The \texttt{HEP-MATH} package\textsuperscript{*}

Extended math macros

Jan Hajer\textsuperscript{†}

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Abstract

The \texttt{HEP-MATH} package provides some additional features beyond the \texttt{mathtools} and \texttt{amsmath} packages.

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

The \texttt{mathtools} \cite{1} package is loaded, which in turn loads the \texttt{AMS-LaTeX amsmath} \cite{2} package. Horizontal spacing in inline equations and page breaks in block equations are marginally adjusted.

Spacing around \texttt{\left} and \texttt{\right} is fixed with the \texttt{mleftright} package \cite{3}.

\section{Macros}

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

\texttt{\i} The imaginary unit \texttt{i} and the differential \texttt{d} are defined using this functionality.

\texttt{\overline} The \texttt{\overline} macro is adjusted to work also outside of math mode using the \texttt{soulutf8} \cite{4} package.

\texttt{\oset} A better looking over left right arrow is defined i.e. $\overset{\text{over}}{\text{math}}$ using a new \texttt{\oset\{over\}\{math\}} functionality.

\texttt{\overleft} Diagonal matrix \texttt{\diag}, signum \texttt{\sgn}, trace \texttt{\tr}, \texttt{\Tr}, and \texttt{\rank} operators are defined.

\texttt{\overleftright} The real and imaginary projectors are redefined to look like ordinary operators.

\texttt{\diag} \texttt{\cos} and \texttt{\tan} are adjusted to have the same height as \texttt{\sin}.

\texttt{\sgn} \texttt{\arccsc} and other inverse trigonometric functions are defined.

\texttt{\Re} \texttt{\Im}

\texttt{\sin} \texttt{\cos}

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

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

\texttt{\nicefrac}

\texttt{\flatfrac}

\texttt{\textfrac}

\texttt{\inv}

\texttt{\textsuperscript{*}This document corresponds to \texttt{HEP-MATH v1.2.}}

\texttt{\textsuperscript{†}jan.hajer@tecnico.ulisboa.pt}

\texttt{\nicefrac}

\texttt{\flatfrac}

\texttt{\textfrac}
Some macros of the \texttt{physics} package \cite{6} are reimplemented with a more conventional typesetting in mind. Finer details about mathematical typesetting can be found in \cite{7}.

### 1.2 Differentials and derivatives

\texttt{\differential{⟨symbol⟩}}, \texttt{\newderivative{⟨name⟩}{⟨symbol⟩}}, and \texttt{\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.

These macros are used for the usual differential and derivative, producing $dx$ via \texttt{\d x} and $\partial^2 f/\partial x \partial y$ via $\partial^2 f/\partial x \partial y$.

\texttt{\eval\langle x \rangle}$ \texttt{\order\langle x \rangle}$ \texttt{\comm{⟨x⟩}{⟨y⟩}}$ \texttt{\acomm{⟨x⟩}{⟨y⟩}}$ \texttt{\newpair{⟨name⟩}{⟨left delim⟩}{⟨right delim⟩}{⟨subscript⟩}{⟨superscript⟩}}$ \texttt{\pb xy}$ \texttt{\comm xy}$ \texttt{\acomm xy}$

Similarly a functional variation and functional derivative are defined.

\texttt{\var\langle characters⟩}$ \texttt{\cancel{⟨characters⟩}}$ \texttt{\slashed{⟨character⟩}}$ respectively.

\texttt{\abs x}$ \texttt{\norm x}$ \texttt{\norm[2]x}$ \texttt{\eval x}_0^\infty$

\texttt{\order{⟨x⟩}}$ \texttt{\eval* x}_0^\infty$

\texttt{\comm{⟨name⟩}{⟨left delimiter⟩}{⟨right delimiter⟩}{⟨subscript⟩}{⟨superscript⟩}}$ macro is defined and used for the definition of (anti-)commutators and Poisson brackets.

\texttt{\cancel{⟨characters⟩}}$ \texttt{\slashed{⟨character⟩}}$
They can easily be redefined using e.g. \texttt{newpair}\comm{\brack}\texttt{brack\_\-}.

Macros for the bra-ket notation are introduced.

\begin{tabular}{llll}
$\langle x |$ & $| x \rangle$ & $\langle x | y \rangle$ & $| x \rangle \langle y |$
\end{tabular}

\begin{tabular}{llll}
$\bra x$ & $\ket x$ & $\braket xy$ & $\ketbra xy$
\end{tabular}

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

\begin{tabular}{lll}
$\langle x | y | z \rangle$ & $\langle x \rangle$ & $(x, y, z)^T$
\end{tabular}

\section{Environments}

\texttt{eqnarray} The \texttt{eqnarray} environment is depreciated, the \texttt{split}, \texttt{multiline}, \texttt{align}, \texttt{multlined}, \texttt{aligned}, \texttt{alignedat}, and \texttt{cases} environments of the \texttt{amsmath} and \texttt{mathtools} packages should be used instead.

\texttt{equation} Use the \texttt{equation} environment for short equations.

\begin{equation}
\begin{aligned}
\text{left} &= \text{right} \\
\end{aligned}
\end{equation}

\texttt{multiline} Use the \texttt{multiline} environment for longer equations.

\begin{equation}
\begin{aligned}
\text{left} &= \text{right 1} \\
+ \text{right 2} \\
\end{aligned}
\end{equation}

\texttt{split} Use the \texttt{split} sub environment for equations in which multiple equal signs should be aligned.

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

\texttt{align} Use the \texttt{align} environment for the vertical alignment and horizontal distribution of multiple equations.

\begin{equation}
\begin{aligned}
\text{left} &= \text{right 1} \quad \text{left} = \text{right 2} \\
\text{left} &= \text{right} \\
\text{left} &= \text{right} \\
\text{left} &= \text{right} \\
\end{aligned}
\end{equation}

\texttt{aligned} Use the \texttt{aligned} environment within a \texttt{equation} environment if the aligned equations should be labeled with a single equation number.

\texttt{multlined} Use the \texttt{multlined} environment if either \texttt{split} or \texttt{align} contain very long lines.
\begin{equation} \begin{split}
\left. \begin{array}{l}
\text{left} \equiv \text{right 1} \\
\text{right 2} \equiv \text{right 3}
\end{array} \right] = \begin{array}{l}
\text{right 1} \\
\text{right 2} + \text{right 3}
\end{array} . \quad (5)
\end{split} \end{equation}

\textbf{alignat} Use the \texttt{alignat} environment together with the \texttt{\mathllap} macro for the alignment of multiple equations with vastly different lengths.

\begin{subequations}
\begin{alignat}{2}
\text{left} &= \text{long right} \quad & , & \hspace{1cm} (6a) \\
\text{le. 2} &= \text{ri. 2} \quad , & \hspace{1cm} \text{le. 3} = \text{ri. 3} & \quad (6b)
\end{alignat}
\end{subequations}

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

\section{Implementation}

\texttt{\<*package>}

Load the \texttt{mathtools} package \cite{mathtools} which loads the \texttt{amsmath} package \cite{amsmath}. Allow page breaks within equations if necessary. Adjust the thick and med mu skips slightly.

\begin{verbatim}
\RequirePackage{mathtools}
\mathtoolsset{centercolon}
\allowdisplaybreaks[1]
\thickmuskip=5mu plus 3mu minus 1mu
\medmuskip=4mu plus 2mu minus 3mu
\end{verbatim}

\texttt{\mathdef} Define the \texttt{\mathdef{\langle name\rangle}{\langle arguments\rangle}{\langle macro\rangle}} macro which (re-)defines macros in math mode only. This macro is implemented using the \texttt{xparse} package \cite{xparse}.

\begin{verbatim}
\RequirePackage{xparse}
\DeclareDocumentCommand{\mathdef}{mO{0}om}{%
\expandafter\let\expandafter\next\csname hep@text\string#1\endcsname=#1
\expandafter\newcommand\csname hep@math\string#1\IfNoValueTF{#3}{\endcsname[#2]}{\endcsname[#2][#3]}{#4}
\DeclareRobustCommand\#1{%\ifmmode
\expandafter\let\expandafter\next\csname hep@math\string#1\endcsname
\else
\expandafter\let\expandafter\next\csname hep@text\string#1\endcsname
\fi
\next
}%
\end{verbatim}

\text{i} Provide an upright imaginary unit in math mode.

\newcommand{\imaginaryunit}{\text{i}} \AtBeginDocument{\mathdef{\text{i}}{\imaginaryunit}}

\overline Redefine \overline to be a text macro using the soulutf8 package [4]. Extend it as a math macro with the original definition from the amsmath package [2].

\RequirePackage{soulutf8}
\def\overline#1{{\renewcommand{\ULdepth}{-1.9ex}{}\uline{#1}}}
\newcommand\textoverline[1]{{\setul{-1.9ex}{}\ul{#1}}}
\let\overline\textoverline
\DeclareRobustCommand{\over@line}[1]{\@@overline{#1}}
\mathdef{\overline}{\over@line}
\newcommand{\hep@widebar}[1]{{\mkern2.5mu\overline{\mkern-2.5mu#1\mkern-.5mu}\mkern.5mu}}
\newcommand{\widebar}[1]{{\settowidth{\dimen0}{\ensuremath{#1}}\ifdim\dimen0>.475em\hep@widebar{#1}\else\bar{#1}\fi}}

\oset Define a new overset macro \oset{⟨offset⟩}{⟨over⟩}{⟨base⟩}.
\newcommand{\oset}[3][-1pt]{{\text{\raisebox{.2ex}{$\mathop{#3}\limits^{\vbox to#1{\kern-2\ex@\hbox{$\scriptscriptstyle#2$}\vss}}$}}}}

\overleftright Define a over left right arrow \overleftright{⟨base⟩}.
\newcommand{\overleft}[1]{{\oset{\leftarrow}{#1}}}
\newcommand{\overright}[1]{{\oset{\rightarrow}{#1}}}
\newcommand{\overleftright}[1]{{\oset{\leftrightarrow}{#1}}}

eqnarray Undefine the eqnarray environment if not prevented by package option.
\newif\ifhep@eqnarray\hep@eqnarraytrue
\ifhep@eqnarray\else
\let\eqnarray\@undefined
\let\endeqnarray\@undefined
\fi

A.1 Operators
\tr Provide the \diag, \sgn, and some other operators.
\DeclareMathOperator{\tr}{tr}
\DeclareMathOperator{\Tr}{Tr}
\DeclareMathOperator{\erf}{erf}
\DeclareMathOperator{\Res}{Res}
\DeclareMathOperator{\sgn}{sgn}
\DeclareMathOperator{\diag}{diag}
Redefine the real and imaginary projectors.
\let\Re\relax\DeclareMathOperator{\Re}{Re}
\let\Im\relax\DeclareMathOperator{\Im}{Im}

Define a transpose symbol.
\let\trans\transpose
\Re\Im
\let\Re\relax\DeclareMathOperator{\Re}{Re}
\let\Im\relax\DeclareMathOperator{\Im}{Im}
\let\Re\relax\DeclareMathOperator{\Re}{Re}
\let\Im\relax\DeclareMathOperator{\Im}{Im}

A.1.1 Trigonometric functions
\cos
\tan
\arccsc
\arcsec
\arccot
\asin
\acos
\atan
\acsc
\asec
\acot
\csch
\sech

A.2 Units and fractions
\unit Load the units package [5] which provides the units and nicefrac macros. Patch the unit macros to behave like mathinner within an equation
\RequirePackage{units}
\let\oldunit\unit
\renewcommand{\unit}[2][]{%
  \ifthenelse{\boolean{mmode}}{%\mathinner{\oldunit[#1]{#2}}%}
  \oldunit[#1]{#2}%
}%
\let\oldunitfrac\unitfrac
\renewcommand{\unitfrac}[3][]{%
  \ifthenelse{\boolean{mmode}}{%\mathinner{\oldunitfrac[#1]{#2}{#3}}%}
  \oldunitfrac[#1]{#2}{#3}%
}%
\inv \textfraction{\textfrac}
\flatfraction{\flatfrac}
\int
\newcommand{\int}[3]{\ensuremath{\textstyle{\int_{#1}^{#2}\text{#3}}}}

A.2.1 Differentials and derivatives
\let\hep\int
\RenewDocumentCommand{\int}{o{_{-}}}{%\def\temp{\hep\flatfrac\{\IfValueT{#2}{#2}\}}{\IfValueT{#1}{\mathop{\temp\mathop{\int}}}{}%\temp}%
\DeclarePairedDelimiterX{\hepflatfrac}[2]{.}{.}{%\kern-\nulldelimiterspace#1\delimsize/%\hepleftdelim#2\kern-\nulldelimiterspace%}
\NewDocumentCommand{\flatfrac}{somm}{%\mathinner{%\IfBooleanTF{#1}{%\hepflatfrac*{#3}{#4}}{%\IfNoValueTF{#2}{\hepleftdelim#3/\hepleftdelim#4}{%\hepflatfrac{#2}{#3}{#4}}}}%}
\texttt{\differential} Define a generic differential \texttt{\differential}.

\begin{verbatim}
\newcommand{\differential}[1]{\mathop{}\!#1}
\end{verbatim}

\texttt{\newderivative} Define a generic derivative.

\begin{verbatim}
\newcommand{\newderivative}[2]{
  \NewDocumentCommand{#1}{somse{^}}{%
    \IfBooleanTF{##4}{%
      \IfBooleanTF{##1}{\nicefrac}{\frac}%
    }{%
      \IfBooleanTF{##1}{\flatfrac}{\dfrac}%
    }{%
      \differential#2\IfValueT{##5}{^{##5\!}}\IfValueT{##2}{##2}%
    }{%
      \differential#2{##3}\IfValueT{##5}{^{##5}}%
    }%
  }{%
}
\end{verbatim}

\texttt{\newpartialderivative} Define a generic partial derivative

\begin{verbatim}
\newcommand{\newpartialderivative}[2]{
  \NewDocumentCommand{#1}{somsE{^}{1}oE{^}{1}oE{^}{1}}{%
    \def\hep@one{\IfValueTF{##6}{##7}{0}}
    \def\hep@two{\IfValueTF{##8}{##9}{0}}
    \def\hep@sum{\the\numexpr##5+\hep@one+\hep@two\relax}
    \IfBooleanTF{##4}{%
      \IfBooleanTF{##1}{\nicefrac}{\frac}%
    }{%
      \IfBooleanTF{##1}{\flatfrac}{\dfrac}%
    }{%
      \differential#2\ifnum\hep@sum=1\relax\else{^\hep@sum}\fi
        \IfValueT{##2}{##2}%
    }{%
      \differential#2{##3}\ifnum##5=1\relax\else{^{##5}}\fi%
        \IfValueT{##6}{#2##6\ifnum##7=1\relax\else{^{##7}}\fi}%
        \IfValueT{##8}{#2##8\ifnum##9=1\relax\else{^{##9}}\fi}%
    }%
  }{%
}
\end{verbatim}

\texttt{\diffsymbol} Define the differential \texttt{\d} and the usual derivative.

\begin{verbatim}
\providecommand{\diffsymbol}{d}
\end{verbatim}

\texttt{\diff} \texttt{\d}

\texttt{\newcommand{\diff}{\differential\diffsymbol}}

\texttt{\AtBeginDocument{\mathdef{\d}{\diff}}}
Define the partial differential and derivative.\]
\newcommand\partialdifferential{\differential\partial}
\newcommand\pd{\partialdifferential}
\newpartialderivative{\partialderivative}{\partial}
\newcommand\pdv{\partialderivative}

Define the gauge covariant differential \D.\]
\providecommand\gaugediffsymbol{D}
\newcommand\gaugediff{\differential\gaugediffsymbol}
\newcommand\D{\gaugediff}

Define the covariant differential \cd.\]
\newcommand\covariantdiff{\differential\nabla}
\newcommand\cd{\covariantdiff}

Define the functional variation and derivative.\]
\newcommand\variation{\differential\delta}
\newcommand\var{\variation}
\newpartialderivative{\functionalderivative}{\delta}
\newcommand\fdv{\functionalderivative}

Load the cancel [8] and slashed [9] packages which provide the \cancel and \slashed macros.\]
\RequirePackage{cancel}
\RequirePackage{slashed}
\declareslashed{}{/}{.14}{0}{L}
\declareslashed{}{/}{.06}{0}{\D}
\declareslashed{}{/}{.055}{0}{\pd}

A.3 Paired delimiters\]
\left \right
\RequirePackage{mleftright}
\mleftright

Allow for macros to have an empty argument using the etoolbox package [11].\]
\RequirePackage{etoolbox}
\newcommand\noargumentsymbol{\cdot}
\newcommand\optionalargument[1]{\ifblank{#1}{\noargumentsymbol}{#1}}

\abs Absolute value and norm.\]
\DeclarePairedDelimiter\abs{\lvert}{\rvert}
\newcommand\hep@norm[1]{\lVert#1\rVert}
\DeclarePairedDelimiterPP\hep@pnorm[2]{}{_{#1}}{#2}
\NewDocumentCommand{\norm}{som}{%
Floor and ceiling paired delimiters.
\texttt{\floor}\texttt{\ceil} Floor and ceiling paired delimiters.

Order symbol and macro.
\texttt{\ordersymbol}\texttt{\order} Order symbol and macro.

Vertical evaluation bar
\texttt{\evaluated}\texttt{\eval} Vertical evaluation bar

Shortcuts for rows and columns
\texttt{\row}\texttt{\column} Shortcuts for rows and columns

Define a generic midbar.
\texttt{\midbar}\texttt{\midbar} Define a generic midbar.
Check if \texttt{nfssect-cfr} is loaded and patch the global \texttt{\set} macro into the \texttt{cfr} namespace

\begin{verbatim}
\RequirePackage{xpatch}
@ifundefined{exfs@merge@families}{}{%
\xpatchcmd{\exfs@merge@families}{\set}{\cfr@set}{}{}%
\xpatchcmd{\exfs@merge@families}{\set}{\cfr@set}{}{}%
\xpatchcmd{\exfs@merge@families}{\set}{\cfr@set}{}{}%}
\end{verbatim}

\textbf{\suchthat} Define a \texttt{\set} macro that allows a midbar via \texttt{\suchthat}.
\begin{verbatim}
\providecommand\suchthat{\midbar}
\DeclarePairedDelimiterX\set[1]\{\}{%  
\renewcommand\suchthat{\midbar[\delimsize]}#1%
\end{verbatim}

\textbf{\probabilitysymbol} Redefine the \texttt{\Pr} macro to a macro that takes a \texttt{\given} macro and generates a midbar.
\begin{verbatim}
\providecommand{\probabilitysymbol}{\operatorname{Pr}}
\providecommand\given{\midbar}
\DeclarePairedDelimiterXPP{\hep@Pr}[1]{\probabilitysymbol}(){}{%  
\renewcommand\given{\midbar[\delimsize]}#1%
\end{verbatim}

\textbf{A.3.2} Commutators
\textbf{\newpair} Define the \texttt{\newpair} macro that generates pairs surrounded by brackets.
\begin{verbatim}
\NewDocumentCommand{\newpair}{mmmme{_}e{^}}{%  
\IfNoValueTF{#4}{%  
\IfNoValueTF{#5}{%  
\DeclarePairedDelimiterX{#1}[2]{#2}{#3}{\hep@Pr[1]{}}%  
\DeclarePairedDelimiterXPP{#1}[2]{}{#2}{#3}{}^{#5}%  
\renewcommand\given{\midbar[\delimsize]}#11%  \end{verbatim}
Poisson bracket, commutator and anti-commutator.

\innerproduct
\poissonbracket
\commutator
\anticommutator
\anticomm

A.3.3 Bra-ket notation

\braket A.3.3 Bra-ket notation -- Define the space within braket notation.

\DeclarePairedDelimiter \braket [2][\langle}{\rangle]{% Define the braket macro.

\DeclarePairedDelimiterX \bra [1][\langle]{\rvert}{\braketinnerspace}{% Define the bra macro.
\textbf{\texttt{\textbackslash ket}} Define the ket macro.

\begin{verbatim}
\DeclarePairedDelimiterXPP{\ket}[1]{{\lvert}{{\rangle}}}{\braketinnerspace}{\hep@left@delim#1\braketouterspace}
\end{verbatim}

\textbf{\texttt{\textbackslash ketbra}} Define the ketbra macro.

\begin{verbatim}
\NewDocumentCommand{\ketbra}{smm}{\IfBooleanTF{#1}{\ket*{#2}\bra*{#3}}{\ket{#2}\bra{#3}}}
\end{verbatim}

\textbf{\texttt{\textbackslash matrixelement}} Define the matrixelement macro.

\begin{verbatim}
\DeclarePairedDelimiterX{\matrixelement}[3]{\langle}{\rangle}{\braketouterspace#1\hep@midvert#2\hep@midvert#3\braketouterspace}
\newcommand{\matrixel}{\matrixelement}
\newcommand{\mel}{\matrixelement}
\end{verbatim}

\textbf{\texttt{\textbackslash expectationvalue}} Define the expectationvalue and vev macros.

\begin{verbatim}
\DeclarePairedDelimiterX{\hep@expvalue}[1]{\langle}{\rangle}{\braketouterspace#1\braketouterspace}
\NewDocumentCommand{\expectationvalue}{som}{\IfNoValueTF{#2}{\IfBooleanTF{#1}{\hep@expvalue*}{\hep@expvalue}{#3}}{\IfBooleanTF{#1}{\matrixelement*}{\matrixelement}{#2}{#3}{#2}}}
\newcommand{\ev}{\expectationvalue}
\newcommand{\vev}[1]{\expectationvalue[0]{#1}}
\end{verbatim}

\textit{B Test}

\begin{verbatim}
\documentclass{article}
\end{verbatim}

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\usepackage{hep-math}

\begin{document}
\begin{gather}
\bra{x}\ket{y}
\braket*{x}{y}\\\n\dv[f]{x}^3\n\pdv[f]{x}{y}^2[z]^3\n\fdv[f]{x}^3[y]\n\set{x \suchthat x \in X}\n\end{gather}
\end{document}

C  Readme

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### Introduction

The 'hep-math' package provides some additional features beyond the 'mathtools' and 'amsmath' packages.

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

### Author

Jan Hajer

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References

[2] \textit{\LaTeX} Team. ‘The \texttt{amsmath} package: AMS mathematical facilities for \LaTeX’ (1994). CTAN: \texttt{amsmath}. URL: \url{ams.org/tex/amslatex}.


