

The Open University of Sri Lanka
Faculty of Engineering Technology
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	: 2023/2024
Date	: 07 th of March 2025
Time	: 14.00 - 17.00 hrs
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 four (4) 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.
9. You are not allowed to use a programmable calculator.

Question 01

- a. What are the elementary or standard signals? Give two examples with appropriate diagrams.
(Show examples for both continuous time and discrete time signals) [3 marks]
- b. Indicate whether the following systems are **causal**, **linear**, **time-invariant**, and/or **memoryless**. Justify your answer. [9 marks]

i.) $y(t) = x(t - 2) + x(2 - t)$

ii.) $y(t) = [\cos(3t)]x(t)$

iii.) $y(t) = \int_{-\infty}^{2t} x(\tau) d\tau$

- c. What are the conditions to be satisfied in order to be a periodic signal? [2 marks]

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

- d. Examine whether the following signals are periodic or non-periodic. [6 marks]

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

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

Question 02

Convolution is a mathematical operation which is used to express the input-output relationship of a LTI system. It relates input and impulse response of the system to output.

- a. What are the properties of convolution (Use appropriate notations). [4 marks]
- b. Convolution of signals may be done either in time domain or frequency domain. Define two theorems of convolution associated with Frequency Transformation. [4 marks]
- c. Find the convolution of following signals using integral form. [6 marks]

$$x_1(t) = \cos t \quad u(t) \quad \text{and} \quad x_2 = u(t)$$

- d. Find the convolution of following signals using graphical method. [6 marks]

$$x(t) = u(t + 2) \quad \text{and} \quad h(t) = u(t - 3)$$

Question 03

- a. State three important classes (forms) of Fourier Series methods available. [4 marks]
- b. Consider the full wave rectified cosine wave given in Figure Q3.1. [8 marks]
- i.) Determine the Trigonometric Fourier series.
- ii.) Derive the corresponding Exponential Fourier Series.

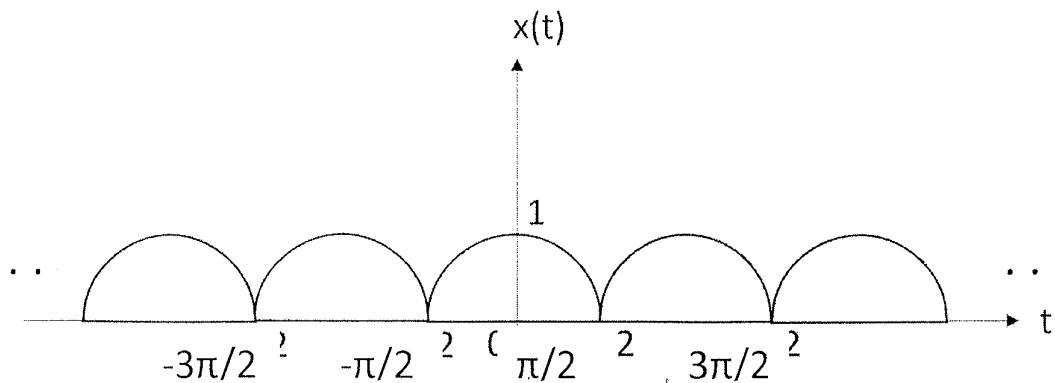


Figure Q3.1

- c. Write down the differences between the Fourier Transform of DT signals and CT signals. [2 marks]
- d. Find the frequency domain representation $X(\omega)$ of the following signal $x(t)$. [6 marks]

$$x(t) = \begin{cases} e^{-|t|}, & \text{for } -2 \leq t \leq 2 \\ 0, & \text{for other wise} \end{cases}$$

Hint:

$$\left. \begin{array}{l} e^{-(-t)} \text{ for } -2 \leq t \leq 0 \\ e^{-(t)} \text{ for } 0 \leq t \leq 2 \end{array} \right\} e^{-|t|}, \text{ for } -2 \leq t \leq 2$$

Question 04

An industrial control system's temperature sensor is creating loud output. Sampled at 1000 Hz, the analog signal from the sensor is transformed into a digital signal for handling. One uses a digital 3-point moving average filter to reduce high-frequency noise. The difference equation helps one to characterize the filter:

$$y[n] = \frac{1}{3} (x[n] + x[n-1] + x[n-2])$$

where $x[n]$ is the input sequence (sampled sensor data) and $y[n]$ is the output sequence (filtered data).

- Determine the impulse response $h[n]$ of this filter. [4 marks]
- Calculate the frequency response $H(e^{j\omega})$ of the filter using the DTFT. [5 marks]
- Sketch the magnitude response $|H(e^{j\omega})|$ for $0 \leq \omega \leq \pi$. [6 marks]
- If the sensor signal contains a significant noise component at 400 Hz, how effective will this filter be in reducing this noise? (Support your answer with calculations.) [5 marks]

Question 05

Z-transform is a powerful tool to convert the difference equations into algebraic equations.

- Write three advantages of use of Z-transform. [3 marks]
- Give 3 properties of ROC. [3 marks]
- Find the Z-transform of the given signal. [8 marks]

$$x(n) = (-1)^n 3^{-n} u(n)$$

- Find the signal $x[n]$ corresponding to Z transform given below. [6 marks]

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

General Hints

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

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

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

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

END