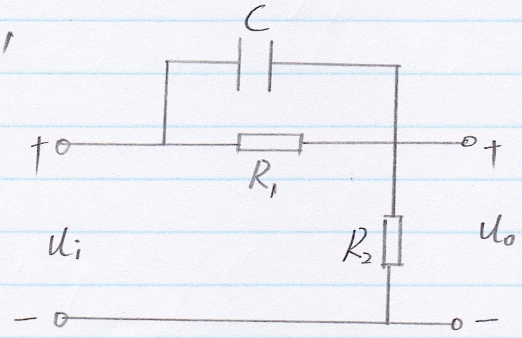
Assignment #1

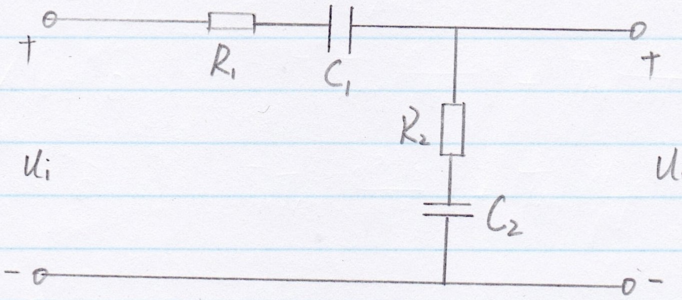
Construct ODEs for the following systems:

1) 10'



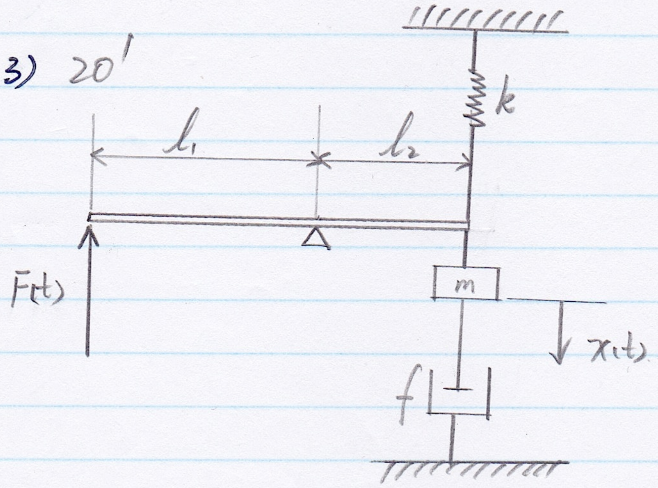
Input: u_i
Output: u_o

2) 10'



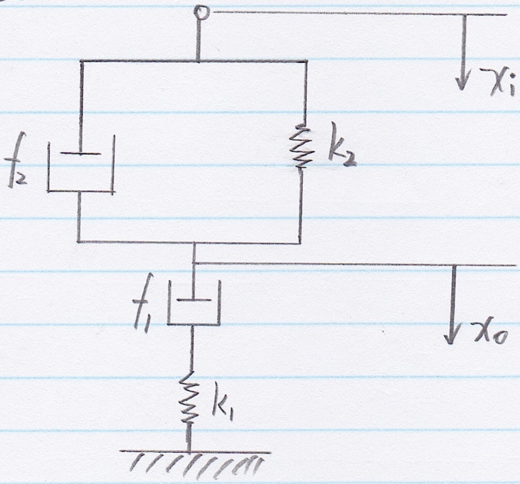
Input: u_i
Output: u_o

3) 20'



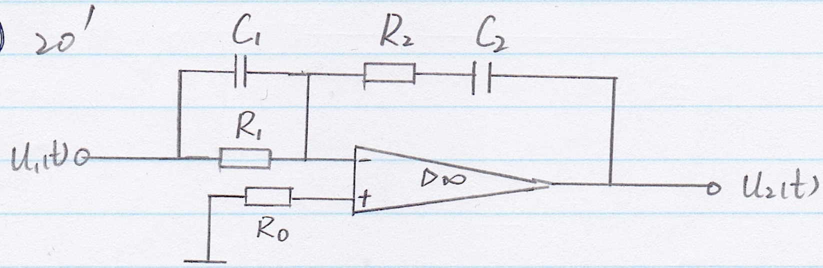
Input: $F(t)$
Output: $x(t)$

4) 20'



Input: x_i
Output: x_o

5) 20'



Input: $u_1(t)$
Output: $u_2(t)$

Assignment # 2.

Due: Thursday. 26th. Sept. 2013.
4:00 pm.

1) 10' The mechanical system, as shown in Fig. 1, has $F(t)$ as the input and $x(t)$ as the output.
Find the transfer function $T(s) = X(s)/F(s)$, with zero initial conditions.

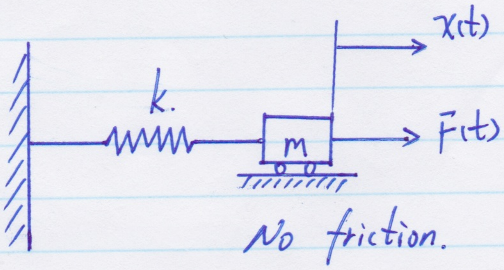


Fig. 1.

2) 10' The mechanical system, as shown in Fig. 2, has $x_i(t)$ as the input and $x_o(t)$ as the output.

Find the transfer function $T(s) = X_o(s)/X_i(s)$, with zero initial conditions. In addition, the gravity can be neglected. but "m" cannot be neglected.

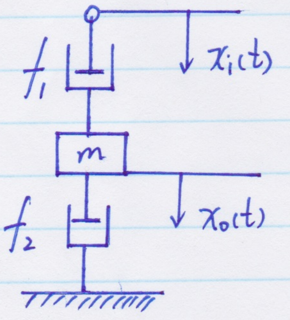


Fig. 2.

20'

3) The height control system of a type of unmanned autonomous vehicle has the following transfer function

$$T(s) = \frac{Y(s)}{R(s)} = \frac{s+1}{(s^2+6s+10)(s+2)}$$

(a) Find the impulse response of the system, that is, $r(t) = \delta(t)$, $y(t) = ?$

(b) Find the unit step response of the system, that is,

$r(t) = u(t)$, $y(t) = ?$

(c) What is the final value of the unit step response?

Hilroy

MECH 380 Automatic Control Engineering: Assignment III

Due: 4:00 pm, Oct. 7th, 2013

I. Problem 1 $10'$

The system block diagram is as shown in Fig. 1. Find the transfer function from $R(s)$ to $Y(s)$. You

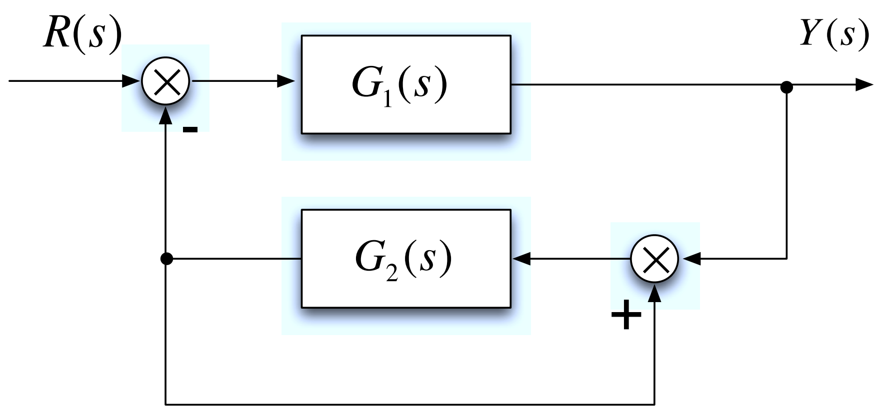


Fig. 1. *System block diagram.*

are required to obtain

$$\Phi(s) = \frac{Y(s)}{R(s)}.$$

II. Problem 2 $30'$

The system block diagram is as shown in Fig. 2. Find the transfer function from $R(s)$ to $Y(s)$ and from $F(s)$ to $Y(s)$, respectively. You are required to obtain

$$\Phi_1(s) = \frac{Y(s)}{R(s)},$$

and

$$\Phi_2(s) = \frac{Y(s)}{F(s)}.$$

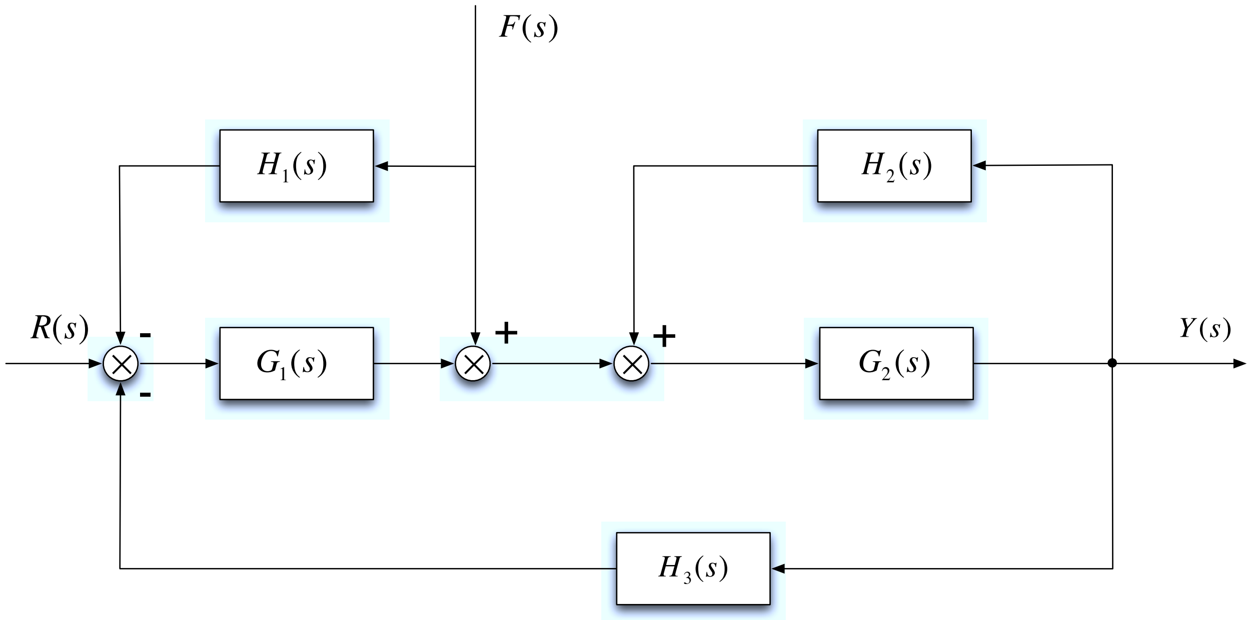


Fig. 2. *System block diagram.*

III. Problem 3 20′

The closed-loop transfer function of a first-order system can be represented by

$$\Phi(s) = \frac{K}{Ts+1}, \tag{1}$$

where K and T are positive constants. The impulse response of this system can be shown in Fig. 3. Try to determine K and T.

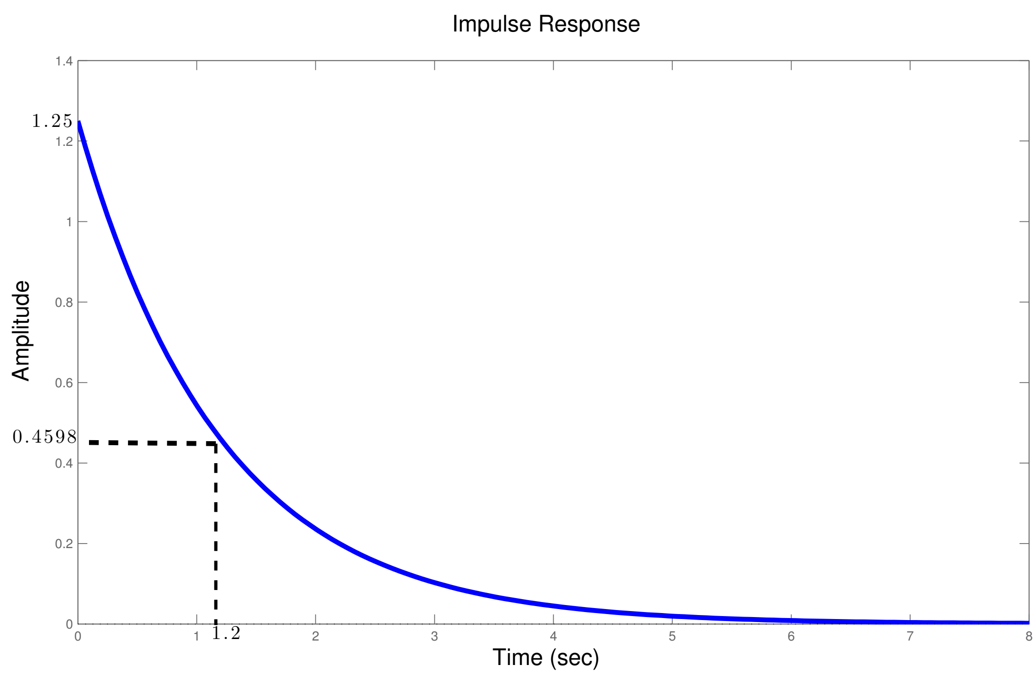


Fig. 3. *Impulse response of the 1st-order system.*

MECH 380 Automatic Control Engineering: Assignment IV

Due: 4:00 pm, Oct. 15th, 2013

I. PROBLEM 1 $10'$

The system block diagram is shown in Fig. 1. Require: (1) overshoot $\delta_p = 16.3\%$; (2) peak time

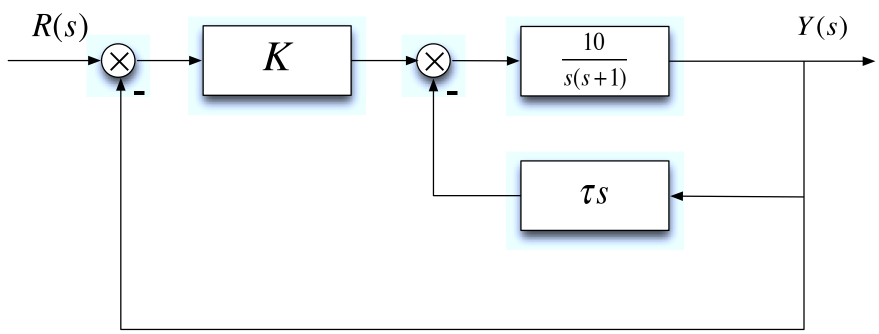


Fig. 1. *System block diagram.*

$t_p = 1sec$. Please determine the values of gain K and inner feedback parameter τ.

II. PROBLEM 2 $10'$

The open-loop transfer function of a unit negative feedback system is

$$G(s) = \frac{1}{s(s+0.6)}. \tag{1}$$

Please determine the overshoot δ_p, rising time t_r, peak time t_p, and settling time t_s of the unit step response of this second-order system.

III. PROBLEM 3 $10'$

The unit step response $y(t)$ of a second-order system can be shown in Fig. 2. Suppose this system is a unit negative feedback system. Please determine the open-loop transfer function $G(s)$ of this system.

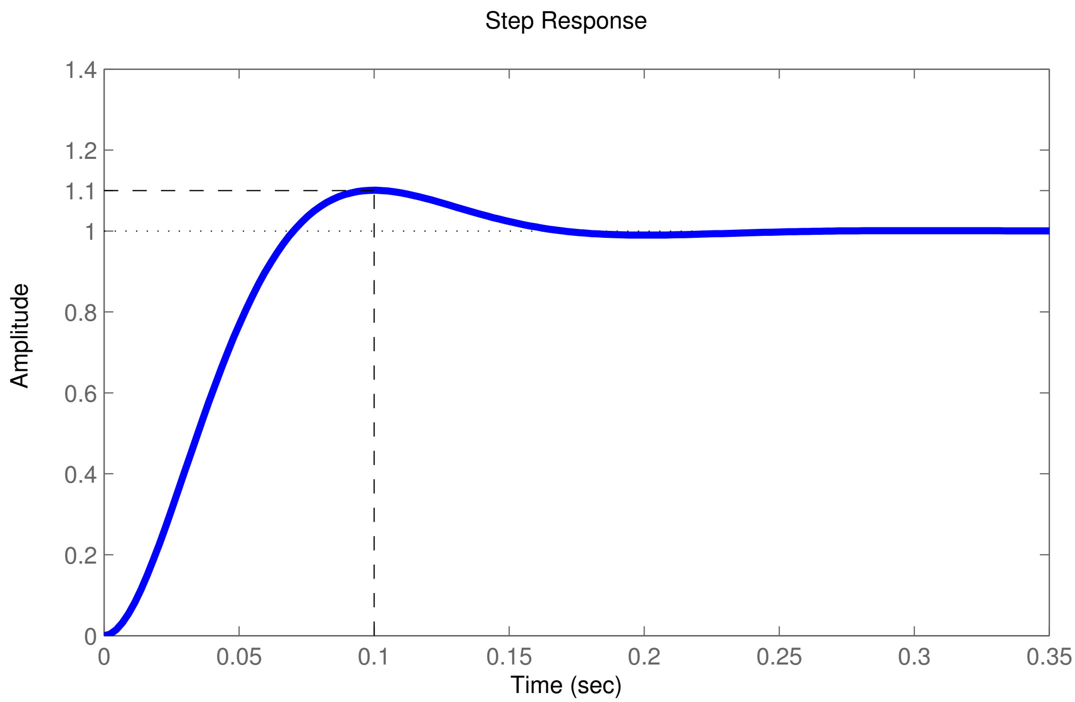


Fig. 2. *Unit step response of the second-order system.*

Assignment #5

Due: Oct. 31st. Thursday 4:00 pm.

10' Problem 1:

The unit step response of a system is.

$$y(t) = 1 + e^{-t} - e^{-2t} \quad (t \geq 0)$$

Please evaluate the stability of this system.

20' Problem 2:

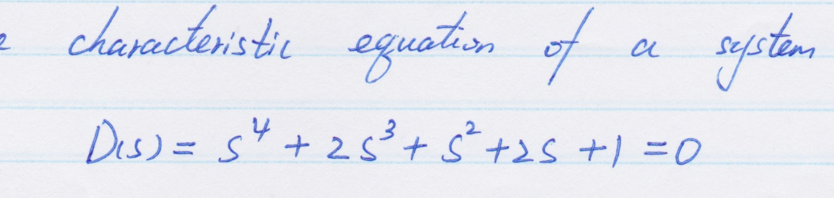
The characteristic equation of a system is

$$D(s) = s^4 + 2s^3 + s^2 + 2s + 1 = 0$$

Please evaluate the stability of this system. If the system is not stable, please point out that how many poles are positive or have positive real parts.

20' Problem 3:

The block diagram of a system can be shown below.



Please determine the range of K that can ① make this system stable. and ② all poles on the left hand side of $s = -2 \pm j\omega$

Assignment # 6

Due Nov. 14. Thursday 4:00 pm

1. The open-loop transfer function of a unit negative feedback system is

$$G(s) = \frac{100}{s(0.1s+1)}$$

If the input signal $r(t) = \sin 5t$, $t \geq 0$. Please determine the steady state error e_{ss}.

2. The block diagram of a control system can be shown below. The disturbance $f(t) = 2u(t)$. Please calculate

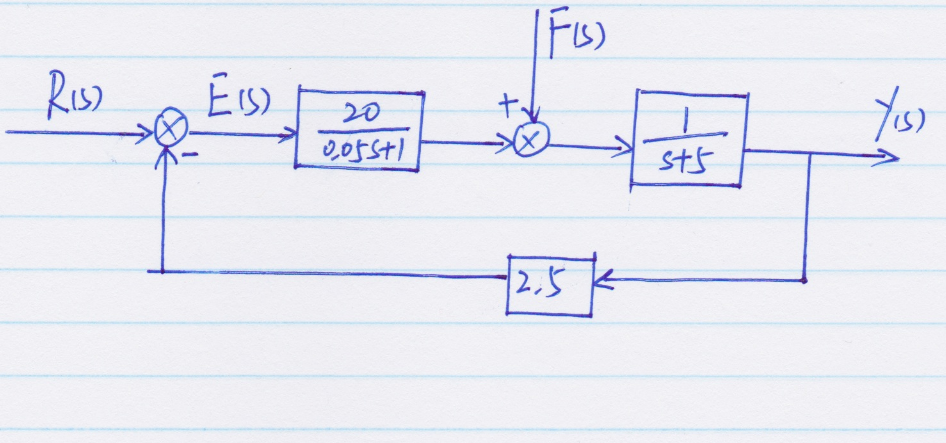
1) Steady state error e_{ssf}.

2) If add $\frac{1}{s}$ before $F(s)$, the value of e_{ssf}.

3) If add $\frac{1}{s}$ after $F(s)$, the value of e_{ssf}.

4) Compare the e_{ssf} in 1), 2), and 3).

Hint: Derive the transfer function from $F(s)$ to $E(s)$ first.



3. The system dynamics of a thermometer can be described as an inertia element, whose transfer function is $1/(Ts+1)$. When using this thermometer to measure the water temperature in a container, we find out that, after 1 minute, the display temperature reaches 98% of the actual water temperature. If we heat this container to increase the water temperature with the rate 10°C/min. Please calculate the steady state error between the display and actual temperature.

Hint: 1) This problem is very challenging

2) Figure out the block diagram

3) $1/Ts+1$ is the closed-loop transfer function

4) Don't mess up "minute" and "second"

Enjoy the Reading Break.

Assignment #7

Due Nov. 28. Thursday.
4:00 pm.

1. The step response of a system is

$$y(t) = 1 - 1.8e^{-4t} + 0.8e^{-9t}, \quad t \geq 0$$

① Find the steady state output of this system if the input signal is $\sin \omega t$.

1) $\omega = 4$ rad/s.
2) $\omega = 7$ rad/s.

② Draft the Nyquist Plot of the frequency response of this system

③ Draft the Bode plot of the frequency response of this system. (magnitude only, asymptote only)

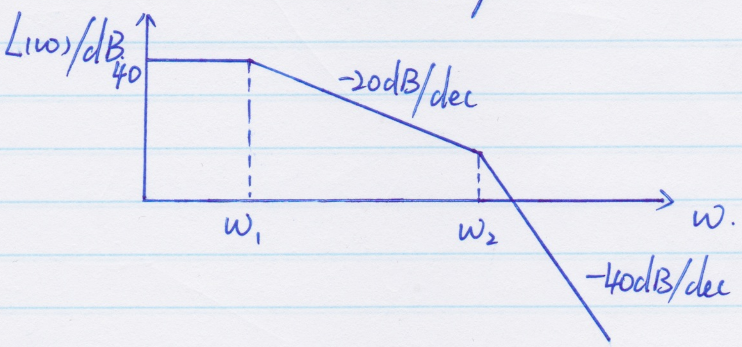
④ When $\omega = 4$, find the error between the asymptote in the Bode plot and magnitude of frequency response in 1.①. (use dB as the unit)

2. The transfer function for a control system is

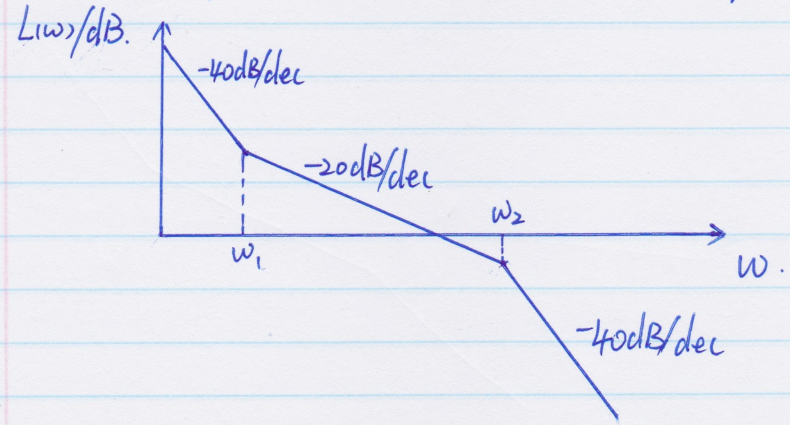
$$T(s) = \frac{\frac{35}{3}(s+\frac{1}{7})}{s(s+\frac{1}{3})(s^2+\frac{1}{2}s+\frac{1}{4})}$$

Please draft the Bode Plot for the frequency response of this system (magnitude only). Do not forget to indicate the corner frequency and slope.

3. The Bode Plot of the frequency response of a system is shown below, please determine the transfer function.

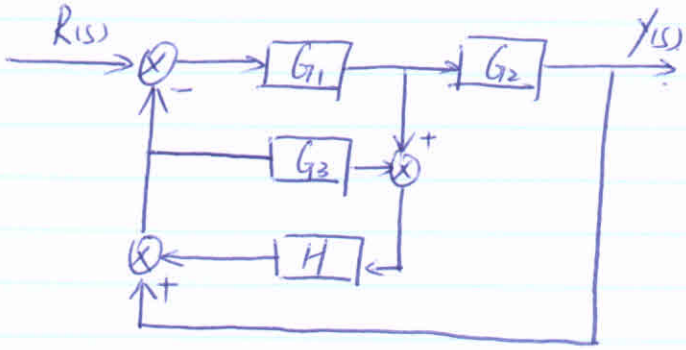


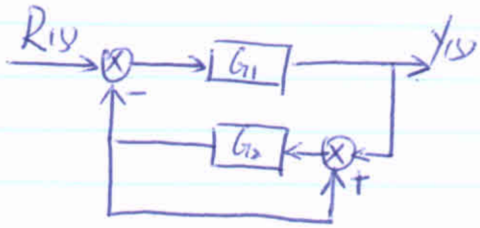
4. The Bode Plot of the frequency response of a system is shown below, please determine the transfer function. (Assume the gain is K)



Assignment #8 No need to submit.

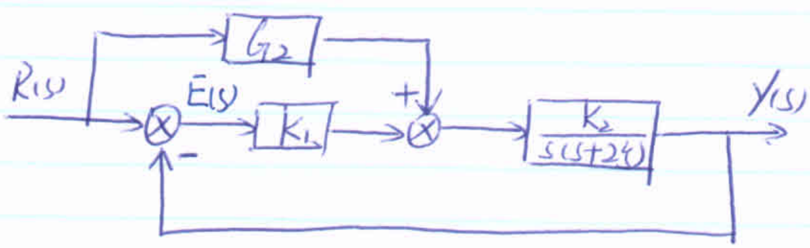
1. Block diagram simplification

① 

② 

2. Methods to reduce / eliminate steady state error.

The block diagram of a control system is shown below.



In order to modify the system type from Type I to Type III, a feedforward channel G_2 is added.

$$G_2(s) = \frac{\lambda_2 s^2 + \lambda_1 s}{Ts+1}$$

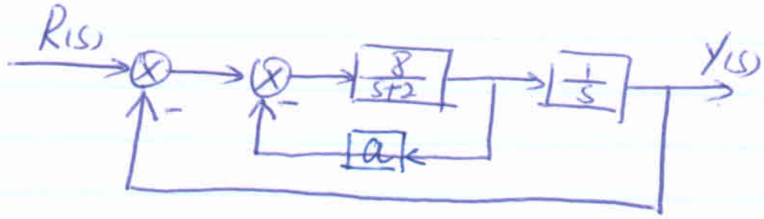
If $K_1=2$, $K_2=50$, $\zeta=0.5$, $T=0.2$. Try to determine λ_1 & λ_2.
Note: obtain the transfer function from $R(s)$ to $E(s)$ first.

3. System characteristic equation

$$D(s) = s^6 + 4s^5 - 4s^4 + 4s^3 - 7s^2 - 8s + 10 = 0$$

Please determine the number of roots on the RHS of the complex plane and determine the conjugate poles.

4. The block diagram of a control system is shown below.



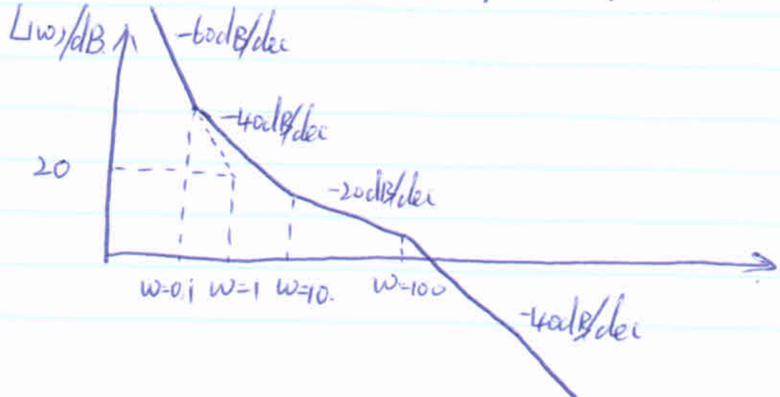
① When $a=0$, determine ξ & ω_n.
② If we need $\xi=0.7$, please determine the value of a.

5. Open-loop transfer function

$$G(s)H(s) = \frac{75(0.2s+1)}{s(s^2+16s+100)}$$

Draft the Bode Plot for this open-loop system.

6. Bode plot of an open-loop system is shown below



Determin the transfer function for the open-loop system.