

# Appendix B

## MATLAB REFERENCE TABLES

MATLAB provides main categories of functions. Some of MATLAB's functions are built into the interpreter, while others take the form of M-files. The M-file functions, and in the case of the built-in functions, M-files containing only help text, are organized into directories, each containing the files associated with a category. The MATLAB command **help** displays an online table of these main categories.

Table B.1 – MATLAB's Main Categories of Functions	
<b>color</b>	Color control and lighting model functions.
<b>datafun</b>	Data analysis and Fourier transform functions.
<b>demos</b>	Demonstrations and samples.
<b>elfun</b>	Elementary math functions.
<b>elmat</b>	Elementary matrices and matrix manipulation.
<b>funfun</b>	Function functions – nonlinear numerical methods.
<b>general</b>	General purpose commands.
<b>graphics</b>	General purpose graphics functions.
<b>iofun</b>	Low-level file I/O functions.
<b>lang</b>	Language constructs and debugging.
<b>matfun</b>	Matrix functions – numerical linear algebra.
<b>ops</b>	Operators and special characters.
<b>plotxy</b>	Two dimensional graphics.
<b>plotxyz</b>	Three dimensional graphics.
<b>polyfun</b>	Polynomial and interpolation functions.
<b>sparfun</b>	Sparse matrix functions.
<b>specfun</b>	Specialized math functions.
<b>specmat</b>	Specialized matrices.
<b>sounds</b>	Sound processing functions.
<b>strfun</b>	Character string functions.

The **help** command will also display the toolboxes that are available to you.

The following tables give General Purpose Commands:

**Table B.2 Managing Commands and Functions**

<b>demo</b>	Run demos.
<b>help</b>	Online documentation.
<b>info</b>	Information about MATLAB and the MathWorks.
<b>lookfor</b>	Keyword search through the help entries.
<b>path</b>	Control MATLAB's search path.
<b>type</b>	List M-file.
<b>what</b>	Directory listing of M-, MAT- and MEX-files.
<b>which</b>	Locate functions and files.

**Table B.3 Managing Variables and the Workspace**

<b>clear</b>	Clear variables and functions from memory.
<b>disp</b>	Display matrix or text.
<b>length</b>	Length of vector.
<b>load</b>	Retrieve variables from disk.
<b>pack</b>	Consolidate workspace memory.
<b>save</b>	Save workspace variables to disk.
<b>size</b>	Size of matrix.
<b>who</b>	List current variables.
<b>whos</b>	List current variables, long form.

**Table B.4 Working with Files and the Operating System**

<b>cd</b>	Change current working directory.
<b>delete</b>	Delete file.
<b>diary</b>	Save text of MATLAB session.
<b>dir</b>	Directory listing.
<b>getenv</b>	Get environment value.
<b>unix</b>	Execute operating system command; return result.
<b>!</b>	Execute operating system command.

**Table B.5 Controlling the Command Window**

<b>clc</b>	Clear command window.
<b>echo</b>	Echo commands inside script files.
<b>format</b>	Set output format.
<b>home</b>	Send cursor home.
<b>more</b>	Control paged output in command window.

**Table B.6 Starting and Quitting from MATLAB**

<b>matlabrc</b>	Master startup M-file.
<b>quit</b>	Terminate MATLAB.
<b>startup</b>	M-file executed when MATLAB is invoked.

Specified Operators and Special Characters are given in the next two tables.

Table B.7 Operators and Special Characters	
+	Plus.
—	Minus.
*	Matrix multiplication.
.*	Array multiplication.
^	Matrix power.
.^	Array power.
kron	Kronecker tensor product.
\	Backslash or left division.
/	Slash or right division.
./	Array division.
:	colon.
( )	Parentheses.
[]	Brackets.
.	Decimal point.
..	Parent directory.
...	Continuation.
,	Comma.
;	Semicolon.
%	Comment.
!	Exclamation point.
'	Transpose and quote.
.'	Nonconjugated transpose.
=	Assignment.
==	Equality.
<>	Relational operators.
&	Logical AND.
	Logical OR.
~	Logical NOT.
xor	Logical EXCLUSIVE OR.

Table B.8 Logical Functions	
all	True if all elements of vector are true.
any	True if any element of vector is true.
exist	Check if variables or functions exist.
find	Find indices of non-zero elements.
finite	True for finite elements.
isempty	True for empty matrix.
isieee	True for IEEE floating point arithmetic.
isinf	True for infinite elements.
ufbab	True for Not-A-Number.
issparse	True for sparse matrix.
isstr	True for text string.

The following are Language Constructs

<b>Table B.9 MATLAB as a Programming Language</b>	
<b>eval</b>	Execute string with MATLAB expression.
<b>feval</b>	Execute function specified by string.
<b>function</b>	Add new function.
<b>global</b>	Define global variable.
<b>nargchk</b>	Validate number of input arguments.

<b>Table B.10 Control Flow</b>	
<b>break</b>	Terminate execution of loop.
<b>else</b>	Used with <b>if</b> .
<b>elseif</b>	Used with <b>if</b> .
<b>end</b>	Terminate the scope of <b>for</b> , <b>while</b> and <b>if</b> statements.
<b>error</b>	Display message and abort function.
<b>for</b>	Repeat statements a specific number of times.
<b>if</b>	Conditionally execute statements.
<b>return</b>	Return to invoking function.
<b>while</b>	Repeat statements an indefinite number of times.

The following tables give Elementary Matrices and Matrix Manipulation

<b>Table B.11 Elementary Matrices</b>	
<b>eye</b>	Identity matrix.
<b>linspace</b>	Linearly spaced vector.
<b>logspace</b>	Logarithmically spaced vector.
<b>meshgrid</b>	X and Y arrays for 3-D plots.
<b>ones</b>	Ones matrix.
<b>rand</b>	Uniformly distributed random numbers.
<b>randn</b>	Normally distributed random numbers.
<b>zeros</b>	Zeros matrix.
<b>:</b>	Regularly spaced vector.

<b>Table B.12 Special Variables and Constants</b>	
<b>ans</b>	Most recent answer.
<b>computer</b>	Computer type.
<b>eps</b>	Floating point relative accuracy.
<b>flops</b>	Count of floating point operations.
<b>i, j</b>	Imaginary unit.
<b>inf</b>	Infinity.
<b>NaN</b>	Not-a-Number.
<b>nargin</b>	Number of function input arguments.
<b>nargout</b>	Number of function output arguments.
<b>pi</b>	3.1415926535897...
<b>realmax</b>	Largest floating point number.
<b>realmin</b>	Smallest floating point number.

Table B.13 Time and Dates	
clock	Wall clock.
cputime	Elapsed CPU time.
date	Calendar.
etime	Elapsed time function.
tic, toc	Stopwatch timer functions.

Table B.14 Matrix Manipulation	
diag	Create or extract diagonals.
fliplr	Flip matrix in the left/right direction.
flipud	Flip matrix in the up/down direction.
reshape	Change size.
rot90	Rotate matrix 90 degrees.
tril	Extract lower triangular part.
triu	Extract upper triangular part.
:	Index into matrix, rearrange matrix.

The next table gives Elementary Functions available in MATLAB

Table B.15 Elementary Math Functions	
abs	Absolute value.
acos	Inverse cosine.
acosh	Inverse hyperbolic cosine.
angle	Phase angle.
asin	Inverse sine.
asinh	Inverse hyperbolic sine.
atan	Inverse tangent.
atan2	Four quadrant inverse tangent.
atanh	Inverse hyperbolic tangent.
ceil	Round towards plus infinity.
conj	Complex conjugate.
cos	Complex conjugate.
cosh	Hyperbolic cosine.
exp	Exponential.
fix	Round towards zero.
floor	Round towards minus infinity.
imag	Complex imaginary part.
log	Natural logarithm.
log10	Common logarithm.
real	Complex real part.
rem	Remainder after division.
round	Round towards nearest integer.
sign	Signum function.
sin	Sine.
sinh	Hyperbolic sine.
sqrt	Square root.
tan	Tangent.
tanh	Hyperbolic tangent.

Specialized Math Functions are given below.

<b>Table B.16 Specialized Math Functions</b>	
<b>bessel</b>	Bessel function.
<b>besselh</b>	Hankel function.
<b>beta</b>	Beta function.
<b>betainc</b>	Incomplete beta function.
<b>betaln</b>	Logarithm of beta function.
<b>ellipj</b>	Jacobi elliptic functions.
<b>ellipke</b>	Complete elliptic integral.
<b>erf</b>	Complementary error function.
<b>erfc</b>	Complementary error function.
<b>erfcx</b>	Scaled complementary error function.
<b>erfinv</b>	Inverse error function.
<b>gamma</b>	Gamma function.
<b>gammainc</b>	Incomplete gamma function.
<b>gammaln</b>	Logarithm of gamma function.
<b>log2</b>	Dissect floating point numbers.
<b>pow2</b>	Scale floating point numbers.
<b>rat</b>	Rational approximation.
<b>rats</b>	Rational output.

Matrix Functions and Numerical Linear Algebra capabilities are given in the next four tables.

<b>Table B.17 Matrix Analysis</b>	
<b>cond</b>	Matrix condition number.
<b>det</b>	Determinant.
<b>norm</b>	Matrix or vector norm.
<b>null</b>	Null space.
<b>orth</b>	Orthogonalization.
<b>rcond</b>	LINPACK reciprocal condition estimator.
<b>rank</b>	Number of linearly independent rows or columns.
<b>rref</b>	Reduced row echelon form.
<b>trace</b>	Sum of diagonal elements.

<b>Table B.18 Linear Equations</b>	
<b>chol</b>	Cholesky factorization.
<b>inv</b>	Matrix inverse.
<b>lscov</b>	Least squares in the presence of known covariance.
<b>lu</b>	Factors from Gaussian elimination.
<b>nnls</b>	Non-negative least-squares.
<b>pinv</b>	Pseudoinverse.
<b>qr</b>	Orthogonal-triangular decomposition.
<b>\ and /</b>	Linear equation solution.

<b>Table B.19 Eigenvalues and Singular Values</b>	
<b>balance</b>	Diagonal scaling to improve eigenvalue accuracy.
<b>cdf2rdf</b>	Complex diagonal form to real block diagonal form.
<b>eig</b>	Eigenvalues and eigenvectors.
<b>hess</b>	Hessenberg form.
<b>poly</b>	Characteristic polynomial.
<b>qz</b>	Generalized eigenvalues.
<b>rsf2csf</b>	Real block diagonal form to complex diagonal form.
<b>schur</b>	Schur decomposition.
<b>svd</b>	Singular value decomposition.

<b>Table B.20 Matrix Functions</b>	
<b>expm</b>	Matrix exponential.
<b>expm1</b>	M-file implementation of <b>expm</b> .
<b>expm2</b>	Matrix exponential via Taylor series.
<b>expm3</b>	Matrix exponential via eigenvalues and eigenvectors.
<b>funm</b>	Evaluate general matrix function.
<b>logm</b>	Matrix logarithm.
<b>sqrtn</b>	Matrix square root.

Data Analysis tools available are given in the next four tables.

<b>Table B.21 Basic Operations</b>	
<b>cumprod</b>	Cumulative product of elements.
<b>cumsum</b>	Cumulative sum of elements.
<b>max</b>	Largest component.
<b>mean</b>	Average or mean value.
<b>median</b>	Median value.
<b>min</b>	Smallest component.
<b>prod</b>	Product of elements.
<b>sort</b>	Sort in ascending order.
<b>std</b>	Standard deviation.
<b>sum</b>	Sum of elements.
<b>trapz</b>	Numerical integration using trapezoidal method.

<b>Table B.22 Finite Differences</b>	
<b>del2</b>	Five-point discrete Laplacian.
<b>diff</b>	Difference function and approximate derivative.
<b>gradient</b>	Approximate gradient (see online help).

<b>Table B.23 Correlation</b>	
<b>corrcoef</b>	Correlation coefficients.
<b>cov</b>	Covariance matrix.

<b>Table B.24 Filtering and Convolution</b>	
<b>conv</b>	convolution and polynomial multiplication.
<b>conv2</b>	Tow-dimensional convolution (see online help).
<b>deconv</b>	Deconvolution and polynomial division.
<b>filter</b>	One-dimensional digital filter (see online help).
<b>filter2</b>	Two-dimensional digital filter (see online help).

Polynomial and Interpolation Functions are given below.

<b>Table B.25 Polynomials</b>	
<b>conv</b>	Multiply polynomials.
<b>deconv</b>	Divide polynomials.
<b>poly</b>	Construct polynomial with specified roots.
<b>polyder</b>	Differentiate polynomial (see online help).
<b>polyfit</b>	Fit polynomial to data.
<b>polyval</b>	Evaluate polynomial.
<b>polyvalm</b>	Evaluate polynomial with matrix argument.
<b>residue</b>	Partial-fraction expansion (residues).
<b>roots</b>	Find polynomial roots.

<b>Table B.26 Data Interpolation</b>	
<b>griddata</b>	Data gridding.
<b>interp1</b>	1-D interpolation (1-D table lookup).
<b>interp2</b>	2-D interpolation (2-D table lookup).
<b>interpft</b>	2-D interpolation using FFT method.

Functions and Numerical Methods available are given in the next table.

<b>Table B.27</b>	
<b>Function Functions – Nonlinear Numerical Methods</b>	
<b>fmin</b>	Minimize function of one variable.
<b>fmins</b>	Minimize function of several variables.
<b>fplot</b>	Plot function.
<b>fzero</b>	Find zero of function of one variable.
<b>ode23</b>	Solve differential equations, low order method.
<b>ode45</b>	Solve differential equations, high order method.
<b>quad</b>	Numerically evaluate integral, low order method.
<b>quad8</b>	Numerically evaluate integral, high order method.



Two Dimensional Graphic capabilities are given below.

<b>Table B.28 Elementary X-Y Graphs</b>	
<b>fill</b>	Draw filled 2-D polygons.
<b>loglog</b>	Log-log scale plot.
<b>plot</b>	Linear plot.
<b>semilogx</b>	Semi-log scale plot.
<b>semilogy</b>	Semi-log scale plot.

<b>Table B.29 Specialized X-Y Graphs</b>	
<b>bar</b>	Bar graph.
<b>compass</b>	Compass plot.
<b>errorbar</b>	Error bar plot.
<b>feather</b>	Feather plot.
<b>fplot</b>	Plot function.
<b>hist</b>	Histogram plot.
<b>polar</b>	Polar coordinate plot.
<b>rose</b>	Angle histogram plot.
<b>stairs</b>	Stairstep plot.

<b>Table B.30 Graph Annotation</b>	
<b>grid</b>	Grid lines.
<b>gtext</b>	Mouse placement of text.
<b>text</b>	Text annotation.
<b>title</b>	Graph title.
<b>xlabel</b>	X-axis label.
<b>ylabel</b>	Y-axis label.

<b>Table B.31 Hardcopy and Storage</b>	
<b>orient</b>	Set paper orientation.
<b>print</b>	Print graph or save graph to file.
<b>printopt</b>	Configure local printer defaults.