D. *The Joy of TEX*, 2nd (revised) edition, American Mathematical Society, Providence, 1990.

Appendix A. Sample Bibliography Input and Output

```
\Refs
\ref\key 4 % assuming \refstyle{C}
\by V. I. Arnol$'$d, A. N. Varchenko,
 and S. M. Guse\u\i n-Zade
\book Singularities of differentiable maps.~\rom I
\publ ``Nauka'' \publaddr Moscow \yr 1982
\lang Russian
\endref

\ref\key 5\bysame
\book Singularities of differentiable maps.~\rom{II}
\publ ``Nauka'' \publaddr Moscow \yr 1984
\lang Russian
\endref

\ref\key 6
\by O. A. Ladyzhenskaya
\book Mathematical problems in the dynamics
 of a viscous incompressible fluid
\bookinfo 2nd rev. aug. ed.
\publ ``Nauka'' \publaddr Moscow \yr 1970
\lang Russian
\transl English transl. of 1st ed.
\book The mathematical theory of viscous
 incompressible flow
\publ Gordon and Breach \publaddr New York
\yr 1963; rev. 1969
\endref
```

```
\ref\key 7
\by P. D. Lax and C. D. Levermore
\paper The small dispersion limit for the
 KdV equation.~\rom I
\jour Comm. Pure Appl. Math. \vol 36 \yr 1983
\pages 253--290 \finalinfo (overview)
\moreref\paper \rom{II}
\jour Comm. Pure Appl. Math.
\vol 36 \yr 1983 \pages 571--594
\moreref\paper \rom{III}
\jour Comm. Pure Appl. Math.
\vol 36 \yr 1983 \pages 809--829 \endref

\ref\key 10 \by S. Osher
\paper Shock capturing algorithms for equations of
 mixed type
\inbook Numerical Methods for Partial Differential
 Equations \eds S. I. Hariharan and T. H. Moulton
\publ Longman \publaddr New York \yr 1986
\pages 305--322
\endref

\ref\key 17 \by G. S. Petrov
\paper Elliptic integrals and their nonoscillatory
 behavior
\jour Funktsional. Anal. i Prilozhen.
\vol 20 \yr 1986 \pages 46--49
\transl\nofrills English transl. in
\jour Functional Anal. Appl. \vol 20\yr 1986
\endref
```

```
% switch to a different references style
\refstyle{A}
\widestnumber\key{GHMR}

\ref\key C1
\by B. Coomes
\book Polynomial flows, symmetry groups, and
 conditions sufficient for injectivity of maps
\bookinfo Ph.D. thesis, Univ. Nebraska--Lincoln
\yr 1988
\endref

\ref\key C2
\bysame % B. Coomes
\paper The Lorenz system does not have a
 polynomial flow
\jour J. Differential Equations
\toappear
\endref

\ref\key GHMR
\by J. Guckenheimer, P. Holmes, M. Martineau,
 and L. P. Robinson
\book Nonlinear oscillations, dynamical systems,
 and bifurcations of vector fields
\bookinfo % fields can be left blank
\publ Springer-Verlag \publaddr New York
\yr 1983
\endRefs
```

References

4. V. I. Arnol′d, A. N. Varchenko, and S. M. Guseĭn-Zade, *Singularities of differentiable maps.* I, "Nauka", Moscow, 1982. (Russian)
5. ———, *Singularities of differentiable maps.* II, "Nauka", Moscow, 1984. (Russian)
6. O. A. Ladyzhenskaya, *Mathematical problems in the dynamics of a viscous incompressible fluid*, 2nd rev. aug. ed., "Nauka", Moscow, 1970 (Russian); English transl. of 1st ed., *The mathematical theory of viscous incompressible flow*, Gordon and Breach, New York, 1963; rev. 1969.

7. P. D. Lax and C. D. Levermore, *The small dispersion limit for the KdV equation.* I, Comm. Pure Appl. Math. **36** (1983), 253–290, (overview); II, Comm. Pure Appl. Math. **36** (1983), 571–594; III, Comm. Pure Appl. Math. **36** (1983), 809–829.
10. S. Osher, *Shock capturing algorithms for equations of mixed type*, Numerical Methods for Partial Differential Equations (S. I. Hariharan and T. H. Moulton, eds.), Longman, New York, 1986, pp. 305–322.
17. G. S. Petrov, *Elliptic integrals and their nonoscillatory behavior*, Funktsional. Anal. i Prilozhen. **20** (1986), 46–49; English transl. in Functional Anal. Appl. **20** (1986).

[C1] B. Coomes, *Polynomial flows, symmetry groups, and conditions sufficient for injectivity of maps*, Ph.D. thesis, Univ. Nebraska–Lincoln, 1988.

[C2] ———, *The Lorenz system does not have a polynomial flow*, J. Differential Equations (to appear).

[GHMR] J. Guckenheimer, P. Holmes, M. Martineau, and L. P. Robinson, *Nonlinear oscillations, dynamical systems, and bifurcations of vector fields*, Springer-Verlag, New York, 1983.

Appendix B
Installation Procedures – PC

B.1. Introduction

The $\mathcal{AMS}$-TEX software can be used with any full implementation of TEX. Sections B.2–B.5 of this appendix describe the installation of $\mathcal{AMS}$-TEX for DOS implementations of TEX on an IBM PC or compatible machine from a DOS diskette or diskettes provided by the American Mathematical Society. PCTEX (from Personal TEX, Inc.) is used as an example. If your operating system is not DOS, or if you obtained $\mathcal{AMS}$-TEX through other channels, you won't be able to use the `install` program that is provided. Instead, follow the generic installation instructions in section B.6. You will have to refer to the documentation for your particular implementation of TEX to work out the details of any necessary variations. Users who encounter difficulties should seek help from the manufacturer of their implementation of TEX, or from the American Mathematical Society's technical support staff.

The TFM files for some of AMSFonts 2.1 (`msam*`, `msbm*`, and `eufm*`) are needed to run $\mathcal{AMS}$-TEX with the AMSPPT documentstyle, even if you don't plan to actually print anything using the AMSFonts. In the diskette distribution TFM files for all AMSFonts are provided in a directory named `\tfm`. They are also available from the AMS Internet archive, `e-MATH.ams.org`, by anonymous FTP.

B.2. Getting Started

The installation procedures consist of moving files to the proper directories, and creating format files. The first step is determining the names of the proper directories, which will vary with different implementations of TEX. You need to know the name of your **TEX inputs directory**, your **TEX TFM directory**, and your **TEX formats directory**. Check your directory structure or consult the documentation for your implementation of TEX to see what these names are. If you have any difficulty determining these directories:

(a) Search for the plain TEX input file, `plain.tex`. The directory where it is located will be your TEX inputs directory.
(b) Search for the font file `cmr10.tfm`. The directory where it is found will be your TEX TFM directory.
(c) Search for the plain TEX format file, `plain.fmt`. The directory where it is found will be your TEX formats directory.

For example, for PCTEX the directory names are `\pctex\texinput`, `\pctex\textfms`, and `\pctex\texfmts`.

Note: If you currently have any of the following files from earlier releases of $\mathcal{AMS}$-TEX, backup and delete them before installing the new version. They are either irrelevant or superseded in the new version of $\mathcal{AMS}$-TEX, and it is best to remove them to avoid confusion. All of them except for the last one would be found in your TEX inputs directory; `amsplain.fmt` would be found in your TEX formats directory.

```
amsfil.chg  amsplain.tex  amsppt.sty    amsppt.mor    amstex.tex
amstex.chg  cyracc.def    cyrmemo.def   cyrmemo.tex   amsplain.fmt
```

Users who did not receive $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX on diskette from the AMS, or those using non-DOS implementations of TEX, should proceed now to section B.6.

B.3. Installing $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX (DOS/diskette)

The following files are used in the installation process for DOS implementations of TEX, for $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX 2.1:

`install.exe` `amsinst.bat` `amstex.ini`

For DOS installation, you need to know on which drive to install $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX. This should be the drive on which you already have installed TEX.

For PCTEX, you will probably want to select the first choice for each of the questions which the installation programs asks you. This will result in placing the $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX files in the directory `\pctex\texinput` and the TFM files in the directory `\pctex\textfms`.

For other DOS implementations of TEX, you will need to know the names of your TEX inputs directory and TEX TFM directory, as described earlier, so that you can enter them when prompted.

When you have the disk and directory information ready, place the disk labeled "$\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX 2.1" in your floppy disk drive and type the following commands (if the disk is in drive B, substitute "b" for "a" in the first line):

`a:` ⟨*return*⟩
`install` ⟨*return*⟩

This will run the `install` program, which will ask you some questions. Enter the answers which you determined from reading the above paragraphs.

B.4. Running INITEX to Create Format Files (DOS)

To complete the installation procedure, you should create a format file. This will enable you to run TEX with $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX, or $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX and the AMSPPT preprint style, preloaded. This preloading will save quite a bit of startup time on slower systems. Note: Each format file takes up 150K–300K of disk space (depending on your implementation of TEX).

Warning: INITEX requires much more memory to run than regular TEX. The first time you try to run INITEX, you may get the message "`Not enough memory to run TeX`" or something similar (or with simpler implementations, it may just crash). If this happens, you must remove as many memory-resident programs as possible (such as communications software and memory-resident utilities [TSRs]) and reboot your system to create enough memory to run INITEX. Consult the documentation for your implementation of TEX for more information on running INITEX.

You are now ready to create a format file so that $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX, or $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX and the AMSPPT preprint style, can be preloaded when you typeset a document. Before creating your format file, you will want to consider whether you habitually use the AMSPPT documentstyle. If you use other documentstyles rarely or never, then you would benefit from the use of a format file with `amsppt.sty` preloaded. If you are likely to use other documenstyles periodically, then you probably do not want to preload `amsppt.sty`. To make a simple $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX format file, proceed with the

next paragraph. To make a format file with `amsppt.sty` preloaded, edit the file `amstex.ini` and remove the percent sign (comment character) at the beginning of the line `\documentstyle{amsppt}`, just before the `\dump` command.

The TEX file named `amstex.ini` should now be installed in your TEX inputs directory. Once you have decided whether to create an $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX or an AMSPPT format file (see previous paragraph), run INITEX on `amstex.ini`. E.g., for PCTEX, you would give the command

```
tex amstex.ini -i          ⟨return⟩
```

This creates an $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX format file named `amstex.fmt`. For other implementations of TEX the form of the INITEX command may be different, e.g., `tex/i amstex.ini`.

Moving the format files to the right directory. Some implementations of TEX, including PCTEX, will automatically place the format file in the proper directory. Otherwise you should now move the file manually into your TEX formats directory.

B.5. Using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX 2.0+ (DOS)

On the distribution diskettes, a DOS batch file `amstex.bat` is provided, to make use of the format file more convenient. `amstex.bat` will have been placed by the installation procedures in the root directory of the drive where TEX is located. If you are connected to that directory or if it is in your system path, you would run $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX on a file called `filename.tex` by typing

```
amstex filename            ⟨return⟩
```

B.6. Installing $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX (Generic)

Use these instructions if you didn't receive $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX on diskettes from the AMS, but obtained it by other methods, or if you have a non-DOS implementation of TEX. You will need to know the names of your TEX inputs directory, TEX TFM directory, and TEX formats directory, as explained in section B.2.

(1) Copy the following files into your TEX inputs directory: `amstex.tex`, `amsppt.sty`, `amssym.tex`, `amstex.ini`, and `amsppt1.tex`.

(2) There are three documentation files: `amsguide.tex`, `joyerr.tex`, and `amsppt.doc`. If you have a documentation directory, or wish to create one, then put these files there; otherwise they can be put in the TEX inputs directory.

(3) Copy the AMSFonts TFM files to your TEX TFM directory. If you don't plan to use any of the AMSFonts, you should still copy `dummy.tfm`, which is needed for $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX's syntax check option, and `msam*.tfm`, `msbm*.tfm`, and `eufm*.tfm`, which are needed for typesetting the *User's Guide*.

(4) You are now ready to create a format file so that $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX, or $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX and the AMSPPT preprint style, can be preloaded when you typeset a document. Before creating your format file, you will want to consider whether you habitually use the AMSPPT documentstyle. If you use other documentstyles rarely or never, then you would benefit from the use of a format file with `amsppt.sty` preloaded. If you are likely to use other documenstyles periodically, then you probably do not want to preload `amsppt.sty`.

To make a simple $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX format file, proceed with the next paragraph. To make a format file with `amsppt.sty` preloaded, edit the file `amstex.ini` and remove the percent sign (comment character) at the beginning of the line `\documentstyle{amsppt}`, just before the `\dump` command.

(5) Check the documentation for your implementation of TEX to find out how to run INITEX and create format files. Format files greatly speed up processing when you are using a large macro package such as $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX. If your implementation of TEX doesn't automatically place format files in the TEX formats directory (check your documentation), you will have to either go to the TEX formats directory before running INITEX, or move the format files there after they are created. The warning in section B.4 will also be relevant, for most PC users. Once you have decided whether to include AMSPPT in your format file (see above paragraph), run the file `amstex.ini` through INITEX, to create the file `amstex.fmt`. This is a preloaded form of $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX. If you included AMSPPT, you may wish to rename it `amsppt.fmt`.

(6) Now move the format file that you just created into your TEX formats directory, if you didn't create it there.

For details of how to use format files with your implementation of TEX, see your documentation. Typically, you use a format file by specifying it on the command line preceded by an ampersand, e.g., `tex &amstex filename`. If you did not receive a printed copy of this *User's Guide* with your distribution, you can use your newly created $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX or AMSPPT format file to typeset the file `amsguide.tex`.

Appendix C
Installation Procedures – Macintosh

C.1. Introduction

These instructions describe the installation of $\mathcal{AMS}$-TEX for use with *Textures*, on the Macintosh. There is one disk in the distribution. The files `amstex.tex` and `amsppt.sty` are *Textures* documents to be input by *Textures*. The file `amsppt.doc` is technical documentation for the macros defined in `amsppt.sty`. The file `amstex.ini` is used in the installation to create format files. The file `amsguide.tex` is the *Textures* source for this *User's Guide*.

The file `joyerr.tex` is a list of errata to the 1986 edition of *The Joy of TEX*. You may typeset it in *Textures* using your new $\mathcal{AMS}$-TEX format file (once it has been created). If you do not have AMSFonts 2.1, the characters in this file which come from the AMS symbol fonts will appear in the default system font. The file `AMSFonts 2.1 metrics` contains the TEX metrics information for AMSFonts 2.1. This file is required to use `amsppt.sty` even if you do not have AMSFonts 2.1. (**Note:** Even if you currently have AMSFonts 2.0, we *strongly* recommend that you obtain version 2.1, as the metrics have changed.)

$\mathcal{AMS}$-TEX Versions 2.0+ can be used with *Textures* without AMSFonts. However, $\mathcal{AMS}$-TEX Versions 2.0+ will not work with releases of AMSFonts previous to Version 2.0. Additionally, if AMSFonts 2.1 are to be used, they require *Textures* version 1.2 or higher. If you have an earlier release of *Textures*, you must upgrade before using these fonts. To upgrade *Textures*, contact the manufacturer: Blue Sky Research, 534 SW Third Ave., Portland, OR 97204; 800-622-8398 or 503-222-9571.

C.2. If You Have a Previous Version of $\mathcal{AMS}$-TEX

Before installing the new version of $\mathcal{AMS}$-TEX, you should backup and delete files from your hard disk which are related to previous releases of $\mathcal{AMS}$-TEX. In particular, you should remove the following files from your `Textures` folder (or any folders contained in your `Textures` folder):

```
amsfil.chg  amsplain.tex  amsppt.sty   amsppt.mor   amstex.tex
amstex.chg  cyracc.def    cyrmemo.def  cyrmemo.tex
```

and you should remove any previous $\mathcal{AMS}$-TEX format files from your `TeX formats` folder. These files are either irrelevant or superseded in the new version of $\mathcal{AMS}$-TEX, and it is best to remove them from your hard disk to avoid confusion.

C.3. Installing $\mathcal{AMS}$-TEX

If you do not have a folder named `TeX inputs` inside the `Textures` folder on your hard disk, create a new folder inside your `Textures` folder and name it `TeX inputs`. Also, if you do not have a `TeX formats` folder, create a new folder inside your `Textures` folder and name it `TeX formats`. Likewise, create a `TeX fonts` folder if you do not already have one.

To install the new version of $\mathcal{AMS}$-TEX on your system, copy the following files into the `TeX inputs` folder inside the `Textures` folder on your hard disk:

```
amstex.tex  amssym.tex  amsppt.sty  amsppt1.tex  amstex.ini
```

Then copy the file `amsfonts 2.1 metrics` into the `TeX fonts` folder inside of the `Textures` folder on your hard disk.

You are now ready to create a format file so that $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX, or $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX and the AMSPPT preprint style, can be preloaded when you typeset a document. Before creating your format file, you will want to consider whether you habitually use the AMSPPT documentstyle. If you use other documentstyles rarely or never, then you would benefit from the use of a format file with `amsppt.sty` preloaded. If you are likely to use other documenstyles periodically, then you probably do not want to preload `amsppt.sty`. To make a simple $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX format file, proceed with the next paragraph. To make a format file with `amsppt.sty` preloaded, edit the file `amstex.ini` and remove the percent sign (comment character) at the beginning of the line `\documentstyle{amsppt}`, just before the `\dump` command.

Open the `TeX inputs` folder (inside your `Textures` folder) and double-click on the file `amstex.ini` to start running *Textures*. Make sure that the line `\input plain` is commented out (begins with a percent sign). If there is not a percent sign at the beginning of this line, insert one. Check under the Typeset menu to make sure that the Plain format is selected (there is a check mark next to it). Select "Typeset" from the Typeset menu. When the dialog box appears asking you what to name the format file, go through the folder hierarchy to place yourself inside the `TeX formats` folder inside your `Textures` folder. You may name the file what you wish, but `2.1` is a good idea. If you included `amsppt.sty` in your format file, name the format file `AMS-TeX/AMSPPT` or something similarly descriptive.

For more information about using formats in *Textures*, see the *Textures User's Guide*.

If you did not receive a printed copy of the *$\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX User's Guide* with your distribution, you can use your newly created $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX or AMSPPT format file to typeset the file `amsguide.tex`.

Questions concerning *Textures* should be directed to:

Blue Sky Research
534 Southwest Third Avenue
Portland, OR 97204
Phone: 800-622-8398 or 503-222-9571