Kirinyaga University

UNIVERSITY EXAMINATION 2021/2022

EXAMINATION FOR THE DEGREE OF BACHELOR OF

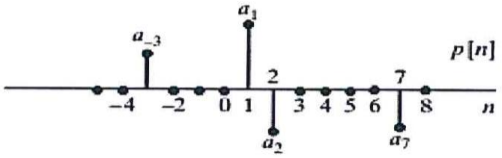
EEE 2429 DIGITAL SIGNAL PROCESSING YEAR IV SEMESTER II

Date: Wednesday 15th June 2022 **Time: 8.30 am – 10.30 am**

Question One

a) Define the term causality in digital signal processing. **(2marks)**

b) An impulse sequence $p[n]$ is represented as a sum of scaled, delayed impulses as shown in the figure below.



Based on the sequence impulses in the figure, write the mathematical expression representing this sequence as a sum of scaled, delayed impulses. **(3 marks)**

c) Consider the signal $x_1[n] = cos((\pi n + N)/4)$. Show that for this signal to be defined as a discrete-time periodic signal, then $N = 8$. **(3 marks)**

d) (i). Define what a memoryless system is. **(2 marks)**

(ii). For each of the signals (1) and (2) below, explain why it is either

$$y[n] = x[n - n_d], \qquad -\infty < n < \infty, \qquad (1)$$

and

$$y[n] = \frac{1}{M_1 + M_2 + 1} \sum_{k=-M_1}^{M_2} x[n-k] \qquad -\infty < n < \infty, \quad (2)$$

a memoryless system or memory system. If it is not memoryless systems, explain the condition the signal must fulfill to make it memoryless **(4 marks)**

e) (i) Using the addictive and scaling properties, show that a linear system must have these two properties. **(4 marks)**

(ii) Mathematically prove that a system with the equation $w[n] = log_{10}(|x[n]|)$ is **not** linear. **(4 marks)**

f) Calculate the z-transform of the following finite duration signal? **(3 marks)**

$$x(n)=\{2,4,5,7,0,1\}?$$
$$\uparrow$$

g) Give the difference equation of an FIR filter with length M with input $x[n]$ and output $y[n]$. **(3 marks)**

h) Differentiate between FIR and IIR filters **(2 marks)**

Question Two

a) The input-output relationship of a finite impulse response filter is given as

$$y(m) = x(m) - 2.5x(m-1) + 5.25x(m-2) - 2.5x(m-3) + x(m-4)$$

(i) Write the z-transfer function of this filter **(3 marks)**

(ii) Show that the filter has a linear phase response. **(5 marks)**

(iii) Find and plot the zeros of this filter and explain the constraints on the position of the zeros of a linear phase filter. **(4 marks)**

b) Using Z-transform, determine the response of the LTI system described by $y(n) - 2rcosy(n-1) + r^2y(n-2) = x(n)$ to an excitation $x(n) = a^n u(n)$ **(8 marks)**

Question Three

a) Define convolution and state at least two of its properties. **(4 marks)**

b) Sketch and give the mathematical expression representation the following discrete signals. **(8 marks)**

(i) Impulse sequence

(ii) Unit Step sequence

(iii) Sinusoidal sequence

(iv) Exponential sequency

c) Find the convolution of the two signals $f(t) = e^{-t}$ and $g(t) = \sin(t)$. **(8 Marks)**

Question Four

The discrete-time system is represented by the following transfer function:

$$H(z) = \frac{3z^3 - 5z^2 + 9z - 3}{[2 - (1/2)][z^2 - z + (1/3)]}$$

a) Calculate its direct form -I realization of the IIR system and draw its structure. **(10 marks)**

b) Calculate its direct form -II realization of the IIR system and draw its structure. **(10 marks)**

Question Five

a) Explain two differences and two similarities between decimation-in-time (DIT) and decimation in frequency (DIF) algorithms. **(8 marks)**

b) Using two figures, show the difference between an 8-point DFT using DIT and DIF algorithm and explain the differences. **(12 marks)**