LaTeX Mathematics Examples

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1 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

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

This is done using the MS Word Equation Editor, can you improve it using LaTex?

$$f(b) - f(a) = \int_a^b \frac{x+x^3}{\alpha x^4 + \left[\frac{x+2x^3}{3x-x^4}\right]^4} dx$$

2 Spacing

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

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

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 $2, 3, 5, 7, 11, 13, 17, 19, 23, 2$ In such cases, perhaps include `\mathcode‘\,="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.

3 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

$$\begin{matrix} -2 & 1 & 0 & 0 & \cdots & 0 \\ 1 & -2 & 1 & 0 & \cdots & 0 \\ 0 & 1 & -2 & 1 & \cdots & 0 \\ 0 & 0 & 1 & -2 & \ddots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \ddots & 1 \\ 0 & 0 & 0 & \cdots & 1 & -2 \end{matrix}$$

4 Equation arrays

In the flow of a fluid film we may report

$$\begin{aligned} u_\alpha &= \epsilon^2 \kappa_{xxx} \left(y - \frac{1}{2} y^2 \right) , && (1) \\ v &= \epsilon^3 \kappa_{xxx} y \, , && (2) \\ p &= \epsilon \kappa_{xx} \, . && (3) \end{aligned}$$

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

$$\begin{aligned}
\omega_1 &= \frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}, \\
\omega_2 &= \frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}, \\
\omega_3 &= \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}.
\end{aligned} \tag{4}$$

Whereas a derivation may look like

$$\begin{aligned}
(p \wedge q) \vee (p \wedge \neg q) &= p \wedge (q \vee \neg q) \quad \text{by distributive law} \\
&= p \wedge T \quad \text{by excluded middle} \\
&= p \quad \text{by identity}
\end{aligned}$$

5 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

$$\begin{aligned}
e^x &= \sum_{n=0}^{\infty} \frac{x^n}{n!} \quad \text{where } n! = \prod_{i=1}^{n} i\,, \\
\overline{U_\alpha} &= \bigcap_\alpha U_\alpha\,.
\end{aligned}$$

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

6 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

$$\dot{\vec{\omega}} = \vec{r} \times \vec{I} \, .$$

7 Command definition

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

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

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

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

8 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 the Definition 1 as $3^2 + 4^2 = 9 + 16 = 25 = 5^2$.

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 $a^2+b^2 = (p^2-q^2)^2+(2pq)^2 = p^4 - 2p^2q^2 + q^4 + 4p^2q^2 = p^4 + 2p^2q^2 + q^4 = (p^2 + q^2)^2 = c^2$.

Can you improve the typesetting of these lines?