國立臺灣科技大學

114學年度碩士班招生

試題

系所組別：0340機械工程系碩士班丁組

科　　目：系統控制

<<503401>>

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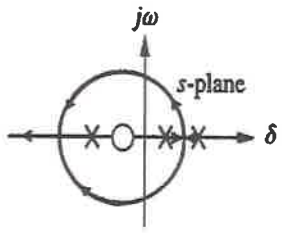
(總分為 100 分；所有試題務必於答案卷內頁依序作答)

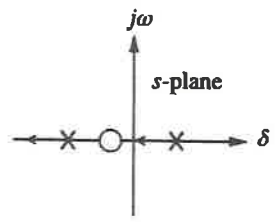
I. Single choice questions (24%). **Please write down your answers on the answer sheer; writing on the examination paper will give NO credits.**

1. Which of the sketches can **Not** be a root locus? (3%)

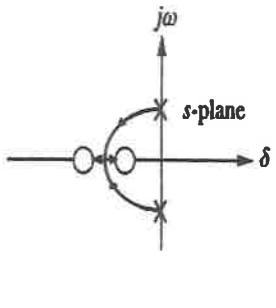
(a)



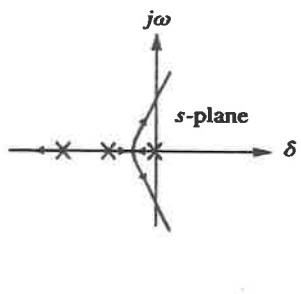
(b)



(c)



(d)



2. Which of the following correctly describes the effect of the integral (I) term in a PID controller? (3%)
   (a) It reduces the steady-state error and improves long-term accuracy.
   (b) It increases the speed of response and improves stability.
   (c) It reduces overshoot by damping the oscillations in the response.
   (d) It acts independently and does not affect the overall system stability.

3. Which of the following statements is correct regarding the steady state error of type 0, type 1, and type 2 systems in response to different input signals? (3%)
   (a) A Type 0 system has zero steady-state error for a step input and a finite steady-state error for a ramp input.
   (b) A Type 1 system has zero steady-state error for both step and ramp inputs.
   (c) A Type 2 system has an infinite steady-state error for a parabolic input.
   (d) A Type 2 system has zero steady-state error for both step and ramp inputs.

4. Which of the following descriptions of the Bode plot is **Incorrect**? (3%)
   (a) It can only be used for linear time-invariant (LTI) systems.
   (b) The phase plot of $G(s) = \frac{(s+20)}{(s+1)(s+7)(s+50)}$ starts from 0° and gradually approaches -180° as frequency increases.
   (c) It is commonly used to describe and analyze the closed-loop behavior of a system

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(d) Both gain and phase margin should be positive for a stable system.

5. The modern control representation of the system can be described by

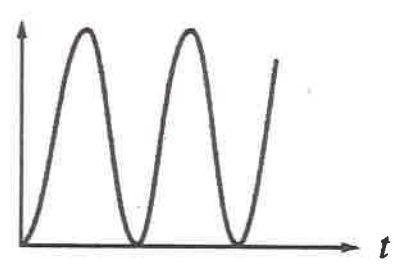
$$\dot{X} = AX + Bu$$
$$y = CX + Du$$

Where

$$A = \begin{bmatrix} 0 & 2 \\ -3 & 0 \end{bmatrix},\ B = \begin{bmatrix} 1 \\ 0 \end{bmatrix},\ C = [0 \quad 1],\ D = [0]$$

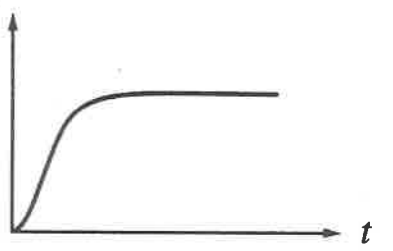
If the input is a step function, please choose the correct output waveform. (3%)

(a)

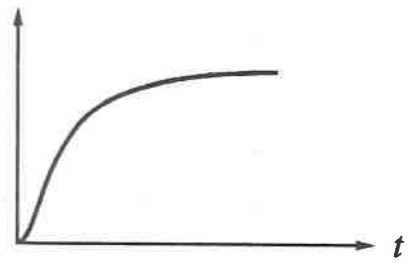


(b)

(c)



(d)



6. Which of the following descriptions of the transfer function is **Incorrect**? (3%)
   (a) It is a mathematical model that expresses the differential equation that relates the output variable to the input variable.
   (b) It depends on the magnitude of the input or driving function.
   (c) It can be established experimentally by introducing known inputs and studying the system's output.
   (d) It does not provide any information concerning the physical structure of the system.

7. Which of the following descriptions of the root-locus plot is **Incorrect**? (3%)
   (a) It describes how the closed-loop poles move in the complex plane.
   (b) The system becomes unstable when a root locus enters the right-half *s* plan.
   (c) The system is marginally stable when a root locus crosses the imaginary axis.
   (d) The root-locus branches start from closed-loop poles and terminate at closed-loop zeros or infinity.

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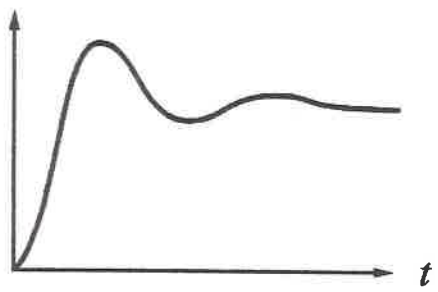
8. The step response of a transfer function is illustrated in the figure below. Select the transfer function that corresponds to this response. (3%)

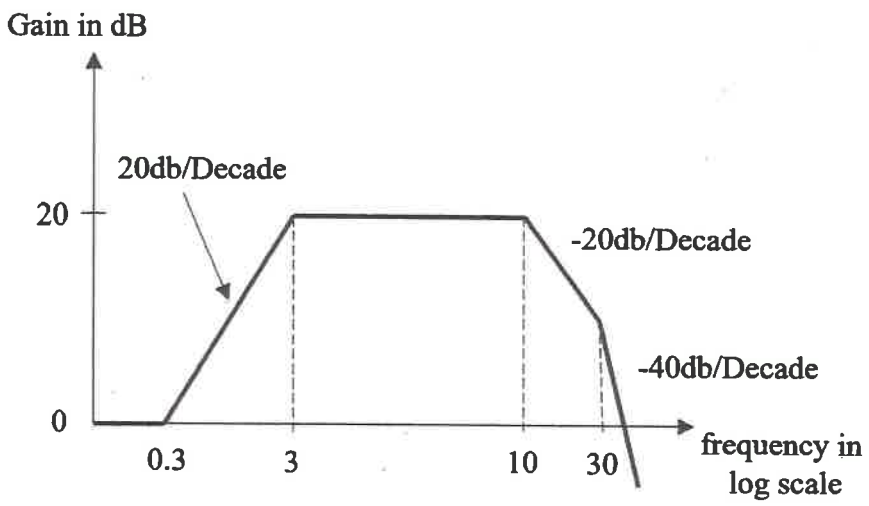


(a) $G(s) = \frac{300}{s^2+18s+300}$　　(b) $G(s) = \frac{800}{s^2+80s+800}$

(c) $G(s) = \frac{250}{s^2+35s+250}$　　(d) $G(s) = \frac{700}{s^2+700}$

II. Single choice question (16%). **Please write down your answers on the answer sheer; writing on the examination paper will give NO credits.**

1. Please Find the transfer function for the Bode plot for magnitude shown in the figure. Assume that it is minimum phase. (4%)



(a) $G(s) = \frac{\left(1+\frac{s}{0.3}\right)}{s\left(1+\frac{s}{3}\right)\left(1+\frac{s}{10}\right)\left(1+\frac{s}{30}\right)}$　　(b) $G(s) = \frac{10\left(1+\frac{s}{0.3}\right)}{\left(1+\frac{s}{3}\right)\left(1+\frac{s}{10}\right)\left(1+\frac{s}{30}\right)}$

(c) $G(s) = \frac{\left(1+\frac{s}{0.3}\right)}{\left(1+\frac{s}{3}\right)\left(1+\frac{s}{10}\right)\left(1+\frac{s}{30}\right)}$　　(d) $G(s) = \frac{\left(1+\frac{s}{0.3}\right)\left(1+\frac{s}{3}\right)}{s\left(1+\frac{s}{10}\right)\left(1+\frac{s}{30}\right)}$

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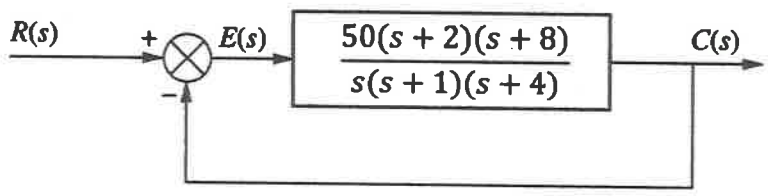
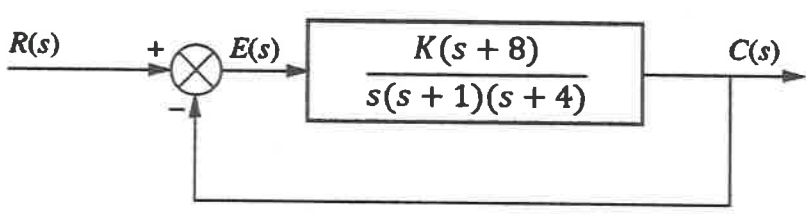
2. The steady-state error of the following system is 5%. Please choose the correct input *R(t)*. The function *u(t)* is the unit step. (4%)



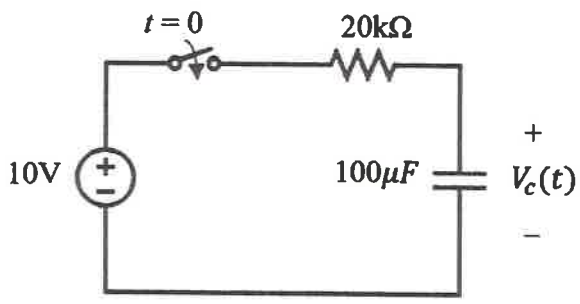
(a) $5u(t)$ (b) $10tu(t)$ (c) $5tu(t)$ (d) $10t^2u(t)$

3. Which value of *K* can make the following unity feedback system stable? (4%)



(a) 15 (b) 10 (c) 5 (d) -2

4. The switch of the following RC circuit closes at $t = 0$ and the initial voltage across the capacitor $V_c(0^-) = 0$. Please find $V_c(t)$ at $t = 1s$. (4%)



(a) 2.4V (b) 3.9V (c) 4.8V (d) 6.3V

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III (20%) For the system depicted by the block diagram in the following Figure. III-1,

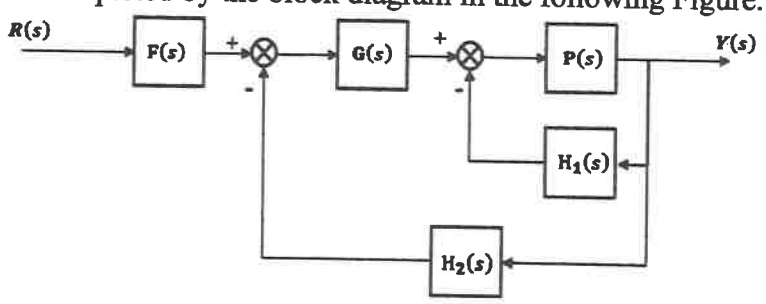
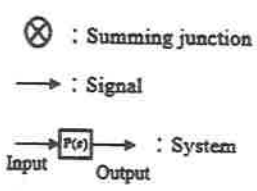


Figure. III-1

where



(a) Find the input-output equivalent transfer function $\mathbf{T}(s) = \frac{Y(s)}{R(s)}$ in terms of $\mathbf{F}(s)$, $\mathbf{G}(s)$, $\mathbf{P}(s)$, $\mathbf{P}(s)$, and $\mathbf{H_2}(s)$. (5%)

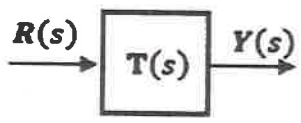


Figure. III-2

(b) If $\mathbf{P}(s) = \frac{2}{(s-3)(s+5)}$, $\mathbf{G}(s) = k$, $\mathbf{F}(s) = 1$, $\mathbf{H_1}(s) = 0.5$, and $\mathbf{H_2}(s) = 1$, find the range of k such that the closed-loop system shown in Figure. III-1 is stable. (4%)

(c) Given $k = 3$ and $\mathbf{r}(t) = 1(t)$, which is an unit step function input, find $\mathbf{y}(\infty) = \mathbf{y}(t)|_{t=\infty}$. (3%)

(d) Given $k = 8$ and $\mathbf{r}(t) = 1(t)$, which is an unit step function input, find $\mathbf{y}(\infty) = \mathbf{y}(t)|_{t=\infty}$. (3%)

(e) Assume $\mathbf{T}(s) = \frac{Y(s)}{R(s)} = \frac{5}{s^2+7s+10}$ in Figure. III-2, and the input is a step input of amplitude 2 as $r(t) = 2 \times 1(t)$. Find the output $y(t)$, assuming all initial conditions are zero. (5%)

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IV (15%) Consider a rotational mechanical system as shown in the Figure. IV-1.

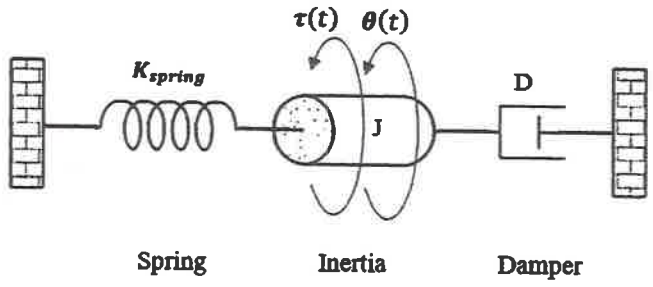

Figure. IV-1

(a) Find the transfer function, $\boldsymbol{P(s)} = \frac{\boldsymbol{\theta(s)}}{\boldsymbol{\tau(s)}}$, of the rotational mechanical system where $\boldsymbol{\tau(t)}$ is the input and $\boldsymbol{\theta(t)}$ is the output. (5%)

(b) Given $\boldsymbol{J} = 2\ \text{kg} - m^2$, $\boldsymbol{D} = 1\ \text{N} - \text{m} - \text{s/rad}$ and $\boldsymbol{K_{spring}} = 8\ \text{N} - \text{m/rad}$, find the damping ratio and the undamped natural frequency of this system. (5%)

(c) Sketch the root locus for the unity feedback system in Figure IV-2 below, where $\boldsymbol{G(s)} = \frac{\boldsymbol{K}}{\boldsymbol{(s+1)^3}}$, K is the feedback gain, and $\boldsymbol{P(s)} = \frac{\boldsymbol{\theta(s)}}{\boldsymbol{\tau(s)}}$ with $\boldsymbol{J} = 2\ \text{kg} - m^2$, $\boldsymbol{D} = 1\ \text{N} - \text{m} - \text{s/rad}$ and $\boldsymbol{K_{spring}} = 8\ \text{N} - \text{m/rad}$ from (b). (5%)

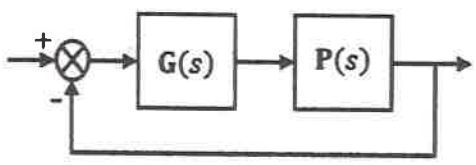

Figure. IV-2

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V (25%) Consider a two-mass translational mechanical system as shown in the Figure. V-1.

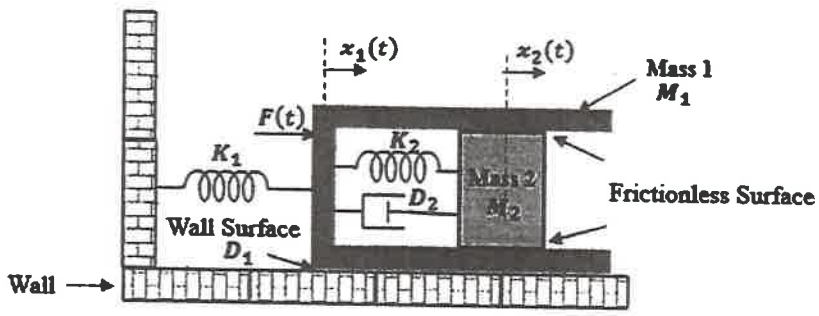

Figure. V-1

All elements are assumed to be linear. The surface between mass number 1 and mass number 2 is assumed to be frictionless. The surface between mass number 1 and the wall is considered as a viscous damping such that the friction force is described as $F_{wall\ friction}(t) = D_1\dot{x}_1(t)$. An external force $F(t)$ is applied on mass number 1.

(a) Find the equation of motion describing this two-mass system in terms of M_1, M_2, D_1, D_2, K_1, and K_2. (5%)

(b) Assume the spring is neglected and thus $K_1 = 0$ N/m, and $K_2 = 0$ N/m. In addition, $M_1 = 2$ kg, $M_2 = 1$ kg, $D_1 = 2$ N − s/m, and $D_2 = 2$ N − s/m. Find the state space representation with $F(t)$ being the input, $\dot{x}_2(t)$ being the output and $\dot{x}_1(t)$ and $\dot{x}_2(t)$ being the state variables. (5%)

(c) Find the transfer function $P(s) = \frac{\dot{x}_2(t)}{F(t)}$ from (c). (5%)

(d) Find the control canonical form of the system described in the state-space representation of (c). (5%)

(e) If we design a control law using state feedback as $F(t) = -[k_1 \quad k_2]X$ on the control canonical form of (d), find the feedback gain $\mathbf{K} = [k_1 \quad k_2]$ such that the closed-loop poles are at -3 and -10. (5%)