複選題 (100%): 共 10 題，每一題全部選項答對得 10 分，錯一個選項得 5 分，錯兩個選項 (含) 以上或空白不予計分。考生應作答於試卷之選擇題作答區，未作答於作答區者，亦不予計分。

Basic problems

1. Consider the operational-amplifier circuit as shown in Figure 1, where $R_1 = 2\text{M}\Omega$, $R_2 = 200\text{k}\Omega$, $R_3 = 8\text{M}\Omega$, $R_4 = 300\text{k}\Omega$, $R_5 = 1\text{M}\Omega$, $R_6 = 1\text{M}\Omega$, $C_1 = 0.1\mu\text{F}$, and $C_2 = 0.5\mu\text{F}$. Let $P(s) = \frac{E_o(s)}{E_i(s)}$, which of the following locations have at least one pole or zero of $P(s)$?
(A) $s = -1$ (B) $s = -2$ (C) $s = -4$ (D) $s = -8$ (E) $s = -10$

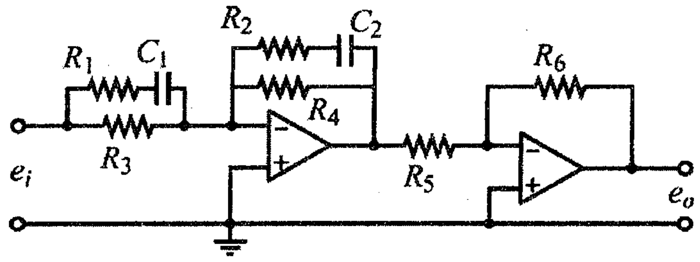

Figure 1: The Op-Amp circuit for problem 1.

2. Consider the system $P(s)$ and input $u(t)$ given by
$$P(s) = \frac{(s-2)(s+5)}{s(s^2+16)(s+3)}, \quad u(t) = 50sin(5t).$$
Which of the following terms are expected to appear in the steady state output of $P(s)$?
(A) 1 (B) e^{2t} (C) e^{-3t} (D) $sin(4t)$ (E) $cos(5t)$

3. Which of the following systems have an impulse response that can be roughly sketched as shown in Figure 2, where a is a real number?
(A) $\frac{1}{s+4}$ (B) $\frac{1}{4s+1}$ (C) $\frac{s+4}{(3s+1)(4s+1)}$ (D) $\frac{s+0.25}{(s+4)(4s+1)}$ (E) $\frac{s+0.33}{(3s+1)(4s+1)}$

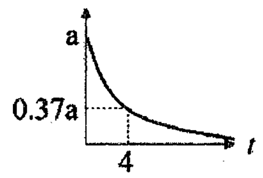

Figure 2: The impulse response for problem 3.

4. Consider the open-loop system $P(s)$ and P-controller $C(s)$ given by
$$P(s) = \frac{3(s+1)(s+10)}{40(s+4)(s+5)}, \quad C(s) = k, \quad k > 0,$$
where the closed-loop control system is constructed as Figure 3 and the input disturbance $w = 0$. Which of the following locations are impossible to have a closed-loop pole?
(A) $s = 2.25$ (B) $s = -2.25$ (C) $s = -4.5$ (D) $s = -13.5$ (E) $s = -1 \pm j$

5. Which type of the following feedback controllers can increase the bandwidth of the closed-loop system?
(A) P controller $C(s) = k$ (B) I controller $C(s) = \frac{k}{s}$ (C) D controller $C(s) = ks$ (D) Lead compensator $C(s) = \frac{\frac{s}{a}+1}{\frac{s}{b}+1}, 0 < a < b$ (E) Lag compensator $C(s) = \frac{\frac{s}{a}+1}{\frac{s}{b}+1}, 0 < b < a$

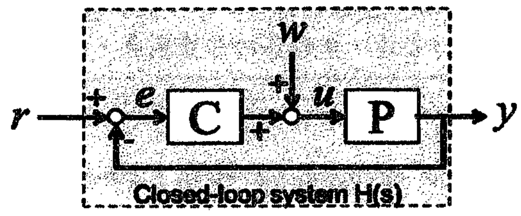

Figure 3: A typical feedback control architecture.

6. Consider the state-space model given by

$$\dot{x} = \begin{bmatrix} -2 & 0 \\ d & -3 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$
$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} x$$

where x is the system state, u is the input, y is the output, and d is an unknown parameter. Which of the following statements are NOT true?
(A) This system is uncontrollable when $d = 0$.
(B) This system is unobservable when $d = -2$.
(C) The pole locations of this system depends on the value of d.
(D) The DC gain of this system is $d/6$.
(E) This system is always stable.

Problem set
Consider the open-loop system $P(s)$ and P-controller $C(s)$ given by

$$P(s) = \frac{s-1}{s^2 - s + 4}, \quad C(s) = k, \quad k > 0,$$

where the closed-loop control system $H(s)$ is constructed as Figure 3 and the input disturbance $w = 0$. Answer Problem 7, 8, 9, and 10 with this configuration.

7. Which of the following ranges of k make the closed-loop system $H(s)$ stable?
(A) $k > 10$ (B) $k > 4$ (C) $k < 4$ (D) $k > 1$ (E) $k < 1$

8. Which of the following values of k yield $t_s \leq 9.2$ seconds, where t_s is the settling time of the closed-loop system $H(s)$?
(A) $k = 0.67$ (B) $k = 1.5$ (C) $k = 2$ (D) $k = 3$ (E) $k = 6$

9. Which of the following values of k yield $|y_{ss}| \leq 1$, where y_{ss} is the steady state output of the closed-loop system $H(s)$ to a unity step input (i.e., $r = 1$ for $t \geq 0$)?
(A) $k = 0.67$ (B) $k = 1.5$ (C) $k = 2$ (D) $k = 3$ (E) $k = 6$

10. Which of the following statements are NOT true?
(A) $H(s)$ has repeated poles at -2 when $k = 3$.
(B) The oscillation in the step response of $H(s)$ becomes smaller when k is increased.
(C) The gain margin of the system becomes 0 dB when $k = 4$.
(D) The Nyquist plot of the loop transfer function (i.e., P(s)C(s)) has 1 counterclockwise encirclement around -1 when $k = 2$.
(E) The Nyquist plot of the loop transfer function (i.e., P(s)C(s)) has no counterclockwise encirclement around -1 when $k = 5$.