REVTEX 4 Author's Guide

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CONTENTS

1. Introduction

This is the author's guide to REVTEX, a system for preparing journal submissions in both print and electronic form, which is implemented as a document class for the LATEX document preparation system. An electronic document created in REVTEX can be typeset in formats suitable for journal submission or for circulation by the author as a manuscript or reprint, but most importantly, it can be used for direct submission as an electronic manuscript, or *compuscript*.

1.1 Choosing REVTEX

You will want to use REVTEX to prepare a paper for submission to an academic journal, if:

- The journal or its society is a participant in the REVTEX project.
- The journal has a compuscript submission program that is consistent with REVTEX.
- Your paper makes significant use of mathematical notation or is highly technical in nature.
- You are familiar with and use the TEX typesetting system, or the LATEX document perparation system for TEX.
- Your document's intended use extends to electronic publishing.
- Your document is destined to be translated to XML or another descriptive markup system.
- You wish to get the most value from your time and effort as an author by focusing on the content and structure of your paper without undue concern for format details such as margins, fonts, and so on.
- You wish to typeset your document in a number of different formats depending on the requirements of the recipient.
- You wish to get the most value from your computer system in using it as a platform for document preparation.

Note that, although LATEX is ultimately a required part of the REVTEX system, you do not need to be an expert user of LATEX in order to be an effective user of REVTEX.

If you adopt REVTEX, you should expect to benefit in the following ways:

- REVTEX provides all the markup elements needed for the preparation of your manuscript, so you will not need to develop special tags.
- REVTEX markup is designed to be acceptable for manuscript submission, so you will not need to be concerned about proper format for editorial offices (double spacing, margin requirements, etc.).
- REVTEX macros accommodate many presubmission distribution needs: you can, for example, assign preprint numbers to your manuscripts or easily change to single-spaced copy to save paper before submission to editorial offices.
- Since REVTEX macros are recognized by numerous physics organizations as a TEX standard for manuscript preparation, you can enjoy the benefits of electronic submission programs.
- REVTEX compuscript files can be used by a variety of publishers to create author proofs, giving you less proofreading, accelerated production schedules, or reduced cost-per-page.

1.2 Historical

The REVTEX system for LATEX, so named for the *Physical Review* journals, began its development in 1986, was first released in 1988, revised to version 2 in 1990, and to version 3.1 in 1996. In its earliest incarnations, it was both an authoring tool and a production tool and was based on LATEX2.09.

These earlier versions of REVTEX were restrictive of what authors were allowed to do and were incompatible with packages that authors wanted to use. REVTEX 3 did not keep pace with the advances of the LATEX community and thus became inconvenient to work with.

1.3 Design Principles of REVTEX 4

REVTEX 4 is designed to bring REVTEX up to date and make it a more valuable tool for the production process of the American Physical Society and for authors who circulate their work on their own. This version of REVTEX is a complete rewrite, with the following set of design goals:

- Make REVTEX fully compatible with LATEX 2ε; it is now a LATEX 2ε document class, similar in function to the standard `article` class.
- Relax the restrictions in REVTEX that had only been necessary for typesetting journal camera-ready copy.
- Rely on standard LATEX 2ε packages for common tasks, e.g, `graphicx`, `color`, `hyperref`, and `longtable`.
- Add macros to support translation to SGML.
- Improve frontmatter macros for tagging author names and affiliations.
- Improve back matter macros for tagging references; actively promote the use of BibTEX.
- Provide a closer approximation of the pages of *Physical Review* and other journals so authors can use REVTEX to check their adherence to length requirements.
- Incorporate new features, such as hypertext, to make REVTEX a desirable e-print format.

The improved tagging will to aid the peer-review and publication process from the moment a REVTEX paper is submitted.

1.4 Status of REVTEX 4

REVTEX 4 is in beta testing. Papers that use REVTEX 4 are not yet eligible for the compuscript program (described in REVTEX Input Guide for REVTEX 3.1). The Americal Physical Society is making this beta release to get feedback on the features and to track down bugs. Please send any comments and bug reports concerning REVTEX 4 to mailto:revtex4@aps.org.

1.5 Documentation Roadmap

This manual applies to version 4 of the REVTEX document class for LATEX. In this manual:

- We give a quickstart guide for experienced users in Section 2.
- We describe REVTEX's system requirements and explain how to get and use the REVTEX tools and documentation in Section 3.
- We give instructions on preparing a REVTEX compuscript (i.e., an instance of the revtex4 document class) in Section 4.
- We provide a reference manual to the REVTEX markup system and illustrate how it applies to scientific papers in Sections 5.1–5.3.
- We describe how to add other LATEX packages to the REVTEX system, so you can exploit their capabilities in your document in Section 5.4.
- We give pointers for troubleshooting in Section 6.
- We describe the requirements of the compuscript program in Section 7.
- We detail your resources for help in Section 8.
- We list books on the use of TEX and LATEX in the Bibliography.

The appendices to this manual contain reference information and information of interest to a restricted audience:

- In Appendix A, we summarize the differences in the markup between REVTEX 4 and the previous release, REVTEX 3.1.
- In Appendix B, we describe how to convert a REVTEX 3.1 document into a REVTEX 4 document.
- In Appendix C, we summarize the differences in the markup between REVTEX 4 and the standard LATEX article class.
- In Appendix F, we list the special characters obtainable through REVTEX.
- In Appendix G, we summarize the REVTEX markup needed for a typical document.

2. Quick Start

This section is for readers impatient to create their first REVTEX 4 document. In order to jump right in, you must:

- Be familiar with LATEX and, ideally, BiBTEX.
- Have available to you a working TEX installation, complete with LATEX, BiBTEX, makeindex, previewer, printer, etc.
- Either have REVTEX installed, possess the distribution media, or have access to the Internet.
- Either have natbib installed or have access to CTAN.

Furthermore, to use the sophisticated length-checking capabilities of REVTEX, you must either possess the requisite fonts, or you must install whatever fonts are required.

To quickstart REVTEX, follow these steps:

1. Pick up the REVTEX document class for LATEX and associated files: see http://publish.aps.org/revtex4/.
2. Install the necessary components by putting all of the .cls, .sty, and .rtx files into a location within your filesystem where they will be available to LATEX.

   Note: under the TDS, they would be placed into textmf/tex/latex/revtex.
3. Put all .bst files where they can be found by BiBTEX; under the TDS, this would be textmf/bibtex/bst/revtex.
4. Make note of the .dvi and .pdf files in the distribution; they are the REVTEX online documentation. Please make yourself familiar with their contents.

   If you wish to move these files into your documentation tree under the TDS, put them in texmf/doc/latex/revtex.
5. The file template.aps is a boilerplate for creating a REVTEX document. Under the TDS, it belongs in texmf/doc/latex/revtex.

   Clone this file under a new name, say mypaper.tex, in your personal area of your filesystem, and typeset that new file.
6. Alter the document to suit your purposes, using the sample markup and embedded comments as a guide.
7. Ensure that your installation has the natbib package installed, or intstall it yourself from ftp://ctan.tug.org/tex-archive/macros/latex/contrib/supported/natbib.
8. You are on your way!

3. Getting Started With REVTEX

3.1 Site Preparation

To use REVTEX, you must have available to you a working TEX installation, complete with LATEX, BiBTEX, makeindex, text editor, previewer, printer, and any ancillary applications needed to operate it. Most new computers sold today are capable of serving your authoring needs.

Commercial and shareware TEX distributions for most computers can be found through the TEX Users Group (http://www.tug.org), in particular, the very powerful and convenient TEX Live CD-ROM (http://www.tug.org/texlive) has runnable binaries for many UNIX flavors, Windows 9x and Windows 2000, and MacOS. All these distributions contain the LATEX document preparation system upon which REVTEX is based.

Follow the installation instructions for your TEX software included with the distribution. Confirm your TEX installation by typesetting, previewing, and printing some sample documents. Then process the following short document to confirm that your system will run REVTEX:

```
%This is la-test.tex
\NeedsTeXFormat{LaTeX2e}[1996/06/01]%
\documentclass{article}
\begin{document}
 Hello, world!
\end{document}
```

3.2 Installation of REVTEX

REVTEX 4 is incorporated into many commercial and shareware TEX distributions, so you may find it unnecessary to install it. To determine if such is the case, create and typeset the `rev-test.tex` document below. If it compiles successfully, you have a working REVTEX and can skip the rest of this section.

The definitive distribution point for REVTEX 4 is http://publish.aps.org/revtex4/. It is also available on the Comprehensive TEX Archive Network, at ftp://ctan.tug.org/tex-archive/macros/latex/contrib/supported/revtex.

Full installation instructions for REVTEX are in the `README` file distributed with REVTEX.

To confirm the integrity of your REVTEX installation, create and typeset the following TEX document:

```
%This is rev-test.tex
\documentclass{revtex4}
\begin{document}
 Hello, world!
\end{document}
```

Note: if you encounter difficulties with REVTEX, the output from the `la-test.tex` job in section 3.1 and the above `rev-test.tex` can help diagnose installation problems.

3.3 Your First REVTEX Document

Let's create a REVTEX document that can ultimately be developed into a full-fledged journal submission.

1. Start by making a copy of the REVTEX-distributed file `template.aps` under a new name, such as `mypaper.tex`. Put this file into a portion of your filesystem where your own documents are stored.

2. Typeset and preview `mypaper.tex` and examine the formatted output. The document is almost devoid of content.

3. Open `mypaper.tex` in your text editor and locate the line

   ```
   \title{}
   ```

   Change this line so that it reads:

   ```
   \title{%
    A Proposal for the
    Routing of Public Rail Service
   }
   ```

4. Locate the line

   ```
   \author{}
   ```

   and change it to read:

   ```
   \author{Hedley Lamarr}
   ```

   (or insert your own name here).

5. Locate the line

   ```
   \affiliation{}
   ```

   and change it to read:

   ```
   \affiliation{%
    B. J. La Petomaine Institute,
    Rock Ridge AZ 12345
   }
   ```

   (or insert your own institution here).

6. Locate the line

   ```
   \section{}
   ```

   and change it to read:

   ```
   \section{%
    A Cautionary Note About Quicksand
   }
   ```

   (or insert your own title here). Likewise insert titles into the `\subsection` and `\subsubsection` commands on the following lines.

7. Follow the `\subsubsection` command with some general text of your own choosing.

8. Save the file and typeset it.

9. Congratulations, you have broken the ice with REVTEX.

4. Creating Your REVTEX Document

Your REVTEX document is a LATEX document (specifically of the `revtex` class), and you create and process it like any other LATEX document.

This section takes you through the steps of creating a REVTEX document in enough detail to allow you to create a full journal submission.

If you are familiar with earlier versions of REVTEX, please read Appendices A and B, which show how to convert from that version. If you are familiar with the LATEX article class, upon which REVTEX is based, you can get a quick overview of REVTEX's distinctive features by reading Appendix C. If you are unfamiliar with LATEX, you are advised to obtain and refer to the manual, the *LATEX User's Guide & Reference Manual*[2].

4.1 Class options

Your document consists of *preamble* and body, the latter delimited by `\begin{document}` and `\end{document}` statements, and the former consisting of all statements preceding the `\end{document}`.

Start your document with a basic shell as follows:

```
\documentclass[<options>]{revtex4}
\usepackage{<package>}
\begin{document}
<content> \end{document}
```

The document class is `revtex4`; class <*options*> are separated by commas and include `eqsecnum` (to number equations by section), `preprint` (to get double-spaced output for submission purposes), `tightenlines` (to get single-spaced output with the preprint style), and `amsfonts` and `amssymb` (see Sec. 4.13).

There are class options for specific societies, called the *society substyle*, such as `aps` for a genera American Physical Society, `aip` for the AMerican Institute of Physics, `osa` for the Optical Society of America, and `seg` for the Society of Exploration Geophysicists. There are class options for specific journals, called the *journal substyle*. Those relating to the APS are `pra`, `prb`, `prc`, `prd`, `pre`, `prl`, `prstab`, and `rmp` for *Physical Review A*, *B*, *C*, *D*, *E*, *Letters*, *Special Topics—Accelerators and Beams*, and *Reviews of Modern Physics*, respectively.

Under the `aps` society substyle, the journal substyle `pra` is the default. The `prb` journal substyle gives superscript reference citations, as is the style for *Physical Review B*. The `prl` substyle yields the slightly different line spacing of *Letters* (use for accurate length estimates). Other than this, there are no substantial differences in the APS journal options.

The `floats` class option enables LATEX-style floating figures and tables. Alternatively, the `endfloats` class option automatically moves the figures and tables to the end of the formatted document. The `twocolumn` class option typesets the document in a two-column layout for your convenience in creating a reprint format.

Please refer to the file `apssamp.tex` for an example of how to invoke these options. Numerous other class options are available; please see Section 5.1 for details.

The document preamble can have any number of `\usepackage` statements; see Section 5.4 for information about REVTEX's compatibility with other LATEX packages.

4.2 Front matter

The document body begins with the frontmatter statements, all of which absorb data for use by the `\maketitle` command that ends the frontmatter. Continue your document with a `\maketitle` command, preceding that command with frontmatter statements as described below.

```
\begin{document} \title{<title>}
\author{<author>}
<frontmatter> \maketitle
```

Enter the title with the `\title`command:

short title`{`<*title text*>`}`

If your document's title is sufficiently long, you may need to provide a truncated title for the purposes of the page running header; enter that as the optional argument to the `\title` command.

Author and Affiliation

Next enter the authors and affiliations. For an article with a single author, give the `\author` and `\affiliation` commands, for example:

```
\author{Jackson P. Jones}
\affiliation{321 Main Street, Everville,
          Illinois 12345-6789}
```

For multiple authors at a single institution, put each author into a separate `\author` command, and follow with the `\affiliation` statement:

```
\author{Jackson P. Jones}
\author{Joan Q. Johnson}
\affiliation{321 Main Street, Everville,
          Illinois 12345-6789}
```

This arrangement is called an *author group*; it has one or more `\author` commands followed by one or more `\affiliation` commands (each author is understood to be affiliated with all of the specified affiliations).

Your frontmatter itself may have more than one author group; this is how you accomodate a mixture of authors and affiliations.

For each individual author, you may give any combination of `\email`, `\homepage`, `\thanks`, or `\altaffiliation` statements:

```
\author{Jackson P. Jones}
 \email{JackP@Jones.org}
 \email{JPJ@ev.il.us}
 \homepage{www.jones.org}
 \thanks{Work supported by Jenny Jones}
 \altaffiliation{Everville Institute}
\affiliation{321 Main Street, Everville,
         Illinois 12345-6789}
```

These author attributes are formatted either as title page footnotes or in the title block itself, depending on the requirements of the journal substyle.

Complex arrangements of authors and affiliations are possible with REVTEX; see Appendix D for more details.

Other Front Matter

Enter the `\date{`<*date*>`}` command to have the date printed on the manuscript. Using `\today` will cause LATEX to insert the current date whenever the file is run:

```
\date{\today}
```

Next enter your abstract in the `abstract` environment:

```
\begin{abstract}
In this paper we show the result of...
\end{abstract}
```

The final element of the frontmatter data is the `\pacs{`<*pacs numbers*>`}` command.

```
\pacs{23.23.+x, 56.65.Dy}
```

The `\maketitle` command must be entered last of all. Note: If you omit this command, your formatted output will have no title block at all. Furthermore, certain features, such as the ability to refer symbolically to the first page of your document (via `\ref{`<*FirstPage*>`}`), will not work properly in a document lacking a title block.

```
\maketitle
```

Please see Section 5.2 for more information about frontmatter commands, and the author/affiliation commands in particular.

4.3 Section headings

Section headings are input as in LATEX. The output is similar, with a few extra features.

Four levels of headings are available in REVTEX:

```
\section[<short title>]{<title text>}
\subsection{<title text>}
\subsubsection{<title text>}
\paragraph{<title text>}
```

Provide the <*short title*> if needed for the sake of the running header (required only by some journal substyles).

Use the starred form of the command to suppress the automatic numbering; e.g.,

```
\section*{Introduction}
```

To label a section heading for cross referencing use the `\label{`<*key*>`}` command *after* the heading; e.g.,

```
\section{Introduction}
\label{sec:intro}
```

In the some journal substyles, such as those of the APS, all text in the `\section` command is automatically set uppercase. If a lowercase letter is needed, use `\lowercase{x}`. For example, to use "He" for helium in a `\section{`<*title text*>`}` command, type `H\lowercase{e}` in `{`<*title text*>`}`.

The `\appendix` command signals that all following sections are appendices, so `\section{`<*title text*>`}` after `\appendix` will set `{`<*title text*>`}` as an appendix heading (an empty `{`<*title text*>`}` is permitted). For a single appendix, use a `\section*{`<*title text*>`}` command to suppress the appendix letter in the section heading.

Use `\protect\\` to force a line break in a section heading. (Fragile commands must be protected in section headings and captions, and `\\` is a fragile command.)

4.4 General Text

Paragraphs always end with a blank input line. Because TEX automatically calculates linebreaks and word hyphenation in a paragraph, you should not force linebreaks or hyphenation in your document. Of course, you nonehteless continue to explicitly hyphenate, e.g., "author-prepared copy."

Use directional quotes for quotation marks around quoted text (`''xxx''`), not straight double quotes (`"xxx"`). (For opening quotes, this is two octal 140 (hexadecimal 60) characters; for closing quotes, this is two octal 047 (hexadecimal 27) characters.)

You can control the width of the text across the page in two-column layout: the `widetext` environment will set the text across the full width of the typing area. This may be needed to set very long equations. See Section 4.7. The `widetext` environment has no effect on the output if you have invoked the `preprint` class option. The preprint style is a uniform width throughout.

Don't use `\vspace`, `\smallskip`, `\bigskip`, or any other vertical motion commands. Likewise, horizontal motion commands like `\hspace`, should be avoided.

LATEX's standard `\footnote` command is available in REVTEX. Your target journal, however, may effectively invoke the `endnotes` class option; these notes will then be placed at the end of the bibliography element.

Note that in such a case, the argument of the `\footnote` command is a moving argument in the sense of the *LATEX User's Guide & Reference Manual*, Appendix C.1.3: any fragile command within that argument must be preceded by a `\protect` command.

4.5 Math in text

REVTEX uses the TEX markup $ for math, e.g.,

the quantity a^z

is obtained from the input

```
the quantity $a^{z}$
```

Within math mode, use `^{<math>}` for superscripts (and `_{<math>}` for subscripts), as you see in the source for this guide. If you omit the braces after the `^`, TEX will superscript the next *token* (generally a single character or command), but it is safest to use explicit braces `{}`.

As with text, your math should not require vertical or horzontal motion commands, because TEX calculates math spacing itself automatically. In particular, please *do not* insert explicit spacing around relations (e.g., =) or operators (e.g., +). These suggestions notwithstanding, some fine-tuning of math is required in specific cases, see Chapter 18 in the TEXbook[1].

4.6 Text in math

There are times when you need to insert text into math, but there are more and less satisfactory ways of doing so.

The `\rm` command only switches to Roman font for math letters. It does not, for example, let you print a normal text hyphen: `${\rm e-p}$` gives "e − p". Using an `\mbox{<text>}` will give you normal text, including a hyphen, but will not scale correctly in superscripts: `$x_{\mbox{e-p}}$` gives "$x_{\text{e-p}}$".

The `\text{<text>}` command is the preferred method of setting text within math mode. It gives you regular text *and* scales correctly in superscripts: `$y=x \text{ for } x_{\text{e-p}}$` gives "$y = x$ for $x_{\text{e-p}}$".

To use the `\text` command, you must load the `amsmath` package: include a `\usepackage{amsmath}` command in your document preamble.

4.7 Displayed equations

Equations are set centered in the column width or flush left depending on the selected journal substyle.

For the simplest type of displayed equation, a numbered, one-line equation, use the `equation` environment. REVTEX takes care of the equation number—the number will be set below the equation if necessary. Use `\[ ... \]` for a single, one-line unnumbered display equation.

Use the `eqnarray` environment when more than one consecutive equation occurs, putting each equation in a separate row of the environment, and using `\nonumber`before the row end (`\\`) to suppress the equation number where necessary. If the equations are related to each other, align each on the respective relation operator (such as =).

When an equation is broken over lines or is continued over multiple relation operators, it is called a multi-line or continued equation, respectively; here, too, use the `eqnarray` environment.

For a continued equation, align each row on the relation operator just as with multiple equations, and use the `\nonumber` command to suppress auto-numbering on broken lines. Also, use the starred form of the row end (`\\*`) to prevent a pagebreak at that juncture.

Short displayed equations that can appear together on a single line separated by `\qquad` space, may be placed in a single `equation` environment.

In two-column mode, if an equation needs to be broken into many lines, for ease of reading set it in a wide column using the `widetext` environment. Then return to the normal text width as soon as possible. However short pieces of paragraph text and/or math between nearly contiguous wide equations should be incorporated into the surrounding wide sections.

In `apssamp.tex`, we illustrate how to obtain each of the above effects.

Numbering displayed equations

The REVTEX macro package allows two methods for numbering equations: you can allow REVTEX to automatically number for you, or you can assign your own equation numbers.

For automatically numbered single-line and multi-line equations, use the `equation` and `eqnarray` environments as described above. For unnumbered single-line equations, use the `\[ ... \]` construction. The command `\nonumber` will suppress the numbering on a single line of an `eqnarray`. For a multi-line equation with no equation numbers at all, use the `eqnarray*` environment.

If you wish a series of equations to be a lettered sequence, e.g., (3a), (3b), and (3c), put the respective `equation` or `eqnarray` environment within the `subequations` environment. You must load the `amsmath` package for this capability; include the statement `\usepackage{amsmath}` in your document preamble.

Use the command `\tag{<number>}` to produce an idiosyncratic equation number: (1′), for example. Numbers assigned by `\tag` are completely independent of REVTEX's automatic numbering. The package `amsmath` is required if you use the `\tag` command: put the statement `\usepackage{amsmath}` in your document preamble.

To have REVTEX number equations by section, use the `eqsecnum` class option in your document preamble.

See `apssamp.tex` for examples.

Cross-referencing displayed equations

To refer to a numbered equation, use the `\label{<key>}` and `\ref{<key>}` commands. The `\label{<key>}` command is used within the referenced equation (on the desired line of the `eqnarray`, if a multi-line equation):
input:

```
\begin{equation}
 A=B \label{pauli}
\end{equation}
 ... It follows from Eq.~(\ref{pauli})
```

```
that this is the case ...
\begin{eqnarray}
 A & = &B,\label{pauli2}\\
 A'& = &B'
\end{eqnarray}
```

output:

$$A = B \tag{1}$$

... It follows from Eq. (1) that this is the case ...

$$A = B, \tag{2}$$
$$A' = B' \tag{3}$$

Please note the parentheses surrounding the `\ref` command. these are *not* provided automatically; you must incorporate them into your electronic document if you want them.

Numbers produced with `\tag` can also be cross-referenced: follow the `\tag` command with a `\label` command.

Using a `\label` after `\begin{subequations}` will allow you to reference the *general* number of the equations in the `subequations` environment. For example, if

```
\begin{subequations}
 \label{allequations} % notice location
 \begin{eqnarray}
  E&=&mc^2,\label{equationa}
 \\
  E&=&mc^2,\label{equationb}
 \\
  E&=&mc^2,\label{equationc}
 \end{eqnarray}
\end{subequations}
```

gives the output

$$E = mc^2, \tag{4a}$$
$$E = mc^2, \tag{4b}$$
$$E = mc^2, \tag{4c}$$

then `Eq.~(\ref{allequations})` gives "Eq. (4)".

Note: incorrect cross-referencing will result if `\label` is used in an unnumbered single-line equation (i.e., within the `\[` and `\]` commands), or if `\label` is used on a line of an eqnarray that is not being numbered (i.e., a line that has a `\nonumber`).

Please see Sec. 4.12 for further information about cross-referencing.

4.8 Special Characters

If you intend to submit your document to a compuscript program, it would be best to avoid the use of specially defined characters; instead choose symbols from those shown in the *LaTeX User's Guide & Reference Manual* or in Section F. These characters are supported by the software that converts your REVTEX document to SGML or other format.

See Appendix F for a list of standard LaTeX symbols, a list of symbols available when the `amsfonts` and `amssymb` options are used, and a list of extra symbols made available by REVTEX.

4.9 Citations and References

References are cited in text using the `\cite{<key>}` command and are listed in the bibliography using the `\bibitem{<key>}` command. Put the list of references after the main body of the paper using one of two alternative methods.

If you are using BibTeX, give the command

`\bibliography{<bib files>}`

where *<bib files>* is a comma-separated list of BibTeX bibliography database files, each with a `.bib` extension. See Section 4.9 for further instructions on using BibTeX.

Alternatively, you may use an explict `thebibliography` environment:

```
\begin{thebibliography}{}
\bibitem[Tal(1982)]{tal82}
Y. Tal and L. J. Bartolotti,
J. Chem. Phys. {\bf 76}, 4056 (1982).
\end{thebibliography}
```

In either case output looks like:

References

† REVTEX 3.1 portions by APS; V4 notes by David Carlisle (mailto:david@carlisle.demon.co.uk), March 31, 1999; V4 guide by Arthur Ogawa (mailto:ogawa@teleport.com)

[1] Y. Tal and L. J. Bartolotti, J. Chem. Phys. **76**, 4056 (1982).

The `\bibitem` command's optional argument specifies information that is used to cite the reference when using author/year citation style. The required argument, here `tal82` is a tag. If you compile your `thebibliography` environment by hand, you can chose the tag for each bibliographic entry as any string of letters and numbers. If using BibTeX, the tag must match that of the desired entry in your bibliographic database.

You use the tag in the `\cite` command to indicate which reference you want to cite. For example,

input:

```
As has been noted previously~\cite{tal82}.
```

output:

As has been noted previously [1].

In journal substyles using superscript reference citations, such as *Physical Review B*, you need an alternative command to get on-line citations; the command `\onlinecite{<key>}` is available for this purpose. For example, `Ref.~\onlinecite{tal82}` will give the output "Ref. 1".

When the citation constitutes part of the grammar of the sentence, you use the `\textcite{<key>}` command, for example, `\textcite{tal82} has shown` will give the output "Tal [1] has shown".

A `\cite` command with multiple keys is formatted with consecutive reference numbers collapsed; e.g., [1,2,3,5,7,8,9] will be output as [1–3,5,7–9]. If you need to split the list over more than one line, use a % character immediately following a comma; thereby ensuring that the list will be processed correctly.

```
. . . as shown in \cite{a,b,c,d,e,f,%
g,h,i,j,k,l,m,n,o,p,q,r,s,t,u,v,w,x,y,z}
```

Note the % inserted after the comma on the first line, which avoids unwanted spaces.

Using BibTeX

The BibTeX application is an adjunct to TeX that aids in the preparation of your bibliography.

To use BibTeX with REVTeX, you must select an appropriate journal substyle, optionally specify your own bibliography style (if you do not, REVTeX selects one based on your journal substyle), issue the `\bibliography` command as described above, give `\cite{<key>}` commands (using as <*key*> that of the desired entry in your bibliographic database), and of course prepare your `.bib` bibliographic databases. In this section, we use the `\cite` command to stand also for `\textcite` and `\onlinecite`.

- Selecting a journal substyle automatically invokes the necessary `\bibliographystyle` command with the appropriate argument. For instance, for APS journals in general, this argument is `apsrev`, but is `apsrmp` in the particular case of the `rmp` (*Reviews of Modern Physics*) journal substyle. Your selected jounal substyle must do likewise.

- You may accept the bibliography style automatically selected by the journal substyle. Alternatively, you can issue the `\bibliographystyle` command explicitly, thereby specifying the bibliography style for your document. Note that unlike standard LaTeX, your `\bibliographystyle` command must appear before the `\begin{document}` statement in order for it to take effect.

- As explained above, the `\bibliography` command performs double duty by specifying both the location within your document where the list of references is to appear, and the set of BibTeX bibliography database files to be used when BibTeX prepares your `.bbl` file.

- Each `\cite` command in your document automatically records its citation key in your document's `.aux` file, for later use by BibTeX.

- An appropriate bibliographic database is required as well. You may have created one of your own, or you may have access to one of the compiled databases, depending on your field of research.

With the above requirements met, you carry out the following steps: (we take the name of your document to be `myfile.tex`)

1. Process your document once under REVTeX as specified elsewhere in this guide, and ignore any LaTeX reports of undefined citations. LaTeX compiles a list of needed references in the `myfile.aux` file from each instance of a `\cite` command in your document.

2. Run BibTeX on the `myfile.aux` file, thereby creating the `myfile.bbl` file. To run BibTeX on a command-line operating system, you might give a shell command like `bibtex myfile`.

3. Process your document a second time under REVTeX, still ignoring any LaTeX reports of undefined citations. LaTeX typesets the bibliography and, for each `\bibitem` statement therein, records the meaning of each reference key in the `.aux` file for use when the key is cited.

4. Process your document a third time under REVTeX. This time a reports of an undefined citation indicates that you have either failed to correctly enter the citation key in your `\cite` command that matches the key in the `.bib` file, or that the `.bib` file lacks any entry with that key.

5. Repair any problems and repeat the whole process from step 1.

6. If you have no reports of undefined citations, your BibTeX work is complete.

For more information on using BibTeX with LaTeX, see Sections 4.3.1 and C.11.3 of the *LaTeX User's Guide & Reference Manual*[2], Section 13.2 of [3], or the online BibTeX manual `http://ctan.tug.org/tex-archive/biblio/bibtex/distribs/doc/btxdoc.tex`.

References by Hand

If you are not using BibTeX, please bear in mind the following when preparing your `\bibitem`s.

- The `\bibitem[<bib text>]{<key>}` command begins each reference item.

- References should be listed in the reference section in the order in which they are first cited in the text if using numerical citations, in alphabetical order if using author/year citations.

- Numerical references are automatically numbered by REVTeX in the order in which they occur in the reference section.

- The <*key*> in `\bibitem{`<*key*>`}` is a tag; you can choose any string of letters and numbers to associate with the reference. This tag is used with the `\cite{`<*key*>`}` command when citing the reference.
- The <*bib text*> in `\bibitem[`<*bib text*>`]` is only used in the case of author/year citations; it should have the structure

  `\bibitem[`<*short-name*>`(`<*year*>`)`<*long-name*>`]`

  where <*short-name*> is the author name used in a parenthetical citation, <*long-name*> that used in a textual citation, and <*year*> is the year.
- If you wish to prepare a bibliography that can serve as the basis for a document using either author/year or numerical citations, then prepare it for the former. If you later choose a journal substyle using numerical citations you need make no changes to your bibliography.

The `reftest` Tool

REVTEX includes a tool for authors who prepare their bibliographies by hand, called `reftest.tex`. It will check to make sure that you have (1) no uncited references, (2) no undefined citations, and (3) your references are in the same order as your citations. Using `reftest`, an author can put the citations in the correct order once, after writing the paper, by using the correct order reported by `reftest.tex`.

This process only works if you use LATEX's `\bibitem{`<*key*>`}` and `\cite{`<*key*>`}` mechanisms.

To check the references for the file `myfile.tex`,

1. Run `myfile.tex` through LATEX as usual, thereby creating an up-to-date auxiliary file `myfile.aux`. (`reftest.tex` uses that file to analyze your references.)
2. Run LATEX on `reftest.tex`: it prompts for the name of the file you wish to check. Answer `myfile` at the prompt (*not* `myfile.tex` or `myfile.aux`).
3. Note messages on your console and in the log file (`reftest.log`) that tell you of any problems. Correct them.
4. Preview or print the file `reftest.dvi` to see the correct order of your references. Note that this information does *not* appear in the log file.

4.10 Figures and Artwork

Figures are part of the compuscript and should be input using the `figure` environment as illustrated below; LATEX will label and automatically number the captions FIG. 1, FIG. 2, etc., or in whatever format required by the chosen journal substyle. Note how the `\label{`<*key*>`}` command is used to cross-reference figures in text. The `\label{`<*key*>`}` command should be inserted inside or after the figure caption, before the end of the figure environment.

input:

```
\begin{figure}
 \caption{Text of first caption.}
 \label{fig1}
\end{figure}

\begin{figure}
 \caption{%
  This is the second caption:
  comparison of the differential cross
  sections for the subprocess
  $qg \rightarrow qggg$ of our
  approximation (dotted line)}
 \label{fig2}
\end{figure}
```

output:

FIG. 1: Text of first caption.

FIG. 2: This is the second caption: comparison of the differential cross sections for the subprocess $qg \rightarrow qggg$ of our approximation (dotted line)

Figures are cited in text with the use of the `\ref{`<*key*>`}` command:

input:

```
 ...It can be seen from Fig.~\ref{fig1}
that the data are inconsistent...
```

output:

...It can be seen from Fig. 1 that the data are inconsistent...

Further information on cross-referencing can be found in Sec. 4.12.

Artwork

Use the standard LATEX `\includegraphics` command, as enhanced by the `graphicx` package, to import an electronic art file into your document, most commonly into a `figure`.

```
\begin{figure}
\includegraphics[<key-vals>]{<filename>}
\caption{<title text>}
\label{<key>}
\end{figure}
```

For more information on the enhancements of the `graphicx` package, see [4] or `ftp://ctan.tug.org/tex-archive/macros/latex/required/graphics/grfguide.ps`.

Figure Placement

As with tables (cf. Section 4.11), figures float to the top or bottom of the page if not otherwise specified, using the standard LaTeX float placement mechanism. Initially, you should put each `figure` environment immediately following its first reference in the text; this will usually result in satisfactory placement on the page. Use the optional argument of the `figure` environment to make adjustments to your float placement

```
\begin{figure}[<placement>]
...
\end{figure}
```

where <*placement*> can be any combination of `htbp!`, signifying "here", "top", "bottom", "page", and "as soon as possible". For more details about float placement, please study the instructions in the *LaTeX User's Guide & Reference Manual*, Appendix C.9.1.

4.11 Tables and Alignments

Tables are part of the compuscript and should be input using the `table` environment as detailed below; LaTeX will label and number the captions TABLE 1, TABLE 2, etc. or in whatever format required by the chosen journal substyle.

Each table must begin with `\begin{table}`, end with `\end{table}`, and have a caption (using the `\caption{`<*text*>`}` command). The optional `\label{`<*key*>`}` command follows the `\caption` and is used for cross-referencing. Use the `\ref{`<*key*>`}` command to cite tables in text.

The content of the `table` environment should be a `tabular{`<*preamble*>`}` environment. Please refer to Section 3.6.3 and Appendix C.10.2 of the *LaTeX User's Guide & Reference Manual* for more details about the `tabular` environment.

Use the commands `\toprule`, `\colrule`, and `\botrule` to structure your `tabular` into the column heads (those rows between `\toprule` and `\colrule`) and the alignment body (those rows between `\colrule` and `\botrule`). Follow current journal style concerning placement of other table rules.

input:

```
\begin{table}
 \begin{tabular}{ll}
 \toprule
  Column 1&Column 2\\
 \colrule
  Cell 1&Cell 2\\
 \botrule
 \end{tabular}
 \caption{Text of table caption.}
 \label{tab1}
\end{table}
```

output:

Column 1	Column 2
Cell 1	Cell 2

TABLE I: Text of table caption.

Some special table considerations

- Use the correct number of descriptive column headings.
- *Numerical columns* should align on the decimal point (or decimal points if more than one is is present). The column specifier `d`, should be used for simple numeric data with a *single* decimal point. Material without a decimal point is simply set in math mode, centered.

  To use the `d` column specifier, you must load the `dcolumn` package; put `\usepackage{dcolumn}` in your document preamble. The entry of a `d` column is typeset in math mode; do note insert any `$` math shift characters into a `d` column. If text is required in the column, use `\text` or `\mbox` as appropriate.

  If multiple decimal points are present then the last is used for alignment. To escape from the `d` column use `\multicolumn` as usual. See `apssamp.tex` for examples.
- Use `$` delimiters for all math in a table; do not put a displayed equation in a table.
- *Footnotes* in a table are labeled *a*, *b*, *c*, etc.; use the LaTeX `\footnote` command. See `apssamp.tex` for examples and explanations of use.
- Use the `\squeezetable` command with tables that do not otherwise fit on the page: placing this command before your `\begin{tabular}` statement makes the fonts in the body of the `tabular` smaller, allowing larger tables to fit onto the page.

Table Placement

Like figures (cf. Section 4.10), tables float to the top or bottom of the page if not otherwise specified, using the standard LaTeX float placement mechanism. Initially, you should put each `table` environment immediately following its first reference in the text; this will usually result in satisfactory placement on the page. Use the optional argument of the `table` environment to make adjustments to your float placement

```
\begin{table}[<placement>]
...
\end{table}
```

where <*placement*> can be any combination of `htbp!`, signifying "here", "top", "bottom", "page", and "as soon as possible". For more details about float placement, please study the instructions in the *LaTeX User's Guide & Reference Manual*, Appendix C.9.1.

Invoking the REVTEX `preprint` class option changes LATEX's float behavior: all tables are automatically printed at the end of your document. This arrangement may be required by your journal's compuscript program.

4.12 Cross-referencing

REVTEX has built-in features for labeling and cross-referencing section headings, equations, tables, and figures. This section contains a simplified explanation of cross-referencing features. The format for using these features with section headings, equations, tables, and figures is discussed in the appropriate section.

Cross-referencing depends upon the use of "tags," which are defined by the user. The `\label{`<*key*>`}` command is used to identify tags for REVTEX. Tags are strings of characters that serve to label section headings, equations, tables, and figures, so that you don't need to know what number REVTEX has assigned to the item in order to talk about it in text.

You will need to process your file through REVTEX twice to ensure that the tags have been properly linked to appropriate numbers. If you add any tags in subsequent editing sessions, you will need to repeat this process: LATEX will display a warning message in the log file that ends with `... Rerun to get cross-references right`. If you see that message, run the file through REVTEX again.

If the error message persists, please check your labels; you may have labelled more than one object with the same <*key*>.

Another LATEX warning is `There were undefined references`, which signifies that you have used a key in a `\ref` without ever using it in a `\label` statement. If you encounter this message after running your document through LATEX twice, search your document for the <*key*> in question: it must appear as the argument of a `\label` command.

REVTEX performs autonumbering exactly as in standard LATEX: when you process your file for the first time, LATEX creates an auxiliary file (with the `.aux` extension) that records the value of each <*key*>. Each subsequent run retrieves the proper number from the auxiliary file and updates the auxiliary file. At the end of each run, any change in the value of a <*key*> produces a LATEX warning message.

4.13 Fonts

REVTEX has been set up to give good results on standard LATEX installations, but we cannot guarantee that you will be able to access all the font options—memory and font restrictions vary in TEX implementations and computers.

Bold symbols in math

If you require bold symbols in math, particularly in superscripts or subscripts, use the `\bm{`<*symbol*>`}` command. You must have the AMS fonts installed and invoke the `amsfonts` class option. You must also load the `bm` package: place the command `\usepackage{bm}` in your document preamble.

The `\bm` command makes the symbol bold in math mode, and it ensures that it is the correct size, even in superscripts. If the correct font in the correct size is not available, then you get `{`<*symbol*>`}` at the correct size in lightface and LATEX will issue a warning that says `No \boldmath typeface in this size`. You can also use `\bm` to get bold greek characters—upper- and lowercase—and other symbols.

The following will come out bold with `\bm`: normal math italic letters, numbers, Greek letters (uppercase and lowercase), small bracketing and operators, and `\mathcal`.

Note that `\bm{`<*math*>`}` is a fragile command.

Extra typefaces in math: `amsfonts` option

In addition to the extra bold capabilities you get in math with the `amsfonts` option, you also gain access to the Fraktur and Blackboard Bold typefaces. You select these with normal font-switching commands: `${\mathfrak{G}}$` gives a Fraktur "$\mathfrak{G}$" and `${\mathbb{Z}}$` gives a Blackboard Bold "$\mathbb{Z}$". Fraktur will become bold in a `\bm`; there is no bold version of Blackboard Bold.

Extra symbols in math: `amssymb` option

Many new symbols are available to you if you have the AMS fonts installed. The `amssymb` class option gives you all the font capabilities of the `amsfonts` class option and further defines the commands to get the symbols shown in Appendix F, which contains examples of the symbols and for instructions on use. These characters will scale correctly in superscripts and heads.

AMS fonts

The AMS fonts, developed by the American Mathematical Society, are available free of charge at `ftp://ctan.tug.org/fonts/amsfonts`. Most LATEX installations incorporate the AMS fonts in many formats, including ATM-compatible Type 1 PostScript fonts. There are two class options for accessing the AMS fonts: `amsfonts` and `amssymb`.

The `amsfonts` option defines the `\mathfrak` and `\mathbb` commands to switch to the Fraktur and Blackboard Bold fonts, respectively. Fraktur characters will come out bold in a `\bm`, Blackboard Bold will not. The `amsfonts` option also adds support for bold math letters and symbols in smaller sizes and in superscripts when a `\bm{`<*symbol*>`}` is used. For example, `$^{\bm{\pi}}$` gives a bold lowercase pi in the superscript position: $^{\boldsymbol{\pi}}$.

`amssymb` gives the capabilities of the `amsfonts` option and additionally defines many new characters for use in math.

REVTEX does not support the use of the extra Euler fonts (the AMS fonts starting with `eur` or `eus`) or the Cyrillic fonts (the AMS fonts starting with `w`).

5. A REVTEX COMMAND REFERENCE

This section is a systematic reference to all REVTEX-specifc commands. Please see the *LATEX User's Guide & Reference Manual* for complete information about LATEX commands.

5.1 DOCUMENT CLASS DECLARATION AND OPTIONS

All REVTEX documents must start with the declaration:

`\documentclass[`<*options*>`]{revtex4}`

There are numerous *options*, as listed below.

The Document Substyle

Among your document class options will be exactly one *substyle*, an option specifying the society or the journal to which your article will be submitted. One such society is the American Physical Society, hence the document class option `aps` signifies that your article is to be submitted to one of the APS journals. Alternatively, you can specify a particular journal. Select a substyle from the following list:

substyle	Journal
`aps`	American Physical Society
`pra`	Physical Review A
`prb`	Physical Review B
`prc`	Physical Review C
`prd`	Physical Review D
`pre`	Physical Review E
`prl`	Physical Review Letters
`prstab`	Physical Review Special Topics—Accelerators and Beams
`rmp`	Reviews of Modern Physics

Another possible society is the OSA, selected with the `osa` substyle; currently unimplemented.

If you invoke a class option that REVTEX does not otherwise know about, it looks for a journal substyle with the corresponding name (with a `.rtx` extension). If no such substyle file exists, that option is made available as a global class option for other packages to use as appropriate.

You should examine your log file for any messages of the sort:

```
LaTeX Warning: Unused global option(s):
```

to see what options you have invoke that are not defined or ever used. If you see on that list the name of a journal substyle, you will know that the corresponding `.rtx` file was not found.

Correct the situation by installing the indicated `.rtx` file in a location on your file system where TEX can find it. Under the TDS, it would be placed into `textmf/tex/latex/revtex`.

Type Size Options

You may select a type size from among the following. Note that selecting a type size is optional; your selected journal has a default type size.

`10pt` The default size.

`11pt` Alternative size for author drafts.

`12pt` The default size in the `preprint` option described below.

Media Size Options

The media size options of the standard LATEX classes are available. Note that selecting the media size does not affect the text area of your formatted article.

AMS Font Options

You may specify one of the following two options:

`amsfonts` Load the AMS font package. (Equivalent to putting `\usepackage{amsfonts}` in the document preamble.)

`noamsfonts` Don't load the AMS fonts package (even if a journal option loads `amsfonts` by default).

You may specify one of the following two options:

`amssymb` Load the AMS symbols package. (Equivalent to putting `\usepackage{amssymb}` in the document preamble.)

`noamssymb` Don't load the AMS symbols package (even if a journal option loads `amssymb` by default).

Author and Address Options

The following four options, all relating to how the authors and affiliations are formatted in the title block, are mutually exclusive. You may have only one of them in effect at one time.

`groupedaddress` List each group of authors with shared addresses separately, followed by the addresses. Each shared address will only be typeset once and all authors that share an address will be typeset in the same group.

`unsortedaddress` List the authors in exactly the order specified even if this means typesetting some addresses more than once.

`runinaddress` List authors similarly to `groupedaddress`, except that the authors are formatted in a paragraph instead of on separate lines.

`supercriptaddress` List all authors in a single list. Author addresses are indicated by superscript markers which index into a numbered list of addresses typeset after the author list.

Note that your chosen journal substyle will make a default choice of one of the above four options, and you may override this choice in your document.

One- or Two-Column Layout

`twocolumn` Selects two-column layout. Unlike the option in the standard classes, the columns on the final page will be balanced.

`onecolumn` A single column across the full page width will be used. This is the default for the `preprint` option.

Preprint and Other Options

`preprint` Sets the article in single column at 12pt with enlarged interline spacing and makes minor layout changes. This option is intended for use when the formatted document is to be copyedited, and it is activated by default.

`galley` Sets the article in a single, narrow column approximating the format of journal article. In `galley` format, the `widetext` environment sets its content using the full page width (over twice the width of general text). This formatting option is one of two ways to gauge the length of a journal article; the other is `lengthcheck`.

`tightenlines` If used in conjunction with the above options, this produces normal single spaced documents.

`draft` This option marks overset lines (`Overfull \hbox in paragraph`), as in the standard classes.

`showpacs` and `noshowpacs` These options determine whether the Physics and Astronomy Classification Scheme data appear in the formatted output.

`final` This item is the opposite of `draft`.

`lengthcheck` This class option specifies that the formatted document should approach as closely as possible the formatting of an actual journal article, thereby facilitating performance of a length check. Note that particular font requirements may be in effect for this option.

`byrevtex` Using the `byrevtex` class option signifies that you want the "Typeset by REVTEX" tagline to appear on your output. In the `aps` substyles, it will appear at the foot of the title page.

Footnote and Bibliography Options

`bibnotes` Instead of putting remarks (`\thanks`, `\email`, `\homepage`, and `\altaffiliation`) associated with authors as footnotes on the title page, put them at the beginning of the bibliography as unnumbered entries.

`nobibnotes` Nullifies the effect of the `bibnotes` option. If the journal substyle effectively invokes that option by default, you can invoke `nobibnotes` to override that choice.

`footinbib` Put all footnotes as numbered entries at the end of the bibliography. (Footnotes in the frontmatter are controlled independently by the `bibnotes` option.)

`nofootinbib` Nullifies the effect of the `footinbib` option. If the journal substyle effectively invokes that option by default, you can invoke `nofootinbib` to override that choice.

`superbib` Number the entries in the bibliography with superscripts rather than with numbers in square brackets. (this is, e.g., the style of *Phys. Rev. B.*)

Equation numbers

`eqsecnum` Number equations within sections.

`fleqn` Typeset equations flush left.

Section Numbering Option

The `secnumarabic` class option specifies that you want the sectioning commands to have arabic numbering.

Floats Option

The `endfloats` option specifies that floating elements such as figures and tables are to be set at the end of the formatted document (end floats).

Specifying the `floats` option means normal LaTeX float behavior and will override those journals which would by default have end floats.

If you specify neither option, then the selection will be made by the journal substyle; usually `floats`.

These options are described in more detail below.

Title Page Options

It should not be necessary to use these options in your document, because the journal substyle sets them as appropriate.

`titlepage` Start a new page after typesetting the title block.

`notitlepage` Typeset the title block above the body of the text.

Formatting for Duplex Printing

The options `twoside` (the default) and `oneside` work as in standard LaTeX classes.

Hypertext Option

Use the option `hyperref` if you want your formatted document to have hypertext capabilities. This option implies the use of the `hyperref` package, available from `ftp://ctan.tug.org/macros/latex/contrib/supported/hyperref`, which is automatically loaded.

Job Macro Package

You can create a "job macro package" for your document that will be read in automatically every time your document is processed. Thus, if your job is a file called `myarticle.tex`, then the file `myarticle.rty` will be read in just the same as if you had placed a `\usepackage{myarticle.rty}` statement immediately following your `\documentclass` statement.

Within your `.rty` file, you can define and use control sequence names that contain the `@` character, and you can override any of the definitions or assignments made by the REVTeX document class or the selected journal substyle. That is, you have the power to make a mess.

If you choose to have a job macro package, be sure to read the LaTeX guide to document classes (`clsguide.tex`) or read up on the subject of packages and classes in *The LaTeX Companion* [3] or a similar book.

The file `template.rty` contains a template for creating your own job macro package.

Example Here is a code fragment suitable for inclusion in your job macro package that defines the sectioning counters to produce arabic numbers instead of the default roman numbers, and which numbers the sectioning commands to the level of `\subparagraph`.

```
\def\thesection{%
 \arabic{section}}%
\def\thesubsection{%
 \arabic{subsection}}%
\def\thesubsubsection{%
 \arabic{subsubsection}}%
\def\theparagraph{%
 \arabic{paragraph}}%
\def\thesubparagraph{%
 \theparagraph.\arabic{subparagraph}}%
\setcounter{secnumdepth}{5}%
```

5.2 Frontmatter Commands

As in the standard classes, the frontmatter is specified by a sequence of declarations that gather information (data commands). The `\maketitle` command then uses this information to typeset the title block.

Data Commands

Title `\title[`<*short title*>`]{`<*title*>`}` The optional *short title* will be used in running heads. If it is not specified, then it defaults to the same value as *title*.

Keywords `\keywords{`<*keyword list*>`}` A comma-separated list of keywords (as used by subject review or abstract publications).

PACS `\pacs{`<*PACS numbers*>`}` PACS Subject classification numbers. You must specify `\pacs` before the `\maketitle` command.

Abstract `\begin{abstract}`*abstract*`\end{abstract}` The abstract is considered part of the frontmatter, and thus the abstract environment must come before the `\maketitle` command in the source file.

Dates and Numbers The following commands specify the volume, issue, year, and electronic identifier of the article, as well as the dates received, revised, accepted, and published.

With the exception of the LaTeX standard `\date` command, these commands are more likely to be used by journal staff than by the author of the document. The argument of each should be in the final typeset form; the class does not parse these arguments.

```
\volumeyear{<year>}
\volumenumber{<number>}
\issuenumber{<number>}
\eid{<identifier>}

\date[<text>]{<date>}
\received[<text>]{<date>}
\revised[<text>]{<date>}
\accepted[<text>]{<date>}
\published[<text>]{<date>}
```

In the latter five commands, `[`<*text*>`]` signifies an alternative value for the text that is produced just before the date, e.g., in the case of `\received`, it might be "Received". You can use the optional argument to override the value chosen by the journal substyle.

LaTeX will calculate page numbering from information taken from the previous run's `.aux` file, if not otherwise specified:

```
\startpage{<number>}
\endpage{<number>}
```

Preprint command

`\preprint{`<*text*>`}` has no effect unless the preprint option has been specified, in which case it adds identifying text to the page headline.

Author/Affiliation Data Commands

The most significant new feature in REVTEX 4 concerns the commands used for specifying author names, affiliations, and other author-related information. They are designed to better mark up the information (e.g., `\email` rather than `\thanks`) for use in the editorial and production processes.

These data are organized into one or more "author groups", each comprised of one or more authors followed by one or more affiliations: the given authors are understood to share all of the given affiliations. Furthermore each author can possess any number of email, homepage, alternative affiliation, and general thanks.

Following an author group is an optional collaboration specification, which is taken to apply to all of the preceding author groups up to the most recent collaboration specification. A collaboration, like an individual author, can have any number of email, homepage, alternative affiliation, and general thanks.

Author `\author{`<*author name*>`}` Contrary to the usage of the `\author` commands in standard LATEX classes, each author should be specified in a *separate* `\author` command.

You may assist your journal in dealing with unusual names by specifying the author's first name, or, independently, surname:

```
\author{
\firstname{<first-name>}
\surname{<surname>}
}
```

Either one or both may be used. For example:

```
\author{Andrew \surname{Lloyd Weber}}
\author{\firstname{Yo yo} Ma}
```

Note: The command `\and` used in the standard LATEX classes is not supported by this class, and simply generates an error message.

The `\author` command may be followed by any combination of author data commands specifying email address, general URL, alternative affiliation, and "thanks". These commands are all implicitly subsidiary to the immediately preceding `\author` command and may be repeated, if so desired, to give, e.g., multiple email addresses.

Email `\email[`*text*`]{`<*email address*>`}` Specify the electronic mail address of the immediately preceding `\author`. The <*text*> phrase is prepended to the email address. Only the actual address should appear in the argument; the `mailto:` is understood.

Homepage `\homepage[`*text*`]{`<*URL*>`}` Specify a URL for the immediately preceding `\author`. This acts in the same way as `\email`, and may refer to a WWW homepage of an author.

Alternative Address

`\altaffiliation[`<*comment*>`]{`<*address*>`}`

Specify an alternative address for the immediately preceding `\author`. This command produces a footnote with text constructed from the two arguments, so the <*comment*> argument will be something like "Currently at" or "Work undertaken while visiting" or other explanatory text to be placed in front of the address in the footnote.

Thanks `\thanks[`*text*`]{`<*Extra remarks*>`}`

In the standard classes `\thanks` is used inside the argument of `\author`, but in this class `\thanks` must *follow* the `\author` command.

Email addresses, URL's, and alternate affiliations should be typeset with the appropriate command above and *not* with the `\thanks` command. The latter should only be used when the other, more specific, choices are not appropriate.

Affiliation

`\affiliation{`<*affiliation*>`}`

The affiliation (or address) of an author (or group of authors) is specified using this command. All authors given since the previous `\affiliation` command (or the start of the document) will be taken as being at this address.

Some journal classes distinguish between "affiliation", which is usually just the name of the department or institution where the work was undertaken, and "address", which is a full postal address. Currently REVTEX does not make this distinction.

If the `supercriptaddress` option is invoked, affiliations will be numbered in the order they appear in the source file. This order is effectively determined by the order in which the authors are listed, and may not be the desired ordering.

To control the numbering, you may give the `\affiliation` commands *before* any authors are specified. This forces the numbering to follow the order of the listed `\affiliation` commands. The addresses can then be re-specified after the relevant authors. In any case, if an address is specified more than once it is only allocated one number, and, except with the `unsortedaddress` option, it will be typeset once.

Collaboration

`\collaboration{`<*collaboration*>`}` Specify a collaboration applying to all prior author groups up to the most recent `\collaboration`.

This command will work only in the `superscriptaddress` mode. The collaboration name will be typeset within parentheses following the list of authors and can have `\email`, `\homepage`, `\altaffiliation`, and `\thanks`commands associated with it. The `\collaboration` command should be followed by a `\noaffiliation` command.

See Appendix D for examples and more details about author/affiliation data commands.

Table of Contents

As with standard LATEX, you use the `\tableofcontents` command to mark the place in your document where the table of contents is to appear, typically immediately after the `\maketitle` command.

Note that you will have to typeset your document at least three times before the information in the contents is valid:

twice to obtain a contents of the correct number of lines and a third time for the pagination therein to be valid.

If using the `rmp` journal substyle, you see proper indentation on the contents only after the third typesetting run.

5.3 Body Commands

Bibliographies with BibTEX

REVTEX facilitates using BibTEX for compiling the bibliography. During the editorial and production processes, it is useful to be able to extract the bibliographic information to check it against definitive databases. This will allow us to catch errors early in the life of the manuscript and to add hyperlinks so that referees can locate electronic versions of cited papers.

Reference component tagging

`\bibinfo{`<*label*>`}{`<*text*>`}`

The extra tagging is achieved by using a `\bibinfo` command that takes a <*label*> argument to identify what is being tagged. The labels correspond, for the most part, to the field names in a `.bib` file. For instance, the author of a cited paper would be tagged with `\bibinfo{`<*author*>`}` and the journal would be tagged with `\bibinfo{`<*journal*>`}`. The *text* argument contains the corresponding string from the BIBTEX file (suitably processed by BIBTEX of course).

The `\bibinfo` command does not affect the typesetting of the information; rather, it is purely informative. Authors may choose to add the `\bibinfo` commands by hand, but this rapidly becomes tedious. To avoid the tedium, we have created a new REVTEX BibTEX file, `apsrev.bst`. This style file will automatically add the correct `\bibinfo` tagging. Futhermore, the style file has been expanded to handle items like URLs and e-prints which now frequently appear in citations. Authors can now add this information to their `.bib` files in a standard manner.

For more details on the BibTEX style files, please see the manual `revbib.tex`, included with the REVTEX 4 distribution.

Limitations in BibTEX The advantages of BibTEX notwithstanding, there are certain common constructions you cannot readily achieve through its use: multiple references and references with lead-in text. The following `thebibliography` environment illustrates each.

```
\begin{thebibliography}{}
\bibitem[Weinberg and Tomozawa(1966)]{Tom66}
 S. Weinberg,
   \prl{\bf 17}, 616 (1966);
 Y. Tomozawa,
   Nuovo Cimento A {\bf 46}, 707 (1966).
\bibitem[Moravcsik and Noyes(1961)]{Mor61}
 For early developments, see:
  M.J. Moravcsik and H.P. Noyes,
  Ann. Rev. Nucl. Sci.
    {\bf 11}, 95 (1961).
\end{thebibliography}
```

The first item gives two citations under a single `\bibitem`, i.e., a multiple reference. The second gives a reference preceded by lead-in text. In both cases you can achieve the effect only by manually editing the `.bbl` file. The author of BibTEX is Oren Patashnick.

Acknowledgments

If your document has an acknowledgments section, use the `acknowledgments` environment as its container. Depending on the journal substyle, this element may be formatted as an unnumbered section.

Float processing

Environments such as `figure` and `table` (and potentially other similar environments defined by loaded packages or journal options) may be positioned using LATEX's standard float placement algorithm (the default), or they may be held back (using an external file) and set at the end of the document (end floats).

You invoke the commands `\printtables` and `\printfigures` at the end of the document, where you wish the tables and figures to be printed. (Similar to the standard `\printindex` command). The *-form of the respective command begins the figures or table on a new page.

When floats are positioned in the document body by the float placement system, these two commands are silently ignored, so it is always safe to use them and to switch between different journal styles that may change the behavior of the formatter.

If the `\printtables` command is missing, the tables will be printed at the end of the document. Likewise, if `\printfigures` is missing, the figures will be printed at the end of the document. Therefore it is safe to omit these commands as long as you are satisfied with REVTEX's default choices.

If you wish greater control over when the end floats are produced, give the `\printfigures` and `\printtables` commands at the exact location (and in the desired order) you please. You may also use the *-form of the respective command to force a pagebreak.

We recommend that you use explicit `\begin{table}` and `\end{table}` markup in your document (likewise with `longtable` and `figure`). Moreover, if you use the `endfloats` option, or if your chosen journal substyle makes this selection, then you *must* use this explicit markup scheme. In particular, please do *not* follow the practice of defining typing shortcuts for table and figure environments, like

```
\def\bt{\begin{table}}% Incompatible!
\def\et{\end{table}}%
```

Such commands will be incompatible with generating end floats.

Tables

The following commands affect the `table` environment. They do not apply to tables set directly in the text with a `tabular` environment not enclosed in a `table`. They do however apply to `longtable` environments if that environment (from the `longtable` package) is used.

By default, tables are set in a smaller size than the text body (`\small`). The `\squeezetable` declaration makes them smaller (`\scriptsize`).

In general you can locally redefine `\tabbodyfont` to be whatever you like. (`\Huge\color{magenta}` ... ?)

`\footnote` works in table environments, producing the text at the end of the table, not at the bottom of the page (as if the body of the environment were enclosed in a `minipage` environment, which is essentially how this feature is implemented).

Using the `tabular` environment REVTEX introduces three commands to help structure your alignments, `\toprule`, `\colrule`, and `\botrule`; use these commands after the row end (`\\`), similar to `\hline`.

The `\toprule` command starts off your `tabular`, and all table rows down to the `\colrule` are understood to comprise the table column heads. The `\botrule` command comes last in your `tabular`, and all table rows below the `\colrule` command are understood to comprise the table body.

Using the `longtable` package

The REVTEX document class is specifically designed to be compatible with the `longtable` package. If any of your tables is so long as to require setting on multiple pages, you are advised to use that package and its `longtable` environment.

To load the `longtable` package, insert a `\usepackage{longtable}` command in your document preamble.

For more documentation on the `longtable` environment and on the package options of the `longtable` package, please see the documentation thereof at `ftp://ctan.tug.org/macros/latex/required/tools/longtable.dtx` or refer to the LaTeX Companion.

Note that the `longtable` package does not allow use of the `longtable` environment on multicolumn pages. If you prefer to see this limitation lifted, please correspond directly with `mailto:bugs@latex-project.org`.

REVTEX 4 symbols and the `revsymb` package

Symbols made available in earlier versions of REVTEX are defined in a separate package, `revsymb`, so that they may be used with other classes. (This might be useful if, say, copying text from a REVTEX document to a set of slides being produced with a class such as `slides`, `seminar` or `foiltex`.)

The following are defined in this package: `\lambdabar`, `\openone`, `\corresponds`, `\succsim`, `\precsim`, `\lesssim`, `\vereq`, `\gtrsim`, `\tensor`, `\overstar`, `\overdots`, `\overcirc`, `\loarrow`, `\roarrow`. See Section 3 for examples.

Bold Math

The Bold Math (`bm`) package is now the basis for creating bold symbols in math mode. The command `\bm{`<*symbol*>`}` makes `{`<*symbol*>`}` bold in math mode, ensuring that it is the correct size, even in superscripts. If the correct font in the correct size is not available then you get `{`<*symbol*>`}` at the correct size in lightface and LaTeX 2ε will issue a warning that says "`No boldmath typeface in this size` ... ".

`widetext` environment

Text that is too wide to fit the narrow measure of the two-column or galley layouts may be placed in a `widetext` environment by using `\begin{widetext}` and `\end{widetext}`.

In two-column mode, this will temporarily return to one-column mode, balancing the text before the environment into two short columns, and returning to two-column mode after the environment has finished.

In galley mode `widetext` increases the measure allowing the text to extend into the (otherwise empty) space at the right-hand side of the page.

In one-column mode the environment has no effect.

5.4 Using LaTeX packages with REVTEX

LaTeX users often employ add-in software packages in order to use higher-level markup than is available with the standard LaTeX document classes, or to achieve particular formatting within their document.

Such packages are available, for instance, on CTAN at `ftp://ctan.tug.org/tex-archive/macros/latex/required/` and at `ftp://ctan.tug.org/tex-archive/macros/latex/contrib/` or may be available on your distribution media, such as the TeX Live CD-ROM `http://www.tug.org/texlive`.

Some of these packages are automatically loaded by REVTEX when you select certain class options; these are "required" packages (see Section 5.4). They will either be distributed with REVTEX or will be a required part of your LaTeX distribution.

Others are declared to be "compatible" with REVTEX (see Section 5.4); we anticipate your need to use these packages, have tested REVTEX's compatibility with them, and are committed to maintaining compatibility.

Still others are declared to be "deprecated," see Section 5.4; their use with REVTEX is discouraged. A package may be included in this category because it establishes markup that is incompatible with the electronic submissions scheme of the

APS, or because its definitions are incompatible with those of REVTEX (they "break" REVTEX).

The customary way to load a package is through the `\usepackage` command; simply invoke this command just after your `\documentclass` statement. For instance, if you wish to load the `longtable` package, your document preamble might look like:

```
\documentclass{revtex}
\usepackage{longtable}
```

Required packages are automatically loaded by REVTEX on an as-needed basis and do not need an explicit `\usepackage` statement in your document.

Required Packages

In order to use some of the advanced functions in REVTEX 4, you will have to install certain LATEX 2ε packages. Most of these packages are standard in any LATEX 2ε distribution, but some are not. If you have problems obtaining any of these packages, please contact REVTEX support for help.

natbib The `natbib` package, available at `ftp://ctan.tug.org/tex-archive/macros/latex/contrib/supported/natbib/`, provides the general framework for citations and references within REVTEX, regardless of the journal substyle.

You must obtain and install the `natbib` package in order to run REVTEX. Please refer to the package's installation instructions.

Note that `natbib` is loaded by REVTEX itself, so you do not need to put a `\usepackage{natbib}` statement in your document preamble.

graphics/graphicx Graphics inclusion should use the LATEX `graphicx` packages and the standard LATEX command `\includegraphics`. This package is a required component of all LATEX distributions. To load the package, put the line:

```
\usepackage{graphicx}
```

in your document preamble.

Compatible Packages

Of the many packages available for use with LATEX, only a small subset are tested for compatibility with REVTEX, and they are documented in this section. If you encounter a bug stemming from the use of one of these packages in conjunction with any of the APS journals, please contact REVTEX support.

AMS packages REVTEX is compatible with and depends upon the AMS packages `amsfonts`, `amssymb`, and `amsmath`.

array, dcolumn The `array` and `dcolumn` packages are part of LATEX's required suite of packages. REVTEX appears to be compatible with these packages.

longtable
`longtable.sty` is used for large tables that will span more than one page and must be loaded using the `\usepackage` command.

hyperref
`hyperref.sty` is a package by Sebastian Rahtz that is used for putting hypertext links into LATEX 2ε documents. REVTEX 4 has hooks to allow e-mail addresses and URL's to become hyperlinks.

bm (Bold Math)
`bm` is used for creating bold symbols in math mode. It is loaded by using the `\usepackage` command and is distributed with REVTEX 4.

ftnright The `ftnright` package makes adjustments to LATEX's footnote placement such that in a two-column page grid, all footnotes are placed at the bottom of the right-hand column.

We know of no reason why this package should be incompatible with REVTEX, however extensive testing has not been done at this time.

Deprecated Packages

Because the APS does not have control over the functions of packages, it cannot commit to making REVTEX work with all available packages. Furthermore, some packages may establish markup conventions that do not work well with the electronic submissions scheme of the APS. Therefore, the use of certain packages may be deprecated.

multicol The `multicol` package, part of LATEX's required packages, lets you format your document in a multiple-column page grid. Although REVTEX provides native support for a two-column page grid, your requirements may for some reason make it necessary to use `multicol`. If so, please be advised that this package does not allow your single-column floats to be placed: you will have to make them all full-page-width floats (e.g., `figure*` instead of `figure`).

At present we know of no other packages in this category.

6. Troubleshooting and Other Questions

This section is intended to help authors with problems and common questions that arise when using REVTEX.

Question: How do I get lowercase letters in the `\section{`<*title text*>`}` command?

In the APS journal substyles, text in the `\section{`<*title text*>`}` command is automatically set uppercase. For a lowercase letter use `\lowercase{x}`. For example, to use "He" for helium in a `\section{`<*title text*>`}` command, type `H\lowercase{e}` in `{`<*title text*>`}`. This also works in math mode: `$\lowercase{e}^2$` in a `\section{`<*title text*>`}` command will output e^2.

Problem: I am getting error messages from my `\section{`<*title text*>`}`, `\subsection{`<*title text*>`}`, `\subsubsection{`<*title text*>`}`,

`\footnote{<text>}`, or `\caption{<text>}` commands, and I can't understand why!

You may have a so-called "fragile" command in a section heading or caption. This is solved in LaTeX by immediately preceding the fragile command with `\protect`. Some common fragile commands include:

```
\footnote \footnotemark \footnotetext
\nocite
\( \) \[ \] \\
```

as well as any command with an optional argument. Moreover, `\verb` must *never* appear in the argument of any command.

If you have one of these commands, or another fragile command (check *LaTeX User's Guide & Reference Manual*), precede it with `\protect` and try running the file again. For example, if you have

```
\section{The result:\\Results in an error!}%
```

change it to

```
\section{The result:\protect\\This is OK.}%
```

Problem: I have tables that do not fit into the preprint width.

Try putting the `\squeezetable` command right after the `\begin{table}` command. This will reduce the size of the type in the body of the table, thus allowing more data to fit.

Problem: TeX (or my device driver) runs out of font space.

Try removing the `amsfonts` and `amssymb` class options. TeX implementations vary, and some implementations will be unable to provide the resources needed to run these options.

Problem: TeX runs out of string space (`pool_size` is too small).

Remove the `amssymb` class option. It defines hundreds of symbol names. Some TeX implementations will be unable to provide the resources needed to run this option.

Problem: (a) The text immediately following an equation is "outdented". That is, indented into the margin. (b) I get a `missing` error in the references, but the input is OK. If I let TeX run through, the output is OK, too.

REVTeX is having a bad interaction with an older version of LaTeX. Upgrading to a newer LaTeX has cured these problems in the past.

Problem: One (or more) of my equations is being cross-referenced incorrectly.

Make sure that you have run LaTeX at least twice since the equation numbering was last disturbed by an input change. Also note that incorrect cross-referencing will result if `\label{<key>}` is used in an unnumbered single line equation (i.e., within the `\[` and `\]` commands), or if `\label{<key>}` is used on a line of an eqnarray that is not being numbered (i.e., a line that has a `\nonumber`).

Problem: I get a LaTeX message at the end of the run that tells me that the references may have changed, no matter how many times I run LaTeX.

Make sure that you have not used the same tag to label two different things. This will produce this effect, but will also produce a warning during the run and is therefore easy to detect. Also make sure that you have not used the same tag for two different `\bibitem`s. That is, make sure that two different `\bibitem{<key>}` commands do not use the same text for `{<key>}`. You will probably *not* get a warning for this, so this a more subtle error.

7. The Compuscript Program

The bright promise of REVTeX is, of course, that your electronic document can qualify for the compuscript program of a participating journal. This manual does not attempt to cover any aspects of such programs except to encourage you to ensure that your document's markup is of the highest quality.

You may obtain further information about the compuscript program of the American Physical Society at `http://publish.aps.org/ESUB/`, the American Institute of Physics at `http://www.aip.org`, the Optical Society of America at `http://www.osa.org`, the Society of Exploration Geologists at `http://www.seg.org`.

8. Contact Information

Should you find any bugs, problems or inconsistencies, contact REVTeX support at `mailto:revtex4@aps.org`. Please try to include information on what you were doing at the time and if possible, a small sample document that manifests the problem.

References

† REVTeX 3.1 portions by APS; V4 notes by David Carlisle (mailto:david@carlisle.demon.co.uk), March 31, 1999; V4 guide by Arthur Ogawa (mailto:ogawa@teleport.com)

[1] Knuth, D.E., *The TeXbook*, Addison Wesley Longman, 1986.

[2] Lamport, L., *LaTeX, a Document Preparation System*, Addison Wesley Longman, 1996.

[3] Goossens, M. et al., *The LaTeX Companion*, Addison Wesley Longman, 1994.

[4] Goossens, M. et al., *The LaTeX Graphics Companion*, Addison Wesley Longman, 1997.

[5] Rahtz, S. et al., *The LaTeX Web Companion*, Addison Wesley Longman, 1999.

Appendix A: Differences From REVTeX 3.1

If you are already an experienced user of REVTeX version 3.1 under LaTeX 2ε, and have installed REVTeX 4, you can immediately start using the new system. Please take note of the following differences

1 Platform Required

REVTeX 4 works solely with LaTeX 2ε; it is not useable as a LaTeX2.09 package. Furthermore, REVTeX 4 requires an up-to-date LaTeX installation (1996/06/01 or later); its use under older versions is not supported.

2 Markup Differences

Documentation of REVTEX 3.1 (ftp://aps.org/revtex/manend.tex) mentions a number of commands particular to that document style (that is, extensions to the LATEX article style). Some of these commands have changed, as noted in Table II, and new extensions to the LATEX 2ε article class have been introduced with REVTEX 4. Furthermore, REVTEX 4 uses certain LATEX commands in a different way than in the `article` class. These are also noted in Section C.

In any case, simply making the transition from using the `article` document style under LATEX2.09 to using the `article` document class under LATEX 2ε mandates changes to your legacy document. You are responsible for such required changes; see Appendix D of the *LATEX User's Guide & Reference Manual* for details.

Appendix B: Converting a REVTEX 3.1 Document to REVTEX 4

To convert a REVTEX 3 document to one compatible with REVTEX 4, carry out the following actions:

- Change `\documentstyle{revtex}` to `\documentclass{revtex4}`, and run the document under LATEX 2ε instead of LATEX2.09.
- If your document used the `preprint` option, you must invoke both the `preprint` and `endfloats` options.
- Replace the `\draft` command with the `draft` class option.
- Replace the `\tighten` command with the `tightenlines` class option.
- For each `\author` command, split the multiple authors into individual `\author` commands. Remove any instances of `\and`.
- Use `\affiliation` instead of `\address`.
- Move `\maketitle` downstream of all `\pacs` commands and downstream of any `abstract` environment instance.
- Convert `quasitable` to `longtable`, and load the `longtable` package.
- If your document used the `\widetext` and `\narrowtext` commands, change these to instances of the `widetext` environment. Usually, the `\begin{widetext}` statement will replace the `\widetext` command, and the `\end{widetext}` statement replaces the matching `\narrowtext` command.

  Note in this connection that due to a curious feature of LATEX itself, REVTEX 4 having a `widetext` environment means that it also has a definition for the `\widetext` command, even though the latter cammand is not intended to be used in your document. Therefore, it is particularly important that you remove all `\widetext` commands from your REVTEX 3 document when converting to REVTEX 4.
- Remove all obsolete commands: `\FL`, `\FR`, `\narrowtext`, and `\mediumtext` (see Table II).
- Replace `\case` with `\frac`. If you need the fraction to be set in text style despite being in a display equation, use the construction `\textstyle\frac`. Note that `\frac` does not support the syntax `\case1/2`.
- Replace `\slantfrac` with `\frac`.
- Change `\frak` to `\mathfrak{`<*char*>`}` and `\Bbb` to `\mathbb{`<*char*>`}`, and invoke one of the class options `amsfonts` or `amssymb`.
- Replace environment `mathletters` with environment `subequations` and load the `amsmath` package.
- Replace `\eqnum` with `\tag` and load the `amsmath` package.
- Replace `\bbox` with `\bm` and load the `bm` package.
- If using the `\text` command, load the `amsmath` package.
- If using the `d` column specifier in `tabular` environments, load the `dcolumn` package, and be aware that the content of each cell in the column is implicitly in math mode: remove any `$` math shift characters appearing in a `d` column.
- Replace `\tablenote` with `\footnote`, `\tablenotemark` with `\footnotemark`, and `\tablenotetext` with `\footnotetext`.
- Replace `\begin{references}` with `\begin{thebibliography}{}`; `\end{references}` with `\end{thebibliography}`.

Appendix C: Differences between REVTEX 4 and the standard LATEX article class

If you are familiar with the standard LATEX `article` document class, you will find that REVTEX provides a familiar environment in which to prepare your article. However, REVTEX is different from the `article` class, as noted here.

In some respects, REVTEX simply extends the `article` class the same way many users do: it incorporates packages from among the LATEX required suite of packages, such as the AMS-authored packages `amsfonts`, `amssymb`, and `amsmath`. These packages introduce the ability to typeset many math symbols not otherwise available to LATEX. The `amsmath` package provides the `subequations` environment and the the `\tag` command.

Other packages from the the required suite of LATEX packages include `bm`, which gives access to bold math through the `\bm` command; and `longtable`, which lets you create tables that can break over pages.

In other respects, REVTEX simply extends the `article` class. It defines new class options, such as the many journal substyles, and defines its own new math symbols, such as `\tensor`, and it defines new commands, such as

REVTEX 3.1 command	**REVTEX 4 replacement**
`\documentstyle[`<*options*>`]{revtex}`	`\documentclass[`<*options*>`]{revtex4}`
option `aps`	is now the default
options `aps`, `osa`, `seg`	the society is now implied by the selection of the journal
option `manuscript`	`preprint`
`\tighten` preamble command	`tightenlines` class option
`\draft` preamble command	`draft` class option
`\title`	`\title` can take an optional argument signifying an alternative title
`\author`	`\author{`<*name*>`}` may appear multiple times; each signifies a new author name.
	`\lastname{`<*surname*>`}` lets you mark up the author's surname
	`\firstname{`<*firstname*>`}` lets you mark up the author's first name
	`\homepage{`<*URL*>`}` gives a URL for the above author
	`\email{`<*email*>`}` gives an email address for the above author
`\and`	obsolete, remove this command
`\address`	`\affiliation{`<*institution*>`}` gives the affiliation for the group of authors above
	`\affiliation[`<*note*>`]` lets you specify a footnote to this institution
	`\noaffiliation` signifies that the above authors have no affiliation
`\altaddress`	`\altaffiliation`; applies to a single `\author`
`\preprint`	`\preprint{`<*number*>`}` can appear multiple times, and must precede `\maketitle`
`\pacs`	`\pacs` must precede `\maketitle`
`abstract` environment	`abstract` environment must precede `\maketitle`
`\maketitle`	`\maketitle` must follow *all* frontmatter data commands
`\narrowtext`	obsolete, remove this command
`\mediumtext`	obsolete, remove this command
`\widetext`	obsolete, replace with `widetext` environment
`\FL`	obsolete, remove this command
`\FR`	obsolete, remove this command
`\eqnum`	replace with `\tag`, load `amsmath`
`mathletters`	replace with `subequations`, load `amsmath`
`quasitable` environment	replace with `longtable`, load `longtable`
`references` environment	replace with `thebibliography{}`
`\case`	replace with `\textstyle\frac`
`\slantfrac`	replace with `\frac`
`\tablenote`	replace with `\footnote`
`\tablenotemark`	replace with `\footnotemark`
`\tablenotetext`	replace with `\footnotetext`

TABLE II: Differences between REVTEX 3.1 and REVTEX 4 markup

`\bibinfo`, that let you mark up your document in a way that enhances its value as an electronic document.

However, using REVTEX will also force you to relearn certain commands and environments, such as the new markup rules for your frontmatter and bibliography. In these incompatible extensions to the standard `article` class, REVTEX either gives you a somewhat more convenient way of marking up your paper, or gives you the ability to do something that is not provided for in the standard `article` class.

- The document class declaration is different: the document class is `revtex4`.

  There is a class option for each APS journal (they are collectively called "journal substyles"): `pra`, `prb`, `prc`, `prd`, `pre`, `prl`, `prstab`, and `rmp` for *Physical Review A*, *B*, *C*, *D*, *E*, *Letters*, *Special Topics—Accelerators and Beams*, and *Reviews of Modern Physics*, respectively. The chosen journal substyle may in turn make default selections of a number of class options; an explicit document class option always overrides this.

  New class options are `eqsecnum` (number equations by section), `preprint` (double-spaced output for submission purposes), `tightenlines` (single-spaced output with the preprint option), and `amsfonts` and `amssymb` (extra font capabilities, see Sec. 4.13).

  The `prb` option gives superscript reference citations, as is the style for *Physical Review B*. The `prl` option yields a slightly different line spacing, giving more accurate PRL length estimates. Apart than this, there are no substantial differences between the substyles for *Physical Review A–E*.

  The `floats` class option enables LATEX-style floating figures and tables. The `endfloats` option causes floating elements to be formatted at the end of the document.

  The `twocolumn` class option causes the document to be formatted in a two-column layout; `onecolumn` in a one-column layout.

- The frontmatter is different in REVTEX; a simple one might look like (cf. `template.aps`)

```
\documentclass[draft,pra,aps]{revtex4}
\begin{document}
\title{Title here}
\author{Author(s) here}
 \affiliation{Address(es) here}
\author{Another author(s) here}
 \affiliation{Another address(es) here}
\date{\today}
\begin{abstract}
Abstract here.
\end{abstract}
\pacs{PACS numbers here}
\maketitle
```

  Note the `\affiliation{`<*text*>`}`, and `\pacs{`<*pacs number*>`}` commands are new, and the `\maketitle` command *follows* the `abstract`. Also, each author appears in a separate `\author` command; the `\and` command is not used. See Sec. 4.2 for details.

- Figures and tables are input the same as in LATEX, however, with the `endfloats` option they are automatically moved to the end of the document; see Sections 5.1 and 5.3 for more details.

- The `\text{`<*text*>`}` command formats <*text*> in text mode within math. In particular, you get hyphens instead of minus signs. Used in a superscript, you get the correct size. See Sec. 4.6.

- Using a `\label{`<*key*>`}` within the `\begin{subequations}` environment allows you to reference the *general* number of the equations in the `subequations` environment. For example:

```
\begin{subequations}
 \label{alleqs}  % observe location
 \begin{eqnarray}
  E    & = &mc^{2},\label{eqa}\\
  c^{2}& = &a^{2} + b^{2},\label{eqb}\\
  E    & = &m(a^{2} + b^{2}),\label{eqc}
 \end{eqnarray}
\end{subequations}
```

  gives the output

$$E = mc^2, \tag{C1a}$$
$$c^2 = a^2 + b^2, \tag{C1b}$$
$$E = m(a^2 + b^2), \tag{C1c}$$

  and `Eq.\ (\ref{alleqs})` gives "Eq. (C1)".

- Using `d` in a tabular specification creates a column centered on the decimal points of the entries. See Sec. 4.11 for details; see `apssamp.tex` for examples.

- These additional diacritics are available: `\tensor` (double-headed overarrow), `\overdots` (triple overdots), `\overstar` (star), `\overcirc` (circle), `\loarrow` (left-going overarrow), and `\roarrow` (right-going overarrow). They scale correctly in superscripts. See Appendix F for examples.

- Style files for use with BIBTEX are bundled with the various journal substyles. The journal substyle automatically issues the needed `\bibliographystyle` command.

- If you wish to specify your own bibliography style, you do so with the `\bibliographystyle` command, but unlike standard LATEX, you must give this command *before* the `\begin{document}` statement.

- For hand-prepared bibliographies, `reftest.tex` checks that your document has (1) no uncited bibitems, (2) no undefined citations, and (3) its `\bibitem`s in the same order as its citations. See Sec. 4.9.

The American Physical Society intends for REVTEX to be as compatible as possible with LATEX and with packages that can be used with LATEX. Please let us know of any LATEX commands incompatible with REVTEX, or of any packages useable with the LATEX article class that are incompatible with REVTEX.

APPENDIX D: SPECIFYING AUTHORS AND AFFILIATIONS

This section provides more detail on how to specify authors and affiliations for your document, and shows how to obtain various title block formatting effects with the class options.

The following examples exhibit a representative cross section of frontmatter blocks. They are taken from actual journal papers; the journal involved is indicated.

[to come]

APPENDIX E: ADDING NEW JOURNAL STYLES

Earlier versions of REVTEX provided formatting for a large group of societies and journals. REVTEX 4 establishes a new, open architecture for adding journal substyles.

To add a new journal substyle to REVTEX: Create a file with a `.rtx` extension and put into it whatever macro definitions or parameter assignments are required. To use the journal substyle, your document should invoke a corresponding document class option, causing your `.rtx` file to be read in.

For instance, in the case of a fictitious publication called the "Journal of Irreproducible Results", you could create a file called `jir.rtx` and invoke that substyle via a `\documentclass` statement like

```
\documentclass[jir]{revtex4}
```

To create a useful substyle `.rtx` file, you might want to use as a model the American Physical Society substyle `aps.rtx`.

Notes:

- Journal substyles should ideally not create new markup syntax. All document-level environments and commands should be defined in REVTEX itself.

  If your journal requires markup (compuscript structure) that goes beyond that supplied by REVTEX, please contact the maintainers of REVTEX.

- The file `aps.rtx` has specific code at the beginning that insists on being run under REVTEX; your substyle should do likewise.

- Your journal substyle, like `aps.rtx`, is read in after all of the code of the `revtex.cls`; it can depend on all of the definitions in that file to be in effect, and can redefine them as needed.

TABLE III: Text accents with letter a.

à `\'{a}`	á `\'{a}`	â `\^{a}`	ä `\"{a}`
ã `\~{a}`	ā `\={a}`	ȧ `\.{a}`	ă `\u{a}`
ǎ `\v{a}`	ȁ `\H{a}`	a͡a `\t{aa}`	ą `\c{a}`
ạ `\d{a}`	a̱ `\b{a}`		

TABLE IV: Math accents with letter a.

$\hat{a}$ `\hat{a}`	$\check{a}$ `\check{a}`	$\dot{a}$ `\dot{a}`	$\ddot{a}$ `\ddot{a}`
$\breve{a}$ `\breve{a}`	$\tilde{a}$ `\tilde{a}`	$\grave{a}$ `\grave{a}`	$\acute{a}$ `\acute{a}`
$\bar{a}$ `\bar{a}`	$\vec{a}$ `\vec{a}`		

- Your journal substyle, like `aps.rtx`, can invoke certain formatting options, but may do so only if the document's options do not specify a preference: the document's options must override any choices made by the journal substyle.

- In some cases, journal-specifc code is sufficiently extensive that it is useful to break it out into a separate file, as in the case of `rmp.rtx`. This file has code that insists that it run under `aps.rtx`; your journal-specific substyle should do likewise.

- Hint: If your journal style has no head above the abstract, you can simply define the procedure `\frontmatter@abstractheading` to do nothing:

  ```
  \def\frontmatter@abstractheading{}%
  ```

- If the journal involved has a compuscript program whose requirements bear on documents prepared according to your journal substyle, the documentation for your substyle should include those requirements (or a pointer to them).

APPENDIX F: CHARACTER SET LISTING

This appendix provides tables showing all of the special characters and mathematical symbols that are available within REVTEX. Some of these symbols require the AMS fonts to be available.

If you are preparing a paper for submission to a journal, you should check that journal's preferences in using special symbols. Typically, a journal will prefer that you use a symbol command taken from the following lists and will deprecate your inventing new command names.

1 LATEXNOTATIONS

Standard LATEXsymbols

Tables III through XIV show the standard symbols for LATEX users.

Negated relations can sometimes be constructed with `\not`. For example,

```
If $x \not< y$ then $x \not\leq z$.
```

TABLE V: Special symbols; any mode.

†	\dagger	§	\S
‡	\ddagger	¶	\P
©	\copyright	£	\pounds

TABLE VI: Other special (foreign) symbols; text mode.

å	\aa	Å	\AA	æ	\ae	Æ	\AE
ø	\o	Ø	\O	œ	\oe	Œ	\OE
ł	\l	Ł	\L	¿	?‘	¡	!‘
ß	\ss						

TABLE VII: Greek letters; used in math mode.

Lowercase

α	\alpha	β	\beta	γ	\gamma	δ	\delta
ε	\epsilon	ε	\varepsilon	ζ	\zeta	η	\eta
θ	\theta	ϑ	\vartheta	ι	\iota	κ	\kappa
λ	\lambda	μ	\mu	ν	\nu	ξ	\xi
o	o	π	\pi	ϖ	\varpi	ρ	\rho
ϱ	\varrho	σ	\sigma	ς	\varsigma	τ	\tau
υ	\upsilon	ϕ	\phi	φ	\varphi	χ	\chi
ψ	\psi	ω	\omega				

Uppercase

Γ	\Gamma	Δ	\Delta	Θ	\Theta	Λ	\Lambda
Ξ	\Xi	Π	\Pi	Σ	\Sigma	Υ	\Upsilon
Φ	\Phi	Ψ	\Psi	Ω	\Omega		

TABLE VIII: Binary operation symbols; used in math mode.

$+$	\pm	$\mp$	\mp	$\times$	\times	$\div$	\div
$*$	\ast	$\star$	\star	$\circ$	\circ	$\bullet$	\bullet
$\cap$	\cap	$\cup$	\cup	$\uplus$	\uplus	$\cdot$	\cdot
$\sqcap$	\sqcap	$\sqcup$	\sqcup	$\vee$	\vee	$\wedge$	\wedge
$\oplus$	\oplus	$\ominus$	\ominus	$\otimes$	\otimes	$\oslash$	\oslash
$\bigtriangleup$	\bigtriangleup	$\odot$	\odot	$\lhd$	\lhd	$\dagger$	\dagger
$\bigtriangledown$	\bigtriangledown	$\bigcirc$	\bigcirc	$\rhd$	\rhd	$\ddagger$	\ddagger
$\triangleleft$	\triangleleft	$\diamond$	\diamond	$\unlhd$	\unlhd	$\setminus$	\setminus
$\triangleright$	\triangleright	$\wr$	\wr	$\unrhd$	\unrhd	$\amalg$	\amalg

TABLE IX: Relation symbols; used in math mode.

$\leq$	\leq	$\geq$	\geq	$\ll$	\ll	$\gg$	\gg
$\equiv$	\equiv	$\asymp$	\asymp	$\neq$	\neq	$\doteq$	\doteq
$\subset$	\subset	$\supset$	\supset	$\subseteq$	\subseteq	$\supseteq$	\supseteq
$\sqsubset$	\sqsubset	$\sqsupset$	\sqsupset	$\sqsubseteq$	\sqsubseteq	$\sqsupseteq$	\sqsupseteq
$\models$	\models	$\perp$	\perp	$\mid$	\mid	$\parallel$	\parallel
$\prec$	\prec	$\succ$	\succ	$\preceq$	\preceq	$\succeq$	\succeq
$\sim$	\sim	$\simeq$	\simeq	$\approx$	\approx	$\cong$	\cong
$\bowtie$	\bowtie	$\Join$	\Join	$\smile$	\smile	$\frown$	\frown
$\in$	\in	$\ni$	\ni	$\vdash$	\vdash	$\dashv$	\dashv
$\propto$	\propto						

TABLE X: Arrow symbols; used in math mode.

$\leftarrow$	\leftarrow	$\rightarrow$	\rightarrow
$\longleftarrow$	\longleftarrow	$\longrightarrow$	\longrightarrow
$\Leftarrow$	\Leftarrow	$\Rightarrow$	\Rightarrow
$\Longleftarrow$	\Longleftarrow	$\Longrightarrow$	\Longrightarrow
$\hookleftarrow$	\hookleftarrow	$\hookrightarrow$	\hookrightarrow
$\leftharpoonup$	\leftharpoonup	$\rightharpoonup$	\rightharpoonup
$\leftharpoondown$	\leftharpoondown	$\rightharpoondown$	\rightharpoondown
$\rightleftharpoons$	\rightleftharpoons	$\rightsquigarrow$	\leadsto
$\leftrightarrow$	\leftrightarrow	$\longleftrightarrow$	\longleftrightarrow
$\Leftrightarrow$	\Leftrightarrow	$\Longleftrightarrow$	\Longleftrightarrow
$\mapsto$	\mapsto	$\longmapsto$	\longmapsto
$\uparrow$	\uparrow		
$\downarrow$	\downarrow		
$\Uparrow$	\Uparrow		
$\Downarrow$	\Downarrow		
$\updownarrow$	\updownarrow		
$\Updownarrow$	\Updownarrow		
$\nearrow$	\nearrow		
$\searrow$	\searrow		
$\swarrow$	\swarrow		
$\nwarrow$	\nwarrow		

TABLE XI: Miscellaneous symbols; used in math mode.

$\flat$	\flat	$\natural$	\natural	$\sharp$	\sharp	$\prime$	\prime
$\backslash$	\backslash	$\forall$	\forall	∞	\infty	$\exists$	\exists
$\emptyset$	\emptyset	$\square$	\Box	∇	\nabla	$\neg$	\neg
$\diamond$	\Diamond	$\surd$	\surd	$\triangle$	\triangle	$\|$	\\|
$\clubsuit$	\clubsuit	$\aleph$	\aleph	$\wp$	\wp	$\top$	\top
$\diamondsuit$	\diamondsuit	$\Re$	\Re	ℓ	\ell	$\bot$	\bot
$\heartsuit$	\heartsuit	$\Im$	\Im	$\imath$	\imath	∂	\partial
$\spadesuit$	\spadesuit	$\hbar$	\hbar	$\jmath$	\jmath	$\angle$	\angle
$\mho$	\mho						

gives

If $x \not< y$ then $x \not\leq z$.

The AMS fonts have many negated relations already constructed. See Appendix 2.

Standard LaTeX typefaces

LaTeX provides a pair of special typefaces, `\mathcal` and `\mathsf`.

TABLE XII: Log-like functions; used in math mode (for example, `\log x` gives $\log x$).

\arccos	\arcsin	\arctan	\arg	\cos
\cosh	\cot	\coth	\csc	\deg
\det	\dim	\exp	\gcd	\hom
\inf	\ker	\lg	\lim	\liminf
\limsup	\ln	\log	\max	\min
\Pr	\sec	\sin	\sinh	\sup
\tan	\tanh			

TABLE XIII: Delimiters; used in math mode.

$($	`(`	$)$	`)`	$/$	`/`
$[$	`[`	$]$	`]`	$\backslash$	`\backslash`
$\{$	`\{`	$\}$	`\}`	$\vert$	`|`
$\langle$	`\langle`	$\rangle$	`\rangle`	$\Vert$	`\\|`
$\uparrow$	`\uparrow`	$\Uparrow$	`\Uparrow`	$\lfloor$	`\lfloor`
$\downarrow$	`\downarrow`	$\Downarrow$	`\Downarrow`	$\rfloor$	`\rfloor`
$\updownarrow$	`\updownarrow`	$\Updownarrow$	`\Updownarrow`	$\lceil$	`\lceil`
				$\rceil$	`\rceil`

TABLE XIV: Miscellaneous symbols; used in math mode.

Σ $\sum$	`\sum`	Π $\prod$	`\prod`	$\coprod$	`\coprod`
$\int$ $\int$	`\int`	$\oint$ $\oint$	`\oint`	$\biguplus$ $\biguplus$	`\biguplus`
$\cap$ $\bigcap$	`\bigcap`	$\cup$ $\bigcup$	`\bigcup`	$\sqcup$ $\bigsqcup$	`\bigsqcup`
$\odot$ $\bigodot$	`\bigodot`	$\otimes$ $\bigotimes$	`\bigotimes`	$\oplus$ $\bigoplus$	`\bigoplus`
$\vee$ $\bigvee$	`\bigvee`	$\wedge$ $\bigwedge$	`\bigwedge`		

Use the `\mathcal` command for script (calligraphic) letters (note the $\mathcal{L}$):

```
\mathcal{L}_{\mathrm{int}} = e F^{3}_{\pi} r^{2}
  B^{0}(r,t) \epsilon \sin(\Omega t)
  \exp(\eta t),
```

gives

$$\mathcal{L}_{\mathrm{int}} = eF_{\pi}^{3}r^{2}B^{0}(r,t)\epsilon\sin(\Omega t)\exp(\eta t),$$

Only uppercase letters are available in the `\mathcal` font.

You can switch to sans serif letters by using the `\mathsf` command (note the M):

```
R(\mathcal{Q}-\mathcal{Q}_{0})
=
R_{0} \exp\left(-\frac{1}{2}\Delta \mathcal{Q}
\cdot \Delta \mathcal{Q}\right).
```

gives

$$R(\mathcal{Q}-\mathcal{Q}_{0}) = R_{0}\exp\left(-\frac{1}{2}\Delta\mathcal{Q}\cdot\mathsf{M}\cdot\Delta\mathcal{Q}\right).$$

Both uppercase and lowercase letters are available with `\mathsf`.

Other notations

The `\overline` command puts a horizontal line above its argument in math mode:

```
$\overline{x}+\overline{y}$
```

gives

$$\overline{x}+\overline{y}$$

There is an analogous `\underline` command that works in text or math mode:

```
The equation \underline{is} $\underline{x+y}$.
```

gives

The equation $\underline{\text{is}}$ $\underline{x+y}$.

Horizontal braces are put above or below an expression with the `\overbrace` and `\underbrace` commands:

```
\[
\underbrace{a_{1} + \overbrace{a_{2}+a_{3}} + a
\]
```

gives

$$\underbrace{a_{1} + \overbrace{a_{2} + a_{3}} + a_{4}}$$

and in displayed math, a subscript or a superscript puts a label on the brace:

```
\[
\underbrace{
 a_{1} + \overbrace{a_{2}+\cdots+a_{n-1}}^{n-2}
 + a_{n}
}_{n}
\]
```

gives

$$\underbrace{a_{1} + \overbrace{a_{2} + \cdots + a_{n-1}}^{n-2} + a_{n}}_{n}$$

Wide versions of the `\hat` and `\tilde` commands are available. They are called `\widehat` and `\widetilde`, respectively. Here is an example:

```
\[
\widehat{a} + \widehat{ab} + \widehat{abc} + \w
```

gives

$$\widehat{a} + \widehat{ab} + \widehat{abc} + \widehat{abcd}$$

2 AMS FONTS NOTATIONS

The AMS fonts are fonts that were developed by the American Mathematical Society and are now made available free of charge by the AMS. The METAFONT source files for these fonts are freely available, as are precompiled `.pk` files and ATM-compatible Type 1 PostScript fonts. There are two class options that can be used to invoke the AMS fonts: `amsfonts` and `amssymb`. Not distributed with REVTEX are the files `amsfonts.sty` and `amssymb.sty` of the $\mathcal{A}\mathcal{M}\mathcal{S}$-LaTeX distribution.

Using the `amsfonts` option

The `amsfonts` class option will give you access to the `\mathfrak` and `\mathbb` fonts and will also use the extra

TABLE XV: Extra lowercase Greek letters available with amssymb option selected.

$\digamma$	\digamma	$\varkappa$	\varkappa

TABLE XVI: Extra Hebrew letters available with amssymb selected.

$\beth$	\beth	$\gimel$	\gimel
$\daleth$	\daleth		

Computer Modern fonts from the AMS in order to provide better access to bold math characters at smaller sizes and in super- and subscripts.

AMS fonts typefaces. With the AMS fonts installed and in use through either the amsfonts or amssymb class option, the \mathfrak and \mathbb commands are available. The command \mathfrak switches to the AMS Fraktur font, while \mathbb switches to the so-called "Blackboard Bold" font. Only uppercase letters are available in Blackboard Bold, and there is no bold version of the font. Fraktur has both uppercase and lowercase letters and will become bold in a \bbox.

Here are the letters "ABCDE" from \mathfrak: $\mathfrak{ABCDE}$. And here are the letters "RIZN" from \mathbb: $\mathbb{RIZN}$.

Here is some math with superscripts and \mathfrak. It demonstrates the output of \bm{<*symbol*>}.

Normal: $\mathfrak{E} = mc^{2\pi}$, \bm: $\boldsymbol{\mathfrak{E}} = mc^{2\boldsymbol{\pi}}$

Using the amssymb *option*

The amssymb class option gives all the font capabilities of the amsfonts option. It also defines names for many extra symbols that are present in the AMS fonts. The names are the same as those the AMS uses. These symbols and their names are shown below, given that you have the AMS fonts installed and the amssymb option selected.

Please be aware that no bold versions are available for any of the characters in this subsection.

3 REVTEX NOTATIONS

An openface numeral "1" is available; it does not change size in superscripts. Here is an example: $\openone$ gives $\mathbb{1}$.

Bold large bracketing is also available. The normal commands \Biggl,\Bigl,..., when used with an extra "b" on the end of the command, come out bold:

```
\[
\Biggl(\biggl(\Bigl(\bigl(
(x)
\bigr)\Bigr)\biggr)\Biggr)
\]
```

TABLE XVII: Binary relations available with amssymb selected.

$\leqq$	\leqq	$\geqq$	\geqq
$\leqslant$	\leqslant	$\geqslant$	\geqslant
$\eqslantless$	\eqslantless	$\eqslantgtr$	\eqslantgtr
$\lesssim$	\lesssim	$\gtrsim$	\gtrsim
$\lessapprox$	\lessapprox	$\gtrapprox$	\gtrapprox
$\approx$	\approx		
$\lessdot$	\lessdot	$\gtrdot$	\gtrdot
$\lll$, $\llless$	\lll, \llless	$\ggg$, $\gggtr$	\ggg, \gggtr
$\lesseqgtr$	\lessgtr	$\gtrless$	\gtrless
$\lesseqgtr$	\lesseqgtr	$\gtreqless$	\gtreqless
$\lesseqgtr$	\lesseqgtr	$\gtreqless$	\gtreqless
$\preccurlyeq$	\preccurlyeq	$\succcurlyeq$	\succcurlyeq
$\curlyeqprec$	\curlyeqprec	$\curlyeqsucc$	\curlyeqsucc
$\precsim$	\precsim	$\succsim$	\succsim
$\precapprox$	\precapprox	$\succapprox$	\succapprox
$\subseteqq$	\subseteqq	$\supseteqq$	\supseteqq
$\Subset$	\Subset	$\Supset$	\Supset
$\sqsubset$	\sqsubset	$\sqsupset$	\sqsupset
$\backsim$	\backsim	$\thicksim$	\thicksim
$\backsimeq$	\backsimeq	$\thickapprox$	\thickapprox
$\doteqdot$, $\Doteq$	\doteqdot, \Doteq	$\eqcirc$	\eqcirc
$\risingdotseq$	\risingdotseq	$\circeq$	\circeq
$\fallingdotseq$	\fallingdotseq	$\triangleq$	\triangleq
$\vartriangleleft$	\vartriangleleft	$\vartriangleright$	\vartriangleright
$\trianglelefteq$	\trianglelefteq	$\trianglerighteq$	\trianglerighteq
$\vDash$	\vDash	$\Vdash$	\Vdash
$\Vvdash$	\Vvdash		
$\smallsmile$	\smallsmile	$\smallfrown$	\smallfrown
$\shortmid$	\shortmid	$\shortparallel$	\shortparallel
$\bumpeq$	\bumpeq	$\Bumpeq$	\Bumpeq
$\between$	\between	$\pitchfork$	\pitchfork

TABLE XVIII: Miscellaneous symbols available with amssymb selected.

$\hbar$	\hbar	$\hslash$	\hslash
$\backprime$	\backprime	$\varnothing$	\varnothing
$\triangle$	\triangle	$\blacktriangle$	\blacktriangle
$\triangledown$	\triangledown	$\blacktriangledown$	\blacktriangledown
$\square$	\square	$\blacksquare$	\blacksquare
$\lozenge$	\lozenge	$\blacklozenge$	\blacklozenge
$\circledS$	\circledS	$\bigstar$	\bigstar
$\angle$	\angle	$\sphericalangle$	\sphericalangle
$\measuredangle$	\measuredangle		
$\nexists$	\nexists	$\complement$	\complement
$\mho$	\mho	$\eth$	\eth
$\Finv$	\Finv	$\Game$	\Game
$\diagup$	\diagup	$\diagdown$	\diagdown
$\Bbbk$	\Bbbk		

TABLE XIX: Binary operators available with amssymb selected.

$\dotplus$	\dotplus	$\ltimes$	\ltimes
$\smallsetminus$	\smallsetminus	$\rtimes$	\rtimes
$\barwedge$	\barwedge	$\curlywedge$	\curlywedge
$\veebar$	\veebar	$\curlyvee$	\curlyvee
$\doublebarwedge$	\doublebarwedge		
$\Cap$, $\doublecap$	\Cap, \doublecap	$\leftthreetimes$	\leftthreetimes
$\Cup$, $\doublecup$	\Cup, \doublecup	$\rightthreetimes$	\rightthreetimes
$\boxtimes$	\boxtimes	$\circledast$	\circledast
$\boxminus$	\boxminus	$\circleddash$	\circleddash
$\boxplus$	\boxplus	$\centerdot$	\centerdot
$\boxdot$	\boxdot	$\circledcirc$	\circledcirc
$\divideontimes$	\divideontimes	$\intercal$	\intercal

TABLE XX: Other miscellaneous symbols available with amssymb selected.

$\propto$	\varpropto	$\ni$	\backepsilon
$\blacktriangleleft$	\blacktriangleleft	$\blacktriangleright$	\blacktriangleright
$\therefore$	\therefore	$\because$	\because

TABLE XXI: Negated relations available with amssymb selected.

$\nsim$	\nsim	$\ncong$	\ncong
$\nless$	\nless	$\ngtr$	\ngtr
$\nleq$	\nleq	$\ngeq$	\ngeq
$\nleqslant$	\nleqslant	$\ngeqslant$	\ngeqslant
$\nleqq$	\nleqq	$\ngeqq$	\ngeqq
$\lneq$	\lneq	$\gneq$	\gneq
$\lneqq$	\lneqq	$\gneqq$	\gneqq
$\lvertneqq$	\lvertneqq	$\gvertneqq$	\gvertneqq
$\lnsim$	\lnsim	$\gnsim$	\gnsim
$\lnapprox$	\lnapprox	$\gnapprox$	\gnapprox
$\nprec$	\nprec	$\nsucc$	\nsucc
$\npreceq$	\npreceq	$\nsucceq$	\nsucceq
$\precneqq$	\precneqq	$\succneqq$	\succneqq
$\precnsim$	\precnsim	$\succnsim$	\succnsim
$\precnapprox$	\precnapprox	$\succnapprox$	\succnapprox
$\ntriangleleft$	\ntriangleleft	$\ntriangleright$	\ntriangleright
$\ntrianglelefteq$	\ntrianglelefteq	$\ntrianglerighteq$	\ntrianglerighteq
$\nshortmid$	\nshortmid	$\nmid$	\nmid
$\nshortparallel$	\nshortparallel	$\nparallel$	\nparallel
$\nvdash$	\nvdash	$\nvDash$	\nvDash
$\nVdash$	\nVdash	$\nVDash$	\nVDash
$\nsubseteq$	\nsubseteq	$\nsupseteq$	\nsupseteq
$\nsubseteqq$	\nsubseteqq	$\nsupseteqq$	\nsupseteqq
$\varsubsetneq$	\varsubsetneq	$\varsupsetneq$	\varsupsetneq
$\subsetneq$	\subsetneq	$\supsetneq$	\supsetneq
$\varsubsetneqq$	\varsubsetneqq	$\varsupsetneqq$	\varsupsetneqq
$\subsetneqq$	\subsetneqq	$\supsetneqq$	\supsetneqq

TABLE XXII: Yet more miscellaneous symbols available with amssymb selected.

$\dashrightarrow$	\dashrightarrow	$\dashleftarrow$	\dashleftarrow
$\dashrightarrow$	\dasharrow		
$\ulcorner$	\ulcorner	$\urcorner$	\urcorner
$\llcorner$	\llcorner	$\lrcorner$	\lrcorner
$\yen$	\yen	$\checkmark$	\checkmark
$\circledR$	\circledR	$\maltese$	\maltese

TABLE XXIII: Extra negated arrows available with amssymb selected.

$\nleftrightarrow$	\nleftrightarrow	$\nLeftrightarrow$	\nLeftrightarrow
$\nleftarrow$	\nleftarrow	$\nrightarrow$	\nrightarrow
$\nLeftarrow$	\nLeftarrow	$\nRightarrow$	\nRightarrow

TABLE XXIV: Extra arrows available with amssymb selected.

$\leftrightarrows$	\leftrightarrows	$\rightleftarrows$	\rightleftarrows
$\leftleftarrows$	\leftleftarrows	$\rightrightarrows$	\rightrightarrows
$\leftrightharpoons$	\leftrightharpoons	$\rightleftharpoons$	\rightleftharpoons
$\Lleftarrow$	\Lleftarrow	$\Rrightarrow$	\Rrightarrow
$\twoheadleftarrow$	\twoheadleftarrow	$\twoheadrightarrow$	\twoheadrightarrow
$\leftarrowtail$	\leftarrowtail	$\rightarrowtail$	\rightarrowtail
$\looparrowleft$	\looparrowleft	$\looparrowright$	\looparrowright
$\Lsh$	\Lsh	$\Rsh$	\Rsh
$\upuparrows$	\upuparrows	$\downdownarrows$	\downdownarrows
$\upharpoonleft$	\upharpoonleft	$\upharpoonright$, $\restriction$	\upharpoonright, \restriction
$\downharpoonleft$	\downharpoonleft	$\downharpoonright$	\downharpoonright
$\curvearrowleft$	\curvearrowleft	$\curvearrowright$	\curvearrowright
$\circlearrowleft$	\circlearrowleft	$\circlearrowright$	\circlearrowright
$\multimap$	\multimap	$\rightsquigarrow$	\rightsquigarrow
$\leftrightsquigarrow$	\leftrightsquigarrow		

gives

$$\Bigg(\bigg(\Big(\big((x)\big)\Big)\bigg)\Bigg)$$

while

```
\[
\Bigglb(\bigglb(\Biglb(\biglb(
(x)
\bigrb)\Bigrb)\biggrb)\Biggrb)
\]
```

gives

$$\Bigg(\bigg(\Big(\big((x)\big)\Big)\bigg)\Bigg)$$

The commands `\lesssim`, `\gtrsim` give the output $\lesssim, \gtrsim$, even without the `amssymb` class option. (The commands `\alt`, `\agt`, respectively, may also be used.) These commands will be fragile if you are not using the `amssymb` option.

Some extra diacritics have been provided. They scale correctly in superscripts. Some examples follow. `$\tensor{x}$` gives $\overleftrightarrow{x}$. `$\overstar{x}$` gives $\overset{*}{x}$. `$\overdots{x}$` gives $\ddot{x}$. `$\overcirc{x}$` gives $\overset{\circ}{x}$. `$\loarrow{x}$` gives $\overleftarrow{x}$. `$\roarrow{x}$` gives $\overrightarrow{x}$. These commands all work correctly in superscripts.

`\corresponds` produces the symbol $\triangleq$ math mode, `\precsim` produces $\precsim$ in math mode, and `\succsim` produces $\succsim$ in math mode. The AMS fonts will be used for these symbols if you have them, but are not necessary.

`\lambdabar` produces "lambda-bar" in math mode: $\lambda\!\!\!^{-}$.

Appendix G: Markup List

In the following pages are brief descriptions of some necessary commands. Those commands that are unique to REVTEX are noted with (R). Please consult the *LaTeX User's Guide & Reference Manual* if you have further questions regarding LaTeX commands.

If commands have arguments, they are so noted with `[<text>]`, or `{<key>}`, as the case may be. The commands are in order of their likely occurrence in a document.

`\documentclass[<options>]{revtex4}`
`[<options>]` is a comma-separated list of option names; see Sections 4.1 and 5.1 for complete option lists and explanations.

You usually select a journal substyle option, e.g., `aps`.

Use the `preprint` option to force formatted output to the "preprint" style, suitable for copyediting. Otherwise, the chosen journal substyle selects a default.

If output is in the preprint style, you can select the `tightenlines` class option to force single line spacing.

To number equations by section, use the `eqsecnum` option.

Use the `showpacs` option to produce the PACS numbers.

`\begin{document}` Begins the body of the REVTEX document.

`\preprint{<text>}` When appearing within the front matter of a document, places *<text>* at the top right corner of the first page in preprint style. Used for site-specific preprint numbers. (R)

`\title[<short title>]{<title text>}` *<title text>* is the title of the paper; *<short title>* optionally specifies a title suitable for the page running head. The title should be broken with the `\protect\\` command.

`\author{<name>}` *<name>* represents an author name.

`\affiliation{<text>}` *<text>* represents an author's address (institution). The address should be broken with `\\` if necessary. (R)

`\date{<date>}` lets you specify a date to be formatted in the title block.

`\begin{abstract}`
`...`
`\end{abstract}` Signals the beginning and end of the abstract, respectively.

`\pacs{<pacs number>}` *<pacs number>* represents valid PACS numbers. Invoke the `showpacs` option to have *<pacs number>* printed. (R)

`\maketitle` Prints the material contained in the `\title{<title text>}`, `\author{<name>}`, `\affiliation{<text>}` and `\date{<date>}` commands.

`\begin{widetext}`
`...`
`\end{widetext}` Sets all enclosed text on the full page width; only effective in a two-column layout. (R)

`\section{<title text>}` *<title text>* represents a primary heading. Fragile commands should be preceded by `\protect`.

`\subsection{<title text>}` *<title text>* represents a secondary heading. Fragile commands should be preceded by `\protect`.

`\subsubsection{<title text>}` *<title text>* represents a third-level heading. Fragile commands should be preceded by `\protect`.

`\paragraph{<title text>}` *<title text>* represents a fourth-level heading. Fragile commands should be preceded by `\protect`.

`\cite{<key>}` Sets a reference or byline footnote citation. *<key>* represents a list of reference keys used with `\bibitem{<key>}`. Lists of consecutive numbers will be collapsed; e.g., [1,2,3] will become [1–3]. The style of citation in your output will depend on the chosen journal substyle. Fragile.

`\textcite{<key>}` Sets a reference citation just like `\cite{<key>}` does, except the citation is part of the text (as, e.g., the subject of the sentence). Fragile. (R)

`\onlinecite{<key>}` Sets a reference citation just like `\cite{<key>}` does, except that it places the citation on the baseline of the text even in styles where the citations are otherwise superscripts. Fragile. (R)

`\openone` Produces an openface one ($\mathbb{1}$). (R)

`\precsim`, `\succsim` Produce the signs $\precsim$ and $\succsim$, respectively, in math mode.

`\lesssim`, `\gtrsim` Produce "approximately less than" and "approximately greater than" signs ($\lesssim, \gtrsim$), respectively, in math mode.

`\tensor{<math>}` `$\tensor{x}$` gives $\overleftrightarrow{x}$. (R)

`\loarrow{<math>}` `$\loarrow{x}$` gives $\overleftarrow{x}$. (R)

`\roarrow{<math>}` `$\roarrow{x}$` gives $\overrightarrow{x}$. (R)

`\overstar{<math>}` `$\overstar{x}$` gives $\overset{*}{x}$. (R)

`\overcirc{<math>}` `$\overcirc{x}$` gives $\overset{\circ}{x}$. (R)

`\biglb(`, etc. Commands to produce large bold bracketing. (R)

`\corresponds` Produces "corresponds" sign in math mode: $\triangleq$.

`\lambdabar` Produces "lambda-bar" in math mode: $\lambda\!\!\!^{-}$. (R)

`\[`, `\]` Signals beginning and end of unnumbered displayed equation.

`\begin{equation}` … `\end{equation}` Signals beginning and end of single-line displayed equation.

`\begin{eqnarray}` … `\end{eqnarray}` Signals beginning and end of multi-line displayed equation.

`\nonumber` Suppresses the numbering of a single line in a eqnarray environment.

`\tag{<number>}` Provides an idiosyncratic number for a single line of an eqnarray. The number can be cross-referenced with `\ref{<key>}` when `\label{<key>}` is used right after `\tag{<number>}`. Numbers set with `\tag{<number>}` are completely independent of the automatic numbering. (R)

`\begin{longtable}` … `\end{longtable}` Environment to produce tables that can break over pages. Requires the `longtable` package; see Section 5.3, and see `apssamp.tex` for an example. (R)

`\label{<key>}` defines a tag. This command appears in displayed equations that need cross-referencing, all tables, and all figure captions. Also used following section headings that need cross-referencing.

`\ref{<key>}` references a tag. Use this command in text wherever sections, numbered equations, tables, or figures are cited.

`acknowledgments` environment A container foracknowledgment section, complete with head. (R)

`\appendix` After using this command, all `\section{<title text>}` commands will set *<title text>* as an appendix heading. `\section*{<title text>}` will set *<title text>* as an appendix heading without a letter (A, B, etc.) and should be used when there is only one appendix.

`\begin{thebibliography}` … `\end{thebibliography}` Signals beginning and end of the list of references. (R)

`\bibitem[<symbol>]{<key>}` Sets a reference in the reference section. *<symbol>* represents an optional, author-specified reference symbol. *<key>* represents the reference tag.

`\begin{figure}` Begins the environment for a numbered figure.

`\includegraphics[<key-vals>]{<filename>}` Import the given graphics file into the document. You must `\usepackage{graphicx}` in order to be able to use the `\includegraphics` command with the `key-vals` syntax.

`\caption{<caption title>}` *<caption title>* represents the text of the caption. Fragile commands must be preceded by `\protect`.

`\label{<key>}` *<key>* represents the figure caption tag.

`\end{figure}` Ends the environment for the figure.

`\begin{table}` Signals the beginning of a table.

`\squeezetable` Used immediately after `\begin{table}`, shrinks tables that would not otherwise fit. (R)

`\caption{<caption title>}` Sets the table caption. *<caption title>* represents the text of the caption. Fragile commands must be preceded by `\protect`.

`\begin{tabular}{<preamble>}` Signals the beginning of the tabular material. *<preamble>* represents formatting commands for the columns.

`\hline` Sets a horizontal rule, separating column headings from data. `\tableline` may also be used.

`\end{tabular}` Signals end of tabular material.

`\end{table}` Signals the end of a table.

`\end{document}` Ends the body of the REVTEX document.

Symbols

A

G

H

I

J

K

L

M

N

R

S