ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Mid-Semester Examination
Course No.: EEE 4701
Course Title: Digital Signal Processing

Winter Semester, A. Y. 2022-2023
Time: 90 Minutes
Full Marks: 75

There are 3 **(three)** questions. Answer all 3 **(three)** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding COs and POs are written in the brackets.

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1. a) You are tasked with designing a digital audio recording system for a music studio. The analog audio signal from a microphone has a frequency range of 20 Hz to 20,000 Hz, and your objective is to ensure high-quality digital recordings without the aliasing effect. **15 (CO1, PO1)**

   i) Calculate the minimum required sampling frequency according to the Nyquist-Shannon sampling theorem to avoid aliasing in this scenario. Show your calculations and reasoning.

   ii) Given a chosen sampling frequency of 15,000 Hz for your recording system, discuss how aliasing could potentially occur. Explain how aliasing would noticeable during the sampling process with approximate frequency spectrum representation.

   iii) Propose modifications to your sampling strategy to prevent aliasing while still maintaining a practical balance between data size and signal quality. Justify your proposed changes.

   b) Describe the concept of negative frequency, and illustrate it using appropriate graphical representations. **10 (CO1, PO2)**

2. a) Elaborate on the concept of the Convolution Sum with the aid of graphical representations. To illustrate this concept, select three sampled arbitrary input signals and four sampled arbitrary impulse response signals. **15 (CO1, PO1)**

   b) Identify the nature of the system described below, indicating whether it is a time-variant or time-invariant system and justify with graphical representation: **10 (CO1, PO2)**

$$y(n) = \frac{n}{2}x(n-1)$$

3. a) Determine the response $y(n), n \geq 0$, of the system described by the second-order difference equation **15 (CO1, PO1)**

$$y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$$

When the input sequence is

$$x(n) = (-1)^n u(n)$$

You have the flexibility to select an appropriate initial condition for this problem.

   b) Determine the DTFT and draw the approximate magnitude and phase response for the following signal: **10 (CO1, PO2)**

$$x(n) = (0.5)^n \mathrm{u(n)}.$$