

The HEP-MATH package*

Extended math macros

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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 $\mathcal{A}\mathcal{M}\mathcal{S}$ - $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ AMSMATH [2] package. Horizontal spacing in inline equations and page breaks in block equations are marginally adjusted.

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

`\right`

1 Macros

`\mathdef` The `\mathdef{<name>}{<arguments>}{<code>}` macro (re-)defines macros only within math mode without changing the text mode definition.

`\i` The imaginary unit `\i` and the differential `\d` are defined using this functionality.

`\d` The `\overline` macro is adjusted to work also outside of math mode using the SOUL [4] package.

`\overline` A better looking over left right arrow is defined i.e. $\overrightarrow{\partial}$ using a new `\oset{<over>}{<math>}` functionality.

`\oset`

`\overleftarrow` Diagonal matrix `\diag`, signum `\sgn`, trace `\tr`, `\Tr`, and `\rank` operators are defined.

`\overrightarrow` The real and imaginary projectors are redefined to look like ordinary operators.

`\overleftrighth` `\cos` and `\tan` are adjusted to have the same height as `\sin`.

`\diag` `\arccsc` and other inverse trigonometric functions are defined.

`\sgn`

`\Re` 1.1 Fractions and units

`\Im` The correct spacing for units is provided by the macro `\unit{<value>}{<unit>}` from the UNITS 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 5fb^{-1} typeset via `\unit[5]{\inv{fb}}`.

`\sin`

`\cos` The `\frac{<number>}{<number>}` macro is accompanied by `\nicefrac{<number>}{<number>}`,

`\tan`

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`\accsc`

`\unit`

`\inv`

`\nicefrac`

`\flatfrac`

`\textfrac`

`\textfrac{⟨number⟩}{⟨number⟩}`, and `\flatfrac{⟨number⟩}{⟨number⟩}` leading to $\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$, and $\frac{1}{2}$. 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` 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.

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

<code>\d</code>	<code>\dv[f]x</code>	<code>\dv*[f]x^n</code>	<code>\dv[f]x*x^n</code>	<code>\dv*[f]x*x^n</code>
<code>\dv</code>	$\frac{df}{dx}$	$d^n f / dx^n$	$\frac{d^n f}{dx^n}$	$d^n f / dx^n$
	<code>\dv x f</code>	<code>\dv*x f</code>	<code>\dv x*f</code>	<code>\dv*x*f</code>
	$\frac{d}{dx} f$	$d/dx f$	$\frac{d}{dx} f$	$d/dx f$

via `\dv*[⟨f⟩]{⟨x⟩}*^{⟨n⟩}`. 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\limits\mathrm d x} f(x)` such that $\int dx f(x)$.

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

<code>\pdv[f]x</code>	<code>\pdv[f]x[y]</code>	<code>\pdv[f]x^3</code>	<code>\pdv[f]x^2[y]</code>
$\frac{\partial f}{\partial x}$	$\frac{\partial^2 f}{\partial x \partial y}$	$\frac{\partial^3 f}{\partial x^3}$	$\frac{\partial^3 f}{\partial x^2 \partial y}$
<code>\pdv[f]x^2[y]^3</code>	<code>\pdv[f]x[y]^3</code>	<code>\pdv x[y]f</code>	
$\frac{\partial^5 f}{\partial x^2 \partial y^3}$	$\frac{\partial^4 f}{\partial x \partial y^3}$	$\frac{\partial^2}{\partial x \partial y} f$	

`\var` Similarly a functional variation and functional derivative are defined.

`\fdv` 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. $\cancel{\emptyset}$, respectively.

1.3 Paired delimiters

`\abs`

`\norm` `\abs x` `\norm x` `\norm[2]x` `\norm*[2]x`
 $|x|$ $\|x\|$ $\|x\|_2$ $\|x\|_2$

`\eval`

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

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

`\comm`

`\acomm`

$$\begin{array}{ccc} \backslash pb\ xy & \backslash comm\ xy & \backslash acomm\ xy \\ \{x,y\} & [x,y] & \{x,y\} \end{array}$$

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

<code>\bra</code>	Macros for the bra-ket notation are introduced.			
<code>\ket</code>	<code>\bra x</code>	<code>\ket x</code>	<code>\braket xy</code>	<code>\ketbra xy</code>
	$\langle x $	$ x \rangle$	$\langle x y \rangle$	$ x \rangle \langle y $
<code>\braket</code>	<code>\mel xyz</code>	<code>\ev x</code>	<code>\ev[\Omega] x</code>	<code>\vev x</code>
	$\langle x y z \rangle$	$\langle x \rangle$	$\langle \Omega x \Omega \rangle$	$\langle 0 x 0 \rangle$
<code>\ketbra</code>				
<code>\mel</code>	Macros for row and column vectors are introduced together with a symbol for transpose vectors.			
<code>\ev</code>	<code>\column{x,y,z}</code>	<code>\row{x,y,z}^{\sim trans}</code>		
<code>\vev</code>	$\begin{pmatrix} x \\ y \\ z \end{pmatrix}$	$(x, y, z)^T$		
<code>\column</code>				
<code>\row</code>				

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 \ .` $\boxed{\text{left}} = \boxed{\text{right}} . \quad (2.1)$
`\end{equation}`

`multline` Use the `multline` environment for longer equations.
`\begin{multline}`
`left = right 1 \\
+ right 2 \ .` $\boxed{\text{left}} = \boxed{\text{right 1}} + \boxed{\text{right 2}} . \quad (2.2)$
`\end{multline}`

`split` Use the `split` sub environment for equations in which multiple equal signs should be aligned.
`\begin{equation} \backslash begin{split}`
`left \&= right 1 \\
\&= right 2 \ .` $\boxed{\text{left}} = \boxed{\text{right 1}} = \boxed{\text{right 2}} . \quad (2.3)$
`\end{split} \end{equation}`

`align` Use the `align` environment for the vertical alignment and horizontal distribution of multiple equations.
`\begin{subequations} \backslash begin{align}`
`left \&= right \ , \&` $\boxed{\text{left}} = \boxed{\text{right}} , \quad \boxed{\text{left}} = \boxed{\text{right}} , \quad (2.4a)$
`left \&= right \ , \\
left \&= right \ , \&` $\boxed{\text{left}} = \boxed{\text{right}} , \quad \boxed{\text{left}} = \boxed{\text{right}} . \quad (2.4b)$
`left \&= right \ .`
`\end{align} \end{subequations}`

`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}

```

$$\begin{aligned}
\boxed{\text{left}} &= \boxed{\text{right 1}} \\
&= \boxed{\text{right 2}} \\
&\quad \boxed{+ \text{right 3}} .
\end{aligned} \tag{2.5}$$

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

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- [4] M. Franz. ‘The `soul` package: Hyphenation for letterspacing, underlining, and more’ (1998). CTAN: `soul`.
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- [7] E. Gregorio. ‘T_EX, L^AT_EX 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`.