MP10.1

----------------------- Code --------------------------------

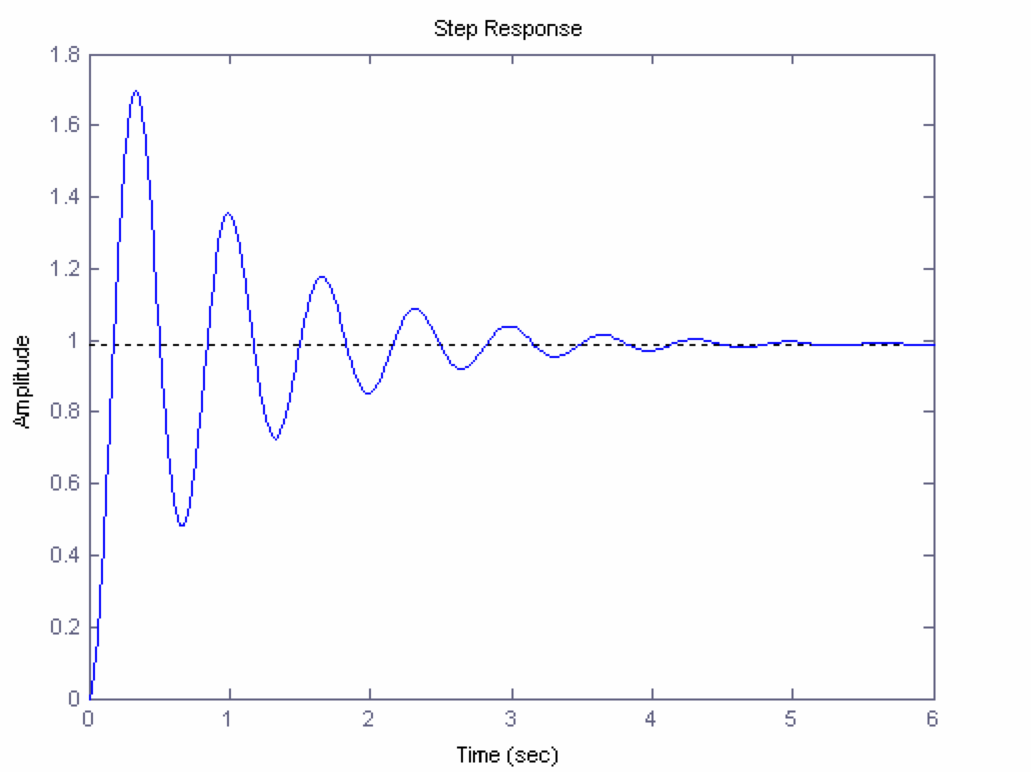
```
numc=[10];denc=[1 1]; sysc=tf(numc,denc);
numg=[9];deng=[1 1]; sysg=tf(numg,deng);
syss=series(sysc, sysg);
[mag, phase, w]=bode(syss);
[gm, pm]=margin(mag, phase, w);
pm

sys_cl=feedback(syss, [1]);
y=step(sys_cl);
step(sys_cl);
ymax=max(y)
```

----------------------- Result Shown -------------------------

pm = 12.1343

ymax = 1.6985

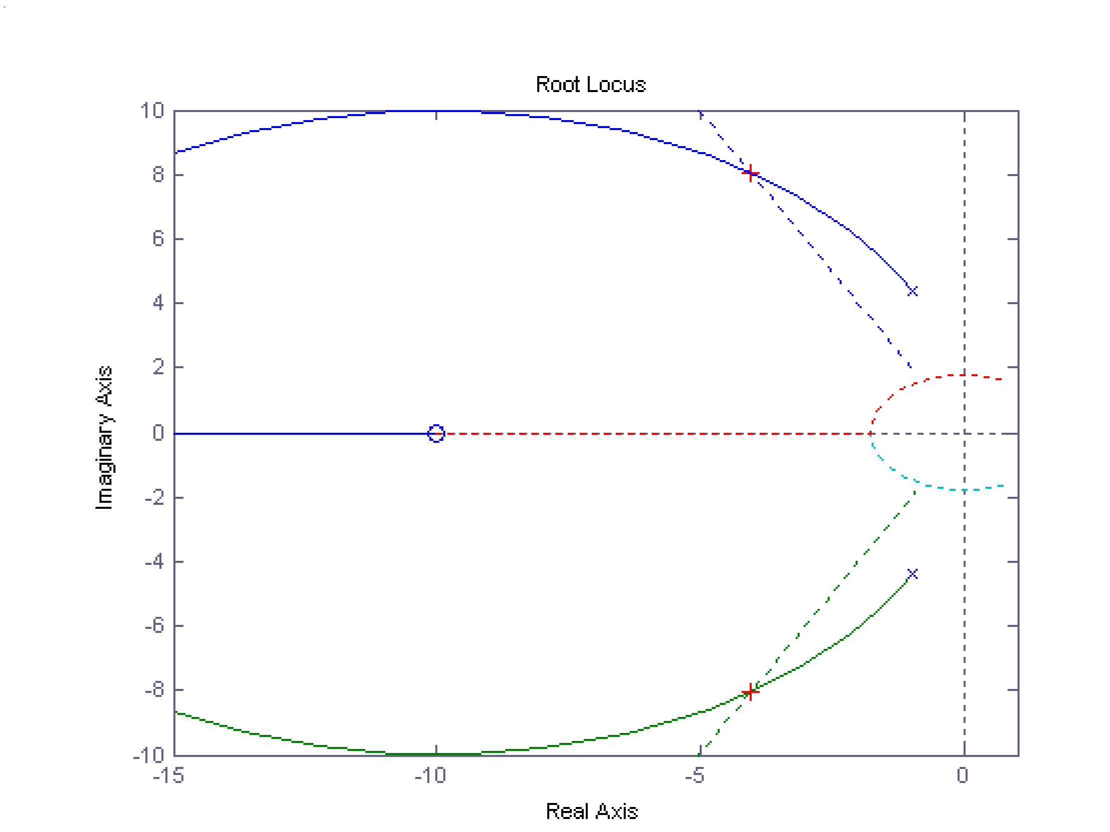


MP10.6

The settling time and phase margin specifications require that the dominant closed-loop poles have natural frequency and damping of omega_n >= 1.78 and zeta >= 0.45. The uncompensated roots locus is shown below

---------------------- Code 1--------------------------------

```
numg=[1 10]; deng=[1 2 20]; sysg=tf(numg, deng);
rlocus(sysg);
axis([-15, 1, -10, 10]);
hold on
zeta=0.45; wn=1.7778;
x=[-10:0.1:-zeta*wn];
y=-(sqrt(1-zeta^2)/zeta)*x;
xc=[-10:0.1:zeta*wn];
c=sqrt(wn^2-xc.^2);
plot(x,y,':',x,-y,':',xc,c,':',xc,-c,':')
rlocfind(sysg),
hold off
---------------------------- Results -----------------------------------
selected_point = -4.0616 + 8.0435i
ans = 6.1210
-----------------------------------------------------------------------------
```



From the final value theorem, we determine that

$$Kp(comp) >= 9$$

With the compensator

$$G_c(s) = K\frac{s+z}{s+p}$$

we find that

Kp(comp) = K*(z/p)*Kp(uncomp)

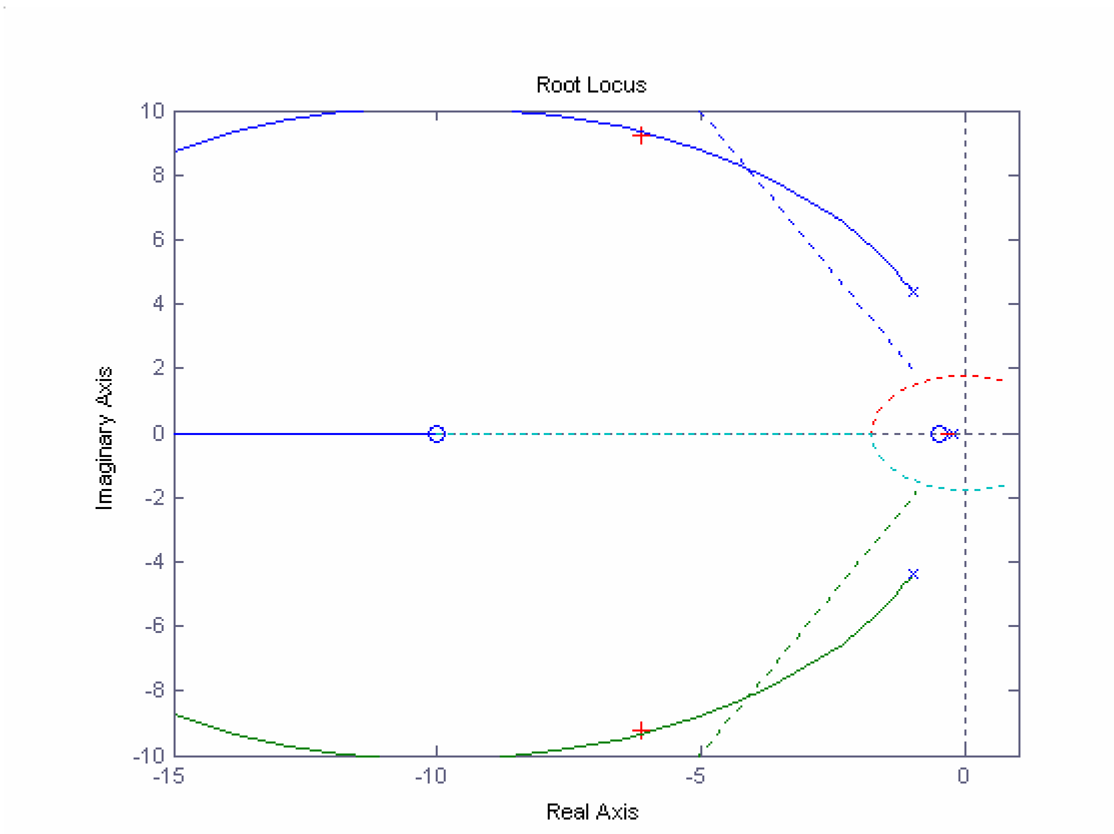
But Kp(uncomp) = 0.5 and a gain of K = 10 results in roots of the characteristic equation in the desired region. Solving for

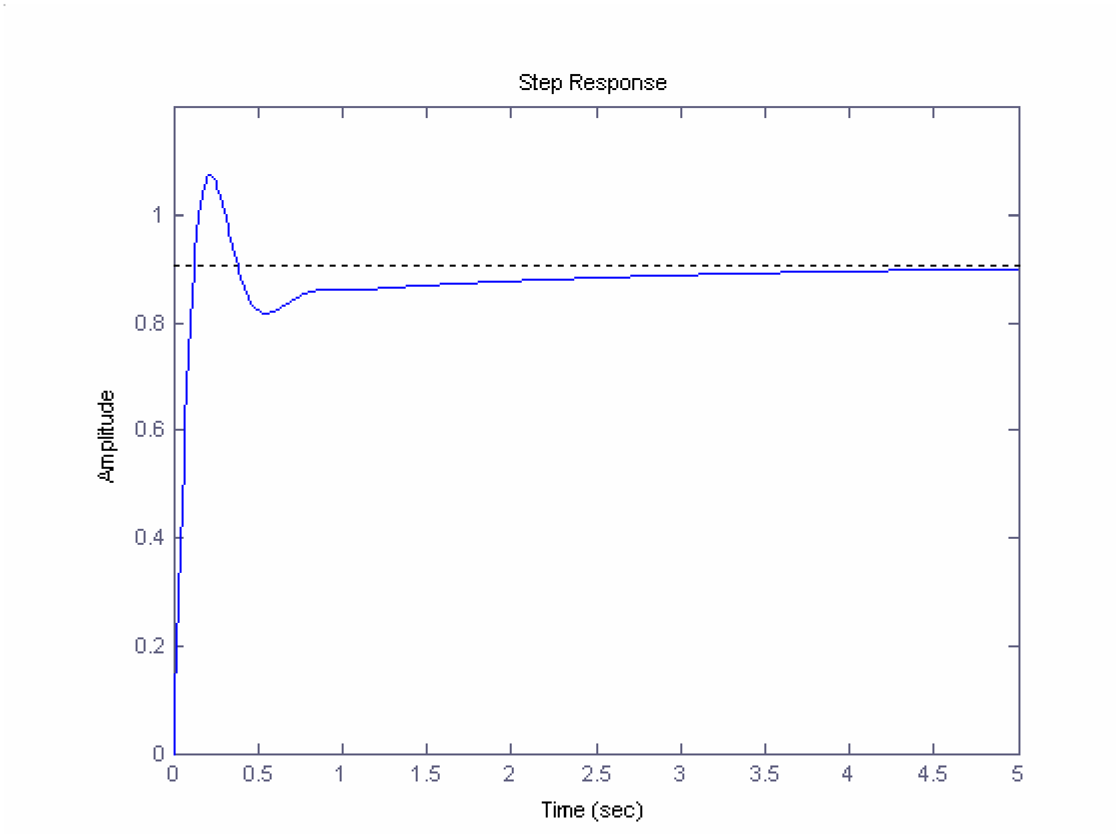
z/p = 1*Kp(comp)/(K*Kp(uncomp)) = 2.

Select z = 0.5 to minimize changing the root locus. Then, p = 0.25, and the compensator is

$$G_c(s) = 10\frac{s+0.5}{s+0.25}$$

The compensated root locus and step response are shown below. The phase margin of the compensated system is P.M. = 62.3 degree and the settling time is less than 5 seconds.





----------------------- Code 2---------------------------------

```
numg=[1 10]; deng=[1 2 20]; sysg=tf(numg, deng);
numc=[1 0.5]; denc=[1 0.25]; sysc=tf(numc, denc);
sys_o=series(sysc, sysg)
rlocus(sys_o);
axis([-15, 1, -10, 10]);
hold on
zeta=0.45; wn=1.7778;
x=[-10:0.1:-zeta*wn];
y=-(sqrt(1-zeta^2)/zeta)*x;
xc=[-10:0.1:zeta*wn];
c=sqrt(wn^2-xc.^2);
plot(x,y,':',x,-y,':',xc,c,':',xc,-c,':')
rlocfind(sysg)
hold off
```

----------------------- Code 3---------------------------------

```
numg=[1 10]; deng=[1 2 20]; sysg=tf(numg, deng);
numc=10*[1 0.5]; denc=[1 0.25]; sysc=tf(numc, denc);
sys_o=series(sysc, sysg)
sys_cl=feedback(sys_o, [1])
t=[0:0.01:5]; step(sys_cl,t);
bode(sys_o), grid
[Gm,Pm]=margin(sys_o);
PmMax=max(Pm)
```

----------------------- Results ---------------------------------
PmMax = 62.0985

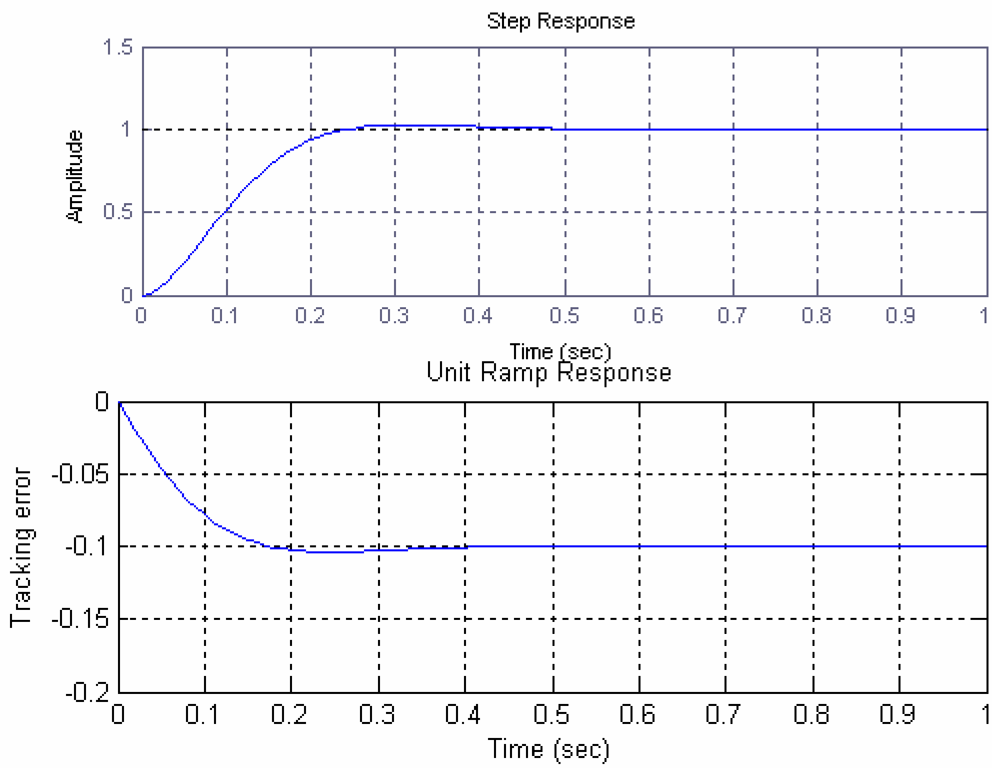
MP10.7

Both design specifications can be satisfied with an integral controller

$$G_c(s) = K_1 + \frac{K_2}{s} = \frac{10}{s}$$

----------------------- Code ---------------------------------

```
K1=0; K2=10;
numc=[K1, K2]; denc=[1 0]; sysc=tf(numc,denc);
numg=[23]; deng=[1 23]; sysg=tf(numg, deng);
sys_o=series(sysc, sysg)
sys_cl=feedback(sys_o, [1])
t=[0:0.01:1]; u=t;
subplot(211)
step(sys_cl,t), grid
subplot(212)
yr=lsim(sys_cl,u,t);
plot(t,yr(:)-u(:))
xlabel('Time (sec)'), ylabel('Tracking error')
title('Unit Ramp Response'), grid
```



Step Response
Amplitude
1.5
1
0.5
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Time (sec)
Unit Ramp Response
Tracking error
0
-0.05
-0.1
-0.15
-0.2
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Time (sec)