

# Package ‘symengine’

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**Title** Interface to the 'SymEngine' Library

**Version** 0.2.11

**Description** Provides an R interface to 'SymEngine' <<https://github.com/symengine/>>, a standalone 'C++' library for fast symbolic manipulation. The package has functionalities for symbolic computation like calculating exact mathematical expressions, solving systems of linear equations and code generation.

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**Imports** methods, Rcpp

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**BugReports** <https://github.com/symengine/symengine.R/issues>

**License** GPL (>= 2)

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## Contents

==,Basic,Basic-method . . . . .	2
as.character,Basic-method . . . . .	4
as.matrix.DenseMatrix . . . . .	5
cbind.SymEngineDataType . . . . .	6
codegen . . . . .	7
D,SymEngineDataType-method . . . . .	8
det . . . . .	8
DoubleVisitor . . . . .	9
evalf . . . . .	10
expand . . . . .	11
Function . . . . .	11
get_type . . . . .	12
lambdify . . . . .	13
LCM . . . . .	14
length,VecBasic-method . . . . .	15
Matrix . . . . .	16
S . . . . .	17
solve . . . . .	18
subs . . . . .	19
symengine . . . . .	20
symengine_version . . . . .	22
t . . . . .	22
use_vars . . . . .	23
Vector . . . . .	24
<b>Index</b>	<b>25</b>

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==,Basic,Basic-method *Bindings for Operators and Math Functions*

---

## Description

These are S4 methods defined for Basic, VecBasic and DenseMatrix.

**Usage**

```
## S4 method for signature 'Basic,Basic'  
e1 == e2  
  
## S4 method for signature 'Basic,Basic'  
e1 != e2  
  
## S4 method for signature 'SymEngineDataType,SymEngineDataType'  
Arith(e1, e2)  
  
## S4 method for signature 'SymEngineDataType,vector'  
Arith(e1, e2)  
  
## S4 method for signature 'vector,SymEngineDataType'  
Arith(e1, e2)  
  
## S4 method for signature 'SymEngineDataType,missing'  
e1 - e2  
  
## S4 method for signature 'SymEngineDataType,missing'  
e1 + e2  
  
## S4 method for signature 'DenseMatrix,DenseMatrix'  
x %*% y  
  
## S4 method for signature 'VecBasic,VecBasic'  
x %*% y  
  
## S4 method for signature 'DenseMatrix,VecBasic'  
x %*% y  
  
## S4 method for signature 'DenseMatrix,vector'  
x %*% y  
  
## S4 method for signature 'VecBasic,DenseMatrix'  
x %*% y  
  
## S4 method for signature 'vector,DenseMatrix'  
x %*% y  
  
## S4 method for signature 'SymEngineDataType'  
Math(x)  
  
## S4 method for signature 'SymEngineDataType'  
sinpi(x)  
  
## S4 method for signature 'SymEngineDataType'  
cospi(x)
```

```
## S4 method for signature 'SymEngineDataType'
tanpi(x)

## S4 method for signature 'SymEngineDataType'
log(x, base)

## S4 method for signature 'SymEngineDataType'
log2(x)

## S4 method for signature 'SymEngineDataType'
log10(x)

## S4 method for signature 'SymEngineDataType'
log1p(x)

## S4 method for signature 'SymEngineDataType'
expm1(x)

## S4 method for signature 'SymEngineDataType'
sum(x, ..., na.rm = FALSE)

## S4 method for signature 'SymEngineDataType'
prod(x, ..., na.rm = FALSE)
```

### Arguments

e1, e2, x, y, base, ...  
                           Objects.  
na.rm                      Ignored

### Value

== and != will return a logical vector. Other functions will return a Basic, VecBasic or DenseMatrix.

---

as.character,Basic-method

*Some Conversion Methods*

---

### Description

Miscellaneous S4 methods defined for converting a Basic or VecBasic object to R number/string/language object.

**Usage**

```
## S4 method for signature 'Basic'  
as.character(x)  
  
## S4 method for signature 'Basic'  
as.numeric(x)  
  
## S4 method for signature 'Basic'  
as.integer(x)  
  
## S4 method for signature 'VecBasic'  
as.character(x)  
  
## S4 method for signature 'VecBasic'  
as.numeric(x)  
  
## S4 method for signature 'VecBasic'  
as.integer(x)  
  
as.language(x)  
  
## S4 method for signature 'Basic'  
as.language(x)
```

**Arguments**

x                    The object to be converted.

**Value**

Same as default methods of these generics. `as.language()` may return symbol, integer, double or call.

---

as.matrix.DenseMatrix *Methods Related to DenseMatrix*

---

**Description**

These are miscellaneous S3/S4 methods defined for DenseMatrix class.

**Usage**

```
## S3 method for class 'DenseMatrix'  
as.matrix(x, ...)  
  
## S4 method for signature 'DenseMatrix'  
dim(x)
```

```

## S4 replacement method for signature 'DenseMatrix'
dim(x) <- value

## S4 replacement method for signature 'VecBasic'
dim(x) <- value

## S4 replacement method for signature 'Basic'
dim(x) <- value

## S4 replacement method for signature 'DenseMatrix'
dimnames(x) <- value

## S4 method for signature 'DenseMatrix'
dimnames(x)

## S4 method for signature 'DenseMatrix'
length(x)

## S4 method for signature 'DenseMatrix,ANY'
x[[i, j, ...]]

## S4 replacement method for signature 'DenseMatrix'
x[[i, j, ...]] <- value

## S4 method for signature 'DenseMatrix'
x[i, j, ..., drop = TRUE]

## S4 replacement method for signature 'DenseMatrix'
x[i, j, ...] <- value

```

### Arguments

**x**                    A `DenseMatrix` object.  
**i, j, value, ..., drop**                    Arguments for subsetting, assignment or replacing.

### Value

Same or similar with the generics of these methods.

---

cbind.SymEngineDataType

*Joining DenseMatrix*

---

### Description

S3 methods of `cbind` and `rbind` defined for `DenseMatrix` and `VecBasic`.

**Usage**

```
## S3 method for class 'SymEngineDataType'
cbind(..., deparse.level)
```

```
## S3 method for class 'SymEngineDataType'
rbind(..., deparse.level)
```

**Arguments**

... DenseMatrix, VecBasic or R objects.  
deparse.level Not used.

**Value**

DenseMatrix S4 object.

---

codegen

*Code Generation*

---

**Description**

Generate C/MathML/LaTeX/JavaScript code string from a Basic or VecBasic object.

**Usage**

```
codegen(x, type = c("ccode", "mathml", "latex", "jscode"))
```

**Arguments**

x A Basic or a VecBasic object.  
type One of "ccode", "mathml", "latex" and "jscode".

**Value**

A character vector.

---

D, SymEngineDataType-method

*Derivatives of a Symbolic Expression*

---

### Description

S4 method of D defined for Basic. It returns the derivative of expr with regards to name. name may be missing if there is only one symbol in expr.

### Usage

```
## S4 method for signature 'SymEngineDataType'
D(expr, name)
```

### Arguments

expr            A Basic object.  
name            A character vector or a Basic object of type Symbol.

### Value

Same type as expr argument.

### Examples

```
expr <- S(~ exp(x))
D(expr) == expr
expr <- S(~ x^2 + 2*x + 1)
D(expr)
```

---

det

*Calculate the Determinant of DenseMatrix*

---

### Description

S4 method of det defined for DenseMatrix.

### Usage

```
det(x, ...)
```

```
## S4 method for signature 'DenseMatrix'
det(x, ...)
```

**Arguments**

x	A DenseMatrix object.
...	Unused.

**Value**

A Basic object.

**Examples**

```
mat <- Matrix(LETTERS[1:9], 3)
det(mat)
```

---

DoubleVisitor

*Double Visitor*


---

**Description**

Construct DoubleVisitor object from Basic or VecBasic and use it to numerically evaluate symbolic expressions.

**Usage**

```
DoubleVisitor(
  exprs,
  args,
  perform_cse = TRUE,
  llvm_opt_level = if (symengine_have_component("llvm")) 3L else -1L
)

visitor_call(visitor, input, do_transpose = FALSE)
```

**Arguments**

exprs	A Basic object or a VecBasic object to be evaluated.
args	A VecBasic object indicating order of input arguments. Can be missing.
perform_cse	Boolean.
llvm_opt_level	Integer. If negative, it will return a LambdaDoubleVisitor, otherwise it will return a LLVMDoubleVisitor with the specified optimization level.
visitor	A DoubleVisitor object.
input	A numeric matrix. Each row is input value for one argument.
do_transpose	Boolean. Matters when exprs is a VecBasic. If true, output will have each column for one symbolic expression, otherwise each row for one symbolic expression.

**Details**

DoubleVisitor constructs the visitor and visitor itself is callable. visitor\_call is the low level function to call the visitor with input.

**Value**

DoubleVisitor returns a callable LambdaDoubleVisitor or LLVMDoubleVisitor. visitor\_call returns a numeric vector or matrix.

**See Also**

[lambdify](#).

**Examples**

```
a <- S("a")
b <- S("b")
c <- S("c")
vec <- c(log(a), log(a)/log(b) + c)
func <- DoubleVisitor(vec, args = c(a, b, c))
args(func)

## Use closure
func(a = 1:10, b = 10:1, c = 1.43)

## Use visitor_call
input <- rbind(a = 1:10, b = 10:1, c = 1.43)
visitor_call(func, input, do_transpose = TRUE)
```

---

 evalf

*Evaluating a SymEngine Object*


---

**Description**

This function will evaluate a SymEngine object to its "numerical" form with given precision. User may further use as.double() to convert to R value.

**Usage**

```
evalf(expr, bits = 53L, complex = FALSE)
```

**Arguments**

expr	A SymEngine object.
bits	The precision.
complex	Whether or not to be evaluated as a complex number.

**Value**

Same type as expr argument.

**Examples**

```
expr <- Constant("pi")
evalf(expr)
as.double(evalf(expr)) == pi
```

---

 expand

*Expand a Symbolic Expression*


---

**Description**

This function takes a SymEngine object and return its expanded form.

**Usage**

```
expand(x)
```

**Arguments**

x                    A Basic/VecBasic/DenseMatrix S4 object.

**Value**

Same type as input.

**Examples**

```
expr <- S(~ (x + y) ^ 3)
expand(expr)
```

---

 Function

*Create a FunctionSymbol*


---

**Description**

FunctionSymbol creates a Basic object with type FunctionSymbol. Function returns a generator.

**Usage**

```
Function(name)
```

```
FunctionSymbol(name, args)
```

**Arguments**

name	Name of the function symbol
args	Dependent symbols

**Value**

FunctionSymbol returns a Basic. Function returns a function that will return a Basic

**See Also**

[S](#)

**Examples**

```
f <- Function("f")
a <- Symbol("a")
b <- Symbol("b")
f(a, b)
e <- f(a, f(a + b))
D(e, a)
FunctionSymbol("f", c(a,b))
```

---

get\_type

*Get Information about Basic Object*

---

**Description**

These functions are used to access the underlying properties of a Basic object.

**Usage**

get\_type(x)

get\_args(x)

get\_hash(x)

get\_str(x)

free\_symbols(x)

function\_symbols(x)

get\_name(x)

get\_prec(x)

**Arguments**

x                    A Basic object.

**Details**

**get\_type** Return the internal type

**get\_args** Return the internal arguments of a Basic object as a VecBasic

**get\_hash** Return the hash as a string

**get\_str** Return the string representation of the Basic object

**free\_symbols** Return free symbols in an expression

**function\_symbols** Return function symbols in an expression

**get\_name** Return name of a Basic object of type FunctionSymbol

**get\_prec** Return precision of a Basic object of type RealMPFR

**Value**

- `get_type()`, `get_hash()`, `get_str()`, `get_name()` return a string.
- `get_args()`, `free_symbols()`, `function_symbols()` return a VecBasic S4 object.
- `get_prec()` returns an integer.

---

lambdify

*Convert A Basic/VecBasic Object to R Function*


---

**Description**

These functions currently use [DoubleVisitor](#) to convert a Basic/VecBasic object to a DoubleVisitor which essentially is a S4 class extending R function.

**Usage**

```
lambdify(x, args, backend = c("auto", "lambda", "llvm"), perform_cse = TRUE)
```

```
## S3 method for class 'BasicOrVecBasic'
as.function(x, args, backend = "auto", perform_cse = TRUE, ...)
```

**Arguments**

x                    A Basic object or a VecBasic object.

args                A VecBasic object specifying the arguments of the resulted function. It will be passed to [DoubleVisitor](#) and can be missing.

backend            One of "auto", "lambda" and "llvm". If "auto", `getOption("lambdify.backend")` will be used to determine the value. If that option is not set, it will be determined based on `symengine_have_component("llvm")`.

perform\_cse        Passed to [DoubleVisitor](#).

...                Not used

**Value**

A DoubleVisitor S4 object.

**See Also**

[DoubleVisitor](#)

---

LCM

*Some Special Math Functions*

---

**Description**

These are some special mathematical functions and functions related to number theory.

**Usage**

LCM(a, b)

GCD(a, b)

nextprime(a)

factorial(x)

## S4 method for signature 'SymEngineDataType'  
factorial(x)

choose(n, k)

## S4 method for signature 'SymEngineDataType'  
choose(n, k)

zeta(a)

lambertw(a)

dirichlet\_eta(a)

erf(a)

erfc(a)

## S4 method for signature 'SymEngineDataType,SymEngineDataType'  
atan2(y, x)

kronecker\_delta(x, y)

```

lowergamma(x, a)

uppergamma(x, a)

## S4 method for signature 'SymEngineDataType,SymEngineDataType'
beta(a, b)

## S4 method for signature 'SymEngineDataType'
psigamma(x, deriv = 0L)

## S4 method for signature 'SymEngineDataType'
digamma(x)

## S4 method for signature 'SymEngineDataType'
trigamma(x)

```

**Arguments**

a, b, x, y, n, k, deriv  
 SymEngine objects (Basic/VecBasic/DenseMatrix). Some functions require Integer type.

**Value**

Same type as input.

---

length, VecBasic-method  
*Methods Related to VecBasic*

---

**Description**

Miscellaneous S4 methods defined for VecBasic class.

**Usage**

```

## S4 method for signature 'VecBasic'
length(x)

## S3 method for class 'VecBasic'
rep(x, ...)

## S3 method for class 'Basic'
rep(x, ...)

## S3 method for class 'VecBasic'
unique(x, ...)

```

```
## S4 method for signature 'BasicOrVecBasic'
c(x, ...)

## S4 method for signature 'VecBasic,numeric'
x[[i, j, ...]]

## S4 method for signature 'VecBasic'
x[i, j, ..., drop = TRUE]

## S4 replacement method for signature 'VecBasic'
x[[i]] <- value

## S4 replacement method for signature 'VecBasic'
x[i, j, ...] <- value
```

**Arguments**

`x` Basic object or Vecbasic object.  
`i, j, ..., drop, value` Arguments for subsetting or replacing.

**Value**

Same or similar to the generics.

---

Matrix

*DenseMatrix Constructor*

---

**Description**

This function constructs a symbolic matrix (DenseMatrix S4 object) with a similar interface with R's `matrix` function.

**Usage**

```
Matrix(data, nrow = 1L, ncol = 1L, byrow = FALSE)
```

**Arguments**

`data` A R object.  
`nrow, ncol` Number of rows and columns.  
`byrow` Boolean value. Whether the data should be filled by row or by column.

**Value**

DenseMatrix S4 object.

---

**S** *Converting R object to Basic*

---

**Description**

'S' and 'Basic' converts a R object to a Basic object. 'Symbol', 'Real' and 'Constant' construct a Basic object with type "Symbol", "RealDouble"/"RealMPFR" and "Constant", respectively.

**Usage**

S(x)

Basic(x)

Symbol(x)

Constant(x)

Real(x, prec = NULL)

**Arguments**

x	A R object.
prec	If supplied, the argument will be parsed as a Basic object of type RealMPFR.

**Details**

For double vector, 'S' will check whether it is a whole number – if true, it will be converted to a Integer type. If this behavior is not desired, you can use 'Basic' or 'as(x, "Basic")'.

**Value**

A Basic S4 object.

**Examples**

```
S("(x + y)^2")
S(~ (x + y)^2)
S(NaN)
S(42)
Basic(42)
as(42, "Basic")
pi <- Constant("pi")
evalf(pi)
if (symengine_have_component("mpfr"))
  evalf(pi, 300)
Real(42)
if (symengine_have_component("mpfr"))
  Real(42, prec = 140)
```

---

 solve

*Solve Symbolic Equations*


---

### Description

Solve system of symbolic equations or solve a polynomial equation. Depending on types of arguments, it supports different modes. See Details and Examples.

### Usage

```

solve(a, b, ...)

## S4 method for signature 'DenseMatrix'
solve(a, b, ...)

## S4 method for signature 'VecBasic'
solve(a, b, ...)

## S4 method for signature 'Basic'
solve(a, b, ...)

```

### Arguments

a, b	Objects, see details.
...	Not used.

### Details

`solve` is a generic function dispatched on the class of the first argument.

- If `a` is a (square) `DenseMatrix`, it solves the equation  $a x = b$  for  $x$ . (similar to `solve.default()`)
- If `a` is a `DenseMatrix` and `b` is missing, `b` is taken to be an identity matrix and `solve` will return the inverse of `a`. (similar to `solve.default()`)
- If `a` is a `VecBasic`, it solves the system of linear equations represented by `a` with regards to symbols represented in `b`.
- If `a` is a `Basic`, it solves the polynomial equation represented by `a` with regards to the symbol represented in `b`.

### Value

A `VecBasic` or `DenseMatrix` S4 object.

**Examples**

```
## Inverse of a symbolic matrix
mat <- Matrix(c("A", "B", "C", "D"), 2)
solve(mat)

## Solve a %% x == b
a <- Matrix(c("a11", "a21", "a12", "a22"), 2) # a is a 2x2 matrix
b <- Vector("b1", "b2") # b is a length 2 vector
solve(a, b) # Solution of x (2x1 matrix)

## Solve the system of linear equations represented by a with regards to
## symbols in b
a <- Vector(~ -2*x + y - 4, # A system of linear equations
           ~ 3*x + y - 9)
b <- Vector(~x, ~y) # Symbols to solve (x and y)
solve(a, b) # Solution of x and y
```

---

subs

---

*Substitute Expressions in SymEngine Objects*


---

**Description**

This function will substitute `expr` with pairs of values in the dot arguments. The length of dot arguments must be an even number.

**Usage**

```
subs(expr, ...)
```

**Arguments**

<code>expr</code>	A Basic S4 object.
<code>...</code>	Pairs of Basic objects or values can be converted to Basic. In the order of "from1, to1, from2, to2, ...".

**Value**

Same type as `expr`.

---

symengine	<i>symengine: R interface to SymEngine C++ library for symbolic computation</i>
-----------	---

---

## Description

symengine is a R package for symbolic computation.

## Details

**SymEngine library** is a standalone fast symbolic manipulation library written in C++. It allows computation over mathematical expressions in a way which is similar to the traditional manual computations of mathematicians and scientists. The R interface of the library tries to provide a user-friendly way to do symbolic computation in R and can be integrated into other packages to help solve related tasks. The design of the package is somehow similar to the **SymPy** package in Python. Unlike some other computer algebra systems, it does not invent its own language or domain specific language but uses R language to manipulate the symbolic expressions.

symengine uses the S4 dispatch system extensively to differentiate between calculation over normal R objects and symengine objects. For example, the semantics of `sin` in `expr <- Symbol("x"); sin(expr)` is different from the `sin` used over normal R numbers.

## Basic class

Basic is simply a S4 class holding a pointer representing a symbolic expression in symengine. Basic objects have the same S4 class but can have different C-level representations which can be accessed via `get_type()`. For example, `Basic(~ 1/2)` will have "Rational" type and `Basic(1/2)` will have "RealDouble" type.

A Basic object will also have a list of associated sub-components which can be accessed via `get_args()`. For example, `(expr <- S("x") * 3L * S("a"))` will have type "Mul", and `as.list(get_args(expr))` will show the three factors of the multiplication.

A Basic object can be constructed via `Basic()`, `S()`, `Symbol()`, `Constant()` or `Real()`.

## VecBasic and DenseMatrix class

VecBasic and DenseMatrix are S4 classes representing a symbolic vector or matrix. They can be constructed with `Vector()`, `V()`, `Matrix()`, `c()`, `rbind()` or `cbind()`. For example the following code will construct a 2x3 matrix.

```
vec <- Vector("a", "b")
cbind(vec, vec^2L, c(S("c"), S("d")))
```

The following functions are expected to work naturally with VecBasic and DenseMatrix classes.

- `[], [[, [<-` and `[[<-` for subsetting and assignment.
- `dim()`, `dim<-`, `length()`, `t()`, `det()`, `rbind()`, `cbind()`, `c()`, `rep()`
- `%*%` for matrix multiplication

- `solve(a, b)`: solve  $a \%*\% x = b$  where  $a$  is a square `DenseMatrix` and  $b$  is a `VecBasic/DenseMatrix`.
- `solve(a)`: find the inverse of  $a$  where  $a$  is a square `DenseMatrix`.
- `solve(a, b)`: solve system of linear equations represented by  $a$  (`VecBasic`) with regards to symbols in  $b$  (`VecBasic`).

Further, the R functions that work on `Basic` objects (e.g. `sin`) are expected work on `VecBasic` and `DenseMatrix` objects as well in a vectorized manner.

### Function bindings

The following is a (incomplete) list of functions that are expected to work with `symengine` objects. Note that these functions can also be used inside a formula or R language objects and passed to `S` or `Basic` or `Vector` to construct `symengine` objects. For example `S(~ sin(x) + 1)` and `S(quote(sin(x) + 1))`.

- `+`, `-`, `*`, `/`, `^`
- `abs`, `sqrt`, `exp`, `expm1`, `log`, `log10`, `log2`, `log1p`
- `cos`, `cosh`, `sin`, `sinh`, `tan`, `tanh`, `acos`, `acosh`, `asin`, `asinh`, `atan`, `atanh`
- `cospi`, `sinpi`, `tanpi`, `gamma`, `lgamma`, `digamma`, `trigamma`
- `lambertw`, `zeta`, `dirichlet_eta`, `erf`, `erfc`
- `atan2`, `kroncker_delta`, `lowergamma`, `uppergamma`, `psigamma`, `beta`

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### See Also

Useful links:

- <https://github.com/symengine/symengine.R>
- Report bugs at <https://github.com/symengine/symengine.R/issues>

---

symengine_version	<i>Information about SymEngine Library</i>
-------------------	--

---

**Description**

Functions to get symengine logo, version and external libraries built with.

**Usage**

```

symengine_version()

symengine_ascii_art()

symengine_have_component(
  which = c("mpfr", "flint", "arb", "mpc", "ecm", "primesieve", "piranha", "boost",
            "pthread", "llvm")
)

symengine_compilation_notes()

```

**Arguments**

which            A character vector.

**Value**

Character vector.

---

t	<i>Transpose (as) a DenseMatrix</i>
---	-------------------------------------

---

**Description**

S4 methods of t defined for Basic, VecBasic and DenseMatrix.

**Usage**

```

t(x)

## S4 method for signature 'Basic'
t(x)

## S4 method for signature 'VecBasic'
t(x)

## S4 method for signature 'DenseMatrix'
t(x)

```

**Arguments**

x                    A SymEngine object.

**Value**

A DenseMatrix S4 object.

---

use\_vars                    *Initializing Variables*

---

**Description**

This is a convenient way to initialize variables and assign them in the given environment.

**Usage**

```
use_vars(..., .env = parent.frame(), .quiet = FALSE)
```

**Arguments**

...                    All the arguments will be quoted and parsed, if a argument is named, the name will be used as the name of variable to assign, otherwise the argument can only be a symbol.

.env                    Environment to assign.

.quiet                    Whether to supress the message.

**Value**

Invisibly returns a list of assigned variables.

**Examples**

```
use_vars(x, y, expr = "a + b", p = 3.14)
p * x + y
expand(expr^2L)
rm(x, y, expr, p)
```

---

Vector

*Symbolic Vector*

---

### Description

A symbolic vector is represented by `VecBasic` S4 class. `Vector` and `V` are constructors of `VecBasic`.

### Usage

```
Vector(x, ...)
```

```
V(...)
```

### Arguments

`x, ...` R objects.

### Details

There are some differences between `Vector` and `V`.

- For double values, `V` will check whether they are whole number, and convert them to integer if so. `Vector` will not.
- `V` does not accept "non-scalar" arguments, like `Vector(c(1, 2, 3))`.

### Value

A `VecBasic`.

### Examples

```
a <- S("a")
b <- S("b")
Vector(a, b, a + b, 42L)
Vector(list(a, b, 42L))
```

```
Vector(1, 2, a)
V(1, 2, a)
```

# Index

- !=, Basic, Basic-method
  - (=, Basic, Basic-method), 2
- +, SymEngineDataType, missing-method
  - (=, Basic, Basic-method), 2
- , SymEngineDataType, missing-method
  - (=, Basic, Basic-method), 2
- ==, Basic, Basic-method, 2
- [, DenseMatrix-method
  - (as.matrix.DenseMatrix), 5
- [, VecBasic-method
  - (length, VecBasic-method), 15
- [<-, DenseMatrix-method
  - (as.matrix.DenseMatrix), 5
- [<-, VecBasic-method
  - (length, VecBasic-method), 15
- [[, DenseMatrix, ANY-method
  - (as.matrix.DenseMatrix), 5
- [[, VecBasic, numeric-method
  - (length, VecBasic-method), 15
- [[<-, DenseMatrix-method
  - (as.matrix.DenseMatrix), 5
- [[<-, VecBasic-method
  - (length, VecBasic-method), 15
- %%%, DenseMatrix, DenseMatrix-method
  - (=, Basic, Basic-method), 2
- %%%, DenseMatrix, VecBasic-method
  - (=, Basic, Basic-method), 2
- %%%, DenseMatrix, vector-method
  - (=, Basic, Basic-method), 2
- %%%, VecBasic, DenseMatrix-method
  - (=, Basic, Basic-method), 2
- %%%, VecBasic, VecBasic-method
  - (=, Basic, Basic-method), 2
- %%%, vector, DenseMatrix-method
  - (=, Basic, Basic-method), 2
- Arith, SymEngineDataType, SymEngineDataType-method
  - (=, Basic, Basic-method), 2
- Arith, SymEngineDataType, vector-method
  - (=, Basic, Basic-method), 2
- Arith, vector, SymEngineDataType-method
  - (=, Basic, Basic-method), 2
- as.character, Basic-method, 4
- as.character, VecBasic-method
  - (as.character, Basic-method), 4
- as.function.BasicOrVecBasic (lambdify), 13
- as.integer, Basic-method
  - (as.character, Basic-method), 4
- as.integer, VecBasic-method
  - (as.character, Basic-method), 4
- as.language
  - (as.character, Basic-method), 4
- as.language, Basic-method
  - (as.character, Basic-method), 4
- as.matrix.DenseMatrix, 5
- as.numeric, Basic-method
  - (as.character, Basic-method), 4
- as.numeric, VecBasic-method
  - (as.character, Basic-method), 4
- atan2, SymEngineDataType, SymEngineDataType-method (LCM), 14
- Basic, 21
- Basic (S), 17
- Basic(), 20
- beta, SymEngineDataType, SymEngineDataType-method (LCM), 14
- c, BasicOrVecBasic-method
  - (length, VecBasic-method), 15
- cbind.SymEngineDataType, 6
- choose (LCM), 14
- choose, SymEngineDataType-method (LCM), 14
- codegen, 7
- constant (S), 17
- Constant(), 20
- cospi, SymEngineDataType-method
  - (=, Basic, Basic-method), 2

- D, SymEngineDataType-method, 8
- det, 8
- det, DenseMatrix-method (det), 8
- digamma, SymEngineDataType-method (LCM), 14
- dim, DenseMatrix-method (as.matrix.DenseMatrix), 5
- dim<- , Basic-method (as.matrix.DenseMatrix), 5
- dim<- , DenseMatrix-method (as.matrix.DenseMatrix), 5
- dim<- , VecBasic-method (as.matrix.DenseMatrix), 5
- dimnames, DenseMatrix-method (as.matrix.DenseMatrix), 5
- dimnames<- , DenseMatrix-method (as.matrix.DenseMatrix), 5
- dirichlet\_eta (LCM), 14
- DoubleVisitor, 9, 13, 14
- erf (LCM), 14
- erfc (LCM), 14
- evalf, 10
- expand, 11
- expm1, SymEngineDataType-method (==, Basic, Basic-method), 2
- factorial (LCM), 14
- factorial, SymEngineDataType-method (LCM), 14
- free\_symbols (get\_type), 12
- Function, 11
- function\_symbols (get\_type), 12
- FunctionSymbol (Function), 11
- GCD (LCM), 14
- get\_args (get\_type), 12
- get\_args(), 20
- get\_hash (get\_type), 12
- get\_name (get\_type), 12
- get\_prec (get\_type), 12
- get\_str (get\_type), 12
- get\_type, 12
- get\_type(), 20
- kronecker\_delta (LCM), 14
- lambdify, 10, 13
- lambertw (LCM), 14
- LCM, 14
- length, DenseMatrix-method (as.matrix.DenseMatrix), 5
- length, VecBasic-method, 15
- log, SymEngineDataType-method (==, Basic, Basic-method), 2
- log10, SymEngineDataType-method (==, Basic, Basic-method), 2
- log1p, SymEngineDataType-method (==, Basic, Basic-method), 2
- log2, SymEngineDataType-method (==, Basic, Basic-method), 2
- lowergamma (LCM), 14
- Math, SymEngineDataType-method (==, Basic, Basic-method), 2
- Matrix, 16
- Matrix(), 20
- nextprime (LCM), 14
- prod, SymEngineDataType-method (==, Basic, Basic-method), 2
- psigamma, SymEngineDataType-method (LCM), 14
- rbind.SymEngineDataType (cbind.SymEngineDataType), 6
- Real (S), 17
- Real(), 20
- rep.Basic (length, VecBasic-method), 15
- rep.VecBasic (length, VecBasic-method), 15
- S, 12, 17, 21
- S(), 20
- sinpi, SymEngineDataType-method (==, Basic, Basic-method), 2
- solve, 18
- solve, Basic-method (solve), 18
- solve, DenseMatrix-method (solve), 18
- solve, VecBasic-method (solve), 18
- subs, 19
- sum, SymEngineDataType-method (==, Basic, Basic-method), 2
- Symbol (S), 17
- Symbol(), 20
- symengine, 20
- symengine-package (symengine), 20

- symengine\_ascii\_art
  - (symengine\_version), [22](#)
- symengine\_compilation\_notes
  - (symengine\_version), [22](#)
- symengine\_have\_component
  - (symengine\_version), [22](#)
- symengine\_version, [22](#)
  
- t, [22](#)
- t, Basic-method (t), [22](#)
- t, DenseMatrix-method (t), [22](#)
- t, VecBasic-method (t), [22](#)
- tanpi, SymEngineDataType-method
  - (=, Basic, Basic-method), [2](#)
- trigamma, SymEngineDataType-method
  - (LCM), [14](#)
  
- unique.VecBasic
  - (length, VecBasic-method), [15](#)
- uppergamma (LCM), [14](#)
- use\_vars, [23](#)
  
- V (Vector), [24](#)
- V(), [20](#)
- Vector, [21](#), [24](#)
- Vector(), [20](#)
- visitor\_call (DoubleVisitor), [9](#)
  
- zeta (LCM), [14](#)