國立成功大學

112學年度碩士班招生考試試題

編　號：71

系　所：機械工程學系

科　目：自動控制

日　期：0206

節　次：第 1 節

備　註：可使用計算機

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1. **(30%)** Consider a closed-loop control system composed of a rotational mechanical system. The design of the rotational mechanical system is shown in Figure 1 (a), where $T(t)$ is the torque input and $\theta(t)$ is the angle output. The transfer function of the mechanical system, $G_s(s)$, is given as

$$G_s(s) = \frac{\theta(s)}{T(s)}$$

The unity-feedback control system is shown in Figure 1 (b) with a forward controller, $G_c(s)$.

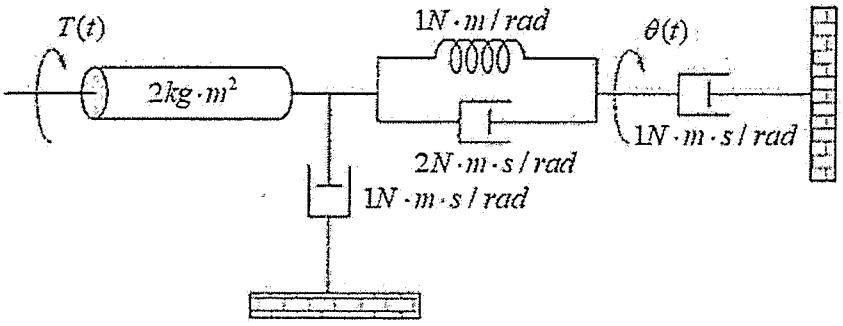

Figure 1 (a). Rotational mechanical system with $T(s)$ as input and $\theta(s)$ as input

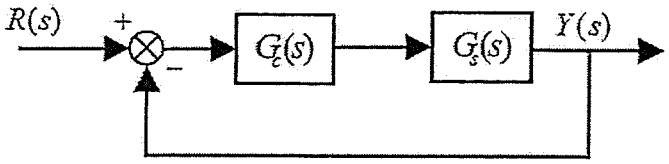

Figure 1 (b). Closed-loop control system with $G_s(s)$ represented in Figure 1 (a)

Do the following:

(1) Design a proportional controller $G_c(s)=K$, so that the system percent overshoot is 30%. Validate the second-order approximation.

(2) Design a controller $G_c(s)$ while the DC-gain of the controller is the same as in Part (1), so that the system percent overshoot is 30% and the steady-state error is zero with the input $r(t)=10+2t$.

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2. **(20%)** Given the following state-space representation of a system, where *u(t)* is the unit step. Find the settling time, peak time, percent overshoot, and steady-state error of the system. Additionally, denote the aforementioned results on the output response.

$$\dot{x} = \begin{bmatrix} -3 & 1 & 0 \\ 0 & -6 & 1 \\ 0 & 0 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} u(t)$$

$$y = \begin{bmatrix} 0 & 1 & 1 \end{bmatrix} x$$

$$x(0) = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

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3. (20%)

A unit feedback control system given by

$$L(s)=G(s)H(s)=\frac{5e^{-sT}}{s(s+3)(s+4)}.$$

(1) **(14%)** Draw the Bode plot indicating gain margin and phase margin for $T=0$.

(2) **(6%)** What is the limiting value of T for stability?

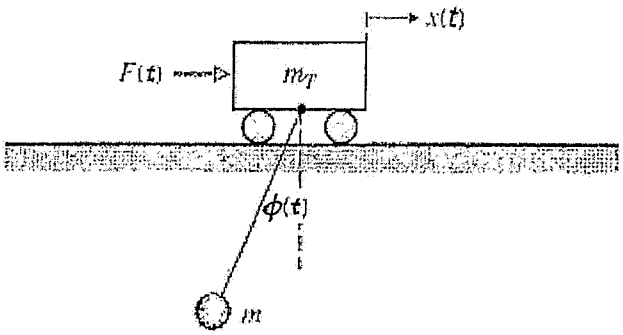
4. (30%)

A pilot crane control is shown below with the controller $G_c(s)=K.$.

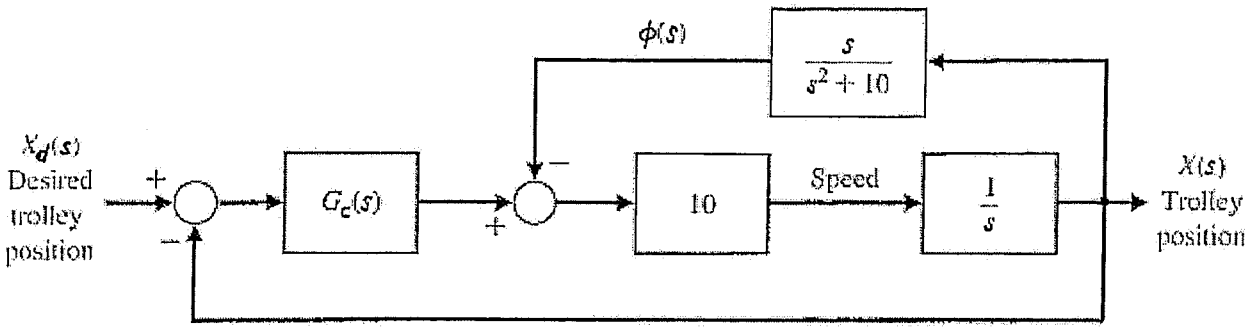
(1) **(15%)** Sketch the root locus.

(2) **(5%)** Determine the value of K to achieve maximum closed-loop damping.

(3) **(10%)** Find the peak overshoot of the system for unit step input.



(a)



(b)