1. For the system with the block diagram shown in Fig. 1(a), .

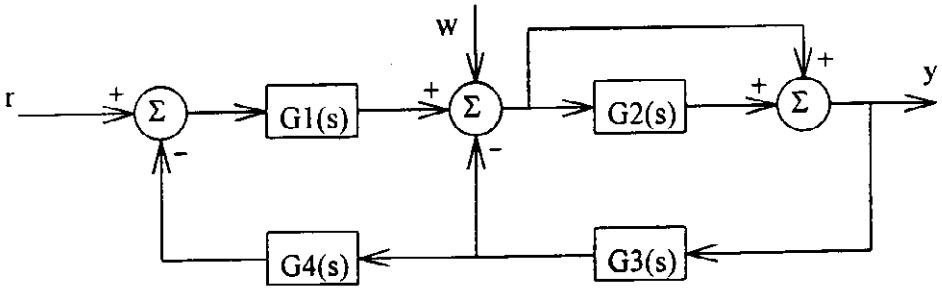

Fig. 1(a)

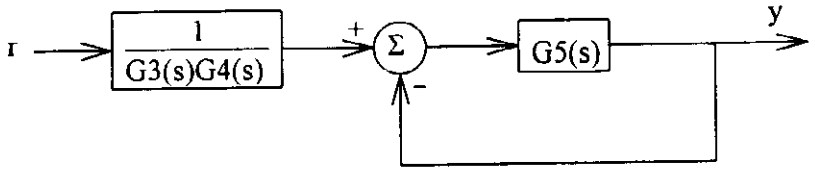

Fig. 1(b)

(a) Find the transfer functions of $\frac{Y}{R}$ and $\frac{Y}{W}$ (You can use G instead of G(s) for simplicity). (7%)

(b) For the reference input r, the system in Fig. 1(a) is equivalent to the unity feedback system in Fig. 1(b). Please find G5(s). (5%)

(c) If $G1(s) = \frac{1}{s+1}$, $G2(s) = \frac{1}{s+2}$, $G3(s) = G4(s) = \frac{1}{s}$, determine the system stability by the Routh's criterion. (5%)

(d) Continued from (c), determine the system type with respect to the reference input r and the disturbance input w. (7%)

(e) If $r = 3 \cdot u(t)$ and $w = t^2 \cdot u(t)$, where u(t) is the unit step function, please find the steady-state value of y. (6%)

2. For a unity feedback system with the block diagram as shown in Fig. 2,

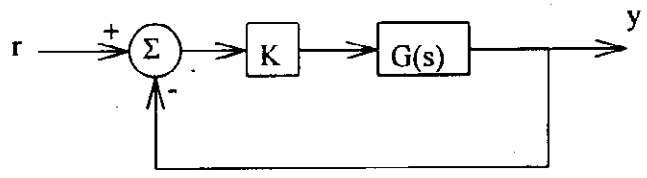

Fig. 2

(a) If $G(s) = \frac{1}{s(s+1)(s+2)}$, complete the root locus in details. (5%)

(b) If the system has a 2nd-order pole, find K and the location of the 3rd closed loop pole. (5%)

(c) If the system is about to be unstable, find K and the locations of the closed loop poles. (5%)

(d) If the damping ratio ζ for the dominating pair of poles is 0.7071, find K and the location of the 3rd pole. (5%)

(e) If the dominating pair of poles have $\omega_n = 1$ and $\zeta = 0.5$, find the maximum value of |z|, where z is the LHP zero of the lag compensator D1(s) inserted in the forward path. If this zero is placed at (−0.5, 0), please design a suitable compensator. (10%)

(f) Continued from (e), if the steady-state error corresponding to a unit ramp input is set to be 0.2, we'll need a lead compensator in the forward path. Please design a suitable lead compensator D2(s), when its zero is placed at (−0.1, 0). What's the major deteriorating effect of this zero? (10%)

3. For a unity feedback system as shown in Fig. 2, the Bode plots of G(s) are approximately illustrated in Fig. 3(a).

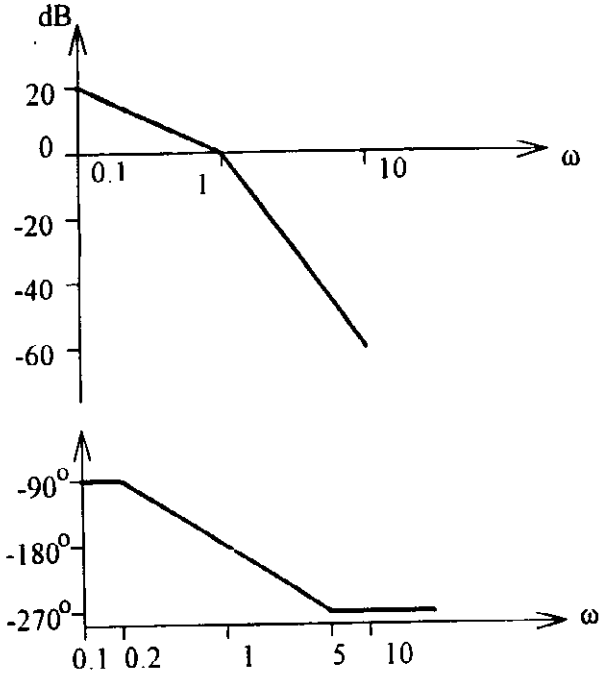

Fig. 3(a)

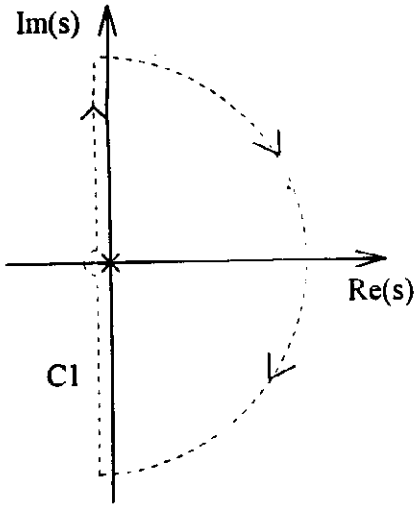

Fig. 3(b)

(a) Determine the system type with respect to the reference input. Find the gain K such that the constant steady state error equals 0.1 (The input is $\frac{t^k}{k!} \cdot u(t)$, where k is the system type). (5%)

(b) If the C1 contour looks like as shown in Fig. 3(b), please construct the Nyquist plot of G(s) in details. (10%)

(c) For $\omega \to 0$, find Re[G(jω)]. (5%)

(d) Determine the relationships between system stability and the gain K. (10%)