國立臺灣科技大學101學年度碩士班招生試題

系所組別： 自動化及控制研究所碩士班乙組

科　　目： 控制系統

(總分為100分)

1. **(15%)** A block diagram is shown in Figure 1. The system parameters are given as $T=0.1$, $J=0.01$, and $K_i=10$.

   (a) When $r(t)=tu_s(t)$, where $u_s(t)$ is a unit step function, determine how the values of K and K_t affect the steady-state value of $e(t)$. Find the restrictions on K and K_t so that the system is stable. **(5%)**

   (b) Let $r(t)=0$. Determine how the values of K and K_t affect the steady-state value of $y(t)$ when the disturbance input $T_d(t)=u_s(t)$. **(5%)**

   (c) Let $K=0.1$ and $r(t)=0$. Find the value of K_t so that the complex roots of the characteristic equation will have a real part of -2.5. Find all three roots of the characteristic equation. **(5%)**

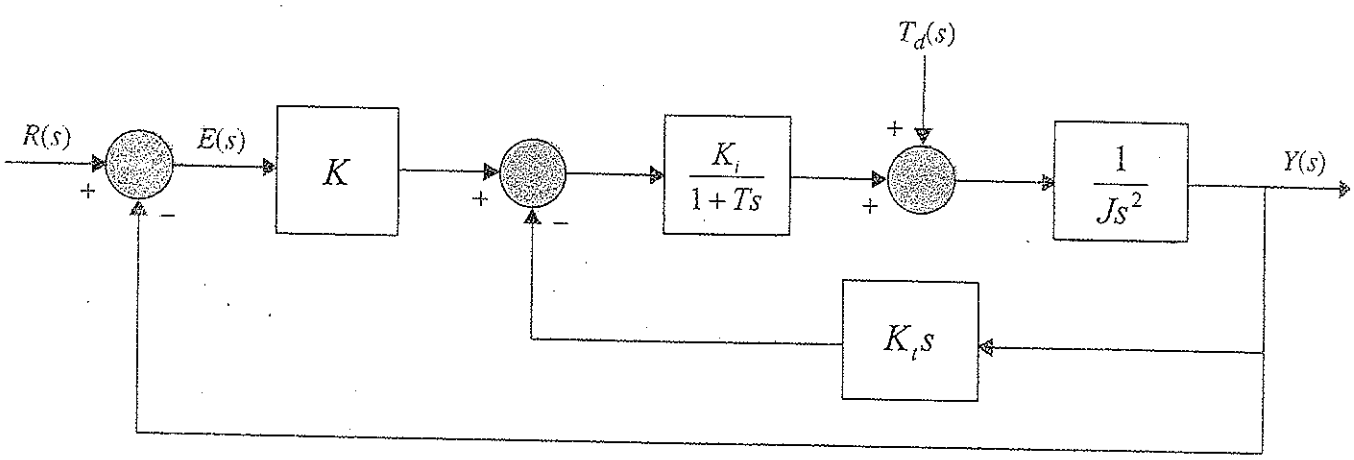

Figure 1

2. **(15%)** A block diagram is shown in Figure 2.

   (a) Construct the characteristic equation. **(5%)**

   (b) For $K=10$, sketch the root locus of the characteristic equation for $K_t \geq 0$. **(5%)**

   (c) Indicate the asymptotes, the intersection of asymptotes, the breakaway-point equation, and the breakaway points. **(5%)**

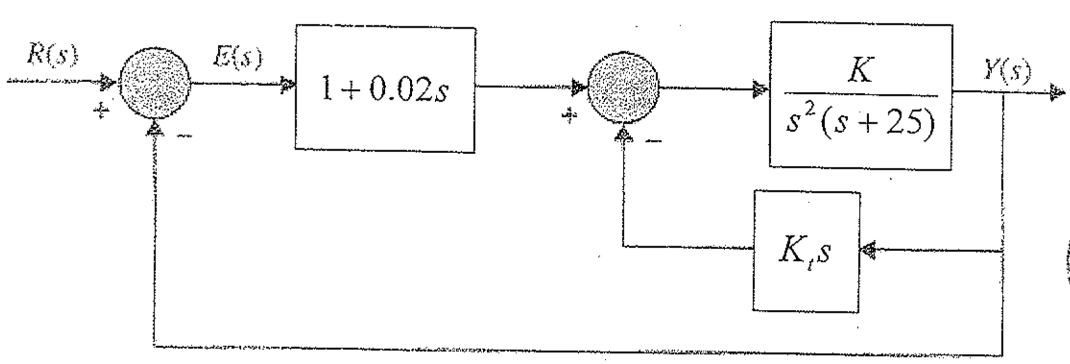

Figure 2

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3. **(15%)** A system is modeled by the following state equations:

$\dot{x}_1 = -2x_2$, $\dot{x}_2 = -2u$

where x_1 and x_2 are the state variables, and u is a control signal.

The output equation is $y = x_1$.

Let the controller be a PD controller, which is $G_c(s) = K_P + K_D s$. The block diagram of the system is shown in Figure 3.

(a) Find the parameters of the PD controller, K_P and K_D, so that the roots of characteristic equation correspond to a damping ratio of 0.707 and a natural frequency of 1 rad/sec. **(8%)**

(b) Find the values of K_P and K_D so that the overshoot is zero and the rise time is less than 0.06 sec. **(7%)**

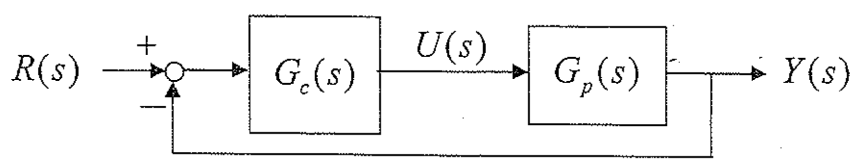

Figure 3

4. **(15%)** A block diagram is shown in Figure 4.

(a) Determine the transfer function $Y(s)/R(s)$. **(5%)**

(b) Find the characteristic equation and its roots of the system. **(5%)**

(c) Determine the values of K that must be avoided if the system is controllable and observable. **(5%)**

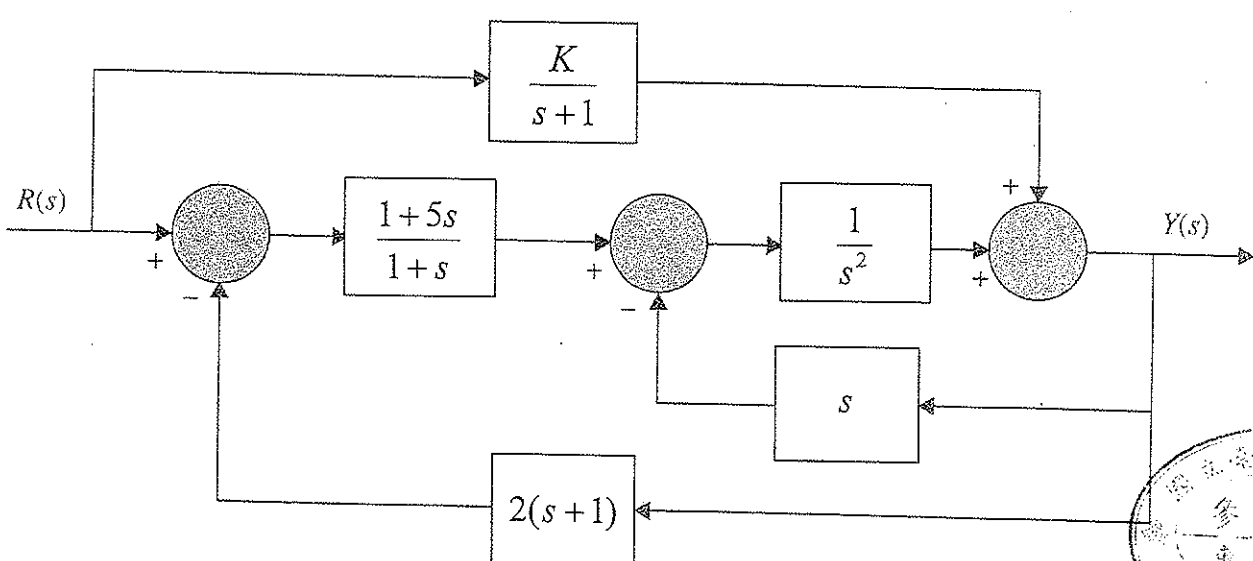

Figure 4

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5. Suppose that a sinusoidal force $p(t) = P\sin\omega t$ is applied to the mechanical system as shown below. In this system, m denotes the mass, b denotes the viscous-friction coefficient, and k denotes the spring constant. Assume that displacement x is measured from the equilibrium position.
   (1) Find the steady-state output. (10%)
   (2) Find the resonant frequency ω_m at which the amplitude is a maximum of the steady-state output. (10%)

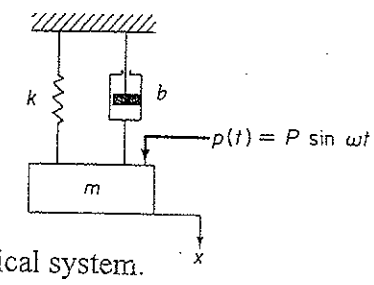

Figure 5. Mechanical system.

6. For the liquid-level system shown below, the steady-state flow rate through the tanks is $\bar{Q}$ and steady-state heads of tank 1 and tank 2 are $\bar{H_1}$ and $\bar{H_2}$, respectively. At t = 0 the inflow rate is changed from $\bar{Q}$ to $\bar{Q}+q$, where q is a small change in the inflow rate. The corresponding changes in the heads (h_1 and h_2) and changes in flow rates (q_1 and q_2) are assumed to be small. The capacitances of tank 1 and tank 2 are C_1 and C_2, respectively. The resistance of the valve between the tanks is R_1 and that of the outflow valve is R_2. Assuming q as the input and q_2 as the output, derive the transfer function for the system. (10%)

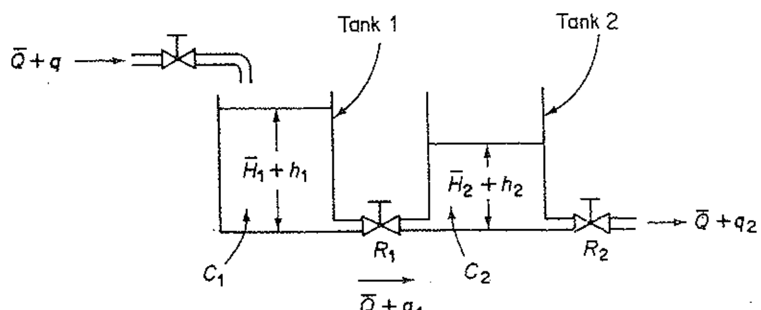

Figure 6. Liquid-level system.

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7. Assume, in the circuit of figure shown below, that voltage e_i is applied to the input terminals and voltage e_o appears at the output terminals. In addition, assume that the input is sinusoidal and is given by $e_i(t) = E_i \sin \omega t$. Find the steady-state current $i(t)$. (10%)

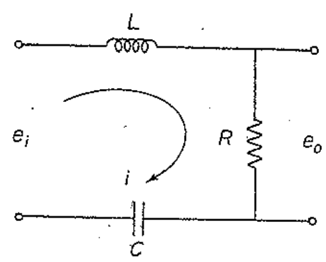

Figure 7. Electrical circuit