90

淡江大學八十九學年度碩士班招生考試試題

系別：航空太空工程學系　　　　科目：自動控制

本試題共 2 頁

本試題雙面印製

1. Given a non-minimum phase transfer function

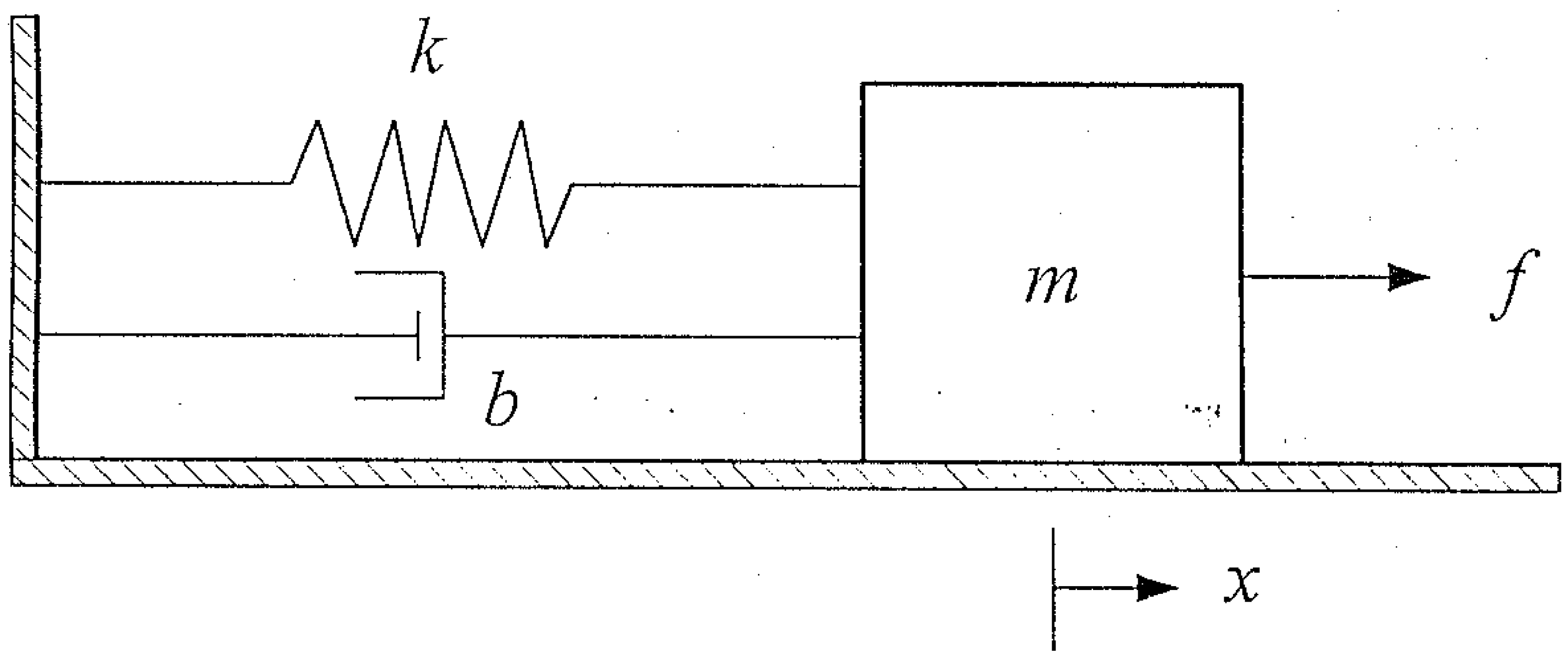
$$G(s)=\frac{(s+4)(s^2-2s+2)}{(s+1)(s+3)(s+5)}$$

(a) Show that there exists a constant K such that the transfer function $G(s)+K$ is minimum phase.(6%)

(b) Find the minimum value of K such that $G(s)+K$ is minimum phase.(7%)

(c) Sketch the zero locus of $G(s)+K$ as K varies from 0 to ∞.(7%)

2. Consider a mass-spring damping system as shown below



where f is the force applied to the mass, k is the spring constant, b is the friction constant, m is the mass, and x is the displacement of the mass. From force balance, the dynamics of the mass-spring damping system can be written as

$$m\frac{d^2x(t)}{dt^2}+b\frac{dx(t)}{dt}+kx(t)=f(t)$$

(a) Use another three different methods to describe the dynamics of the mass-spring damping system. (12%)

(b) Determine the conditions for the coefficients m, b, and k, (the relations among m, b, and k) so that the system will be (i) overdamped, (ii) critically damped, (iii) underdamped. (6%)

3. Given a linear time-invariant system $y = G(s)u$, with

$$G(s)=\frac{1000}{s(s+10)(s+100)}$$

(a) Suppose the input $u(t)=5\cos 5t+10\sin(50t+30^o)$, find the output $y(t)$ at steady state condition. (8%)

(b) Sketch the Bode plot of the system $G(s)$.(6%)

(c) Now, the control loop is closed using unit feedback. Find the phase margin and gain margin of the system.(8%)

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4. (15%) A feedback control system has a loop transfer function

$$GH(s) = \frac{K}{s(s+1)(s+4)}$$

Design a phase lag cascade compensator such that the closed-loop system satisfies the following specifications

(a) damping ratio $\zeta = 0.5$

(b) settling time t_s=10 sec.

(c) velocity error constant $K_v \geq 5$ sec^{-1}

5. An airplane is found to have poor short-period flying qualities in a particular flight regime. To improve the flying qualities, a stability augmentation system is to be employed. Assume that the original short-period dynamics are given by

$$\begin{bmatrix} \Delta\dot{\alpha} \\ \Delta\dot{q} \end{bmatrix} = \begin{bmatrix} -0.334 & 1.0 \\ -2.520 & -0.387 \end{bmatrix} \begin{bmatrix} \Delta\alpha \\ \Delta q \end{bmatrix} + \begin{bmatrix} -0.027 \\ -2.6 \end{bmatrix} \Delta\delta_e$$

where $\Delta\alpha$ is the change in angle of attack, Δq is the change in pitch rate, and $\Delta\delta_e$ is the change in elevator deflection.

(a) Is the system stable ? (5%)

(b) Is the system controllable ? (5%)

(c) Find the transfer function from $\Delta\delta_e$ to $\Delta\alpha$. (5%)

(d) Can we find a full state feedback control so that the airplane's short-period characteristics are $\lambda_{sp} = -2.1 \pm j2.14$? If your answer is ``Yes'', find it, otherwise, give the reason why ? (10%)

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