

# L<sup>A</sup>T<sub>E</sub>X 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

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

## 2 Spacing

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

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

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 `\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

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

## 4 Equation arrays

In the flow of a fluid film we may report

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

$$v = \epsilon^3 \kappa_{xxx} y, \quad (2)$$

$$p = \epsilon \kappa_{xx}. \quad (3)$$

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

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

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 type-set 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,

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

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,  $\text{Ai}(x)$ , 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:

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

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 mathematics, and you do not mind some rough typesetting, then perhaps invoke `\parbox` to help as follows:

$$\begin{aligned} u_1 = & -2\gamma\epsilon^2s_2 + \mu\epsilon^3\left(\frac{3}{8}s_2 + \frac{1}{8}s_1i\right) + \epsilon^3\left(-\frac{81}{32}s_4s_2^2 - \right. \\ & \left. \frac{27}{16}s_4s_2s_1i + \frac{9}{32}s_4s_1^2 + \frac{27}{32}s_3s_2^2i - \frac{9}{16}s_3s_2s_1 - \frac{3}{32}s_3s_1^2i\right) + \\ & \int_a^b 1 - 2x + 3x^2 - 4x^3 dx \end{aligned}$$

Also, sometimes use `\parbox` to typeset multiline entries in tables.

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