Midterm Exam, Control System, 110-1 (2021)

Date: Friday, November 12, 2021. Time: 9am-11am.

Closed books, closed notes, no calculators.

Only pens and erasers are allowed.

姓名：

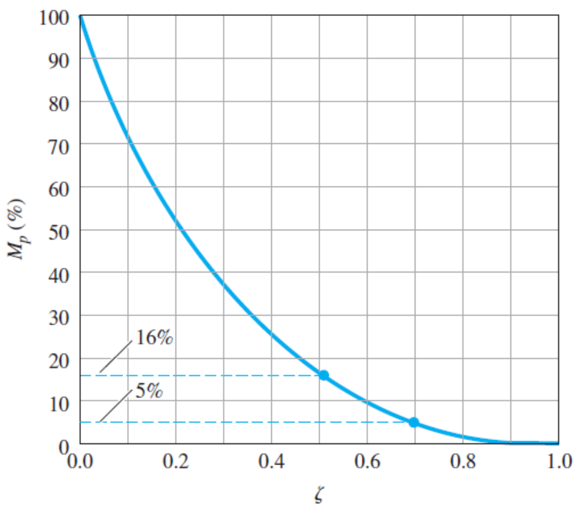
學號：

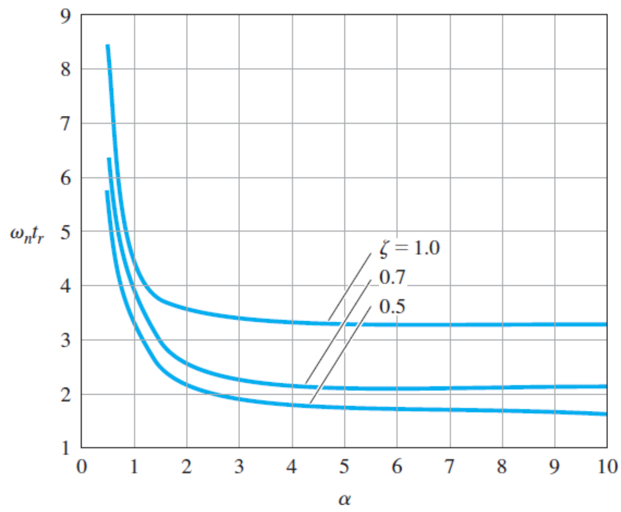
系級：

[Helpful Information]

$\lim_{s\to\infty} sF(s)$	$f(0^+)$	Initial Value Theorem
$\lim_{s\to 0} sF(s)$	$\lim_{t\to\infty} f(t)$	Final Value Theorem

$$t_r \cong \frac{1.8}{w_n},\quad t_p = \frac{\pi}{w_d},\quad M_p = e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}},\quad t_s = \frac{4.6}{\zeta w_n} = \frac{4.6}{\sigma}$$





Ziegler–Nichols Tuning for the Regulator $D_c(s) = k_P(1 + 1/T_I s + T_D s)$, for a Decay Ratio of 0.25

Type of Controller	Optimum Gain
P	$k_P = 1/RL$
PI	$k_P = 0.9/RL$ $T_I = L/0.3$
PID	$k_P = 1.2/RL$ $T_I = 2L$ $T_D = 0.5L$

Ziegler–Nichols Tuning for the Regulator $D_c(s) = k_P(1 + 1/T_I s + T_D s)$, Based on the Ultimate Sensitivity Method

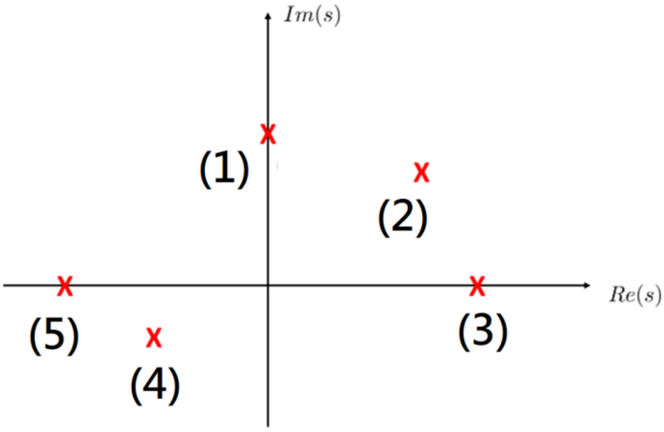
Type of Controller	Optimum Gain
P	$k_P = 0.5K_u$
PI	$k_P = 0.45K_u$ $T_I = \frac{P_u}{1.2}$
PID	$k_P = 1.6K_u$ $T_I = 0.5P_u$ $T_D = 0.125P_u$

Errors as a Function of System Type

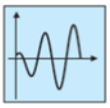
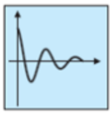
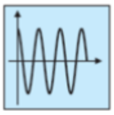
Type Input	Step (position)	Ramp (velocity)	Parabola (acceleration)
Type 0	$\frac{1}{1+K_p}$	∞	∞
Type 1	0	$\frac{1}{K_v}$	∞
Type 2	0	0	$\frac{1}{K_a}$

Part A. [30%] Find the best choice. (評分標準：只需寫出正確選項)

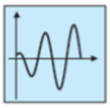
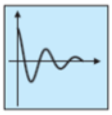
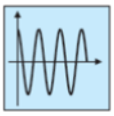
For the pole locations shown in the figure below, please identify the corresponding responses.



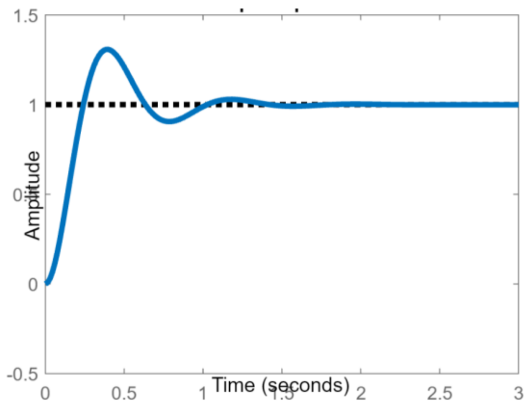
(A1) The response corresponds to Position (1) is:

(A)  ; (B)  ; (C)  ; (D)  .

(A2) The response corresponds to Position (4) is:

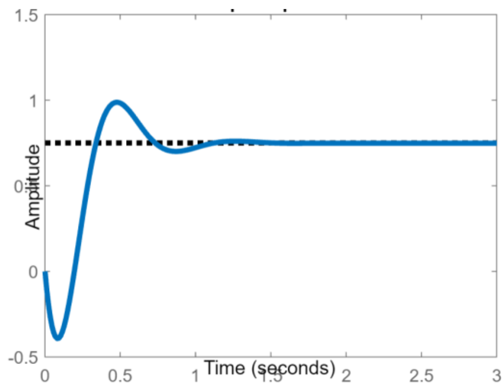
(A)  ; (B)  ; (C)  ; (D)  .

(A3) For the step response shown in the following figure, please find the best possible transfer function:



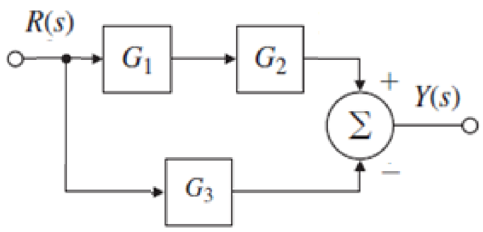
(A) $\frac{73}{(s^2+6s+73)}$; (B) $\frac{72}{(s^2+17s+72)}$; (C) $\frac{400}{(s^2+6s+409)}$; (D) $\frac{400}{(s^2+40s+375)}$;

(A4) For the step response shown in the following figure, please find the best possible transfer function:



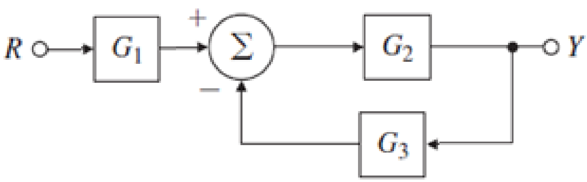
(A) $\frac{(60-10s)}{(s^2+8s+80)}$; (B) $\frac{(20-10s)}{(s^2+8s+80)}$; (C) $\frac{(20-10s)}{(s^2+12s+32)}$; (D) $\frac{(60-10s)}{(s^2+12s+32)}$;

(A5) For the block diagram shown in the following figure, please find the transfer function from R to Y:



(A) $G_1+G_2+G_3$; (B) $G_1G_2-G_3$; (C) $G_1+G_2G_3$; (D) $G_1G_2+G_3$;

(A6) For the block diagram shown in the following figure, please find the transfer function from R to Y:



(A) $\frac{G_1G_2}{1+G_1G_2G_3}$; (B) $\frac{G_1G_2}{1+G_2G_3}$; (C) $\frac{G_1G_2G_3}{1+G_1G_2G_3}$; (D) $\frac{G_1}{1+G_2G_3}$;

Part B. [70%] Write down proper description for the following problems.

(B1) (10%=5%+5%)

A unit negative feedback system has the following open-loop transfer function:

$$G(s) = \frac{1}{(a\,s + b)}$$

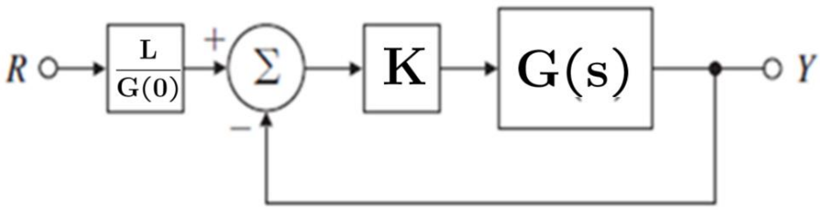
(a) Compute the sensitivity of the closed-loop transfer function to changes in parameter *a*.
(b) Compute the sensitivity of the closed-loop transfer function to changes in parameter *b*.

(B2) (30%=5%*6)

For a second-order system with transfer function:

$$G(s) = \frac{16}{s^2 + s + 16}.$$

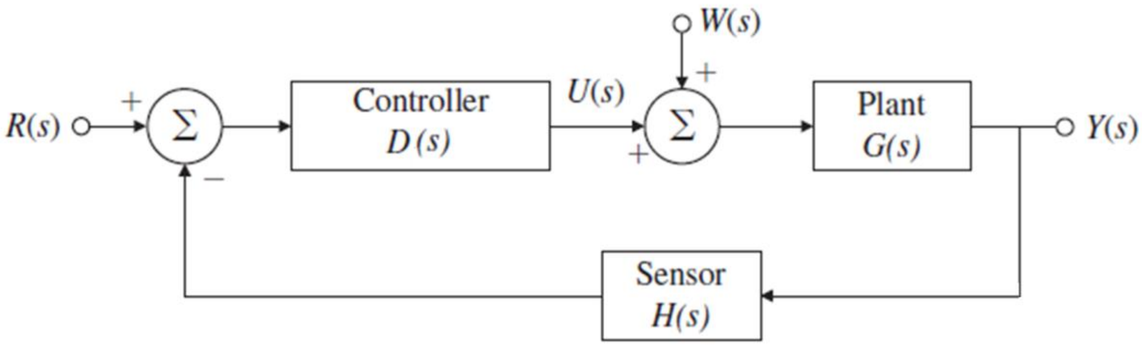
Assume that System *G(s)* is added into the following block diagram, where *K* and *L* are two constants:



(a) Find the poles and zeros of system *G(s)*.
(b) Determine whether the system is stable and why?
(c) Determine the overshoot and rise time of system *G(s)* if unit-step input is applied.
(d) Determine the closed-loop transfer function *T(s)* from *R* to *Y*, in terms of *K* and *L*.
(e) Determine *L* such that the steady-state value of the of the closed-loop system *T(s)* is equal to 1 if *R* is the unit-step input and *K=3*.
(f) Determine the overshoot and rise time of the closed-loop system *T(s)* if *R* is the unit-step input and *K=3*.

(B3) (30%=5%*6)

A standard feedback control block diagram is shown as follows:



where $G(s) = \frac{2}{s}; \quad D(s) = \frac{(s+8)}{(s+2)}; \quad H(s) = \frac{100}{(s+100)}.$

(a) Let $W = 0$ and compute the transfer function from R to Y.
(b) Let $R = 0$ and compute the transfer function from W to Y.
(c) What is the tracking error if R is a unit-step input and $W = 0$?
(d) What is the tracking error if R is a unit-ramp input and $W = 0$?
(e) What is the tracking error if R is a unit-step input and W is a 0.1-unit-step input?
(f) What is the system type with respect to the reference inputs R and the corresponding error coefficients?