LAB 4 -TrevorCallow- MAT 275

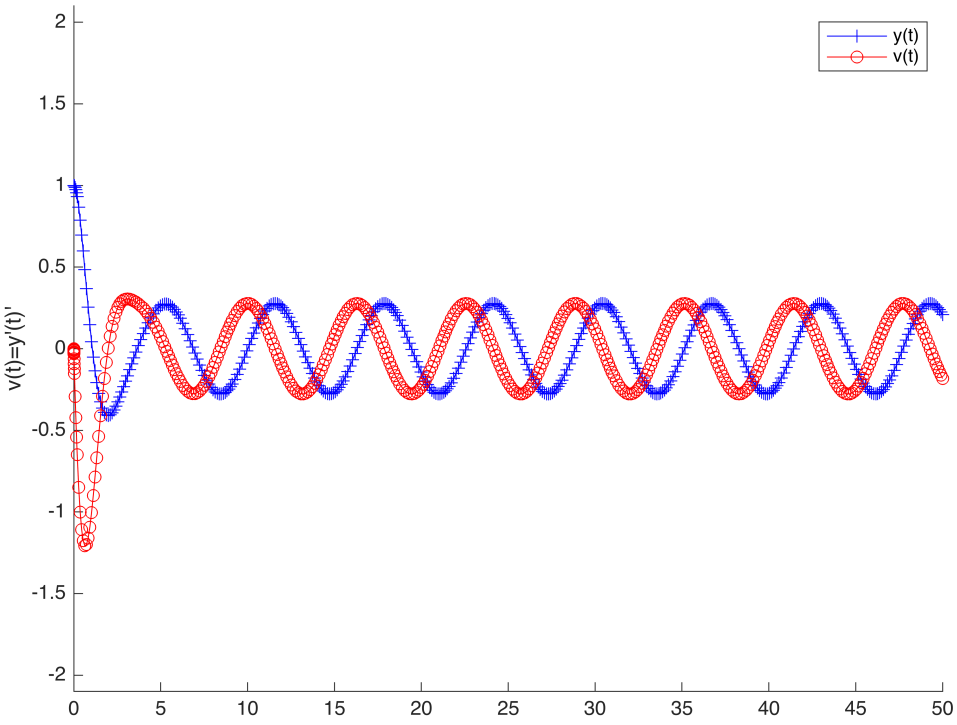
Exercise 1

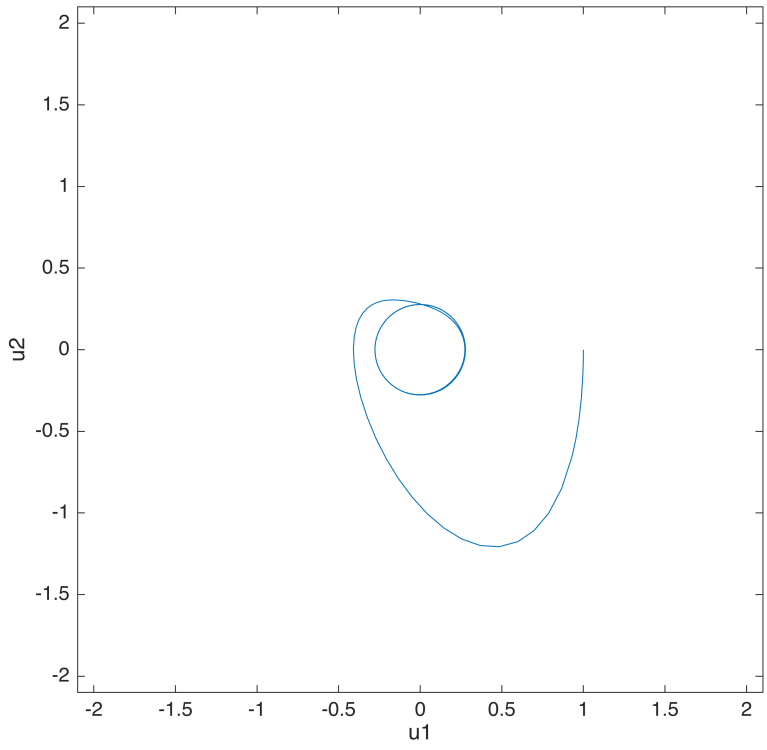
Part (a)

```
type 'LAB04ex1b.m'
```

```
t0 = 0; tf = 50; y0 = [1;0];
[t,Y] = ode45(@f,[t0,tf],y0);
u1 = Y(:,1); u2 = Y(:,2);

figure(1)
hold on;
plot(t, u1, 'b-+');ylabel('u1');
plot(t, u2, 'ro-');ylabel("v(t)=y'(t)'");
legend('y(t)', 'v(t)');
ylim([-2.1, 2.1])
hold off;

figure(2)
plot(u1, u2);
axis square;
xlabel('u1');
ylabel('u2');
ylim([-2.1, 2.1])
xlim([-2.1, 2.1])

A = [t, Y(:,1), Y(:,2)];
index = abs(A(:,2:3)) >= 0.025;

%-----------------------------------------------------------------------
function dydt = f(t,Y)
    y = Y(1); v = Y(2);
    dydt = [ v ; -sin(t) - 2*v - 4*y ];
end
```

```
LAB04ex1b
```


y(t)
v(t)
v(t)=y'(t)'
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
5
10
15
20
25
30
35
40
45
50


u2
u1
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2

Part (b)

```
%1.25594321575479e-05
%Tvalues
%2.51188643150958e-05
%3.76782964726437e-05
%5.02377286301916e-05
%0.000113034889417931
%0.000175832050205671
%0.000238629210993410
%0.000301426371781150
%0.000615412175719847
%0.000929397979658545
%0.0012433837835972 4
%0.0015573695875359 4
%0.003127298607229 43
%0.004697227626922 92
%0.006267156646616 40
%0.007837085666309 89
%0.015686730764777 3
%0.023536375863244 8
%0.031386020961712 2
%0.039235666060179 6
%0.078483891552516 8
%0.11773211704485 4
%0.15698034253719 1
%Yvalue
%0.999999999684524    -5.02371765418548e-05
%0.999999998738104    -0.000100473248904395
%0.999999997160754    -0.000150708217083659
%0.999999994952489    -0.000200942081075688
%0.999999974447912    -0.000452094838088734
%0.999999938172523    -0.000703219989827277
%0.999999886128053    -0.000954317535797148
%0.999999818316237    -0.00120538747550466
%0.999999242807642    -0.00246032306286135
%0.999998273375448    -0.00371456841988278
```

do not print the entire vectors t and Y, but include a few values which show where the last three maxima occur

Part (c)

The long term behavior is that it will contiue to repeat until it reaches 0

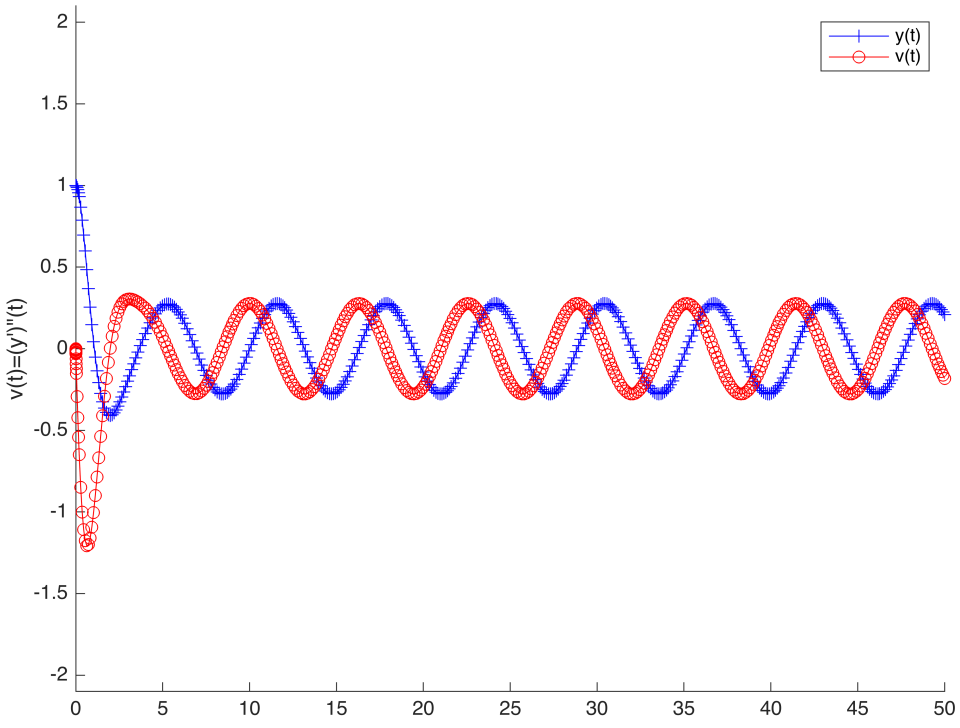
Part (d)

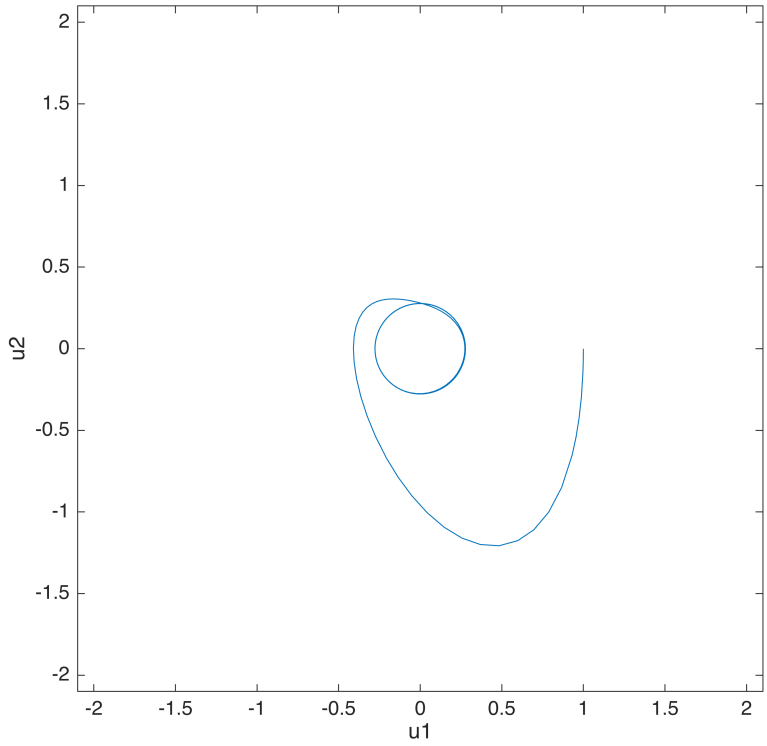
NOTE: *create a file "LAB04ex1d" which is a duplicate of LAB04ex1, but with the initial conditions for y and v changed. figure(1) and figure(2) also need to be changed to figure(3) and igure(4) (in order to plot part a and part d on separate figures so they can be compared). Delete this note upon submission.*

```
type LAB04ex1d
```

```
t0 = 0; tf = 50; y0 = [1;0];

[t,Y] = ode45(@f,[t0,tf],y0);
u1 = Y(:,1); u2 = Y(:,2);    % y in output has 2 columns corresponding to u1 and u2
figure(1);
hold on
plot(t,u1,'b-+'); ylabel('t');
plot(t,u2,'ro-'); ylabel("v(t)=(y')''(t)");
legend("y(t)","v(t)")
ylim([-2.1,2.1])
hold off
figure(2)
plot(u1,u2);
axis square;
xlabel('u1');
ylabel('u2');
ylim([-2.1,2.1])
xlim([-2.1,2.1])
A= [ t,Y(:,1),Y(:,2)]
index= abs(A(:,2,3)) >=.025
 %-----------------------------------------------------------------------
function dydt = f(t,Y)
y = Y(1); v = Y(2);
dydt = [ v ; -sin(t)-2*v-4*y ];
end
```

```
LAB04ex1d
```






```
A = 429×3
         0    1.0000         0
    0.0000    1.0000   -0.0001
    0.0000    1.0000   -0.0001
    0.0000    1.0000   -0.0002
    0.0001    1.0000   -0.0002
    0.0001    1.0000   -0.0005
    0.0002    1.0000   -0.0007
    0.0002    1.0000   -0.0010
    0.0003    1.0000   -0.0012
    0.0006    1.0000   -0.0025
     ⋮
```

The longer term behavior will continue until 0 just like the graphs previuously because they are very simliar start tyhe same way. if you look at the graphs above they are extremely similar.

Exercise 2

Read the instructions in your lab pdf file carefully!

Part (a)

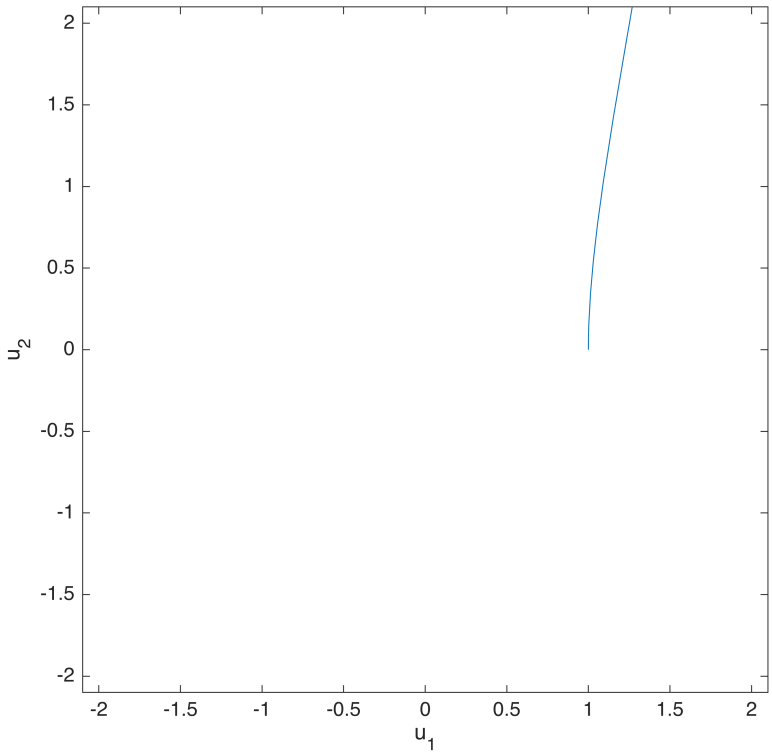
Create a new M-file with the differential equation changed

```
type  LAB04ex2
```

```
t0 = 0;
tf = 50;
y0 = [1,0];
[t,y] = ode45(@f,[t0,tf],y0);
u1 = y(:,1); u2 = y(:,2);
figure(5)
hold on;
plot(t,u1,'b-+')
ylabel('u1');
plot(t,u2,'ro-')
ylabel('v(t)=y(t)');
legend('y(t)','v(t)')
ylim([-2.1,2.1])
hold off
figure(6)
plot(u1,u2);axis square;xlabel('u_1');ylabel('u_2');
ylim([-2.1,2.1])
xlim([-2.1,2.1])
A = [t, y(:,1),y(:,2)];
index = abs(A(:,2:3)) >=.025;
%
function dYdt= f(t,Y)
y=Y(1); v=Y(2);
dYdt = [v;sin(t)+2*(y^2)*v+4*y];
end
```

LAB04ex2

```
Warning: Failure at t=6.580930e-01.  Unable to meet integration tolerances without reducing the
step size below the smallest value allowed (1.776357e-15) at time t.
```



Part (b)

they are very similar to the previous questions however in the short term they are larger thne get smaller faster

Part (c)

long term behavior of both end with it eventually making it to zero, the oclations contiue to get smaller and smller unitl it reeaches zero.

Part (d)

You will have to create another M-file, LAB04ex2d.

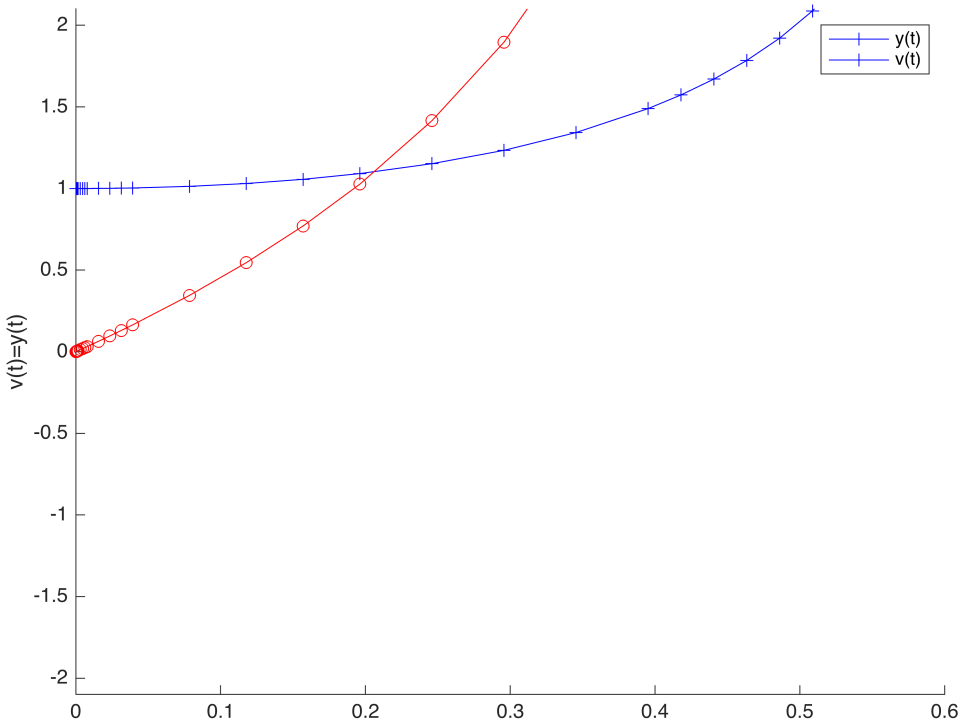
NOTE: *there should only be ONE output plot for the code you write in LAB04ex2d. The plot should superimposes solutions for y(t) from euler.m and ode45. Include a legend to label each solution. Delete this note upon submission.*

```
type LAB04ex2d
```

```
t0=0;tf=50;y0=[1,0];
[t,y]=ode45(@f,[t0,tf],y0);
[te,ye]=euler(@f,[t0,tf],y0,500);
u1=y(:,1);u2=y(:,2);
figure(7)
hold on
plot(t,u1,'b-+')
ylabel('u1');
plot(t,u2,'ro-')
ylabel('v(t)=y(t)');
legend('y(t)','v(t)')
ylim([-2.1,2.1])
hold off
figure(8)
plot(u1,u2);axis square;xlabel('u_1');ylabel('u_2');
ylim([-2.1,2.1])
xlim([-2.1,2.1])
A = [t, y(:,1), y(:,2)];
index = abs(A(:,2:3)) >=.025;
%-----------------------------------------------
function dYdt= f(t,Y)
y=Y(1); v=Y(2);
dYdt = [v;sin(t)+2*(y^2)*v+4*y];
end
function [t,y] = euler(f,tspan,y0,N)
m= length(y0);
t0=tspan(1);
tf=tspan(2);
h=(tf-t0)/N;
t=linspace(t0,tf,N+1);
y=zeros(m,N+1);
y(:,1)=y0';
for n=1:N
    y(:,n+1)=y(:,n)+h*f(t(n),y(:,n));
end
t=t';y=y';
end
```

```
LAB04ex2d
```

```
Warning: Failure at t=6.580930e-01.  Unable to meet integration tolerances without reducing the
step size below the smallest value allowed (1.776357e-15) at time t.
```



The solutions are not identical but very similar, if you increase the value of N the ocsilations get smaller faster and the graph becomes more precise.

Exercise 3

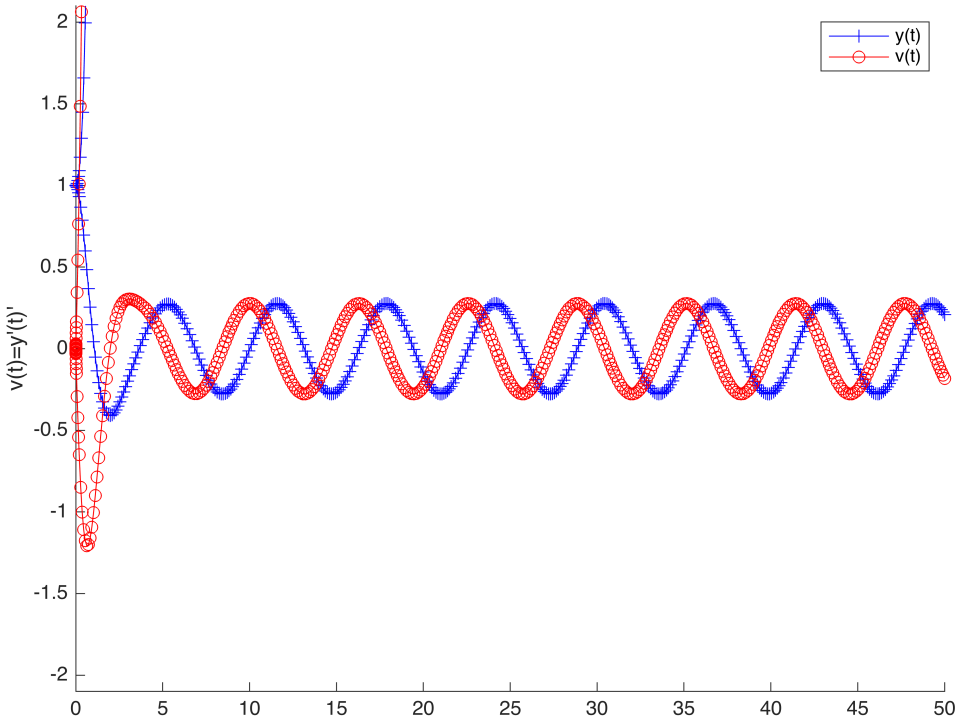
NOTE: *the code for this part should be very similar to what you wrote for EX1-A. You just need to modify the system of differential equations. It's OK if you get an error message. Delete this note upon submission.*

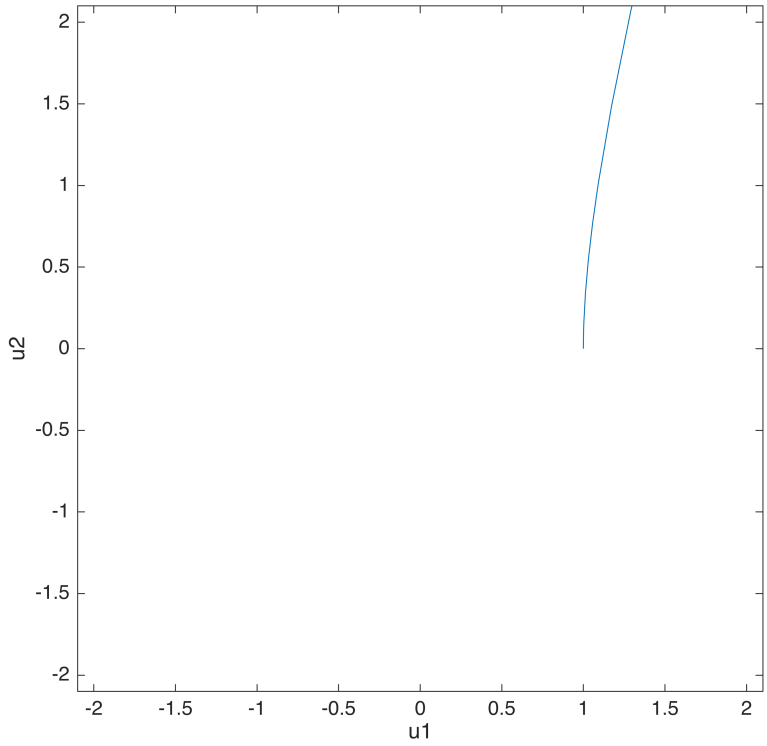
```
type LAB04ex3
```

```
t0 = 0; tf = 50; y0 = [1;0];
[t,Y] = ode45(@f,[t0,tf],y0);
u1 = Y(:,1); u2 = Y(:,2);

figure(1)
hold on;
plot(t, u1, 'b-+');ylabel('u1');
plot(t, u2, 'ro-');ylabel("v(t)=y'(t)'")
legend('y(t)', 'v(t)');
ylim([-2.1, 2.1]);
hold off;

figure(2)
plot(u1, u2)
axis square;
```

```
xlabel('u1');
ylabel('u2');
ylim([-2.1, 2.1]);
xlim([-2.1, 2.1]);

A = [t, Y(:,1), Y(:,2)];
index = abs(A(:,2:3)) >= 0.025;

%-----------------------------------------------------------------------
function dydt = f(t,Y)
    y = Y(1); v = Y(2);
    dydt = [ v ; sin(t)+2*v+4*y ];
end
```

LAB04ex3





The behavior of the solution is similar to that of 7.

matlab is not giving me any warnings until problem 4

Exercise 4

NOTE: *this code should also be very similar to what you wrote for EX1-A and EX3. When defining the function f at the bottom of your LAB04ex4.m file, dYdt now needs to be a column with THREE elements. LAB04ex4 should include commands which reproduce the plots shown in the lab4 document. Delete this note upon submission.*

```
type LAB04ex4
```

```
t0 = 0 ; tf=50; y0= [0,0,.5];
[t,y]=ode45(@f,[t0,tf],y0);
u1 = y(:,1);u2=y(:,2);u3=y(:,3);
figure(1)
hold on
plot(t,u1,'b-+');ylabel('u1');
plot(t,u2,'ro-');ylabel("v(t)=y'(t)'");
plot(t,u3,'k-');ylabel("3v(t)=y3(t)'");
legend('y(t)','v(t)')
ylim([-2.1,2.1])
hold off
figure(2)
plot3(u1,u2,u3);
hold on
view([-40,60])
xlabel('y');ylabel('v=y');zlabel('w=y');
```

```
ylim([-2.1,2.1])
xlim([-2.1,2.1])
A=[t,y(:,1),y(:,2)];
index=abs(A(:,2:3)) >=.025;
function dYdt = f(t,Y)
y=Y(1); v = Y(2); w=Y(3);
dYdt = [v;w;cos(t)+2*(y^2)*w+4*v];
end
```

LAB04ex4

```
Warning: Failure at t=1.716672e+00.  Unable to meet integration tolerances without reducing the
step size below the smallest value allowed (3.552714e-15) at time t.
```