

Extended Equation Numbering in Plain TeX

James Nearing
Physics Department
University of Miami

This is a macro package designed to provide automatic equation numbering.* It has various options: allow chapter (or section) numbers; allow forward references to equations or figures; allow equations to be labeled by chapter number as well as equation number; allow automatic lettering of appendices.

The five commands used for equation numbers and for reference to the equations are

```
\eqnum
\eqalignnum
\eqlabel{...}
\eqalignlabel{...}
\eqref{...}
```

The first (`\eqnum`) is the simplest. Simply place it at the end of a displayed equation, and a new equation number will be put at the end of the equation. The third (`\eqlabel{...}`) not only inserts the correct equation number, it assigns a label of your choice to the equation so that you can refer to it in the text. You will use another command (`\eqref`) to refer to the equation by label instead of by number; future editing will not then affect the reference.

Example:

```
$$
\int_0^\infty dx e^{-x^2} = \sqrt{\pi}/2
\eqnum
$$
$$
p_x = -i\hbar \frac{\partial}{\partial x}
\eqlabel{momentum}
$$
```

will produce

$$\int_0^\infty dx e^{-x^2} = \sqrt{\pi}/2 \quad (7)$$

$$p_x = -i\hbar \frac{\partial}{\partial x} \quad (8)$$

The second and fourth commands are like the first and third, except that they are to be used in another context. When you want numbers on an *aligned* equation, the syntax is different; you must use these instead to produce the same results. They are used when you use the `\eqalignno` command to get a numbered aligned equation. For example,

```
$$\eqalignno{
\sqrt{-1}&=2+1\cdot 5+2\cdot 5^2+\cdots
\eqalignnum\cr
(p\llap{/}-m)\psi&=0
\eqalignlabel{zap}\cr
}$$
```

will produce

$$\sqrt{-1} = 2 + 1 \cdot 5 + 2 \cdot 5^2 + \cdots \quad (9)$$

$$(p - m)\psi = 0 \quad (10)$$

References to equations produced as above are done by `\eqref{...}` where the dots are the label that was introduced when either of the commands `\eqlabel` or `\eqalignlabel` are used. The sequence `\eqlabel{momentum}` will produce (8) and `\eqlabel{zap}` will be (10).

If you use the same label for two different equations, the first one is discarded as soon as the second one appears. Sometimes you will want to refer to a particular equation immediately after its appearance, but you know that you will never refer to it again. In this case it is convenient to pick some standard, simple label for continual re-use. For example you can use `\eqlabel{x}` or `\eqalignlabel{x}` any time this circumstance arises.

Another simple but useful command in this series is `\eq`. It is nothing more than an abbreviation for "Eq. ~". Equation references in the text will then appear as `\eq\eqref{...}`, thereby generating the appearance of "Eq. (10)" in the final document.

When you first use the macros as stated above, you should set the system to operate in "proofmode." This shows the equation labels you have defined in the margin; it puts the date, filename, and pagenumber in the headline; it pushes the text to the left on the page; if you have forward references, it stops the error messages that would result from an undefined equation label. To do this, use the set of three commands

```
\input eqmacros
\proofmodetrue
\initialeqmacro
```

If you want the option of referring to equations that have not yet appeared in the text, there is another step to take. The setup is

```
\input eqmacros
\proofmodetrue
\forwardreferencetrue
\initialeqmacro
```

In this case, you *must* also create in your directory an empty file with the name LABELFILE.TEX. This

* An earlier article by J. E. Pittman, TUGboat Vol. 9, No. 3, showed a more limited method for automatic equation numbering.

is needed because the program must write out the equation labels to a file in order to have access to them the next time that \TeX is run.

When you are ready for a final copy, simply modify `\proofmodetrue` to `\proofmodefalse`.

You may prefer a style in which the text is divided into chapters or sections. You may even want all of the equations to be marked in this way, as (1.5) and (4.2). The internal variable `\chapno` is used for this purpose. It is started at zero; when you begin a new chapter it is incremented and numbered with one of the commands

```
\chapnum      or      \chaplabe{...}
```

They are used in a way exactly parallel to `\eqnum` and `\eqlabel`. There is a corresponding command `\chapref` used to refer to a labeled chapter. Instead of using `\chapnum` or `\chaplabe` directly, it is typically better to use a macro for the section or chapter titles. This makes the presentation uniform.

Examples of such commands are

```
\centerhead{label}{Title}
\lefthead{label}{Title}
\bighead{label}{Title}
```

They provide labels for reference to the chapter, and give standard formats for the appearance of the title. These are macros in the `eqmacros.tex` package, so you can use them as models for the particular format that you want.

If you want the appendices to be labeled by *letters* instead of *numbers*, place the command

```
\chapno=-1
```

at the beginning of the chapter, just before a command such as `\chapnum` or `\centerhead`.

If you want to use the chapter number (or letter) in a headline, use the command `\chapfolio`. This will give a number or a letter as appropriate.

If you do nothing else, then the equation numbers will only contain a single number, as (7). If you prefer that all the equations have both the chapter number and equation number (3.7) or (B.7), place the command `\chapternumberstrue` in your file. In either case, when you use `\eqref` to refer to an equation in another chapter it will always use the full form (2.9).

For figures, the corresponding commands are

```
\fignum      \figlabel{...}  \figref{...}
\figurechapternumberstrue
```

Example

```
\input eqmacros
\proofmodetrue
\forwardreferencetrue
\chapternumberstrue
\initialeqmacro
\centerhead{intro}{Introduction}
Some introductory text. We shall see
in section \chapref{venus} that  $2+2$ 
is indeed 4, but in section
\chapref{mars} that it is not.
```

```
\centerhead{venus}{The Ineffable All}
 $a+b=c$ \eqnum  $a+b=c$ 
but obviously we see that
 $c+d=e$ \eqlabel{cde}
implying that \eq\eqref{cde} tells it
all. \eq\eqref{deltatron} will imply
even more.
```

```
\lefthead{zap}{The Contradiction}
This header for the section is
equivalent to a combination of commands
‘noindent,’ ‘boldface,’
‘chaplabe,’ and ‘hfil break.’
 $q+w&=e$ \eqalignlabel{x}\cr
 $1+1&=0$ \eqalignlabel{xx}\cr
}
```

```
\chapno=-1
\bighead{apple}{Appendix: Still More}
and this is still another macro to
place a heading. Here, the chapters are
lettered because the chapternumber,
\chapno, is negative.
etc.
```

Summary

<code>\eqnum</code>	Number this equation, but make no reference to it.
<code>\eqlabel{alabel}</code>	" " " , and set up a reference to it.
<code>\eqalignnum</code>	like <code>\eqnum</code> but in the context of <code>\eqalignno</code>
<code>\eqalignlabel{alabel}</code>	" <code>\eqlabel</code> " " " " " "
<code>\eqref{alabel}</code>	refer to a labeled equation.
<code>\chapnum</code>	Number this chapter, but make no reference to it.
<code>\chaplabe{alabel}</code>	" " " , and set up a reference to it.
<code>\chapref{alabel}</code>	refer to a labeled chapter.
<code>\fignum</code>	Number this figure, but make no reference to it.
<code>\figlabel{alabel}</code>	" " " , and set up a reference to it.
<code>\figref{alabel}</code>	refer to a labeled figure.
<code>\eq</code>	Eq.~ convenient if you change your mind
<code>\eqs</code>	Eqs.~
<code>\fig</code>	Figure~
<code>\figs</code>	Figures~
<code>\centerhead{alabel}{TITLE}</code>	Typical macros for labeled titles
<code>\lefthead{alabel}{TITLE}</code>	
<code>\bighead{alabel}{TITLE}</code>	
<code>\input eqmacros</code>	To use these macros:
<code>\proofmodetrue</code>	Initially set to true, later false
<code>\forwardreferencetrue</code>	If you plan on any, set true
<code>\chapternumberstrue</code>	If you want equation numbers like (3.2)
<code>\figurechapternumberstrue</code>	" " " figure " " "
<code>\initialeqmacro</code>	To initialize the setup:
<code>\bumpchapno</code>	Like <code>\chapnum</code> , but doesn't display number
<code>\continuousnumberingtrue</code>	If you DON'T want eq numbers to restart fresh
<code>\continuousfigurenumberingtrue</code>	" " " " fig " " " "
<code>\chapfolio</code>	The current chapter number or letter
<code>\today</code>	Today's date (<code>\proofmode</code> puts it in headline)
<code>\chapno=-1</code>	Starts LETTERING instead of NUMBERING

Macros

```

\newif\ifproofmode           % true => wide right margin, eqn.
\proofmodefalse             % labels shown; date in headline

\newif\ifforwardreference    % true => allow reference to an
\forwardreferencefalse       % equation that appears later

\newif\ifchapternumbers     % true => equations labeled as e.g.
\chapternumbersfalse        % (3.7) instead of (7)

\newif\ifcontinuousnumbering % true => don't reset numbering of
\continuousnumberingfalse   % equations in each chapter

\newif\iffigurechapternumbers % true => figures labeled as e.g.
\figurechapternumbersfalse  % (3.7) instead of (7)

\newif\ifcontinuousfigurenumbering % true => don't reset numbering of
\continuousfigurenumberingfalse % figures in each chapter

\font\eqsixrm=CMR6          % given these odd names to avoid
\font\eqtwelvrm=CMR12       % possible conflict with a user.
\def\marginstyle{\eqsixrm} % for proofmode labels

\newtoks\chapletter         % for appendices
\newcount\chapno            % chapter number
\newcount\eqlabelno         % equation #'s
\newcount\figureno         % figure numbers

\chapno=0
\eqlabelno=0
\figureno=0

% This returns either a number or a letter depending on the sign
% of \chapno. It uses the CURRENT value of \chapno. Typically used
% only by other macros. The user may however, want to place the chapter
% number (or letter) into the headline, then \chapfolio should be used.
%
\def\chapfolio{\ifnum \chapno>0 \the\chapno \else \the\chapletter \fi}

% This increments \chapno in the correct direction (more positive OR
% more negative). If as is normal, there is NO continuous numbering
% of equations and figures, those variables are reset. It is typically
% used only by the other macros, not directly by the user.
%
\def\bumpchapno{\ifnum \chapno>-1 \global \advance \chapno by 1
\else \global \advance \chapno by -1 \setletter\chapno \fi
\ifcontinuousnumbering \else \global\eqlabelno=0 \fi
\ifcontinuousfigurenumbering \else \global\figureno=0 \fi}

```

```
% This is a very awkward way to turn a number into a letter, but some
% difficulty with simpler methods occurs in the \write routines.
```

```
%
\def\setletter#1{\ifcase-#1 {} \or{} \or\global\chapletter={A}
\or\global\chapletter={B} \or\global\chapletter={C} \or\global\chapletter={D}
\or\global\chapletter={E} \or\global\chapletter={F} \or\global\chapletter={G}
\or\global\chapletter={H} \or\global\chapletter={I} \or\global\chapletter={J}
\or\global\chapletter={K} \or\global\chapletter={L} \or\global\chapletter={M}
\or\global\chapletter={N} \or\global\chapletter={O} \or\global\chapletter={P}
\or\global\chapletter={Q} \or\global\chapletter={R} \or\global\chapletter={S}
\or\global\chapletter={T} \or\global\chapletter={U} \or\global\chapletter={V}
\or\global\chapletter={W} \or\global\chapletter={X} \or\global\chapletter={Y}
\or\global\chapletter={Z}\fi}
```

```
% And a non-global version of the above:
```

```
%
\def\tempsetletter#1{\ifcase-#1 {} \or{} \or\chapletter={A} \or\chapletter={B}
\or\chapletter={C} \or\chapletter={D} \or\chapletter={E}
\or\chapletter={F} \or\chapletter={G} \or\chapletter={H}
\or\chapletter={I} \or\chapletter={J} \or\chapletter={K}
\or\chapletter={L} \or\chapletter={M} \or\chapletter={N}
\or\chapletter={O} \or\chapletter={P} \or\chapletter={Q}
\or\chapletter={R} \or\chapletter={S} \or\chapletter={T}
\or\chapletter={U} \or\chapletter={V} \or\chapletter={W}
\or\chapletter={X} \or\chapletter={Y} \or\chapletter={Z}\fi}
```

```
% A utility: it produces a number or a letter, depending on
% the sign of the argument. Used by other macros for appendices.
% (It is like \chapfolio, but need not refer to the current chapter.)
```

```
%
\def\chapshow#1{\ifnum #1>0 \relax #1%
\else {\tempsetletter{\number#1}\chapno=#1 \chapfolio} \fi}
```

```
% In proofmode, it is useful to put today's date on each output page.
```

```
%
\def\today{\number\day\space \ifcase\month\or Jan\or Feb\or
Mar\or Apr\or May\or Jun\or Jul\or Aug\or Sep\or
Oct\or Nov\or Dec\fi, \number\year}
```

```
% The initialization procedure. Output registers 1 and 2 are used.
```

```
%
\def\initialeqmacro{\ifproofmode
\headline{\tenrm \today\hfill \jobname\ --- draft\hfill\folio}
\hoffset=-1cm \immediate\openout2=allcrossreferfile \fi
\ifforwardreference \input labelfile
\ifproofmode \immediate\openout1=labelfile \fi \fi}
```

```
\def\initialeqmacros{\initialeqmacro} % either spelling
```

```

% Various ways to place a number on a chapter (or section):
%
\def\chapnum{\bumpchapno \chapfolio}

\def\chaplabe#1{\bumpchapno \ifproofmode \ifforwardreference
  \immediate\write1{\noexpand\expandafter\noexpand\def
  \noexpand\csname CHAPLABEL#1\endcsname{\the\chapno}}\fi\fi
  \global\expandafter\edef\csname CHAPLABEL#1\endcsname
  {\the\chapno}\ifproofmode\llap{\hbox{\marginstyle #1\ }}\fi\chapfolio}

\def\chapref#1{\ifundefined{CHAPLABEL#1}??\ifproofmode\ifforwardreference
  \else \write16{ ***Undefined Chapter Reference #1*** }\fi
  \else \write16{ ***Undefined Chapter Reference #1*** }\fi
  \else \edef\LABxx{\getlabel{CHAPLABEL#1}}\chapshow\LABxx\fi
  \ifproofmode\write2{Chapter #1}\fi}

% Various ways to place a number on an equation.
%
\def\eqnum{\global\advance\eqlabelno by 1
  \eqno(\ifchapternumbers\chapfolio.\fi\the\eqlabelno)}

\def\eqlabel#1{\global\advance\eqlabelno by 1 \ifproofmode\ifforwardreference
  \immediate\write1{\noexpand\expandafter\noexpand\def
  \noexpand\csname EQLABEL#1\endcsname{\the\chapno.\the\eqlabelno?}}\fi\fi
  \global\expandafter\edef\csname EQLABEL#1\endcsname
  {\the\chapno.\the\eqlabelno?} \eqno(\ifchapternumbers\chapfolio.\fi
  \the\eqlabelno)\ifproofmode\rlap{\hbox{\marginstyle #1}}\fi}

\def\equalignum{\global\advance\eqlabelno by 1
  &(\ifchapternumbers\chapfolio.\fi\the\eqlabelno)}

\def\equalignlabel#1{\global\advance\eqlabelno by 1 \ifproofmode
  \ifforwardreference\immediate\write1{\noexpand\expandafter\noexpand\def
  \noexpand\csname EQLABEL#1\endcsname
  {\the\chapno.\the\eqlabelno?}}\fi\fi
  \global\expandafter\edef\csname EQLABEL#1\endcsname
  {\the\chapno.\the\eqlabelno?}&(\ifchapternumbers\chapfolio.\fi
  \the\eqlabelno)\ifproofmode\rlap{\hbox{\marginstyle #1}}\fi}

\def\eqref#1{(\ifundefined{EQLABEL#1}***\ifproofmode\ifforwardreference)%
  \else \write16{ ***Undefined Equation Reference #1*** }\fi
  \else \write16{ ***Undefined Equation Reference #1*** }\fi
  \else \edef\LABxx{\getlabel{EQLABEL#1}}}%
  \def\LAByy{\expandafter\stripchap\LABxx}\ifchapternumbers
  \chapshow{\LAByy}.\expandafter\stripeq\LABxx
  \else\ifnum \number\LAByy=\chapno \relax\expandafter\stripeq\LABxx
  \else\chapshow{\LAByy}.\expandafter\stripeq\LABxx\fi\fi)\fi
  \ifproofmode\write2{Equation #1}\fi}

```

```

% These are analogous to \eqnum etc. They will automatically
% generate figure numbers and in the second case accept your
% label for later reference.
%
\def\fignum{\global\advance\figureno by 1 \relax
  \iffigurechapternumbers\chapfolio.\fi\the\figureno}

\def\figlabel#1{\global\advance\figureno by 1\relax
  \ifproofmode\ifforwardreference
  \immediate\write1{\noexpand\expandafter\noexpand\def
  \noexpand\csname FIGLABEL#1\endcsname{\the\chapno.\the\figureno?}}\fi\fi
  \global\expandafter\edef\csname FIGLABEL#1\endcsname
  {\the\chapno.\the\figureno?}\iffigurechapternumbers\chapfolio.\fi
  \ifproofmode\llap{\hbox{\marginstyle #1\ }}\relax\fi\the\figureno}

\def\figref#1{\ifundefined{FIGLABEL#1}!!!!\ifproofmode\ifforwardreference
  \else \write16{ ***Undefined Figure Reference #1*** }\fi
  \else \write16{ ***Undefined Figure Reference #1*** }\fi
  \else \edef\LABxx{\getlabel{FIGLABEL#1}}%
  \def\LAByy{\expandafter\stripchap\LABxx}%
  \iffigurechapternumbers\chapshow{\LAByy}.\expandafter\stripeq\LABxx
  \else\ifnum\number\LAByy=\chapno \relax\expandafter\stripeq\LABxx
  \else\chapshow{\LAByy}.\expandafter\stripeq\LABxx\fi\fi
  \ifproofmode\write2{Figure #1}\fi\fi}

\def\eq{Eq.~}
\def\eqs{Eqs.~}
\def\fig{Figure~}
\def\figs{Figures~}

% TYPICAL macros to place headers on chapters or sections:
% Form to use is:      \...head{label}{Title}
%
\def\centerhead#1#2{\vskip10pt\centerline{\chaplabel{#1}. #2}\vskip10pt}
\def\lefthead#1#2{{\bf \noindent \chaplabel{#1}. #2\hfil\break}}
\def\bighead#1#2{\vskip10pt%
  \centerline{{\eqtwelverm \chaplabel{#1}. #2}}\vskip10pt}

% Utilities for use by other macros
%
\def\getlabel#1{\csname#1\endcsname}
\def\ifundefined#1{\expandafter\ifx\csname#1\endcsname\relax}
\def\stripchap#1.#2?{#1}
\def\stripeq#1.#2?{#2}

```