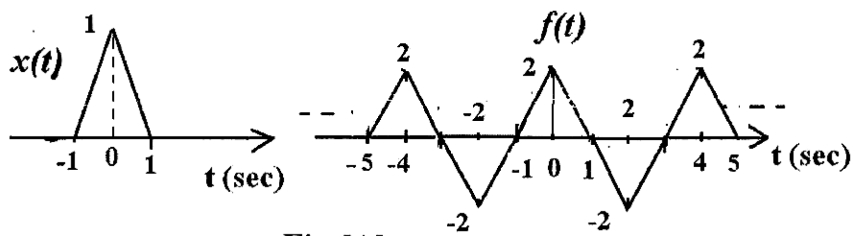
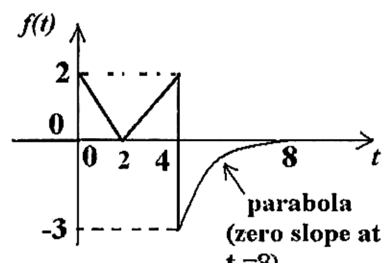
B.E. ELECTRICAL ENGINEERING SECOND YEAR SECOND SEMESTER EXAMINATION, 2019

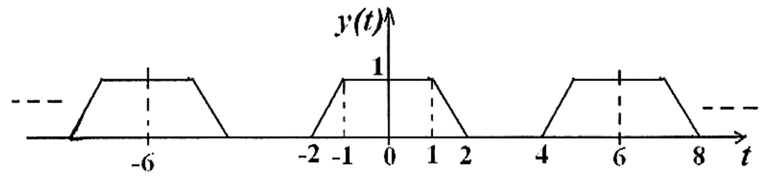
SIGNALS AND SYSTEMS

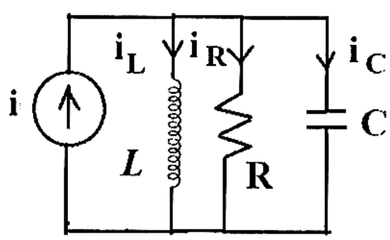
Full Marks 100

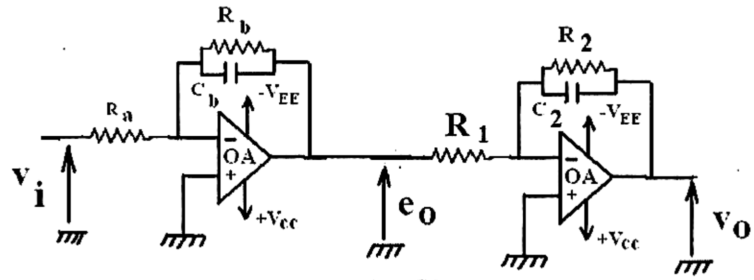
Time: Three hours (50 marks for each part)

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)	Check whether or not the signal $\gamma(t) = \frac{a}{2}e^{-a\|t\|}$ can be a candidate for approximating a unit impulse function. If yes, under what condition can it approximate the unit impulse?	4
(b)	Consider the *x(t)* shown in Fig. [A]. The convolution of *x(t)* with a certain signal *g(t)* yields the periodic signal *f(t)* shown in the same figure. Derive the expression for *g(t)*, and also sketch the signal *g(t)*. Give clear explanations.  Fig. [A]	4
(c)	Give a well-labeled sketch of the derivative of the signal *f(t)* shown in the Fig. [B]. Also express *f(t)* as a sum of singularity functions.  Fig. [B]	8

Question No.	PART I	Marks
	OR	
1. (c)	**The unit step response of a linear time-invariant (LTI) system is** $s(t) = -\frac{1}{3}e^{-3t}u(t) + \frac{1}{2}e^{-2t}u(t) - \frac{1}{6}u(t)$. **Determine the expression for the response of the system when excited by a parabola** $p_1(t) = \frac{5}{2}t^2u(t)$. ***Do not use any transform method.***	8
2. (a)	**Examine whether the signal** $\Psi(t) = Ae^{-3\lvert t\rvert}$ **is an energy signal or power signal or none. Is it possible to determine the percentage of the total energy or average power of the signal contained in the frequency range** $\lvert f\rvert < 3/\pi$**? If possible, obtain this value.**	6
(b)	**Determine the exponential Fourier series representation of the signal *y(t)* shown in Fig. [C]. Determine and sketch the two-sided amplitude spectrum function obtained by Fourier transform, and also the one-sided power density spectrum.**  **Fig. [C]**	10
3. (a)	**Show that** $\Phi(t) = \text{Sinc}^3(t/3)$ **is a bandlimited signal. If *t* is in seconds, obtain the bandwidth of the signal.**	3
(b)	**The input to an electrical network is a voltage pulse** $v(t) = 3[u(t) - u(t-3)]$ **V. The impulse response of the network is** $h(t) = 3r(t) - 3r(t-2) - 6u(t-2)$ **A/V. The unit of time is sec. The output is a current signal *i(t)* flowing through a resistor. Without explicitly determining the expression for *i(t)*, calculate the *electric charge*(in coulomb) flowing through the resistor. Give necessary explanations.**	3
(c)	**Derive the expression for the Fourier transform of a causal exponentially decaying signal. Use this expression to determine the Fourier transform of the unit step.**	6
(d)	**Justify or negate the following statement, with the help of relevant mathematical derivations.**	

Question No.	PART I	Marks
	“ The Fourier transform of the signal $y(t) = \text{Sin}(\omega_o t)u(t)$ is $Y(j\omega) = j\pi\left[\delta(\omega - \omega_o) + \delta(\omega + \omega_o)\right]$”. **If the statement is incorrect, obtain the correct expression for the** $Y(j\omega)$.	**4**
4. (a)	**For the electrical network shown in Fig. [D] with the input current *i(t)*, consider the current i_L(t) through the inductor as the output. Derive an expression for the frequency response function of the network. Give sketches of the amplitude response curves. If the input *i(t)* is sinusoidal, ascertain whether or not under any circumstances, under steady-state condition, the RMS value of $i_L(t)$ can exceed that of *i*(t). *If yes, under what condition and for what range of frequencies (of the input current), can that happen?* Give relevant explanations.**  **Fig. [D]** **OR**	**10**
4. (a)	**In the circuit shown in Fig. [E], determine the expression for the frequency response, considering v_i as the input and v_o as the output. Sketch a well labeled family of curves representing the amplitude responses of the circuit. Under what condition satisfied by the circuit components, will the dc gain of the system be unity? Under what condition, will the steady-state gain magnitude of the circuit be greater than the dc gain over a band of frequencies? Derive an expression for this band of frequencies, in terms of the circuit parameters. Give relevant explanations.**	**10**
(b)	**How is the energy spectral density (ESD) and the autocorrelation function (ACF) of the output of an LTI system related to ESD and the ACF respectively, of the input? Give derivations.**	**6**

Question No.	PART I	Marks
	 Fig. [E]	
5.	**Write short notes on <u>any two</u> of the following.**	
(a)	**Parseval's formula for periodic signals and energy signals.**	8+8
(b)	**"Duty Cycle" and "Crest Factor" of periodic trains of rectangular pulses.**	
(c)	**Power spectral density.**	
(d)	**Transition from 'Fourier Series' to 'Fourier Integral and Transform'.**	
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Ref. No.: EX/EE/T/224/2019

B. ELECTRICAL ENGINEERING 2ND YEAR 2ND SEMESTER EXAMINATION, 2019

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)	Find the value of $x(t)$ as $t \to \infty$ (if it exists) for $$X(s) = \mathfrak{L}[x(t)] = \frac{10(s+1)}{s^2+4s+8}$$	5
	(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 $e^{-at}u(t)$.	5
	(c)	Find state equations for the following system $\ddot{y}(t) - 4y(t) = u(t)$.	5
	(d)	Obtain the analog simulation for the equation $y = 3x$, given $\lvert x\rvert_{max} = 20$, and $\lvert y\rvert_{max} = 20$. Consider full amplifier range of 0 to 10 volts.	5
Q2	(a)	For a standard 2nd order system find the expressions for time-response (indicate respective pole locations) for (i) un-damped and (ii) critically damped condition.	4+4
	(b)	A mechanical system, as shown in Figure Q-2(b), 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 displacement of 0.1 ft. Determine m, b, and k of the system. The displacement x is measured from the point where spring and mass are at static equilibrium.	12

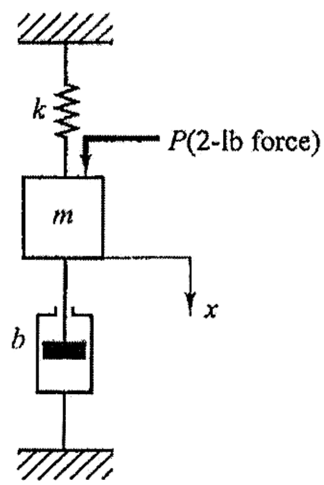

Figure Q-2(b)

Q3	(a)	Draw an asymptotic Bode magnitude plot for the following system: $$G(s) = \frac{(s+3)}{(s+2)(s^2+2s+25)}$$	8

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(b) Given the electrical network of Figure Q-3(b), find a state-space representation considering the current through the resistor as the output. 12

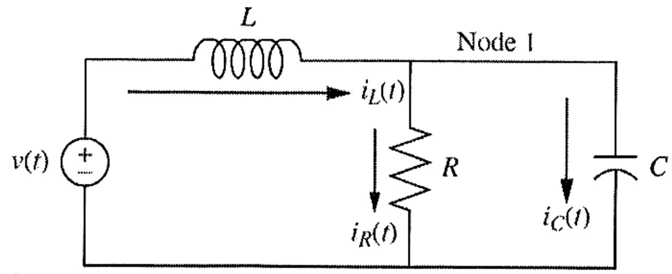

Figure Q-3(b)

Q4 (a) Solve the following differential equations using the Laplace Transform method 8

$$\ddot{y} + 4\dot{y} + 20y = 2\dot{x} - x, \quad x(t) = u(t), \qquad x(0) = 0, y(0) = 0, \dot{y}(0) = 1.$$

(b) Consider the mechanical system shown in Figure Q-4(b). Assume that the system is linear.

The external force $u(t)$ is the input to the system, and the displacement $y(t)$ of the mass is the output.

The displacement $y(t)$ is measured from the equilibrium position in the absence of the external force. 6+6

(i) Obtain a state-space representation of the system.

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

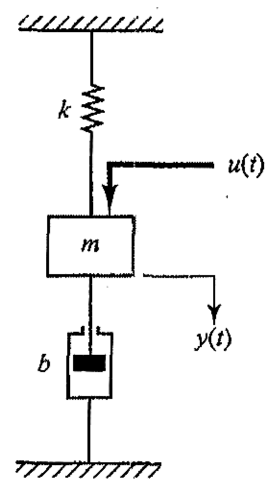

Figure Q-4(b)

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

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

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

(b) Obtain the transfer function, $E_o(s)/E_i(s)$, for the Op-amp circuit shown in Figure Q-5(b). 8

Consider the Op-amp to be an ideal one.

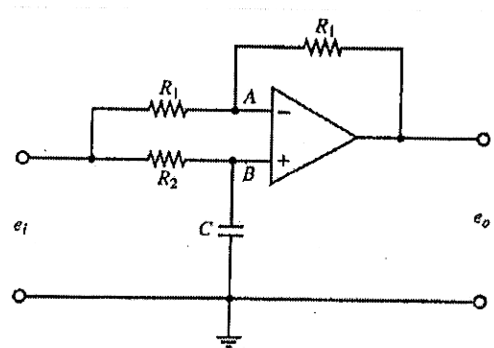

Figure Q-5(b)