TeX 101

Typing Mathematical Expressions

The TeX system created by Donald Knuth, along with its derivatives such as LaTeX, has become the standard means of producing documents and books in mathematics, physics, and some other fields. (Crudely speaking, it is a “mathematical word processor”, but its fans prefer the term “typesetting system”.) Many scientists now type their own papers in TeX instead of turning the task over to professional typists. With so many people using TeX and being familiar with its input language, naturally the users began using TeX’s syntax informally to communicate among themselves in electronic mail, where there is no way to type real mathematical expressions with a standard keyboard. Even students who don’t intend to use TeX to produce printed documents, therefore, will benefit from learning the most common bits of this private language.

This document is limited to the bare minimum of TeX syntax that is necessary and useful for communicating mathematical expressions in ASCII text. Writing to human beings is a different problem from writing to a computer, so there are many things that are necessary in true TeX input but should be avoided in “pidgin TeX”, because they would just interfere with the human reader’s rapid comprehension. Students who want to write homework papers in TeX will have more things to learn and a few things to unlearn; with luck, we will be able to return to them in later lessons (TeX 102, . . .).

The mathematical part of TeX syntax is fairly natural, and parts of it are similar to syntax that students may be familiar with from computer algebra programs such as *Maple* and *Mathematica* or programming languages such as **C** or FORTRAN.

Superscripts and subscripts. The first annoyance one encounters in writing mathematics with an ordinary typewriter, or computer keyboard, is that there is no convenient way to type superscripts and subscripts. At the very least, everyone should learn that “`^`” indicates that the next character is a superscript (exponent) and “`_`” similarly indicates a subscript. If the ’script consists of more than one character, it should be enclosed in braces (“curly brackets”). Thus

`x_i^2 y^{p_i}` means $x_i^2 y^{p_i}$.

Algebraic symbols and relations. Symbols that are not available on the keyboard are usually indicated in TeX by a “control sequence” consisting of a backslash followed by a string of letters. For instance, TeX provides both common symbols for multiplication,

$\times$	`\times`	$\cdot$	`\cdot`

(“`cdot`” standing for “centered dot”). Here are some more useful symbols:

$\pm$	`\pm`	$\mp$	`\mp`		
$\ne$	`\ne`	$\le$	`\le`	$\ge$	`\ge`
∞	`\infty`	$\emptyset$	`\emptyset`		
$\to$	`\to`	$\downarrow$	`\downarrow`	$\perp$	`\perp`

(`uparrow` also exists.) By itself, $\perp$ is a relation between two vectors or subspaces (as in $\vec{v} \perp \vec{u}$); when it means “orthogonal complement” it should be typed as a superscript:

`S^\perp` means $S^\perp$. Then there is a slew of relation symbols that indicate that two things are "like" each other to some degree or another:

$\equiv$	`\equiv`	$\propto$	`\propto`
$\approx$	`\approx`	$\sim$	`\sim`

Integrals and sums. Integral and summation signs are indicated by `int` and `sum`, with the upper and lower limits (in either order) attached like a superscript and a subscript:

`\int^2_0`   `\sum_{j=0}^N` .

There is also `\prod`, which gives a large capital Π to indicate a product of an indexed sequence of factors, as in

$$n! \equiv \prod_{i=1}^{n} i.$$

TEX also provides `\oint` for the integral sign with a circle on top of it that appears in vector calculus.

Fractions, derivatives, and roots. There are two ways to write $\frac{1}{10}$ in TEX:

`{ 1 \over 10 }`   `\frac 1 {10}` .

(Actually, the second of these is not part of standard TEX. More about that later.) Derivatives in Leibniz notation can be typed as fractions (`{ dy \over dx }`). There are symbols for partial and vector derivatives:

∂	`\partial`	∇	`\nabla`

Not surprisingly, $\sqrt{a+b}$ is `\sqrt{a + b}` ; $\sqrt[3]{2}$ is `\root 3 \of 2` .

Set-theory symbols.

$\in$	`\in`	$\subset$	`\subset`	$\cap$	`\cap`
$\notin$	`\notin`	$\subseteq$	`\subseteq`	$\cup$	`\cup`

Decorated letters. Several control sequences put accents over the characters that follow them:

$\hat{}$	`\hat`	$\vec{}$	`\vec`	$\tilde{}$	`\tilde`

Similar are `\overline` and `\underline` , which also can be applied to strings of more than one character (enclosed in braces). Finally, boldface and script letters can be indicated this way:

$\mathbf{R}$	`{\bf R}`	$\mathcal{G}$	`{\cal G}`

(In real TEX, the braces are essential here; in e-mail you can leave them out if you think that makes the material more readable.)

Greek letters. The elementary way to type Greek letters is to spell them out:

α	`\alpha`	β	`\beta`	...	Ω	`\Omega`

Capitalizing the first letter of the name gives the capital Greek letter. (In standard TEX this won't work for capital letters that are indistinguishable from Latin letters, such as P ("`\Rho`"), but we don't need to worry about that complication now.)

User definitions (macros). If your equations contain lots of Greek letters, spelling them out can be very tedious and produce long, unreadable expressions. If you are sure that your reader understands what you mean, you can introduce abbreviations for Greek letters (or for anything else you and the readers agree upon). This can also be done in a TEX file to be read by a computer, by a "macro" command of the form

`\def\za{\alpha}` .

I prefer to associate every Greek letter with a closely corresponding Latin letter in this way.

β	`\zb`	γ	`\zg`	Φ	`\zF`

etc. Unfortunately, for some letters there is not a universal agreement on what the "corresponding" Latin letter is, and this document already contains enough arbitrary conventions to be memorized, so we won't push the point here.

The `\frac` command mentioned earlier is defined as a macro in LATEX and some other systems built on top of plain TEX. Some other (less standard) abbreviations I use are

∂	`\zv`	∇	`\zV`

and a streamlined way of typing derivatives:

$\frac{dy}{dx}$	`\od y x`	$\frac{\partial^2 y}{\partial x^2}$	`\pd{^2y}{x^2}`