SIGNALS & SYSTEMS
(ELE2203)

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

(ii) 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.

(iii) Fourier transform of a gate signal is
(a) sine wave (b) sinc function
(c) unit step signal (d) none of these

(iv) The sampling frequency of the signal $x(t) = 4\sin(150\pi t) + 2\cos(50\pi t)$ should be
(a) greater or equal to 75 Hz (b) greater or equal to 150 Hz
(c) lesser or equal to 150 Hz (d) greater or equal to 25 Hz

(v) The **R.O.C** of $z - transform$ for the discrete signal $x(n) = 2(2^n)u(n)$ is
(a) R.O.C : Outside the unit circle of z − plane (b) R.O.C : $|z| > 2$
(c) R.O.C : Complete z − complex plane (d) R.O.C : $|z| < 2$

(vi) The inverse $z - transform$ for the discrete signal $X(z) = z/(z - \frac{1}{3})$ for R.O.C : $|z| > \frac{1}{3}$ is
(a) $x(n) = (\frac{1}{3})^n u(n)$ (b) $x(n) = (3)^n u(n)$
(c) $x(n) = (\frac{1}{3})^n u(-n-1)$ (d) $x(n) = (3)^n u(-n-1)$

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

(viii) The unit step response of the system $G(s) = \frac{1}{0.2s+1}$ reaches 98% of its final value after
(a) 0.6 sec (b) 0.8 sec
(c) 2 sec (d) 1sec

(ix) A second order system has $= \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix}$, the system is

(a) underdamped (b) overdamped
(c) critically damped (d) undamped.

(x) The transfer function can be found form state space representation using the relation:
(a) $C(sI - A)^{-1}B + D$ (b) $B(sI - A)^{-1}C + D$
(c) $D(sI - A)^{-1}B + C$ (d) $D(sI - A)^{-1}C + B$

Fill in the blanks with the correct word

(xi) The value of the integral $\int_{-\infty}^{\infty} \delta(at)\, dt$ is _____.

(xii) The unit step signal is a _____ signal.

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

(xiv) For the 2nd order system $G(s) = \frac{49}{s^2+10s+49}$ the natural frequency of oscillation is_____.

(xv) A system is described by the differential equation $\ddot{x} + 5\dot{x} + 4x = f(t)$. The 'C' matrix of the system is _____.

Group - B

2. (a) Examine whether signal $x(t) = \mathrm{e}^{-4\mathrm{t}}$ 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 $h(t) = u(t+3)$ 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. 3(a). Hence find out the exponential Fourier series coefficients.

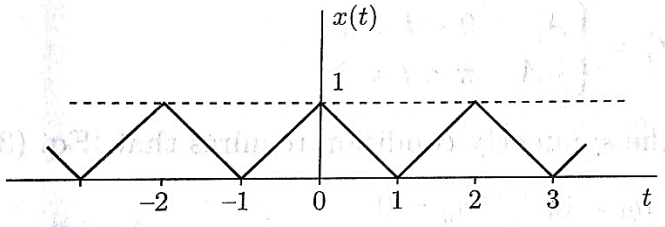

Fig.-3(a) *(CO1) (Analyze/IOCQ)]*

(b) Find the Fourier transform of the signal $x(t)$ shown in Fig. 3(b). Also sketch the amplitude and phase spectrum of the signal.

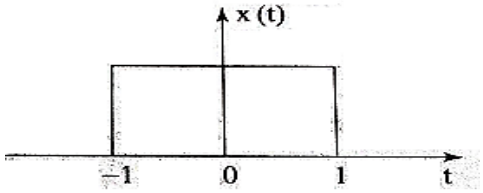

Fig. 3(b) *[(CO1) (Analyze/IOCQ)]*

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-transform and ROC 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 + 3) = 12

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

   (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 impulse response of the system whose input $(x(n))$ and output $(y(n))$ relationship is given by the difference equation $y(n) = 5y(n-1) - 6y(n-2) + x(n)$. *[(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. 6(b) using force-voltage and force-current analogy.

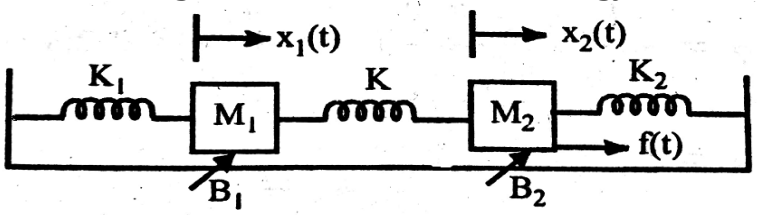

Fig. 6(b)

[(CO4) (Evaluate /HOCQ)]

2 + (5 + 5) = 12

7. (a) State the advantages and disadvantages of the transfer function approach. *[(CO5) (Understand/LOCQ)]*

   (b) A system is described by a differential equation, Where $c(t)$ is the output and $r(t)$ is the input to the system.

$$\frac{d^2c}{dt^2} + 7\frac{dc}{dt} + 49\,c(t) = 49\,r(t)$$

   Determine 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 of the unit step response of the system.

[(CO5) (Analyze/IOCQ)]

2 + 10 = 12

Group - E

8. (a) Obtain the state space representation of the mechanical system shown in Fig. 8(a).

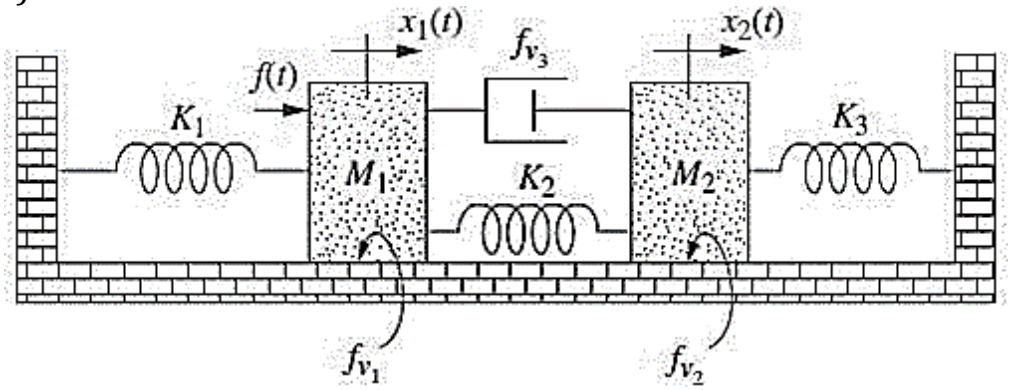

Fig. 8(a)

[(CO6) (Analyze/IOCQ)]

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

$$G(s) = \frac{10s + 11}{s^3 + 8s^2 + 9s + 10}$$

[(CO6) (Analyze/IOCQ)]

8 + 4 = 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	14.6	53.1	32.3