B.Sc. Engg. CSE 6th Semester **14 January 2021**

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

MID SEMESTER EXAMINATION **SUMMER SEMESTER, 2020-2021**

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. Marks of each question and corresponding CO and PO are written in the right margin with brackets.

1.

a) Characterize the following signals in terms of whether they are – (1) one or multi-dimensional, (2) single or multi-channel, (3) analog or digital, and for each case, mention how many channels or dimensions the signal has and what those are. (3+3+3) (CO1) (PO1, PO2)

i. The signal that gets sent to the monitor from CPU over a period of time.

ii. The signal that gets sent to the CPU from a mouse at a particular time. Assume that the mouse only sends its position, and state of the left and right buttons.

iii. An accelerometer that reads acceleration along the three axes – x, y and z.

b) i. Why do we prefer digital signal processing instead of directly performing analog signal processing? (4+4) (CO1) (PO1, PO2)

ii. Can you always recreate any analog signal $x_a(n)$ after it has been digitized? Explain you answer.

c) What is the significance of Nyquist rate in reconstructing analog signals after it has been digitized? (4+4) (CO2) (PO2, PO3)

Consider the following analog signal,

$$x_a(t) = 5\cos 4000\pi t + 3\sin 7000\pi t + 8\cos 9000\pi t$$

i. What is the Nyquist rate for this signal?

ii. If the signal is sampled at $F_s = 3000$ samples/s. What is the discrete-time signal obtained after sampling?

2.

a) i. Why do we prefer to work with "linear" systems instead of nonlinear ones? (4+5) (CO1) (PO1, PO2)

ii. What is correlation and what is it primarily used for? How is it related to convolution?

b) A signal containing 720 points is convolved with a signal containing 64 points. (3+3) (CO2) (PO2, PO3)

i. What is the length of the output signal?

ii. How many samples are not useful/noisy in the output signal?

c) i. Given the signal, $x[n]=\{\widehat{4}, 3, 1, 7, -1, 2, P, Q\}$, where P and Q are respectively the first and last digit of your student ID. (3+7) (CO2) (PO2, PO3)

Now, resolve $x[n]$ as a sum of shifted and weighted/scaled impulse responses.

ii. Suppose, the signal from (i), $x[n]$, passes through the linear systems S1 and S2 placed in cascade like the figure below.

The impulse response of S1 is $h_{S1}[n]=\{1, \widehat{2}, -1\}$ and, the impulse response of S2 is $h_{S2}[n]=\{\widehat{3}, 2\}$. Now, find out $y[n]$.

3.

a) The following questions pertain to Discrete Fourier Transform - (5+4) (CO3) (PO2, PO4)

i. Why are basis functions picked in such a way so that if any two of them are multiplied elementwise, the sum of the samples of the resulting signal will be equal to zero?

ii. Why do we first scale the values of ReX and ImX before using them for synthesis. Why do the end points have a different scale than the rest?

b) i. DFT transforms a signal with N samples into a signal with N+2 samples. Where is this extra information coming from? (5+4) (CO1) (PO1, PO2)

iii. Is the impulse response for calculating first difference or discrete derivative causal? Justify your answer.

c) i. 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 32-point signal in time domain is transformed to the frequency domain. What will be the fraction of the sampling rate for the 7th sample in frequency domain? (4+3) (CO5) (PO5)

ii. Suppose, you have a signal in the frequency domain which has only one impulse in ReX. What will be the output of inverse DFT of this signal? Justify your answer.