※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

1. A control system is represented by the following set of equations:

$$\dot{x}_1(t) = -x_1(t) + 5x_2(t), \quad \dot{x}_2(t) = -6x_1(t) + u(t), \quad \text{and}$$

$$y(t) = x_1(t), \quad u(t) = -k_1x_1(t) - k_2x_2(t) + r(t),$$

where k_1 and k_2 are positive real constants, $y(t)$ is the output, and $r(t)$ is the reference input.

a) Draw the block diagram with proper labels to represent the system. (8%)
b) Derive the closed-loop transfer function for the system. (7%)
c) Find k_1 and k_2 so that the estimated peak time is less than 0.8 sec. and settling time is less than 2 seconds with 3% criterion. (10%)

2. The open-loop transfer function of a negative unity feedback system is given as

$$G(s) = \frac{k(s+a)}{s(s+1)(s+4)}.$$

a) What is the system type? (5%)
b) Derive the sensitivity function for the steady state error to the variation of parameter a with ramp input. (5%)
c) Find the dominant poles and the associated gain k that would give an estimated overshoot smaller than 5% for $a = 7$ and a step input to the system. (15%)

(背面仍有題目,請繼續作答)

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3. Consider the feedback system with loop transfer function $G(s)=\dfrac{K(s-5)}{s(s+10)}$, as shown in Fig.3.

(a). Plot Bode plot of G(s) with $K=1$. (5%)
(b). Plot Nyquist plot of G(s) with $K=1$ and its corresponding $\mathcal{D}$ contour. (10%)
(c). Determine the range of K such that the closed-loop system is stable using Nyquist plot obtained by (b). (5%)
(d). Determine the value of K such that the gain margin of the system is 6dB. (5%)

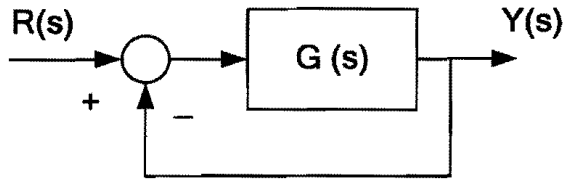

Fig. 3 Block diagram of the feedback system.

4. Consider the feedback system shown in Fig. 4, with

$$G(s)=\frac{5}{s(s-5)} \quad \text{and} \quad C(s)=K_P+K_Ds$$

(a). Determine the characteristic equation of the closed-loop system. (5%)
(b). Let $\tau=K_P/K_D$. Plot the root locus for $0\le K_D<\infty$ when $\tau=6$ (5%)
(c). For $\tau=6$, determine the range of K_D, such that the closed-loop system is stable. (5%)
(d). Determine the value of K_D and K_P such that the closed-loop poles will have damping ratio $\zeta=0.5$ and natural frequency $\omega_n=10$ rad/sec using the root locus method. (10%)

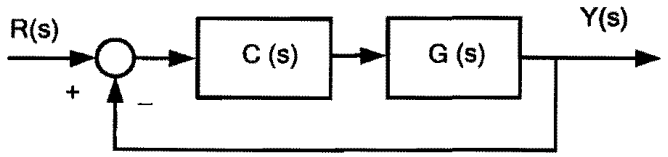

Fig. 4 Block diagram of the feedback system.