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Many papers have been written by Knuth himself and by others on the topic of math typesetting. Here I’d like to present some personal ideas on the subject, coming from almost thirty year long experience in mathematical typesetting. I’ll also present some recent developments and new tricks made available with expl3.
\TeX{} has three main modes

1. Vertical mode
2. Horizontal mode
3. Math mode

Each mode has two flavors. In particular, math mode can be inline or display.
TeX has three main modes

1. vertical mode
\LaTeX{} has three main modes

1. vertical mode
2. horizontal mode
The \TeX\ has three main modes

1. vertical mode
2. horizontal mode
3. math mode
TEX has three main modes

1. vertical mode
2. horizontal mode
3. math mode

Each mode has two flavors. In particular, math mode can be *inline* or *display*.
\[ \sum_{k=1}^{n} k^2 = \frac{1}{3} n \left( n + \frac{1}{2} \right) (n+1) \]
Math modes

\[ \sum_{k=1}^n k^2 = \frac{1}{3}n \left( n + \frac{1}{2} \right)(n+1) \]

If this code is put between \(\(...\)\) we get
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Between \[\[\ldots\]\] we get
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Do you see something strange in the following formula?

\[ A \setminus B = \{ x \mid x \in A, x \notin B \} \]
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**Warning**

the code \,\setminus \, should not be typed in
In a paper I had to massage for publication in a volume, the separator in the set builder notation was denoted like

\[ \{ x \mid x \in A, x \notin B \} \]
\[ \{ x : x \in A, x \notin B \} \]
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Repetitive constructions must be packed in a command, say one of

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Repetitive constructions **must** be packed in a command, say one of

\newcommand{\suchthat}{\,|,\,}
\newcommand{\suchthat}{\mid}
\newcommand{\suchthat}{:}
\newcommand{\suchthat}{;}

There are very good reasons to do this!
Fussy supervisors are my favorite example here: after months of blood, toil, sweat and tears, a student hands in her thesis.
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*Nice, but shouldn’t the separator in set builder notation be a colon, rather than a vertical bar?*
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Now you know why to use `\suchthat`
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*Nice, but shouldn’t the separator in set builder notation be a colon, rather than a vertical bar?*

Now you know why to use \texttt{\textbackslash suchthat}

### An important exception

In the abstract there should be *no* use of personal macros. It should be able to typeset with a ‘naked’ version of \LaTeX: it’s very common nowadays that the abstract is fed to some web page that maybe uses MathML, MathJax or similar device for handing the text to browsers.
Fine points of mathematical typing

\[
\begin{align*}
\begin{cases}
    a^6 + 2a^3b^3 + b^6 &= q^2 \\
    4a^3b^3 &= -\frac{4}{27}p^3 \\
    a^3 + b^3 &= -q \\
    a^6 - 2a^3b^3 + b^6 &= q^2 + \frac{4}{27}p^3 \\
    (a^3 - b^3)^2 &= q^2 + \frac{4}{27}p^3 \\
    a^3 + b^3 &= -q \\
    a^3 - b^3 &= \sqrt{q^2 + \frac{4}{27}p^3}
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The ugly
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The bad

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    \end{cases}
\end{align*}
\]

The ugly
### Fine points of mathematical typing

<table>
<thead>
<tr>
<th>The good</th>
<th>The bad</th>
<th>The ugly</th>
</tr>
</thead>
</table>
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Alignments

\[
\begin{pmatrix}
A_\mu \\
\rho_\mu^*
\end{pmatrix} \rightarrow \begin{pmatrix}
\cos \theta & -\sin \theta \\
\sin \theta & \cos \theta
\end{pmatrix} \begin{pmatrix}
A_\mu \\
\rho_\mu^*
\end{pmatrix}, \quad \tan \theta = \frac{g_{el}}{g_*}
\]

\[
\begin{pmatrix}
\psi_L \\
\chi_L
\end{pmatrix} \rightarrow \begin{pmatrix}
\cos \varphi_{\psi_L} & -\sin \varphi_{\psi_L} \\
\sin \varphi_{\psi_L} & \cos \varphi_{\psi_L}
\end{pmatrix} \begin{pmatrix}
\psi_L \\
\chi_L
\end{pmatrix}, \quad \tan \varphi_{\psi_L} = \frac{\Delta}{m}
\]

\[
\begin{pmatrix}
\tilde{\psi}_R \\
\tilde{\chi}_R
\end{pmatrix} \rightarrow \begin{pmatrix}
\cos \varphi_{\tilde{\psi}_R} & -\sin \varphi_{\tilde{\psi}_R} \\
\sin \varphi_{\tilde{\psi}_R} & \cos \varphi_{\tilde{\psi}_R}
\end{pmatrix} \begin{pmatrix}
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\tilde{\chi}_R
\end{pmatrix}, \quad \tan \varphi_{\tilde{\psi}_R} = \frac{\tilde{\Delta}}{\tilde{m}}
\]
Alignments

\[
\begin{align*}
\begin{pmatrix} A_\mu \\ \rho_\mu^* \end{pmatrix} & \rightarrow \begin{pmatrix} \cos \theta & - \sin \theta \\ \sin \theta & \cos \theta \end{pmatrix} \begin{pmatrix} A_\mu \\ \rho_\mu^* \end{pmatrix}, & \tan \theta = \frac{g_{el}}{g_*}, \\
\begin{pmatrix} \psi_L \\ \chi_L \end{pmatrix} & \rightarrow \begin{pmatrix} \cos \varphi_{\psi_L} & - \sin \varphi_{\psi_L} \\ \sin \varphi_{\psi_L} & \cos \varphi_{\psi_L} \end{pmatrix} \begin{pmatrix} \psi_L \\ \chi_L \end{pmatrix}, & \tan \varphi_{\psi_L} = \frac{\Delta}{m}, \\
\begin{pmatrix} \tilde{\psi}_R \\ \tilde{\chi}_R \end{pmatrix} & \rightarrow \begin{pmatrix} \cos \varphi_{\tilde{\psi}_R} & - \sin \varphi_{\tilde{\psi}_R} \\ \sin \varphi_{\tilde{\psi}_R} & \cos \varphi_{\tilde{\psi}_R} \end{pmatrix} \begin{pmatrix} \tilde{\psi}_R \\ \tilde{\chi}_R \end{pmatrix}, & \tan \varphi_{\tilde{\psi}_R} = \frac{\tilde{\Delta}}{\tilde{m}}.
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We also fill a hole.

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\begin{pmatrix}
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Be consistent! Also with your choice of “phi.”
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Be consistent! Also with your choice of “phi”.

The eagle-eyed people in the audience will have spotted the small but important differences.

The difference is the same as between $2\log x$ and $2\log x$ but in this case TEX automatically the thin space. In the formulas above we have to add $\,\,$ manually where needed.
Thin points of mathematical typing

\[
\frac{f(x + h) - f(x)}{h} + b \frac{g(x + h) - g(x)}{h} = \frac{(1 + \sqrt{z - 1})z^2}{(1 + \sqrt{z - 1})z^2}
\]

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\[
\frac{f(x + h) - f(x)}{h} \cdot a + \frac{g(x + h) - g(x)}{h} \cdot b
\]

\[
\frac{f(x + h) - f(x)}{h} \cdot a + \frac{g(x + h) - g(x)}{h} \cdot b
\]

\[
\left(1 + \sqrt{z - 1}\right)z^2
\]

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a \frac{f(x + h) - f(x)}{h} & \quad + \quad b \frac{g(x + h) - g(x)}{h}
\end{align*}
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but in this case \(\TeX\) automatically the *thin space*.
In the formulas above we have to add \(\text{"\,}\), manually where needed.
To ISO or not to ISO?

The ISO 80000-2:2009 standard is mandatory for technical writing involving mathematics. Engineers and mathematicians agree to disagree in this respect. Physicists disagree with each other. Should the Euler number or the imaginary unit symbols be printed in upright or italic type? ISO prescribes upright type. Mathematicians mostly use italic.
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The differential $d$

\newcommand{\diff}{\mathop{}!d}$
The *differential* $d$

\newcommand{\diff}{\mathop{!}d}

or $\mathsf{d}$ if one *really* prefers the abomination

\[ \int_0^x t \diff t = \frac{x^2}{2} \]

A double integral

\[ \iint_{D} f(x,y) \diff x \diff y \]

Choose whatever form of $d$ you like, but be consistent.
The differential $\diff$ or $\mathrm{d}$ if one really prefers the abomination

$$\int_0^x t \, dt = \frac{x^2}{2}$$
The differential $d$

\newcommand{\diff}{\mathop{\!d}}

or $\mathrm{d}$ if one really prefers the abomination

$$\int_{0}^{x} t \diff t = \frac{x^2}{2}$$

A double integral

$$\iint\limits_{D} f(x,y) \diff x \diff y$$
The differential $d$

\newcommand{\diff}{\mathop{\!d}}

or $\text{d}$ if one *really* prefers the abomination

\[ \int_{0}^{x} t \diff t = \frac{x^2}{2} \]

A double integral

\[ \iint\limits_{D} f(x,y) \diff x \diff y \]

Choose whatever form of $d$ you like, but *be consistent*
Would you like to type something like
\[ \left\{ x \mid \frac{1}{2} < x < \frac{1 + \sqrt{5}}{2} \right\} \]
whenever you have a set denotation?
Would you like to type something like
\[
\left\{ x \mid \frac{1}{2} < x < \frac{1+\sqrt{5}}{2}\right\}
\]
whenever you have a set denotation?

Wouldn’t the code
\[
\set*{x \suchthat \frac{1}{2} < x < \frac{1+\sqrt{5}}{2}}
\]
be better?
Sets, bras and kets

Would you like to type something like
\[
\left\{ x \;\middle|\; \frac{1}{2} < x < \frac{1+\sqrt{5}}{2}\right\}
\]
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Wouldn’t the code
\[
\set*{x \suchthat \frac{1}{2} < x < \frac{1+\sqrt{5}}{2}}
\]
be better?

Or something like
\[
\langle x| \quad |y\rangle \quad \langle x \mid y\rangle
\]
which are a “bra”, a “ket” and a “braket”?

\[
\langle x\mid y\rangle \quad \langle x \mid y\rangle
\]
Good news: the paper contains code for easing the input:

\[ \bra{x} \ket{y} \braket{x|y} \braket{x|y|z} \]
Good news: the paper contains code for easing the input:

\texttt{\bra{x} \ket{y} \braket{x|y} \braket{x|y|z}}

The code also provides easy way to increase the size of the delimiters when needed
What I agree with ISO on is typesetting numbers and units
What I agree with ISO on is typesetting numbers and units. Have you ever seen road signs saying that something is \textit{mt. 100} ahead? Isn't 7,400,043,022,221 much better to parse? It would be 7,400,043,022,221 for our American or British friends.
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Another piece of good news: we have the `siunitx` package that does most of the work for us.
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\SI{100}{\meter} \SI{100}{\metre}
\SI{20}{\kilo\gram}
\SI{600}{\cubic\centi\meter} \SI{600}{\cubic\centi\metre}
\num{7400043022221} \num[group-separator=\{,\}]{7400043022221}
Another piece of good news: we have the \texttt{siunitx} package that does most of the work for us.

\SI{100}{\meter} \SI{100}{\metre}
\SI{20}{\kilo\gram}
\SI{600}{\cubic\centi\meter} \SI{600}{\cubic\centi\metre}
\num{7400043022221} \num[group-separator={,,}]{7400043022221}

100 m 100 m
20 kg
600 cm$^3$ 600 cm$^3$
7 400 043 022 221 7,400,043,022,221
The author of \texttt{siunitx} is Joseph Wright, who started “expanding and fixing” the \texttt{Siunits} package and finished becoming a member of the \LaTeX{} team.
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The \textit{Bureau international des poids et mesures} (BIPM) publishes very detailed information about how to typeset numbers with (or without) units attached. It also states what are the legal units to use in technical documents, the so-called \textit{Système International} (SI). The BIPM standards are also endorsed by the ISO and the national authorities, in Italy it is UNI, so they have the force of law in some contexts. No, it’s not illegal if a mathematical paper uses “log” for the natural logarithm. But the project of a building might be rejected on the ground of not using proper SI units. Remember the Mars Climate Orbiter crash?
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Remember the Mars Climate Orbiter crash?
The acceleration due to gravity near the surface of the Earth is

\[ 9.8 \text{ m s}^{-2} = 9.8 \frac{\text{m}}{\text{s}^2} = 9.8 \text{ m/s}^2 \]

The three realizations have all been input with

\texttt{\SI{9.8}{\meter\per\square\second}}

by just changing some runtime options
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\[9.8 \text{ m s}^{-2} = 9.8 \frac{\text{m}}{\text{s}^2} = 9.8 \text{ m/s}^2\]

The three realizations have all been input with

\[
\SI{9.8}{\meter\per\square\second}
\]

by just changing some runtime options

\texttt{\sisetup{per-mode=reciprocal}} % default
\texttt{\sisetup{per-mode=fraction}}
\texttt{\sisetup{per-mode=symbol}}

so it’s easy to adapt a paper to the publisher’s requirements \textit{without changing the code} in the \texttt{document} environment.
The acceleration due to gravity near the surface of the Earth is

\[ 9.8 \text{ m s}^{-2} = 9.8 \frac{\text{m}}{\text{s}^2} = 9.8 \text{ m/s}^2 \]

The three realizations have all been input with

\[
\text{\SI{9.8}{\meter\per\square\second}}
\]

by just changing some runtime options

\text{\sisetup{per-mode=reciprocal} % default}
\text{\sisetup{per-mode=fraction}}
\text{\sisetup{per-mode=symbol}}

so it's easy to adapt a paper to the publisher's requirements \textit{without changing the code} in the document environment

OK, I cheated: the middle term has been typeset with

\[
\text{\SI[per-mode=fraction]{9.8}{\meter\per\square\second}}
\]
You now shouldn’t be surprised that the following three tables have all been typeset with *the same input code* for the table body.

<table>
<thead>
<tr>
<th>Nation</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>640 375</td>
</tr>
<tr>
<td>Germany</td>
<td>232 803</td>
</tr>
<tr>
<td>France</td>
<td>100 002</td>
</tr>
<tr>
<td>Turkey</td>
<td>91 329</td>
</tr>
<tr>
<td>Spain</td>
<td>1 003 000</td>
</tr>
</tbody>
</table>

Source: Mr Leporello, private communication
You now shouldn’t be surprised that the following three tables have all been typeset with *the same input code* for the table body.

<table>
<thead>
<tr>
<th>Nation</th>
<th>Number</th>
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<th>Number</th>
<th>Nation</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>640 375</td>
<td>Italy</td>
<td>640,375</td>
<td>Italy</td>
<td>640 × 10³</td>
</tr>
<tr>
<td>Germany</td>
<td>231 803</td>
<td>Germany</td>
<td>231,803</td>
<td>Germany</td>
<td>232 × 10³</td>
</tr>
<tr>
<td>France</td>
<td>100 002</td>
<td>France</td>
<td>100,002</td>
<td>France</td>
<td>100 × 10³</td>
</tr>
<tr>
<td>Turkey</td>
<td>91 329</td>
<td>Turkey</td>
<td>91,329</td>
<td>Turkey</td>
<td>91.3 × 10³</td>
</tr>
<tr>
<td>Spain</td>
<td>1 003 000</td>
<td>Spain</td>
<td>1,003,000</td>
<td>Spain</td>
<td>1.00 × 10⁶</td>
</tr>
</tbody>
</table>

Source: Mr Leporello, private communication.
Numbers and tables

The first two tables

\begin{tabular}{l S[table-format=7.0]}
\toprule
Nation & Number \\
\midrule
Italy & 640375 \\
Germany & 231803 \\
France & 100002 \\
Turkey & 91329 \\
Spain & 1003000 \\
\bottomrule
\end{tabular}
**Numbers and tables**

The first two tables

\begin{tabular}{l S[table-format=7.0]}
\toprule
Nation & {Number} \\
\midrule
Italy & 640375 \\
Germany & 231803 \\
France & 100002 \\
Turkey & 91329 \\
Spain & 1003000 \\
\bottomrule
\end{tabular}

The third table

\begin{tabular}{l S[table-format=3.2e1]}
\toprule
Nation & {Number} \\
\midrule
Italy & 640375 \\
Germany & 231803 \\
France & 100002 \\
Turkey & 91329 \\
Spain & 1003000 \\
\bottomrule
\end{tabular}
The first table has been typeset with no special setting.
Numbers and tables

The first table has been typeset with no special setting

The second table with \sisetup{group-separator=\{,\}}
The first table has been typeset with no special setting

The second table with \sisetup{group-separator=\{,\}}

The third table with
\sisetup{
  round-mode=figures,
  round-precision=3,
  scientific-notation=engineering
}
The math and technical typesetting would be different without

Claudio Beccari, “Typesetting mathematics for science and technology according to ISO 31/XI». TUGboat, 18 (1), 1997

and without Claudio, to begin with
Grazie, Claudio