LATEX Mathematics Examples

Prof Tony Roberts

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1 Theorems et al.

**Definition 1** (right-angled triangles). A right-angled triangle is a triangle whose sides of length $a$, $b$ and $c$, in some permutation of order, satisfies $a^2 + b^2 = c^2$.

**Lemma 2.** The triangle with sides of length $3$, $4$ and $5$ is right-angled.

This lemma follows from **Definition 1** since $3^2 + 4^2 = 9 + 16 = 25 = 5^2$.

**Theorem 3** (Pythagorean triplets). Triangles with sides of length $a = p^2 - q^2$, $b = 2pq$ and $c = p^2 + q^2$ are right-angled triangles.

Prove this **Theorem 3** by the algebra $a^2 + b^2 = (p^2 - q^2)^2 + (2pq)^2 = p^4 - 2p^2q^2 + q^4 + 4p^2q^2 = p^4 + 2p^2q^2 + q^4 = (p^2 + q^2)^2 = c^2$.

2 Accents

Mathematical accents are performed by a short command with one argument, such as

$$\tilde{f}(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} f(x)e^{-i\omega x} \, dx,$$

or

$$\dot{\omega} = \vec{r} \times \vec{l}.$$

3 Relations

LaTeX knows to typeset extra space around relations $=, \approx$, and

- inequalities $<, >, \leq, \geq$
• very much so ≪, ≫
• set relations ∈, ⊂
• and so on.

For example, $0 < \epsilon \ll 1$ is $0 < \epsilon \ll 1$, not the common error $0 < \epsilon << 1$ which produces the ugly $0 < \epsilon \ll 1$.

4 Delimiters

See how the delimiters are of reasonable size in these examples

$$(a + b) \left[ 1 - \frac{b}{a + b} \right] = a,$$

$$\sqrt{|xy|} \leq \left| \frac{x + y}{2} \right|,$$

even when there is no matching delimiter

$$\int_a^b u \frac{d^2v}{dx^2} dx = u \frac{dv}{dx} \bigg|_a^b - \int_a^b \frac{du}{dx} \frac{dv}{dx} dx.$$

5 Spacing

Differentials often need a bit of help with their spacing as in

$$\int \int x y^2 \, dx \, dy = \frac{1}{6} x^2 y^3,$$

whereas vector problems often lead to statements such as

$$u = \frac{-y}{x^2 + y^2}, \quad v = \frac{x}{x^2 + y^2}, \quad \text{and} \quad w = 0.$$
Occasionally one gets horrible line breaks when using a list in mathematics such as listing the first twelve primes 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37. In such cases, perhaps include \textbackslash mathcode\textbackslash ,='213B inside the inline maths environment so that the list breaks: 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37. Be discerning about when to do this as the spacing is different.

6 Functions

Observe that trigonometric and other elementary functions are typeset properly, even to the extent of providing a thin space if followed by a single letter argument:

$$\exp(i\theta) = \cos \theta + i \sin \theta, \quad \sinh(\log x) = \frac{1}{2} \left( x - \frac{1}{x} \right).$$

With sub- and super-scripts placed properly on more complicated functions,

$$\lim_{q \to \infty} \|f(x)\|_q = \max_x |f(x)|,$$

and large operators, such as integrals and

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} \quad \text{where} \quad n! = \prod_{i=1}^{n} i,$$

$$\overline{U_\alpha} = \bigcap_{\alpha} U_\alpha.$$

In inline mathematics the scripts are correctly placed to the side in order to conserve vertical space, as in $1/(1 - x) = \sum_{n=0}^{\infty} x^n.$
7 Command definition

The Airy function, $\text{Ai}(x)$, may be incorrectly defined as this integral

$$\text{Ai}(x) = \int \exp(s^3 + isx) \, ds.$$ 

This vector identity serves nicely to illustrate two of the new commands:

$$\nabla \times \mathbf{q} = i \left( \frac{\partial w}{\partial y} - \frac{\partial v}{\partial z} \right) + j \left( \frac{\partial u}{\partial z} - \frac{\partial w}{\partial x} \right) + k \left( \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right).$$

8 Arrays

Arrays of mathematics are typeset using one of the matrix environments as in

$$\begin{bmatrix} 1 & x & 0 \\ 0 & 1 & -1 \end{bmatrix} \begin{bmatrix} 1 \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} 1 + xy \\ y - 1 \end{bmatrix}.$$ 

Case statements use cases:

$$|x| = \begin{cases} x, & \text{if } x \geq 0, \\ -x, & \text{if } x < 0. \end{cases}$$

Many arrays have lots of dots all over the place as in

$$\begin{array}{cccccc}
-2 & 1 & 0 & 0 & \cdots & 0 \\
1 & -2 & 1 & 0 & \cdots & 0 \\
0 & 1 & -2 & 1 & \cdots & 0 \\
0 & 0 & 1 & -2 & \cdots & 1 \\
\vdots & \vdots & \vdots & \ddots & \ddots & 1 \\
0 & 0 & 0 & \cdots & 1 & -2
\end{array}$$
9 Equation arrays

In the flow of a fluid film we may report

\[ u_\alpha = \epsilon^2 \kappa_{xxx} \left( y - \frac{1}{2} y^2 \right), \tag{1} \]

\[ v = \epsilon^3 \kappa_{xxx} y, \tag{2} \]

\[ p = \epsilon \kappa_{xx}. \tag{3} \]

Alternatively, the curl of a vector field \((u, v, w)\) may be written with only one equation number:

\[ \omega_1 = \frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}, \]

\[ \omega_2 = \frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}, \tag{4} \]

\[ \omega_3 = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}. \]

Whereas a derivation may look like

\[(p \land q) \lor (p \land \neg q) = p \land (q \lor \neg q) \quad \text{by distributive law} \]

\[= p \land T \quad \text{by excluded middle} \]

\[= p \quad \text{by identity} \]

Use subequations for parts of a whole  The subequations environment generates labels for the enclosed mathematics which are a base number followed by \(a,b,c,\ldots\) in sequence, as illustrated below.

\[ u_\alpha = \epsilon^2 \kappa_{xxx} \left( y - \frac{1}{2} y^2 \right), \tag{5a} \]

\[ v = \epsilon^3 \kappa_{xxx} y, \tag{5b} \]

\[ p = \epsilon \kappa_{xx}. \tag{5c} \]

Cross-reference to any individual equation or to the collective \((5)\).
Typesetting long expressions  Recall that typesetting multi-line mathematics is an art normally too hard for computer recipes. Nonetheless, if you need to be automatically flexible about multi-line long algebraic expressions, and you do not mind some crude typesetting, then perhaps invoke \parbox to help as follows:

\[ u_1 = -2\gamma \epsilon^2 s_2 + \mu \epsilon^3 \left( \frac{3}{8} s_2 + \frac{1}{8} s_1 i \right) + \epsilon^3 \left( -\frac{81}{32} s_4 s_2^2 - \frac{27}{16} s_4 s_2 s_1 i + \frac{9}{32} s_4 s_1^2 + \frac{27}{32} s_3 s_2^2 i - \frac{9}{16} s_3 s_2 s_1 - \frac{3}{32} s_3 s_1^2 \right) + \int_a^b 1 - 2x + 3x^2 - 4x^3 \, dx \]

The \texttt{breqn} package is not yet reliable enough for general use. Also, remember to use \parbox to typeset multiline entries in tables.