(命題用紙)

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：工程技術研究所

學程別：自動化及控制學程 組別：丙組 科目：控制系統

1. Develop a model for the heights h_1 and h_2 in the liquid level system shown in Fig. 1. The input volume flow rate q is given. Assume that laminar flow exists in the pipes. The laminar resistances are R_1 and R_2, and the bottom areas of the tanks are A_1 and A_2. Also, draw the system block diagram. (20%)

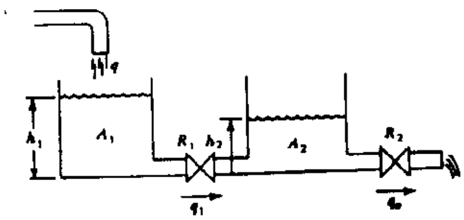

Fig. 1. Liquid-level system.

2. For a unity feedback hydraulic position servo with loop gain function

$$G = \frac{K}{s(s^2 + 2s + 5)}$$

(a) Sketch the loci of the closed-loop poles for varying K. (5%)

(b) Find reasonably accurately the value of K for which the time constant of the dominating pair of closed-loop poles is 2 sec. (5%)

(c) Determine the position of the third pole. (5%)

(d) Calculate the unit step response. (5%)

3. In Fig. 3 with $G(s) = 1/[(s + 1)(s + 4)]$, design a physically realizable controller $G_c(s)$ such that: (20%)

(1) The steady-state error for step inputs is zero.

(2) The dominating time constant is 0.5 sec.

(3) The damping ratio is about 0.7.

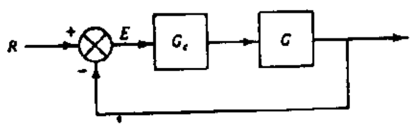

Fig. 3

命題請勿超出線外

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4. Fig. 4a. shows the schematic diagram of a dc-motor control system for control of the printwheel. The load in this case is the printwheel, which is coupled directly to the motor shaft. The following parameters and variables are defined: K_s is the error-detector gain (V/rad), K_i the torque constant (oz-in./A), K the amplifier gain (V/V), K_b the back-emf constant (V/rad/sec), n the gear train ratio $= \theta_2/\theta_m = T_m/T_2$, B_m the motor viscous-friction coefficient (oz-in.-sec), J_m the motor inertia (oz-in.-sec^2), K_L the torsional spring constant of the motor shaft (oz-in./rad), and J_L the load inertia (oz-in.-sec^2).

(a) Write the cause-and-effect equations of the system and rearrange these equations into the form of state equations with $x_1 = \theta_o$, $x_2 = \omega_o = \frac{d\theta_o}{dt}$, $x_3 = \theta_m$, $x_4 = \omega_m = \frac{d\theta_m}{dt}$, and $x_5 = i_a$. (7%)

(b) Draw a state diagram using the nodes shown in Fig. 4b. (7%)

(c) Find the closed-loop transfer function $M(s) = \Theta_o(s)/\Theta_r(s)$. (6%)

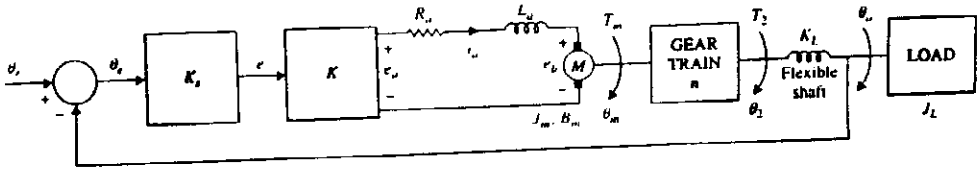

Fig. 4a.

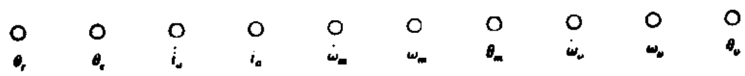

Fig. 4b.

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5. Consider the inverted pendulum system shown in Fig. 5, where an inverted pendulum is mounted on a motor-driven cart. Here we consider only the two-dimensional problem where the pendulum moves only in the plane of the paper. The inverted pendulum is unstable in that it may fall over any time unless a suitalbe control force is applied. Assume that the pendulum mass is concentrated at the end of the rod as shown in the figure. (We assume that the rod is massless.) The control force u is applied to the cart.
In the diagram, θ is the angle of the rod from the vertical line. We assume that angle θ is small so that we may approximate $\sin\theta$ by θ, $\cos\theta$ by 1, and also assume that $\dot{\theta}$ is small so that $\theta\dot{\theta}^2 \doteq 0$. (Under these conditions, the system's nonlinear equations can be linearized.)
It is desired to keep the pendulum upright in the presence of disturbances (such as a gust of wind acting on the mass m, an unexpected force applied to the cart). The slanted pendulum can be brought back to the vertical position when appropriate control force u is applied to the cart. At the end of each control process, it is desired to bring the cart back to x =0, the reference position.

Design a control system such that given any initial conditions (caused by disturbances) the pendulum can be brought back to the vertical position and also the cart can be brought back to the reference position (x = 0) quickly (with settling time of about 2 sec) and with reasonable damping (equivalent to $\zeta = 0.7$ in the standard second-order system). Assume the following numerical values for M, m, and l :

$$M = 1\text{kg}, \qquad m = 0.1\text{ kg}, \qquad l = 0.5\text{ m}$$

(20%)

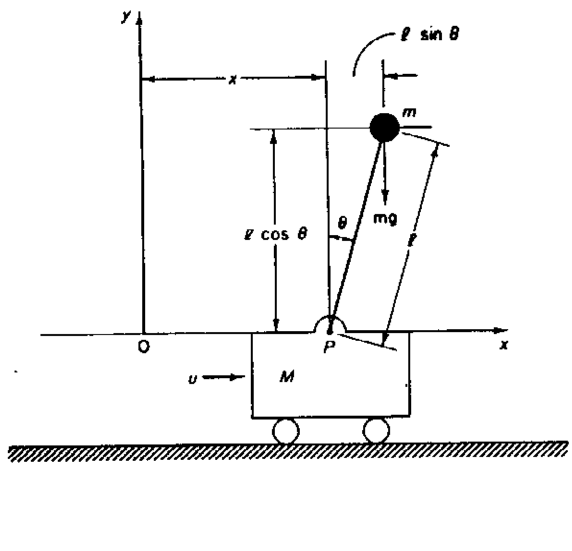

Fig. 5 Inverted pendulum system