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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	: 2020/2021
Date	: 18th February 2022
Time	: 1400-1700 hrs
Duration	: **3 hours**

1. Read all instructions carefully before answering the questions
2. This question paper consists of **Seven (7)** questions in Six (6) 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. Scientific calculators are allowed.

Question 1 **[20 marks]**

a) Explain the following in brief

i. Continuous time and discrete time signals. [2 marks]

ii. Analog and digital signals. [2 marks]

iii. Periodic and Aperiodic signals. [2 marks]

b) Sketch the graphs for the following:

i. Analog, continuous-time signal. [2 marks]

ii. Digital, continuous-time signal. [2 marks]

iii. Analog, discrete-time signal. [2 marks]

iv. Digital, discrete-time signal. [2 marks]

c) An exponential function $f(t) = e^{-2t}$ shown in Fig.Q1 is delayed by 1second. Sketch and mathematically describe the delayed function. Repeat the problem if $f(t)$ is advanced by one second. [6 marks]

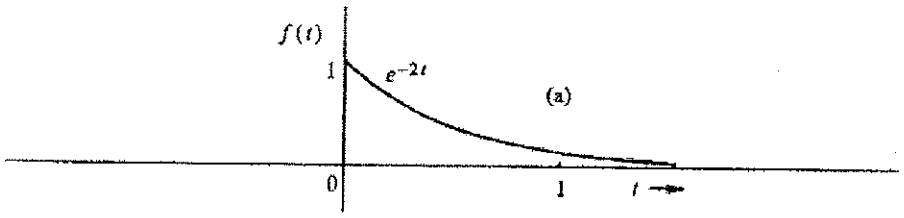

Fig.Q1

Question 2 **[20 marks]**

a) List down five classifications of systems. [3 marks]

b) What does mean by a discrete time system? Represent it in the form of a block diagram and a mathematical expression. [4 marks]

c) Explain the concept of linearity. [3 marks]

d) The unit impulse response *h(t)* of a Linear time invariant continuous system (LTIC) is described by the nth order differential equation given by,

$$h(t) = b_n\delta(t) + [P(D)y_n(t)]u(t),$$

where b_n is the coefficient of the nth order term in P(D) and $y_n(t)$ is a linear combination of the characteristic modes of the system subjected to following initial conditions.

$$y_n^{(n-1)}(0) = 1, \quad \text{and} \quad y_n(0) = \dot{y}_n(0) = \ddot{y}_n(0) = \cdots = y_n^{(n-2)}(0) = 0$$

$$n = 1: \; y_n(0) = 1$$

$$n = 2: \; y_n(0) = 0 \text{ and } \dot{y}_n(0) = 1$$

$$n = 3: \; y_n(0) = \dot{y}_n(0) = 0 \text{ and } \ddot{y}_n(0) = 1$$

$$n = 4: \; y_n(0) = \dot{y}_n(0) = \ddot{y}_n(0) = 0 \text{ and } \dddot{y}_n(0) = 1$$

Determine the unit impulse response $h(t)$ for a system specified by the following equation.

i. $(D^2 + 3D + 2)y(t) = Df(t)$ [5 marks]

ii. $(D + 2)y(t) = (3D + 5)f(t)$ [5 marks]

Question 3 **[20 marks]**

a) List down five general convolution properties with their respective equations. [10 marks]

b) Consider the convolution problem that involves shifted signals as presented in Fig.Q3. Find the convolution of the shifted signal $f_1(t + 1)$ and the signal $f_2(t)$. Let $f(t + 1)$ represent the convolution of $f_1(t + 1)$ and $f_2(t)$. Obtain the convolution through the regular convolution procedure with $f_1(t + 1)$ and $f_2(t)$. State the convolution process graphically for the given signals and state the convolution in each appropriate time intervals. [10 marks]

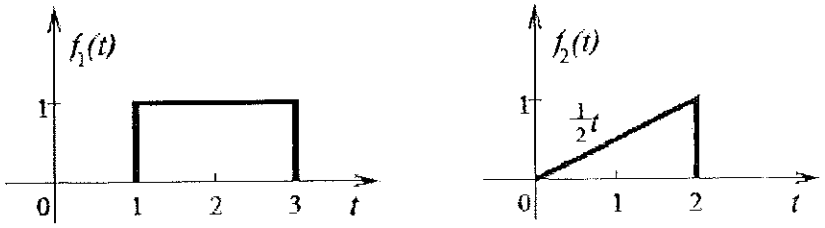

Fig.Q3

Question 4 **[20 marks]**

a) Briefly discuss the difference between the Fourier series and Fourier transformation. [3 marks]

b) If *x(t)* is a periodic signal with a fundamental period of T_0, write an expression for the Complex Exponential Fourier series and Trigonometric Fourier series. [3 marks]

c) The compact trigonometric Fourier series is the combination of sine and cosine terms of the same frequency in the trigonometric Fourier series to obtain a single sinusoid of the same frequency.

$$f(t) = C_0 + \sum_{n=1}^{\infty} C_n \cos(n\omega_o t + \theta_n) \qquad t_1 \le t \le t_1 + T_0$$

Where,

$$C_n = \sqrt{{a_n}^2 + {b_n}^2}$$

$$\theta_n = \tan^{-1}\left(\frac{-b_n}{a_n}\right)$$

Find the compact trigonometric Fourier series for the exponential $e^{-t/2}$ depicted in the Fig.Q4 over the shaded interval $0 \le t \le \pi$. [5 marks]

d) Explain the relation between the Fourier transform and the Z-transform using proper expressions. [4 marks]

e) Briefly explain the process of Amplitude modulation with graphical examples of modulation. [5 marks]

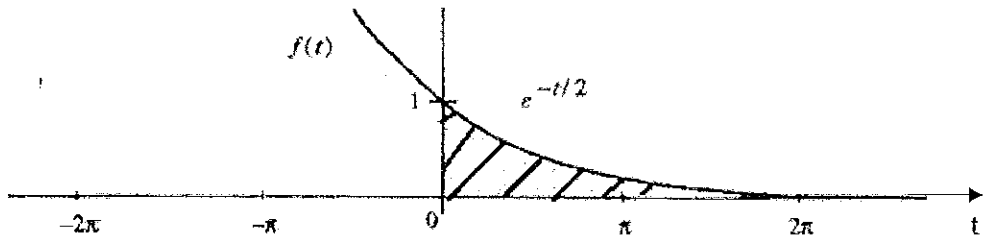

Fig.Q4

Question 5 **[20 marks]**

a) Write down the expression for the following, for a periodic sequence x[n] with a fundamental period No. [6 marks]

i. Discrete Fourier series representation.

ii. Duality property of Discrete Fourier series.

iii. Parseval's Theorem.

b) Find the discrete time Fourier series for the periodic sampled gate function shown in Fig.Q5. [5 marks]

c) Find the discrete-time Fourier series (DTFS) and sketch their spectra $|D_r|$ and $<D_r$ for $0 \leq r \leq N_0 - 1$ for the following periodic signal.

$$f[k] = 4cos2.4xk + 2sin3.2\pi k$$

Hint: Reduce frequency to the fundamental range ($0 \leq \Omega \leq 2\pi$). The fundamental frequency Ω_0 is the largest number of which the frequency appearing in the Fourier series are integral multiplies. [9 marks]

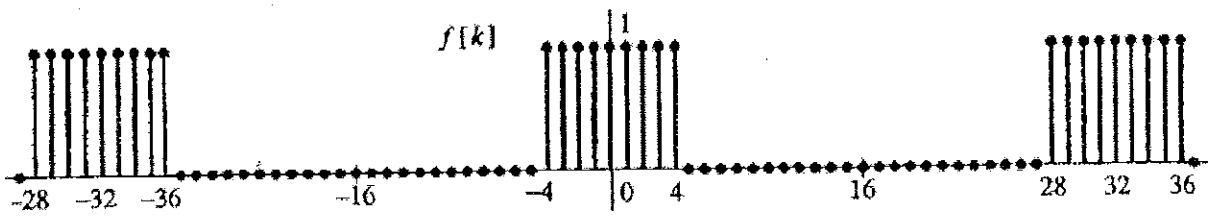

Fig.Q5

Question 6 **[20 marks]**

a) A sampling of a signal is done in several ways. Basically, there are three types of sampling techniques. Name and briefly explain the main three sample techniques. [6 marks]

b) Compare the sampling techniques among four sampling parameters. [4 marks]

c) Explain the applications of sampling theorem. [2 marks]

d) List down the advantages of digital signals over analog signals. [2 marks]

e) Calculate the Nyquist rate and the Nyquist interval for the following [6 marks]

i. $x(t) = 4\sin(30\pi t) + 3\cos(70\pi t)$
ii. $x(t) = 8\sin(50\pi t)$
iii. $x(t) = \sin(500\pi t)/\pi t$

Question 7 **[20 marks]**

a) Discuss the digital filtering capabilities with proper expressions and graphical representation of available filter types. [10 marks]

b) Explain briefly the following;

i. Band-limited signal. [5 marks]
ii. Absolute bandwidth. [5 marks]

End of the paper