ELEC 372

Supplementary Problem Set #3

Not to be handed in

These problems form the foundation of Quiz #3

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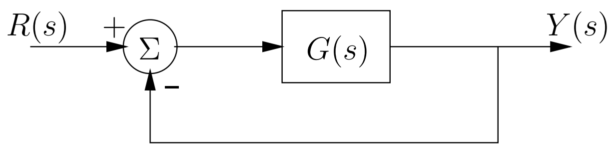
1. A chemical process is designed to follow a desired path described by

$$r(t) = (5 - t + 0.5t^2)u_1(t)$$

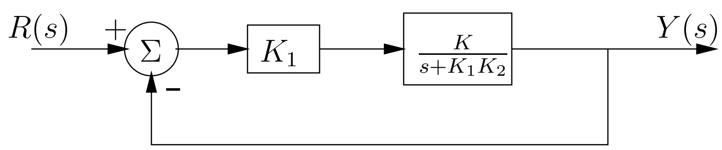
where $r(t)$ is the reference input and $u_1(t)$ is the unit step function. Consider a unity feedback system



Compute the steady-state error ($E(s) = R(s) - Y(s)$) when the open loop transfer function is

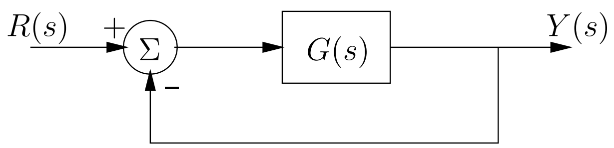
$$G(s) = \frac{10(s+1)}{s^2(s+5)}$$

2. Consider the block diagram a submersible vehicle



Find the steady-state tracking error to a unit step.

3. Consider the unity feedback controls system



where

$$G(s) = \frac{K}{s(s+a)}$$

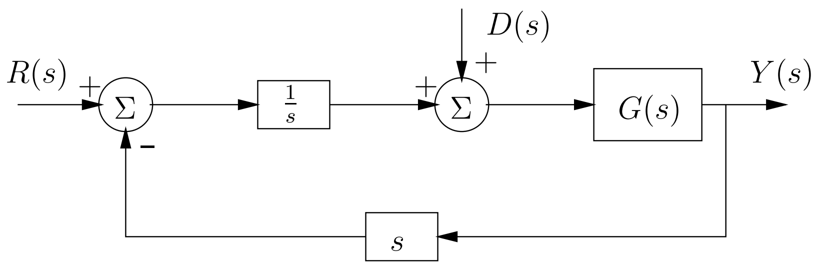
The design specifications are:

(a) Peak time $T_p \leq 1$.

(b) Percent overshoot $P.O. \leq 10\%$.

Find acceptable ranges of values for K and a.

4. Consider the machine-tool control system



where

$$G(s) = \frac{10}{s+10}$$

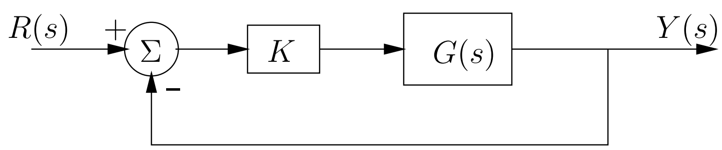
(a) Find the steady-state value of the output to a unit step disturbance $d(t) = u_1(t)$.

(b) Using a 2% criterion, compute the settling time t_s to a unit step disturbance.

5. A plant with open-loop transfer function

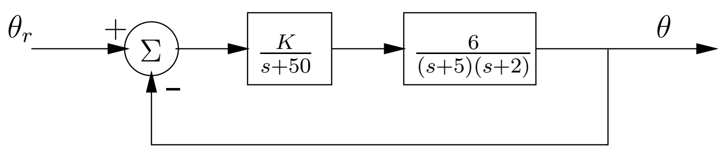
$$G(s) = \frac{1}{(1+s)(1+0.5s)}$$

is controlled by a proportional controller K, as shown in the block diagram below:



Find the value of K that yields a steady-state error equal to 0.01 to a unit step input.

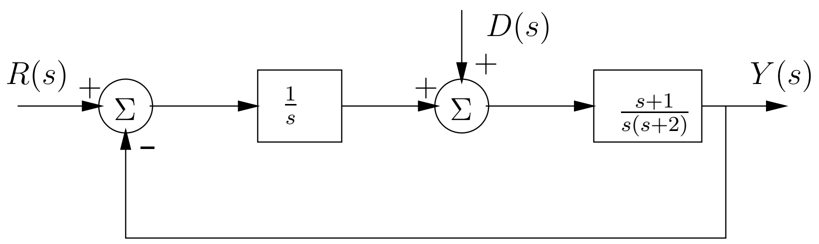
6. Consider a satellite control system to maintain the altitude orientation.



(a) Find a second-order approximation of the open-loop system in the forward path.

(b) Using the second-order approximation, estimate gain K so that percent overshoot is less than 15%.

7. Consider the following block diagram:



(a) Find the steady-state value of the output to a unit step disturbance $d(t) = u_1(t)$.

(b) Find the steady-state error when $r(t) = (1+t)u_1(t)$, and noting that $e = r - y$, conclude the steady-state value of the output when $r(t) = (1+t)u_1(t)$.

(c) Find the steady-state value of the output when the disturbance is $d(t) = u_1(t)$ AND the reference is $r(t) = (1+t)u_1(t)$.