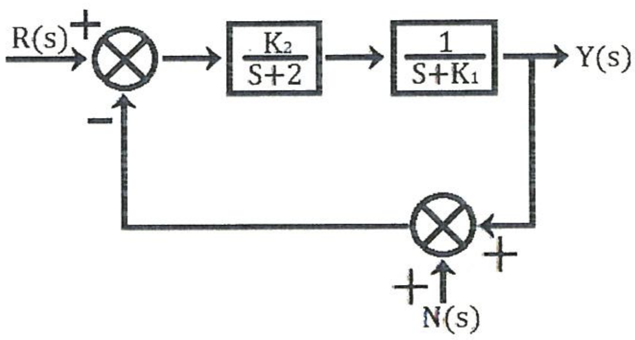
1. (25%) Consider the following system



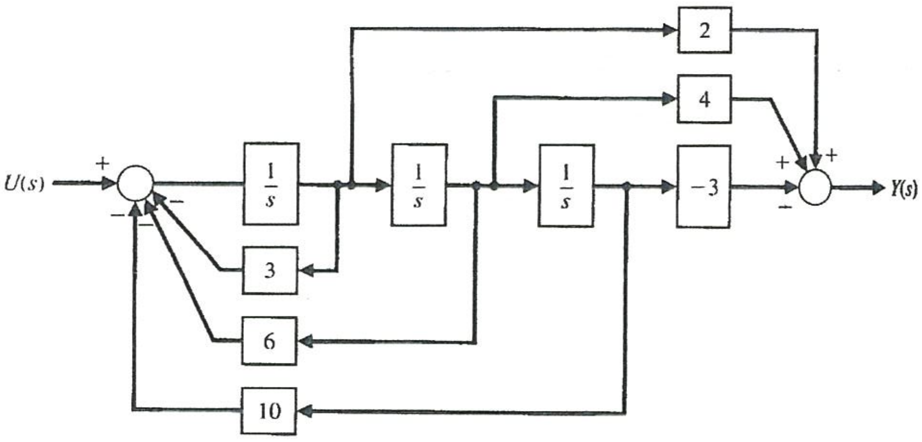
a、 (5%) Suppose T is the transfer function from $R(s)$ to $Y(s)$, find the sensitivity of T to the variation in k_1, i.e. $S_{k_1}^{T}=?$

b、 (5%) Suppose k_1=10, find the value of k_2 such that the closed-loop system is critical damping.

c、 (5%) Using the values found in (2), determine the steady-state error of the system given a unit step input R and a sinusoidal noise n(t)=0.1sin(60t). (N(s)=L｛n(t)｝)

d、 (10%) Determine the value of k_1 and range of k_2 such that both the following specifications are satisfied: (i) the steady-state error due to a step input is zero, (ii) there is an overshoot in the output due to a step input, but the percentage overshoot is less than 5%.

2. (25%) Consider the following system



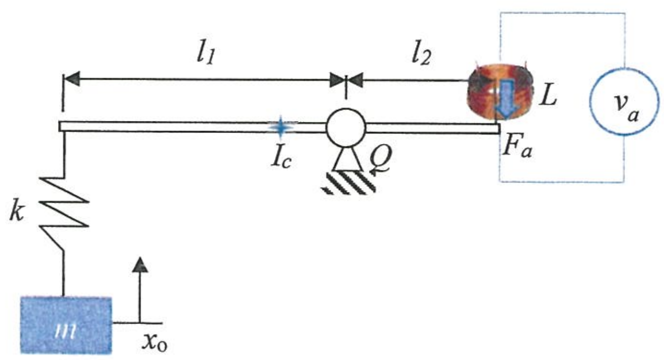
a、 (6%) Write down the corresponding state variable model for the system.

b、 (6%) Is the system completely controllable? completely observable?

c、 (6%) What is the closed-loop transfer function?

d、 (7%) If a unity feedback control system will be designed, please use pole assignment technique to design the controller.

3. Consider modeling a suspension system as shown in the diagram. The purpose is to control the position of the suspended ballast mass, m. The input force is generated from a voice coil with inductance L and force constant K_a (One can neglect the internal resistance, and the force-current relationship for voice coil motor is also $F_a = K_a i_a$). The output position of the ballast mass is x_a. Assume the moment of inertia of the rod about the pivot point Q is I_Q. $l = l_1 + l_2$ is the length of the rod, and the l_1 and l_2 are the distances from the ballast mass, m, and the voice coil motor to the support, Q, respectively.



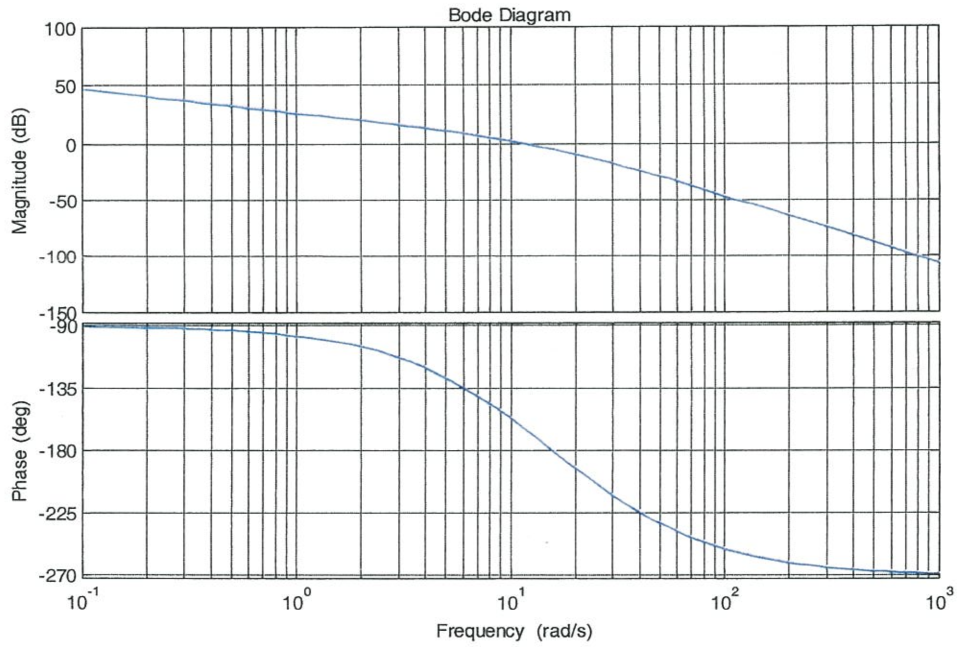
(a) (10%) Write down the system equations from

見背面

the input voltage $v_a(t)$ to the vertical displacement of the body $x_0(t)$.
(b) (5%) How many state variables do you need to describe the positioning dynamics of the system?
(c) (10%) Derive the transfer function of the system $X_0(s)/V_a(s)$.

4. (15%) Consider the system $G(s) = \frac{0.233}{s(s^2+16)}$. The engineers decided to use a notch filter to filter out the 4 rad/sec oscillation. The senior engineer proposed a very sharp notch of $G_c(s) = 124\frac{1+0.0062s+(0.35s)^2}{1+0.18s+(0.13s)^2}$. The junior engineer proposed a more damped notch of $G_c(s) = 124\frac{1+0.1s+(0.2s)^2}{1+0.18s+(0.13s)^2}$. Give your opinion on which one is better and why?

5. (10%) A system $G(s) = \frac{10000}{s^3+35s^2+250s}$ can be represented by the Bode diagram shown in the following figure.



Find the approximate gain margin and phase margin of the system.
We would like to somehow increase the phase margin by adding 45° the phase margin using the phase-lead compensator. Using the controller of the form $G_c(s) = \frac{1+aTs}{1+Ts}$, what would be the value of a and T to place the maximum phase lead of 45° at the appropriate new gain crossover frequency.

試題隨卷繳回