# CNBC Matlab Mini-Course

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Day 2: More Stuff

# Scientific Functions

| | |
|---|---|
| Trig: | sin, cos, tan, asin, acos, atan<br>sinh, cosh, tanh, asinh, acosh, ... |
| Rounding: | floor, ceil, round, fix |
| Modular: | rem, mod |
| Exponential: | exp, log, log2, log10, sqrt |
| Primes: | factor, primes |
| Polynomials: | roots, polyfit, polyval |

# Matrix Functions

| | |
|---|---|
| Determinant: | det |
| Inverse: | inv, pinv |
| Eigenvalues: | eig, svd |
| Fourrier: | fft |

*And many, many more...*

# Inf and NaN

3/0  returns  Inf

0/0  returns  NaN

3+Inf

Inf/Inf

-Inf, -NaN

# Complex Numbers

sqrt(-16)

3.5i

2 - 3.5i

(2+3i) * (4+5i)

# Predicates

```
isreal(3)
isprime(1 : 13)
isnumeric([2 3 5])
isempty([ ])
isinf(Inf)
isnan(NaN)
islogical(1 == 1)
ischar('a')
isequal('foo', 'aardvark')
```

What percentage of the first 1000 integers is prime?

```
  mean(isprime(1:1000))
```

## Return Values

Functions can return multiple values:

```
 A = rand(5, 3);

s = size(A)

[rows, cols] = size(A)
```

## Optional Return Values

Functions can choose whether to return values, depending on if the user is asking for values.

```
plot([1 2 3], [3 1 2])              no return value

h = plot([1 2 3], [3 1 2])          single return value
set(h, 'LineStyle', '--')
set(h, 'LineWidth', 8)
```

## Variable Number of Arguments

Some functions accept a variable number of arguments:

```
peaks

peaks(10)
```

## Variable In and Out

```
hist(randn(2000,1))

hist(randn(2000,1), 50)

counts = hist(randn(2000,1), 5)

[counts, centers] = hist(randn(2000,1), 5)
```

## **nargin** and **nargout**

Inside a function, **nargin** is the number of input arguments supplied with the call.

**nargout** is the number of output arguments requested with the call.

## Testing nargin/nargout

```
function [x,y,z] = nargtest(p,q,r,s,t)
  if nargout >= 1
    x = 50;
    if nargout >= 2
      y = 'foo';
      if nargout >= 3
        z = 3:7;
      end
    end
  end
  whos     % show the local workspace
end
```

Try:

```
  a = nargtest(5,6,7)
  [a, b] = nargtest(3)
  [a, ~, c] = nargtest(9,8)
```

## Name Spaces

- **Base workspace:** variables created outside of any function exist in the base workspace.

- **Local workspaces:** each function executes in a separate local workspace holding the arguments, return variables, and any local variables created by the function.

  Functions cannot access variables of the base workspace.

## Name Spaces (cont.)

- **Global workspace:** variables declared global by a function are accessed in the global workspace.

  It's a good idea to also declare the variable global in the base workspace.

## Global Variables

```
global pts
pts = 0 : pi/20 : 2*pi ;
```

```
function h = circ(x,y)
    % draws a circle centered on (x,y)
  global pts
  hh = plot(x+cos(pts), y+sin(pts));
  if nargout > 0
    h = hh;    % return h only if requested
  end
end
```

## Scripts Called By Functions

- Scripts do not have their own workspaces.

- A script called from the keyboard executes in the base workspace.

- A script called from within a function executes in the function's local workspace.

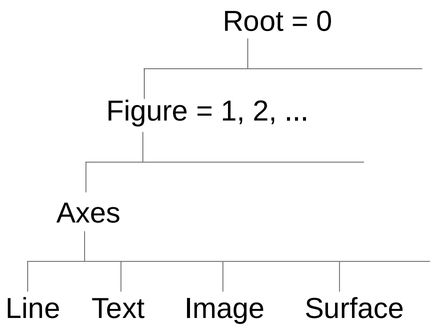
## Resetting Variables

| | |
|---|---|
| clear x | removes variable x and<br>undoes any global declaration |

*You can also click on a variable in the workspace pane and hit the Delete key, or right-click on the variable and choose from the menu.*

| | |
|---|---|
| clear all | clears everything |
| clear global | clears global declarations |
| whos global | shows all global variables |

## Handle Graphics



# Taking Apart A Figure

```
clf, plot(rand(5, 3))

ax = get(gcf, 'Children')
get(ax)

lines = get(gca, 'Children')
get(lines(1))
```

# Multiple Axes: Subplot

```
clf
```

Row-major order

```
subplot(2,2,1),  plot(rand(5, 5))
subplot(2,2,2),  bar3(rand(5, 3))
subplot(2,2,3),  a=rand(15, 1);  pie(a, a > 0.7)
subplot(2,2,4),  polar(cos(0:150))

set(gca, 'Position', [0.32  0.1  0.4  0.4])
```

# Exploring Graphics Objects

```
set(gca,'Units')
set(gca)
propedit(gca)
```

*click on “More Properties”*

Matlab online documentation:
Help pulldown menu or '?' icon:
> Documentation
> MATLAB
> Graphics
> Graphics Objects

# 3D Graphics

```
peaks
rotate3d on
```

*or put mouse in figure area and*
*click on the 3D rotation arrow in the toolbar*

```
set(gca,  'CameraViewAngleMode',  'manual')
```

*or right-click in the figure,*
*select Rotate Options, then*
*select Fixed Aspect Ratio Axes*

# Plotting Surfaces

```
[x, y, z] = peaks;

surf(x, y, z, z)

surf(x, y, z, x)

surf(x, y, z, rand(length(x)))
```

# Plotting in 3D

Don't type all this in! Download this file:
*www.cs.cmu.edu/~dst/Tutorials/Matlab/helix.m*
or *cd  /afs/andrew/usr/dst/matlab*

```
function helix
  pts = 0 : pi/20 : 4*pi;
  x1 = cos(pts);  y1 = sin(pts);
  x2 = cos(pts+pi);  y2 = sin(pts+pi);
  z = pts/(2*pi);

  clf, whitebg(gcf, [0 0 0]), hold on
  plot3(x1, y1, z, 'y')
  plot3(x2, y2, z, 'w')
  axis([ -3 3  -3 3  0 2])
  view(95, 9)
end
```

## Helix (cont.)

```
colors = 'rgbm';

for i = 4 : 4 : length(pts)-4
  plot3([x1(i) x2(i)], [y1(i) y2(i)], z([i i]), ...
          colors(ceil(rand(1)*length(colors))), 'LineWidth', 3)
end

axis off
set(gcf, 'Color', 'k')
set(gca, 'CameraViewAngleMode', 'manual')

az = -180 ;

while true
  view(az, 9), pause(0.05)
  az = az + 5 ;
end
```

## Color Maps

```
clf reset, peaks, colorbar

m = colormap;
whos m

colormap(spring)
brighten(0.5)

colormap(jet)

colormap(parula)

colormap(bone)

colormap(hot)

colormapeditor
```

Northern parula

## 2D Data

```
[x, y] = meshgrid(-2 : 0.05 : 2) ;

z = sin(x) .* cos(y);

contour(z, 20)

imagesc(z)

colormap(hot)

imagesc(x(:), y(:), z)

surf(z), colormap(jet)

surfc(z)
```

## Surface Objects

```
sphere

[x,y,z] = sphere(20);
x(1 : 5 : 21*21) = NaN;
surf(x, y, z)
alpha(0.7)
```

*Use the rotate tool to rotate the sphere; set Fixed Aspect Ratio Axes first.*

```
surf(x, y, z, rand(size(x)))
shading interp, grid off, axis off
set(gcf, 'Color', 'w')
```

## Data From Files

Create a file temps.txt:
  Use the “New Script” button.

Enter this data:

```
   38     50
   42     53
   33     57
   45     56
   44     46
   41     40
```

*Save the file as temps.txt*

```
load temps.txt

plot(temps)
```

## Importing Data From Files

- You can import data from Excel (and many other file formats) using the Import Data button.

  Select the file you want to import; the wizard will guide you through the rest.

- There are also built-in functions specifically for dealing with Excel files:
  ```
  doc xlsread
  doc xlswrite
  ```

## Curve Fitting for Extrapolation

```
x = randn(1, 2000);
y = sin(x) + 0.2 * randn(1, 2000) ;
clf, hold on, plot(x, y, '.')

c = polyfit(x, y, 3)
```

Example polynomial representation:

*c = [ 5 -1 4 3]*

$5x^3 - x^2 + 4x + 3$

```
pts = min(x) : range(x)/100 : max(x);

plot(pts, polyval(c, pts), 'r', 'LineWidth', 3)
```

## Saving Variables

```
clear all

a = 'aardvark'

[x, y, z] = sphere(5);

save stuff.mat

clear all

whos -file stuff.mat

load stuff.mat


save junk.dat x y -ascii

type junk.dat
```

## General Operating System Stuff

```
pwd

cd

dir

ls *.m

delete stuff.mat

!ps -a
```

## Debugging

Poor man's debugger:
  Remove semicolons from assignments.
  Add 'quoted strings' in appropriate places.
  Add a call to **keyboard**.  (Use **return** to return from keyboard input mode.)

```
function y = buggy(vec)
  p = vec > 5
  'got this far'
  keyboard
  z = p * vec
  y = sin(z) ;
end
```

Try:  buggy([4 6])
Type 'return' to exit keboard mode and continue.

## The Matlab Debugger

```
dbtype helix

dbstop helix 5

helix

dbstep

dbstep 7

whos
```

*Look at the Stack pulldown menu in the toolbar.*

```
dbstep 30

dbquit

dbclear helix

doc debug
```

## Formatted Output

```
for i = 1 : 10
  fprintf('The square root of %2d is %f \n', ...
          i, sqrt(i))
end


doc fprintf


title(sprintf('f(x) over range %g to %g', ...
       -3.5, 5.125))
```