DIGITAL SIGNAL PROCESSING & APPLICATIONS
(ECEN 3202)

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 ROC of a finite duration discrete time signal is as follows,
(a) entire z-plane except at z = 0 (b) entire z-plane except at z = ∞
(c) entire z-plane (d) a ring in the z-plane.

(ii) Given the z-transform, the corresponding DTFT, if it exists, is obtained by replacing z by
(a) jω (b) –jω (c) $e^{j\omega}$ (d) $e^{-j\omega}$

(iii) The N-point DFT of a finite length signal x(n) = δ(n) is
(a) 0 (b) z^{-1} (c) 1 (d) W_N.

(iv) In the bilinear transformation method, the relationship between the analog frequency Ω and digital frequency ω is given by
(a) $\Omega = \tan\frac{\omega}{2}$ (b) $\Omega = \frac{2}{T}\tan\frac{\omega}{2}$ (c) $\Omega = \frac{T}{2}\tan\frac{\omega}{2}$ (d) $\Omega = \frac{2}{T}\tan\frac{2}{\omega}$

(v) The N-point DFT of a finite duration sequence can be obtained as
(a) $X(k) = X(z)\big|_{z=e^{j\frac{2\pi n}{N}}}$ (b) $X(k) = X(z)\big|_{z=e^{j\frac{2\pi kn}{N}}}$
(c) $X(k) = X(z)\big|_{z=e^{-j\frac{2\pi kn}{N}}}$ (d) $X(k) = X(z)\big|_{z=e^{-j\frac{2\pi n}{N}}}$

(vi) Which linear filter has equiripple characteristics in the passband and varies monotonically in the stopband
(a) Type I Chebyshev filter (b) Type II Chebyshev filter
(c) Butterworth filter (d) Elliptic filter.

(vii) The poles of a Butterworth filter lie on a/an
(a) Circle (b) Parabola (c) Ellipse (d) Helix.

(viii) Total number of complex multiplications required in radix-2 DIT-FFT algorithm is
(a) $N\log_2 N$ (b) $N\log_2\frac{N}{2}$ (c) $\frac{N}{2}\log_2 N$ (d) $\frac{N}{2}\log_2\frac{N}{2}$

(ix) FIR filter is always stable because all of its poles are _____
(a) at the origin (b) at the infinity
(c) at the ROC (d) none of these.

(x) A baseband signal has a spectral range that extends from 20 Hz to 82 kHz. The acceptable range of the sampling frequency is
(a) >40 Hz,<82 kHz (b) 40 Hz to 82 kHz
(c) ≥164 kHz (d) ≤164 kHz.

Group – B

2. (a) A continuous–time signal x(t) is obtained at the output of an ideal LPF with a cut-off frequency $\Omega_c = 1000\pi$. If instantaneous sampling is performed on x(t), which of the following sampling periods would guarantee that x(t) can be recovered from its sampled version using an appropriate LPF?
(i) $T_s = 0.5 \times 10^{-3}$ (ii) $T_s = 2 \times 10^{-3}$ (iii) $T_s = 10^{-4}$.
[(CO1)(Evaluate/HOCQ)]

(b) If the Nyquist rate for x(t) is Ωs, find the Nyquist rate for each of the following signals:
(i) x(2t) (ii) $x\left(\frac{t}{3}\right)$. [(CO1)(Analyse/IOCQ)]

(c) (i) Explain aliasing effect.
(ii) How can we combat the effect? [(CO1)(Understand/LOCQ)]

3 + (3 + 3) + 3 = 12

3. (a) An LTI system is characterized by the system function

$$H(z) = \frac{-1 - 0.4z^{-1}}{1 - 2.8z^{-1} + 1.6z^{-2}}$$

Determine x(n), if the ROC is
(i) $|z| > 2$ (ii) $|z| < 0.8$ (iii) $0.8 < |z| < 2$.
[(CO1)(Evaluate/HOCQ)]

(b) Using final value theorem, find the steady-state value of x(n) = $[0.5^n - 0.5]u(n)$.
[(CO2)(Apply/IOCQ)]

6 + 6 = 12

Group – C

4. (a) Perform the circular convolution of the following two sequences using graphical method x1(n)={1,2,1,3,3} x2(n)={1,3,2,1,2}.
↑ ↑
[(CO2)(Apply/IOCQ)]

(b) A length-8 sequence is given by x(n)={-2,5,3,-3,0,-1,4,2}, 0≤n≤7, with an
↑
8-point DFT given by X(k). Determine the sequence y(n) whose 8-point DFT is given by $Y(k) = e^{-\frac{j2\pi 3k}{4}} X(k)$. [(CO2) (Evaluate/IOCQ)]

(c) What do you mean by zero-padding? [(CO2)(Understand/LOCQ)]

6 + 5 + 1 = 12

5. (a) Evaluate the DFT of the sequence x(n)={4,1,2,2} using DIF-FFT algorithm.
↑
[(CO2)(Apply/IOCQ)]

(b) Explain the computational advantage of DIT-FFT over direct computation of DFT. [(CO2)(Understand/LOCQ)]

(c) Given a sequence x(n) whose N-point DFT is X(k). Find the N-point DFT of $x(n)\cos\left(\frac{2\pi n}{N}\right)$. [(CO2)(Understand/LOCQ)]

5 + 3 + 4 = 12

Group – D

6. (a) Compare between IIR Digital filter and FIR Digital filter.
[(CO3)(Understand/LOCQ)]

(b) (i) Explain the disadvantage of impulse-invariant method.
(ii) How is the disadvantage overcome using bilinear-transformation method?
(iii) Explain warping effect and prewarping. [(CO3)(Understand/LOCQ)]

4 + (2 + 3 + 3) = 12

7. (a) Explain the necessity of windowing method in FIR filters.
[(CO3)(Understand/LOCQ)]

(b) Determine the poles of Butterworth LPF for N=2. Sketch the poles of $H_a(s)H_a(-s)$ and hence determine the Butterworth LPF system function $H_a(s)$.
[(CO3)(Analyse/IOCQ)]

(c) Obtain the digital filter transfer function H(z) from its analog counterpart with transfer function $H_a(s)$ using impulse-invariant method.
[(CO3)(Analyse/IOCQ)]

3 + 4 + 5 = 12

Group – E

8. (a) Obtain the Direct Form-I and Direct Form-II realization for a third order IIR transfer function which is expressed as below
$$H(z) = \frac{0.28z^2 + 0.319z + 0.04}{0.5z^3 + 0.3z^2 + 0.17z - 0.2}.$$
[(CO3)(Evaluate/HOCQ)]

(b) Determine a cascade realization of the system characterized by the transfer function which is expressed as under:
$$H(z) = \frac{2(z+2)}{(z-0.1)(z+0.5)}$$
[(CO3) (Evaluate/HOCQ)]

(4 + 4) + 4 = 12

9. (a) Explain the advantages of multi-rate signal processing.
[(CO4)(Understand/LOCQ)]

(b) Differentiate between (i) interpolation and decimation
(ii) Direct form-I and Direct-form II realization of filters.
[(CO4)(Analyse/IOCQ)]

4 + (4 + 4) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25	41.7	27.08

Course outcomes (CO):

After completing this course, the students will be able to:

1 Use concepts of trigonometry, complex algebra, Fourier transform, z-transform to analyze the operations on signals and acquire knowledge about Systems

2 Apply computational tools to evaluate Fourier transform on a digital computer, implementation of many signal processing algorithm and designed hardware.

3 Design, implementation, analysis and comparison of digital filters for processing of discrete time signals

4 Application of multi-rate signal processing for conversion of A/D, D/A and can design multiplexing system for communication.

5 Student can analyze the application of microprocessor with architecture and instruction sets optimized DSP operation.

6 Assess the techniques, skills, and modern engineering tools necessary for analysis of different communication signals and filtering out noise signals in engineering practice. Also develop creative and innovative designs that achieve desired performance criteria within specified objectives and constraints, understand the need for lifelong learning and continuing professional education.