(25%) 1. Shown in Figure 1 is the step response of a second-order system whose transfer function is given below. Find the system parameters a, b, and c.

$$\frac{Y(s)}{R(s)} = \frac{c}{s^2 + as + b}, \quad R(s) = \frac{1}{s}$$

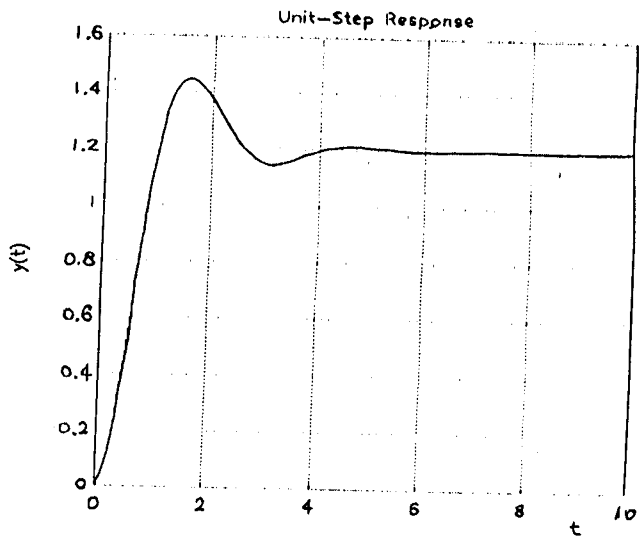
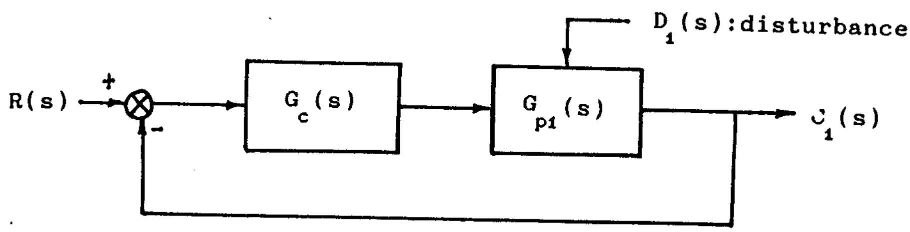


Figure 1

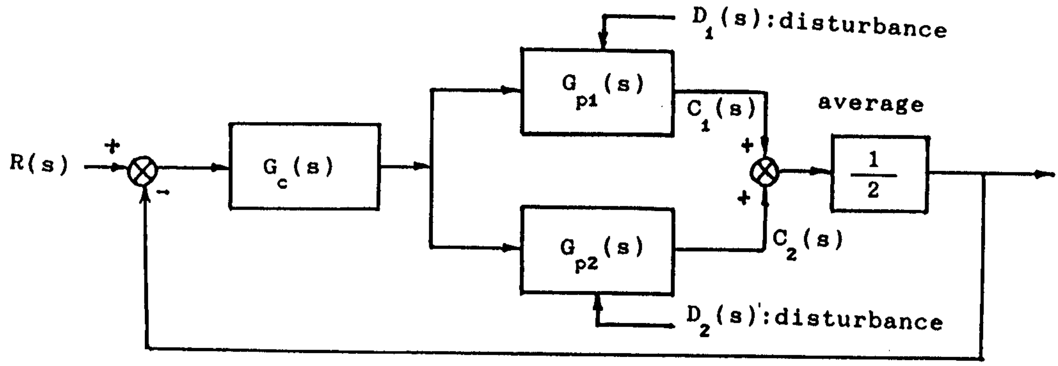
2.

(10%) (1). An unstable linear control object ($G_{p1}(s)$) is successfully under feedback control



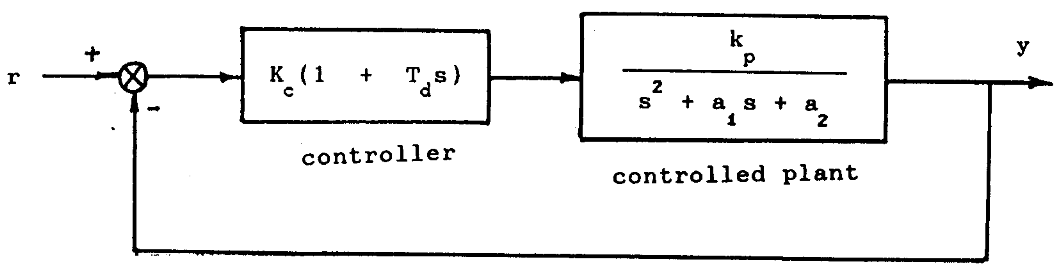
where $G_c(s) = \dfrac{B_c(s)}{A_c(s)}$ and $G_{p1}(s) = \dfrac{B(s)}{A(s)}$.

There is another unstable control object $G_{p2}(s)$ which is identical characteristics as $G_{p1}(s)$; i.e. $G_{p2}(s) = G_{p1}(s) = \dfrac{B(s)}{A(s)}$. Unfurtunately, there is only one controller available. As a temporary solution, one engineer from National T university suggested to let $G_{p2}(s)$ and $G_{p1}(s)$ share the controller as follows.



Do you support this scheme? (State with proof)

(15%)(2) It is claimed that the closed loop reference input response can be made close to a first order process response by making K_c very large (high-gain feedback): i.e. the second order process behaves like a first order process.



(a). show that this is true and obtain the first order response that approximate the response y(t) for

$$r(t) \begin{cases} = r_o & t = 0 \\ = 0 & t > 0 \end{cases}$$

(b). $T_d s$ is the controller has been replaced by a realisable filter, $\frac{T_d s}{1 + T_f s}$. It has been also noted that the transducer used for measuring y(t) has dynamics $\frac{1}{T_m s + 1}$. Comment on the effect of T_f and T_m on the high gain feedback scheme.

3. Roughly sketch the root locus of the following system. Also, show the corresponding asymptotes for $s \to \infty$ on each plot. A proper choice of axes are given for each case.

(1). $\dfrac{64\ k}{s(s+4)(s+16)}$ (3%) [H(-17,3) V(-15,15)]

(2). $\dfrac{k}{s(s+3)(s^2+6s+64)}$ (3%) [H(-8,2) V(-5,5)]

(3). $\dfrac{k(s+1)}{s(s-1)(s+6)}$ (3%) [H(-8,2) V(-5,5)]

(4). $\dfrac{2e^{-3.0s}}{s(s+1)}$ (3%) [H(-5,5) V(-5,5)]

4. Please answer the following questions.

(1). What is the time constant of the system with a transfer function $\dfrac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$. (2%)

(2). What is the peak resonance? What is its relationship to the overshoot? Is this relationship established for a general transfer function? (4%)

(3). What is the bandwidth? What is the relationship between the bandwidth and the response time? (4%)

(4). How do you determine phase margin and gain margin from a Nyquist plot? a Bode plot? a Nichols plot? (Show it using the corresponding figures). (6%)

(5). What property, gain or phase, of a phase-lead compensator do we use in the compensation? For what type of Bode plot is the phase-lead compensation not effective? (5%)

(6). State any two advantages and any two disadvantages of a control system design using feedback. (4%)

5. Consider a system $\dfrac{y(s)}{r(s)} = \dfrac{s+1}{s^2+6s+8}$

(1). Show the controller canonical form (realization) of this system. (6%)

(2). Draw up a patching diagram for analog simulation of the above realization using the following components. (7%)