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 $\int_{-\infty}^{\infty} \delta(at)\, dt$ is
(a) $\frac{1}{a^2}$ (b) $\frac{1}{|a|}$ (c) $\frac{1}{a}$ (d) $\frac{-1}{a}$

(ii) If a signal f(t) has energy E, the energy of the signal $f(0.5t)$ is equal to
(a) 2E (b) E/4 (c) E/2 (d) E.

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

(iv) If a periodic signal has an even 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) Fourier transform of a gate signal is a
(a) sine wave (b) sinc function
(c) unit step signal (d) ramp signal.

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

(vii) The unit step response of the system $G(s) = \frac{1}{0.2s+1}$ reaches 63.2% of its final value after
(a) 20 sec (b) 0.2 sec (c) 2 sec (d) 1 sec.

(viii) The magnitude response of a second order system has a resonant peak if the damping ratio is
(a) 1 (b) 0.707
(c) less than 0.707 (d) less than 1.

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

(x) A second order system has $A = \begin{bmatrix} -2 & 0 \\ 0 & -2 \end{bmatrix}$, the system is
(a) underdamped (b) overdamped
(c) critically damped (d) undamped.

Group - B

2. (a) Examine whether signal $x(t) = r(t)$ is an energy or a power signal or none. [(CO1)(Analyse/IOCQ)]

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

(c) Sketch the even and odd component of a signal $x(t) = Ae^{-at}u(t)$. [(CO1)(Understand/LOCQ)]

(d) Determine the output of a system whose impulse response $h(t) = u(t-3)$ for an input $x(t) = u(t-1)$using graphical convolution method. [(CO2)(Evaluate/HOCQ)]

3 + 2 + 2 + 5 = 12

3. (a) Find the exponential Fourier series for the signal $x(t)$ shown in Fig.1. [(CO1)(Analyze/IOCQ)]

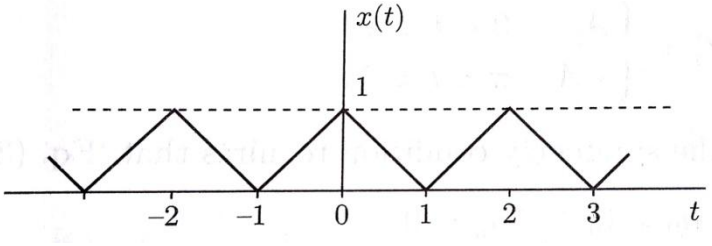

Fig. 1

(b) Find the Fourier transform of the signal $x(t)$ shown in Fig.2. Also sketch the amplitude and phase spectra of the signal. [(CO1)(Analyze/IOCQ)]

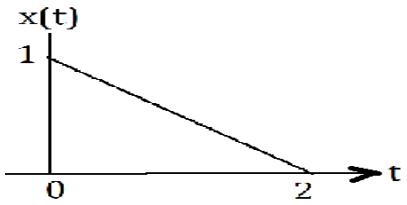

Fig.2

6 + 6 = 12

Group - C

4. (a) What do you mean by aliasing phenomenon? How we can prevent aliasing? [(CO3)(Remember/LOCQ)]

(b) Find the z-transforms and ROCs of the following signals.
(i) $x(n) = [(\frac{2}{3})^n]u(n) + [(\frac{1}{2})^n]u(-n-1)$
(ii) $g(n) = A\sin(w_0 n)\,u(n)$

(iii) $x(n) = n(\frac{1}{4})^n\, u(n)$. [(CO3)(Analyze/IOCQ)]

3 + (3 × 3) = 12

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

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

(ii) $X(z) = \frac{1+3z^{-1}}{1+3z^{-1}+2z^{-2}}$, ROC $|z| > 2$. [(CO3)(Analyze/IOCQ)]

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

$y(n) + \frac{1}{3}y(n-1) = x(n)$. [(CO3)(Evaluate/HOCQ)]

(4 + 4) + 4 =12

Group – D

6. (a) Define Linear Time invariant system? [(CO4)(Understand/LOCQ)]

(b) Develop the electrical analogous circuit of the mechanical system shown in Fig.3 using force-voltage and force-current analogy. [(CO4)(Evaluate/HOCQ)]

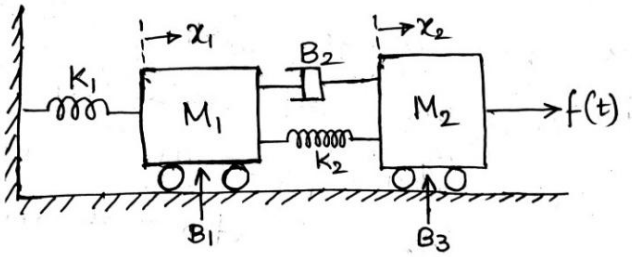

Fig.3

2 + (5 + 5) = 12

7. (a) What do you mean by the transfer function of a system? [(CO5)(Understand/LOCQ)]

(b) A system is described by a differential equation,

$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + 16\, y(t) = 16\, x(t)$$

Where $y(t)$ is the output and $x(t)$is the input to the system.

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 space representation of an armature controlled DC servo motor. [(CO6)(Analyze/IOCQ)]

(b) Develop the state variable model of the system whose transfer function is given by $G(s) = \frac{s^2+3s+4}{s^5+3s^4+7s^3+9s^2+11s+13}$. [(CO6)(Analyze/IOCQ)]

6 + 6 = 12

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

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

Evaluate the

(i) transfer function of the system.
(ii) state transition matrix.
(iii) zero input response if $x_1(0) = 0$ and $x_2(0) = 1$.
(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	9.38	58.33	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