

SIGNALS AND SYSTEMS
(ECE2103)

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 periodic signal has an even symmetry, the Fourier series contains
(a) only sine terms (b) constant and cosine terms
(c) both sine and cosine terms (d) only cosine terms
- (ii) Given $x(n) = a^{|n|}$, $|a| < 1$ is
(a) an energy signal (b) a power signal
(c) both energy and power signal (d) neither energy nor a power signal
- (iii) Fourier Transform of a d.c signal with unity strength is
(a) zero (b) 1
(c) $2\pi\delta(\omega)$ (d) $2\delta(\omega)$
- (iv) Laplace transform of $u(t)$ is
(a) s (b) $1/s$
(c) $2/s^2$ (d) $2/s^3$
- (v) For an RLC circuit, the Laplace transform is used to compute
(a) Voltage across a resistor only
(b) Only the steady-state response
(c) Impulse response and transient behavior
(d) Only DC analysis
- (vi) A Fourier Transform $X(\omega)$ of a real aperiodic signal $x(t)$ will have the amplitude and phase spectrum characteristics as
(a) even and even spectrums (b) odd and even spectrums
(c) even and odd spectrums (d) odd and oven spectrums
- (vii) The region of convergence of a causal finite duration discrete time signal is
(a) the entire z-plane except $z=0$ (b) the entire z-plane except $z=\infty$
(c) ring in z-plane (d) the entire z-plane

- (viii) The spectral density of white noise is
 (a) exponential (b) uniform
 (c) Poisson (d) Gaussian
- (ix) If the maximum frequency of a signal $x(t)$ generated by a low pass filter is 5 kHz then, the maximum frequency in $x(t)\cos(2000\pi t)$, in kHz is
 (a) 5 kHz (b) 1 kHz
 (c) 4 kHz (d) 6 kHz
- (x) Aliasing occurs when
 (a) Sampling rate is higher than Nyquist rate
 (b) Sampling rate is equal to Nyquist rate
 (c) Sampling rate is less than twice the maximum frequency of the signal
 (d) The signal has no frequency components

Fill in the blanks with the correct word

- (xi) The step function $u(t)$ is integral of _____ with respect to time t .
- (xii) The integral $\int_0^5 \delta(t)\sin 2\pi t dt$ results into _____.
- (xiii) The system is stable if all the poles of $H(s)$ lie in the _____ half of the complex plane.
- (xiv) The energy of the signal $e^{-3t}u(t)$ is _____.
- (xv) The period of the signal $x(t)=\cos 60\pi t + \sin 50\pi t$ is _____.

Group - B

2. (a) Determine whether each of the system with impulse response/output is causal and stable
 (i) $h(n)=\delta(n)+\cos(n\pi)$
 (ii) $h(n)=e^{3n}u(n-2)$. [[CO2](Understand/LOCQ)]
- (b) Check whether the given digital systems are BIBO stable or not:
 (i) $y(n)=ax(n+1)+bx(n-1)$
 (ii) $y(n)=ax(n)+bx^2(n-1)$. [[CO1](Understand/LOCQ)]

(3 + 3) + (3 + 3) = 12

3. (a) Find the even and odd component of the following signal:
 $x(t) = \cos(\omega_0 t + \frac{\pi}{2})$ [[CO2](Analyse/IOCQ)]
- (b) Determine the power and rms value of the signal $x(t) = A \sin(\omega_0 t + \theta)$ [[CO2](Remember/LOCQ)]
- (c) Determine the causality of the following signal
 $x(n) = u(n + 4) - u(n - 2)$ [[CO2](Apply/IOCQ)]

3 + 6 + 3 = 12

Group - C

4. (a) The input and output of a causal LTI system are related by the differential equation

$$\frac{d^2y(t)}{dt^2} + 5 \frac{dy(t)}{dt} + 6y(t) = x(t)$$

Find the impulse response of the system.

[[CO6](Evaluate/HOCQ)]

- (b) Find the convolution of the following two sequences by graphical method.

$$x(n) = \{1, 1, 0, -2\}$$

$$h(n) = \{2, 1, 5, -1, 0\}$$

[[CO3](Evaluate/HOCQ)]

5 + 7 = 12

5. (a) Estimate the Fourier transform of $x(t) = e^{-at} \cdot u(t)$ [[CO3] (Analyze /IOCQ)]
 (b) Obtain the Transfer function of the system if $y(t) = e^{-t} - 2e^{-2t} + e^{-3t}$ and $x(t) = e^{-0.5t}$. [[CO3](Understand/LOCQ)]
 (c) Compute the initial and final values for the transform $X(S) = \frac{s+5}{s^2+3s+2}$. [[CO3](Apply/IOCQ)]
4 + 4 + 4 = 12

Group - D

6. (a) Given that $x(n)$ and $h(n)$ are non-zero only for $n=0,1,2$ and is zero otherwise. Whereas the value of $x(0)=1$, $x(1)=2$, $x(2)=1$, $h(0)=1$, $y(1) =3$ and $y(2) = 4$ are given. Find the value of $10y(3) + y(4)$. [[CO3](Analyze/IOCQ)]
 (b) The input and output of a causal LTI system are related by the differential equation

$$\frac{d^2y(t)}{dt^2} + 5 \frac{dy(t)}{dt} + 6y(t) = x(t)$$

- (i) Find the frequency response of the system.
 (ii) Find impulse response of the system.

[[CO3](Analyze/IOCQ)]

6 + 6 = 12

7. (a) Given the impulse response of a system $h(n) = \left(\frac{1}{2}\right)^n u(n)$. Using convolution theorem evaluate the response of the system to the input expressed as $x(n) = \left(\frac{3}{4}\right)^n u(n)$. [[CO3](Analyse/HOCQ)]

- (b) Let $x[n]=\delta[n]+2\delta[n-1]-\delta[n-3]$ and $h[n]=2\delta[n+1]+2\delta[n-1]$. Compute $y[n]=x[n]*h[n]$ using graphical method. [[CO4](Remember/LOCQ)]
6 + 6 = 12

Group - E

8. (a) State different types of sampling methods with proper diagram. Why pre-aliasing filter is used in sampling? [[CO3](Analyse/HOCQ)]
 (b) Find the Nyquist rate and the Nyquist interval for the following signal.
 $x(t) = 6 \cos 50\pi t + 20 \sin 300\pi t - 10 \cos 100\pi t$. [[CO4](Remember/LOCQ)]
(3 + 3) + 6 = 12

9. (a) Explain the difference between ergodic process and stationary process. [[CO3)(Analyse/HOCQ)]
- (b) Probability density function (PDF) is given by the expression $f_X(x) = a e^{-b|x|}$. Here X is a random variable whose values lie in the range $x = -\infty$ to $x = +\infty$. Determine (i) the relationship between a and b. (ii) The probability that outcome lies between 1 and 2. [[CO4)(Remember/LOCQ)]
- (c) Explain the term cumulative distribution function (CDF)? State the relation between PDF and CDF? [[CO2)(Apply/IOCQ)]

3 + 6 + 3 = 12

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| Cognition Level | LOCQ | IOCQ | HOCQ |
| Percentage distribution | 41.66 | 30.21 | 28.13 |