### Sound Processing Functions

#### General Sound Functions
- **saxis**
  - Sound axis scaling.
- **sound**
  - Convert vector into sound.

#### SPARCS station-specific Sound Functions
- **aurad**
  - Read Sun audio file.
- **aurite**
  - Write Sun audio file.
- **lin2mu**
  - Linear to u-law conversion.
- **m2lmn**
  - Mu-law to linear conversion.

### Character String Functions

#### General
- **abs**
  - Convert string to numeric values.
- **eval**
  - Execute string.
- **issstr**
  - Test for string.
- **setstr**
  - Convert numeric values to string.
- **string**
  - About character strings.
- **str2mat**
  - Form text matrix.

#### String Conversion
- **sprintf**
  - Write formatted data to string.
- **sscanf**
  - Read string under format control.

#### String Comparison
- **lower**
  - Convert string to lowercase.
- **strcmp**
  - Compare strings.
- **upper**
  - Convert string to uppercase.

#### String to Number Conversion
- **int2str**
  - Convert integer to string.
- **num2str**
  - Convert number to string.
- **sprintf**
  - Convert number to string.
- **str2num**
  - Convert string to number.
- **sscanf**
  - Convert string to number.

#### Hexadecimal to Number Conversion
- **dec2hex**
  - Convert decimal integer to hex string.
- **hex2dec**
  - Convert hex string to decimal integer.
- **hex2num**
  - Convert hex string to floating point.

### Low-level File I/O Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>fclose</td>
<td>Close file.</td>
</tr>
<tr>
<td>fopen</td>
<td>Open file.</td>
</tr>
</tbody>
</table>

### Unformatted I/O

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>fread</td>
<td>Read binary data from file.</td>
</tr>
<tr>
<td>fwrite</td>
<td>Write binary data to file.</td>
</tr>
</tbody>
</table>

### Formatted I/O

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>getl</td>
<td>Read line from file, discard new line.</td>
</tr>
<tr>
<td>gets</td>
<td>Read line from file, keep new line.</td>
</tr>
<tr>
<td>fprintf</td>
<td>Write formatted data to file.</td>
</tr>
<tr>
<td>fscanf</td>
<td>Read formatted data from file.</td>
</tr>
</tbody>
</table>

### File Positioning

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ferror</td>
<td>Inquire file I/O error status.</td>
</tr>
<tr>
<td>frewind</td>
<td>Rewind file.</td>
</tr>
<tr>
<td>fseek</td>
<td>Set file position indicator.</td>
</tr>
<tr>
<td>ftell</td>
<td>Get file position indicator.</td>
</tr>
</tbody>
</table>

### Graphics

MATLAB provides 20 main categories of functions. The MATLAB help command displays an online table of these categories. Typing help category name (e.g., help general) displays the tables within that category.

### Main Categories of Functions

#### General
- **General purpose commands.**
- **operators**
  - Operators and special characters.
- **lang**
  - Language constructs and debugging.
- **elmat**
  - Elementary matrices and matrix manipulation.
- **specialmat**
  - Specialized matrices.
- **elfun**
  - Elementary math functions.
- **specfun**
  - Matrix functions – numerical linear algebra.
- **matfun**
  - Data analysis and Fourier transform functions.
- **datafun**
  - Polynomial and interpolation functions.
- **polyfun**
  - Function functions – nonlinear numerical methods.
- **sparfun**
  - Sparse matrix functions.
- **plotxy**
  - Two-dimensional graphics.
- **plotxyz**
  - Three-dimensional graphics.
- **graphics**
  - General purpose graphics functions.
- **color**
  - Color control and lighting model functions.
- **sounds**
  - Sound processing functions.
- **strfun**
  - Character string functions.
- **iofun**
  - Low-level file I/O functions.
- ** demos**
  - Demonstrations and samples.

### Line Editing and Recall Keys

#### VMS Keys
- Delete
  - Delete character before cursor.
- Ctrl-U, Ctrl-X
  - Clear line of text and move cursor to beginning of next line.

#### UNIX Keys
- Linefeed, Ctrl-J
  - Delete word before cursor.
- Ctrl-E
  - Move to end of line.
- Ctrl-D
  - Move to left character.
- Ctrl-F
  - Move forward (right) character.
- Backspace, Ctrl-H
  - Move to beginning of line.
- Ctrl-B
  - Recall previous command.
- Ctrl-N
  - Recall next command.
- Ctrl-R
  - Redisplay current line.
- Ctrl-A
  - Toggle insert/overstrike mode.

---

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For more information, visit www.mathworks.com
### General Purpose Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>demo</td>
<td>Run demos.</td>
</tr>
<tr>
<td>help</td>
<td>Online documentation.</td>
</tr>
<tr>
<td>info</td>
<td>Information about MATLAB and The MathWorks.</td>
</tr>
<tr>
<td>lookfor</td>
<td>Keyword search through the help entries.</td>
</tr>
<tr>
<td>path</td>
<td>Execute operating system command.</td>
</tr>
<tr>
<td>type</td>
<td>List M-file.</td>
</tr>
<tr>
<td>what</td>
<td>Directory listing of M-, MAT-, and MEX-files.</td>
</tr>
<tr>
<td>which</td>
<td>Locate functions and files.</td>
</tr>
</tbody>
</table>

### Managing Variables and the Workspace

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>clear</td>
<td>Clear variables and functions from memory.</td>
</tr>
<tr>
<td>disp</td>
<td>Display matrix or text.</td>
</tr>
<tr>
<td>length</td>
<td>Length of vector.</td>
</tr>
<tr>
<td>load</td>
<td>Retrieve variables from disk.</td>
</tr>
<tr>
<td>pack</td>
<td>Execute operating system command.</td>
</tr>
<tr>
<td>save</td>
<td>Save workspace variables to disk.</td>
</tr>
<tr>
<td>size</td>
<td>Size of matrix.</td>
</tr>
<tr>
<td>who</td>
<td>List current variables.</td>
</tr>
<tr>
<td>whois</td>
<td>List current variables, long form.</td>
</tr>
</tbody>
</table>

### Working with Files and the Operating System

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cd</td>
<td>Change current working directory.</td>
</tr>
<tr>
<td>delete</td>
<td>Delete file.</td>
</tr>
<tr>
<td>diary</td>
<td>Save text of MATLAB session.</td>
</tr>
<tr>
<td>dir</td>
<td>Directory listing.</td>
</tr>
<tr>
<td>getenv</td>
<td>Get environment value.</td>
</tr>
<tr>
<td>unix</td>
<td>Execute operating system command; return result.</td>
</tr>
</tbody>
</table>

### Controlling the Command Window

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>clc</td>
<td>Clear command window.</td>
</tr>
<tr>
<td>echo</td>
<td>Echo commands inside script files.</td>
</tr>
<tr>
<td>format</td>
<td>Set output format.</td>
</tr>
<tr>
<td>home</td>
<td>Send cursor home.</td>
</tr>
<tr>
<td>more</td>
<td>Control paged output.</td>
</tr>
</tbody>
</table>

### Starting and Quitting from MATLAB

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>matlabrc</td>
<td>Master startup M-file.</td>
</tr>
<tr>
<td>quit</td>
<td>Terminate MATLAB.</td>
</tr>
<tr>
<td>startup</td>
<td>M-file executed at startup.</td>
</tr>
</tbody>
</table>

### Operators and Special Characters

#### Arithmetic and Matrix Operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Plus.</td>
</tr>
<tr>
<td>-</td>
<td>Minus.</td>
</tr>
<tr>
<td>*</td>
<td>Matrix multiplication.</td>
</tr>
<tr>
<td>.*</td>
<td>Array multiplication.</td>
</tr>
<tr>
<td>./</td>
<td>Array power.</td>
</tr>
</tbody>
</table>
| .
| kron      | Kronecker tensor product. |
| \         | Backslash or left division. |
| /         | Slash or right division. |
| .\        | Array division. |
| ./        | Transpose. |
| .\*       | Nonconjugated transpose. |

#### Relational Operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;</td>
<td>Greater than.</td>
</tr>
<tr>
<td>&lt;</td>
<td>Less than.</td>
</tr>
<tr>
<td>&gt;=</td>
<td>Greater than or equal to.</td>
</tr>
<tr>
<td>&lt;=</td>
<td>Less than or equal to.</td>
</tr>
<tr>
<td>==</td>
<td>Equal to.</td>
</tr>
<tr>
<td>~=</td>
<td>Not equal to.</td>
</tr>
</tbody>
</table>

#### Logical Operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp;</td>
<td>Logical AND.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>~</td>
<td>Logical NOT.</td>
</tr>
<tr>
<td>.</td>
<td></td>
</tr>
</tbody>
</table>

#### Special Characters

<table>
<thead>
<tr>
<th>Character</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>:</td>
<td>Colon.</td>
</tr>
<tr>
<td>(</td>
<td>Parentheses.</td>
</tr>
<tr>
<td>)</td>
<td>Brackets.</td>
</tr>
<tr>
<td>.</td>
<td>Decimal point.</td>
</tr>
<tr>
<td>,</td>
<td>Parent directory.</td>
</tr>
<tr>
<td>.</td>
<td>Continuation.</td>
</tr>
<tr>
<td>.</td>
<td>Comm.</td>
</tr>
<tr>
<td>.</td>
<td>Semicolon.</td>
</tr>
<tr>
<td>/</td>
<td>Comment.</td>
</tr>
<tr>
<td>!</td>
<td>Exclamation point.</td>
</tr>
<tr>
<td>=</td>
<td>Assignment.</td>
</tr>
<tr>
<td>'</td>
<td>Quote.</td>
</tr>
</tbody>
</table>

#### Logical Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>all</td>
<td>True if all elements of vector are true.</td>
</tr>
<tr>
<td>any</td>
<td>True if any element of vector is true.</td>
</tr>
<tr>
<td>exist</td>
<td>Check if variables or functions exist.</td>
</tr>
</tbody>
</table>

### Functions and the Operating System

- `whos` lists current variables.
- `size` lists size of matrix.
- `length` lists length of vector.
- `disp` displays matrix or text.
- `clear` clears variables and functions from memory.
- `who` lists current variables.
- `which` lists function and file locations.
- `exists` checks if variables or functions exist.
- `which` lists current variables.
- `whos` lists current variables, long form.
- `load` retrieves variables from disk.
- `save` saves workspace variables to disk.
- `length` lists length of vector.
- `size` lists size of matrix.
- `who` lists current variables.
- `whos` lists current variables, long form.
- `cd` changes current working directory.
- `delete` deletes file.
- `diary` saves text of MATLAB session.
- `dir` lists directory listing.
- `getenv` gets environment value.
- `unix` executes operating system command.
- `who` lists current variables.
- `whos` lists current variables, long form.

### Managing Commands and Functions

- `demo` runs demos.
- `help` provides online documentation.
- `info` provides information about MATLAB and The MathWorks.
- `lookfor` searches help entries.
- `path` executes operating system command.
- `type` lists M-file.
- `what` lists M-, MAT-, and MEX-files.
- `which` locates functions and files.

### Debugging and Troubleshooting

- `whos` lists current variables.
- `size` lists size of matrix.
- `length` lists length of vector.
- `disp` displays matrix or text.
- `clear` clears variables and functions from memory.
- `who` lists current variables.
- `whos` lists current variables, long form.
- `cd` changes current working directory.
- `delete` deletes file.
- `diary` saves text of MATLAB session.
- `dir` lists directory listing.
- `getenv` gets environment value.
- `unix` executes operating system command.
- `who` lists current variables.
- `whos` lists current variables, long form.
- `clc` clears command window.
- `echo` echoes commands inside script files.
- `format` sets output format.
- `home` sends cursor home.
- `more` controls paged output.
- `matlabrc` master startup M-file.
- `quit` terminates MATLAB.
- `startup` M-file executed at startup.

### Logical Functions

- `all` checks if all elements of vector are true.
- `any` checks if any element of vector is true.
- `exist` checks if variables or functions exist.

### Logical AND

- `&` logical AND.

### Logical OR

- `|` logical OR.

### Logical NOT

- `~` logical NOT.

### Logical EXCLUSIVE OR

- `.~` logical EXCLUSIVE OR.

### English

- `break` terminate execution of loop.
- `else` used with `if`.
- `elseif` used with `if`.
- `end` terminate scope of `for`, `while`, and `if`.
- `error` display message and abort function.
- `for` repeat a specific number of times.
- `if` conditional execution statements.
- `return` return to invoking function.
- `while` repeat an indefinite number of times.

### Special Variables and Constants

- `ans` most recent answer.
- `computer` computer type.
- `eps` floating point relative accuracy.
- `flops` count of floating point operations.
- `i` imaginary unit.
- `inf` infinity.
- `NaN` not-a-number.
- `nargin` number of function input arguments.
- `nargout` number of function output arguments.
- `pi` 3.1415926535897...
- `realmax` largest floating point number.
- `realmin` smallest floating point number.

### Time and Dates

- `clock` wall clock.
- `cputime` elapsed CPU time.
- `date` calendar.
- `etime` elapsed time function.
- `tic`, `toc` stopwatch timer functions.

### Matrix Manipulation

- `diag` create or extract diagonals.
- `flipl` flip matrix in the left direction.
- `fliph` flip matrix in the up/down direction.
- `reshape` change size.
- `rot90` rotate matrix 90 degrees.
- `triu` extract lower triangular part.
- `tril` extract upper triangular part.
- `ind2sub` index into matrix, rearrange matrix.
Specialized Math Functions

- betainc: Incomplete beta function.
- betaln: Logarithm of beta function.
- ellipj: Jacob elliptic functions.
- ellipke: Complete elliptic integral.
- erf: Error function.
- erfz: Complementary error function.
- erfcx: Scaled complementary error function.
- erfiv: Error function.
- gamma: Gamma function.
- gammaln: Logarithm of gamma function.
- gammainc: Incomplete gamma function.
- log2: Dissect floating-point numbers.
- pow2: Scale floating-point numbers.
- rat: Rational approximation.
- rats: Rational output.

Matrix Functions

- Matrix Analysis
  - cond: Matrix condition number.
  - det: Determinant.
  - norm: Matrix or vector norm.
  - null: Null space.
  - orth: Orthogonalization.
  - rank: Number of linearly independent rows or columns.
  - rcond: LINPACK reciprocal condition estimator.
  - rref: Reduced row echelon form.
  - trace: Sum of diagonal elements.

- Linear Equations
  - chol: Cholesky factorization.
  - inv: Matrix inverse.
  - laevd: Least squares in the presence of known covariance.
  - lu: Factors from Gaussian elimination.
  - nnls: Nonnegative least-squares.
  - pinv: Pseudoinverse.
  - qr: Orthogonal-triangular decomposition.

- Eigenvalues and Singular Values
  - balance: Diagonal scaling to improve eigenvalue accuracy.
  - cdf2rdf: Complex diagonal to real block diagonal form.
  - eig: Eigenvalues and eigenvectors.
  - hess: Hessenberg form.
  - poly: Characteristic polynomial.
  - qz: Generalized eigenvalues.
  - rsf2csf: Real block diagonal to complex diagonal form.
  - schur: Schur decomposition.
  - svd: Singular value decomposition.

Matrix Functions - Numerical Linear Algebra

- chol: Cholesky factorization.
- inv: Matrix inverse.
- laevd: Least squares in the presence of known covariance.
- lu: Factors from Gaussian elimination.
- nnls: Nonnegative least-squares.
- pinv: Pseudoinverse.
- qr: Orthogonal-triangular decomposition.

Data Analysis and Fourier Transform Functions

- Basic Operations
  - cumprod: Cumulative product of elements.
  - cumsum: Cumulative sum of elements.
  - inv: Matrix inverse.
  - max: Largest component.
  - mean: Average or mean value.
  - median: Median value.
  - min: Smallest component.
  - prod: Product of elements.
  - sort: Sort in ascending order.
  - std: Standard deviation.
  - sum: Sum of elements.
  - trapz: Numerical integration using trapezoidal method.

- Finite Differences
  - de25: Five-point discrete Laplacian.
  - diff: Difference function and approximate derivative.
  - grad: Approximate gradient.

- Correlation
  - corr: Correlation coefficients.
  - cova: Covariance matrix.

- Filtering and Convolution
  - conv: Convolution and polynomial multiplication.
  - conv2: 2-D convolution.
  - deconv: Deconvolution and polynomial division.
  - filter2: 2-D digital filter.

- Fourier Transforms
  - abs: Magnitude.
  - angle: Phase angle.
  - cplxpair: Sort numbers into complex conjugate pairs.
  - fft: Discrete Fourier transform.
  - fft2: 2-D discrete Fourier transform.
  - fftshift: Move zeroth lag to center of spectrum.
  - ifft: Inverse discrete Fourier transform.
  - ifft2: 2-D inverse discrete Fourier transform.
  - nextpow2: Next higher power of 2.
  - unwrap: Remove phase angle jumps across 360° boundaries.

Polynomial and Interpolation Functions

- Polynomials
  - conv: Multiply polynomials.
  - deconv: Divide polynomials.
  - poly: Construct polynomial with specified roots.
  - polyder: Differentiate polynomial.
  - polyfit: Fit polynomial to data.
  - polyval: Evaluate polynomial.
  - polyvalm: Evaluate polynomial with matrix argument.

- Data Interpolation
  - gridded: Data gridding.
  - interp1: 1-D interpolation (1-D table lookup).
  - interp2: 2-D interpolation (2-D table lookup).
  - interpft: 1-D interpolation using FFT method.

- Function Functions

- Nonlinear Numerical Methods
  - fmin: Minimize function of one variable.
  - fmins: Minimize function of several variables.
  - fplot: Plot function.
  - fzero: Find zero of function of one variable.
  - ode23: Solve differential equations, low order.
  - ode45: Solve differential equations, high order.
  - quad: Numerically evaluate integral, low order.
  - quad8: Numerically evaluate integral, high order.

Sparse Matrix Functions

- Elementary Sparse Matrices
  - spdiag: Sparse matrix formed from diagonals.
  - speye: Sparse identity matrix.
  - sprandn: Sparse random matrix.
  - sprandsym: Sparse symmetric random matrix.

- Full to Sparse Conversion
  - full: Convert sparse matrix to full matrix.
  - find: Find indices of nonzero entries.
  - sparse: Create sparse matrix.
  - spconvert: Convert from sparse external format.
Linear plot.

Elementary \( x-y \) Graphs

- **fill**: Draw filled 2-D polygons.
- **loglog**: Log–log scale plot.
- **plot**: Linear plot.
- **semilogx**: Semi-log scale plot (x-axis).
- **semilogy**: Semi-log scale plot (y-axis).

Specialized \( x-y \) Graphs

- **bar**: Bar graph.
- **compass**: Compass plot.
- **errorbar**: Error bar plot.
- **feather**: Feather plot.
- **fplot**: Plot function.
- **histogram**: Histogram plot.
- **polar**: Polar coordinate plot.
- **rose**: Angle histogram plot.
- **stairs**: Step plot.

Graph Annotation

- **grid**: Grid lines.
- **gtext**: Mouse placement of text.
- **title**: Graph title.
- **xlabel**: x-axis label.
- **ylabel**: y-axis label.

Three-Dimensional Graphics

Line and Area Fill Commands

- **fill3**: Draw filled 3-D polygons in 3-D space.
- **plot3**: Plot lines and points in 3-D space.

Contour and Other 2-D Plots of 3-D Data

- **clabel**: Contour plot elevation labels.
- **contour**: Contour plot.
- **contour3**: 3-D contour plot.
- **contourc**: Contour plot computation.
- **image**: Display image.
- **pcolor**: Pseudocolor (checkerboard) plot.
- **quiver**: Quiver plot.

Surface and Mesh Plots

- **mesh**: 3-D mesh surface.
- **meshc**: Combination mesh/contour plot.
- **meshz**: 3-D mesh with zero plane.
- **slice**: Volumetric visualization plot.
- **surf**: 3-D shaded surface.
- **surf2**: Combination surf/contour plot.
- **surf3**: 3-D shaded surface with lighting.
- **waterfall**: Waterfall plot.

Graph Appearance

- **axis**: Axis scaling and appearance.
- **caxis**: Pseudocolor axis scaling.
- **colorbar**: Color lookup table.
- **hidden**: Mesh hidden line removal mode.
- **shading**: Color shading mode.
- **view**: 3-D graph viewpoint specification.

Graph Annotation

- **grid**: Grid lines.
- **gtext**: Mouse placement of text.
- **title**: Graph title.
- **xlabel**: x-axis label.
- **ylabel**: y-axis label.

3-D Objects

- **cylinder**: Generate cylinder.
- **sphere**: Generate sphere.

General Purpose Graphics Functions

Figure Window Creation and Control

- **clf**: Clear current figure.
- **close**: Close figure.
- **figure**: Create figure.
- **gcf**: Get handle to current figure.

Axis Creation and Control

- **axes**: Create axes in arbitrary positions.
- **axis**: Control axis scaling and appearance.
- **caxis**: Control pseudocolor axis scaling.
- **cla**: Clear current axes.
- **gca**: Get handle to current axes.
- **hold**: Hold current graph.
- **subplot**: Create axes in tiled positions.

Handle Graphics™ Objects

- **axes**: Create axes.
- **figure**: Create figure window.
- **image**: Create image.
- **line**: Create line.
- **patch**: Create patch.
- **surface**: Create surface.
- **text**: Create text.

Miscellaneous

- **ginput**: Graphical input, from mouse.
- **ishold**: Return hold state.

Color Control and Lighting Model Functions

Color Controls

- **caxis**: Pseudocolor axis scaling.
- **colorbar**: Color lookup table.
- **shading**: Color shading mode.

Color Maps (see online help)

- **bone**: Gray-scale with a tinge of blue.
- **cool**: Shades of cyan and magenta.
- **copper**: Linear copper-tones.
- **flag**: Red, white, and blue.
- **gray**: Linear gray-scale.
- **hot**: Black-red-yellow-white.
- **pink**: Pastel shades of pink.

Color Map Related Functions

- **brighten**: Brighten or darken color map.
- **hsv2rgb**: Hue-saturation-value to red-green-blue.
- **rgbplot**: Plot color map.
- **rgb2hsv**: Red-green-blue to hue-saturation-value.
- **spinmap**: Spin color map.