SIGNALS & SYSTEMS
(ELEC 2202)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The value of the integral $\int_{-\infty}^{\infty} \delta(-2t)\, dt$ is
(a) $\frac{1}{4}$ (b) $\frac{1}{6}$ (c) $\frac{1}{2}$ (d) $\frac{-1}{2}$.

(ii) If a signal f(t) has energy E, the energy of the signal $f(2t)$ is equal to
(a) 2E (b) E/4 (c) E/2 (d) E .

(iii) Integration of a ramp signal is
(a) step signal (b) impulse signal (c) parabolic signal (d) gate signal.

(iv) If a periodic signal has an odd symmetry, the Fourier series contains
(a) only sine terms (b) only cosine terms
(c) constant and cosine terms (d) both sine and cosine terms.

(v) The z-transform of unit step function is
(a) 1 (b) $\frac{1}{z-1}$ (c) $\frac{z}{z-1}$ (d) $\frac{z}{z^2-1}$.

(vi) In force-current analogy, mass is analogous to
(a) resistance (b) inductance (c) capacitance (d) conductance.

(vii) The unit step response of the system $G(s) = \frac{1}{0.25s+1}$ reaches 98% of its final value after
(a) 0.25 sec (b) 0.5 sec (c) 2 sec (d) 1sec.

(viii) The time response of a second order system is underdamped if the damping factor is
(a) 1 (b) 0 (c) less than 0.707 (d) less than 1.

(ix) For a 3-input, 3 state and two output system, the dimension of C matrix is
(a) 2 × 3 (b) 3 × 2 (c) 3 × 3 (d) 2 × 1.

(x) A second order system has $A = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$, the system is
(a) underdamped (b) overdamped (c) critically damped (d) undamped.

Group - B

2. (a) Examine whether signal $x(t) = e^{-4t}$ is an energy or a power signal.
[(CO1)(Analyse/IOCQ)]

(b) Sketch the signal $x(t) = r(t) - 2r(t-3) + r(t-6)$.
[(CO1)(Understand/LOCQ)]

(c) Sketch the even and odd component of a unit step signal.
[(CO1)(Understand/LOCQ)]

(d) Determine the output of a system whose impulse response is $h(t) = u(t+3)$, for an input $x(t) = e^{-2t}u(t)$, using graphical convolution method.
[(CO2)(Evaluate/HOCQ)]

3 + 2 + 2 + 5 = 12

3. (a) Determine the Trigonometric Fourier series for the signal $x(t)$ shown in Fig.1. Hence find out the exponential Fourier series coefficients.

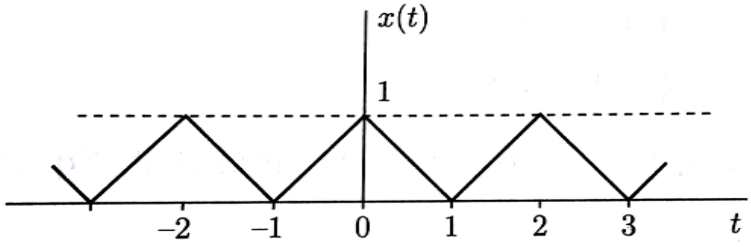

Fig.1

[(CO1)(Analyze/IOCQ)]

(b) Find the Fourier transform of the signal $x(t) = sgn(t)$.
[(CO1)(Analyze/IOCQ)]

6 + 6 = 12

Group – C

4. (a) Explain the aliasing phenomenon? How can we prevent aliasing?
[(CO3)(Remember/LOCQ)]

(b) Find the z-transforms and their ROCs for the following signals.
[(CO3)(Analyze/IOCQ)]

(i) $x(n) = (-0.8)^n u(-n-1)$
(ii) $g(n) = nu(n)$
(iii) $x(n) = \{2, 4, \underset{\uparrow}{6}, 8, 10\}$.

3 + (3 + 3 + 3) = 12

5. (a) Find the inverse z-transforms using partial fraction method of the following functions.

(i) $X(z) = \frac{2-4z^{-1}}{1+2z^{-1}-3z^{-2}}$, ROC $|z| > 3$

(ii) $X(z) = \frac{1}{1-4.5z^{-1}+3.5z^{-2}}$, ROC $|z| < 1$. [(CO3)(Analyze/IOCQ)]

(b) Determine the impulse response of the system whose input $(x(n))$ and output $(y(n))$ relationship is given by the difference equation

$$y(n) = 4y(n-1) - 4y(n-2) + x(n).$$

[(CO3) (Evaluate /HOCQ)]

(4 + 4) + 4 = 12

Group – D

6. (a) State the difference between causal and non-causal systems.

[(CO4)(Understand/LOCQ)]

(b) Develop the electrical analogous circuit of the mechanical system shown in Fig. 2 using force-voltage and force-current analogy. The symbols have their usual meaning.

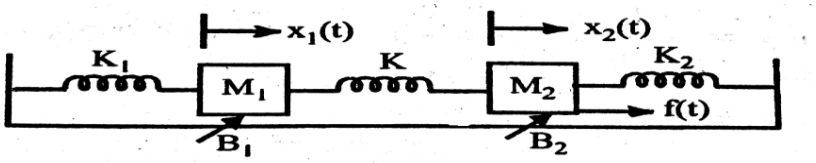

Fig. 2 [(CO4)(Evaluate/HOCQ)]

2 + (5 + 5) = 12

7. (a) What do you mean by poles and zeros of a system? [(CO5)(Understand/LOCQ)]

(b) A system is described by the following differential equation, where $y(t)$ is the output and $x(t)$ is the input to the system.

$$\frac{d^2y}{dt^2} + 9\frac{dy}{dt} + 25\,y(t) = 25\,x(t)$$

Find out the

(i) transfer function of the system
(ii) natural frequency of oscillation and damping ratio of the system
(iii) unit step response of the system
(iv) peak time, over shoot and settling time of the system
(v) sketch the unit step response of the system. [(CO5)(Analyze/IOCQ)]

2 + 10 = 12

Group – E

8. (a) Obtain the state variable model of a series R-L-C circuit. Select voltage across resistor (V_R), voltage across inductor (V_L), voltage across capacitor (V_C) as output variables and current (I), and voltage across capacitor (V_C) as state variables.

[(CO6)(Analyze/IOCQ)]

(b) Develop the state variable model of the system whose transfer function is given by

$$G(s) = \frac{4s^3+5s^2+6s+7}{s^5+8s^4+9s^3+10s^2+11s+12}.$$ [(CO6)(Analyze/IOCQ)]

6 + 6 =12

9. The state variable model of a system is given by,

$$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -4 & 0 \\ 0 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u \text{ and } y = [1 \quad 0] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Evaluate the

(i) transfer function of the system.
(ii) state transition matrix
(iii) zero input response if $x_1(0) = 1$ and $x_2(0) = 0$
(iv) state response due to unit impulse input
(v) time response $y(t)$. [(CO6)(Evaluate/HOCQ)]

(3 + 3 + 2 + 3 + 1) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	11.46	56.25	32.29

Course Outcome (CO):

After the completion of the course students will be able to

CO1: Understand the concept of signals and analyze the spectral content in periodic and aperiodic signals.
CO2: Understand the impulse response of a system, convolution of two signals and its application to dynamic systems.
CO3: Understand the concept of sampling of a signal; obtain the output of a system using z – transform.
CO4: Describe the mathematical model of physical systems and understand the concept of BIBO stability.
CO5: Possess a basic understanding of the concept of frequency response and time response of dynamic systems and analyze their implications.
CO6: Describe the mathematical model of dynamical systems in state-space form and its time domain solution using the concept of "state transition matrix".

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.