淡江大學九十四學年度碩士班招生考試試題 103-1

系別：航空太空工程學系　　科目：自　動　控　制

准帶項目請打「V」	
V	簡單型計算機

1. (10%) Consider the cruise control system as shown in Figure 1 below, where v is the speed of the car, v_r is the desired speed (a constant), disturbance b is the road slope. Assume the plant dynamics with disturbance is

$$\frac{dv(t)}{dt} + 0.02v(t) = u(t) - 10b$$

where the disturbance (the road slope) b is a constant. We further assumed that a PI controller

$$u(t) = u_0 + K_p e(t) + K_I \int_0^t e(\tau)d\tau$$

is adopted for the speed regulation. Define $e(t) = v_r - v(t)$. Choose K_p and K_I such that the dynamics of the error signal $e(t)$ has a damping ratio $\zeta = 0.8$ and undamped natural frequency $\omega_n = 0.1$.

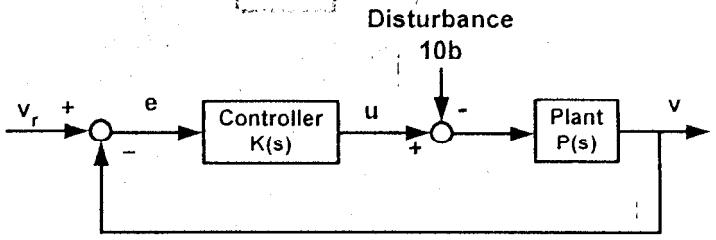

Figure 1

2. (25%) Consider the feedback system shown in Figure 2, with $P(s) = \frac{1}{s(s-1)}$. Note that the plant is open-loop unstable.

(a). Plot the root loci to determine whether the system can be stabilized by proportional control, $C(s) = K$, (5%)

(b). Could the unstable pole of $P(s)$ be cancelled by a zero of $C(s)$ to stabilize the system? Why? (5%)

(c). Now, choose a compensator $C(s) = \frac{K(s+1)}{s+4}$. Could the unstable plant be stabilized by the compensator? Provide your justification by sketching the root loci in detail. How does the compensator affect the transient and steady-state behavior? (15%)

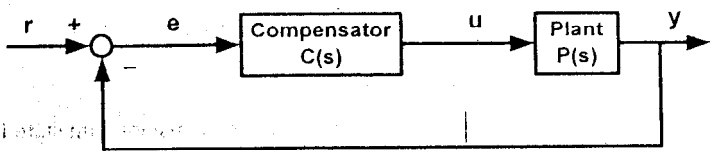

Figure 2

淡江大學九十四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

准帶項目請打「V」	
V	簡單型計算機

3. (15%) The transfer function of a first order dynamical system is given by

$$\frac{Y(s)}{R(s)} = G(s) = \frac{K}{\tau s + 1}$$

(a). Find the impulse response to an impulse of strength A. (5%)

(b). Find the step response to a step of strength A. (5%)

(c). Find the response to sinusoidal signal $A\sin\omega t$. (5%)

Identify the steady-state and transient components of the response in each case.

4. (25%) A cascade system is shown in Figure 3 below.

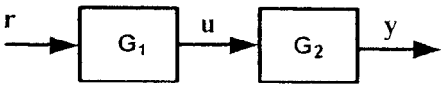

Figure 3.

Assume the dynamics of the systems G_1 and G_2 are

$$G_1: \quad \frac{du(t)}{dt} + u(t) = \frac{dr(t)}{dt} - r(t)$$

$$G_2: \quad \frac{dy(t)}{dt} - y(t) = u(t)$$

(a). Find the transfer function of system $G_1(s)$. Is it stable? (3%)

(b). Find the transfer function of system $G_2(s)$. Is it stable? (2%)

(c). Find the transfer function of the cascaded system $G_2G_1(s)$. Find the pole(s) and zero(s) of the system. (5%)

(d). Find a state-space realization of the cascaded system $G_2G_1(s)$. (10%)

(e). Assume $G_2(s)$ is the plant to be controlled, and $G_1(s)$ is the selected compensator. Does the cascaded system make sense to you? Explain your answer in detail. (5%)

5. (10%) A linear time-invariant system is described by the following state equation.

$$\dot{x}(t) = Ax(t) + Bu(t)$$

where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -1 \end{bmatrix} \; ; \; B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

(a). Is the open loop system stable? Why? (3%)

(b). Assume the closed-loop system is implemented by constant gain state feedback, so that $u(t) = -Kx(t)$, where $K = \begin{bmatrix} k_1 & k_2 & k_3 \end{bmatrix}$. Determine the constraints on the elements of the control gain K so that the closed-loop system is asymptotically stable. (7%)

系別：航空太空工程學系　　科目：自 動 控 制

准帶項目請打「V」	
V	簡單型計算機

6. (15%) Nyquist plots.

(a). The Nyquist plot of the loop transfer function of a unity-feedback system is shown in Figure 4 below. Determine (roughly) the gain margin and phase margin of the system. (You need to show how to obtain these margins). (5%)

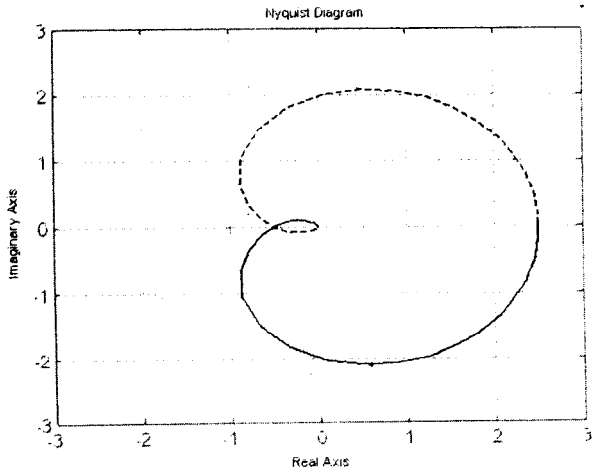

Figure 4.

(b). Give an example of Nyquist plot with poor phase margin and infinite gain margin. (Sketch a Nyquist plot and explain it). (5%)

(c). Give an example of Nyquist plot with poor gain margin and infinite phase margin. (Sketch a Nyquist plot and explain it). (5%)