SIGNALS & SYSTEMS
(ELEC 2202)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Integration of an impulse signal is
(a) ramp signal (b) step signal
(c) parabolic signal (d) gate signal

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

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

(iv) The odd component of the signal $x(t) = u(t) - u(t-1)$ with $u(t) = unit\ step\ function$ is
(a) $x_o(t) = \begin{cases} 1 \text{ for } -1 \le t \le 2 \\ 0 \text{ ; elsewhere} \end{cases}$ (b) $x_o(t) = \begin{cases} 0.5 \text{ for } -1 \le t \le 1 \\ 0 \text{ ; elsewhere} \end{cases}$
(c) $x_o(t) = \begin{cases} 0.5 \text{ for } 0 \le t \le 1 \\ -0.5 \text{ ; elsewhere} \end{cases}$ (d) $x_o(t) = \begin{cases} 0.5 \text{ for } 0 \le t \le 1 \\ -0.5 \text{ ; } -1 \le t \le 0 \end{cases}$

(v) The inverse$z-transform$ for the discrete signal $X(z) = z/(z-\frac{1}{2})$ for R.O.C :$|z| < \frac{1}{2}$ is
(a) $x(n) = (\frac{1}{2})^n u(n)$ (b) $x(n) = (2)^n u(n)$
(c) $x(n) = (\frac{1}{2})^n u(-n-1)$ (d) $x(n) = (2)^n u(-n-1)$

(vi) The time response of a second order system gives critically damped characteristics if damping factor is
(a) 1 (b) 0.707 (c) less than 0.707 (d) less than 1

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

(viii) The transfer function of a 2nd order system is $G(s) = \frac{100}{s^2+12s+100}$. Its damping factor is

(a) 0.8 (b) 1 (c) 2 (d) 0.6

(ix) The state variable analysis can used to analyse

(a) linear time-invariant system (b) time-variant system

(c) nonlinear system (d) all of the above

(x) A system is describe by the differential equation $\ddot{x} + 5\dot{x} + 6x = f(t)$. The 'A' matrix of the system is given by

(a) $A = \begin{bmatrix} 0 & -1 \\ -6 & -5 \end{bmatrix}$ (b) $A = \begin{bmatrix} 0 & -1 \\ 6 & -5 \end{bmatrix}$

(c) $A = \begin{bmatrix} 0 & 1 \\ -5 & -6 \end{bmatrix}$ (d) $A = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix}$

Fill in the blanks with the correct word

(xi) All periodic signals are an example of _____ signal.

(xii) For the system the settling time is _____.

(xiii) The z-transform of unit ramp sequence is _____.

(xiv) In state variable analysis response due in initial condition is also known as _____.

(xv) A system is said to be linear if it follows _____.

Group - B

2. (a) Examine whether unit step signal is an energy or power signal. *[(CO1)(Analyse/IOCQ)]*

(b) Sketch the signal $f(t) = r(t+2) - r(t+1) - r(t-1) + r(t-2)$. *[(CO1)(Understand/LOCQ)]*

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

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

3 + 2 + 2 + 5 = 12

3. (a) Determine the exponential Fourier series for the signal $x(t)$ shown in Fig. 1.

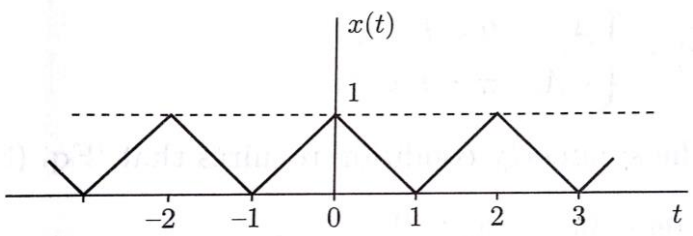

Fig. 1

[(CO1)(Analyze/IOCQ)]

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

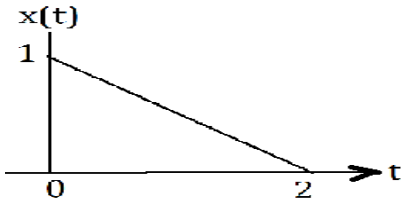

Fig. 2

6 + 6 = 12

Group - C

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

   (b) Find the z-transform and their ROC for the following signals.
   (i) $x(n) = [(\frac{2}{5})^n + (\frac{1}{3})^n]u(n)$ (ii) $g(n) = n(r)^n u(n)$ *[(CO3)(Analyze/IOCQ)]*

(2 + 2) + (4 + 4) = 12

5. (a) Find the inverse z-transform of the following functions using partial fraction method.
   (i) $X(z) = \frac{1}{1-0.8z^{-1}+0.15z^{-2}}$, ROC $|z| > 0.5$
   (ii) $X(z) = \frac{z}{z^2+6z+8}$, ROC $|z| > 2$ *[(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 $y(n) = 6y(n-1) - 9y(n-2) + x(n)$. *[(CO3)(Evaluate/HOCQ)]*

(4 + 4) + 4 = 12

Group - D

6. (a) State the difference between time variant and time invariant system. *[(CO4)(Understand/LOCQ)]*

   (b) Develop the force equilibrium equations for the mechanical system shown in Fig. 3. Hence, draw the force-voltage and force-current analogous circuit.

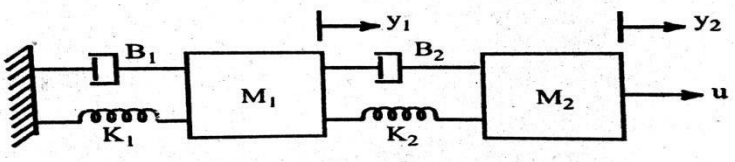

Fig. 3

[(CO4) (Evaluate /HOCQ)]

2 + (2 + 4 + 4) = 12

7. (a) Define 'Rise time' and 'Peak time' of a system. *[(CO5)(Understand/LOCQ)]*

   (b) A system is described by a differential equation $\frac{d^2c}{dt^2} + 10\frac{dc}{dt} + 49\,c(t) = 49\,r(t)$, where c$(t)$ is the output and $r(t)$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 and sketch the output
   (iv) peak time and percentage over shoot of the system.

(v) rise time and settling time of the system. *[(CO5)(Analyze/IOCQ)]*

2 + 10 = 12

Group - E

8. (a) Obtain the state variable model of an armature controlled D.C servo motor. *[(CO6) (Analyze/IOCQ)]*

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

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

6 + 6 = 12

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

$\begin{bmatrix}\dot{x_1}\\ \dot{x_2}\end{bmatrix} = \begin{bmatrix}-1 & 0\\ 0 & -2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}2\\ 1\end{bmatrix}u$ 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) response due to unit impulse input. *[(CO6)(Evaluate/HOCQ)]*

(3 + 3 + 2 + 4) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	12.5	55.2	32.3

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.*