Typesetting Mathematics−User's Guide (Second Edition)

Brian W. Kernighan

Lorinda L. Cherry

Bell Laboratories
Murray Hill, New Jersey 07974

ABSTRACT

This is the user's guide for a system for typesetting mathematics, using the phototypesetters on the UNIX† operating systems.

Mathematical expressions are described in a language designed to be easy to use by people who know neither mathematics nor typesetting. Enough of the language to set in-line expressions like $\lim_{x \to \pi/2} (\tan x)^{\sin 2x} = 1$ or display equations like

$$G(z) = e^{\ln G(z)} = \exp\left(\sum_{k \geq 1} \frac{S_k z^k}{k}\right) = \prod_{k \geq 1} e^{S_k z^k / k}$$

$$= \left(1 + S_1 z + \frac{S_1^2 z^2}{2!} + \ldots\right)\left(1 + \frac{S_2 z^2}{2} + \frac{S_2^2 z^4}{2^2 \cdot 2!} + \ldots\right) \ldots$$

$$= \sum_{m \geq 0} \left(\sum_{\substack{k_1, k_2, \ldots, k_m \geq 0 \\ k_1 + 2k_2 + \ldots + mk_m = m}} \frac{S_1^{k_1}}{1^{k_1} k_1!} \, \frac{S_2^{k_2}}{2^{k_2} k_2!} \cdots \frac{S_m^{k_m}}{m^{k_m} k_m!} \right) z^m$$

can be learned in an hour or so.

The language interfaces directly with the phototypesetting language TROFF, so mathematical expressions can be embedded in the running text of a manuscript, and the entire document produced in one process. This user's guide is an example of its output.

The same language may be used with the UNIX formatter NROFF to set mathematical expressions on DASI terminals and Model 37 *TELETYPE*® terminals.

1. Introduction

EQN is a program for typesetting mathematics on phototypesetters on UNIX. The EQN language was designed to be easy to use by people who know neither mathematics nor typesetting. Thus EQN knows relatively little about mathematics. In particular, mathematical symbols like +, −, ×, parentheses, and so on have no special meanings. EQN is quite happy to set garbage (but it will look good).

EQN works as a preprocessor for the typesetter formatter, TROFF [1], so the normal mode of operation is to prepare a document with both mathematics and ordinary text interspersed, and let EQN set the mathematics while TROFF does the body of the text.

On UNIX, EQN will also produce mathematics on DASI terminals and on Model 37 *TELETYPE* terminals. The input is identical, but you have to use the programs NEQN and NROFF instead of EQN and TROFF. Of course, some

† UNIX is a Trademark of Bell Laboratories.

things won't look as good because terminals don't provide the variety of characters, sizes and fonts that a typesetter does, but the output is usually adequate for proofreading.

To use EQN on UNIX,

```
eqn files | troff
```

2. Displayed Equations

To tell EQN where a mathematical expression begins and ends, we mark it with lines beginning .EQ and .EN. Thus if you type the lines

```
.EQ
x=y+z
.EN
```

your output will look like

$$x=y+z$$

The .EQ and .EN are copied through untouched; they are not otherwise processed by EQN. This means that you have to take care of things like centering, numbering, and so on yourself. The most common way is to use the TROFF and NROFF macro packages '–ms' and '–mm' [3,4], which allow you to center, indent, left-justify, and number equations.

With the '–ms' package, equations are centered by default. To left-justify an equation, use .EQ L instead of .EQ. To indent it, use .EQ I. Any of these can be followed by an arbitrary 'equation number' which will be placed at the right margin. For example, the input

```
.EQ I (3.1a)
x = f(y/2) + y/2
.EN
```

produces the output

$$x=f\,(y/2)+y/2 \qquad (3.1a)$$

There is also a shorthand notation so in-line expressions like π_i^2 can be entered without .EQ and .EN. We will talk about it in section 19.

3. Input spaces

Spaces and new-lines within an expression are thrown away by EQN. (Normal text is left absolutely alone.) Thus between .EQ and .EN,

```
x=y+z
```

and

```
x = y + z
```

and

```
x   =   y
   + z
```

and so on all produce the same output

$$x=y+z$$

You should use spaces and new-lines freely to make your input equations readable and easy to edit. In particular, very long lines are a bad idea, since they are often hard to fix if you make a mistake.

4. Output spaces

To force extra spaces into the *output,* use a tilde '' ~ '' for each space you want:

```
x~=~y~+~z
```

gives

$$x~=~y~+~z$$

You can also use a circumflex ''^'', which gives a space half the width of a tilde. It is mainly useful for fine-tuning. Tabs may also be used to position pieces of an expression, but the tab stops must be set by TROFF commands.

5. Symbols, Special Names, Greek

EQN knows some mathematical symbols, some mathematical names, and the Greek alphabet. For example,

```
x=2 pi int sin ( omega t)dt
```

produces

$$x=2\pi\int\sin(\omega t)dt$$

Here the spaces in the input are **necessary** to tell EQN that *int, pi, sin* and *omega* are separate entities that should get special treatment. The *sin,* digit 2, and parentheses are set in roman type instead of italic; *pi* and *omega* are made Greek; and *int* becomes the integral sign.

When in doubt, leave spaces around separate parts of the input. A *very* common error is to type *f(pi)* without leaving spaces on both sides of the *pi.* As a result, EQN does not recognize *pi* as a special word, and it appears as $f\,(pi)$ instead of $f\,(\pi)$.

A complete list of EQN names appears in section 23. Knowledgeable users can also use TROFF four-character names for anything EQN doesn't know about, like *\(bs* for the Bell System sign ♥.

6. Spaces, Again

The only way EQN can deduce that some sequence of letters might be special is if that sequence is separated from the letters on either side of it. This can be done by surrounding a special word by ordinary spaces (or tabs or newlines), as we did in the previous section.

You can also make special words stand out by surrounding them with tildes or circumflexes:

    x˜=˜2˜pi˜int˜sin˜(˜omega˜t˜)˜dt

is much the same as the last example, except that the tildes not only separate the magic words like *sin*, *omega*, and so on, but also add extra spaces, one space per tilde:

$$x \; = \; 2 \; \pi \; \int \; \sin \; (\; \omega \; t \;) \; dt$$

Special words can also be separated by braces { } and double quotes "...", which have special meanings that we will see soon.

7. Subscripts and Superscripts

Subscripts and superscripts are obtained with the words *sub* and *sup.*

    x sup 2 + y sub k

gives

$$x^2 + y_k$$

EQN takes care of all the size changes and vertical motions needed to make the output look right. The words *sub* and *sup* must be surrounded by spaces; *x sub2* will give you $xsub2$ instead of x_2. Furthermore, don't forget to leave a space (or a tilde, etc.) to mark the end of a subscript or superscript. A common error is to say something like

    y = (x sup 2)+1

which causes

$$y=(x^{2)+1}$$

instead of the intended

$$y=(x^2)+1$$

Subscripted subscripts and superscripted superscripts also work:

    x sub i sub 1

is

$$x_{i_1}$$

A subscript and superscript on the same thing are printed one above the other if the subscript comes *first:*

    x sub i sup 2

is

$$x_i^2$$

Other than this special case, *sub* and *sup* group to the right, so *x sup y sub z* means x^{y_z}, not ${x^y}_z$.

8. Braces for Grouping

Normally, the end of a subscript or superscript is marked simply by a blank (or tab or tilde, etc.) What if the subscript or superscript is something that has to be typed with blanks in it? In that case, you can use the braces { and } to mark the beginning and end of the subscript or superscript:

    e sup {i omega t}

is

$$e^{i\omega t}$$

Rule: Braces can *always* be used to force EQN to treat something as a unit, or just to make your intent perfectly clear. Thus:

    x sub {i sub 1} sup 2

is

$$x_{i_1}^2$$

with braces, but

    x sub i sub 1 sup 2

is

$$x_{i_1^2}$$

which is rather different.

Braces can occur within braces if necessary:

    e sup {i pi sup {rho +1}}

is

$$e^{i\pi^{\rho+1}}$$

The general rule is that anywhere you could use some single thing like *x*, you can use an arbitrarily complicated thing if you enclose it in braces. EQN will look after all the details of positioning it and making it the right size.

In all cases, make sure you have the right number of braces. Leaving one out or adding an extra will cause EQN to complain bitterly.

Occasionally you will have to print braces. To do this, enclose them in double quotes, like "{". Quoting is discussed in more detail in section 14.

9. Fractions

To make a fraction, use the word *over:*

a+b over 2c =1

gives

$$\frac{a+b}{2c}=1$$

The line is made the right length and positioned automatically. Braces can be used to make clear what goes over what:

{alpha + beta} over {sin (x)}

is

$$\frac{\alpha+\beta}{\sin(x)}$$

What happens when there is both an *over* and a *sup* in the same expression? In such an apparently ambiguous case, EQN does the *sup* before the *over,* so

–b sup 2 over pi

is $\frac{-b^2}{\pi}$ instead of $-b^{\frac{2}{\pi}}$. The rules which decide which operation is done first in cases like this are summarized in section 23. When in doubt, however, *use braces* to make clear what goes with what.

10. Square Roots

To draw a square root, use *sqrt:*

sqrt a+b + 1 over sqrt {ax sup 2 +bx+c}

is

$$\sqrt{a+b}+\frac{1}{\sqrt{ax^2+bx+c}}$$

Warning – square roots of tall quantities look lousy, because a root-sign big enough to cover the quantity is too dark and heavy:

sqrt {a sup 2 over b sub 2}

is

$$5\sqrt{\frac{a^2}{b_2}}5$$

Big square roots are generally better written as something to the power ½:

$$(a^2/b_2)^{½}$$

which is

(a sup 2 /b sub 2) sup half

11. Summation, Integral, Etc.

Summations, integrals, and similar constructions are easy:

sum from i=0 to {i= inf} x sup i

produces

$$\sum_{i=0}^{i=\infty} x^i$$

Notice that we used braces to indicate where the upper part $i=\infty$ begins and ends. No braces were necessary for the lower part $i=0$, because it contained no blanks. The braces will never hurt, and if the *from* and *to* parts contain any blanks, you must use braces around them.

The *from* and *to* parts are both optional, but if both are used, they have to occur in that order.

Other useful characters can replace the *sum* in our example:

int prod union inter

become, respectively,

$$\int \quad \prod \quad \cup \quad \cap$$

Since the thing before the *from* can be anything, even something in braces, *from-to* can often be used in unexpected ways:

lim from {n –> inf} x sub n =0

is

$$\lim_{n\to\infty} x_n=0$$

12. Size and Font Changes

By default, equations are set in 10-point type (the same size as this guide), with standard mathematical conventions to determine what characters are in roman and what in italic. Although EQN makes a valiant attempt to use esthetically pleasing sizes and fonts, it is not perfect. To change sizes and fonts, use *size n* and *roman, italic, bold* and *fat.* Like *sub* and *sup,* size and font changes affect only the thing that follows them, and revert to the normal situation at the end of it. Thus bold x y

is

$$\mathbf{x}y$$

and

size 14 bold x = y +
  size 14 {alpha + beta}

gives

$$\mathbf{x}=y+\alpha+\beta$$

As always, you can use braces if you want to affect something more complicated than a single letter. For example, you can change the size of an entire equation by

size 12 { … }

Legal sizes which may follow *size* are 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, 20, 22, 24, 28, 36. You can also change the size *by* a given amount; for example, you can say *size +2* to make the size two points bigger, or *size −3* to make it three points smaller. This has the advantage that you don't have to know what the current size is.

If you are using fonts other than roman, italic and bold, you can say *font X* where *X* is a one character TROFF name or number for the font. Since EQN is tuned for roman, italic and bold, other fonts may not give quite as good an appearance.

The *fat* operation takes the current font and widens it by overstriking: *fat grad* is ∇ and *fat {x sub i}* is $\boldsymbol{x_i}$.

If an entire document is to be in a non-standard size or font, it is a severe nuisance to have to write out a size and font change for each equation. Accordingly, you can set a ''global'' size or font which thereafter affects all equations. At the beginning of any equation, you might say, for instance,

```
.EQ
gsize 16
gfont R
 …
.EN
```

to set the size to 16 and the font to roman thereafter. In place of R, you can use any of the TROFF font names. The size after *gsize* can be a relative change with + or −.

Generally, *gsize* and *gfont* will appear at the beginning of a document but they can also appear throughout a document: the global font and size can be changed as often as needed. For example, in a footnote‡ you will typically want the size of equations to match the size of the footnote text, which is two points smaller than the main text. Don't forget to reset the global size at the end of the footnote.

13. Diacritical Marks

To get funny marks on top of letters, there are several words:

x dot	$\dot{x}$
x dotdot	$\ddot{x}$
x hat	$\hat{x}$
x tilde	$\tilde{x}$
x vec	$\vec{x}$
x dyad	$\overleftrightarrow{x}$
x bar	$\bar{x}$
x under	$\underline{x}$
x utilde	$\utilde{x}$

The diacritical mark is placed at the right height. The *bar* and *under* are made the right length for the entire construct, as in $\overline{x+y+z}$; other marks are centered.

14. Quoted Text

Any input entirely within quotes ("…") is not subject to any of the font changes and spacing adjustments normally done by the equation setter. This provides a way to do your own spacing and adjusting if needed:

italic "sin(x)" + sin (x)

is

sin(x)+sin(*x*)

Quotes are also used to get braces and other EQN keywords printed:

"{ size alpha }"

is

{ size alpha }

and

roman "{ size alpha }"

is

‡Like this one, in which we have a few random expressions like x_i and π^2. The sizes for these were set by the command *gsize −2*.

```
{ size alpha }
```

The construction "" is often used as a place-holder when grammatically EQN needs something, but you don't actually want anything in your output. For example, to make ${}^{2}\mathrm{He}$, you can't just type *sup 2 roman He* because a *sup* has to be a superscript *on* something. Thus you must say

```
"" sup 2 roman He
```

To get a literal quote use ``\"''. TROFF characters like *\(bs* can appear unquoted, but more complicated things like horizontal and vertical motions with *\h* and *\v* should always be quoted. (If you've never heard of *\h* and *\v*, ignore this section.)

15. Lining up Equations

Sometimes it's necessary to line up a series of equations at some horizontal position, often at an equals sign. This is done with two operations called *mark* and *lineup.*

The word *mark* may appear once at any place in an equation. It remembers the horizontal position where it appeared. Successive equations can contain one occurrence of the word *lineup.* The place where *lineup* appears is made to line up with the place marked by the previous *mark* if at all possible. Thus, for example, you can say

```
.EQ I
x+y mark = z
.EN
.EQ I
x lineup = 1
.EN
```

to produce

$$x+y=z$$

$$\phantom{x+{}}x=1$$

For reasons too complicated to talk about, when you use EQN and '−ms', use either .EQ I or .EQ L. mark and *lineup* don't work with centered equations. Also bear in mind that *mark* doesn't look ahead;

```
x mark =1
 ...
x+y lineup =z
```

isn't going to work, because there isn't room for the $x+y$ part after the *mark* remembers where the x is.

16. Big Brackets, Etc.

To get big brackets [ ], braces { }, parentheses ( ), and bars | | around things, use the *left* and *right* commands:

```
left { a over b + 1 right }
 ~=~ left ( c over d right )
 + left [ e right ]
```

is

$$\left\{ \frac{a}{b}+1 \right\} = \left(\frac{c}{d} \right) + \left[e \right]$$

The resulting brackets are made big enough to cover whatever they enclose. Other characters can be used besides these, but the are not likely to look very good. One exception is the *floor* and *ceiling* characters:

```
left floor x over y right floor
<= left ceiling a over b right ceiling
```

produces

$$\left\lfloor \frac{x}{y} \right\rfloor \le \left\lceil \frac{a}{b} \right\rceil$$

Several warnings about brackets are in order. First, braces are typically bigger than brackets and parentheses, because they are made up of three, five, seven, etc., pieces, while brackets can be made up of two, three, etc. Second, big left and right parentheses often look poor, because the character set is poorly designed.

The *right* part may be omitted: a ``left something'' need not have a corresponding ``right something''. If the *right* part is omitted, put braces around the thing you want the left bracket to encompass. Otherwise, the resulting brackets may be too large.

If you want to omit the *left* part, things are more complicated, because technically you can't have a *right* without a corresponding *left.* Instead you have to say

```
left "" ..... right )
```

for example. The *left ""* means a ``left nothing''. This satisfies the rules without hurting your output.

17. Piles

There is a general facility for making vertical piles of things; it comes in several flavors. For example:

```
A ˜=˜ left [
  pile { a above b above c }
  ˜˜ pile { x above y above z }
right ]
```

will make

$$A = \left[\begin{matrix} a & x \\ b & y \\ c & z \end{matrix} \right]$$

The elements of the pile (there can be as many as you want) are centered one above another, at the right height for most purposes. The keyword *above* is used to separate the pieces; braces are used around the entire list. The elements of a pile can be as complicated as needed, even containing more piles.

Three other forms of pile exist: *lpile* makes a pile with the elements left-justified; *rpile* makes a right-justified pile; and *cpile* makes a centered pile, just like *pile.* The vertical spacing between the pieces is somewhat larger for *l-*, *r-* and *cpiles* than it is for ordinary piles.

```
roman sign (x)˜=˜
left {
   lpile {1 above 0 above −1}
   ˜˜ lpile
    {if˜x>0 above if˜x=0 above if˜x<0}
```

makes

$$\mathrm{sign}(x) = \left\{ \begin{array}{ll} 1 & \text{if } x>0 \\ 0 & \text{if } x=0 \\ -1 & \text{if } x<0 \end{array} \right.$$

Notice the left brace without a matching right one.

18. Matrices

It is also possible to make matrices. For example, to make a neat array like

$$\begin{matrix} x_i & x^2 \\ y_i & y^2 \end{matrix}$$

you have to type

```
matrix {
  ccol { x sub i above y sub i }
  ccol { x sup 2 above y sup 2 }
}
```

This produces a matrix with two centered columns. The elements of the columns are then listed just as for a pile, each element separated by the word *above.* You can also use *lcol* or *rcol* to left or right adjust columns. Each column can be separately adjusted, and there can be as many columns as you like.

The reason for using a matrix instead of two adjacent piles, by the way, is that if the elements of the piles don't all have the same height, they won't line up properly. A matrix forces them to line up, because it looks at the entire structure before deciding what spacing to use.

A word of warning about matrices − *each column must have the same number of elements in it.* The world will end if you get this wrong.

19. Shorthand for In-line Equations

In a mathematical document, it is necessary to follow mathematical conventions not just in display equations, but also in the body of the text, for example by making variable names like x italic. Although this could be done by surrounding the appropriate parts with .EQ and .EN, the continual repetition of .EQ and .EN is a nuisance. Furthermore, with '−ms', .EQ and .EN imply a displayed equation.

EQN provides a shorthand for short in-line expressions. You can define two characters to mark the left and right ends of an in-line equation, and then type expressions right in the middle of text lines. To set both the left and right characters to dollar signs, for example, add to the beginning of your document the three lines

```
.EQ
delim $$
.EN
```

Having done this, you can then say things like

> Let $alpha sub i$ be the primary variable, and let $beta$ be zero. Then we can show that $x sub 1$ is $>=0$.

This works as you might expect − spaces, newlines, and so on are significant in the text, but not in the equation part itself. Multiple equations can occur in a single input line.

Enough room is left before and after a line that contains in-line expressions that something like $\sum_{i=1}^{n} x_i$ does not interfere with the lines surrounding it.

To turn off the delimiters,

```
.EQ
delim off
.EN
```

Warning: don't use braces, tildes, circumflexes, or double quotes as delimiters – chaos will result. Also, in-line font changes must be closed before in-line equations are encountered.

20. Definitions

EQN provides a facility so you can give a frequently-used string of characters a name, and thereafter just type the name instead of the whole string. For example, if the sequence

```
x sub i sub 1 + y sub i sub 1
```

appears repeatedly throughout a paper, you can save re-typing it each time by defining it like this:

```
define xy ′x sub i sub 1 + y sub i sub 1′
```

This makes *xy* a shorthand for whatever characters occur between the single quotes in the definition. You can use any character instead of quote to mark the ends of the definition, so long as it doesn't appear inside the definition.

Now you can use *xy* like this:

```
.EQ
f(x) = xy …
.EN
```

and so on. Each occurrence of *xy* will expand into what it was defined as. Be careful to leave spaces or their equivalent around the name when you actually use it, so EQN will be able to identify it as special.

There are several things to watch out for. First, although definitions can use previous definitions, as in

```
.EQ
define xi ′ x sub i ′
define xi1 ′ xi sub 1 ′
.EN
```

don't define something in terms of itself! A favorite error is to say

```
define X ′ roman X ′
```

This is a guaranteed disaster, since X *is* now defined in terms of itself. If you say

```
define X ′ roman "X" ′
```

however, the quotes protect the second X, and everything works fine.

EQN keywords can be redefined. You can make / mean *over* by saying

```
define / ′ over ′
```

or redefine *over* as / with

```
define over ′ / ′
```

If you need different things to print on a terminal and on the typesetter, it may be worth defining a symbol differently in NEQN and EQN. This can be done with *ndefine* and *tdefine.* A definition made with *ndefine* only takes effect if you are running NEQN; if you use *tdefine,* the definition only applies for EQN. Names defined with plain *define* apply to both EQN and NEQN.

21. Local Motions

Although EQN tries to get most things at the right place on the paper, it isn't perfect, and occasionally you will need to tune the output to make it just right. Small extra horizontal spaces can be obtained with tilde and circumflex. You can also say *back n* and *fwd n* to move small amounts horizontally. *n* is how far to move in 1/100's of an em (an em is about the width of the letter 'm'.) Thus *back 50* moves back about half the width of an m. Similarly you can move things up or down with *up n* and *down n.* As with *sub* or *sup,* the local motions affect the next thing in the input, and this can be something arbitrarily complicated if it is enclosed in braces.

22. A Large Example

Here is the complete source for the three display equations in the abstract of this guide.

```
.EQ I
G(z)~mark =~ e sup { ln ~ G(z) }
~=~ exp left (
sum from k>=1 {S sub k z sup k} over k right )
~=~  prod from k>=1 e sup {S sub k z sup k /k}
.EN
.EQ I
lineup = left ( 1 + S sub 1 z +
{ S sub 1 sup 2 z sup 2 } over 2! + … right )
left ( 1+ { S sub 2 z sup 2 } over 2
+ { S sub 2 sup 2 z sup 4 } over { 2 sup 2 cdot 2! }
+ … right ) …
.EN
.EQ I
lineup =  sum from m>=0 left (
sum from
pile { k sub 1 ,k sub 2 ,…, k sub m  >=0
above
k sub 1 +2k sub 2 + … +mk sub m =m}
{ S sub 1 sup {k sub 1} } over {1 sup k sub 1 k sub 1 ! } ~
{ S sub 2 sup {k sub 2} } over {2 sup k sub 2 k sub 2 ! } ~
```

```
...
{ S sub m sup {k sub m} } over {m sup k sub m k sub m ! }
right ) z sup m
.EN
```

23. Keywords, Precedences, Etc.

If you don't use braces, EQN will do operations in the order shown in this list.

dyad vec under utilde bar tilde hat dot dotdot
fwd back down up
fat roman italic bold size
sub sup sqrt over
from to

These operations group to the left:

over sqrt left right

All others group to the right.

Digits, parentheses, brackets, punctuation marks, and these mathematical words are converted to Roman font when encountered:

sin cos tan sinh cosh tanh arc
max min lim log ln exp
Re Im and if for det

These character sequences are recognized and translated as shown.

>=	≥
<=	≤
==	≡
!=	≠
+–	±
–>	→
<–	←
<<	≪
>>	≫
inf	∞
partial	∂
half	½
prime	′
approx	≈
nothing	
cdot	·
times	×
del	∇
grad	∇
...	...
,...,	,...,
sum	$\sum$
int	$\int$
prod	$\prod$
union	$\bigcup$
inter	$\bigcap$
dollar	$

To obtain Greek letters, simply spell them out in whatever case you want:

DELTA	Δ	iota	ι
GAMMA	Γ	kappa	κ
LAMBDA	Λ	lambda	λ
OMEGA	Ω	mu	μ
PHI	Φ	nu	ν
PI	Π	omega	ω
PSI	Ψ	omicron	ο
SIGMA	Σ	phi	φ
THETA	Θ	pi	π
UPSILON	Υ	psi	ψ
XI	Ξ	rho	ρ
alpha	α	sigma	σ
beta	β	tau	τ
chi	χ	theta	θ
delta	δ	upsilon	υ
epsilon	ε	xi	ξ
eta	η	zeta	ζ
gamma	γ		

These are all the words known to EQN (except for characters with names), together with the section where they are discussed.

above	17, 18	lpile	17
back	21	mark	15
bar	13	matrix	18
bold	12	ndefine	20
ccol	18	over	9
col	18	pile	17
cpile	17	rcol	18
define	20	right	16
delim	19	roman	12
dot	13	rpile	17
dotdot	13	size	12
down	21	sqrt	10
dyad	13	sub	7
fat	12	sup	7
font	12	tdefine	20
from	11	tilde	13
fwd	21	to	11
gfont	12	under	13
gsize	12	up	21
hat	13	vec	13
italic	12	˜, ˆ	4, 6
lcol	18	{ }	8
left	16	"..."	8, 14
lineup	15	utilde	13

24. Troubleshooting

If you make a mistake in an equation, like leaving out a brace (very common) or having one too many (very common) or having a *sup* with nothing before it (common), EQN will tell you with the message

syntax error between lines x and y, file z

where *x* and *y* are approximately the lines between which the trouble occurred, and *z* is the name of the file in question. The line numbers are approximate – look nearby as well. There are also self-explanatory messages that arise if you leave out a quote or try to run EQN on a non-existent file.

If you want to check a document before actually printing it,

```
eqn  files >/dev/null
```

will throw away the output but print the messages.

If you use something like dollar signs as delimiters, it is easy to leave one out. This causes very strange troubles. The program *checkeq* checks for misplaced or missing dollar signs and similar troubles.

In-line equations can only be so big because of an internal buffer in TROFF. If you get a message ''word overflow'', you have exceeded this limit. If you print the equation as a displayed equation this message will usually go away. The message ''line overflow'' indicates you have exceeded an even bigger buffer. The only cure for this is to break the equation into two separate ones.

On a related topic, EQN does not break equations by itself – you must split long equations up across multiple lines by yourself, marking each by a separate .EQ … .EN sequence. EQN does warn about equations that are too long to fit on one line.

25. Use on UNIX

To print a document that contains mathematics on the typesetter,

```
eqn files | troff
```

If there are any TROFF options, they go after the TROFF part of the command. For example,

```
eqn files | troff –ms              (or –mm)
```

If you are using a non-standard typesetter, you have to tell eqn with the same -T argument that you use with TROFF:

```
eqn –Taps files | troff –Taps ...
```

A compatible version of EQN can be used on devices like *TELETYPE* terminals and DASI terminals which have half-line forward and reverse capabilities. To print equations on a Model 37 *TELETYPE* terminal, for example, use

```
neqn files | nroff
```

The language for equations recognized by NEQN is identical to that of EQN, although of course the output is more restricted.

To use a DASI terminal as the output device,

neqn files | nroff –T*x*

where *x* is the terminal type you are using, such as *300* or *300s.*

EQN and NEQN can be used with the TBL program [2] for setting tables that contain mathematics. Use TBL before [N]EQN, like this:

```
tbl  files  |  eqn  |  troff
tbl  files  |  neqn  |  nroff
```

26. Acknowledgements

We are deeply indebted to J. F. Ossanna, the author of TROFF, for his willingness to extend TROFF to make our task easier, and for his continuous assistance during the development and evolution of EQN. We are also grateful to A. V. Aho for advice on language design, to S. C. Johnson for assistance with the YACC compiler-compiler, and to all the EQN users who have made helpful suggestions and criticisms.

References

[1] J. F. Ossanna. *NROFF/TROFF User's Manual,* Bell Laboratories, 1976.

[2] M. E. Lesk. *Typing Documents on UNIX*, Bell Laboratories, 1976.

[3] M. E. Lesk. *TBL–A Program for Setting Tables*, Bell Laboratories, 1976.

[4] D. W. Smith and J. R. Mashey. *MM–Memorandum Macros,* Bell Laboratories, 1980.