Ref. No.: Ex/EE/PC/B/T/224/2023 (O)

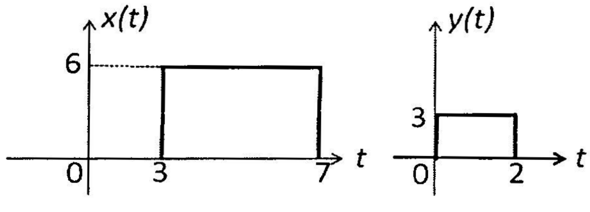
B. E. ELECTRICAL ENGINEERING 2ND YEAR 2ND SEMESTER EXAMINATION, 2023

SUBJECT: - SIGNALS AND SYSTEMS

Full Marks 100
(50 marks for each part)

Time: **Three hours**

Use a separate Answer-Script for each part

No. of Questions	PART I	Marks
	Answer any **Five**	
1.	Derive an expression of Complex Fourier series from the definition of Trigonometric Fourier series. Hence, define magnitude spectrum and phase spectrum. Show that these two spectra are even and odd, respectively, for all real signals available in time domain.	10
2.	Determine the Fourier Transform of a) $x(t) = (e^{-3t+} te^{-5t})u(t)$ b) $x(t) = 10[u(t+5) - u(t-5)]\cos 2\pi t$	5+5
3.	Define "Duty Cycle" and "Crest Factor" for a periodic train of rectangular pulses. Show that the crest factor of a periodic train of rectangular pulses attains a minimum for a certain value of duty cycle. Find out the duty cycle and corresponding crest factor.	10
4.	Perform graphically the convolution between signals *x(t)* and *y(t)* and sketch the resulting signal. 	10
5.	a) "When a signal is compressed in time, its energy is reduced by the same factor." – State whether the statement is correct or not. Give reasons in favour of your argument.	5
	b) Show that the energy of a signal $x(t)$ is the sum of the energies of its even and odd components.	5

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6.	Write short notes on any **one**: a) Properties of Fourier Transform. b) Properties of convolution.	1x10=10
7.	a) Determine whether the following signal is a power or an energy signal and find the value of the same. $f(t) = r(t+3) - r(t-3)$, where $r(t)$ represents a unit ramp function.	5
	b) State Parseval's formula for periodic signal.	5

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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 whether the system characterized by the differential equation $\ddot{y}(t) - \dot{y}(t) + 2y(t) = x(t)$ is stable or not? Assume zero initial conditions. 5

(b) Derive state equations for the following system $\ddot{y}(t) + 2\dot{y}(t) + 4y(t) = 2u(t)$. 5

(c) The unit impulse response of an LTI system is the unit step function $u(t)$. Find the response of the system to an excitation $e^{-at}u(t)$. 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) For a standard 2nd order system define the following: (i) undamped natural frequency and (ii) damping ratio. 2+2

(b) Find the expressions for time-response for an (i) undamped, and (ii) critically damped 2nd order system for a unit step input. Indicate the pole locations. 4+4

(c) Find the transfer function, $Y(s)/X(s)$, for the circuit shown in Figure Q2(c). Find the values of ξ and ω_n for $C_1=C_2=100\mu F$, $R_1=R_2=2000\Omega$. 8

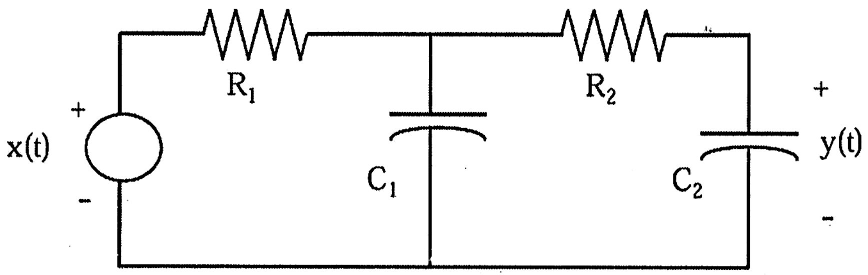

Figure Q2(c)

Q3 (a) State and prove (i) Initial Value Theorem and (ii) Final Value Theorem. 4+4

(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) Solve the following differential equations using the Laplace Transform method $\ddot{y} + 4\dot{y} + 20y = 2\dot{x} - x,\ \ x(t) = u(t),\ x(0) = 0, y(0) = 0, \dot{y}(0) = 1.$ 8

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Q4 (a) 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

(b) Consider an LTI system given by the transfer function:

$$G(s) = \frac{s^2 + 7s + 2}{s^3 + 9s^2 + 26s + 24}$$ 8+4

Obtain the state-space model of the system in the phase variable canonical form. Draw the corresponding block diagram indicating the individual states.

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

$$\ddot{x} + 4\dot{x} + 16x = 0, \quad x(0) = 10, \quad \dot{x}(0) = 0,$$

with, $|x|_{max} = 40, \; |\dot{x}|_{max} = 100.$ 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) Derive the differential equation governing the dynamic behaviour of the mechanical system, as shown in Figure Q5(b).

Obtain the analogous electrical network based on *force-voltage* analogy. 4+4

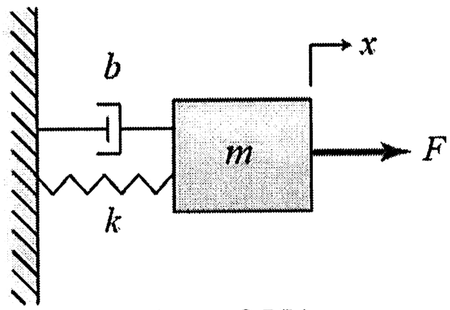

Figure Q5(b)