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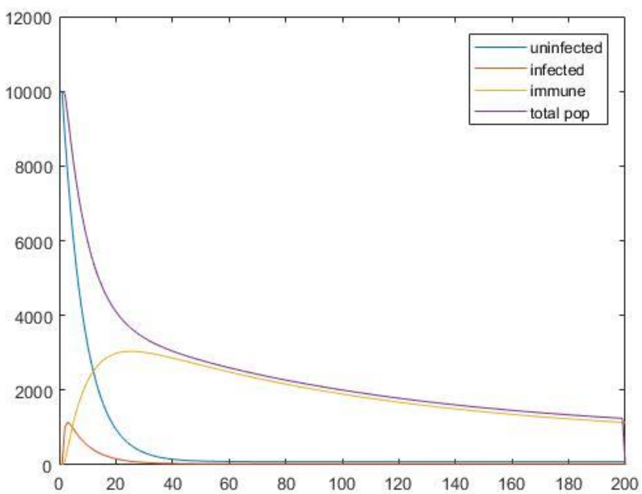
EE 362K

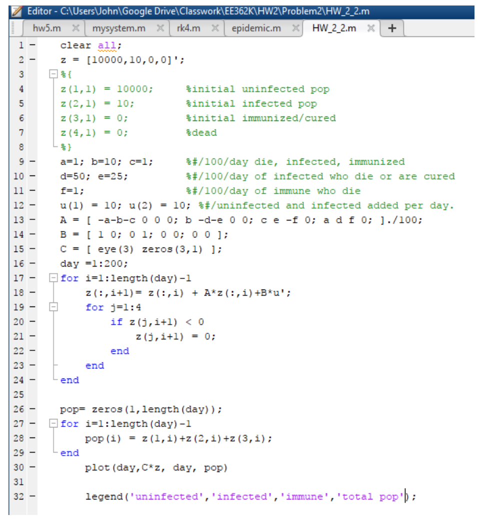
HW 2

1.) I completed the exercises

2.)

Code and Graph for part 1 (modification of code)



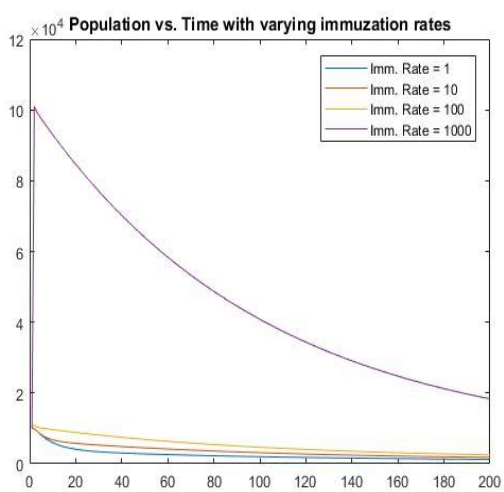


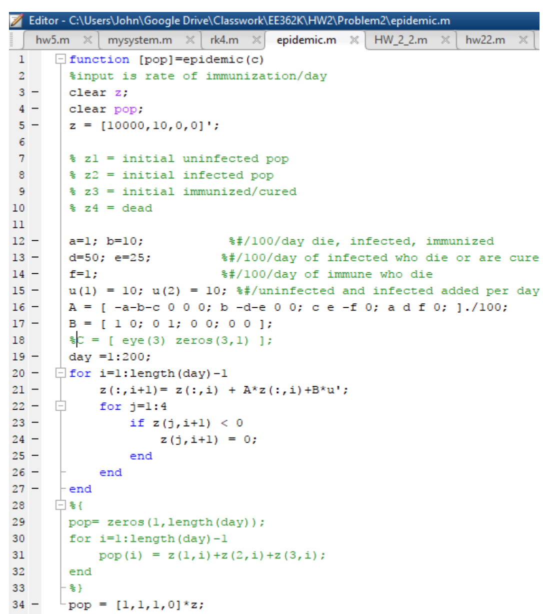

```
clear all;
z = [10000,10,0,0]';
%{
z(1,1) = 10000;     %initial uninfected pop
z(2,1) = 10;        %initial infected pop
z(3,1) = 0;         %initial immunized/cured
z(4,1) = 0;         %dead
%}
a=1; b=10; c=1;     %#/100/day die, infected, immunized
d=50; e=25;         %#/100/day of infected who die or are cured
f=1;                %#/100/day of immune who die
u(1) = 10; u(2) = 10; %#/uninfected and infected added per day.
A = [ -a-b-c 0 0 0; b -d-e 0 0; c e -f 0; a d f 0; ]./100;
B = [ 1 0; 0 1; 0 0; 0 0 ];
C = [ eye(3) zeros(3,1) ];
day =1:200;
for i=1:length(day)-1
    z(:,i+1)= z(:,i) + A*z(:,i)+B*u';
    for j=1:4
        if z(j,i+1) < 0
            z(j,i+1) = 0;
        end
    end
end

pop= zeros(1,length(day));
for i=1:length(day)-1
    pop(i) = z(1,i)+z(2,i)+z(3,i);
end
    plot(day,C*z, day, pop)

    legend('uninfected','infected','immune','total pop');
```

Code and Graph for part 2 (pop vs imm. rates)






```
function [pop]=epidemic(c)
%input is rate of immunization/day
clear z;
clear pop;
z = [10000,10,0,0]';

% z1 = initial uninfected pop
% z2 = initial infected pop
% z3 = initial immunized/cured
% z4 = dead

a=1; b=10;              %#/100/day die, infected, immunized
d=50; e=25;            %#/100/day of infected who die or are cure
f=1;                   %#/100/day of immune who die
u(1) = 10; u(2) = 10; %#/uninfected and infected added per day
A = [ -a-b-c 0 0 0; b -d-e 0 0; c e -f 0; a d f 0; ]./100;
B = [ 1 0; 0 1; 0 0; 0 0 ];
%C = [ eye(3) zeros(3,1) ];
day =1:200;
for i=1:length(day)-1
    z(:,i+1)= z(:,i) + A*z(:,i)+B*u';
    for j=1:4
        if z(j,i+1) < 0
            z(j,i+1) = 0;
        end
    end
end
%{
pop= zeros(1,length(day));
for i=1:length(day)-1
    pop(i) = z(1,i)+z(2,i)+z(3,i);
end
%}
pop = [1,1,1,0]*z;
```

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Editor - C:\Users\John\Google Drive\Classwork\EE362K\HW2\Problem2\hw22.m

hw5.m | mysystem.m | rk4.m | epidemic.m | HW_2_2.m | hw22.m

```
%hw 2 problem 2

t = 1:200;
plot(t,epidemic(1),t,epidemic(10),t,epidemic(100),t,epidemic(1000));
title('Population vs. Time with varying immuzation rates')
legend('Imm. Rate = 1', 'Imm. Rate = 10', 'Imm. Rate = 100', 'Imm. Rate = 1000');
```

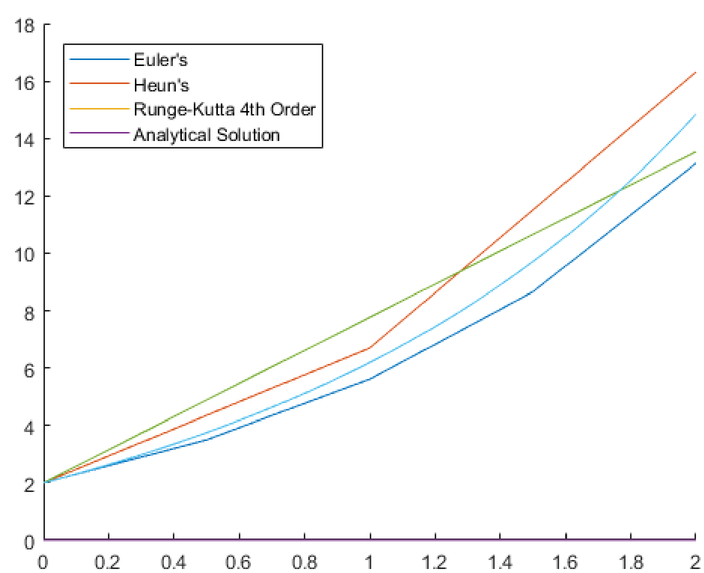
3.)

a.) x(2) = 13.1334

b.) x(2) = 16.3198

c.) x(2) = 13.5388

d.) graph and code



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```
function [y] = eulers

% This function solves equations of the type dy/dt = f(y, t)
% Method: y(new) = y(old) + slope * step size


% First define variables
clear t
clear y

h = 0.5;          % Step size
t = 0:h:2;

y = zeros(1, length(t));   % y = a vector
y(1) = 2;        % y(IC) = y0

for i = 1: length(t)-1
    phi = 4*exp(0.8*t(i)) - 0.5 * y(i);
    y(1, i+1) = y(1, i) + phi * h;
end


plot(t,y,'b:'); hold on;
```

```
function [y] = heuns

% This function solves equations of the type dy/dt = f(y, t)
% Method: y(new) = y(old) + slope * step size


% First define variables
clear t; clear y;

h = 1;           % Step size
t = 0:h:2;
y = zeros(1, length(t));   % y = a vector
y(1,1) = 2;        % y(IC) = y0

for i = 1: length(t)-1
    si = 4*exp(0.8*t(i)) - 0.5*y(1,i);        % si is the slope at beg of interval
    y(1, i+1) = y(1,i) + si*h;              % find y(i+1) w/ si
    sf = 4*exp(0.8*(t(i+1))) - 0.5*y(1,i+1);  % estimate final slope
    phi = (si+sf)/2;                        % let slope be avg between i/f
    y(i+1) = y(i) + phi*h;
end

plot(t,y, 'r--'); hold on;
```

```
function [y] = rk4

clear y;
h=2;
t = 0:h:2;
y = zeros(1,length(t));
y(1)=2;              %Initial Condition
F_ty = @(t,y)  (4)*exp(0.8*t) - 0.5*y;

for i=1:length(t)-1
    k1 = F_ty(t(i), y(i));
    k2 = 2 * F_ty(t(i) + 0.5*h, y(i) + 0.5*h*k1);
    k3 = 2 * F_ty(t(i) + 0.5*h, y(i) + 0.5*h*k2);
    k4 = F_ty(t(i) + h, y(i) + h*k3);
    y(i+1) = y(i) + (k1 + k2 + k3 + k4)/6;
end

plot(t,y, 'g-.*'); hold on;
```

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```
function [yt]=yt

t = linspace(0,2);
yt = (4/1.3)*(exp(0.8*t)-exp(-0.5*t)) + 2*exp(-0.5*t);

plot(t, yt, 'c');
```

```
function hw3

eulers;
heuns;
rk4;
yt;
legend('show','Location','northwest');
legend('Euler''s','Heun''s','Runge-Kutta 4th Order','Analytical Solution');
hold off;
```

4.)

Something is wrong with these numbers… I went back over code. Ran out of time.

y(2.5) = 18.657 by runge kutta

y(2.5) = 7.9102 by analysis

absolute error = 1.36

```
function [error] = hw4

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% HW question 4 - Error calculation of RK4 analysis of ODE (f_ty) and
% analytical solution (f_t = y)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

f_ty = @(t,y) (1+t)*sqrt(y);            %%ODE
tf = 2.5;
h = 2.5;
ic = 1;


[t1, y1] = rk4(f_ty,h,tf,ic);              %%RK4 approximation of solution
n = length(t1);
rkans = y1(n);
f_t = @(t) ((t+(t.^2)/2)/2).^2;
ans = f_t(2.5);
error = abs((f_t(2.5) - rkans))/f_t(2.5);
```

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```
function [t,y]=rk4(F_ty,h,tf,ic)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Pass in an ODE F_ty and a step size h, this method returns two
% vectors, t and y which you can plot as classical fourth order Runge Kutta
% solutions to your ODE F_ty
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%


clear y;
t = 0:h:tf;                        %Time span of interest
y = zeros(1,length(t));
y(1)=ic;                         %Initial Condition

for i=1:length(t)-1
    k1 = F_ty(t(i), y(i));
    k2 = 2 * F_ty(t(i) + 0.5*h, y(i) + 0.5*h*k1);
    k3 = 2 * F_ty(t(i) + 0.5*h, y(i) + 0.5*h*k2);
    k4 = F_ty(t(i) + h, y(i) + h*k3);
    y(i+1) = y(i) + (k1 + k2 + k3 + k4)/6;
end
```

5.)

HW2 Problem 5

Wednesday, September 20, 2017 6:40 PM

Convert ODE to S.S. Form: $\dddot{x} + 3\ddot{x} + 0.5\dot{x} + 4x = u(t)$

Consider $u(t) = 0$

Then;

$$z_1 = x \qquad \dot{z}_1 = z_2$$
$$z_2 = \dot{x} \longrightarrow \dot{z}_2 = z_3$$
$$z_3 = \ddot{x} \qquad \dot{z}_3 = -4z_1 - 0.5z_2 - 3z_3$$

So;

$$\frac{d\bar{z}}{dt} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -4 & -0.5 & -3 \end{bmatrix} \bar{z}$$

Then, we are looking for z_1 ($z_1 = x$) at $t=4$

Running the code below shows $\boxed{z_1 = 0.1373 \times 10^{-3} \text{ for 1 step and, } z_1 = 0.5824 \times 10^{-3} \text{ for 4 steps}}$

```
clear all

h = 1;
tf = 4;
clear y;
t = 0:h:tf;                    %Time span of interest
y = zeros(3,1,length(t));
y(:,:,1)= [1,1,1]';                      %Initial Condition

dy = @(y) [0,1,0;0,0,1;-4,-0.5,-3]*y(:,:);

%k's become vectors, so

for i=1:length(t)-1
    k1 = dy(y(:,:,i));
    k2 = 2 * dy(y(:,:,i) + 0.5*h*k1);
    k3 = 2 * dy(y(:,:,i) + 0.5*h*k2);
    k4 = dy(y(:,:,i) + h*k3);
    y(:,:,i+1) = y(:,:,i) + (k1 + k2 + k3 + k4)/6;
end
```

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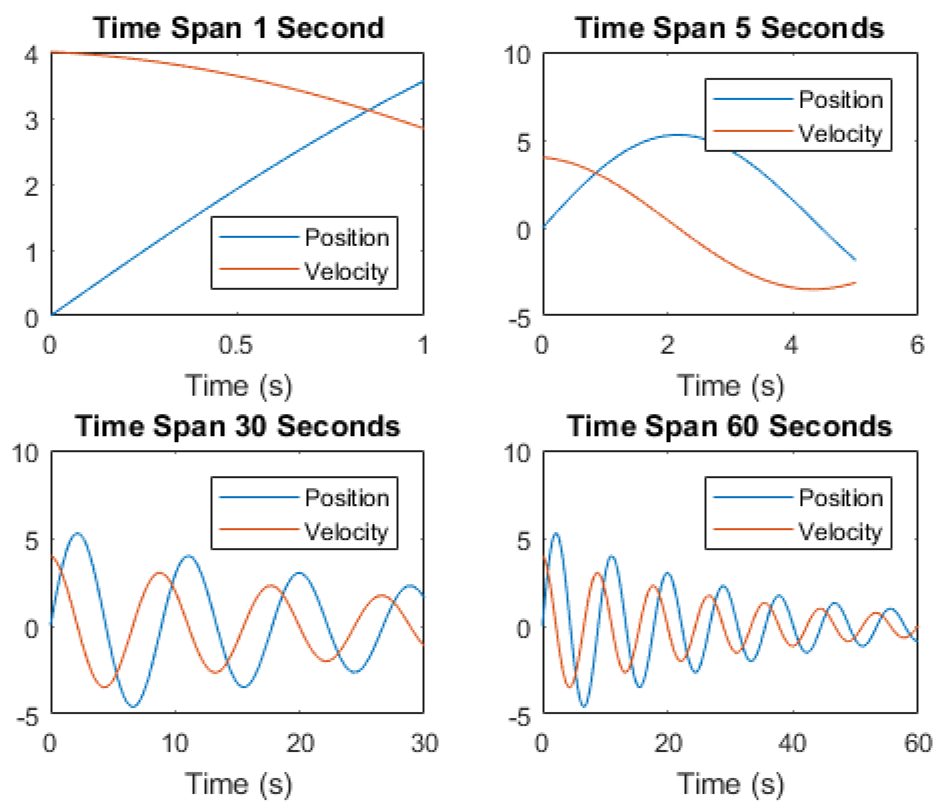
```
function zprime=mysystem(t,z)

zprime = [z(2);z(3);-4*z(1) - 0.5*z(2) - 3*z(3)];
%zprime is a column vector
```

6.)

First graph, k = 2



Second graph, k =4

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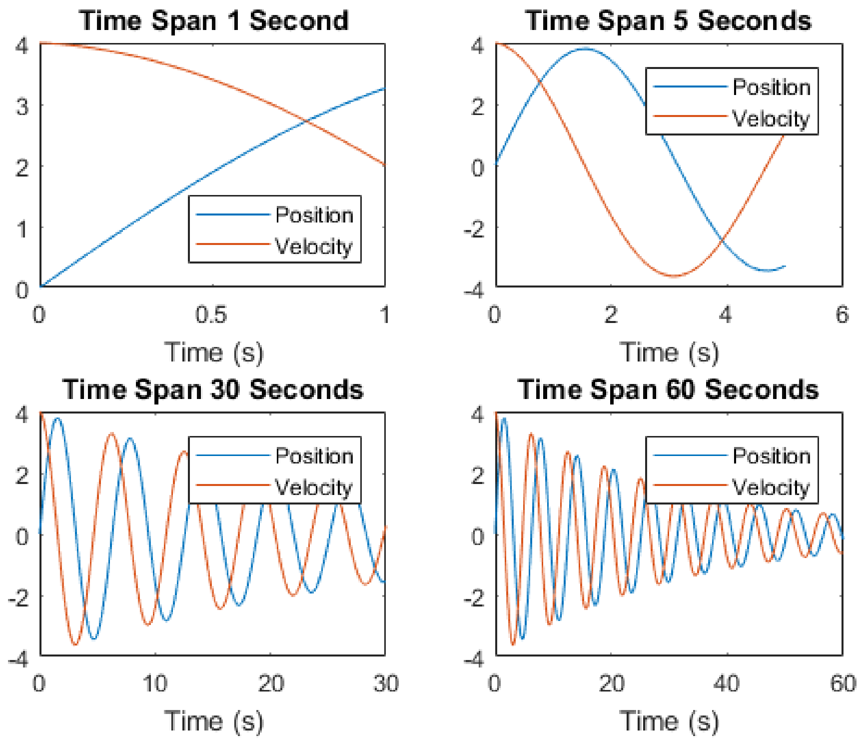

Code:

```
function zprime = MSD(t,z)
k = 4;
b = 0.25;
m = 4;
zprime = [z(2); -k/m*z(1)+ -b/m*z(2)];
```

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```
function hw6

%first round of subplots for k = 2;
subplot(2,2,1);
[t,y] = ode45(@MSD,[0 1],[0 4]);
plot (t,y(:,1),t,y(:,2))
xlabel('Time (s)')
legend('Position','Velocity', 'Location','southeast')
title('Time Span 1 Second')

clear t; clear y;
subplot(2,2,2);
[t,y] = ode45(@MSD,[0 5],[0 4]);
plot (t,y(:,1),t,y(:,2))
xlabel('Time (s)')
legend('Position','Velocity', 'Location','northeast')
title('Time Span 5 Seconds')

clear t; clear y;
subplot(2,2,3);
[t,y] = ode45(@MSD,[0 30],[0 4]);
plot (t,y(:,1),t,y(:,2))
xlabel('Time (s)')
legend('Position','Velocity', 'Location','northeast')
title('Time Span 30 Seconds')

clear t; clear y;
subplot(2,2,4);
[t,y] = ode45(@MSD,[0 60],[0 4]);
plot (t,y(:,1),t,y(:,2))
xlabel('Time (s)')
legend('Position','Velocity', 'Location','northeast')
title('Time Span 60 Seconds')
```

For the final plot, I changed the mass to 20 kg. As expected it increased the settling time of the system. It also increased the amplitude of the position, and decreased velocity.

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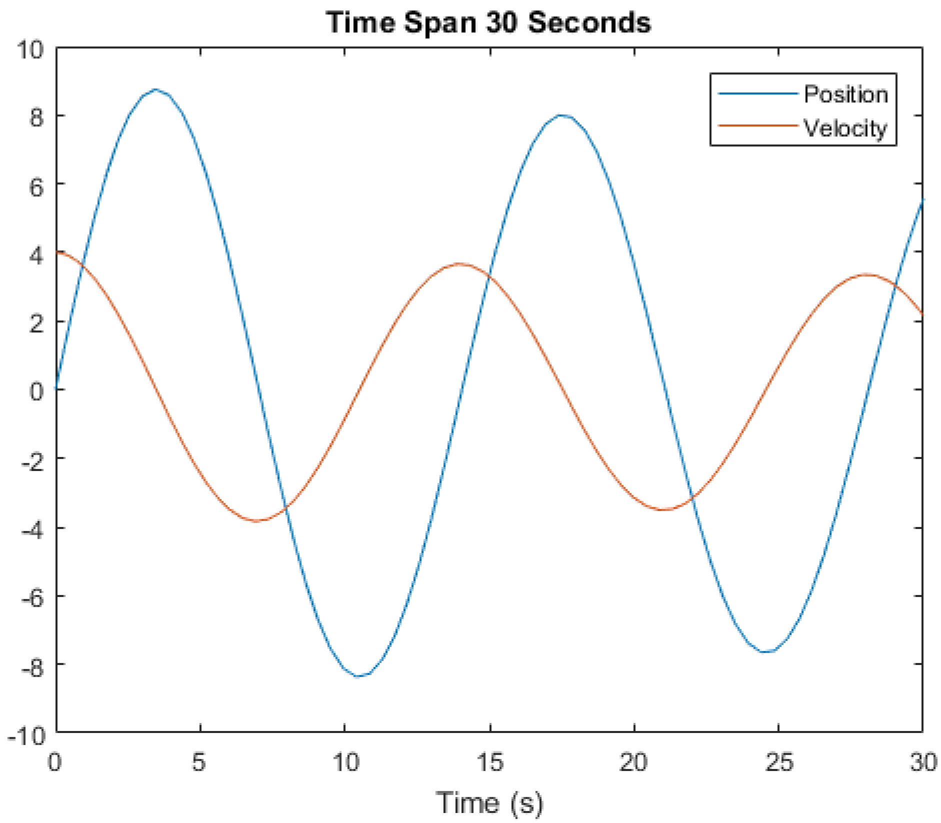

7.) Please see attached sheet.

8.)