THE UNIVERSITY OF TEXAS AT SAN ANTONIO
EE 3413
ANALYSIS AND DESIGN OF CONTROL SYSTEMS

HOMEWORK # 8
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The objective of this homework is to test your understanding of the content of Module 8. Due date of the homework is: **Wednesday, April 13, 2016, @ 11:59pm**.
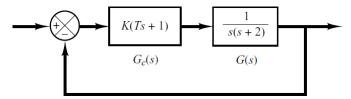
Solve the following problems.

1. Design a lead compensator for a system with $G(s) = \dfrac{10}{s(s+1)}$ such that the desired damping ratio is $\zeta_d = 0.5$ and the desired natural frequency is $\omega_{nd} = 3$. You should come up with two design solutions.

   The first solution should be based on the one we learned in class, and the other can be based on selecting the zero of the compensator as the pole of $G(s)$ at $s = -1$.

   For the two designs, find the SSE corresponding to a unit ramp input (i.e., find the static-velocity error constant K_v).
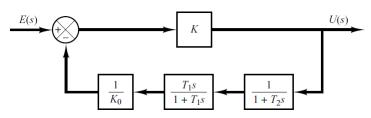
   Also, show the step response for the uncompensated and compensated system. What do you conclude?

2. For the system shown in the below figure,

   find K, T such that the desired closed loop system poles are located at $-2 \pm j2$. Plot the step response before and after the addition of the compensator to the system.

3. Design a lead compensator for a system with $G(s) = \dfrac{5}{s(0.5s+1)}$ such that the desired closed loop system poles are located at $-2 \pm j2\sqrt{3}$. Plot the step response before and after the compensator design.

4. This figure

   shows the block diagram representation of a compensator $(U(s)/E(s)$. Prove that this block diagram can be reduced into a PID controller with the three gains for the proportional, derivative, and integrator components. Derive these constants, i.e., derive K_i, T_i, T_d in terms of K_0, T_1, T_2, K.

5. For a unity feedback system, with $G(s) = \dfrac{1}{s(s+1)(s+5)}$, we want to design a PID controller of this form:

$$G_{PID}(s) = K\frac{(s+a)^2}{s},$$

   where:

- $2 \leq K \leq 50$ and $0.05 \leq a \leq 2$,
- the desired maximum overshoot is between 2 and 10 percent,
- the settling time is less than 3 seconds,
- Time simulation is for 5 seconds,
- You can iterate K and a with increments of 1 and 0.1 respectively.

In this problem, you will have to write a MATLAB program that finds the optimal value for K and a given the above ranges for K and a and the design specifications. First, you will have to obtain the CLTF in terms of K and a (in standard form). After that, you'll have to write MATLAB code with two for loops (one that iterates K and other that iterates a) and if conditions that compute settling time and maximum overshoot. The output of your program should be the optimal K and a, as well as a plot that shows the step response.

Here's a pseudo-code that you can follow:

```
time = 0:0.01:5; % defining time
for K = 2:1:50 % for loop for K
for a = 0.05:0.1:2; $ for loop for a
num = [......]; % Numerator for the CLTF in terms of K, a
den = [.......]; % Denominator for the CLTF in terms of K, a
y_step = step(num,den,time); % generating the step response for
% the specific K and a
.....   % Your code here
..... % Your code here
..... % Your code here
..... % Here, in these few lines of code (above), you have to write
% statements which includes testing for the design specs that
% are required from you. You can use the max MATLAB function, if-else statements,
% breaks, and while to do that.
end % ending the first for loop
end % ending the second for loop
plot(time,y_step)
ylabel('Output')
solution = .... % Extract your solution from the loops
```