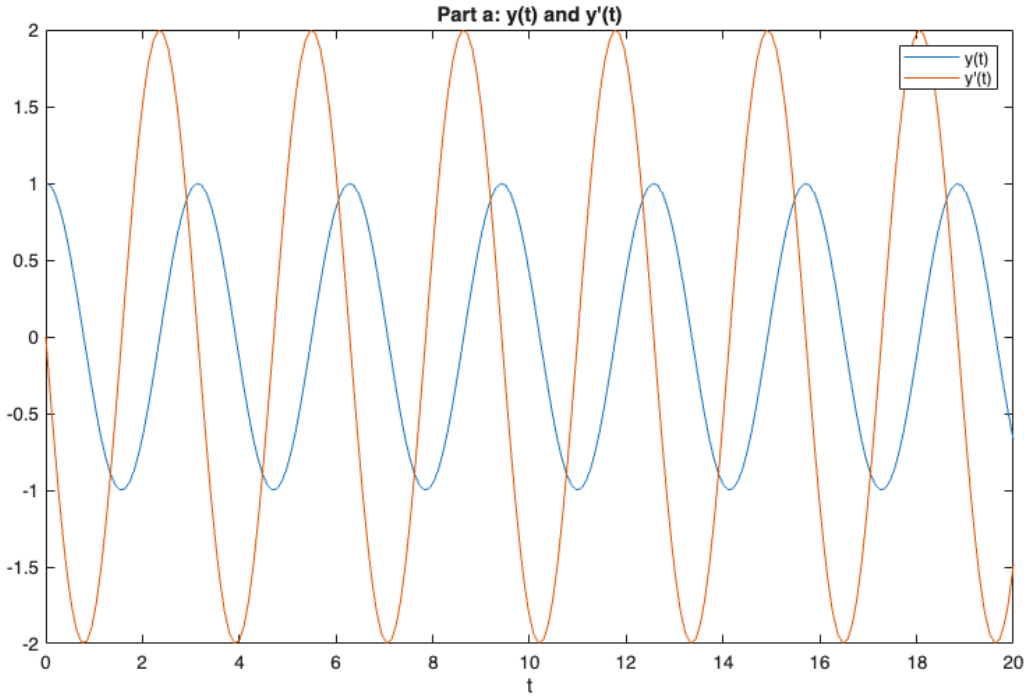
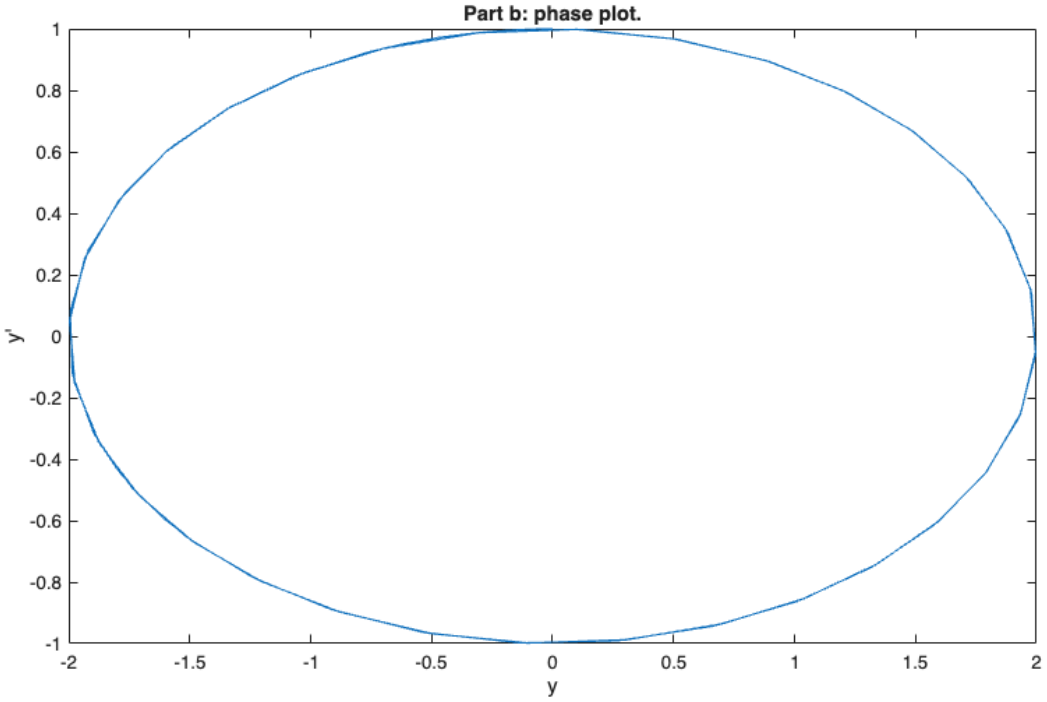
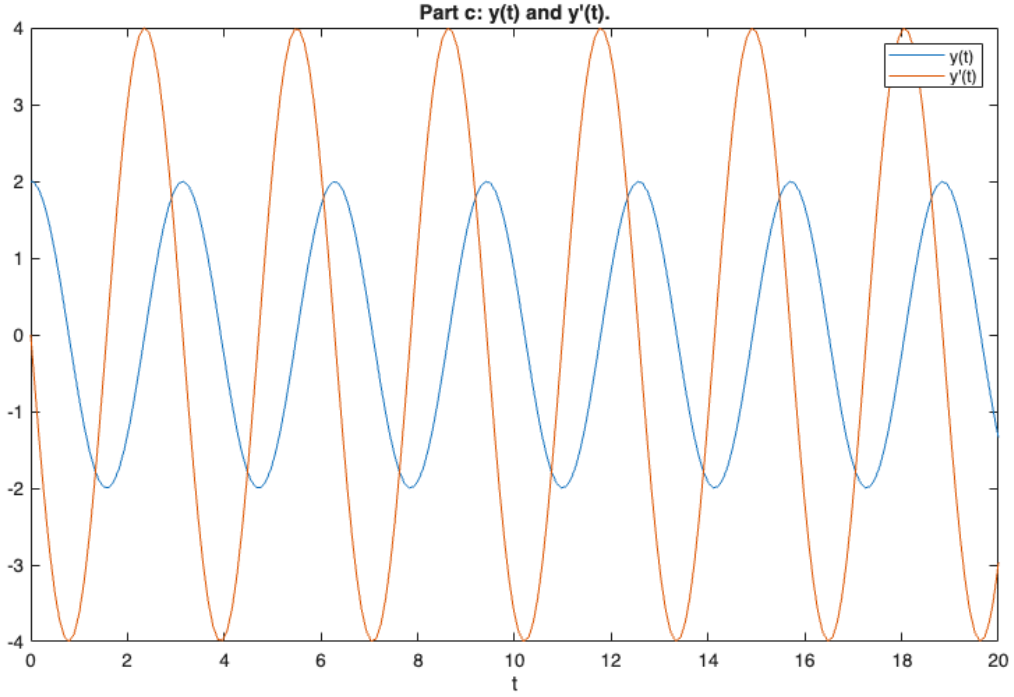
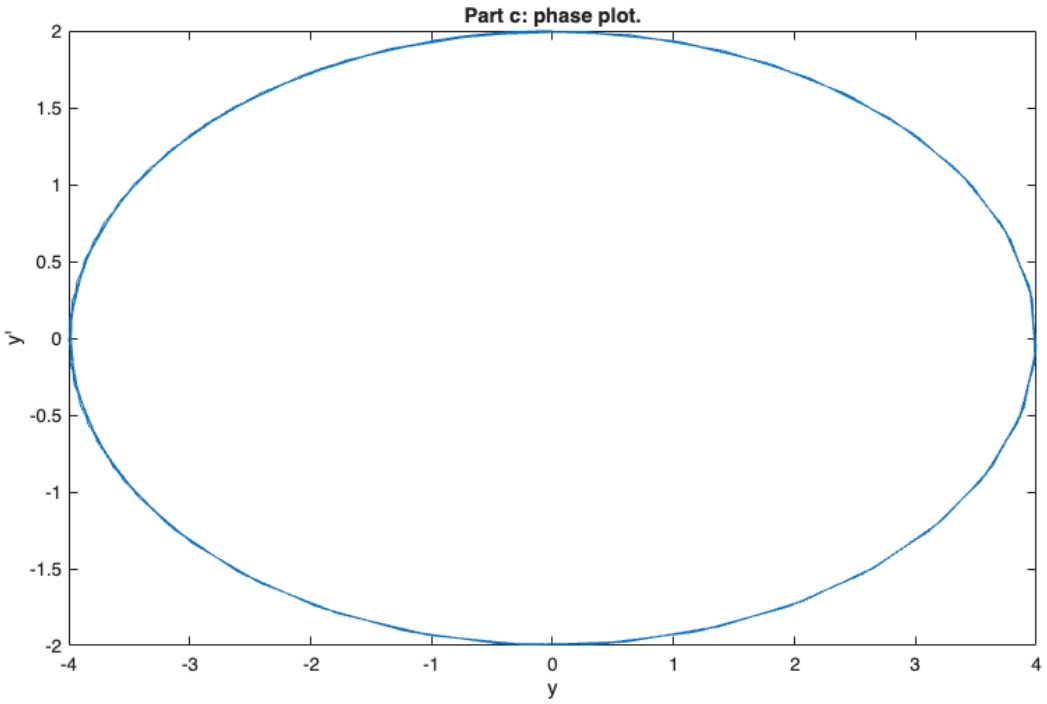
```
%==========Solution to Sim03Q1==========%

clc % clear command window
clear all % remove all variables from workspace
close all % close all figures

% given: y''+4y = 0
% set: y_1 = y
% set: y_2 = y'
% convert differential equation: y_2'+4y_1 = 0
% solve for y_2' = -4y_1
% obtain system:
% y_1' = y_2
% y_2' = -4y_1

% define column vector f(t,[y_1;y_2]) = [y_2; -4y_1]
f = @(t,y) [y(2); -4*y(1)];

% define tspan 0 <= t <= 30
tspan = [0 20];

%----------Q1a----------%

% initial value y_1(0) = 1 and y_2(0) = 0 for solution
y0 = [1;0];

% solve dy/dt = f(t,y) with y(0) = [1;0]
[t,y] = ode45(f, tspan,y0);

% plot y and y' against t
figure % new figure window
plot(t,y(:,1)) % plot y(t) against t
hold on
plot(t,y(:,2)) % plot y'(t) against t
xlabel("t") % label the x-axis as t
legend("y(t)","y'(t)") % label the graphs in the order they were plotted
title("Part a: y(t) and y'(t)") % indicate that this is y and y' versus t

%----------Q1b----------%

% plot y' against y
figure % new figure window
plot(y(:,2),y(:,1)) % plot y'(t) against y(t)
xlabel("y") % label the x-axis as y
ylabel("y'") % label the y-axis as y'
title("Part b: phase plot.") % indicate that this is the phase plot

%----------Q1c----------%

% redefine initial values y_1(0) = 2 and y_2(0) = 0 for solution
y0 = [2;0];
```

```
% solve dy/dt = f(t,y) with y(0) = [1;0]
[t,y] = ode45(f, tspan,y0);

% plot y and y' against t
figure % new figure window
plot(t,y(:,1)) % plot y(t) against t
hold on
plot(t,y(:,2)) % plot y'(t) against t
xlabel("t") % label the x-axis as t
legend("y(t)","y'(t)") % label the graphs in the order they were plotted
title("Part c: y(t) and y'(t).") % indicate that this is y and y' versus t

% plot y' against y
figure % new figure window
plot(y(:,2),y(:,1)) % plot y'(t) against y(t)
xlabel("y") % label the x-axis as y
ylabel("y'") % label the y-axis as y'
title("Part c: phase plot.") % indicate that this is the phase plot
```




Part b: phase plot.
y'
y
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2


Part c: y(t) and y'(t).
y(t)
y'(t)
t
4
3
2
1
0
-1
-2
-3
-4
0
2
4
6
8
10
12
14
16
18
20



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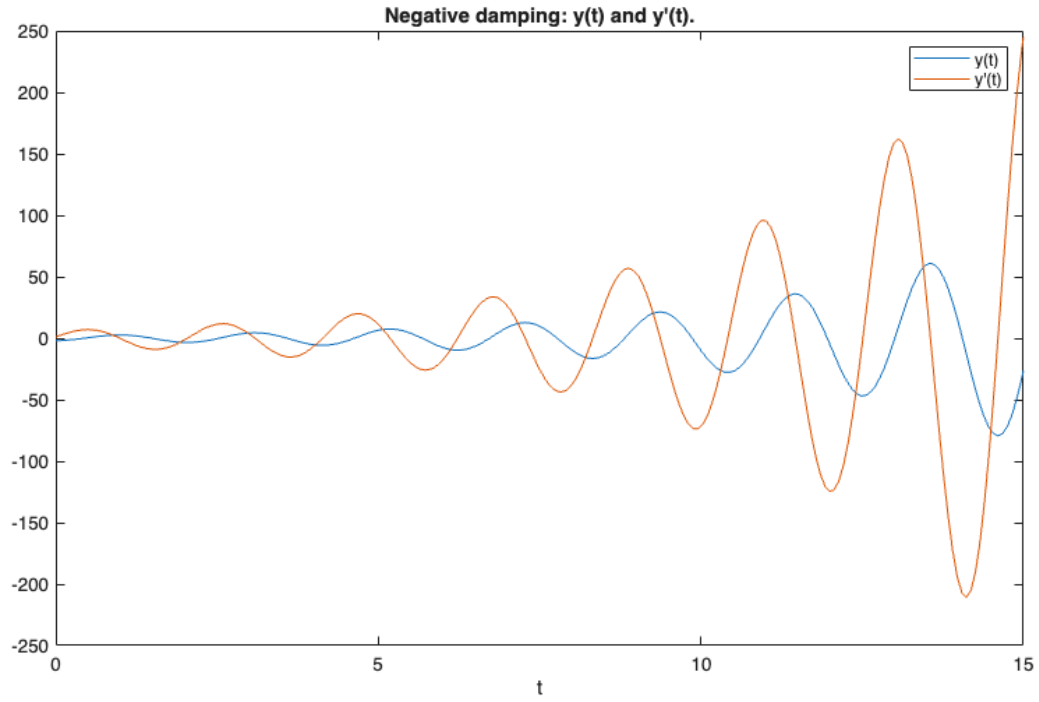
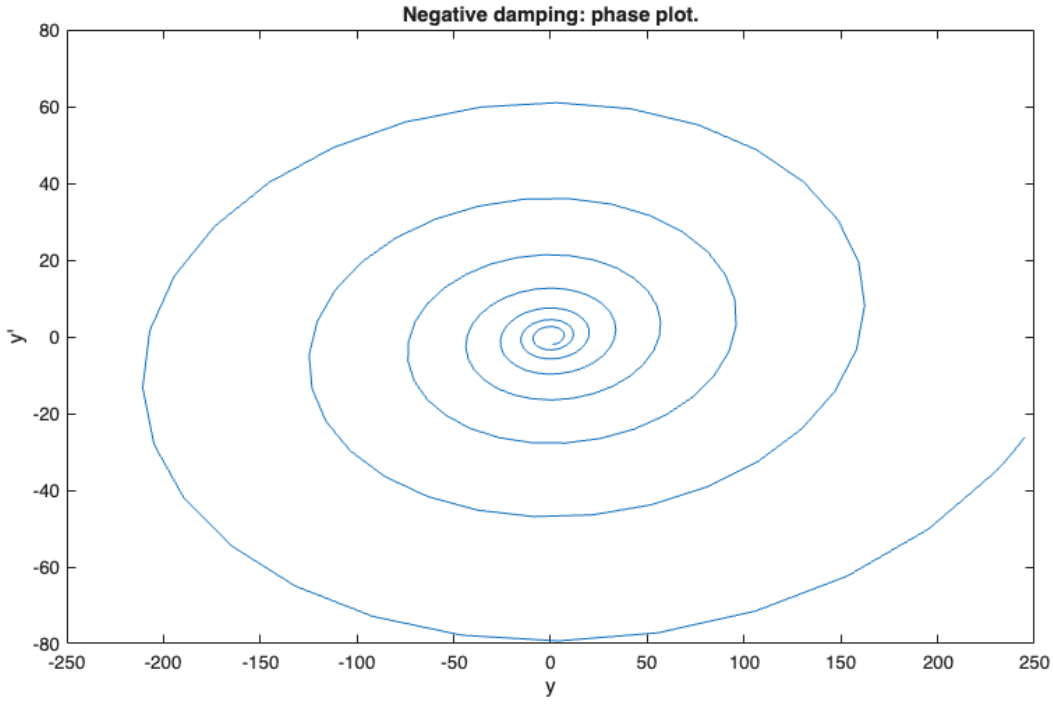
```
%==========Solution to Sim03Q2==========%

clc % clear command window
clear all % remove all variables from workspace
close all % close all figures

% given: 16y''+ay'+145y = 0
% set: y_1 = y
% set: y_2 = y'
% convert differential equation: 16y_2'+ay_2+145y_1 = 0
% solve for y_2' = -(145/16)y_1-(a/16)y_2
% obtain system:
% y_1' = y_2
% y_2' = -(145/16)y_1-(a/16)y_2

% define column vector f(t,[y_1;y_2]) = [y_2; -(145/16)y_1-(a/16)y_2]
f = @(t,y,a) [y(2); -(145/16).*y(1)-(a/16).*y(2)];

% define tspan 0 <= t <= 15
tspan = [0 15];

% initial value y_1(0) = -2 and y_2(0) = 1 for solution
y0 = [-2;1];

%----------Q1a----------%

% negative damping: a = -8
fnegdamp = @(t,y) f(t,y,-8)

% solve dy/dt = f(t,y) with y(0) = [-2;1]
[t,y] = ode45(fnegdamp, tspan,y0);

% plot y and y' against t
figure % new figure window
plot(t,y(:,1)) % plot y(t) against t
hold on
plot(t,y(:,2)) % plot y'(t) against t
xlabel("t") % label the x-axis as t
legend("y(t)","y'(t)") % label the graphs in the order they were plotted
title("Negative damping: y(t) and y'(t).") % indicate that this is y and y'
versus t

%----------Q1b----------%

% plot y' against y
figure % new figure window
plot(y(:,2),y(:,1)) % plot y'(t) against y(t)
xlabel("y") % label the x-axis as y
ylabel("y'") % label the y-axis as y'
title("Negative damping: phase plot.") % indicate that this is the phase plot

%----------Q1c----------%
```

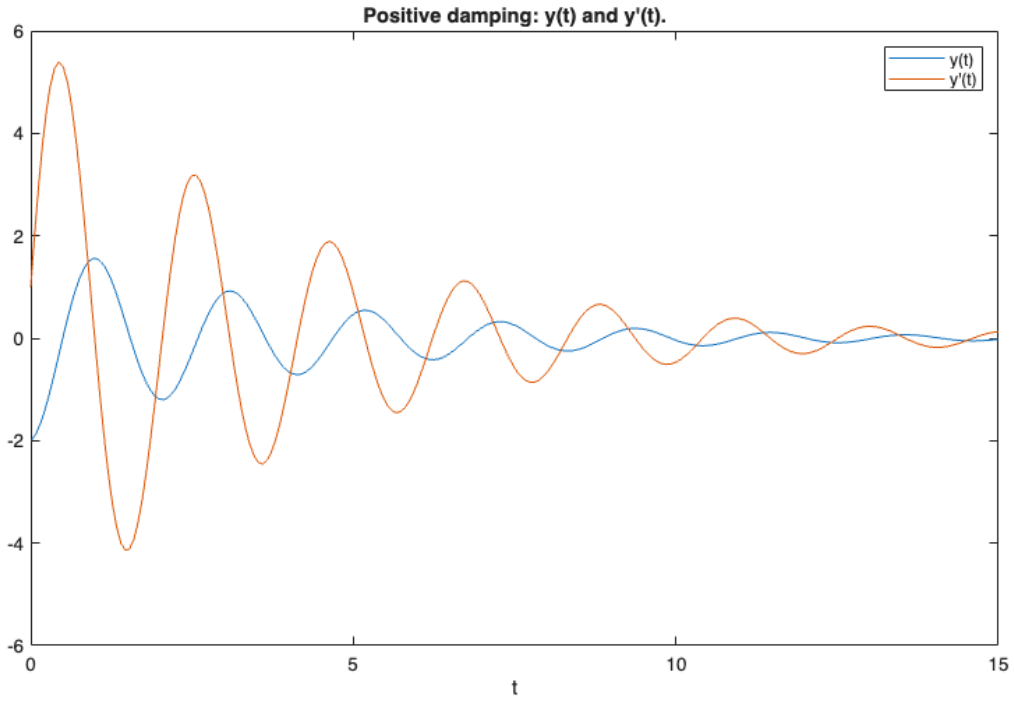
```
% positive damping: a = 8
fposdamp = @(t,y) f(t,y,8)

% solve dy/dt = f(t,y) with y(0) = [1;0]
[t,y] = ode45(fposdamp, tspan,y0);

% plot y and y' against t
figure % new figure window
plot(t,y(:,1)) % plot y(t) against t
hold on
plot(t,y(:,2)) % plot y'(t) against t
xlabel("t") % label the x-axis as t
legend("y(t)","y'(t)") % label the graphs in the order they were plotted
title("Positive damping: y(t) and y'(t).") % indicate that this is y and y'
versus t

% plot y' against y
figure % new figure window
plot(y(:,2),y(:,1)) % plot y'(t) against y(t)
xlabel("y") % label the x-axis as y
ylabel("y'") % label the y-axis as y'
title("Positive damping: phase plot.") % indicate that this is the phase plot
```

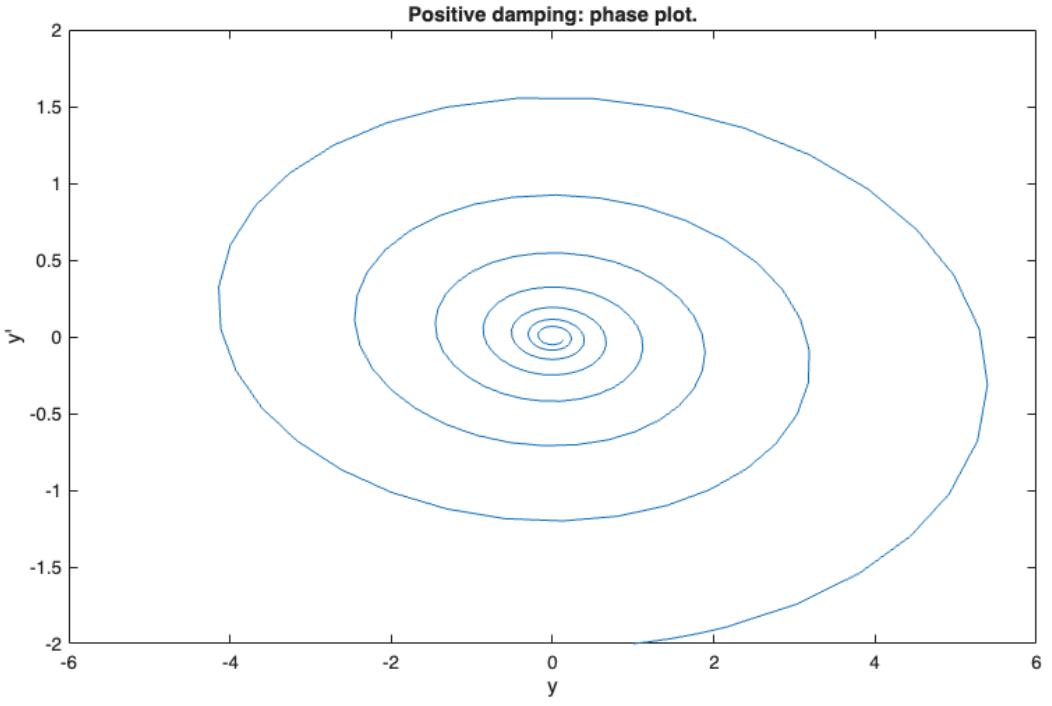
```
fnegdamp =

  function_handle with value:

    @(t,y)f(t,y,-8)
```

```
fposdamp =

  function_handle with value:

    @(t,y)f(t,y,8)
```


Negative damping: y(t) and y'(t).
y(t)
y'(t)
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
5
10
15
t


Negative damping: phase plot.
80
60
40
20
0
-20
-40
-60
-80
y'
-250
-200
-150
-100
-50
0
50
100
150
200
250
y





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