The \texttt{physics} package

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December 12, 2012

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1 Before you start

1.1 The purpose of this package

The goal of this package is to make typesetting equations for physics simpler, faster, and more human-readable. To that end, the commands included in this package have names that make the purpose of each command immediately obvious and remove any ambiguity while reading and editing \texttt{physics} code. From a practical standpoint, it is handy to have a well-defined set of shortcuts for accessing the long-form of each of these commands. The commands listed below are therefore defined in terms of their long-form names and then shown explicitly in terms of the default shorthand command sequences. These shorthand commands are meant make it easy to remember both the shorthand names and what each one represents.

1.2 Other required packages

The \texttt{physics} package requires \texttt{xparse} and \texttt{amsmath} to work properly in your \LaTeX{} document. The \texttt{amsmath} package comes standard with most \LaTeX{} distributions and is loaded by \texttt{physics} for your convenience. You may also already have \texttt{xparse} installed on your system as it is a popular package for defining \LaTeX{} macros, however, if you are unsure you can either install it again using your local package manager (comes with most distributions) or by visiting the CTAN online package database, or you could even just try to use \texttt{physics}
without worrying about it. Many modern \LaTeX compilers will locate and offer to download missing packages for you.

1.3 Using physics in your \LaTeX document

To use the physics package, simply insert \usepackage{physics} in the preamble of your document, before \begin{document} and after \documentclass{class}:
\documentclass{class}
\usepackage{physics}
\begin{document}
content...
\end{document}

2 List of commands

2.1 Automatic bracing

\begin{verbatim}
\quantity \qty(\typical) \rightarrow ( ) automatic ( ) braces
\qty(\tall) \rightarrow ( )
\qty(\grande) \rightarrow ( )
\qty[\typical] \rightarrow [ ] automatic [ ] braces
\qty[\tall] \rightarrow [ ]
\qty[\grande] \rightarrow [ ]
\qty\big{} \rightarrow \{} manual sizing (works with any of the above bracket types)
\qty\Big{} \rightarrow \{}
\qty\bigg{} \rightarrow \{}
\qty\Bigg{} \rightarrow \{}
\pqty{} \leftrightarrow \qty() alternative syntax; robust and more \LaTeX-friendly
\bqty{} \leftrightarrow \qty[]
\vqty{} \leftrightarrow \qty||
\Bqty{} \leftrightarrow \qty{}
\absolutevalue \abs{a} \rightarrow |a| automatic sizing; equivalent to \qty|a|
\abs\Big{a} \rightarrow |a| inherits manual sizing syntax from \qty
\abs*{\grande} \rightarrow |a| star for no resize
\norm \norm{a} \rightarrow \| a \|
\norm\Big{a} \rightarrow \| a \|
\norm\Bigg{a} \rightarrow \| a \|
\norm*{\grande} \rightarrow \| a \| star for no resize
\evaluated \eval{x}_0^\infty \rightarrow x_0^\infty vertical bar for evaluation limits
\end{verbatim}
\eval(x|_0^\infty \to \left[ \begin{array}{c} x \\ 0 \end{array} \right]^\infty \) alternate form
\eval[x|_0^\infty \to \left[ \begin{array}{c} x \\ 0 \end{array} \right]^\infty \) alternate form
\eval\*[venti|_0^\infty \to \left[ \begin{array}{c} x \\ 0 \end{array} \right]^\infty \) star for no resize
\order \order{x^2} \to O(x^2) order symbol; automatic sizing and space handling
\order\Big{x^2} \to O(x^2) manual sizing
\order*\{grande\} \to O(x^2) star for no resize
\comm{A}{B} \to [A,B] automatic sizing
\comm\Big{A}{B} \to [A,B] manual sizing
\comm*{A}{\grande} \to [A,\] star for no resize
\anticommutator \acomm{A}{B} \to \{A,B\} same as \poissonbracket
\poissonbracket \pb{A}{B} \to \{A,B\} same as \anticommutator

2.2 Vector notation

The default del symbol $\nabla$ used in physics vector notation can be switched to appear with an arrow $\vec{\nabla}$ by including the option arrowdel in the document preamble $\usepackage[arrowdel]{physics}$. $\vectorbold \vb{a} \to a$ upright/no Greek
$\vectorbold \vb{\theta} \to a, \theta$ italic/Greek
$\vectorarrow \va{a} \to \vec{a}$ upright/no Greek
$\vectorarrow \va{\theta} \to \vec{a}, \theta$ italic/Greek
$\vectorunit \vu{a} \to \hat{a}$ upright/no Greek
$\vectorunit \vu{\theta} \to \hat{a}, \hat{\theta}$ italic/Greek
$\dotproduct \vdot \to \cdot as in a \cdot b$ note: \dp is a protected \TeX primitive
$\crossproduct \cross \to \times as in a \times b$ alternate name shorthand name
$\grad \grad \to \nabla$ default mode
$\grad\Psi \to \nabla\Psi$ long-form (like \qty but also handles spacing)
$\div \div \to \nabla \cdot$ note: amsmath symbol $\div$ renamed $\divisionsymbol$
$\div a \to \nabla \cdot a$ default mode
$\div(a+b) \to \nabla \cdot (a + b)$ long-form
$\curl \curl \to \nabla \times$ default mode
$\curl a \to \nabla \times a$ long-form
\curl{\vb{a}+\v{tall}} \rightarrow \nabla \times [a+\v{tall}]

\laplacian \rightarrow \nabla^2
\laplacian{\Psi} \rightarrow \nabla^2 \Psi \quad \text{default mode}
\laplacian{\Psi+\v{tall}} \rightarrow \nabla^2 \left(\Psi + \v{tall}\right) \quad \text{long-form}

2.3 Operators

The standard set of trig functions is redefined in physics to provide automatic braces that behave like \qty(). In addition, an optional power argument is provided. This behavior can be switched off by including the option notrig in the preamble \rightarrow \usepackage[notrig]{physics}.

Example trig redefinitions:
\sin \rightarrow \sin \left(\v{tall}\right) \quad \text{automatic braces; old \sin renamed \sine}
\sin[2](x) \rightarrow \sin^2(x) \quad \text{optional power}
\sin x \rightarrow \sin x \quad \text{can still use without an argument}

The full set of available trig functions in physics includes:
\sin(x) \sinh(x) \arcsin(x) \asin(x)
\cos(x) \cosh(x) \arccos(x) \acos(x)
\tan(x) \tanh(x) \arctan(x) \atan(x)
\csc(x) \csch(x) \arccsc(x) \acsc(x)
\sec(x) \sech(x) \arcsec(x) \asec(x)
\cot(x) \coth(x) \arccot(x) \acot(x)

The standard trig functions (plus a few that are missing in amsmath) are available without any automatic bracing under a new set of longer names:
\sine \hypsin \arcsine \asine
\cosine \hypcos \arccos \acosine
\tangent \hyptan \arctangent \atan
\cotangent \hypcot \arccot \acot

Similar behavior has also been extended to the following functions:
\exp(\v{tall}) \rightarrow \exp(\v{tall}) \quad \text{exponential}
\log(\v{tall}) \rightarrow \log(\v{tall}) \quad \text{logarithm}
\ln(\v{tall}) \rightarrow \ln(\v{tall}) \quad \text{old definitions \Rightarrow natural logarithm}
\det(\v{tall}) \rightarrow \det(\v{tall}) \quad \text{determinant}
\Pr(\v{tall}) \rightarrow \Pr(\v{tall}) \quad \text{Probability}

New operators:
\trho \rightarrow \rho \quad \text{trace; same bracing as trig functions}
\Trho \rightarrow \Tr \rho \quad \text{alternate}
\rank \rightarrow \rank \ M \quad \text{matrix rank}
\erf(\v{tall}) \rightarrow \erf(\v{tall}) \quad \text{Gauss error function}
\Res[\v{tall}] \rightarrow \Res[\v{tall}] \quad \text{residue; same bracing as trig functions}
\PV[\v{tall}] \rightarrow \PV[\v{tall}] \quad \text{Cauchy principal value}

alternate
2.4 Quick quad text

This set of commands produces text in math-mode padded by $\text{\textbackslash quad}$ spacing on either side. This is meant to provide a quick way to insert simple words or phrases in a sequence of equations. Each of the following commands includes a starred version which pads the text only on the right side with $\text{\textbackslash quad}$ for use in aligned environments such as cases.

General text:

\begin{itemize}
  \item \texttt{\qqtext} \rightarrow \texttt{\qq{}} \rightarrow \texttt{\qq{word or phrase}} \rightarrow \texttt{__ word or phrase__} \rightarrow \texttt{\qq*{word or phrase}} \rightarrow \texttt{word or phrase\textunderscore starred mode; right \quad only}
  \item \texttt{\qcomma} \rightarrow , \rightarrow \texttt{right \quad only}
  \item \texttt{\qcc} \rightarrow c.c. \rightarrow \texttt{complex conjugate; left and right \quad unless starred \qcc* \rightarrow c.c.\textunderscore starred mode; right \quad only}
  \item \texttt{\qif} \rightarrow if \rightarrow \texttt{left and right \quad unless starred \qif* \rightarrow if\textunderscore starred mode; right \quad only}
\end{itemize}

Special macros:

\begin{itemize}
  \item \texttt{\qcomma} \rightarrow , \rightarrow \texttt{right \quad only}
  \item \texttt{\qcc} \rightarrow c.c. \rightarrow \texttt{complex conjugate; left and right \quad unless starred \qcc* \rightarrow c.c.\textunderscore starred mode; right \quad only}
  \item \texttt{\qif} \rightarrow if \rightarrow \texttt{left and right \quad unless starred \qif* \rightarrow if\textunderscore starred mode; right \quad only}
\end{itemize}

Similar to \texttt{\qif}:

\begin{itemize}
  \item \texttt{\qthen}, \texttt{\qelse}, \texttt{\qotherwise}, \texttt{\qunless}, \texttt{\qgiven}, \texttt{\qusing}, \texttt{\qassume}, \texttt{\qsince}, \texttt{\qlet}, \texttt{\qfor}, \texttt{\qall}, \texttt{\qif\textunderscore even}, \texttt{\qodd}, \texttt{\qinteger}, \texttt{\qand}, \texttt{\qor}, \texttt{\qas}, \texttt{\qin}
\end{itemize}

2.5 Derivatives

The default differential symbol $d$ which is used in $\text{\textbackslash differential}$ and $\text{\textbackslash derivative}$ can be switched to an italic form \textit{d} by including the option \texttt{italicdiff} in the preamble $\rightarrow \texttt{\usepackage[italicdiff]{physics}}$.

\begin{itemize}
  \item $\text{\textbackslash differential}$ \rightarrow $d$
  \item $\text{\textbackslash dd} \rightarrow \text{\textbackslash d}$
  \item $\text{\textbackslash dd} x \rightarrow \text{\textbackslash d}x$
  \item $\text{\textbackslash dd}(x) \rightarrow \text{\textbackslash d}_x$
  \item $\text{\textbackslash dd}[3](x) \rightarrow \text{\textbackslash d}^3x$
  \item $\text{\textbackslash dd}(\cos \theta) \rightarrow \text{\textbackslash d}(\cos \theta)$
  \item $\text{\textbf{\textbackslash differential}}$ \rightarrow $\text{d} \frac{\text{d}}{\text{d}x}$
  \item $\text{\texttt{\vd}}(f)(x) \rightarrow \frac{\text{d}f}{\text{d}x}$
  \item $\text{\texttt{\vd}}(f)[n](x) \rightarrow \frac{\text{d}^n f}{\text{d}x^n}$
  \item $\text{\texttt{\vd}}(x)(\text{grande}) \rightarrow \frac{\text{d}}{\text{d}x} (\text{\textcircled{1}})$
  \item $\text{\texttt{\vd}}(x)[n] \rightarrow \text{\texttt{\vd}}(f)[n] \rightarrow \frac{\text{d}^n f}{\text{d}x^n}$
  \item $\text{\texttt{\vd}}(x)[n] \rightarrow \frac{\text{d}^n f}{\text{d}x^n}$
  \item $\text{\texttt{\vd}}(x) \rightarrow \frac{\text{d}f}{\text{d}x}$
  \item $\text{\texttt{\vd}}(x)[n] \rightarrow \frac{\text{d}^n f}{\text{d}x^n}$
  \item $\text{\texttt{\vd}}(x)[n] \rightarrow \frac{\text{d}^n f}{\text{d}x^n}$
  \item $\text{\texttt{\vd}}(x)[n] \rightarrow \frac{\text{d}^n f}{\text{d}x^n}$
  \item $\text{\texttt{\vd}}(x)[n] \rightarrow \frac{\text{d}^n f}{\text{d}x^n}$
  \item $\text{\texttt{\vd}}(x)[n] \rightarrow \frac{\text{d}^n f}{\text{d}x^n}$
  \item $\text{\texttt{\vd}}(x)[n] \rightarrow \frac{\text{d}^n f}{\text{d}x^n}$
\end{itemize}
\begin{align*}
\pdv{x}(\grande) & \rightarrow \frac{\partial}{\partial x} \\
\pdv{f}{y} & \rightarrow \frac{\partial^2 f}{\partial x \partial y} \quad \text{mixed partial} \\
\pdv{f}{x} & \rightarrow \frac{\partial f}{\partial x} \quad \text{inline form using flatfrac} \\
\var{F}[g(x)] & \rightarrow \delta F[g(x)] \quad \text{functional variation (works like \texttt{dd})} \\
\var{E-TS} & \rightarrow \delta(E-\text{TSS}) \quad \text{long-form} \\
\fdv{g}{f} & \rightarrow \frac{\delta f}{\delta g} \quad \text{functional derivative (works like \texttt{dv})} \\
\fdv{V}(E-TS) & \rightarrow \frac{\delta V}{\delta(E-TS)} \quad \text{long-form} \\
\fdv{F}{g} & \rightarrow \frac{\delta F}{\delta g} \quad \text{inline form using flatfrac}
\end{align*}

### 2.6 Dirac bra-ket notation

The following collection of macros for Dirac notation contains two fundamental commands, \texttt{\bra} and \texttt{\ket}, along with a set of more specialized macros which are essentially combinations of the fundamental pair. The specialized macros are both useful and descriptive from the perspective of generating physics code, however, the fundamental commands are designed to contract with one another algebraically when appropriate and are thus suggested for general use. For instance, the following code renders correctly\textsuperscript{1}

\begin{align*}
\bra{\phi} \ket{\psi} & \rightarrow \langle \phi | \psi \rangle \\
\bra{\phi} \dyad{\psi}{\xi} & \rightarrow \langle \phi || \psi \rangle \langle \xi |
\end{align*}

whereas a similar construction with higher-level macros will not contract in a robust manner

\begin{align*}
\bra{\phi} \dyad{\psi}{\xi} & \rightarrow \langle \phi || \psi || \xi |
\end{align*}

On the other hand, the correct output can be generated by sticking to the fundamental commands,

\begin{align*}
\bra{\phi} \ket{\psi} \bra{\xi} & \rightarrow \langle \phi | \psi \rangle \langle \xi |
\end{align*}

allowing the user to type out complicated quantum mechanical expressions without worrying about bra-ket contractions. That being said, the high-level macros do have a place in convenience and readability, as long as the user is aware of rendering issues that may arise due to an absence of automatic contractions.

\begin{align*}
\ket & \rightarrow \rangle \\
\ket{} & \rightarrow \rangle \\
\bra & \rightarrow \langle \\
\bra{} & \rightarrow \langle \\
\innerproduct & \rightarrow \langle a | b \rangle \\
\innerproduct & \rightarrow \langle a | a \rangle
\end{align*}

\textsuperscript{1}Note the lack of a space between the bra and ket commands. This is necessary in order for the bra to find the corresponding ket and form a contraction.
\begin{pmatrix} 1 & 0 \\ a & b \end{pmatrix}
\end{pmatrix}

To specify elements on the right of left sides of our \texttt{imat{2}} sub-matrix we use the grouping command \texttt{matrixquantity} or \texttt{mqty} to effectively convert \texttt{imat{2}} into a single matrix element of a larger matrix:

\begin{pmatrix} \texttt{mqty{imat{2}}} & \texttt{mqty{a\&b}} \end{pmatrix} & \texttt{mqty{c \& d}} & \texttt{e} \\
\texttt{mqty{imat{2}}} & \texttt{mqty{a\&b}} \end{pmatrix} & \texttt{mqty{c \& d}} & \texttt{e}

The extra \texttt{mqty} groups were required in this case in order to get the \texttt{a} and \texttt{b} elements to behave as a single element, since \texttt{mqty{imat{2}}} also acts like a single matrix element (the same can be said of the grouped \texttt{c} and \texttt{d} elements). Finally, the outermost \texttt{pmatrix} environment could have also been replaced with the \texttt{physics} macro \texttt{mqty{()}}, allowing the above example to be written on one line:

\begin{pmatrix} \texttt{mqty{()}{imat{2}}} & \texttt{mqty{a\&b}} \end{pmatrix} & \texttt{mqty{c \& d}} & \texttt{e}

\begin{pmatrix} 1 & 0 \\ a & b \end{pmatrix}
\end{pmatrix} & \texttt{mqty{()}{imat{2}}} & \texttt{mqty{a\&b}} \end{pmatrix} & \texttt{mqty{c \& d}} & \texttt{e}

\begin{pmatrix} 1 & 0 & a \\ 0 & 1 & b \\ c & d & e \end{pmatrix}
The matrix quantity \( \mqty(a & b \ c & d) \) groups a set of matrix elements into a single object. Parentheses are used with \( \mqty(a & b \ c & d) \rightarrow (a \ b \ c \ d) \). Alternate parentheses are used with \( \mqty*(a & b \ c & d) \rightarrow \begin{pmatrix} a \ b \\ c \ d \end{pmatrix} \). Square brackets are used with \( \mqty[a & b \ c & d] \rightarrow [a \ b \ c \ d] \). Vertical bars are used with \( \mqty|a & b \ c & d| \rightarrow \begin{vmatrix} a \ b \\ c \ d \end{vmatrix} \). The smallmatrix form of \( \mqty(a & b \ c & d) \) is \( \smqty(a \ b \ c \ d) \). The matrix determinant is \( \mdet{a & b \ c & d} \rightarrow \begin{vmatrix} a \ b \\ c \ d \end{vmatrix} \). The small matrix determinant is \( \smdet{a & b \ c & d} \rightarrow \begin{vmatrix} a \ b \\ c \ d \end{vmatrix} \). The identity matrix is \( \imat{n} \rightarrow \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \). The Pauli matrix is \( \pmat{n} \rightarrow \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \) for \( n \in \{ 0, 1 \} \). The diagonal matrix \( \dmat{a,b,c,...} \rightarrow \begin{pmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{pmatrix} \). The antidiagonal matrix \( \admat{a,b,c,...} \rightarrow \begin{pmatrix} 0 & 0 & 2 \\ 1 & 0 & 0 \\ 2 & 1 & 0 \end{pmatrix} \).