

Islamic University of Gaza
Electrical and Computer Engineering Department
EELE 3371 Control System
Final Exam
June 6, 2007

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Name:

Exam Time 9:00-11:00
ID. #

1. For the system shown in Fig. 1, do the following: (12 PT.)
- Find the transfer function $G(s) = X(s)/F(s)$.
 - Find % OS, T_s , T_p , and T_r .

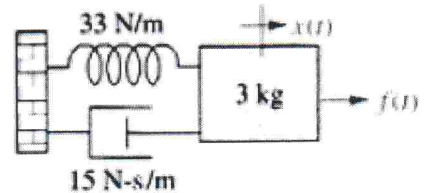


Fig. 1

a) $M\ddot{x} + B\dot{x} + kx = f(t)$

$\therefore Ms^2X(s) + B s X(s) + k X(s) = F(s)$

$$\therefore \frac{X(s)}{F(s)} = \frac{1}{3s^2 + 15s + 33} = \frac{1/3}{s^2 + 5s + 11}$$

b) $\omega_n^2 = 11 \Rightarrow \omega_n = 3.32$

$2f_{wn} = 5 \Rightarrow f = 0.754$

$\therefore \% OS = e^{-\frac{f\pi}{\sqrt{1-f^2}}} = 2.7\%$

$T_s = \frac{4}{f_{wn}} = 1.6s$

$\omega_n T_r = 2.296$

$T_r = \frac{2.296}{3.32}$

$\therefore T_r = 0.695s$

$T_p = \frac{\pi}{\omega_n \sqrt{1-f^2}} = 1.44$

2. The block diagram shown in Fig. 2, find $Y(s)/R(s)$

(10 PT.)

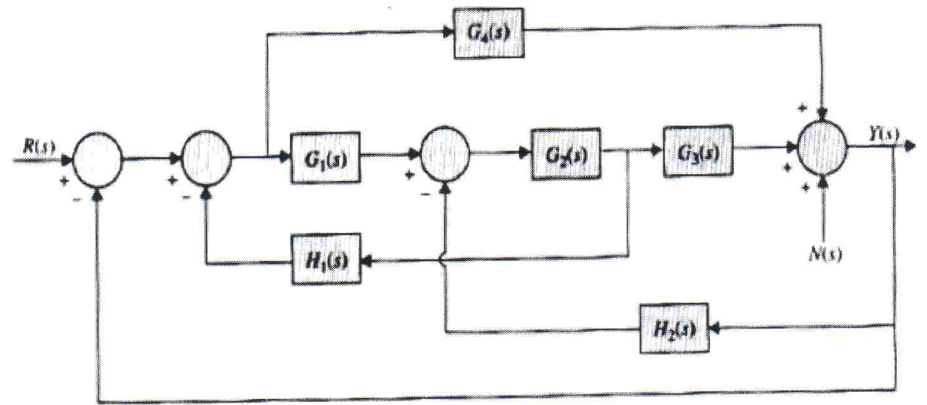
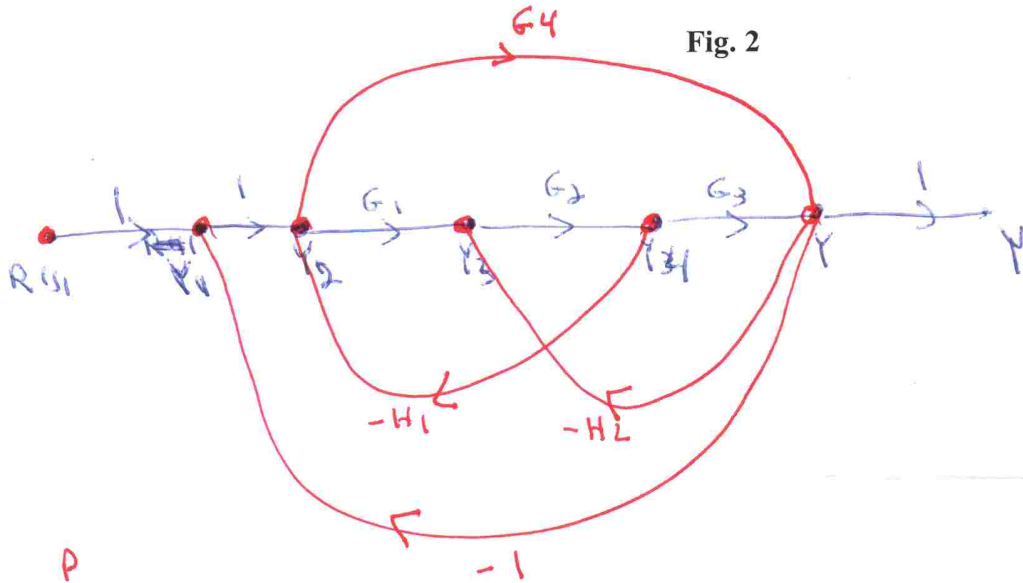


Fig. 2



$$\frac{Y(s)}{R(s)} = \frac{1}{\Delta} \sum_{k=1}^P M_k \Delta_k$$

$$P = 2$$

$$L_1 = -G_1 G_2 G_3, \quad L_2 = -G_1 G_2 H_1, \quad L_3 = -G_2 G_3 H_2, \quad L_4 = -G_4$$

$$L_5 = G_4 H_2 G_2 H_1$$

$$M_1 = G_1 G_2 G_3, \quad M_2 = G_4$$

$$\Delta_1 = 1, \quad \Delta_2 = 1$$

$$\frac{Y(s)}{R(s)} = \frac{M_1 \Delta_1 + M_2 \Delta_2}{\Delta} = \frac{G_1 G_2 G_3 + G_4}{\Delta}$$

$$\Delta = 1 + G_1 G_2 G_3 + G_1 G_2 H_1 + G_2 G_3 H_2 + G_4 + G_4 H_2 G_2 H_1$$

3. a) The block diagram of a control system is shown in Figure 3

(10 PT.)

$$G_c(s) = k, \quad G_p(s) = \frac{1}{s(s+2)(s+4)(s+10)}$$

$$H(s) = 1$$

Sketch the root locus with respect to K for the system showing in Figure 3. Also find the value of K with locations of poles when the R-L crosses the imaginary- axis, if any.

$$\alpha = 4, \quad \theta_m = \pm 45^\circ, \pm 135^\circ$$

$$G_p(s) = \frac{1}{s^4 + 16s^3 + 68s^2 + 80s}$$

$$B.P. = -8.11, -3.88, -7.981$$

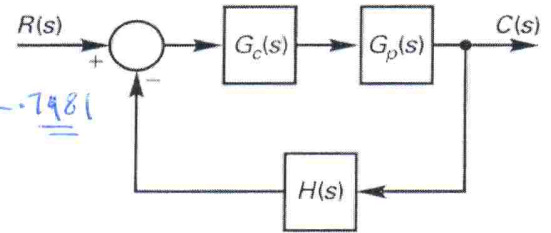
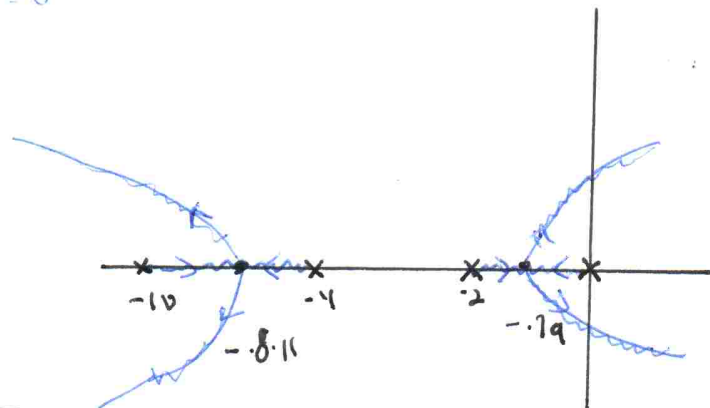


Fig. 3

$$1 + KG_p(s) = 0$$

$$\text{charit eqn} \quad s^4 + 16s^3 + 68s^2 + 80s + k = 0$$

s^4	1	68	k
s^3	16	80	0
s^2	63	k	
s^1	$\frac{-16k + 5040}{63}$	0	
s^0	k		



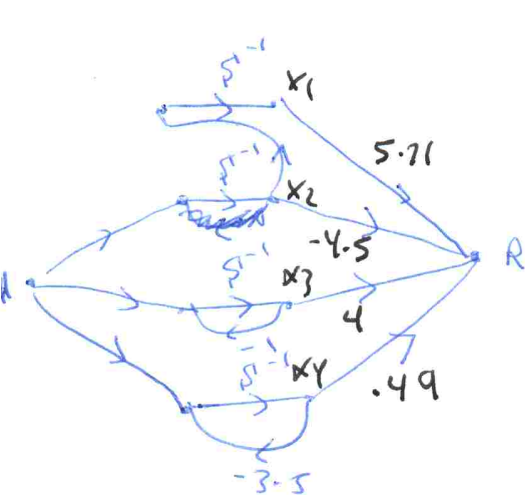
$$\therefore k > 0, \quad \frac{-16k + 5040}{63} > 0$$

$$0 < k < 315$$

$$63s^2 + k = 0 \Rightarrow s^2 = -\frac{k}{63} \Rightarrow s_{1,2} = \pm j 2.236 \quad (k = 315)$$

b) Write state-space equations for the transfer function by using parallel decomposition. Make certain that you have a minimum number of integrators (7 PT.)

$$G(s) = \frac{10(s+2)}{s^2(s+1)(s+3.5)} = \frac{-4.5}{s} + \frac{.49}{s+3.5} + \frac{4}{s+1} + \frac{5.71}{s^2}$$



$$\dot{\underline{x}} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -3.5 \end{bmatrix} \underline{x} + \begin{bmatrix} 0 \\ 1 \\ 1 \\ 1 \end{bmatrix} u$$

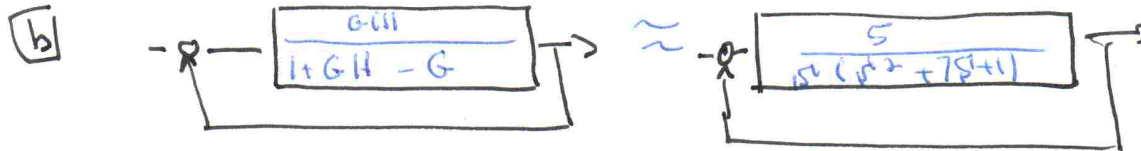
$$y = [5.71 \quad -4.5 \quad 4 \quad .49] \underline{x}$$

4. Consider the plant transfer function shown in Figure. 3

$$G_p(s) = \frac{1}{s^2(s+7)}$$

- (a) Find steady-state error due to a unit step, a unit ramp, and a unit parabolic. For $G_C(s) = K$, and unity feedback. (3 PT.)
 (b) For the system with gain $G_C(s) = 5$ and feedback $H(s) = 0.2(s+5)$, find the steady-state error due to a unit step, a unit ramp, and a unit parabolic. (5 PT.)

[a] system is unstable because charact. eq = $s^3 + 7s^2 + k$ does not satisfy the necessary cond.



System is type 1:

$$e_{ss} |_{\text{step}} = 0$$

$$e_{ss} |_{\text{parabla}} = \infty$$

$$e_{ss} |_{\text{ramp}} = 1/k_v$$

$$k_v = \lim_{s \rightarrow 0} s k G H = 5$$

$$\therefore e_{ss} |_{\text{ramp}} = 1/5 = 0.2$$

C) Choose the right answer;

(5 Points)

- The most important advantage of the closed-loop system over open loop system is
 - More gain.
 - Better stability.
 - ☒ Greater control over system dynamics.
 - No advantage.
- The transfer function of the plant is $G(s) = \frac{1}{s-1}$ and the feedback path $H(s) = (s-b)$. The value of b for which the system will be stable is
 - $b \geq 0$.
 - $b \leq 0$.
 - $b > 1$.
 - ☒ $b < -1$.
- The effect of addition of a pole to an open-loop transfer function will
 - Pull the root locus towards the imaginary axis.
 - Pull the root locus to the right of imaginary axis.
 - Have no effect on the root locus.
 - ☒ Pull the root locus to the left of imaginary axis.
- When the gain k of a system is increased, the steady state error of the system
 - Increases.
 - Remains unchanged.
 - May increase or decrease.
 - ☒ Decreases.
- Open loop control
 - Takes account of actual output and compares this to desired output
 - has feedback
 - ☒ Is blind to actual output.
 - Results more accurate than closed loop system