Ref. No.: Ex/IEE/PC/B/T/311/2025

B.E. INSTRUMENTATION AND ELECTRONICS ENGINEERING
THIRD YEAR FIRST SEMESTER EXAM 2025
DIGITAL SIGNAL PROCESSING

Time: 3Hrs.

Full Marks: 100

Module 1: Answer any one question from Module-1

1. a) Define energy and power of a signal. 1+1

b) Obtain energy for the signal 4

$x(n) = \alpha^n u(n) \quad where \quad |\alpha| < 1$

c) Determine whether the following systems are time-invariant or not.

i) $y(n) = x(n^2)$ 3

ii) y(n)=x(n)+nx(n-1) 3

d) Define recursive,non-recursive causal and non-causal systems with example. 4x2=8

2. a) Determine whether or not the following signals are periodic. If periodic specify its fundamental period

A) $x(n) = \cos(n/8)\cos(\pi\, n/8)$ 5+5

B) $x(n) = \cos(n\,\pi/2) - \sin(n\,\pi/8) + 3\cos(\pi\, n/4 + \pi/3)$

b) Obtain the linear convolution of the following sequence using matrix method 5

$$x(n) = \{1, 1, \underset{\uparrow}{0}, 1, 1\} \quad and \quad h(n) = \{1, -2, -3, \underset{\uparrow}{4}\}$$

c) Explain the given systems with respect to the following properties:

i) Dynamic ii) time invariance iii) linearity iv) causality v) stability 5

A) $y(n) = \sum_{k=-\infty}^{n} x(k)$ B) $y(n) = \mathrm{sgn}[x(n)]$

Module 2: Answer any two questions from Module-2

3. a) Obtain **DTFT** of the below signals

i) $x(n) = a^n u(n) + a^n u(-n-1)$

[Turn over

ii)

$$x(n) = A \quad for \quad 0 \le n \le L-1$$
$$\quad 0 \quad otherwise$$

b) Calculate the DFT of the sequence $x(n) = \{1,1,0,0\}$.

c) Given the two sequences of length 4 are:

$x(n) = \{0,1,2,3\}$

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

Find the circular convolution with matrix method

d) Compute the 8-point circular convolution for the following sequence

$x_1(n) = \{1,1,1,1,0,0,0,0\}$

$x_2(n) = \sin(\frac{3\pi n}{8}) \quad 0 \le n \le 7$

{(2+3)+5+5+5}=20

4)

a) Determine the z-transform and sketch the ROC of :

$$x(n) = (\frac{1}{3})^n \quad for \quad n > 0$$
$$(\frac{1}{2})^{-n} \quad for \quad n < 0$$

c) Determine the Z-transform and ROC of

$x(n) = (\frac{1}{2})^{-n} \quad u(-n)$

d) Find the Z-transform of $x(n) = \frac{a^n}{n!} \quad , \quad n \ge 0$

e) Obtain the Z-transform of the signal 4x5=20

$x(n) = nu(n)$

5.

a) Find inverse Z-transform:

$X(Z) = \log(1 + aZ^{-1}). \quad |Z| > |a|$

b) Find the linear convolution of x_1 (n) and x_2 (n) using Z-transform

$$x_1(n) = \{1, 2, \underset{\uparrow}{3}, 4\} \text{ and } x_2(n) = \{1, 2, \underset{\uparrow}{0}, 2, 1\}.$$

c) Determine inverse z-transform of:

$$X(Z) = \frac{4Z^{-2} + 3Z^{-1} + 2}{\frac{1}{2}Z^{-2} - \frac{3}{2}Z^{-1} + 1} \quad \text{for causal sequence}$$

d) Find the frequency response and impulse response of an LTI system whose input and output satisfy the difference equation

$$y(n) - \frac{1}{2}y(n-1) = x(n) + 2x(n-1) + x(n-2)$$

(5+5+5+5)=20

Module-3: Answer any one question from Module-3

6. a) Develop direct form-II realization the transfer function

$$X(Z) = \frac{1 + \frac{1}{5}Z^{-1}}{(1 - 0.5Z^{-1} - \frac{1}{3}Z^{-2})(1 + 0.25Z^{-1})}$$ 10

b) Discuss bilinear transformation method to design digital filter 10

7. a

Find out H(Z) using impulse invariance method at 5 Hz sampling frequency from H(s) as given below :

$$H(s) = \frac{2}{(s+1)(s+2)}$$

b) Write the comparison between Impulse invariance and the Bilinear transformation method

c)

The system transfer function of analog filter is given by,

$$H(s) = \frac{s+0.1}{(s+0.1)^2 + 16}$$

Obtain the system transfer function of digital filter using BLT which is resonant at $\omega_r = \frac{\pi}{2}$.

d)
Using bilinear transformation, design a butterworth filter which satisfies the following conditions :

$0.8 \le |H(e^{j\omega})| \le 1 \qquad 0 \le \omega \le 0.2\pi$

$|H(e^{j\omega})| \le 0.2 \qquad 0.6\pi \le \omega \le \pi$

6+2+6+6=20

8.
a.
A digital low pass IIR filter is to be designed with butter- worth approximation using bilinear transformation technique. Find the order of filter to meet the following specifications.

(i) Passband magnitude is constant within 1 dB for frequencies below 0.2π.

(ii) Stopband attenuation is greater than 15 dB for frequencies between 0.3π to π.

b. Discuss the design of the FIR filter using the window method.

c. Design a linear phase FIR low pass filter of order seven with cut-off frequency 1rad/sec using rectangular window.

6+7+7=20

Module-4: Answer all the questions Module-4

9)
A. What does *multi-rate* mean?

b. Discuss the use of multi-rate DSP?

c) State the Various advantages of Multirate DSP

d) What are the categories of multi-rate?

e) Discuss the Basic Sampling Rate Alteration Devices

4+4+4+4+4=20