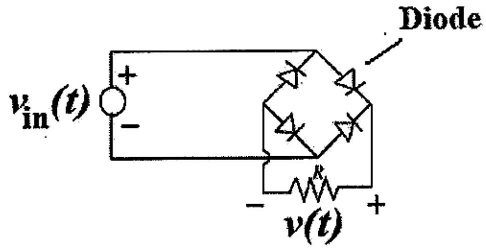
B.E. ELECTRICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAMINATION, 2023

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 and well-organized answers.*** **Give proper units wherever necessary.**	
1. (a)	**Consider the circuit shown in Fig. [A].** **$v_{in}(t)$ over one complete cycle can be expressed as $v_{in}(t) = r(t) - r(t-2) - 3u(t-2) + u(t-4)$. Sketch the signal $v(t)$, and express $v(t)$ as an exponential Fourier series.** **Depict the one-sided power spectrum of $v(t)$, up to the 5th harmonic.**  **Fig. [A]**	3+9
(b)	**A periodic signal $f(t)$ has an RMS value of 2V. Determine the RMS value of the signal $f(3t-1)$. Give relevant derivation.**	4
2. (a)	**If $X(j\omega) = \dfrac{(j\omega+2)^2\, j\omega}{(j\omega+3)(j\omega+1)}$, obtain the expression for the inverse Fourier transform of $X(j\omega)$.**	5
(b)	**Consider the signal $x(t) = \left(1 - e^{-\lvert t\rvert}\right)\left[u(t+1) - u(t-1)\right]$. Without actually obtaining the Fourier transform $X(j\omega)$ of $x(t)$, answer the following:**	

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Question No.	PART I	Marks

(i) Whether or not $X(j\omega)$ is real.

(ii) Whether or not $X(j\omega)$ is even. — **4**

Give appropriate justification for your answers.

(c) Consider the signal

$$x(t) = Sin(\omega_o t) \text{ for } -\frac{2\pi}{\omega_o} \le t \le \frac{2\pi}{\omega_o}$$

and $x(t) = 0$ otherwise. — **7**

Verify whether or not the amplitude spectrum function of $x(t)$ is

$$|X(j\omega)| = \frac{2\omega_o \, Sin\left(\frac{2\pi\omega}{\omega_o}\right)}{\omega_o^2 - \omega^2}$$

3. (a) Depict the signal $\phi(t) = 2y(-4t+1.5)$, where $y(t)$ is the signal shown in Fig. [B]. Show clearly all the steps involved in obtaining φ(t), with the help of well-labeled sketches. — **7**

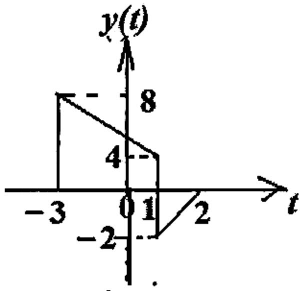

Fig. [B]

(b) A series L-R circuit (with a time constant of 1s) is excited by a voltage signal *f(t)* depicted in Fig. C. The voltage *v(t)* across R is considered as the output. — **9**

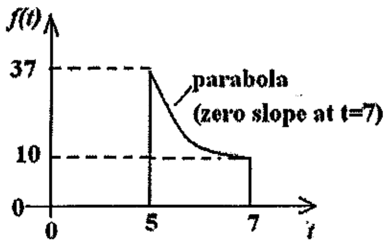

Fig.[C]

Determine the expression for *v(t)*.

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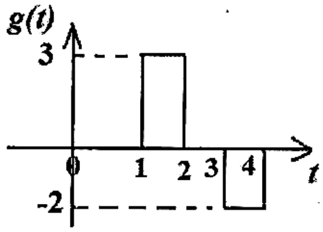
Question No.	PART I	Marks
4. (a)	**Evaluate the following integral.** $$I = \int_{-\infty}^{+\infty} \left[\frac{Sin(2\pi t)}{\pi t} \delta(t) + (3t^2 + 2t + 1) u_1 (t-1) \right] dt$$ **Where $u_n(t)$ is the n^{th} derivative of unit impulse.** **Prove the relevant properties of singularity functions utilized.**	6
(b)	**A linear time-invariant system has an impulse response g(t) as shown in Fig.[D]. It is excited by a signal $x(t) = e^{-t}[u(t) - u(t-1)]$. Perform time-domain operations to obtain expressions for the system output.**  **Fig. [D]**	10
5.	**Write short notes on <u>any two</u> of the following.**	
(a)	**Duty cycle and AC coupled crest factor of periodic trains of rectangular pulses.**	8+8
(b)	**Properties of convolution..**	
(c)	**Power signals and Energy signals.**	
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B. ELECTRICAL ENGINEERING 2ND YEAR 1ST 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 given by

$$y(t) = \cos(100\pi t)\, x(t)$$ 5

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

(b) Determine the unit impulse response of an LTI system described by

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

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

Assume zero initial condition.

(c) Find state equations for the following system

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

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

(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) Find the *forced* and the *natural* response of the system described by

$$\frac{d^2y(t)}{dt^2} + 5\frac{dy(t)}{dt} + 6y(t) = \frac{dx(t)}{dt} + 6x(t)$$ 8

where, the input, $x(t)$, is a unit step function (with $x(0^+) = 1$) and the initial conditions are given as $y(0^+) = 1$ and $\dot{y}(0^+) = 2$.

(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.

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Q3 (a) For a standard 2nd order system obtain the expressions for unit step response for (i) un-damped condition and (ii) critically damped condition. Also indicate the respective pole locations for each case. 4+4

(b) A mechanical system, as shown in Figure Q3(a), is subjected to 2 lb of force (step-input) at time t=0. The resulting response (displacement x in ft) exhibits a peak overshoot of 9.5% at time t =2 sec and finally settles down to a value of 0.1 ft as shown in Figure Q3(b). 12

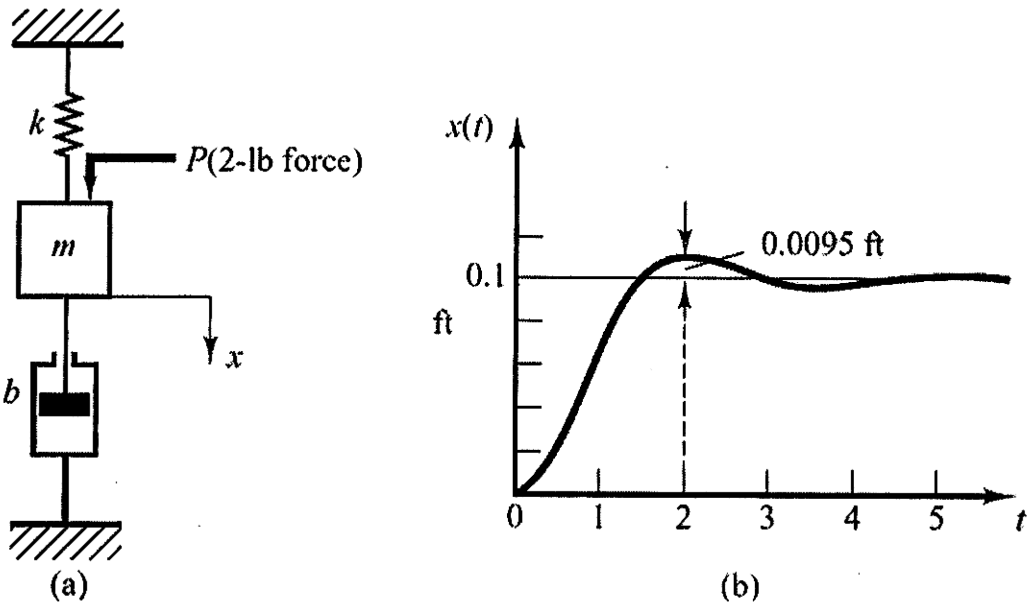

Figure Q3

Determine m, b, and k of the system.

The displacement x is measured from the point where spring and mass are at static equilibrium.

Q4 (a) Use one-sided Laplace Transform to find the output $y(t)$ of a system given by 8

$$\frac{d^2y(t)}{dt^2} + 9\frac{dy(t)}{dt} + 20y(t) = x(t)$$

with, $x(t) = 2u(t)$, ($u(t)$ being the unit step function (with $u(0^+) = 1$)), and $y(0^+) = 1, \dot{y}(0^+) = -2$

(b) Stating the simplifying assumptions obtain the transfer function of an armature controlled d. c. motor driving a load with viscous friction. Develop the block diagram for the system. 8+4

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

(ii) obtain magnitude-scaled analog simulation of the system to utilize the full amplifier range of 0 to 10 volts without any overloading. 4+8

$$\ddot{x} + 2\dot{x} + 25x = 0, \quad x(0) = 20, \quad \dot{x}(0) = 0,$$

$$\text{with, } |x|_{max} = 20, \ |\dot{x}|_{max} = 100.$$

(b) Obtain the transfer function, $E_o(s)/E_i(s)$, for the bridged-T-network shown in Figure Q5. 8

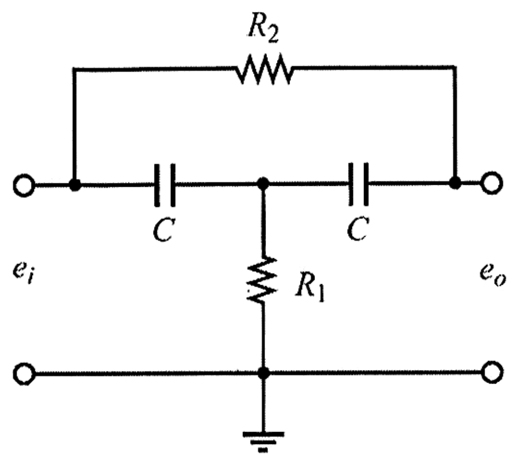

Figure Q5