Size, spacing and alignment in LaTeX math mode

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Ref.: spacing.tex
Ver. code: 20211216e

Abstract

LaTeX uses a special mode (math mode) for typesetting mathematical expressions. But the text in this mode does not behave like normal paragraph mode (text mode). Here are some examples.

1 Math mode in LaTeX

LaTeX [2, 1] is most frequently used for typesetting text which is rich in mathematical expressions. This article is a sequel to the articles [5, 6]. In this article, we examine spacing and alignment issues in mathematical expressions made with LaTeX .

1.1 Why use math mode ?

Imagine a long expression which exceeds one line length : x +y+z +p+ Q*r + s -d/e = g

With math mode, you get : $x + y + z + p + Q * r + s - d/e = g$

Notice the following :

1. The spacing before or after operators + and - is uniform in maths mode
2. A special font is used for the mathematical expression, to make it stand out from the rest of the text
3. All font sizes, spacing and alignment is adjusted automatically by LaTeX It is not a good idea to modify any of these manually, although LaTeX gives you facilities for making changes, as explained in the rest of this article.

LaTeX uses math mode to distinguish variables from ordinary letters. Variables are typeset in math italic, a special style that is not the same as ordinary italic prose. Here is an example:

Given a matrix A and vector b, solve $Ax = b$. (LaTeX math syle)
Given a matrix A and vector b, solve Ax = b. (Italics text)

The first sentence was written as

```
Given a matrix $A$ and vector $b$, solve $Ax = b$.
```

and, the second sentence was written as:

```
{\it{Given a matrix A and vector b, solve Ax = b}}.
```

1.2 Font sizes

The usual way LaTeX sets maths is very complex to explain.

The expression $f(x) = \frac{1}{1+\frac{1}{x}}$ looks different from the expression $f(x) = \dfrac{1}{1+\dfrac{1}{x}}$ because they were created with `\frac` and `\dfrac` respectively.

In the expression $f(x) = \frac{1}{1+\frac{1}{x}}$ the math sizes are automatically adjusted so that the positioning of the rest of the text is not disturbed.

You can set the above expression with a different style: $f(x) = \dfrac{1}{1+\frac{1}{x}}$ using the `displaystyle` command. You may notice the change in line spacing to accomodate the denominator.

Things will get much more ugly, when you use `\dfrac` , like in the earlier example $f(x) = \dfrac{1}{1+\dfrac{1}{x}}$. This what you get if you use `\dfrac` thoughtlessly. The abnormal-looking line spacing can be very irritating in an otherwise beautiful text.

Here is one more example of the usage of `displaystyle` :

$\frac{1}{x+\frac{1}{x}}$ and $\dfrac{1}{x+\frac{1}{x}}$ and $\dfrac{1}{x+\dfrac{1}{x}}$

In fact, you may choose any size you want, using
`displaystyle, scriptsyle, scripscriptstyle` commands :

$f(x) = \dfrac{1}{1+x}$ ..... This is displaystyle
$f(x) = \frac{1}{1+x}$ ..... This is scriptstyle
$f(x) = \frac{1}{1+x}$ ..... This is scriptscriptstyle

Notice the size of the exponent, as you go higher :

$$2 = \sqrt{2}^{\sqrt{2}^{\sqrt{2}^{\sqrt{2}^{\sqrt{2}^{\cdot^{\cdot^{\cdot}}}}}}} \tag{1}$$

LaTeX modifies the size of the exponents automatically, to respect the rules of mathematical typesetting.

Now, take a look at the same expression

$$2 = \sqrt{2}^{\sqrt{2}^{\sqrt{2}^{\sqrt{2}^{\sqrt{2}^{\cdot^{\cdot^{\cdot}}}}}}} \tag{2}$$

The size of the exponents was reset using the `\displaystyle` command.

This is of course not a good writing practice in maths typesetting.

You can even set all these sizes globally (in the Preamble part of your document), using the `\DeclareMathSizes{<surrounding text size>}{<math text size>}{<math script size>}{<math scriptscript size>}`.

Warning : It is usually not a good idea to modify font sizes like this, in math expressions. It may cause ugly side-effects in subsequent alignments and positioning.

1.3 Spacing and sizes in math mode

Spacing is tricky in math mode. Spacing in maths texts is very different from spacing in normal texts. LaTeX uses many complex spacing rules in maths texts. The difference may be very subtle, but it improves the legibility of maths-rich texts substantially. Here are a few examples:

Text spacing inside math mode

`$x+y is the same as y+x$` gives :
$x + yisthesameasy + x$

You can bring back the spaces using backslashes, placed at the right points using with `\ ` ::
$x + y$ *is the same as* $y + x$

Or, by using the `\text` command::
$x + y$ is the same as $y + x$

Negative spacing (squeeze to left)

$x + y = z$ Normal math positioning
$x\!+ y = z$ The + is squeezed to left.
$x\!\!+ y = z$ The + is squeezed more to left.
$x\!\!\!+ y = z$ The + is squeezed much more to left.

Positive spacing (stretch to right)

In the next three lines, the + sign is moving to the right progressively. Zoom in to see the change.

$x + y = z$ (no added spacing)
$x \> + y = z$ (with `\>`)
$x \; + y = z$ (with `\;`)
$x \ + y = z$ (with `\ `)

Some more examples

x^2 Normal spacing
$x^{\!2}$ Squeeze left (with `\!`)
$x^{\!\!2}$ Squeeze more to left (with `\!\!`)

x^{2} Stretch right (with `\;`)

Spacing with `\quad` and `\qquad`

$x + y = z$
$x \quad + y = z$ (with `\quad`)
$x \qquad + y = z$ (with `\qquad`)
$x \ + y = z$ (with `\ `)

Dollar signs

$ gives a dollar sign

`\[` is tricky. It does not give the [symbol. You have to use `[` , or use `]`, to get].

Differentials, most commonly the dx , used for differentials, should have a little space separating it from other elements. The dx is a unit and so it needs a little space to keep from looking like the product of d and x. You can do this in LaTeX by inserting , before and between differentials.

$\int_0^1 f(x)\,dx$
$\int_0^1 f(x)dx$

The first integral was written as

```
\int_0^1 f(x) \, dx
```

while the second forgot the , and was written as

```
\int_0^1 f(x)  dx
```

Multiple differentials The need for a little extra space around differentials becomes more obvious in multiple differentials.

$dx\,dy = r\,dr\,d\theta$
$dxdy = rdrd\theta$
The first was written as

```
dx , dy = r , dr \, d\theta
```

while, the second was written as

```
dx  dy = r  dr  d\theta
```

Function names The LaTeX commands for typesetting functions like sin, cos, log, max, etc. begin with a backslash. The command log keeps log, for example, from looking like the product of variables l, o, and g.
$\log e^x = x$
$log\, e^x = x$

The first example above was written as
```
\log e^x = x
```
and the second as
```
log \, e^x = x
```

The expression: `log e^x = x` gives $loge^x = x$ (which is clearly ugly).

Angle multiples The double angle identity for sine is readable when properly typeset, and a jumbled mess, when the necessary backslashes are left out.

$\sin 2u = 2 \sin u \cos u$

$sin2u = 2sinucosu$

The first example was written

```
\sin 2u = 2 \sin u \cos u
```
and the second as
```
sin 2u = 2 sin u cos u
```

Greek letters Greek letters are not spaced like normal English letters, in mathematical expressions :

$a * b + c/d$

$\alpha * \beta + \gamma/\delta$

$a + \alpha * c - \delta + \gamma/\omega$

Parantheses : Parentheses don't come out the right size if you use simple (or) to typeset an expression that is vertically large, e.g. $(\frac{a^5}{x^3})^2$.

But, if we put `\left` and `\right` before the relevant parentheses, we get a prettier expression, like this:

$\left(\frac{a^5}{x^3}\right)^2$ (Notice the size of the parantheses with respect to the text size).

LaTeX makes these parantheses grow and shrink automatically, depending on the size of the text they enclose:

$\left(\frac{a^5}{x^3}\right)^2 * \left(\frac{1}{1+\frac{a^5}{x^3}}\right)^2 + \lambda$
and they are aligned (vertically) depending upon the context. The sizes of the individual variables, superscripts and subscripts get adjusted also, automatically.

2 Mathematical equations

Equations form a significant component of mathematical text. Several facilities are available in LaTeX for handling equations.

A stack of **multi-line equations** will look like this (each line of the equation is numbered) :

$$\begin{aligned} e^x &\approx 1 + x + x^2/2! + && (3)\\ &\quad x^3/3! + x^4/4! + && (4)\\ &\quad x^5/5! && (5) \end{aligned}$$

Or make equations without numbers

$$\begin{aligned} x + v^3 - g/h &= a + b + c + d + e + \\ &\quad f + g + h + \cos\beta \\ x^2 - y^2 &= (x + y)(x - y) \\ (x + y)(x - y) &= x^2 - y^2 \end{aligned}$$

Notice the vertical alignment of the various subequations. The vertical alignment is provided automatically by LaTeX .

The above equations use the `eqnarray` environment.

2.1 Avoid eqnarray

There is a huge controversy concerning the `eqnarray` environment. [7] gives a detailed explanation on this subject. Instead, the `align` environment is highly recommended.

The **align** environment is used for two or more equations when vertical alignment is desired; usually binary relations such as equal signs are aligned. Here are a few examples:

Left align stack of multiple equations.

$$f(u) = \sum_{j=1}^{n} x_j f(u_j) \tag{6}$$

$$= \sum_{j=1}^{n} x_j \sum_{i=1}^{m} a_{ij} v_i \tag{7}$$

$$= \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij} x_j v_i \tag{8}$$

Stack of equations is aligned in the centre.

$$f(u) = \sum_{j=1}^{n} x_j f(u_j) \tag{9}$$

$$= \sum_{j=1}^{n} x_j \sum_{i=1}^{m} a_{ij} v_i \tag{10}$$

$$= \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij} x_j v_i \tag{11}$$

The whole stack can be numbered as one equation.

$$
\begin{aligned}
f(u) &= \sum_{j=1}^{n} x_j f(u_j) \\
&= \sum_{j=1}^{n} x_j \sum_{i=1}^{m} a_{ij} v_i \\
&= \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij} x_j v_i
\end{aligned}
\tag{12}
$$

3 Concluding remarks

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4 About the author

Figure 1: The pensive Professor

Parthasarathy is an aggressive supporter of FOSS. He teaches discrete mathematics, and preaches LaTeX and Linux, to students of Computer Science, at Hyderabad, India, and at Kathmandu, Nepal. He would be happy to assist anyone, particularly students, teachers, and institutions, who are genuinely interested in these topics. His contact address is : `drpartha@gmail.com`

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