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

MATLAB TUTORIALS-2 DATE: 23-12-2014

IN TUTORIALS-2, PLOTTING NULLCLINESAND DIRECTIONFIELDS OF 1 and 2D ODE WILL BE COVERED.

%---------------**PROBLEM-1** --
%% Consider the differential equation y'(x) = xy
% % Use the in-built MATLAB function dsolve to get closed form solution of the 1D ODE.

*>> y = dsolve('Dy = x*y ', 'x')*

You should get the output as y = C2*exp(x^2/2)

%%%% ----------------**PROBLEM-2**--
%% To solve the initial value problem, say the above equation with y(1) = 1;
%% You should get the solution as y = exp(-1/2)*exp(x^2/2)

%%% ------------------ **PROBLEM-3** --

```
>> x = linspace(0,1,20);
>> z = eval(vectorize(y));
>> plot(x,z)
```

%%% ---------------------**PROBLEM-4**---
% Let us consider second order equation of the form *y*
y''(*x*) + 8*y*'(*x*) + 2*y*(*x*) = cos(*x*); *y*(0) = 0; *y*'(0) = 1

% Type in the command line

```
>> eqn2 = 'D2y + 8*Dy + 2*y = cos(x)';  % This gives the equation.
>> inits2 = 'y(0)=0, Dy(0)=1';            % This gives the initial condition.
>> y=dsolve(eqn2,inits2,'x')
```

% The solution output from MATLAB should be

y = (14^(1/2)*exp(4*x - 14^(1/2)*x)*exp(x*(14^(1/2) - 4))*(sin(x) - cos(x)*(14^(1/2) - 4)))/(28*((14^(1/2) - 4)^2 + 1)) - (14^(1/2)*exp(4*x + 14^(1/2)*x)*exp(-x*(14^(1/2) + 4))*(sin(x) + cos(x)*(14^(1/2) + 4)))/(28*((14^(1/2) + 4)^2 + 1)) - (14^(1/2)*exp(-x*(14^(1/2) + 4))*(7*14^(1/2) + 27))/(28*(8*14^(1/2) + 31)) - (14^(1/2)*exp(x*(14^(1/2) - 4))*(393*14^(1/2) + 1531))/(28*(8*14^(1/2) - 31)*(8*14^(1/2) + 31)^2).

%% ----------------------**PROBLEM-5**--
%% Plotting direction field.

```
%%%  Consider the ODE, dy/dx = x + sin(y)
>> [x,y]=meshgrid(-3:.3:3,-2:.3:2);
>> dy = x + sin(y);
>> dx = ones(size(dy));  %% Think of ODE as dy/dx = (x + sin(y))/1
>> quiver(x,y,dx,dy,0.5)
```

%% In the plot the arrows are of different length. Since we are concerned only with the %% direction, we can make all the vectors unit length.

```
>> dyu = dy./sqrt(dx.^2+dy.^2);  % Normalized by the norm;
>> dxu = dx./sqrt(dx.^2+dy.^2);
>> quiver(x,y,dxu,dyu,0.5)
```

%% --------------**EXERCISE-1**---

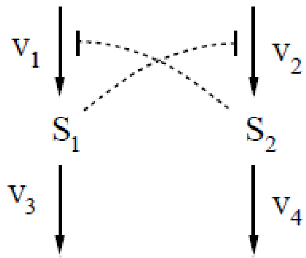
%% Plot the direction field for the ODE $dy/dx = x^2 - y$

%% ----------------**PROBLEM-6**---
%% Plotting the phase diagrams and nullclines using MATLAB command quiver and ezplot
%% Equations of the pendulum where dx/dt = y, and dy/dt = -g/l Sin(x); $g = 9.81 m/s^2$.

```
>> ncfun1 = @(x,y) y;
>> ncfun2 = @(x,y) -9.81*sin(x);
>> figure(1); hold on
>> ezplot(@(x,y) ncfun1(x,y), [-6 6 -10 10]);
>> ezplot(@(x,y) ncfun2(x,y), [-6 6 -10 10]);
>> [x,y]=meshgrid(-5:.4:5,-10:.51:10);
>> [x,y]=meshgrid(-5:.4:5,-10:.51:10);
>> dy = -9.81*sin(x)./y;
>> dx = ones(size(dy));
>> dxu=dx./sqrt(dx.^2+dy.^2);
>> dyu=dy./sqrt(dx.^2+dy.^2);
>> quiver(x,y,dxu,dyu,0.5)
```

%% ------------------------**PROBLEM-7**--

Allosteric inhibition of symmetric biochemical network.

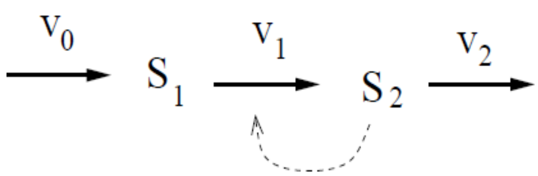


$$\frac{d}{dt}s_1(t) = \frac{k_1}{1+(s_2(t)/K_2)^{n_1}} - k_3 s_1(t)$$
$$\frac{d}{dt}s_2(t) = \frac{k_2}{1+(s_1(t)/K_1)^{n_2}} - k_4 s_2(t)$$

Choose parameter values *k1 = k2* = 20; K1 = K2 = 1; n1 = 4, n2 = 1. k3 = k4 = 5; Determine the dimensions of k's. Using MATLAB simulate the phase plot and numerically simulate the time series of S1 and S2.

%% ------------------------**PROBLEM-8**--

Autocatalytic biochemical reaction network. Species S_2 activates its own production.



$$\frac{d}{dt}s_1(t) = k_0 - k_1[1+(s_2(t)/K)^n]s_1(t)$$
$$\frac{d}{dt}s_2(t) = k_1[1+(s_2(t)/K)^n]s_1(t) - k_2 s_2,$$

Choose parameter values *k0*= 8; k1 = 1; K = 1, k2 = 5, n=2; Determine the dimensions of k's. Using MATLAB simulate the phase plot and numerically simulate the time series of S1 and S2. Why the network with positive feedback generates oscillations (damped/limit-cycle)? What dynamics you expect if the Hill's coefficient of n increased from 2 to 2.5? Do you still get oscillations? Use phase plane to illustrate your answer.

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

Write the system of ODE equations for each of the following wiring diagrams (a-d). Identify the type of feedback loops in each of the circuit. Draw the nullclines, direction fields and phase plane diagrams. Identify the type of dynamics.

(a) **(b)** **(c)** **(d)**