# Octave C++ Classes

Edition 1.0 for Octave version 7.2.0

**The Octave Project Developers**

This is the first edition of the documentation for Octave's C++ classes, and is consistent with version 7.2.0 of Octave.

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In addition to John W. Eaton, several people have written parts of liboctave. (This has been removed because it is the same as what is in the Octave manual.)

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# 2 A Brief Introduction to Octave

This manual documents how to run, install and port Octave's C++ classes, and how to report bugs.

# 3 Arrays

## 3.1 Constructors and Assignment

`Array<T>` (*void*) [Constructor]
Create an array with no elements.

`Array<T>` (*int* `n` [, *const T &*`val`]) [Constructor]
Create an array with *n* elements. If the optional argument *val* is supplied, the elements are initialized to *val*; otherwise, they are left uninitialized. If *n* is less than zero, the current error handler is invoked (see Chapter 13 [Error Handling], page 47).

`Array<T>` (*const Array<T> &*`a`) [Constructor]
Create a copy of the *Array<T>* object *a*. Memory for the *Array<T>* class is managed using a reference counting scheme, so the cost of this operation is independent of the size of the array.

`Array<T>& operator =` (*const Array<T> &*`a`) [Assignment on `Array<T>`]
Assignment operator. Memory for the *Array<T>* class is managed using a reference counting scheme, so the cost of this operation is independent of the size of the array.

`int capacity` (*void*) *const* [Method on `Array<T>`]
`int length` (*void*) *const* [Method on `Array<T>`]
Return the length of the array.

`T& elem` (*int* `n`) [Method on `Array<T>`]
`T& checkelem` (*int* `n`) [Method on `Array<T>`]
If *n* is within the bounds of the array, return a reference to the element indexed by *n*; otherwise, the current error handler is invoked (see Chapter 13 [Error Handling], page 47).

`T& operator ()` (*int* `n`) [Indexing on `Array<T>`]

`T elem` (*int* `n`) *const* [Method on `Array<T>`]
`T checkelem` (*int* `n`) *const* [Method on `Array<T>`]
If *n* is within the bounds of the array, return the value indexed by *n*; otherwise, call the current error handler. See Chapter 13 [Error Handling], page 47.

`T operator ()` (*int* `n`) *const* [Indexing on `Array<T>`]

`T& xelem` (*int* `n`) [Method on `Array<T>`]
`T xelem` (*int* `n`) *const* [Method on `Array<T>`]
Return a reference to, or the value of, the element indexed by *n*. These methods never perform bounds checking.

`void resize` (*int* `n` [, *const T &*`val`]) [Method on `Array<T>`]
Change the size of the array to be *n* elements. All elements are unchanged, except that if *n* is greater than the current size and the optional argument *val* is provided,

the additional elements are initialized to *val*; otherwise, any additional elements are left uninitialized. In the current implementation, if *n* is less than the current size, the length is updated but no memory is released.

`const T* data` (*void*) *const* [Method on `Array<T>`]

`Array2<T>` *Array2<T> Array2* (*void*) [Constructor]
`Array2<T>` (*int* `n`, *int* `m`) [Constructor]
`Array2<T>` (*int* `n`, *int* `m`, *const T* &`val`) [Constructor]
`Array2<T>` (*const Array2<T>* &`a`) [Constructor]
`Array2<T>` (*const DiagArray<T>* &`a`) [Constructor]

`Array2<T>& operator =` (*const Array2<T>* &`a`) [Assignment on `Array2<T>`]

`int dim1` (*void*) *const* [Method on `Array2<T>`]
`int rows` (*void*) *const* [Method on `Array2<T>`]

`int dim2` (*void*) *const* [Method on `Array2<T>`]
`int cols` (*void*) *const* [Method on `Array2<T>`]
`int columns` (*void*) *const* [Method on `Array2<T>`]

`T& elem` (*int* `i`, *int* `j`) [Method on `Array2<T>`]
`T& checkelem` (*int* `i`, *int* `j`) [Method on `Array2<T>`]

`T& operator ()` (*int* `i`, *int* `j`) [Indexing on `Array2<T>`]

`void resize` (*int* `n`, *int* `m`) [Method on `Array2<T>`]
`void resize` (*int* `n`, *int* `m`, *const T* &`val`) [Method on `Array2<T>`]

`Array3<T>` (*void*) [Constructor]
`Array3<T>` (*int* `n`, *int* `m`, *int* `k`) [Constructor]
`Array3<T>` (*int* `n`, *int* `m`, *int* `k`, *const T* &`val`) [Constructor]
`Array3<T>` (*const Array3<T>* &`a`) [Constructor]

`Array3<T>& operator =` (*const Array3<T>* &`a`) [Assignment on `Array3<T>`]

`int dim1` (*void*) *const* [Method on `Array3<T>`]
`int dim2` (*void*) *const* [Method on `Array3<T>`]
`int dim3` (*void*) *const* [Method on `Array3<T>`]

`T& elem` (*int* `i`, *int* `j`, *int* `k`) [Method on `Array3<T>`]
`T& checkelem` (*int* `i`, *int* `j`, *int* `k`) [Method on `Array3<T>`]

`T& operator ()` (*int* `i`, *int* `j`, *int* `k`) [Indexing on `Array3<T>`]

`void resize` (*int* `n`, *int* `m`, *int* `k`) [Method on `Array3<T>`]
`void resize` (*int* `n`, *int* `m`, *int* `k`, *const T* &`val`) [Method on `Array3<T>`]

`DiagArray<T>` (*void*) [Constructor]
`DiagArray<T>` (*int* `n`) [Constructor]
`DiagArray<T>` (*int* `n`, *const T* &`val`) [Constructor]
`DiagArray<T>` (*int* `r`, *int* `c`) [Constructor]
`DiagArray<T>` (*int* `r`, *int* `c`, *const T* &`val`) [Constructor]
`DiagArray<T>` (*const Array<T>* &`a`) [Constructor]
`DiagArray<T>` (*const DiagArray<T>* &`a`) [Constructor]

`operator =` (*const DiagArray<T>* &`a`) [Assignment on `DiagArray<T>&`]

`int dim1` (*void*) *const* [Method on `DiagArray<T>`]
`int rows` (*void*) *const* [Method on `DiagArray<T>`]

`int dim2` (*void*) *const* [Method on `DiagArray<T>`]
`int cols` (*void*) *const* [Method on `DiagArray<T>`]
`int columns` (*void*) *const* [Method on `DiagArray<T>`]

`T& elem` (*int* `r`, *int* `c`) [Method on `DiagArray<T>`]
`T& checkelem` (*int* `r`, *int* `c`) [Method on `DiagArray<T>`]

`T& operator ()` (*int* `r`, *int* `c`) [Indexing on `DiagArray<T>`]

`void resize` (*int* `n`, *int* `m`) [Method on `DiagArray<T>`]
`void resize` (*int* `n`, *int* `m`, *const T &val*) [Method on `DiagArray<T>`]

The real and complex `ColumnVector` and `RowVector` classes all have the following functions. These will eventually be part of an `MArray<T>` class, derived from the `Array<T>` class. Then the `ColumnVector` and `RowVector` classes will be derived from the `MArray<T>` class.

Element by element vector by scalar ops.

`RowVector operator +` (*const RowVector &*`a`, *const double &*`s`)
`RowVector operator -` (*const RowVector &*`a`, *const double &*`s`)
`RowVector operator *` (*const RowVector &*`a`, *const double &*`s`)
`RowVector operator /` (*const RowVector &*`a`, *const double &*`s`)

Element by element scalar by vector ops.

`RowVector operator +` (*const double &*`s`, *const RowVector &*`a`)
`RowVector operator -` (*const double &*`s`, *const RowVector &*`a`)
`RowVector operator *` (*const double &*`s`, *const RowVector &*`a`)
`RowVector operator /` (*const double &*`s`, *const RowVector &*`a`)

Element by element vector by vector ops.

`RowVector operator +` (*const RowVector &*`a`, *const RowVector &*`b`)
`RowVector operator -` (*const RowVector &*`a`, *const RowVector &*`b`)

`RowVector product` (*const RowVector &*`a`, *const RowVector &*`b`)
`RowVector quotient` (*const RowVector &*`a`, *const RowVector &*`b`)

Unary MArray ops.

`RowVector operator -` (*const RowVector &*`a`)

The `Matrix` classes share the following functions. These will eventually be part of an `MArray2<T>` class, derived from the `Array2<T>` class. Then the `Matrix` class will be derived from the `MArray<T>` class.

Element by element matrix by scalar ops.

`Matrix operator +` (*const Matrix &*`a`, *const double &*`s`)
`Matrix operator -` (*const Matrix &*`a`, *const double &*`s`)
`Matrix operator *` (*const Matrix &*`a`, *const double &*`s`)
`Matrix operator /` (*const Matrix &*`a`, *const double &*`s`)

Element by element scalar by matrix ops.

`Matrix operator +` (*const double &s, const Matrix &a*)
`Matrix operator -` (*const double &s, const Matrix &a*)
`Matrix operator *` (*const double &s, const Matrix &a*)
`Matrix operator /` (*const double &s, const Matrix &a*)
Element by element matrix by matrix ops.

`Matrix operator +` (*const Matrix &a, const Matrix &b*)
`Matrix operator -` (*const Matrix &a, const Matrix &b*)

`Matrix product` (*const Matrix &a, const Matrix &b*)
`Matrix quotient` (*const Matrix &a, const Matrix &b*)
Unary matrix ops.

`Matrix operator -` (*const Matrix &a*)
The `DiagMatrix` classes share the following functions. These will eventually be part of an `MDiagArray<T>` class, derived from the `DiagArray<T>` class. Then the `DiagMatrix` class will be derived from the `MDiagArray<T>` class.

Element by element MDiagArray by scalar ops.

`DiagMatrix operator *` (*const DiagMatrix &a, const double &s*)
`DiagMatrix operator /` (*const DiagMatrix &a, const double &s*)
Element by element scalar by MDiagArray ops.

`DiagMatrix operator *` (*const double &s, const DiagMatrix &a*)
Element by element MDiagArray by MDiagArray ops.

`DiagMatrix operator +` (*const DiagMatrix &a, const DiagMatrix &b*)
`DiagMatrix operator -` (*const DiagMatrix &a, const DiagMatrix &b*)

`DiagMatrix product` (*const DiagMatrix &a, const DiagMatrix &b*)

Unary MDiagArray ops.

`DiagMatrix operator -` (*const DiagMatrix &a*)

# 4 Matrix and Vector Operations

`Matrix` (*void*)
`Matrix` (*int* `r`, *int* `c`)
`Matrix` (*int* `r`, *int* `c`, *double* `val`)
`Matrix` (*const Array2*<*double*> &`a`)
`Matrix` (*const Matrix* &`a`)
`Matrix` (*const DiagArray*<*double*> &`a`)
`Matrix` (*const DiagMatrix* &`a`)

`Matrix& operator =` (*const Matrix* &`a`)

`int operator ==` (*const Matrix* &`a`) *const*
`int operator !=` (*const Matrix* &`a`) *const*

`Matrix& insert` (*const Matrix* &`a`, *int* `r`, *int* `c`)
`Matrix& insert` (*const RowVector* &`a`, *int* `r`, *int* `c`)
`Matrix& insert` (*const ColumnVector* &`a`, *int* `r`, *int* `c`)
`Matrix& insert` (*const DiagMatrix* &`a`, *int* `r`, *int* `c`)

`Matrix& fill` (*double* `val`)
`Matrix& fill` (*double* `val`, *int r1*, *int c1*, *int r2*, *int c2*)

`Matrix append` (*const Matrix* &`a`) *const*
`Matrix append` (*const RowVector* &`a`) *const*
`Matrix append` (*const ColumnVector* &`a`) *const*
`Matrix append` (*const DiagMatrix* &`a`) *const*

`Matrix stack` (*const Matrix* &`a`) *const*
`Matrix stack` (*const RowVector* &`a`) *const*
`Matrix stack` (*const ColumnVector* &`a`) *const*
`Matrix stack` (*const DiagMatrix* &`a`) *const*

`Matrix transpose` (*void*) *const*

`Matrix extract` (*int r1*, *int c1*, *int r2*, *int c2*) *const*

`RowVector row` (*int* `i`) *const*
`RowVector row` (*char* **s*) *const*

`ColumnVector column` (*int* `i`) *const*
`ColumnVector column` (*char* **s*) *const*

`Matrix inverse` (*void*) *const*
`Matrix inverse` (*int* &`info`) *const*
`Matrix inverse` (*int* &`info`, *double* &`rcond`) *const*

`ComplexMatrix fourier` (*void*) *const*
`ComplexMatrix ifourier` (*void*) *const*

`DET determinant` (*void*) *const*
`DET determinant` (*int* &`info`) *const*
`DET determinant` (*int* &`info`, *double* &`rcond`) *const*

`Matrix solve` (*const Matrix* &`b`) *const*

`Matrix solve` (*const Matrix &b, int &info*) *const*
`Matrix solve` (*const Matrix &b, int &info, double &rcond*) *const*

`ComplexMatrix solve` (*const ComplexMatrix &b*) *const*
`ComplexMatrix solve` (*const ComplexMatrix &b, int &info*) *const*
`ComplexMatrix solve` (*const ComplexMatrix &b, int &info, double &rcond*) *const*

`ColumnVector solve` (*const ColumnVector &b*) *const*
`ColumnVector solve` (*const ColumnVector &b, int &info*) *const*
`ColumnVector solve` (*const ColumnVector &b, int &info, double &rcond*) *const*

`ComplexColumnVector solve` (*const ComplexColumnVector &b*) *const*
`ComplexColumnVector solve` (*const ComplexColumnVector &b, int &info*) *const*
`ComplexColumnVector solve` (*const ComplexColumnVector &b, int &info, double &rcond*) *const*

`Matrix lssolve` (*const Matrix &b*) *const*
`Matrix lssolve` (*const Matrix &b, int &info*) *const*
`Matrix lssolve` (*const Matrix &b, int &info, int &rank*) *const*

`ComplexMatrix lssolve` (*const ComplexMatrix &b*) *const*
`ComplexMatrix lssolve` (*const ComplexMatrix &b, int &info*) *const*
`ComplexMatrix lssolve` (*const ComplexMatrix &b, int &info, int &rank*) *const*

`ColumnVector lssolve` (*const ColumnVector &b*) *const*
`ColumnVector lssolve` (*const ColumnVector &b, int &info*) *const*
`ColumnVector lssolve` (*const ColumnVector &b, int &info, int &rank*) *const*

`ComplexColumnVector lssolve` (*const ComplexColumnVector &b*) *const*
`ComplexColumnVector lssolve` (*const ComplexColumnVector &b, int &info*) *const*
`ComplexColumnVector lssolve` (*const ComplexColumnVector &b, int &info, int &rank*) *const*

`Matrix& operator +=` (*const Matrix &a*)
`Matrix& operator -=` (*const Matrix &a*)

`Matrix& operator +=` (*const DiagMatrix &a*)
`Matrix& operator -=` (*const DiagMatrix &a*)

`Matrix operator !` (*void*) *const*

`ComplexMatrix operator +` (*const Matrix &a, const Complex &s*)
`ComplexMatrix operator -` (*const Matrix &a, const Complex &s*)
`ComplexMatrix operator *` (*const Matrix &a, const Complex &s*)
`ComplexMatrix operator /` (*const Matrix &a, const Complex &s*)

`ComplexMatrix operator +` (*const Complex &s, const Matrix &a*)
`ComplexMatrix operator -` (*const Complex &s, const Matrix &a*)
`ComplexMatrix operator *` (*const Complex &s, const Matrix &a*)

`ComplexMatrix operator /` (*const Complex &*`s`, *const Matrix &*`a`)

`ColumnVector operator *` (*const Matrix &*`a`, *const ColumnVector &*`b`)
`ComplexColumnVector operator *` (*const Matrix &*`a`, *const ComplexColumnVector &*`b`)

`Matrix operator +` (*const Matrix &*`a`, *const DiagMatrix &*`b`)
`Matrix operator -` (*const Matrix &*`a`, *const DiagMatrix &*`b`)
`Matrix operator *` (*const Matrix &*`a`, *const DiagMatrix &*`b`)

`ComplexMatrix operator +` (*const Matrix &*`a`, *const ComplexDiagMatrix &*`b`)
`ComplexMatrix operator -` (*const Matrix &*`a`, *const ComplexDiagMatrix &*`b`)
`ComplexMatrix operator *` (*const Matrix &*`a`, *const ComplexDiagMatrix &*`b`)

`Matrix operator *` (*const Matrix &*`a`, *const Matrix &*`b`)
`ComplexMatrix operator *` (*const Matrix &*`a`, *const ComplexMatrix &*`b`)

`ComplexMatrix operator +` (*const Matrix &*`a`, *const ComplexMatrix &*`b`)
`ComplexMatrix operator -` (*const Matrix &*`a`, *const ComplexMatrix &*`b`)

`ComplexMatrix product` (*const Matrix &*`a`, *const ComplexMatrix &*`b`)
`ComplexMatrix quotient` (*const Matrix &*`a`, *const ComplexMatrix &*`b`)

`Matrix map` (*d_d_Mapper* `f`, *const Matrix &*`a`)
`void map` (*d_d_Mapper* `f`)

`Matrix all` (*void*) *const*
`Matrix any` (*void*) *const*

`Matrix cumprod` (*void*) *const*
`Matrix cumsum` (*void*) *const*
`Matrix prod` (*void*) *const*
`Matrix sum` (*void*) *const*
`Matrix sumsq` (*void*) *const*

`ColumnVector diag` (*void*) *const*
`ColumnVector diag` (*int* `k`) *const*

`ColumnVector row_min` (*void*) *const*
`ColumnVector row_min_loc` (*void*) *const*

`ColumnVector row_max` (*void*) *const*
`ColumnVector row_max_loc` (*void*) *const*

`RowVector column_min` (*void*) *const*
`RowVector column_min_loc` (*void*) *const*

`RowVector column_max` (*void*) *const*
`RowVector column_max_loc` (*void*) *const*

`ostream& operator <<` (*ostream &*`os`, *const Matrix &*`a`)
`istream& operator >>` (*istream &*`is`, *Matrix &*`a`)

`ColumnVector` (*void*)
`ColumnVector` (*int* `n`)
`ColumnVector` (*int* `n`, *double* `val`)

`ColumnVector` (*const Array<double> &a*)
`ColumnVector` (*const ColumnVector &a*)

`ColumnVector& operator =` (*const ColumnVector &a*)

`int operator ==` (*const ColumnVector &a*) *const*
`int operator !=` (*const ColumnVector &a*) *const*

`ColumnVector& insert` (*const ColumnVector &a, int r*)

`ColumnVector& fill` (*double val*)
`ColumnVector& fill` (*double val, int r1, int r2*)

`ColumnVector stack` (*const ColumnVector &a*) *const*

`RowVector transpose` (*void*) *const*

`ColumnVector extract` (*int r1, int r2*) *const*

`ColumnVector& operator +=` (*const ColumnVector &a*)
`ColumnVector& operator -=` (*const ColumnVector &a*)

`ComplexColumnVector operator +` (*const ColumnVector &a, const Complex &s*)
`ComplexColumnVector operator -` (*const ColumnVector &a, const Complex &s*)
`ComplexColumnVector operator *` (*const ColumnVector &a, const Complex &s*)
`ComplexColumnVector operator /` (*const ColumnVector &a, const Complex &s*)

`ComplexColumnVector operator +` (*const Complex &s, const ColumnVector &a*)
`ComplexColumnVector operator -` (*const Complex &s, const ColumnVector &a*)
`ComplexColumnVector operator *` (*const Complex &s, const ColumnVector &a*)
`ComplexColumnVector operator /` (*const Complex &s, const ColumnVector &a*)

`Matrix operator *` (*const ColumnVector &a, const RowVector &a*)

`ComplexMatrix operator *` (*const ColumnVector &a, const ComplexRowVector &b*)

`ComplexColumnVector operator +` (*const ComplexColumnVector &a, const ComplexColumnVector &b*)

`ComplexColumnVector operator -` (*const ComplexColumnVector &a, const ComplexColumnVector &b*)

`ComplexColumnVector product` (*const ComplexColumnVector &a, const ComplexColumnVector &b*)

`ComplexColumnVector quotient` (*const ComplexColumnVector &a, const ComplexColumnVector &b*)

`ColumnVector map` (*d_d_Mapper f, const ColumnVector &a*)

`void map` (*d_d_Mapper* `f`)

`double min` (*void*) *const*
`double max` (*void*) *const*

`ostream& operator <<` (*ostream &os, const ColumnVector &a*)

`RowVector` (*void*)
`RowVector` (*int n*)
`RowVector` (*int n, double val*)
`RowVector` (*const Array<double> &a*)
`RowVector` (*const RowVector &a*)

`RowVector& operator =` (*const RowVector &a*)

`int operator ==` (*const RowVector &a*) *const*
`int operator !=` (*const RowVector &a*) *const*

`RowVector& insert` (*const RowVector &a, int c*)

`RowVector& fill` (*double val*)
`RowVector& fill` (*double val, int c1, int c2*)

`RowVector append` (*const RowVector &a*) *const*

`ColumnVector transpose` (*void*) *const*

`RowVector extract` (*int c1, int c2*) *const*

`RowVector& operator +=` (*const RowVector &a*)
`RowVector& operator -=` (*const RowVector &a*)

`ComplexRowVector operator +` (*const RowVector &a, const Complex &s*)
`ComplexRowVector operator -` (*const RowVector &a, const Complex &s*)
`ComplexRowVector operator *` (*const RowVector &a, const Complex &s*)
`ComplexRowVector operator /` (*const RowVector &a, const Complex &s*)

`ComplexRowVector operator +` (*const Complex &s, const RowVector &a*)
`ComplexRowVector operator -` (*const Complex &s, const RowVector &a*)
`ComplexRowVector operator *` (*const Complex &s, const RowVector &a*)
`ComplexRowVector operator /` (*const Complex &s, const RowVector &a*)

`double operator *` (*const RowVector &a, ColumnVector &b*)

`Complex operator *` (*const RowVector &a, const ComplexColumnVector &b*)

`RowVector operator *` (*const RowVector &a, const Matrix &b*)

`ComplexRowVector operator *` (*const RowVector &a, const ComplexMatrix &b*)

`ComplexRowVector operator +` (*const RowVector &a, const ComplexRowVector &b*)
`ComplexRowVector operator -` (*const RowVector &a, const ComplexRowVector &b*)

`ComplexRowVector product` (*const RowVector &a, const ComplexRowVector &b*)

`ComplexRowVector quotient` (*const RowVector &*`a`, *const ComplexRowVector &*`b`)

`RowVector map` (*d_d_Mapper* `f`, *const RowVector &*`a`)
`void map` (*d_d_Mapper* `f`)

`double min` (*void*) *const*
`double max` (*void*) *const*

`ostream& operator <<` (*ostream &*`os`, *const RowVector &*`a`)

`DiagMatrix` (*void*)
`DiagMatrix` (*int* `n`)
`DiagMatrix` (*int* `n`, *double* `val`)
`DiagMatrix` (*int* `r`, *int* `c`)
`DiagMatrix` (*int* `r`, *int* `c`, *double* `val`)
`DiagMatrix` (*const RowVector &*`a`)
`DiagMatrix` (*const ColumnVector &*`a`)
`DiagMatrix` (*const DiagArray<double> &*`a`)
`DiagMatrix` (*const DiagMatrix &*`a`)

`DiagMatrix& operator =` (*const DiagMatrix &*`a`)

`int operator ==` (*const DiagMatrix &*`a`) *const*
`int operator !=` (*const DiagMatrix &*`a`) *const*

`DiagMatrix& fill` (*double* `val`)
`DiagMatrix& fill` (*double* `val`, *int* `beg`, *int* `end`)
`DiagMatrix& fill` (*const ColumnVector &*`a`)
`DiagMatrix& fill` (*const RowVector &*`a`)
`DiagMatrix& fill` (*const ColumnVector &*`a`, *int* `beg`)
`DiagMatrix& fill` (*const RowVector &*`a`, *int* `beg`)

`DiagMatrix transpose` (*void*) *const*

`Matrix extract` (*int r1*, *int c1*, *int r2*, *int c2*) *const*

`RowVector row` (*int* `i`) *const*
`RowVector row` (*char *s*) *const*

`ColumnVector column` (*int* `i`) *const*
`ColumnVector column` (*char *s*) *const*

`DiagMatrix inverse` (*void*) *const*
`DiagMatrix inverse` (*int &*`info`) *const*

`DiagMatrix& operator +=` (*const DiagMatrix &*`a`)
`DiagMatrix& operator -=` (*const DiagMatrix &*`a`)

`Matrix operator +` (*const DiagMatrix &*`a`, *double* `s`)
`Matrix operator -` (*const DiagMatrix &*`a`, *double* `s`)

`ComplexMatrix operator +` (*const DiagMatrix &*`a`, *const Complex &*`s`)
`ComplexMatrix operator -` (*const DiagMatrix &*`a`, *const Complex &*`s`)

`ComplexDiagMatrix operator *` (*const DiagMatrix &*`a`, *const Complex &*`s`)

`ComplexDiagMatrix operator /` (*const DiagMatrix &*`a`, *const Complex &*`s`)

`Matrix operator +` (*double* `s`, *const DiagMatrix &*`a`)
`Matrix operator -` (*double* `s`, *const DiagMatrix &*`a`)

`ComplexMatrix operator +` (*const Complex &*`s`, *const DiagMatrix &*`a`)
`ComplexMatrix operator -` (*const Complex &*`s`, *const DiagMatrix &*`a`)

`ComplexDiagMatrix operator *` (*const Complex &*`s`, *const DiagMatrix &*`a`)

`ColumnVector operator *` (*const DiagMatrix &*`a`, *const ColumnVector &*`b`)

`ComplexColumnVector operator *` (*const DiagMatrix &*`a`, *const ComplexColumnVector &*`b`)

`ComplexDiagMatrix operator +` (*const DiagMatrix &*`a`, *const ComplexDiagMatrix &*`b`)
`ComplexDiagMatrix operator -` (*const DiagMatrix &*`a`, *const ComplexDiagMatrix &*`b`)

`ComplexDiagMatrix product` (*const DiagMatrix &*`a`, *const ComplexDiagMatrix &*`b`)

`Matrix operator +` (*const DiagMatrix &*`a`, *const Matrix &*`b`)
`Matrix operator -` (*const DiagMatrix &*`a`, *const Matrix &*`b`)
`Matrix operator *` (*const DiagMatrix &*`a`, *const Matrix &*`b`)

`ComplexMatrix operator +` (*const DiagMatrix &*`a`, *const ComplexMatrix &*`b`)
`ComplexMatrix operator -` (*const DiagMatrix &*`a`, *const ComplexMatrix &*`b`)
`ComplexMatrix operator *` (*const DiagMatrix &*`a`, *const ComplexMatrix &*`b`)

`ColumnVector diag` (*void*) *const*
`ColumnVector diag` (*int* `k`) *const*

`ostream& operator <<` (*ostream &*`os`, *const DiagMatrix &*`a`)

`ComplexMatrix` (*void*)
`ComplexMatrix` (*int* `r`, *int* `c`)
`ComplexMatrix` (*int* `r`, *int* `c`, *const Complex &*`val`)
`ComplexMatrix` (*const Matrix &*`a`)
`ComplexMatrix` (*const Array2<Complex> &*`a`)
`ComplexMatrix` (*const ComplexMatrix &*`a`)
`ComplexMatrix` (*const DiagMatrix &*`a`)
`ComplexMatrix` (*const DiagArray<Complex> &*`a`)
`ComplexMatrix` (*const ComplexDiagMatrix &*`a`)

`ComplexMatrix& operator =` (*const ComplexMatrix &*`a`)

`int operator ==` (*const ComplexMatrix &*`a`) *const*
`int operator !=` (*const ComplexMatrix &*`a`) *const*

`ComplexMatrix& insert` (*const Matrix &*`a`, *int* `r`, *int* `c`)
`ComplexMatrix& insert` (*const RowVector &*`a`, *int* `r`, *int* `c`)
`ComplexMatrix& insert` (*const ColumnVector &*`a`, *int* `r`, *int* `c`)
`ComplexMatrix& insert` (*const DiagMatrix &*`a`, *int* `r`, *int* `c`)

`ComplexMatrix& insert` (*const ComplexMatrix &*`a`, *int* `r`, *int* `c`)

`ComplexMatrix& insert` (*const ComplexRowVector &*`a`, *int* `r`, *int* `c`)
`ComplexMatrix& insert` (*const ComplexColumnVector &*`a`, *int* `r`, *int* `c`)
`ComplexMatrix& insert` (*const ComplexDiagMatrix &*`a`, *int* `r`, *int* `c`)

`ComplexMatrix& fill` (*double* `val`)
`ComplexMatrix& fill` (*const Complex &*`val`)
`ComplexMatrix& fill` (*double* `val`, *int r1*, *int c1*, *int r2*, *int c2*)
`ComplexMatrix& fill` (*const Complex &*`val`, *int r1*, *int c1*, *int r2*, *int c2*)

`ComplexMatrix append` (*const Matrix &*`a`) *const*
`ComplexMatrix append` (*const RowVector &*`a`) *const*
`ComplexMatrix append` (*const ColumnVector &*`a`) *const*
`ComplexMatrix append` (*const DiagMatrix &*`a`) *const*

`ComplexMatrix append` (*const ComplexMatrix &*`a`) *const*
`ComplexMatrix append` (*const ComplexRowVector &*`a`) *const*
`ComplexMatrix append` (*const ComplexColumnVector &*`a`) *const*
`ComplexMatrix append` (*const ComplexDiagMatrix &*`a`) *const*

`ComplexMatrix stack` (*const Matrix &*`a`) *const*
`ComplexMatrix stack` (*const RowVector &*`a`) *const*
`ComplexMatrix stack` (*const ColumnVector &*`a`) *const*
`ComplexMatrix stack` (*const DiagMatrix &*`a`) *const*

`ComplexMatrix stack` (*const ComplexMatrix &*`a`) *const*
`ComplexMatrix stack` (*const ComplexRowVector &*`a`) *const*
`ComplexMatrix stack` (*const ComplexColumnVector &*`a`) *const*
`ComplexMatrix stack` (*const ComplexDiagMatrix &*`a`) *const*

`ComplexMatrix transpose` (*void*) *const*

`Matrix real` (*const ComplexMatrix &*`a`)
`Matrix imag` (*const ComplexMatrix &*`a`)
`ComplexMatrix conj` (*const ComplexMatrix &*`a`)

`ComplexMatrix extract` (*int r1*, *int c1*, *int r2*, *int c2*) *const*

`ComplexRowVector row` (*int* `i`) *const*
`ComplexRowVector row` (*char *s*) *const*

`ComplexColumnVector column` (*int* `i`) *const*
`ComplexColumnVector column` (*char *s*) *const*

`ComplexMatrix inverse` (*void*) *const*
`ComplexMatrix inverse` (*int &*`info`) *const*
`ComplexMatrix inverse` (*int &*`info`, *double &*`rcond`) *const*

`ComplexMatrix fourier` (*void*) *const*
`ComplexMatrix ifourier` (*void*) *const*

`ComplexDET determinant` (*void*) *const*
`ComplexDET determinant` (*int &*`info`) *const*
`ComplexDET determinant` (*int &*`info`, *double &*`rcond`) *const*

`ComplexMatrix solve` (*const Matrix &*`b`) *const*

`ComplexMatrix solve` (*const Matrix &*`b`, *int &*`info`) *const*
`ComplexMatrix solve` (*const Matrix &*`b`, *int &*`info`, *double &*`rcond`) *const*

`ComplexMatrix solve` (*const ComplexMatrix &*`b`) *const*
`ComplexMatrix solve` (*const ComplexMatrix &*`b`, *int &*`info`) *const*
`ComplexMatrix solve` (*const ComplexMatrix &*`b`, *int &*`info`, *double &*`rcond`) *const*

`ComplexColumnVector solve` (*const ComplexColumnVector &*`b`) *const*
`ComplexColumnVector solve` (*const ComplexColumnVector &*`b`, *int &*`info`) *const*
`ComplexColumnVector solve` (*const ComplexColumnVector &*`b`, *int &*`info`, *double &*`rcond`) *const*

`ComplexMatrix lssolve` (*const ComplexMatrix &*`b`) *const*
`ComplexMatrix lssolve` (*const ComplexMatrix &*`b`, *int &*`info`) *const*
`ComplexMatrix lssolve` (*const ComplexMatrix &*`b`, *int &*`info`, *int &*`rank`) *const*

`ComplexColumnVector lssolve` (*const ComplexColumnVector &*`b`) *const*
`ComplexColumnVector lssolve` (*const ComplexColumnVector &*`b`, *int &*`info`) *const*
`ComplexColumnVector lssolve` (*const ComplexColumnVector &*`b`, *int &*`info`, *int &*`rank`) *const*

`ComplexMatrix& operator +=` (*const DiagMatrix &*`a`)
`ComplexMatrix& operator -=` (*const DiagMatrix &*`a`)

`ComplexMatrix& operator +=` (*const ComplexDiagMatrix &*`a`)
`ComplexMatrix& operator -=` (*const ComplexDiagMatrix &*`a`)

`ComplexMatrix& operator +=` (*const Matrix &*`a`)
`ComplexMatrix& operator -=` (*const Matrix &*`a`)

`ComplexMatrix& operator +=` (*const ComplexMatrix &*`a`)
`ComplexMatrix& operator -=` (*const ComplexMatrix &*`a`)

`Matrix operator !` (*void*) *const*

`ComplexMatrix operator +` (*const ComplexMatrix &*`a`, *double* `s`)
`ComplexMatrix operator -` (*const ComplexMatrix &*`a`, *double* `s`)
`ComplexMatrix operator *` (*const ComplexMatrix &*`a`, *double* `s`)
`ComplexMatrix operator /` (*const ComplexMatrix &*`a`, *double* `s`)

`ComplexMatrix operator +` (*double* `s`, *const ComplexMatrix &*`a`)
`ComplexMatrix operator -` (*double* `s`, *const ComplexMatrix &*`a`)
`ComplexMatrix operator *` (*double* `s`, *const ComplexMatrix &*`a`)
`ComplexMatrix operator /` (*double* `s`, *const ComplexMatrix &*`a`)

`ComplexColumnVector operator *` (*const ComplexMatrix &*`a`, *const ColumnVector &*`b`)

`ComplexColumnVector operator *` (*const ComplexMatrix &*`a`, *const ComplexColumnVector &*`b`)

`ComplexMatrix operator +` (*const ComplexMatrix &*`a`, *const DiagMatrix &*`b`)

`ComplexMatrix operator -` (*const ComplexMatrix &*`a`, *const DiagMatrix &*`b`)
`ComplexMatrix operator *` (*const ComplexMatrix &*`a`, *const DiagMatrix &*`b`)

`ComplexMatrix operator +` (*const ComplexMatrix &*`a`, *const ComplexDiagMatrix &*`b`)
`ComplexMatrix operator -` (*const ComplexMatrix &*`a`, *const ComplexDiagMatrix &*`b`)
`ComplexMatrix operator *` (*const ComplexMatrix &*`a`, *const ComplexDiagMatrix &*`b`)

`ComplexMatrix operator +` (*const ComplexMatrix &*`a`, *const Matrix &*`b`)
`ComplexMatrix operator -` (*const ComplexMatrix &*`a`, *const Matrix &*`b`)

`ComplexMatrix operator *` (*const ComplexMatrix &*`a`, *const Matrix &*`b`)
`ComplexMatrix operator *` (*const ComplexMatrix &*`a`, *const ComplexMatrix &*`b`)

`ComplexMatrix product` (*const ComplexMatrix &*`a`, *const Matrix &*`b`)
`ComplexMatrix quotient` (*const ComplexMatrix &*`a`, *const Matrix &*`b`)

`ComplexMatrix map` (*c_c_Mapper* `f`, *const ComplexMatrix &*`a`)
`Matrix map` (*d_c_Mapper* `f`, *const ComplexMatrix &*`a`)
`void map` (*c_c_Mapper* `f`)

`Matrix all` (*void*) *const*
`Matrix any` (*void*) *const*

`ComplexMatrix cumprod` (*void*) *const*
`ComplexMatrix cumsum` (*void*) *const*
`ComplexMatrix prod` (*void*) *const*
`ComplexMatrix sum` (*void*) *const*
`ComplexMatrix sumsq` (*void*) *const*

`ComplexColumnVector diag` (*void*) *const*
`ComplexColumnVector diag` (*int* `k`) *const*

`ComplexColumnVector row_min` (*void*) *const*
`ComplexColumnVector row_min_loc` (*void*) *const*

`ComplexColumnVector row_max` (*void*) *const*
`ComplexColumnVector row_max_loc` (*void*) *const*

`ComplexRowVector column_min` (*void*) *const*
`ComplexRowVector column_min_loc` (*void*) *const*

`ComplexRowVector column_max` (*void*) *const*
`ComplexRowVector column_max_loc` (*void*) *const*

`ostream& operator <<` (*ostream &*`os`, *const ComplexMatrix &*`a`)
`istream& operator >>` (*istream &*`is`, *ComplexMatrix &*`a`)

`ComplexColumnVector` (*void*)
`ComplexColumnVector` (*int* `n`)
`ComplexColumnVector` (*int* `n`, *const Complex &*`val`)
`ComplexColumnVector` (*const ColumnVector &*`a`)

`ComplexColumnVector` (*const Array<Complex> &a*)
`ComplexColumnVector` (*const ComplexColumnVector &a*)

`ComplexColumnVector& operator =` (*const ComplexColumnVector &a*)

`int operator ==` (*const ComplexColumnVector &a*) *const*
`int operator !=` (*const ComplexColumnVector &a*) *const*

`ComplexColumnVector& insert` (*const ColumnVector &a, int r*)
`ComplexColumnVector& insert` (*const ComplexColumnVector &a, int r*)

`ComplexColumnVector& fill` (*double val*)
`ComplexColumnVector& fill` (*const Complex &val*)
`ComplexColumnVector& fill` (*double val, int r1, int r2*)
`ComplexColumnVector& fill` (*const Complex &val, int r1, int r2*)

`ComplexColumnVector stack` (*const ColumnVector &a*) *const*
`ComplexColumnVector stack` (*const ComplexColumnVector &a*) *const*

`ComplexRowVector transpose` (*void*) *const*

`ColumnVector real` (*const ComplexColumnVector &a*)
`ColumnVector imag` (*const ComplexColumnVector &a*)
`ComplexColumnVector conj` (*const ComplexColumnVector &a*)

`ComplexColumnVector extract` (*int r1, int r2*) *const*

`ComplexColumnVector& operator +=` (*const ColumnVector &a*)
`ComplexColumnVector& operator -=` (*const ColumnVector &a*)

`ComplexColumnVector& operator +=` (*const ComplexColumnVector &a*)
`ComplexColumnVector& operator -=` (*const ComplexColumnVector &a*)

`ComplexColumnVector operator +` (*const ComplexColumnVector &a, double s*)
`ComplexColumnVector operator -` (*const ComplexColumnVector &a, double s*)
`ComplexColumnVector operator *` (*const ComplexColumnVector &a, double s*)
`ComplexColumnVector operator /` (*const ComplexColumnVector &a, double s*)

`ComplexColumnVector operator +` (*double s, const ComplexColumnVector &a*)
`ComplexColumnVector operator -` (*double s, const ComplexColumnVector &a*)
`ComplexColumnVector operator *` (*double s, const ComplexColumnVector &a*)
`ComplexColumnVector operator /` (*double s, const ComplexColumnVector &a*)

`ComplexMatrix operator *` (*const ComplexColumnVector &a, const ComplexRowVector &b*)

`ComplexColumnVector operator +` (*const ComplexColumnVector &*`a`, *const ColumnVector &*`b`)
`ComplexColumnVector operator -` (*const ComplexColumnVector &*`a`, *const ColumnVector &*`b`)

`ComplexColumnVector product` (*const ComplexColumnVector &*`a`, *const ColumnVector &*`b`)
`ComplexColumnVector quotient` (*const ComplexColumnVector &*`a`, *const ColumnVector &*`b`)

`ComplexColumnVector map` (*c_c_Mapper* `f`, *const ComplexColumnVector &*`a`)
`ColumnVector map` (*d_c_Mapper* `f`, *const ComplexColumnVector &*`a`)
`void map` (*c_c_Mapper* `f`)

`Complex min` (*void*) *const*
`Complex max` (*void*) *const*

`ostream& operator <<` (*ostream &*`os`, *const ComplexColumnVector &*`a`)

`ComplexRowVector` (*void*)
`ComplexRowVector` (*int* `n`)
`ComplexRowVector` (*int* `n`, *const Complex &*`val`)
`ComplexRowVector` (*const RowVector &*`a`)
`ComplexRowVector` (*const Array<Complex> &*`a`)
`ComplexRowVector` (*const ComplexRowVector &*`a`)

`ComplexRowVector& operator =` (*const ComplexRowVector &*`a`)

`int operator ==` (*const ComplexRowVector &*`a`) *const*
`int operator !=` (*const ComplexRowVector &*`a`) *const*

`ComplexRowVector& insert` (*const RowVector &*`a`, *int* `c`)
`ComplexRowVector& insert` (*const ComplexRowVector &*`a`, *int* `c`)

`ComplexRowVector& fill` (*double* `val`)
`ComplexRowVector& fill` (*const Complex &*`val`)
`ComplexRowVector& fill` (*double* `val`, *int c1*, *int c2*)
`ComplexRowVector& fill` (*const Complex &*`val`, *int c1*, *int c2*)

`ComplexRowVector append` (*const RowVector &*`a`) *const*
`ComplexRowVector append` (*const ComplexRowVector &*`a`) *const*

`ComplexColumnVector transpose` (*void*) *const*

`RowVector real` (*const ComplexRowVector &*`a`)
`RowVector imag` (*const ComplexRowVector &*`a`)
`ComplexRowVector conj` (*const ComplexRowVector &*`a`)

`ComplexRowVector extract` (*int c1*, *int c2*) *const*

`ComplexRowVector& operator +=` (*const RowVector &*`a`)
`ComplexRowVector& operator -=` (*const RowVector &*`a`)

`ComplexRowVector& operator +=` (*const ComplexRowVector &*`a`)
`ComplexRowVector& operator -=` (*const ComplexRowVector &*`a`)

`ComplexRowVector operator +` (*const ComplexRowVector &*`a`, *double* `s`)

`ComplexRowVector operator -` (*const ComplexRowVector &*`a`, *double* `s`)
`ComplexRowVector operator *` (*const ComplexRowVector &*`a`, *double* `s`)
`ComplexRowVector operator /` (*const ComplexRowVector &*`a`, *double* `s`)

`ComplexRowVector operator +` (*double* `s`, *const ComplexRowVector &*`a`)
`ComplexRowVector operator -` (*double* `s`, *const ComplexRowVector &*`a`)
`ComplexRowVector operator *` (*double* `s`, *const ComplexRowVector &*`a`)
`ComplexRowVector operator /` (*double* `s`, *const ComplexRowVector &*`a`)

`Complex operator *` (*const ComplexRowVector &*`a`, *const ColumnVector &*`b`)

`Complex operator *` (*const ComplexRowVector &*`a`, *const ComplexColumnVector &*`b`)

`ComplexRowVector operator *` (*const ComplexRowVector &*`a`, *const ComplexMatrix &*`b`)

`ComplexRowVector operator +` (*const ComplexRowVector &*`a`, *const RowVector &*`b`)
`ComplexRowVector operator -` (*const ComplexRowVector &*`a`, *const RowVector &*`b`)

`ComplexRowVector product` (*const ComplexRowVector &*`a`, *const RowVector &*`b`)
`ComplexRowVector quotient` (*const ComplexRowVector &*`a`, *const RowVector &*`b`)

`ComplexRowVector map` (*c_c_Mapper* `f`, *const ComplexRowVector &*`a`)
`RowVector map` (*d_c_Mapper* `f`, *const ComplexRowVector &*`a`)
`void map` (*c_c_Mapper* `f`)

`Complex min` (*void*) *const*
`Complex max` (*void*) *const*

`ostream& operator <<` (*ostream &*`os`, *const ComplexRowVector &*`a`)

`ComplexDiagMatrix` (*void*)
`ComplexDiagMatrix` (*int* `n`)
`ComplexDiagMatrix` (*int* `n`, *const Complex &*`val`)
`ComplexDiagMatrix` (*int* `r`, *int* `c`)
`ComplexDiagMatrix` (*int* `r`, *int* `c`, *const Complex &*`val`)
`ComplexDiagMatrix` (*const RowVector &*`a`)
`ComplexDiagMatrix` (*const ComplexRowVector &*`a`)
`ComplexDiagMatrix` (*const ColumnVector &*`a`)
`ComplexDiagMatrix` (*const ComplexColumnVector &*`a`)
`ComplexDiagMatrix` (*const DiagMatrix &*`a`)
`ComplexDiagMatrix` (*const DiagArray<Complex> &*`a`)
`ComplexDiagMatrix` (*const ComplexDiagMatrix &*`a`)

`ComplexDiagMatrix& operator =` (*const ComplexDiagMatrix &*`a`)

`int operator ==` (*const ComplexDiagMatrix &*`a`) *const*
`int operator !=` (*const ComplexDiagMatrix &*`a`) *const*

`ComplexDiagMatrix& fill` (*double* `val`)

`ComplexDiagMatrix& fill` (*const Complex &val*)
`ComplexDiagMatrix& fill` (*double val, int beg, int end*)
`ComplexDiagMatrix& fill` (*const Complex &val, int beg, int end*)
`ComplexDiagMatrix& fill` (*const ColumnVector &a*)
`ComplexDiagMatrix& fill` (*const ComplexColumnVector &a*)
`ComplexDiagMatrix& fill` (*const RowVector &a*)
`ComplexDiagMatrix& fill` (*const ComplexRowVector &a*)
`ComplexDiagMatrix& fill` (*const ColumnVector &a, int beg*)
`ComplexDiagMatrix& fill` (*const ComplexColumnVector &a, int beg*)
`ComplexDiagMatrix& fill` (*const RowVector &a, int beg*)
`ComplexDiagMatrix& fill` (*const ComplexRowVector &a, int beg*)

`ComplexDiagMatrix transpose` (*void*) *const*

`DiagMatrix real` (*const ComplexDiagMatrix &a*)
`DiagMatrix imag` (*const ComplexDiagMatrix &a*)
`ComplexDiagMatrix conj` (*const ComplexDiagMatrix &a*)

`ComplexMatrix extract` (*int r1, int c1, int r2, int c2*) *const*

`ComplexRowVector row` (*int i*) *const*
`ComplexRowVector row` (*char *s*) *const*

`ComplexColumnVector column` (*int i*) *const*
`ComplexColumnVector column` (*char *s*) *const*

`ComplexDiagMatrix inverse` (*int &info*) *const*
`ComplexDiagMatrix inverse` (*void*) *const*

`ComplexDiagMatrix& operator +=` (*const DiagMatrix &a*)
`ComplexDiagMatrix& operator -=` (*const DiagMatrix &a*)

`ComplexDiagMatrix& operator +=` (*const ComplexDiagMatrix &a*)
`ComplexDiagMatrix& operator -=` (*const ComplexDiagMatrix &a*)

`ComplexMatrix operator +` (*const ComplexDiagMatrix &a, double s*)
`ComplexMatrix operator -` (*const ComplexDiagMatrix &a, double s*)

`ComplexMatrix operator +` (*const ComplexDiagMatrix &a, const Complex &s*)
`ComplexMatrix operator -` (*const ComplexDiagMatrix &a, const Complex &s*)

`ComplexDiagMatrix operator *` (*const ComplexDiagMatrix &a, double s*)
`ComplexDiagMatrix operator /` (*const ComplexDiagMatrix &a, double s*)

`ComplexMatrix operator +` (*double s, const ComplexDiagMatrix &a*)
`ComplexMatrix operator -` (*double s, const ComplexDiagMatrix &a*)

`ComplexMatrix operator +` (*const Complex &s, const ComplexDiagMatrix &a*)
`ComplexMatrix operator -` (*const Complex &s, const ComplexDiagMatrix &a*)

`ComplexDiagMatrix operator *` (*double s, const ComplexDiagMatrix &a*)

`ComplexColumnVector operator *` (*const ComplexDiagMatrix &*`a`, *const ColumnVector &*`b`)

`ComplexColumnVector operator *` (*const ComplexDiagMatrix &*`a`, *const ComplexColumnVector &*`b`)

`ComplexDiagMatrix operator +` (*const ComplexDiagMatrix &*`a`, *const DiagMatrix &*`b`)
`ComplexDiagMatrix operator -` (*const ComplexDiagMatrix &*`a`, *const DiagMatrix &*`b`)

`ComplexDiagMatrix product` (*const ComplexDiagMatrix &*`a`, *const DiagMatrix &*`b`)

`ComplexMatrix operator +` (*const ComplexDiagMatrix &*`a`, *const Matrix &*`b`)
`ComplexMatrix operator -` (*const ComplexDiagMatrix &*`a`, *const Matrix &*`b`)
`ComplexMatrix operator *` (*const ComplexDiagMatrix &*`a`, *const Matrix &*`b`)

`ComplexMatrix operator +` (*const ComplexDiagMatrix &*`a`, *const ComplexMatrix &*`b`)
`ComplexMatrix operator -` (*const ComplexDiagMatrix &*`a`, *const ComplexMatrix &*`b`)
`ComplexMatrix operator *` (*const ComplexDiagMatrix &*`a`, *const ComplexMatrix &*`b`)

`ComplexColumnVector diag` (*void*) *const*
`ComplexColumnVector diag` (*int* `k`) *const*

`ostream& operator <<` (*ostream &*`os`, *const ComplexDiagMatrix &*`a`)

# 5 Matrix Factorizations

AEPBALANCE (*void*)
AEPBALANCE (*const Matrix &*a, *const char* **balance_job*)
AEPBALANCE (*const AEPBALANCE &*a)

AEPBALANCE& operator = (*const AEPBALANCE &*a)

Matrix balanced_matrix (*void*) *const*
Matrix balancing_matrix (*void*) *const*

ostream& operator << (*ostream &*os, *const AEPBALANCE &*a)

ComplexAEPBALANCE (*void*)
ComplexAEPBALANCE (*const ComplexMatrix &*a, *const char* **balance_job*)
ComplexAEPBALANCE (*const ComplexAEPBALANCE &*a)

ComplexAEPBALANCE& operator = (*const ComplexAEPBALANCE &*a)

ComplexMatrix balanced_matrix (*void*) *const*
ComplexMatrix balancing_matrix (*void*) *const*

ostream& operator << (*ostream &*os, *const ComplexAEPBALANCE &*a)

DET (*void*)
DET (*const DET &*a)

DET& operator = (*const DET &*a)

int value_will_overflow (*void*) *const*
int value_will_underflow (*void*) *const*

double coefficient (*void*) *const*
int exponent (*void*) *const*
double value (*void*) *const*

ostream& operator << (*ostream &*os, *const DET &*a)

ComplexDET (*void*)
ComplexDET (*const ComplexDET &*a)

ComplexDET& operator = (*const ComplexDET &*a)

int value_will_overflow (*void*) *const*
int value_will_underflow (*void*) *const*

Complex coefficient (*void*) *const*
int exponent (*void*) *const*
Complex value (*void*) *const*

ostream& operator << (*ostream &*os, *const ComplexDET &*a)

GEPBALANCE (*void*)
GEPBALANCE (*const Matrix &*a, *const Matrix &, const char* **balance_job*)
GEPBALANCE (*const GEPBALANCE &*a)

GEPBALANCE& operator = (*const GEPBALANCE &*a)

`Matrix balanced_a_matrix` (*void*) *const*
`Matrix balanced_b_matrix` (*void*) *const*
`Matrix left_balancing_matrix` (*void*) *const*
`Matrix right_balancing_matrix` (*void*) *const*

`ostream& operator <<` (*ostream &os, const GEPBALANCE &a*)

`CHOL` (*void*)
`CHOL` (*const Matrix &a*)
`CHOL` (*const Matrix &a, int &info*)
`CHOL` (*const CHOL &a*)

`CHOL& operator =` (*const CHOL &a*)

`Matrix chol_matrix` (*void*) *const*

`ostream& operator <<` (*ostream &os, const CHOL &a*)

`ComplexCHOL` (*void*)
`ComplexCHOL` (*const ComplexMatrix &a*)
`ComplexCHOL` (*const ComplexMatrix &a, int &info*)
`ComplexCHOL` (*const ComplexCHOL &a*)

`ComplexCHOL& operator =` (*const ComplexCHOL &a*)

`ComplexMatrix chol_matrix` (*void*) *const*

`ostream& operator <<` (*ostream &os, const ComplexCHOL &a*)

`HESS` (*void*)
`HESS` (*const Matrix &a*)
`HESS` (*const Matrix&a, int &info*)
`HESS` (*const HESS &a*)

`HESS& operator =` (*const HESS &a*)

`Matrix hess_matrix` (*void*) *const*
`Matrix unitary_hess_matrix` (*void*) *const*

`ostream& operator <<` (*ostream &os, const HESS &a*)

`ComplexHESS` (*void*)
`ComplexHESS` (*const ComplexMatrix &a*)
`ComplexHESS` (*const ComplexMatrix &a, int &info*)
`ComplexHESS` (*const ComplexHESS &a*)

`ComplexHESS& operator =` (*const ComplexHESS &a*)

`ComplexMatrix hess_matrix` (*void*) *const*
`ComplexMatrix unitary_hess_matrix` (*void*) *const*

`ostream& operator <<` (*ostream &os, const ComplexHESS &a*)

`SCHUR` (*void*)
`SCHUR` (*const Matrix &a, const char *ord*)
`SCHUR` (*const Matrix &a, const char *ord, int &info*)
`SCHUR` (*const SCHUR &a, const char *ord*)

`SCHUR& operator =` (*const SCHUR &a*)

`Matrix schur_matrix` (*void*) *const*
`Matrix unitary_matrix` (*void*) *const*

`ostream& operator <<` (*ostream &os, const SCHUR &a*)

`ComplexSCHUR` (*void*)
`ComplexSCHUR` (*const ComplexMatrix &a, const char *ord*)
`ComplexSCHUR` (*const ComplexMatrix &a, const char *ord, int &info*)
`ComplexSCHUR` (*const ComplexSCHUR &a, const char *ord*)

`ComplexSCHUR& operator =` (*const ComplexSCHUR &a*)

`ComplexMatrix schur_matrix` (*void*) *const*
`ComplexMatrix unitary_matrix` (*void*) *const*

`ostream& operator <<` (*ostream &os, const ComplexSCHUR &a*)

`SVD` (*void*)
`SVD` (*const Matrix &a*)
`SVD` (*const Matrix &a, int &info*)
`SVD` (*const SVD &a*)

`SVD& operator =` (*const SVD &a*)

`DiagMatrix singular_values` (*void*) *const*
`Matrix left_singular_matrix` (*void*) *const*
`Matrix right_singular_matrix` (*void*) *const*

`ostream& operator <<` (*ostream &os, const SVD &a*)

`ComplexSVD` (*void*)
`ComplexSVD` (*const ComplexMatrix &a*)
`ComplexSVD` (*const ComplexMatrix &a, int &info*)
`ComplexSVD` (*const ComplexSVD &a*)

`ComplexSVD& operator =` (*const ComplexSVD &a*)

`DiagMatrix singular_values` (*void*) *const*
`ComplexMatrix left_singular_matrix` (*void*) *const*
`ComplexMatrix right_singular_matrix` (*void*) *const*

`ostream& operator <<` (*ostream &os, const ComplexSVD &a*)

`EIG` (*void*)
`EIG` (*const Matrix &a*)
`EIG` (*const Matrix &a, int &info*)
`EIG` (*const ComplexMatrix &a*)
`EIG` (*const ComplexMatrix &a, int &info*)
`EIG` (*const EIG &a*)

`EIG& operator =` (*const EIG &a*)

`ComplexColumnVector eigenvalues` (*void*) *const*

`ComplexMatrix eigenvectors` (*void*) *const*

`ostream& operator <<` (*ostream &os, const EIG &a*)

`LU` (*void*)
`LU` (*const Matrix &*`a`)
`LU` (*const LU &*`a`)

`LU& operator =` (*const LU &*`a`)

`Matrix L` (*void*) *const*
`Matrix U` (*void*) *const*
`Matrix P` (*void*) *const*

`ostream& operator <<` (*ostream &*`os`, *const LU &*`a`)

`ComplexLU` (*void*)
`ComplexLU` (*const ComplexMatrix &*`a`)
`ComplexLU` (*const ComplexLU &*`a`)

`ComplexLU& operator =` (*const ComplexLU &*`a`)

`ComplexMatrix L` (*void*) *const*
`ComplexMatrix U` (*void*) *const*
`Matrix P` (*void*) *const*

`ostream& operator <<` (*ostream &*`os`, *const ComplexLU &*`a`)

`QR` (*void*)
`QR` (*const Matrix &*`A`)
`QR` (*const QR &*`a`)

`QR& operator =` (*const QR &*`a`)

`Matrix Q` (*void*) *const*
`Matrix R` (*void*) *const*

`ostream& operator <<` (*ostream &*`os`, *const QR &*`a`)

`ComplexQR` (*void*)
`ComplexQR` (*const ComplexMatrix &*`A`)
`ComplexQR` (*const ComplexQR &*`a`)

`ComplexQR& operator =` (*const ComplexQR &*`a`)

`ComplexMatrix Q` (*void*) *const*
`ComplexMatrix R` (*void*) *const*

`ostream& operator <<` (*ostream &*`os`, *const ComplexQR &*`a`)

# 6 Ranges

`Range` (*void*)
`Range` (*const Range &*`r`)
`Range` (*double* `b`, *double* `l`)
`Range` (*double* `b`, *double* `l`, *double* `i`)

`double base` (*void*) *const*
`double limit` (*void*) *const*
`double inc` (*void*) *const*

`void set_base` (*double* `b`)
`void set_limit` (*double* `l`)
`void set_inc` (*double* `i`)

`int nelem` (*void*) *const*

`double min` (*void*) *const*
`double max` (*void*) *const*

`void sort` (*void*)

`ostream& operator <<` (*ostream &*`os`, *const Range &*`r`)
`istream& operator >>` (*istream &*`is`, *Range &*`r`)

`void print_range` (*void*)

# 7 Nonlinear Functions

`NLFunc` (*void*)
`NLFunc` (*const* ***`nonlinear_fcn`***)
`NLFunc` (*const* ***`nonlinear_fcn`***, *const* `jacobian_fcn`)
`NLFunc` (*const NLFunc &*`a`)

`NLFunc& operator =` (*const NLFunc &*`a`)

`nonlinear_fcn function` (*void*) *const;*

`NLFunc& set_function` (*const nonlinear_fcn* `f`)

`jacobian_fcn jacobian_function` (*void*) *const;*

`NLFunc& set_jacobian_function` (*const jacobian_fcn* `j`)

# 8 Nonlinear Equations

`NLEqn_options` (*void*)
`NLEqn_options` (*const NLEqn_options &*`opt`)

`NLEqn_options& operator =` (*const NLEqn_options &*`opt`)

`void init` (*void*)

`void copy` (*const NLEqn_options &*`opt`)

`void set_default_options` (*void*)

`void set_tolerance` (*double* `val`)

`double tolerance` (*void*)

`NLEqn` (*void*)
`NLEqn` (*const ColumnVector&, const* `NLFunc`)
`NLEqn` (*const NLEqn &*`a`)

`NLEqn& operator =` (*const NLEqn &*`a`)

`void resize` (*int* `n`)

`void set_states` (*const ColumnVector &*`x`)

`ColumnVector states` (*void*) *const*

`int size` (*void*) *const*

`ColumnVector solve` (*void*)
`ColumnVector solve` (*const ColumnVector &*`x`)

`ColumnVector solve` (*int &*`info`)
`ColumnVector solve` (*const ColumnVector &*`x`, *int &*`info`)

# 9 Optimization

## 9.1 Objective Functions

`Objective` (*void*)
`Objective` (*const* `objective_fcn`)
`Objective` (*const* `objective_fcn`, *const* `gradient_fcn`)
`Objective` (*const Objective &*`a`)

`Objective& operator =` (*const Objective &*`a`)

`objective_fcn objective_function` (*void*) *const;*

`Objective& set_objective_function` (*const* `objective_fcn`)

`gradient_fcn gradient_function` (*void*) *const;*

`Objective& set_gradient_function` (*const* `gradient_fcn`)

## 9.2 Bounds

`Bounds` (*void*)
`Bounds` (*int* `n`)
`Bounds` (*const ColumnVector* `lb`, *const ColumnVector* `ub`)
`Bounds` (*const Bounds &*`a`)

`Bounds& operator =` (*const Bounds &*`a`)

`Bounds& resize` (*int* `n`)

`double lower_bound` (*int* `index`) *const;*
`double upper_bound` (*int* `index`) *const;*

`ColumnVector lower_bounds` (*void*) *const;*
`ColumnVector upper_bounds` (*void*) *const;*

`int size` (*void*) *const;*

`Bounds& set_bound` (*int* `index`, *double* `low`, *double* `high`)

`Bounds& set_bounds` (*double* `low`, *double* `high`)
`Bounds& set_bounds` (*const ColumnVector* `lb`, *const ColumnVector* `ub`)

`Bounds& set_lower_bound` (*int* `index`, *double* `low`)
`Bounds& set_upper_bound` (*int* `index`, *double* `high`)

`Bounds& set_lower_bounds` (*double* `low`)
`Bounds& set_upper_bounds` (*double* `high`)

`Bounds& set_lower_bounds` (*const ColumnVector* `lb`)
`Bounds& set_upper_bounds` (*const ColumnVector* `ub`)

`ostream& operator <<` (*ostream &*`os`, *const Bounds &*`b`)

## 9.3 Linear Constraints

`LinConst` (*void*)
`LinConst` (*int* `nclin`, *int* `nx`)
`LinConst` (*int* `nclin_eq`, *int* `nclin_ineq`, *int* `nx`)
`LinConst` (*const ColumnVector &*`lb`, *const Matrix &*`A`, *const ColumnVector &*`ub`)
`LinConst` (*const Matrix &*`A_eq`, *const ColumnVector &*`b_eq`, *const Matrix &*`A_ineq`, *const ColumnVector &*`b_ineq`)
`LinConst` (*const LinConst &*`a`)

`LinConst& operator =` (*const LinConst &*`a`)

`LinConst& resize` (*int* `nclin`, *int* `n`)

`Matrix constraint_matrix` (*void*) *const;*

`LinConst& set_constraint_matrix` (*const Matrix &*`A`)

`Matrix eq_constraint_matrix` (*void*) *const;*
`Matrix ineq_constraint_matrix` (*void*) *const;*

`ColumnVector eq_constraint_vector` (*void*) *const;*
`ColumnVector ineq_constraint_vector` (*void*) *const;*

`ostream& operator <<` (*ostream &*`os`, *const LinConst &*`b`)

## 9.4 Nonlinear Constraints

`NLConst` (*void*)
`NLConst` (*int* `n`)
`NLConst` (*const ColumnVector* `lb`, *const NLFunc* `f`, *const ColumnVector* `ub`)
`NLConst` (*const NLConst &*`a`)

`NLConst& operator =` (*const NLConst &*`a`)

## 9.5 Quadratic Programming

`QP` (*void*)
`QP` (*const ColumnVector &*`x`, *const Matrix &*`H`)
`QP` (*const ColumnVector &*`x`, *const Matrix &*`H`, *const ColumnVector &*`c`)
`QP` (*const ColumnVector &*`x`, *const Matrix &*`H`, *const Bounds &*`b`)
`QP` (*const ColumnVector &*`x`, *const Matrix &*`H`, *const LinConst &*`lc`)
`QP` (*const ColumnVector &*`x`, *const Matrix &*`H`, *const ColumnVector &*`c`, *const Bounds &*`b`)
`QP` (*const ColumnVector &*`x`, *const Matrix &*`H`, *const ColumnVector &*`c`, *const LinConst &*`lc`)
`QP` (*const ColumnVector &*`x`, *const Matrix &*`H`, *const Bounds &*`b`, *const LinConst &*`lc`)
`QP` (*const ColumnVector &*`x`, *const Matrix &*`H`, *const ColumnVector &*`c`, *const Bounds &*`b`, *const LinConst &*`lc`)

`virtual ColumnVector minimize` (*void*)

`virtual ColumnVector minimize` (*double &objf*)
`virtual ColumnVector minimize` (*double &objf*, *int &inform*)
`virtual ColumnVector minimize` (*double &objf*, *int &inform*, *ColumnVector &lambda*) = *0;*

`virtual ColumnVector minimize` (*const ColumnVector &x*)
`virtual ColumnVector minimize` (*const ColumnVector &x*, *double &objf*)
`virtual ColumnVector minimize` (*const ColumnVector &x*, *double &objf*, *int &inform*)
`virtual ColumnVector minimize` (*const ColumnVector &x*, *double &objf*, *int &inform*, *ColumnVector &lambda*)

`ColumnVector minimize` (*double &objf*, *int &inform*, *ColumnVector &lambda*)

## 9.6 Nonlinear Programming

`NLP` (*void*)
`NLP` (*const ColumnVector &x*, *const Objective &phi*)
`NLP` (*const ColumnVector &x*, *const Objective &phi*, *const Bounds &b*)
`NLP` (*const ColumnVector &x*, *const Objective &phi*, *const Bounds &b*, *const LinConst &lc*)
`NLP` (*const ColumnVector &x*, *const Objective &phi*, *const Bounds &b*, *const LinConst &lc*, *const NLConst &nlc*)
`NLP` (*const ColumnVector &x*, *const Objective &phi*, *const LinConst &lc*)
`NLP` (*const ColumnVector &x*, *const Objective &phi*, *const LinConst &lc*, *const NLConst &nlc*)
`NLP` (*const ColumnVector &x*, *const Objective &phi*, *const NLConst &nlc*)
`NLP` (*const ColumnVector &x*, *const Objective &phi*, *const Bounds &b*, *const NLConst &nlc*)

`NLP& operator =` (*const NLP &a*)

`int size` (*void*) *const*

`ColumnVector minimize` (*void*)
`ColumnVector minimize` (*double &objf*)
`ColumnVector minimize` (*double &objf*, *int &inform*)
`ColumnVector minimize` (*double &objf*, *int &inform*, *ColumnVector &lambda*)

`ColumnVector minimize` (*const ColumnVector &x*)
`ColumnVector minimize` (*const ColumnVector &x*, *double &objf*)
`ColumnVector minimize` (*const ColumnVector &x*, *double &objf*, *int &inform*)
`ColumnVector minimize` (*const ColumnVector &x*, *double &objf*, *int &inform*, *ColumnVector &lambda*)

# 10 Quadrature

`Quad` (*integrand_fcn* `fcn`)
`Quad` (*integrand_fcn* `fcn`, *double* `abs`, *double* `rel`)

`virtual double integrate` (*void*)
`virtual double integrate` (*int &*`ier`)
`virtual double integrate` (*int &*`ier`, *int &*`neval`)
`virtual double integrate` (*int &*`ier`, *int &*`neval`, *double &*`abserr`) = *0*

`Quad_options` (*void*)
`Quad_options` (*const Quad_options &*`opt`)

`Quad_options& operator =` (*const Quad_options &*`opt`)

`void init` (*void*)

`void copy` (*const Quad_options &*`opt`)

`void set_default_options` (*void*)

`void set_absolute_tolerance` (*double* `val`)

`void set_relative_tolerance` (*double* `val`)

`double absolute_tolerance` (*void*)
`double relative_tolerance` (*void*)

`DefQuad` (*integrand_fcn* `fcn`)
`DefQuad` (*integrand_fcn* `fcn`, *double* `ll`, *double* `ul`)
`DefQuad` (*integrand_fcn* `fcn`, *double* `ll`, *double* `ul`, *double* `abs`, *double* `rel`)
`DefQuad` (*integrand_fcn* `fcn`, *double* `ll`, *double* `ul`, *const ColumnVector &*`sing`)
`DefQuad` (*integrand_fcn* `fcn`, *const ColumnVector &*`sing`, *double* `abs`, *double* `rel`)
`DefQuad` (*integrand_fcn* `fcn`, *const ColumnVector &*`sing`)
`DefQuad` (*integrand_fcn* `fcn`, *double* `ll`, *double* `ul`, *const ColumnVector &*`sing`, *double* `abs`, *double* `rel`)

`IndefQuad` (*integrand_fcn* `fcn`)
`IndefQuad` (*integrand_fcn* `fcn`, *double* `b`, *IntegralType* `t`)
`IndefQuad` (*integrand_fcn* `fcn`, *double* `b`, *IntegralType* `t`, *double* `abs`, *double* `rel`)
`IndefQuad` (*integrand_fcn* `fcn`, *double* `abs`, *double* `rel`)

## 10.1 Collocation Weights

`CollocWt` (*void*)
`CollocWt` (*int* `n`, *int* `inc_l`, *int* `inc_r`)
`CollocWt` (*int* `n`, *int* `inc_l`, *int* `inc_r`, *double* `l`, *double* `r`)
`CollocWt` (*int* `n`, *double* `a`, *double* `b`, *int* `inc_l`, *int* `inc_r`)
`CollocWt` (*int* `n`, *int* `inc_l`, *int* `inc_r`, *double* `l`, *double* `r`)
`CollocWt` (*const CollocWt&*)

`CollocWt& operator =` (*const CollocWt&*)

`CollocWt& resize` (*int* `ncol`)

`CollocWt& add_left` (*void*)
`CollocWt& add_right` (*void*)

`CollocWt& delete_left` (*void*)
`CollocWt& delete_right` (*void*)

`CollocWt& set_left` (*double* `val`)
`CollocWt& set_right` (*double* `val`)

`CollocWt& set_alpha` (*double* `val`)
`CollocWt& set_beta` (*double* `val`)

`int ncol` (*void*) *const*

`int left_included` (*void*) *const*
`int right_included` (*void*) *const*

`double left` (*void*) *const*
`double right` (*void*) *const*
`double width` (*void*) *const*

`double alpha` (*void*) *const*
`double beta` (*void*) *const*

`ColumnVector roots` (*void*)
`ColumnVector quad` (*void*)
`ColumnVector quad_weights` (*void*)

`Matrix first` (*void*)
`Matrix second` (*void*)

`ostream& operator <<` (*ostream &*`os`, *const CollocWt &*`c`)

# 11 Ordinary Differential Equations

`ODE_options` (*void*)
`ODE_options` (*const ODE_options &*`opt`)

`ODE_options& operator =` (*const ODE_options &*`opt`)

`void init` (*void*)

`void copy` (*const ODE_options &*`opt`)

`void set_default_options` (*void*)

`void set_absolute_tolerance` (*double* `val`)

`void set_initial_step_size` (*double* `val`)

`void set_maximum_step_size` (*double* `val`)

`void set_minimum_step_size` (*double* `val`)

`void set_relative_tolerance` (*double* `val`)

`double absolute_tolerance` (*void*)
`double initial_step_size` (*void*)
`double maximum_step_size` (*void*)
`double minimum_step_size` (*void*)
`double relative_tolerance` (*void*)

`ODE` (*void*)
`ODE` (*int* `n`)
`ODE` (*const ColumnVector &*`state`, *double* `time`, *const ODEFunc &*`f`)

`virtual int size` (*void*) *const*

`virtual ColumnVector state` (*void*) *const*

`virtual double time` (*void*) *const*

`virtual void force_restart` (*void*)

`virtual void initialize` (*const ColumnVector &*`x`, *double* `t`)

`virtual void set_stop_time` (*double* `t`)

`virtual void clear_stop_time` (*void*)

`virtual ColumnVector integrate` (*double* `t`)

`void integrate` (*int* `nsteps`, *double* `tstep`, *ostream &*`s`)

`Matrix integrate` (*const ColumnVector &*`tout`)
`Matrix integrate` (*const ColumnVector &*`tout`, *const ColumnVector &*`tcrit`)

# 12 Differential Algebraic Equations

`DAE` (*void*)
`DAE` (*int* `n`)
`DAE` (*const ColumnVector &*`x`, *double* `time`, *DAEFunc &*`f`)
`DAE` (*const ColumnVector &*`x`, *ColumnVector &*`xdot`, *double* `time`, *DAEFunc &*`f`)

`ColumnVector deriv` (*void*)

`virtual void initialize` (*const ColumnVector &*`x`, *double* `t`)
`virtual void initialize` (*const ColumnVector &*`x`, *ColumnVector &*`xdot`, *double* `t`)

`ColumnVector integrate` (*double* `t`)

`Matrix integrate` (*const ColumnVector &*`tout`, *Matrix &*`xdot_out`)
`Matrix integrate` (*const ColumnVector &*`tout`, *Matrix &*`xdot_out`, *const ColumnVector &*`tcrit`)

# 13 Error Handling

# 14 Installation

# 15 Bugs

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## H



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