# DIGITAL SIGNAL PROCESSING
## (ECEN 3102)

**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) What is the ROC of the signal $x(n)=\delta(n-k)$, $k>0$?
(a) $z=0$ (b) $z=\infty$
(c) Entire z-plane, except at $z=0$ (d) Entire z-plane, except at $z=\infty$.

(ii) If $x(n)=\{1, 4, 5, 3, 2, 7\}$ is a periodic sequence with periodicity N=8,
$\uparrow$
what should be the value of x(25)?
(a) 5 (b) 2 (c) 4 (d) 7.

(iii) The main lobe width of length M rectangular window is
(a) $\frac{4\pi}{M}$ (b) $\frac{8\pi}{M}$ (c) $\frac{12\pi}{M}$ (d) variable.

(iv) The addition of zeros at the end of the sequence when it is represented as the power of integer is refer as
(a) Zero padding (b) Bilateral transform
(c) Region of convergence (d) Impulse invariance.

(v) if X(k) is the N/2 point DFT of the sequence x(n), then what is the value of X(k+N/2)?
(a) $F_1(k)+F_2(k)$ (b) $F_1(k)-W_N^k F_2(k)$
(c) $F_1(k)+W_N^k F_2(k)$ (d) $F_1(k)-F_2(k)$.

(vi) The poles of Chebyshev filter lies
(a) on the ellipse (b) on the circle
(c) on the hyperbola (d) none of the above.

(vii) Compared to Butterworth filter, the transition band of Chebyshev filters is
(a) more (b) less
(c) equal (d) none of the above.

(viii) The total number of complex additions in an N-point DFT is
(a) $N \log_2 N$ (b) $(N/2)\log_2 N$
(c) $\log_2 N$ (d) $N(N-1)$.

(ix) What is the process of converting a signal from a given rate to a different rate?
(a) Sampling (b) Normalizing
(c) Sampling rate conversion (d) None of above.

(x) 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.

## Group - B

2. (a) If y(n) denotes the convolution of h(n) and g(n), where $h(n) = (1/2)^n u(n)$ and g(n) is a causal sequence. If y(0) =1and y(1) =1/2, then evaluate the value of g(1). [(CO2) ( Evaluate/HOCQ)]

(b) Find the z- transform and ROC of the given sequence
$x(n) = ½\ \delta(n+1)+5\ (1/2)^{-n}\ u(n) + u(-n-1)$. [(CO2) (Evaluate/HOCQ)]

(c) Write down the properties of Region of Convergence (ROC) of z-transformation. [(CO2) (Remember/LOCQ)]

**5 + 5 + 2 = 12**

3. (a) A System is described by the difference equation $y(n) = ½\ y(n-1) + x(n)$. If the input to the system is $(1/3)^n\ u(n)$ and the initial condition is y(-1) =1. Determine (i) zero input response (ii) zero state response. [(CO1)(Analyze/IOCQ)]

(b) Find Inverse z-transformation of $X(z) = \log(1-az^{-1})$ using differentiation property. [(CO2)(Analyze/IOCQ)]

(c) Explain the mapping between s –plane and z– plane? [(CO2)(Remember/LOCQ)]

**6 + 3 + 3 = 12**

## Group - C

4. (a) Evaluate the response of FIR filter with impulse response h(n)={1,3,-1} to the input sequence x(n)={1,2} using graphical method of circular convolution. [(CO3)(Evaluate/HOCQ)]

(b) Consider an 8-point sequence x(n) with an 8-point DFT X(k). Explain the reduced computational complexity in stage 2 of DIT-FFT with the help of required equations. [(CO3)(Understand /LOCQ]

(c) Explain the significance of zero-padding w.r.t. DFT. [(CO3)(Understand /LOCQ]

**5 + 5 + 2 = 12**

5. (a) Using radix-2 DIF-FFT algorithm, evaluate the DFT of the sequence x(n) = {-2, 1, 2, 3}
↑
[(CO3)(Apply/IOCQ)]

(b) Evauate the linear convolution of the following sequences using overlap-add method.
x(n)={1,2,-1,2,3,-2,-3,-1,1,1,2,-1} and h(n)={1,2,3}
[(CO3)(Evaluate/HOCQ)]

**5 + 7 = 12**

## Group - D

6. (a) Compare between impulse invariance method and bilinear transformation method of transforming analog system function to digital system function.
[(CO4)(Understand/LOCQ)]

(b) Given $H_a(s) = \frac{1}{(s+1)(s+2)}$, evaluate the corresponding H(z) using impulse invariant method. [(CO4)(Evaluate/HOCQ)]

(c) Explain the necessity of windowing method in FIR filters.[(CO4)(Understand/LOCQ)]

**3 + 5 + 4 = 12**

7. (a) Design a digital Butterworth filter that satisfies the following constraints using blinear transformation. Assuming T=1 sec

$0.9 \le |H(e^{jw})| \le 1 \quad 0 \le w \le \pi/2$

$|H(e^{jw})| \le 0.2 \quad 3\pi/4 \le w \le \pi.$ [(CO4)(Creative/HOCQ)].

(b) What do you mean by warping effect and how it can be overcome?
[(CO4)(Understand/LOCQ)]

**8 + 4 = 12**

## Group - E

8. (a) Design a ideal high pass FIR filter with frequency response using Fourier series method

$H_d(e^{jw}) = 1 \quad \text{for} \quad \pi/4 \le w \le \pi$

$= 0 \quad |w| \le \pi/4$

Find the value of h(n) for N=11and also H(z) . [(CO5)(Creative/HOCQ]

(b) Explain briefly the procedure for designing FIR filter using windows technique.
[(CO5)(Understand/LOCQ)]

**8 + 4 = 12**

9. (a) Explain the architecture of TMSC32067x processor with the help of block diagram.
[(CO6)(Understand/LOCQ)]

(b) Explain the concept of up-sampling with suitable equations and diagrams.
[(CO5)(Understand/LOCQ)]

**7 + 5 = 12**

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| Cognition Level | LOCQ | IOCQ | HOCQ |
|---|---|---|---|
| Percentage distribution | 40.63 | 14.58 | 44.79 |

## Course Outcomes (CO):

After the completion of the course students will be able to

1. Recall the concepts of trigonometry, complex algebra, Fourier transform to analyze different signals and systems.
2. Apply the concept of z-transformation, convolution to determine the transfer function of a system and evaluate the output of the system.
3. Extend the knowledge of discrete-time Fourier transform to interpret DFT, FFT and apply the concept as a frequency transformation tool.
4. Design transfer functions of IIR / FIR filters applying transformation techniques / windowing methods.
5. Construct and model digital filters from their transfer function, develop concept of multirate signal processing and architecture of digital signal processor.
6. Develop a thorough understanding of the central elements of digital signal processing theory and apply this theory to real-world signal processing applications.

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