Equations in mathematics

matheqn.tex

Equations are the most common expressions in mathematical texts. LaTeX offers a bewildering choice for writing maths equations.

1 Equations

Write a numbered equation ::

$$\sin^2(x) + \cos^2(x) = 1 \tag{1}$$

..and an equation without number :

$$\sin(x + y) = \sin(x)\cos(y) + \cos(x)\sin(y)$$

Here are two equations without subnumbers:

$$a = b + c \tag{2}$$

$$a = c * d/2 \tag{3}$$

some equations with subnumbers

$$a = b + c \tag{4a}$$

$$d = e + f + g \tag{4b}$$

$$h = i + j \tag{4c}$$

$$= \frac{k + p}{m - n} \tag{4d}$$

1.1 Put them in boxes

Sometimes, you may want to give equations more prominence. You put them in boxes.

Put the equation in a box (and numbering outside) ::

$$\boxed{x^2 + y^2 = z^2} \tag{5}$$

Put the equation in a box (and NO numbering outside) ::

$$\boxed{x^2 + y^2 = z^2}$$

Or put a whole line (with the equation number) in the box ::

$$x^2 + y^2 = z^2 \tag{6}$$

A boxed equation without numbers ...

$$x^2 + y^2 = z^2$$

Now put two equations in the box :

Solution of a quadratic equation : $m_1 x^2 + m_2 x + m_3 = 0$

$$x_1 = -\,{}^1\!/_2\,\frac{m_2}{m_1} + \frac{\sqrt{(m_2 + 2\sqrt{m_1.m_3}).(m_2 - 2\sqrt{m_1.m_3})}}{2.m_1} \tag{7}$$

$$x_2 = -\,{}^1\!/_2\,\frac{m_2}{m_1} - \frac{\sqrt{(m_2 + 2\sqrt{m_1.m_3}).(m_2 - 2\sqrt{m_1.m_3})}}{2.m_1} \tag{8}$$

1.2 Continued fractions

The "Golden ratio" can be expressed as a continued fraction (using an innovative delimiter):

$$\left.1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cdots}}}}}\right\} = \phi \tag{9}$$

Or, use a "left side only" delimiter like this:

$$\phi = \left\{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cdots}}}}}\right. \tag{10}$$

1.3 A case for cases

In maths, one often needs to enumerate cases. Here is an example (using `cases` environment):

$$P_{(r-j)} = \begin{cases} 0 & \text{if } r-j \text{ is odd,} \\ r! & \text{if } r-j \text{ is even,} \\ 1 & \text{if } r-j \text{ is 0} \end{cases} \tag{11}$$

Notice that the above is given a single equation number (automatically).

1.4 By definition

It is often necessary to use an equation to define certain entities in mathematics. Use the `\stackrel` command to put "def" on top of an equal sign to denote equal-by-definition:

$$LHS \stackrel{\text{def}}{=} RHS$$

For instance,

$$\sum_{i=0}^{\infty} a_i \stackrel{\text{def}}{=} \lim_{n\to\infty} \sum_{i=0}^{n} a_i$$

1.5 Big sized expressions and big brackets

$$f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right)$$

$$f(n) = \left[\frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \cdots + \frac{1}{n} \right]$$

$$S_n = \left\{ \frac{1}{a_1}, \frac{1}{a_2}, \frac{1}{a_3}, \frac{1}{a_4} + \cdots + \frac{1}{a_n} \right\}$$

1.6 Big sized expressions

$$(\frac{a_1}{k}), \left(\frac{a_2}{k}\right), \left(\frac{a_3}{k}\right), \left(\frac{a_4}{k}\right)$$

$$[\frac{b_1}{k}], \left[\frac{b_2}{k}\right], \left[\frac{b_3}{k}\right], \left[\frac{b_4}{k}\right]$$

$$\{\frac{c_1}{k}\}, \left\{\frac{c_2}{k}\right\}, \left\{\frac{c_3}{k}\right\}, \left\{\frac{c_4}{k}\right\}$$

$$\langle\frac{d_1}{k}\rangle, \left\langle\frac{d_2}{k}\right\rangle, \left\langle\frac{d_3}{k}\right\rangle, \left\langle\frac{d_4}{k}\right\rangle$$

Expressios made with `\usepackage{physics}`

$$\phi = a\cos\left(\cos\left(\frac{2\pi t + \phi}{A}\right)A - 2\pi f t\right)$$

$$\tan^{-1}\left[\frac{2\left[\frac{1-x}{1+x}\right]}{1-\left[\frac{1-x}{1+x}\right]^2}\right]$$

$$\mathbf{Q} = \left\{\frac{a}{b} | a, b \,\epsilon\, \mathbf{Z}, b \neq 0\right\}$$

If the size and shape of the expression are large, the size of the bracket should also be large. And big brackets will be needed in the latex document to represent multiple line expressions.

$$r = (I_n - (.85)M^T)^{-1}\Big(\frac{1-(.85)}{5}\Big).1$$

$$\int_1^\infty \frac{1}{x^2}dx = \Big[-\frac{1}{x}\Big]_1^\infty = 1$$

$$a_n = \Big\{-\Big(\frac{1}{n}\Big)^n\Big\}$$

2 Array of equations

Sometimes, we need to display together, a family of related equations. The use of the command `\eqnarray` is discouraged and forbidden, for many reasons. Instead, the command `\align` is proposed.

2.1 align

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2 \tag{12}$$

$$= v_0 \sin(\theta)\frac{v_0 \sin(\theta)}{g} - \frac{g}{2}\left(\frac{v_0 \sin(\theta)}{g}\right)^2 \tag{13}$$

$$= \frac{1}{2}\frac{v_0^2 \sin^2(\theta)}{g} \tag{14}$$

Without `\align` command:
$\frac{64}{16} = \frac{\not{6}4}{1\not{6}} = \frac{4}{1}$
$\frac{15}{5} = 42/14 = 3$

With `\align` command:

$$\frac{64}{16} = \frac{\not{6}4}{1\not{6}} = \frac{4}{1} \tag{15}$$

$$\frac{15}{5} = 42/14 = 3 \tag{16}$$

$$\frac{26}{65} = \frac{2\not{6}}{\not{6}5} = \frac{2}{5} \tag{17}$$

$$\frac{19}{95} = \frac{1\not{9}}{\not{9}5} = \frac{1}{5} \tag{18}$$

$$\frac{49}{98} = \frac{4\not{9}}{\not{9}8} = \frac{1}{2} \tag{19}$$

$$\frac{166}{664} = \frac{1\not{6}\not{6}}{\not{6}\not{6}4} = \frac{1}{4} \tag{20}$$

$$\frac{64}{16} = \frac{6\not{4}}{1\not{6}} = \frac{4}{1} \tag{21}$$

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$$\frac{19}{95} = \frac{1\not{9}}{\not{9}5} = \frac{1}{5} \tag{23}$$

$$\frac{49}{98} = \frac{4\not{9}}{\not{9}8} = \frac{1}{2} \tag{24}$$

$$\frac{166}{664} = \frac{1\not{6}\not{6}}{\not{6}\not{6}4} = \frac{1}{4} \tag{25}$$

2.2 gather and split

The command `\gather` gives a numbering to each equation.

$$3(a - x) = 3.5x + a - 1 \tag{26}$$

$$3a - 3x = 3.5x + a - 1 \tag{27}$$

$$a = \frac{13}{4}x - \frac{1}{2} \tag{28}$$

The command `\aligned` gives a single numbering to all equations.

$$\begin{aligned} 3(a - x) &= 3.5x + a - 1 \\ 3a - 3x &= 3.5x + a - 1 \\ a &= \frac{13}{4}x - \frac{1}{2} \end{aligned} \tag{29}$$

3 Handling long equations

Here is an example of a long equation:

$$\begin{aligned} Q(\lambda, \hat{\lambda}) = -\frac{1}{2} P(O \mid \lambda) \sum_s \sum_m \sum_t \gamma_m^{(s)}(t) \Big(& n \log(2\pi) + \log \left| C_m^{(s)} \right| \\ & + \left(\mathbf{o}_t - \hat{\mu}_m^{(s)} \right)^T C_m^{(s)-1} \left(\mathbf{o}_t - \hat{\mu}_m^{(s)} \right) \Big) \end{aligned} \tag{30}$$

The same equation, cast using a `\multline` command:

$$Q(\lambda, \hat{\lambda}) = -\frac{1}{2} P(O \mid \lambda) \sum_{s} \sum_{m} \sum_{t} \gamma_m^{(s)}(t) \Bigg(n \log(2\pi) + \log \left| C_m^{(s)} \right| + \left(\mathbf{o}_t - \hat{\mu}_m^{(s)} \right)^T C_m^{(s)-1} \left(\mathbf{o}_t - \hat{\mu}_m^{(s)} \right) \Bigg) \quad (31)$$

Multline command does not use CR for newline.

$$A + B + C + 58 + D + E + F + 76 \Rightarrow x = 9 \quad (32)$$

Use equation to fit in one line:

$$1 + 2 + 3 + 4 + 8x + 7 = 1 + 2 + 3 + 4 + 4x + 35 \Rightarrow x = 7 \quad (33)$$

Use *multline* to split equations without alignment:

$$1 + 2 + 3 + 4 + 8x + 7 = 1 + 2 + 3 + 4 + 4x + 35 \Rightarrow x = 7 \quad (34)$$

$$p(x) = 3x^6 + 14x^5y + 590x^4y^2 + 19x^3y^3 - 12x^2y^4 - 12xy^5 + 2y^6 - a^3b^3$$

$$p(x) = 3x^6 + 14x^5y + 590x^4y^2 + 19x^3y^3 - 12x^2y^4 - 12xy^5 + 2y^6 - a^3b^3 \quad (35)$$

3.1 split

Use **split** to split equations with alignment

$$\begin{aligned} 1 + 2 + 3 + 4 + 8x + 7 &= 1 + 2 + 3 + 4 + 4x + 35 \\ &\Rightarrow x = 7 \end{aligned} \quad (36)$$

$$A = \frac{\pi r^2}{2} = \frac{1}{2}\pi r^2 \tag{37}$$

Notice that both parts are given a single equation number.

In addition to all the above, you can put equations inline with other texts $a^2 + b^2 = c^2$ like this. But this choice makes your text less readable.

Beautiful maths is now much easier to write with LaTeX .

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