1. The *system sensitivity* is defined as the ratio of the percentage change in the system transfer function to the percentage change in the process transfer function. For a feedback system with closed-loop transfer function $T(s)$, open-loop transfer function $G(s)$, and the controller transfer function $H(s)$, the system sensitivity to $G(s)$ is defined as $S_G^T = \dfrac{\Delta T(s)/T(s)}{\Delta G(s)/G(s)} \approx \dfrac{T(s)}{G(s)} \dfrac{\partial T(s)}{\partial G(s)}$. The same goes for S_H^T.

   (a) Compute S_G^T for the feedback system shown in Fig. 1. What is your answer when the feedback loop is opened? (5%)

   (b) With the results obtained in (a), comments on the benefit of the feedback control. (5%)

   (c) Compute S_H^T for the same feedback system. Does the difference between S_G^T and S_H^T tell you anything about the implementation of the controller? (10%)

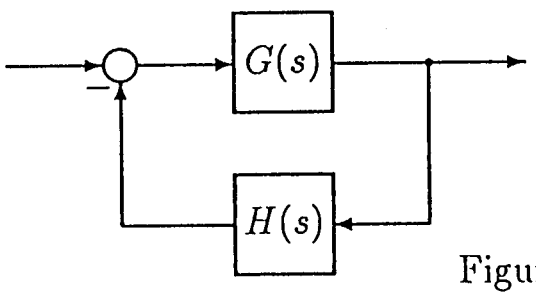

Figure 1

2. An interacting control system with two inputs and two outputs is shown in Fig. 2. Solve for $C_1(s)/R_1(s)$ and $C_2(s)/R_1(s)$. (20%)

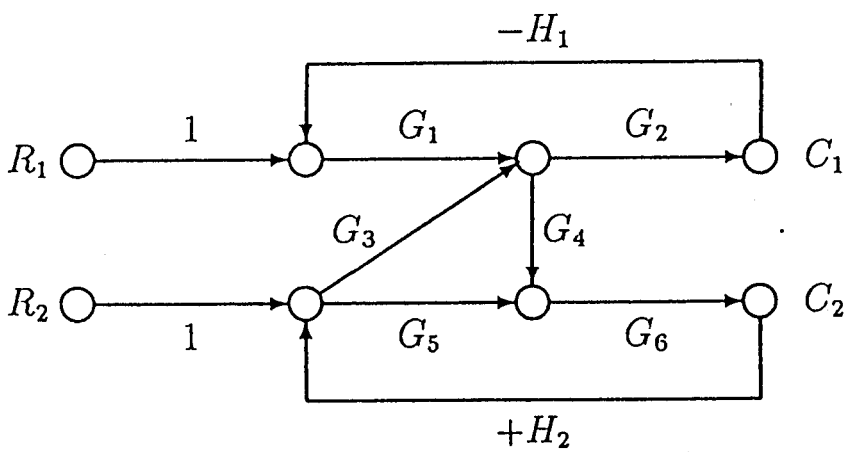

Figure 2

3. A feedback control system is shown in Fig. 3. The filter $G_c(s)$ is often called a compensator and the design problem is that of selecting the parameters α and β. Using the roots locus method, determine the effect of varying the parameters. Select a suitable filter so that the settling time is less than 4 second and the damping ratio of the dominant roots is greater than 0.60. Note that the settling time of an oscillatory system is defined as four time constants of the dominant response. (25%)

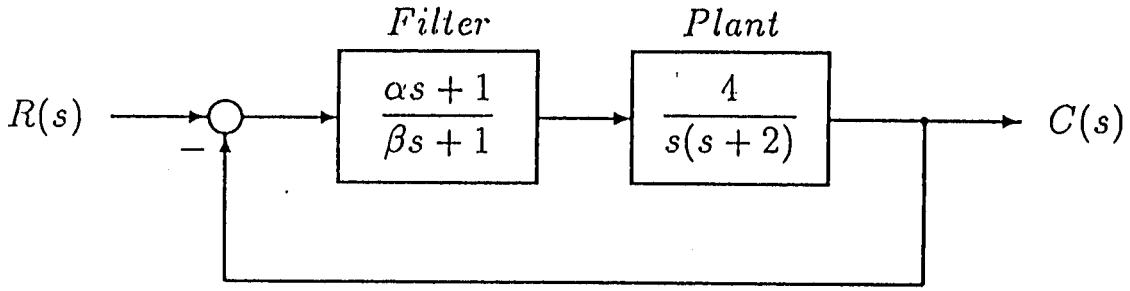

Figure 3

4. A feedback system is to be designed for the plant with open-loop transfer function $G(s) = \dfrac{10}{s(s+10)^2}$.

   (a) Draw the Bode diagram of the open-loop system. (5%)

   (b) Using the Bode diagram compensation technique to design a phase-lag compensator so that the phase margin of the feedback path is at least 65°. (10%)

   (c) Can the design be done with a phase-lead compensator? (5%)

5. Explain the following terminologies:

   (a) Minimum phase system. (5%)

   (b) Nonminimum phase system. (5%)

   (c) The Nichols chart. (5%)