ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Department of Computer Science and Engineering (CSE)

MID SEMESTER EXAMINATION **SUMMER SEMESTER, 2019-2020**

DURATION: 1 Hour 30 Minutes **FULL MARKS: 75**

CSE 4631: Digital Signal Processing

Submit the answers of all the questions together upon completion of the exam. The images of the answer script must be clearly readable and in correct sequence.

There are 3 **(three)** questions. Answer all of them.

Figures in the right margin indicate marks.

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1. a) Provide a **conceptual definition** and a **mathematical definition** of a signal. What are the differences between **signal** and **system**. 2+2+4

   b) i) Why do we prefer digital signal processing instead of directly performing analog signal processing using various devices like transistors, op-amps etc.? 5+6

   ii) Prove that for a discrete-time sinusoid to be periodic, its frequency must be a rational number.

   c) Briefly describe one application of digital signal processing in each of the following fields: 2+2+2

   i) Telecommunication

   ii) Audio Processing

   iii) Echo location

2. a) Sketch the block diagram representation of the discrete-time sinusoid described as follows: 6

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

   b) i) Compute the convolution $y(n)$ and correlation $\gamma(n)$ where the input *x(n)* and impulse response *h(n)* are given as: 6+2

   x(n) = {1, 2, P, 3, 4, -2}

   h(n) = {-1, Q, -1}

   Here, *P* and *Q* are respectively the 1st and 2nd of the last two digits of your ID. For example, if your ID is 170041001, then *P = 0* and *Q = 1*. Also, here underline determines the origin sample.

   ii) Are the convolution and correlation results exactly the same?

   c) i) We know that the **impulse response** of a system is given as *h(n)*. Usually we define the output *y(n)* of a system in terms of its input and impulse response. Suppose the **step response** of that same system is defined as *s(n) = h(n)*u(n)*, where *u(n)* is the step function. Now, instead of using the input and impulse response, express the output *y(n)* of an LTI system in terms of the input *x(n)* and step response *s(n)*. 5+6

   ii) Three systems with impulse responses $h_1(n) = \delta(n) - \delta(n-1)$, $h_2(n) = u(n)$ and $h_3(n) = h(n)$ are connected in cascade. What is the impulse response of the overall system? Does the ordering of the interconnection affect the overall system in this case?

3. a) Consider the impulse response as given below: 10

$$h(n) = \begin{cases} 2^n, & 0 \le n \le 3 \\ 0, & elsewhere \end{cases}$$

   Determine the input sequence $x(n)$ for $0 \le n \le 6$ that will generate the output sequence $y(n) = \{1, 0, 4, 12, 6, 45, 26, -12, 8\}$

   b) i) If $x(n)$ is a 1024 point signal in the **time domain**, then what components and how many of them will we get in the **frequency domain** after performing DFT on it? 4+3+2

ii) Why do we usually select the number of samples **N** in the time domain signal to be a power of 2?

iii) Why do we have more components in the frequency domain than the number of points in the time domain signal? Where is this extra information coming from?

c) i) Suppose a discrete-time signal $x(n) = 10 \times ID \times \cos\left(\frac{\pi}{10}n\right)$ is quantized with a resolution of $\Delta = 0.1$. Here, ID is the value obtained by taking the last two digits of your student ID. For example, if your ID is 170041001, then you should consider $x(n) = 10 \times 1 \times \cos\left(\frac{\pi}{10}n\right) = 10\cos\left(\frac{\pi}{10}n\right)$. What is the minimum number of bits required for the ADC if you are performing analog to digital conversion? 4+2

ii) There are different ways of representing the horizontal axis of the frequency domain. In the first method, we use the sample number, k. And in the second method, we use the fraction of the sampling rate, f. Now suppose a 64 point signal in time domain is transformed to the frequency domain. What will be the fraction of the sampling rate for the 11^{th} sample in frequency domain?