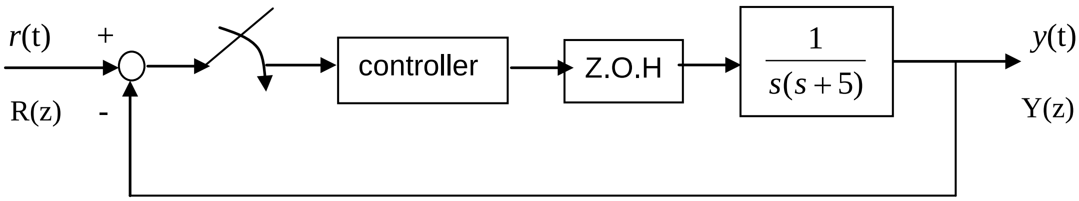
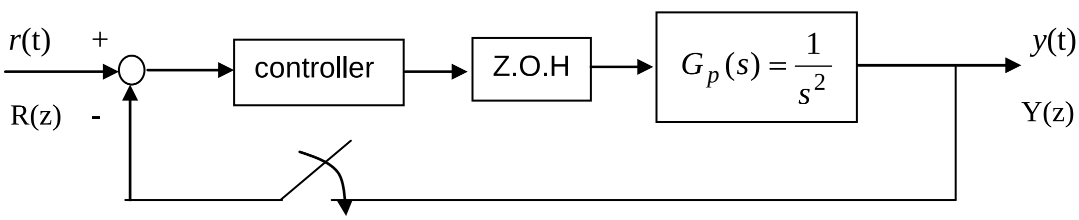
ME 576 Homework #5 Due: 4/6/2021 Name :

1. Design a discrete proportional controller for the control system shown below such that the closed-loop damping ratio becomes approximately 0.7 using the root-locus method. T=0.1 sec.



2. Design a discrete proportional-derivative (PD) controller for the control system shown below such that the closed-loop damping ratio and the natural frequency become approximately 0.5 and 4 rad/sec. The sampling interval T=0.1 seconds. (Use the backward transformation for the controller).
Hint: Draw the root-locus including open-loop system pole at z=0 and determine the zero location using the angle condition.
Desired discrete system pole locations can be determined by using $z_{1,2} = e^{\left(-\zeta\omega_n \pm j\omega_n\sqrt{1-\zeta^2}\right)T}$



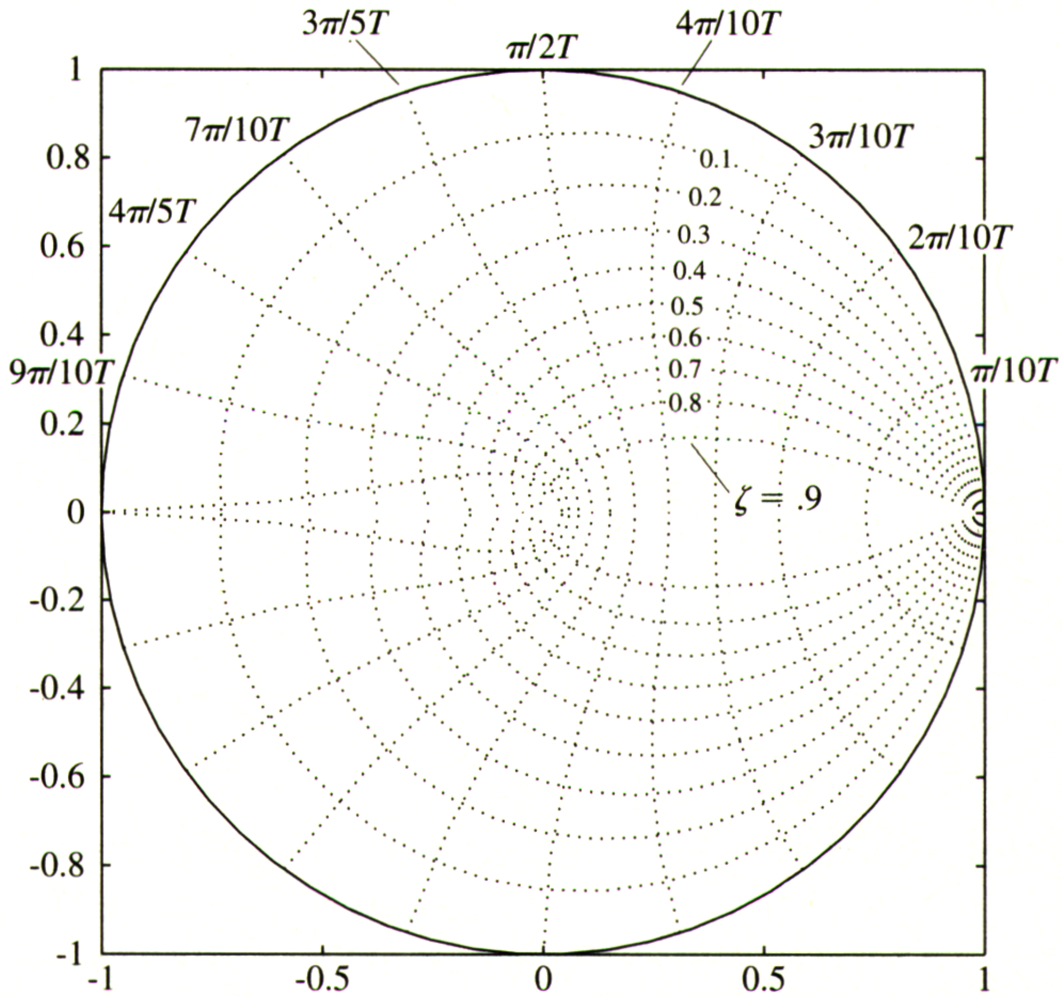
3. Design a discrete proportional controller for the control system shown in Problem 2 such that the closed-loop damping ratio becomes approximately 0.7 using the frequency domain approach by:
   a) using the sampling interval of 0.1 sec.
   b) using the sampling interval of 0.02 sec.

Use the following program to draw the Bode plot of the discrete system.

```
%
% Matlab m-file:
% draws bode diagram for discrete system
%
nump=1;
denp=[1 5 0];
T=0.1;
[numz,denz]=c2dm(nump,denp,T,'zoh');
w=logspace (-1,2,200);
w=w';

s=exp(j*w*T);
g=polyval(numz,s) ./polyval (denz,s);
mag=abs(g);
phase=unwrap(angle(g));
phase=phase;
phase=(180/pi)*phase;
magdB=20*log10(mag);

clf
subplot(2,1,1), semilogx(w,magdB)
xlabel('Frequency(rad/sec)')
ylabel('Magnitude(dB)')
axis([0.1 100 -80 40])
set(gca,'YTick',-80:20:40)
grid
subplot(2,1,2),semilogx(w,phase)
axis([0.1 100 -180 0])
set(gca,'YTick',-180:20:0)
xlabel('Frequency(rad/sec)')
ylabel('Phase(deg)')
grid
```



3π/5T
π/2T
4π/10T
7π/10T
3π/10T
4π/5T
2π/10T
9π/10T
π/10T
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
ζ = .9
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.5
0
0.5
1