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MATLAB Engine API for C, C++, and Fortran

Call MATLAB<sup>®</sup> from C/C++ and Fortran programs  
Engine applications are standalone C/C++ or Fortran programs that allow you to call MATLAB from your own programs, using MATLAB as a computation engine. Engine applications require an installed version of MATLAB; you cannot run the MATLAB engine on a machine that only has the MATLAB Runtime.

C and Fortran Engine Library Functions

|                                |                                                       |
|--------------------------------|-------------------------------------------------------|
| engOpen (C and Fortran)        | Start MATLAB engine session                           |
| engOpenSingle (C)              | Start MATLAB engine session for single, nonshared use |
| engClose (C and Fortran)       | Quit MATLAB engine session                            |
| engIn (C)                      | Type for MATLAB engine                                |
| engEvalString (C and Fortran)  | Evaluate expression in string                         |
| engGetVariable (C and Fortran) | Copy variable from MATLAB engine workspace            |
| engSetVariable (C and Fortran) | Put variable into MATLAB engine workspace             |
| engSetVisible (C)              | Determine visibility of MATLAB engine session         |
| engSetVisible (C)              | Show or hide MATLAB engine session                    |
| engGetBuffer (C and Fortran)   | Specify buffer for MATLAB output                      |

Functions

|    |                                                      |
|----|------------------------------------------------------|
| mx | Build MEX function from C/C++ or Fortran source code |
|----|------------------------------------------------------|

Examples and How To

- Call MATLAB Functions from C/C++ Applications
- Call MATLAB Functions from Fortran Applications
- Build Windows Engine Application
- Run Windows Engine Application
- Build Linux Engine Application
- Run Linux Engine Application
- Attach to Existing MATLAB Sessions

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- Set Run-Time Library Path on Windows Systems
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Related Information

- C/C++ Matrix Library API
- Fortran Matrix Library API
- MATLAB COM Automation Server
- Supported and Compatible Compilers
- MATLAB Engine for Python

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EngOpen (C and Fortran)

C Syntax

```
#include "engine.h"
Engine *engOpen(const char *startcd);
```

Fortran Syntax

```
mpointer engOpen(startcd)
character(*) startcd
```

Arguments

startcd
String to start the MATLAB® process. On Windows® systems, the startcd string must be NULL.

Returns

Pointer to an engine handle, or NULL if the open fails.

Description

This routine allows you to start a MATLAB process for using MATLAB as a computational engine.
engOpen starts a MATLAB process using the command specified in the string startcd, establishes a connection, and returns an engine pointer.
On UNIX® systems, if startcd is NULL or the empty string, engOpen starts a MATLAB process on the current host using the command matlab. If startcd is a hostname, engOpen starts a MATLAB process on the designated host by embedding the specified hostname string into the larger string
"rsh hostname \"/B&A/csh -c 'setenv DISPLAY\
hostname-B; matlab\""

If startcd is any other string (has white space in it, or nonalphanumeric characters), MATLAB executes the string literally.

On UNIX systems, engOpen performs the following steps:

- 1. Creates two pipes.
- 2. Forks a new process. Sets up the pipes to pass stdin and stdout from MATLAB (parent) software to two file descriptors in the engine program (child).
- 3. Executes a command to run MATLAB software (rsh for remote execution).

On Windows systems, engOpen opens a COM channel to MATLAB. The MATLAB software you registered during installation starts. If you did not register during installation, enter the following command at the MATLAB prompt:

```
matlab -regserver
```

See MATLAB COM Integration for additional details.

Examples

See the following examples in actlabroot\extern\examples\eng\_mat.

- engdemo.c for a C example on UNIX operating systems.
- engcintdemo.c for a C example on Microsoft® Windows operating systems.
- fengdemo.f for a Fortran example.

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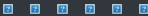


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## engineOpenSingleUse (C)

C Syntax

```
#include "engine.h"
Engine *engineOpenSingleUse(const char *startcmd, void *dcom,
int *retstatus);
```

Arguments

startcmd

String to start MATLAB® process. On Microsoft® Windows® systems, the startcmd string must be NULL.

dcom

Reserved for future use; must be NULL.

retstatus

Return status; possible cause of failure.

Returns

Microsoft Windows Operating Systems Only

Pointer to an engine handle, or NULL if the open fails.

UNIX Operating Systems

Not supported on UNIX® systems.

Description

This routine allows you to start multiple MATLAB processes using MATLAB as a computational engine.

engineOpenSingleUse starts a MATLAB process, establishes a connection, and returns a unique engine identifier, or NULL if the open fails. Each call to engineOpenSingleUse starts a new MATLAB process.

engineOpenSingleUse opens a COM channel to MATLAB. This starts the MATLAB software you registered during installation. If you did not register during installation, enter the following command at the MATLAB prompt:

```
matlab -ngserver
```

engineOpenSingleUse allows single-use instances of an engine server. engineOpenSingleUse differs from engineOpen, which allows multiple applications to use the same engine server.

See [MATLAB COM integration](#) for additional details.

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[https://www.mathworks.com/help/releases/R2025a/matlab/engref/engineopeningleuse.html\[3/2/2021 1:45:38 PM\]](https://www.mathworks.com/help/releases/R2025a/matlab/engref/engineopeningleuse.html[3/2/2021 1:45:38 PM])



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engClose (C and Fortran)

C Syntax

```
#include "engine.h"
int engClose(engine *ep);
```

Fortran Syntax

```
integer*4 engClose(ep)
call pointer ep
```

Arguments

ep  
Engine pointer

Returns

0 on success, and 1 otherwise. Possible failure includes attempting to terminate an already-terminated MATLAB® engine session.

Description

This routine sends a quit command to the MATLAB engine session and closes the connection.

Examples

See the following examples in `matlabroot/extern/examples/eng_mat`.

- `engdemo.c` for a C example on UNIX® operating systems.
- `engCdemo.c` for a C example on Microsoft® Windows® operating systems.
- `engdemo.f` for a Fortran example.

See Also

[engOpen](#)

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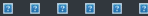
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Engine (C)

Description

A handle to a MATLAB® engine object.  
Engine is a C language opaque type.  
You can call MATLAB software as a computational engine by writing C and Fortran programs that use the MATLAB engine library. Engine is the link between your program and the separate MATLAB engine process.  
The header file containing this type is:  
#include "engine.h"

Examples

See the following examples in `actlabroot/extern/examples/eng_ext`.  
• `engdemo.c` shows how to call the MATLAB engine functions from a C program.  
• `engindemo.c` show how to call the MATLAB engine functions from a C program for Windows® systems.  
• `Fengdemo.f` shows how to call the MATLAB engine functions from a Fortran program.

See Also

[engOpen](#)

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engEvalString (C and Fortran)

C Syntax

```
#include "engine.h"
int engEvalString(engine *ep, const char *string);
```

Fortran Syntax

```
integer*4 engEvalString(ep, string)
muPointer ep
character(*) string
```

Arguments

- ep  
Engine pointer
- string  
String to execute

Returns

1 if the engine session is no longer running or the engine pointer is invalid or NULL. Otherwise, returns 0 even if the MATLAB® engine session cannot evaluate the command.

Description

engEvalString evaluates the expression contained in string for the MATLAB engine session, ep, previously started by engOpen.

UNIX Operating Systems

On UNIX® systems, engEvalString sends commands to the MATLAB workspace by writing down a pipe connected to the MATLAB `strfx` process. MATLAB reads back from `stdout` any output resulting from the command that ordinarily appears on the screen, into the buffer defined by `engOutputBuffer`.

To turn off output buffering in C, use:

```
engOutputBuffer(ep, NULL, 0);
```

To turn off output buffering in Fortran, use:

```
engOutputBuffer(ep, '')
```

Microsoft Windows Operating Systems

On a Windows® system, engEvalString communicates with MATLAB software using a Component Object Model (COM) interface.

Examples

See the following examples in `rootlabroot/extern/examples/eng_mat`.

- `engdemo.c` for a C example on UNIX operating systems.
- `engdemo.c` for a C example on Microsoft® Windows operating systems.
- `fortdemo.f` for a Fortran example.

See Also

engOpen, engOutputBuffer

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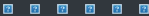


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engGetVariable (C and Fortran)

C Syntax

```
#include "engine.h"
 mxArray *engGetVariable(engine *ep, const char *name);
```

Fortran Syntax

```
muPointer engGetVariable(ep, name)
muPointer ep
character(*) name
```

Arguments

- ep
Engine pointer
- name
Name of mxArray to get from MATLAB® workspace

Returns

Pointer to a newly allocated mxArray structure, or NULL if the attempt fails. engGetVariable fails if the named variable does not exist.

Description

engGetVariable reads the named mxArray from the MATLAB engine session associated with ep. The limit for the size of data transferred is 2 GB. Use muDestroyArray to destroy the mxArray created by this routine when you are finished with it.

Examples

- See the following examples in `actlabroot/extern/examples/eng_mat`:
- `engdemo.c` for a C example on UNIX® operating systems.
  - `engdemo.c` for a C example on Microsoft® Windows® operating systems.

See Also

engPutVariable, muDestroyArray

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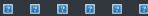


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engPutVariable (C and Fortran)

C Syntax

```
#include "engine.h"
int engPutVariable(engine *ep, const char *name, const mxArray
    *pa);
```

Fortran Syntax

```
Integer*4 engPutVariable(ep, name, pa)
mupointer ep, pa
character(*) name
```

Arguments

- ep Engine pointer
- name Name of mxArray in the engine workspace
- pa mxArray pointer

Returns

0 if successful and 1 if an error occurs.

Description

engPutVariable writes mxArray pa to the engine ep, giving it the variable name name. If the mxArray does not exist in the workspace, the function creates it. If an mxArray with the same name exists in the workspace, the function replaces the existing mxArray with the new mxArray. The limit for the size of data transferred is 2 GB.

Do not use MATLAB® function names for variable names. Common variable names that conflict with function names include `1`, `j`, `mode`, `char`, `size`, or `path`. To determine whether a particular name is associated with a MATLAB function, use the `which` function. The engine application owns the original mxArray and is responsible for freeing its memory. Although the engPutVariable function sends a copy of the mxArray to the MATLAB workspace, the engine application does not need to account for or free memory for the copy.

Examples

- See the following examples in `matlabroot/extern/examples/eng_ext`.
- `engdemo.c` for a C example on UNIX® operating systems.
  - `engLdemo.c` for a C example on Microsoft® Windows® operating systems.

See Also

engGetVariable

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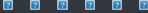


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engSetVisible(C)

C Syntax

```
#include "engine.h"
int engSetVisible(engine *ep, bool *value);
```

Arguments

- ep
Engine pointer
- value
Pointer to value returned from engSetVisible

Returns

Microsoft Windows Operating Systems Only
0 on success, and 1 otherwise.

Description

engSetVisible returns the current visibility setting for MATLAB® engine session, ep. A visible engine session runs in a window on the Windows® desktop, thus making the engine available for user interaction. MATLAB removes an invisible session from the desktop.

Examples

The following code opens engine session ep and disables its visibility.

```
Engine *ep;
bool vis;

ep = engOpen(NULL);
engSetVisible(ep, 0);
```

To determine the current visibility setting, use:
engSetVisible(ep, &vis);

See Also

engSetVisible

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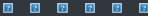


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engSetVisible(C)

C Syntax

```
#include "engine.h"
int engSetVisible(engine *ep, bool value);
```

Arguments

- ep Engine pointer
- value Value to set the Visible property to. Set value to 1 to make the engine window visible, or to 0 to make it invisible.

Returns

Microsoft Windows Operating Systems Only  
0 on success, and 1 otherwise.

Description

engSetVisible makes the window for the MATLAB® engine session, ep, either visible or invisible on the Windows® desktop. You can use this function to enable or disable user interaction with the MATLAB engine session.

Examples

The following code opens engine session ep and disables its visibility.

```
Engine *ep;
bool vis;

ep = engOpen(NULL);
engSetVisible(ep, 0);
```

To determine the current visibility setting, use:

```
engSetVisible(ep, &vis);
```

See Also

engSetVisible

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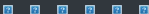


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engOutputBuffer (C and Fortran)

C Syntax

```
#include "engine.h"
int engOutputBuffer(engine *ep, char *p, int n);
```

Fortran Syntax

```
integer*4 engOutputBuffer(ep, p)
nullpointer ep
character*n p
```

Arguments

- ep Engine pointer
- p Pointer to character buffer
- n Length of buffer p

Returns

1 if you pass it a NULL engine pointer. Otherwise, returns 0.

Description

engOutputBuffer defines a character buffer for engEvalString to return any output that ordinarily appears on the screen. The default behavior of engEvalString is to discard any standard output caused by the command it is executing. A call to engOutputBuffer with a buffer of nonzero length tells any subsequent calls to engEvalString to save output in the character buffer pointed to by p. To turn off output buffering in C, use: engOutputBuffer(ep, NULL, 0); To turn off output buffering in Fortran, use: engOutputBuffer(ep, '')

Note The buffer returned by engEvalString is not NULL terminated.

Examples

- See the following examples in `matlabroot/extern/examples/eng_mat`.
- engdemo.c for a C example on UNIX® operating systems.
  - engLdemo.c for a C example on Microsoft® Windows® operating systems.
  - Fengdemo.f for a Fortran example.

See Also

engOpen, engEvalString

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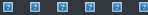
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### Syntax

```
mex filenames
mex option1 ... optionN filenames

mex -setup lang
```

collapse all in page

### Description

`mex` *filenames* compiles and links one or more C, C++, or Fortran source files into a binary MEX file, callable from MATLAB®. *Filenames* specify the source files. Also builds executable files for standalone MATLAB engine and MAT-file applications. MATLAB automatically selects a compiler, if installed, based on the language of the *filenames* arguments.

`mex` *option1* ... *optionN* *filenames* builds with the specified build options. The *option1* ... *optionN* arguments supplement or override the default `mex` build configuration.

`mex` -setup *lang* selects a compiler for the given *lang*. Use this option when you want to change the default compiler for the given language.

example

example

### Examples

collapse all

#### ▼Build C MEX File

Build a single C program, `yprime.c`, into a MEX file.

Each example is based on MEX examples in the `mexlabroot\extern\examples` subfolders. To build the example code, copy the source file to a writable folder on your path, such as `c:\work`. Set the current folder to `c:\work`.

```
[s,msg,msgId] = mkdir('c:\work');
if (isempty(msgId))
    mkdir('c:\work')
end
cd c:\work
```

Copy the source code, `yprime.c`.

```
copyfile(fullfile(matlabroot,'extern','examples','mex','yprime.c'),',','f')
```

Build the MEX file.

```
mex yprime.c
```

Building with "Microsoft Visual C++ 2010 (C)".  
MEX completed successfully.

The output displays information specific to your compiler.

Test:

```
T=1;
Y=2.4;
yprime(T,Y)
```

```
ans =
    2.0000    8.9585    4.0000   -1.8947
```

#### ▼Display Detailed Build and Troubleshooting Information

To display the compile and link commands and other information useful for troubleshooting, use verbose mode.

```
mex -v -compatibleArrayDims yprime.c
```

The output displays information specific to your platform and compiler.

#### ▼Override Default Compiler Switch Option

Build the `yprime.c` MEX file by appending the value `-Wall` to the existing compiler flag. Because the value includes a space character, you must delimitate the string; the character you use depends on the platform.

At the MATLAB prompt, use MATLAB single quotes (').

```
mex -v $COMPILEFLAGS-$COMPILEFLAGS -Wall' yprime.c
```

At the Windows® Command Prompt, use double quotes (").

```
mex -v $COMPILEFLAGS-$COMPILEFLAGS -Wall" yprime.c
```

At the shell command line on Mac and Linux®, use single quotes (').

```
mex -v $CFLAGS-$CFLAGS -Wall' yprime.c
```

#### ▼Build MEX File from Multiple Source Files

The MEX file example, `fulltoSparse`, consists of two Fortran source files, `loadSparse.F` and `fulltoSparse.F`.

To run this example, you need a supported Fortran compiler installed on your system.

Copy the source files to the current folder.

```
copyfile(fullfile(matlabroot,'extern','examples','refbook','loadSparse.F'),',','f')
copyfile(fullfile(matlabroot,'extern','examples','refbook','fulltoSparse.F'),',','f')
```

Build the `fulltoSparse` MEX file.

```
mex -largeArrayDims fulltoSparse.F loadSparse.F
```

The MEX file name is `fulltoSparse` because `fulltoSparse.F` is the first file on the command line.

Test:

```
full = eye(5);
spar = fulltoSparse(full)
```

```
spar =
 (1,1)    1
 (2,2)    1
 (3,3)    1
 (4,4)    1
 (5,5)    1
```

#### ▼Preview Build Commands

To preview the build command details without executing the commands, use the `-n` option.

```
mex -n yprime.c
```

The output displays information specific to your platform and compiler.

#### ▼Create and Link to Separate Object Files

You can link to object files that you compile separately from your source MEX files.

The MEX file example, `fulltoSparse`, consists of two Fortran source files, `loadSparse.F` and `fulltoSparse.F`. The `fulltoSparse` file is the gateway routine (contains the `mexFunction` subroutine) and `loadSparse` contains the computational routine.

To run this example, you need a supported Fortran compiler installed on your system.

Copy the computational subroutine to your current folder.

```
copyfile(fullfile(matlabroot,'extern','examples','refbook','loadSparse.F'),',','f')
```

Compile the subroutine and place the object file in a separate folder, `c:\objfiles`.

```
mkdir c:\objfiles
mex -largeArrayDims -c -outdir c:\objfiles loadSparse.F
```

Copy the gateway subroutine to your current folder. Compile and link with the `loadSparse` object file.

```
copyfile(fullfile(matlabroot,'extern','examples','refbook','fulltoSparse.F'),',','f')
mex -largeArrayDims fulltoSparse.F c:\objfiles\loadSparse.obj
```

#### ▼Specify Path to Include File

To specify the path to include the MATLAB LAPACK library subroutines for handling complex number routines, use the `-I` option. To use these subroutines, your MEX file must access the header file, `fort.h`.

Copy the `mexridivideComplex.c` example to the current folder.

```
copyFile(fullfile(matlabroot,'extern','examples','refbook','mexridivideComplex.c'),','f')
```

Create the `-I` argument by concatenating `'I'` with the path to `fort.h` file.

```
lpath = ['-I' fullfile(matlabroot,'extern','examples','refbook')];
```

Create variables for the names and paths to the LAPACK library file and the file, `fort.c`, containing the complex number handling routines.

```
lapacklib = fullfile(matlabroot,'extern','lib',computer('arch'),'microsoft','libmwlpack.lib');  
fortFile = fullfile(matlabroot,'extern','examples','refbook','fort.c');
```

Build the MEX file.

```
mex('-v','-largeArrayDims',lpath,'mexridivideComplex.c',fortFile,lapacklib)
```

▼Specify Path to Library File

Build the `mexridivide.c` example on a Windows platform using the `-L` and `-l` options to specify the `libmwlpack.lib` library. The library file is located in the folder, `matlabroot\extern\lib\arch\microsoft`.

Copy the `mexridivide.c` example to the current folder.

```
copyFile(fullfile(matlabroot,'extern','examples','refbook','mexridivide.c'),','f')
```

Capture the value of `matlabroot`.

```
matlabroot
```

```
ans =
```

```
C:\Program Files\MATLAB\R2014a
```

Capture the value of `arch`.

```
computer('arch')
```

```
ans =
```

```
win64
```

To build the MEX file, copy the values of `matlabroot` and `arch` into the `mex` command, as shown in the following statement.

```
mex -largeArrayDims '-L:C:\Program Files\MATLAB\R2014a\extern\lib\win64\microsoft\...',  
libmwlpack mexridivide.c
```

You must use the `'` characters because `Program Files` in the path includes a space.

▼Define Directive

Define the character to use between strings in a matrix.

The MATLAB example, `mxcreatecharmatrixfroestr.c`, uses a `#define` symbol, `SPACE_PADDING`, to determine what character to use between strings in a matrix. To set the value, build the MEX file with the `-D` option.

Copy the `mxcreatecharmatrixfroestr.c` example to the current folder.

```
copyFile(fullfile(matlabroot,'extern','examples','me','mxcreatecharmatrixfroestr.c'),','f')
```

Set the `SPACE_PADDING` directive to add a space between strings.

```
mex mxcreatecharmatrixfroestr.c -DSPACE_PADDING
```

▼Build Engine Application

Copy the `engindemo.c` engine example to the current folder.

```
copyFile(fullfile(matlabroot,'extern','examples','eng_mex','engindemo.c'),','f')
```

```
mex -client engine engindemo.c
```

Run the example.

```
engindemo
```

▼Select C Compiler

```
mex -setup
```

MATLAB displays the options for your version and system based on the list of [Supported and Compatible Compilers](#).

Related Examples

- Table of MEX File Source Code Files

[collapse all](#)

Input Arguments

▼**fileNamees** — One or more file names  
string

One or more file names, including name and file extension, specified as a string. If the file is not in the current folder, specify the full path to the file. File names can be any combination of:

- C, C++, or Fortran language source files
- Simulink® S-function files
- object files
- library files

The first source code file listed in **fileNamees** is the name of the binary MEX file. To override this naming convention, use the `'-output'` option.

**Data Types:** char

▼**optlist**, ... **option** — One or more build options  
strings corresponding to valid option flags

One or more build options, specified as one of these values. Options can appear in any order on any platform, except where indicated.

| Option                                                                                       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>@refFile</code>                                                                        | Uses Windows RSP file. An RSP file is a text file containing command-line options.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <code>-c</code>                                                                              | Compiles an object file only. Does not build a binary MEX file.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <code>-client engine</code>                                                                  | Build engine application.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <code>-compatibleArrayDims</code><br>(Default)                                               | Links with the specified MATLAB array-handling API. <ul style="list-style-type: none"><li><code>-compatibleArrayDims</code> — Uses the MATLAB Version 7.2 array-handling API, which limits arrays to <math>2^{31}-1</math> elements. Default option.</li><li><code>-largeArrayDims</code> — Uses the MATLAB large array-handling API. This API handles arrays with more than <math>2^{31}-1</math> elements. Must use this option when calling LAPACK or BLAS functions.</li></ul>                                                                                                                                                                                                                                                                                                                                                                                           |
| <code>-largeArrayDims</code>                                                                 | In verbose mode ( <code>-v</code> option), if you do not specify either the <code>-compatibleArrayDims</code> or the <code>-largeArrayDims</code> option, MATLAB displays a message showing the default option.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <code>-symbolName</code><br><code>-symbolName:symbolValue</code><br><code>-symbolName</code> | The <code>-D</code> options define C preprocessor macros. Equivalent to the following in the source file: <ul style="list-style-type: none"><li><code>#define symbolName</code></li><li><code>#define symbolName:symbolValue</code></li></ul> The <code>-U</code> option removes any initial definition of the C preprocessor macro <code>symbolName</code> . Inverse of the <code>-D</code> option.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                                                              | Do not add a space between <code>D</code> or <code>U</code> and <code>symbolName</code> . Do not add spaces around the <code>#</code> sign.<br>Example: <a href="#">Define Directive</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <code>-f filePath</code>                                                                     | To build engine applications, use the <code>-client engine</code> option.<br>Specifies name and location of the <code>mex</code> configuration file. Overrides the default compiler selection. For information about using a non-default compiler, see <a href="#">Change Default Compiler</a> . <code>filePath</code> is the name and full path of the configuration file, specified as a string.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <code>-f</code>                                                                              | Adds symbolic information and disables optimizing built object code. Use for debugging. To debug with optimization, add the <code>-D</code> option.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <code>-fInclude</code>                                                                       | Displays help for <code>mex</code> . Use from an operating system prompt.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <code>-IpathName</code>                                                                      | Adds <code>pathName</code> to the list of folders to search for <code>#include</code> files.<br>Do not add a space between <code>I</code> and <code>pathName</code> .<br>Example: <a href="#">Specify Path to Include File</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <code>-l libName</code><br><code>-l libFolder -l libName</code>                              | Links with object library <code>libName</code> in optional <code>libFolder</code> .<br>MATLAB expands <code>libName</code> to: <ul style="list-style-type: none"><li><code>( libName.lib or libName.lib — Windows systems</code></li><li><code>libName.dylib — Mac systems</code></li><li><code>libName.so — Linux systems</code></li></ul> If used, the <code>-L</code> option must precede the <code>-l</code> option. When you use the <code>-l</code> option on Linux or Mac systems, you also must set the runtime library path, as explained in <a href="#">Setting Run-Time Library Path</a> .<br>Do not add a space between <code>l</code> and <code>libName</code> or between <code>L</code> and <code>libFolder</code> .<br>Specify the <code>-l</code> option with the lowercase letter <code>L</code> .<br>Example: <a href="#">Specify Path to Library File</a> |
| <code>-largeArrayDims</code><br><code>-compatibleArrayDims</code><br>(Default)               | Links with the specified MATLAB array-handling API. <ul style="list-style-type: none"><li><code>-compatibleArrayDims</code> — Uses the MATLAB Version 7.2 array-handling API, which limits arrays to <math>2^{31}-1</math> elements. Default option.</li><li><code>-largeArrayDims</code> — Uses the MATLAB large array-handling API. This API handles arrays with more than <math>2^{31}-1</math> elements. Must use this option when calling LAPACK or BLAS functions.</li></ul>                                                                                                                                                                                                                                                                                                                                                                                           |
| <code>-v</code>                                                                              | In verbose mode ( <code>-v</code> option), if you do not specify either the <code>-compatibleArrayDims</code> or the <code>-largeArrayDims</code> option, MATLAB displays a message showing the default option.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <code>-x</code>                                                                              | Displays, but does not execute, commands that <code>mex</code> would execute.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <code>-O</code>                                                                              | Example: <a href="#">Preview Build Commands</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <code>-O</code>                                                                              | Optimizes the object code. Use this option to compile with optimization.<br>Optimization is enabled by default. Optimization is disabled when the <code>-g</code> option appears without the <code>-O</code> option.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <code>-outdir dirName</code>                                                                 | Specify this option with the capital letter <code>O</code> .<br>Places all output files in folder <code>dirName</code> .<br>Example: <a href="#">Create and Link to Separate Object File</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <code>-output: fileName</code>                                                               | Overrides the default MEX file naming mechanism. Creates binary MEX file named <code>fileName</code> with the appropriate MEX file extension.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <code>-setup: lang</code>                                                                    | Change the default compiler to build Lang language MEX files. When you use this option, all other command-line options are ignored.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <code>-silent</code>                                                                         | Suppresses informational messages. The <code>mex</code> function still reports errors and warnings, even when you specify <code>-silent</code> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <code>-UsymbolName</code>                                                                    | Removes any initial definition of the C preprocessor macro <code>symbolName</code> . Inverse of the <code>-D</code> option.)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                                                              | Do not add a space between <code>U</code> and <code>symbolName</code> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <code>-v</code>                                                                              | Builds in verbose mode. Displays values for internal variables after all command-line arguments are considered. Displays each compile and link step fully evaluated. Use for troubleshooting compiler setup problems.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

|                               |                                                                                                                                         |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
|                               | Example: <a href="#">Display Detailed Build and Troubleshooting Information</a>                                                         |
| <code>varname=varvalue</code> | Overrides default setting for variable <code>varname</code> . This option is processed after all command-line arguments are considered. |
|                               | Example: <a href="#">Override Default Compiler Switch Option</a> .                                                                      |

▼ **Lang** — Language

C (default) | C++ | CPP | Fortran

Language, specified as one of these values.

|            |                            |
|------------|----------------------------|
| C          | C compiler, including C++. |
| C++ or CPP | C++ compilers.             |
| Fortran    | Fortran compiler.          |

**More About**

[expand all](#)

▼ **Tips**

- You can run mex from:
  - MATLAB Command Window
  - Windows system prompt
  - Mac Terminal
  - Linux shell
- For command-line usage outside of MATLAB, the mex program is located in the folder specified by `[matlabroot 'bin']`.
- The MEX file has a platform-dependent extension. You can place binary MEX files for different platforms in the same folder.

**MEX-File Platform-Dependent Extension**

| Platform                    | Binary MEX-File Extension |
|-----------------------------|---------------------------|
| Linux (64-bit)              | <code>mex64</code>        |
| Apple Mac (64-bit)          | <code>mexmac64</code>     |
| Microsoft® Windows (32-bit) | <code>mexw32</code>       |
| Windows (64-bit)            | <code>mexw64</code>       |

- To identify the MEX file extension, use the `mexext` function.
- To use mex to build executable files for standalone MATLAB engine and MAT-file applications, use the `-client` engine option.
- [Build MEX File](#)
- [Change Default Compiler](#)
- [Troubleshoot MEX Files](#)
- [Supported and Compatible Compilers](#)

**See Also**

[C/C++ Matrix Library API](#) | [clear](#) | [computer](#) | [dlmex](#) | [Fortran Matrix Library API](#) | [lsmex](#) | [loadlibrary](#) | [mex\\_getCompilerConfigurations](#) | [mexext](#) | [pcode](#) | [prefdir](#) | [system](#)

**Introduced before R2006a**

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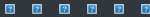
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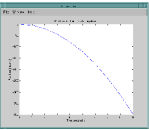
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Call MATLAB Functions from C/C++ Applications

The program engdemo.c, in the `root\labroot\extern\examples\eng_mat` folder, illustrates how to call the engine functions from a standalone C program. For the Microsoft® Windows® version of this program, see `engdemo.c`. To see `engdemo.c`, [open this file](#) in MATLAB® Editor. To see the Windows version `engdemo.c`, [open this file. There is a C++ version of `engdemo` in the `root\labroot\extern\examples\eng\_mat` folder. To see `engdemo.cpp`, \[open this file. The first part of this program starts MATLAB and sends it data. MATLAB analyzes the data and plots the results.\]\(#\)](#)



The program continues with:  
Press Return to continue

Pressing **Return** continues the program:  
Done for Part I.  
Enter a MATLAB command to evaluate. This command should create a variable `x`. This program will then determine what kind of variable you created.  
For example: `x = 1:5`

Entering `x = 17.5` continues the program execution.  
`x = 17.5`  
`x =`  
`17.5000`

Retrieving `x`...  
`x` is class double  
Done!

Finally, the program frees memory, closes the MATLAB engine, and exits.

Related Examples

- Build Windows Engine Application
- Build Linux Engine Application

More About

- Build Engine Applications with IDE

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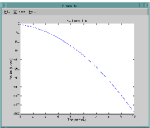
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Call MATLAB Functions from Fortran Applications

The program `fengdemo.F`, in the `matlabroot/extern/examples/eng_out` folder, illustrates how to call the engine functions from a standalone Fortran program. To see the code, [open this file](#). Executing this program starts MATLAB®, sends it data, and plots the results.



The program continues with:  
Type 0 <returns> to Exit  
Type 1 <returns> to continue

Entering 1 at the prompt continues the program execution:

```
1
MATLAB computed the following distances:
time(s) distance(m)
1.00 -4.39
2.00 -19.6
3.00 -44.1
4.00 -78.4
5.00 -123.
6.00 -176.
7.00 -246.
8.00 -314.
9.00 -397.
10.0 -499.
```

Finally, the program frees memory, closes the MATLAB engine, and exits.

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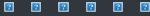


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Build Windows Engine Application

This example shows how to verify the build process on Windows® platforms using the C example, engulndemo.c.

Start MATLAB® as a user with administrator privileges. Based on your User Account Control (UAC) settings, you might need to right-click the MATLAB icon and select **Run as administrator**. If that option is not available, contact your system administrator.

Register MATLAB as a COM server.

```
!matlab -regserver
```

MATLAB displays a second, minimized command window. Close that window.

Verify your current folder is writable and copy the example.

```
copyFile(fullfile(matlabroot,'extern','examples','eng_mat','engulndemo.c'), '.', 'f')
```

Build the application.

```
 mex -v -c -client engine engulndemo.c
```

Build Standalone Application with MinGW Compiler

If you have installed one of the professional editions of the Microsoft® Visual Studio® compiler and want to build with the MinGW compiler, use the following command to override the default Microsoft compiler.

```
 mex -v -c -client engine -f %matlabroot%\bin\win64\msxopts\mingw64.exe engulndemo.c
```

If the only compiler on your system is the MinGW compiler, your build command is:

```
 mex -v -c -client engine engulndemo.c
```

See Also

mex

Related Examples

- Call MATLAB Functions from C/C++ Applications
- Run Windows Engine Application

More About

- Register MATLAB as a COM Server

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Run Windows Engine Application

This example shows how to run the C example, `engxindemo.c`, from the Windows® system prompt. You need to know the value of `matlabroot` (the folder where MATLAB® is installed) and the value returned by the MATLAB `computer('arch')` command (`arch`). Set the run-time library path by modifying the system `PATH` variable.

```
set PATH=matlabroot\bin\arch;%PATH%
```

Make sure that you include the `;` path terminator character. Run the example. The `engxindemo` application must be on your system path.

```
engxindemo
```

MATLAB Starts and displays the results. Click **OK** in the MATLAB whos window to close the application.

See Also

`computer` | `matlabroot`

Related Examples

- Build Windows Engine Application
- Call MATLAB Functions from C/C++ Applications

More About

- Set Run-Time Library Path on Windows Systems

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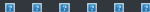


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Build Linux Engine Application

This example shows how to verify the build process on a Linux® platform using the C example, engdemo.c.

Open MATLAB®.

Verify your current folder is writable and copy the example.

```
copyFile(fullfile(matlabroot,'extern','examples','eng_mat','engdemo.c'), '.', 'f')
```

Build the application.

```
mex -v -c client engine engdemo.c
```

See Also

mex

Related Examples

- Call MATLAB Functions from C/C++ Applications
- Run Linux Engine Application

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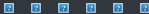
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Run Linux Engine Application

This example shows how to run the C example, engdemo.c, from the Linux® system prompt. You need to know the value of MATLABROOT, the folder where MATLAB® is installed.

Set the run-time library path:

```
setenv LD_LIBRARY_PATH MATLABROOT/bin/glnxa64:MATLABROOT/sys/os/glnxa64
```

This command replaces the value, if any, in LD\_LIBRARY\_PATH.

Set the path:

```
setenv PATH MATLABROOT/bin:PATH
```

Make sure that you include the : path terminator character.

Run the example. The engdemo application must be on your system path.

```
./engdemo
```

MATLAB starts and displays a figure.

Press Return to close the figure.

Create variable X, for example:

```
X = 'hello'
```

MATLAB displays the results and closes.

Related Examples

- Build Linux Engine Application
- Call MATLAB Functions from C/C++ Applications

More About

- Set Run-Time Library Path on Mac and Linux Systems

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Attach to Existing MATLAB Sessions

This example shows how to attach an engine program to a MATLAB® session that is already running.

On a Windows® platform, start MATLAB with `-automation` in the command line. When you call `engopen`, it connects to this existing session. You should only call `engopen` once, because any `engopen` calls now connect to this one MATLAB session.

The `-automation` option also causes the command window to be minimized. You must open it manually.

On the Mac and Linux® platforms, you cannot make an engine program connect to an existing MATLAB session.

Shut down any MATLAB sessions.

From the **Start** button on the Windows menu bar, click **Run**.

In MATLAB, capture the value returned by the command:

```
path = fullfile(matlabroot,'bin',computer('arch'))
```

In the **Run** dialog box **Open** field, type the following command, replacing `path` with the value from the previous step:

```
path\matlab.exe -automation
```

Click **OK**. This starts MATLAB.

In MATLAB, copy the `engindemo.c` example to a writable folder.

```
copyfile(fullfile(matlabroot,'extern','examples','eng_mat','engindemo.c'), '-','f')
```

Build the example.

```
mx -client engine engindemo.c
```

Run the `engindemo` program by typing at the MATLAB prompt:

```
!engindemo
```

This does not start another MATLAB session, but rather uses the MATLAB session that is already open.

More About

- Launch MATLAB as Automation Server in Desktop Mode
- MATLAB COM Integration

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Getting Started

- To build an engine application, you need:
- The ability to write C/C++ or Fortran source code. You can create these files with the MATLAB® Editor.
  - A compiler supported by MATLAB. For an up-to-date list of supported compilers, see the [Supported and Compatible Compilers](#) website.
  - C/C++ [Matrix Library API](#) or [Fortran Matrix Library API](#) functions.
  - C and Fortran Engine Library functions.
  - The mex build script with the -cilent\_ engine option.
  - To use your own build tools, see [Build Engine Applications with IDE](#).

- To run the application:
- [Set Run-Time Library Path on Windows Systems](#)
  - [Register MATLAB as a COM Server](#)
  - [Set Run-Time Library Path on Mac and Linux Systems](#)

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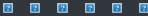
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Introducing MATLAB Engine API for C/C++ and Fortran

The MATLAB® C/C++ and Fortran engine library contains routines that allow you to call MATLAB from your own programs, using MATLAB as a computation engine. Using the MATLAB engine requires an installed version of MATLAB; you cannot run the MATLAB engine on a machine that only has the MATLAB Runtime.

Engine programs are standalone programs. These programs communicate with a separate MATLAB process via pipes, on UNIX® systems, and through a Microsoft® Component Object Model (COM) interface, on Microsoft Windows® systems. MATLAB provides a library of functions that allows you to start and end the MATLAB process, send data to and from MATLAB, and send commands to be processed in MATLAB.

Some of the things you can do with the MATLAB engine are:

- Call a math routine, for example, to invert an array or to compute an FFT from your own program. When employed in this manner, MATLAB is a powerful and programmable mathematical subroutine library.
- Build an entire system for a specific task. For example, the front end (user interface) is programmed in C/C++ and the back end (analysis) is programmed in MATLAB.

The MATLAB engine operates by running in the background as a separate process from your own program. Some advantages are:

- On UNIX systems, the engine can run on your machine, or on any other UNIX machine on your network, including machines of a different architecture. This configuration allows you to implement a user interface on your workstation and perform the computations on a faster machine located elsewhere on your network. For more information, see the [engOpen](#) reference page.
- Instead of requiring your program to link to the entire MATLAB program (a substantial amount of code), it links to a smaller engine library.

The MATLAB engine cannot read MAT-files in a format based on HDF5. These MAT-files save data using the -v7.3 option of the save function or are opened using the w7.3 mode argument to the C or Fortran `matOpen` function.

**Note:** To run MATLAB engine on the UNIX platform, you must have the C shell `csh` installed at `/bin/csh`.

Communicating with MATLAB Software

On UNIX systems, the engine library communicates with the engine using pipes, and, if needed, `rsh` for remote execution. On Microsoft Windows systems, the engine library communicates with the engine using a Component Object Model (COM) interface.

More About

- [MATLAB COM Integration](#)
- [MATLAB Engine for Python](#)

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Set Run-Time Library Path on Windows Systems

At run time, tell the operating system where the API shared libraries reside by setting the Path environment variable. Set the value to the path string returned by the following MATLAB® command:

```
res = fullfile(matlabroot,'bin',computer('arch'))
```

Change Path Each Time You Run the Application

To set the run-time library path from the Windows® command prompt, type the following command, where res is the string returned from the fullfile command. Set the path every time you open the Windows Command Processor.

set PATH=res;%PATH%

You must set the path each time that you open the Windows prompt.

Permanently Change Path

To set the run-time library path permanently to res, modify the Path variable using the Control Panel. For the setting to take effect, close the command prompt window, then open a new command prompt window.

To remove the run-time library path, follow the same instructions, deleting the path name from the variable.

Windows 7

- Select **Computer** from the Start menu.
- Choose **System properties** from the context menu.
- Click **Advanced system settings** > **Advanced** tab.
- Click **Environment Variables**.
- Under **System variables**, select Path and click **Edit**.
- Modify Path by inserting res at the beginning of the **Variable value** text field.
- Click **Ok** to close the dialog boxes, then close the **Control Panel** dialog box.

Troubleshooting

If you have multiple versions of MATLAB installed on your system, the version you use to build your engine applications must be the first listed in your system Path environment variable. Otherwise, MATLAB displays Can't start MATLAB engine.

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Set Run-Time Library Path on Mac and Linux Systems

At run time, tell the operating system where the API shared libraries reside by setting an environment variable. Set the path every time you run MATLAB®. Alternatively, place the commands in a MATLAB startup script. The shell command you use and the value you provide to set the run-time library path depend on your shell and system architecture. The following table lists the name of the environment variable, *envvar*, and the value, *pathspec*, to assign to it. In the *pathspec* string, replace *matlabroot* with the string returned by the *matlabroot* command.

| Operating System | envvar            | pathspec                                         |
|------------------|-------------------|--------------------------------------------------|
| 64-bit Apple Mac | DYLD_LIBRARY_PATH | matlabroot/bin/mac164:matlabroot/sys/os/mac164   |
| 64-bit Linux®    | LD_LIBRARY_PATH   | matlabroot/bin/glnxa64:matlabroot/sys/os/glnxa64 |

These commands replace the existing value in *envvar*. If *envvar* is already defined, prepend the *pathspec* to the existing value. If you have multiple versions of MATLAB installed on your system, the version you use to build your engine applications must be the first listed in your system Path environment variable. Otherwise, MATLAB displays Can't start MATLAB engine.

C Shell

Set the library path using the following command, replacing the terms *envvar* and *pathspec* with the appropriate values from the table.

```
setenv envvar pathspec
```

For example, for MATLAB R2015a on a Mac system:

```
setenv DYLD_LIBRARY_PATH /Applications/MATLAB_R2015a.app/bin/mac164:/Applications/MATLAB_R2015a.app/sys/os/mac164
```

You can place these commands in a startup script, such as `~/cshrc`.

Bourne Shell

Set the library path using the following command, replacing the terms *envvar* and *pathspec* with the appropriate values from the table.

```
envvar = pathspec:envvar export envvar
```

For example, for MATLAB R2015a on a Mac system:

```
DYLD_LIBRARY_PATH=/Applications/MATLAB_R2015a.app/bin/mac164:/Applications/MATLAB_R2015a.app/sys/os/mac164:$DYLD_LIBRARY_PATH  
export DYLD_LIBRARY_PATH
```

You can place these commands in a startup script such as `~/profile`.

See Also

matlabroot

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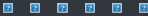


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Build Engine Applications with IDE

Configuring the IDE

If your integrated development environment (IDE) has a MATLAB®-supported compiler, you can use the IDE to build engine applications. For an up-to-date list of supported compilers, see the [Supported and Compatible Compilers](#) website. Engine applications require the Engine Library libeng, the Matrix Library libmx, and supporting include files. When you build using the mex command, MATLAB is configured to locate these files. When you build in your IDE, you must configure the IDE to locate them. Where these settings are depends on your IDE. Refer to your product documentation.

Engine Include Files

Header files contain function declarations with prototypes for the routines you access in the API libraries. These files are in the `matlabroot\extern\include` folder and are the same for Windows®, Mac, and Linux® systems. Engine applications use:

- `engine.h` — function prototypes for engine routines.
- `matrix.h` — definition of the `mxArray` structure and function prototypes for matrix access routines.

In your IDE, set the pre-processor include path to the value returned by the following MATLAB command:

```
fullfile(matlabroot,'extern','include')
```

Engine Libraries

You need the libeng and libmx shared libraries. The name of the file is platform-specific, as shown in the following table.

Library File Names by Operating System

| Windows®1  | Linux     | Mac          |
|------------|-----------|--------------|
| libeng.lib | libeng.so | libeng.dylib |
| libmx.lib  | libmx.so  | libmx.dylib  |

<sup>[1]</sup> These files are located in the folder `fullfile(matlabroot,'extern','lib','computer('arch'),'microsoft')`.

Add these library names to your IDE configuration. Set the library path to the value returned by the following MATLAB command:

```
fullfile(matlabroot,'bin',computer('arch'))
```

Refer to your IDE product documentation for instructions.

Library Files Required by libeng

The libeng library requires additional third-party library files. MATLAB uses these libraries to support Unicode® character encoding and data compression in MAT-files.

These library files must reside in the same folder as the libmx library. You can determine what these libraries are using the platform-specific commands shown in the following table. Once you identify these files, update your IDE.

Library Dependency Commands

| Windows                                              | Linux                         | Mac                                |
|------------------------------------------------------|-------------------------------|------------------------------------|
| See the following instructions for Dependency Walker | <code>ldd -d libeng.so</code> | <code>otool -L libeng.dylib</code> |

On Windows systems, to find library dependencies, use the third-party product Dependency Walker. Dependency Walker is a free utility that scans any 32-bit or 64-bit Windows module and builds a hierarchical tree diagram of all dependent modules. For each module found, it lists all the functions exported by that module, and which of those functions are called by other modules. Download the Dependency Walker utility from the website <http://www.dependencywalker.com/>. See <http://www.mathworks.com/matlabcentral/answers/92962-how-do-i-determine-which-libraries-my-mex-file-or-standalone-application-requires> for information on using the Dependency Walker.

Drag and drop the libeng.dll file into the Depends window. Identify the dependent libraries and add them to your IDE configuration.

Related Examples

- Build Windows Engine Application
- Build Linux Engine Application

External Websites

- How can I compile a MATLAB Engine application using Microsoft Visual Studio 9.0 or 10.0?
- How can I build an Engine application using the Xcode IDE on Mac?

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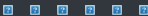


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Register MATLAB as a COM Server

To run the engine application on a Windows® operating system, you must register MATLAB® as a COM server. Do this for every session, to ensure that the current version of MATLAB is the registered version. If you run older versions, the registered version could change. If there is a mismatch of version numbers, MATLAB displays Can't start MATLAB engine.

To register MATLAB manually as a server, start MATLAB as a user with administrator privilege. Then type:

```
matlab -register
```

Close the MATLAB window that appears.

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Callbacks in Applications

If you have a user interface that executes many callbacks through the MATLAB® engine, force these callbacks to be evaluated in the context of the base workspace. Use `evalin` to specify the base workspace for evaluating the callback expression. For example: `engEvalString(ep, "evalin('base', expression)")`

Specifying the base workspace ensures MATLAB processes the callback correctly and returns results for that call. This advice does not apply to computational applications that do not execute callbacks.

See Also

`engEvalString` | `evalin`

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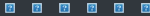
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Can't Start MATLAB Engine

If you have multiple versions of MATLAB® installed on your system, the version you use to build your engine applications must be the first listed in your system Path environment variable. Otherwise, MATLAB displays Can't start MATLAB engine. On Windows® operating systems, you also must register MATLAB as a COM server. If you have multiple versions of MATLAB, the version you are using must be the registered version.

Related Examples

- Register MATLAB as a COM Server

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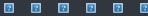
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Debug MATLAB Functions Used in Engine Applications

When creating MATLAB® functions for use in engine applications, it is good practice to debug the functions in MATLAB before calling them through the engine library functions. Although you cannot use the MATLAB Editor/Debugger from an engine application, you can use the MATLAB workspace to examine variables passed to MATLAB. For example, you have the following MATLAB function:

```
function y = myfcn(x)
    y = x+2;
end
```

Your engine application calls myfcn with your variable myxarray, as shown in the following code:

```
engineVariable(ep, "xVar", myxarray);
engineEvalString(ep, "result = myfcn(xVar)");
myxarrayResult = engineVariable(ep,"result");
```

If you do not get the expected result, you can examine two possibilities: if the input, myxarray, is incorrect, or if the MATLAB function is incorrect. To examine the input to myfcn, first modify the function to save the MATLAB workspace to the file debugmyfcn.mat.

```
function y = myfcn(x)
    save debugmyfcn.mat
    y = x+2;
end
```

Execute your engine application, then start MATLAB and load debugmyfcn.mat.

```
load debugmyfcn.mat
whos x
```

Variable x contains the value from myxarray. If x is not what you expect, debug your engine code. If x is correct, debug the MATLAB function. To debug myfcn, open the function in the MATLAB Editor/Debugger, and then call the function from the MATLAB command line:

```
myfcn(x)
```

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User Input Not Supported

A MATLAB® engine application runs MATLAB as a computational server. MATLAB functions that interact with the user or disrupt program flow are not supported. Examples of such functions include debugging commands, Input, keyboard, and pause.

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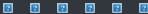
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Multithreaded Applications

MATLAB® libraries are not thread-safe. If you create multithreaded applications, make sure that only one thread accesses the engine application.

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C/C++ Matrix Library API

Write C/C++ programs that work with the MATLAB® mxArray data structure. For examples using these library functions, see:

- Table of MEX File Source Code Files
- Table of MATLAB File Source Code Files
- See individual functions for example information. For example, see `mxIsChar`.

Data Types

C language types and constants

Create or Delete Array

Create array of specified type, allocate and free memory

Validate Data

Determine type or characteristic of array data

Access Data

Read or write data to array

Convert Data Types

Convert strings, and structure array to object array

Related Information

MEX File Creation API

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Fortran Matrix Library API

Write Fortran programs that work with the MATLAB® mxArray data structure. For examples using these library functions, see Table of MEX File Source Code Files.

- Data Types  
Types and constants
- Create or Delete Array  
Create array of specified type, allocate and free memory
- Validate Data  
Determine type or characteristic of array data
- Access Data  
Read or write data to array
- Convert Arrays  
Convert array to pass by reference, not by value

Related Information

- MEX File Creation API
- MATLAB Engine API for C, C++, and Fortran
- MAT File API
- C/C++ Matrix Library API

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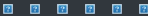
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MATLAB COM Automation Server

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Automation is a COM protocol that allows one application (the controller or client) to control objects exported by another application (the server). MATLAB supports COM Automation server capabilities on Microsoft<sup>®</sup> Windows<sup>®</sup> operating systems. Any Windows program that can be configured as an Automation controller can control MATLAB. Some examples are Microsoft Excel<sup>®</sup> and Microsoft Access<sup>™</sup>, and many Microsoft Visual Basic<sup>®</sup> and Microsoft Visual C++<sup>®</sup> programs.  
If you build client application using C/C++, or Fortran, use MATLAB Engine API for C, C++, and Fortran instead of an Automation server.

Functions

|                                    |                                                               |
|------------------------------------|---------------------------------------------------------------|
| <code>Execute</code>               | Execute MATLAB command in Automation server                   |
| <code>Eval</code>                  | Evaluate MATLAB function in Automation server                 |
| <code>GetCharArray</code>          | Character array from Automation server                        |
| <code>PutCharArray</code>          | Store character array in Automation server                    |
| <code>GetFullMatrix</code>         | Matrix from Automation server workspace                       |
| <code>PutFullMatrix</code>         | Matrix in Automation server workspace                         |
| <code>GetVariable</code>           | Data from variable in Automation server workspace             |
| <code>GetWorkspaceData</code>      | Data from Automation server workspace                         |
| <code>PutWorkspaceData</code>      | Data in Automation server workspace                           |
| <code>MaximizeCommandWindow</code> | Open Automation server window                                 |
| <code>MinimizeCommandWindow</code> | Minimize size of Automation server window                     |
| <code>Quit</code>                  | Terminate MATLAB Automation server                            |
| <code>RegisterAsServer</code>      | Register current MATLAB as Automation server                  |
| <code>enableService</code>         | Enable, disable, or report status of MATLAB Automation server |

Examples and How To

- Call MATLAB Function from Visual Basic .NET Client
- Call MATLAB Function from C# Client
- Pass Complex Data to MATLAB from C# Client
- View MATLAB Functions from Visual Basic .NET Object Browser
- Launch MATLAB as Automation Server in Desktop Mode
- Manually Create Automation Server

Concepts

- Register MATLAB as Automation Server
- MATLAB COM Automation Server Interface
- Create MATLAB Server
- Connect to Existing MATLAB Server
- Conversion of MATLAB Types to COM Types
- Conversion of COM Types to MATLAB Types
- Shared or Dedicated Server
- VT\_DATE Data Type
- Data Types For Visual Basic .NET Clients
- Visible Property
- MATLAB Application as DCOM Server

Troubleshooting

- Waiting for MATLAB Application to Complete

Related Information

- Call COM Objects

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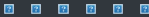


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MATLAB Engine for Python

Call MATLAB® functions from Python®  
The MATLAB Engine for Python provides a package for Python to call MATLAB as a computational engine. The engine supports the reference implementation (CPython) for Python versions 2.7, 3.3, and 3.4.  
• To install and start the engine, see [Get Started with MATLAB Engine for Python](#).  
• To call Python functions from MATLAB, see [Call Python Libraries](#).

Functions

| Python Functions                          |                                                                    |
|-------------------------------------------|--------------------------------------------------------------------|
| <code>matlab.engine.start_matlab</code>   | Start MATLAB Engine for Python                                     |
| <code>matlab.engine.find_matlab</code>    | Find shared MATLAB sessions to connect to MATLAB Engine for Python |
| <code>matlab.engine.connect_matlab</code> | Connect shared MATLAB session to MATLAB Engine for Python          |
| MATLAB Functions                          |                                                                    |
| <code>matlab.engine.shareEngine</code>    | Convert running MATLAB session to shared session                   |
| <code>matlab.engine.engineName</code>     | Return name of shared MATLAB session                               |
| <code>matlab.engine.isEngineShared</code> | Determine if MATLAB session is shared                              |

Classes

| Python Classes                          |                                                                          |
|-----------------------------------------|--------------------------------------------------------------------------|
| <code>matlab.engine.MatlabEngine</code> | Python object using MATLAB as computational engine within Python session |
| <code>matlab.engine.FutureResult</code> | Results of asynchronous call to MATLAB function stored in Python object  |

Examples and How To

- [Install MATLAB Engine for Python](#)
- [Start and Stop MATLAB Engine for Python](#)
- [Connect Python to Running MATLAB Session](#)
- [Call MATLAB Functions from Python](#)
- [Call MATLAB Functions Asynchronously from Python](#)
- [Call User Script and Function from Python](#)
- [Redirect Standard Output and Error to Python](#)
- [Use MATLAB Engine Workspace in Python](#)
- [Use MATLAB Handle Objects in Python](#)
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Concepts

- [Get Started with MATLAB Engine for Python](#)
- [System Requirements for MATLAB Engine for Python](#)
- [Pass Data to MATLAB from Python](#)
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- [MATLAB Arrays as Python Variables](#)
- [Default Numeric Types in MATLAB and Python](#)

Troubleshooting

- [Limitations to MATLAB Engine for Python](#)
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The Language of Technical Computing

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MATLAB® is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, you can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets or traditional programming languages, such as C/C++ or Java®. You can use MATLAB for a range of applications, including signal processing and communications, image and video processing, control systems, test and measurement, computational finance, and computational biology. More than a million engineers and scientists in industry and academia use MATLAB, the language of technical computing.

Language Fundamentals

Syntax, operators, data types, array indexing and manipulation

Mathematics

Linear algebra, basic statistics, differentiation and integrals, Fourier transforms, and other mathematics

Graphics

Two- and three-dimensional plots, images, animation, visualization

Programming Scripts and Functions

Program files, control flow, editing, debugging

Data Import and Export

Text files, spreadsheets, and other file formats; big data; web access

GUI Building

Application development using GUIDE and callbacks

Advanced Software Development

Object-oriented programming; code performance; unit testing; external interfaces to Java®, C/C++, .NET and other languages

Desktop Environment

Preferences and settings, platform differences

Supported Hardware

Support for third-party hardware, such as webcam, Raspberry Pi™, and Arduino® hardware

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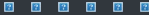
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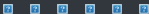


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More Examples



Getting Started with MATLAB (7 min)



Video



Working in The Development Environment (5 min, 21 sec)



Video

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Basic Matrix Operations



Script



Matrix Manipulation



Script



Working with Arrays (8 min, 16 sec)



Video



Manipulating Multidimensional Arrays



Script



Introducing MATLAB Fundamental Classes (Data Types) (5 min, 46 sec)



Video



Tables and Categorical Arrays (8 min, 9 sec)



Video



Introducing Structures and Cell Arrays (5 min, 4 sec)



Video



Create a Structure Array



Script

Mathematics



Integer Arithmetic



Script



Single Precision Math



Script



Creating and Editing Delaunay Triangulations



Script



Predicting the US Population



Script



FFT for Spectral Analysis



Script



Square Wave from Sine Waves



Script



Using FFT



Script



Grid-based Interpolation



Script



Splines in Two Dimensions



Script



Eig & Singular Value Show



App



Finite Difference Laplacian



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Matrix Exponentials



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Differential Equations - Examples



App



Numerical Integration of Differential Equations



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Optimal Fit of a Nonlinear Function



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Graphical Representation of Sparse Matrices



Script



Graphs and Matrices



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Sparse Matrices



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Controlling Random Number Generation



Script



Controlling Random Number Generation (5 min, 54 sec)



Video



Graphical Approach to Solving Inequalities



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Loma Prieta Earthquake



Script

Graphics

2-D Plots

|                                                                                 |                                                     |                                                                                          |
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|   | Creating a Basic Plot Interactively (3 min, 56 sec) |  Video    |
|  | Using Basic Plotting Functions (5 min, 52 sec)      |  Video  |
|  | Creating 2-D Plots                                  |  Script |
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|  | Controlling Individual Axis Properties in a Plot    |  Script |
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|  | Plotting Categorical Data                           |  Script |
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3-D Plots and 4-D Visualization

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|  | Creating 3-D Plots                           |  Script |
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|                                                                                   |                                                            |                                                                                            |
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|  | Using Colormaps                                            |  Script |
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|  | Using Mathematical Expressions to Label and Annotate Plots |  Script |
|  | Including Symbols in Plots and User Interfaces             |  Script |
|  | Clipping in Plots and Graphs                               |  Script |
|  | Using Graphics Smoothing                                   |  Script |
|  | Changing Transparency of Images, Patches or Surfaces       |  Script |

Animation

|                                                                                   |                          |                                                                                            |
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|  | Creating Line Animations |  Script |
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|                                                                                   |                                           |                                                                                            |
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|  | Displaying Image Data                     |  Script |
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Programming Scripts and Functions

|                                                                                   |                                                 |                                                                                            |
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|  | Programming with COM on Windows®                |  Script |
|  | Publishing Code from the Editor (5 min, 15 sec) |  Video  |
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|                                                                                 |                                                                            |                                                                                          |
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|   | Importing Data from Files Programmatically (3 min, 55 sec)                 |  Video    |
|  | Importing Data from Text Files Interactively (7 min, 1 sec)                |  Video  |
|  | Importing Spreadsheets (2 min, 24 sec)                                     |  Video  |
|  | Reading Arbitrary Format Text Files with TEXTSCAN                          |  Script |
|  | Using the MAT file Object to Load and Save Part of an Array (6 min, 9 sec) |  Video  |
|  | Process "Big Data" in MATLAB using MapReduce                               |  Script |

•GUI Building

|                                                                                 |                                                |                                                                                          |
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|  | Creating a GUI with GUIDE (10 min, 28 sec)     |  Video  |
|  | Creating a User Interface with Tab Panels      |  Script |
|  | Creating User Interface with a Graphical Table |  Script |

•New Features Videos

|                                                                                   |                                                                                   |                                                                                           |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| Release 2014b                                                                     |                                                                                   |                                                                                           |
|    | New MATLAB Graphics System (3 min, 30 sec)                                        |  Video   |
| Release 2014a                                                                     |                                                                                   |                                                                                           |
|    | Pop-up Command History (2 min, 41 sec)                                            |  Video   |
|    | Webcam Support (2 min, 54 sec)                                                    |  Video   |
| Release 2013b                                                                     |                                                                                   |                                                                                           |
|    | Tables and Categorical Arrays (6 min, 9 sec)                                      |  Video   |
| Release 2013a                                                                     |                                                                                   |                                                                                           |
|    | MATLAB Unit Testing Framework (9 min, 24 sec)                                     |  Video   |
| Release 2012b                                                                     |                                                                                   |                                                                                           |
|    | New MATLAB Desktop (5 min, 19 sec)                                                |  Video   |
|    | Import Tool Enhancements for Text Files (6 min, 21 sec)                           |  Video   |
|    | Suggestions for Mistyped Commands (2 min, 11 sec)                                 |  Video   |
|  | Packaging and Installing MATLAB Apps (2 min, 58 sec)                              |  Video |
|  | Redesigned Help (5 min, 43 sec)                                                   |  Video |
| Release 2012a                                                                     |                                                                                   |                                                                                           |
|  | New Variable Editor Features (2 min, 17 sec)                                      |  Video |
|  | Syntax Highlighting for Commented MATLAB Code in Published Scripts (2 min, 5 sec) |  Video |
| Release 2011b                                                                     |                                                                                   |                                                                                           |
|  | Spreadsheet Import Tool (6 min, 50 sec)                                           |  Video |
|  | Automatic Variable and Function Renaming (2 min, 52 sec)                          |  Video |
|  | MAT-File Object (6 min, 9 sec)                                                    |  Video |
| Release 2011a                                                                     |                                                                                   |                                                                                           |
|  | Plot Catalog Enhancements (4 min, 13 sec)                                         |  Video |
|  | Support Request Submission Feature (2 min, 05 sec)                                |  Video |
|  | RNG Function for Controlling Random Number Generation (5 min, 50 sec)             |  Video |
| Release 2010b                                                                     |                                                                                   |                                                                                           |
|  | Variable and Subfunction Highlighting in the Editor (4 min, 21 sec)               |  Video |
|  | Zip File Browsing in the Current Folder Browser (2 min, 13 sec)                   |  Video |
|  | File Preview Enhancements in the Current Folder Browser (1 min, 18 sec)           |  Video |
|  | Enumeration Classes (7 min, 33 sec)                                               |  Video |
|  | VideoWriter Object (3 min, 17 sec)                                                |  Video |
| Release 2010a                                                                     |                                                                                   |                                                                                           |
|  | Development Environment (5 min, 2 sec)                                            |  Video |
| Release 2009b                                                                     |                                                                                   |                                                                                           |
|  | MATLAB File Exchange Access (4 min, 51 sec)                                       |  Video |
|  | Desktop Plotting Features (3 min, 26 sec)                                         |  Video |
|  | Current Folder Browser Enhancements (2 min, 17 sec)                               |  Video |
|  | Customizable Keyboard Shortcuts (4 min, 15 sec)                                   |  Video |

|                                                                                  |                                                         |                                                                                          |
|----------------------------------------------------------------------------------|---------------------------------------------------------|------------------------------------------------------------------------------------------|
|    | Help Browser Enhancements (1 min, 21 sec)               |  Video   |
|   | Publishing to PDF (9 min, 38 sec)                       |  Video  |
|   | Language and Programming (2 min, 49 sec)                |  Video  |
| Release 2009a                                                                    |                                                         |                                                                                          |
|   | Development Environment (3 min, 32 sec)                 |  Video  |
|   | Mathematics (7 min, 50 sec)                             |  Video  |
|   | External Interfacing (8 min, 39 sec)                    |  Video  |
| Release 2008b                                                                    |                                                         |                                                                                          |
|   | Development Environment (5 min, 25 sec)                 |  Video  |
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| Release 2008a                                                                    |                                                         |                                                                                          |
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|   | Graphics and GUI Building (9 min, 31 sec)               |  Video  |
| Release 2007b                                                                    |                                                         |                                                                                          |
|   | Performance and Large Data Set Handling (4 min, 57 sec) |  Video  |
|   | Development Environment (3 min, 39 sec)                 |  Video  |
|   | Language and Programming (2 min, 9 sec)                 |  Video  |
|   | Mathematics (1 min, 6 sec)                              |  Video  |
|   | File IO and External Interfacing (3 min, 2 sec)         |  Video  |
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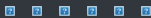
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Language Fundamentals

Entering Commands

|           |                                           |
|-----------|-------------------------------------------|
| ans       | Most recent answer                        |
| clc       | Clear Command Window                      |
| clear     | Save Command Window text to file          |
| format    | Set Command Window output display format  |
| home      | Send cursor home                          |
| iskeyword | Determine whether input is MATLAB keyword |
| more      | Control paged output for Command Window   |

Matrices and Arrays

Array Creation and Concatenation

|           |                                                           |
|-----------|-----------------------------------------------------------|
| cat       | Construct array with accumulation                         |
| blkdiag   | Construct block diagonal matrix from input arguments      |
| diag      | Create diagonal matrix or get diagonal elements of matrix |
| eye       | Identity matrix                                           |
| false     | Logical 0 (false)                                         |
| freqspace | Frequency spacing for frequency response                  |
| linspace  | Generate linearly spaced vector                           |
| logspace  | Generate logarithmically spaced vector                    |
| meshgrid  | Rectangular grid in 2-D and 3-D space                     |
| ndgrid    | Rectangular grid in N-D space                             |
| ones      | Create array of all ones                                  |
| rand      | Uniformly distributed random numbers                      |
| true      | Logical 1 (true)                                          |
| zeros     | Create array of all zeros                                 |
| cat       | Concatenate arrays along specified dimension              |
| horzcat   | Concatenate arrays horizontally                           |
| vertcat   | Concatenate arrays vertically                             |

Indexing

|         |                                                            |
|---------|------------------------------------------------------------|
| colon   | Create vectors, array subscripting, and for-loop iterators |
| and     | Terminate block of code, or indicate last array index      |
| end2end | Subscripts from linear index                               |
| sub2ind | Convert subscripts to linear indices                       |

Array Dimensions

|          |                                          |
|----------|------------------------------------------|
| length   | Length of largest array dimension        |
| ndims    | Number of array dimensions               |
| numel    | Number of array elements                 |
| size     | Array dimensions                         |
| height   | Number of table rows                     |
| width    | Number of table variables                |
| iscolumn | Determine whether input is column vector |
| isempty  | Determine whether array is empty         |
| ismatrix | Determine whether input is matrix        |
| isrow    | Determine whether input is row vector    |
| isscalar | Determine whether input is scalar        |
| isvector | Determine whether input is vector        |

Sorting and Reshaping Arrays

|            |                                                           |
|------------|-----------------------------------------------------------|
| blkdiag    | Construct block diagonal matrix from input arguments      |
| circshift  | Shift array circularly                                    |
| ctranspose | Complex conjugate transpose                               |
| diag       | Create diagonal matrix or get diagonal elements of matrix |
| flip       | Flip order of elements                                    |
| fliplr     | Flip array left to right                                  |
| flipud     | Flip array up to down                                     |
| ipermute   | Inverse permute dimensions of N-D array                   |
| permute    | Rearrange dimensions of N-D array                         |
| repmat     | Repeat copies of array elements                           |
| repeat     | Repeat copies of array                                    |
| reshape    | Reshape array                                             |
| rot90      | Rotate array 90 degrees                                   |
| shiftdim   | Shift dimensions                                          |
| isortd     | Determine whether set elements are in sorted order        |
| sort       | Sort array elements                                       |
| sortrows   | Sort array rows                                           |
| squeeze    | Remove singleton dimensions                               |
| transpose  | Transpose vector or matrix                                |
| vectorize  | Vectorize expression                                      |

Operators and Elementary Operations

Arithmetic

|          |                                                    |
|----------|----------------------------------------------------|
| plus     | Addition                                           |
| uplus    | Unary plus                                         |
| minus    | Subtraction                                        |
| uminus   | Unary minus                                        |
| times    | Element-wise multiplication                        |
| rdivide  | Right array division                               |
| ldivide  | Left array division                                |
| power    | Element-wise power                                 |
| mtimes   | Matrix Multiplication                              |
| mrdivide | Solve systems of linear equations $Ax = B$ for $x$ |
| ldivide  | Solve systems of linear equations $Ax = B$ for $x$ |
| mpower   | Matrix power                                       |
| comprod  | Cumulative product                                 |
| cumsum   | Cumulative sum                                     |
| diff     | Differences and Approximate Derivatives            |
| prod     | Product of array elements                          |
| sum      | Sum of array elements                              |
| ceil     | Round toward positive infinity                     |
| fix      | Round toward zero                                  |
| floor    | Round toward negative infinity                     |
| ldivide  | Integer division with rounding option              |
| mod      | Remainder after division (modulo operators)        |
| rem      | Remainder after division                           |
| round    | Round to nearest decimal or integer                |

Relational Operations

|                      |                                                        |
|----------------------|--------------------------------------------------------|
| Relational Operators | Relational operations                                  |
| eq                   | Determine equality                                     |
| ge                   | Determine greater than or equal to                     |
| gt                   | Determine greater than                                 |
| le                   | Determine less than or equal to                        |
| lt                   | Determine less than                                    |
| ne                   | Determine inequality                                   |
| isequal              | Determine array equality                               |
| isequaln             | Determine array equality, treating NaN values as equal |

Logical Operations

|                                  |                                                     |
|----------------------------------|-----------------------------------------------------|
| Logical Operators: Short-circuit | Logical operations with short-circuiting            |
| and                              | Find logical AND                                    |
| not                              | Find logical NOT                                    |
| or                               | Find logical OR                                     |
| xor                              | Logical exclusive-OR                                |
| all                              | Determine if all array elements are nonzero or true |
| any                              | Determine if any array elements are nonzero         |
| false                            | Logical 0 (false)                                   |
| find                             | Find indices and values of nonzero elements         |
| islogical                        | Determine if input is logical array                 |
| logical                          | Convert numeric values to logicals                  |
| true                             | Logical 1 (true)                                    |

Set Operations

|           |                                              |
|-----------|----------------------------------------------|
| intersect | Set intersection of two arrays               |
| ismember  | Array elements that are members of set array |

|                          |                                                          |
|--------------------------|----------------------------------------------------------|
| <code>ismembertol</code> | Members of set within tolerance                          |
| <code>issorted</code>    | Determine whether set elements are in sorted order       |
| <code>setdiff</code>     | Set difference of two arrays                             |
| <code>setxor</code>      | Set exclusive OR of two arrays                           |
| <code>union</code>       | Set union of two arrays                                  |
| <code>unique</code>      | Unique values in array                                   |
| <code>unique2</code>     | Unique values within tolerance                           |
| <code>join</code>        | Merge two tables by matching up rows using key variables |
| <code>innerjoin</code>   | Inner join between two tables                            |
| <code>outerjoin</code>   | Outer join between two tables                            |

Bit-Wise Operations

|                        |                                       |
|------------------------|---------------------------------------|
| <code>bitand</code>    | Bit-wise AND                          |
| <code>bitcomp</code>   | Bit-wise complement                   |
| <code>bitset</code>    | Get bit at specified position         |
| <code>bitxor</code>    | Bit-wise XOR                          |
| <code>bitset</code>    | Set bit at specific location          |
| <code>bitshiftr</code> | Shift bits specified number of places |
| <code>bitxor</code>    | Bit-wise XOR                          |
| <code>swapbytes</code> | Swap byte ordering                    |

Special Characters

|                                 |                                                            |
|---------------------------------|------------------------------------------------------------|
| <code>Special Characters</code> | Special characters                                         |
| <code>colon</code>              | Create vectors, array subscripting, and for-loop iterators |

Data Types

Numeric Types

|                        |                                                      |
|------------------------|------------------------------------------------------|
| <code>double</code>    | Convert to double precision                          |
| <code>single</code>    | Convert to single precision                          |
| <code>int8</code>      | Convert to 8-bit signed integer                      |
| <code>int16</code>     | Convert to 16-bit signed integer                     |
| <code>int32</code>     | Convert to 32-bit signed integer                     |
| <code>int64</code>     | Convert to 64-bit signed integer                     |
| <code>uint8</code>     | Convert to 8-bit unsigned integer                    |
| <code>uint16</code>    | Convert to 16-bit unsigned integer                   |
| <code>uint32</code>    | Convert to 32-bit unsigned integer                   |
| <code>uint64</code>    | Convert to 64-bit unsigned integer                   |
| <code>cast</code>      | Cast variable to different data type                 |
| <code>typecast</code>  | Convert data types without changing underlying data  |
| <code>isinteger</code> | Determine if input is integer array                  |
| <code>isfloat</code>   | Determine if input is floating-point array           |
| <code>isnumeric</code> | Determine if input is numeric array                  |
| <code>isreal</code>    | Determine whether array is real                      |
| <code>isfinite</code>  | Array elements that are finite                       |
| <code>isinf</code>     | Array elements that are infinite                     |
| <code>isnan</code>     | Array elements that are NaN                          |
| <code>eps</code>       | Floating-point relative accuracy                     |
| <code>fintmax</code>   | Largest consecutive integer in floating-point format |
| <code>Inf</code>       | Infinity                                             |
| <code>intmax</code>    | Largest value of specified integer type              |
| <code>intmin</code>    | Smallest value of specified integer type             |
| <code>NaN</code>       | Not-a-Number                                         |
| <code>realmax</code>   | Largest positive floating-point number               |
| <code>realmin</code>   | Smallest positive normalized floating-point number   |

Characters and Strings

Create and Concatenate Strings

|                        |                                                  |
|------------------------|--------------------------------------------------|
| <code>blanks</code>    | Create character array of blanks                 |
| <code>cellstr</code>   | Convert to cell array of strings                 |
| <code>char</code>      | Convert to character array (string)              |
| <code>iscellstr</code> | Determine whether input is cell array of strings |
| <code>ischar</code>    | Determine whether item is character array        |
| <code>sprintf</code>   | Format data into string                          |
| <code>strcat</code>    | Concatenate strings horizontally                 |
| <code>strjoin</code>   | Join strings in cell array into single string    |

Parse Strings

|                             |                                                   |
|-----------------------------|---------------------------------------------------|
| <code>ischar</code>         | Determine whether item is character array         |
| <code>isletter</code>       | Array elements that are alphabetic letters        |
| <code>isspace</code>        | Array elements that are space characters          |
| <code>isstringp</code>      | Determine whether string is of specified category |
| <code>scanf</code>          | Read formatted data from string                   |
| <code>strfind</code>        | Find one string within another                    |
| <code>strrep</code>         | Find and replace substring                        |
| <code>strsplit</code>       | Split string at specified delimiter               |
| <code>strtok</code>         | Selected parts of string                          |
| <code>validatestring</code> | Check validity of text string                     |
| <code>symvar</code>         | Determine symbolic variables in expression        |
| <code>regex</code>          | Match regular expression (case sensitive)         |
| <code>regexpi</code>        | Match regular expression (case insensitive)       |
| <code>regexprep</code>      | Replace string using regular expression           |
| <code>regextranslate</code> | Translate string into regular expression          |

Compare Strings

|                       |                                                          |
|-----------------------|----------------------------------------------------------|
| <code>strcmp</code>   | Compare strings                                          |
| <code>strcmpi</code>  | Compare strings (case insensitive)                       |
| <code>strcmpc</code>  | Compare first n characters of strings (case sensitive)   |
| <code>strcmpci</code> | Compare first n characters of strings (case insensitive) |

Change String Case, Blanks, and Justification

|                      |                                                     |
|----------------------|-----------------------------------------------------|
| <code>blanks</code>  | Create character array of blanks                    |
| <code>deblank</code> | Strip trailing blanks from end of string            |
| <code>strtrim</code> | Remove leading and trailing white space from string |
| <code>lower</code>   | Convert string to lowercase                         |
| <code>upper</code>   | Convert string to uppercase                         |
| <code>strjust</code> | Justify character array                             |

Dates and Time

Create Date and Time Arrays

|                               |                                                                             |
|-------------------------------|-----------------------------------------------------------------------------|
| <code>datetime</code>         | Create array based on current date, or convert from date strings or numbers |
| <code>timezones</code>        | List time zones                                                             |
| <code>years</code>            | Duration in years                                                           |
| <code>days</code>             | Duration in days                                                            |
| <code>hours</code>            | Duration in hours                                                           |
| <code>minutes</code>          | Duration in minutes                                                         |
| <code>seconds</code>          | Duration in seconds                                                         |
| <code>milliseconds</code>     | Duration in milliseconds                                                    |
| <code>duration</code>         | Create duration array from numeric values                                   |
| <code>calyears</code>         | Calendar duration in years                                                  |
| <code>calquarters</code>      | Calendar duration in quarters                                               |
| <code>calmonths</code>        | Calendar duration in months                                                 |
| <code>calweeks</code>         | Calendar duration in weeks                                                  |
| <code>caldays</code>          | Calendar duration in days                                                   |
| <code>calendarDuration</code> | Create calendar duration array from numeric values                          |
| <code>excel2iix</code>        | Convert MATLAB datetime to Excel date number                                |
| <code>jul2iixdate</code>      | Convert MATLAB datetime to Julian date                                      |
| <code>posix2iix</code>        | Convert MATLAB datetime to POSIX time                                       |
| <code>yyyyymmdd</code>        | Convert MATLAB datetime to 'YYYYMMDD' numeric value                         |

Components of Dates and Time

|                        |                                                         |
|------------------------|---------------------------------------------------------|
| <code>year</code>      | Year number                                             |
| <code>quarter</code>   | Quarter number                                          |
| <code>month</code>     | Month number and name                                   |
| <code>week</code>      | Week number                                             |
| <code>day</code>       | Day number or name                                      |
| <code>hour</code>      | Hour number                                             |
| <code>minute</code>    | Minute number                                           |
| <code>second</code>    | Second number                                           |
| <code>ye</code>        | Year, month, and day numbers of datetime                |
| <code>hes</code>       | Hour, minute, and second numbers of duration            |
| <code>split</code>     | Split calendar duration into numeric and duration units |
| <code>time</code>      | Convert time of calendar duration to duration           |
| <code>timeofday</code> | Elapsed time since midnight for datetimes               |
| <code>isdst</code>     | Determine daylight saving time elements                 |
| <code>isweekend</code> | Determine weekend elements                              |
| <code>offset</code>    | Time zone offset from UTC                               |

Date and Time Arithmetic and Plotting

|                                 |                                                   |
|---------------------------------|---------------------------------------------------|
| <code>between</code>            | Calendar math differences                         |
| <code>caldiff</code>            | Calendar math successive differences              |
| <code>dateShift</code>          | Shift date or generate sequence of dates and time |
| <code>isbetween</code>          | Determine elements within date and time interval  |
| <code>isdatetime</code>         | Determine if input is datetime array              |
| <code>isduration</code>         | Determine if input is duration array              |
| <code>iscalendarduration</code> | Determine if input is calendar duration array     |
| <code>isnat</code>              | Determine NaN (Not-a-Time) elements               |
| <code>Nat</code>                | Not-a-Time                                        |

Dates and Time as Numbers and Strings

|                        |                                               |
|------------------------|-----------------------------------------------|
| <code>datetime</code>  | Convert date and time to serial date number   |
| <code>datetime</code>  | Convert date and time to vector of components |
| <code>datestr</code>   | Convert date and time to string format        |
| <code>char</code>      | Convert to character array (string)           |
| <code>cellstr</code>   | Convert to cell array of strings              |
| <code>now</code>       | Current date and time as serial date number   |
| <code>clock</code>     | Current date and time as date vector          |
| <code>date</code>      | Current date string                           |
| <code>calendar</code>  | Calendar for specified month                  |
| <code>month</code>     | Last day of month                             |
| <code>weekday</code>   | Day of week                                   |
| <code>addtodate</code> | Modify date number by field                   |
| <code>etlax</code>     | Time elapsed between date vectors             |

Categorical Arrays

|                            |                                                                 |
|----------------------------|-----------------------------------------------------------------|
| <code>categorical</code>   | Create categorical array                                        |
| <code>iscategorical</code> | Determine whether input is categorical array                    |
| <code>categories</code>    | Categories of categorical array                                 |
| <code>iscategory</code>    | Test for categorical array categories                           |
| <code>isordinal</code>     | Determine whether input is ordinal categorical array            |
| <code>isprotected</code>   | Determine whether categories of categorical array are protected |
| <code>addcats</code>       | Add categories to categorical array                             |
| <code>mergecats</code>     | Merge categories in categorical array                           |
| <code>removecats</code>    | Remove categories from categorical array                        |
| <code>renumcats</code>     | Rename categories in categorical array                          |
| <code>reordercats</code>   | Reorder categories in categorical array                         |
| <code>sortcats</code>      | Sort categories in categorical array                            |
| <code>summary</code>       | Print summary of table or categorical array                     |
| <code>countcats</code>     | Count occurrences of categorical array elements by category     |
| <code>isundefined</code>   | Find undefined elements in categorical array                    |

Tables

|                                 |                                                           |
|---------------------------------|-----------------------------------------------------------|
| <code>table</code>              | Create table from workspace variables                     |
| <code>array2table</code>        | Convert homogeneous array to table                        |
| <code>cell2table</code>         | Convert cell array to table                               |
| <code>struct2table</code>       | Convert structure array to table                          |
| <code>table2array</code>        | Convert table to homogeneous array                        |
| <code>table2cell</code>         | Convert table to cell array                               |
| <code>table2struct</code>       | Convert table to structure array                          |
| <code>readtable</code>          | Create table from file                                    |
| <code>writetable</code>         | Write table to file                                       |
| <code>istable</code>            | Determine whether input is table                          |
| <code>height</code>             | Number of table rows                                      |
| <code>width</code>              | Number of table variables                                 |
| <code>summary</code>            | Print summary of table or categorical array               |
| <code>intersect</code>          | Set intersection of two arrays                            |
| <code>ismember</code>           | Array elements that are members of set array              |
| <code>setdiff</code>            | Set difference of two arrays                              |
| <code>setxor</code>             | Set exclusive OR of two arrays                            |
| <code>unique</code>             | Unique values in array                                    |
| <code>union</code>              | Set union of two arrays                                   |
| <code>join</code>               | Merge two tables by matching up rows using key variables  |
| <code>innerjoin</code>          | Inner join between two tables                             |
| <code>outerjoin</code>          | Outer join between two tables                             |
| <code>sortrows</code>           | Sort array rows                                           |
| <code>stack</code>              | Stack data from multiple variables into single variable   |
| <code>unstack</code>            | Unstack data from single variable into multiple variables |
| <code>ississing</code>          | Find table elements with missing values                   |
| <code>standardizeMissing</code> | Insert missing value indicators into table                |
| <code>varfun</code>             | Apply function to table variables                         |
| <code>rowfun</code>             | Apply function to table rows                              |
| <code>findgroups</code>         | Find groups and return group numbers                      |
| <code>splitapply</code>         | Split data into groups and apply function                 |

Structures

|                           |                                                      |
|---------------------------|------------------------------------------------------|
| <code>struct</code>       | Create structure array                               |
| <code>fieldnames</code>   | Field names of structure, or public fields of object |
| <code>getfield</code>     | Field of structure array                             |
| <code>isfield</code>      | Determine whether input is structure array field     |
| <code>isstruct</code>     | Determine whether input is structure array           |
| <code>orderfields</code>  | Order fields of structure array                      |
| <code>removefield</code>  | Remove fields from structure                         |
| <code>setfield</code>     | Assign values to structure array field               |
| <code>arrayfun</code>     | Apply function to each element of array              |
| <code>structfun</code>    | Apply function to each field of scalar structure     |
| <code>table2struct</code> | Convert table to structure array                     |
| <code>struct2table</code> | Convert structure array to table                     |
| <code>cell2struct</code>  | Convert cell array to structure array                |
| <code>struct2cell</code>  | Convert structure to cell array                      |

Cell Arrays

|                          |                                                                    |
|--------------------------|--------------------------------------------------------------------|
| <code>cell</code>        | Create cell array                                                  |
| <code>cell2mat</code>    | Convert cell array to ordinary array of the underlying data type   |
| <code>cell2struct</code> | Convert cell array to structure array                              |
| <code>cell2table</code>  | Convert cell array to table                                        |
| <code>cell2sep</code>    | Display cell array contents                                        |
| <code>cellfun</code>     | Apply function to each cell in cell array                          |
| <code>cellsize</code>    | Graphically display structure of cell array                        |
| <code>cellstr</code>     | Convert to cell array of strings                                   |
| <code>iscell</code>      | Determine whether input is cell array                              |
| <code>iscellstr</code>   | Determine whether input is cell array of strings                   |
| <code>matchcells</code>  | Convert array to cell array with potentially different sized cells |
| <code>num2cell</code>    | Convert array to cell array with consistently sized cells          |
| <code>strjoin</code>     | Join strings in cell array into single string                      |
| <code>splitstr</code>    | Split string at specified delimiter                                |
| <code>struct2cell</code> | Convert structure to cell array                                    |
| <code>table2cell</code>  | Convert table to cell array                                        |

Function Handles

|                             |                                                        |
|-----------------------------|--------------------------------------------------------|
| <code>feval</code>          | Evaluate function                                      |
| <code>fun2str</code>        | Construct string from function handle                  |
| <code>str2func</code>       | Construct function handle from string                  |
| <code>localFunctions</code> | Function handles to all local functions in MATLAB file |
| <code>functions</code>      | Information about function handle                      |

Map Containers

|                             |                                                   |
|-----------------------------|---------------------------------------------------|
| <code>containers.Map</code> | Map values to unique keys                         |
| <code>iskey</code>          | Determine if containers.Map object contains key   |
| <code>keys</code>           | Identify keys of containers.Map object            |
| <code>remove</code>         | Remove key-value pairs from containers.Map object |
| <code>values</code>         | Identify values in containers.Map object          |

Time Series

|                             |                                                             |
|-----------------------------|-------------------------------------------------------------|
| Time Series Basics          |                                                             |
| <code>append</code>         | Concatenate time series objects in time dimension           |
| <code>get</code>            | Query timeseries object property values                     |
| <code>getDataSource</code>  | Size of data samples in timeseries object                   |
| <code>getQualityDisc</code> | Data quality descriptors                                    |
| <code>getSamples</code>     | Subset of time series samples using subscripted index array |
| <code>plot</code>           | Plot time series                                            |
| <code>set</code>            | Set properties of timeseries object                         |
| <code>tsdata_event</code>   | Construct event object for timeseries object                |
| <code>timeseries</code>     | Create timeseries object                                    |

Data Manipulation

|                                   |                                                                          |
|-----------------------------------|--------------------------------------------------------------------------|
| <code>addsample</code>            | Add data sample to timeseries object                                     |
| <code>deletesample</code>         | Remove sample from timeseries object                                     |
| <code>detrend</code>              | Subtract mean or best fit line and all lags from timeseries object       |
| <code>filter</code>               | Shape frequency content of time series                                   |
| <code>getExtrInfo</code>          | Extract data string time vector into cell array                          |
| <code>getInterpMethod</code>      | Interpolation method for timeseries object                               |
| <code>getSampleVecOrigTime</code> | Extract data samples into new timeseries object                          |
| <code>loadExtrInfo</code>         | Apply load (noncausal) filter to timeseries object                       |
| <code>resample</code>             | Select or interpolate timeseries data using new time vector              |
| <code>setExtrInfo</code>          | Set times of timeseries object as date strings                           |
| <code>setInterpMethod</code>      | Set default interpolation method for timeseries object                   |
| <code>synchronize</code>          | Synchronize and resample two timeseries objects using common time vector |

Event Data

|                                  |                                                                 |
|----------------------------------|-----------------------------------------------------------------|
| <code>addEvent</code>            | Add event to timeseries object                                  |
| <code>delEvent</code>            | Remove tsdata.event objects from timeseries object              |
| <code>getAfterEvent</code>       | New timeseries object with samples occurring at or after event  |
| <code>getBeforeEvent</code>      | New timeseries object with samples occurring after event        |
| <code>getBeforeLastEvent</code>  | New timeseries object with samples occurring at event           |
| <code>getBeforeFirstEvent</code> | New timeseries object with samples occurring before or at event |
| <code>getBeforeLastEvent</code>  | New timeseries object with samples occurring before event       |
| <code>getBetweenEvents</code>    | New timeseries object with samples occurring between events     |

Descriptive Statistics

|                     |                                        |
|---------------------|----------------------------------------|
| <code>iqr</code>    | Interquartile range of timeseries data |
| <code>max</code>    | Maximum value of timeseries data       |
| <code>mean</code>   | Mean value of timeseries data          |
| <code>median</code> | Median value of timeseries data        |
| <code>min</code>    | Minimum value of timeseries data       |
| <code>std</code>    | Standard deviation of timeseries data  |
| <code>sum</code>    | Sum of timeseries data                 |
| <code>var</code>    | Variance of timeseries data            |

Time Series Collections

|                                                  |                                                                  |
|--------------------------------------------------|------------------------------------------------------------------|
| <code>get (tscollection)</code>                  | Query tscollection object property values                        |
| <code>isempty (tscollection)</code>              | Determine whether tscollection object is empty                   |
| <code>length (tscollection)</code>               | Length of time vector                                            |
| <code>plot (tscollection)</code>                 | Plot time series                                                 |
| <code>set (tscollection)</code>                  | Set properties of tscollection object                            |
| <code>size (tscollection)</code>                 | Size of tscollection object                                      |
| <code>tscollection</code>                        | Create tscollection object                                       |
| <code>addSampleToTSCollection</code>             | Add sample to tscollection object                                |
| <code>adds</code>                                | Add timeseries object to tscollection object                     |
| <code>deletesampleFromTSCollection</code>        | Remove sample from tscollection object                           |
| <code>deleteTime (tscollection)</code>           | Extract data using time vector into cell array                   |
| <code>getSampleVecOrigTime (tscollection)</code> | Extract data samples into new tscollection object                |
| <code>getTimeSeriesNames</code>                  | Cell array of names of timeseries objects in tscollection object |
| <code>horcatz (tscollection)</code>              | Horizontal concatenation for tscollection objects                |
| <code>remove</code>                              | Remove timeseries objects from tscollection object               |
| <code>resample (tscollection)</code>             | Select or interpolate data in tscollection using new time vector |
| <code>setExtrInfo (tscollection)</code>          | Set times of tscollection object as date strings                 |

|                                    |                                                |
|------------------------------------|------------------------------------------------|
| <code>timeseriesnames</code>       | Change name of timeseries object in collection |
| <code>vertical</code> (collection) | Vertical concatenation for collection objects  |

Data Type Identification

|                                 |                                                   |
|---------------------------------|---------------------------------------------------|
| <code>isa</code>                | Determine if input is object of specified class   |
| <code>iscalendarduration</code> | Determine if input is calendar duration array     |
| <code>iscategorical</code>      | Determine whether input is categorical array      |
| <code>iscell</code>             | Determine whether input is cell array             |
| <code>iscellstr</code>          | Determine whether input is cell array of strings  |
| <code>ischar</code>             | Determine whether item is character array         |
| <code>isdatetime</code>         | Determine if input is datetime array              |
| <code>isduration</code>         | Determine if input is duration array              |
| <code>isfield</code>            | Determine whether input is structure array field  |
| <code>isfloat</code>            | Determine if input is floating-point array        |
| <code>isgraphics</code>         | True for valid graphics object handles            |
| <code>isinteger</code>          | Determine if input is integer array               |
| <code>isjava</code>             | Determine if input is Java object                 |
| <code>islogical</code>          | Determine if input is logical array               |
| <code>isnumeric</code>          | Determine if input is numeric array               |
| <code>ismatrxct</code>          | Determine if input is MATLAB object               |
| <code>isreal</code>             | Determine whether array is real                   |
| <code>isenum</code>             | Determine if variable is enumeration              |
| <code>isstruct</code>           | Determine whether input is structure array        |
| <code>isstable</code>           | Determine whether input is stable                 |
| <code>is*</code>                | Detect state                                      |
| <code>class</code>              | Determine class of object                         |
| <code>validateattributes</code> | Check validity of array                           |
| <code>whos</code>               | List variables in workspace, with sizes and types |

Data Type Conversion

|                             |                                                                    |
|-----------------------------|--------------------------------------------------------------------|
| <code>char</code>           | Convert to character array (string)                                |
| <code>cellstr</code>        | Convert to cell array of strings                                   |
| <code>int32tr</code>        | Convert integer to string                                          |
| <code>int8tr</code>         | Convert matrix to string                                           |
| <code>num2str</code>        | Convert number to string                                           |
| <code>str2double</code>     | Convert string to double-precision value                           |
| <code>str2num</code>        | Convert string to number                                           |
| <code>native2unicode</code> | Convert numeric bytes to Unicode character representation          |
| <code>unicode2native</code> | Convert Unicode character representation to numeric bytes          |
| <code>base2dec</code>       | Convert base N number string to decimal number                     |
| <code>bin2dec</code>        | Convert binary number string to decimal number                     |
| <code>dec2base</code>       | Convert decimal to base N number in string                         |
| <code>dec2bin</code>        | Convert decimal to binary number in string                         |
| <code>dec2hex</code>        | Convert decimal to hexadecimal number in string                    |
| <code>hex2bin</code>        | Convert hexadecimal number string to decimal number                |
| <code>hex2num</code>        | Convert hexadecimal number string to double-precision number       |
| <code>table2array</code>    | Convert tables and doubles to IEEE hexadecimal settings            |
| <code>table2cell</code>     | Convert table to homogeneous array                                 |
| <code>table2struct</code>   | Convert table to cell array                                        |
| <code>array2table</code>    | Convert table to structure array                                   |
| <code>cell2table</code>     | Convert homogeneous array to table                                 |
| <code>struct2table</code>   | Convert cell array to table                                        |
| <code>struct2struct</code>  | Convert structure array to table                                   |
| <code>cell2mat</code>       | Convert cell array to ordinary array of the underlying data type   |
| <code>cell2struct</code>    | Convert cell array to structure array                              |
| <code>mat2cell</code>       | Convert array to cell array with potentially different sized cells |
| <code>num2cell</code>       | Convert array to cell array with consistently sized cells          |
| <code>struct2cell</code>    | Convert structure to cell array                                    |

Mathematics

Elementary Math

Arithmetic

|                       |                                                    |
|-----------------------|----------------------------------------------------|
| <code>plus</code>     | Addition                                           |
| <code>uplus</code>    | Unary plus                                         |
| <code>minus</code>    | Subtraction                                        |
| <code>uminus</code>   | Unary minus                                        |
| <code>times</code>    | Element-wise multiplication                        |
| <code>rdivide</code>  | Right array division                               |
| <code>ldivide</code>  | Left array division                                |
| <code>power</code>    | Element-wise power                                 |
| <code>etimes</code>   | Matrix Multiplication                              |
| <code>mdivide</code>  | Solve systems of linear equations $Ax = B$ for $x$ |
| <code>mldivide</code> | Solve systems of linear equations $Ax = B$ for $x$ |
| <code>mpower</code>   | Matrix power                                       |
| <code>cumprod</code>  | Cumulative product                                 |
| <code>cumsum</code>   | Cumulative sum                                     |
| <code>diff</code>     | Differences and Approximate Derivatives            |
| <code>prod</code>     | Product of array elements                          |
| <code>sum</code>      | Sum of array elements                              |
| <code>ceil</code>     | Round toward positive infinity                     |
| <code>fix</code>      | Round toward zero                                  |
| <code>floor</code>    | Round toward negative infinity                     |
| <code>ldivide</code>  | Integer division with rounding option              |
| <code>mod</code>      | Remainder after division (modulo operation)        |
| <code>rem</code>      | Remainder after division                           |
| <code>round</code>    | Round to nearest decimal or integer                |

Trigonometry

|                      |                                          |
|----------------------|------------------------------------------|
| <code>sin</code>     | Sine of argument in radians              |
| <code>kind</code>    | Sine of argument in degrees              |
| <code>asin</code>    | Inverse sine in radians                  |
| <code>asind</code>   | Inverse sine in degrees                  |
| <code>sinh</code>    | Hyperbolic sine of argument in radians   |
| <code>asinh</code>   | Inverse hyperbolic sine                  |
| <code>cos</code>     | Cosine of argument in radians            |
| <code>cosd</code>    | Cosine of argument in degrees            |
| <code>acos</code>    | Inverse cosine in radians                |
| <code>acod</code>    | Inverse cosine in degrees                |
| <code>cosh</code>    | Hyperbolic cosine                        |
| <code>acosh</code>   | Inverse hyperbolic cosine                |
| <code>tan</code>     | Tangent of argument in radians           |
| <code>tand</code>    | Tangent of argument in degrees           |
| <code>atan</code>    | Inverse tangent in radians               |
| <code>atand</code>   | Inverse tangent in degrees               |
| <code>atan2</code>   | Four-quadrant inverse tangent            |
| <code>atan2d</code>  | Four-quadrant inverse tangent in degrees |
| <code>tanh</code>    | Hyperbolic tangent                       |
| <code>atanh</code>   | Inverse hyperbolic tangent               |
| <code>csc</code>     | Cosecant of input angle in radians       |
| <code>cscd</code>    | Cosecant of argument in degrees          |
| <code>acsc</code>    | Inverse cosecant in radians              |
| <code>acscd</code>   | Inverse cosecant in degrees              |
| <code>csch</code>    | Hyperbolic cosecant                      |
| <code>acsch</code>   | Inverse hyperbolic cosecant              |
| <code>sec</code>     | Secant of angle in radians               |
| <code>secd</code>    | Secant of argument in degrees            |
| <code>asec</code>    | Inverse secant in radians                |
| <code>asecd</code>   | Inverse secant in degrees                |
| <code>sech</code>    | Hyperbolic secant                        |
| <code>asech</code>   | Inverse hyperbolic secant                |
| <code>cot</code>     | Cotangent of angle in radians            |
| <code>cotd</code>    | Cotangent of argument in degrees         |
| <code>acot</code>    | Inverse cotangent in radians             |
| <code>acotd</code>   | Inverse cotangent in degrees             |
| <code>coth</code>    | Hyperbolic cotangent                     |
| <code>acoth</code>   | Inverse hyperbolic cotangent             |
| <code>hypot</code>   | Square root of sum of squares            |
| <code>deg2rad</code> | Convert angle from degrees to radians    |
| <code>rad2deg</code> | Convert angle from radians to degrees    |

Exponents and Logarithms

|                        |                                                                                |
|------------------------|--------------------------------------------------------------------------------|
| <code>exp</code>       | Exponential                                                                    |
| <code>expm1</code>     | Compute $\exp(x) - 1$ accurately for small values of $x$                       |
| <code>log</code>       | Natural logarithm                                                              |
| <code>log10</code>     | Common logarithm (base 10)                                                     |
| <code>log1p</code>     | Compute $\log(1+x)$ accurately for small values of $x$                         |
| <code>log2</code>      | Base 2 logarithm and dissect floating-point numbers into exponent and mantissa |
| <code>nextpow2</code>  | Exponent of next higher power of 2                                             |
| <code>sqrt</code>      | Real nth root of real numbers                                                  |
| <code>pow</code>       | Base 2 power and scale floating-point numbers                                  |
| <code>reallog</code>   | Natural logarithm for nonnegative real arrays                                  |
| <code>realpow</code>   | Array power for real-only output                                               |
| <code>reallog1p</code> | Square root for nonnegative real arrays                                        |
| <code>sqrt</code>      | Square root                                                                    |

Descriptive Statistics

|                          |                                            |
|--------------------------|--------------------------------------------|
| <code>corrcoef</code>    | Correlation coefficients                   |
| <code>cov</code>         | Covariance                                 |
| <code>max</code>         | Largest elements in array                  |
| <code>cummax</code>      | Cumulative maximum                         |
| <code>mean</code>        | Average or mean value of array             |
| <code>median</code>      | Median value of array                      |
| <code>min</code>         | Smallest elements in array                 |
| <code>cummin</code>      | Cumulative minimum                         |
| <code>mode</code>        | Most frequent values in array              |
| <code>std</code>         | Standard deviation                         |
| <code>var</code>         | Variance                                   |
| <code>histcounts</code>  | Histogram bin counts                       |
| <code>histcounts2</code> | Bivariate histogram bin counts             |
| <code>discretize</code>  | Group numeric data into bins or categories |

|            |                                           |
|------------|-------------------------------------------|
| findgroups | Find groups and return group numbers      |
| splitapply | Split data into groups and apply function |

Complex Numbers

|          |                                                      |
|----------|------------------------------------------------------|
| abs      | Absolute value and complex magnitude                 |
| angle    | Phase angle                                          |
| complex  | Create complex array                                 |
| conj     | Complex conjugate                                    |
| conjpair | Sort complex numbers into complex conjugate pairs    |
| i        | Imaginary unit                                       |
| imag     | Imaginary part of complex number                     |
| isreal   | Determine whether array is real                      |
| j        | Imaginary unit                                       |
| real     | Real part of complex number                          |
| sign     | Sign function (signum function)                      |
| unwrap   | Correct phase angles to produce smoother phase plots |

Discrete Math

|           |                                                 |
|-----------|-------------------------------------------------|
| factor    | Prime factors                                   |
| factorial | Factorial of input                              |
| gcd       | Greatest common divisor                         |
| isprime   | Determine which array elements are prime        |
| lcm       | Least common multiple                           |
| nchoosek  | Binomial coefficient or all combinations        |
| perms     | All possible permutations                       |
| primes    | Prime numbers less than or equal to input value |
| rat       | Rational fraction approximation                 |
| rats      | Rational output                                 |

Polynomials

|          |                                                              |
|----------|--------------------------------------------------------------|
| poly     | Characteristic polynomial or polynomial with specified roots |
| polyeig  | Polynomial eigenvalue problem                                |
| polyfit  | Polynomial curve fitting                                     |
| residue  | Partial fraction expansion (partial fraction decomposition)  |
| roots    | Polynomial roots                                             |
| polyval  | Polynomial evaluation                                        |
| polyvalm | Matrix polynomial evaluation                                 |
| conv     | Convolution and polynomial multiplication                    |
| deconv   | Deconvolution and polynomial division                        |
| polyint  | Polynomial integration                                       |
| polyder  | Polynomial differentiation                                   |

Special Functions

|             |                                                      |
|-------------|------------------------------------------------------|
| airy        | Airy Functions                                       |
| besselh     | Bessel function of third kind (Hankel function)      |
| besseli     | Modified Bessel function of first kind               |
| besselj     | Bessel function of first kind                        |
| bessely     | Modified Bessel function of second kind              |
| bessell     | Bessel function of second kind                       |
| beta        | Beta function                                        |
| betainc     | Incomplete beta function                             |
| betaincinv  | Beta inverse cumulative distribution function        |
| betaln      | Logarithm of beta function                           |
| ellipj      | Jacobi elliptic functions                            |
| ellipke     | Complete elliptic integrals of first and second kind |
| erf         | Error function                                       |
| erfc        | Complementary error function                         |
| erfcinv     | Inverse complementary error function                 |
| erfcx       | Scaled complementary error function                  |
| erflaw      | Inverse error function                               |
| expint      | Exponential integral                                 |
| gamma       | Gamma function                                       |
| gammainc    | Incomplete gamma function                            |
| gammaincinv | Inverse incomplete gamma function                    |
| gamaln      | Logarithm of gamma function                          |
| legendre    | Associated Legendre functions                        |
| psi         | Psi (polygamma) function                             |

Cartesian Coordinate System Conversion

|          |                                                         |
|----------|---------------------------------------------------------|
| cart2pol | Transform Cartesian coordinates to polar or cylindrical |
| cart2sph | Transform Cartesian coordinates to spherical            |
| pol2cart | Transform polar or cylindrical coordinates to Cartesian |
| sph2cart | Transform spherical coordinates to Cartesian            |

Constants and Test Matrices

|           |                                                      |
|-----------|------------------------------------------------------|
| eps       | Floating-point relative accuracy                     |
| flintmax  | Largest consecutive integer in floating-point format |
| i         | Imaginary unit                                       |
| j         | Imaginary unit                                       |
| inf       | Infinity                                             |
| pi        | Ratio of circle's circumference to its diameter      |
| NaN       | Not-a-Number                                         |
| isFinite  | Array elements that are finite                       |
| isInf     | Array elements that are infinite                     |
| isnan     | Array elements that are NaN                          |
| compar    | Comparison matrix                                    |
| gallery   | Test matrices                                        |
| hadamard  | Hadamard matrix                                      |
| hankel    | Hankel matrix                                        |
| hilb      | Hilbert matrix                                       |
| invhils   | Inverse of Hilbert matrix                            |
| magic     | Magic square                                         |
| pascal    | Pascal matrix                                        |
| rosser    | Classic symmetric eigenvalue test problem            |
| twoside   | Toeplitz matrix                                      |
| vander    | Vandermonde matrix                                   |
| wilkinson | Wilkinson's eigenvalue test matrix                   |

Linear Algebra

Matrix Operations

|           |                                         |
|-----------|-----------------------------------------|
| cross     | Cross product                           |
| det       | Det product                             |
| kron      | Kronecker tensor product                |
| surfFour  | Compute and display 3-D surface normals |
| tril      | Lower triangular part of matrix         |
| triu      | Upper triangular part of matrix         |
| transpose | Transpose vector or matrix              |

Linear Equations

|           |                                                        |
|-----------|--------------------------------------------------------|
| cond      | Condition number with respect to inversion             |
| condest   | 1-norm condition number estimate                       |
| inv       | Matrix inverse                                         |
| linsolve  | Solve linear system of equations                       |
| lsqr      | Least-squares solution in presence of known covariance |
| lsqnonneg | Solve nonnegative least-squares constraints problem    |
| pinv      | Moore-Penrose pseudoinverse of matrix                  |
| rcond     | Reciprocal condition number                            |
| rsolve    | Solve Sylvester equation AX + XB = C for X             |
| rdivide   | Solve systems of linear equations AX = B for x         |
| rdivide   | Solve systems of linear equations xA = B for x         |

Matrix Decomposition

|            |                                                           |
|------------|-----------------------------------------------------------|
| chol       | Cholesky factorization                                    |
| cholz      | Incomplete Cholesky factorization                         |
| cholupdate | Rank 1 update to Cholesky factorization                   |
| lu         | Incomplete LU factorization                               |
| lu         | LU matrix factorization                                   |
| qr         | Orthogonal-triangular decomposition                       |
| qrdelete   | Remove column or row from QR factorization                |
| qrinsert   | Insert column or row into QR factorization                |
| qrupdate   | Rank 1 update to QR factorization                         |
| planneret  | Givens plane rotation                                     |
| ldl        | Block LDL factorization for Hermitian indefinite matrices |
| cdldf      | Convert complex diagonal form to real block diagonal form |
| rf2cdf     | Convert real Schur form to complex Schur form             |
| gsvd       | Generalized singular value decomposition                  |
| svd        | Singular value decomposition                              |

Eigenvalues and Singular Values

|          |                                                              |
|----------|--------------------------------------------------------------|
| balanc   | Diagonal scaling to improve eigenvalue accuracy              |
| cd2cdf   | Convert complex diagonal form to real block diagonal form    |
| condbig  | Condition number with respect to eigenvalues                 |
| eig      | Eigenvalues and eigenvectors                                 |
| eigs     | Largest eigenvalues and eigenvectors of matrix               |
| gsvd     | Generalized singular value decomposition                     |
| hess     | Hessenberg form of matrix                                    |
| ordbig   | Eigenvalues of quasi-triangular matrices                     |
| ordqr    | Reorder eigenvalues in QZ factorization                      |
| ordschur | Reorder eigenvalues in Schur factorization                   |
| poly     | Characteristic polynomial or polynomial with specified roots |
| polyeig  | Polynomial eigenvalue problem                                |
| qr       | QZ factorization for generalized eigenvalues                 |
| rf2cdf   | Convert real Schur form to complex Schur form                |
| schur    | Schur decomposition                                          |
| sqm      | Matrix square root                                           |
| sv2tf    | Convert state-space representation to transfer function      |
| svd      | Singular value decomposition                                 |
| svds     | Find singular values and vectors                             |

Matrix Analysis

|             |                                                     |
|-------------|-----------------------------------------------------|
| bandwidth   | Lower and upper matrix bandwidth                    |
| cond        | Condition number with respect to inversion          |
| condsig     | Condition number with respect to eigenvalues        |
| det         | Matrix determinant                                  |
| isbanded    | Determine if matrix is within specific bandwidth    |
| isdiag      | Determine if matrix is diagonal                     |
| ishermitian | Determine if matrix is Hermitian or skew-Hermitian  |
| issymmetric | Determine if matrix is symmetric or skew-symmetric  |
| istril      | Determine if matrix is lower triangular             |
| istriu      | Determine if matrix is upper triangular             |
| norm        | Vector and matrix norms                             |
| normest     | 2-norm estimate                                     |
| null        | Null space                                          |
| orth        | Orthonormal basis for range of matrix               |
| rank        | Rank of matrix                                      |
| rcond       | Reciprocal condition number                         |
| rref        | Reduced row echelon form (Gauss-Jordan elimination) |
| subspace    | Angle between two subspaces                         |
| trace       | Sum of diagonal elements                            |

|                         |                                                                                          |
|-------------------------|------------------------------------------------------------------------------------------|
| <b>Matrix Functions</b> |                                                                                          |
| expm                    | Matrix exponential                                                                       |
| logm                    | Matrix logarithm                                                                         |
| sqrtm                   | Matrix square root                                                                       |
| bsxfun                  | Apply element-by-element binary operation to two arrays with singleton expansion enabled |
| funs                    | Evaluate general matrix function                                                         |
| arrayfun                | Apply function to each element of array                                                  |
| accarray                | Construct array with accumulation                                                        |
| findgroups              | Find groups and return group numbers                                                     |
| splitapply              | Split data into groups and apply function                                                |
| mpower                  | Matrix power                                                                             |

|                                 |                                             |
|---------------------------------|---------------------------------------------|
| <b>Random Number Generation</b> |                                             |
| rand                            | Uniformly distributed random numbers        |
| randn                           | Normally distributed random numbers         |
| randi                           | Uniformly distributed pseudorandom integers |
| randperm                        | Random permutation                          |
| rng                             | Control random number generation            |
| RandStream                      | Random number stream                        |

|                          |                                                          |
|--------------------------|----------------------------------------------------------|
| <b>Interpolation</b>     |                                                          |
| <b>1-D Interpolation</b> |                                                          |
| interp1                  | 1-D data interpolation (table lookup)                    |
| griddataInterpant        | Gridded data interpolation                               |
| pchip                    | Piecewise Cubic Hermite Interpolating Polynomial (PCHIP) |
| spline                   | Cubic spline data interpolation                          |
| pval                     | Evaluate piecewise polynomial                            |
| mkpp                     | Make piecewise polynomial                                |
| unmkpp                   | Piecewise polynomial details                             |
| padecurf                 | Padé approximation of time delays                        |
| interpft                 | 1-D interpolation using FFT method                       |

|                                   |                                                                        |
|-----------------------------------|------------------------------------------------------------------------|
| <b>Gridded Data Interpolation</b> |                                                                        |
| interp2                           | Interpolation for 2-D gridded data in meshgrid format                  |
| interp3                           | Interpolation for 3-D gridded data in meshgrid format                  |
| interpn                           | Interpolation for 2-D, 2-D, 3-D, and N-D gridded data in ndgrid format |
| griddataInterpant                 | Gridded data interpolation                                             |
| ndgrid                            | Rectangular grid in N-D space                                          |
| meshgrid                          | Rectangular grid in 2-D and 3-D space                                  |

|                                     |                                                        |
|-------------------------------------|--------------------------------------------------------|
| <b>Scattered Data Interpolation</b> |                                                        |
| griddata                            | Interpolate scattered data                             |
| griddataN                           | Data gridding and hypersurface fitting (dimension > 2) |
| scatteredInterpant                  | Scattered data interpolation                           |

|                     |                                                                                   |
|---------------------|-----------------------------------------------------------------------------------|
| <b>Optimization</b> |                                                                                   |
| fminbnd             | Find minimum of single-variable function on fixed interval                        |
| fminsearch          | Find minimum of unconstrained multivariable function using derivative-free method |
| fzero               | Root of nonlinear function                                                        |
| fmincon             | Solve nonnegative least-squares constrained problem                               |
| optimset            | Optimization options values                                                       |
| optimset1           | Create or edit optimization options structure                                     |

Numerical Integration and Differential Equations

|                                        |                                                                              |
|----------------------------------------|------------------------------------------------------------------------------|
| <b>Ordinary Differential Equations</b> |                                                                              |
| lsodes                                 | Solve nons stiff differential equations; medium order method                 |
| ode15s                                 | Solve stiff differential equations and DAEs; variable order method           |
| ode23                                  | Solve nons stiff differential equations; low order method                    |
| ode113                                 | Solve nons stiff differential equations; variable order method               |
| ode23s                                 | Solve moderately stiff ODEs and DAEs; implicit Euler rule                    |
| ode23tb                                | Solve stiff differential equations; low order method                         |
| ode23t                                 | Solve stiff differential equations; low order method                         |
| ode15i                                 | Solve fully implicit differential equations; variable order method           |
| deval                                  | Compute consistent initial conditions for ode15i                             |
| odevarnd                               | Extend solution of initial value problem for ordinary differential equation  |
| odeget                                 | Ordinary differential equation options parameters                            |
| odevar1                                | Create or alter options structure for ordinary differential equation solvers |
| deval1                                 | Evaluate solution of differential equation problem                           |

|                                |                                                                   |
|--------------------------------|-------------------------------------------------------------------|
| <b>Boundary Value Problems</b> |                                                                   |
| bvp4c                          | Solve boundary value problems for ordinary differential equations |
| bvp5c                          | Solve boundary value problems for ordinary differential equations |
| bvp4c1                         | Form initial guess for BVP solvers                                |
| bvpgetnd                       | Form guess structure for extending boundary value solutions       |
| bvpget                         | Extract properties from options structure created with bvpget     |
| bvpset                         | Create or alter options structure of boundary value problem       |
| deval1                         | Evaluate solution of differential equation problem                |

|                                     |                                                                        |
|-------------------------------------|------------------------------------------------------------------------|
| <b>Delay Differential Equations</b> |                                                                        |
| dde23                               | Solve delay differential equations (DDEs) with constant delays         |
| dde45                               | Solve delay differential equations (DDEs) with general delays          |
| ddemd                               | Solve delay differential equations (DDEs) of neutral type              |
| ddget                               | Extract properties from delay differential equations options structure |
| ddset                               | Create or alter delay differential equations options structure         |
| deval1                              | Evaluate solution of differential equation problem                     |

|                                       |                                                                          |
|---------------------------------------|--------------------------------------------------------------------------|
| <b>Partial Differential Equations</b> |                                                                          |
| pdepe                                 | Solve initial-boundary value problems for parabolic-elliptic PDEs in 1-D |
| pdeval1                               | Evaluate numerical solution of PDE using output of pdepe                 |

|                                                  |                                                                  |
|--------------------------------------------------|------------------------------------------------------------------|
| <b>Numerical Integration and Differentiation</b> |                                                                  |
| integrate1                                       | Numerical integration                                            |
| integrate12                                      | Numerically evaluate double integral                             |
| integrate13                                      | Numerically evaluate triple integral                             |
| quadgk                                           | Numerically evaluate integral, adaptive Gauss-Kronrod quadrature |
| quad2d                                           | Numerically evaluate double integral, tiled method               |
| conttrapz                                        | Cumulative trapezoidal numerical integration                     |
| trapz                                            | Trapezoidal numerical integration                                |
| polyint                                          | Polynomial integration                                           |
| ds12                                             | Discrete Laplacian                                               |
| diff                                             | Differences and Approximate Derivatives                          |
| grad1ant                                         | Numerical gradient                                               |
| polyder                                          | Polynomial differentiation                                       |

|                                       |                                                             |
|---------------------------------------|-------------------------------------------------------------|
| <b>Fourier Analysis and Filtering</b> |                                                             |
| abs                                   | Absolute value and complex magnitude                        |
| angle                                 | Phase angle                                                 |
| abs2syr                               | Sort complex numbers into complex conjugate pairs           |
| fft                                   | Fast Fourier transform                                      |
| fft2                                  | 2-D fast Fourier transform                                  |
| fftN                                  | N-D fast Fourier transform                                  |
| fftshift                              | Shift zero frequency component to center of spectrum        |
| fftw                                  | Interface to FFTW library run-time algorithm tuning control |
| ifft                                  | Inverse fast Fourier transform                              |
| ifft2                                 | 2-D inverse fast Fourier transform                          |
| ifftN                                 | N-D inverse fast Fourier transform                          |
| ifftshift                             | Inverse FFT shift                                           |
| nextpow2                              | Exponent of next higher power of 2                          |
| unwrap                                | Correct phase angles to produce smoother phase plots        |
| conv                                  | Convolution and polynomial multiplication                   |
| conv2                                 | 2-D convolution                                             |
| convn                                 | N-D convolution                                             |
| deconv                                | Deconvolution and polynomial division                       |
| detrend                               | Remove linear trends                                        |
| filter                                | 1-D digital filter                                          |
| filter2                               | 2-D digital filter                                          |

|                               |                                                      |
|-------------------------------|------------------------------------------------------|
| <b>Sparse Matrices</b>        |                                                      |
| <b>Sparse Matrix Creation</b> |                                                      |
| spalloc                       | Allocate space for sparse matrix                     |
| spdiags                       | Extract and create sparse band and diagonal matrices |
| speye                         | Sparse identity matrix                               |
| sprand                        | Sparse uniformly distributed random matrix           |
| sprandn                       | Sparse normally distributed random matrix            |
| sprandsym                     | Sparse symmetric random matrix                       |
| sparse                        | Create sparse matrix                                 |
| spconvert                     | Import from sparse matrix external format            |

|                                              |                                                          |
|----------------------------------------------|----------------------------------------------------------|
| Sparse Matrix Manipulation                   |                                                          |
| <code>issparse</code>                        | Determine whether input is sparse                        |
| <code>nnz</code>                             | Number of nonzero matrix elements                        |
| <code>nnzmax</code>                          | Nonzero matrix elements                                  |
| <code>nnzmax</code>                          | Amount of storage allocated for nonzero matrix elements  |
| <code>spfun</code>                           | Apply function to nonzero sparse matrix elements         |
| <code>spones</code>                          | Replace nonzero sparse matrix elements with ones         |
| <code>spoptions</code>                       | Set parameters for sparse matrix routines                |
| <code>spy</code>                             | Visualize sparsity pattern                               |
| <code>find</code>                            | Find indices and values of nonzero elements              |
| <code>full</code>                            | Convert sparse matrix to full matrix                     |
| Reordering Algorithms                        |                                                          |
| <code>colamd</code>                          | Approximate minimum degree permutation                   |
| <code>colperm</code>                         | Column approximate minimum degree permutation            |
| <code>colperm</code>                         | Sparse column permutation based on nonzero count         |
| <code>disperm</code>                         | Outdegree Minrelaxium decomposition                      |
| <code>randperm</code>                        | Random permutation                                       |
| <code>symamd</code>                          | Symmetric approximate minimum degree permutation         |
| <code>symrcm</code>                          | Sparse reverse Cuthill-McKee ordering                    |
| Sparse Linear Algebra                        |                                                          |
| Linear Equations                             |                                                          |
| <code>pcg</code>                             | Preconditioned conjugate gradients method                |
| <code>minres</code>                          | Minimum residual method                                  |
| <code>symmls</code>                          | Symmetric LQ method                                      |
| <code>gmres</code>                           | Generalized minimum residual method (with restart)       |
| <code>bicg</code>                            | Biconjugate gradients method                             |
| <code>bicgstab</code>                        | Biconjugate gradients stabilized method                  |
| <code>bicgstab</code>                        | Biconjugate gradients stabilized (l) method              |
| <code>cgs</code>                             | Conjugate gradients squared method                       |
| <code>qmr</code>                             | Quasi-minimal residual method                            |
| <code>tfqr</code>                            | Transpose-free quasi-minimal residual method             |
| <code>lsqr</code>                            | LSQR method                                              |
| <code>ichol</code>                           | Incomplete Cholesky factorization                        |
| <code>ilu</code>                             | Incomplete LU factorization                              |
| Eigenvalues and Singular Values              |                                                          |
| <code>eigs</code>                            | Largest eigenvalues and eigenvectors of matrix           |
| <code>svals</code>                           | Find singular values and vectors                         |
| <code>normest</code>                         | 2-norm estimate                                          |
| <code>condest</code>                         | 1-norm condition number estimate                         |
| Structural Analysis                          |                                                          |
| <code>isrwk</code>                           | Structural rank                                          |
| <code>etree</code>                           | Elimination tree                                         |
| <code>symfact</code>                         | Symbolic factorization analysis                          |
| <code>spaugment</code>                       | Form least squares augmented system                      |
| <code>disperm</code>                         | Outdegree Minrelaxium decomposition                      |
| <code>etreeplot</code>                       | Plot elimination tree                                    |
| <code>treelayout</code>                      | Lay out tree or forest                                   |
| <code>treeplot</code>                        | Plot picture of tree                                     |
| <code>gplot</code>                           | Plot nodes and lines representing adjacency matrix       |
| <code>unswch</code>                          | Convert edge matrix to coordinate and Laplacian matrices |
| Graph and Network Algorithms                 |                                                          |
| <code>graph</code>                           | Create undirected graph                                  |
| <code>digraph</code>                         | Create directed graph                                    |
| <code>addnode</code>                         | Add new node to graph                                    |
| <code>rmnode</code>                          | Remove node from graph                                   |
| <code>addedge</code>                         | Add new edge to graph                                    |
| <code>rmedge</code>                          | Remove edge from graph                                   |
| <code>numnodes</code>                        | Number of nodes in graph                                 |
| <code>numedges</code>                        | Number of edges in graph                                 |
| <code>findnode</code>                        | Locate node in graph                                     |
| <code>findedge</code>                        | Locate edge in graph                                     |
| <code>reordernodes</code>                    | Reorder graph nodes                                      |
| <code>subgraph</code>                        | Extract subgraph                                         |
| <code>bfsearch</code>                        | Breadth-first graph search                               |
| <code>dfsearch</code>                        | Depth-first graph search                                 |
| <code>maxflow</code>                         | Maximum flow in graph                                    |
| <code>conncomp</code>                        | Connected graph components                               |
| <code>minspantree</code>                     | Minimum spanning tree of graph                           |
| <code>testacyc</code>                        | Test graph order or directed acyclic graph               |
| <code>isdag</code>                           | Determine if graph is acyclic                            |
| <code>transclosure</code>                    | Transitive closure                                       |
| <code>transreduction</code>                  | Transitive reduction                                     |
| <code>shortestpath</code>                    | Shortest path between two single nodes                   |
| <code>shortestpathtree</code>                | Shortest path tree from node                             |
| <code>distances</code>                       | Shortest path distances of all node pairs                |
| <code>adjacency</code>                       | Graph adjacency matrix                                   |
| <code>incidence</code>                       | Graph incidence matrix                                   |
| <code>laplacian</code>                       | Graph Laplacian matrix                                   |
| <code>degree</code>                          | Degree of graph nodes                                    |
| <code>neighbors</code>                       | Neighbors of graph node                                  |
| <code>indegree</code>                        | In-degree of nodes                                       |
| <code>outdegree</code>                       | Out-degree of nodes                                      |
| <code>predecessors</code>                    | Node predecessors                                        |
| <code>successors</code>                      | Node successors                                          |
| <code>plot</code>                            | Graph plot                                               |
| <code>labeledge</code>                       | Label graph edges                                        |
| <code>labelnode</code>                       | Label graph nodes                                        |
| <code>layout</code>                          | Change layout of graph plot                              |
| <code>highlight</code>                       | Highlight nodes and edges in plotted graph               |
| <code>graph</code>                           | Graph with undirected edges                              |
| <code>digraph</code>                         | Graph with directed edges                                |
| <code>GraphPlot</code>                       | Graph plot for directed and undirected graphs            |
| Computational Geometry                       |                                                          |
| Triangulation Representation                 |                                                          |
| <code>triangulation</code>                   | Triangulation in 2-D or 3-D                              |
| <code>tetramesh</code>                       | Tetrahedron mesh plot                                    |
| <code>tri mesh</code>                        | Triangular mesh plot                                     |
| <code>triplot</code>                         | 2-D triangular plot                                      |
| <code>triurf</code>                          | Triangular surface plot                                  |
| Delaunay Triangulation                       |                                                          |
| <code>delaunayTriangulation</code>           | Delaunay triangulation in 2-D and 3-D                    |
| <code>delaunay</code>                        | Delaunay triangulation                                   |
| <code>delaunayn</code>                       | N-D Delaunay triangulation                               |
| <code>tetramesh</code>                       | Tetrahedron mesh plot                                    |
| <code>tri mesh</code>                        | Triangular mesh plot                                     |
| <code>triplot</code>                         | 2-D triangular plot                                      |
| <code>triurf</code>                          | Triangular surface plot                                  |
| Spatial Search                               |                                                          |
| <code>triangulation</code>                   | Triangulation in 2-D or 3-D                              |
| <code>delaunayTriangulation</code>           | Delaunay triangulation in 2-D and 3-D                    |
| <code>dsearchn</code>                        | N-D nearest point search                                 |
| <code>tsearchn</code>                        | N-D closest simplex search                               |
| <code>delaunay</code>                        | Delaunay triangulation                                   |
| <code>delaunayn</code>                       | N-D Delaunay triangulation                               |
| Bounding Regions                             |                                                          |
| <code>boundary</code>                        | Boundary of a set of points in 2-D or 3-D                |
| <code>alphaShape</code>                      | Polygons and polyhedra from points in 2-D and 3-D        |
| <code>convhull</code>                        | Convex hull                                              |
| <code>convhulln</code>                       | N-D convex hull                                          |
| <code>alphaShape</code>                      | Polygons and polyhedra from points in 2-D and 3-D        |
| Voronoi Diagram                              |                                                          |
| <code>patch</code>                           | Create one or more filled polygons                       |
| <code>voronoi</code>                         | Voronoi diagram                                          |
| <code>voronoin</code>                        | N-D Voronoi diagram                                      |
| Elementary Polygons                          |                                                          |
| <code>polyarea</code>                        | Area of polygon                                          |
| <code>inpolygon</code>                       | Points located inside or on edge of polygonal region     |
| <code>rectint</code>                         | Rectangle intersection area                              |
| Graphics                                     |                                                          |
| 2-D and 3-D Plots                            |                                                          |
| Line Plots                                   |                                                          |
| <code>plot</code>                            | 2-D line plot                                            |
| <code>plotyy</code>                          | 2-D line plots with y-axes on both left and right side   |
| <code>plot3</code>                           | 3-D line plot                                            |
| <code>loglog</code>                          | Log-log scale plot                                       |
| <code>semilogx</code>                        | Semilogarithmic plot                                     |
| <code>semilogy</code>                        | Semilogarithmic plot                                     |
| <code>errorbar</code>                        | Plot error bars along curve                              |
| <code>fplot</code>                           | Plot function between specified limits                   |
| <code>ezplot</code>                          | Easy-to-use function plotter                             |
| <code>ezplot3</code>                         | Easy-to-use 3-D parametric curve plotter                 |
| <code>LineSpec (Line Specification)</code>   | Line specification string syntax                         |
| <code>ColorSpec (Color Specification)</code> | Color specification                                      |
| Pie Charts, Bar Plots, and Histograms        |                                                          |
| <code>bar</code>                             | Bar graph                                                |

|             |                                       |
|-------------|---------------------------------------|
| bar         | Plot 3-D bar graph                    |
| barh        | Plot bar graph horizontally           |
| barb        | Plot horizontal 3-D bar graph         |
| histogram   | Histogram plot                        |
| histcounts  | Histogram bin counts                  |
| histogram2  | Bivariate histogram plot              |
| histcounts2 | Bivariate histogram bin counts        |
| rose        | Angle histogram plot                  |
| pareto      | Pareto chart                          |
| area        | Filled area 2-D plot                  |
| pie         | Pie chart                             |
| pie3        | 3-D pie chart                         |
| histogram   | Histogram bar plot for numeric data   |
| histogram2  | Histogram bar plot for bivariate data |

Discrete Data Plots

|            |                                 |
|------------|---------------------------------|
| stem       | Plot discrete sequence data     |
| stairs     | Stairstep graph                 |
| stem3      | Plot 3-D discrete sequence data |
| scatter    | Scatter plot                    |
| scatter3   | 3-D scatter plot                |
| spy        | Visualize sparsity pattern      |
| plotmatrix | Scatter plot matrix             |

Polar Plots

|                                 |                                      |
|---------------------------------|--------------------------------------|
| polar                           | Polar coordinate plot                |
| rose                            | Angle histogram plot                 |
| compass                         | Plot arrows emanating from origin    |
| quiver                          | Easy-to-use polar coordinate plotter |
| LineSpec (Line Specification)   | Line specification string syntax     |
| ColorSpec (Color Specification) | Color specification                  |

Contour Plots

|              |                                      |
|--------------|--------------------------------------|
| contour      | Contour plot of matrix               |
| contourf     | Filled 2-D contour plot              |
| contourc     | Low-level contour plot computation   |
| contour3     | 3-D contour plot                     |
| contourslice | Draw contours in volume slice planes |
| clabel       | Label contour plot elevation         |
| acountour    | Easy-to-use contour plotter          |
| acountourf   | Easy-to-use filled contour plotter   |

Vector Fields

|            |                                              |
|------------|----------------------------------------------|
| quiver     | Plot velocity vectors                        |
| quiver     | Quiver or velocity plot                      |
| compass    | Plot arrows emanating from origin            |
| quiver3    | 3-D quiver or velocity plot                  |
| streamline | Plot streamlines in slice planes             |
| streamline | Plot streamlines from 2-D or 3-D vector data |

Surfaces, Volumes, and Polygons

Surface and Mesh Plots

|            |                                                 |
|------------|-------------------------------------------------|
| surf       | 3-D shaded surface plot                         |
| surfz      | Contour plot under a 3-D shaded surface plot    |
| surface    | Create surface object                           |
| surf1      | Surface plot with colormap-based lighting       |
| surfnorm   | Compute and display 3-D surface normals         |
| mesh       | Mesh plot                                       |
| meshc      | Plot a contour graph under mesh graph           |
| meshz      | Plot a curtain around mesh plot                 |
| waterfall  | Waterfall plot                                  |
| ribbon     | Ribbon plot                                     |
| contour3   | 3-D contour plot                                |
| peaks      | Example function of two variables               |
| cylinder   | Generate cylinder                               |
| ellipsoid  | Generate ellipsoid                              |
| sphere     | Generate sphere                                 |
| pcolor     | Pseudocolor (checkerboard) plot                 |
| surf2patch | Convert surface data to patch data              |
| surfz      | Easy-to-use 3-D colored surface plotter         |
| surf3      | Easy-to-use combination surface/contour plotter |
| mesh       | Easy-to-use 3-D mesh plotter                    |
| meshc      | Easy-to-use combination mesh/contour plotter    |

Volume Visualization

|                   |                                                    |
|-------------------|----------------------------------------------------|
| contourslice      | Draw contours in volume slice planes               |
| fun               | Simple function of three variables                 |
| isosax            | Compute isosurface and cap geometry                |
| isoscolors        | Calculate isosurface and patch colors              |
| isosnormals       | Compute normals of isosurface vertices             |
| isosurface        | Extract isosurface data from volume data           |
| reducerepatch     | Reduce number of patch faces                       |
| reducerevolume    | Reduce number of elements in volume data set       |
| shrinkfaces       | Reduce size of patch faces                         |
| slice             | Volumetric slice plot                              |
| smooth3           | Smooth 3-D data                                    |
| subvolume         | Extract subset of volume data set                  |
| volumerounds      | Coordinate and color limits for volume data        |
| complext          | Plot velocity vectors as cones in 3-D vector field |
| curl              | Compute curl and angular velocity of vector field  |
| divergence        | Compute divergence of vector field                 |
| interpstreamspeed | Interpolate stream-line velocities from flow speed |
| stream            | Compute 3-D streamline data                        |
| stream3           | Compute 3-D streamline data                        |
| streamline        | Plot streamlines from 2-D or 3-D vector data       |
| streamparticles   | Plot stream particles                              |
| streamribbon      | 3-D stream ribbon plot from vector-volume data     |
| streamslice       | Plot streamlines in slice planes                   |
| streamtube        | Create 3-D stream tube plot                        |

Polygons

|            |                                    |
|------------|------------------------------------|
| fill       | Filled 2-D polygons                |
| fill3      | Filled 3-D polygons                |
| patch      | Create one or more filled polygons |
| surf2patch | Convert surface data to patch data |

Animation

|               |                                                     |
|---------------|-----------------------------------------------------|
| movie         | Play recorded movie frames                          |
| getframe      | Capture axes or figure as movie frame               |
| frame2im      | Return image data associated with movie frame       |
| im2frame      | Convert image to movie frame                        |
| animatedline  | Create animated line                                |
| comet         | 3-D comet plot                                      |
| comet3        | 3-D comet plot                                      |
| drawnow       | Update figures and process callbacks                |
| refreshdata   | Refresh data in graph when data source is specified |
| animated_line | Line animations                                     |

Formatting and Annotation

Titles and Labels

|            |                                               |
|------------|-----------------------------------------------|
| title      | Add title to current axes                     |
| xlabel     | Label x-axis                                  |
| ylabel     | Label y-axis                                  |
| zlabel     | Label z-axis                                  |
| clabel     | Label contour plot elevation                  |
| legend     | Add legend to graph                           |
| colorbar   | Colorbar showing color scale                  |
| text       | Add text descriptions to data points          |
| textlabel  | Format text into TeX string                   |
| gtext      | Add text to figure using mouse                |
| line       | Create line object                            |
| rectangle  | Create rectangle with sharp or curved corners |
| annotation | Create annotations                            |

Coordinate System

|          |                                           |
|----------|-------------------------------------------|
| axis     | Set or query x-axis limits                |
| ylim     | Set or query y-axis limits                |
| zlim     | Set or query z-axis limits                |
| axis     | Set axis limits and appearance            |
| box      | Display axes outline                      |
| grid     | Display or hide axes grid lines           |
| daspect  | Control data unit length along each axis  |
| daspect1 | Control relative lengths of each axis     |
| datetick | Date formatted tick labels                |
| hold     | Retain current plot when adding new plots |
| subplot  | Create axes in tiled positions            |
| axes     | Create axes graphics object               |
| figure   | Create figure window                      |
| gc       | Current axes handle                       |
| cla      | Clear axes                                |

Colormaps

|                |                                                      |
|----------------|------------------------------------------------------|
| colormap       | View and set current colormap                        |
| colormapeditor | Open colormap editor                                 |
| colorbar       | Colorbar showing color scale                         |
| lightgray      | Brighten or darken colormap                          |
| contrast       | Grayscale colormap for contrast enhancement          |
| shading        | Set color shading properties                         |
| graymap        | Set default figure properties for grayscale monitors |
| caxis          | Color axis scaling                                   |
| hsv2rgb        | Convert HSV colormap to RGB colormap                 |

|                         |                                                                |
|-------------------------|----------------------------------------------------------------|
| <code>rgb2hsv</code>    | Convert RGB colormap to HSV colormap                           |
| <code>rgb2plot</code>   | Plot colormap                                                  |
| <code>spincolmap</code> | Spin colormap                                                  |
| <code>colororder</code> | Set default property values to display different color schemes |
| <code>whictheg</code>   | Change axes background color                                   |

|                             |                                                                 |
|-----------------------------|-----------------------------------------------------------------|
| <b>Data Exploration</b>     |                                                                 |
| <code>hidden</code>         | Remove hidden lines from mesh plot                              |
| <code>pan</code>            | Pan view of graph interactively                                 |
| <code>reset</code>          | Reset graphics object properties to their defaults              |
| <code>rotate</code>         | Rotate object about specified origin and direction              |
| <code>rotate3d</code>       | Rotate 3-D view using mouse                                     |
| <code>zoom</code>           | Turn zooming on or off or magnify by factor/magnify by a factor |
| <code>datacursormode</code> | Enable, disable, and manage interactive data cursor mode        |
| <code>ginput</code>         | Graphical input from mouse or cursor                            |
| <code>figurepalette</code>  | Show or Hide Figure Palette                                     |
| <code>plotbrowser</code>    | Show or Hide Figure Plot Browser                                |
| <code>plotedit</code>       | Interactively edit and annotate plots                           |
| <code>plottools</code>      | Show or hide plot tools                                         |
| <code>propertyeditor</code> | Show or Hide Property Editor                                    |
| <code>propedit</code>       | Open Property Editor                                            |
| <code>showplottool</code>   | Show or hide figure plot tool                                   |

|                             |                                                                     |
|-----------------------------|---------------------------------------------------------------------|
| <b>Data Brushing</b>        |                                                                     |
| <code>brush</code>          | Interactively mark, delete, modify, and save observations in graphs |
| <code>datacursormode</code> | Enable, disable, and manage interactive data cursor mode            |
| <code>linkdata</code>       | Automatically update graphs when variables change                   |
| <code>linkaxes</code>       | Synchronize limits of specified 2-D axes                            |
| <code>linkaxes3</code>      | Keep same value for corresponding properties of graphics objects    |
| <code>refreshdata</code>    | Refresh data in graph when data source is specified                 |

|                            |                                                    |
|----------------------------|----------------------------------------------------|
| <b>3-D Scene Control</b>   |                                                    |
| <b>Camera Views</b>        |                                                    |
| <code>view</code>          | Viewpoint specification                            |
| <code>axisalignform</code> | Create 4-by-4 transform matrix                     |
| <code>viewmtx</code>       | View transformation matrices                       |
| <code>cameratoolbar</code> | Control camera toolbar programmatically            |
| <code>camobj</code>        | Rotate camera target around camera position        |
| <code>zoom</code>          | Zoom in and out on scene                           |
| <code>camobj2y</code>      | Move camera position and target                    |
| <code>camobjset</code>     | Position camera to view object or group of objects |
| <code>camobjr1</code>      | Rotate camera position around camera target        |
| <code>camobjx</code>       | Set or query camera position                       |
| <code>camobjy</code>       | Set or query projection type                       |
| <code>camobjz</code>       | Rotate camera about view axis                      |
| <code>camtarget</code>     | Set or query location of camera target             |
| <code>camup</code>         | Set or query camera up vector                      |
| <code>camva</code>         | Set or query camera view angle                     |

|                                  |                                                          |
|----------------------------------|----------------------------------------------------------|
| <b>Lighting and Transparency</b> |                                                          |
| <code>camlight</code>            | Create or move light object in camera coordinates        |
| <code>light</code>               | Create light object                                      |
| <code>lightangle</code>          | Create or position light object in spherical coordinates |
| <code>lighting</code>            | Specify lighting algorithm                               |
| <code>diffuse</code>             | Calculate diffuse reflectance                            |
| <code>material</code>            | Control reflectance properties of surfaces and patches   |
| <code>specular</code>            | Calculate specular reflectance                           |
| <code>axis</code>                | Set or query axes alpha limits                           |
| <code>alpha</code>               | Add transparency to objects in axes                      |
| <code>alphamap</code>            | Specify figure alphamap (transparency)                   |

|                        |                                                                                               |
|------------------------|-----------------------------------------------------------------------------------------------|
| <b>Images</b>          |                                                                                               |
| <code>imshow</code>    | Display image                                                                                 |
| <code>image</code>     | Display image from array                                                                      |
| <code>imagesc</code>   | Display image with scaled colors                                                              |
| <code>imread</code>    | Read image from graphics file                                                                 |
| <code>imwrite</code>   | Write image to graphics file                                                                  |
| <code>infoinfo</code>  | Information about graphics file                                                               |
| <code>imformats</code> | Manage image file format registry                                                             |
| <code>frame2im</code>  | Return image data associated with movie frame                                                 |
| <code>im2frame</code>  | Convert image to movie frame                                                                  |
| <code>im2java</code>   | Convert image to Java image                                                                   |
| <code>im2double</code> | Convert image to double precision                                                             |
| <code>im2rgb</code>    | Convert indexed image to RGB image                                                            |
| <code>rgb2gray</code>  | Convert RGB image or colormap to grayscale                                                    |
| <code>rgb2ind</code>   | Convert RGB image to indexed image                                                            |
| <code>imcmap</code>    | Approximate indexed image by reducing number of colors                                        |
| <code>dither</code>    | Convert image, increasing apparent color resolution by dithering                              |
| <code>cmpermute</code> | Rearrange colors in colormap                                                                  |
| <code>cmunique</code>  | Eliminate duplicate colors in colormap; convert grayscale or truecolor image to indexed image |

|                            |                                              |
|----------------------------|----------------------------------------------|
| <b>Printing and Saving</b> |                                              |
| <code>print</code>         | Print figure or save to specific file format |
| <code>saveas</code>        | Save figure to specific file format          |
| <code>getframe</code>      | Capture axes or figure as movie frame        |
| <code>savefig</code>       | Save figure and contents to FIG-file         |
| <code>openfig</code>       | Open figure saved in FIG-file                |
| <code>orient</code>        | Hardcopy paper orientation                   |
| <code>figexport</code>     | Export figure                                |
| <code>printsetup</code>    | Configure printer defaults                   |

|                                   |                                                    |
|-----------------------------------|----------------------------------------------------|
| <b>Graphics Objects</b>           |                                                    |
| <b>Graphics Object Properties</b> |                                                    |
| <code>get</code>                  | Query graphics object properties                   |
| <code>set</code>                  | Set graphics object properties                     |
| <code>reset</code>                | Reset graphics object properties to their defaults |
| <code>inspect</code>              | Open Property Inspector                            |

|                                       |                                                                |
|---------------------------------------|----------------------------------------------------------------|
| <b>Graphics Object Identification</b> |                                                                |
| <code>gca</code>                      | Current axes handle                                            |
| <code>get</code>                      | Current figure handle                                          |
| <code>gcf</code>                      | Handle of figure containing object whose callback is executing |
| <code>gco</code>                      | Handle of object whose callback is executing                   |
| <code>gc</code>                       | Handle of current object                                       |
| <code>groot</code>                    | Graphics root object                                           |
| <code>ancestor</code>                 | Ancestor of graphics object                                    |
| <code>allchild</code>                 | Find all children of specified objects                         |
| <code>findall</code>                  | Find all graphics objects                                      |
| <code>findobj</code>                  | Locate graphics objects with specific properties               |
| <code>findfigs</code>                 | Find visible offscreen figures                                 |
| <code>gobjects</code>                 | Initialize array for graphics objects                          |
| <code>graphics</code>                 | True for valid graphics object handles                         |
| <code>isvalid</code>                  | Test for valid graphics or Java object handle                  |
| <code>copyobj</code>                  | Copy graphics objects and their descendants                    |
| <code>delete</code>                   | Delete files or objects                                        |

|                                    |                                                 |
|------------------------------------|-------------------------------------------------|
| <b>Graphics Object Programming</b> |                                                 |
| <code>gobjects</code>              | Initialize array for graphics objects           |
| <code>isgraphics</code>            | True for valid graphics object handles          |
| <code>isempty</code>               | Determine whether array is empty                |
| <code>isequal</code>               | Determine array equality                        |
| <code>isa</code>                   | Determine if input is object of specified class |
| <code>clf</code>                   | Clear current figure window                     |
| <code>c1a</code>                   | Clear axes                                      |
| <code>close</code>                 | Remove specified figure                         |

|                                          |                                               |
|------------------------------------------|-----------------------------------------------|
| <b>Interactive Control and Callbacks</b> |                                               |
| <code>uicontextmenu</code>               | Create context menu                           |
| <code>uimenu</code>                      | Create menus and menu items on figure windows |
| <code>dragrect</code>                    | Drag rectangles with mouse                    |
| <code>rbbbox</code>                      | Create rubberband box for area selection      |
| <code>refresh</code>                     | Redraw current figure                         |
| <code>shg</code>                         | Show most recent graph window                 |

|                            |                                  |
|----------------------------|----------------------------------|
| <b>Object Containers</b>   |                                  |
| <code>hggroup</code>       | Create group object              |
| <code>hgtransform</code>   | Create transform graphics object |
| <code>axisalignform</code> | Create 4-by-4 transform matrix   |
| <code>eye</code>           | Identity matrix                  |

|                                              |                                           |
|----------------------------------------------|-------------------------------------------|
| <b>Specifying Target for Graphics Output</b> |                                           |
| <code>hold</code>                            | Retain current plot when adding new plots |
| <code>holdall</code>                         | Current hold state                        |
| <code>holdoff</code>                         | Determine where to draw graphics objects  |
| <code>clf</code>                             | Clear current figure window               |
| <code>c1a</code>                             | Clear axes                                |

|                             |                                      |
|-----------------------------|--------------------------------------|
| <b>Graphics Performance</b> |                                      |
| <code>afname</code>         | Update figures and process callbacks |
| <code>opengl</code>         | Control OpenGL rendering             |

Programming Scripts and Functions

|                                        |                                               |
|----------------------------------------|-----------------------------------------------|
| <b>Control Flow</b>                    |                                               |
| <code>if...elseif...else</code>        | Execute statements if condition is true       |
| <code>for</code>                       | Execute statements specified number of times  |
| <code>parfor</code>                    | Parallel for loop                             |
| <code>switch...case...otherwise</code> | Execute one of several groups of statements   |
| <code>try...catch</code>               | Execute statements and catch resulting errors |

|          |                                                        |
|----------|--------------------------------------------------------|
| while    | Repeat execution of statements while condition is true |
| break    | Terminate execution of for or while loop               |
| continue | Pass control to next iteration of for or while loop    |
| end      | Terminate block of code, or indicate last array index  |
| pause    | Stop MATLAB execution temporarily                      |
| return   | Return control to invoking function                    |

Scripts

|            |                                                                                  |
|------------|----------------------------------------------------------------------------------|
| edit       | Edit or create file                                                              |
| input      | Request user input                                                               |
| publish    | Generate view of MATLAB file in specified format                                 |
| runeforink | Open MATLAB Notebook in Microsoft Word software (on Microsoft Windows platforms) |
| grabscode  | Extract MATLAB code from file published to HTML                                  |
| snagimg    | Force snapshot of image for inclusion in published document                      |

Functions

Function Basics

|          |                                            |
|----------|--------------------------------------------|
| function | Declare function name, inputs, and outputs |
|----------|--------------------------------------------|

Input and Output Arguments

|                    |                                      |
|--------------------|--------------------------------------|
| nargin             | Number of function input arguments   |
| nargout            | Number of function output arguments  |
| varargout          | Variable-length input argument list  |
| varargout          | Variable-length output argument list |
| narginchk          | Validate number of input arguments   |
| nargoutchk         | Validate number of output arguments  |
| validatearraytypes | Check validity of array              |
| validatestring     | Check validity of text string        |
| inputParser        | Parse function inputs                |
| inputname          | Variable name of function input      |

Variables

|                               |                                                       |
|-------------------------------|-------------------------------------------------------|
| persistent                    | Define persistent variable                            |
| isvarname                     | Determine whether input is valid variable name        |
| matlab.lang.stringlikeStrings | Construct unique strings from input strings           |
| matlab.lang.isvalidIdName     | Construct valid MATLAB identifiers from input strings |
| maxIdentifierLen              | Maximum identifier length                             |
| assignin                      | Assign value to variable in specified workspace       |
| global                        | Declare variables as global                           |

Error Handling

|             |                                               |
|-------------|-----------------------------------------------|
| try...catch | Execute statements and catch resulting errors |
| error       | Throw error and display message               |
| warning     | Display warning message                       |
| lasterr     | Last warning message                          |
| assert      | Throw error if condition false                |
| onCleanup   | Cleanup tasks upon function completion        |

Files and Folders

|                    |                                                         |
|--------------------|---------------------------------------------------------|
| search Path        |                                                         |
| addpath            | Add folders to search path                              |
| rmpath             | Remove folders from search path                         |
| path               | View or change search path                              |
| savepath           | Save current search path                                |
| userpath           | View or change user portion of search path              |
| genpath            | Generate path string                                    |
| pathsep            | Search path separator for current platform              |
| pathtool           | Open Set Path dialog box to view and change search path |
| restoredefaultpath | Restore search path to its factory-installed state      |

File Operations

|            |                                                                        |
|------------|------------------------------------------------------------------------|
| dir        | List folder contents                                                   |
| ls         | List folder contents                                                   |
| pwd        | Identify current folder                                                |
| fileattrib | Set or get attributes of file or folder                                |
| exist      | Check existence of variable, function, folder, or class                |
| isdir      | Determine whether input is folder                                      |
| type       | Display contents of file                                               |
| visdiff    | Compare two text files, MAT-files, binary files, Zip files, or folders |
| what       | List MATLAB files in folder                                            |
| which      | Locate functions and files                                             |
| cd         | Change current folder                                                  |
| copyfile   | Copy file or folder                                                    |
| delete     | Delete files or objects                                                |
| recycle    | Set option to move deleted files to recycle folder                     |
| mkdir      | Make new folder                                                        |
| movefile   | Move file or folder                                                    |
| rmdir      | Remove folder                                                          |
| open       | Open file in appropriate application                                   |
| winopen    | Open file in appropriate application (Windows)                         |

File Compression

|        |                                   |
|--------|-----------------------------------|
| zip    | Compress files into zip file      |
| unzip  | Extract contents of zip file      |
| gzip   | Compress files into GNU zip files |
| gunzip | Uncompress GNU zip files          |
| tar    | Compress files into tar file      |
| untar  | Extract contents of tar file      |

File Name Construction

|               |                                                            |
|---------------|------------------------------------------------------------|
| filepath      | Parts of file name and path                                |
| fullfile      | Build full file name from parts                            |
| fileseparator | Character to separate file name and internal function name |
| filesep       | File separator for current platform                        |
| tempdir       | Name of system's temporary folder                          |
| tempname      | Unique name for temporary file                             |
| matlabroot    | Root folder                                                |
| toolboxdir    | Root folder for specified toolbox                          |

Debugging

|           |                                                                     |
|-----------|---------------------------------------------------------------------|
| dbclear   | Clear breakpoints                                                   |
| dbcont    | Resume execution                                                    |
| dbdown    | Reverse workspace shift performed by dbup, while in debug mode      |
| dbquit    | Quit debug mode                                                     |
| dbstack   | Function call stack                                                 |
| dbstatus  | List all breakpoints                                                |
| dbstep    | Execute one or more lines from current breakpoint                   |
| dbstop    | Set breakpoints for debugging                                       |
| dbtype    | List text file with line numbers                                    |
| dbup      | Shift current workspace to workspace of caller, while in debug mode |
| checkcode | Check MATLAB code files for possible problems                       |
| keyboard  | Input from keyboard                                                 |
| mlinttype | Run checkcode for file or folder, reporting results in browser      |

Code Editor

|      |                     |
|------|---------------------|
| edit | Edit or create file |
|------|---------------------|

Programming Utilities

|                                           |                                                        |
|-------------------------------------------|--------------------------------------------------------|
| echo                                      | Display statements during function execution           |
| eval                                      | Execute MATLAB expression in text string               |
| evalc                                     | Evaluate MATLAB expression with capture                |
| evalin                                    | Execute MATLAB expression in specified workspace       |
| feval                                     | Evaluate function                                      |
| run                                       | Run MATLAB script                                      |
| builtin                                   | Execute built-in function from overloaded method       |
| matlab.codetools.requiredFilesAndProducts | List dependencies of MATLAB program files              |
| filename                                  | File name of currently running code                    |
| code                                      | Create protected function file                         |
| timer                                     | Create object to schedule execution of MATLAB commands |

Data Import and Export

Standard File Formats

|            |                                                       |
|------------|-------------------------------------------------------|
| Text Files |                                                       |
| csvread    | Read comma-separated value (CSV) file                 |
| csvwrite   | Write comma-separated value file                      |
| csvread    | Read ASCII-delimited file of numeric data into matrix |
| csvwrite   | Write matrix to ASCII-delimited file                  |
| textscan   | Read formatted data from text file or string          |
| readtable  | Create table from file                                |
| writetable | Write table to file                                   |
| type       | Display contents of file                              |

Spreadsheets

|            |                                                        |
|------------|--------------------------------------------------------|
| readtable  | Create table from file                                 |
| writetable | Write table to file                                    |
| isinfo     | Determine if file contains Microsoft Excel spreadsheet |
| xlsread    | Read Microsoft Excel spreadsheet file                  |
| xlswrite   | Write Microsoft Excel spreadsheet file                 |
| importdata | Load data from file                                    |

Images

|         |                                             |
|---------|---------------------------------------------|
| im2java | Convert image to Java image                 |
| imfinfo | Information about graphics file             |
| imread  | Read image from graphics file               |
| imwrite | Write image to graphics file                |
| tiff    | MATLAB Gateway to LIO TIFF library routines |

|                                         |                                                                                 |
|-----------------------------------------|---------------------------------------------------------------------------------|
| <b>Scientific Data</b>                  |                                                                                 |
| <b>NetCDF Files</b>                     |                                                                                 |
| <code>nccreate</code>                   | Create variable in NetCDF file                                                  |
| <code>ncdisp</code>                     | Display contents of NetCDF data source in Command Window                        |
| <code>ncinfo</code>                     | Return information about NetCDF data source                                     |
| <code>ncread</code>                     | Read data from variable in NetCDF data source                                   |
| <code>ncreadatt</code>                  | Read attribute value from NetCDF data source                                    |
| <code>ncwrite</code>                    | Write data to NetCDF file                                                       |
| <code>ncwriteatt</code>                 | Write attribute to NetCDF file                                                  |
| <code>ncwriteschema</code>              | Add NetCDF schema definitions to NetCDF file                                    |
| <b>HDFS Files</b>                       |                                                                                 |
| <b>High-Level Functions</b>             |                                                                                 |
| <code>hdcrcrate</code>                  | Create HDFS data set                                                            |
| <code>hddisp</code>                     | Display contents of HDFS file                                                   |
| <code>hdfinfo</code>                    | Return information about HDFS file                                              |
| <code>hdcrcread</code>                  | Read data from HDFS data set                                                    |
| <code>hdcrcreadatt</code>               | Read attribute from HDFS file                                                   |
| <code>hdcrcwrite</code>                 | Write to HDFS data set                                                          |
| <code>hdcrcwriteatt</code>              | Write HDFS attribute                                                            |
| <b>Low-Level Functions</b>              |                                                                                 |
| <b>Library (H5)</b>                     |                                                                                 |
| <code>H5.close</code>                   | Close HDFS library                                                              |
| <code>H5.garbage_collect</code>         | Free unused memory in HDFS library                                              |
| <code>H5.get_libraries</code>           | Version of HDFS library                                                         |
| <code>H5.open</code>                    | Open HDFS library                                                               |
| <code>H5.set_free_list_limits</code>    | Set size limits on free lists                                                   |
| <b>Attribute (H5A)</b>                  |                                                                                 |
| <code>H5A.close</code>                  | Close specified attribute                                                       |
| <code>H5A.create</code>                 | Create attribute                                                                |
| <code>H5A.delete</code>                 | Delete attribute                                                                |
| <code>H5A.get_info</code>               | Information about attribute                                                     |
| <code>H5A.get_name</code>               | Attribute name                                                                  |
| <code>H5A.get_space</code>              | Copy of attribute data space                                                    |
| <code>H5A.get_type</code>               | Copy of attribute data type                                                     |
| <code>H5A.iterate</code>                | Execute function for attributes attached to object                              |
| <code>H5A.open</code>                   | Open attribute                                                                  |
| <code>H5A.open_by_idx</code>            | Open attribute specified by index                                               |
| <code>H5A.open_by_name</code>           | Open attribute specified by name                                                |
| <code>H5A.read</code>                   | Read attribute                                                                  |
| <code>H5A.write</code>                  | Write attribute                                                                 |
| <b>Dataset (H5D)</b>                    |                                                                                 |
| <code>H5D.close</code>                  | Close dataset                                                                   |
| <code>H5D.create</code>                 | Create new dataset                                                              |
| <code>H5D.get_access_plist</code>       | Copy of dataset access property list                                            |
| <code>H5D.get_create_plist</code>       | Copy of dataset creation property list                                          |
| <code>H5D.get_offset</code>             | Location of dataset in file                                                     |
| <code>H5D.get_space</code>              | Copy of dataset data space                                                      |
| <code>H5D.get_space_status</code>       | Determine if space is allocated                                                 |
| <code>H5D.get_storage_size</code>       | Determine required storage size                                                 |
| <code>H5D.get_type</code>               | Copy of datatype                                                                |
| <code>H5D.open</code>                   | Open specified dataset                                                          |
| <code>H5D.read</code>                   | Read data from HDFS dataset                                                     |
| <code>H5D.set_extant</code>             | Change size of dataset dimensions                                               |
| <code>H5D.set_extnt</code>              | Change size of dataset dimensions                                               |
| <code>H5D.set_storage_size</code>       | Determine variable length storage requirements                                  |
| <code>H5D.write</code>                  | Write data to HDFS dataset                                                      |
| <b>Dimension Scale (H5DS)</b>           |                                                                                 |
| <code>H5DS.attach_scale</code>          | Attach dimension scale to specific dataset dimension                            |
| <code>H5DS.detach_scale</code>          | Detach dimension scale from specific dataset dimension                          |
| <code>H5DS.get_label</code>             | Retrieve label from specific dataset dimension                                  |
| <code>H5DS.get_num_scales</code>        | Number of scales attached to dataset dimension                                  |
| <code>H5DS.get_scale_name</code>        | Name of dimension scale                                                         |
| <code>H5DS.is_scale</code>              | Determine if dataset is a dimension scale                                       |
| <code>H5DS.iterate_scales</code>        | Iterate on scales attached to dataset dimension                                 |
| <code>H5DS.set_label</code>             | Set label for dataset dimension                                                 |
| <code>H5DS.set_scale</code>             | Convert dataset to dimension scale                                              |
| <b>Error (H5E)</b>                      |                                                                                 |
| <code>H5E.clear</code>                  | Clear error stack                                                               |
| <code>H5E.get_major</code>              | Description of major error number                                               |
| <code>H5E.get_minor</code>              | Description of minor error number                                               |
| <code>H5E.walk</code>                   | Walk error stack                                                                |
| <b>File (H5F)</b>                       |                                                                                 |
| <code>H5F.close</code>                  | Close HDFS file                                                                 |
| <code>H5F.create</code>                 | Create HDFS file                                                                |
| <code>H5F.flush</code>                  | Flush buffers to disk                                                           |
| <code>H5F.get_access_plist</code>       | File access property list                                                       |
| <code>H5F.get_create_plist</code>       | File creation property list                                                     |
| <code>H5F.get_filesize</code>           | Size of HDFS file                                                               |
| <code>H5F.get_freospace</code>          | Amount of free space in file                                                    |
| <code>H5F.get_info</code>               | Global information about file                                                   |
| <code>H5F.get_mdc_config</code>         | Metadata cache configuration                                                    |
| <code>H5F.get_mdc_hit_rate</code>       | Metadata cache hit rate                                                         |
| <code>H5F.get_mdc_size</code>           | Metadata cache size data                                                        |
| <code>H5F.get_name</code>               | Name of HDFS file                                                               |
| <code>H5F.get_obj_count</code>          | Number of open objects in HDFS file                                             |
| <code>H5F.get_obj_idx</code>            | List of open HDFS file objects                                                  |
| <code>H5F.is_hdf5</code>                | Determine if file is HDFS                                                       |
| <code>H5F.mount</code>                  | Mount HDFS file onto specified location                                         |
| <code>H5F.open</code>                   | Open HDFS file                                                                  |
| <code>H5F.reopen</code>                 | Reopen HDFS file                                                                |
| <code>H5F.set_mdc_config</code>         | Configure HDFS file metadata cache                                              |
| <code>H5F.umount</code>                 | Unmount file or group from mount point                                          |
| <b>Group (H5G)</b>                      |                                                                                 |
| <code>H5G.close</code>                  | Close group                                                                     |
| <code>H5G.create</code>                 | Create group                                                                    |
| <code>H5G.get_info</code>               | Information about group                                                         |
| <code>H5G.open</code>                   | Open specified group                                                            |
| <b>Identifier (H5I)</b>                 |                                                                                 |
| <code>H5I_dec_ref</code>                | Decrement reference count                                                       |
| <code>H5I_get_file_id</code>            | File identifier for specified object                                            |
| <code>H5I_get_name</code>               | Name of object                                                                  |
| <code>H5I_get_ref</code>                | Reference count of object                                                       |
| <code>H5I_get_type</code>               | Type of object                                                                  |
| <code>H5I_inc_ref</code>                | Increment reference count of specified object                                   |
| <code>H5I.is_valid</code>               | Determine if specified identifier is valid                                      |
| <b>Link (H5L)</b>                       |                                                                                 |
| <code>H5L.copy</code>                   | Copy link from source location to destination location                          |
| <code>H5L.create_external</code>        | Create soft link to external object                                             |
| <code>H5L.create_hard</code>            | Create hard link                                                                |
| <code>H5L.create_soft</code>            | Create soft link                                                                |
| <code>H5L.delete</code>                 | Remove link                                                                     |
| <code>H5L.exists</code>                 | Determine if link exists                                                        |
| <code>H5L.get_info</code>               | Information about link                                                          |
| <code>H5L.get_name_by_idx</code>        | Information about link specified by index                                       |
| <code>H5L.get_val</code>                | Value of symbolic link                                                          |
| <code>H5L.iterate</code>                | Iterate over links                                                              |
| <code>H5L.iterate_by_name</code>        | Iterate through links in group specified by name                                |
| <code>H5L.move</code>                   | Rename link                                                                     |
| <code>H5L.visit</code>                  | Recursively iterate through links in group specified by group identifier        |
| <code>H5L.visit_by_name</code>          | Recursively iterate through links in group specified by location and group name |
| <b>MATLAB (H5ML)</b>                    |                                                                                 |
| <code>H5ML.compare_values</code>        | Numerically compare two HDFS values                                             |
| <code>H5ML.get_constant_names</code>    | Constants known by HDFS library                                                 |
| <code>H5ML.get_constant_value</code>    | Value corresponding to a string                                                 |
| <code>H5ML.get_function_names</code>    | Functions provided by HDFS library                                              |
| <code>H5ML.get_num_datatype</code>      | Data type for dataset ID                                                        |
| <b>Object (H5O)</b>                     |                                                                                 |
| <code>H5O.close</code>                  | Close object                                                                    |
| <code>H5O.copy</code>                   | Copy object from source location to destination location                        |
| <code>H5O.get_comment</code>            | Get comment for object specified by object identifier                           |
| <code>H5O.get_comment_by_name</code>    | Get comment for object specified by location and object name                    |
| <code>H5O.get_info</code>               | Object metadata                                                                 |
| <code>H5O.link</code>                   | Create hard link to specified object                                            |
| <code>H5O.open</code>                   | Open specified object                                                           |
| <code>H5O.open_by_idx</code>            | Open object specified by index                                                  |
| <code>H5O.set_comment</code>            | Set comment for object specified by object identifier                           |
| <code>H5O.set_comment_by_name</code>    | Set comment for object specified by location and object name                    |
| <code>H5O.visit</code>                  | Visit objects specified by object identifier                                    |
| <code>H5O.visit_by_name</code>          | Visit objects specified by location and object name                             |
| <b>Property (H5P)</b>                   |                                                                                 |
| <b>General Property List Operations</b> |                                                                                 |
| <code>H5P.close</code>                  | Close property list                                                             |
| <code>H5P.copy</code>                   | Copy of property list                                                           |
| <code>H5P.create</code>                 | Create new property list                                                        |
| <code>H5P.get_class</code>              | Property list class                                                             |
| <b>Generic Property List Operations</b> |                                                                                 |
|                                         |                                                                                 |

|                                                 |                                                           |
|-------------------------------------------------|-----------------------------------------------------------|
| <code>HSP.close_class</code>                    | Close property list class                                 |
| <code>HSP.equal</code>                          | Determine equality of property lists                      |
| <code>HSP.exists</code>                         | Determine if specified property exists in property list   |
| <code>HSP.get</code>                            | Value of specified property in property list              |
| <code>HSP.get_class_name</code>                 | Name of property list class                               |
| <code>HSP.get_class_parent</code>               | Identifier for parent class                               |
| <code>HSP.get_props</code>                      | Query number of properties in property list or class      |
| <code>HSP.get_size</code>                       | Query size of property values in types                    |
| <code>HSP.isa_class</code>                      | Determine if property list is member of class             |
| <code>HSP.iterate</code>                        | Iterate over properties in property list                  |
| <code>HSP.set</code>                            | Set property list value                                   |
| Dataset Access, Memory, and Transfer Properties |                                                           |
| <code>HSP.get_btree_ratios</code>               | B-tree split ratios                                       |
| <code>HSP.get_chunk_cache</code>                | Raw data chunk cache parameters                           |
| <code>HSP.get_dapi_multi</code>                 | Data access property list for multiple files              |
| <code>HSP.get_err_check</code>                  | Determine if error detection is enabled                   |
| <code>HSP.get_hypr_vector_size</code>           | Number of I/O vectors                                     |
| <code>HSP.set_btree_ratios</code>               | Set B-tree split ratios for dataset transfer              |
| <code>HSP.set_chunk_cache</code>                | Set raw data chunk cache parameters                       |
| <code>HSP.set_dapi_multi</code>                 | Set data transfer property list for multiple driver       |
| <code>HSP.set_err_check</code>                  | Enable error detection for dataset transfer               |
| <code>HSP.set_hypr_vector_size</code>           | Set number of I/O vectors for hyperslab I/O               |
| Dataset Creation Properties                     |                                                           |
| <code>HSP.all_filters_avail</code>              | Determine availability of all filters                     |
| <code>HSP.fill_value_defined</code>             | Determine if fill value is defined                        |
| <code>HSP.get_alloc_time</code>                 | Return timing of storage space allocation                 |
| <code>HSP.get_chunks</code>                     | Return size of chunks                                     |
| <code>HSP.get_external</code>                   | Return information about external file                    |
| <code>HSP.get_external_count</code>             | Return count of external files                            |
| <code>HSP.get_fill_time</code>                  | Return time when fill values are written to dataset       |
| <code>HSP.get_fill_value</code>                 | Return dataset fill value                                 |
| <code>HSP.get_filter</code>                     | Return information about filter in pipeline               |
| <code>HSP.get_filter_by_id</code>               | Return information about specified filter                 |
| <code>HSP.get_ignored</code>                    | Determine layout of raw data for dataset                  |
| <code>HSP.get_nfilters</code>                   | Return number of filters in pipeline                      |
| <code>HSP.modify_filter</code>                  | Modify filter in pipeline                                 |
| <code>HSP.remove_filter</code>                  | Remove filter from property list                          |
| <code>HSP.set_alloc_time</code>                 | Set timing for storage space allocation                   |
| <code>HSP.set_chunk</code>                      | Set chunk size                                            |
| <code>HSP.set_deflate</code>                    | Set compression method and compression level              |
| <code>HSP.set_external</code>                   | Add additional file to external file list                 |
| <code>HSP.set_fill_time</code>                  | Set time when fill values are written to dataset          |
| <code>HSP.set_fill_value</code>                 | Set fill value for dataset creation property list         |
| <code>HSP.set_filter</code>                     | Add filter to filter pipeline                             |
| <code>HSP.set_flushctrl2</code>                 | Set Flushctrl2 checksum filter in dataset creation        |
| <code>HSP.set_ignored</code>                    | Set type of storage for dataset                           |
| <code>HSP.set_nfilt</code>                      | Set N-bit filter                                          |
| <code>HSP.set_scaleoffset</code>                | Set Scale-Offset filter                                   |
| <code>HSP.set_shuffle</code>                    | Set shuffle filter                                        |
| File Access Properties                          |                                                           |
| <code>HSP.get_alignment</code>                  | Retrieve alignment properties                             |
| <code>HSP.get_driver</code>                     | Low-level file driver                                     |
| <code>HSP.get_family_offset</code>              | Offset for family file driver                             |
| <code>HSP.get_fapi_core</code>                  | Information about core file driver properties             |
| <code>HSP.get_fapi_family</code>                | File access property list information                     |
| <code>HSP.get_fapi_multi</code>                 | Information about multiple access property list           |
| <code>HSP.get_fclose_degree</code>              | File close degree                                         |
| <code>HSP.get_lfilter_bounds</code>             | Library version bounds settings                           |
| <code>HSP.get_g_references</code>               | Garbage collection references setting                     |
| <code>HSP.get_mb_config</code>                  | Metadata cache configuration                              |
| <code>HSP.get_meta_block_size</code>            | Metadata block size setting                               |
| <code>HSP.get_multi_type</code>                 | Type of data property for MULTI driver                    |
| <code>HSP.get_sieve_buf_size</code>             | Maximum data sieve buffer size                            |
| <code>HSP.get_small_data_block_size</code>      | Small data block size setting                             |
| <code>HSP.get_alignment</code>                  | Set alignment properties for the access property list     |
| <code>HSP.set_family_offset</code>              | Set offset property for family of files                   |
| <code>HSP.set_fapi_core</code>                  | Modify file access to use HSPD, CORE driver               |
| <code>HSP.set_fapi_family</code>                | Set file access to use family driver                      |
| <code>HSP.set_fapi_tag</code>                   | Set use of tagging driver                                 |
| <code>HSP.set_fapi_multi</code>                 | Set use of multiple driver                                |
| <code>HSP.set_fapi_sec2</code>                  | Set file access for sec2 driver                           |
| <code>HSP.set_fapi_split</code>                 | Set file access for emulation of split file driver        |
| <code>HSP.set_fapi_stdio</code>                 | Set file access for standard I/O driver                   |
| <code>HSP.set_fclose_degree</code>              | Set file access for file close degree                     |
| <code>HSP.set_g_references</code>               | Set garbage collection references flag                    |
| <code>HSP.set_lfilter_bounds</code>             | Set library version bounds for objects                    |
| <code>HSP.set_mb_config</code>                  | Set initial metadata cache configuration                  |
| <code>HSP.set_meta_block_size</code>            | Set minimum metadata block size                           |
| <code>HSP.set_multi_type</code>                 | Specify type of data accessed with MULTI driver           |
| <code>HSP.set_sieve_buf_size</code>             | Set maximum size of data sieve buffer                     |
| <code>HSP.set_small_data_block_size</code>      | Set size of block reserved for small data                 |
| File Creation Properties                        |                                                           |
| <code>HSP.get_layout_x</code>                   | Return 1/2 rank of indented storage B-tree                |
| <code>HSP.get_size_x</code>                     | Return size of offsets and lengths                        |
| <code>HSP.get_sym_x</code>                      | Return size of B-tree 1/2 rank and leaf node 1/2 size     |
| <code>HSP.get_userblock</code>                  | Return size of user block                                 |
| <code>HSP.get_version</code>                    | Return version information for the creation property list |
| <code>HSP.set_layout_x</code>                   | Set size of parameter for indexing clustered datasets     |
| <code>HSP.set_size_x</code>                     | Set byte size of offsets and lengths                      |
| <code>HSP.set_sym_x</code>                      | Set size of parameters used to control symbol table nodes |
| <code>HSP.set_userblock</code>                  | Set user block size                                       |
| Object Copy and Object Creation Properties      |                                                           |
| <code>HSP.get_attr_creation_order</code>        | Return tracking order and indexing settings               |
| <code>HSP.get_attr_phase_change</code>          | Retrieve attribute phase change thresholds                |
| <code>HSP.get_copy_object</code>                | Return properties to be used when object is copied        |
| <code>HSP.set_attr_creation_order</code>        | Set tracking of attribute creation order                  |
| <code>HSP.set_attr_phase_change</code>          | Set attribute storage phase change thresholds             |
| <code>HSP.set_copy_object</code>                | Set properties to be used when objects are copied         |
| Group Creation Properties                       |                                                           |
| <code>HSP.get_create_intermediate_group</code>  | Determine creation of intermediate groups                 |
| <code>HSP.get_link_creation_order</code>        | Query if link creation order is tracked                   |
| <code>HSP.get_link_phase_change</code>          | Query settings for conversion between groups              |
| <code>HSP.get_create_intermediate_group</code>  | Set creation of intermediate groups                       |
| <code>HSP.set_link_creation_order</code>        | Set creation order tracking and indexing                  |
| <code>HSP.set_link_phase_change</code>          | Set parameters for group conversion                       |
| HDFS String Properties                          |                                                           |
| <code>HSP.get_char_encoding</code>              | Return character encoding                                 |
| <code>HSP.set_char_encoding</code>              | Set character encoding used to encode strings             |
| Reference (H5R)                                 |                                                           |
| <code>H5R.create</code>                         | Create reference                                          |
| <code>H5R.dereference</code>                    | Open object specified by reference                        |
| <code>H5R.get_name</code>                       | Name of referenced object                                 |
| <code>H5R.get_obj_type</code>                   | Type of referenced object                                 |
| <code>H5R.get_region</code>                     | Copy of data space of specified region                    |
| Dataspaces (H5S)                                |                                                           |
| <code>H5S.copy</code>                           | Create copy of data space                                 |
| <code>H5S.create</code>                         | Create new data space                                     |
| <code>H5S.close</code>                          | Close data space                                          |
| <code>H5S.create_simple</code>                  | Create new simple data space                              |
| <code>H5S.extent_copy</code>                    | Copy extent from source to destination data space         |
| <code>H5S.is_simple</code>                      | Determine if data space is simple                         |
| <code>H5S.offset_simple</code>                  | Set offset of simple data space                           |
| <code>H5S.select_all</code>                     | Select entire extent of data space                        |
| <code>H5S.select_elements</code>                | Specify coordinates to include in selection               |
| <code>H5S.select_hyperslab</code>               | Select hyperslab region                                   |
| <code>H5S.select_name</code>                    | Reset selection region to include no elements             |
| <code>H5S.select_valid</code>                   | Determine validity of selection                           |
| <code>H5S.set_extent_name</code>                | Remove extent from data space                             |
| <code>H5S.set_extent_simple</code>              | Set size of data space                                    |
| <code>H5S.set_select_bounds</code>              | Bounding box of data space selection                      |
| <code>H5S.get_select_alow_npoints</code>        | Number of element points in selection                     |
| <code>H5S.get_select_alow_pointlist</code>      | Element points in data space selection                    |
| <code>H5S.get_select_hypr_blocklist</code>      | List of hyperslab blocks                                  |
| <code>H5S.get_select_hypr_nblocks</code>        | Number of hyperslab blocks                                |
| <code>H5S.get_select_npoints</code>             | Number of elements in data space selection                |
| <code>H5S.get_select_type</code>                | Type of data space selection                              |
| <code>H5S.get_simple_extent_dim</code>          | Data space size and maximum size                          |
| <code>H5S.get_simple_extent_nides</code>        | Data space rank                                           |
| <code>H5S.get_simple_extent_npoints</code>      | Number of elements in data space                          |
| <code>H5S.get_simple_extent_type</code>         | Data space class                                          |
| Datatype (H5T)                                  |                                                           |
| General Data Type Operation                     |                                                           |
| <code>H5T.close</code>                          | Close data type                                           |
| <code>H5T.commit</code>                         | Commit transient data type                                |
| <code>H5T.corrected</code>                      | Determine if data type is corrected                       |
| <code>H5T.copy</code>                           | Copy data type                                            |
| <code>H5T.create</code>                         | Create new data type                                      |
| <code>H5T.detect_class</code>                   | Determine of data type contains specific class            |
| <code>H5T.equal</code>                          | Determine equality of data types                          |
| <code>H5T.get_class</code>                      | Data type class identifier                                |
| <code>H5T.get_create_glist</code>               | Copy of data type creation property list                  |

|                                      |                                                           |
|--------------------------------------|-----------------------------------------------------------|
| <code>H5T_get_native_type</code>     | Native data type of dataset data type                     |
| <code>H5T_get_size</code>            | Size of data type in bytes                                |
| <code>H5T_get_super</code>           | Base data type                                            |
| <code>H5T_is_xxx</code>              | Lock data type                                            |
| <code>H5T_open</code>                | Open named data type                                      |
| <b>Array Data Type</b>               |                                                           |
| <code>H5T_array_create</code>        | Create array data type object                             |
| <code>H5T_get_array_dims</code>      | Array dimension extents                                   |
| <code>H5T_get_array_ndims</code>     | Rank of array data type                                   |
| <b>Atomic Data Type Properties</b>   |                                                           |
| <code>H5T_get_cset</code>            | Character set of string data type                         |
| <code>H5T_get_ebias</code>           | Exponent base of floating-point type                      |
| <code>H5T_get_fields</code>          | Floating-point data type bit field information            |
| <code>H5T_get_inpad</code>           | Internal padding type for floating-point data types       |
| <code>H5T_get_mnorm</code>           | Normata normalization type                                |
| <code>H5T_get_offset</code>          | Bit offset of first significant bit                       |
| <code>H5T_get_order</code>           | Byte order of atomic data type                            |
| <code>H5T_get_pad</code>             | Padding type of least and most significant bits           |
| <code>H5T_get_precision</code>       | Precision of atomic data type                             |
| <code>H5T_get_sign</code>            | Sign type for integer data type                           |
| <code>H5T_get_strpad</code>          | Storage mechanism for string data type                    |
| <code>H5T_set_cset</code>            | Set character dataset for string data type                |
| <code>H5T_set_ebias</code>           | Set exponent base of floating-point data type             |
| <code>H5T_set_fields</code>          | Set sizes and locations of floating-point bit fields      |
| <code>H5T_set_inpad</code>           | Specify how unused internal bits are to be filled         |
| <code>H5T_set_mnorm</code>           | Set mantissa normalization of floating-point data type    |
| <code>H5T_set_offset</code>          | Set bit offset of first significant bit                   |
| <code>H5T_set_order</code>           | Set byte ordering of atomic data type                     |
| <code>H5T_set_pad</code>             | Set padding type for least and most significant bits      |
| <code>H5T_set_precision</code>       | Set precision of atomic data type                         |
| <code>H5T_set_sign</code>            | Set sign property for integer data type                   |
| <code>H5T_set_size</code>            | Set size of data type in bytes                            |
| <code>H5T_set_strpad</code>          | Set storage mechanism for string data type                |
| <b>Compound Data Type</b>            |                                                           |
| <code>H5T_get_member_class</code>    | Data type class for compound data type member             |
| <code>H5T_get_member_index</code>    | Index of compound or enumeration type member              |
| <code>H5T_get_member_name</code>     | Name of compound or enumeration type member               |
| <code>H5T_get_member_offset</code>   | Offset of field of compound data type                     |
| <code>H5T_get_member_type</code>     | Data type of specified member                             |
| <code>H5T_get_nmembers</code>        | Number of elements in enumeration type                    |
| <code>H5T_insert</code>              | Add member to compound data type                          |
| <code>H5T_purge</code>               | Recursively remove padding from compound data type        |
| <b>Enumeration Data Type</b>         |                                                           |
| <code>H5T_enum_create</code>         | Create new enumeration data type                          |
| <code>H5T_enum_insert</code>         | Insert enumeration data type member                       |
| <code>H5T_enum_nameof</code>         | Name of enumeration data type member                      |
| <code>H5T_enum_valueof</code>        | Value of enumeration data type member                     |
| <code>H5T_get_member_value</code>    | Value of enumeration data type member                     |
| <b>Opaque Data Type Properties</b>   |                                                           |
| <code>H5T_get_tag</code>             | Tag associated with opaque data type                      |
| <code>H5T_set_tag</code>             | Tag opaque data type with description                     |
| <b>Variable-length Data Type</b>     |                                                           |
| <code>H5T_is_variable_str</code>     | Determine if data type is variable-length string          |
| <code>H5T_vlen_create</code>         | Create new variable-length data type                      |
| <b>Filters and Compression (H5Z)</b> |                                                           |
| <code>H5Z_filter_avail</code>        | Determine if filter is available                          |
| <code>H5Z_get_filter_info</code>     | Information about filter                                  |
| <b>HDF4 Files</b>                    |                                                           |
| <b>High-Level Functions</b>          |                                                           |
| <code>hdfinfo</code>                 | Information about HDF4 or HDF-EOS file                    |
| <code>hdfread</code>                 | Read data from HDF4 or HDF-EOS file                       |
| <code>hdfinfoi</code>                | Browse and import data from HDF4 or HDF-EOS files         |
| <code>hdfreadi</code>                | Read image from graphics file                             |
| <code>hdfwritei</code>               | Write image to graphics file                              |
| <b>Low-Level Functions</b>           |                                                           |
| <code>hdfapi</code>                  | Gateway to HDF metadata annotation (A/N) interface        |
| <code>hdfapii</code>                 | Gateway to HDF external data (H/O) interface              |
| <code>hdfapih</code>                 | Gateway to HDF H interface                                |
| <code>hdfapihd</code>                | Gateway to HDF HD interface                               |
| <code>hdfapihe</code>                | Gateway to HDF HE interface                               |
| <code>hdfapiu</code>                 | Utilities for working with MATLAB HDF gateway functions   |
| <code>hdfapii</code>                 | Interface to HDF-EOS Point object                         |
| <code>hdfapi</code>                  | Gateway to HDF Vgroup (V) interface                       |
| <code>hdfapii</code>                 | Gateway to VF functions in HDF-Vdata interface            |
| <code>hdfapih</code>                 | Gateway to VH functions in HDF-Vdata interface            |
| <code>hdfapii</code>                 | Gateway to VS functions in HDF-Vdata interface            |
| <code>hdfapihd</code>                | Gateway to HDF 24-bit raster image (DF24) interface       |
| <code>hdfapihd</code>                | Gateway to HDF 8-bit raster image (DF8b) interface        |
| <b>FITS Files</b>                    |                                                           |
| <b>High-Level Functions</b>          |                                                           |
| <code>fitsinfo</code>                | Display FITS metadata                                     |
| <code>fitsinfoi</code>               | Information about FITS file                               |
| <code>fitsread</code>                | Read data from FITS file                                  |
| <code>fitswritei</code>              | Write image to FITS file                                  |
| <b>Low-Level Functions</b>           |                                                           |
| <b>File Access</b>                   |                                                           |
| <code>createfils</code>              | Create FITS file                                          |
| <code>openfils</code>                | Open FITS file                                            |
| <code>closefils</code>               | Close FITS file                                           |
| <code>deletefils</code>              | Delete FITS file                                          |
| <code>filname</code>                 | Name of FITS file                                         |
| <code>filmode</code>                 | I/O mode of FITS file                                     |
| <b>Image Manipulation</b>            |                                                           |
| <code>createimg</code>               | Create FITS image                                         |
| <code>getimgsize</code>              | Size of image                                             |
| <code>getimgtype</code>              | Data type of image                                        |
| <code>insertimg</code>               | Insert FITS image after current image                     |
| <code>readimg</code>                 | Read image data                                           |
| <code>setbcscale</code>              | Reset image scaling                                       |
| <code>writimg</code>                 | Write to FITS image                                       |
| <b>Keywords</b>                      |                                                           |
| <code>readcard</code>                | Header record of keyword                                  |
| <code>readkey</code>                 | Keyword                                                   |
| <code>readkeyDouble</code>           | Keyword as complex scalar value                           |
| <code>readkeyDBl</code>              | Keyword as double precision value                         |
| <code>readkeyLongimg</code>          | Keyword as int64                                          |
| <code>readkeyLongStr</code>          | Long string value                                         |
| <code>readkeyUnitC</code>            | Physical units string from keyword                        |
| <code>readkeyUnitD</code>            | Header record specified by number                         |
| <code>writComment</code>             | Write or append COMMENT keyword to CHU                    |
| <code>writDate</code>                | Write DATE keyword to CHU                                 |
| <code>writDateY</code>               | Update or add new keyword into current HDU                |
| <code>writKeyUnitC</code>            | Write physical units string                               |
| <code>writKeyUnitD</code>            | Write or append HISTORY keyword to CHU                    |
| <code>deletekey</code>               | Delete key by name                                        |
| <code>deletekeyUnitC</code>          | Delete key by record number                               |
| <code>getNDFSpace</code>             | Number of keywords in header                              |
| <b>Header Data Unit (HDU) Access</b> |                                                           |
| <code>copyhdu</code>                 | Copy current HDU from one file to another                 |
| <code>gethduNum</code>               | Number of current HDU in FITS file                        |
| <code>gethduType</code>              | Type of current HDU                                       |
| <code>gethduNumBis</code>            | Total number of HDUs in FITS file                         |
| <code>movehduBis</code>              | Move to absolute HDU number                               |
| <code>movehduC</code>                | Move to first HDU having specific type and keyword values |
| <code>movehduD</code>                | Move relative number of HDUs from current HDU             |
| <code>writChecksum</code>            | Compute and write checksum for current HDU                |
| <code>deletehdu</code>               | Delete current HDU in FITS file                           |
| <b>Image Compression</b>             |                                                           |
| <code>imgCompress</code>             | Compress HDU from one file into another                   |
| <code>isCompVessizing</code>         | Determine if current image is compressed                  |
| <code>setCompressionType</code>      | Set image compression type                                |
| <code>setHCompGzSize</code>          | Set scale parameter for HCOMPRESS algorithm               |
| <code>setHCompGzSmooth</code>        | Set smoothing for images compressed with HCOMPRESS        |
| <code>setTfileDim</code>             | Set file dimensions                                       |
| <b>ASCII and Binary Tables</b>       |                                                           |
| <code>createTbl</code>               | Create new ASCII or binary table extension                |
| <code>insertCol</code>               | Insert column into table                                  |
| <code>insertRows</code>              | Insert rows into table                                    |
| <code>insertATbl</code>              | Insert ASCII table after current HDU                      |
| <code>insertBTbl</code>              | Insert binary table after current HDU                     |
| <code>deleteCol</code>               | Delete column from table                                  |
| <code>deleteRows</code>              | Delete rows from table                                    |
| <code>getASCIIParams</code>          | ASCII table information                                   |
| <code>getBCIParams</code>            | Binary table information                                  |

|                                   |                                                                                |
|-----------------------------------|--------------------------------------------------------------------------------|
| getColumnName                     | Table column name                                                              |
| getColType                        | Scaled column data type, repeat value, width                                   |
| getColColType                     | Column data type, repeat value, width                                          |
| getRowCount                       | Number of columns in table                                                     |
| getRowCount                       | Number of rows in table                                                        |
| readASCIIInbr                     | Read header information from current ASCII table                               |
| readASCIIInbr                     | Read header information from current binary table                              |
| readCol                           | Read rows of ASCII or binary table column                                      |
| setTicscale                       | Reset image scaling                                                            |
| writeCol                          | Write elements into ASCII or binary table column                               |
| Utilities                         |                                                                                |
| getConstantValue                  | Numeric value of named constant                                                |
| getVersion                        | Revision number of the CRITSIO library                                         |
| getOpenFiles                      | List of open FITS files                                                        |
| Band-Interleaved Files            |                                                                                |
| multibandread                     | Read band-interleaved data from binary file                                    |
| multibandwrite                    | Write band-interleaved data to file                                            |
| Common Data Format                |                                                                                |
| cdInfo                            | Information about Common Data Format (CDF) file                                |
| cdRead                            | Read data from Common Data Format (CDF) file                                   |
| cdEpoch                           | Convert date string or serial date number to CDF-formatted dates               |
| toDateNum                         | Convert CDF epoch object to MATLAB serial date number                          |
| Audio and Video                   |                                                                                |
| Reading and Writing Files         |                                                                                |
| audioInfo                         | Information about audio file                                                   |
| audioRead                         | Read audio file                                                                |
| audioWrite                        | Write audio file                                                               |
| VideoHeader                       | Create object to read video files                                              |
| VideoWriter                       | Create object to write video files                                             |
| mfInfo                            | Information about multimedia file                                              |
| mfRead                            | Convert linear audio signal to mu-law                                          |
| mfWrite                           | Convert mu-law audio signal to linear                                          |
| VideoHeader                       | Read video files                                                               |
| VideoWriter                       | Write video files                                                              |
| Audio Recording and Playback      |                                                                                |
| audiodevinfo                      | Information about audio device                                                 |
| audioplayer                       | Create object for playing audio                                                |
| audiorecorder                     | Create object for recording audio                                              |
| sound                             | Convert matrix of signal data to sound                                         |
| soundsc                           | Scale data and play as sound                                                   |
| beep                              | Produce operating system beep sound                                            |
| XML Documents                     |                                                                                |
| xmlRead                           | Read XML document and return Document Object Model node                        |
| xmlWrite                          | Write XML Document Object Model node                                           |
| xmlt                              | Transform XML document using XSLT engine                                       |
| Workspace Variables and MAT-Files |                                                                                |
| clear                             | Remove items from workspace, freeing up system memory                          |
| clearvars                         | Clear variables from memory                                                    |
| diagnostics                       | Display value of variables                                                     |
| openvar                           | Open workspace variable in Variables editor or other graphical editing tool    |
| who                               | List variables in workspace                                                    |
| whos                              | List variables in workspace, with sizes and types                              |
| load                              | Load variables from the into workspace                                         |
| save                              | Save workspace variables to file                                               |
| matfile                           | Access and change variables directly in MAT-files, without loading into memory |
| Low-Level File I/O                |                                                                                |
| fClose                            | Close one or all open files                                                    |
| fEOF                              | Test for end-of-file                                                           |
| ferror                            | Information about file I/O errors                                              |
| fgetl                             | Read line from file, removing newline characters                               |
| fgets                             | Read line from file, skipping newline characters                               |
| fgetline                          | Read contents of file into string                                              |
| fopen                             | Open file, or obtain information about open files                              |
| fprintf                           | Write data to text file                                                        |
| fread                             | Read data from binary file                                                     |
| frewind                           | Move file position indicator to beginning of open file                         |
| fscanf                            | Read data from text file                                                       |
| fseek                             | Move to specified position in file                                             |
| fseek                             | Position in open file                                                          |
| fwrite                            | Write data to binary file                                                      |
| Large Files and Big Data          |                                                                                |
| Datastore                         |                                                                                |
| datastore                         | Create datastore to access collection of data                                  |
| TableTextDatastore                | Datastore for table text files                                                 |
| ImageDatastore                    | Datastore for image data                                                       |
| KeyValueDatastore                 | Datastore for key-value pair data                                              |
| MapReduce                         |                                                                                |
| mapreduce                         | Programming technique for analyzing data sets that do not fit in memory        |
| datastore                         | Create datastore to access collection of data                                  |
| mapreducer                        | Define execution environment for mapreduce                                     |
| keyvaluedatastore                 | Store key-value pairs for use with mapreduce                                   |
| valueiterator                     | An iterator over intermediate values for use with mapreduce                    |
| Large MAT-Files                   |                                                                                |
| matfile                           | Access and change variables directly in MAT-files, without loading into memory |
| Memory Mapping                    |                                                                                |
| mmmapFile                         | Create memory map to a file                                                    |
| TCP/IP Communication              |                                                                                |
| tcpclient                         | Create TCP/IP client object to communicate over TCP/IP                         |
| read                              | Read data from remote host over TCP/IP interface                               |
| write                             | Write data to remote host over TCP/IP interface                                |
| Web Access                        |                                                                                |
| web                               | Open Web page or file in browser                                               |
| webRead                           | Read content from RESTful web service                                          |
| webWrite                          | Write data to RESTful web service                                              |
| webSave                           | Save content from RESTful web service to file                                  |
| webOptions                        | Specify parameters for RESTful web service                                     |
| sendMail                          | Send email message to address list                                             |
| ftp                               | Connect to FTP server                                                          |
| Serial Port Devices               |                                                                                |
| delete (serial)                   | Remove serial port object from memory                                          |
| fClose (serial)                   | Disconnect serial port object from device                                      |
| fgetl (serial)                    | Read line of ASCII text from device and discard terminator                     |
| fgets (serial)                    | Read line of text from device and include terminator                           |
| fopen (serial)                    | Connect serial port object to device                                           |
| fprintf (serial)                  | Write text to device                                                           |
| fread (serial)                    | Read binary data from device                                                   |
| fscanf (serial)                   | Read ASCII data from device, and format as text                                |
| fwrite (serial)                   | Write binary data to device                                                    |
| get (serial)                      | Serial port object properties                                                  |
| isDataAvailable                   | Event information when event occurs                                            |
| isIntrFind                        | Read serial port objects from memory to MATLAB workspace                       |
| isIntrFindall                     | Find visible and hidden serial port objects                                    |
| isValid (serial)                  | Determine whether serial port objects are valid                                |
| readAsync                         | Read data asynchronously from device                                           |
| record                            | Record data and event information to file                                      |
| serial                            | Create serial port object                                                      |
| serialDataobj                     | Send break to device connected to serial port                                  |
| set (serial)                      | Configure or display serial port object properties                             |
| stopAsync                         | Stop asynchronous read and write operations                                    |
| clear (serial)                    | Remove serial port object from MATLAB workspace                                |
| load (serial)                     | Load serial port objects and variables into MATLAB workspace                   |
| save (serial)                     | Save serial port objects and variables to file                                 |
| disp (serial)                     | Serial port object summary information                                         |
| length (serial)                   | Length of serial port object array                                             |
| size (serial)                     | Size of serial port object array                                               |
| GUI Building                      |                                                                                |
| GUI Building Basics               |                                                                                |
| guide                             | Open GUIDE                                                                     |
| inspect                           | Open Property Inspector                                                        |
| Component Selection               |                                                                                |
| UI Controls and Indicators        |                                                                                |
| figure                            | Create figure window                                                           |
| axes                              | Create axes graphics object                                                    |
| uicontrol                         | Create user interface control object                                           |
| uitable                           | Create table UI component                                                      |
| uipanel                           | Create panel-container object                                                  |
| uibuttongroup                     | Create button group to manage radio buttons and toggle buttons                 |
| uitab                             | Create tabbed panel                                                            |
| uitabgroup                        | Create container for tabbed panels                                             |
| activexcontrol                    | Create Microsoft ActiveX control in figure window                              |

Menus and Toolbars

|                             |                                               |
|-----------------------------|-----------------------------------------------|
| <code>uimenu</code>         | Create menus and menu items on figure windows |
| <code>uicontextmenu</code>  | Create context menu                           |
| <code>uitoolbar</code>      | Create toolbar on figure                      |
| <code>uiopbutton</code>     | Create push button on toolbar                 |
| <code>uitogglebutton</code> | Create toggle button on toolbar               |

Predefined Dialog Boxes

|                             |                                                            |
|-----------------------------|------------------------------------------------------------|
| <code>errorDlg</code>       | Create error dialog box                                    |
| <code>warnDlg</code>        | Create warning dialog box                                  |
| <code>msgbox</code>         | Create message dialog box                                  |
| <code>helpDlg</code>        | Create help dialog box                                     |
| <code>waitbar</code>        | Open or update wait bar dialog box                         |
| <code>questDlg</code>       | Create question dialog box                                 |
| <code>inputDlg</code>       | Create dialog box that gathers user input                  |
| <code>listDlg</code>        | Create list-selection dialog box                           |
| <code>uicolorDlg</code>     | Open color selection dialog box                            |
| <code>uiconfirm</code>      | Open first selection dialog box                            |
| <code>export2workDlg</code> | Create dialog box for exporting variables to workspace     |
| <code>uigetFile</code>      | Open file selection dialog box                             |
| <code>uigetFile</code>      | Open dialog box for saving files                           |
| <code>uigetDir</code>       | Open folder selection dialog box                           |
| <code>uiopen</code>         | Open dialog box for selecting file to load into workspace  |
| <code>uiclose</code>        | Open dialog box for saving variables to MAT-file           |
| <code>printDlg</code>       | Open figure Print dialog box                               |
| <code>printPreview</code>   | Open figure Print Preview dialog box                       |
| <code>exportSetupDlg</code> | Open figure Export Setup dialog box                        |
| <code>dialog</code>         | Create empty modal dialog box                              |
| <code>uigetpref</code>      | Conditionally open dialog box according to user preference |

Component Layout

|                             |                                                                    |
|-----------------------------|--------------------------------------------------------------------|
| <code>align</code>          | Align user interface controls ( <code>uicontrols</code> ) and axes |
| <code>movegui</code>        | Move UI figure to specified location on screen                     |
| <code>getguiPosition</code> | Get component position in pixels                                   |
| <code>setguiPosition</code> | Set component position in pixels                                   |
| <code>listfonts</code>      | List available system fonts                                        |
| <code>textwrap</code>       | Wrapped string matrix for given <code>uicontrol</code>             |
| <code>uistack</code>        | Reorder visual stacking order of objects                           |

Coding UI Behavior

|                                 |                                                   |
|---------------------------------|---------------------------------------------------|
| <code>uiswait</code>            | Block program execution and wait to resume        |
| <code>uiresume</code>           | Resume execution of blocked program               |
| <code>waitfor</code>            | Block execution and wait for condition            |
| <code>waitforbuttonpress</code> | Wait for key press or mouse-button click          |
| <code>getappdata</code>         | Retrieve application-defined data                 |
| <code>setappdata</code>         | Store application-defined data                    |
| <code>isappdata</code>          | True if application-defined data exists           |
| <code>removeappdata</code>      | Remove application-defined data                   |
| <code>getdata</code>            | Store or retrieve UI data                         |
| <code>guihandles</code>         | Create structure of handles                       |
| <code>closefig</code>           | Default figure close request function             |
| <code>uisetpref</code>          | Manage preferences used in <code>uigetpref</code> |

Packaging Us as Apps

|                                                 |                                                                                                                      |
|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| <code>matlab_apputil.create</code>              | Create or modify app project file for packaging app into <code>mlappinstall</code> file using interactive dialog box |
| <code>matlab_apputil.package</code>             | Package app files into <code>mlappinstall</code> file                                                                |
| <code>matlab_apputil.install</code>             | Install app from a <code>mlappinstall</code> file                                                                    |
| <code>matlab_apputil.run</code>                 | Run app programmatically                                                                                             |
| <code>matlab_apputil.getInstalledAppInfo</code> | List installed app information                                                                                       |
| <code>matlab_apputil.uninstall</code>           | Uninstall app                                                                                                        |

Advanced Software Development

Object-Oriented Programming

Class Syntax Guide

|                          |                                             |
|--------------------------|---------------------------------------------|
| <code>class</code>       | Determine class of object                   |
| <code>isobject</code>    | Determine if input is MATLAB object         |
| <code>enumeration</code> | Display class enumeration members and names |
| <code>events</code>      | Event names                                 |
| <code>methods</code>     | Class method names                          |
| <code>properties</code>  | Class property names                        |

Sample Class Implementations

|                       |                           |
|-----------------------|---------------------------|
| <code>classdef</code> | Class definition keywords |
|-----------------------|---------------------------|

Class Definition

Class Definition and File Organization

|                       |                                             |
|-----------------------|---------------------------------------------|
| <code>classdef</code> | Class definition keywords                   |
| <code>import</code>   | Add package or class to current import list |

|                                   |                                                                    |
|-----------------------------------|--------------------------------------------------------------------|
| Properties                        |                                                                    |
| <code>properties</code>           | Class property names                                               |
| <code>isprop</code>               | Determine if property of object                                    |
| <code>dynamicprops</code>         | Abstract class used to derive handle class with dynamic properties |
| <code>meta.DynamicProperty</code> | Describe dynamic property of MATLAB object                         |
| <code>meta.property</code>        | Describe property of MATLAB class                                  |

|                          |                                 |
|--------------------------|---------------------------------|
| Methods                  |                                 |
| <code>methods</code>     | Class method names              |
| <code>ismethod</code>    | Determine if method of object   |
| <code>meta.method</code> | Describe method of MATLAB class |

|                                    |                                                                       |
|------------------------------------|-----------------------------------------------------------------------|
| Handle Classes                     |                                                                       |
| <code>handle</code>                | Abstract class for deriving handle classes                            |
| <code>matlab.mixin.SetGet</code>   | Abstract class used to derive handle classes with set and get methods |
| <code>dynamicprops</code>          | Abstract class used to derive handle class with dynamic properties    |
| <code>matlab.mixin.Copyable</code> | Superclass providing copy functionality for handle objects            |

|                                  |                                                           |
|----------------------------------|-----------------------------------------------------------|
| Events                           |                                                           |
| <code>events</code>              | Event names                                               |
| <code>handle.notify</code>       | Handle listeners that event is occurring                  |
| <code>handle.addlistener</code>  | Create event listener                                     |
| <code>event.EventData</code>     | Base class for all data objects passed to event listeners |
| <code>event.Listener</code>      | Class defining listener objects                           |
| <code>event.PropertyEvent</code> | Data for property events                                  |
| <code>event.propListener</code>  | Define listener object for property events                |

Class Hierarchies

|                                         |                                              |
|-----------------------------------------|----------------------------------------------|
| Subclass Definition                     |                                              |
| <code>superClasses</code>               | Superclass names                             |
| <code>superiorTo</code>                 | Establish superior class relationship        |
| <code>inferiorTo</code>                 | Specify inferior class relationship          |
| <code>matlab.mixin.Heterogeneous</code> | Superclass for heterogeneous array formation |

|                                   |                                             |
|-----------------------------------|---------------------------------------------|
| Enumerations                      |                                             |
| <code>enumeration</code>          | Display class enumeration members and names |
| <code>isenum</code>               | Determine if variable is enumeration        |
| <code>meta.EnumeratedValue</code> | Describe enumeration member of MATLAB class |

Class Customization

|                                       |                                                                           |
|---------------------------------------|---------------------------------------------------------------------------|
| Object Indexing                       |                                                                           |
| <code>numElementsFromSubscript</code> | Number of arguments for customized indexing methods                       |
| <code>subref</code>                   | Redefine subscripted reference for objects                                |
| <code>subasgn</code>                  | Redefine subscripted assignment                                           |
| <code>substruct</code>                | Convert object to array index                                             |
| <code>substruct</code>                | Create structure argument for <code>subasgn</code> or <code>subref</code> |

|                                         |                                              |
|-----------------------------------------|----------------------------------------------|
| Object Arrays                           |                                              |
| <code>empty</code>                      | Create empty array                           |
| <code>matlab.mixin.Heterogeneous</code> | Superclass for heterogeneous array formation |

|                                              |                                         |
|----------------------------------------------|-----------------------------------------|
| Object Display                               |                                         |
| <code>display</code>                         | Display text and numeric expressions    |
| <code>details</code>                         | Display array details                   |
| <code>matlab.mixin.CustomDisplay</code>      | Display customization interface class   |
| <code>matlab.mixin.ui.PropertiesGroup</code> | Custom property list for object display |

|                      |                                |
|----------------------|--------------------------------|
| Object Save and Load |                                |
| <code>saveobj</code> | Modify save process for object |
| <code>loadobj</code> | Modify load process for object |

|                   |                     |
|-------------------|---------------------|
| Class Editing     |                     |
| <code>edit</code> | Edit or create file |

|                                          |                                                                   |
|------------------------------------------|-------------------------------------------------------------------|
| Class Metadata                           |                                                                   |
| <code>metaclass</code>                   | Obtain <code>meta.class</code> object                             |
| <code>meta.abstractDetails</code>        | Find abstract methods and properties                              |
| <code>meta.class.FromName</code>         | Return <code>meta.class</code> object associated with named class |
| <code>meta.package.FromName</code>       | Return <code>meta.package</code> object for specified package     |
| <code>meta.package.getAllPackages</code> | Get all top-level packages                                        |
| <code>properties</code>                  | Class property names                                              |
| <code>methods</code>                     | Class method names                                                |
| <code>events</code>                      | Event names                                                       |
| <code>superClasses</code>                | Superclass names                                                  |
| <code>meta.class</code>                  | Describe MATLAB class                                             |
| <code>meta.property</code>               | Describe property of MATLAB class                                 |
| <code>meta.method</code>                 | Describe method of MATLAB class                                   |
| <code>meta.event</code>                  | Describe event of MATLAB class                                    |
| <code>meta.package</code>                | Describe MATLAB package                                           |
| <code>meta.DynamicProperty</code>        | Describe dynamic property of MATLAB object                        |
| <code>meta.EnumeratedValue</code>        | Describe enumeration member of MATLAB class                       |

|                               |                                     |
|-------------------------------|-------------------------------------|
| <a href="#">meta-PerfData</a> | Superset for MATLAB object metadata |
|-------------------------------|-------------------------------------|

Calling External Functions

Call MEX-File Functions

|                        |                                                  |
|------------------------|--------------------------------------------------|
| <a href="#">mexext</a> | Binary MEX-file name extension                   |
| <a href="#">mexm</a>   | Names of functions, MEX files, classes in memory |

Call C Shared Libraries

|                                  |                                                                          |
|----------------------------------|--------------------------------------------------------------------------|
| <a href="#">loadlibrary</a>      | Load C/C++ shared library into MATLAB                                    |
| <a href="#">unloadlibrary</a>    | Unload shared library from memory                                        |
| <a href="#">libloaded</a>        | Determine if shared library is loaded                                    |
| <a href="#">calllib</a>          | Call function in shared library                                          |
| <a href="#">libFunctions</a>     | Return information on functions in shared library                        |
| <a href="#">libFunctionsView</a> | Display shared library function signatures in window                     |
| <a href="#">libconvert</a>       | Convert MATLAB structure to C-type structure for use with shared library |
| <a href="#">libpointer</a>       | Pointer object for use with shared library                               |
| <a href="#">lib_pointer</a>      | Pointer object compatible with C pointer                                 |

Call Java Libraries

|                                                |                                                         |
|------------------------------------------------|---------------------------------------------------------|
| <a href="#">javaarray</a>                      | Construct Java array object                             |
| <a href="#">javaclasspath</a>                  | Return Java class path or specify dynamic path          |
| <a href="#">javaddpath</a>                     | Add entries to dynamic Java class path                  |
| <a href="#">javacmpath</a>                     | Remove entries from dynamic Java class path             |
| <a href="#">javaerror</a>                      | Error message based on Java feature support             |
| <a href="#">isjava</a>                         | Determine if input is Java object                       |
| <a href="#">isjava</a>                         | Determine if Java feature is available                  |
| <a href="#">javaMethod</a>                     | Call Java method                                        |
| <a href="#">javaMethodEDT</a>                  | Call Java method from Event Dispatch Thread (EDT)       |
| <a href="#">javaobjct</a>                      | Call Java constructor                                   |
| <a href="#">javaobjctEDT</a>                   | Call Java constructor on Event Dispatch Thread (EDT)    |
| <a href="#">call</a>                           | Create call array                                       |
| <a href="#">class</a>                          | Determine class of object                               |
| <a href="#">clear</a>                          | Remove items from workspace, freeing up system memory   |
| <a href="#">depfun</a>                         | List dependencies of function or P-file                 |
| <a href="#">exist</a>                          | Check existence of variable, function, folder, or class |
| <a href="#">FieldNames</a>                     | Field names of structure, or public fields of object    |
| <a href="#">is2java</a>                        | Convert image to Java image                             |
| <a href="#">import</a>                         | Add package or class to current import list             |
| <a href="#">names</a>                          | Names of functions, MEX files, classes in memory        |
| <a href="#">inspect</a>                        | Open Property Inspector                                 |
| <a href="#">isA</a>                            | Determine if input is object of specified class         |
| <a href="#">methods</a>                        | Class method names                                      |
| <a href="#">methodsView</a>                    | View class methods                                      |
| <a href="#">which</a>                          | Locate functions and files                              |
| <a href="#">matlab_exception_javaException</a> | Capture error information for Java exception            |

Call .NET Libraries

|                                           |                                                   |
|-------------------------------------------|---------------------------------------------------|
| Getting Started with Microsoft .NET       |                                                   |
| <a href="#">NET_assembly</a>              | Make .NET assembly visible to MATLAB              |
| <a href="#">NET_isNetSupported</a>        | Check for supported Microsoft .NET Framework      |
| <a href="#">NET_invokeMethod</a>          | Summary of functions in MATLAB .NET interface     |
| <a href="#">enableNetFromNetworkDrive</a> | Enable access to .NET commands from network drive |
| <a href="#">NET_Asembly</a>               | Members of .NET assembly                          |
| <a href="#">NET_NetException</a>          | Capture error information for .NET exception      |

Data Types

|                                            |                                                                                                                    |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <a href="#">cell</a>                       | Create cell array                                                                                                  |
| <a href="#">NET_createArray</a>            | Array for nonprimitive .NET types                                                                                  |
| <a href="#">NET_createAutoReleaseClass</a> | Link .NET object representing a Run-Time Callable Wrapper (COM Wrapper) so that MATLAB does not release COM object |
| <a href="#">NET_enableAutoReleaseClass</a> | Unlink .NET object representing a Run-Time Callable Wrapper (COM Wrapper) so that MATLAB releases COM object       |

|                                       |                               |
|---------------------------------------|-------------------------------|
| Properties                            |                               |
| <a href="#">NET_varStaticProperty</a> | Static property or field name |

Events and Delegates

|                             |                                                                                           |
|-----------------------------|-------------------------------------------------------------------------------------------|
| <a href="#">BeginInvoke</a> | Initiate asynchronous .NET delegate call                                                  |
| <a href="#">EndInvoke</a>   | Retrieve result of asynchronous call initiated by .NET System.Delegate BeginInvoke method |
| <a href="#">Combine</a>     | Convenience function for static .NET System.Delegate Combine method                       |
| <a href="#">Remove</a>      | Convenience function for static .NET System.Delegate Remove method                        |
| <a href="#">RemoveAll</a>   | Convenience function for static .NET System.Delegate RemoveAll method                     |

|                        |                                                      |
|------------------------|------------------------------------------------------|
| Enumerations           |                                                      |
| <a href="#">bitand</a> | Bit-wise AND                                         |
| <a href="#">bitor</a>  | Bit-wise OR                                          |
| <a href="#">bitxor</a> | Bit-wise XOR                                         |
| <a href="#">bitnot</a> | .NET enumeration object bit-wise NOT instance method |

|                                         |                                                  |
|-----------------------------------------|--------------------------------------------------|
| Generic Classes                         |                                                  |
| <a href="#">NET_convertArray</a>        | Convert numeric MATLAB array to .NET array       |
| <a href="#">NET_createGeneric</a>       | Create instance of specialized .NET generic type |
| <a href="#">NET_invokeGenericMethod</a> | Invoke generic method of object                  |
| <a href="#">NET_genericClass</a>        | Represent parameterized generic type definitions |

Call COM Objects

|                                          |                                                                             |
|------------------------------------------|-----------------------------------------------------------------------------|
| <a href="#">activexserver</a>            | Create COM server                                                           |
| <a href="#">activexctrl</a>              | Create Microsoft ActiveX control in figure window                           |
| <a href="#">activexctrlinit</a>          | List currently installed Microsoft ActiveX controls                         |
| <a href="#">activexctrlselect</a>        | Create Microsoft ActiveX control from UI                                    |
| <a href="#">activexctrlRunningServer</a> | Handle to running instance of automation server                             |
| <a href="#">iscom</a>                    | Determine whether input is COM or ActiveX object                            |
| <a href="#">isprop</a>                   | Determine whether input is COM object property                              |
| <a href="#">get</a>                      | Get property value from interface, or display properties                    |
| <a href="#">set</a>                      | Set object or interface property to specified value                         |
| <a href="#">addproperty</a>              | Add custom property to COM object                                           |
| <a href="#">deleteproperty</a>           | Remove custom property from COM object                                      |
| <a href="#">inspect</a>                  | Open Property Inspector                                                     |
| <a href="#">properties</a>               | Open built-in property page for control                                     |
| <a href="#">FieldNames</a>               | Field names of structure, or public fields of object                        |
| <a href="#">ismethod</a>                 | Determine whether input is COM object method                                |
| <a href="#">methods</a>                  | Class method names                                                          |
| <a href="#">methodsView</a>              | View class methods                                                          |
| <a href="#">invoke</a>                   | Invoke method on COM object or interface, or display methods                |
| <a href="#">isevent</a>                  | Determine whether input is COM object event                                 |
| <a href="#">events</a>                   | List of events COM object can trigger                                       |
| <a href="#">eventListeners</a>           | List event handler functions associated with COM object events              |
| <a href="#">registerevent</a>            | Associate event handler for COM object event at run time                    |
| <a href="#">unregisterallevents</a>      | Unregister all event handlers associated with COM object events at run time |
| <a href="#">unregisterevent</a>          | Unregister event handler associated with COM object event at run time       |
| <a href="#">interfaceInfo</a>            | Determine whether input is COM interface                                    |
| <a href="#">interfaces</a>               | List custom interfaces exposed by COM server object                         |
| <a href="#">release</a>                  | Release COM interface                                                       |
| <a href="#">delete</a>                   | Remove COM control or server                                                |
| <a href="#">move</a>                     | Move or release control in parent window                                    |
| <a href="#">load</a>                     | Initialize control object from file                                         |
| <a href="#">save</a>                     | Serialize control object to file                                            |

Call Python Libraries

|                                              |                                                |
|----------------------------------------------|------------------------------------------------|
| Getting Started with Python                  |                                                |
| <a href="#">pyversion</a>                    | Change default version of Python interpreter   |
| <a href="#">matlab_exception_PyException</a> | Capture error information for Python exception |

Data Types

|                        |                                             |
|------------------------|---------------------------------------------|
| <a href="#">pyargs</a> | Create keyword argument for Python function |
|------------------------|---------------------------------------------|

Call WSDL Web Service

|                                                    |                                                                                            |
|----------------------------------------------------|--------------------------------------------------------------------------------------------|
| <a href="#">matlab_wsd_client_wsdlWSDLClient</a>   | Create interface to SOAP-based web service                                                 |
| <a href="#">matlab_wsd_client_wsdlWSDLToolPath</a> | Location of WSDL tools                                                                     |
| <a href="#">createSoapFromWSDL</a>                 | Create MATLAB class based on WSDL document                                                 |
| <a href="#">createSoapMessage</a>                  | Create SOAP (Simple Object Access Protocol) message to send to server                      |
| <a href="#">callSoapService</a>                    | Send SOAP (Simple Object Access Protocol) message to endpoint                              |
| <a href="#">parseSoapResponse</a>                  | Convert response string from SOAP (Simple Object Access Protocol) server into MATLAB types |

Toolbox Distribution

|                                  |                                         |
|----------------------------------|-----------------------------------------|
| <a href="#">buildDocsearchdb</a> | Build searchable documentation database |
|----------------------------------|-----------------------------------------|

Exception Handling

|                             |                                                      |
|-----------------------------|------------------------------------------------------|
| <a href="#">try_catch</a>   | Execute statements and catch resulting errors        |
| <a href="#">MEexception</a> | Capture error information                            |
| <a href="#">addCause</a>    | Record additional causes of exception                |
| <a href="#">getReport</a>   | Get error message for exception                      |
| <a href="#">last</a>        | Return last uncaught exception                       |
| <a href="#">rethrow</a>     | Rethrow previously caught exception                  |
| <a href="#">throw</a>       | Throw exception                                      |
| <a href="#">throwCaller</a> | Throw exception as if occurs within calling function |

Unit Testing Framework

Script-Based Unit Tests

|                            |                                |
|----------------------------|--------------------------------|
| <a href="#">assert</a>     | Throw error if condition false |
| <a href="#">runTests</a>   | Run set of tests               |
| <a href="#">TestResult</a> | Result of running test suite   |

Function-Based Unit Tests

|                                  |                                                                        |
|----------------------------------|------------------------------------------------------------------------|
| <a href="#">functionTests</a>    | Create array of tests from handles to local functions                  |
| <a href="#">runTests</a>         | Run set of tests                                                       |
| <a href="#">TestSuite.run</a>    | Run TestSuite array using TestRunner object configured for text output |
| <a href="#">Test</a>             | Specification of a single test method                                  |
| <a href="#">FunctionTestCase</a> | TestCase used for function-based tests                                 |
| <a href="#">TestResult</a>       | Result of running test suite                                           |

Class-Based Unit Tests



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- Functions
- Release Notes
- PDF Documentation

Other Documentation

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- Symbolic Math Toolbox
- Statistics and Machine Learning Toolbox
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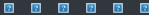
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