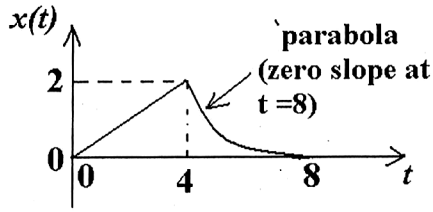
B.E.ELECTRICAL ENGINEERING SECOND YEAR SECOND SEMESTER EXAMINATION, 2022

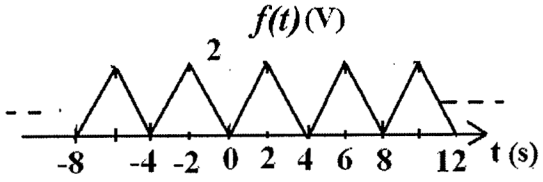
SIGNALS AND SYSTEMS

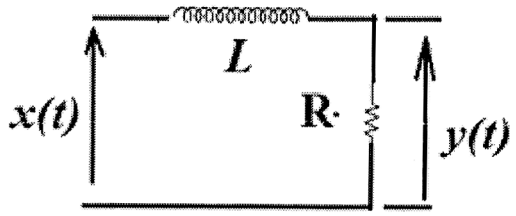
Full Marks 100

Time: Three hours **(50 marks for each part)**

Use a separate Answer-Script for each part

Question No.	PART I	Marks
	Answer any THREE questions ***Two marks reserved for neatness.*** **Give proper units wherever necessary.**	
1. (a)	**Give a well-labeled free-hand sketch for the derivative of the signal *x((t)* shown in Fig. [A], and express *x(t)* as a sum of singularity functions.**  **Fig. [A]**	**2+6**
(b)	**Introduce the concept of total energy and average power of signals. Hence define energy signals and power signals.** **Consider the voltage signal** $x(t) = 5(t-2)^2\left[u(t-2)-u(t-4)\right]$ **mV.** **Examine whether *x(t)* is a power signal or energy signal or none. Give appropriate unit wherever necessary.**	**3+5**
2(a)	**Two non-interacting linear time-invariant (LTI) systems with impulse responses *g(t)* and *h(t)* are in cascade, where** $g(t) = 1 - e^{-0.2t}$ **for** $1 \le t \le 5$**,** **and 0 otherwise.** $h(t) = e^{-0.1t}$ **for** $0 \le t \le 6$**,** **and 0 otherwise.** **Determine the expression for the impulse response of the combination. *Do not use any transform method.***	**10**

Question No.	PART I	Marks
(b)	If $x(t) * z(t) = \int_{-\infty}^{t}\int_{-\infty}^{\tau} x(\lambda)d\lambda d\tau$, what function does *z(t)* represent? Give relevant derivation, starting from the definition of convolution.	6
3. (a)	If a current signal is $f(t) = \delta\left(3t^2 - 7t + 2\right)\ \mu A$, obtain the values of $\int_{-\infty}^{+\infty} f(t)dt$ and $\int_{0}^{1.5} f(t)dt$, where *t* is in s.	6
(b)	Give an appropriate definition for the signal $q(t) = -4\delta(t+2)$. State the properties of $q(t)$.	6
(c)	Define duty cycle and AC coupled crest factor of periodic trains of rectangular pulses.	4
4. (a)	Determine the exponential Fourier series for the periodic signal *x(t)* shown in Fig. [B]. Sketch the double sided amplitude and the phase spectra, up to 3rd harmonic.  Fig. [B]	7
(b)	The autocorrelation function of a power signal *x(t)* is $R_x(\tau) = 3\,Sinc^2(2\tau).Cos(20\pi\tau)$. Determine the expression for the power spectral density $S_x(f)$ of *x(t)*, and sketch $S_x(f)$ as a function of *f*, with proper labeling. *Use any valid relation between $R_x(\tau)$ and $S_x(f)$* <u>*without proof.*</u> What is the average power in the signal *x(t)?*	7+2

Question No.	PART I	Marks
	OR	
(b)	**In the L-R circuit shown in Fig. [C}, L is 100 mH and R is 10 Ω.**	**9**
	 **Fig. [C]**	
	The input voltage signal is $x(t) = 5 + 10Cos(64\pi t - 5°) + 4Cos(128\pi t - 10°) + 2Cos(256\pi t - 30°)$. **The steady state output signal in volt is $y(t)$. Derive the expression for $y(t)$. Give detailed derivation.**	
5.	**Write short notes on <u>any two</u> of the following.**	**8+8**
(a)	**Parseval's formula for periodic signals and energy signals.**	
(b)	**Frequency response of second order system.**	
(c)	**Fourier transforms of unit DC signal, signum function and unit step.**	
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Ref. No.: Ex/EE/PC/B/T/224/2022

B. E. ELECTRICAL ENGINEERING 2ND YEAR 2ND SEMESTER EXAMINATION, 2022

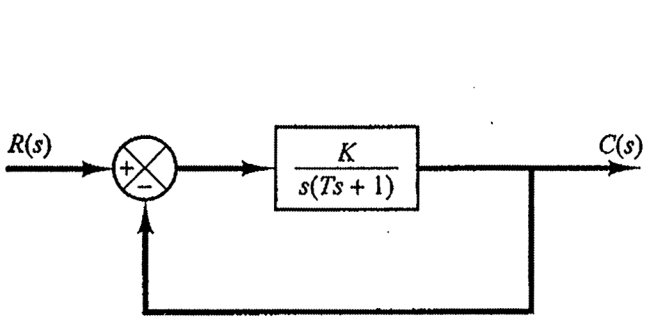
Subject: SIGNALS & SYSTEMS **Time: Three Hours** **Full Marks: 100**

Part II (50 marks)

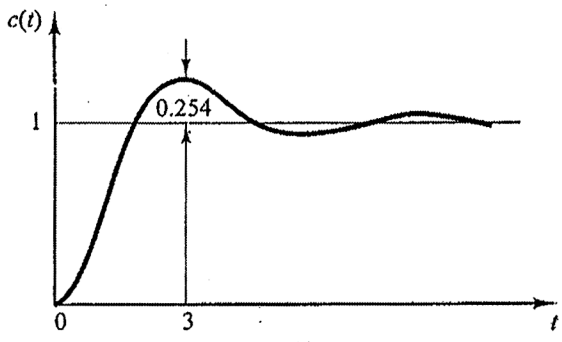
Question 1 is compulsory

Answer ***Any Two*** questions from the rest (2×20)

Question No.		Marks
Q1	Answer ***any Two*** of the following:	
	(a) Determine if the system $y(t) = \dot{x} + x(t)$ is time-invariant, linear, causal, and/or memoryless?	5
	(b) Derive state equations for the following system $\ddot{y}(t) + 2\dot{y}(t) + 4y(t) = 2u(t)$.	5
	(c) Find the initial value of $\frac{df(t)}{dt}$ for $F(s) = \mathfrak{L}[f(t)] = \frac{2s+1}{s^2+s+1}$	5
	(d) Find an analog simulation that converts feet into inches utilizing the full amplifier range of 0 to +10 volts and is capable of converting up to 5feet.	5
Q2	(a) (i) Define damping ratio (ξ) and undamped natural frequency (ω_n) for a second order system?	
	(ii) Show that the locus of the poles of a 2nd order system for ξ varying from 0 to 1, with ω_n held constant, will be a circle of radius ω_n with its center at origin.	4+4
	(b) The unit impulse response of an LTI system is the unit step function $u(t)$. Find the response of the system to an excitation $e^{-at}u(t)$.	4
	(c) When the system shown in Figure (a) is subjected to a unit-step input, the system output responds as shown in Figure (b). Determine the values of K and T from the response curve. Assume steady-state value of 1 and time scale to be in seconds.	8



(a)



(b)

Q3 (a) State (i) Initial Value Theorem and (ii) Final Value Theorem. 2+2

(b) Solve the following differential equation using the Laplace Transform method 8

$\ddot{y} + 4\dot{y} + 20y = 2\dot{x} - x$, with, $x(t) = u(t)$ (unit step), $y(0) = 0, \dot{y}(0) = 1$

(c) Obtain the transfer function $V_C(s)/V(s)$, for the network shown in Figure P-3(c). 8

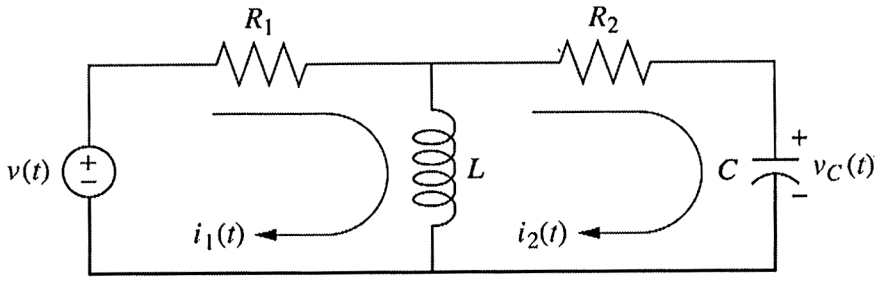


Figure P-3(c)

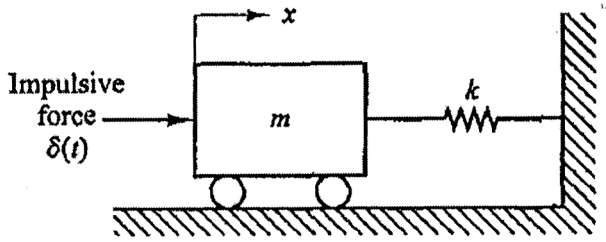
Q4 (a) (i) Define state equation and output equation for an LTI system.

(ii) Consider an LTI system given by the transfer function: 4+8

$$G(s) = \frac{10s + 10}{s^2 + 5s + 10}$$

Obtain the state-space model of the system in the phase variable canonical form.

(b) Consider the mechanical system as shown in Figure. Suppose the system is at rest initially. At t=0 it is set into motion by a unit impulse force. Obtain the transfer function model for the system. Derive the state space representation of the system. 4+4



Q5 (a) (i) Draw analog simulation diagram for the following system.

$$\ddot{x} + 8\dot{x} + 25x = 500, \qquad x(0) = 40, \dot{x}(0) = 150,$$

with, $|x|_{max} = 50$, $|\dot{x}|_{max} = 250$. 4+8

(ii) Obtain magnitude-scaled analog simulation of the system to utilize the full amplifier range of 0 to +10 volts without any overloading.

(b) Draw the asymptotic Bode magnitude plot for the system having a transfer function 8

$$G(s) = \frac{10s}{(s+1)(s+5)^2}$$