Algologic Technical Report # 3/2012

LaTeX torture tests

S. Parthasarathy[1]
drpartha@gmail.com

Ref.: `torture2.tex`
Ver.: 20220630c

1 Preamble

Do you use LaTeX ? Do you indulge in mathematically rich subjects, and write often about them ? Do you want to check out how well you (or your students/colleagues) know, or use LaTeX ? Do you want to check your LaTeX installation ? Try creating the following material using LaTeX [2]

It is impossible to demonstrate all the mathematical features of LaTeX in a single document like this. Use this as a starter, and try out features which have not been demonstrated here. The series of tests shown here, is a followup of two other articles [1] and [2]. The tests shown below are a mixture of some simple stuff, and some not-so-simple stuff. Some interesting examples of unusual printing, are given in [3]. A good introduction to the use of LaTeX for writing mathematics is given in [4].

What follows is NOT a test for your mathematical problem-solving skills.

1.1 Why LaTeX for maths ?

Why is it necessary to use a special maths environment ? The answer is easy.

See the sample text, typed in usual paragraph style : a = b+c/d + x* y.

See the same sample text, set in math mode of LaTeX : $a = b + c/d + x * y$

Notice, the following ::

[1] Algologic Research and Solutions, 78 Sancharpuri Colony, Bowenpally, Secunderabad 500 011, India WWW-URL – http://algolog.tripod.com/nupartha.htm

[2] You can get the LaTeX source of this document, by sending a mail to `drpartha@gmail.com`. Please quote the Ref. code and version code given at the beginning of this document.

- The uniform spacing of mathematical operators
- The equation stands out from the text, because of a special font style

There is a whole lot of other things LaTeX does when in math mode.

1.2 The tests

Try some sans serif type face like this. A quick brown fox jumps over the little lazy dog and gets hurt. Yankee doodle went to town.

`Typewriter -- Some typewriter like text. A quick brown fox jumps over the little lazy dog and gets hurt. Yankee doodle went to town.`

Roman. – A quick brown fox jumps over the little lazy dog and gets hurt. Yankee doodle went to town.

Italics. – A quick brown fox jumps over the little lazy dog and gets hurt. Yankee doodle went to town.

Boldface. – A quick brown fox jumps over the little lazy dog and gets hurt. Yankee doodle went to town.

Bold and italics text

`Typewriter and italics text`

Back to sans serif.

Here are some examples, drawn from [4].

Write a numbered equation ::

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

..and an equation without number :

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

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

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

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

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

Or put a whole line in the box ::

$$\boxed{x^2 + y^2 = z^2 \qquad (3)}$$

A boxed equation without numbers ...

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

Now put two equations in the box :

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

$$x_1 = -\,{}^1\!/_2\,\frac{m_2}{m_1} + \frac{\sqrt{(m_2 + 2\sqrt{m_1.m_3}).(m_2 - 2\sqrt{m_1.m_3})}}{2.m_1} \qquad (4)$$

$$x_2 = -\,{}^1\!/_2\,\frac{m_2}{m_1} - \frac{\sqrt{(m_2 + 2\sqrt{m_1.m_3}).(m_2 - 2\sqrt{m_1.m_3})}}{2.m_1} \qquad (5)$$

$$1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \dots}}}}} \qquad (6)$$

L'Hôpital's rule ::

$\lim_{x\to 0} \frac{e^x - 1}{2x} \lim_{x\to 0} \frac{e^x}{2} = \frac{1}{2}$

How about some extensible arrows ? These arrows stech and shrink automatically !

$X \xleftarrow{n+\mu} Y \xrightarrow[T]{n\pm\beta+i-1} Z$

What is a complex number ?

$$z = \overbrace{\underbrace{x}_{\text{real}} + \underbrace{iy}_{\text{imaginary}}}^{\text{complex number}}$$

Or, make some multi-part definitions like this :

$$\mu(n) = \begin{cases} 1 & \text{if } n = 1 \\ 0 & \text{if } a^2 \,|\, n \text{ for some } a > 1 \\ (-1)^r & \text{if } n \text{ has } r \text{ distinct prime factors} \end{cases}$$

Continued fractions look like this:

$$x = \left[a_0 + \frac{1}{a_1 + \frac{1}{a_2 + \frac{1}{a_3 + a_4}}} \right] \tag{7}$$

The most famous equation in mathematics (Euler's equation)::

$$e^{i\pi} \; + \; 1 \; = \; 0$$

The cutest formula in mathematics (Heron's formula)

$$A \;=\; \sqrt{s.(s-a).(s-b).(s-c)} \tag{8}$$

where

$$A = Area\ of\ the\ triangle \tag{9}$$
$$a, b, c = \ sides\ of\ the\ triangle \tag{10}$$
$$s = semi - perimeter \tag{11}$$
$$= \frac{a+b+c}{2} \tag{12}$$

Can you compute:

$\int_0^1 e^x (1-x)^{100} dx$

Do you see any difference between the next two equations ?

$$x = \frac{b^c}{a_0 + \frac{1}{a_1 + \frac{1}{a_2 + \frac{1}{a_3 + a_4}}}} \tag{13}$$

$$x = \cfrac{b^c}{a_0 + \cfrac{1}{a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + a_4}}}} \tag{14}$$

Here are two equations without subnumbers:

$$a = b + c \tag{15}$$

$$a = c * d/2 \tag{16}$$

some equations with subnumbers

$$a = b + c \tag{17a}$$

$$d = e + f + g \tag{17b}$$

$$h = i + j \tag{17c}$$

Build your own matrices.

$$\begin{bmatrix} a & b & \begin{pmatrix} g & h \\ i & j \end{pmatrix} \\ d & e & f \end{bmatrix}$$

Or, try something more elaborate :

$$\begin{bmatrix} \frac{\theta}{\alpha+\beta+\gamma} & \frac{\omega+\delta}{\psi-(\chi*\pi)} & \begin{pmatrix} g & h \\ i & j \end{pmatrix} \\ d & e & f \end{bmatrix}^{-1}$$

Or, compute a determinant ::

$$\begin{vmatrix} \frac{\theta}{\alpha+\beta+\gamma} & \frac{\omega+\delta}{\psi-(\chi*\pi)} & g \\ i & j & h \\ d & e & f \end{vmatrix}$$

Matrices can be delimited in different ways and styles.

$$\begin{pmatrix} \alpha & \beta^* \\ \gamma^* & \delta \end{pmatrix}$$

They can also be numbered, like equations.

$$\begin{bmatrix} \alpha & \beta^* \\ \gamma^* & \delta \end{bmatrix} \tag{18}$$

$$\begin{Bmatrix} \alpha & \beta^* \\ \gamma^* & \delta \end{Bmatrix} \tag{19}$$

$$\begin{vmatrix} \alpha & \beta^* \\ \gamma^* & \delta \end{vmatrix}$$

$$\begin{Vmatrix} \alpha & \beta^* \\ \gamma^* & \delta \end{Vmatrix}$$

And here is a small-sized $\left(\begin{smallmatrix} \alpha & \beta^* \\ \gamma^* & \delta \end{smallmatrix} \right)$ in-line matrix you may need some time.

Write matrices which are side by side to each other

$$\begin{pmatrix} 1 & 0 \\ 0 & e^{i\pi} \end{pmatrix} \begin{pmatrix} u \\ v \end{pmatrix} = \begin{pmatrix} u \\ -v \end{pmatrix}$$

2 Complex maths does not hurt

Don't ask me what these formulae do !

Complex maths does not hurt, so let's try:

$$F(b) - F(a) = \int_a^b \sum_{j=0}^{n} f(x_j) \prod_{\substack{k=0 \\ k \neq j}}^{n} \frac{x - x_k}{x_j - x_k} \, dx \tag{20}$$

Or, try this snippet borrowed (and then customised) from [6]

$$
\begin{aligned}
F(s) &= 1+\sum_{r=1}^{\infty}\frac{\lambda(2^r)}{2^{rs}}+\sum_{r=1}^{\infty}\frac{\lambda(3^r)}{3^{rs}}+\sum_{r=1}^{\infty}\frac{\lambda(5^r)}{5^{rs}}+\sum_{r=1}^{\infty}\frac{\lambda(2\times 3^r)}{2^s3^{rs}} \\
&+\sum_{r=1}^{\infty}\frac{\lambda(7^r)}{7^{rs}}+\sum_{r=1}^{\infty}\frac{\lambda(2\times 5^r)}{2^s5^{rs}}+\sum_{r=1}^{\infty}\frac{\lambda(11^r)}{11^{rs}}+\sum_{k=2}^{\infty}\frac{\lambda(2^k\times 3)}{2^{ks}3^s} \\
&+\sum_{r=1}^{\infty}\frac{\lambda(13^r)}{13^{rs}}+\sum_{r=1}^{\infty}\frac{\lambda(2\times 7^r)}{2^s7^{rs}}+\sum_{r=1}^{\infty}\frac{\lambda(3\times 5^r)}{3^s5^{rs}}+\sum_{r=1}^{\infty}\frac{\lambda(17^r)}{17^{rs}} \\
&+\sum_{r=1}^{\infty}\frac{\lambda(19^r)}{19^{rs}}+\sum_{k=2}^{\infty}\frac{\lambda(2^k\times 5)}{2^{ks}5^s}+\sum_{r=1}^{\infty}\frac{\lambda(3\times 7^r)}{3^s7^{rs}}\sum_{r=1}^{\infty}\frac{\lambda(2\times 11^r)}{2^s11^{rs}} \\
&+\sum_{r=1}^{\infty}\frac{\lambda(23^r)}{23^{rs}}+\sum_{r=1}^{\infty}\frac{\lambda(2\times 13^r)}{2^s13^{rs}}+\sum_{k=2}^{\infty}\frac{\lambda(2^k\times 7)}{2^{ks}7^s}+\sum_{r=1}^{\infty}\frac{\lambda(29^r)}{29^{rs}} \\
&+\sum_{r=1}^{\infty}\frac{\lambda(2\times 3\times 5^r)}{2^s3^s5^{rs}}+... \qquad (21)
\end{aligned}
$$

Where

$$\sum_{r=1}^{\infty}\frac{\lambda(m.p^r)}{m^s.p^{rs}} = \frac{\lambda(m.p)}{m^s.p^s}[1-\frac{1}{p^s}+\frac{1}{p^{2s}}-\frac{1}{p^{3s}}+...+\frac{(-1)^X}{p^{Xs}}]$$

or

$$\sum_{k=2}^{\infty}\frac{\lambda(m.p^k.u)}{m^s.p^{ks}} = \frac{\lambda(m.p^2.u)}{m^s.p^{2s}.us}[1-\frac{1}{p^s}+\frac{1}{p^{2s}}-\frac{1}{p^{3s}}+...+\frac{(-1)^X}{p^{Xs}}] \qquad (22)$$

and

$$F(s)=\sum_m\sum_p\sum_u F^T_{m;p;u}(s)+\sum_m\sum_p F^T_{m;p;1}(s), \qquad (23)$$

This leads to :

$$G^T_{m;p;u}(s)=\sqrt{\sum_{k=2}^{\infty}\frac{\lambda(mp^ku)}{m^sp^{ks}u^s}*\sum_{r=1}^{\infty}\frac{\lambda(mp^r)}{m^sp^{rs}}}+\theta-\phi^{\omega} \qquad (24)$$

3 Ugly ducklings

Try to create the following expressions using LaTeX :

$$\frac{1}{\pi} = \frac{2\sqrt{2}}{9801} \sum_{k=0}^{\infty} \frac{(4k!)(1103 + 26390k)}{(k!)^4(396^{4k})} \tag{25}$$

This expression is reputed to be the ugliest equation in mathematics and is a creation of Ramanujan.

Or, try rewriting these expressions in LATEX :

$$\forall\ \epsilon > 0,\ \exists\ \delta > 0 : 0 < |x - x_0| < \delta \Rightarrow |f(x) - f(x_0)| < \epsilon$$

$$\frac{1}{\pi} = 12 \sum_{k=0}^{\infty} \frac{(-1)^k (6k)!(545140134k + 13591409)}{(3k)!(k!)^3\,(640320)^{3k+3/2}}$$

$$\lim_{n\to\infty} \lim_{m\to\infty} \frac{n}{m+n} \neq \lim_{m\to\infty} \lim_{n\to\infty} \frac{n}{m+n}$$

More to follow.
Watch this space

4 Concluding remarks

This is a LATEX document, created under Linux, using Kile. You can get the LATEX source of this document from drpartha@gmail.com. Please mention the Reference Code, and Version code, given at the top of this document.

If you found this article useful, please send a note to `drpartha@gmail.com`

This article, and several other articles related to mathematics can be downloaded from `http://profpartha.webs.com/publications/downloadmath.htm`.

As always, suggestions and constructive comments are always welcome.

5 About the author

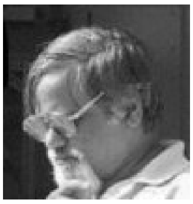

Figure 1: The pensive Professor

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

References

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[2] Parthasarathy S, *When grace meets beauty, again*, Algologic Technical Report.

[3] Parthasarathy S, *Who says LaTeX is only for serious stuff ?* Algologic Technical Report, March 2008.

[4] Michael Downes, AMS: *Short Math Guide for LATEX*, ftp://ftp.ams.org/ams/doc/amsmath/short-math-guide.pdf

[5] Creative Commons By Attribution - NonCommercial - ShareAlike 3.0 Unported License. `http://$creativecommons.org/licenses/by-nc-sa/3.0/deed.en_US$`

[6] K. Eswaran, The Dirichlet Series for the Liouville Function and the Riemann Hypothesis, RSPA-2016-0679-LG-23-September.tex

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