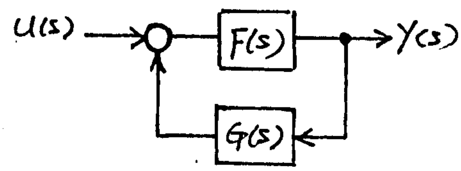
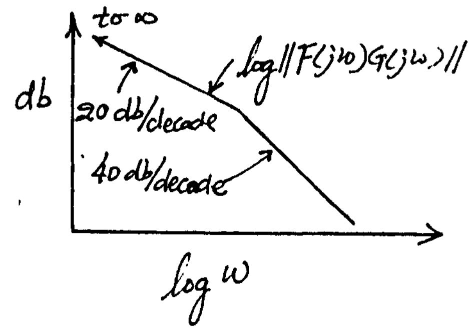
1) For the system shown in the right figures,

a) What will be the steady state error of the closed loop system subjected to a step input? (Assume the closed loop system is stable.) (10%)





b) What is the order of the closed loop transfer function? (Assume no pole-zero cancellation.) (5%)

c) If F(s) is a first order system, what kind of the feedback compensator the G(s) would most likely be? (15%)

2) Explain why we always emphasize high gain margin and high phase margin in designing a feedback control system? (25%)

3) Let

$$\begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{Bmatrix} = \begin{bmatrix} -.75 & 600 \\ -.005 & -.3 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} + \begin{Bmatrix} -1.6 \\ -8 \end{Bmatrix} u$$

(a) Find the eigenvalues and eigenvectors of the above equations. (10%)

(b) Find $x_1(t)$ and $x_2(t)$, if the initial condition $x_1(0)$ and $x_2(0)$ are given and $u(t) = u_0$, (u_0 is a constant) Express the solution in the matrix form.

$$\underline{X}(t) = [F(t)]\,\underline{X}(0) + [G(t)]\,u_0 \qquad (15\%)$$

(Continued on the next page)

4) Consider a servosystem which controls the orientation θ of a device relative to a reference orientation θ_{ref}. The important torques are those due to a torque motor and a constant disturbance, D. The torque mortor and its drive amplifier behave according to:

Torque motor torque $= M = K_M i$

Torque motor current $= i = \frac{1}{R}(e - K_B \dot{\theta})$

Close the simplest possible feedback loop by commanding

$$e = K(\theta_{ref.} - \theta)$$

Numerical values are

$K_M = 10$ ft-lb/amp

$R = 2$ ohms

$K_B = 0.5$ volts/rad/sec

$D = 1$ ft-lb

$I = 200$ slug-ft^2 = load moment of inertia

(1) What value of K produces a closed loop system damping ratio of 0.707? (10%)

(2) With that gain, what is the angular error induced by the disturbance torque? (10%)

(3) Does this simple design seem adequate? (5%)