7.81 / 8.591 / 9.531
Systems Biology

Recitation
Matlab Crash Course

web.mit.edu/biophysics/sbio/
Today’s objective

Get comfortable playing with Matlab...

- Interacting with Matlab
- Enter Data
- Operations
- Some Commonly Used Functions
- Making Pretty Pictures
- M-Files and Scripts
- For, While, and If
- Solving ODEs
What is Matlab?

• Matlab = Matrix Laboratory
• Problem-solving environment
• Designed for convenient *numerical* computations (e.g. matrix manipulation, differential eqns, stats, and graphics)
• Developed by Cleve Moler in 1970s as a teaching tool
• Now ubiquitous in education and industry
Why Matlab?

• Great tool for simulation and data analysis
• User-friendly interface
• Many easy to use built-in functions and toolboxes
• Easy visualization
• Easy to get help:
  – help function_name
  – lookfor topic
  – www.mathworks.com
How to get Matlab?


**Software at MIT**

Name: Matlab  
Category: Numerical/Math - Matrix Manipulation  
Last modified: Mo Jun 1, 2009

*Problems or Questions?*

**Contents**

- What is Matlab? Where does it come from?  
- Matlab on Athena  
- Matlab at MIT  
- Documentation, Tutorials, and Other Resources  
  - Online Documentation  
  - Introductory Guides and Tutorials  
  - General Matlab Resources

New (6/1/09): **Matlab 7.8 is now the default**

**Matlab is now available for installation on student machines (MIT certificate and student status required)**
Useful Resources

• http://www.greenteapress.com/matlab/

Physical Modeling in MATLAB

by Allen B. Downey

*Physical Modeling in MATLAB* is an introduction to programming in MATLAB and simulation of physical systems.

Download the book in PDF now, or buy the paperback edition from Lulu.com or Amazon.com.

• Google
  - Search for ‘matlab plot’
Interacting with Matlab

```matlab
clear
cd directory_name
pwd
```
Entering Data

Try 'help linspace', or google 'matlab linspace'
400 linearly spaced entries from 0 to 100

obtain the 5th entry of r

the 1st column of B

(row, column)
create a row vector filled with 1’s

create another row vector filled with 0’s

merge the two

try out: eye, rand, randn
Operations

You can also do: log(a), log10(a), exp(a), sum(a), max(a), etc.
Plotting Data / Making Pretty Pictures

```
>> x = 0:.1:2*pi;
>> y = sin(x);
>> plot(x,y);
>> hold on
>> plot(x,cos(x),'r')
>>
```

plot multiple sets of data on the same figure
Try 'help plot', 'help title', 'help legend', and 'help axis' for more info
More About Plotting

t = 0:pi/20:2*pi;
[x,y] = meshgrid(t);  % look up meshgrid

subplot(2,2,1)  % creates a 2x2 array of plots, and plot in the first subplot
plot(sin(t),cos(t))
axis equal  % this is a parametric plot

subplot(2,2,2)
z = sin(x)+cos(y);  % z is a matrix
plot(t,z)
axis([0 2*pi -2 2])  % plotting each column of z
                     % versus t

subplot(2,2,3)
z = sin(x).*cos(y);
plot(t,z)
axis([0 2*pi -1 1])

subplot(2,2,4)
z = (sin(x).^2)-(cos(y).^2);
plot(t,z);
axis([0 2*pi -1 1])

% for 3-D plotting, try mesh, surf, surfl, waterfall, etc
M-Files and Functions

• Let’s make our own functions
• To start the editor, type ‘edit’
M-Files and Functions

• Local workspace and Scoping
• To make variables global: `global variable_name`

```matlab
function y = myfactorial(x)
% function y = myfactorial(x)
if x==1
    y = 1;
else
    y = x*myfactorial(x-1);
end

% this file should be saved with the same name, i.e. 'myfactorial.m'
```

```matlab
>> myfactorial(5)
ans =
    120
>>
```
For, While, and If

for m = 1:100
    num = 1/(m+1)
end
-----------------------------
% find all the powers
% of 2 below 10000
while num < 10000
    num = 2^i;
    v = [v; num];
    i = i+1;
end
-----------------------------
i = 6; j = 21;
if i > 5
    k = i;
elseif (i > 1) & (j == 20)
    k = 5*i+j;
else
    k = 1;
end

• And: a & b
• Or: a | b
• Not-equal: a ~= b
• Equal: a == b
Solving ODEs

• A very simple case: \( \frac{dy}{dt} = y(t) \quad 0 \leq t \leq 2 \quad y(0) = 1 \)

function dy = simpleode(t,y)
   dy = y; .Annotation save as simpleode.m

• Type in command line:

   [t y] = ode45(@simpleode, [0, 2], [1]);
   subplot(1,2,1),plot (t,y,'o',t,exp(t),'.'),'
   subplot(1,2,2),plot(t,(y-exp(t))/exp(t))
Solving ODEs

- A system of eqns:

\[
\begin{align*}
\frac{dx}{dt} &= 2x - y + 3(x^2 - y^2) + 2xy \\
\frac{dy}{dt} &= x - 3y - 3(x^2 - y^2) + 3xy
\end{align*}
\]

\[0 \leq t \leq \frac{1}{2}\]

\[y(0) = 3, \quad x(0) = 5\]

```matlab
function xdot = aode(t,y)
    % y(1) = x
    % y(2) = y
    xdot = zeros(2,1);  % initialize the xdot vector
    xdot = [2*y(1)-y(2)+3*(y(1)^2-y(2)^2)+2*y(1)*y(2),
            y(1)-3*y(2)-3*(y(1)^2-y(2)^2)+3*y(1)*y(2)];
    %save as aode.m
```

- Type in command line:

```matlab
[t,y] = ode45(@aode,[0,.5],[3;5]);
subplot(2,1,1),plot(t,y)
subplot(2,1,2),plot(y(:,1),y(:,2))  % plot the phase portrait
```
Solving ODEs

• A second order system:

\[
\ddot{\theta} + \omega^2 \sin \theta = 0 \quad \theta(0) = 1 \\
\dot{\theta}(0) = 0
\]

• First, convert to a system of two first-order equations, by hand.

let \( u_1 = \theta \), then

\[
\begin{bmatrix}
\dot{u}_1 \\
\dot{u}_2
\end{bmatrix} =
\begin{bmatrix}
u_2 \\
-\omega^2 \sin(u_1)
\end{bmatrix}
\]

function udot = pend(t,u,omega)
udot = zeros(2,1)
udot = [u(2); -omega^2*sin(u(1))];
%save as pend.m

• Type in command line:

%omega = 1.56
[t, y] = ode45(@pend,[0 20],[1;0],[],1.56);
subplot(2,1,1),plot(t,y)
subplot(2,1,2),plot(y(:,1),y(:,2)) % plot the phase portrait