Prob. 1 For the two block diagrams as shown in Figure 1, indicate which one will have better disturbance rejection, provided that G(s) is a plant with all poles and zeros all located on the left-half s-plane. Here, d is the constant disturbance, r is the command and c is the output. Give any mathematical formula, and/or description to support your answers. (5 pts)

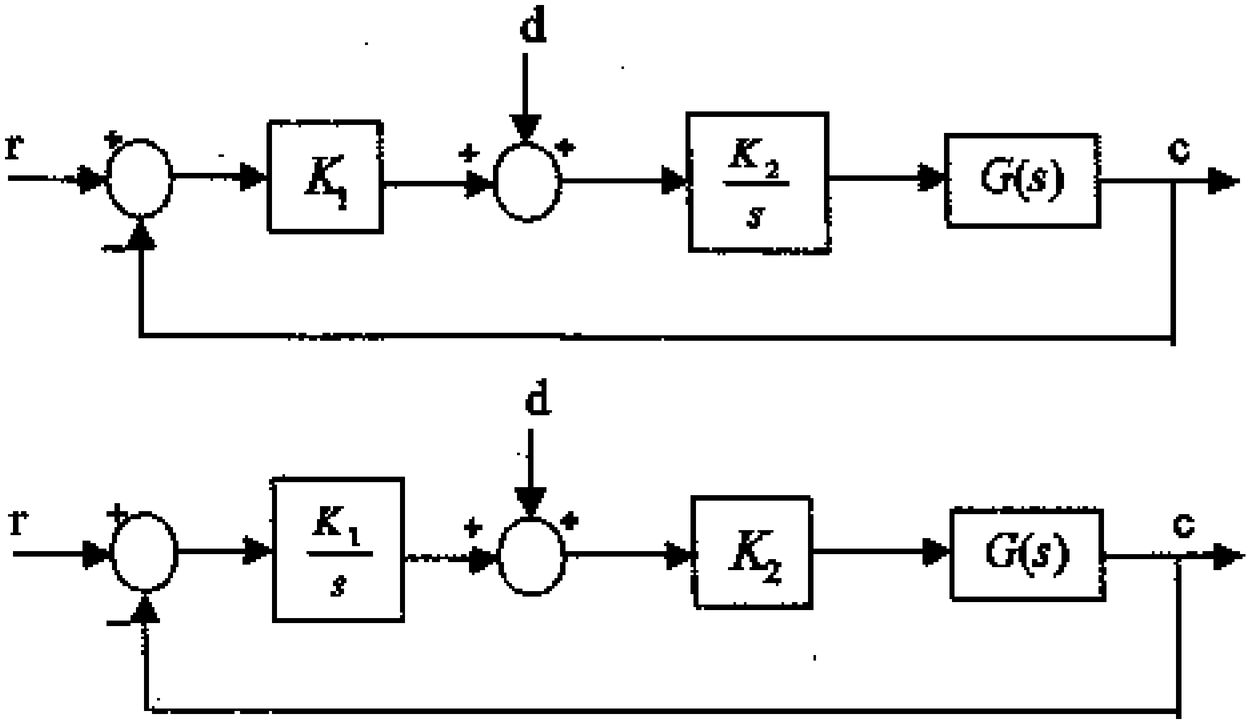


Figure 1

Prob. 2 Sketch the boundaries of the acceptable region in the s-plane of a second order system with finite zero and (a) rise time of 5 ms, (b) settling time for 20 ms, (c) the maximum percent overshot is less than 5%. (6 pts)

Prob. 3 A system block diagram is given and as shown in Figure 2. Assuming that the system is stable in all cases for this problem. (24 pts)

(a) If K_2=0, what are the steady state errors to unit step, unit ramp and unit acceleration, respectively.

(b) What is the system "type" for K_2=0 ?

(c) For $K_1K_2 \neq 0$, what are the steady state errors to unit step, unit ramp and unit acceleration, respectively.

(d) What is the system "type" for $K_1K_2 \neq 0$?

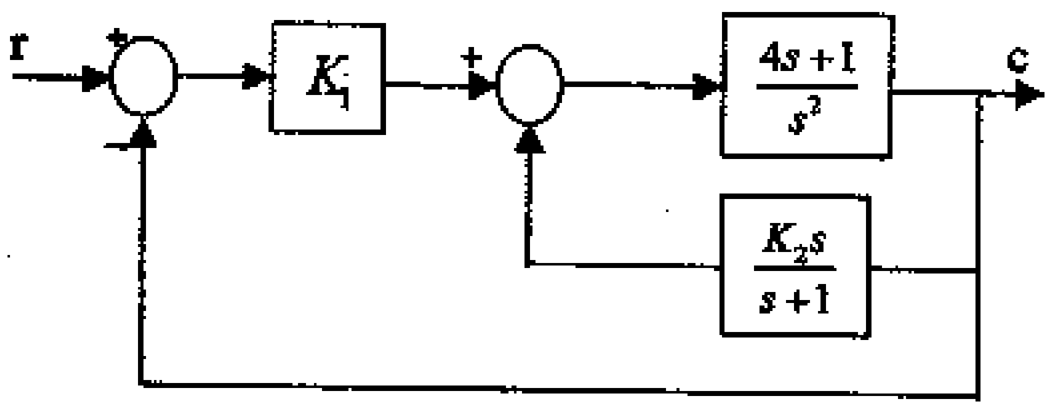


Figure 2

Prob. 4 The Nichols plots of an uncompensated and compensated systems are shown in Figure 3.

(a) What are the resonant peaks of the uncompensated and compensated systems? (2 pts)

(b) What are the phase and gain margins of the uncompensated and compensated systems? (2 pts)

(c) What are the bandwidths of the uncompensated and compensated systems? (2 pts)

(d) What type of the compensation has been adopted? Give an approximated transfer function of the compensator. (9 pts)

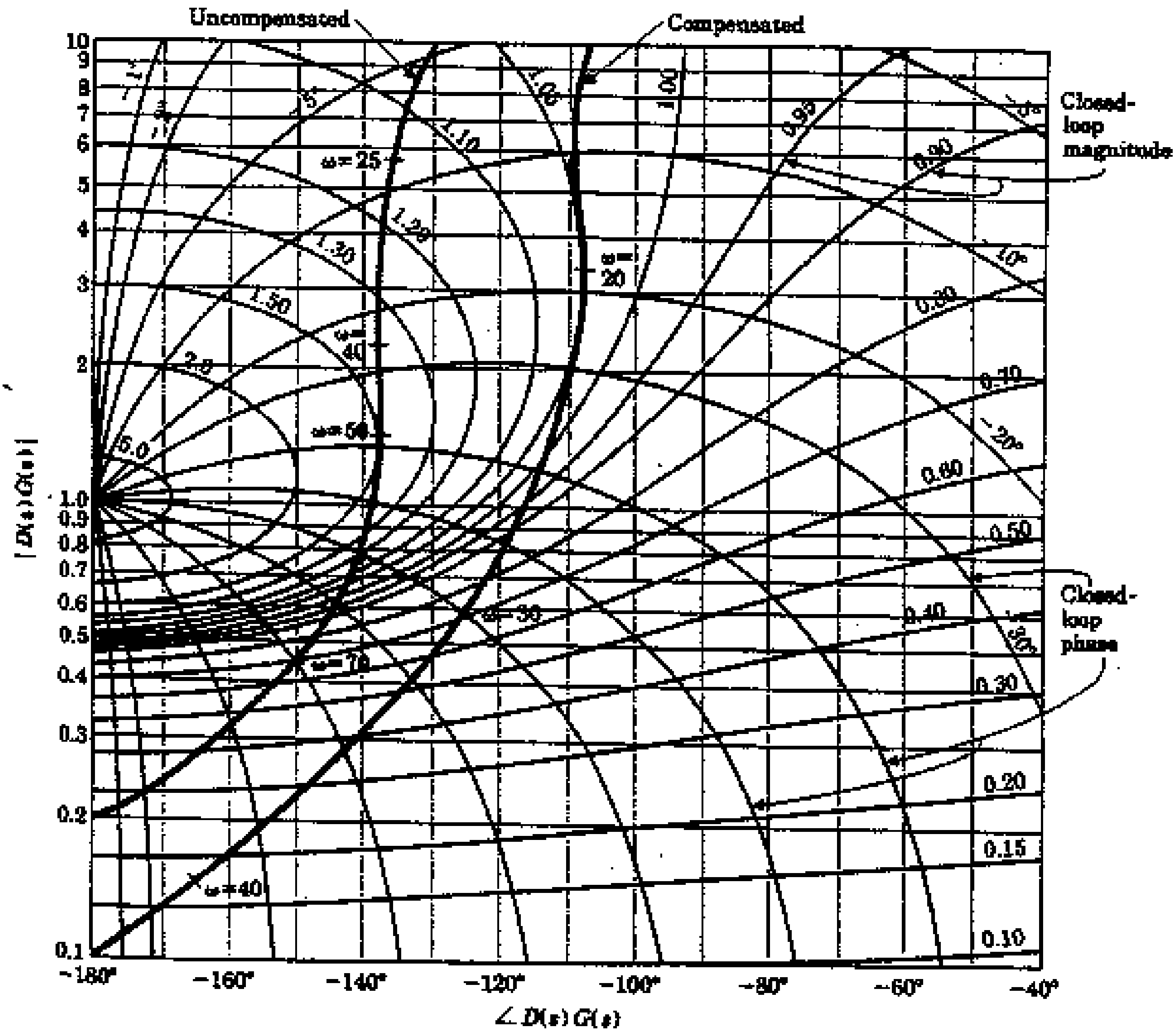
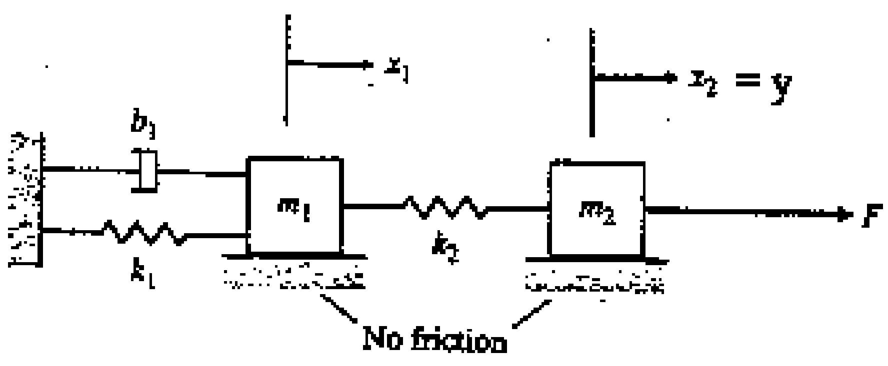


Figure 3

Prob. 5 Write the state-space representation for the following mechanical system, where F is the input force, x_1 and x_2 are the displacements of m_1 and m_2 respectively, and y is output. Let θ_1, θ_2, θ_3 and θ_4 be the states of x_1, $\dot{x}_1$, x_2, and $\dot{x}_2$ respectively. (5 pts)



Prob. 6 Consider a system with the following transfer function

$$g(s) = \frac{s^2 + 2s}{(s+1)(s+2)(s+3)}$$

(a) Find the state-space representation of g(s) in controllable canonical form. (5 pts)

(b) Test the controllability and observability for the system represented by (a). (5 pts)

(c) Find the irreducible realization (i.e. controllable and observable) for g(s) in Jordan canonical form. (5 pts)

Prob. 7 Consider the following system

$$\dot{x} = \begin{pmatrix} 1 & 1 \\ 0 & -2 \end{pmatrix} x + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u \equiv F x + G u$$

$$y = [\ 1 \quad 0\ ]\, x \equiv H x$$

(a) Design a state-feedback law $u = k x + v$ to move the poles of the system to -3 and -4. (10 pts)

(b) Design a full order state estimator $\dot{\hat{x}} = F\hat{x} + G u + L(y - H\hat{x})$ with roots at -5 and -10. (10 pts)

Prob. 8 Consider a sampled-data system as shown. Find the range of k so that the system is stable. (10 pts)