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，未作答於選擇題作答區者，以零分計。

1. Consider the operational-amplifier circuit as shown in Figure 1. Which of the following parameter assignments implement a lead-lag compensator $C(s) = \frac{E_o(s)}{E_i(s)} = \frac{3(s+1)(s+10)}{40(s+4)(s+5)}$?
(A) $R_1 = 2\text{M}\Omega$, $R_2 = 500\text{k}\Omega$, $R_3 = 8\text{M}\Omega$, $R_4 = 300\text{k}\Omega$, $R_5 = 1\text{M}\Omega$, and $R_6 = 1\text{M}\Omega$.
(B) $R_1 = 2\text{M}\Omega$, $R_2 = 200\text{k}\Omega$, $R_3 = 8\text{M}\Omega$, $R_4 = 300\text{k}\Omega$, $R_5 = 1\text{M}\Omega$, and $R_6 = 1\text{M}\Omega$.
(C) $R_1 = 2\text{M}\Omega$, $R_2 = 200\text{k}\Omega$, $R_3 = 8\text{M}\Omega$, $R_4 = 300\text{k}\Omega$, $R_5 = 3\text{M}\Omega$, and $R_6 = 1\text{M}\Omega$.
(D) $C_1 = 0.1\mu\text{F}$ and $C_2 = 0.5\mu\text{F}$.
(E) $C_1 = 0.5\mu\text{F}$ and $C_2 = 0.1\mu\text{F}$.

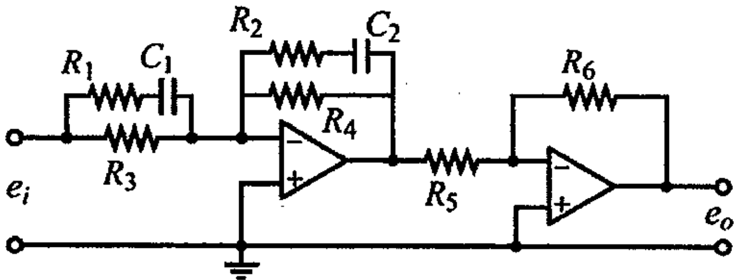

Figure 1: The Op-Amp circuit for problem 1.

2. Consider a non-linear dynamic model

$$\dot{x}_1 = x_2$$
$$\dot{x}_2 = -10sin(x_1) - x_2$$

Which of the following statements are true?
(A) The linearized model at the equilibrium point $x_1 = x_2 = 0$ has poles at $-0.5 \pm j3.12$
(B) The linearized model at the equilibrium point $x_1 = x_2 = 0$ has poles at $0.5 \pm j3.12$
(C) The linearized model at the equilibrium point $x_1 = \pi, x_2 = 0$ has poles at -3.7 and 2.7
(D) The linearized model at the equilibrium point $x_1 = \pi, x_2 = 0$ has poles at 3.7 and -2.7
(E) The linearized model at the equilibrium point $x_1 = \pi, x_2 = 0$ has poles at $0.5 \pm j3.12$

3. Which of the following statements regarding non-minimum phase (NMP) zeros are true?
(A) The effects of NMP zeros can be cancelled by feedback control techniques.
(B) The effects of NMP zeros can be cancelled by feedforward control techniques.
(C) The transfer function of the system that contains NMP zeros cannot be uniquely determined from the magnitude plot of the Bode diagram.
(D) NMP zeros add leading phase to a system.
(E) There is always a undershoot in the step response if the corresponding system has NMP zeros.

4. Consider the system $P(s)$ and input $u(t)$ given by

$$P(s) = \frac{(s-2)(s+5)}{s(s^2+9)(s+3)}, \quad u(t) = sin(5t).$$

Which of the following terms are expected to appear in the steady state output of $P(s)$?
(A) 1 (B) e^{-3t} (C) e^{-5t} (D) $sin(4t)$ (E) $cos(5t)$

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5. Consider a second-order LTI plant $P(s)$

$$P(s) = \frac{8}{s^2 + 6s + 16}$$

Which of the following statements are true?
(A) The D.C. gain of $P(s)$ is 0.5.
(B) The natural frequency of $P(s)$ is 16 rad/s.
(C) The rise time of the step response of $P(s)$ is larger than 1 s.
(D) The settling time of the step response of $P(s)$ is less than 1 s.
(E) The maximum overshoot of the step response of $P(s)$ is less than 5%.

6. Which of the following statements are true?
(A) Given the characteristic equation $3s^2 + 5s + k = 0$ of a linear control system, increasing the value of k will decrease the frequency of oscillation of the system.
(B) $P(s) = \frac{10}{s(s+1)(s+20)}$ can be approximated by $P_L(s) = \frac{10}{s(s+1)}$ since the pole at -20 is much larger than the dominant poles at 0 and -1.
(C) For a stable open-loop system with a perfect model $P(s)$, it is always possible to have a stable and causal feedforward controller $F(s)$ such that $P(s)F(s) = 1$.
(D) The maximum overshoot of $H(s) = \frac{w_n^2(1+Ts)}{s^2 + 2\zeta w_n s + w_n^2}$ is possibly exceed 100 percent when ζ, w_n, and T are all positive.
(E) If a unity-feedback control system type is 2, then it is certain that the steady-state error of the system to a step or a ramp input will be zero.

7. Consider the closed-loop feedback control architecture shown in Fig. 2, where $P(s)$ is the open-loop plant, $C_1(s)$ and $C_2(s)$ are the feedback controllers, and $H(s)$ is the transfer function from the reference $r(t)$ to the output $y(t)$, respectively. Assume that $C_1(s) = \frac{1}{1 - e^{-0.1s}}$ and $H(s)$ is asymptotically stable, which of the following reference signal $r(t)$ can be tracked by $H(s)$ without steady-state error?
(A) $r(t) = sin(10t)$. (B) $r(t) = sin(20\pi t)$. (C) $r(t) = sin(0.1t)$. (D) $r(t) = sin(0.2\pi t)$.
(E) A 100 Hz triangular wave reference $r(t)$.

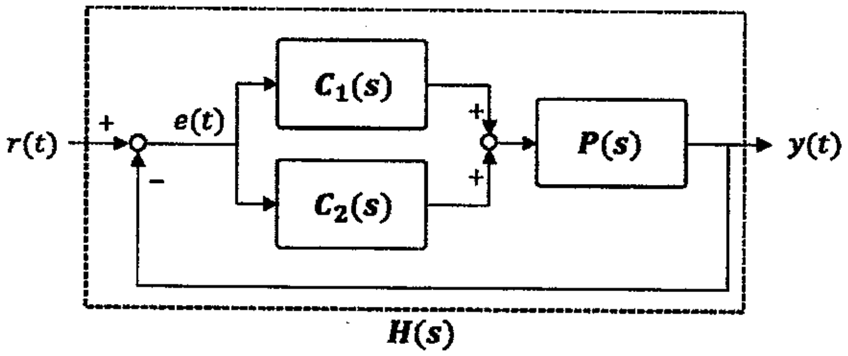

Figure 2: The closed-loop feedback control architecture applied in Problem 7.

8. Which of the following statements regarding system robustness are true?
(A) A closed-loop system must become unstable when the transmission lag is large enough.
(B) A closed-loop system must be stable when both gain margin and phase margin are positive.
(C) The gain margin is always infinite for second-order systems.
(D) It is possible to have infinite phase margin.
(E) Reduction of gain increases the gain margin without sacrificing the steady-state error.

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9. Consider the state-space model given by

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

where x is the system state, u is the input, and y is the output. Which of the following statements are true?
(A) This state-space model is a minimal realization.
(B) The poles of this model are at -2 and 4.
(C) The transfer function of this model from u to y is $\frac{(s+3)}{s^2-2s-8}$.
(D) This model has a transmission zero at -3.
(E) The state feedback law $u = -Kx$ yields the closed-loop poles at -10 and -20 when $k = [32 \;\; 80]$.

10. Read the following paragraph that introduces the concept of model predictive control (MPC): *Model predictive control (MPC) is an advanced method of process control that is used to control a process while satisfying a set of constraints. It has been in use in the process industries in chemical plants and oil refineries since the 1980s. In recent years it has also been used in power system balancing models and in power electronics. Model predictive controllers rely on dynamic models of the process, most often linear empirical models obtained by system identification. The main advantage of MPC is the fact that it allows the current timeslot to be optimized, while keeping future timeslots in account. This is achieved by optimizing a finite time-horizon, but only implementing the current timeslot and then optimizing again, repeatedly, thus differing from Linear-Quadratic Regulator (LQR). Also MPC has the ability to anticipate future events and can take control actions accordingly. PID controllers do not have this predictive ability. MPC is nearly universally implemented as a digital control, although there is research into achieving faster response times with specially designed analog circuitry. (text acquired from Wikipedia)*
According to the above paragraph, which of the following statements are true?
(A) MPC applies an optimization solver to acquire the optimal control action with the consideration of the predicted responses and system constraints.
(B) PID controllers do not have the predictive ability because they can be tuned without knowing the dynamic model.
(C) The performance of MPC may be deteriorated if the dynamic model is inaccurate.
(D) LQR control cannot optimize the control action over a finite time-horizon.
(E) Although it is possible to implement MPC on analog circuitry, MPC is usually implemented on computers or microprocessors.