Ref. No.: Ex/EE/5/T/221/2023

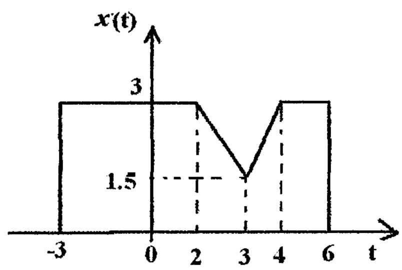
BACHELOR OF ENGINEERING (ELECTRICAL ENGINEERING)
SECOND YEAR SECOND SEMESTER EXAM 2023

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.**	
1 (a)	Express the signal $x(t)$ shown in Fig.[A] in terms of singularity functions. Also sketch the derivative of $x(t)$.  Fig. [A]	10
(b)	Evaluate the following integrals. $\int_{-\infty}^{+\infty} Sin(t)\delta\left(t-\frac{\pi}{3}\right)dt$ $\int_{-\infty}^{+\infty} \sqrt{t}\left[\delta(t-9)-\delta(t-4)\right]dt$	6
2. (a)	Consider the signal shown in Fig. [B]. Sketch the signals *f(t/4)*, *f(3t)* and *f(−3t+1)*. Give necessary explanations.	9

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Ref. No.: Ex/EE/5/T/221/2023

Question No.	PART I	Marks

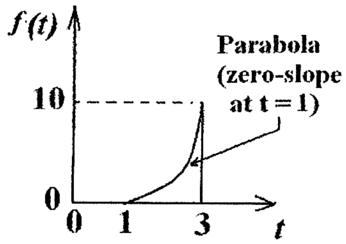

Fig. [B]

(b) **Consider the signal shown in Fig. [C].** **7**

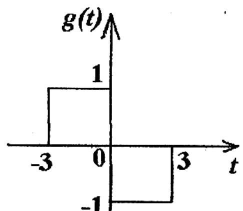

Fig.[C]

Check whether or not the magnitude spectrum function of *g(t)* is
$$|G(j\omega)| = \left|\frac{2}{\omega}\left[1 - Cos(3\omega)\right]\right|.$$

3. (a) **Starting from the expression of trigonometric Fourier series, obtain the expression for exponential Fourier series of a periodic signal. Point out how the complex Fourier coefficient can be determined.** **8**

(b) **Determine the exponential Fourier series coefficients for the signal *y*(t) shown in Fig. [D]. Sketch the two-sided amplitude spectrum up to 5th harmonic.** **8**

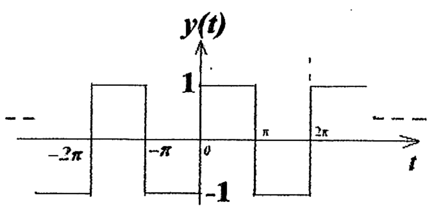

Fig. [D]

Ref. No.: Ex/EE/5/T/221/2023

<table>
<tr><th>Question No.</th><th>PART I</th><th>Marks</th></tr>
<tr><td>4. (a)</td><td>

Decompose the signal x(t) shown in Fig. [E], into odd and even components.

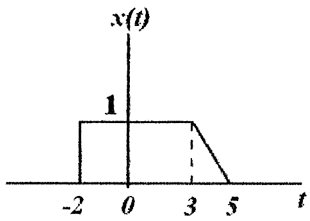

Fig. [E]

</td><td>8</td></tr>
<tr><td>(b)</td><td>

Convolve the signals shown in Fig. [F] graphically and sketch the result of convolution.

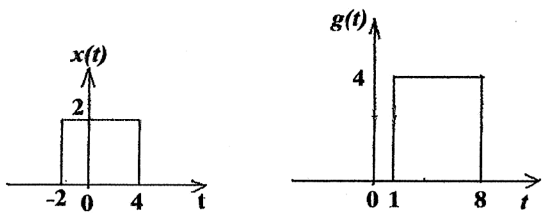

Fig. [F]

</td><td>8</td></tr>
<tr><td>5.</td><td>

Write short notes on any two of the following.

(a) 'Duty cycle' and 'Crest Factor' of periodic trains of rectangular pulses.

(b) Fourier transforms of DC signal, signum function and step signal.

(c) Energy and power signals

</td><td>8+8</td></tr>
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Ref. No.: Ex/EE/5/T/221/2023

B. E. (ELECTRICAL ENGINEERING) 2^{ND} YEAR 2^{ND} SEMESTER EXAMINATION, 2023

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

Part II (50 marks)

Question No.	Question 1 is compulsory Answer *Any Two* questions from the rest (2×20)	Marks
Q1	Answer ***any Two*** of the following:	
(a)	Determine if the system $\dot{y}(t) + 4ty(t) = 2x(t)$ is time-invariant, linear, causal, and/or memoryless?	5
(b)	Determine whether the system characterized by the differential equation $\ddot{y}(t) + 2\dot{y}(t) + 2y(t) = x(t)$ is stable or not? Assume zero initial conditions.	5
(c)	Find state equations for the following system $\ddot{y}(t) - 4y(t) = u(t)$.	5
(d)	Find an analog simulation for the equation $y = 3x$, given $\|x\|_{max} = 20$, and $\|y\|_{max} = 20$. Consider full amplifier range of 0 to 10 volts.	5
Q2 (a)	(i) Define damping ratio (ξ) and undamped natural frequency (ω_n) for a second order system? (ii) Show the location of the poles of a 2^{nd} order system for un-damped, under-damped, critically damped and over-damped conditions.	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)	(i) Define Transfer Function for an LTI system. (ii) Find $\frac{V_o(s)}{V_i(s)}$ for the R-L-C network shown in Figure Q2(c).	2+6

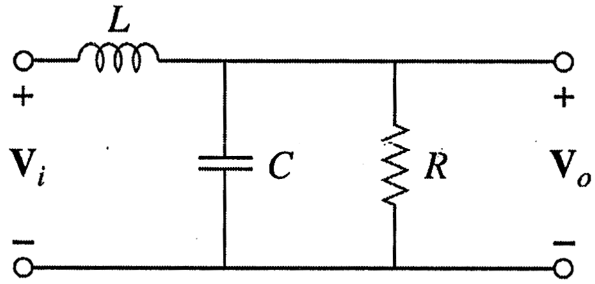

Figure Q2(c)

Ref. No.: Ex/EE/5/T/221/2023

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

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

(c) (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.

Q4 (a) (i) Define state and output equations for an LTI system. Draw the block diagram representation of the state and the output equations. (4+4)

(ii) Obtain a State Space Model for an R-L-C series circuit driven by a constant voltage source assuming the voltage across the Capacitor to be the output. +4

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

$$\ddot{y} + 9\dot{y} + 20y = x, \text{ with, } x(t) = 2u(t), y(0) = 1, \dot{y}(0) = -2$$

Q5 (a) (i) Write the differential equation governing the dynamic behaviour of the mechanical system, as shown in Figure Q5(a).

(ii) Derive the transfer function assuming displacement, x, to be the output. Assume all initial conditions to be zero.

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

(iv) Obtain the state-space model in phase variable canonical form for the mechanical system shown in Figure Q5(a).

(v) Draw the corresponding block diagram indicating the state variables.

4+4+4 +4+4

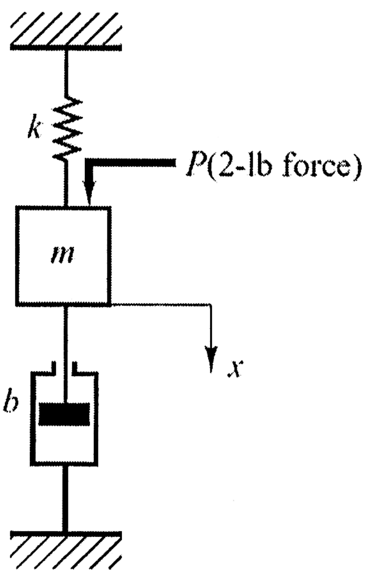

Figure Q5(a)