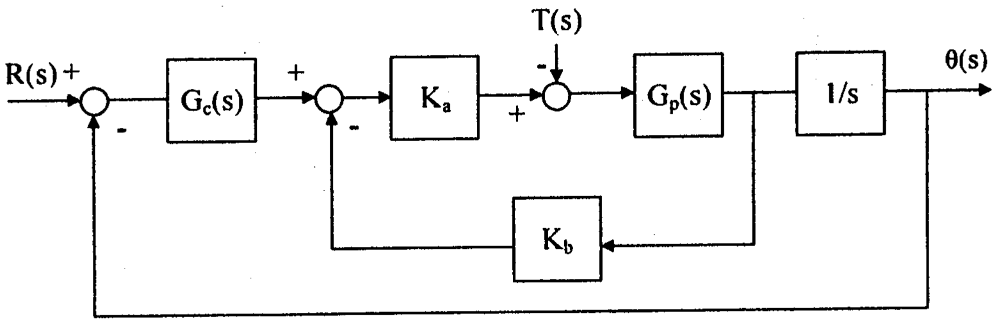
題號： 234　　國立臺灣大學 108 學年度碩士班招生考試試題
科目： 控制系統(A)
節次： 7

1. (25%) The block diagram of a position control system is shown in the figure, where $G_p(s)=1/(Js+1)$; J is the moment of inertia; K_a and K_b are the torque and back-emf constants of the DC motor; $T(s)$ is the load frictional torque.

   a. The angular displacement can be expressed as $\theta(s)=G_1(s)R(s)+G_2(s)T(s)$. Obtain the transfer functions $G_1(s)$, $G_2(s)$ in terms of $G_c(s)$, $G_p(s)$, K_a, K_b.

   b. Assume that $T(s)=0$ and the proportional control ($G_c(s)=K_p$) are applied on the feedback system. (1) Find natural frequency (ω_n) and K_p in terms of K_a, K_b, and J such that the closed-loop system is critically damped. (2) If J=1 kg-m^2, K_a=1 Nm/A, and K_b=1 V/(rad/s), find $\theta(t)$ for a unit step input $r(t)$.



2. (25%) Two systems are discussed in this problem.

   a. Consider the following input-output transfer function: $G(s)=\dfrac{Y(s)}{U(s)}=\dfrac{s+2}{(s+1)(s+3)(s+4)}$. Derive the state-space form $\dot{\mathbf{x}}(t)=\mathbf{A}\mathbf{x}(t)+\mathbf{B}\mathbf{u}(t)$; $\mathbf{y}(t)=\mathbf{C}\mathbf{x}(t)+\mathbf{D}\mathbf{u}(t)$. For a specific full-state feedback controller $\mathbf{K}=[K_1\ K_2\ 1]$, determine the values of K_1, K_2 such that the dominant closed-loop poles have the damping ratio (ζ) of 0.5 and natural frequency (ω_n) is 3 rad/sec.

   b. Consider a unity feedback system, where the open-loop transfer function is $G_c(s)G_p(s)=\dfrac{as+2}{s^2}$. Determine the value of a as that the phase margin is equal to 45°. Sketch the root locus diagram for $a\geq 0$ to explain the effect of a on the closed-loop system stability.

3. (25%) Consider the following unity feedback system with

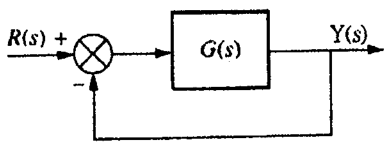
$$G(s)=\frac{K(s+6)}{s(s+2)(s+3)}$$

It is operating with a 25% overshot. (Hint: You can design a controller either in frequency domain or time domain. Semi-log diagrams are attached, if need them.)

   a. Find the settling time.

   b. Find K_v.

   c. Please design a compensator that will yield a threefold improvement in K_v and a twofold reduction in settling time while keeping the overshot at 25%.



4. (25%) The open-loop frequency response shown below, was experimentally obtained from a unity feedback system. Please (a) identify the system transfer function, (b) estimate the percent overshoot and steady-state error of the closed-loop system.

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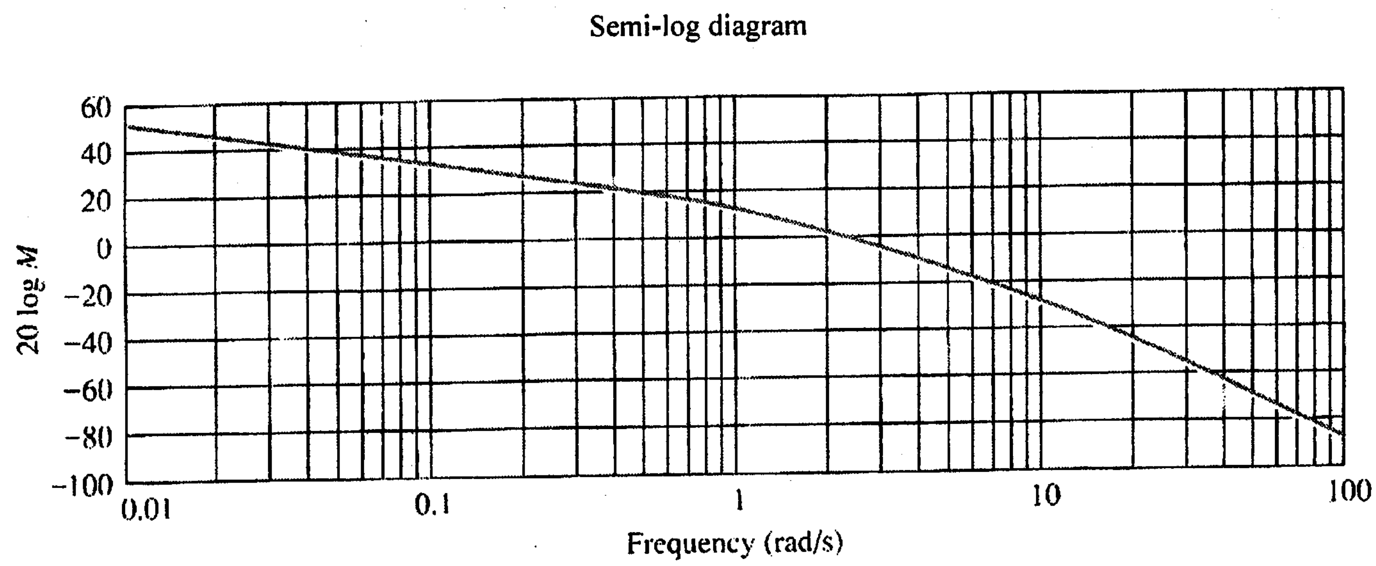
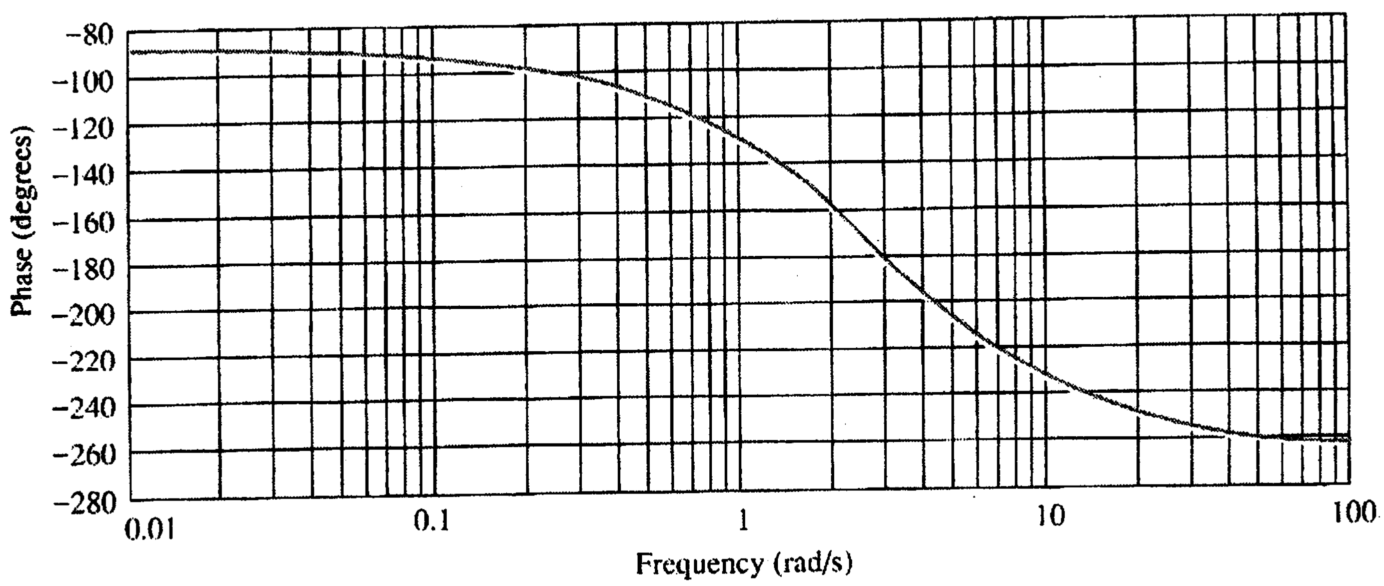

Semi-log diagram
60
40
20
0
-20
-40
-60
-80
-100
20 log M
0.01
0.1
1
10
100
Frequency (rad/s)


-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
Phase (degrees)
0.01
0.1
1
10
100
Frequency (rad/s)

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