Table of Contents

Lab 1

```
%Introduction to Matlab
```

Matlab basics

```
a=50
b=77
c=a+b
c=a+b;
whos
a/b
format long
ans
format compact
log(a)
log10(a)
whos
clear b
whos
clear
whos
sqrt(-1)
z=2+3i
help log %getting help
helpwin %help in Matlab
```

Vectors and Matrices

```
n=1:10
```

```
m=15:-2:1
t=2:.1:4
n=linspace(1,10,10)
A=[1 3 4]
B=[1;3;4]
A*B
B*A
size(A)
size(B)
C=[2 2 3;4 5 6;5 8 9]
C' %complex conjugate transpose
inv(C)
det(C)
C
C(2,3)
C(:,2)
C(1,:)
C([1,2],3)
C(1:2,3)
C(1:2,end)
C*C %Matrix multiplication
C.*C %Elementwise multiplication
```

Useful built-in functions

```
A= randn(3,4)
A=randn(3)
Z=zeros(5,2)
I=eye(9)
O=ones(10,2)
```

Scripts and functions

the_script.m is a script that should be in your current directory. Create it if it does not already exist. Its full contents is:

```
%thescript.m
a=0;
while a<10
    b=20-a;
    disp([a b]);
    a=a+1;
end
```

the_funct.m is a function that should be in your current directory. Its full contents is:

```
function [a,b]=the_funct(n)
for a=0:(n-1)
    b=20-a;
    disp([a b]);
end
```

```
clear
```

```
type the_script
type the_funct
a=32;
whos
the_script
whos
a
[m,n]=the_funct(12)
whos
a
```

Vectorizing loops

```
clear
n=1e4
t=linspace(0,100*pi,n);
tic
toc
tic, for i=1:n,sin_of_t(i)=sin(t(i)); end; toc
sin_of_t=zeros(1,n);
tic, for i=1:n,sin_of_t(i)=sin(t(i)); end; toc
tic, sin_of_t_2=sin(t);toc
isequal(sin_of_t,sin_of_t_2)
whos
x=rand(1,n);
tic, s=0;for i=1:n, s=s+x(i)^2;end;toc
tic, s=sum(x.^2);toc
```

Graphics and Visualization

2-D Plotting

```
help graph2d

% plot(X,Y,'CL','property','value',...)
x=1:0.15:20;
y=1./x.*cos(x.*log(x));
plot(x,y,'r-','linewidth',1.5)

% line(X,Y), line(X,Y,Z)
line([0 0.3 1 0.3 0 -0.3 -1 -0.3 0],[1 0.3 0 -0.3 -1 -0.3 0 0.3 1])

% contour(X,Y,Z,N), contourf(X,Y,Z)
contour(peaks,50)
figure
contourf(peaks,50)
colorbar

% stem(X,Y)
x=1:0.25:10;
stem(x,cos(x),'r')
```

```
% loglog(X,Y,'CL','property','value',...), semilogy(), semilogx()
x=1:1000;
loglog(x,x.^2.5)

% plotyy(X1,Y1,X2,Y2,FUN1,FUN2)
x1=1:.1:10;
y1=log(x1);
y2=sin(x1);
plotyy(x1,y1,x1,y2)
```

3-D Plotting

```
%plot3(X,Y,Z,...)
t=0:pi/50:10*pi;
p=plot3(sin(t),cos(t),t);

% surf(X,Y,Z,C,'property','value',...), mesh(X,Y,Z,C,'property','value',...)
[X,Y]=meshgrid(-10:0.35:10);
Z=peaks(size(X,2));
S=surf(X,Y,Z);

% waterfall(X,Y,Z)
W=waterfall(membrane);

% stem3(X,Y,Z)
th=(0:127)/128*2*pi; x=cos(th); y=sin(th); f=abs(fft(ones(10,1),128));
stem3(x,y,f','d','fill'); view([-65 30])
xlabel('Real'); ylabel('Imaginary'); zlabel('Amplitude');
title('Magnitude frequency components')
```

Special Plots

```
clf
help specgraph

% bar(X,Y), bar3(X,Y), barh(X,Y), bar3h(X,Y)
subplot(1,2,1), bar3(peaks(5));subplot(1,2,2),bar3(rand(5),'stacked')

% ezplot('function',[min max]), ezplot3(...)
ezplot('exp(exp(sin(x)))',[0 50])

% hist(Y,X)
hist(randn(100),20)

% quiver(U,V)
clf
[X,Y]=meshgrid(-10:0.65:10); Z=peaks(size(X,2)); contour(X,Y,Z,20);
hold on
[Px,Py]=gradient(Z,1e-4,1e-4); quiver(X,Y,Px,Py); axis tight
colorbar
```

Labeling plots

xlabel('xlabel_text'), ylabel('ylabel_text'), zlabel('zlabel_text') title('title_text') text(x,y,'Text String') gtext('some text') Note that many LaTeX characters, including the greek alphabet, can be used in annotations. Such as title('\alpha=1')

Brief introduction to MATLAB graphics objects

MATLAB did a major revamp of its graphics system in R2014b. Most commands work similarly in the old version, but the innards are different depending on your version. Regardless, the basic idea is that any graphics command can return either a handle (the old form) or an object (the new form), which you can use to manipulate the graphics. e.g.,

```
    h=plot(1:10,1:10);
% where p is the object.

% Inside the figure window can be any number of axes, though often there is
% just one, unless you're being fancy.
```

Useful commands include

```
    get(h); %gets the properties of object h, shows what you can set
    set(h); %sets the properties of object h
    f=gcf; %get current figure
    a=gca; %get current axis
    o=gco; %get last object clicked on (get current object)

% Most properties can be set by clicking on the figure, as well.
```

Other useful commands

axis - allows a number of default axis settings, including

```
    axis equal, axis tight, axis square, axis off, axis on %...

% hold on, hold off - allow more than one plot on a single axis
    plot(sin(0:.1:2*pi)); hold on; plot(cos(0:0.1:2*pi),'r')

% subplot(m,n,i) - allows an m x n grid of axes on a single figure,
% and select the i-th one to be current
    subplot(2,1,1), plot(sin(0:.1:2*pi))
    subplot(2,1,2), plot(cos(0:0.1:2*pi))

% grid on, grid off, box on, box off - turn a grid or a box on, off

% colormap - set the way colour is used in 3D plots. Also try colormenu
    surf(peaks), colormap(winter)

% shading - set the way shading is done on a 3-d plot. Can be set to
% interp, faceted, flat
    surf(peaks), shading interp
```

Printing and exporting figures

The basic command to print or export MATLAB figures is print. There are a large number of options with this command, and you can also get export_fig from the MATLAB file exchange, which I use myself for all my printing. You can choose to print to eps, bmp, jpg, png, pdf, and I generally recommend printing directly to pdf. See help print for more information.

Questions

At the end of this introduction, you should be able to do the following things:

- Use MATLAB to perform basic arithmetic operations on both scalars and matrices
- Create your own function and understand the difference between that function and a MATLAB script
- Manipulate matrix entries effectively
- Write efficient **vectorized** MATALB code with minimal use of for loops
- Use the help to find out how to use a large number of built-in functions

Start a blank document in the MATLAB editor and answer the following questions. When you are done, Publish the answer and put it in the dropbox on the website.

1(a) What command can you use to create a matrix of dimension 5x4 with normally distributed random entries?

(b) How would you select the lower-right 3x3 section?

(c) How would you swap the 1st and 2nd columns of the matrix (in one command)?

(d) How would you reverse the order of the rows of the matrix (in one command)?

2(a) What built-in MATLAB function is used to compute the eigenvalues of a dense, square matrix? (b) How would you obtain the eigenvectors, too?

3 Write three MATLAB functions to compute the following (**not** written in MATLAB syntax) (a) f(x,y) = 3x^2+2y

```
(b) a vector function g(x,y) where the first component is 3x^2+2y and
the second component is y sin(x).
```

```
(c) a=3x^2+2y, and b=y sin(x);
```

4 (a) Vectorize the following code to make it more efficient

```
    n=1e4;
    for i=1:n, t(i)=sin(i)/sqrt(i); end;
    for i=1:n, a(i)=3*t(i)-1; end;
    b=1;
    for i=1:n, b=b*a(i); end;
```

```
% (b) how much faster is the new code?
```