1 Introduction

This package aims to provide semantic commands for ease of use in mathematics to see better what you semantically mean which should be distinct/split from how it is realised in \LaTeX.
The package is a spin-off and developed in the suite of packages from the former numapde-group in Chemnitz, see the original repository at https://gitlab.hrz.tu-chemnitz.de/numapde-public/numapde-latex.

Throughout this documentation most commands are directly illustrated by examples, which are both displayed as code (or for math examples) and its rendered result in \LaTeX. Two examples are
\begin{verbatim}
\bbR R
\end{verbatim}
and
\begin{verbatim}
\eg e.g.
\end{verbatim}
The aim is to first ease the use of some often used letters and low-level formats like bold face letters \bbR, but also to provide high level commands that make typing mathematics easier, for example using \[ \abs{\frac{1}{2}} \quad \text{and} \quad \abs[\Big]{\frac{1}{2}} \] This is the main goal in Section 4 about syntactical commands for mathematics. A next more support/helping section about abbreviations and names is Section 5.

The first main part on general semantic commands is Section 7.

While all these are loaded by default. The next part, Section 8, introduces semantic commands for specific topics. These are given in separate sub-packages and can be loaded if you work in this area and want to use the commands.

The package should be loaded late, since it might overwrite a few commands, currently most prominently \d which is overwritten by cleveref in case minted is loaded. So for more flexibility, there is the alternative command \dInt.

## 2 Package Options

| shortbb | use shorter notations for the blackboard-bold math letters \C, \K, \N, \Q, \R, \Z |

## 3 Required Packages

| amssymb.sty | defines mathematical symbol fonts |
| ifthen.sty | facilitates the definition of conditional commands |
| ifxetex.sty | provides a way to check if a document is being processed by XeLaTeX and company |
| mathtools.sty | provides lots of improvements for math typesetting (includes amsmath.sty) |
\textbf{xivthen.sty} extends \textit{ifthen.sty} by adding new boolean conditions

\textbf{xparse.sty} provides a high-level interface to define new commands

\textbf{xspace.sty} adds space depending on context

\section{Syntax}

The \texttt{mathsemantics-syntax.sty} package provides mainly symbols and short commands, which can be used in semantic definitions for ease of notation. They usually are rather simple commands without too many parameters.

\subsection{Letters}

- \texttt{ba. . . bz} lower-case \texttt{bold-face letters} \( \backslash b r, \backslash b f \) \( r, f \)
- \texttt{bA. . . bZ} upper-case \texttt{bold-face letters} \( \backslash b R, \backslash b F \) \( R, F \)
- \texttt{balpha. . . bomega} lower-case \texttt{bold-face Greek letters} \( \backslash b a l p h a, \backslash b o l d e t a \) \( \alpha, \eta \) (the latter being an exception)
- \texttt{bAlpha. . . bOmega} upper-case \texttt{bold-face Greek letters} \( \backslash b G a m m a, \backslash b D e l t a \) \( \Gamma, \Delta \)
- \texttt{bnull} \texttt{bold-face zero} \( \backslash b n u l l \) \( 0 \)
- \texttt{bone} \texttt{bold-face one} \( \backslash b o n e \) \( 1 \)
- \texttt{cA. . . cZ} upper-case \texttt{calligraphic letters} \( \backslash c M, \backslash c N \) \( M, N \)
- \texttt{fA. . . fZ} upper-case \texttt{fraktur letters} \( \backslash f M, \backslash f N, \backslash f X \) \( \mathfrak{M}, \mathfrak{N}, \mathfrak{X} \)
- \texttt{sA. . . sZ} upper-case \texttt{script letters} \( \backslash s M, \backslash s N, \backslash s X \) \( \mathcal{M}, \mathcal{N}, \mathcal{X} \)
- \texttt{va. . . vz} lower-case letters with a vector accent \( \backslash v a, \backslash v b \) \( \vec{a}, \vec{b} \)
- \texttt{vA. . . vZ} upper-case letters with a vector accent \( \backslash v A, \backslash v B \) \( \vec{A}, \vec{B} \)
- \texttt{valpha. . . vomega} lower-case Greek letters with a vector accent \( \backslash v a l p h a, \backslash v b e t a \) \( \vec{\alpha}, \vec{\beta} \)
vAlpha...vOmega  upper-case Greek letters with a vector accent $\vec{\Gamma}, \vec{\Delta}$

vnull  vector zero $\vec{0}$

vone  vector one $\vec{1}$

bbA,...,bbZ  blackboard-bold uppercase letters

$\mathbb{C}, \mathbb{K}, \mathbb{N}, \mathbb{Q}, \mathbb{R}, \mathbb{S}, \mathbb{Z}$

use the package option shortbb to introduce

$\mathbb{C}, \mathbb{K}, \mathbb{N}, \mathbb{Q}, \mathbb{R}, \mathbb{Z}$  if not already defined elsewhere (i.e. they are not redefined, only provided.

4.2 Syntax Helpers

enclspacing  provides spacing after the opening and before the closing delimiters for $\enclose$. This is by default set to be empty.

enclose  is a command which encloses some content in scaled delimiters. It is meant as a helper to facilitate the definition of other commands. Its syntax is $\enclose[#1]{#2}{#3}{#4}$. The first (optional) argument is used to scale the delimiters to the standard amsmath sizes. The second and fourth arguments specify the opening and closing delimiters, respectively. The third argument is the content to be enclosed.

$\enclose[\text{[]}]{\dfrac{1}{2}}{\text{[]}}$  $\left[\frac{1}{2}\right]$

$\enclose[\text{Big}]{\dfrac{1}{2}}{\text{[]}}$  $\left[\frac{1}{2}\right]$

$\enclose[\text{auto}]{\dfrac{1}{2}}{\text{[]}}$  $\left[\frac{1}{2}\right]$

$\enclose[\text{none}]{\dfrac{1}{2}}{\text{[]}}$  $\left[\frac{1}{2}\right]$

Note 1. none is merely meant for testing when having arguments in brackets whether it is useful to omit them. You can also deactivate the absolute value vertical lines this way, so use this option with care.

Note 2. This command should normally be used only in the definition of other commands. For instance, $\abs$ is using it internally. See \paren for the

\footnote{big, Big, bigg, Bigg or auto, which uses left and right as well as none to easily deactivate brackets.}
nicer command to use

**enclspacingSet** provides spacing before and after the center delimiter \( \encloseSet \). This is by default set to \( \, \). 

**encloseSet** is a command which encloses some content in scaled delimiters. It is meant as a helper to facilitate the definition of other commands. Its syntax is \( \encloseSet[\text{#1}]{\text{#2}}{\text{#3}}{\text{#4}}{\text{#5}}{\text{#6}} \). The first (optional) argument is used to scale the delimiters including the center one to the standard amsmath sizes.\(^1\) The second and sixth arguments specify the opening and closing delimiters, respectively. The fourth argument specifies the center delimiter and the third and fifth argument are the content to be enclosed.

\[
\encloseSet[\text{big}]{\{}{x\in\mathbb{R}}{\mid}{x>5}\}\{\}
\]

\[
\encloseSet[\text{auto}]{\{}{x\in\mathbb{R}}{\mid}{x>\frac{1}{2}}\}\{\}
\]

**Note.** This command should normally be used only in the definition of other commands. For instance, \( \setDef \) is using it internally.

**paren** is an alternative to \( \enclose \), with a different ordering of arguments. Its syntax is \( \paren[\text{#1}]{\text{#2}}{\text{#3}}{\text{#4}} \), which is simply mapped to \( \enclose[\text{#1}]{\text{#2}}{\text{#4}}{\text{#3}} \).

\[
\paren[\text{Big}]{[}{\frac{1}{2}}{]}
\]

\[
\paren[\text{Big}]{[}{\frac{1}{2}}{]}
\]

\[
\paren[\text{auto}]{[}{\frac{1}{2}}{]}
\]

**Spacing Helpers**

**clap** complements the standard \TeX commands \( \llap \) and \( \rlap \). These commands horizontally smash their arguments.

\[
\text{Let us } \llap{\text{smash}} \text{ something.} \quad \text{Let us smash something.}
\]

\[
\text{Let us } \clap{\text{smash}} \text{ something.} \quad \text{Let us smash something.}
\]

\[
\text{Let us } \rlap{\text{smash}} \text{ something.} \quad \text{Let us smash something.}
\]

**mathllap** corresponds to \( \llap \) in math mode.
\\[
\sum_{\mathllap{1\le i\le j\le n}} X_{ij}
\]

**mathclap**

corresponds to \texttt{\clap} in math mode.

\[
\sum_{\mathclap{1\le i\le j\le n}} X_{ij}
\]

**mathrlap**

corresponds to \texttt{\rlap} in math mode.

\[
\sum_{\mathrlap{1\le i\le j\le n}} X_{ij}
\]

**mrep**

stands for *math replace* and it typesets an argument while reserving the space for another. Its syntax is \texttt{\mrep[#1]{#2}{#3}} The first (optional) argument is one of \{l,c,r\} and it is used to define the alignment. c is the default.

\[
\texttt{\mrep[l]{1}{-1}-1} \quad \texttt{\mrep[c]{1}{-1}-1} \quad \texttt{\mrep[r]{1}{-1}-1}
\]

5 **Abbreviations**

5.1 **English**

**aa**  
amost all \texttt{\aa}  
a.a.

**ale**  
amost everywhere \texttt{\ale}  
a.e.

**eg**  
exempli gratia (for example) \texttt{\eg}  
e.g.

**etc**  
et cetera (and so on) \texttt{\etc}  
etc.

**ie**  
id est (id est) \texttt{\ie}  
i.e.

**iid**  
independent and identically distributed \texttt{\iid}  
i.i.d.

**spd**  
symmetric positive definite \texttt{\spd}  
s.p.d.

**st**  
such that or subject to \texttt{\st}  
s.t.
wrt

with respect to \wrt \begin{example} w.r.t. \end{example}

5.2 German

bspw

beispielsweise (for example) \bspw \begin{example} bspw. \end{example}

bzgl

bezüglich (with regard to) \bzgl \begin{example} bzgl. \end{example}

bzw

beziehungsweise (respectively) \bzw \begin{example} bzw. \end{example}

Dah

Das heißt (That is, beginning of phrase) \Dah \begin{example} D. h. \end{example}

dah

das heißt (that is) \dah \begin{example} d. h. \end{example}

evtl

eventuell (possibly) \evtl \begin{example} evtl. \end{example}

fs

fast sicher \fs \begin{example} f. s. \end{example}

fue

fast überall \fue \begin{example} f. ü. \end{example}

IA

Im Allgemeinen (beginning of phrase) \IA \begin{example} I. A. \end{example}

iA

im Allgemeinen \iA \begin{example} i. A. \end{example}

idR

in der Regel \idR \begin{example} i. d. R. \end{example}

IdR

In der Regel (beginning of phrase) \IdR \begin{example} I. d. R. \end{example}

iW

im Wesentlichen \iW \begin{example} i. W. \end{example}

IW

Im Wesentlichen (beginning of phrase) \IW \begin{example} I. W. \end{example}

mE

meines Erachtens \mE \begin{example} m. E. \end{example}

oBdA

ohne Beschränkung der Allgemeinheit \oBdA \begin{example} o. B. d. A. \end{example}

OBdA

ohne Beschränkung der Allgemeinheit (beginning of phrase) \OBdA \begin{example} O. B. d. A. \end{example}

og

oben genannt \og \begin{example} o. g. \end{example}

oae

oder ähnliche \oae \begin{example} o. ä. \end{example}
so siehe oben \(\text{so}\) \(\text{s. t.}\)

\textit{ua} unter anderem \(\text{ua}\) \(\text{u. a.}\)

\textit{Ua} Unter anderem (beginning of phrase) \(\text{Ua}\) \(\text{U. a.}\)

\textit{ug} unten genannt \(\text{ug}\) \(\text{u. g.}\)

\textit{usw} und so weiter (and so on) \(\text{usw.}\)

\textit{uU} unter Umst¨anden \(\text{uU}\) \(\text{u. U.}\)

\textit{UnU} Unter Umst¨anden (beginning of phrase) \(\text{UnU}\) \(\text{U. U.}\)

\textit{vgl} vergleiche (compare) \(\text{vgl}\) \(\text{vgl.}\)

\textit{zB} zum Beispiel \(\text{zB}\) \(\text{z. B.}\)

\textit{ZB} Zum Beispiel (beginning of phrase) \(\text{ZB}\) \(\text{Z. B.}\)

\textit{zHd} zu H¨anden \(\text{zHd}\) \(\text{z. Hd.}\)

6 Names

\texttt{adimat} \(\text{ADiMat}\)

\texttt{ampl} \(\text{AMPL}\)

\texttt{BibTeX} \(\text{BiTeX}\)

\texttt{BibLaTeX} \(\text{BiLaTeX}\)

\texttt{cg} \(\text{CG}\)

\texttt{cpp} \(\text{C++}\)

\texttt{cppmat} \(\text{CPPMAT}\)

\texttt{dolfin} \(\text{DOLFIN}\)

\texttt{dolfinplot} \(\text{DOLFIN-Plot}\)

\texttt{dolfinadjoint} \(\text{DOLFIN-Adjoint}\)
7 SEMANTIC COMMANDS

Build upon Syntax from Section 4 this part provides semantic mathematical commands.
absolute value. Its syntax is \texttt{\textbackslash abs[#1]{#2}}. The first (optional) argument is used to scale the delimiters enclosing the arguments to the standard amsmath sizes. The second argument denotes the argument.

\begin{verbatim}
\texttt{\textbackslash abs(a)} \quad |a|
\newline
\texttt{\textbackslash abs[Big]{\dfrac{1}{2}}} \quad \dfrac{1}{2}
\newline
\texttt{\textbackslash abs[auto]{\dfrac{1}{2}}} \quad \dfrac{1}{2}
\end{verbatim}

affine hull \texttt{\textbackslash aff} \quad \texttt{aff}

area hyperbolic cosine \texttt{\textbackslash arcosh} \quad \texttt{arcosh}

area hyperbolic cotangens \texttt{\textbackslash arcoth} \quad \texttt{arcoth}

maximizer of a function \texttt{\textbackslash argmax}_{x \in \bbR} f(x) \quad \texttt{arg max}_{x \in \bbR} f(x)

set of maximizers of a function \texttt{\textbackslash Argmax}_{x \in \bbR} f(x) \quad \texttt{Arg max}_{x \in \bbR} f(x)

minimizer of a function \texttt{\textbackslash argmin}_{x \in \bbR} f(x) \quad \texttt{arg min}_{x \in \bbR} f(x)

set of minimizers of a function \texttt{\textbackslash Argmin}_{x \in \bbR} f(x) \quad \texttt{Arg min}_{x \in \bbR} f(x)

area hyperbolic cotangens \texttt{\textbackslash arsinh} \quad \texttt{arsinh}

area hyperbolic tangens \texttt{\textbackslash artanh} \quad \texttt{artanh}

bold (meaning: vector) divergence of a matrix-valued function \texttt{\textbackslash bdiv} \quad \texttt{div}

integer larger or equal to input. Its syntax is \texttt{\textbackslash ceil[#1]{#2}}. The first (optional) argument is used to scale the delimiters enclosing the arguments to the standard amsmath sizes. The second argument denotes the argument.

\begin{verbatim}
\texttt{\textbackslash ceil(a)} \quad [a]
\newline
\texttt{\textbackslash ceil[Big]{\dfrac{1}{2}}} \quad \dfrac{1}{2}
\end{verbatim}
clconv  closure of the convex hull of a set \( \text{clconv} \ M \)

closure  closure of a set \( \text{closure} \ M \)

cofac  cofactor matrix \( \text{cofac}(A) \)

compactly  compact embedding of topological spaces \( \text{compactly} \)

cone  conic hull \( \text{cone} \)

conv  convex hull of a set \( \text{conv} \ M \)

corresponds  binary operator for correspondence \( A \corresponds B \)

cov  covariance \( \text{cov} \)

curl  the curl operator \( \text{curl} \)

d, dInt  integral symbol with prepended space, as in

\( \int_{\mathbb{R}} \exp(-x^2) \, dx \)

Since \( d \) is often overridden, \( \text{dInt} \) is the safe alternative

dev  deviator of a matrix \( \text{dev} \ A \)

diag  diagonal matrix composed of entries in a vector, or diagonal of a matrix

\( \text{diag}(a) \)

\( \text{diag}(A) \)

diam  diameter \( \text{diam}(M) \)

distOp  the mathematical operator denoting the distance

\( \text{dist} \)

dist  distance from a point to a set. Its syntax is \( \text{dist}[#1\{#2\}{#3}] \) or \( \text{dist}[#1\{#2}] \). The first (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes. The second argument denotes the set. The third argument denotes the point; it can be omitted. The command \( \text{distOp} \) is used to typeset the operator.

\( \text{dist}[\text{Big}][\text{C}][\text{dfrac}(x){2}] \)
\text{div} \quad \text{divergence} \quad \text{Div} \quad \text{(row-wise) divergence}

\text{dom} \quad \text{domain}

\text{dotcup} \quad \text{distinct union}

\text{dprod} \quad \text{double contraction of matrices} \quad A \cdot B = \sum_{i,j} A_{ij} B_{ij} = \text{trace}(A^T B)

\text{dual} \quad \text{duality pairing. Its syntax is} \quad \text{\textbackslash dual[#1]{#2}{#3}. The first (optional) argument is used to scale the delimiters enclosing the arguments to the standard amsmath sizes.} \quad \text{The second argument denotes the first factor. The third argument denotes the second factor.}

\text{e} \quad \text{Euler’s number}

\text{embed} \quad \text{embedding of topological spaces} \quad \text{\textbackslash embed} \quad \ni

\text{essinf} \quad \text{essential infimum}

\text{esssup} \quad \text{essential supremum}

\text{eR} \quad \text{extended real line} \quad \text{\bbR} = \mathbb{R} \cup \{\pm \infty\}

\text{embeds} \quad \text{synonym of} \quad \text{\textbackslash embed} \quad \ni

\text{epi} \quad \text{epigraph} \quad \ni

\text{epi} \quad \text{synonym of} \quad \ni

\text{epi} \quad \text{synonym of} \quad \ni
file
typesets a file name (using \nolinkurl)

\file{test.txt} test.txt

floor
integer less or equal to input. Its syntax is \floor[#1]{#2}. The first (optional) argument is used to scale the delimiters enclosing the arguments to the standard amsmath sizes.\(^1\) The second argument denotes the argument.

\floor{a} [a]

\floor[Big]{\dfrac{1}{2}} \left\lfloor \frac{1}{2}\right\rfloor

grad
gradient (of a function) \grad F \ \text{grad } F

Graph
graph of a function \Graph Graph

id
identity operator \id id

image
image of a function \image image

inj
injectivity (radius) \inj inj

inner
inner product. Its syntax is \inner[#1]{#2}{#3}. The first (optional) argument is used to scale the parentheses enclosing the arguments to the standard amsmath sizes.\(^1\) The second argument denotes the first factor. The third argument denotes the second factor.

\inner{a}{b} (a, b)

\inner[Big]{a}{\dfrac{b}{2}} \left( a, \frac{b}{2} \right)

interior
\interior int

jump
jump of a quantity, e. g., across a finite element facet. Its syntax is \jump[#1]{#2}. The first (optional) argument is used to scale the delimiters enclosing the arguments to the standard amsmath sizes.\(^1\) The second argument denotes the argument.

\jump{a} [a]

\jump[Big]{\dfrac{1}{2}} \left\lbrack \frac{1}{2}\right\rbrack

laplace
the Laplace operator \laplace u \ \Delta u
**lin**  linear hull of a set of vectors \( \langle v_1, v_2 \rangle \)

**norm**  norm of a vector. Its syntax is \( \| a \| \). The first (optional) argument is used to scale the delimiters enclosing the arguments to the standard amsmath sizes. The second argument denotes the argument.

\( \| a \| \)

\( \| \frac{c}{2} \| \)

\( \| \frac{c}{2} \| \)

**projOp**  the mathematical operator denoting the projection \( \text{proj} \)

**proj**  projection onto a set. Its syntax is \( \text{proj}(\#1)(\#2) \) or \( \text{proj}(\#1)(\#2) \). The first (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes. The second argument denotes the set and can also be left out. The third argument denotes the point; it can be omitted. The command \( \text{projOp} \) is used to typeset the operator.

\( \text{proj}(x) \)

\( \text{proj}(\mathcal{C}) \)

\( \text{proj}(\mathcal{C})(x) \)

\( \text{proj}\left(\frac{x}{2}\right) \)

\( \text{proj}\left(\mathcal{C}\left(\frac{x}{2}\right)\right) \)

**proxOp**  the mathematical operator denoting the proximal map

**prox**  the proximal operator of a function. Its syntax is \( \text{prox}(\#1)(\#2)(\#3) \) or \( \text{prox}(\#1)(\#2) \). The first (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes. The second argument denotes the set. The third argument denotes the point; it can be omitted. The command \( \text{proxOp} \) is used to typeset the operator.
\( \text{prox} \) \( \lambda F \) \( x \) \( \text{prox}_\lambda \mathcal{F}(x) \)

range

rank (of a matrix) \( \text{rank} \)

range of some operator \( \text{range} \)

restr

restriction/evaluation. Its syntax is \( \text{restr}[\#1]\{\#2\}{\#3} \). The first (optional) argument is used to scale the delimiters enclosing the arguments to the standard amsmath sizes.\(^1\) The second argument denotes the argument to be restricted/evaluated. The third argument denotes the restriction set/evaluation point.

\( \text{ri} \)

relative interior \( \text{ri} \)

setDef

define a set, where \( \text{setMid} \) serves as the center divider. Its syntax is \( \text{setDef}[\#1]\{\#2\}{\#3} \). The first (optional) argument is used to scale the parentheses enclosing the argument and the center divider to the standard amsmath sizes.\(^1\) The second argument denotes the left part of the definition, naming the potential elements of the set being defined. The third argument denotes the condition to include the elements in the set.

\( \text{sym} \)

symmetric part (of a matrix) \( \text{sym} \)
trace

trace (of a matrix) \(\text{trace } A\) \(\text{trace } A\)

transp

transpose of a vector or matrix.

\(A^\text{transp}\) \(A^\text{T}\)

transposeSymbol

symbol to use for the transpose

\(\text{transposeSymbol}\) \(T\)

var

variance \(\text{var}\) \(\text{Var}\)

weakly

weak convergence of a sequence \(\text{weakly}\) \(\text{\(\rightarrow\)}\)

weaklystar

weak star convergence of a sequence \(\text{weaklystar}\) \(\text{\(\Rightarrow\)}\)

8 Additional Semantics by Topic

While semantic commands might be suitable for all mathematical topics, the following subsections collect commands which are most useful in one particular mathematical area and hence might clutter the general semantic file. Any semantic topic files should always build on mathsemantics-semantic.sty.

8.1 Manifolds: mathsemantics-manifolds.sty

The semantic file mathsemantics-manifolds.sty collects definitions and notations for Riemannian manifolds.

bitangentSpace

the bi tangent space. Its syntax is \(\text{bitangent}\{#1[#2]\}.\) The first argument denotes the base point. The second (optional) argument denotes the manifold, which defaults to \(\mathcal{M}\).

\(\text{bitangentSpace}\{p\}\) \(T_p^{**}\mathcal{M}\)

\(\text{bitangentSpace}\{q\}[\text{cN}]\) \(T_q^{**}\mathcal{N}\)

bitangentSpaceSymbol

the symbol used within \text{bitangentSpace}.

\(\text{bitangentSpaceSymbol}\) \(T^{**}\)
**cotangentSpace**

the cotangent space. Its syntax is `\cotangentSpace{#1}[#2]`. The first argument denotes the base point. The second (optional) argument denotes the manifold, which defaults to $\mathcal{M}$.

\[
\cotangentSpace{p} \odot T_p^*\mathcal{M}
\]
\[
\cotangentSpace{q}[\mathcal{N}] \odot T_q^*\mathcal{N}
\]

**cotangentBundle**

the cotangent bundle. Its syntax is `\cotangentBundle[#1]`. The (optional) argument denotes the manifold, which defaults to $\mathcal{M}$.

\[
\cotangentBundle \odot T^*\mathcal{M}
\]
\[
\cotangentBundle[\mathcal{N}] \odot T^*\mathcal{N}
\]

**cotangentSpaceSymbol**

the symbol used within `\cotangent`.

\[
\cotangentSpaceSymbol \odot T^*
\]

**covariantDerivative**

is the covariant derivative. Its syntax is `\covariantDerivative[#1][#2][#3]`. The first argument is the vector (or vector field) determining the direction of differentiation. The second (optional) argument denotes the tensor field being differentiated.

\[
\covariantDerivative{X}{Y} \odot D_X Y
\]

**covariantDerivativeSymbol** the symbol used for the covariant derivative `\covariantDerivative`.

\[
\covariantDerivativeSymbol \odot \nabla
\]

**exponential**

the exponential map. Its syntax is `\exponential[#1][#2][#3]`. The first argument can be used to scale the third. The second argument denotes the base point and is mandatory. The third argument denotes the tangent vector, which is optional, but if provided, the argument is put in brackets. The first following example illustrates the case, where no brackets are put. Note that the space is mandatory.

\[
\exponential{p} X \odot \exp_p X
\]
\[
\exponential{p}(X) \odot \exp_p(X)
\]
\[
\exponential[\text{Big}]{p}(\frac{X}{2}) \odot \exp_p\left(\frac{X}{2}\right)
\]

**expOp**

the symbol used within the `\exponential`.

\[
\expOp
\]
a geodesic. Its syntax is `\geodesic #1—#2—#3–#4˝–#5˝(#6)—`. The first argument can be used to use a different symbol (locally) for the geodesic. The second (optional) argument is used to modify the style of the geodesic (symbol, long, arc or plain, where the last is the default). The third (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes. It is ignored when the sixth argument is not given. The fourth argument denotes the initial point (at \(t = 0\)). The fifth argument denotes either the final point (at \(t = 1\)) for types \(l\) and \(a\), or the initial tangent vector for type \(p\). The sixth (optional) argument denotes the evaluation point. The command `\geodesicSymbol` is used to typeset the geodesic symbol default (i.e. globally).

\[ \text{\geodesicSymbol symbol to use for the geodesic in \geodesic} \]

\[ \text{\inverseRetract use an inverse retraction, the arguments are similar to \logarithm but use the \retractionSymbol} \]

\[ \text{\inverseRetract(p)q \ retraction symbol} \]
the logarithmic map. Its syntax is \logarithm\[#1\]{#2}\(#3\). The first argument can be used to scale the third. The second argument denotes the base point and is mandatory. The third argument denotes another point, which is optional, but if provided, the argument is put in brackets. The first following example illustrates the case, where no brackets are put. Note that the space is mandatory.

\logarithm{p}q = \log_p q

\logarithm{p}(q) = \log_p(q)

\logarithm[Big]{p}(q) = \log_p(q)

logOp

the symbol used within the \logarithm.

\logOp = \log

parallelTransport

the parallel transport.

Its syntax is \parallelTransport\[#1\]{#2}\(#3\){#4}\(#5\). The first (optional) argument is used to scale the parentheses enclosing the argument #4. The second argument is the start point of parallel transport on a manifold. The third argument is the end point of parallel transport on a manifold. The fourth (optional) argument is the tangent vector that is transported. Putting it in brackets enables the scaling by the first argument. The fifth (optional) argument specifies an exponent, for example to parallel transport along a curve c

\parallelTransport{p}{q}(X) = P_{q→p}(X)

\parallelTransport{p}{q}(X) = P_{q→p}(X)

\parallelTransport[big]{p}{q}(X) = P_{q→p}(X)

\parallelTransport{p}{q}(X)[c] = P^{c}_{q→p}(X)

\parallelTransport{p}{q}[c] = P^{c}_{q→p}

parallelTransportDir

similar to \parallelTransport, but the third argument is a direction to transport into. This can be rewritten to the classical notation applying an exponential map from the base point (#2) to th direction (#3). The fifth
(optional) argument specifies an exponent, for example to parallel transport along a curve \( e \)

\[
\parallelTransportDir{p}{Y}(X) \quad P_{p,Y}(X)
\]

\[
\parallelTransportDir{big}{p}{Y}(X) \quad P_{p,Y}(X)
\]

\[
\parallelTransportDir{p}{Y}(X)[c] \quad P^{c}_{p,Y}(X)
\]

\[
\parallelTransportDir{p}{Y}[c] \quad P^{c}_{p,Y}(X)
\]

\textbf{parallelTransportSymbol} \quad \text{the symbol to use within} \ \parallelTransport \ \text{and} \ \parallelTransportDir

\[
\parallelTransportSymbol{P}
\]

\textbf{retract} \quad \text{a retraction.}

Its syntax is \texttt{retract[#1]{#2}{#3}{#4}}. The first argument can be used to scale the third. The second argument denotes the base point. The third argument denotes the tangent vector, which is optional, but if provided, the argument is put in brackets. The first following example illustrates the case, where no brackets are put. Note that the space is mandatory.

\[
\retract{p}X \quad \retr_{p}X
\]

\[
\retract{p}(X) \quad \retr_{p}(X)
\]

\[
\retract{Big}{p}(\frac{X}{2}) \quad \retr_{p}\left(\frac{X}{2}\right)
\]

\textbf{retractionSymbol} \quad \text{symbol to use for a retraction and an inverse retraction, see} \ \retract \ \text{and} \ \inverseRetract

\[
\retractionSymbol{retr}
\]

\textbf{riemannian} \quad \text{the Riemannian metric (family of inner products on the tangent spaces). Its syntax is} \ \riemannian[#1]{#2}{#3}{#4}. The first (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes.\footnote{The second argument denotes the first factor. The third argument denotes the second factor. The fourth (optional) argument denotes the base point of the tangent space.

\[
\riemannian{X_1}{X_2} \quad (X_1, X_2)
\]

\[
\riemannian{Y_1}{Y_2}[q] \quad (Y_1, Y_2)_q
\]
\[ \text{riemanniannorm} \] the norm induced by the Riemannian metric. Its syntax is \texttt{\riemanniannorm}[#1]{#2}[#3]. The first (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes. The second argument denotes the argument. The third (optional) argument denotes the base point of the tangent space.

\[ \text{secondCovariantDerivative} \] is the second-order covariant derivative. Its syntax is \texttt{\secondCovariantDerivative}{#1}{#2}[#3]. The first argument is the vector (or vector field) determining the first direction of differentiation. The second argument is the vector (or vector field) determining the second direction of differentiation. The third (optional) argument denotes the tensor field being differentiated.

\[ \text{tangentSpace} \] the tangent space. Its syntax is \texttt{\tangentSpace}{#1}[#2]. The first argument denotes the base point. The second (optional) argument denotes the manifold, which defaults to \( \mathcal{M} \).

\[ \text{tangentBundle} \] the tangent bundle. Its syntax is \texttt{\tangentBundle}[#1]. The (optional) argument denotes the manifold, which defaults to \( \mathcal{M} \).

\[ \text{tangentSpaceSymbol} \] the symbol used within \texttt{\tangent}. 

\[ \text{secondCovariantDerivativeSymbol} \] the symbol used for the second covariant derivative. This is used within \texttt{\secondCovariantDerivative}. 

\[ \text{tangentBundleSymbol} \] the symbol used within \texttt{\tangent}. 

\[ \text{tangentSpaceSymbol} \] the symbol used within \texttt{\tangent}. 

\[ \text{secondCovariantDerivativeSymbol} \] the symbol used for the second covariant derivative. This is used within \texttt{\secondCovariantDerivative}.
the tensor bundle. Its syntax is $\text{\textbackslash tensorBundle}(r)(s)$, $\text{T}^{(r,s)}M$. The first argument denotes the number $r$ of elements of the cotangent space the tensors accept. The second argument denotes the number $s$ of elements of the tangent space the tensors accept. The third (optional) argument denotes the manifold, which defaults to $M$.

$\text{\textbackslash tensorBundle}(r)(s)[\text{cN}]$ $\text{T}^{(r,s)}N$

tensorSpace

a tensor space over a vector space $V$. Its syntax is $\text{\textbackslash tensorSpace}(r)(s)[V]$, $\text{T}^{(r,s)}(V)$.

tensorSpaceSymbol

the symbol used within $\text{\textbackslash tensorSpace}$ and $\text{\textbackslash tensorBundle}$.

vectorTransport

a vector transport. Its syntax is $\text{\textbackslash vectorTransport}(p)(q)(X)$, $\text{T}_{q-p}X$. The first (optional) argument is used to scale the parentheses enclosing the argument #4. The second argument is the start point of vector transport on a manifold. The third argument is the end point of vector transport on a manifold. The fourth (optional) argument is the tangent vector that is transported. Putting it in brackets enables the scaling by the first argument. Finally a retraction symbol can be added in the exponent to distinguish vector transports as #5.

$\text{\textbackslash vectorTransport}(p)(q)(X)[\text{retractionSymbol}]$ $\text{T}_{q-p}^{\text{re}X}$

vectorTransportDir

similar to $\text{\textbackslash vectorTransport}$, but the third argument is a direction to transport into. This can be rewritten to the classical notation applying an retraction
from the base point (2) to the direction (3).

\[ \text{vectorTransportDir}(p)(Y)(X) \quad \mathcal{T}_{p,Y}(X) \]

\[ \text{vectorTransportDir}[\text{big}](p)(Y)(X) \quad \mathcal{T}_{p,Y}(X) \]

\[ \text{vectorTransportDir}(p)(Y)(X)[\text{retractionSymbol}] \quad \mathcal{T}_{p,Y}^\text{retr}(X) \]

The symbol to use within \text{vectorTransport} and \text{vectorTransportDir}

\[ \text{vectorTransportSymbol} \quad \mathcal{T} \]

8.2 **Optimization**: mathsemantics-optimization.sty

The semantic file mathsemantics-optimization.sty collects definitions and notations related to optimization.

\textbf{linearizingcone} the linearizing cone. Its syntax is \texttt{\linearizingcone[#1][#2][#3]}. The first (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes.\(^1\) The second argument denotes the set. The third argument denotes the base point.

\[ \text{linearizingcone}(A)(x) \quad \mathcal{T}_A^\text{lin}(x) \]

\[ \text{linearizingcone}(A)(x^2) \quad \mathcal{T}_A^\text{lin}(x^2) \]

\[ \text{linearizingcone}[\text{big}](A)(x^2) \quad \mathcal{T}_A^\text{lin}(x^2) \]

\textbf{normalcone} the normal cone. Its syntax is \texttt{\normalcone[#1][#2][#3]}. The first (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes.\(^1\) The second argument denotes the set. The third argument denotes the base point.

\[ \text{normalcone}(A)(x) \quad \mathcal{N}_A(x) \]

\[ \text{normalcone}(A)(x^2) \quad \mathcal{N}_A(x^2) \]

\[ \text{normalcone}[\text{big}](A)(x^2) \quad \mathcal{N}_A(x^2) \]

\textbf{polarcone} the polar cone of a set \texttt{\polarcone(A)} \quad \mathcal{A}^\circ
the radial cone. Its syntax is $\texttt{radialcone[#1][#2][#3]}$. The first (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes. The second argument denotes the set. The third argument denotes the base point.

\begin{align*}
\texttt{radialcone}(A, x) &\quad \mathcal{K}_A(x) \\
\texttt{radialcone}(A, x^2) &\quad \mathcal{K}_A(x^2) \\
\texttt{radialcone}(A, x^2) &\quad \mathcal{K}_A(x^2) \\
\end{align*}

the tangent cone. Its syntax is $\texttt{tangentcone[#1][#2][#3]}$. The first (optional) argument is used to scale the parentheses enclosing the argument to the standard amsmath sizes. The second argument denotes the set. The third argument denotes the base point.

\begin{align*}
\texttt{tangentcone}(A, x) &\quad \mathcal{T}_A(x) \\
\texttt{tangentcone}(A, x^2) &\quad \mathcal{T}_A(x^2) \\
\texttt{tangentcone}(A, x^2) &\quad \mathcal{T}_A(x^2) \\
\end{align*}