國立臺灣科技大學 109 學年度碩士班招生試題

系所組別：自動化及控制研究所碩士班

科　　目：自動控制系統

(總分為 100 分)

1. Experiments to identify precision grip dynamics between the index finger and thumb have been performed using a ball-drop experiment. A subject holds a device with a small receptacle into which an object is dropped, and the response is measured. Assuming a step input, it has been found that the response of the motor subsystem together with the sensory system is of the form

$$G(s)=\frac{Y(s)}{R(s)}=\frac{s+c}{(s^2+as+b)(s+d)}$$

Convert this transfer function to a state-space representation. (15%)

2. Cutting forces should be kept constant during machining operations to prevent changes in spindle speeds or work position. Such changes would deteriorate the accuracy of the work's dimensions. A control system is proposed to control the cutting force. The plant is difficult to model, since the factors that affect cutting force are time varying and not easily predicted. However, assuming the simplified force control model shown in Figure 1, use the Routh-Hurwitz criterion to find the range of K to keep the system stable. (15%)

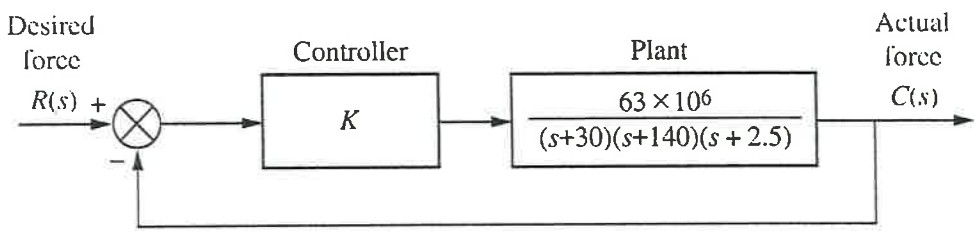

Figure 1 Cutting force control system.

3. For the unity feedback system shown in Figure 2, where

$$G(s)=\frac{K(s+5)}{(s^2+10s+26)(s+1)^2(s+\alpha)}$$

design K and α so that the dominant complex poles of the closed-loop function have a damping ratio of 0.45 and a natural frequency of 9/8 rad/s. (20%)

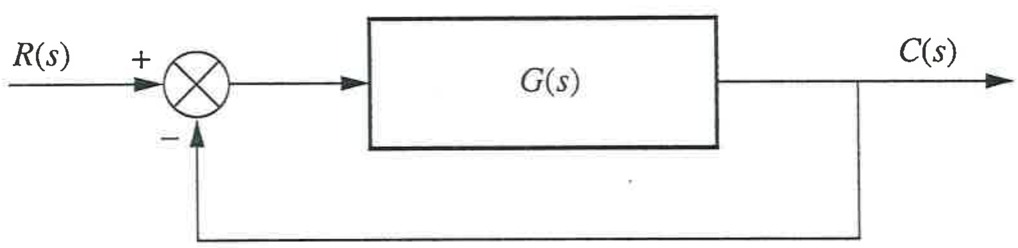

Figure 2

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4. Given

$$G(s)=\frac{100[(s/10)+1]}{s[(s/1)-1][(s/100)+1]}$$

(a) Sketch the Bode plot for $G(s)$. (5%)

(b) Sketch the Nyquist plot for $G(s)$. (5%)

(c) Is the closed-loop system shown in Figure 2 stable? Explain the reasons. (5%)

(d) Will the system be stable if the gain is lowered by a factor of 100? Sketch the root locus for the system and qualitatively confirm your answer. (5%)

5. For the unity feedback system of Figure 2, where $G(s)=\dfrac{K}{s(s+3)(s+5)}$, find the range of gain K, for stability, instability, and the value of gain for marginal stability. For marginal stability also find the frequency of oscillation. Use the Nyquist criterion. (10%)

6. Consider the system,

$$\dot{\mathbf{x}}=\mathbf{A}\mathbf{x}+\mathbf{B}u=\begin{bmatrix}0 & 4 & 0 & 0\\ -1 & -4 & 0 & 0\\ 5 & 7 & 1 & 15\\ 0 & 0 & 3 & -3\end{bmatrix}\mathbf{x}+\begin{bmatrix}0\\0\\1\\0\end{bmatrix}u$$

(a) Find the eigenvalues of this system, and find the controllable and uncontrollable modes of this system. (*Hint*: Note the block-triangular structure.) (5%)

(b) For each of the uncontrollable modes, find a vector $\mathbf{v}$ such that $\mathbf{v}^T\mathbf{B}=0$ and $\mathbf{v}^T A=\lambda\mathbf{v}^T$. (5%)

(c) Show that there are an infinite number of feedback gains $\mathbf{K}$ that will relocate the modes of the system to -5, -3, -2, and -2. (5%)

(d) Find the unique matrix $\mathbf{K}$ that achieves these pole locations and prevents initial conditions on the uncontrollable part of the system from ever affecting the controllable part. (5%)