# ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

MID SEMESTER EXAMINATION SUMMER SEMESTER, 2022-2023

DURATION: 1 HOUR 30 MINUTES FULL MARKS: 75

## CSE 4631: Digital Signal Processing

**Programmable calculators are not allowed. Do not write anything on the question paper.**

Answer **all 3 (three)** questions. Figures in the right margin indicate full marks of questions with corresponding COs and POs in parentheses.

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1. a) Illustrate the block diagram of the discrete-time system given as follows in Equation 1: 11 (CO1) (PO1)

$$y(n) = x_1(n) + 2x_2(n-1) + 4x_1(n+1)x_2(-n-1) + x_3(n)y(n-1) \quad (1)$$

b) Suppose an input signal, $x(n)$, is passed through a system with impulse response, $h(n)$, producing the output, $y(n)$. The input signal and impulse response is given as follows: 7 (CO2) (PO1)

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

$$h(n) = \{-1, 2, -3, 4\}$$

Here, both $x(n)$ and $h(n)$ start from the origin. Compute the output $y(n)$.

c) Refer to the input signal given in Question 1.b. For the same input, find the impulse response of the system that produces the following output: 7 (CO2) (PO1)

$$y(n) = \{-4, 11, -16, 23, -27, 29, -18, 9, -3\}$$

2. a) Explain why we prefer digital signal processing instead of directly performing analog signal processing using various devices like transistors, op-amps etc. 8 (CO1) (PO1)

b) Consider the following analog sinusoidal signal:

$$x_a(t) = 2\sin(200\pi t)$$

i. The signal is sampled with a sampling rate $F_s = 300$ samples/s. Determine the frequency and the fundamental period of the resulting discrete-time signal $x(n)$. 6 (CO2) (PO1)

ii. Find the minimum sampling rate $F_s$ for which the signal can reach its peak value of 2. 5 (CO2) (PO1)

c) A discrete-time signal given as $x(n) = 12.75\cos(\frac{\pi n}{10})$ is quantized with a resolution $\Delta = 0.1$. Find the minimum number of bits required for coding in the A/D converter. 6 (CO2) (PO1)

3. a) Suppose $x(n)$ is a signal with 64 points in the time domain.

i. Provide the justifications regarding the number of components and the number of points in each component in the frequency domain representation of $x(n)$. 6 (CO3) (PO2)

ii. Describe the different ways of representing the horizontal axis of the frequency domain, and also how to convert from one representation to another. 4 (CO3) (PO2)

iii. Explain why we usually select the number of samples $N$ in the time domain signal to be a power of 2. 4 (CO3) (PO2)

b) The following input-output pairs have been observed during the operation of a time-invariant system: 6 (CO2) (PO1)

$$x_1(n) = \{1, 0, 2\} \xrightarrow{\tau} y_1(n) = \{0, 1, 2\}$$

$$x_2(n) = \{0, 0, 3\} \xrightarrow{\tau} y_2(n) = \{0, 1, 0, 2\}$$

$$x_3(n) = \{0, 0, 0, 1\} \xrightarrow{\tau} y_3(n) = \{1, 2, 1\}$$

Here, the leftmost point is the origin for each of the signals and $\tau$ represents the system. Provide justifications regarding the linearity of the system.

c) Examine the following systems and determine whether they are static or dynamic, linear or nonlinear, time invariant or time variant, causal or noncausal, and, stable or unstable. 5 (CO1) (PO1)

i. $y(n) = \sum_{k=-\infty}^{n+1} x(k)$
ii. $y(n) = x(2n)$
iii. $y(n) = |x(n)|$
iv. $y(n) = x(n)\cos(\omega n)$
v. $y(n) = x(n) + nx(n+1)$