MATH 5520
Basics of MATLAB

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Spring 2009

Topics

- Sources.
- Entering Matrices. Basic Operations with Matrices.
- Build in Matrices. Build in Scalar and Matrix Functions.
- if, while, for
- m-files
- Graphics.
- Sparse Matrices.



Resources.

There are many good books on Matlab besides the textbook. Recent Cleve Moler's book Experiments with MATLAB has many fun problems and is also available online.

Good introduction is Matlab primer

The MATHWORKS has a lot of useful information



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In addition, books by Andrew Knight, *BASICS OF MATLAB and Beyond* and

by D.J. Nigham and N.J. Nigham *MATLAB Guide*

are pretty useful.



Entering Matrices.

Matlab is standing for matrix laboratory and was basically designed for operations with matrices. We will essentially only work with matrices. A scalar is 1-by-1 matrix.



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Matrices can be introduced into MATLAB in several different ways:

- Entered by an explicit list of elements
- Generated by built-in statements and functions
- Loaded from external data files or applications



Basic Matrix Operations.

The following are the basic matrix operations in MATLAB:

- $+$ addition
- $-$ subtraction
- $*$ multiplication
- $\wedge$ power
- \ conjugate transpose
- / left division
- \ right division



Matrix Building Functions.

Matrices can also be build from the functions:

- **eye** identity matrix
- **zeros** matrix of zeros
- **ones** matrix of ones
- **diag** create or extract diagonals
- **triu** upper triangular part of a matrix
- **tril** lower triangular part of a matrix
- **rand** randomly generated matrix
- **hilb** Hilbert matrix
- **magic** magic square



for

General syntax for **for** loop

for *variable* = *expression*,
  statement,
  ...,
  statement
end

Examples.



for

General syntax for **for** loop

for *variable* = *expression*,
  statement,
  ...,
  statement
end

Examples.

As a general rule try to avoid such loops.



while

General syntax for **while** loop

while *expression*
  statement
  ...
  statement
end

Examples.



if

General syntax for **if** statement

if *expression*,
  statements,
elseif *expression*
  statement
else *expression*
  statement
end

Examples.



Relations

- $<$ less than
- $>$ greater than
- $<=$ less than or equal
- $>=$ greater than or equal
- $==$ equal
- $\sim=$ not equal.
- $\&$ and
- $|$ or
- $\sim$ not



Scalar functions.

Certain MATLAB functions operate essentially on scalars, but operate element-wise when applied to a matrix.

- sin
- $asin$
- exp
- abs
- $round$
- cos
- $acos$
- log (natural log)
- $sqrt$
- $floor$
- tan
- $atan$
- rem (remainder)
- $sign$
- $ceil$



Vector functions.

Certain MATLAB functions operate essentially on scalars, but operate element-wise when applied to a matrix.Other MATLAB functions operate essentially on a vector (row or column), but act on an m-by-n matrix $(m \geq 2)$ in a column-by-column fashion to produce a row vector containing the results of their application to each column.

- max
- min
- sum
- $prod$
- $median$
- $mean$
- all
- any



Matrix functions.

Much of MATLAB's power comes from its matrix functions.

- eig eigenvalues and eigenvectors
- $chol$ cholesky factorization
- svd singular value decomposition
- inv inverse
- lu LU factorization
- qr QR factorization
- $hess$ hessenberg form
- $schur$ schur decomposition
- $rref$ reduced row echelon form
- $expm$ matrix exponential
- $sqrtm$ matrix square root
- $poly$ characteristic polynomial
- det determinant
- $size$ size
- $norm$ 1-norm, 2-norm, F-norm, 1-norm
- $cond$ condition number in the 2-norm
- $rank$ rank



Graphics functions.

MATLAB can produce planar plots of curves, 3-D plots of curves, 3-D mesh surface plots, and 3-D faceted surface plots. The primary commands for these facilities are:

- $plot$
- $polar$
- $plot3$
- $mesh$
- $surf$

There are others.



Sparse Matrices.

In many applications, like solving systems of PDEs, most elements of the resulting matrices are zeros (sparse). MATLAB has ability to store and manipulate sparse matrices. For almost any matrix function there is a corresponding sparse matrix function. Most useful are:

- $speye$ sparse identity matrix
- $sparse$ create sparse matrix; convert full matrix to sparse
- $spones$ replace nonzero entries with ones
- $spdiags$ sparse matrix formed from diagonals
- $sprandn$ sparse random matrix
- $full$ convert sparse matrix to full matrix
- spy visualize sparsity structure
- nnz number of nonzero entries
- $nzmax$ amount of storage allocated for nonzero entries
- $issparse$ true if matrix is sparse
- $spalloc$ allocate memory for nonzero entries

There are other commands (cf. Primer.).

