Introduction

- What is MATLAB?
  - MATLAB (MATrix LABoratory) is an interactive program for scientific and engineering **numeric** calculation. Applications include:
    - matrix manipulation
    - finding the roots of polynomials
    - digital signal processing
    - x-y and polar plotting
    - 3-dimensional graphics
  - Combines:
    - The mathematics of linear algebra
    - C++ programming environment
    - The UNIX command shell
    - High-level functions
    - This combination makes MATLAB ideal for signal processing applications.

Getting Started

- There are a couple of different ways to start MATLAB on Athena:
  - From *Dash*
    - *Numerical/Math//Analysis and Plotting//MATLAB*
    - To use software designed for 6.003 *Courseware//EECS//6.003//6.003MATLAB*
  - From *Athena prompt*

    -
      ```
      athena% add matlab
      athena% matlab
      ```

    -
      ```
      athena% add 6.003
      athena% ~6.003/startup
      ```
- Getting Help
  - MATLAB on MIT server
    http://web.mit.edu/matlab/www/
  - Mathworks website
    http://www.mathworks.com/access/helpdesk/help/techdoc/matlab.shtml
  - 6.003 MATLAB pico-course
    - Run *picocrse.m* script in ~6.003/picocouse directory

MATLAB Navigation

- Getting help from within MATLAB
  `>> help <functionname>`
  Shows help document for a give function
  `>> lookfor <keyword>`
  Searches all the help documents for a given keyword
  `>> demo`
- Navigation within MATLAB is done using regular UNIX commands
  `>> cd` (change directory)
  `>> pwd` (show the path)
  `>> ls` (list contents of directory)
  `>> !<unix command>` (access the UNIX shell)
- Useful MATLAB Commands
  `>> path <directory>`
  `>> what` (lists MATLAB specific files)
  `>> info` (gives information about toolboxes)

Variables

Real Scalars
```
>>x  =  5
x = 5
```

Complex Scalars
```
>> x = 5+10j   %5+10i works, but not 5+10*j
x =
   5.0000 +10.0000i
```

Row Vector (1 x 3)
```
>> x = [1 2 3]
x =
     1     2     3
```

Column Vector (3 x 1)
```
>> x = [1;2;3]; %”;” suppresses output
>> x
x =
     1
     2
     3
```

Matrix (3 x 3)
```
>> x = [ 1 2 3; 4 5 6; 7 8 9]
x =
     1     2     3
     4     5     6
     7     8    9
```

Note: Variable Names are case sensitive

Matrices & Vectors

Generating Vectors (Useful for time axis)

```
>> x = [0:0.2:1] %0 to 1 in incr. Of 0.2
x =
 0    0.20  0.40     0.60    0.80    1.00
```
0 to 1 in increments of 0.2

```
>> x = linspace(0,1,6)
x =
 0    0.20  0.40     0.60    0.80    1.00
```
6 points from 0 to 1 on a linear scale

```
>> x = logspace(0,1,6)
x =
 1.0000    1.5849    2.5119    3.9811
   6.3096  10.0000
```
6 points from 10^0 to 10^1 on a log scale

Accessing Matrix Elements

```
» A= [ 1 2 3; 4 5 6; 7 8 9];
» x = A(1,3)  %A(<row>,<column>)
x =
     3

» y =A(2,:)
y =
     4     5   6

» z = A(1:2,1:3)
z =
     1     2   3
     4     5   6
```

Matrix Operations

Complex Number Operations

```
>> x = 3+4j
>> abs(x)       %Absolute value.
 x = 5
>> angle(x)     %Phase angle.
 x = 0.9273
>> conj(x)      %Complex conjugate.
 x = 3-4j
>> imag(x)    %Complex   imaginary part.
 x = 4
>> real(x)      %Complex real part.
 x = 3
```

Other Matrix operations

Math Functions

```
sin(x), cos(x), tan(x), atan(x), exp(x),
  log(x), log10(x), sqrt(x)
```

Operators

```
Usual operators +,-,*,^,
>> M = A'  %Conjugate transpose of matrix
>> M =A.'  %Unconjugated transpose
>> y = A\b %left division is soln to A*y=b
>> y = b/A %right division is soln to y*A=b

Element-by-Element Operators (.*,.^,./)
>>A = [ 1 2; 3 4]
A =
     1     2
     3     4
>> B=A*A                  >> C=A.*A
B =                       C =
     7    10                   1     4
    15    22                   9    16
```

Programming in MATLAB

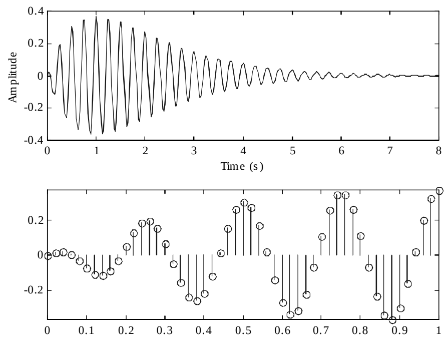
- M-Files
  - Sets of MATLAB commands can be executed via scripts
  - Scripts are written into files with extensions **.m*
    Ex. *filename.m*
  - These scripts are executed in MATLAB by entering the name of *.m* file
    `>> filename`
- Functions
  - Commonly performed operations can be written into functions
  - In a file named *functionname.m*
    ```
    Function [output]=functionname(input)
      Command 1
      Command 2
    ```
- Flow Control operations and operators
  - Similar to C can use *for, while, if, do* statements with &, |, ~ operators
  - Also have <, <=, >, >=, ==, ~= operators available for programming

Plotting and Output

- Simple plotting commands
```
>>plot(t,y) %Plot Continuous Function
>>stem(y)   %Plot Discrete samples
>>loglog(f,Y)    %Log on x and y
>>semilogx(f,Y) %Log x and linear y
>>xlabel('time')
>>ylabel('Voltage')
>>title('Voltage vs. Time')
>>Axis([xmin xmax ymin ymax])
>>Figure(n) %Makes figure n current
>>subplot(r,c,n)
  %Creates r x c sub-figures, and n is
  used to reference the sub-figures
```
- Printing
```
>> print -dps filename.ps
  %output current figure to ps file
>> print -Pprintername
  %outputs to printer
```
- Saving variables
```
>> save filename.mat <variable names>
  %Saves variables in binary form
>> load filename
  %Loads binary data or ascii matrix data
```

Plotting Example

```
>> t = linspace(0,8, 401);
>> x = t.*exp(-t).*cos(2*pi*4*t);
>> figure(1)
>> subplot(2,1,1)
>> plot(t,x);
>> xlabel('Time (s)');
>> ylabel('Amplitude')
>> subplot(2,1,2)
>> stem(t,x);
>> axis([0 1 min(x) max(x)])
```



Other Examples

- Polynomials factorization
  Find the roots of the following expression

$$13x^3+25x^2+3x+4$$

```
>> C = [13 25 3 4];
>> r = roots(C)
r =
  -1.8872
  -0.0179 + 0.4034i
  -0.0179 - 0.4034i
```

- Partial Fractions

$$\frac{5s+3}{s^3+3s^2-4}$$

```
>> [R,P,K] = Residue([5,3],[1 3 0 -4])
R =
   -0.8889
    2.3333
    0.8889
P =
   -2.0000
   -2.0000
    1.0000
K =
     []
```

$$\frac{\frac{-8}{9}}{s+2}+\frac{\frac{7}{3}}{(s+2)^2}+\frac{\frac{8}{9}}{s-1}$$