Package 'CVXR'

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Type Package

Title Disciplined Convex Optimization

Version 1.8.1

URL https://cvxr.rbind.io, https://www.cvxgrp.org/CVXR/

BugReports https://github.com/cvxgrp/CVXR/issues

Description An object-oriented modeling language for disciplined convex programming (DCP) as described in Fu, Narasimhan, and Boyd (2020, <doi:10.18637/jss.v094.i14>). It allows the user to formulate convex optimization problems in a natural way following mathematical convention and DCP rules. The system analyzes the problem, verifies its convexity, converts it into a canonical form, and hands it off to an appropriate solver to obtain the solution. This version uses the S7 object system for improved performance and maintainability.

Depends R (>= 4.3.0)

Imports S7 (>= 0.2), methods, Matrix (>= 1.7), Rcpp (>= 1.1), clarabel (>= 0.11), cli (>= 3.6), gmp (>= 0.7), highs (>= 1.12), osqp (>= 1.0), scs (>= 3.2), slam (>= 0.1)

Suggests jsonlite (>= 1.9), knitr, rmarkdown, testthat (>= 3.3), rlang

Enhances Rmosek, gurobi (>= 13.0), Rglpk (>= 0.6), ECOSolveR (>= 0.6), Rcplex (>= 0.3), cccp (>= 0.3), piqp (>= 0.6)

Additional_repositories https://bnaras.r-universe.dev

LinkingTo Rcpp, RcppEigen

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Author Anqi Fu [aut, cre],
Balasubramanian Narasimhan [aut],
Steven Diamond [aut],
John Miller [aut],
Stephen Boyd [ctb]

Maintainer Anqi Fu <anqif@alumni.stanford.edu>

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Contents

And *Logical AND*

Description

Returns 1 if and only if all arguments equal 1, and 0 otherwise. For two operands, can also be written with the & operator: x & y.

Usage

```
And(..., id = NULL)
```

Arguments

...	Two or more boolean Variables or logic expressions.
id	Optional integer ID (internal use).

Value

An And expression.

See Also

Not(), Or(), Xor(), implies(), iff()

Examples

```
## Not run:
x <- Variable(boolean = TRUE)
y <- Variable(boolean = TRUE)
both <- x & y            # operator syntax
both <- And(x, y)        # functional syntax
all3 <- And(x, y, z)     # n-ary

## End(Not run)
```

`as_cvxr_expr` *Convert a value to a CVXR Expression*

Description

Wraps numeric vectors, matrices, and Matrix package objects as CVXR Constant objects. Values that are already CVXR expressions are returned unchanged.

Usage

```
as_cvxr_expr(x)
```

Arguments

`x`	A numeric vector, matrix, Matrix::Matrix object, Matrix::sparseVector object, or CVXR expression.

Value

A CVXR expression (either the input unchanged or wrapped in Constant).

Matrix package interoperability

Objects from the **Matrix** package (`dgCMatrix`, `dgeMatrix`, `ddiMatrix`, `sparseVector`, etc.) are S4 classes. Because S4 dispatch preempts S7/S3 dispatch, **raw Matrix objects cannot be used directly with CVXR operators** (`+`, `-`, `*`, `/`, `%*%`, `>=`, `==`, etc.).

Use `as_cvxr_expr()` to wrap a Matrix object as a CVXR Constant before combining it with CVXR variables or expressions. This preserves sparsity (unlike `as.matrix()`, which densifies).

Base R `matrix` and `numeric` objects work natively with CVXR operators — no wrapping is needed.

Examples

```
x <- Variable(3)

## Sparse Matrix needs as_cvxr_expr() for CVXR operator dispatch:
A <- Matrix::sparseMatrix(i = 1:3, j = 1:3, x = 1.0)
expr <- as_cvxr_expr(A) %*% x

## All operators work with wrapped Matrix objects:
y <- Variable(c(3, 3))
expr2 <- as_cvxr_expr(A) + y
constr <- as_cvxr_expr(A) >= y

## Base R matrix works natively (no wrapping needed):
D <- matrix(1:9, 3, 3)
expr3 <- D %*% x
```

`available_solvers` *List available solvers*

Description

Returns the names of installed solvers that are not currently excluded. Use `exclude_solvers()` to temporarily disable solvers.

Usage

```
available_solvers()

exclude_solvers(solvers)

include_solvers(solvers)

set_excluded_solvers(solvers)
```

Arguments

`solvers`	A character vector of solver names.

Value

A character vector of solver names.

The current exclusion list (character vector), invisibly.

Functions

- `exclude_solvers()`: Add solvers to the exclusion list
- `include_solvers()`: Remove solvers from the exclusion list
- `set_excluded_solvers()`: Replace the entire exclusion list

See Also

`installed_solvers()`, `exclude_solvers()`, `include_solvers()`, `set_excluded_solvers()`

bmat *Construct a Block Matrix*

Description

Takes a list of lists. Each internal list is stacked horizontally. The internal lists are stacked vertically.

Usage

```
bmat(block_lists)
```

Arguments

`block_lists`	A list of lists of Expression objects (or numerics). Each inner list forms one block row.

Value

An Expression representing the block matrix.

cdiac *Global Monthly and Annual Temperature Anomalies (degrees C), 1850-2015 (Relative to the 1961-1990 Mean) (May 2016)*

Description

Global Monthly and Annual Temperature Anomalies (degrees C), 1850-2015 (Relative to the 1961-1990 Mean) (May 2016)

Usage

```
cdiac
```

Format

A data frame with 166 rows and 14 variables:

year Year

jan Anomaly for month of January

feb Anomaly for month of February

mar Anomaly for month of March

apr Anomaly for month of April

may Anomaly for month of May

jun Anomaly for month of June

jul Anomaly for month of July

aug Anomaly for month of August

sep Anomaly for month of September

oct Anomaly for month of October

nov Anomaly for month of November

dec Anomaly for month of December

annual Annual anomaly for the year

Source

https://ess-dive.lbl.gov/

References

https://ess-dive.lbl.gov/

`ceil_expr` *Elementwise Ceiling*

Description

Returns the ceiling (smallest integer >= x) of each element. This atom is quasiconvex and quasiconcave but NOT convex or concave, so it can only be used in DQCP problems (solved with `qcp = TRUE`).

Usage

```
ceil_expr(x)
```

Arguments

`x`	A CVXR expression.

Value

A `Ceil` expression.

See Also

`floor_expr`

condition_number *Condition number of a PSD matrix*

Description

Computes the condition number lambda_max(A) / lambda_min(A) for a positive semidefinite matrix A. This is a quasiconvex atom.

Usage

```
condition_number(A)
```

Arguments

A	A square matrix expression (must be PSD)

Value

An expression representing the condition number of A

Constant *Create a Constant Expression*

Description

Wraps a numeric value as a CVXR constant for use in optimization expressions. Constants are typically created implicitly when combining numeric values with CVXR expressions via arithmetic operators.

Usage

```
Constant(value, name = NULL)
```

Arguments

value	A numeric scalar, vector, matrix, or sparse matrix.
name	Optional character string name.

Value

A `Constant` object (inherits from `Leaf` and `Expression`).

Examples

```
c1 <- Constant(5)
c2 <- Constant(matrix(1:6, 2, 3))
```

constants *Get the Constants in an Expression*

Description

Get the Constants in an Expression

Usage

```
constants(x, ...)
```

Arguments

x	An expression or problem object.
...	Not used.

Value

List of `Constant` objects.

constraints *Get Problem Constraints (read-only)*

Description

Returns a copy of the problem's constraint list.

Usage

```
constraints(x)
```

Arguments

x	A Problem object.

Details

Problem objects are **immutable**: constraints cannot be modified after construction. To change constraints, create a new `Problem()`. This matches CVXPY's design where problems are immutable except through Parameter value changes.

Value

A list of constraint objects.

See Also

Problem(), objective()

Examples

```
x <- Variable(2)
prob <- Problem(Minimize(sum_entries(x)), list(x >= 1))
length(constraints(prob))  # 1
```

---

conv *1D discrete convolution*

Description

1D discrete convolution

Usage

```
conv(a, b)
```

Arguments

a	An Expression (vector, one must be constant)
b	An Expression (vector)

Value

A Convolve atom

---

cummax_expr *Cumulative maximum along an axis*

Description

Cumulative maximum along an axis

Usage

```
cummax_expr(x, axis = 2L)
```

Arguments

x	An Expression
axis	1 (across rows) or 2 (down columns, default)

Value

A Cummax atom

cumsum_axis *Cumulative sum along an axis*

Description

Cumulative sum along an axis

Usage

```
cumsum_axis(x, axis = NULL)
```

Arguments

x	An Expression
axis	NULL (all), 1 (across rows), or 2 (down columns)

Value

A Cumsum atom

curvature *Get Expression Curvature*

Description

Returns the DCP curvature of an expression as a string.

Usage

```
curvature(x)
```

Arguments

x	A CVXR expression.

Value

Character: "CONSTANT", "AFFINE", "CONVEX", "CONCAVE", or "UNKNOWN".

See Also

is_convex(), is_concave(), is_affine(), is_constant()

cvar — *Conditional Value at Risk (CVaR)*

Description

CVaR at confidence level beta: average of the (1-beta) largest values.

Usage

```
cvar(x, beta)
```

Arguments

x	An Expression (vector)
beta	Confidence level in [0, 1)

Value

An Expression representing the CVaR

cvxr_diff — *Compute kth Order Differences of an Expression*

Description

Takes in an expression and returns an expression with the kth order differences along the given axis. The output shape is the same as the input except the size along the specified axis is reduced by k.

Usage

```
cvxr_diff(x, k = 1L, axis = 2L)
```

Arguments

x	An Expression or numeric value.
k	Integer. The number of times values are differenced. Default is 1. (Mapped from R's `lag` argument in diff.default; use `differences` for repeated differencing which maps to k here.)
axis	Integer. The axis along which the difference is taken. 2 = along rows/down columns (default), 1 = along columns/across rows.

Value

An Expression representing the kth order differences.

cvxr_mean *Mean of an expression*

Description

Computes the arithmetic mean of an expression along an axis.

Usage

```
cvxr_mean(x, axis = NULL, keepdims = FALSE)
```

Arguments

x	An Expression or numeric value.
axis	NULL (all), 1 (row-wise), or 2 (column-wise).
keepdims	Logical; keep reduced dimension?

Value

An Expression representing the mean.

cvxr_norm *Compute a norm of an expression*

Description

Compute a norm of an expression

Usage

```
cvxr_norm(x, p = 2, axis = NULL, keepdims = FALSE, max_denom = 1024L)
```

Arguments

x	An Expression
p	Norm type: 1, 2, Inf, or "fro" (Frobenius)
axis	NULL (all), 0 (columns), or 1 (rows)
keepdims	Logical
max_denom	Integer max denominator

Value

A norm atom

cvxr_outer *Outer product of two vectors*

Description

Computes the outer product `x %*% t(y)`. Both inputs must be vectors.

Usage

```
cvxr_outer(x, y)
```

Arguments

x	An Expression or numeric value (vector).
y	An Expression or numeric value (vector).

Value

An Expression of shape (length(x), length(y)).

cvxr_std *Standard deviation of an expression*

Description

Computes the standard deviation of an expression.

Usage

```
cvxr_std(x, axis = NULL, keepdims = FALSE, ddof = 0)

std(x, axis = NULL, keepdims = FALSE, ddof = 0)
```

Arguments

x	An Expression or numeric value.
axis	NULL (all), 1 (row-wise), or 2 (column-wise).
keepdims	Logical; keep reduced dimension?
ddof	Degrees of freedom correction (default 0, population std).

Value

An Expression representing the standard deviation.

cvxr_var *Variance of an expression*

Description

Computes the variance. Only supports full reduction (axis = NULL).

Usage

```
cvxr_var(x, axis = NULL, keepdims = FALSE, ddof = 0)
```

Arguments

x	An Expression or numeric value.
axis	NULL only (axis reduction not yet supported).
keepdims	Logical; keep reduced dimension?
ddof	Degrees of freedom correction (default 0, population variance).

Value

An Expression representing the variance.

DiagMat *Extract Diagonal from a Matrix*

Description

Extracts the k-th diagonal of a square matrix as a column vector.

Usage

```
DiagMat(x, k = 0L, id = NULL)
```

Arguments

x	A CVXR expression (square matrix).
k	Integer diagonal offset. k = 0 (default) is the main diagonal, k > 0 is above, k < 0 is below.
id	Optional integer ID.

Value

A DiagMat expression of shape c(n - abs(k), 1).

See Also

DiagVec

DiagVec *Vector to Diagonal Matrix*

Description

Constructs a diagonal matrix from a column vector. If `k != 0`, the vector is placed on the `k`-th super- or sub-diagonal.

Usage

```
DiagVec(x, k = 0L, id = NULL)
```

Arguments

`x`	A CVXR expression (column vector).
`k`	Integer diagonal offset. `k = 0` (default) is the main diagonal, `k > 0` is above, `k < 0` is below.
`id`	Optional integer ID.

Value

A `DiagVec` expression of shape `c(n + abs(k), n + abs(k))`.

See Also

`DiagMat`

diff_pos *The difference x - y with domain x > y > 0*

Description

Equivalent to x * one_minus_pos(y / x).

Usage

```
diff_pos(x, y)
```

Arguments

`x`	An Expression (positive)
`y`	An Expression (positive, elementwise less than x)

Value

A product expression

dist_ratio *Distance ratio*

Description

Computes norm(x - a)_2 / norm(x - b)_2, where a and b are constants. This is a quasiconvex atom.

Usage

```
dist_ratio(x, a, b)
```

Arguments

x	A vector expression
a	A numeric constant vector
b	A numeric constant vector

Value

An expression representing the distance ratio

dotsort *Weighted sorted dot product*

Description

Computes <sort(vec(X)), sort(vec(W))> where X is an expression and W is a constant. A generalization of sum_largest and sum_smallest.

Usage

```
dotsort(X, W)
```

Arguments

X	An Expression or numeric value.
W	A constant numeric vector or matrix.

Value

A scalar convex Expression.

dspop *Direct Standardization: Population*

Description

Randomly generated data for direct standardization example. Sex was drawn from a Bernoulli distribution, and age was drawn from a uniform distribution on $10, \ldots, 60$. The response was drawn from a normal distribution with a mean that depends on sex and age, and a variance of 1.

Usage

```
dspop
```

Format

A data frame with 1000 rows and 3 variables:

y Response variable

sex Sex of individual, coded male (0) and female (1)

age Age of individual

See Also

dssamp

dssamp *Direct Standardization: Sample*

Description

A sample of dspop for direct standardization example. The sample is skewed such that young males are overrepresented in comparison to the population.

Usage

```
dssamp
```

Format

A data frame with 100 rows and 3 variables:

y Response variable

sex Sex of individual, coded male (0) and female (1)

age Age of individual

See Also

dspop

dual_value *Get the Dual Value of a Constraint*

Description

Returns the dual variable value(s) associated with a constraint after solving. Returns `NULL` before the problem is solved.

Usage

```
dual_value(x)
```

Arguments

`x`	A `Constraint` object.

Value

A numeric matrix (single dual variable) or a list of numeric matrices (multiple dual variables), or `NULL`.

entr *Create an entropy atom -x * log(x)*

Description

Create an entropy atom -x * log(x)

Usage

```
entr(x)
```

Arguments

`x`	An Expression

Value

An Entr atom

Equality *Create an Equality Constraint*

Description

Constrains two expressions to be equal elementwise: $lhs = rhs$. Typically created via the == operator on CVXR expressions.

Usage

```
Equality(lhs, rhs, constr_id = NULL)
```

Arguments

lhs	A CVXR expression (left-hand side).
rhs	A CVXR expression (right-hand side).
constr_id	Optional integer constraint ID.

Value

An Equality constraint object.

See Also

Zero, Inequality

ExpCone *Create an Exponential Cone Constraint*

Description

Constrains (x, y, z) to lie in the exponential cone:

$$K = \{(x, y, z) \mid y \exp(x/y) \leq z,\ y > 0\}$$

Usage

```
ExpCone(x_expr, y_expr, z_expr, constr_id = NULL)
```

Arguments

x_expr	A CVXR expression.
y_expr	A CVXR expression.
z_expr	A CVXR expression.
constr_id	Optional integer constraint ID.

Details

All three arguments must be affine, real, and have the same shape.

Value

An ExpCone constraint object.

---

expr_H *Conjugate-Transpose of an Expression*

Description

Equivalent to CVXPY's .H property. For real expressions, returns t(x). For complex expressions, returns Conj(t(x)).

Usage

```
expr_H(x)
```

Arguments

x	A CVXR Expression.

Value

The conjugate-transpose expression.

---

expr_sign *Get the DCP Sign of an Expression*

Description

Returns the sign of an expression under DCP analysis. Use this instead of sign(), which conflicts with the base R function.

Usage

```
expr_sign(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Character string: "POSITIVE", "NEGATIVE", "ZERO", or "UNKNOWN".

eye_minus_inv *Unity resolvent (I - X) inverse for positive square matrix X*

Description

Log-log convex atom for DGP. Solve with `psolve(problem, gp = TRUE)`.

Usage

```
eye_minus_inv(X)
```

Arguments

`X`	An Expression (positive square matrix with spectral radius < 1)

Value

An EyeMinusInv atom

Examples

```
X <- Variable(c(2, 2), pos = TRUE)
prob <- Problem(Minimize(sum(eye_minus_inv(X))), list(X <= 0.4))
## Not run: psolve(prob, gp = TRUE, solver = "SCS")
```

FiniteSet *FiniteSet Constraint*

Description

Constrain each entry of an Expression to take a value in a given finite set of real numbers.

Usage

```
FiniteSet(expre, vec, ineq_form = FALSE, constr_id = NULL)
```

Arguments

`expre`	An affine Expression.
`vec`	A numeric vector (or set) of allowed values.
`ineq_form`	Logical; controls MIP canonicalization strategy. If `FALSE` (default), uses equality formulation (one-hot binary). If `TRUE`, uses inequality formulation (sorted differences + ordering).
`constr_id`	Optional integer constraint ID (internal use).

Value

A `FiniteSet` constraint.

floor_expr *Elementwise Floor*

Description

Returns the floor (largest integer <= x) of each element. This atom is quasiconvex and quasiconcave but NOT convex or concave, so it can only be used in DQCP problems (solved with qcp = TRUE).

Usage

```
floor_expr(x)
```

Arguments

x	A CVXR expression.

Value

A Floor expression.

See Also

ceil_expr

gen_lambda_max *Maximum generalized eigenvalue*

Description

Computes the maximum generalized eigenvalue lambda_max(A, B). Requires A symmetric and B positive semidefinite. This is a quasiconvex atom.

Usage

```
gen_lambda_max(A, B)
```

Arguments

A	A square symmetric matrix expression
B	A square PSD matrix expression of the same dimension as A

Value

An expression representing the maximum generalized eigenvalue

geo_mean *(Weighted) geometric mean of a vector*

Description

(Weighted) geometric mean of a vector

Usage

```
geo_mean(x, p = NULL, max_denom = 1024L, approx = TRUE)
```

Arguments

x	An Expression (vector)
p	Numeric weight vector (default: uniform)
max_denom	Maximum denominator for rational approximation
approx	If TRUE (default), use SOC approximation. If FALSE, use exact power cone.

Value

A GeoMean or GeoMeanApprox atom

get_problem_data *Get Problem Data for a Solver (deprecated)*

Description

[Deprecated]

Usage

```
get_problem_data(x, solver = NULL, ...)
```

Arguments

x	A Problem object.
solver	Character string naming solver, or NULL for automatic selection.
...	Additional arguments.

Details

Use problem_data instead.

Value

A list with components `data`, `chain`, and `inverse_data`.

See Also

`problem_data`

`gmatmul` *Geometric matrix multiplication A diamond X*

Description

Computes the geometric matrix product where (A diamond X)_ij = prod_k X_kj^A_ik. Log-log affine atom for DGP. Solve with `psolve(problem, gp = TRUE)`.

Usage

```
gmatmul(A, X)
```

Arguments

`A`	A constant matrix
`X`	An Expression (positive matrix)

Value

A Gmatmul atom

Examples

```
x <- Variable(2, pos = TRUE)
A <- matrix(c(1, 0, 0, 1), 2, 2)
prob <- Problem(Minimize(sum(gmatmul(A, x))), list(x >= 0.5))
## Not run: psolve(prob, gp = TRUE)
```

harmonic_mean *Harmonic mean: n / sum(1/x_i)*

Description

Harmonic mean: n / sum(1/x_i)

Usage

```
harmonic_mean(x)
```

Arguments

x	An Expression (must be positive for DCP)

Value

An Expression representing the harmonic mean

hstack *Horizontal concatenation of expressions*

Description

Horizontal concatenation of expressions

Usage

```
hstack(...)
```

Arguments

...	Expressions (same number of rows)

Value

An HStack atom

huber *Create a Huber loss atom*

Description

Create a Huber loss atom

Usage

```
huber(x, M = 1)
```

Arguments

x	An Expression
M	Numeric threshold (default 1)

Value

A Huber atom

id *Get Expression ID*

Description

Returns the unique integer identifier for a CVXR object.

Usage

```
id(x)
```

Arguments

x	A CVXR expression, variable, parameter, or constraint.

Value

An integer.

iff *Logical Biconditional*

Description

Logical biconditional: x <=> y. Returns 1 if and only if x and y have the same value. Equivalent to `Not(Xor(x, y))`.

Usage

```
iff(x, y)
```

Arguments

x, y	Boolean Variables or logic expressions.

Value

A Not expression wrapping Xor.

See Also

`implies()`, `Not()`, `And()`, `Or()`, `Xor()`

Examples

```
## Not run:
x <- Variable(boolean = TRUE)
y <- Variable(boolean = TRUE)
expr <- iff(x, y)

## End(Not run)
```

implies *Logical Implication*

Description

Logical implication: x => y. Returns 1 unless x = 1 and y = 0. Equivalent to `Or(Not(x), y)`.

Usage

```
implies(x, y)
```

Arguments

x, y	Boolean Variables or logic expressions.

Value

An Or expression representing `!x | y`.

See Also

`iff()`, `Not()`, `And()`, `Or()`, `Xor()`

Examples

```
## Not run:
x <- Variable(boolean = TRUE)
y <- Variable(boolean = TRUE)
expr <- implies(x, y)

## End(Not run)
```

`indicator` *Indicator function for constraints*

Description

Creates an expression that equals 0 if all constraints are satisfied and +Inf otherwise. Use this to embed constraints into the objective.

Usage

```
indicator(constraints, err_tol = 0.001)
```

Arguments

`constraints`	A list of constraint objects
`err_tol`	Numeric tolerance for checking constraint satisfaction (default 1e-3)

Value

An Indicator expression

Inequality *Create an Inequality Constraint*

Description

Constrains the left-hand side to be less than or equal to the right-hand side elementwise: $lhs \leq rhs$. Typically created via the <= operator on CVXR expressions.

Usage

```
Inequality(lhs, rhs, constr_id = NULL)
```

Arguments

lhs	A CVXR expression (left-hand side).
rhs	A CVXR expression (right-hand side).
constr_id	Optional integer constraint ID.

Value

An Inequality constraint object.

See Also

Equality, NonPos, NonNeg

installed_solvers *List installed solvers*

Description

Returns the names of solvers whose R packages are available.

Usage

```
installed_solvers()
```

Value

A character vector of solver names.

inv_pos *Inverse position: $x^{\wedge}-1$ (for x > 0)*

Description

Inverse position: x^{-1} (for x > 0)

Usage

```
inv_pos(x)
```

Arguments

x	An Expression

Value

A Power atom with p=-1

inv_prod *Reciprocal of product of entries*

Description

Computes the reciprocal of the product of entries. Equivalent to `geo_mean(x)^(-n)` where n is the number of entries.

Usage

```
inv_prod(x, approx = TRUE)
```

Arguments

x	An Expression or numeric value (must have positive entries).
approx	Logical; if TRUE (default), use SOC approximation.

Value

A convex Expression representing the reciprocal product.

is_affine *Check if an Expression is Affine*

Description

Check if an Expression is Affine

Usage

```
is_affine(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_concave *Check if an Expression is Concave*

Description

Check if an Expression is Concave

Usage

```
is_concave(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_constant *Check if an Expression is Constant*

Description

Check if an Expression is Constant

Usage

```
is_constant(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_convex *Check if an Expression is Convex*

Description

Check if an Expression is Convex

Usage

```
is_convex(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_dcp *Check if an Expression is DCP-Compliant*

Description

Tests whether an expression follows the Disciplined Convex Programming (DCP) rules.

Usage

```
is_dcp(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_dgp *Check if a Constraint is DGP-Compliant*

Description

Check if a Constraint is DGP-Compliant

Usage

```
is_dgp(x, ...)
```

Arguments

x	A constraint object.
...	Not used.

Value

Logical scalar.

is_dpp *Check DPP Compliance*

Description

Determines whether an expression or problem satisfies the rules of Disciplined Parameterized Programming (DPP). A DPP-compliant problem enables caching the compilation across parameter value changes.

Usage

```
is_dpp(x, ...)
```

Arguments

x	An expression, constraint, or problem object.
...	Not used.

Value

Logical scalar.

is_dqcp *Check if Expression is DQCP-Compliant*

Description

Tests whether an expression follows the Disciplined Quasiconvex Programming (DQCP) rules.

Usage

```
is_dqcp(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_log_log_affine *Check if Expression is Log-Log Affine*

Description

Check if Expression is Log-Log Affine

Usage

```
is_log_log_affine(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_log_log_concave *Check if Expression is Log-Log Concave*

Description

Check if Expression is Log-Log Concave

Usage

```
is_log_log_concave(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_log_log_convex *Check if Expression is Log-Log Convex*

Description

Check if Expression is Log-Log Convex

Usage

```
is_log_log_convex(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_lp *Check if a Problem is a Linear Program*

Description

Check if a Problem is a Linear Program

Usage

```
is_lp(x, ...)
```

Arguments

x	A Problem object.
...	Not used.

Value

Logical scalar.

is_matrix *Is the Expression a Matrix?*

Description

Returns TRUE if the expression has both dimensions greater than 1.

Usage

```
is_matrix(x)
```

Arguments

x	A CVXR expression.

Value

Logical.

See Also

size(), is_scalar(), is_vector()

is_mixed_integer *Check if a Problem is Mixed-Integer*

Description

Returns TRUE if any variable in the problem has a boolean or integer attribute.

Usage

```
is_mixed_integer(problem)
```

Arguments

problem	A Problem object.

Value

Logical scalar.

is_nonneg *Check if Expression is Non-Negative*

Description

Check if Expression is Non-Negative

Usage

```
is_nonneg(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_nonpos *Check if Expression is Non-Positive*

Description

Check if Expression is Non-Positive

Usage

```
is_nonpos(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_nsd *Check if Expression is Negative Semidefinite*

Description

Check if Expression is Negative Semidefinite

Usage

```
is_nsd(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_psd *Check if Expression is Positive Semidefinite*

Description

Check if Expression is Positive Semidefinite

Usage

```
is_psd(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_pwl *Check if Expression is Piecewise Linear*

Description

Check if Expression is Piecewise Linear

Is the Expression Piecewise Linear?

Usage

```
is_pwl(x, ...)
```

Arguments

x	A CVXR expression.
...	Not used.

Value

Logical scalar.

Logical.

is_qp *Check if a Problem is a Quadratic Program*

Description

Check if a Problem is a Quadratic Program

Usage

```
is_qp(x, ...)
```

Arguments

x	A Problem object.
...	Not used.

Value

Logical scalar.

is_quadratic *Check if an Expression is Quadratic*

Description

Check if an Expression is Quadratic

Usage

```
is_quadratic(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_quasiconcave *Check if Expression is Quasiconcave*

Description

Check if Expression is Quasiconcave

Usage

```
is_quasiconcave(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_quasiconvex *Check if Expression is Quasiconvex*

Description

Check if Expression is Quasiconvex

Usage

```
is_quasiconvex(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_quasilinear *Check if Expression is Quasilinear*

Description

Check if Expression is Quasilinear

Usage

```
is_quasilinear(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_scalar *Is the Expression a Scalar?*

Description

Is the Expression a Scalar?

Usage

```
is_scalar(x)
```

Arguments

x	A CVXR expression.

Value

Logical.

See Also

size(), is_vector(), is_matrix()

is_symmetric *Check if Expression is Symmetric*

Description

Check if Expression is Symmetric

Usage

```
is_symmetric(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

is_vector *Is the Expression a Vector?*

Description

Returns TRUE if the expression has at most one dimension greater than 1.

Usage

```
is_vector(x)
```

Arguments

x	A CVXR expression.

Value

Logical.

See Also

size(), is_scalar(), is_matrix()

is_zero *Check if Expression is Zero*

Description

Check if Expression is Zero

Usage

```
is_zero(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

Logical scalar.

kl_div — *KL Divergence: x*log(x/y) - x + y*

Description

KL Divergence: x*log(x/y) - x + y

Usage

```
kl_div(x, y)
```

Arguments

x	An Expression
y	An Expression

Value

A KlDiv atom

kron — *Kronecker product of two expressions*

Description

Kronecker product of two expressions

Usage

```
kron(a, b)
```

Arguments

a	An Expression (one must be constant)
b	An Expression

Value

A Kron atom

lambda_max *Maximum eigenvalue*

Description

Maximum eigenvalue

Usage

```
lambda_max(A)
```

Arguments

A	A square matrix expression

Value

An expression representing the maximum eigenvalue of A

lambda_min *Minimum eigenvalue*

Description

Minimum eigenvalue

Usage

```
lambda_min(A)
```

Arguments

A	A square matrix expression

Value

An expression representing the minimum eigenvalue of A

lambda_sum_largest *Sum of largest k eigenvalues*

Description

Sum of largest k eigenvalues

Usage

```
lambda_sum_largest(A, k)
```

Arguments

A	A square matrix expression
k	Number of largest eigenvalues to sum (positive integer)

Value

An expression representing the sum of the k largest eigenvalues

lambda_sum_smallest *Sum of smallest k eigenvalues*

Description

Sum of smallest k eigenvalues

Usage

```
lambda_sum_smallest(A, k)
```

Arguments

A	A square matrix expression
k	Number of smallest eigenvalues to sum (positive integer)

Value

An expression representing the sum of the k smallest eigenvalues

length_expr *Length of a Vector (Last Nonzero Index)*

Description

Returns the index of the last nonzero element of a vector (1-based). This atom is quasiconvex but NOT convex, so it can only be used in DQCP problems (solved with `qcp = TRUE`).

Usage

```
length_expr(x)
```

Arguments

x	A CVXR vector expression.

Value

A `Length` expression (scalar).

See Also

`ceil_expr`, `floor_expr`

log1p_atom *Log(1 + x) – elementwise*

Description

Log(1 + x) – elementwise

Usage

```
log1p_atom(x)

log1p_expr(x)
```

Arguments

x	An Expression

Value

A Log1p atom

loggamma — *Elementwise log of the gamma function*

Description

Piecewise linear approximation of `log(gamma(x))`. Has modest accuracy over the full range, approaching perfect accuracy as x goes to infinity.

Usage

```
loggamma(x)
```

Arguments

x	An Expression or numeric value (must be positive for DCP).

Value

A convex Expression representing log(gamma(x)).

logistic — *Logistic function: log(1 + exp(x)) – elementwise*

Description

Logistic function: log(1 + exp(x)) – elementwise

Usage

```
logistic(x)
```

Arguments

x	An Expression

Value

A Logistic atom

log_det *Log-determinant*

Description

Computes log(det(A)) for PSD matrix A.

Usage

```
log_det(A)
```

Arguments

A	A square PSD matrix expression

Value

An expression representing log(det(A))

log_normcdf *Elementwise log of the standard normal CDF*

Description

Quadratic approximation of `log(pnorm(x))` with modest accuracy over the range -4 to 4.

Usage

```
log_normcdf(x)
```

Arguments

x	An Expression or numeric value.

Value

A concave Expression representing log(Phi(x)).

log_sum_exp *Log-sum-exp: log(sum(exp(x)))*

Description

Log-sum-exp: log(sum(exp(x)))

Usage

```
log_sum_exp(x, axis = NULL, keepdims = FALSE)
```

Arguments

x	An Expression
axis	NULL (all), 1 (row-wise), or 2 (column-wise)
keepdims	Logical: keep reduced dimensions?

Value

A LogSumExp atom

make_sparse_diagonal_matrix *Make a CSC sparse diagonal matrix*

Description

Make a CSC sparse diagonal matrix

Usage

```
make_sparse_diagonal_matrix(size, diagonal = NULL)
```

Arguments

size	number of rows or columns
diagonal	if specified, the diagonal values, in which case size is ignored

Value

a compressed sparse column diagonal matrix

`math_atoms` *Standard R Functions for CVXR Expressions*

Description

CVXR registers methods so that standard R functions create the appropriate atoms when applied to `Expression` objects.

For CVXR expressions, computes the matrix/vector norm atom. For other inputs, falls through to `norm`.

For CVXR expressions, computes the standard deviation atom (ddof=0 by default, matching CVXPY/numpy convention). For numeric inputs, falls through to `sd`.

For CVXR expressions, computes the variance atom (ddof=0 by default). For numeric inputs, falls through to `var`.

For CVXR expressions, computes the outer product of two vectors. For other inputs, falls through to `outer`.

Usage

```
norm(x, type = "2", ...)

sd(x, ...)

var(x, ...)

outer(X, Y, ...)
```

Arguments

`x`	An Expression or numeric.
`type`	Norm type: `"1"`, `"2"` (default), `"I"/"i"` (infinity), `"F"/"f"` (Frobenius).
`...`	For non-Expression inputs: passed to `outer`.
`X`	An Expression or numeric.
`Y`	An Expression or numeric.

Value

An Expression or numeric value.

An Expression or numeric value.

An Expression or numeric value.

An Expression or matrix.

Math group (elementwise, via S3 group generic)

`abs(x)` Absolute value (convex, nonneg)

`exp(x)` Exponential (convex, positive)

`log(x)` Natural logarithm (concave, domain x >= 0)

`sqrt(x)` Square root via `power(x, 0.5)` (concave)

`log1p(x)` log(1+x) compound expression (concave)

`log2(x)`, `log10(x)` Base-2/10 logarithm

`cumsum(x)` Cumulative sum (affine)

`cummax(x)` Cumulative max (convex)

`cumprod(x)` Cumulative product

`ceiling(x)`, `floor(x)` Round up/down (MIP)

Summary group (via S3 group generic)

`sum(x)` Sum all entries (affine)

`max(x)` Maximum entry (convex)

`min(x)` Minimum entry (concave)

S3 generic methods

`mean(x)` Arithmetic mean; pass `axis`/`keepdims` via `...`

`diff(x)` First-order differences; also `cvxr_diff`

Masking wrappers

These mask the base/stats versions and dispatch on argument type:

`norm(x)` 2-norm; use `type` for "1", "I" (infinity), "F" (Frobenius)

`sd(x)` Standard deviation (ddof=0 for expressions)

`var(x)` Variance (ddof=0 for expressions)

`outer(X, Y)` Outer product of two vector expressions

Advanced usage

For axis-aware reductions, keepdims, or other options not available through the standard interface, use the explicit functions: `cvxr_norm`, `cvxr_mean`, `cvxr_diff`, `cvxr_std`, `cvxr_var`, `cvxr_outer`.

See Also

`power`, `sum_entries`, `max_entries`, `min_entries`

`cvxr_norm` for the full-featured version with `axis` and `keepdims` arguments

`cvxr_std` for the full-featured version

`cvxr_var` for the full-featured version

`cvxr_outer` for the CVXR-specific version

matrix_frac *Matrix fractional function*

Description

Computes $\mathrm{trace}(X^T P^{-1} X)$. If P is a constant matrix, uses a QuadForm shortcut for efficiency.

Usage

```
matrix_frac(X, P)
```

Arguments

X	A matrix expression (n by m)
P	A square matrix expression (n by n), must be PSD

Value

An expression representing $\mathrm{trace}(X^T P^{-1} X)$

matrix_trace *Trace of a square matrix expression*

Description

Trace of a square matrix expression

Usage

```
matrix_trace(x)
```

Arguments

x	An Expression (square matrix)

Value

A Trace atom (scalar)

Maximize *Create a Maximization Objective*

Description

Specifies that the objective expression should be maximized. The expression must be concave and scalar for a DCP-compliant problem.

Usage

```
Maximize(expr)
```

Arguments

expr	A CVXR expression or numeric value to maximize.

Value

A Maximize object.

See Also

Minimize, Problem

Examples

```
x <- Variable()
obj <- Maximize(-x^2 + 1)
```

max_elemwise *Elementwise maximum of expressions*

Description

Elementwise maximum of expressions

Usage

```
max_elemwise(...)
```

Arguments

...	Expressions (at least 2)

Value

A Maximum atom

max_entries *Maximum entry of an expression*

Description

Maximum entry of an expression

Usage

```
max_entries(x, axis = NULL, keepdims = FALSE)
```

Arguments

x	An Expression
axis	NULL (all), 1 (row-wise), or 2 (column-wise)
keepdims	Logical

Value

A MaxEntries atom

Minimize *Create a Minimization Objective*

Description

Specifies that the objective expression should be minimized. The expression must be convex and scalar for a DCP-compliant problem.

Usage

```
Minimize(expr)
```

Arguments

expr	A CVXR expression or numeric value to minimize.

Value

A `Minimize` object.

See Also

`Maximize`, `Problem`

Examples

```
x <- Variable()
obj <- Minimize(x^2 + 1)
```

`min_elemwise` *Elementwise minimum of expressions*

Description

Elementwise minimum of expressions

Usage

```
min_elemwise(...)
```

Arguments

`...`	Expressions (at least 2)

Value

A Minimum atom

`min_entries` *Minimum entry of an expression*

Description

Minimum entry of an expression

Usage

```
min_entries(x, axis = NULL, keepdims = FALSE)
```

Arguments

`x`	An Expression
`axis`	NULL (all), 1 (row-wise), or 2 (column-wise)
`keepdims`	Logical

Value

A MinEntries atom

mixed_norm *Mixed norm (L_p, q norm): column-wise p-norm, then q-norm*

Description

Mixed norm ($L_{p,q}$ norm): column-wise p-norm, then q-norm

Usage

```
mixed_norm(X, p = 2, q = 1)
```

Arguments

X	An Expression (matrix)
p	Inner norm parameter (default 2)
q	Outer norm parameter (default 1)

Value

An Expression representing the mixed norm

multiply *Elementwise multiplication (deprecated)*

Description

[Deprecated]

Usage

```
multiply(x, y)
```

Arguments

x, y	Expressions or numeric values.

Details

Use the * operator instead: x * y.

Value

An Expression representing the elementwise product.

name *Get Expression Name*

Description

Returns a human-readable string representation of a CVXR expression, variable, or constraint.

Usage

```
name(x)
```

Arguments

x	A CVXR expression, variable, parameter, constant, or constraint.

Value

A character string.

Examples

```
x <- Variable(2, name = "x")
name(x)  # "x"
name(x + 1)  # "x + 1"
```

neg *Negative part: -min(x, 0)*

Description

Negative part: -min(x, 0)

Usage

```
neg(x)
```

Arguments

x	An Expression

Value

A negated Minimum atom

NonNeg *Create a Non-Negative Constraint*

Description

Constrains an expression to be non-negative elementwise: $x \geq 0$.

Usage

```
NonNeg(expr, constr_id = NULL)
```

Arguments

expr	A CVXR expression.
constr_id	Optional integer constraint ID.

Value

A NonNeg constraint object.

See Also

NonPos, Inequality

NonPos *Create a Non-Positive Constraint*

Description

Constrains an expression to be non-positive elementwise: $x \leq 0$.

Usage

```
NonPos(expr, constr_id = NULL)
```

Arguments

expr	A CVXR expression.
constr_id	Optional integer constraint ID.

Value

A NonPos constraint object.

See Also

NonNeg, Inequality

norm1 *L1 norm of an expression*

Description

L1 norm of an expression

Usage

```
norm1(x, axis = NULL, keepdims = FALSE)
```

Arguments

x	An Expression
axis	NULL (all), 1 (row-wise), or 2 (column-wise)
keepdims	Logical: keep reduced dimensions?

Value

A Norm1 atom

norm2 *Euclidean norm (deprecated alias)*

Description

[Deprecated]

Usage

```
norm2(x)
```

Arguments

x	An Expression.

Details

Use `p_norm(x, 2)` instead.

Value

An Expression representing the L2 norm.

See Also

`p_norm()`

norm_inf *L-infinity norm of an expression*

Description

L-infinity norm of an expression

Usage

```
norm_inf(x, axis = NULL, keepdims = FALSE)
```

Arguments

x	An Expression
axis	NULL (all), 1 (row-wise), or 2 (column-wise)
keepdims	Logical: keep reduced dimensions?

Value

A NormInf atom

norm_nuc *Nuclear norm (sum of singular values)*

Description

Nuclear norm (sum of singular values)

Usage

```
norm_nuc(A)
```

Arguments

A	A matrix expression

Value

An expression representing the nuclear norm of A

Not *Logical NOT*

Description

Returns `1 - x`, flipping 0 to 1 and 1 to 0. Can also be written with the `!` operator: `!x`.

Usage

```
Not(x, id = NULL)
```

Arguments

`x`	A boolean Variable or logic expression.
`id`	Optional integer ID (internal use).

Value

A `Not` expression.

See Also

`And()`, `Or()`, `Xor()`, `implies()`, `iff()`

Examples

```
## Not run:
x <- Variable(boolean = TRUE)
not_x <- !x          # operator syntax
not_x <- Not(x)      # functional syntax

## End(Not run)
```

objective *Get Problem Objective (read-only)*

Description

Returns the problem's objective.

Usage

```
objective(x)
```

Arguments

`x`	A Problem object.

Details

Problem objects are **immutable**: the objective cannot be modified after construction. To change the objective, create a new `Problem()`.

Value

A Minimize or Maximize object.

See Also

`Problem()`, `constraints()`

Examples

```
x <- Variable(2)
prob <- Problem(Minimize(sum_entries(x)), list(x >= 1))
objective(prob)
```

---

one_minus_pos *The difference 1 - x with domain (0, 1)*

Description

Log-log concave atom for DGP. Solve with `psolve(problem, gp = TRUE)`.

Usage

```
one_minus_pos(x)
```

Arguments

x	An Expression (elementwise in (0, 1))

Value

A OneMInusPos atom

Examples

```
x <- Variable(pos = TRUE)
prob <- Problem(Maximize(one_minus_pos(x)), list(x >= 0.1, x <= 0.5))
## Not run: psolve(prob, gp = TRUE)
```

Or *Logical OR*

Description

Returns 1 if and only if at least one argument equals 1, and 0 otherwise. For two operands, can also be written with the | operator: `x | y`.

Usage

```
Or(..., id = NULL)
```

Arguments

...	Two or more boolean Variables or logic expressions.
id	Optional integer ID (internal use).

Value

An `Or` expression.

See Also

`Not()`, `And()`, `Xor()`, `implies()`, `iff()`

Examples

```
## Not run:
x <- Variable(boolean = TRUE)
y <- Variable(boolean = TRUE)
either <- x | y          # operator syntax
either <- Or(x, y)       # functional syntax
any3 <- Or(x, y, z)      # n-ary

## End(Not run)
```

Parameter *Create a Parameter*

Description

Constructs a parameter whose numeric value can be changed without re-canonicalizing the problem. Parameters are treated as constants for DCP purposes but their value can be updated between solves.

Usage

```
Parameter(
  shape = c(1L, 1L),
  name = NULL,
  value = NULL,
  id = NULL,
  latex_name = NULL,
  ...
)
```

Arguments

shape	Integer vector of length 1 or 2 giving the parameter dimensions. A scalar n is interpreted as c(n, 1). Defaults to c(1, 1) (scalar).
name	Optional character string name. If NULL, an automatic name "param<id>" is generated.
value	Optional initial numeric value.
id	Optional integer ID.
latex_name	Optional character string giving a custom LaTeX name for use in visualizations. For example, "\\gamma". If NULL (default), visualizations auto-generate a LaTeX name.
...	Additional attributes: nonneg, nonpos, etc.

Value

A Parameter object (inherits from Leaf and Expression).

Examples

```
p <- Parameter()
value(p) <- 5
p_vec <- Parameter(3, nonneg = TRUE)
gamma <- Parameter(1, name = "gamma", latex_name = "\\gamma")
```

---

parameters *Get the Parameters in an Expression*

Description

Get the Parameters in an Expression

Usage

```
parameters(x, ...)
```

Arguments

x	An expression or problem object.
...	Not used.

Value

List of Parameter objects.

---

partial_trace *Partial trace of a tensor product expression*

Description

Assumes expr is a 2D square matrix representing a Kronecker product of length(dims) subsystems. Returns the partial trace over the subsystem at index axis (1-indexed).

Usage

```
partial_trace(expr, dims, axis = 1L)
```

Arguments

expr	An Expression (2D square matrix)
dims	Integer vector of subsystem dimensions
axis	Integer (1-indexed) subsystem to trace out

Value

An Expression representing the partial trace

---

partial_transpose *Partial transpose of a tensor product expression*

Description

Assumes expr is a 2D square matrix representing a Kronecker product of length(dims) subsystems. Returns the partial transpose with the transpose applied to the subsystem at index axis (1-indexed).

Usage

```
partial_transpose(expr, dims, axis = 1L)
```

Arguments

`expr`	An Expression (2D square matrix)
`dims`	Integer vector of subsystem dimensions
`axis`	Integer (1-indexed) subsystem to transpose

Value

An Expression representing the partial transpose

`perspective` *Perspective Transform*

Description

Creates the perspective transform of a scalar convex or concave expression. Given a scalar expression `f(x)` and a nonneg variable `s`, the perspective is `s * f(x/s)`.

Usage

```
perspective(f, s, f_recession = NULL)
```

Arguments

`f`	A scalar convex or concave Expression.
`s`	A nonneg Variable (scalar).
`f_recession`	Optional recession function for handling `s = 0`.

Value

A `Perspective` expression.

`pf_eigenvalue` *Perron-Frobenius eigenvalue of a positive matrix*

Description

Log-log convex atom for DGP. Solve with `psolve(problem, gp = TRUE)`.

Usage

```
pf_eigenvalue(X)
```

Arguments

`X`	An Expression (positive square matrix)

Value

A PfEigenvalue atom (scalar)

Examples

```
X <- Variable(c(2, 2), pos = TRUE)
prob <- Problem(Minimize(pf_eigenvalue(X)),
                list(X[1,1] >= 0.1, X[2,2] >= 0.1))
## Not run: psolve(prob, gp = TRUE)
```

---

pos *Positive part: max(x, 0)*

Description

Positive part: max(x, 0)

Usage

```
pos(x)
```

Arguments

x	An Expression

Value

A Maximum atom

PowCone3D *Create a 3D Power Cone Constraint*

Description

Constrains (x, y, z) to lie in the 3D power cone:

$$x^{\alpha} \cdot y^{1-\alpha} \geq |z|, \quad x \geq 0,\ y \geq 0$$

Usage

```
PowCone3D(x_expr, y_expr, z_expr, alpha, constr_id = NULL)
```

Arguments

x_expr	A CVXR expression.
y_expr	A CVXR expression.
z_expr	A CVXR expression.
alpha	A CVXR expression or numeric value in $(0, 1)$.
constr_id	Optional integer constraint ID.

Value

A PowCone3D constraint object.

See Also

PowConeND

PowConeND *Create an N-Dimensional Power Cone Constraint*

Description

Constrains (W, z) to lie in the N-dimensional power cone:

$$\prod W_i^{\alpha_i} \geq |z|, \quad W \geq 0$$

where $\alpha_i > 0$ and $\sum \alpha_i = 1$.

Usage

```
PowConeND(W, z, alpha, axis = 2L, constr_id = NULL)
```

Arguments

W	A CVXR expression (vector or matrix).
z	A CVXR expression (scalar or vector).
alpha	A CVXR expression with positive entries summing to 1 along the specified axis.
axis	Integer, 2 (default, column-wise) or 1 (row-wise).
constr_id	Optional integer constraint ID.

Value

A PowConeND constraint object.

Known limitations

The R **clarabel** solver does not currently support the PowConeND cone specification. Problems involving PowConeND (e.g., exact geometric mean with more than 2 arguments) should use SCS or MOSEK as the solver, or use approximation-based atoms (e.g., geo_mean(x, approx = TRUE)).

See Also

PowCone3D

`power` *Create a Power atom*

Description

Create a Power atom

Usage

```
power(x, p, max_denom = 1024L, approx = TRUE)
```

Arguments

`x`	An Expression
`p`	Numeric exponent
`max_denom`	Maximum denominator for rational approximation
`approx`	If TRUE (default), use SOC approximation. If FALSE, use exact power cone.

Value

A Power or PowerApprox atom

Note

`sqrt(x)` on a CVXR expression dispatches to `Power(x, 0.5)` via the Math group generic. See `math_atoms` for all standard R function dispatch.

`Problem` *Create an Optimization Problem*

Description

Constructs a convex optimization problem from an objective and a list of constraints. Use `psolve` to solve the problem.

Usage

```
Problem(objective, constraints = list())
```

Arguments

objective	A Minimize or Maximize object.
constraints	A list of Constraint objects (e.g., created by ==, <=, >= operators on expressions). Defaults to an empty list (unconstrained).

Value

A Problem object.

Known limitations

- Problems must contain at least one Variable. Zero-variable problems (e.g., minimizing a constant) will cause an internal error in the reduction pipeline.

Examples

```
x <- Variable(2)
prob <- Problem(Minimize(sum_entries(x)), list(x >= 1))
```

---

problem_data *Get Problem Data for a Solver*

Description

Returns the problem data that would be passed to a specific solver, along with the reduction chain and inverse data for solution retrieval.

Usage

```
problem_data(x, solver = NULL, ...)
```

Arguments

x	A Problem object.
solver	Character string naming solver, or NULL for automatic selection.
...	Additional arguments.

Value

A list with components data, chain, and inverse_data.

problem_solution *Get the Raw Solution Object (deprecated)*

Description

[Deprecated]

Usage

```
problem_solution(x)
```

Arguments

x	A Problem object.

Details

Use solution instead.

Value

A Solution object, or NULL if the problem has not been solved.

See Also

solution

problem_status *Get the Solution Status of a Problem (deprecated)*

Description

[Deprecated]

Usage

```
problem_status(x)
```

Arguments

x	A Problem object.

Details

Use status instead.

Value

Character string, or NULL if the problem has not been solved.

See Also

status

---

problem_unpack_results

Unpack Solver Results into a Problem

Description

Inverts the reduction chain and unpacks the raw solver solution into the original problem's variables and constraints. This is step 3 of the decomposed solve pipeline:

1. problem_data() – compile the problem
2. solve_via_data(chain, data) – call the solver
3. problem_unpack_results() – invert and unpack

Usage

```
problem_unpack_results(problem, solution, chain, inverse_data)
```

Arguments

problem	A Problem object.
solution	The raw solver result from solve_via_data().
chain	The SolvingChain from problem_data().
inverse_data	The inverse data list from problem_data().

Details

After calling this function, variable values are available via value() and constraint duals via dual_value().

Value

The problem object (invisibly), with solution unpacked.

See Also

problem_data, solve_via_data

prod_entries *Product of entries along an axis*

Description

Used in DGP (geometric programming) context. Solve with `psolve(problem, gp = TRUE)`.

Usage

```
prod_entries(x, axis = NULL, keepdims = FALSE)
```

Arguments

`x`	An Expression
`axis`	NULL (all), 1 (row-wise), or 2 (column-wise)
`keepdims`	Whether to keep reduced dimensions

Value

A Prod atom

Examples

```
x <- Variable(3, pos = TRUE)
prob <- Problem(Minimize(prod_entries(x)), list(x >= 2))
## Not run: psolve(prob, gp = TRUE)
```

PSD *Create a Positive Semidefinite Constraint*

Description

Constrains a square matrix expression to be positive semidefinite (PSD): $X \succeq 0$. The expression must be square.

Usage

```
PSD(expr, constr_id = NULL)
```

Arguments

`expr`	A CVXR expression representing a square matrix.
`constr_id`	Optional integer constraint ID.

Value

A `PSD` constraint object.

psolve *Solve a Convex Optimization Problem*

Description

Solves the problem and returns the optimal objective value. After solving, variable values can be retrieved with value, constraint dual values with dual_value, and solver information with solver_stats.

Usage

```
psolve(
  problem,
  solver = NULL,
  gp = FALSE,
  qcp = FALSE,
  verbose = FALSE,
  warm_start = FALSE,
  feastol = NULL,
  reltol = NULL,
  abstol = NULL,
  num_iter = NULL,
  ...
)
```

Arguments

problem	A Problem object.
solver	Character string naming the solver to use (e.g., "CLARABEL", "SCS", "OSQP", "HIGHS"), or NULL for automatic selection.
gp	Logical; if TRUE, solve as a geometric program (DGP).
qcp	Logical; if TRUE, solve as a quasiconvex program (DQCP) via bisection. Only needed for non-DCP DQCP problems.
verbose	Logical; if TRUE, print solver output.
warm_start	Logical; if TRUE, use the current variable values as a warm-start point for the solver.
feastol	Numeric or NULL; feasibility tolerance. Mapped to the solver-specific parameter name (e.g., tol_feas for Clarabel, eps_prim_inf for OSQP). If NULL (default), the solver's own default is used.
reltol	Numeric or NULL; relative tolerance. Mapped to the solver-specific parameter name (e.g., tol_gap_rel for Clarabel, eps_rel for OSQP/SCS). If NULL (default), the solver's own default is used.
abstol	Numeric or NULL; absolute tolerance. Mapped to the solver-specific parameter name (e.g., tol_gap_abs for Clarabel, eps_abs for OSQP/SCS). If NULL (default), the solver's own default is used.

num_iter	Integer or NULL; maximum number of solver iterations. Mapped to the solver-specific parameter name (e.g., max_iter for Clarabel/OSQP, max_iters for SCS). If NULL (default), the solver's own default is used.
...	Additional solver-specific options passed directly to the solver. If a solver-native parameter name conflicts with a standard parameter (e.g., both feastol = 1e-3 and tol_feas = 1e-6 are given), the solver-native name in ... takes priority. For DQCP problems (qcp = TRUE), additional arguments include low, high, eps, max_iters, and max_iters_interval_search.

Value

The optimal objective value (numeric scalar), or Inf / -Inf for infeasible / unbounded problems.

See Also

Problem, status, solver_stats, solver_default_param

Examples

```
x <- Variable()
prob <- Problem(Minimize(x), list(x >= 5))
result <- psolve(prob, solver = "CLARABEL")
```

---

ptp *Peak-to-peak (range): max(x) - min(x)*

Description

Computes the range of values along an axis: max(x) - min(x). The result is always nonnegative.

Usage

```
ptp(x, axis = NULL, keepdims = FALSE)
```

Arguments

x	An Expression or numeric value.
axis	NULL (all), 0 (columns), or 1 (rows).
keepdims	Logical; keep reduced dimension?

Value

An Expression representing max(x) - min(x).

p_norm *General p-norm of an expression*

Description

General p-norm of an expression

Usage

```
p_norm(
  x,
  p = 2,
  axis = NULL,
  keepdims = FALSE,
  max_denom = 1024L,
  approx = TRUE
)
```

Arguments

x	An Expression
p	Numeric exponent (default 2)
axis	NULL (all), 1 (row-wise), or 2 (column-wise)
keepdims	Logical
max_denom	Integer max denominator for rational approx
approx	If TRUE (default), use SOC approximation. If FALSE, use exact power cone.

Value

A Pnorm, PnormApprox, Norm1, or NormInf atom

quad_form *Quadratic form x^T P x*

Description

When x is constant, returns t(Conj(x)) %*% P %*% x (affine in P). When P is constant, returns a QuadForm atom (quadratic in x). At least one of x or P must be constant.

Usage

```
quad_form(x, P, assume_PSD = FALSE)
```

Arguments

x	An Expression (vector)
P	An Expression (square matrix, symmetric/Hermitian)
assume_PSD	If TRUE, assume P is PSD without checking (only when P is constant).

Value

A QuadForm atom or an affine Expression

---

quad_over_lin *Sum of squares divided by a scalar*

Description

Sum of squares divided by a scalar

Usage

```
quad_over_lin(x, y, axis = NULL, keepdims = FALSE)
```

Arguments

x	An Expression
y	An Expression (scalar, positive)
axis	NULL (all), 1 (row-wise), or 2 (column-wise)
keepdims	Logical: keep reduced dimensions?

Value

A QuadOverLin atom

---

rel_entr *Relative Entropy: x*log(x/y)*

Description

Relative Entropy: x*log(x/y)

Usage

```
rel_entr(x, y)
```

Arguments

x	An Expression
y	An Expression

Value

A RelEntr atom

---

reshape_expr *Reshape an expression to a new shape*

Description

Reshape an expression to a new shape

Usage

```
reshape_expr(x, dim, order = "F")
```

Arguments

x	An Expression or numeric value.
dim	Integer vector of length 2: the target shape c(nrow, ncol). A single integer is treated as c(dim, 1). Use -1 to infer a dimension.
order	Character: "F" (column-major, default) or "C" (row-major).

Value

A Reshape expression.

---

residual *Get the Residual of a Constraint*

Description

Returns the residual of a constraint, measuring how much the constraint is violated or satisfied.

Usage

```
residual(x, ...)
```

Arguments

x	A constraint object.
...	Not used.

Value

Numeric array, or NULL if expression has no value.

---

resolvent *Resolvent inverse(sI - X)*

Description

Equivalent to (1/s) * eye_minus_inv(X / s).

Usage

```
resolvent(X, s)
```

Arguments

X	An Expression (positive square matrix)
s	A positive scalar

Value

An expression for the resolvent

---

scalar_product *Scalar product (alias for vdot)*

Description

Scalar product (alias for vdot)

Usage

```
scalar_product(x, y)
```

Arguments

x	An Expression or numeric value.
y	An Expression or numeric value.

Value

A scalar Expression representing sum(x * y).

scalene *Scalene penalty: alpha * pos(x) + beta * neg(x)*

Description

Scalene penalty: alpha * pos(x) + beta * neg(x)

Usage

```
scalene(x, alpha, beta)
```

Arguments

x	An Expression
alpha	Coefficient for the positive part
beta	Coefficient for the negative part

Value

An Expression representing the scalene penalty

set_label *Set a Label on a Constraint*

Description

Attaches a human-readable label to a constraint for use in visualizations and pretty-printing. Labels are visualization-only and never affect the solver pipeline.

Usage

```
set_label(constraint, label)
```

Arguments

constraint	A Constraint object.
label	A character string label.

Details

Because R uses copy-on-modify semantics, you must either assign the result back or use set_label fluently when building constraint lists.

Value

The modified constraint (invisibly).

Examples

```
## Not run:
x <- Variable(3, name = "x")

# Assign back
con <- (x >= 0)
con <- set_label(con, "non-negativity")

# Fluent use in constraint lists
constraints <- list(
  set_label(x >= 1, "lower bound"),
  set_label(sum_entries(x) <= 10, "budget")
)

## End(Not run)
```

`sigma_max` *Maximum singular value*

Description

Maximum singular value

Usage

```
sigma_max(A)
```

Arguments

`A`	A matrix expression

Value

An expression representing the maximum singular value of A

`size` *Get Expression Size*

Description

Returns the total number of elements in the expression.

Usage

```
size(x)
```

Arguments

x	A CVXR expression.

Value

An integer (product of shape dimensions).

See Also

is_scalar(), is_vector(), is_matrix()

SOC *Create a Second-Order Cone Constraint*

Description

Constrains $\|X_i\|_2 \leq t_i$ for each column or row i, where t is a vector and X is a matrix.

Usage

```
SOC(t, X, axis = 2L, constr_id = NULL)
```

Arguments

t	A CVXR expression (scalar or vector) representing the upper bound.
X	A CVXR expression (vector or matrix) whose columns/rows are bounded.
axis	Integer, 2 (default, column-wise) or 1 (row-wise). Determines whether columns (2) or rows (1) of X define the individual cones.
constr_id	Optional integer constraint ID.

Value

An SOC constraint object.

solution *Get the Raw Solution Object*

Description

Returns the raw `Solution` object from the most recent solve, containing primal and dual variable values, status, and solver attributes.

Usage

```
solution(x)
```

Arguments

x	A `Problem` object.

Value

A `Solution` object, or `NULL` if the problem has not been solved.

solver-constants *Solver Name Constants*

Description

Character string constants identifying the available solvers.

Usage

```
SCS_SOLVER

OSQP_SOLVER

CLARABEL_SOLVER

HIGHS_SOLVER

MOSEK_SOLVER

GUROBI_SOLVER

GLPK_SOLVER

GLPK_MI_SOLVER

ECOS_SOLVER
```

ECOS_BB_SOLVER

CPLEX_SOLVER

CVXOPT_SOLVER

PIQP_SOLVER

Format

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

Value

A character string.

---

solver_default_param *Standard Solver Parameter Mappings*

Description

Returns a named list mapping standard CVXR parameter names (reltol, abstol, feastol, num_iter) to solver-specific parameter names and their default values. Used internally by psolve to translate standard parameters into solver-native names.

Usage

```
solver_default_param()
```

Value

A named list keyed by solver name (e.g. `"CLARABEL"`, `"OSQP"`). Each element is a list of standard parameter mappings, where each mapping has `name` (solver-native parameter name) and `value` (default value).

See Also

`psolve`

`solver_stats` *Get Solver Statistics*

Description

Returns solver statistics from the most recent solve, including solve time, setup time, and iteration count.

Usage

```
solver_stats(x)
```

Arguments

`x`	A `Problem` object.

Value

A `SolverStats` object, or `NULL` if the problem has not been solved.

`solve_via_data` *Solve via Raw Data*

Description

Calls the solver on pre-compiled problem data (step 2 of the decomposed solve pipeline). Dispatches on `x`: when `x` is a `SolvingChain`, delegates to the terminal solver with proper cache management.

Usage

```
solve_via_data(
  x,
  data,
  warm_start = FALSE,
  verbose = FALSE,
  solver_opts = list(),
  ...
)
```

Arguments

x	A SolvingChain (preferred) or Solver object.
data	Named list of solver data from problem_data().
warm_start	Logical; use warm-start if supported.
verbose	Logical; print solver output.
solver_opts	Named list of solver-specific options.
...	Additional arguments (e.g., problem for SolvingChain dispatch, solver_cache for Solver dispatch).

Value

Solver-specific result (a named list).

See Also

problem_data, problem_unpack_results

---

square *Square of an expression: x^2*

Description

Square of an expression: x^2

Usage

```
square(x)
```

Arguments

x	An Expression

Value

A Power atom with p=2

status — *Get the Solution Status of a Problem*

Description

Returns the status string from the most recent solve, such as `"optimal"`, `"infeasible"`, or `"unbounded"`.

Usage

```
status(x)
```

Arguments

x	A `Problem` object.

Value

Character string, or `NULL` if the problem has not been solved.

See Also

`OPTIMAL`, `INFEASIBLE`, `UNBOUNDED`

status-constants — *Solution Status Constants*

Description

Character string constants representing the possible solution statuses returned by `problem_status`.

Usage

```
OPTIMAL

INFEASIBLE

UNBOUNDED

SOLVER_ERROR

OPTIMAL_INACCURATE

INFEASIBLE_INACCURATE

UNBOUNDED_INACCURATE
```

USER_LIMIT

INFEASIBLE_OR_UNBOUNDED

Format

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

An object of class character of length 1.

Value

A character string.

See Also

status, psolve

---

sum_entries *Sum the entries of an expression*

Description

Sum the entries of an expression

Usage

```
sum_entries(x, axis = NULL, keepdims = FALSE)
```

Arguments

x	An Expression or numeric value.
axis	NULL (sum all), 1 (row-wise, like apply(X,1,sum)), or 2 (column-wise, like apply(X,2,sum)).
keepdims	Logical: if TRUE, keep the reduced dimension as size 1.

Value

A SumEntries expression.

sum_largest *Sum of k largest entries*

Description

Sum of k largest entries

Usage

```
sum_largest(x, k)
```

Arguments

x	An Expression
k	Number of largest entries to sum

Value

A SumLargest atom

sum_smallest *Sum of k smallest entries*

Description

Sum of k smallest entries

Usage

```
sum_smallest(x, k)
```

Arguments

x	An Expression
k	Number of smallest entries to sum

Value

An Expression equal to -SumLargest(-x, k)

sum_squares *Sum of squares (= quad_over_lin(x, 1))*

Description

Sum of squares (= quad_over_lin(x, 1))

Usage

```
sum_squares(x, axis = NULL, keepdims = FALSE)
```

Arguments

x	An Expression
axis	NULL (all), 1 (row-wise), or 2 (column-wise)
keepdims	Logical: keep reduced dimensions?

Value

A QuadOverLin atom

total_variation *Total variation of a vector or matrix*

Description

Computes total variation using L1 norm of discrete gradients for vectors and L2 norm of discrete gradients for matrices.

Usage

```
total_variation(value, ...)
```

Arguments

value	An Expression or numeric constant (vector or matrix)
...	Additional matrix expressions extending the third dimension

Value

An Expression representing the total variation

to_latex *Convert CVXR Object to LaTeX*

Description

Renders a CVXR `Problem`, `Expression`, or `Constraint` as a LaTeX string. Problem-level output uses the `optidef` package (`mini*`/`maxi*` environments) and atom macros from `dcp.sty` (shipped as `system.file("sty", "dcp.sty", package = "CVXR")`).

Usage

```
to_latex(x, ...)
```

Arguments

`x`	A `Problem`, `Expression`, `Constraint`, or `Objective`.
`...`	Reserved for future options.

Value

A character string containing LaTeX code.

Examples

```
x <- Variable(3, name = "x")
cat(to_latex(p_norm(x, 2)))
# \cvxnorm{x}_2
```

tr_inv *Trace of matrix inverse*

Description

Computes $\mathrm{tr}(X^{-1})$ for PSD matrix X.

Usage

```
tr_inv(X)
```

Arguments

`X`	A square PSD matrix expression

Value

An expression representing $\mathrm{tr}(X^{-1})$

tv — *Total variation (deprecated alias)*

Description

[Deprecated]

Usage

```
tv(...)
```

Arguments

`...`	Arguments passed to `total_variation()`.

Details

Use `total_variation()` instead.

See Also

`total_variation()`

unpack_results — *Unpack Results (backward-compatible alias)*

Description

[Deprecated]

Usage

```
unpack_results(problem, solution, chain, inverse_data)
```

Arguments

`problem`	A `Problem` object.
`solution`	The raw solver result from `solve_via_data()`.
`chain`	The `SolvingChain` from `problem_data()`.
`inverse_data`	The inverse data list from `problem_data()`.

Details

Use `problem_unpack_results()` instead. This alias exists for backward compatibility with older CVXR examples.

Value

The problem object (invisibly), with solution unpacked.

See Also

problem_unpack_results()

---

upper_tri *Extract strict upper triangle of a square matrix*

Description

Extract strict upper triangle of a square matrix

Usage

```
upper_tri(x)
```

Arguments

x	An Expression (square matrix)

Value

An UpperTri atom (column vector)

---

value *Get the Numeric Value of an Expression*

Description

Returns the numeric value of a CVXR expression, variable, or constant. For variables, the value is set after solving a problem.

Usage

```
value(x, ...)
```

Arguments

x	An expression object.
...	Not used.

Value

A numeric matrix, or NULL if no value has been set.

value<- *Set the Value of a Leaf Expression*

Description

Assigns a numeric value to a `Variable` or `Parameter`.

Usage

```
value(x) <- value
```

Arguments

`x`	A leaf expression object.
`value`	The value to assign.

Value

The modified object (invisibly).

Variable *Create an Optimization Variable*

Description

Constructs a variable to be used in a CVXR optimization problem. Variables are decision variables that the solver optimizes over.

Usage

```
Variable(shape = c(1L, 1L), name = NULL, var_id = NULL, latex_name = NULL, ...)
```

Arguments

`shape`	Integer vector of length 1 or 2 giving the variable dimensions. A scalar `n` is interpreted as `c(n, 1)`. Defaults to `c(1, 1)` (scalar).
`name`	Optional character string name for the variable. If `NULL`, an automatic name `"var<id>"` is generated.
`var_id`	Optional integer ID. If `NULL`, a unique ID is generated.
`latex_name`	Optional character string giving a custom LaTeX name for use in visualizations. For example, `"\\mathbf{x}"`. If `NULL` (default), visualizations auto-generate a LaTeX name.
`...`	Additional attributes: `nonneg`, `nonpos`, `PSD`, `NSD`, `symmetric`, `boolean`, `integer`, etc.

Value

A `Variable` object (inherits from `Leaf` and `Expression`).

Examples

```
x <- Variable(3)        # 3x1 column vector
X <- Variable(c(2, 3))  # 2x3 matrix
y <- Variable(2, nonneg = TRUE)  # non-negative variable
z <- Variable(3, name = "z", latex_name = "\\mathbf{z}")  # custom LaTeX
```

`variables` *Get the Variables in an Expression*

Description

Get the Variables in an Expression

Usage

```
variables(x, ...)
```

Arguments

`x`	An expression or problem object.
`...`	Not used.

Value

List of `Variable` objects.

`vdot` *Vector dot product (inner product)*

Description

Computes the inner product: sum of element-wise products after flattening. Returns a scalar expression.

Usage

```
vdot(x, y)
```

Arguments

`x`	An Expression or numeric value.
`y`	An Expression or numeric value.

Value

A scalar Expression representing sum(x * y).

`vec` *Vectorize an expression (column vector)*

Description

Reshapes an expression into a column vector of shape (n*m, 1).

Usage

```
vec(x)
```

Arguments

`x`	An Expression or numeric value.

Value

A Reshape atom (column vector).

`vec_to_upper_tri` *Reshape a vector into an upper triangular matrix*

Description

Inverts `upper_tri`. Takes a flat vector and returns an upper triangular matrix (row-major order, matching CVXPY convention).

Usage

```
vec_to_upper_tri(expr, strict = FALSE)
```

Arguments

`expr`	An Expression (vector).
`strict`	Logical. If TRUE, returns a strictly upper triangular matrix (diagonal is zero). If FALSE, includes the diagonal. Default is FALSE.

Value

An Expression representing the upper triangular matrix.

violation *Get the Violation of a Constraint*

Description

Returns the scalar violation (distance to feasibility) of a constraint.

Usage

```
violation(x, ...)
```

Arguments

x	A constraint object.
...	Not used.

Value

Numeric scalar.

visualize *Visualize the Canonicalization Pipeline of a CVXR Problem*

Description

Displays the Smith form decomposition of a convex optimization problem, showing each stage of the DCP canonicalization pipeline: expression tree, Smith form, relaxed Smith form, conic form, and (optionally) standard cone form and solver data.

Usage

```
visualize(
  problem,
  output = c("text", "json", "html", "latex", "tikz"),
  solver = NULL,
  digits = 4L,
  file = NULL,
  open = interactive(),
  doc_base = "https://cvxr.rbind.io/reference/"
)
```

Arguments

problem	A Problem object.
output	Character: output format. "text" Console display (default). "json" JSON data model (for interop with HTML/Python). "html" Interactive D3+KaTeX HTML (Phase 2). "latex" LaTeX align* environments (Phase 3). "tikz" TikZ forest tree diagrams (Phase 3).
solver	Solver specification for matrix stuffing stages (4-5). NULL (default) shows only Stages 0-3 with zero overhead. TRUE uses the default solver (same as psolve()). A character string (e.g., "Clarabel") uses that specific solver.
digits	Integer: significant digits for displaying scalar constants. Integer-valued constants (0, 1, -3) always display without decimals regardless of this setting. Defaults to 4.
file	Character: path for HTML output file. If NULL (default), a temporary file is used.
open	Logical: whether to open the HTML file in a browser. Defaults to TRUE in interactive sessions.
doc_base	Character: base URL for atom documentation links. Defaults to the CVXR pkgdown site.

Value

For "text": invisible model list. For "json": a JSON string (or list if jsonlite not available). For "html": the file path (invisibly). For other formats: the rendered output (Phase 2+).

Examples

```
## Not run:
x <- Variable(3, name = "x")
prob <- Problem(Minimize(p_norm(x, 2)), list(x >= 1))
visualize(prob)                          # Stages 0-3 only
visualize(prob, solver = TRUE)           # Stages 0-5, default solver
visualize(prob, solver = "Clarabel")     # Stages 0-5, specific solver
visualize(prob, output = "html", solver = TRUE)

## End(Not run)
```

---

vstack *Vertical concatenation of expressions*

Description

Vertical concatenation of expressions

Usage

```
vstack(...)
```

Arguments

...	Expressions (same number of columns)

Value

A VStack atom

---

xexp *x * exp(x) – elementwise*

Description

x * exp(x) – elementwise

Usage

```
xexp(x)
```

Arguments

x	An Expression

Value

An Xexp atom

Xor *Logical XOR*

Description

For two arguments: result is 1 iff exactly one is 1. For n arguments: result is 1 iff an odd number are 1 (parity).

Usage

```
Xor(..., id = NULL)
```

Arguments

...	Two or more boolean Variables or logic expressions.
id	Optional integer ID (internal use).

Details

Note: R's ^ operator is used for power(), so Xor is functional syntax only.

Value

A Xor expression.

See Also

Not(), And(), Or(), implies(), iff()

Examples

```
## Not run:
x <- Variable(boolean = TRUE)
y <- Variable(boolean = TRUE)
exclusive <- Xor(x, y)

## End(Not run)
```

Zero *Create a Zero Constraint*

Description

Constrains an expression to equal zero elementwise: $x = 0$.

Usage

```
Zero(expr, constr_id = NULL)
```

Arguments

expr	A CVXR expression.
constr_id	Optional integer constraint ID.

Value

A Zero constraint object.

See Also

Equality, NonPos, NonNeg

%>>% *Positive Semidefinite Constraint Operator*

Description

Creates a PSD constraint: `e1 - e2` is positive semidefinite. This is the R equivalent of Python's `A >> B`.

Usage

```
e1 %>>% e2
```

Arguments

`e1, e2`	CVXR expressions or numeric matrices.

Value

A `PSD` constraint object.

See Also

`PSD()`

Examples

```
## Not run:
X <- Variable(3, 3, symmetric = TRUE)
constr <- X %>>% diag(3)  # X - I is PSD

## End(Not run)
```

%<<% *Negative Semidefinite Constraint Operator*

Description

Creates an NSD constraint: `e2 - e1` is positive semidefinite, i.e., `e1` is NSD relative to `e2`. This is the R equivalent of Python's `A << B`.

Usage

```
e1 %<<% e2
```

Arguments

`e1, e2`	CVXR expressions or numeric matrices.

Value

A PSD constraint object.

See Also

PSD()

Examples

```
## Not run:
X <- Variable(3, 3, symmetric = TRUE)
constr <- X %<<% diag(3)  # I - X is PSD (X is NSD relative to I)

## End(Not run)
```

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