KATHMANDU UNIVERSITY
End Semester Examination
February, 2025

10 FEB 2025

Level : B.E.		Marks Scored:
Year : III		Course : ETEG 305
		Semester : II
Exam Roll No. :	Time: 30 mins.	F. M. : 10
Registration No.:		Date :

SECTION "A"
[20 Q. × 0.5 = 10 marks]

Choose and encircle the most appropriate option from each set of choices

1. The output signal when a signal $x[n] = \{\dot{1},2,3,0\}$ is processed through a unit delay system is:
   a. {0, 1, 2, 3} b. {1, 2, 3, 0} c. {0, 0, 1, 2} d. {3, 2, 1, 0}

2. A period of discrete-time signal $x[n] = e^{\frac{j2\pi n}{5}} + e^{j0.1\pi n}$ is
   a. 5 b. 10 c. 20 d. Aperiodic

3. If the output of the system at any time 'n' depends only on the past and present values of the input then the system is said to be:
   a. Time invariant b. Stable c. Linear d. Causal

4. The convolution sum is given by:
   a. $y(n) = \sum_{n=0}^{N-1} x(n)h(n-k)$ b. $y(n) = \sum_{n=-\infty}^{\infty} x(n)h(n-k)$
   c. $y(n) = \sum_{k=0}^{N-1} x(n)h(k-n)$ d. $y(n) = \sum_{k=-\infty}^{\infty} x(n-k)h(k)$

5. What is the highest frequency that is contained in the sampled signal?
   a. $2F_s$ b. $F_s/2$ c. F_s d. $1/F_s$

6. Consider the analog signal $x(t) = 3\cos 100\pi t$. Suppose that the signal is sampled at the rate F_s= 200 Hz. What is the frequency of discrete time signal obtained after sampling?
   a. ¼ b) 2/3 c)1/3 d) ½

7. If X(z) is the z-transform of the signal x[n], then the z-transform of x[-n] is
   a. X(-z) b. -X(z) c. $X(z^{-1})$ d. $X^{-1}(z)$

8. If $u[n] \overset{z}{\longleftrightarrow} \frac{1}{1-z^{-1}}$, based on the property of z-transform, the inverse z-transform of $\frac{1}{1-z}$ is
   a. u[n-1] b. u[-n] c. -u[n] d. -u[-n]

9. If $x[n] \overset{z}{\longleftrightarrow} X(z)$, then the z-transform of nx[n-1], is ________?
   a. $-z\frac{d}{dz}X(z)$ b. $-z\frac{d}{dz}\left\{\frac{X(z)}{z}\right\}$ c. $z\frac{d}{dz}X(-z)$ d. $-z\frac{d}{dz}\{zX(z)\}$

10. If X(z) is the z-transform of $x[n] = 3\left(-\frac{1}{2}\right)^n u[n] - 3^n u[-n-1]$, the ROC of X(z) is
    a. |z|>3 b. |z|<3 c. ½<|z|<3 d. |z|>1/2

11. The value of twiddle factor is given as

a. $e^{\frac{j2\pi}{N}}$ b. $e^{-\frac{j2\pi}{N}}$ c. $e^{\frac{j2\pi kn}{N}}$ d. $e^{\frac{-j2\pi kn}{N}}$

12. Which of the following is true regarding the number of computations require to compute an N-point DFT?

a. N^2 complex multiplications and N(N-2) complex additions

b. N^2 complex additions and N(N-1) complex multiplications

c. (N^2-1) complex multiplication and N(N-1) complex additions

d. N^2 complex multiplication and (N^2-N) complex additions

13. In DFT, if $W_4^{16} = W_x^{32}$, then the value of x is

a. 2 b. 4 c. 8 d. 16

14. How many complex additions are performed in computing the N-point DFT of a sequence using divide and conquer approach if N = LM

a. N(L+M+2) b. N(L+M+1) c. N(L+M-1) d. N(L+M-2)

15. The first 5 points of the eight-point DFT of a real-valued sequence are {12, 1+ j3, 5, 2 + j6, 4}, The remaining three points are:

a. {2 - j6, 5, 1 - j3} b. {1 + j3, 5, 2 + j6}

c. {2 - j6, -5, 1 - j3} d. {1 - j3, 5, 2 - j6}

16. The FIR filter with system function is given by

$H(z) = 1 + \frac{2}{3}z^{-1} + \frac{3}{5}z^{-2} + \frac{1}{3}z^{-3}$, then the value of lattice parameter K_3 is

a. ⅓ b. ⅔ c. ⅙ d. ⅛

17. For an analog LTI system to be stable, where should the poles of the system function H(s) should lie

a. Right half of s-plane b. Left half of s-plane

c. on imaginary axis d. on real axis

18. The time domain representation of ideal lowpass filter is

a. Rectangular b. Sinc c. Sinusoidal d. Exponential

19. Which of the following is not used as traditional window function in FIR filter design?

a. Hanning b. Hamming c. Bartlett d. Gaussian

20. Which of the following is not the condition of system to be linear phase filter?

a. h[n]= h[M-1-n] b. h[n] = -h[M-1-n] c. h[-n] = h[M-1-n] d. h[-n] = h[M-1+n]

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SECTION "B"
[5 Q. × 8 = 40 marks]

Attempt ANY FIVE questions. Symbols have their usual meanings. Urgent appropriate assumptions are permissible. Marks are indicated inside brackets.

1.

a. Enumerate the basic advantages of Digital signal processing. Briefly explain the applications of DSP. [2+2]

b. Define the following terms [2+2]

i. Causality of LTI system

ii. Stability of LTI system

2.

a. Define z-transform and ROC. Determine the z-transform of the following sequence using different z-transform properties [4]

$$x[n] = n0.4^n u[n-2]$$

b. Consider two LTI systems described by impulse responses are parallel interconnected. Determine the overall impulse response and response to the input signal x[n]. [4]

$$h_1[n] = \left\{-2, \underset{\uparrow}{3}, 1\right\}, h_2\left\{\underset{\uparrow}{3}, 1, 1\right\}, x[n] = u[n+1] - u[n-4]$$

3.

a. Find 8-point DFT of the following signal using radix-2 decimation in frequency FFT algorithm. Use butterfly diagram for the computation. [4]

$$x[n] = \{1, 1, 2, 2, 3, 3, 4, 4\}$$

b. Determine the possible ROCs and find the inverse z-transform of the following signal for stable system. [4]

$$H(z) = \frac{2 + z^{-1}}{(1 - 0.2z^{-1})(1 - 0.6z^{-1})^2}$$

4.

a. Define circular convolution. Find circular convolution of the following sequences [3]

$$x_1[n] = \{1, 2, 1, 5\} \;\&\; x_2[n] = \{-2, 3, 1, 4, 2\}$$

b. Draw the cascade structure of the following system [3]

$$H(z) = \frac{1 - 2z^{-1}}{1 - 0.7z^{-1} + 0.12z^{-2}}$$

c. What to you understand by "Quantization effect" in digital system? Discuss about the pole perturbation. [2]

P.T.O.

5.

a. Draw the lattice ladder structure for the following system:

$$H(z) = \frac{1 - 0.8z^{-1} + 0.15z^{-2}}{2 + 0.4z^{-1} - 1.4z^{-2}}$$

Is this system stable? [4]

b. Obtain the filter coefficients for a lowpass FIR filter with 7 coefficients for the following specifications

$$H_d(\omega) = \begin{cases} e^{-\frac{j(M-1)}{2}}, & for\ |\omega| \le 0.55\pi \\ 0, & for\ 0.55\pi < |\omega| \le \pi \end{cases}$$

Use Hamming window in your design. [4]

6.

a. Derive the transformation equation for Bilinear transformation method of IIR filter design. Discuss the nature of mapping from analog to digital frequency in Bilinear transformation method. Also explain frequency warping. [3]

b. The specification of the desired low pass filter is

$$0.8 \le |H(\omega)| \le 1.0;\ \ 0 \le \omega \le 0.2\pi$$
$$|H(\omega)| \le 0.2;\ \ 0.35\pi \le \omega \le \pi$$

Design Butterworth digital filter using impulse invariance method. [5]

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Some useful relationships:

1. Window functions:

$$i.\, Hanning\ window, W[n] = 0.5\left(1 - \cos\frac{2\pi n}{M-1}\right)$$

$$ii.\, Hamming\ window, W[n] = 0.54 - 0.46\cos\frac{2\pi n}{M-1}$$

2. For impulse invariance method the mapping relations are:

Analog Domain H(s)	**Digital Domain H(z)**
$\frac{1}{s-p_k}$	$\frac{1}{1-e^{p_k T}z^{-1}}$
$\frac{s+a}{(s+a)^2+b^2}$	$\frac{1-e^{-aT}cos(bT)z^{-1}}{1-2e^{-aT}cos(bT)z^{-1}+e^{-2aT}z^{-2}}$
$\frac{b}{(s+a)^2+b^2}$	$\frac{e^{-aT}sin(bT)z^{-1}}{1-2e^{-aT}cos(bT)z^{-1}+e^{-2aT}z^{-2}}$

3. Normalized Butterworth denominator polynomials:

Order of Filter N	**Transfer function H(s) = 1/A(s) where A(s)**
1	$(s+1)$
2	$(s^2+1.414s+1)$
3	$(s^2+s+1)(s+1)$
4	$(s^2+0.766s+1)(s^2+1.848s+1)$
5	$(s^2+0.618s+1)(s^2+1.618s+1)(s+1)$
6	$(s^2+0.518s+1)(s^2+4.414s+1)(s^2+1.932s+1)$
7	$(s^2+1.802s+1)(s^2+1.247s+1)(s^2+0.445s+1)(s+1)$