

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD

CYFNOD ARHOLIADAU

MAY 2025

MAI 2025

MODULE CODE: GOEE5003

DSP AND COMMUNICATIONS

TIME: 2 HOURS

ANSWER ALL QUESTIONS

SHOW ALL CALCULATIONS AND WORKINGS CLEARLY

Equipment or materials required – Calculator, Formula Sheets

Question One (25 marks)

- a. A discrete time system is given by:

$$y[n] = x[n] - 4$$

Determine whether the system is linear?

[6]

- b. A system is defined by:

$$y[n] = 2x[n - 3]$$

Determine whether the system is time-invariant?

[6]

- c. Determine whether the systems below are causal?

i. $y[n] = 4x[n - 1] - 3x[n - 2] + 2y[n - 1]$

ii. $y[n] = 6x[n + 2] - 7x[n] + y[n + 1]$

[6]

- d. A filter is described by the following difference equation:

$$y[n] = -0.3y[n - 1] + 0.7x[n]$$

The general form of a difference equation is:

$$y(n) = -\sum_{i=1}^N a_i y(n - i) + \sum_{j=0}^M b_j x(n - j)$$

where $a_1, a_2, \dots, a_N$ and $b_0, b_1, b_2, \dots, b_M$ are coefficients of the difference equation.

- i. Determine whether this is a **recursive or non-recursive** difference equation.
- ii. Identify filter coefficients a_k and b_k .
- iii. If the input $x[n]$ is $u[n]$ (unit step function), calculate the first 5 samples of the output $y[n]$, assuming the initial condition $y[-1] = 0$.

[7]

Question Two (25 marks)

- a. A discrete time signal $x[n]$ is generated by sampling the analogue signal:

$$x(t) = 8 \sin(2\pi ft) u(t) \quad \text{at a sampling frequency of } f_s = 10\text{kHz}$$

- Write the discrete time signal $x[n]$ in terms of n , given that the frequency f of the sine wave is 1kHz .
- Calculate the first five samples of $x[n]$
- Sketch the discrete time signal for $n = 0, 1, 2, 3, 4$

[9]

- b. Write the discrete input signal $x[n]$ in Figure1 as a linear sum of shifted and scaled unit impulse signals.

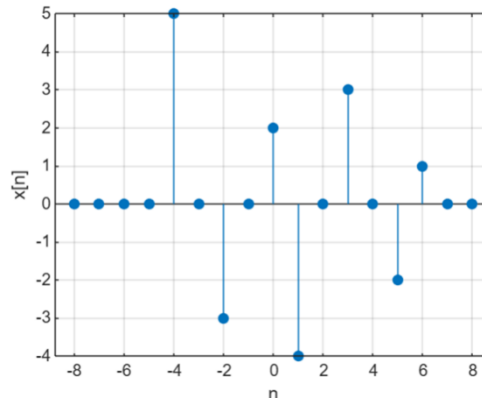


Figure1

[4]

- c. Consider a causal discrete time Linear Time Invariant (LTI) system with an FIR filter described by the impulse response:

$$h[n] = [2, \quad -1, \quad 4]$$

The system's input is given by:

$$x[n] = [1, \quad 3, \quad 0, \quad 2]$$

- Find the system's output $y[n]$ using time-domain convolution (tabulate the convolution operation).
- Sketch the resulting output signal.

[8]

- d. Consider the analogue signal:-

$$x(t) = 4 \cos(6000\pi t) + 2 \cos(16000\pi t) - 2 \cos(8000\pi t)$$

Determine the frequency components and the Nyquist sampling frequency.

[4]

Question Three (25 mark)

- a. Use the z-transform table provided to find the z-transform of the following input signal:

$$x(n) = (3^n) \cos(0.25\pi n) u(n)$$

[7]

- b. The input $x[n]$ and output $y[n]$ of a causal discrete time LTI system are related by the following difference equation:

$$3y[n] - 2y[n - 1] + y[n - 2] - x[n] + 0.5x[n - 1] - x[n - 2] = 0$$

Find the transfer function $H(z)$ of the system.

[8]

- c. The input $x[n]$ and output $y[n]$ of a continuous-time LTI system is given by the following difference equation:

$$y[n] + 0.5 y[n - 1] - 0.25 y[n - 2] - x[n] + 0.6 x[n - 1] - 0.4 x[n - 2]$$

Find the frequency response function $H(e^{j\omega})$ of the system.

[10]

Question Four (25 mark)

- a. Design a 7-tap bandpass FIR filter with lower and upper cutoff frequencies of 800Hz and 3000Hz, respectively. Assume the sampling frequency is 12000Hz. Calculate the filter parameters, including the normalized cutoff frequencies and the filter length. Then, list the FIR filter coefficients after applying a suitable window function.

[10]

- b. Briefly explain the meaning of:

- i. Multiplexing
- ii. Analogue Modulation
- iii. ASK digital modulation
- iv. FSK digital modulation
- v. Baseband system

[15]

Diwedd/End