ME EN 6200
Homework 8
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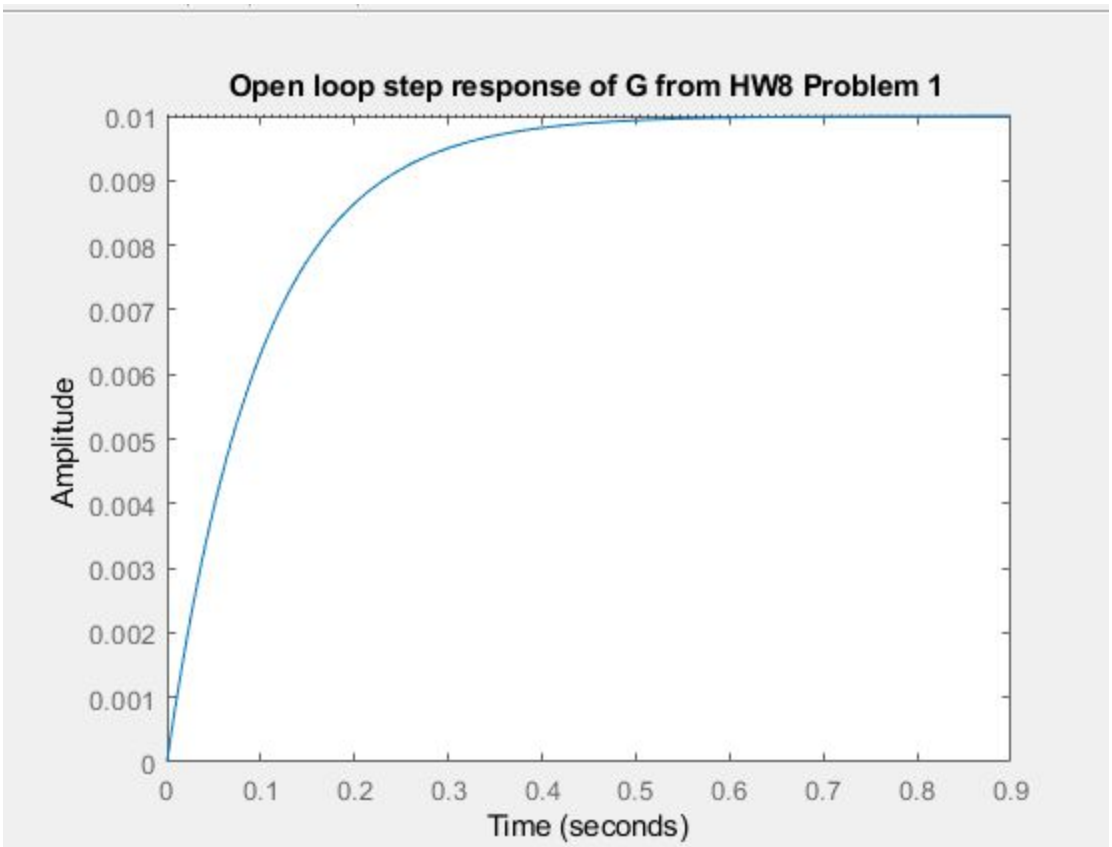
Problem 1

c)

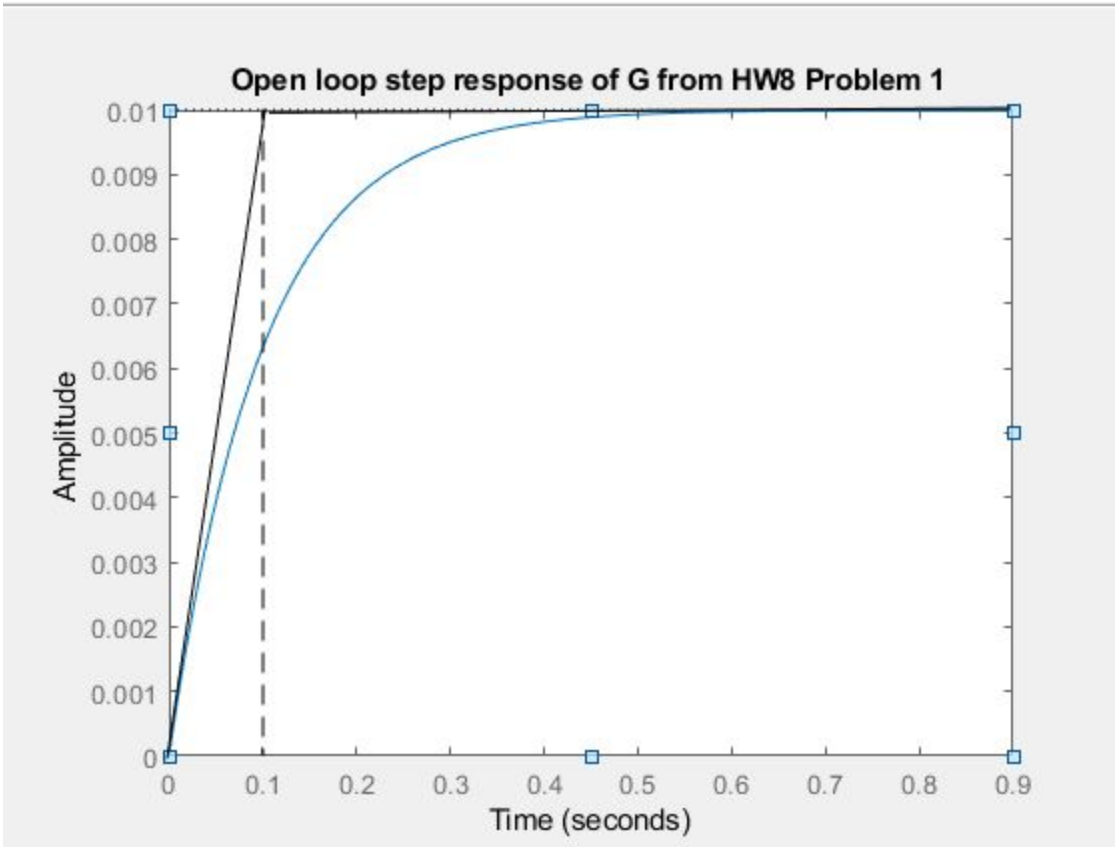



```
OLTF: Steady state value is 0.010000 and the settling time is 0.391207s
```

```
% c
a = 0.1;
b = 10;

% Open loop step response
G = tf(a,[1 b]);
figure;
step(G);
title('Open loop step response of G from HW8 Problem 1');
G_step_info = stepinfo(G);
fprintf('OLTF: Steady state value is %f and the settling time is %fs\n\n',
G_step_info.SettlingMax, G_step_info.SettlingTime);
```

d)



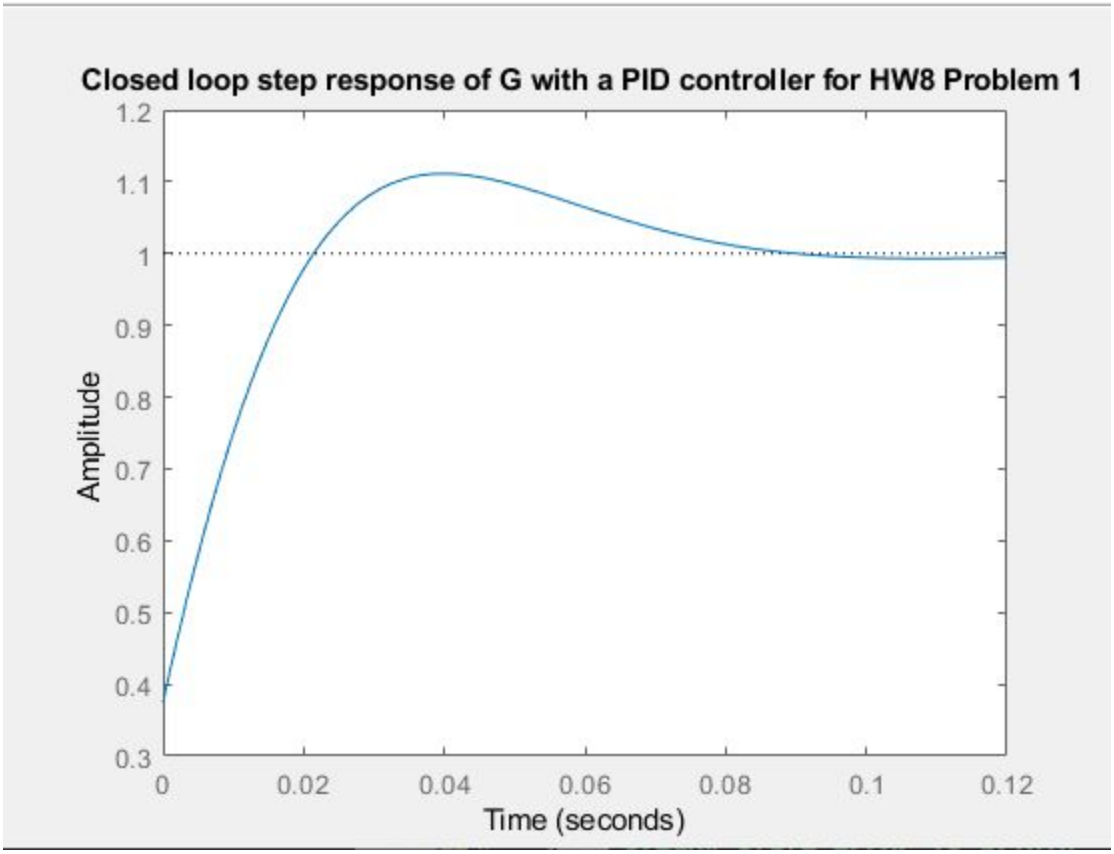

```
25 Percent Method Gains: Kp=1200.000000, Ki=60000.000000, and Kd=6.000000
```

```
% d
% 25% method
L = 0.01;
A = 0.01;
tau = 0.1;
R = A/tau;

kp = 1.2/(R*L);
Ti = 2*L;
Td = 0.5*L;
ki = kp/Ti;
kd = kp*Td;

fprintf('25 Percent Method Gains: Kp=%f, Ki=%f, and Kd=%f\n\n', kp,ki,kd);
```

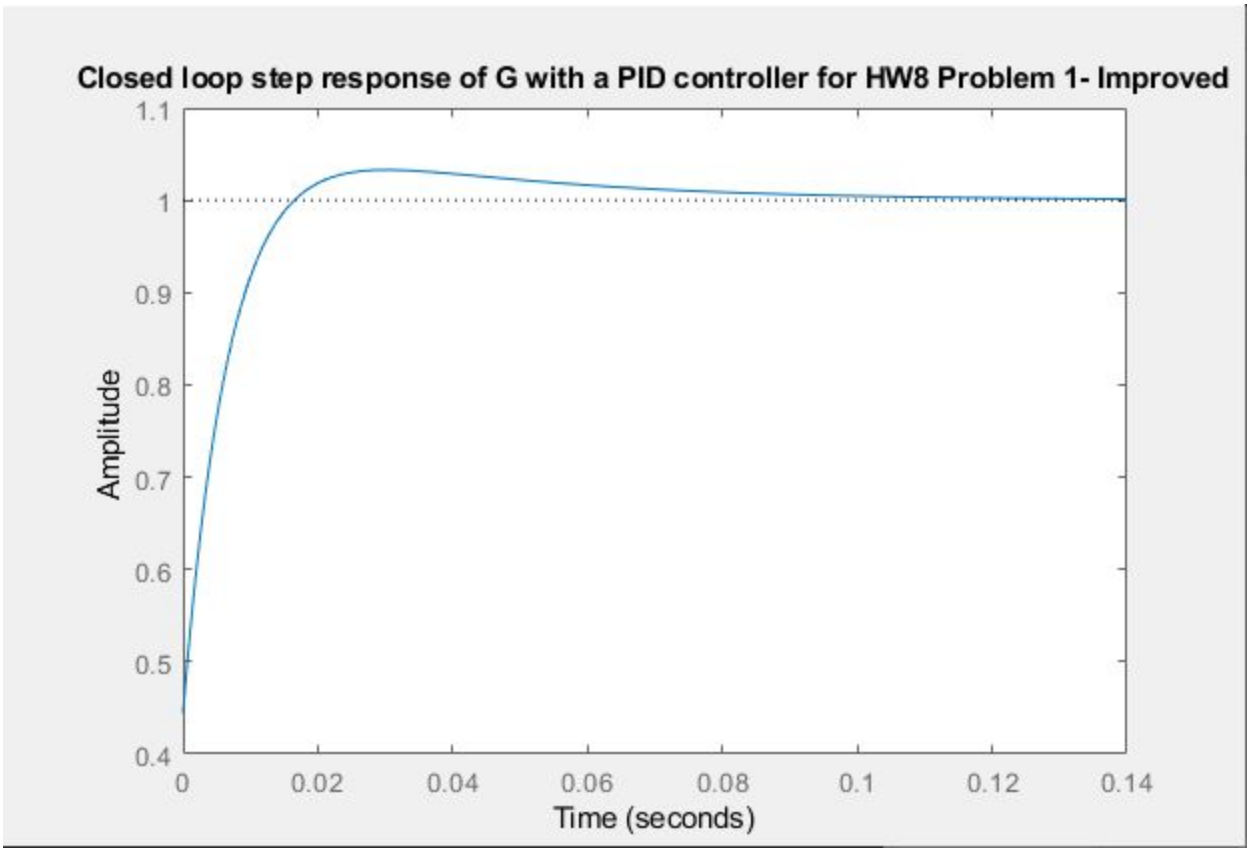
e)




```
CLTF: Percent overshoot is 11.132516, the settling time is 0.080225s, and the steady state error is 0.006623
```

```
% e
% Closed loop step response for optimum gains
cltf = tf([a*kd a*kp a*ki],[(kd*a+1) (kp*a+b) (ki*a)]);
figure;
step(cltf);
[cltf_response,~] = step(cltf);
title('Closed loop step response of G with a PID controller for HW8 Problem
1');
cltf_ss_error = 1 - cltf_response(end);
cltf_step_info = stepinfo(cltf);
fprintf('CLTF: Percent overshoot is %f, the settling time is %fs, and the
steady state error is %f\n\n', cltf_step_info.Overshoot,
cltf_step_info.SettlingTime, cltf_ss_error);
```

f)



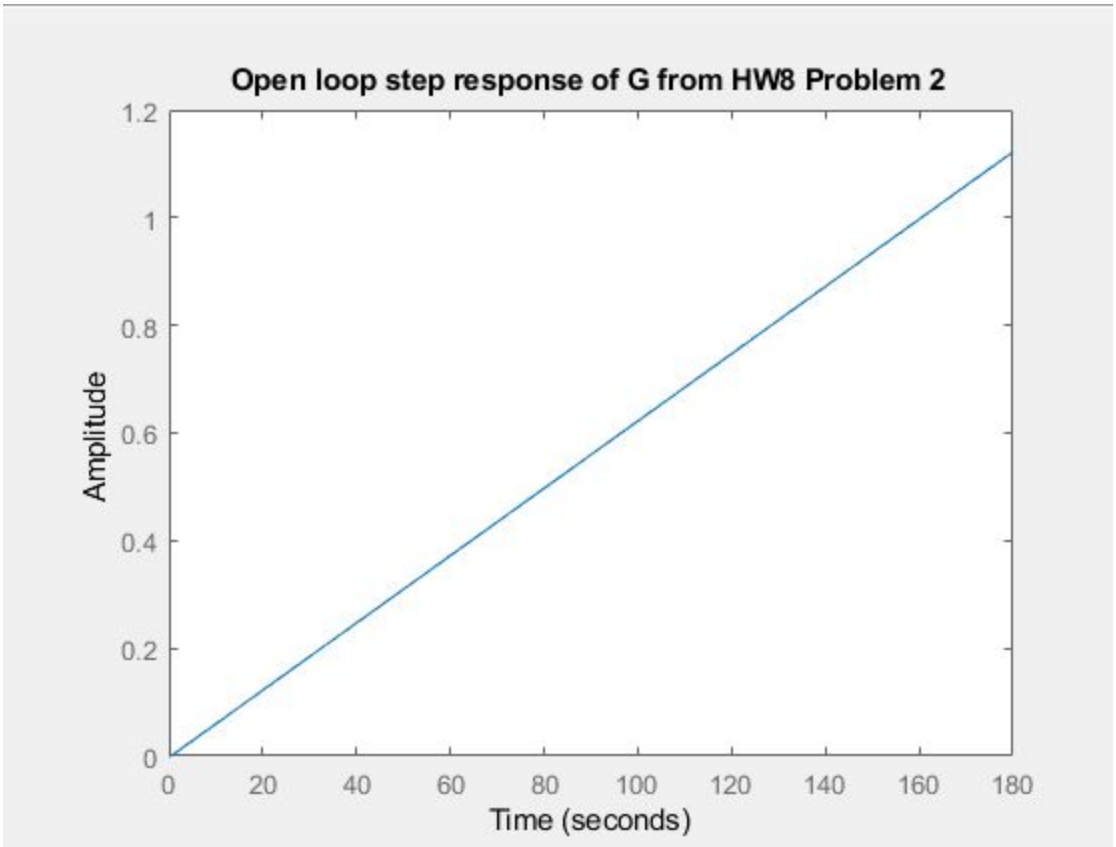

```
CLTF Improved: Percent overshoot is 3.286701, the settling time is 0.072497s, and the steady state error is 0.006623
```

```
% f
% Improving tuning values
kp=3000;
ki=80000;
kd=8;
cltf = tf([a*kd a*kp a*ki],[(kd*a+1) (kp*a+b) (ki*a)]);

figure;
step(cltf);
title('Closed loop step response of G with a PID controller for HW8 Problem
1- Improved');
cltf_ss_error = 1 - cltf_response(end);
cltf_step_info = stepinfo(cltf);
fprintf('CLTF Improved: Percent overshoot is %f, the settling time is %fs,
and the steady state error is %f\n\n\n', cltf_step_info.Overshoot,
cltf_step_info.SettlingTime, cltf_ss_error);
```

Problem 2

c)

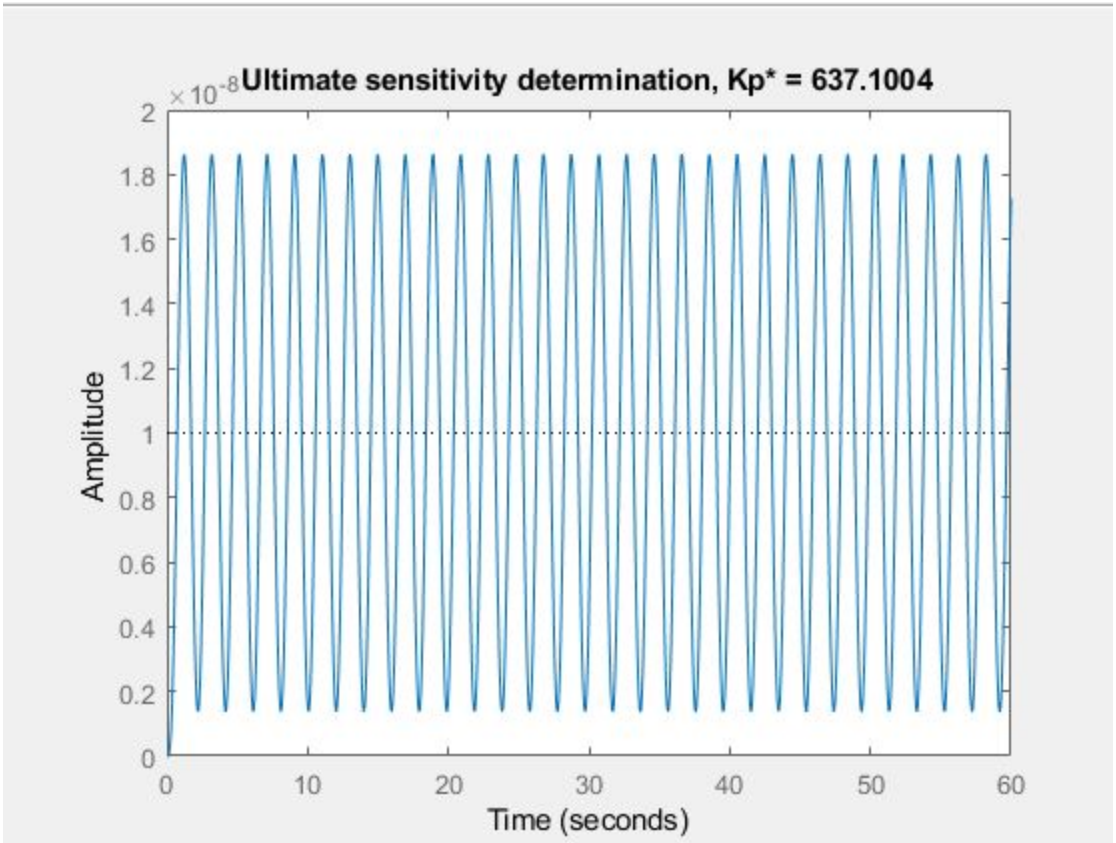



```
OLTF: Steady state value is NaN and the settling time is NaNs
```
\

```
% c
b = 10;
zeta = 0.707;
wn = 4; % rad/s

% Open loop step response
G = tf(1,[1 (2*zeta*wn+b) (wn^2+2*zeta*wn*b) (b*wn^2) 0]);
figure;
step(G);
title('Open loop step response of G from HW8 Problem 2');
G_step_info = stepinfo(G);
fprintf('OLTF: Steady state value is %f and the settling time is %fs\n\n',
G_step_info.SettlingMax, G_step_info.SettlingTime);
```

d)

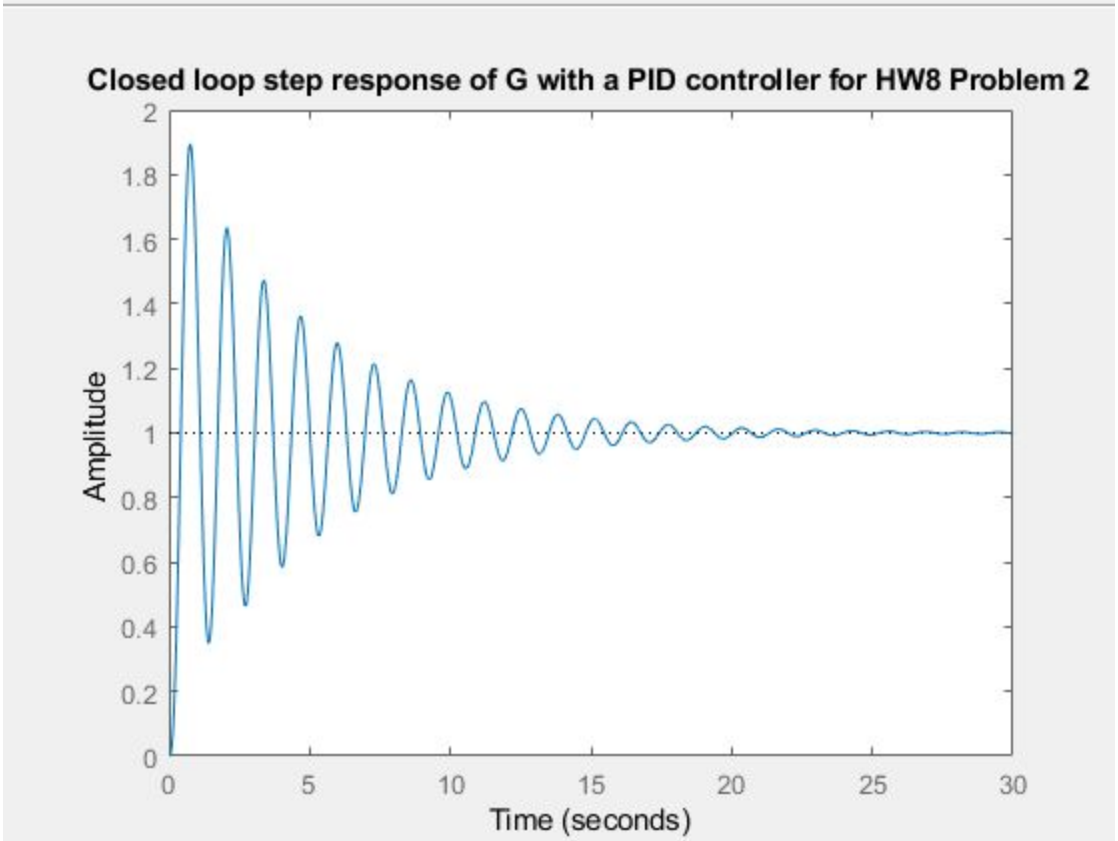



```
Ultimate Sensitivity Gains: Kp=1019.360640, Ki=1019.360640, and Kd=254.840160
```

```
% d
% Ultimate sensitivity
kp_star = 637.1004;
opt = stepDataOptions('StepAmplitude', 0.00000001);
G_kp = tf(kp_star,[1 (2*zeta*wn+b) (wn^2+2*zeta*wn*b) (b*wn^2) kp_star]);
figure;
step(G_kp, opt);
title('Ultimate sensitivity determination, Kp* = 637.1004');
Pu = 2; % s % From inspection

% Optimum gains from Zieglaer-Nichols
kp = 1.6*kp_star;
Ti = 0.5*Pu;
Td = 0.125*Pu;
ki = kp/Ti;
kd = kp*Td;
fprintf('Ultimate Sensitivity Gains: Kp=%f, Ki=%f, and Kd=%f\n\n',
kp,ki,kd);
```

e)

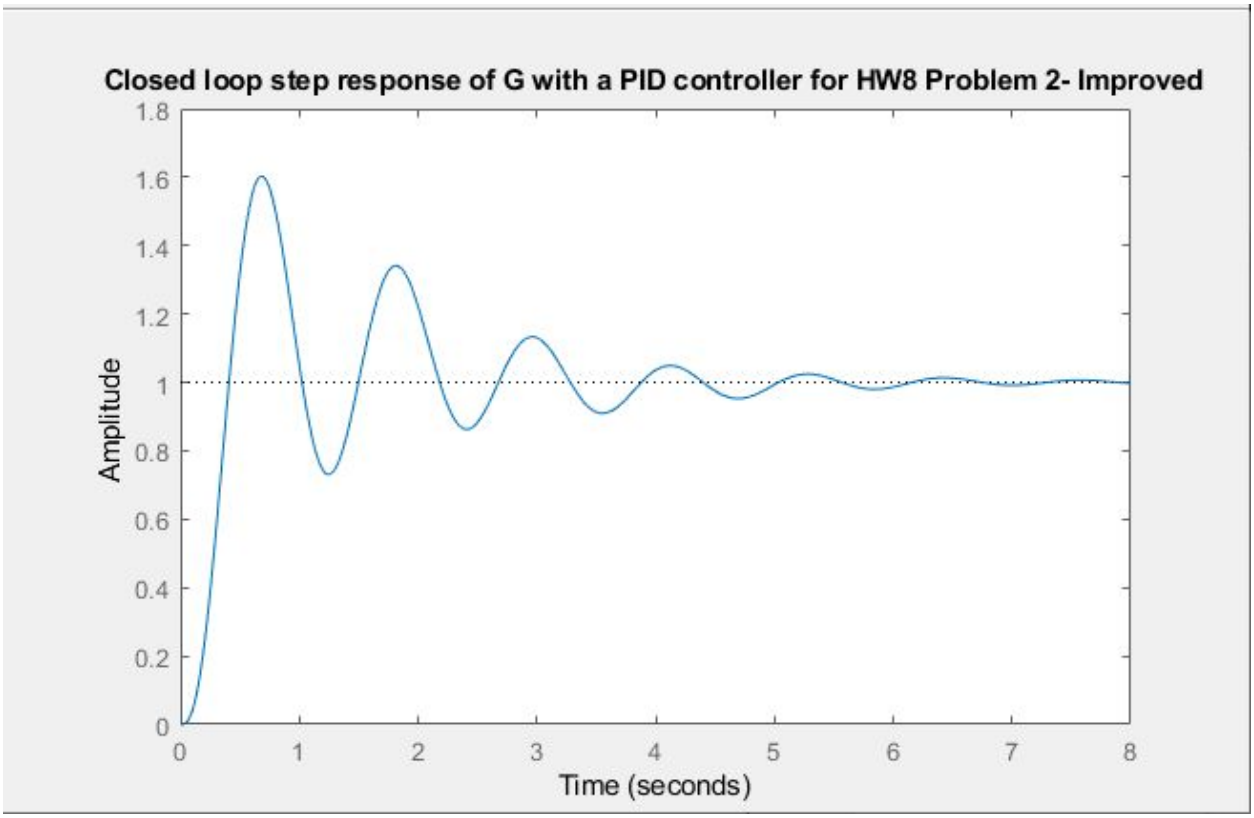



```
CLTF: Percent overshoot is 89.528380, the settling time is 18.497767s, and the steady state error is 0.002816
```

```
% e
% Closed loop step response for optimum gains
cltf = tf([kd kp ki],[1 (2*zeta*wn+b) (wn^2+2*zeta*wn*b) (b*wn^2 + kd) kp
ki]);
figure;
step(cltf);
[cltf_response,~] = step(cltf);
title('Closed loop step response of G with a PID controller for HW8 Problem
2');

cltf_step_info = stepinfo(cltf);
cltf_ss_error = 1 - cltf_response(end);
fprintf('CLTF: Percent overshoot is %f, the settling time is %fs, and the
steady state error is %f\n\n', cltf_step_info.Overshoot,
cltf_step_info.SettlingTime, cltf_ss_error);
```

f)




```
CLTF Improved: Percent overshoot is 60.318252, the settling time is 5.386918s, and the steady state error is 0.002816
```

```
% f
% Improving tuning values
kp=750;
ki=750;
kd=330;
cltf = tf([kd kp ki],[1 (2*zeta*wn+b) (wn^2+2*zeta*wn*b) (b*wn^2 + kd) kp
ki]);

figure;
step(cltf);
title('Closed loop step response of G with a PID controller for HW8 Problem
2- Improved');
cltf_ss_error = 1 - cltf_response(end);
cltf_step_info = stepinfo(cltf);
fprintf('CLTF Improved: Percent overshoot is %f, the settling time is %fs,
and the steady state error is %f\n\n\n', cltf_step_info.Overshoot,
cltf_step_info.SettlingTime, cltf_ss_error);
```