八十五學年度國立台灣工業技術學院研究所碩士班招生考試

所別：纖維及高分子工程技術研究所　組別：纖維乙組　科目：控制系統

1. Consider the liquid-level system shown in Fig. 1. At steady state the inflow rate is $\bar{Q}$ and the outflow rate is also $\bar{Q}$. Assume that at t = 0 the inflow rate is changed from $\bar{Q}$ to $\bar{Q} + q_i$, where q_i is a small quantity. The disturbance input is q_d, which is also a small quantity. Draw a block diagram of the system and simplify it to obtain $H_2(s)$ as a function of $Q_i(s)$ and $Q_d(s)$. The capacitances of tanks 1 and 2 are C_1 and C_2, respectively. (20%)

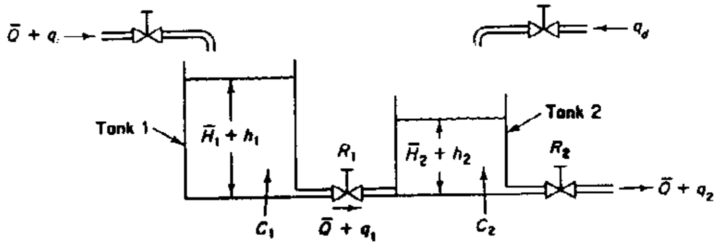


Fig. 1. Liquid-level system.

2. In Fig. 2 a plant transfer function G(s) = 1/[s(s - 2)] may represent a tall rocket. Such a plant is open-loop unstable (i.e., unstable without feedback control), like a pencil standing on its end.

(a) Plot the loci to determine whether the system can be stabilized by P control $G_c = K_c$ (7%).

(b) If not, could the unstable pole of G be canceled by a zero of G_c to stabilize the system, and if not, why not? (7%)

(c) Choose an idealized controller that can stabilize the system, and find the corresponding range of gains for stability. (6%)

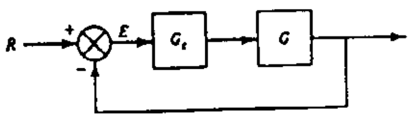
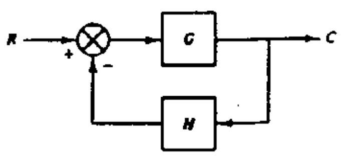


Fig. 2

3 For an open-loop unstable system with loop gain function

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

sketch the loci of the system poles and find K for a system time constant of 1 sec from the loci. (20%)



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4. The block diagram of a linear control system is shown in Fig. 4, where r(t) is the reference input and n(t) is the disturbance.

(a) Find the steady-state value of e(t) when n(t) = 0 and $r(t) = tu_s(t)$, where $u_s(t)$ is an unit step function. (7%)

(b) Find the conditions on the values of α and K so that the solution of (a) is valid. (7%)

(c) Find the steady-state value of y(t) when r(t) = 0 and $n(t) = u_s(t)$. (6%)

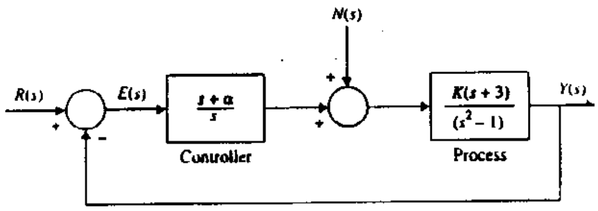

Fig. 4

命題請勿超出線外

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5. In Fig. 5. This is a model of the attitude control of a space booster on takeoff. The objective of the attitude control problem is to keep the space booster in a vertical position. The actual space booster (or the inverted pendulum in this problem) is unstable in that it may fall over any time in any direction unless a suitable control force is applied. Here we consider only a two-dimensional problem so that the pendulum in Fig. 5 moves only in the plane of the page.

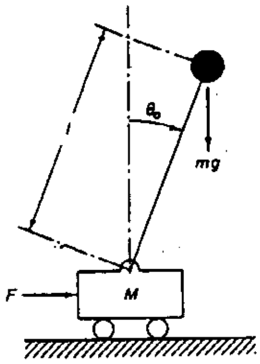

Fig. 5. Inverted pendulum mounted on a motor-driven cart.

Let us define the angle of the rod from the vertical line as θ_0. The positive direction of θ_0 is shown in the diagram. The positive direction of the force F to the cart needed to control the pendulum position also appears in the diagram. Note that if angle θ_0 is positive, then in order to reduce angle θ_0 and keep the inverted pendulum vertical, we must apply a force F in the positive direction.

Assuming the numerical values

$$M = 1000 \text{ kg}$$
$$m = 100 \text{ kg}$$
$$l = 10 \text{ m}$$

Disign a suitable controller such taht the system has a damping ratio ζ of 0.7 and an undamped natural frequency ω_n of 0.5 rad/s. Assume also that the pendulum mass is concentrated at the end of the rod, that the weight of the rod is negligible, that external forces such as gusts of wind are negligible, and that there is neither friction at the pivot nor slip at the wheels of the cart. (20%)