The HEP-MATH package*

Math macros for operators, derivatives, delimiters, bra-ket notation and expectation values

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Abstract

The HEP-MATH package extends MATHTOOLS and AMSMATH with HEP-oriented math notation. It provides math-only command definitions, improved overlines and arrow accents, operator names, fractions and unit helpers, differentials and derivative builders, paired delimiters, probabilities, brackets, quantum-mechanical bra-ket notation, matrix elements, and expectation values.

To use the package place `\usepackage{hep-math}` in the preamble.

The MATHTOOLS [1] package is loaded, which in turn loads the $\mathcal{AMS}$-LaTeX AMSMATH [2] package. Horizontal spacing in inline equations and page breaks in block equations are marginally adjusted.

`\left` `\right` Spacing around `\left` and `\right` is fixed with the MLEFTRIGHT package [3].

1 Macros

`\mathdef` The `\mathdef{`⟨*name*⟩`}[`⟨*arguments*⟩`]{`⟨*code*⟩`}` macro (re-)defines macros only within math mode without changing the text mode definition.

`\i` `\d` The imaginary unit `\i` and the differential `\d` are defined using this functionality. Their math definitions are set at the beginning of the document, unless they have been defined with `\mathdef` in the preamble, e.g. via `\mathdef{\d}{\mathrm d}`. Repeated uses of `\mathdef` for the same macro replace its math definition and keep its text definition.

`\overline` The `\overline` macro is adjusted to work also outside of math mode using the SOUL [4] package. Text containing macros unknown to SOUL, such as `\ref{`⟨*key*⟩`}`, is overlined as a whole without line breaks.

`\oset` `\overleft` `\overright` `\overleftright` A better looking over left right arrow is defined i.e. $\overleftrightarrow{\partial}$ using a new `\oset{`⟨*over*⟩`}{`⟨*math*⟩`}` functionality.

`\diag` `\sgn` `\arccsc` `\sin` `\cos` `\tan` Diagonal matrix `\diag`, signum `\sgn`, trace `\tr`, `\Tr`, and `\rank` operators are defined.

`\arccsc` and other inverse trigonometric functions are defined, including the short forms `\asin`, `\acos`, and so on.

`\cos`, `\tan`, and all other trigonometric functions and their inverses are adjusted to have the same height as `\sin`.

*This document corresponds to HEP-MATH v1.6.

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1.1 Fractions and units

\unit \inv

The correct spacing for units is provided by the macro `\unit[⟨value⟩]{⟨unit⟩}` from the SIUNITX package [5] which can also be used in text mode. The macro `\inv[⟨power⟩]{⟨text⟩}` allows to avoid math mode also for inverse units such as $5\,\mathrm{fb}^{-1}$ typeset via `\unit[5]{\inv{fb}}`.

\nicefrac \flatfrac \textfrac

The `\frac{⟨number⟩}{⟨number⟩}` macro is accompanied by `\nicefrac{⟨number⟩}{⟨number⟩}`, `\textfrac{⟨number⟩}{⟨number⟩}`, and `\flatfrac{⟨number⟩}{⟨number⟩}` leading to $\frac{1}{2}$, $1/2$, $1/2$, and 1/2. The `\textfrac` macro is mostly intended if a font with oldstyle numerals is used.

Some macros of the PHYSICS package [6] are reimplemented with a more conventional typesetting in mind. Finer details about mathematical typesetting can be found in [7].

1.2 Differentials and derivatives

\differential \newderivative \newpartialderivative

The three macros `\differential{⟨symbol⟩}`, `\newderivative {\name}{⟨symbol⟩}`, and `\newpartialderivative {\name}{⟨symbol⟩}` allow to define a differential with correct spacing, a derivative using this differential, and if necessary a partial derivative that can handle three dimensional derivatives.

\d \dv

These macros are used for the usual differential and derivative, producing dx via `\d x` and

`\dv[f]x`	`\dv*[f]x^n`	`\dv[f]x*^n`	`\dv*[f]x*^n`
$\frac{df}{dx}$	d^nf/dx^n	$\frac{d^nf}{dx^n}$	d^nf/dx^n
`\dv xf`	`\dv*xf`	`\dv x*f`	`\dv*x*f`
$\frac{d}{dx}f$	$d/dx\,f$	$\frac{d}{dx}f$	$d/dx\,f$

via `\dv*[⟨f⟩]{⟨x⟩}*^{⟨n⟩}`. The fraction follows the math style, like `\frac`. The first star selects the flat fraction `\flatfrac` and the second star the small fractions `\tfrac` and `\nicefrac`, respectively. Upright differential can be produced via `\renewcommand{\diffsymbol}{\mathrm d}`. The differential takes care of the correct spacing as long as it is placed at the end of the integral $\int f(x)\,dx$. In order to archive correct spacing when it is placed at the beginning of the integral it is advisable to place the whole expression in a `\mathop{\int\d x} f(x)` such that $\int dx\,f(x)$.

\pd \pdv

Similarly a partial differential and derivative are defined that can be used according to `\pdv*[⟨f⟩]{⟨x⟩}*^{⟨a⟩}[⟨y⟩]^{⟨b⟩}[⟨z⟩]^{⟨c⟩}`.

`\pdv[f]x`	`\pdv[f]x[y]`	`\pdv[f]x^3`	`\pdv[f]x^2[y]`
$\frac{\partial f}{\partial x}$	$\frac{\partial^2 f}{\partial x\partial y}$	$\frac{\partial^3 f}{\partial x^3}$	$\frac{\partial^3 f}{\partial x^2\partial y}$
`\pdv[f]x^2[y]^3`	`\pdv[f]x[y]^3`	`\pdv x[y]f`	
$\frac{\partial^5 f}{\partial x^2\partial y^3}$	$\frac{\partial^4 f}{\partial x\partial y^3}$	$\frac{\partial^2}{\partial x\partial y}f$	

Integer orders are summed in the numerator, while other orders are added, as in $\frac{\partial^{n+1} f}{\partial x^n\partial y}$ typeset via `\pdv[f]x^n[y]`.

\var

Similarly a functional variation and functional derivative are defined.

\fdv \cancel \slashed

The `\cancel{⟨characters⟩}` macro from the CANCEL package [8] and the `\slashed {⟨character⟩}` macro from the SLASHED package [9] allow to ~~cancel~~ math and use the Dirac slash notation i.e. $\not{\partial}$, respectively.

1.3 Paired delimiters

\abs \norm

`\abs x`	`\norm x`	`\norm[2]x`	`\norm*[2]x`
$\lvert x\rvert$	$\lVert x\rVert$	$\lVert x\rVert_2$	$\lVert x\rVert_2$

\eval
\order

```
\order x   \eval x_0^\infty   \eval* x_0^\infty
```
$$\mathcal{O}(x) \qquad x\big|_0^\infty \qquad x\Big|_0^\infty$$

\newpair
\comm
\acomm

The `\newpair{`⟨*name*⟩`}{`⟨*left delim*⟩`} {`⟨*right delim*⟩`}_{`⟨*subscript*⟩`}^{`⟨*superscript*⟩`}` macro is defined and used for the definition of (anti-)commutators and Poisson brackets.

```
\pb xy   \comm xy   \acomm xy
```
$$\{x,y\} \qquad [x,y] \qquad \{x,y\}$$

They can easily be redefined using e.g. `\newpair\comm\lbrack\rbrack_-`.

\bra
\ket
\braket
\ketbra
\mel
\ev
\vev

Macros for the bra-ket notation are introduced.

```
\bra x    \ket x     \braket xy      \ketbra xy
\mel xyz  \ev x    \ev[\Omega] x     \vev x
```
$$\langle x| \qquad |x\rangle \qquad \langle x|y\rangle \qquad |x\rangle\langle y|$$
$$\langle x|y|z\rangle \qquad \langle x\rangle \qquad \langle \Omega|x|\Omega\rangle \qquad \langle 0|x|0\rangle$$

\column
\row

Macros for row and column vectors are introduced together with a symbol for transpose vectors.

```
\column{x,y,z}   \row{x,y,z}^\trans
```
$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} \qquad (x,\, y,\, z)^{\mathsf{T}}$$

1.4 PDF strings

If the HYPERREF package [10] is loaded, the macros also work in moving arguments that end up in PDF strings such as bookmarks. There `\i` and `\d` become i and d, overlines and slashes keep their argument, operators such as `\cos` keep their name, `\unit[5]{GeV}` becomes 5 GeV, `\inv{fb}` becomes fb^-1, `^\trans` becomes ^T, and fractions become flat as in 1/2. Other macros such as derivatives and paired delimiters keep only their arguments.

2 Environments

eqnarray

The `eqnarray` environment is depreciated, the `split`, `multline`, `align`, `multlined`, `aligned`, `alignedat`, and `cases` environments of the AMSMATH and MATHTOOLS packages should be used instead.

equation

Use the `equation` environment for short equations.

```
\begin{equation}
  left = right \ .
\end{equation}
```

$$\boxed{\text{left}} = \boxed{\text{right}}\,. \tag{2.1}$$

multline

Use the `multline` environment for longer equations.

```
\begin{multline}
  left = right 1 \\
  + right 2 \ .
\end{multline}
```

$$\boxed{\text{left}} = \boxed{\text{right 1}} \\ \boxed{+\ \text{right 2}}\,. \tag{2.2}$$

split

Use the `split` sub environment for equations in which multiple equal signs should be aligned.

```
\begin{equation} \begin{split}
  left &= right 1 \\
  &= right 2 \ .
\end{split} \end{equation}
```

$$\boxed{\text{left}} = \boxed{\text{right 1}} \\ = \boxed{\text{right 2}} \ . \tag{2.3}$$

`align` Use the `align` environment for the vertical alignment and horizontal distribution of multiple equations.

```
\begin{subequations} \begin{align}
  left &= right \ , &
  left &= right \ , \\
  left &= right \ , &
  left &= right \ .
\end{align} \end{subequations}
```

$$\boxed{\text{left}} = \boxed{\text{right}} \ , \quad \boxed{\text{left}} = \boxed{\text{right}} \ , \tag{2.4a}$$
$$\boxed{\text{left}} = \boxed{\text{right}} \ , \quad \boxed{\text{left}} = \boxed{\text{right}} \ . \tag{2.4b}$$

`aligned` Use the `aligned` environment within a `equation` environment if the aligned equations should be labeled with a single equation number.

`multlined` Use the `multlined` environment if either `split` or `align` contain very long lines.

```
\begin{equation} \begin{split}
  left &= right 1 \\ &=
  \begin{multlined}[t]
     right 2 \\ + right 3 \ .
  \end{multlined}
\end{split} \end{equation}
```

$$\boxed{\text{left}} = \boxed{\text{right 1}} \\ = \boxed{\text{right 2}} \\ \boxed{\text{+ right 3}} \ . \tag{2.5}$$

`alignat` Use the `alignat` environment together with the `\mathllap` macro for the alignment of multiple equations with vastly different lengths.

```
\begin{subequations}
\begin{alignat}{2}
  left &= long right && \ , \\
  le. 2 &= ri. 2 \ , &
  \mathllap{le. 3 = ri. 3} & \ .
\end{alignat}
\end{subequations}
```

$$\boxed{\text{left}} = \boxed{\text{long right}} \ , \tag{2.6a}$$
$$\boxed{\text{le. 2}} = \boxed{\text{ri. 2}} \ , \quad \boxed{\text{le. 3}} = \boxed{\text{ri. 3}} \ . \tag{2.6b}$$

As a rule of thumb if you have to use `\notag`, `\nonumber`, or perform manual spacing via `\quad` you are probably using the wrong environment.

References

[1] L. Madsen, M. Høgholm, W. Robertson, and J. Wright. 'The `mathtools` package: Mathematical tools to use with `amsmath`' (2004). CTAN: `mathtools`.

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[3] H. Oberdiek. 'The `mleftright` package: Variants of delimiters that act as maths open/close' (2010). CTAN: `mleftright`.

[4] M. Franz. 'The `soul` package: Hyphenation for letterspacing, underlining, and more' (1998). CTAN: `soul`.

[5] J. Wright. 'The `siunitx` package: A comprehensive (SI) units package' (2008). CTAN: `siunitx`.

[6] S. C. de la Barrera. 'The `physics` package: Macros supporting the Mathematics of Physics' (2012). CTAN: `physics`.

[7] E. Gregorio. 'TEX, LATEX and math' (2020). URL: latex-project.org/publications/2020-egreg-TUB-tb127gregorio-math.pdf.
[8] D. Arseneau. 'The cancel package: Place lines through maths formulae' (2013). CTAN: cancel.
[9] D. Carlisle. 'The slashed package: Put a slash through characters' (1987). CTAN: slashed.
[10] *LATEX3 Project*. 'Hypertext marks in LATEX: a manual for hyperref: Extensive support for hypertext in LATEX' (1995). CTAN: hyperref. GitHub: latex3/hyperref.