The Open University of Sri Lanka

Faculty of Engineering Technology

039

Department of Mechanical Engineering

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**DMX4411 Signal Processing**
Academic Year	:	2021/2022
Date	:	17th of February 2023
Time	:	09:30-12:30 Hrs.
Duration	:	**3 hours**

General Instructions

1. Read all instructions carefully before answering the questions

2. This question paper consists of **Seven (7)** questions in Four (4) pages.

3. Answer any **Five (5)** questions only. All questions carry equal marks.

4. Answer for each question should commence from a new page.

5. This is a Closed Book Test (**CBT**).

6. The symbols used in this paper have their usual meanings.

7. Clearly state any assumptions that you may make.

8. Answers should be in clear handwriting.

9. Do not use red color pen.

10. You are not allowed to use a programmable calculator.

11. Appropriate mathematical hints are provided in the end of the paper.

Question 01

    a. State and briefly explain the two types of classification of signals.   [2 marks]

    b. When we consider the analog to digital conversion of signals, two techniques are involved. Name them and describe each technique.   [2 marks]

    c. Briefly explain the following properties of a system.   [4 marks]

        i)   Causal System
        ii)   Linear system
        iii)   Time invariant System
        iv)   Memoryless System

d. Indicate whether the following systems are *causal, linear, time-invariant, and/or memoryless*. Justify your answer. [4x3 marks]

i) $y(t) = x(t/3)$

ii) $y(t) = x(t-2) + x(2-t)$

iii) $y(t) = \cos(x(t))$

Question 02

a. What is the difference between a periodic sigal and a non-periodic signal? [2 marks]

b. What are the condtions to be satisfied in order to be a periodic signal? [2 marks]

(Write appropriate expresseions for both continuous time signal and discrete time signal.)

c. Examine and state if the following signals are periodic or non-periodic. [16 marks]

i.) $x(t) = 3u(t) + 2\sin(2t)$

ii.) $x(t) = je^{j6t}$

iii.) $x[n] = \cos 4n$

iv.) $x[n] = 1 + e^{j(2\pi/3)n} - e^{j(4\pi/7)n}$

Question 03

a. Breifly explain the concept of convolution in respect to signals. [2 marks]

b. State four properties of convolution. [2 marks]

c. Find the convolution of following signals. [6 marks]

$x_1(t) = \cos t \ u(t)$ and $x_2 = u(t)$

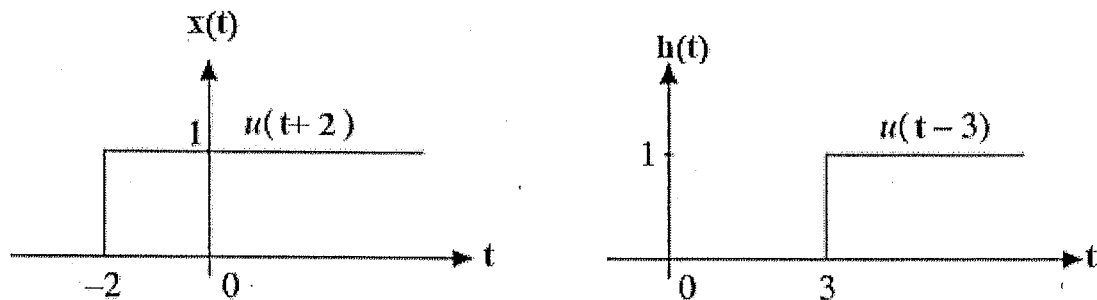d. Find the convolution of following signals using graphical method. [10 marks]

Figure 01

Question 04

a. Consider the DT (Discrete Time) system, $y[n] = x[2n]$.

For each property listed below, either prove that the property holds or not. Justify your answers. [3 marks]

i) Linearity

ii) Shift Invarience

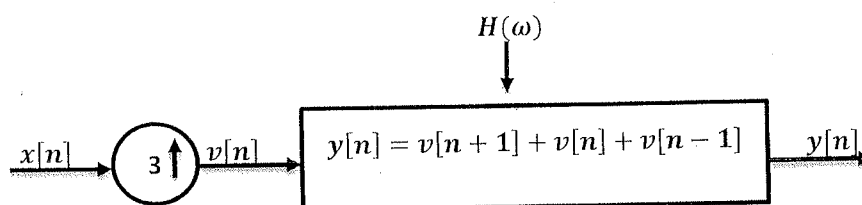iii) Causality

b. Consider system given below in figure 2.

$$H(\omega)$$

$$x[n] \rightarrow \boxed{3} \uparrow \xrightarrow{v[n]} \boxed{y[n] = v[n+1] + v[n] + v[n-1]} \xrightarrow{y[n]}$$

Figure 02

If the input x[n] is given by:

$$x[n] = (4 - n)(u[n] - u[n-4])$$

Plot,

    i.)   Input x[n]

    ii.)   Output y[n] if the input is given by: $x[n] = (4 - n)(u[n] - u[n-4])$

                                                                [9 marks]

c. Consider the waveform x(t) given in figure 03.

$$x(t)$$
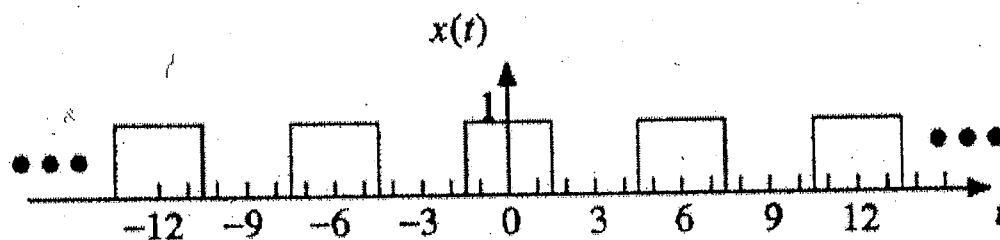

Figure 03

This signal is sampled at interval T=1 to generate the signal x[n].

    i.)   Plot the input signal x[n]

    ii.)   Suppose x[n] is input to the system $y[n] = \frac{1}{2}(x[n] + x[n-1])$. Plot the output signal y[n].

                                                                [8 marks]

Question 05

    a. Breifly explain the signal analysis method, "**Cross Correlation**".   [2 marks]

    b. Why is Fourier transform important than Fourier series in signal analysis?   [2 marks]

    c. What are conditions to be satisfied for the existence of Fourier transform?   [3 marks]

    d. Consider the signal $x[n]$ defined by;

$$x[n] = \begin{cases} & \text{for} \quad 0 \leq n \leq N \\ 0 & \text{otherwise} \end{cases}$$

    i.)   Plot the grapgh x[n].

    ii.)   Obtain the discrete time Fourier Transform $X(e^{j\omega})$ of $x[n]$ using first principles.

                                                                [13 marks]

Question 06

a. Why is frequency domain better than the time domain for signal analysis? [1 marks]

b. What information is needed in order to compute the output of a discrete-time LTI system? [2 marks]

c. State three important classes (forms) of Fourier Series methods available. [3 marks]

d. Consider the full wave rectified cosine wave given in figure 04.

    i.) Determine the Trigonometric Fourier series.

    ii.) Derive the corresponding Exponential Fourier Series.

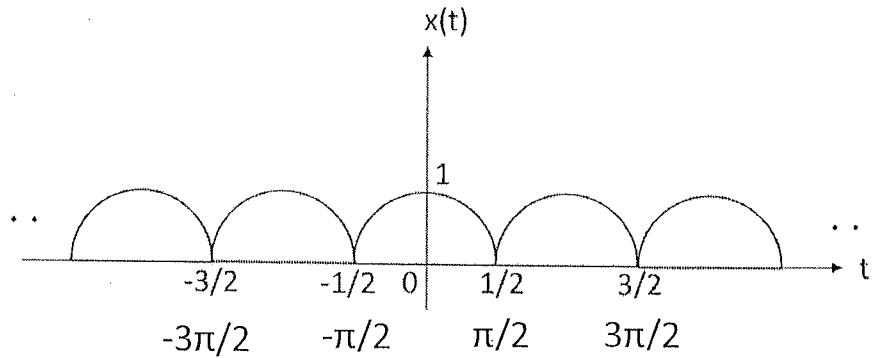   iii.) Find the Exponential Fourier Series directly.

[14 marks]

Figure 04

Question 07

a. Give the definition of the z-transform of a discrete-time signal x[n]. [2 marks]

b. What is meant by the region of convergence (ROC) in the context of the z-transform?

[2 marks]

c. Find the signal x[n] coresponig to Z transform given below. [6 marks]

$$X(z) = \frac{3}{(1 + z^{-1}) + (1 - \frac{1}{2}z^{-1})}$$

d. Find the Z transform and the ROC for $x[n] = a^n u[n]$ using first pricples, where a is a costant. [10 marks]

General Hints:

$$x^3 + 1 = (x+1)(x^2 - x + 1), \quad e^{j\pi/3} = \frac{1 + j\sqrt{3}}{2}$$

$$\sum_{n=0}^{\infty} x^n = \frac{1}{1-x} = 1 + x + x^2 + x^3 + \ldots\ldots$$

$$\sum_{n=0}^{\infty} nx^{n-1} = \frac{1}{(1-x)^2} = 1 + 2x + 3x^2 + 4x^3 + \ldots\ldots$$

$$\sum_{n=0}^{\infty} a^n = \frac{1 - \alpha^{N+1}}{1 - \alpha}$$

END