NATIONAL NETWORK FOR MATHEMATICAL AND COMPUTATIONAL BIOLOGY (NNMCB-DELHI CHAPTER)

MATLAB TUTORIALS-1 DATE: 22-12-2014

IN TUTORIAL-1, BASICS OF MATLAB WILL BE COVERED IN THE FORM OF SMALL PROBLEMS. BESIDES, PHASE PORTRAITS WILL BE COVERED.

```
%---------------PROBLEM-1  ------------------------------------------
% is comment in MATLAB
 x = [2 3 4 5];
 y = -1:1:2;

% % % This provides element to element operation.

 r1 =  x.^y
 r2 = x.*y
 r3 = x./y
% r4 = x*y'    %%%%%%% This provides usual matrix multiplication.

% %% -------------PROBLEM-2-------------------------------------------
% %% ----------- This is about extraction of elements from matrix -------------------
% %%   (a) Set up the following matrix in the command window

 A = [1 5 8 ;84 81 7; 12 34 71]

% % %-------- and examine the contents of--------------------------------
 A(1,1),  A(2,1), A(1,2) , A(3,3), A(1:2, :),
 A(:,1),A(3,:), A(:,2:3)


%------------PROBLEM-3----------------------------------------------
% ---------- How to create plots in MATLAB? -----------------------------------

 x = -4:0.05:4; y=exp(-0.5*x).*sin(5*x);
figure(1) ;
 plot(x,y);
 xlabel('x-axis') ; ylabel('y-axis');
 hold on;
 y=exp(-0.5*x).*cos(5*x) ;
 plot(x,y) ;
 grid;
gtext('Two tails ... ') ;
 hold off
```

```
%------------------------- Problem-4------------------------------
%------------------ How to create subplots? -------------------------

 x = 0.1:.1:5;
 subplot(2,3,1);plot(x, x) ;title('plot of x');
 xlabel('x'); ylabel('y');
 subplot(2,3,2);plot(x,x.^2);title('plot of x^2');
 xlabel('x'); ylabel('y');
 subplot(2,3,3),plot(x,x.^3);title('plot of x^3')
 xlabel('x'); ylabel('y ');
 subplot(2,3,4),plot(x,cos(x));title('plot of cos(x)');
 xlabel('x'); ylabel('y');
 subplot(2,3,5) , plot(x,cos(2*x)); title('plot of cos(2x)');
 xlabel('x'); ylabel('y');
 subplot(2,3,6) ,plot(x,cos(3*x));title('plot of cos(3x)');
 xlabel('x'); ylabel('y');

% -------------- Problem -5 -------------------------------------
% -------------- How to create mesh plots--------------------------

%% -- For the function z=f(x,y), the MATLAB function meshgrid is used to --
%% -- generate complete set 0f points in the x-y plane for the three-dimensional --
%% -- plotting/functions.We can then compute the values of z and these are --
%% -- finally plotted by using one of the functions mesh, surf, surfl or surfc.--

 clf
 [x,y] = meshgrid(-4.0:0.2:4.0,-4.0:0.2:4.0);
 z=0.5*(-20*x.^2+x)+0.5*(-15*y.^2+5.*y);
 figure(1);
 surfl(x,y,z);
 axis([-4 4 -4 4 -400 0] )
 xlabel('x -axis'); ylabel('y-axis'); zlabel('z-axis');
 figure(2);
 contour3(x,y,z,15);
 axis([-4 4 -4 4 -400 0] )
 xlabel('x-axis'); ylabel('y_axis'); zlabel('z-axis');

%--------------- PROBLEM-6 ----------------------------------------
%---------- How to write function file in MATLAB?------------

 function slowfastloop
 x = 2:.04:4;
 y = f101(x) ;
```

```
plot(x,y);
xlabel('x'); ylabel('y');
figure(2)
fplot('f101',[2 4],10)
xlabel('x'); ylabel('y');

% ---------- Function file f101 ---------------------
function v = f101(x)
v = sin(x.^3);
```

%------------------- **Problem-7**------------------------------------

```
%% ------   Using the inbuilt function fzero to determine zeros of function

function slowfastloop
solution = fzero(@fun1,-2.9)

function p = fun1(x)
% %% --------- A simple function definition
% %x = x/2.4;
% %p = x^3 - 2*x + cos(pi*x);
%
% %%% ------ Another simple function ---------------------
% p = x^2 - 4;
```

%%% --------------**EXERCISE-1** Example to complete

```
%%%  Determine the solution of quadratic equation in MATLAB--------

function slowfastloop
%% ------- Calling function- twoways to do --------------------
[sol1 sol2] = rootquad(4,6,4)
[sol3 sol4] = feval(@rootquad,4,6,4)


function [xl,x2]= rootquad (a,b,c)
%% This function solves a simple quadratic
% % equation a*x^2+ b*x + c = 0 given the
% % coefficients a,b,c. The solutions are
% % assigned ta xl and xZ
d =  b*b -4*a*c;
xl = (-b + sqrt(d))/(2*a);
x2 = (-b + sqrt(d))/(2*a);
```

%% ------------------- **PROBLEM-8** --------------------------------------
%% -------------------- How to write loops in MATLAB? --------------------------------------

```
% % Fill b with square roots of 1 to 1000 using a for loop
 clear;
 tic;
 for i = 1:1000
 b(i)= sqrt(i);
 end
 t = toc;
 disp(['Time taken for toop method is', num2str(t)]);


% % Fill b with square roots of 1 to 1000 using a vector
 clear;
 tic;
 a = 1:1:1000;
 b= sqrt(a);
 t = toc;
 disp(['Time taken for toop method is', num2str(t)]);
```

%% ------------- **PROBLEM-9**--

```
A = [1 2 3; 4 5 6; 7 8 9];
B = [5 -6 -9; 1 1 0; 24 1 0];
n = size(A); n = n(1);
m = size(B); m = m(1);

for i = 1:n
for j = 1:m
C(i,j) =  A(i,j)+cos((i+j)*pi/(n+m))*B(i,j);
end
end
disp('This will display C = ')
disp(C)
for k= n+2:-1:n/2
a(k)=sin(pi*k);
b(k)=cos(pi*k);
end
disp('This will display a = ');disp(a)
disp('This will display b =');disp(b)
```

%%---------------------Example - iteration------ --------------

%% An iterative equation for solving the equation x^2 - x - 1 = 0 is given by
%%% X(r+1) = 1 + (1/x(r),)for r = O,1,2,..... Given Xo is 2
%%% write a MATLAB script to solve the equation. Sufficient accuracy
%%% is obtained when abs(x(r+1) - x(r)) < 0.0005. Include a check on the answer.

%%% ----------------- **Problem -10** -----------------------------------

<u>Problem-11: Programming in MATLAB:</u> Simulate the following 3 different ODE's. Explain which MATLAB ODE routine (ode 23, ode 45, ode15s etc.) to use and why is that so? For all the three equations, write the function file and integrate the equations with a constant step size.

dx / dt = s (y - x), dy /dt = -y - x z ; dz / dt = x y - b z - br . The parameter values are s = 10, b = 8/3, and r = 25. This is famously called as Lorenz chaotic equation.

(a) Use the intial condition (x , y, z) = (0.1 0.1 0.1) and evolve the equations for 100 time steps. Use time step dt as 0.05. Plot the x - time series. Hold the plot. change the initial condition to (0.15 0.15 0.15). Plot it in different colors. See whether the time series are same or different after considerable evolution of time.? Use subplot MATLAB command. Subplot should be (4,1,1).

(b) Plot (x, y), (y, z) and (x, z) in the same figure using subplot.

%%%----------------------**EXERCISE-2**--

(1) Change r value from 1 to 24 in steps of 2 to see whether you find any difference.

(2) For various r values (10 to 100 in steps of 0.5) collect the maximum of x time-series and plot it against r. This is called as bifurcation diagram. See what you get. Also, plot x(i) vs x(i+1).

%%% ----------------- **EXERCISE -4** -----------------------------------

Simulate the following ODE (Vander Pol Oscillator)

$d^2x/dt^2 + e\ (x^2 - 1)\ dx/dt + x = 0$. Choose e << 1. How do you decompose this equation to set of first order equations. Plot (x, y), in the same figure for 5 different initial conditions in different colors. What happens to the plot for different initial conditions when e = 0.

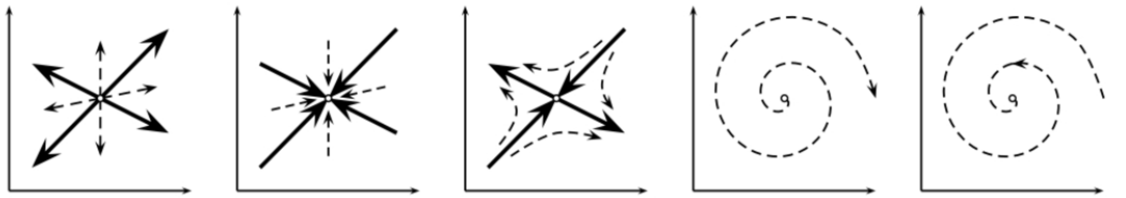
%%%% -------------------------------**PROBLEM-11**---

Consider the **<u>linear</u>** ODE $\dot{X} = A\ X$. Based on the 2 x 2 matrix of 'A' given below, find its eigenvalues and eigenvectors. Find its stability and dynamics (Node, saddle, Focus).

(i) A = [-2 1 ; 1 -2]'. (ii) [1 4 ; 1 1]. (iii) [-0.5 -1 ; 1 0.5]

%%%--------------------**PROBLEM-12**---

Explain the type of dynamics from the phase portraits (a-e) given below. Assume that it is got from 2D system. What can be the signs of the jacobian for each of the jacobian matrix ? Can you also draw the nullclines for each of the cases?



(a) (b) (c) (d) (e)

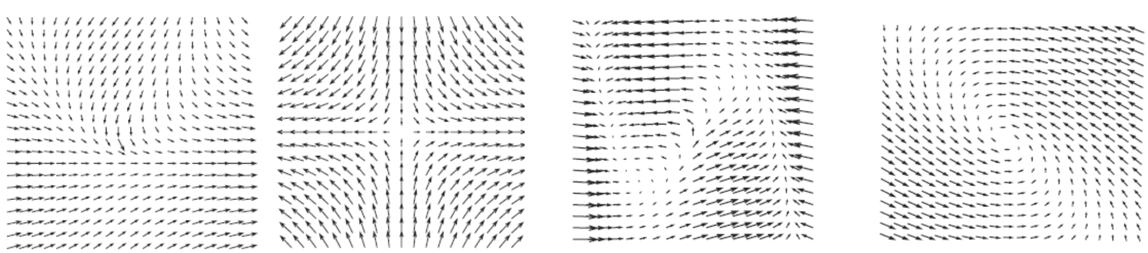
%%%% ----------------------------**PROBLEM-13**--

If the eigen values of the linear system of ODE is a + ib and a - ib, what is the period of the system? What are the dynamics expected when a = 0, a < 0 and a > 0.

%%%% ----------------------------**PROBLEM-14**--

In the following use pencil and draw the phase portrait. After drawing, determine the dynamics and corresponding signs of the eigenvalues for each of the fixed points identified.

(i) (ii) (iii) (iv)



%%%% ----------------------------**PROBLEM-15**--

Draw the vector field for the following based on the information provided in the plot.