FUNDAMENTALS OF DIGITAL SIGNAL PROCESSING
(AEIE 3104)

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 digital signal is same as discrete time signal except
(a) the time of the discrete time signal is discretized
(b) the magnitude of the digital signal is discretized
(c) the magnitude of the discrete time signal is discretized
(d) the time of the digital signal is discretized .

(ii) If F_s is sampling frequency then the relation between analog frequency F and digital frequency f is
(a) $f = \frac{F}{2F_s}$ (b) $f = \frac{F_s}{F}$ (c) $f = \frac{F}{F_s}$ (d) $f = \frac{2F}{F_s}$.

(iii) An LTI discrete time system is causal if and only if,
(a) $h(n) \neq 0\ for\ n < 0$ (b) $h(n) = 0\ for\ n < 0$
(c) $h(n) \neq \infty\ for\ n < 0$ (d) $h(n) \neq 0\ for\ n > 0$.

(iv) The system $y(n) = \sin[x(n)]$ is,
(a) stable (b) BIBO stable (c) unstable (d) none of the above.

(v) The convolution N_1 sample and N_2 sample sequence produces another sequence consisting of
(a) $(N_1 + N_2)$ samples (b) $(N_1 + N_2 - 1)$ samples
(c) $(N_1 + N_2 + 1)$ samples (d) $(N_1 - N_2)$ samples.

(vi) The Z-transform is a,
(a) finite series (b) infinite power series
(c) geometric series (d) both (a) and (c)

(vii) The normalized transfer function of 3rd order low pass Butterworth filter is
(a) $\frac{1}{s_n^3 + 1.4141 s_n^2 + s_n + 1}$ (b) $\frac{1}{(s_n + 1)(s_n^2 + s_n + 1)}$
(c) $\frac{1}{s_n^2 (s_n + 1)}$ (d) $\frac{1}{s_n^3 + s_n^2 + s_n + 1}$.

(viii) In impulse invariant transformation the digital frequency ω for a given analog frequency, Ω is given by,
(a) $\omega = \Omega T$ (b) $\omega = \frac{\Omega}{T}$ (c) $\omega = \frac{T}{\Omega}$ (d) $\omega = tan\Omega T$

(ix) In an N-point sequence, if N = 16, the total number of complex additions and multiplications using Radix-2 FFT are,
(a) 64 and 80 (b) 80 and 64 (c) 64 and 32 (d) 24 and 12.

(x) In impulse invariant transformation the analog system with transfer function, $H(s) = \frac{0.3}{s+0.7}$ is transformed to a digital system with transfer function
(a) $\frac{-0.3}{1-e^{-0.7T}z^{-1}}$ (b) $\frac{0.3}{1-e^{-0.7T}z^{-1}}$ (c) $\frac{0.7}{1-e^{-0.3T}z^{-1}}$ (d) $\frac{-0.7}{1-e^{-0.3T}z^{-1}}$.

Group – B

2. (a) Represent the sequence $x(n) = \{4, 2, -1, \underset{\uparrow}{1}, 3, 2, 1, 5\}$ as sum of shifted unit impulses. [(CO1)(Remember/LOCQ)]

(b) Determine the inverse Z-transform of the function, $X(z) = \frac{3+2z^{-1}+z^{-2}}{3-3z^{-1}+2z^{-2}}$ by the following two methods and prove that the inverse Z-transform is unique
(i) Residue method
(ii) Partial fraction Expansion Method. [(CO2)(Apply/IOCQ)]

2 + (5 + 5) = 12

3. (a) Determine the impulse response for the cascade of two LTI systems having impulse responses, $h_1(n) = \left(\frac{2}{5}\right)^n u(n)$ and $h_2(n) = \left(\frac{1}{5}\right)^n u(n)$. [(CO1)(Evaluate/HOCQ)]

(b) Determine the Z-transform and their ROC of the following discrete time signal.
$x(n) = 0.3^n u(n) + 0.8^n u(-n-1)$. [(CO2)(Apply/HOCQ)]

(c) If $Z\{x(n)\} = X(z)$ and $Z\{y(n)\} = Y(z)$, then prove that $Z\{r_{xy}(m)\} = X(z)Y(z^{-1})$, where, $r_{xy}(m) = \sum_{n=-\infty}^{+\infty} x(n)y(n-m)$. [(CO2)(Analyse/IOCQ)]

4 + 4 + 4 = 12

Group – C

4. (a) Determine the linear convolution of following sequences using overlap add method:
$x(n) = \{1,2,3,-1,-2,-3,4,5,6\}$; $h(n) = \{2,1,-1\}$. [(CO3)(Apply/IOCQ)]

(b) The input $x(n)$ and impulse response $h(n)$ of a LTI system are given by, $x(n) = \{-1,1,-2,2\}$; $h(n) = \{1,-1,2,1\}$. Perform the circular convolution of the two sequences. [(CO3)(Apply/IOCQ)]

8 + 4 = 12

5. (a) Find the DFT of a sequence $x(n) = \{-1,2,2,2,-1\}$ using 8 point DIT FFT algorithm. [(CO3)(Analyze/IOCQ)]

(b) How many multiplications and additions are involved in N-point radix-2 FFT? [(CO3)(Understand/LOCQ)]

10 + 2 = 12

Group – D

6. (a) Determine the order and the poles of low pass Butterworth filter that has a 3 dB attenuation at 500 Hz and an attenuation of 40 dB at 1000 Hz. [(CO5)(Analyze/IOCQ)]

(b) Obtain the direct form-I realization for the system described by difference equation $y(n) = 0.5y(n-1) - 0.25y(n-2) + x(n) + 0.4x(n-1)$ [(CO5)(Analyze/IOCQ)]

6 + 6 = 12

7. (a) Obtain the cascade and parallel form realization for the system described by difference equation: $y(n) = -0.1y(n-1) + 0.2y(n-2) + 3x(n) + 3.6x(n-1) + 0.6x(x-2)$. [(CO5)(Analyze/IOCQ)]

(b) What is the advantage in cascade and parallel realization of IIR systems? [(CO5)(Remember/LOCQ)]

(c) What is wrapping effect? [(CO5)(Remember/LOCQ)]

(d) What are the advantages in linear phase realization of FIR system? [(CO5)(Understand/LOCQ)]

(3 + 3) + 2 + 2 + 2 = 12

Group – E

8. (a) Give advantages of multi-rate DSP. Explain the sampling rate conversion method by a fractional number with block diagram. [(CO6)(Remember/LOCQ)]

(b) What are the advantages of DCT over DFT? Write the applications of DCT. [(CO6)(Understand/LOCQ)]

(2 + 5) + (3 + 2) = 12

9. (a) What is multi-rate DSP? [(CO6)(Remember/LOCQ)]

(b) Give some examples of multirate digital systems. How different sampling rates are achieved in these types of systems? [(CO6)(Remember/LOCQ)]

(c) Show that the up-sampler and down-sampler are time invariant system. [(CO6)(Analyze/IOCQ)]

(b) What is decimator? Draw the symbolic representation of a decimator. [(CO6)(Understand/LOCQ)]

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

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	32.25	60.42	8.33

Course Outcome (CO):

After the completion of the course students will be able to

1. Characterize and analyze the properties of discrete time signals and systems.
2. Analyze a discrete linear time invariant system using Z-transform.
3. Perform Fourier Transform of Discrete-Time signals and learn implementation of Fast Fourier Transform algorithms.

4. Distinguish between analog and digital filter, methods to transform from one type to another types of filter.
5. Design digital FIR and IIR filters according to the given specification and realize structure of a digital filter for given transfer function
6. Familiarize with short time Fourier transform, discrete cosine transform, wavelet transform and multirate digital signal processing.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.