Lab 4 - Joseph Riley Guest - MAT 275 Lab

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MATLAB solvers for First-Order IVP

EX 1

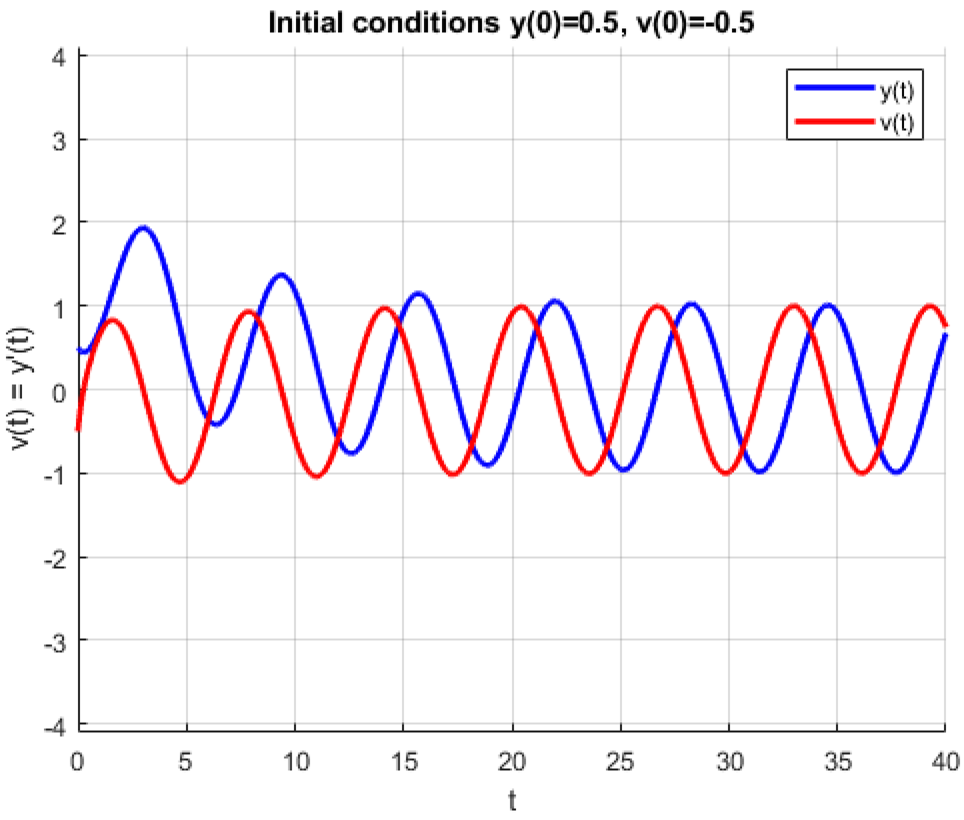
A

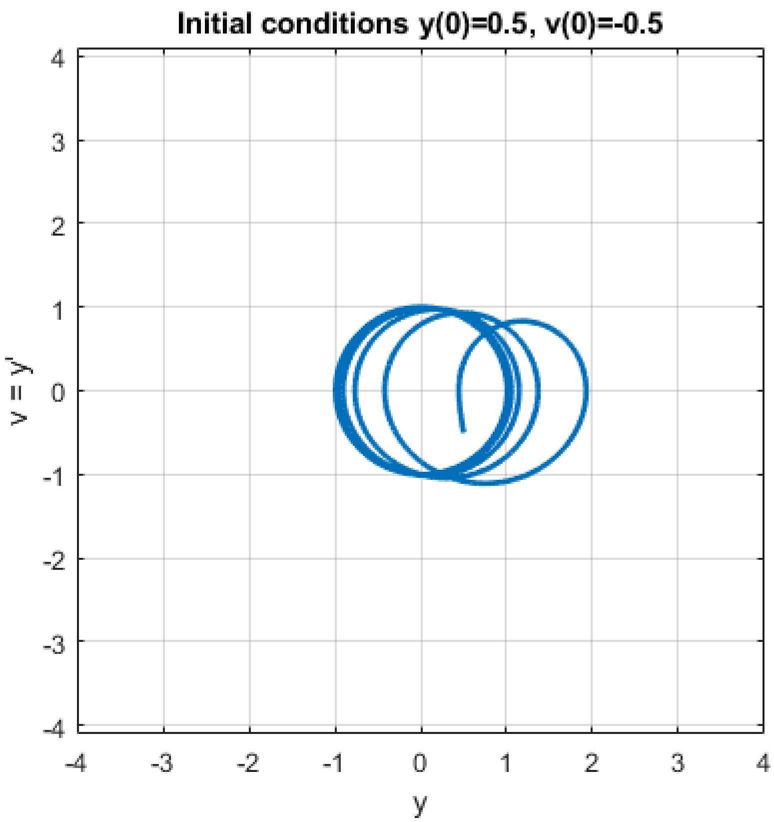
```
type 'LAB04ex1'
LAB04ex1;


clc % clear command window
t0 = 0; tf = 40; % range values for 0 < t < 40
y0 = [0.5;-0.5]; % initial values for y and y'
[t,Y] = ode45(@f,[t0,tf],y0); % using ode45 so solve the function
 below
u1 = Y(:,1); u2 = Y(:,2);    % y in output has 2 columns corresponding
 to u1 and u2
figure(1); % starting figure 1
hold on; grid on; % holding all further plots on, turning grid on
plot(t,u1,'b', 'Linewidth', 2); % plotting y vs t
plot(t,u2,'r', 'Linewidth', 2); % plotting v vs t
ylim([-4.1,4.1]) % adding y limits
legend('y(t)', 'v(t)') % inserting legend
xlabel('t') % adding x axis label
ylabel("v(t) = y'(t)") % adding y axis label
title('Initial conditions y(0)=0.5, v(0)=-0.5') % inserting title
hold off;
figure(2) % starting figure 2
plot(u1,u2, 'Linewidth', 2); % plotting y vs v
```

```
axis square; grid on; % making axis square and turning grid on
xlabel('y'); ylabel("v = y'"); % adding x and y axis labels
xlim([-4,4]); ylim([-4.1,4.1]);   % plot the phase plot
title('Initial conditions y(0)=0.5, v(0)=-0.5') % adding the title
% [t, Y(:,1), Y(:,2)]
 %----------------------------------------------------------------------

function LAB04ex1= f(t,Y)
y=Y(1); v=Y(2);
LAB04ex1 = [v; 7*sin(t)-7*v-y];
end
```





B

The last three local maxima. ---------------------------- 21.9661 1.0588 0.0164 28.2296 1.0227 0.0413 34.5508 1.0094 0.0054 ----------------------------

C

To be a continuous sinusoidal wave, this is because the initial conditions being near / around the equilibrium.

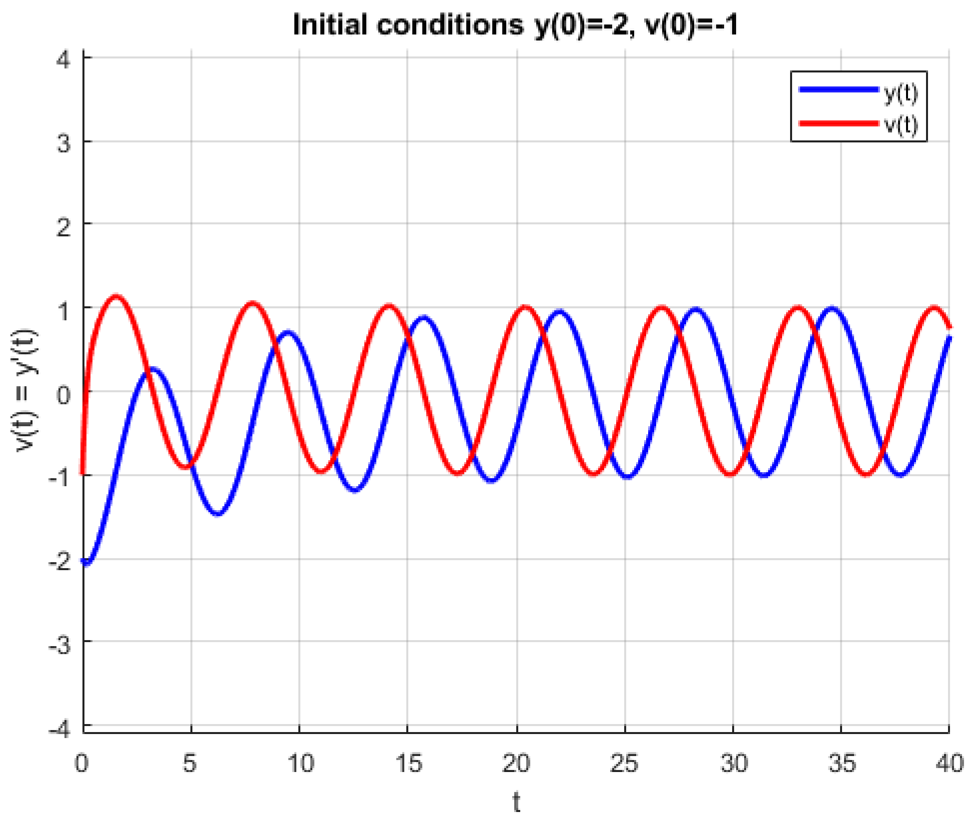
D

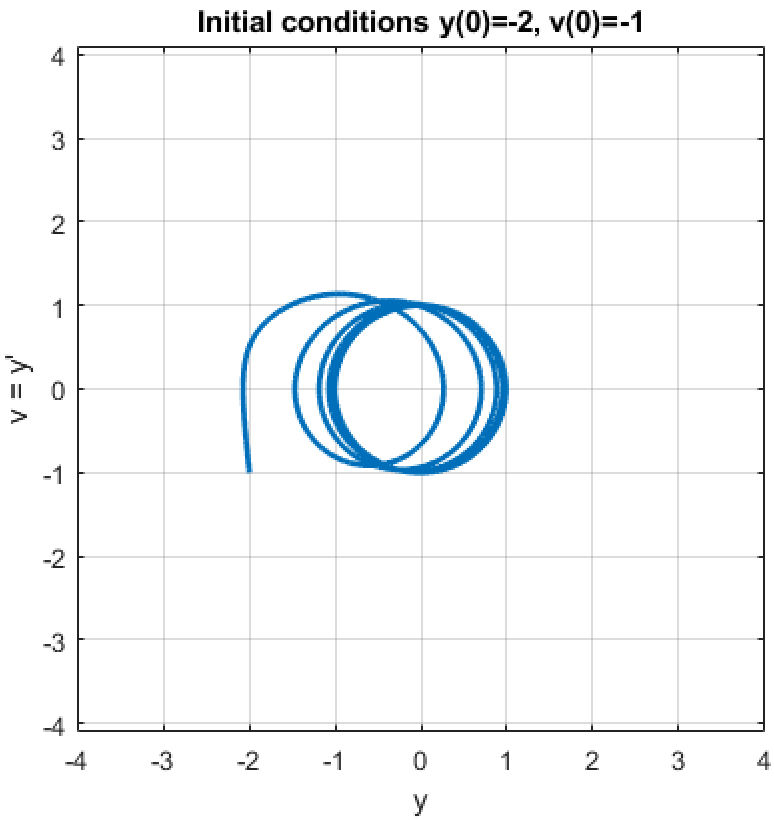
```
type 'LAB04ex1d'
LAB04ex1d;


clc % clear command window
t0 = 0; tf = 40; % time range values for t
y0 = [-2;-1]; % initial values for y, and y' these were modified
[t,Y] = ode45(@f,[t0,tf],y0); % using ode45 to solve function at
 parameter
u1 = Y(:,1); u2 = Y(:,2);    % y in output has 2 columns corresponding
 to u1 and u2
figure(3); % starting figure 3
```

```
hold on;grid on % holding all further plots on, and turning grid on
plot(t,u1,'b', 'Linewidth', 2); % plotting y
plot(t,u2,'r', 'Linewidth', 2); % plotting v
ylim([-4.1,4.1]) % setting y axis limits
legend('y(t)', 'v(t)') % adding legend
xlabel('t') % adding x label
ylabel("v(t) = y'(t)") % adding y label
title('Initial conditions y(0)=-2, v(0)=-1') % adding title to plot
hold off;
figure(4) % starting figure 4
plot(u1,u2, 'Linewidth', 2); % plotting y and v
axis square; grid on; % turning the axis to square and grid on
xlabel('y'); ylabel("v = y'"); % adding x and y axis labels
xlim([-4,4]); ylim([-4.1,4.1]);   % plot the phase plot
title('Initial conditions y(0)=-2, v(0)=-1') % adding title to graph
% [t, Y(:,1), Y(:,2)];
 %-----------------------------------------------------------------------

function LAB04ex1d= f(t,Y) % defining function
y=Y(1); v=Y(2); % defining y and v as arrays
LAB04ex1d = [v; 7*sin(t)-7*v-y]; % solution to IVP
end % ending function
```





The long term behavior for initial conditions y(0)= -2, v(0)= -1 will remain a sinusoidal wave, just like figure 2. The reason for this is due to the choice of initial conditions, if you choose initial conditions that are around / near the equilibrium.

EX2

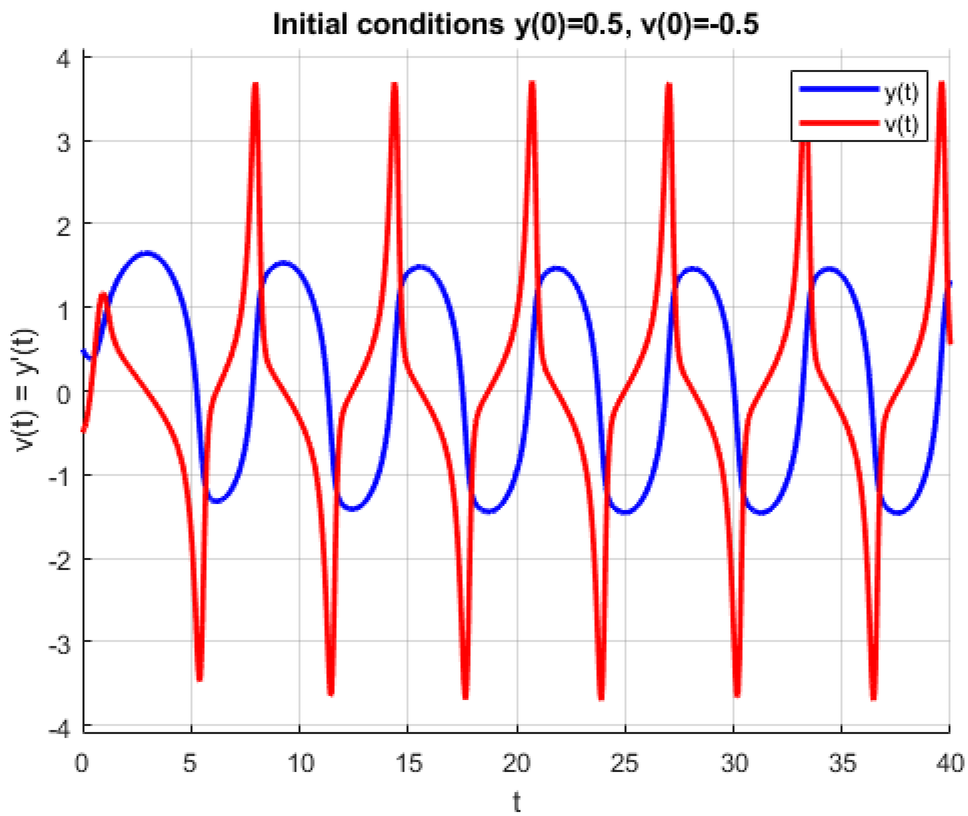
A

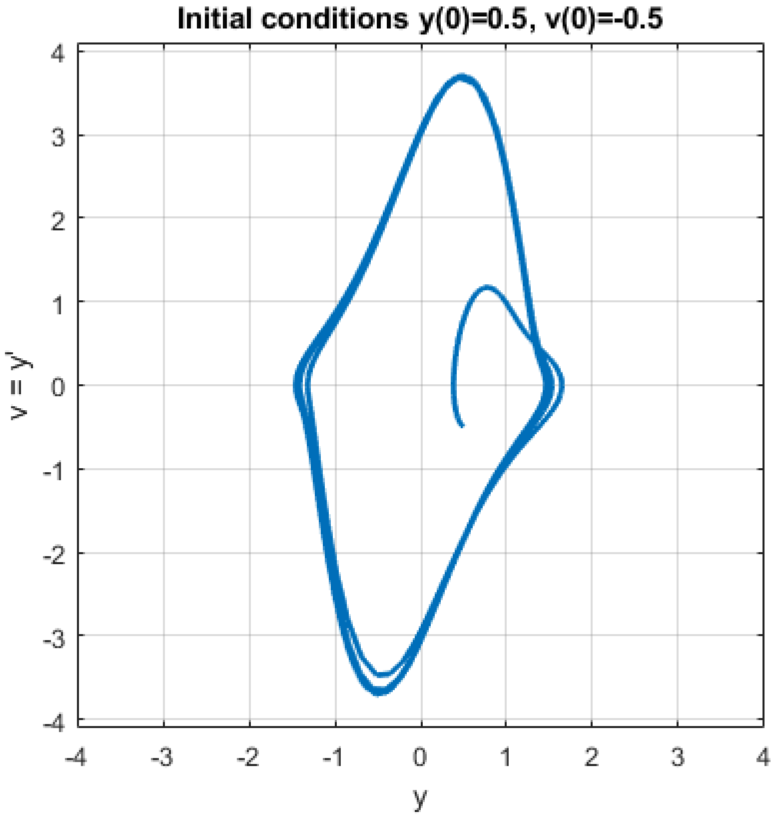
```
type 'LAB04ex2'
LAB04ex2;


clc % clear command window
t0 = 0; tf = 40; % declaring time values of t
y0 = [0.5;-0.5]; % initial values of y and y'
[t,Y] = ode45(@f,[t0,tf],y0); % using ode45 solver for the function
u1 = Y(:,1); u2 = Y(:,2);    % y in output has 2 columns corresponding
 to u1 and u2
figure(5); % starting figure 1
hold on;grid on; % holding all further plots on, turning grid on
plot(t,u1,'b', 'Linewidth', 2); % plotting y vs. t
plot(t,u2,'r', 'Linewidth', 2); % plotting y'=v vs. t
ylim([-4.1,4.1]) % setting y limits
legend('y(t)', 'v(t)') % adding legend
xlabel('t') % labeling x axis
```

```
ylabel("v(t) = y'(t)") % labeing y axis
title('Initial conditions y(0)=0.5, v(0)=-0.5') % inserting graph
 title
hold off;
figure(6) % starting figure 2
plot(u1,u2, 'Linewidth', 2); axis square; grid on; % potting y & v
xlabel('y'); ylabel("v = y'"); % labeling x and y axis
xlim([-4,4]); ylim([-4.1,4.1]);   % plot the phase plot
title('Initial conditions y(0)=0.5, v(0)=-0.5'); % inserting title
% [t, Y(:,1), Y(:,2)];
 %-----------------------------------------------------------------------

function LAB04ex2 = f(t,Y) % declaring function
y=Y(1); v=Y(2); % declaring arrays y and v=y'
LAB04ex2 = [v; 7*sin(t)-7*y^2*v-y]; % solution to IVP
end % ending function
```





B

If you look at the plot, between t = 0 and t= 3, you notice the amplitude of v, this is because of the input of t being 1 through 3. As t increases so does the amplitude of v. The opposite happens with y as v is the derivative of y.

C

The amplitudes of 4 will have amplitudes for y and v at ~ 1. The amplitudes of 7 for y will be constant at ~ 1.466 and v at 3.111, which v is roughly 2 times larger than y. This is due to the y^2 term in the left hand side of the equation.

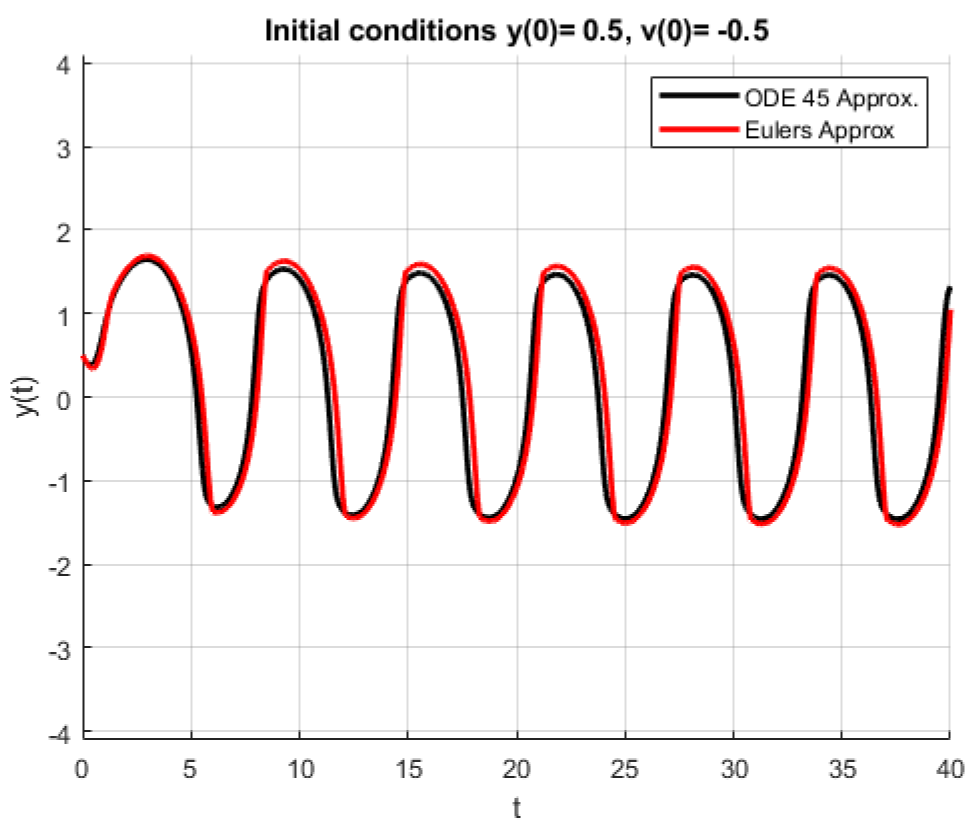
D

```
type 'LAB04ex2d'
LAB04ex2d;
```

```
clc % clear command window
t0 = 0; tf = 40; % time values for 0 < t < 40
y0 = [0.5;-0.5]; % initial conditions
[t,Y] = ode45(@f,[t0,tf],y0); % using ode45 to solve
[te,Ye] = euler(@f, [t0,tf],y0, 400); % using euler's method N=400
u1 = Y(:,1); u2 = Y(:,2);   % y in output has 2 columns corresponding
 to u1 and u2
```

```
t1 = Ye(:,1); t2 = Ye(:,2); % ye output has 2 columns correspoinding
 to t1 and t2
figure(7); % defining figure 7
hold on;grid on % holding on, turning grid on
plot(t,u1,'k', 'Linewidth', 2); % plotting ode45 solution
plot(te,t1,'r', 'Linewidth', 2); % plotting euler's solution
ylim([-4.1,4.1]) % setting limits of y axis
legend('ODE 45 Approx.', 'Eulers Approx') % adding legend
xlabel('t') % adding label for x-axis
ylabel("y(t)") % adding label for y-axis
title('Initial conditions y(0)= 0.5, v(0)= -0.5') % inserting title
 for graph
 %----------------------------------------------------------------------

function LAB04ex2d = f(t,Y) % defining function
y=Y(1); v=Y(2); % defining y and v as arrays of Y
LAB04ex2d = [v; 7*sin(t)-7*y^2*v-y]; % solution to diffeq
end % end of function
```



The solutions are not identical. Euler's approximation at N = 400 seems be a bit more irratic/coarse. When increasing the number of steps N = 800, 1200, 1600, Euler's approximation gets closer to being identical and superimposing on ODE45's approximation.

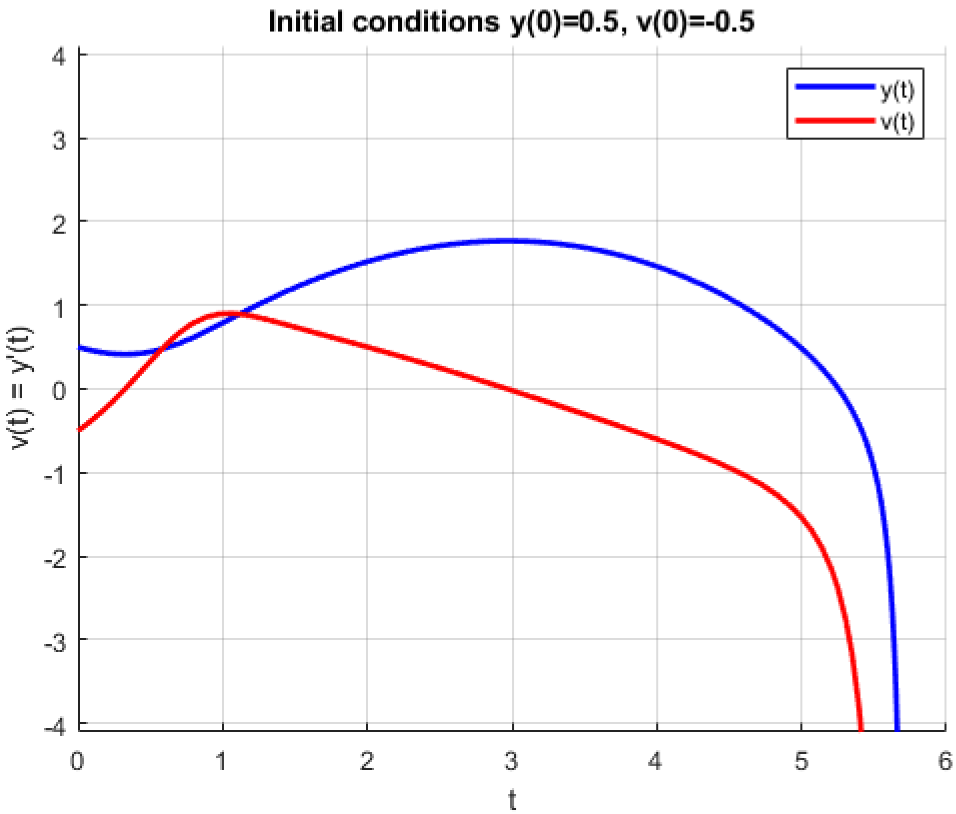
EX 3

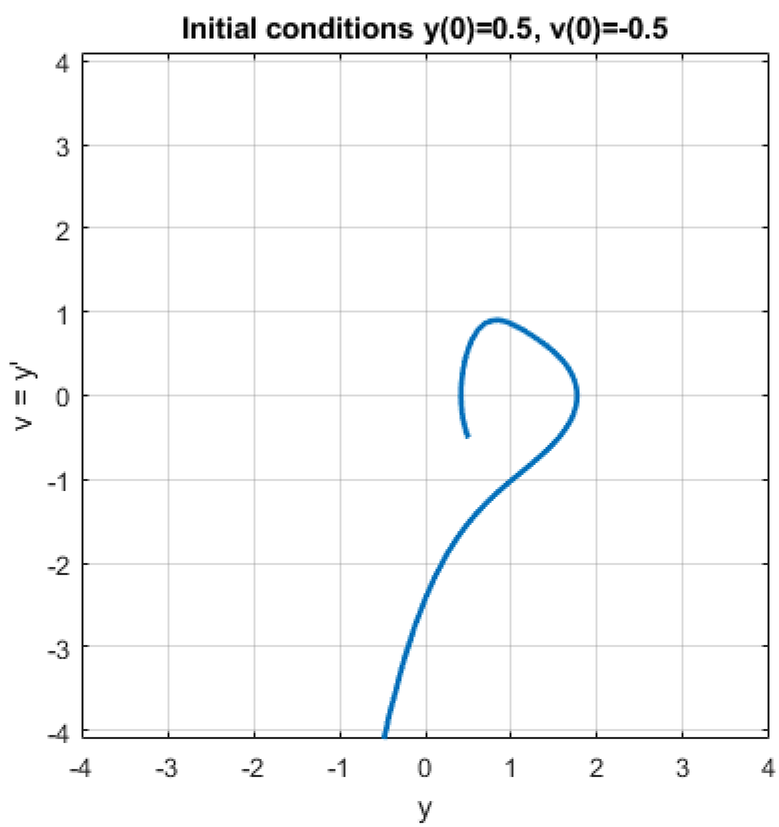
```
type 'LAB04ex3'
LAB04ex3;


clc % clear command window
t0 = 0; tf = 40; % time range of t
y0 = [0.5;-0.5]; % initial conditions of y(0) and y'(0)=v
[t,Y] = ode45(@f,[t0,tf],y0); % using ode45 solver for the function
u1 = Y(:,1); u2 = Y(:,2);    % y in output has 2 columns corresponding
 to u1 and u2
figure(8); % starting figure one
hold on;grid on % holding all further plots on, turning grid on
plot(t,u1,'b', 'Linewidth', 2); % plotting y
plot(t,u2,'r', 'Linewidth', 2); % plotting v
ylim([-4.1,4.1]) % setting y limits
legend('y(t)', 'v(t)') % adding legend
xlabel('t') % labeling x axis
ylabel("v(t) = y'(t)") % labeling y axis
title('Initial conditions y(0)=0.5, v(0)=-0.5') % adding title
hold off;
figure(9) % starting figure two
plot(u1,u2, 'Linewidth', 2); axis square; grid on; % plotting y and v
xlabel('y'); ylabel("v = y'"); % adding x and y labels
xlim([-4,4]); ylim([-4.1,4.1]);   % plot the phase plot
title('Initial conditions y(0)=0.5, v(0)=-0.5') % adding title
 %----------------------------------------------------------------------

function LAB04ex1= f(t,Y) % defining function
y=Y(1); v=Y(2); % declaring arrays for y, y'=v
LAB04ex1 = [v; 7*sin(t)-7*y*v-y]; % solution to IVP
end % end the function

Warning: Failure at t=5.728472e+00.  Unable to meet integration
 tolerances
without reducing the step size below the smallest value allowed
 (1.421085e-14)
at time t.
```


Initial conditions y(0)=0.5, v(0)=-0.5
y(t)
v(t)
v(t) = y'(t)
t
4
3
2
1
0
-1
-2
-3
-4
0
1
2
3
4
5
6


Initial conditions y(0)=0.5, v(0)=-0.5
v = y'
y
4
3
2
1
0
-1
-2
-3
-4
-4
-3
-2
-1
0
1
2
3
4

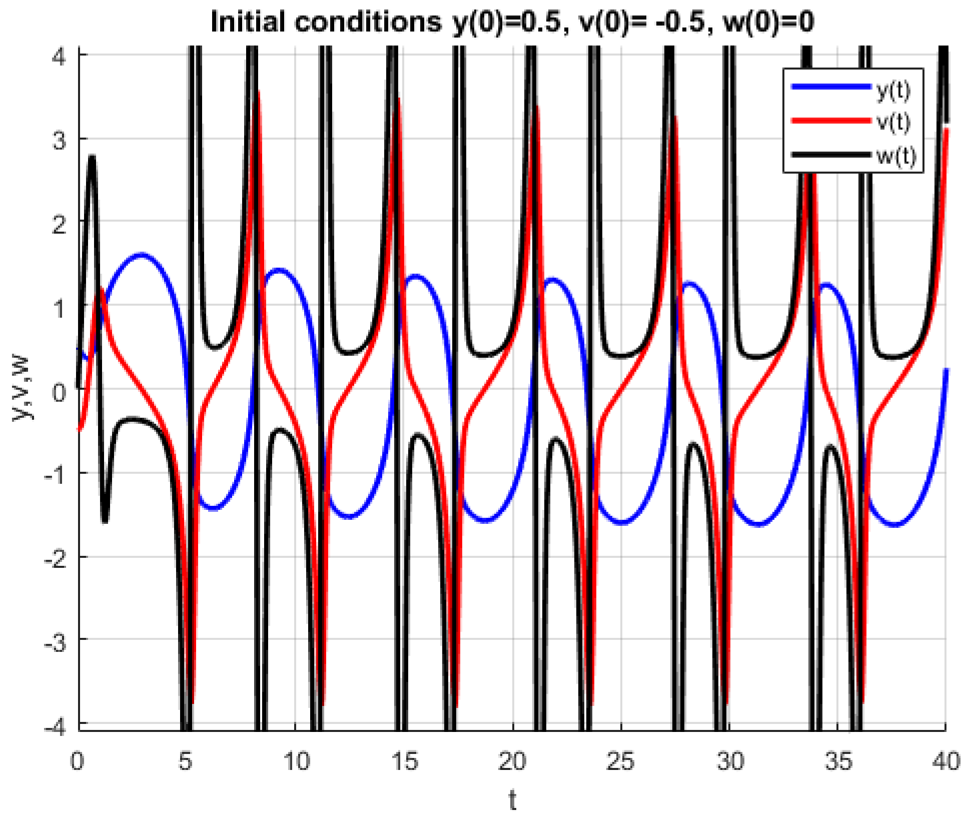
Yes, it's giving me a warning/error due to the compiler encountering the step value necessary for the ode integrator to be less than the minimum value allowed in matlab. So, it was not able to compute the values of y for first few values of t.

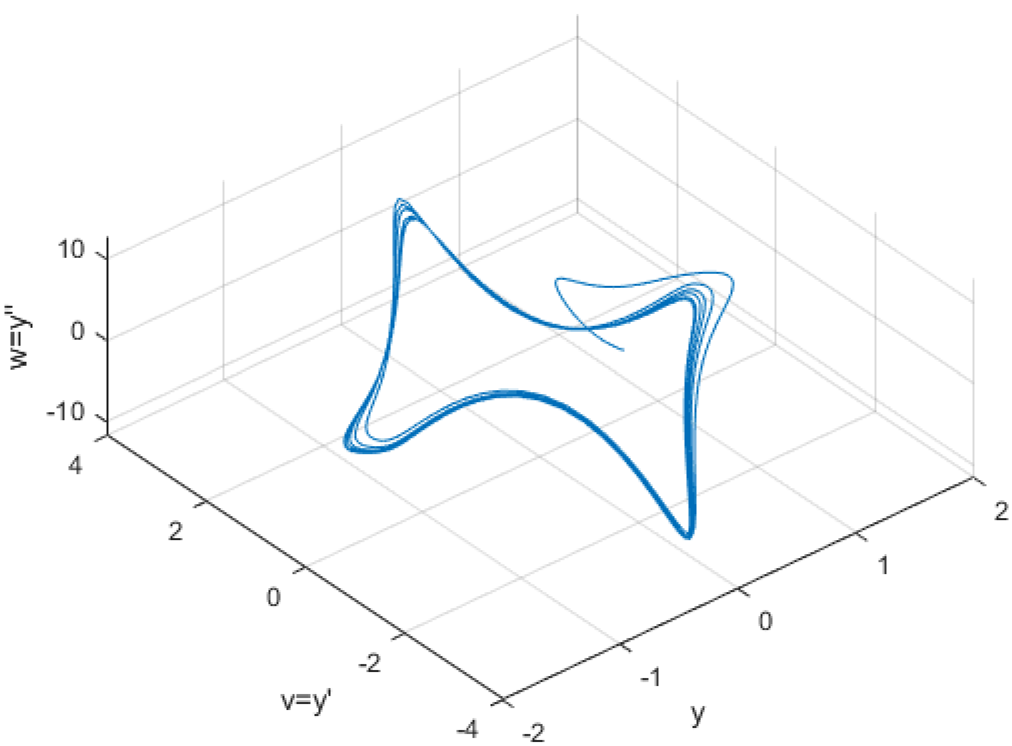
EX4

```
type 'LAB04ex4'
LAB04ex4;


clc % clear command window
t0 = 0; tf = 40; % time range values of t
y0 = [0.5;-0.5;0.0]; % initial values of y, y', y''
[t,Y] = ode45(@f,[t0,tf],y0); % calling ode45 to solve the function at
 values
u1 = Y(:,1); u2 = Y(:,2); u3 = Y(:,3); % y in output has 3 columns
 corresponding to u1 and u2
figure(10); % declaring figure 1
hold on; grid on; % holding all further plots, turning grid on
plot(t,u1,'b', 'Linewidth', 2); % plotting y vs t
plot(t,u2,'r', 'Linewidth', 2); % plotting y' vs t
plot(t,u3,'k', 'Linewidth', 2); % plotting y'' vs t
ylim([-4.1,4.1]) % declaring limits of the x axis
legend('y(t)', 'v(t)','w(t)' ) % adding legend for 3 plots
xlabel('t') % labeling x axis
ylabel('y,v,w') % labeling y axis
title('Initial conditions y(0)=0.5, v(0)= -0.5, w(0)=0') % inserting
 title
figure(11); plot3(u1,u2,u3); grid on; % starting phase plot
hold on; view ([ -40 ,60]) % holding on graph, 3d azimuth angles
xlabel ('y'); ylabel ('v=y'''); zlabel ('w=y'''''); % adding labels to
 x,y,z axes
 %-----------------------------------------------------------------------

function LAB04ex4= f(t,Y) % declaring function
y=Y(1); v=Y(2); w = Y(3); % declaring y,v,w as y,y',y'' arrays
LAB04ex4 = [v; w; 7*cos(t)-7*y^2*w-14*y*v^2-v]; % solution to equation
 8
end % end the function
```


Initial conditions y(0)=0.5, v(0)= -0.5, w(0)=0
y(t)
v(t)
w(t)
y,v,w
t


w=y''
v=y'
y

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