

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	: 2024/25
Date	: 01 st March 2026
Time	: 1330-1630h
Duration	: 3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Five (5)** questions in **three (3)** pages.
3. Answer **all** questions.
4. All questions carry equal marks.
5. Answer for each question should commence from a new page.
6. This is a Closed Book Test **(CBT)**.

Question 01

- a. Define the following types of elementary signals using appropriate waveform. (04 marks)
 - i.) Unit Impulse function
 - ii.) Unit Step function
 - iii.) Unit Ramp function
 - iv.) Unit Parabolic function
- b. Determine whether the following signals are periodic or aperiodic. If periodic, find the fundamental period. (04 marks)
 - i.) $x(t) = 3 \cos(4\pi t) + 2 \sin(6\pi t)$
 - ii.) $x[n] = \cos(\pi n/4)$
- c. Determine whether the following systems are linear, time-invariant, causal, and stable. Justify your answers. (12 marks)
 - i.) $y(t) = 3x(t) + 5$
 - ii.) $y[n] = x[n^2]$

Question 02

- a. Define Fourier Series and state three important classes of Fourier Series. (02 marks)
- b. A periodic signal $x(t)$ with period $T = 4$ seconds is defined as:

$$x(t) = \begin{cases} 2, & 0 \leq t < 2 \\ -2, & 2 \leq t < 4 \end{cases}$$

- i.) Sketch the signal for two complete periods. (01 marks)
- ii.) Find the Fourier Series of the signal $x(t)$ (06 marks)
- iii.) Write the Fourier Series representation up to third harmonic. (01 marks)
- c. Differentiate Fourier Series (FS) and Fourier Transform (FT) concepts. (02 marks)
- d. A rectangular pulse signal $x(t)$ is defined as:

$$x(t) = \begin{cases} A, & |t| \leq T/2 \\ 0, & \text{otherwise} \end{cases}$$

- i.) Sketch the signal $x(t)$ (01 marks)
- ii.) Find the Fourier Transform $X(\omega)$ of the signal $x(t)$ (04 marks)
- iii.) Draw the amplitude spectrum of the function $|X(\omega)|$ (02 marks)
- iv.) Draw the phase spectrum of the function $\angle X(\omega)$ (01 marks)

Question 03

- a. State the Nyquist sampling theorem and explain its significance in digital signal processing. (03 marks)
- b. Compare Discrete Fourier Transform (DFT), Discrete-time Fourier Transform (DTFT). (03 marks)
- c. Consider the continuous-time signal given below:

$$x(t) = 4 \cos(200\pi t) + 2 \cos(800\pi t)$$

The signal is sampled at $f_s = 1000$ Hz.

- i.) Find the discrete-time signal $x[n]$
- ii.) Determine the DTFT $X(e^{j\omega})$ of $x[n]$ (03 marks)
- iii.) Sketch the magnitude spectrum $|X(e^{j\omega})|$ for $-\pi \leq \omega \leq \pi$ (03 marks)
- (02 marks)
- d. Explain the process of the Analog to Digital conversion (ADC) using appropriate diagrams. (06 marks)

Question 04

- a. Define the following theorems of convolution. (02 marks)
- i.) Time Convolution Theorem
 - ii.) Frequency Convolution Theorem.
- b. Explain the concept of correlation in signal processing and define the two types of correlation. (04 marks)
- c. Consider the following two signals.

$$x(t) = e^{-3t}u(t)$$

$$h(t) = u(t + 3)$$

Find the convolution of signals $x(t)$ and $h(t)$ using:

- i.) Integral method (06 marks)
- ii.) Graphical Method (08 marks)

Question 05

- a. Compare Laplace Transform and Z Transform. (04 marks)
- b. Consider the following system.

$$X(z) = \frac{\left(\frac{1}{4}\right)z}{\left[1 - \left(\frac{1}{2}\right)z\right]\left[1 - \left(\frac{1}{4}\right)z\right]}$$

- i.) Draw the all-possible ROCs (Region of the Convergence). (03 marks)
 - ii.) Hence, determine all possible signals $x(n)$ associated with the above Z-transform. (06 marks)
- c. Consider the following sequence.

$$x[n] = 2\left(\frac{5}{6}\right)^n u(-1-n) + 3\left(\frac{1}{4}\right)^n u(n)$$

- i.) Find the Z transform of $x[n]$ and ROC (05 marks)
- ii.) Draw the corresponding pole-zero plot (02 marks)

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