1. (30%) In each of the following 10 questions, pick up the best from the underlined five options and write it (A, B, C, D, or E) to the answer sheet.

(1) What is the impulse response of the dynamical system G described by $\ddot{y}+y=\dot{u}$, where y and u represent the single output and input, respectively? (A) e^t (B) $1-\cos t$ (C) $\sin t$ (D) $1-\sin t$ (E) $\cos t$.

(2) Following Problem (1), what is the step response of G, i.e. u is a unit step? (A) e^t (B) $1-\cos t$ (C) $\sin t$ (D) $1-\sin t$ (E) $\cos t$.

(3) Following Problem (1), what is the steady amplitude of the output y provided that the input u is a persistent excitation, $u(t)=\sin t$? (A) 1 (B) -1 (C) infinity (D) $\sqrt{2}$ (E) 0.

(4) Suppose a linear dynamics G has the impulse response g. Given G a series of discretely impulsive inputs with intensities $\{u_0,u_2,\cdots,u_{10}\}$ at the time $\{0,1,2,\cdots,10\}$, what is the value of the output y at $t=11$, $y(11)$?
(A) $u_0g(10)+u_1g(9)+\cdots+u_9g(1)+u_{10}g(0)$
(B) $u_0g(0)+u_1g(1)+\cdots+u_9g(9)+u_{10}g(10)$
(C) $u_0g(11)+u_1g(10)+\cdots+u_9g(2)+u_{10}g(1)$
(D) $u_1g(10)+u_2g(9)+\cdots+u_9g(2)+u_{10}g(1)$
(E) $u_0g(1)+u_1g(2)+\cdots+u_9g(10)+u_{10}g(11)$.

(5) A dynamical system with double poles at $\pm j$ exhibits in (A) marginal instability (B) marginal stability (C) sustained oscillation (D) exponential instability (E) BIBO stability.

(6) The term "*Bandwidth*" specifies the (A) damping ratio of a dynamics (B) swiftness of a dynamical system (C) variation rate of a signal (D) intensity of a noise (E) DC gain of a linear system.

(7) Suppose the impulse response of the system G is $g(t)=e^{-0.1t}\sin t+2e^{-0.01t}\cos 2t$, then what is the order of G? (A) 2 (B) 4 (C) 3 (D) 6 (E) the information is not enough to determine the order.

(8) Exponential functions are introduced into the kernel of Laplace Transform, mainly because (A) Fourier transform applies exponential functions to its kernel (B) the time derivatives of exponential functions are still exponential functions (C) exponential functions are analytic (D) exponential functions

are monotonically increasing or decreasing (E) exponential functions include sinusoidal functions.

(9) The realization of a linear dynamics by a transfer function is based on (A) the principle of convolution (B) mathematical induction (C) Lagrange dynamics (D) causality of time propagation (E) Fourier transform.

(10) Feedback control programmed into microcontrollers mounted on the controller board advantages a machine or component to (A) run more robustly (B) improve steady-state energy-efficiency (C) be more sensitive to the environment (D) change to a proper operation point (E) to be more powerful.

2. (20%) Consider that a binary signal is contaminated by white-noise, and the RC circuit in Figure 2 is applied to extract the binary signal out of the white-noise contamination. (Note: the "white" regarding to white-noise means equal components across the whole frequency spectrum)

(a) (5%) Derive the transfer function of the RC circuit with respect to the input voltage u and output voltage y. Do define all the symbols that you use in the process of derivation.

(b) (15%) Do you agree to the following statement:

Along with decreasing values of Time Constant $\tau = RC$, *the output signal* y *bears increasing levels of closeness to the input signal* u?

Perform an analysis to support your answer.

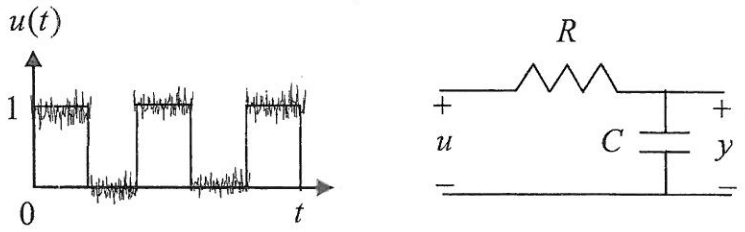

Figure 2

3. (25%) For the system given in Figure 3(a), please find the following:
(a) (5%) Sketch the root locus
(b) (5%) Find the asymptotes and breakaway points
(c) (5%) Find the range of K for stability
(d) (5%) Find the value of K to yield a 0.7 damping ratio for the dominant second-order pair. You might show the steps of how to obtain the value of K without calculating the exact value and partial scores will be granted.
(e) (5%) To improve stability, we desire the root locus to cross the $j\omega$-axis at $j5.5$. To accomplish this, the open-loop function is cascaded with a zero, as shown in Figure 3 (b). Please find the value of α. You might show the steps of how to obtain the value of α without calculating the exact value and partial scores will be granted.

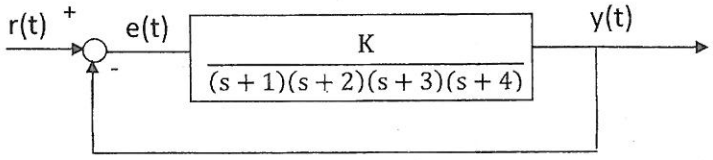

Fig 3(a)

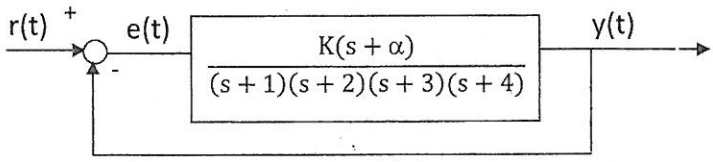

Fig 3(b)

4. (25%) Consider the closed loop system as shown in Figure 4.
(a) (10%) Plot the bode plot of open loop system when the time delay is equal to 0.
(b) (5%) Determine the gain margin and phase margin of the system when the delay is equal to 0.
(c) (5%) For the time delay time equal to 0.1, determine the gain margin.
(d) (5%) Determine the range of the delay time approximately which make the system become unstable.

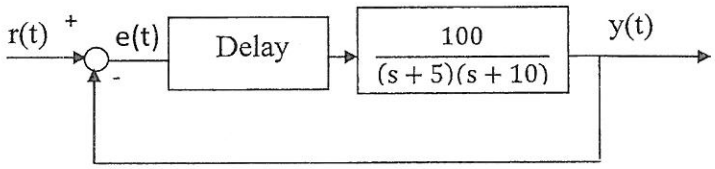

Figure 4