國立臺灣大學101學年度碩士班招生考試試題

Note: 請將提號及答案標示清楚

1. (20%) As shown in Figure 1, a pendulum is composed of a point mass with mass m and a massless bar with length l. Its configuration is parameterized by the pendulum orientation θ. A torsion spring with stiffness, k, and a damper with viscous friction constant, b, are both connected the bar to the inertial frame. The spring is in its natural orientation when $\theta = \theta_0$. In addition, torque, τ, is also applied to the bar from the inertia frame. Gravity constant is g.
   (a) (5%) Obtain the differential equation describing the system.
   (b) (5%) Derive the steady-state condition of the system.
   (c) (5%) Describe the conditions within which the system can behave like a linear system.
   (d) (5%) Assuming the torque τ is the input and the pendulum orientation θ is the output, derive impulse response of the "linearized" system.

2. (15%) Following the system presented in Problem 1, assume (i) the system is placed horizontally (i.e., no gravity effect), (ii) the spring and the damper originally connected to the inertial frame is now connected to the motor output shaft (i.e., you may treat θ_0 as a variable), (iii) the torque is now generated by the motor and directly applied on the spring and damper (i.e., instead of acting on the pendulum bar, the torque is now applied on the thick dashed line), and (iv) motor also has viscous effect with constant c.
   (a) (5%) Utilizing pendulum speed, motor speed, and angle difference $\theta - \theta_0$ as the state, format the system in the state-space form.
   (b) (5%) Represent the system in a signal-flow graph.
   (c) (5%) Derive transfer function of the system.

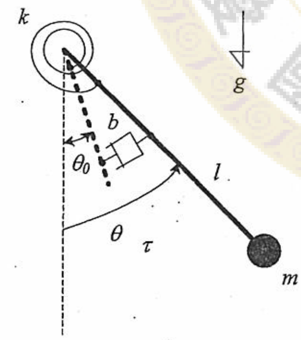

Figure 1

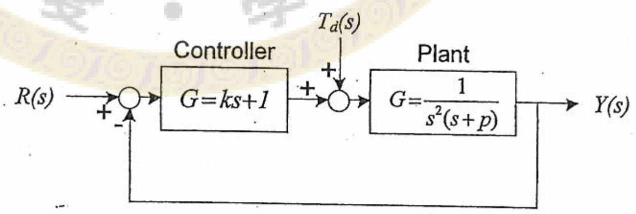

Figure 2

3. (15%) A system is shown in Figure 2.
   (a) (5%) Determine the sensitivity of the system parameter, p, to the closed-loop transfer function $T(s) = Y(s)/R(s)$.
   (b) (5%) Assuming disturbance $T_d = 0$, determine the values of K for which the closed-loop system is stable.
   (c) (5%) Assuming the system is stable, describe the characteristics of the disturbances, T_d, which yield the steady state error of the system being 0, a fixed value, or infinite, respectively.

見背面

國立臺灣大學101學年度碩士班招生考試試題

4. (25%) Consider a control system described by the block diagram shown in Figure 3.

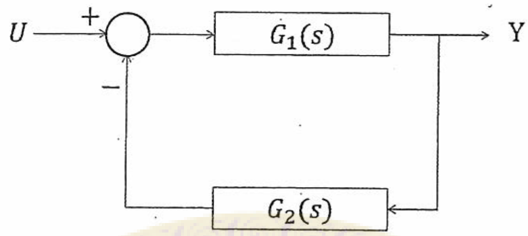

Figure 3

(a) (10%) Suppose that $G_1(s) = \frac{K(s-1)}{(s+1)^2}$ and $G_2(s) = 1$, draw the Nyquist plot and apply the Nyquist criterion to determine the range of K for stability.

(b) (5%) Also, determine the number of roots in the right-half s-plane for the values of K where the system is unstable.

(c) (10%) Suppose that $G_1(s) = \frac{100e^{-T_d s}}{s(s^2+10s+100)}$ and $G_2(s) = 1$, determine the maximum time delay T_d in seconds for the closed-loop system to be stable.

5. (25%) Answer the following questions.

(a) (7%) For the *phase-lead* controller, $G_c(s) = \frac{(1+aTs)}{(1+Ts)}$, $a > 1$, what is the effect of the controller on the steady-state performance of the system?

(b) (10%) Consider a unity-feedback control system whose forward-loop transfer function is $G_p(s) = \frac{500(s+10)}{s(s^2+10s+1000)}$. Design a series second-order *notch controller/filter* with the transfer function $\mathrm{C}(s) = \frac{s^2+2\zeta_z\omega_n s+\omega_n^2}{s^2+2\zeta_p\omega_n s+\omega_n^2}$, so that its zeros cancel the <u>undesired poles</u> of $G_p(s)$. What is/are the undesired poles of $G_p(s)$ to be canceled? <u>Explain</u> your answer and determine the value of ζ_p by considering the maximum attenuation required at the resonant frequency ω_n.

(c) (8%) Following (b), find the phase-margin PM, gain-margin GM, resonant peak M_r, and bandwidth BW of the designed system.

試題隨卷繳回