EE 4015 Digital Signal Processing

Semester A 2022-2023

Assignment 1

"It is not that I'm so smart. But I stay with the questions much longer." ~ Albert Einstein

Due Date: 11:00PM, Oct. 4, 2022 (Week 6)

1. Find the Continuous-Time Fourier Series coefficients for the following continuous-time signal:

$$x(t) = \begin{cases} 1, & 1 > t > 0 \\ 2, & 2 > t > 1 \end{cases}$$

with fundamental period of $T = 2$. [10 marks]

2. Compute the Continuous-Time Fourier Transform of $x(t) = e^{-2|t-1|}$.

[10 marks]

3. Consider a discrete-time system with input $x[n]$ and output $y[n]$, which is related by the following equation:

$$y[n] = x[n]x[n-1] - 3x[n+2]$$

(a) Is the system causal? Explain your answer. [3 marks]

(b) Is the system linear? Explain your answer. [3 marks]

(c) Is the system time-invariant? Explain your answer. [3 marks]

(d) Is the system stable? Explain your answer. [3 marks]

(e) Determine $y[n]$ when the input is $x[n] = 2u[n-2] + u[n-1]$. Write down the values of $y[0]$, $y[1]$, $y[2]$, and $y[3]$. [8 marks]

4. Consider two discrete-time signals $x[n] = u[-1-n]$ and $h[n] = (0.5)^n u[n]$, and compute $y[n] = x[n] * h[n]$ using the convolution formula.

[10 marks]

5. Let $x[n] = \{1,4,0,2\}$ and $h[n] = \{1,2,1\}$. Find their convolution with both of the sequence start at $n = 0$.

[10 marks]

6. Given a continuous-time signal:

$$x(t) = \sin\left(\frac{\pi}{2}t\right)$$

We sample it with a sampling period $T = 1$ sec. to produce the discrete-time signal $x[n]$. Find $x[0]$, $x[1]$, $x[2]$, $x[3]$ and $x[4]$. Is $x[n]$ a periodic signal?

[10 marks]

7. Figure 1 shows a discrete-time system which consists of an interconnection of four LTI systems with impulse responses $h_1[n], h_2[n], h_3[n]$, and $h_4[n]$. Determine the overall impulse response of the system, $h[n]$, in terms of $h_1[n], h_2[n], h_3[n]$, and $h_4[n]$.

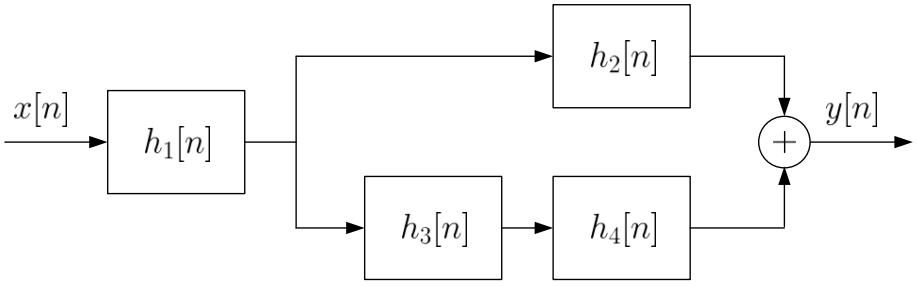

Figure 1

[10 marks]

8. For an analog signal of $x(t) = 3\cos(70\pi t)$, find the Nyquist sampling rate in Hz and also determine the discrete-time angular frequency and the discrete-time signal $x[n]$ mathematical expression of $x(t)$ sampled at the Nyquist rate.

[10 marks]

9. A difference equation for a particular discrete-time system is given by

$$y[n] = 0.1x[n] - 0.1x[n-1] + 0.8x[n-3] + 0.1x[n-4] + 0.6x[n-6]$$

Find the impulse response of the system.

[10 marks]