Ref No: **Ex/EE/PC/B/T/211/2024**

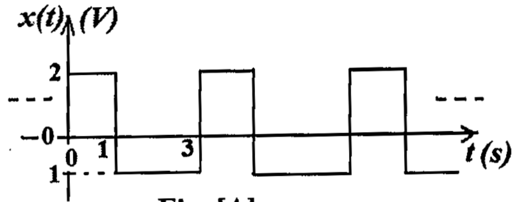
B.E.ELECTRICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAMINATION, 2024

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 Question No. 5 and any TWO from rests. **Give proper units wherever necessary.**	
1. (a)	**Evaluate the following integrals.** $(i)\int_{-\infty}^{+\infty}\delta(bt-a)\mathrm{Cos}^2(t-c)\,dt$, **from the definition of** $\delta(t)$, **where** $b>0$. $(ii)\int_{-\infty}^{+\infty}\frac{1}{3}Sinc^2(3t)\,dt$	7
(b)	**The impulse response of a linear time-invariant (LTI) system is** $h(t)=e^{-t}\left[u(t-3)-u(t-5)\right]$. ***Without actually determining the expression for the frequency response,*** **obtain the value of the DC gain of the system.**	5
(c)	**Determine the 'Duty Cycle" and "AC Coupled Crest factor" of the pulse train** ***x(t)*** **depicted in Fig.[A].**  **Fig. [A]** **[CO2-K2]**	4
2. (a)	**The response of an LTI system to a unit parabola input is** $\phi(t)=\frac{3}{2}t^2u(t)-e^{-2t}u(t)$. **Perform time-domain analysis to obtain the expression for the**	7

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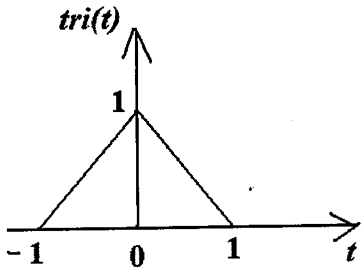
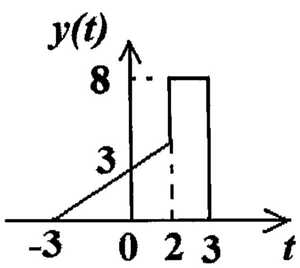
Question No.	PART I	Marks
	response of the system to an input $f(t) = tri\,(t-1)$**, where** $tri(t)$ **is shown in Fig. [B].**  **Fig. [B]**	
(b)	**The input** $x(t)$ **to an LTI system has an autocorrelation function** $R_X(\tau) = 2\delta(\tau)$**. The impulse response function of the system is** $g(t) = 3e^{-5t}u(t)$**. Determine the expression for the autocorrelation function of the output.**	**5**
(c)	**Determine the energy of the signal** $x(t) = Sin(\omega_o t)$ **for** $-\frac{2\pi}{\omega_o} \le t \le \frac{2\pi}{\omega_o}$ **and** $x(t) = 0$ **otherwise, where** t **is in seconds and** $x(t)$ **is in A.** **[CO3-K3]**	**4**
3. (a)	**With the help of neat labeled sketches, determine and sketch the odd component of the signal** $y(t)$ **shown in Fig. [C]. Also sketch the derivative of** $y(t)$**.**  **Fig. [C]**	**7**
(b)	**Obtain the one-sided line amplitude spectrum, phase spectrum and the power density spectrum (up to 3rd harmonic) for the periodic signal** $x(t)$ **shown in Fig. [A].** **Is the integral of** $x(t)$ **periodic? Explain.** **[CO4-K2]**	**7+2**

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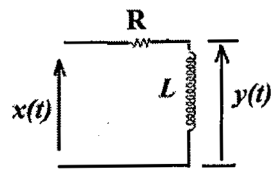
Question No.	PART I	Marks
4.	**In the circuit shown in Fig. [D], if R=10 Ω and L=1 H, determine the expression for the steady state output *y(t)* and for an input $x(t)=2\text{Cos}(2t)+3\text{Cos}(4t)$, where t is in seconds. Also determine the expressions for the step response of the circuit and the response corresponding to an input $x(t)=e^{-3t}u(t)$. [CO5-K3]**	6+4+6
	 **Fig. [D]**	
5.	**Write short notes on *any two* of the following. [CO1-K1]**	9+9
(a)	**Frequency response of second-order system.**	
(b)	**Energy spectral density and power spectral density.**	
(c)	**Periodicity of linear combination of periodic signals.**	
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B. E. ELECTRICAL ENGINEERING 2ND YEAR 1ST SEMESTER EXAMINATION, 2024

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

Part II (50 marks)

Question No. | **Question 1 is compulsory** | Marks

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

Q1 Answer ***any Two*** of the following:

(a) Determine if the system given by

$$\frac{dy(t)}{dt} + \sin(t)\, y(t) = 4x(t)$$ 5

is time-invariant, linear, causal, and/or memoryless?

(b) An LTI system has an impulse response $h(t) = e^{-at}u(t)$. When it is excited by an input signal $x(t)$ its output is $y(t) = [e^{-bt} - e^{-ct}]u(t)$. Determine $x(t)$. 5

(c) Find state equations for the following system

$$\frac{d^2y(t)}{dt^2} + 2\frac{dy(t)}{dt} + 4y(t) = 2u(t)$$ 5

where, $y(t)$ and $u(t)$ are output and input, respectively.

(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) When the system shown in Figure Q2(a) is subjected to a unit-step input, the system output responds as shown in Figure Q2(b). 6

Determine the values of K and T from the response curve.

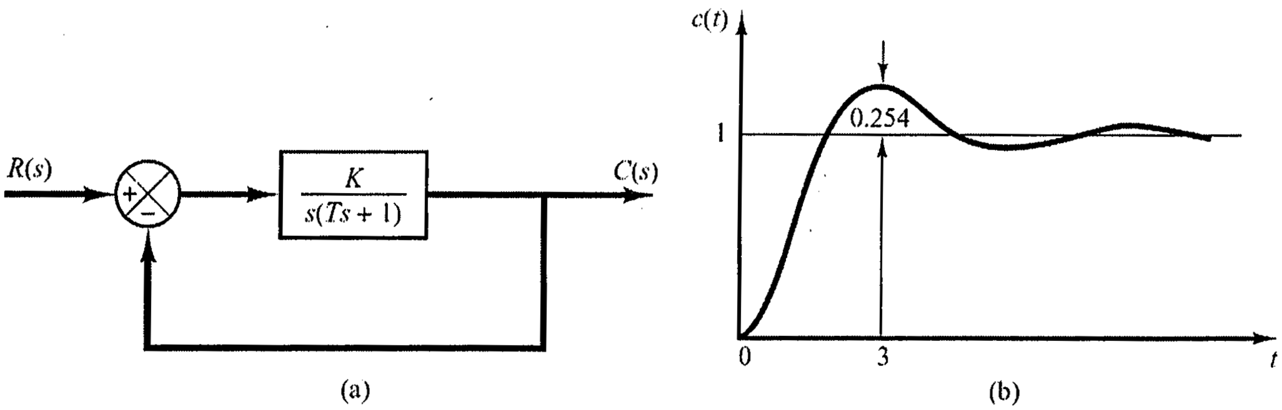

Figure Q2

(b) Define State and Output equations for an LTI system. 2+2

For n-th order SISO, LTI system indicate the dimensions of the matrices and vectors involved in State and Output equations. 4

(c) Consider an LTI system given by the differential equation:

$$2\frac{d^3y(t)}{dt^3} + 4\frac{d^2y(t)}{dt^2} + 6\frac{dy(t)}{dt} + 8y(t) = 10u(t)$$ 6

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

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Q3 (a) (i) Define damping ratio (ξ) and undamped natural frequency (ω_n) for a second order system? 2+2

(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

(b) Obtain the transfer function of the circuit, shown in Figure Q3(b), in terms of R_1, R_2, C, and L.

Determine the poles of the circuit for $R_1 = R_2 = 2000\ \Omega$, C = 100mF, L = 10mH. 8+4

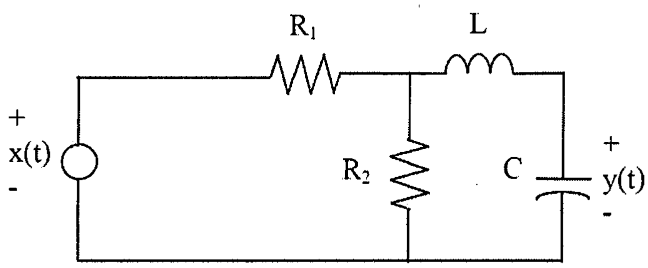

Figure Q3(b)

Q4 (a) (i) State and prove the Final Value Theorem for Laplace Transform. 4

(ii) Find the initial value of $\frac{df(t)}{dt}$ for $F(s) = \mathfrak{L}[f(t)] = \frac{2s+1}{s^2+s+1}$ 4

(b) Use one-sided Laplace Transform to find the output $y(t)$ of a system given by

$$\frac{dy(t)}{dt} + 4y(t) = 3x(t)$$ 6

with, $x(t) = sin(2t)$, and $y(0^+) = 1$

(c) Simplify the block diagram shown in Figure Q4(c) to find the transfer function. 6

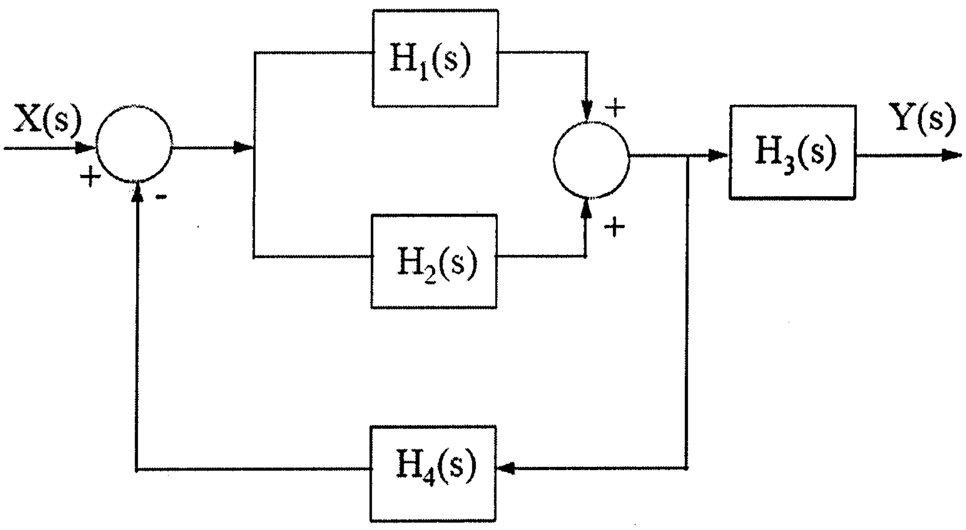

Figure Q4(c)

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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) (i) In the system shown in Figure Q5(b), the numerical values of m, b, and k are given as

m=1 kg, b=2 N-sec/m, and k =100 N/m.

The mass is displaced 0.05 m and released without initial velocity.

Find the frequency observed in the vibration. 4+4

(ii) Obtain the analogous electrical network based on *force-voltage* analogy.

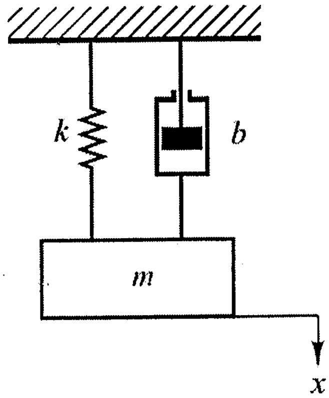

Figure Q5(b)