1. The loop transfer function of a single-feedback-loop system is given as $L(s) = 0.1K/[s(s+1)(s^2+s+1)]$. (1) Sketch the Nyquist plot of $L(j\omega)/K$ for $\omega = 0$ to $\omega = \infty$.【計分：8 分】(2) Determine the stability of the closed-loop system.【計分：2 分】

2. The block diagram of a control system is shown in **Fig. A**. Find the region in the K-versus-α plane for the system to be asymptotically stable. (Use K as vertical and α as the horizontal axis.)【計分：10 分】

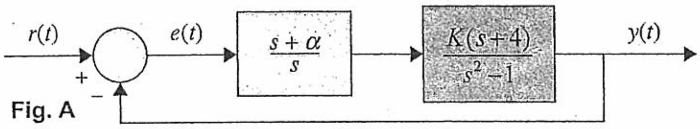
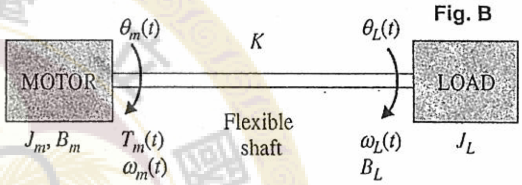


Fig. A

3. The schematic diagram of a motor-load system is shown in **Fig. B**. The following parameters and variables are defined: $T_m(t)$ is the motor torque; $\omega_m(t)$, the motor velocity; $\theta_m(t)$, the motor displacement; $\omega_L(t)$, the load velocity; $\theta_L(t)$, the load displacement; K, the torsional spring constant; J_m, the motor inertia; J_L, the load inertia; B_m, the motor viscous-friction coefficient; and B_L, the load viscous-friction coefficient. (1) Write the torque equation of the system.【計分：2 分】(2) Using $x_1 = \theta_m - \theta_L$, $x_2 = d\theta_L/dt$, and $x_3 = d\theta_m/dt$, as state variables, plot the state diagram of the system.【計分：2 分】(3) Find the transfer functions $\Theta_L(s)/T_m(s)$ and $\Theta_m(s)/T_m(s)$.【計分：2 分】(4) Find the characteristic equation of the system.【計分：1 分】(5) Let $T_m(t) = T_m$ be a constant applied torque; show that $\omega_m = \omega_L$ = constant in the steady state. Find the steady-state speeds ω_m and ω_L.【計分：2 分】(6) Repeat part (5) when the value of J_L is doubled, but J_m stays the same.【計分：1 分】

Fig. B



4. The schematic diagram of a feedback control system using a dc motor is shown in **Fig. C**. The torque developed by the motor is $T_m(t) = K_i i_a(t)$, where K_i is the torque constant. The parameters of the system are: $K_s = 2$; $R_a = 0.1\ \Omega$; $R_s = 0.1\ \Omega$; $K_b = 4.008$ V/rad/sec; $K_i = 5$ N-m/A; $K = 2$; $L_a \cong 0$ H; $J_m + J_L = 0.1$ N-m-sec^2; $B_m \cong 0$ N-m-sec. Assume that all the units are consistent so that no conversion is necessary. (1) Let the state variables be assigned as $x_1 = \theta_y$ and $x_2 = d\theta_y/dt$. Let the output be $y = \theta_y$. Write the state equation in vector-matrix form. Show that the matrices **A** and **B** are in CCF (Controllability Canonical Form).【計分：4 分】(2) Let θ_r be a unit-step function. Find $\mathbf{x}(t)$ in terms of $\mathbf{x}(0)$, the initial state.【計分：8 分】(3) Find the characteristic equation, eigenvalues and eigenvectors of **A**.【計分：6 分】(4) Comment on the purpose of the feedback resistor R_s.【計分：2 分】

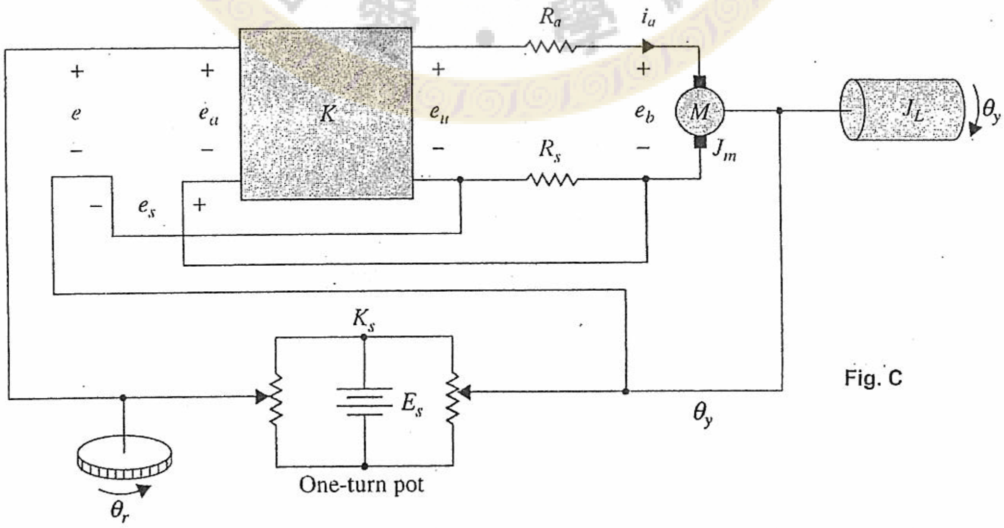


Fig. C

5 A feedback control system is shown in the **Fig. D** (1) Let a =10, please find the root locus as K increases from 0 to ∞ 【計分：10 分】(2) Let K=9, please find the root locus as a increase from 0 to ∞ 【計分：15 分】

見背面

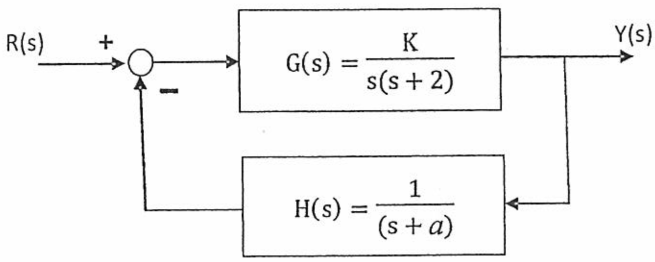


Fig. D

6 If the transfer function of a system is $G(s) = \frac{1}{s^2+1.414s+1}$, please sketch the unit step response and the bode plot of the system in as much detail as you can. (Assume the initial condition is zero) 【計分：15 分】

7 Fluid flows are common in many control systems. One of the physical relations governing fluid flow is continuity. The continuity relation is simply a statement of the conservation of matter:

$$\dot{h} = \frac{1}{A\rho}(w_{in} - w_{out})$$

where ρ: density of water, h: height of water, A: area of tank, w_{in} : mass flow rate into the tank, w_{out}= mass flow rate out of the tank. Furthermore

$$w_{out} = \frac{1}{R}\sqrt{p_1 - p_a}$$

where R is a constant related to the type of restriction, $p_1 = \rho g h$ is the hydrostatic pressure, g: gravity constant, p_a is ambient pressure outside the restriction. Please determine the differential equation describing the height h of the water in the tank shown in **Fig. E** and linearize the dynamic equation around the operating point h_0 . (Note: $\Delta h = h - h_0$, $\Delta p = p_1 - p_0$ and $p_0 = \rho g h_0$) 【計分：10 分】

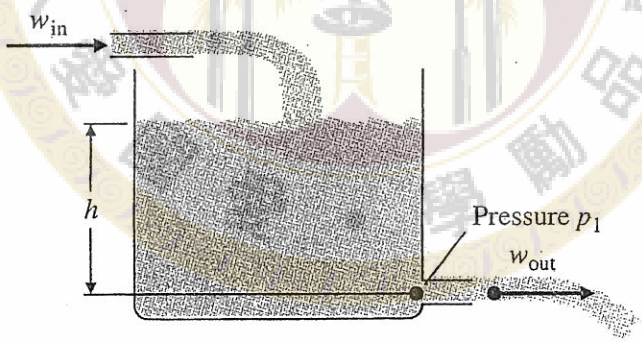


Fig. E

試題隨卷繳回