
HW 01 - State Variable Systems

Table of Contents

Document Information:	1
HW 01 - State Variable Systems:	1
Van der Pol Oscillator:	1
Lorenz Attractor Chaotic System:	5
Voltera Predator-Prey System:	7

Document Information:

- Author: Bardia Mojra
- Date: 09/07/2021
- 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. Lorenz 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')
```

```

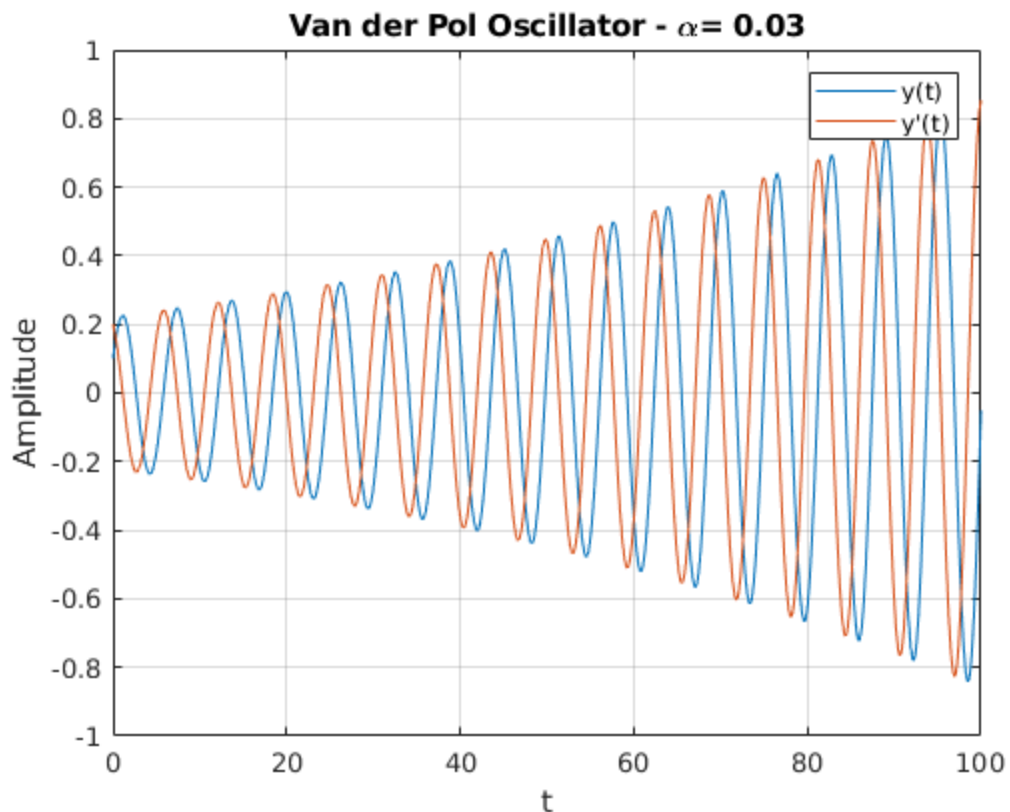
disp('Set initial conditions for y(0) and ydot(0):')
disp('Plot y(t) vs t for \alpha=0.03')
x0 = [0.1, 0.2]';
t_interval= [0 100];

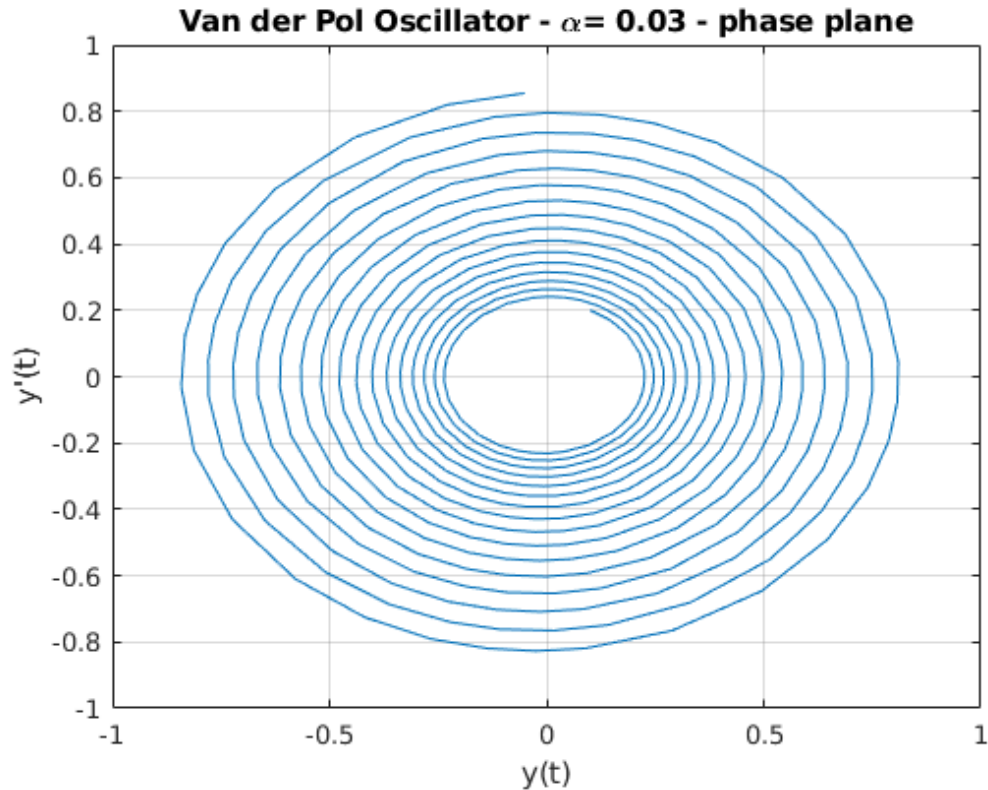
figure
[t,x]= ode23('VanDerPolA', t_interval, x0);
plot(t,x)
ylabel('Amplitude');
xlabel('t');
grid on;
title('Van der Pol Oscillator - \alpha= 0.03');
legend('y(t)', "y'(t)");

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

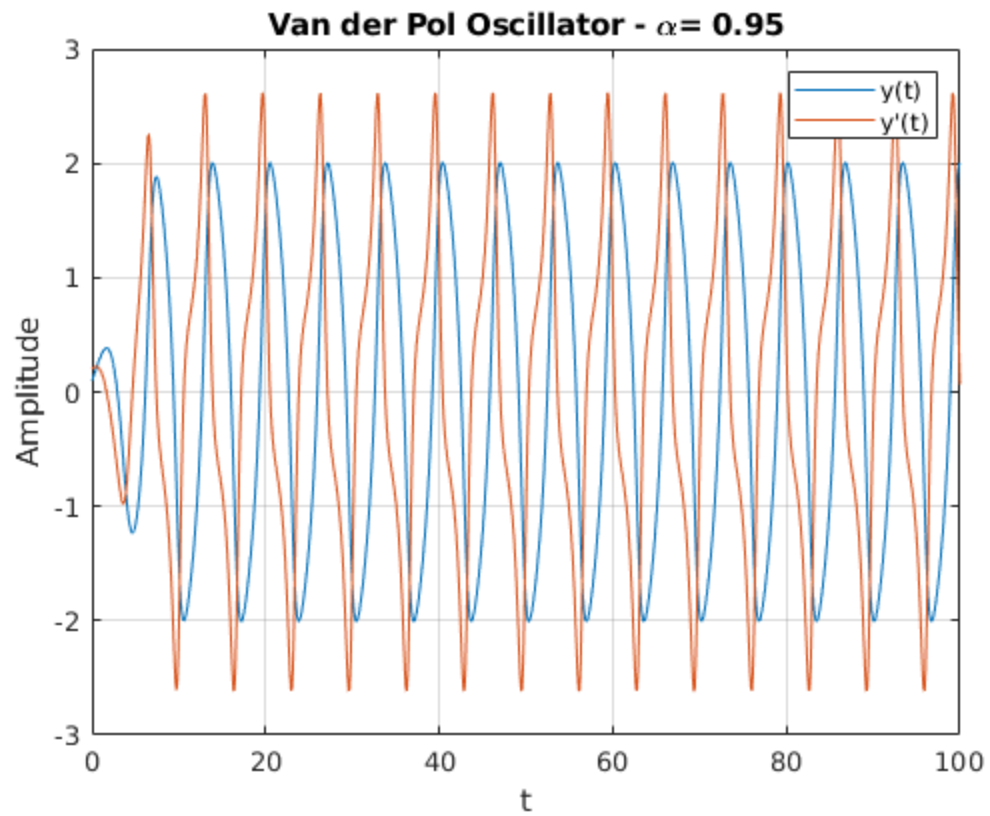
clc
disp('P01-B Van der Pol - \alpha=0.95')
disp('Set initial conditions for y(0) and ydot(0):')
disp('Plot y(t) vs t for \alpha=0.95')

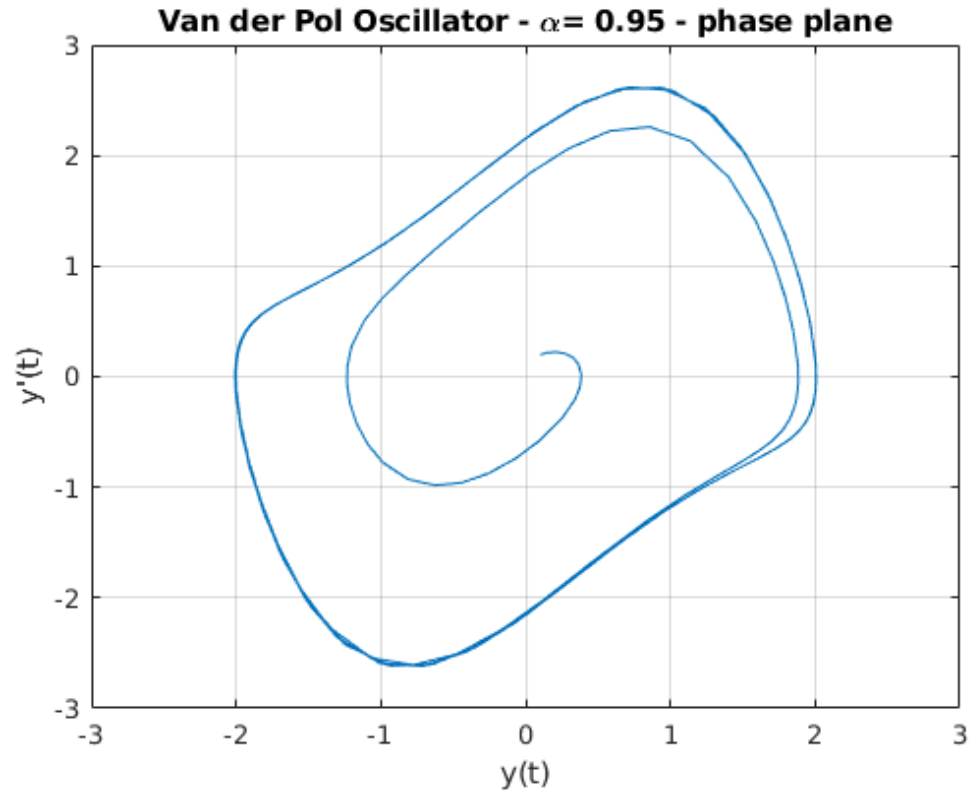
figure
[t,x]= ode23('VanDerPolB', t_interval, x0);
plot(t,x)
ylabel('Amplitude');
xlabel('t');
grid on;
title('Van der Pol Oscillator - \alpha= 0.95');
legend('y(t)', "y'(t)");

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 $\dot{y}(0)$:
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 initial condition equal to 0.5.
- Plot state versus time and 3D plot of x_1 , x_2 , x_3 .

```
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);
```

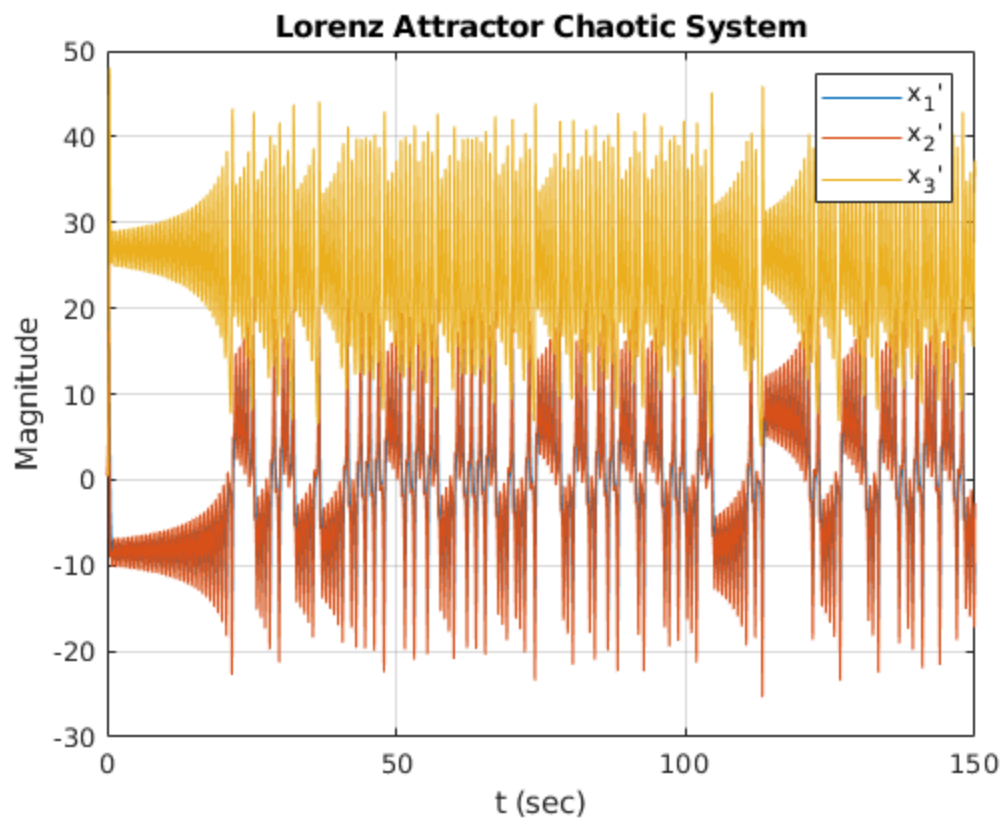
```
figure
```

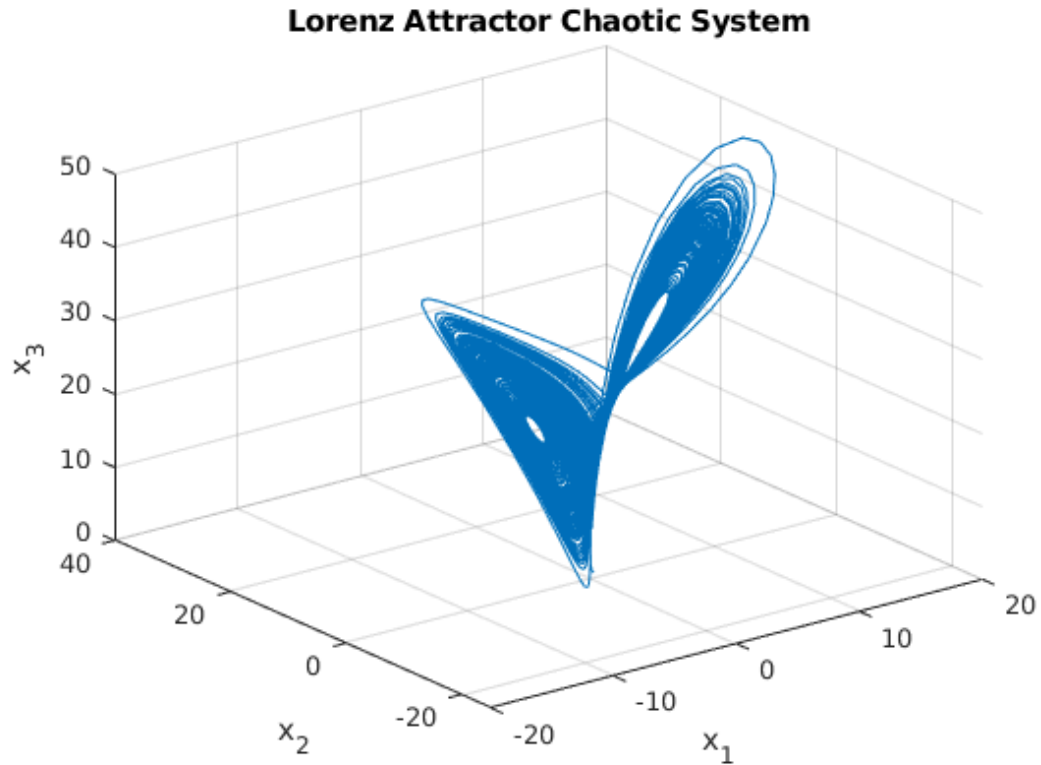
```

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:

- $\dot{x}_1 = -x_1 + x_1x_2$
- $\dot{x}_2 = x_2 - x_1x_2$
- 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;

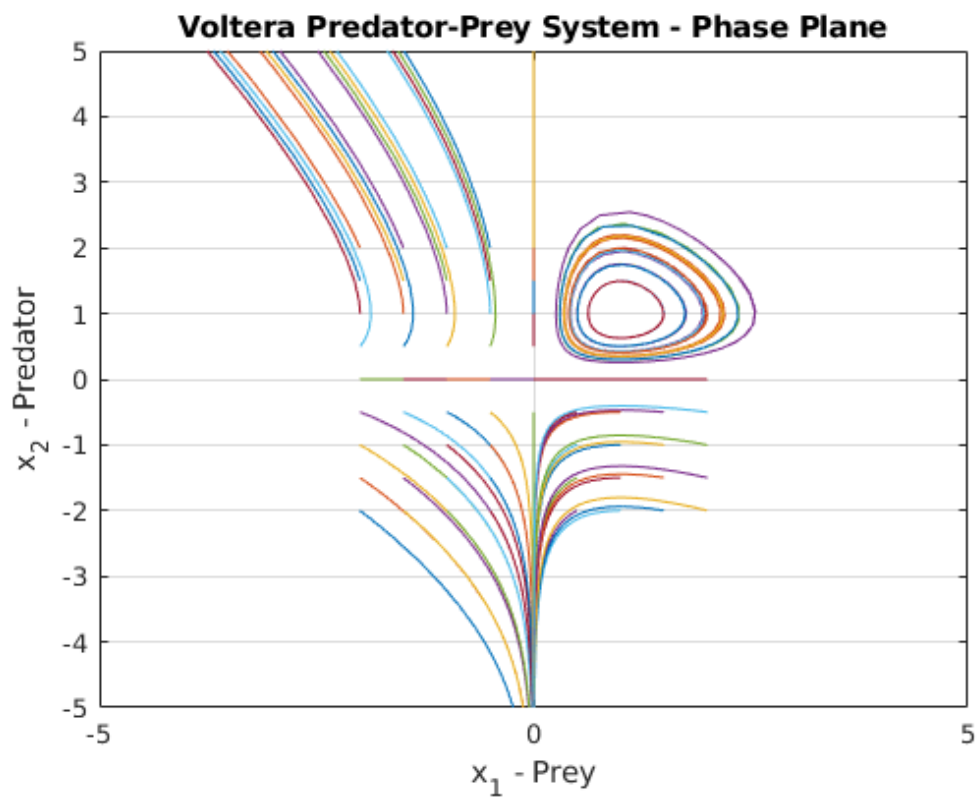
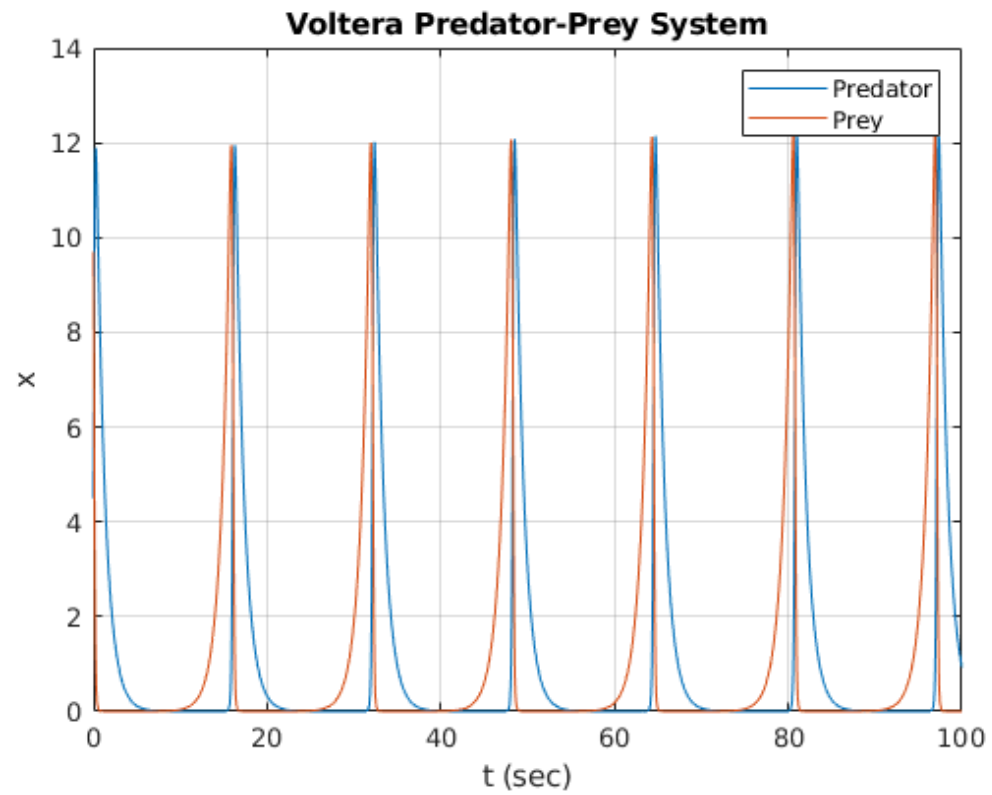
```

```

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
```

Published with MATLAB® R2021a