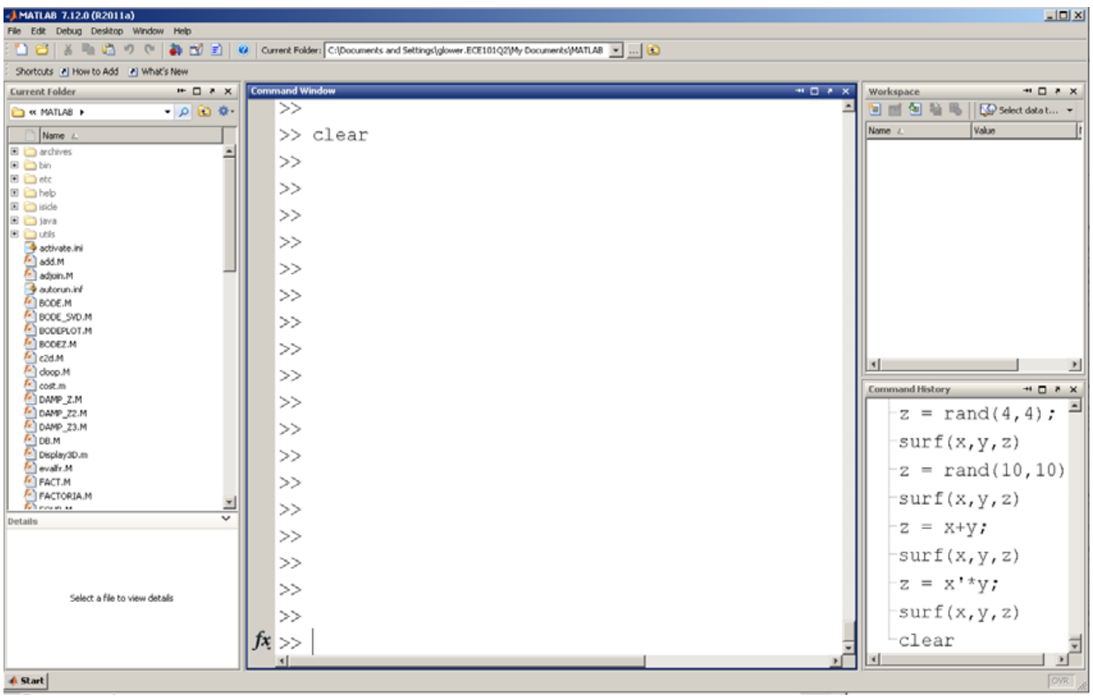
Matlab for Review

Becoming familiar with MATLAB

- The console
- The editor
- The graphics windows
- The help menu
- Saving your data (diary)

General environment and the console



Simple numerical calculations

```
>> x = 17/3
     5.6667
>> y = (3+4)*5
     35
```

Particular numbers

```
>> e = exp(1)
     2.7183
>> pi
```

```
    3.1416

>> i

        0 + 1.0000i

>> j

        0 + 1.0000i
```

Do and don't display results

```
>> x = 2*pi

    6.2832

>> x = 2*pi;
```

Displaying number of decimal places

```
>> format short
>> pi

    3.1416

>> format long
>> pi

   3.141592653589793

>> format longe
>> pi^30

    8.212893304027486e+014

>> format shorteng
>> pi^30

   821.2893e+012
```

Matrices

- [start of matrix
-] end of matrix
- , next element
- ; next row

```
>> A = [1,2,3]

    1     2     3
```

```
>> B = [1,2,3;4,5,6]

     1     2     3
     4     5     6

>> C = A'

     1
     2
     3

>> D = zeros(1,3)

     0     0     0

>> E = rand(3,2)

    0.5860    0.0835
    0.2467    0.6260
    0.6664    0.6609
```

Loops

for for loop

```
>> for i=1:3
   x(i) = i^2;
   end
>> x

     1     4     9
```

if - end if statement

```
>> for i=1:3
   x(i) = i^2;
   if (i == 2) x(i) = 7;
      end
   end
>> x

     1     7     9

>>

if - else - end

while - end
```

Controls Related Functions

poly: Create a polynomial with a given set of roots

```
>> poly([-1,-2,-3,-4])

     1    10    35    50    24

     s^4   s^3   s^2   s      1
```

roots: Roots to a polynomial

```
>> roots([1,10,35,50,24])'

   -4.0000   -3.0000   -2.0000   -1.0000
```

ss: Input a system in state-space form

Convert a system to state-space form

zpk: Input a system in zeros - poles - gain form

Convert a system to zeros - poles - gain form

tf: Input a system in transfer function form

Convert a system to transfer function form.

Example: Starting from zeros-poles-gain form:

```
>> G = zpk(-1,[-2,-3,-4],5)

     5 (s+1)
-----------------
(s+2) (s+3) (s+4)

>> tf(G)

        5 s + 5
-----------------------
s^3 + 9 s^2 + 26 s + 24
```

Example: Starting from transfer function form:

```
>> G = tf([1,2,3],[4,5,6,7])

     s^2 + 2 s + 3
-----------------------
4 s^3 + 5 s^2 + 6 s + 7

>> zpk(G)

       0.25 (s^2 + 2s + 3)
---------------------------------
(s+1.208) (s^2 + 0.04225s + 1.449)
```

Example: Starting from state-space

```
>> A = [-2.1,1,0,0;1,-2.1,1,0;0,1,-2.1,1;0,0,1,-1.1];
```

```
>> B = [1;0;0;0];
>> C = [0,0,0,1];
>> D = 0;
>> G = ss(A,B,C,D);
>> zpk(G)

                   1
--------------------------------------
(s+3.632) (s+2.447) (s+1.1) (s+0.2206)



>> tf(G)

                      1
--------------------------------------------
s^4 + 7.4 s^3 + 17.16 s^2 + 13.21 s + 2.157
```

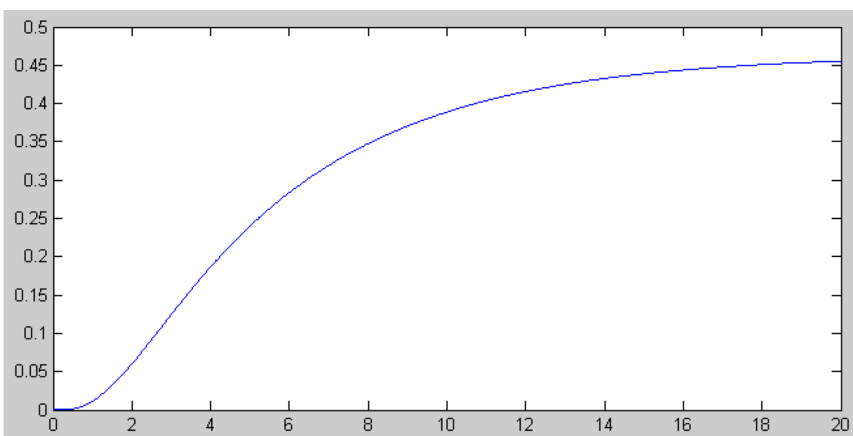
evalfr(G, s): Calculate G(s) at point s.

```
>> evalfr(G,j*3)

  -0.0023 + 0.0052i
```

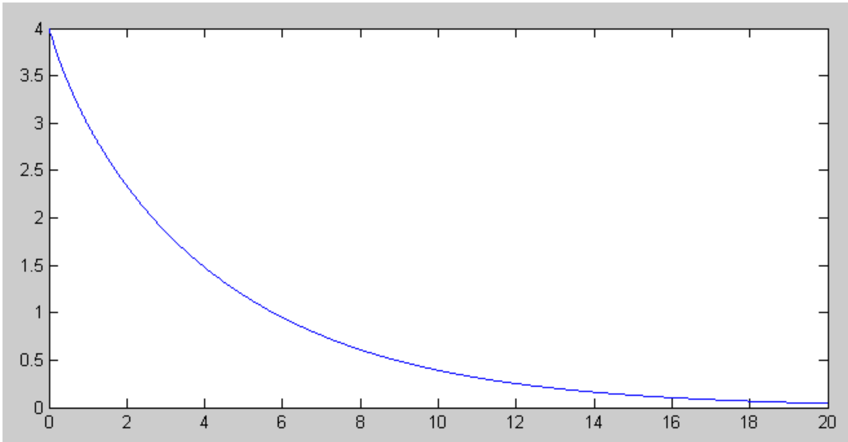
step(G,t): Response to a unit step input:

```
>> t = [0:0.01:20]';
>> y = step(G,t);
>> plot(t,y)
```



impulse(G,t): Impulse response. Also the zero-input response with initial condition X0:

```
>>
>> X0 = [1,2,3,4]';
>> G = ss(A,X0,C,D);
>> y = impulse(G,t);
>> plot(t,y);
```



eig(A): Eigenvalues of matrix A

```
>> A

   -2.1000    1.0000         0         0
    1.0000   -2.1000    1.0000         0
         0    1.0000   -2.1000    1.0000
         0         0    1.0000   -1.1000

>> eig(A)

   -3.6321
   -2.4473
   -1.1000
   -0.2206
```

poly(eig(A)): Characteristic polynomial of matrix A

```
>> poly(eig(A))

    1.0000    7.4000   17.1600   13.2140    2.1571
```

[M,N] = eig(A): Eigenvectors (M) and Eigenvalues (N) of matrix A

```
>> [M,N] = eig(A)

M =
   -0.4285   -0.6565    0.5774    0.2280
    0.6565    0.2280    0.5774    0.4285
   -0.5774    0.5774   -0.0000    0.5774
    0.2280   -0.4285   -0.5774    0.6565


N =

   -3.6321         0         0         0
         0   -2.4473         0         0
         0         0   -1.1000         0
         0         0         0   -0.2206
```

det(A): Determinant of matrix A. Also equal to the product of the eigenvalues.

```
>> det(A)
```

```
    2.1571
>> prod(eig(A))
    2.1571
```

trace(A): Trace of matrix A. Also equal to the sum of the eigenvalues.

```
>> trace(A)
   -7.4000
>> sum(eig(A))
   -7.4000
```

Analysis

• sqrt(x)	square root of x
• log(x)	log base e
• log10(x)	log base 10
• exp(x)	e^x
• exp10(x)	10^x
• abs(x)	|x|
• round(x)	round to the nearest integer
• floor(x)	round down (integer value of x)
• ceil(x)	round up to the next integer
• real(x)	real part of a complex number
• imag(x)	imaginary part of a complex number
• abs(x)	absolute value of x, magnitude of a complex number
• angle(x)	angle of a complex number (answer in radians)
• unwrap(x)	remove the discontinuity at pi (180 degrees) for a vector of angles

Polynomials

- poly(x)
- roots(x)
- conv(x,y)

Trig Functions

• sin(x)	sin(x) where x is in radians
• cos(x)	cos()
• tan(x)	tan()
• asin(x)	arcsin(x)
• acos(x)	arccos(x)
• atan(x)	arctan(x)
• atan2(y,x)	angle to a point (x,y)

Probability and Statistics

• factorial(x)	(x-1)!
• gamma(x)	x!
• rand(n,m)	create an nxm matrix of random numbers between 0 and 1
• randn(n,m)	create an nxm matrix of random numbers with a normal distribution
• sum(x)	sum the columns of x
• prod(x)	multiply the columns of x
• sort(x)	sort the columns of x from smallest to largest
• length(x)	return the dimensions of x
• mean(x)	mean (average) of the columns of x
• std()	standard deviation of the columns of x

Display Functions

• plot(x)	plot x vs sample number
• plot(x,y)	plot x vs. y
• semilogx(x,y)	log(x) vs y
• semilogy(x,y)	x vs log(y)

• loglog(x,y)	log(x) vs log(y)
• mesh(x)	3d plot where the height is the value at x(a,b)
• contour(x)	contour plot
• bar(x,y)	draw a bar graph
• xlabel('time')	label the x axis with the word 'time'
• ylabel()	label the y axis
• title()	put a title on the plot
• grid()	draw the grid lines

Useful Commands

• hold on	don't erase the current graph
• hold off	do erase the current graph
• diary	create a text file to save whatever goes to the screen
• linepace(a, b, n)	create a 1xn array starting at a, increment by b
• logspace(a,b,n)	create a 1xn array starting at 10^a going to 10^b, spaced logarithmically
• subplot()	create several plots on the same screen
• disp('hello')	display the message *hello*

Utilities

• format	set the display format
• zeros(n,m)	create an nxm matrix of zeros
• eye(n,m)	create an nxm matrix with ones on the diagonal
• ones(n,m)	create an nxm matrix of ones
• help	help using different functions
• pause(x)	pause x seconds (can be a fraction). Show the graph as well
• clock	the present time
• etime	the difference between to times
• tic	start a stopwatch
• toc	the number of seconds since tic

System Analysis

• G = tf([2,3],[1,4,5,6]);	Input a system G(s) as numerator and denominator polynomials
• G = zpk([-1],[-2,-3],10);	Input a system by its zeros, poles, and gain
• G = ss(A,B,C,D);	Input a system in state-space form
• eig(G)	Eigenvalues of system G
• eig(A)	Eigenvalues of matrix A
• poly([-1,-2,-3])	Find a polynomial with roots at {-1, -2, -3}
• roots([1,2,3,4])	Find the roots to s4 + 2s2 + 3s + 4 = 0
• evalfr(G,-2+j*3)	Evaluate G(s) at s = -2 + j3
• y = step(G,t);	Compute the step response of G(s)
• Kx = lrq(A, B, Q, R)	LQR method for finding feedback gains