How various formats can deal with LaTeX math

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May 25, 2016

Abstract

The purpose of this document is to test LaTeX math in DocOnce with various output formats. Most LaTeX math constructions are renedered correctly by MathJax in plain HTML, but some combinations of constructions may fail. Unfortunately, only a subset of what works in html MathJax also works in sphinx MathJax. The same is true for markdown MathJax expresions (e.g., Jupyter notebooks). Tests and examples are provided to illustrate what may go wrong.

The recommendation for writing math that translates to MathJax in html, sphinx, and markdown is to stick to the environments `\[ ... \]`, `equation`, `equation*`, `align`, `align*`, `alignat`, and `alignat*` only. Test the math with sphinx output; if it works in that format, it should work elsewhere too.

The current version of the document is translated from DocOnce source to the format **pdflatex**.

Test 1: Inline math. We can get an inline equation `$u(t)=e^{-at}$` rendered as $u(t) = e^{-at}$.

Test 2: A single equation with label. An equation with number,

```
!bt
\begin{equation} u(t)=e^{-at} label{eq1a}\end{equation}
!et
```

looks like

$$u(t) = e^{-at} \tag{1}$$

Maybe this multi-line version is what we actually prefer to write:

```
!bt
\begin{equation}
u(t)=e^{-at}
label{eq1b}
\end{equation}
!et
```

The result is the same:

$$u(t) = e^{-at} \tag{2}$$

We can refer to this equation through its label `eq1b`: (2).

Test 3: Multiple, aligned equations without label and number. MathJax has historically had some problems with rendering many LaTeX math environments, but the `align*` and `align` environments have always worked.

```
!bt
\begin{align*}
u(t)&=e^{-at}\\
v(t) - 1 &= \frac{du}{dt}
\end{align*}
!et
```

Result:

$$\begin{aligned} u(t) &= e^{-at} \\ v(t) - 1 &= \frac{du}{dt} \end{aligned}$$

Test 4: Multiple, aligned equations with label. Here, we use `align` with user-prescribed labels:

```
!bt
\begin{align}
u(t)&=e^{-at}
label{eq2b}\\
v(t) - 1 &= \frac{du}{dt}
label{eq3b}
\end{align}
!et
```

Result:

$$u(t) = e^{-at} \tag{3}$$
$$v(t) - 1 = \frac{du}{dt} \tag{4}$$

We can refer to the last equations as the system (3)-(4).

Test 5: Multiple, aligned equations without label. In LaTeX, equations within an `align` environment is automatically given numbers. To ensure that an html document with MathJax gets the same equation numbers as its latex/pdflatex companion, DocOnce generates labels in equations where there is no label prescribed. For example,

```
!bt
\begin{align}
u(t)&=e^{-at}
\\
v(t) - 1 &= \frac{du}{dt}
\end{align}
!et
```

is edited to something like

```
!bt
\begin{align}
u(t)&=e^{-at}
label{_auto5}\\
v(t) - 1 &= \frac{du}{dt}
label{_auto6}
\end{align}
!et
```

and the html output gets the two equation numbered.

$$
\begin{align}
u(t) &= e^{-at} \tag{5}\\
v(t) - 1 &= \frac{du}{dt} \tag{6}
\end{align}
$$

Test 6: Multiple, aligned equations with multiple alignments. The `align` environment can be used with two `&` alignment characters, e.g.,

```
!bt
\begin{align}
\frac{\partial u}{\partial t} &= \nabla^2 u, & x\in (0,L),
\ t\in (0,T]\\
u(0,t) &= u_0(x), & x\in [0,L]
\end{align}
!et
```

The result in pdflatex becomes

$$
\begin{align}
\frac{\partial u}{\partial t} &= \nabla^2 u, & x\in (0,L),\ t\in (0,T] \tag{7}\\
u(0,t) &= u_0(x), & x\in [0,L] \tag{8}
\end{align}
$$

A better solution is usually to use an `alignat` environment:

```
!bt
\begin{alignat}{2}
\frac{\partial u}{\partial t} &= \nabla^2 u, & x\in (0,L),
\ t\in (0,T]\\
u(0,t) &= u_0(x), & x\in [0,L]
\end{alignat}
!et
```

with the rendered result

$$\frac{\partial u}{\partial t} = \nabla^2 u,\ \ x \in (0,L),\ \ t \in (0,T] \tag{9}$$

$$u(0,t) = u_0(x), \qquad x \in [0,L] \tag{10}$$

Test 7: Multiple, aligned eqnarray equations without label. Let us try the old `eqnarray*` environment.

```
!bt
\begin{eqnarray*}
u(t)&=& e^{-at}\\
v(t) - 1 &=& \frac{du}{dt}
\end{eqnarray*}
!et
```

which results in

$$\begin{aligned} u(t) &= e^{-at} \\ v(t) - 1 &= \frac{du}{dt} \end{aligned}$$

Test 8: Multiple, eqnarrayed equations with label. Here we use `eqnarray` with labels:

```
!bt
\begin{eqnarray}
u(t)&=& e^{-at}
label{eq2c}\\
v(t) - 1 &=& \frac{du}{dt}
label{eq3c}
\end{eqnarray}
!et
```

which results in

$$u(t) = e^{-at} \tag{11}$$

$$v(t) - 1 = \frac{du}{dt} \tag{12}$$

Can we refer to the last equations as the system (11)-(12) in the pdflatex format?

Test 9: The `multiline` environment with label and number. The LaTeX code

```
!bt
\begin{multline}
\int_a^b f(x)dx = \sum_{j=0}^{n} \frac{1}{2} h(f(a+jh) +
f(a+(j+1)h)) \\
=\frac{h}{2}f(a) + \frac{h}{2}f(b) + \sum_{j=1}^n f(a+jh)
label{multiline:eq1}
\end{multline}
!et
```

gets rendered as

$$\int_a^b f(x)dx = \sum_{j=0}^{n} \frac{1}{2} h(f(a+jh) + f(a+(j+1)h)) \\ = \frac{h}{2}f(a) + \frac{h}{2}f(b) + \sum_{j=1}^n f(a+jh) \quad (13)$$

and we can hopefully refer to the Trapezoidal rule as the formula (13).

Test 10: Splitting equations using a split environment. Although `align` can be used to split too long equations, a more obvious command is `split`:

```
!bt
\begin{equation}
\begin{split}
\int_a^b f(x)dx = \sum_{j=0}^{n} \frac{1}{2} h(f(a+jh) +
f(a+(j+1)h)) \\
=\frac{h}{2}f(a) + \frac{h}{2}f(b) + \sum_{j=1}^n f(a+jh)
\end{split}
\end{equation}
!et
```

The result becomes

$$\begin{split}\int_a^b f(x)dx &= \sum_{j=0}^{n} \frac{1}{2} h(f(a+jh) + f(a+(j+1)h)) \\ &= \frac{h}{2}f(a) + \frac{h}{2}f(b) + \sum_{j=1}^n f(a+jh)\end{split} \quad (14)$$

Test 11: Newcommands and boldface bm vs pmb. First we use the plain old pmb package for bold math. The formula

```
!bt
\[ \frac{\partial\u}{\partial t} +
\u\cdot\nabla\u = \nu\nabla^2\u -
\frac{1}{\varrho}\nabla p,\]
!et
```

and the inline expression `$\nabla\u (\x)\cdot\normalvec$` (with suitable newcommands using pmb) get rendered as

$$\frac{\partial\boldsymbol{u}}{\partial t} + \boldsymbol{u}\cdot\nabla\boldsymbol{u} = \nu\nabla^2\boldsymbol{u} - \frac{1}{\varrho}\nabla p,$$

and $\nabla\boldsymbol{u}(\boldsymbol{x})\cdot\boldsymbol{n}$.

Somewhat nicer fonts may appear with the more modern `\bm` command:

```
!bt
\[ \frac{\partial\ubm}{\partial t} +
\ubm\cdot\nabla\ubm = \nu\nabla^2\ubm -
\frac{1}{\varrho}\nabla p,\]
!et
```

(backslash `ubm` is a newcommand for bold math u), for which we get

$$\frac{\partial\boldsymbol{u}}{\partial t} + \boldsymbol{u}\cdot\nabla\boldsymbol{u} = \nu\nabla^2\boldsymbol{u} - \frac{1}{\varrho}\nabla p.$$

Moreover,

```
$\nabla\bm{u}(\bm{x})\cdot\bm{n}$
```

becomes $\nabla\boldsymbol{u}(\boldsymbol{x})\cdot\boldsymbol{n}$.

Problematic equations. Finally, we collect some problematic formulas in MathJax. They all work fine in LaTeX.

```
!bt
\[ {\color{blue}\frac{\partial\u}{\partial t}} +
\nabla\cdot\nabla\u = \nu\nabla^2\u -
\frac{1}{\varrho}\nabla p,\]
!et
```

results in

$${\color{blue}\frac{\partial\boldsymbol{u}}{\partial t}} + \nabla\cdot\nabla\boldsymbol{u} = \nu\nabla^2\boldsymbol{u} - \frac{1}{\varrho}\nabla p,$$

but correct rendering in sphinx requires omitting the `\color` command.

Sometimes one must be extra careful with the LaTeX syntax to get sphinx MathJax to render a formula correctly. Consider the combination of a bar over a bold math symbol:

```
!bt
\[ \bar\f = f_c^{-1}\f,\]
!et
```

which for pdflatex output results in

$$\bar{\boldsymbol{f}} = f_c^{-1}\boldsymbol{f}.$$

With sphinx, this formula is not rendered. However, using curly braces for the bar,

```
!bt
\[ \bar{\f} = f_c^{-1}\f,\]
!et
```

makes the output correct also for sphinx:

$$\bar{\boldsymbol{f}} = f_c^{-1}\boldsymbol{f},$$

Matrix Environment. Nested environments with labled pmatrix environments cause wired representation in ipynb and html.

```
!bt
\begin{align}
\begin{pmatrix}
G_2 + G_3 & -G_3 & -G_2 & 0 \\
-G_3 & G_3 + G_4 & 0 & -G_4 \\
-G_2 & 0 & G_1 + G_2 & 0 \\
0 & -G_4 & 0 & G_4
\end{pmatrix}
&=
\begin{pmatrix}
v_1 \\
v_2 \\
v_3 \\
v_4
\end{pmatrix}
+ \cdots \\
\begin{pmatrix}
C_5 + C_6 & -C_6 & 0 & 0 \\
-C_6 & C_6 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0
\end{pmatrix}
\frac{d}{dt} &=
\begin{pmatrix}
v_1 \\
v_2 \\
v_3 \\
v_4
\end{pmatrix} =
\begin{pmatrix}
0 \\
0 \\
0 \\
-i_0
\end{pmatrix}
\end{align}
!et
```

which becomes

$$\begin{pmatrix} G_2 + G_3 & -G_3 & -G_2 & 0 \\ -G_3 & G_3 + G_4 & 0 & -G_4 \\ -G_2 & 0 & G_1 + G_2 & 0 \\ 0 & -G_4 & 0 & G_4 \end{pmatrix} = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix} + \cdots \tag{15}$$

$$\begin{pmatrix} C_5 + C_6 & -C_6 & 0 & 0 \\ -C_6 & C_6 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \frac{d}{dt} = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ -i_0 \end{pmatrix} \tag{16}$$

The same matrices without labels seem to translate better:

```
!bt
\begin{align*}
\begin{pmatrix}
G_2 + G_3 & -G_3 & -G_2 & 0 \\
-G_3 & G_3 + G_4 & 0 & -G_4 \\
-G_2 & 0 & G_1 + G_2 & 0 \\
0 & -G_4 & 0 & G_4
\end{pmatrix}
&=
\begin{pmatrix}
v_1 \\
v_2 \\
v_3 \\
v_4
\end{pmatrix}
+ \cdots \\
\begin{pmatrix}
C_5 + C_6 & -C_6 & 0 & 0 \\
-C_6 & C_6 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0
\end{pmatrix}
\frac{d}{dt} &=
\begin{pmatrix}
v_1 \\
v_2 \\
v_3 \\
v_4
\end{pmatrix} =
\begin{pmatrix}
0 \\
0 \\
0 \\
-i_0
\end{pmatrix}
\end{align*}
!et
```

which becomes

$$
\begin{pmatrix} G_2+G_3 & -G_3 & -G_2 & 0 \\ -G_3 & G_3+G_4 & 0 & -G_4 \\ -G_2 & 0 & G_1+G_2 & 0 \\ 0 & -G_4 & 0 & G_4 \end{pmatrix} = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix} + \cdots
$$

$$
\begin{pmatrix} C_5+C_6 & -C_6 & 0 & 0 \\ -C_6 & C_6 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \frac{d}{dt} = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ -i_0 \end{pmatrix}
$$