B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING
THIRD YEAR SECOND SEMESTER EXAMINATION, 2025

DIGITAL SIGNAL PROCESSING

Time: Three Hours | Full Marks: 100

Answer ***any five*** questions.

1. a) An IIR filter is described by the following difference equation.

$$y(n) = x(n) + 0.6\,y(n-1) - 0.08\,y(n-2)$$

Draw the direct form - I structure of the filter. Convert it into a suitable structure and hence obtain the impulse response intuitively. 10

b) An IIR filter is described by the following difference equation.

$$y(n) = 0.1\,x(n) + 0.9\,y(n-1)$$

Compute the frequency response and hence obtain the dc gain. Determine the cutoff frequency of the filter. Is this filter lowpass bandpass or highpass? 10

2. a) An FIR filter is described by the following difference equation.

$$y(n) = x(n) - x(n-4)$$

Compute and sketch its magnitude and phase response. 10

b) Determine the coefficients of a linear phase FIR filter

$$y(n) = b0.x(n) + b1.x(n-1) + b2.x(n-2)$$

such that
(i) it rejects completely a frequency component at $w = 2.(\pi/3)$, and
(ii) its response is normalized at dc.

10

3. a) Obtain expressions for amplitude and phase frequency responses of a Type I linear phase FIR filter. What is the advantage of a linear phase FIR filter? Comment on the automatic zero locations of Type II linear phase FIR filters. 10

b) Consider the following system function of a filter.

$$\mathbf{H(z) = (1 - 0.9\, z^{-1} - 0.1\, z^{-2}) / (1 + 0.3\, z^{-1} - 0.04\, z^{-2})}$$

Obtain the cascade form realization structure of the filter. 10

4. a) Design the simplest possible first-order FIR highpass filter through the pole-zero placement method. Find the frequency response of the filter, plot the magnitude response, and calculate the 3-dB cutoff frequency. What is the limitation of the filter thus designed? Suggest a suitable method to overcome this limitation. 10

b) Obtain the pole-zero plot for the filter with the system function given below. Comment on the nature of the filter intuitively from the plot itself. Justify your comment analytically.

$$\mathbf{H(z) = 1 / (1 + z^{-2})}$$ 10

5. a) An IIR filter is described by the following difference equation.

$$\mathbf{y(n) = 3\, x(n) - 3\, x(n-1) + 3\, y(n-1)}$$

Compute the response due to the following input:

$$\mathbf{x(n) = \{\ldots\ldots, 12, 6, 4, 6, 12, 6, 4, 6, 12, 6, 4, 6, \ldots\ldots\}}$$ 10
$$\uparrow$$

b) An LTI discrete-time system is characterized by the system function

$$\mathbf{H(z)} = \frac{(3 - 4z^{-1})}{(1 - 3.5z^{-1} + 1.5z^{-2})}$$

Specify the ROC of H(z) and determine h(n) for the following conditions:
(i) The system is causal and unstable.
(ii) The system is noncausal and stable.
(iii) The system is anti-causal and unstable.

10

6. a) Determine the circular convolution of the following two sequences x1(n) = {1, 1, 2, 2} and x2(n) = {1, 2, 3, 4} by DFT/IDFT method. 10

   b) Derive the Butterfly structure for 4-point **inverse FFT** using the decimation-in-frequency method. 10

7. a) Design a first-order allpass filter whose pole is placed at **z = -0.4;** Mention some of the applications of allpass filters. 10

   b) Design a 5-tap FIR bandstop filter with a lower cut-off frequency of 2000 Hz and an upper cut-off frequency of 2400 Hz at a sampling rate of 8000 Hz using the Hamming window method. 10

8. Discuss the principle of echo generation and cancellation with the help of DSP blocks and write MATLAB code for the same. 20