The Open University of Sri Lanka

Faculty of Engineering Technology

Department of Mechanical Engineering

Study Programme	:	Bachelor of Science Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**DMX4411 Signal Processing**
Academic Year	:	2022/2023
Date	:	17th of February 2024
Time	:	09.30-12.30
Duration	:	**3 hours**

General Instructions

1. Read all instructions carefully before answering the questions
2. This question paper consists of **Five (5) compulsory** questions in Three (3) pages.
3. All questions carry equal marks.
4. Answer to 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. Do not use a red pen.
10. You are not allowed to use a programmable calculator.
11. Appropriate mathematical hints are provided at the end of the paper.

Question 01

a. Briefly explain the difference between a signal and a system. [2 marks]

b. When processing a signal, it may undergo several manipulations involving the independent variable or the amplitude of the signal. List down four basic operations on signals and briefly describe two of them using appropriate examples. [6 Marks]

c. What conditions must be satisfied to classify a signal as an energy signal or a power signal? [2 marks]

d. Determine whether the following signals are energy signals or power signals and calculate their energy or power. [10 marks]

i.) $x(t) = sin^2(\omega_0 t)$

ii.) $x(t) = u(t)$

Question 02

a. What is meant by the fundamental period of a signal? (Define for both discrete and continuous time signals). [1 mark]

b. Determine whether the following signals are periodic or non-periodic? [8 marks]

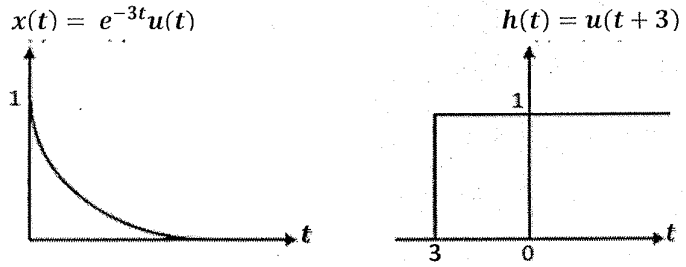
i.) $x(t) = 3\sin(200\pi t) + 4\cos(100t)$

ii.) $x(n) = \cos\frac{n}{6}\cos\frac{n\pi}{6}$

c. Write two factors that should be fulfilled by a system to become a linear system and determine whether the given system is a linear system. [3 marks]

$$y(n) = x(n)\cos(\omega n)$$

d. Convolution is a mathematical operation which is used to express the input-output relationship of an LTI system. Find the convolution of the given two signals x(t) and h(t) below using the graphical method. [8 marks]



Question 03

a. Define sampling frequency and state two basic conditions to be satisfied if x(t) is to be recovered from its samples? [2 mark]

b. What are the three important classes of Fourier series methods available and briefly describe two of them. [4 marks]

c. State Dirichlet's conditions. [2 marks]

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

d. Consider the waveform shown in Figure Q3.1 and answer the following questions.

i.) Obtain the exponential Fourier series.

ii.) Derive trigonometric Fourier series using exponential Fourier series.

iii.) Draw the frequency spectrum.

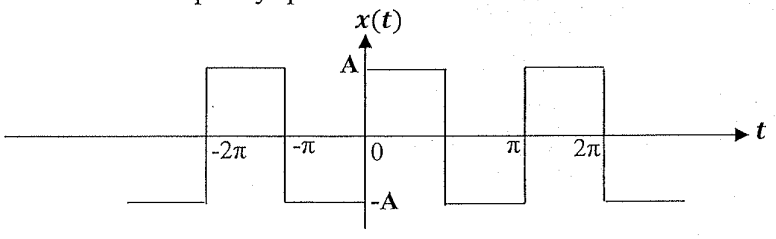


Figure Q3.1 [12 marks]

Question 04

a. How can Fourier transform be developed from Fourier series? [2 marks]

b. Find the Fourier transform of the signal x(t) shown in figure Q4.1. [8 marks]

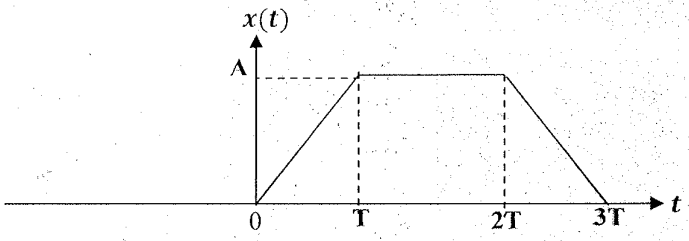


Figure Q4.1

c. List differences between Fourier transform of discrete time signals (DT) and analog signals (CT). [2 marks]

d. Find the discrete time Fourier transform (DTFT) of the following signals. [8 marks]

i.) $x(n) = \cos\frac{n\pi}{3}u(n)$

ii.) $x(n) = \left(\frac{1}{2}\right)^{n-2}u(n-2)$

Question 05

a. How are discrete time systems analyzed using Z-transform? [2 marks]

b. Define the ROC for the following cases. [2 marks]

i.) Infinite duration causal sequence.

ii.) Infinite duration non-causal sequence.

iii.) Infinite duration two-sided sequence.

iv.) Infinite duration two or more sequences.

c. Find the signal x[n] corresponding to Z transform given below. [8 marks]

$$X(z) = \frac{z^{-1}}{3 - 4z^{-1} + Z^{-2}}; \qquad ROC: |z| > 1$$

d. Find the Z transform of the following signal. [8 marks]

$$x(n) = n\left(\frac{1}{2}\right)^{n+2}u(n+2)$$

General Hints:

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

$$\sum_{n=1}^{\infty} nx^{n-1} = \frac{1}{(1-x)^2} = 1 + 2x + x3^2 + 4x^3 + \cdots$$

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

END