<u>EE 5323 Nonlinear Control Systems</u>

Homework Pledge of Honor

On all homeworks in this class - YOU MUST WORK ALONE.

Any cheating or collusion will be severely punished.

It is very easy to compare your software code and determine if you worked together
It does not matter if you change the variable names.

Please sign this form and include it as the first page of all of your submitted homeworks.

....

Typed Name: Bardia Mojra

Pledge of honor:

"On my honor I have neither given nor received aid on this homework."

e-Signature: Bardia Mojra

HW 01 - State Variable Systems

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Document Information:

- Author: Bardia Mojra
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- Title: HW 01 - State Variable Systems
- Term: Fall 2021
- Class: EE 5323 - Nonlinear Systems
- Dr. Lewis

HW 01 - State Variable Systems:

1. Van der Pol Oscillator
2. Lozenz Attractor Chaotic System
3. Voltera Predator-Prey System

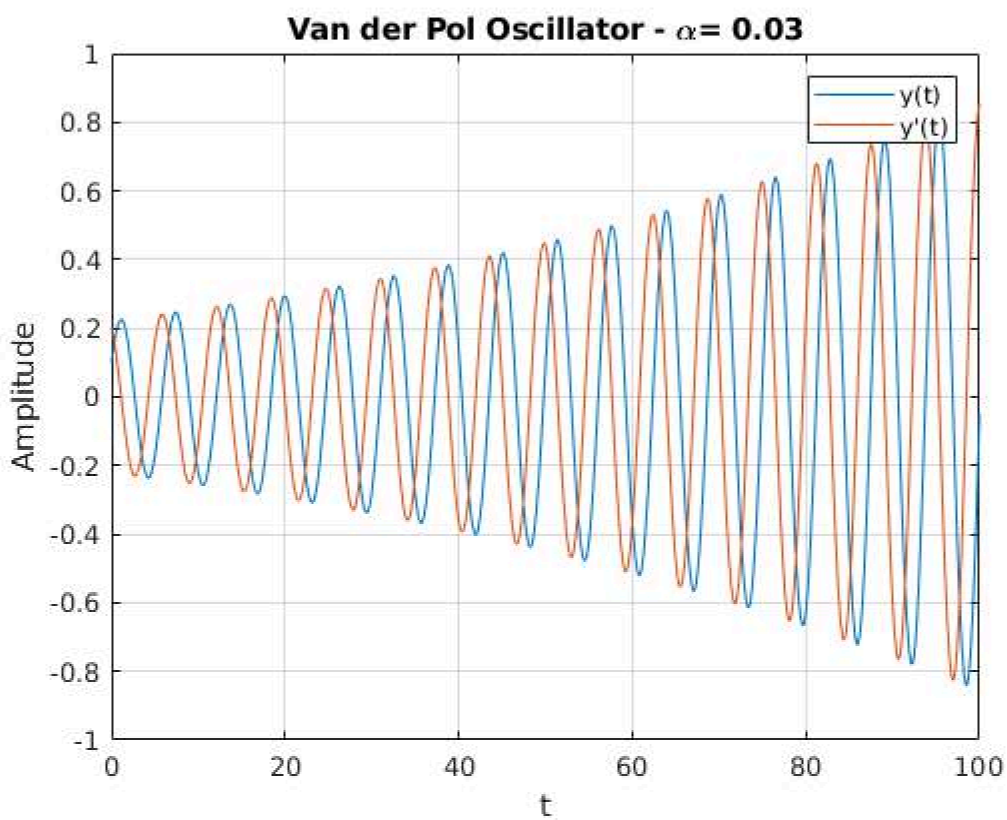
Van der Pol Oscillator:

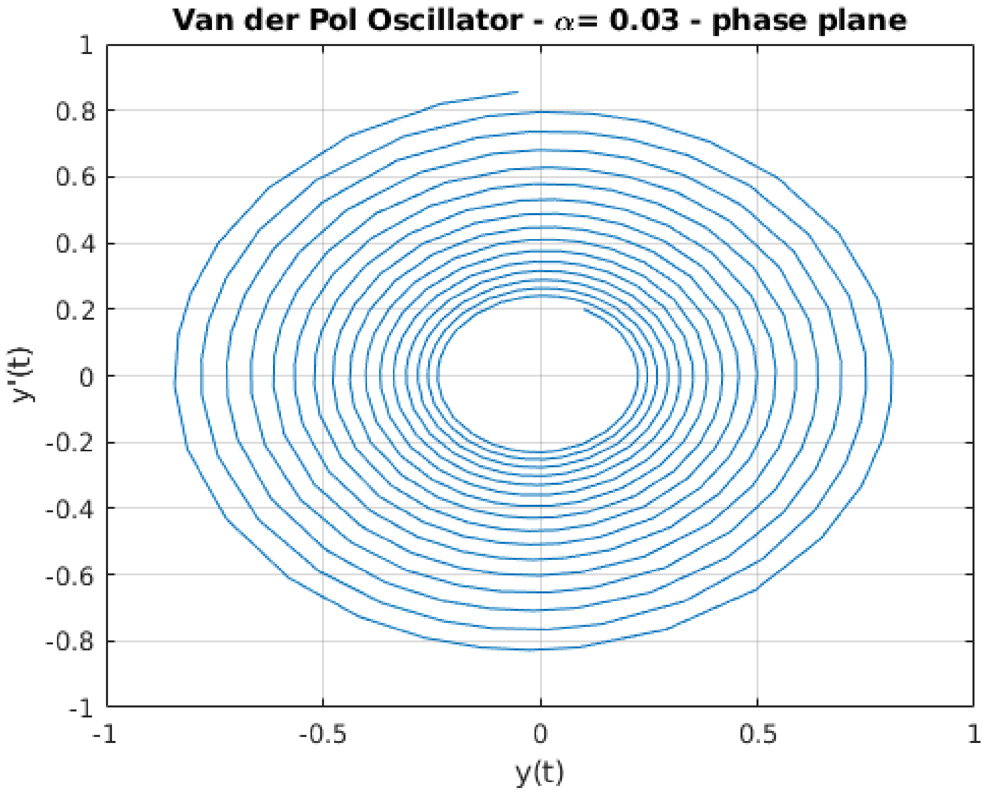
- $y" + \alpha(y^2 - 1)y' + y = 0$.
- Use $y(0) = 0.1, y'(0) = 0.2$ as initial conditions.
- Plot $y(t) vs. t$.
- Plot the phase plane plot $y'(t)$ vs. $y(t)$.

```
clc
close all


disp('P01-A Van der Pol - \alpha=0.3')
```

```
disp('Set initial conditions for y(0) and ydot(0):')
disp('Plot y(t) vs t for \alpha=0.03')
x0 = [0.1, 0.2]';
t_interval= [0 100];

figure
[t,x]= ode23('VanDerPolA', t_interval, x0);
plot(t,x)
ylabel('Amplitude');
xlabel('t');
grid on;
title('Van der Pol Oscillator - \alpha= 0.03');
legend('y(t)', "y'(t)");

disp("Plot y(t) vs y'(t) for \alpha=0.03")
figure
plot(x(:,1),x(:,2))
xlabel('y(t)');
ylabel("y'(t)");
grid on;
title('Van der Pol Oscillator - \alpha= 0.03 - phase plane');
```

```
P01-A Van der Pol - \alpha=0.3
Set initial conditions for y(0) and ydot(0):
Plot y(t) vs t for \alpha=0.03
Plot y(t) vs y'(t) for \alpha=0.03
```

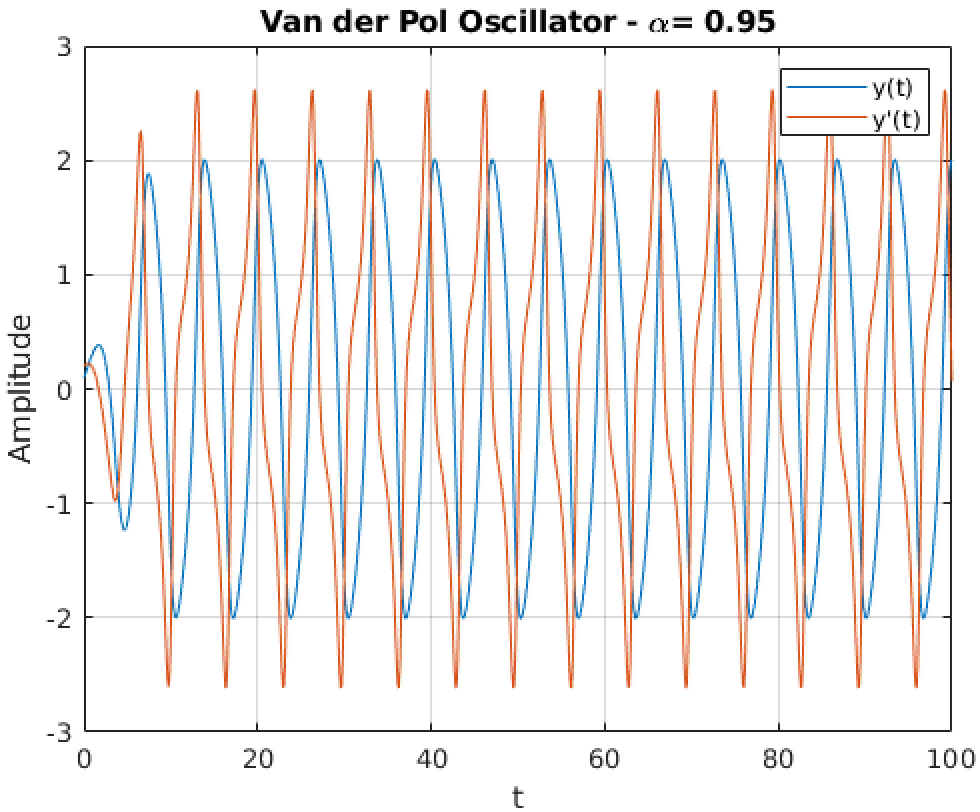


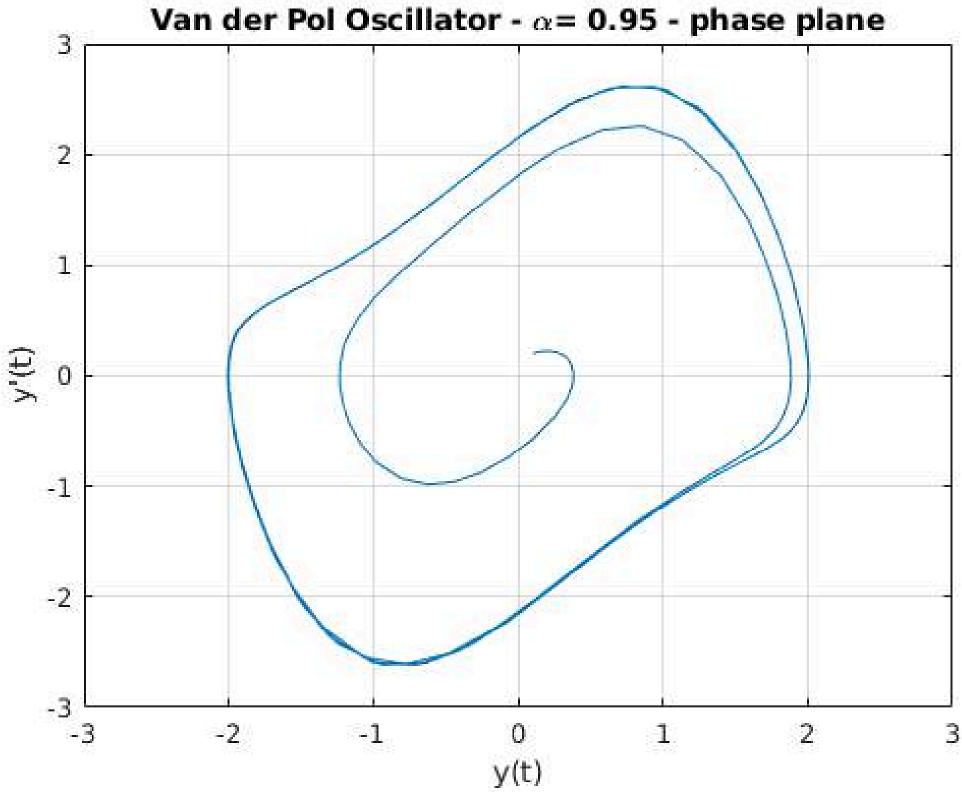



```
function xdot = VanDerPolA(t,x)
  alpha= 0.03;
  xdot = [x(2); -alpha*((x(1)^2)-1)*x(2) - x(1)];
end

clc
disp('P01-B Van der Pol - \alpha=0.95')
disp('Set initial conditions for y(0) and ydot(0):')
disp('Plot y(t) vs t for \alpha=0.95')

figure
[t,x]= ode23('VanDerPolB', t_interval, x0);
plot(t,x)
ylabel('Amplitude');
xlabel('t');
grid on;
title('Van der Pol Oscillator - \alpha= 0.95');
legend('y(t)', "y'(t)");

disp("Plot y(t) vs y'(t) for \alpha=0.95")
figure
plot(x(:,1),x(:,2))
xlabel('y(t)');
ylabel("y'(t)");
grid on;
title('Van der Pol Oscillator - \alpha= 0.95 - phase plane');
```

P01-B Van der Pol - \alpha=0.95

```
Set initial conditions for y(0) and ydot(0):
Plot y(t) vs t for \alpha=0.95
Plot y(t) vs y'(t) for \alpha=0.95
```





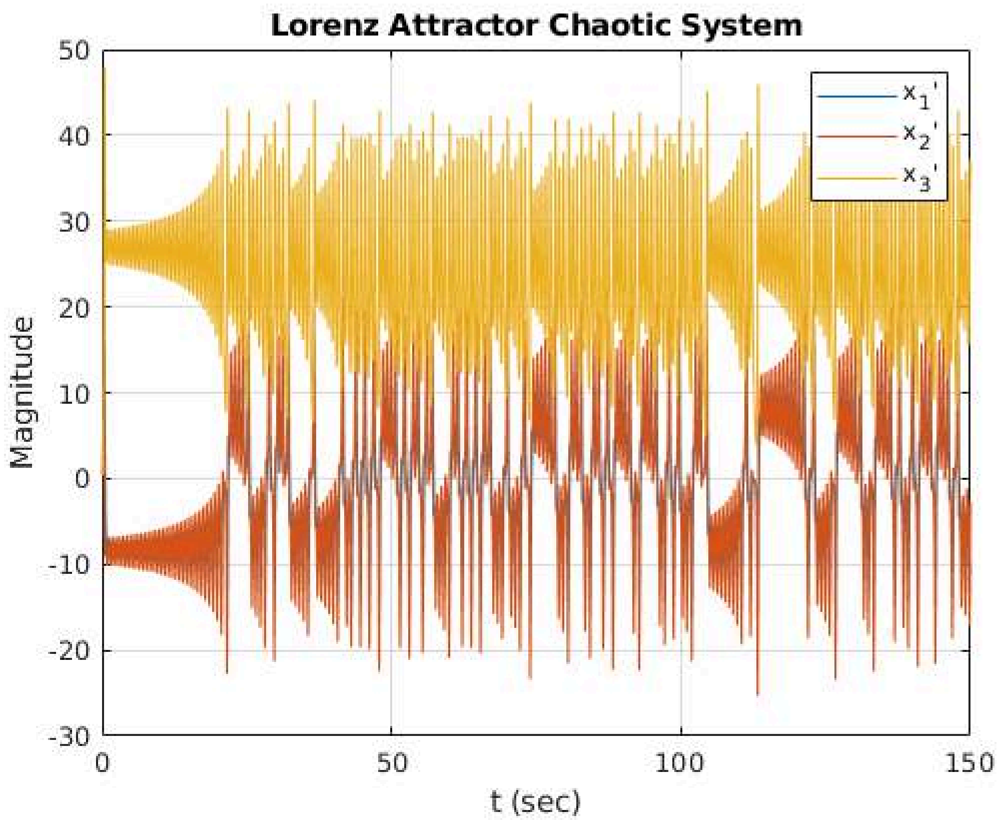

```
function xdot = VanDerPolB(t,x)
  alpha= 0.95;
  xdot = [x(2); -alpha*((x(1)^2)-1)*x(2) - x(1)];
end
```

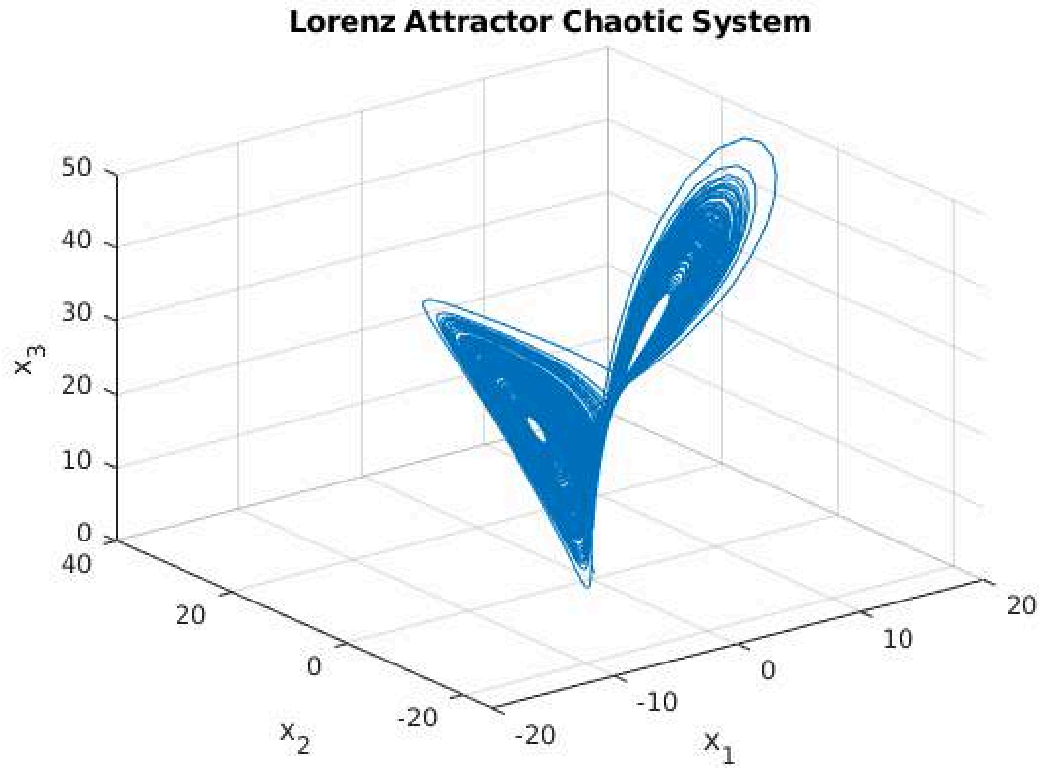
Lorenz Attractor Chaotic System:

- $\dot{x}_1 = -\sigma(x_1 - x_2)$
- $\dot{x}_2 = rx_1 - x_2 - x_1x_3$
- $\dot{x}_3 = -bx_3 + x_1x_2$
- Time Interval 150 sec.
- All inital condition equal to 0.5.
- Plot state versus time and 3D plot of x1, x2, x3.

```
clc

t_intv= [0 150];
x_0= [0.5 0.5 0.5]'; % initial conditions for x(t)
[t,x]= ode23('Lorenz', t_intv, x_0);

figure
```

```
plot(t,x)
grid on;
title('Lorenz Attractor Chaotic System');
ylabel('Magnitude');
xlabel('t (sec)');
legend("x_1'", "x_2'", "x_3'");
hold on;

figure
plot3(x(:,1),x(:,2),x(:,3))
grid on;
title('Lorenz Attractor Chaotic System');
ylabel('x_2');
xlabel('x_1');
zlabel('x_3');
hold on;
```






```
function xdot = Lorenz(t,x)
  sigma= 10; r=28; b=8/3;
  xdot = [-sigma*(x(1)-x(2)); r*x(1)-x(2)-x(1)*x(3); -
b*x(3)+x(1)*x(2)];
end
```

Voltera Predator-Prey System:

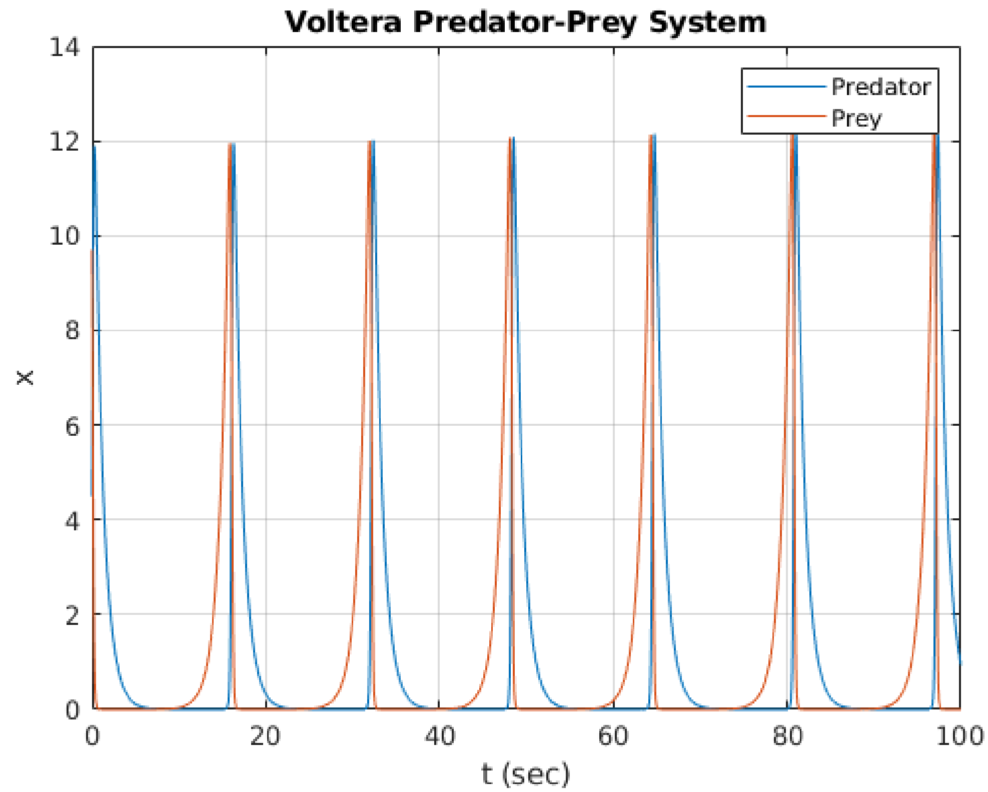
- $\dot{x}_1 = -x_1 + x_1 x_2$
- $\dot{x}_2 = x_2 - x_1 x_2$
- Initial conditions to be evenly spaced for $x_1 = [-2, 2], x_2 = [-2, 2]$.
- Plot phase plane on $[-5, 5]$ by $[-5, 5]$

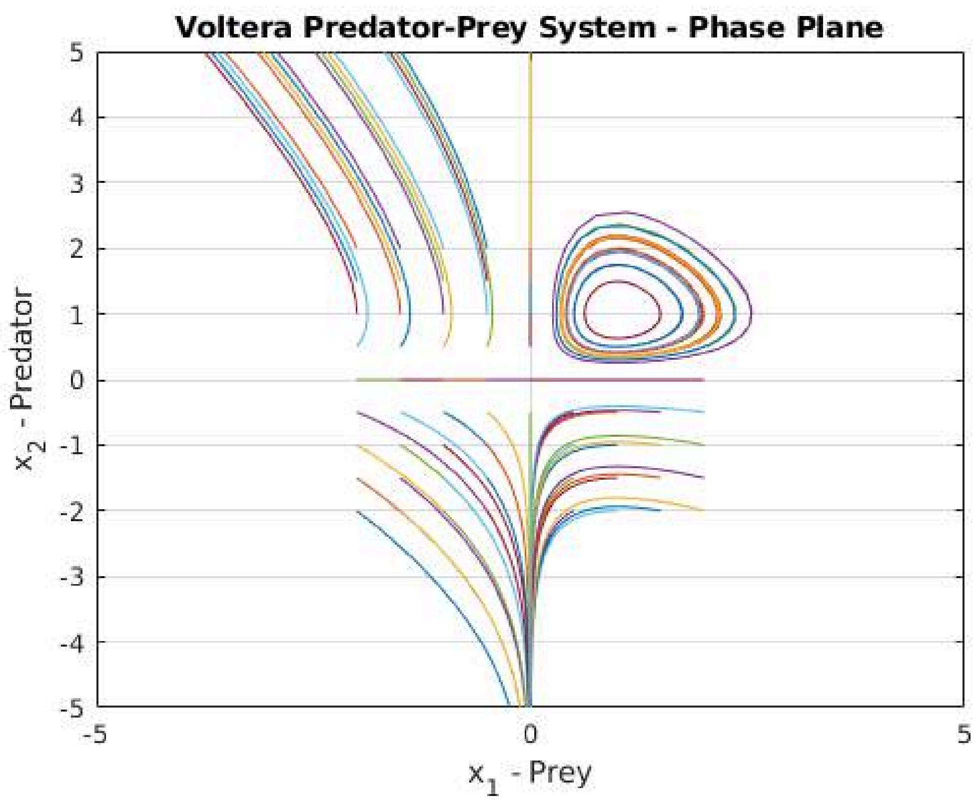
```
clc

x0_set = -2:.5:2;
t_intv= [0 100];
x_0= [4.5, 9.7]'; % initial conditions for x(t)

figure
[t,x]= ode23('Voltera', t_intv, x_0);
plot(t,x)
hold on;
grid on;
```

```
title('Voltera Predator-Prey System');
ylabel('x');
xlabel('t (sec)');
legend('Predator', 'Prey');


t_intv= [0 10];
figure
for i=x0_set
  for j=x0_set
    x0 = [i; j];
    [t,x]= ode45('Voltera', t_intv, x0);
    plot(x(:,1),x(:,2))
    hold on;
  end
end
title('Voltera Predator-Prey System - Phase Plane');
ylabel('x_2 - Predator');
xlabel('x_1 - Prey');
axis([-5 5 -5 5]);
grid on;
```

```
Warning: Failure at t=9.607443e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=6.992429e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=5.735898e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=4.954144e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (8.881784e-16)
at time t.
Warning: Failure at t=1.122368e+00.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (3.552714e-15)
at time t.
Warning: Failure at t=8.061033e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=6.560092e-01.  Unable to meet integration
 tolerances
```

```
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=5.634725e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=1.363111e+00.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (3.552714e-15)
at time t.
Warning: Failure at t=9.655655e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=7.787441e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=6.645068e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=1.771098e+00.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (3.552714e-15)
at time t.
Warning: Failure at t=1.244444e+00.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (3.552714e-15)
at time t.
Warning: Failure at t=9.954311e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
Warning: Failure at t=8.433868e-01.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.776357e-15)
at time t.
```






```
function xdot = Voltera(t,x)
```

```
    xdot = [-x(1)+x(1)*x(2); x(2)-x(1)*x(2)];
end
```

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