

LEVEL 5 ASSESSMENT SPECIFICATION

Student name:	Carys Williams	Student ID number:	
Programme:	HND/HNC Electrical/Electronic Engineering, HNC Instrumentation Engineering & HNC Power System Engineering		
Module:	Electrical Principles, Methods and Simulation		
Module code:	PSDE5009	Contribution to Overall Module Assessment (%):	50%
Lecturer:	Jason Pointer	Internal Verifier:	Steve Roberts
Assignment Title:	Control Systems	Word count (or equivalent):	2000
Submission deadline:	16/05/19	Return date of provisional marks & written feedback:	
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

1. Analyse and evaluate electrical circuits, electronic systems and **control systems**.
2. Simulate standard electrical circuits, electronic systems and **control systems**.

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	0	0
2. Knowledge and Understanding Skills	30	20.2
Achieved 75% for Task 1. Achieved 75% for Task 2. Achieved 56% for Task 3. Achieved 65% for Task 4. Achieved 65% for Task 5. Knowledge is reasonably extensive and accurate in most parts. Show a very good understanding of most concepts and principles covered by this assignment but not all of the elements were covered for some of the task.		
3. Cognitive and Intellectual Skills	10	4
Some evaluation and analysis of concepts and principles, though descriptive in parts.		
4. Practical Application Skills	50	34.8
Achieved 72% for Task 1. Achieved 76% for Task 2. Achieved 60% for Task 3. Achieved 68% for Task 4. Achieved 72% for Task 5. A very good application of established methods in the use of Matlab, Multisim and Simulink but in places not all of the required work was produced.		
5. Transferable Skills for Life and Professional Practice	10	5
Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed.		

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)

Late Submission Penalties (tick if appropriate)

Up to 1 week late (40% Max)

Over 1 week late (0%)

64%

Course Title: HND Electrical/Electronic Engineering
Module: Electrical Principle, Methods and Simulation
Assignment Number: 2
Assignment Title: Control Systems
Student Name: Carys Williams
Student Number: 110538
Date: 16/05/2019
Lecturer Name: Jason Pointer

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Task 1

This task is all about RC circuits in first order systems. Figure 1 shows a RC circuit that can be analysis using time and frequency response.

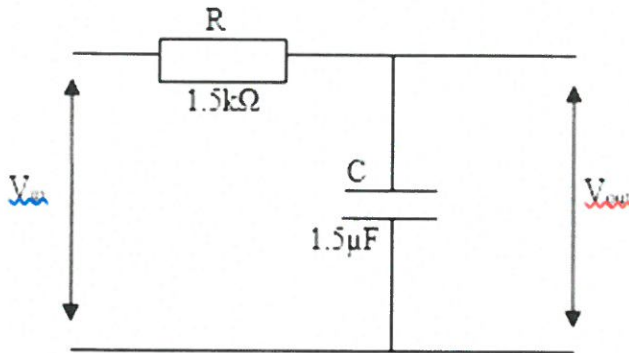


Figure 1

a) Below shows the equation used to determine the transfer function for the circuit.

$$\text{Voltage, } R = Ri(t)$$

$$\text{Voltage, } C = \frac{1}{C} \int i(t) dt$$

$$\text{Kirchhoff law: } Ri(t) + \frac{1}{C} \int i(t) dt = V_{in}(t)$$

Taking the first derivative on both sides above

$$R \frac{di(t)}{dt} + \frac{1}{C} i(t) = \frac{dV_{in}(t)}{dt}$$

Using Laplace transform, the series electric RC circuit can be modelled by

$$sRI(s) + \frac{I(s)}{C} = sV_{in}(s) \approx I(s) \left[sR + \frac{1}{C} \right] = sV_{in}(s) \approx I(s) \left[R + \frac{1}{Cs} \right] = V_{in}(s)$$

$$V_{in}(s) = I(s) \left[R + \frac{1}{Cs} \right] \text{ (Equation (1))}$$

$$V_{out} = \frac{1}{C} \int i(t) dt$$

$$\frac{dV_{out}}{dt} = \frac{i(t)}{C}$$

Using Laplace transform

$$sV_{out}(s) = \frac{I(s)}{C}$$

$$I(s) = sV_{out}(s) \times C$$

Sub into equation (1)

$$V_{in}(s) = sV_{out}(s) \times C \left[R + \frac{1}{Cs} \right] \approx \frac{V_{in}(s)}{V_{out}(s)} = sC \left[R + \frac{1}{Cs} \right] = CRs + 1$$

So

$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{1}{CRs + 1}$$

Divide top and bottom by **CR**

$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{1/CR}{s + 1/CR}$$

To convert into a function of time take inverse Laplace transforms:

$$\frac{V_{out}(t)}{V_{in}(t)} = \frac{1}{CR} \times e^{-\frac{t}{CR}}$$

$$V_{out}(t) = V_{in}(t) \times \frac{1}{CR} e^{-\frac{t}{CR}}$$

- b) This task shows the time response plot when 20V DC is applied at V_{in} . The calculation for the time constant, delay time and rise time where all made on multisim. This is how the response RC circuit graph was created.

```
% First order response of a RC circuit.  By - Carys Williams

% Input value for Resistor, capacitor and voltage
- R = input('Enter the Resistance value:'); %Value R = 3.3*10^3
- C = input('Enter the Capacitor value:'); %Value C = 22*10^-6
- V = input('Enter the Voltage value:'); %Value V = 30

% Calculate time constant
- tC = R * C;

%Delay Time
- dT = -tC*log(0.5);

%Rise Time
- rT = tC*(log(0.9)-log(0.1));

% Set initial conditions
- t = 0;
- Vout = 0;

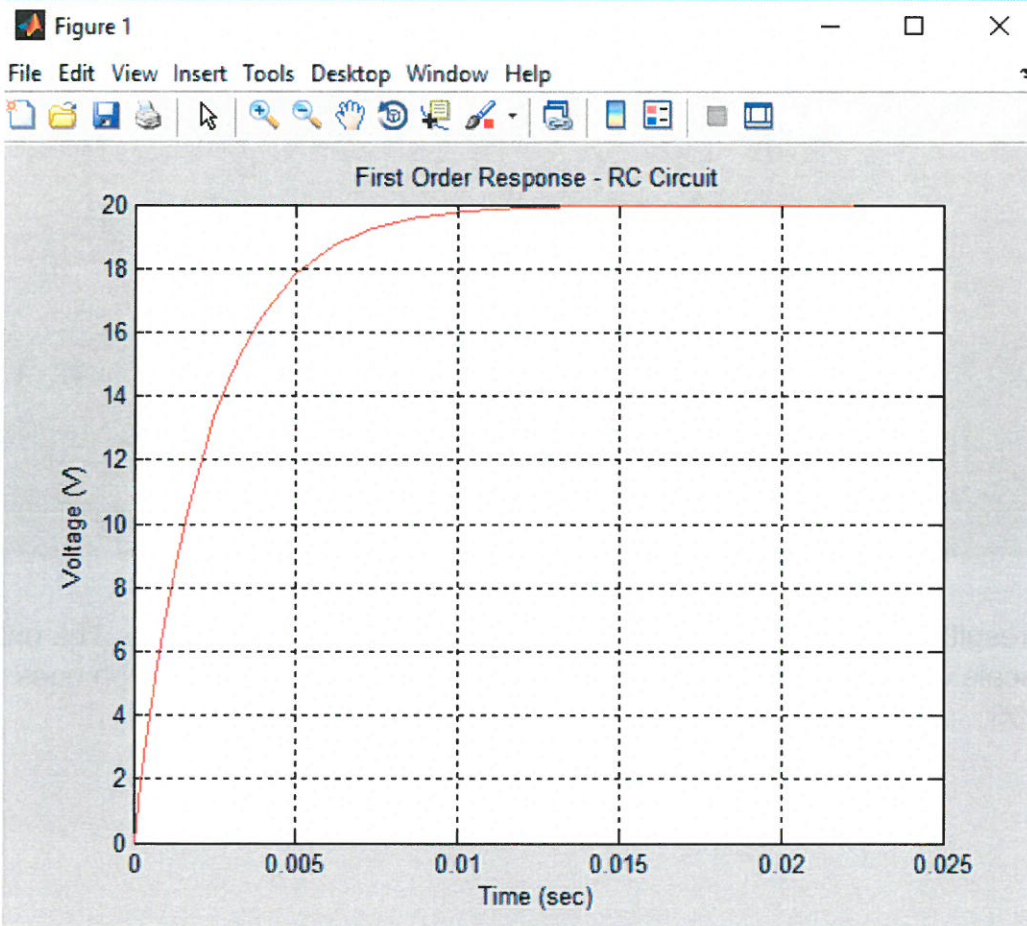
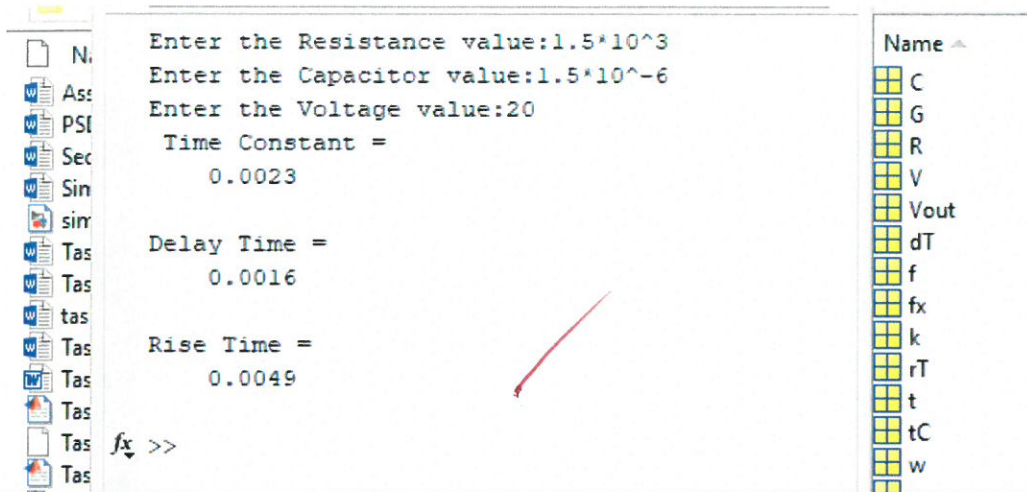
% Determine the output voltage for t
- for k = 1:100
-     t(k)=(k-1)*tC/10;
-     Vout(k)=V*(1-exp(-t(k)/tC));
- end;

% Display the Vout against time
- plot(t,Vout,'r-');
- title('First Order Response - RC Circuit')
- xlabel('Time (sec)')
- ylabel('Voltage (V)')
- grid

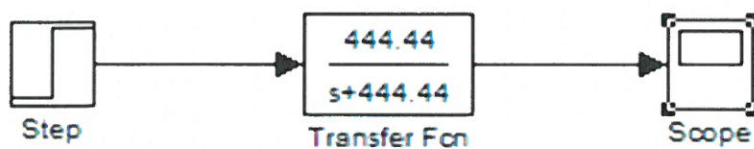
%Time Constant
- disp(' Time Constant =');
- disp(tC);

%Delay Time
- disp('Delay Time = ');
- disp(dT);

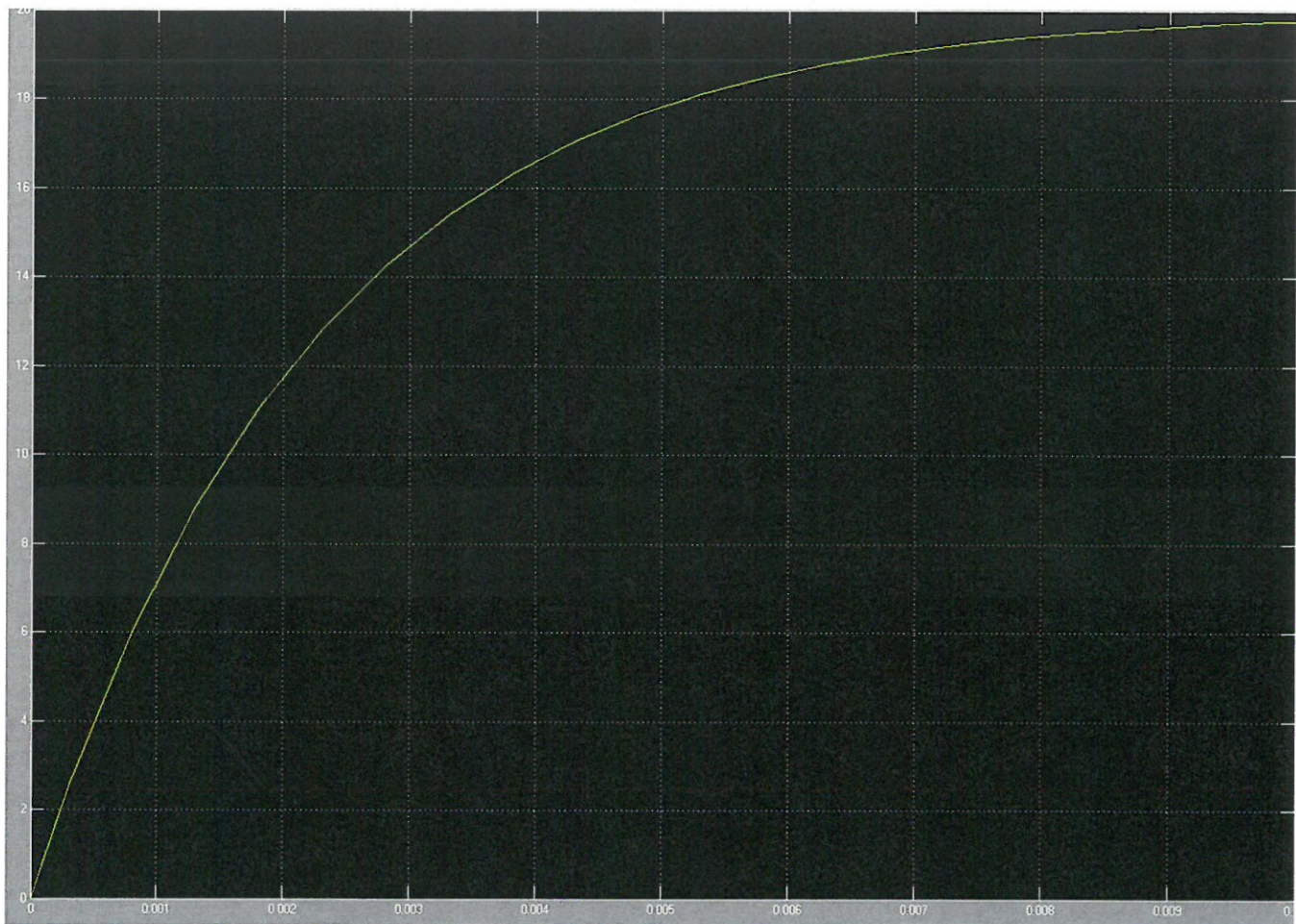
%Rise Time
- disp('Rise Time = ');
- disp(rT);
```



Here is an image of the circuit that was created on Simulink and the equation that was used to calculate the transfer function.



$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{1/2.25 \times 10^{-3}}{s + 1/2.25 \times 10^{-3}} = \frac{444.44}{s + 444.44}$$



When comparing the result from Matlab and Simulink graphs the results are the same. The only difference is that the scale on the Simulink goes across in 0.001 as for the Matlab graph goes up in increments of 0.05.

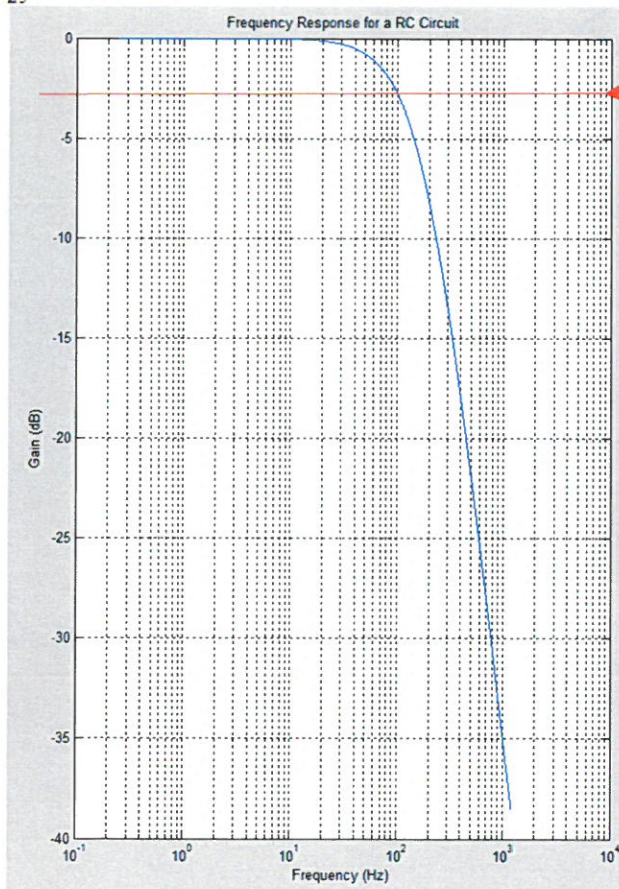
c)

In this section it will determine the cut off frequency. This is shown using Matlab.

```

1  % Obtain the Time Response          By - Carys Williams
2  % Frequency response for a RC circuit with a 1V sine wave
3  % The component values
4  R = 1.5*10^3; C = 1.5*10^-6;      % Component values
5  f=0;                               % Set initial conditions
6
7  %Time Constant
8  tC = R*C;
9
10  fx=0:0.25:1200;
11  z=length(fx);
12  % For loop
13  for x=1:z
14      f=f+0.1;
15
16      % Angular velocity
17      w(x)=2*pi*f;
18
19      % Time response
20      G(x)=20*log(1/(sqrt(1+w(x)^2*tC^2)));
21  end
22
23  % The frequency Response
24  semilogx(fx,G)
25  xlabel('Frequency (Hz)')
26  ylabel('Gain (dB)')
27  title('Frequency Response for a RC Circuit')
28  grid
29

```

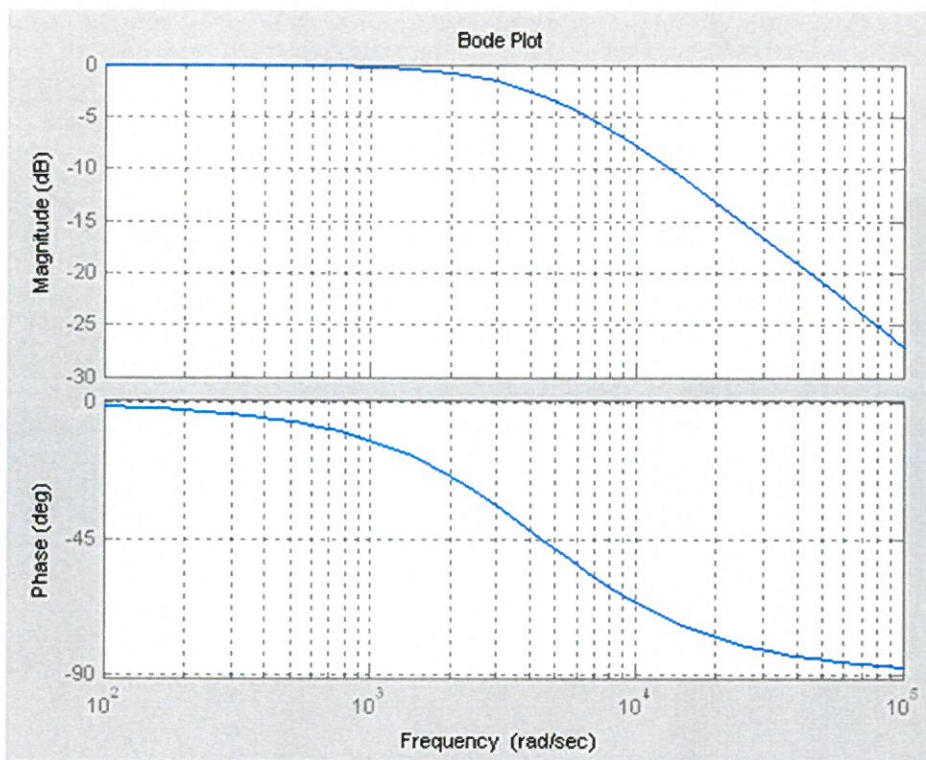


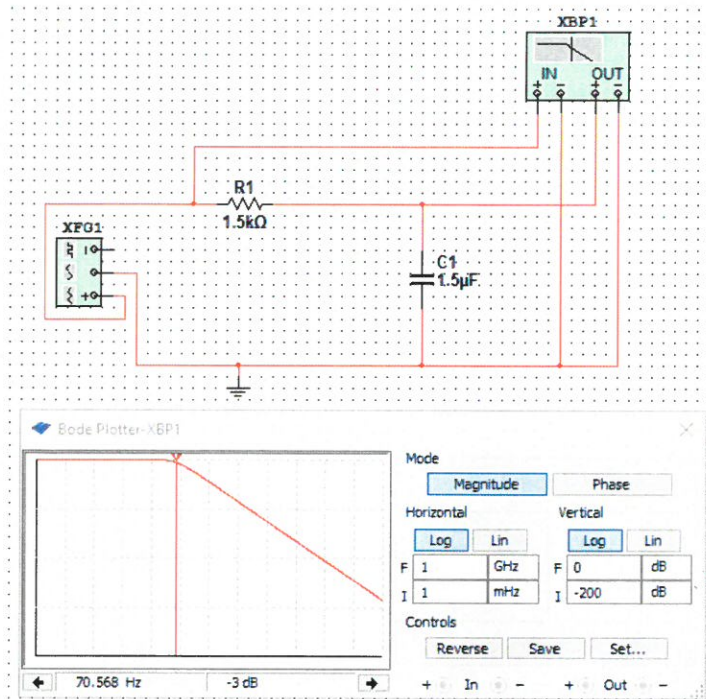
Here is the cut-off point at 100Hz.
Which is roughly around -3 dB.

d)

Here is a screenshot showing the program that was created in order to create the frequency response using a bode plot

```
1      %Task 1 C
2      %Carys Williams
3      %Produce frequency response using bode plot
4
5      %Transfer Function
6 -    G = tf([1],[0.000225,1]);
7
8      %Bode Plot
9 -    bode (G)
10 -    grid
11 -    title ('Bode Plot')
12
```





When comparing the circuit that has been created on multisim and the result from the Matlab there are some difference in the values. Even though they are both at -3dB the frequency for the Matlab is 100Hz and for the multisim it is 70.568Hz.

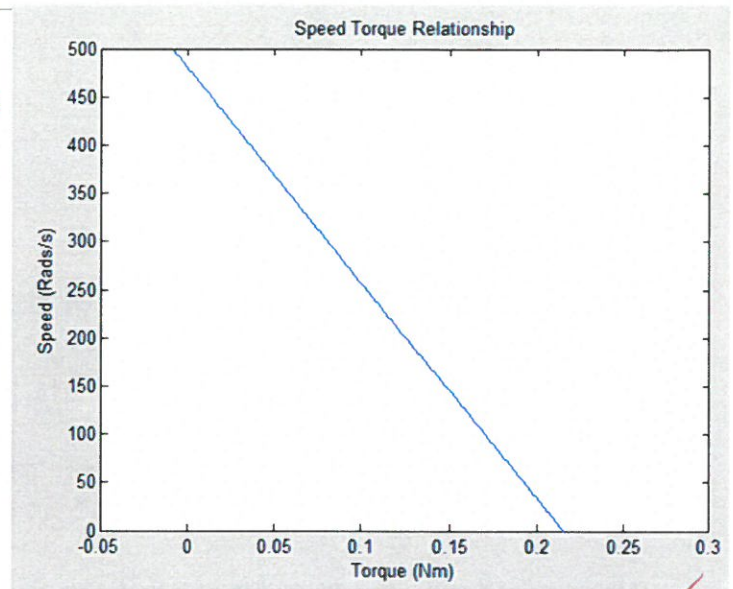
Task 2

a)

```

1  % DC Motor
2  Ra=1.4; Va=12; Ts=0.21453;    % Motor parameters
3
4  km=(Ts*Ra)/Va;                % Calculation of Motor constant
5
6  % MAX speed
7  MS = Va/km;
8
9  % Speed Range
10 W=0:2:500;
11 T=km*(Va-km*W)/Ra;
12
13 % Display of results
14 disp('The Motor Constant, km')
15 disp(km)
16 disp('The Motor Maximum Speed, Rads/s')
17 disp(W)
18 plot(T,W,'b-')
19 xlabel('Torque (Nm)')
20 ylabel('Speed (Rads/s)')
21 title('Speed Torque Relationship')
22

```



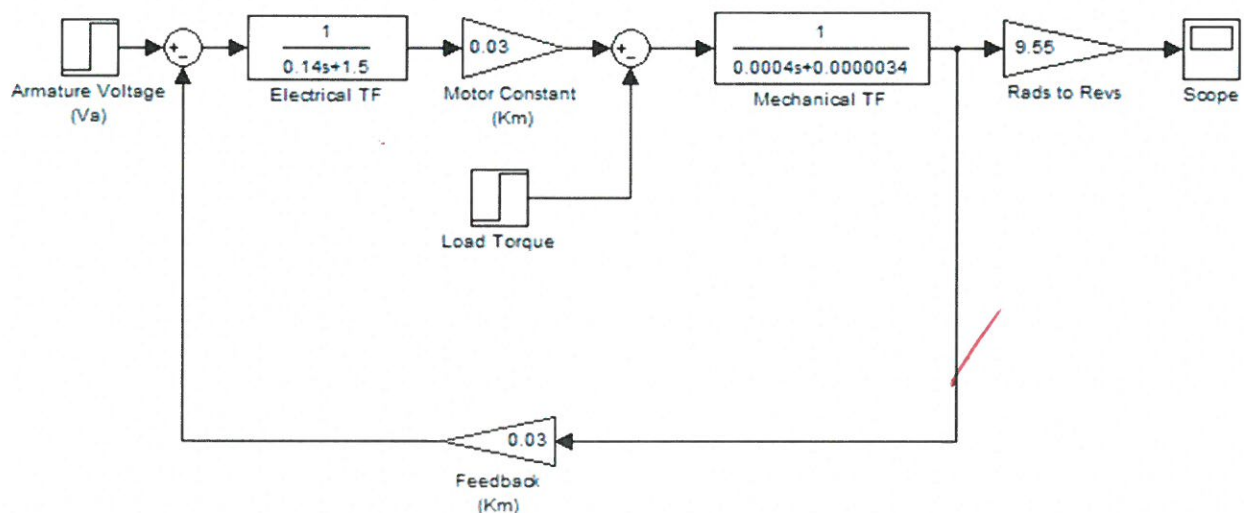
The Motor Constant, km
0.0250

The Motor Maximum Speed, Rads/s
479.4534

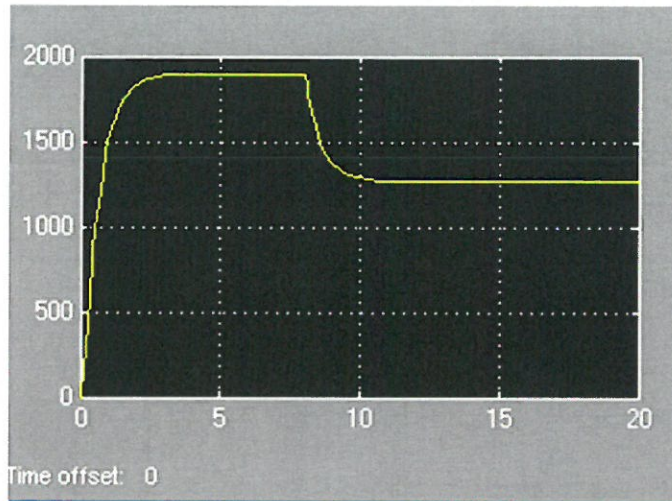
Here is a Matlab program and the graph that was produced after the program ran. And the image to the left shows the values for both motor constant and the maximum speed of the motor.

b)

Here is a screen shot of the armature-voltage controlled DC motor.

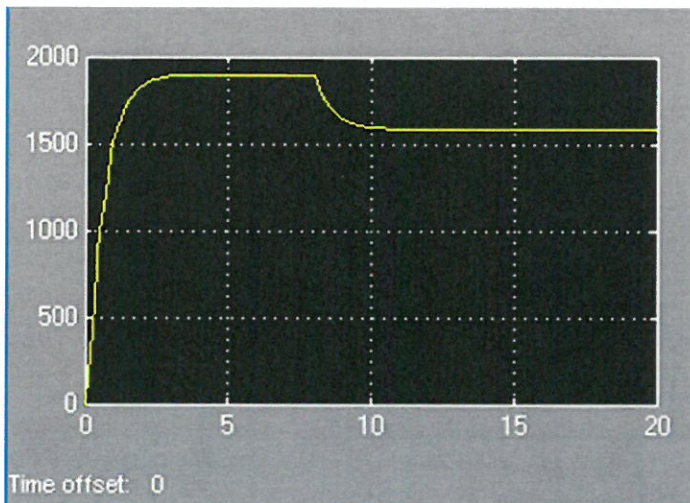


c)



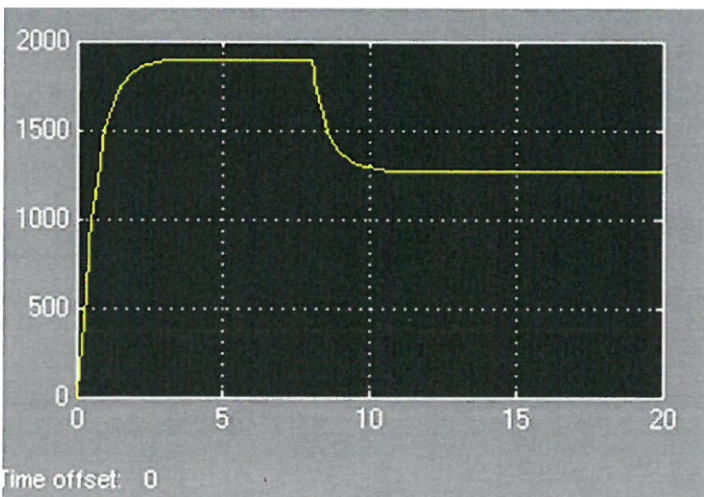
Here is the result of the speed response from the armature-voltage controlled DC motor.

d)



Here is a screen shot showing the steady state angular speeds.

In the first screen shot it shows the result when the load is at 0.02Nm. The steady state speed is around 1600 rpms.

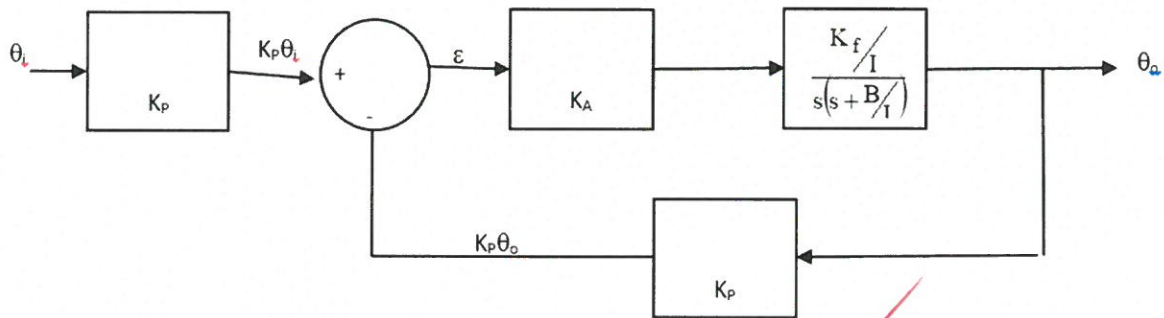


In the screenshot here it shows the result when the load is at 0.04Nm. And the steady state speed is around 1250 rpms.

Task 3

a)

Here is a block diagram that shows a position control servo.



b)

The transfer function is shown below

$$\frac{\theta_o}{\theta_i} = \frac{G(s)}{1 + G(s)H(s)} = G(s) = K_A \times \frac{K_f/I}{s(s + B/I)} = H(s) = K_P$$

Transfer function

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{K_P \times \left(\frac{K_A K_F / I}{s(s + B/I)} \right)}{1 + K_P \times \left(\frac{K_A K_F / I}{s(s + B/I)} \right)} = \frac{\left(\frac{K_P K_A K_F / I}{s^2 + Bs/I} \right)}{1 + \left(\frac{K_P K_A K_F / I}{s^2 + Bs/I} \right)}$$

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{\left(\frac{(s^2 + Bs/I) \times K_P K_A K_F / I}{s^2 + Bs/I} \right)}{(s^2 + Bs/I) \times 1 + \left(\frac{(s^2 + Bs/I) \times K_P K_A K_F / I}{s^2 + Bs/I} \right)} \approx \frac{\theta_o(s)}{\theta_i(s)} = \frac{\left(\frac{K_P K_A K_F}{I} \right)}{s^2 + \left(\frac{Bs}{I} \right) + \left(\frac{K_P K_A K_F}{I} \right)}$$

c)

A unit step input is to be applied to the position control servomechanism and the following parameters are applied:

- $K_A = 1.0$
- $K_P = 5Vr^{-1}$
- $K_f = 8mAV^{-1}$
- $I = 2 \times 10^{-4} Kgm^2$

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{\left(\frac{K_P K_A K_F}{I}\right)}{s^2 + \left(\frac{Bs}{I}\right) + \left(\frac{K_P K_A K_F}{I}\right)} \approx \frac{\theta_o(s)}{\theta_i(s)} = k_{ss} \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{\left(\frac{5 \times 1 \times 8 \times 10^{-3}}{2 \times 10^{-4}}\right)}{s^2 + \left(\frac{Bs}{2 \times 10^{-4}}\right) + \left(\frac{5 \times 1 \times 8 \times 10^{-3}}{2 \times 10^{-4}}\right)} = \frac{200}{s^2 + 5000Bs + 200}$$

$$\omega_n^2 = 200$$

$$\text{Steady state, } k_{ss} = 1$$

$$\text{Natural frequency, } \omega_n = \sqrt{200} = 14.14 \text{ rad/sec}$$

$$2\zeta\omega_n = 5000B$$

$$\text{Critically damping, } \zeta = 1$$

$$2 \times 1 \times 14.14 = 5000B$$

$$B = \frac{28.28}{5000} = 5.66 \times 10^{-3} \text{ N/ms}^{-1}$$

Poles for critically damped

$$(s^2 + 2\omega_n s + \omega_n^2) = 0$$

$$s = -\omega_n, -\omega_n = -14.14$$

```
%Carys Williams
%Task 3 C
%Critical Damping System
```

```
%Create numerator
N = [200]
```

```
%Create Denominator
D = [1 28.28 200];
```

```
% Transfer Function
sys = tf(N,D)
```

```
% Poles
pole(sys)
```

```
% Plotting the Poles
subplot(211), pzmap(sys)
axis([-30 1 -15 15])
```

```
% Plotting response
subplot(212), step(sys)
```

To get started, select [MATLAB Help](#) or [Demos](#) from the Help menu.

N =

200

Transfer function:

200

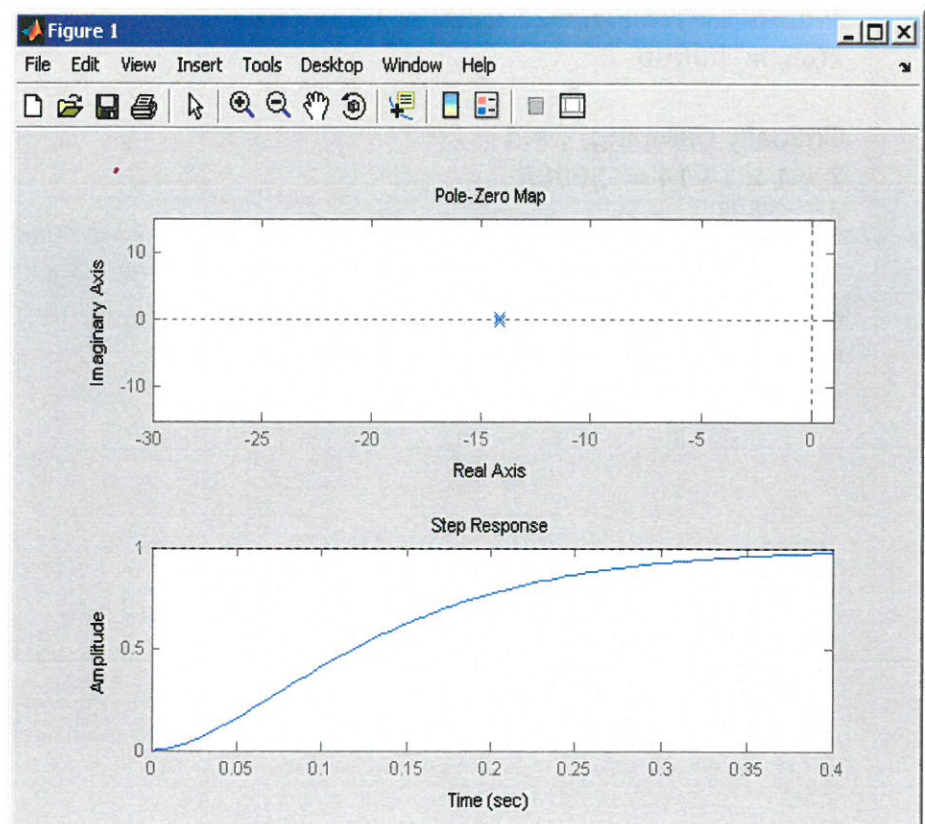
 $s^2 + 28.28 s + 200$

ans =

-14.1400 + 0.2458i

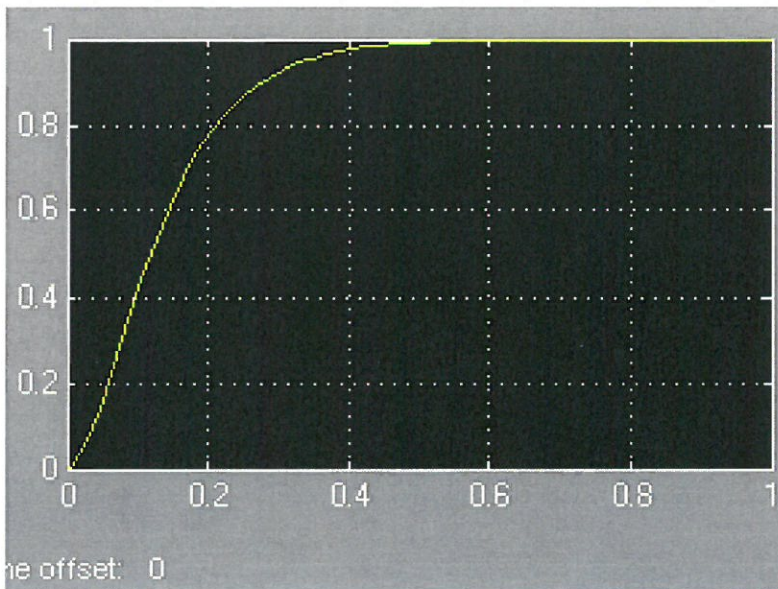
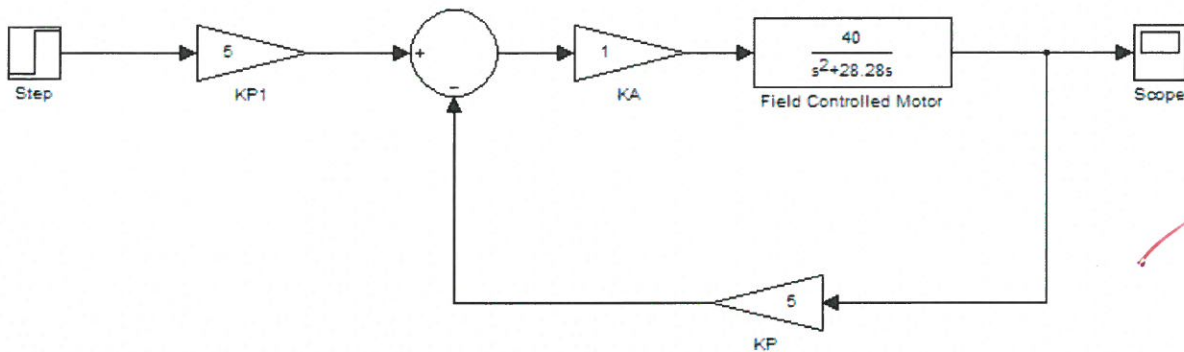
-14.1400 - 0.2458i

>>



d)

The circuit below has been created on Simulink, and the result from the circuit is below as well.



Here is the result from the scope in the circuit. It shows the time response of the system. When comparing the result from Simulink and the result from Matlab the results are very similar.

e)

```
%Carys Williams
%Task 3 E
%Time response and pole plot for differnt values of B

% selecting value for B
B = input('Please Prosent a value for B:');

%this is caculating B/I
BI = B/(2*10^-4);

% Create Numerator
N = [200];

% Create Denominator
D = [1 BI 200];

% Transfer Function
sys = tf(N,D)

% Poles
pole(sys)

% Plotting the Poles
subplot(211), pzmap(sys)
    axis([-50 1 -15 15])

% Plotting the response for an unit step
subplot(212), step(sys)
```

No Damping, B = 0

```
N =
    200

Transfer function:
      200
-----
s^2 + 28.28 s + 200

ans =

-14.1400 + 0.2458i
-14.1400 - 0.2458i

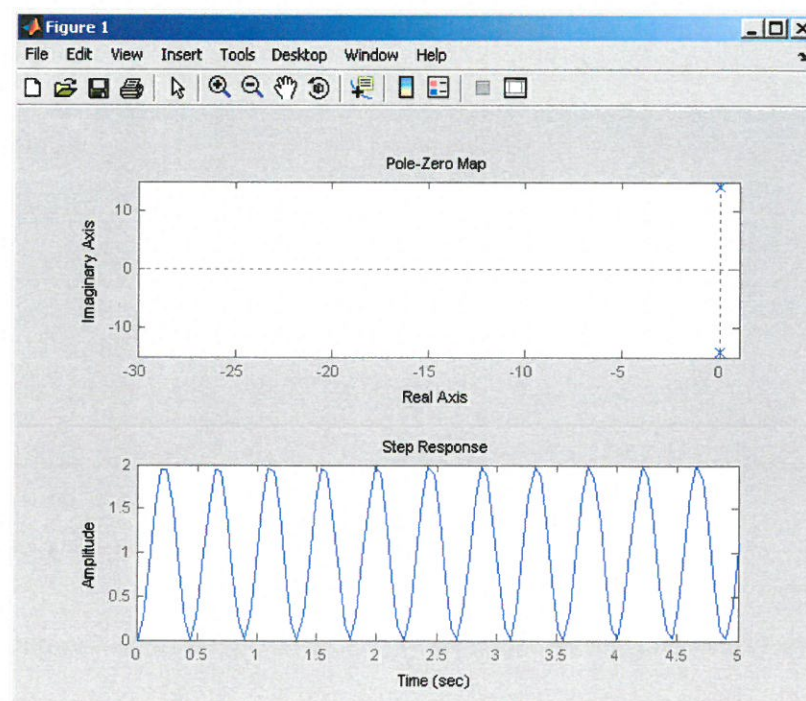
Please Prosent a value for B:0

Transfer function:
      200
-----
s^2 + 200

ans =

    0 +14.1421i
    0 -14.1421i

>>
```



Under Damped, $B = 0.0035$

Please Present a value for B:0.0035

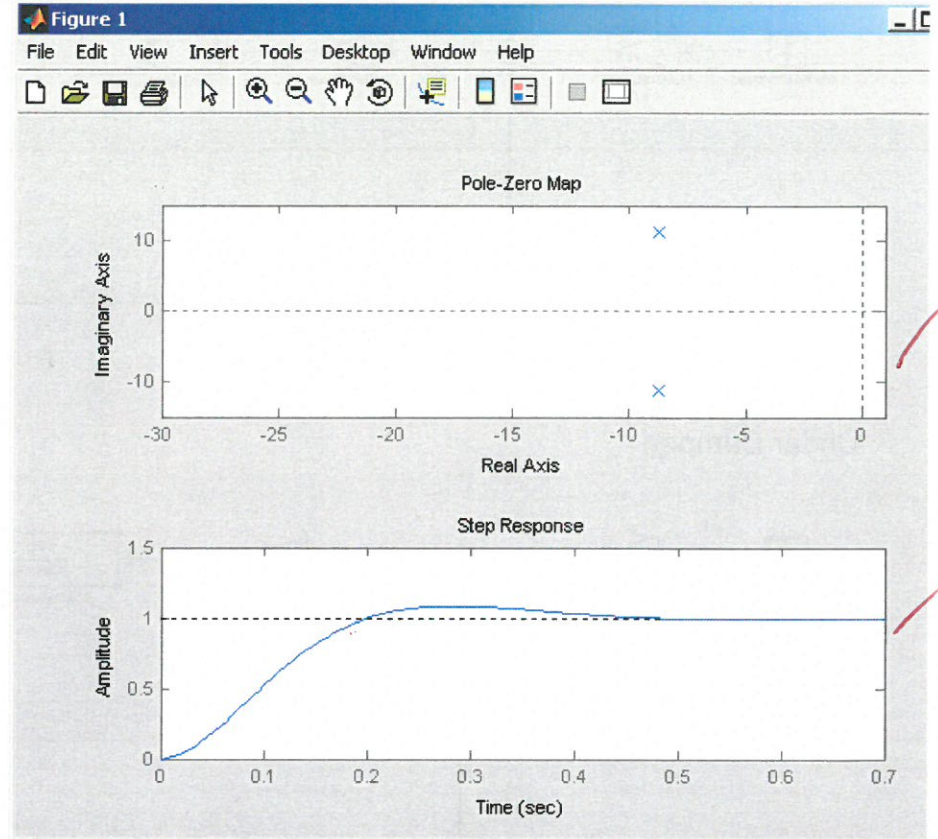
Transfer function:
200

$$s^2 + 17.5s + 200$$

ans =

-8.7500 +11.1102i
-8.7500 -11.1102i

>>



Over Damped, $B = 0.008$

ans =

-8.7500 +11.1102i
-8.7500 -11.1102i

Please Present a value for B:0.008

Transfer function:
200

$$s^2 + 40s + 200$$

ans =

-34.1421
-5.8579

Please Present a value for B:0.008

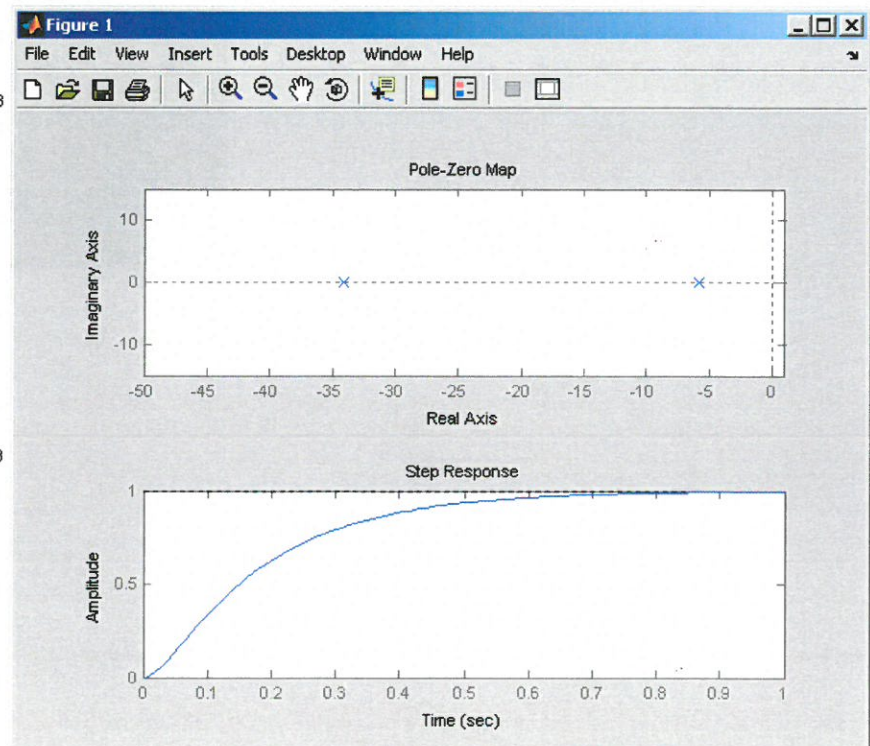
Transfer function:
200

$$s^2 + 40s + 200$$

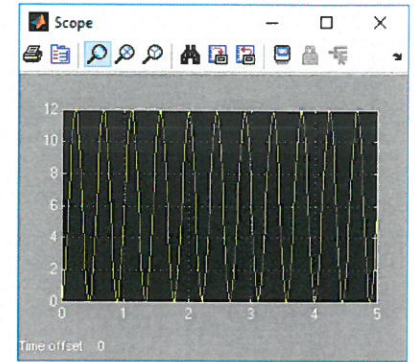
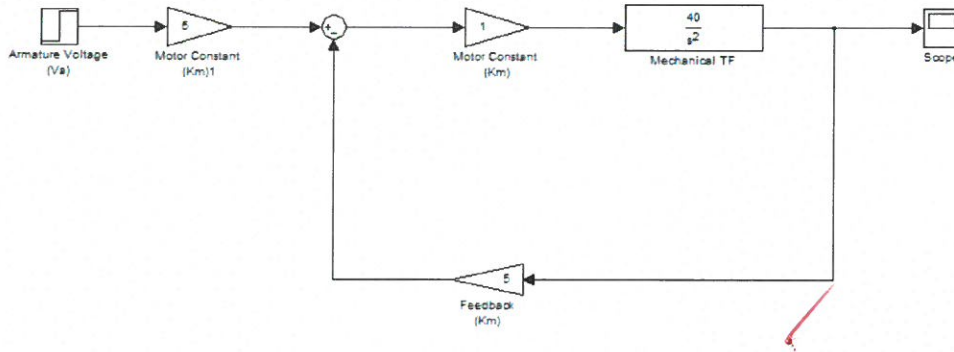
ans =

-34.1421
-5.8579

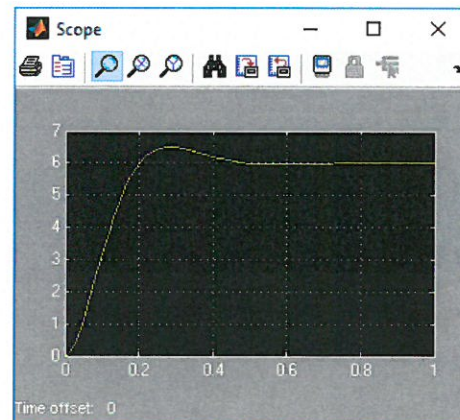
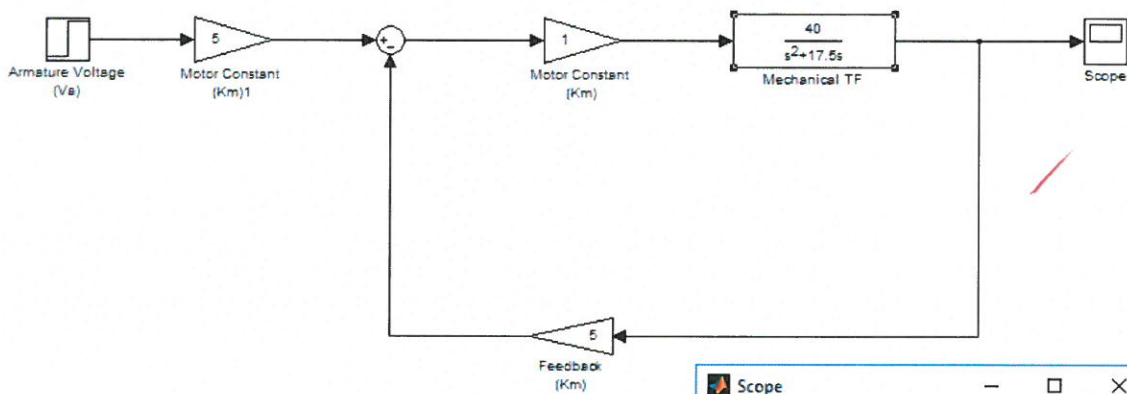
>>



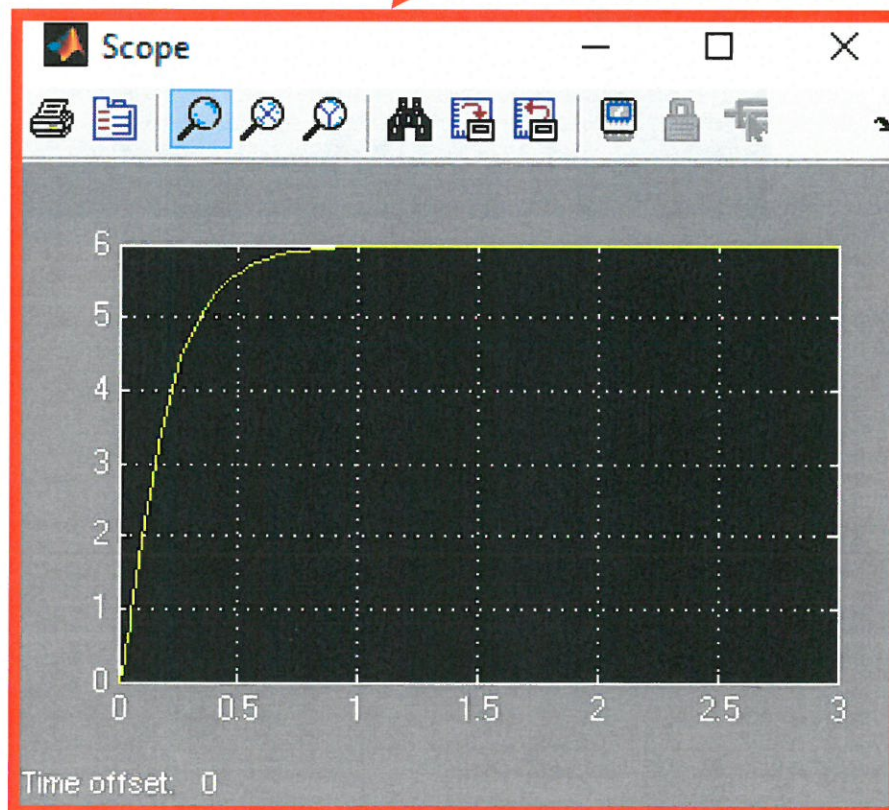
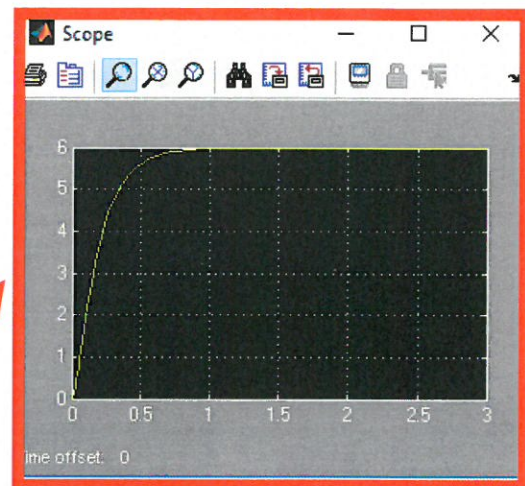
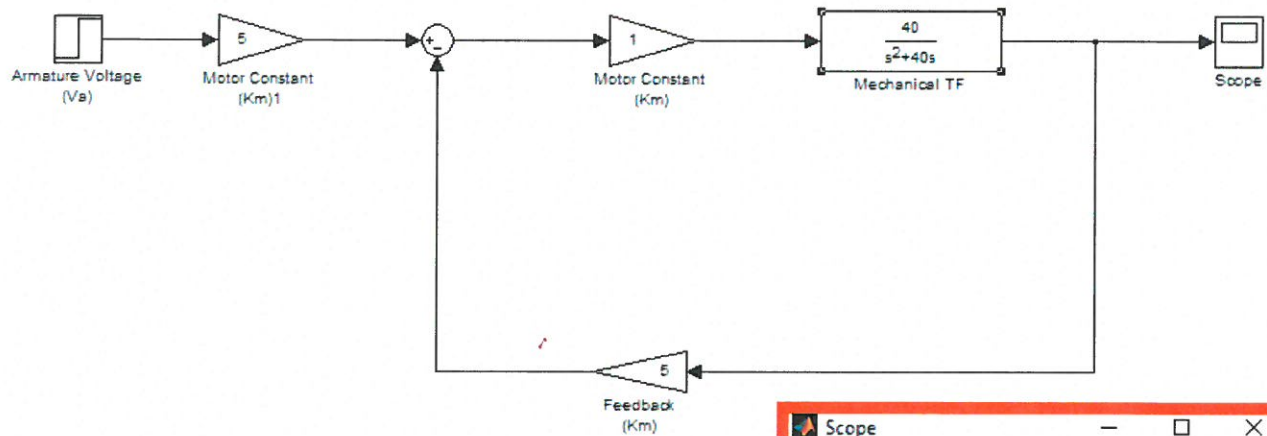
No Damping



Under Damped



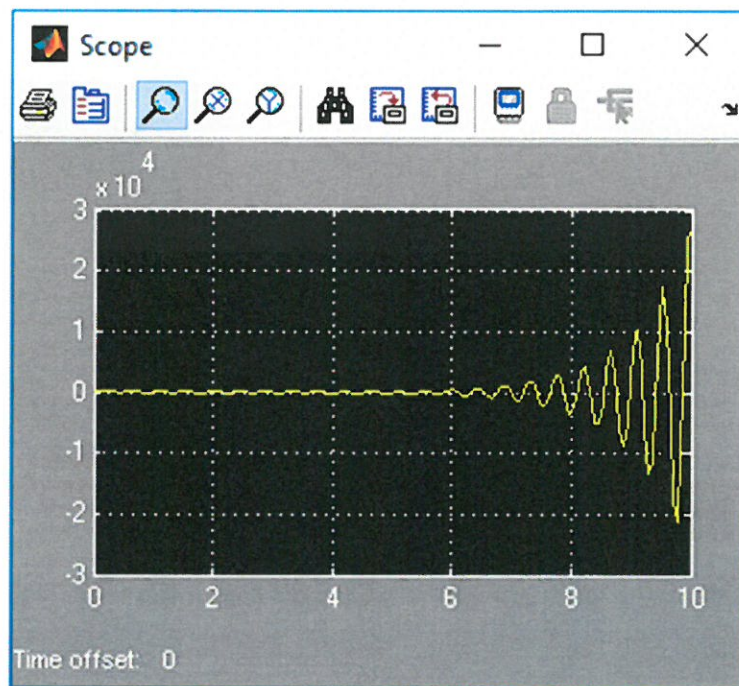
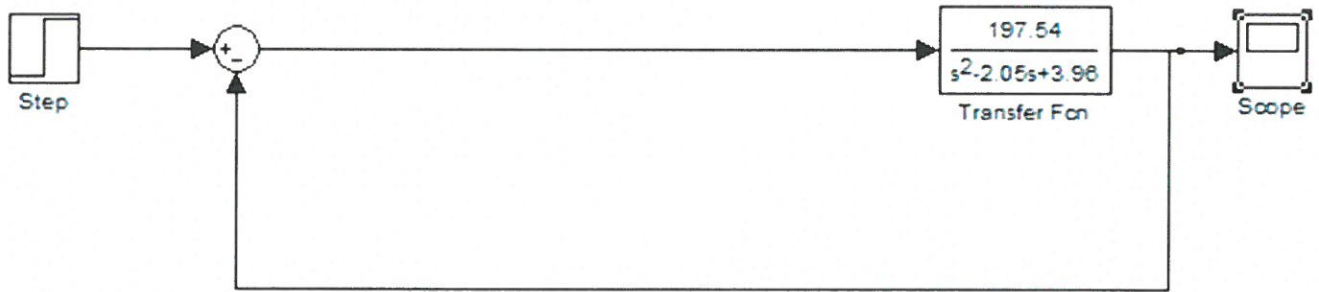
Over Damped



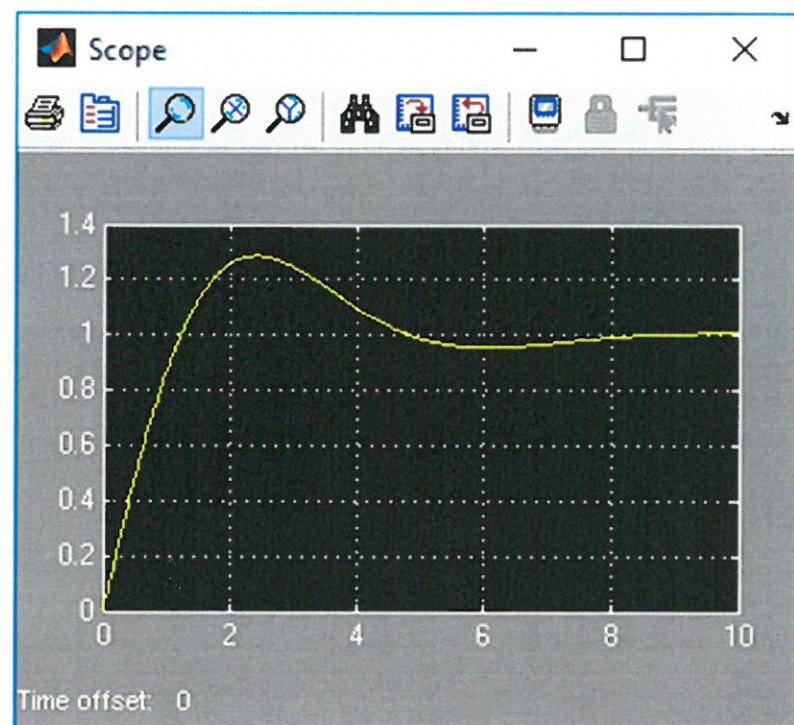
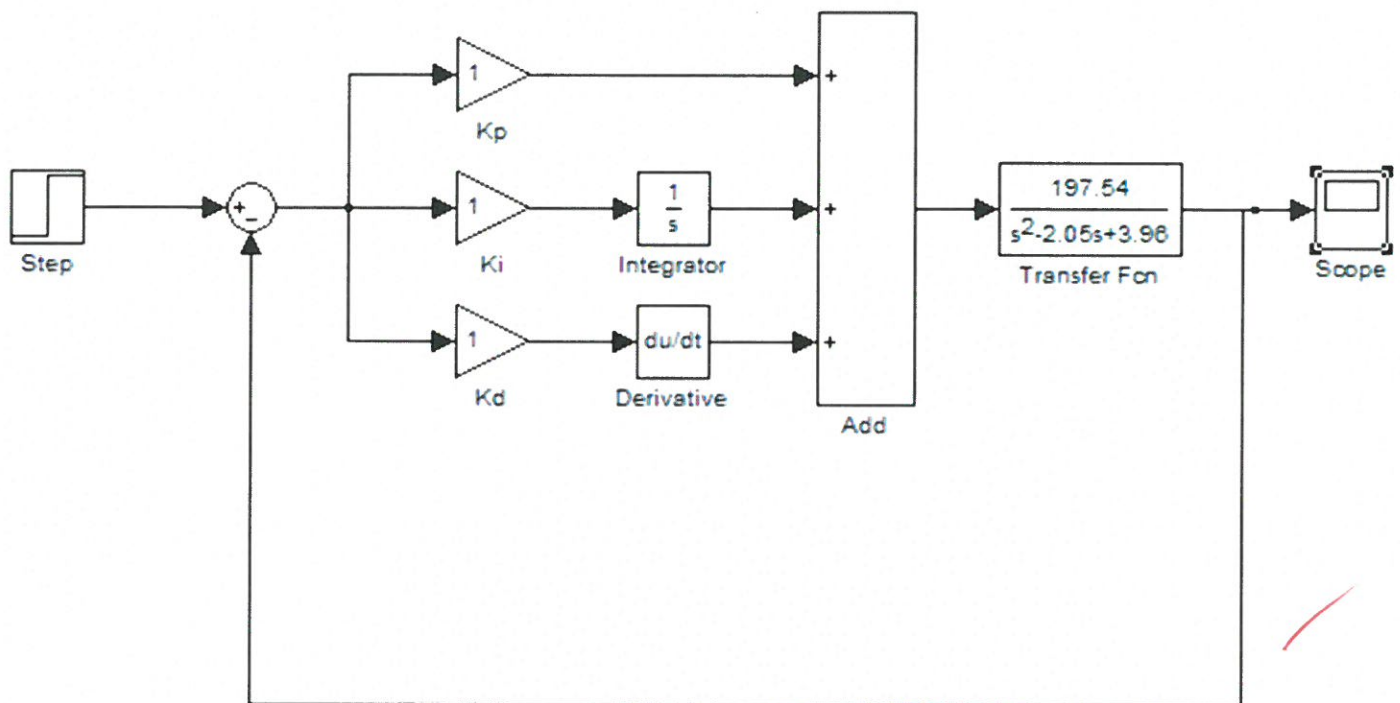
You are missing part f) for this task.

Task 4

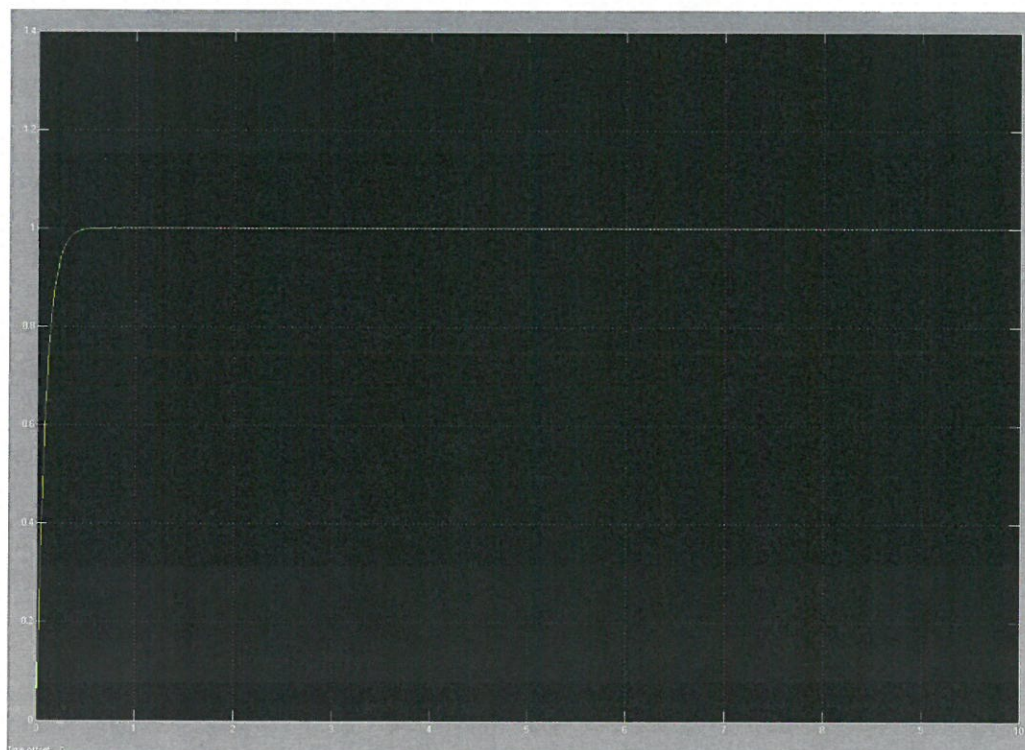
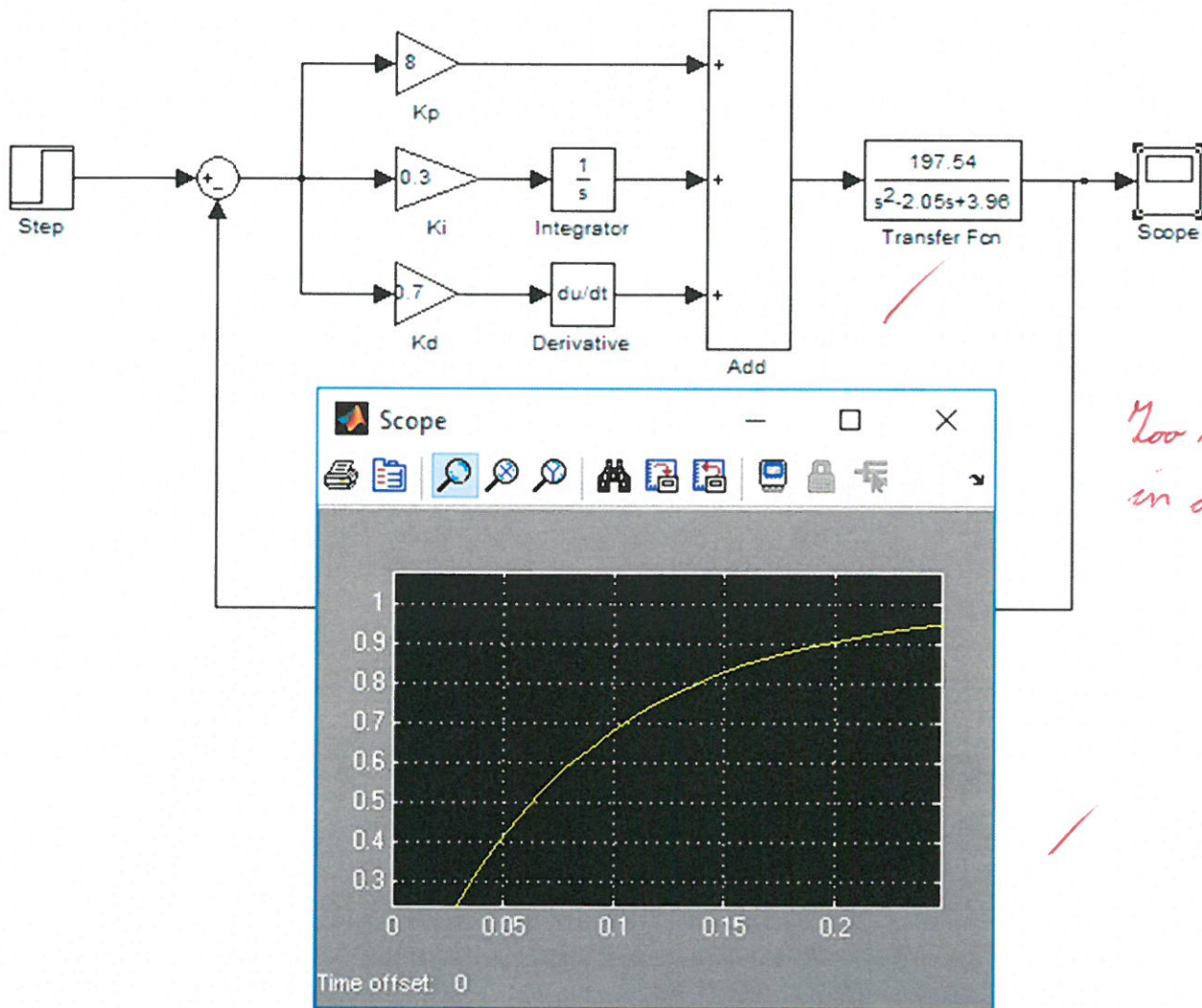
The image below shows the system that does not contain PID control.

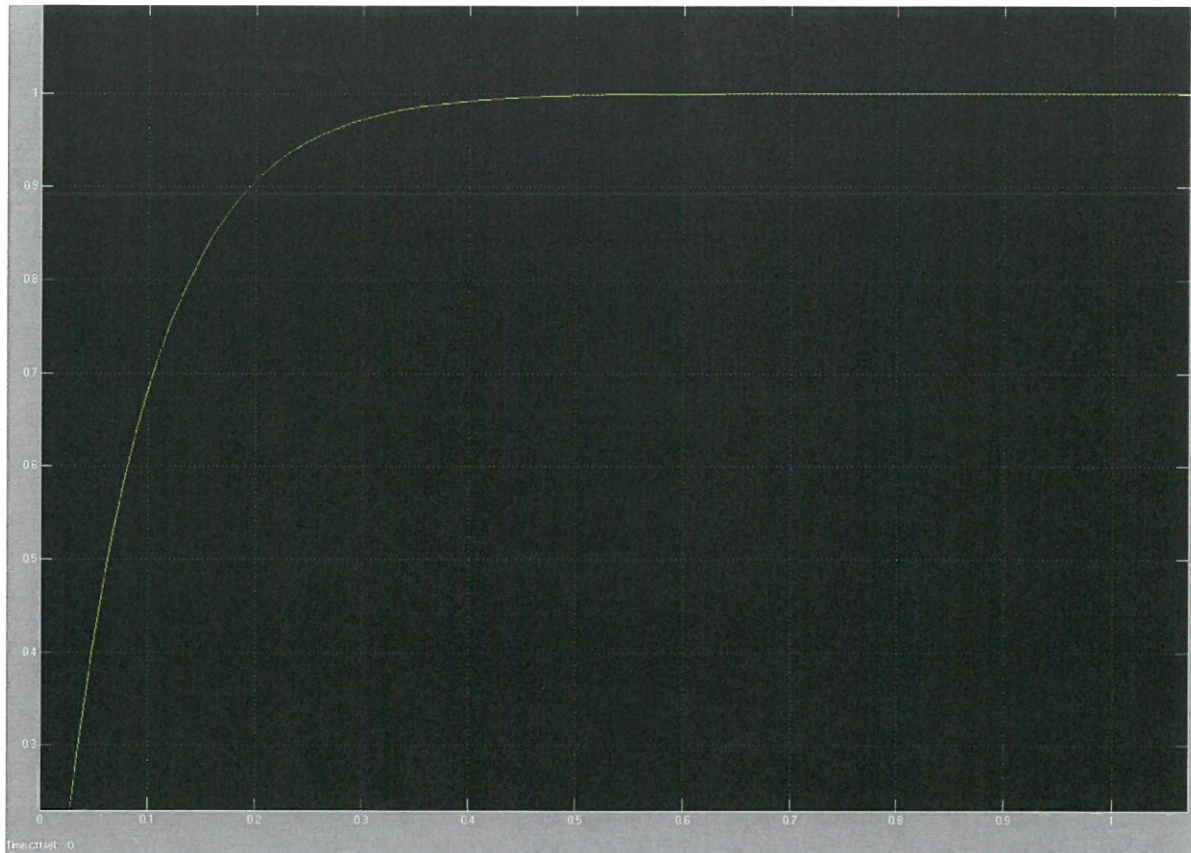


In the following image below it shows the system with PID. It does contain an over shoot.



Here it shows the result after adjusting the values of Kp, Ki and Kd. There are 3 images in total to show the result from the same values.





As seen in the following images the over shoot is no longer there ($\sigma = 0\%$) and the rise time t_r less than 0.18 second and zero steady-state error.

Task 5

Need to state the requirement of the task.

a)

$$G_c(s) = \frac{0.03868s^3 - 5.369s^2 - 97.34s + 13450}{s^3 + 169.8s^2 + 1730s + 159 + 0.03868s^3 - 5.369s^2 - 97.34s + 13450}$$

$$G_c(s) = \frac{0.03868s^3 - 5.369s^2 - 97.34s + 13450}{1.03868s^3 + 164.43s^2 + 1632.66s + 13609}$$

```
%Carys Williams
```

```
%Task 5 A
```

```
%Obtain Myquist Diagram
```

```
%Component Value
```

```
N = [0.03868 -5.369 -97.34 13450];
```

```
D = [1 169.8 1730 159];
```

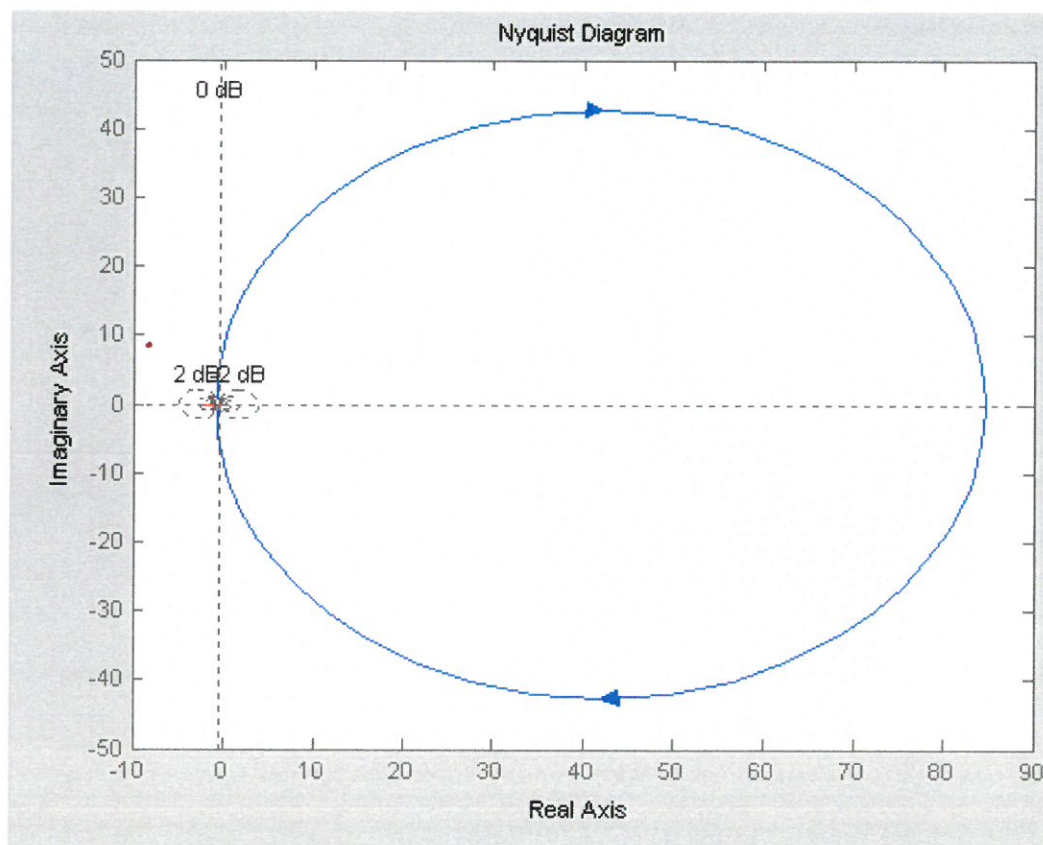
```
% Transfer function
```

```
Nr = tf([N],[D])
```

```
% Plots Nyquist response
```

```
nyquist(Nr)
```

```
grid
```



```

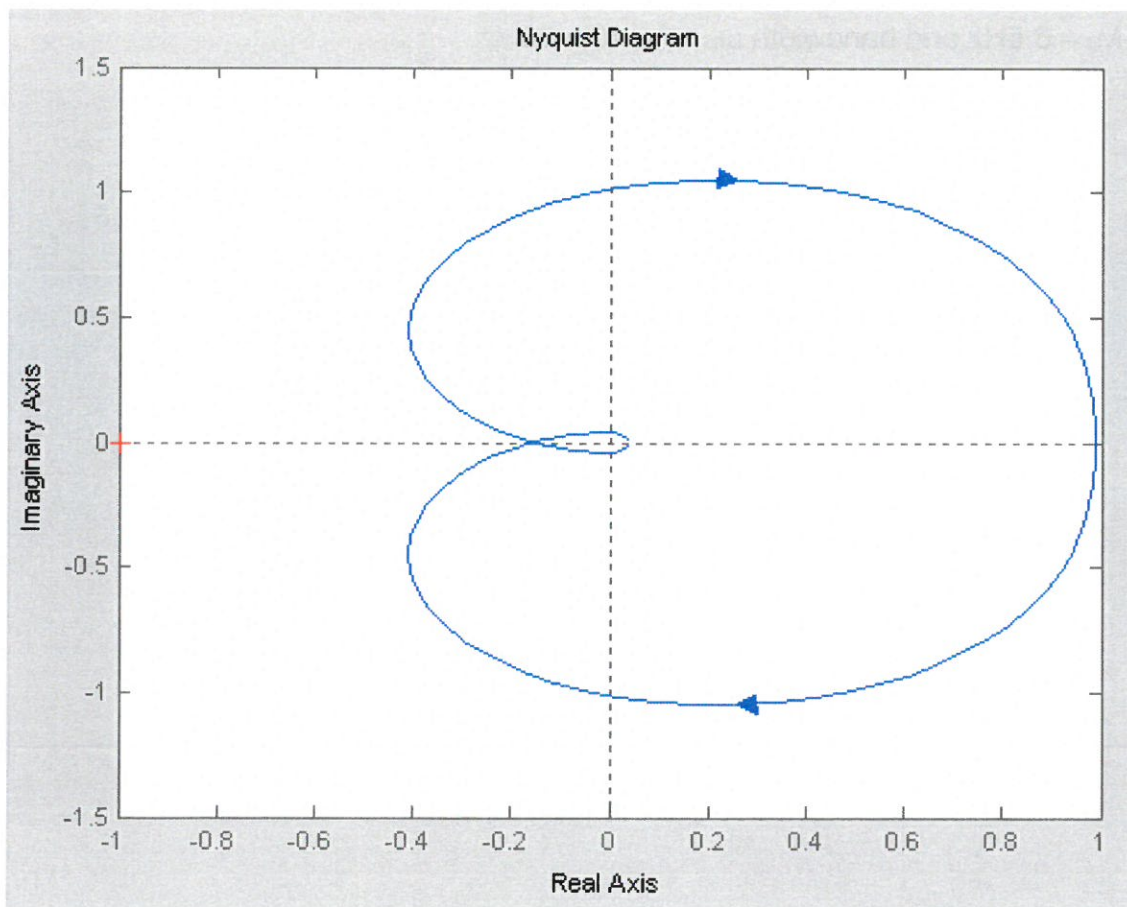
%Carys Williams
%Task 5 b

%Component Value
N=[0.03868 -5.369 -97.34 13450];
D=[1.03868 164.43 1632.66 13609];

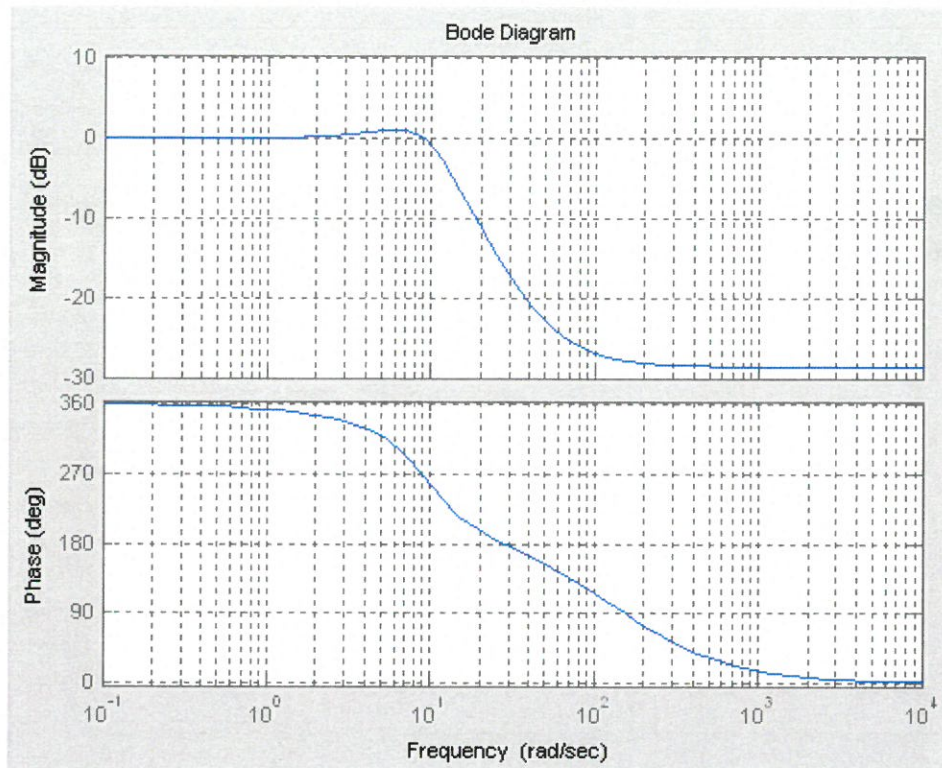
% transfer function
Nr = tf([N],[D])
B = tf([N],[D])

% Plot response
nyquist(Nr)
pause
% Bode plot
bode(B)
grid

```

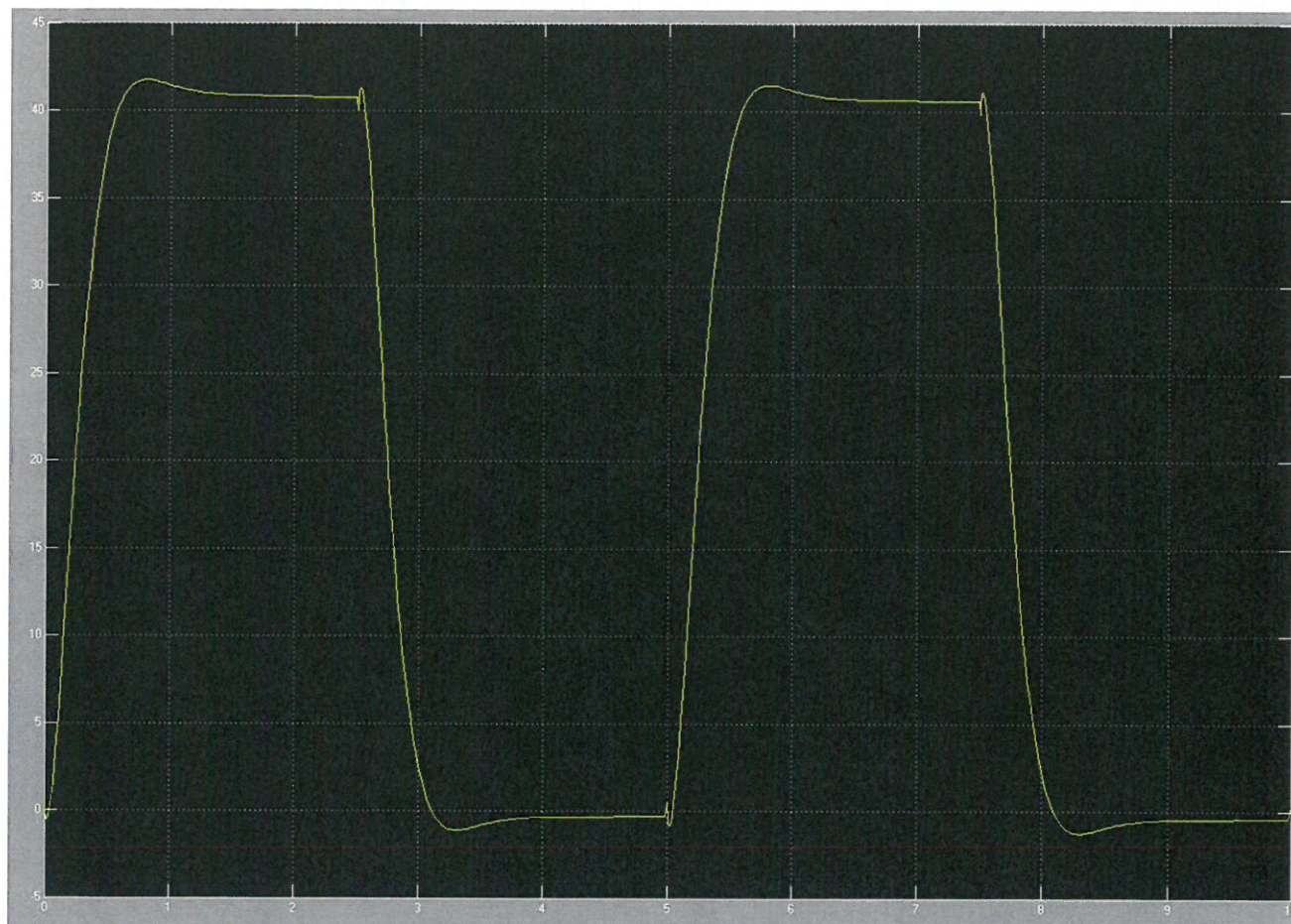
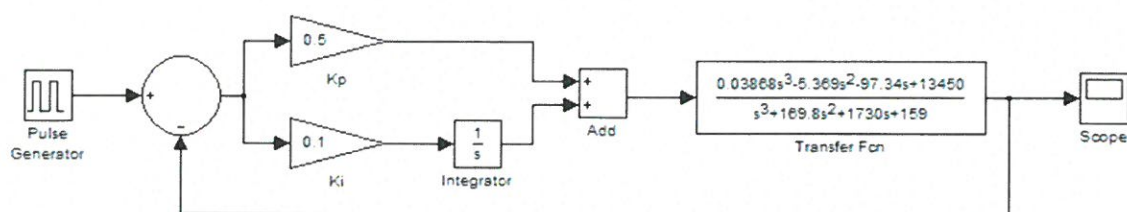


This shows that the system is stable as the response is in the negative axis. Phase margin is $= \infty$, gain margin $= 20\log(1/0.17) = 15.39\text{dB}$.

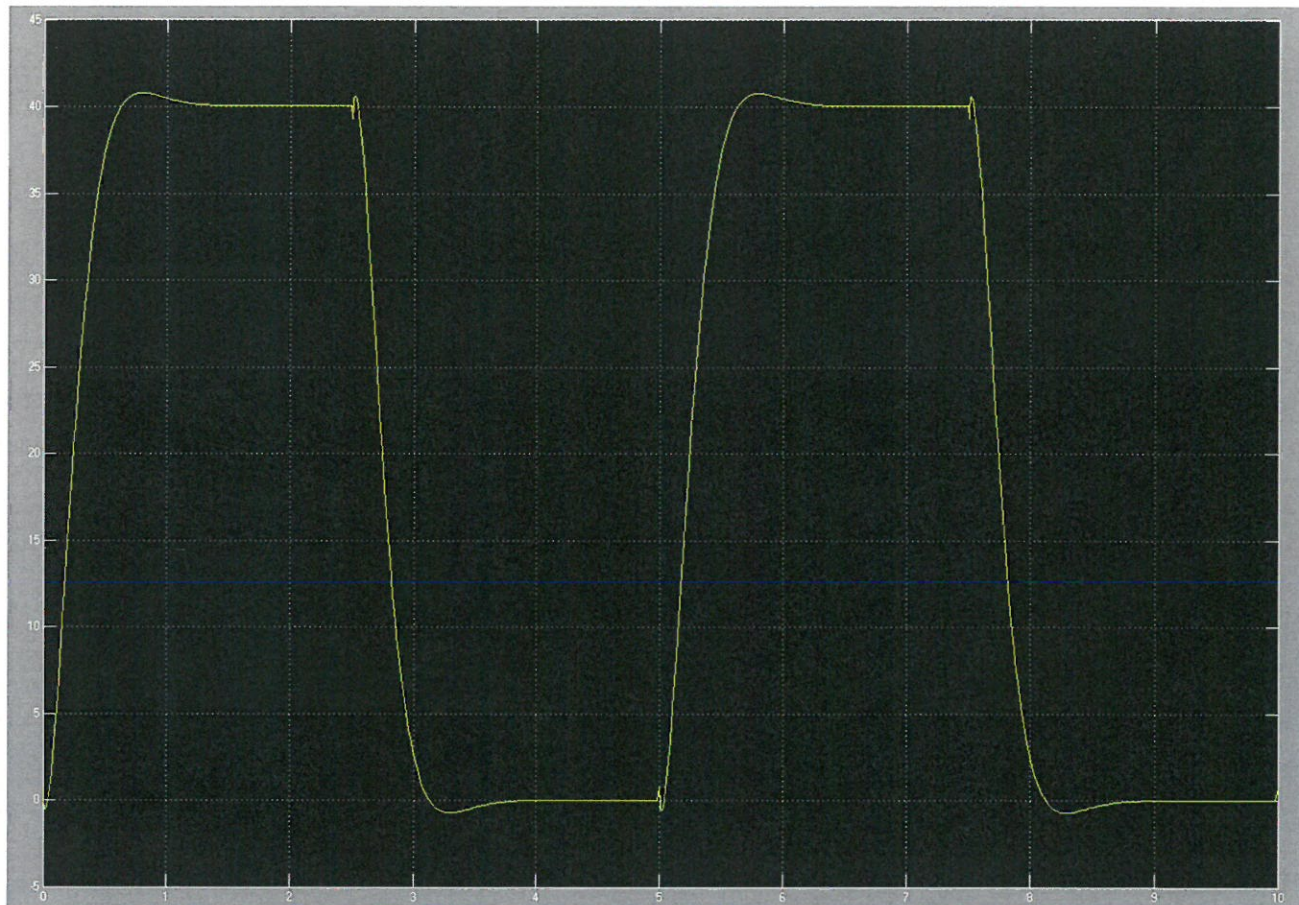
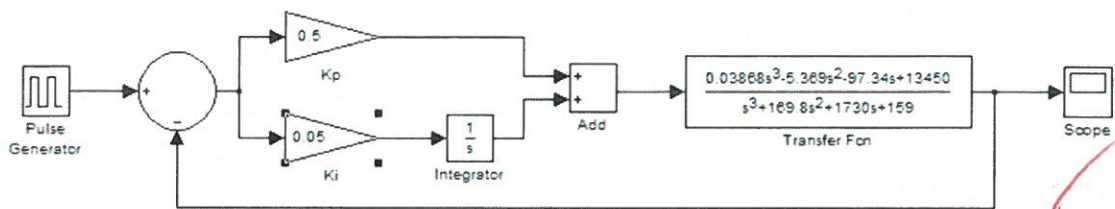


Peak resonance $M_p = 6.5\text{Hz}$ and bandwidth $\omega_b = 30 - 10 = 20\text{Hz}$.

As seen below in both the images this is the result after creating the circuit. By having Kp value as 0.5 and the Ki as 0.1 it causes the waveform to be distorted.



By changing the value of K_i to 0.05 it makes the waveform to work under the specification of this task. However the wave form is still distored.



You have not completed the tuning process.