UNIVERSITI TENAGA NASIONAL
The National Energy University

COLLEGE OF ENGINEERING
PUTRAJAYA CAMPUS
FINAL EXAMINATION

SEMESTER 2, 2018 / 2019

PROGRAMME	:	Bachelor of Electrical & Electronic Engineering (Honours) / Bachelor of Electrical Power Engineering (Honours) / Bachelor of Computer and Communication Engineering (Honours).
SUBJECT CODE	:	EEEB 363
SUBJECT	:	Digital Signal Processing
DATE	:	January/February 2019
DURATION	:	3 Hours

INSTRUCTIONS TO CANDIDATES:

1. This paper contains **SIX (6)** questions.
2. Answer **ALL** questions.
3. Write all answers in the answer booklet provided.
4. Write answer to each question on a new page.

THIS QUESTION PAPER CONSISTS OF FIVE (5) PRINTED PAGES INCLUDING THIS COVER PAGE

QUESTION 1 [20 MARKS]

A digital signal processing system is described by the finite impulse response, $h[n]$, shown in Figure 1.

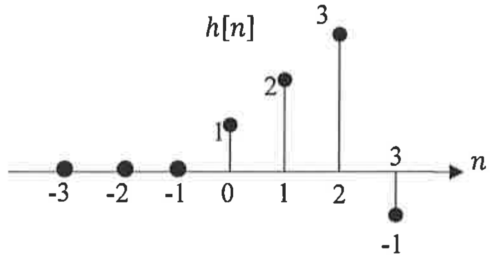

Figure 1: The finite impulse response of the system of Question 1.

The signal $x[n]$ below is provided as the input sequence to the system above.

$$x[n] = \{\ 1,\ 3,\ -2,\ 4\ \}; \qquad 0 \leq n \leq 3.$$

(a) Express $x[n]$ in terms of the unit step sequence, $u[n]$. **[3 marks]**

(b) Determine both the even **AND** odd parts of the sequence, $x[n]$. **[4 marks]**

(c) Evaluate the auto-correlation sequence of $x[n]$. **[4 marks]**

(d) Evaluate output sequence, $y[n]$ using linear convolution of $x[n]$ and $h[n]$. **[5 marks]**

(e) Determine the total energy of $y[n]$. **[2 marks]**

(f) Determine the Discrete-Time Fourier Transform (DTFT) of $y[n]$. **[2 marks]**

QUESTION 2 [15 MARKS]

(a) Describe three effects of sampling in the frequency domain. **[3 marks]**

(b) A continuous-time signal, $x(t)$ is composed of a linear combination of cosine signals with frequencies $300Hz$, $500Hz$ and $1.2KHz$. The signal $x_a(t)$ is sampled at $2kHz$ rate and the sampled sequence is passed through an ideal highpass filter with a cut-off frequency of $1.5KHz$ generating a continuous-time signal, $y_a(t)$. In your calculation, please assume the k value is $-1 \leq k \leq 1$.

(i) Describe the process of above system in diagram form. **[2 marks]**

(ii) What are the frequency components present in the reconstructed signal, $y_a(t)$. **[10 marks]**

QUESTION 3 [15 MARKS]

(a) The following five samples of a 9-point DFT $X[k]$ of a real length-9 sequence are given:

$$X[0] = 11$$
$$X[2] = 1.2 - j2.3$$
$$X[3] = -7.2 - j4.1$$
$$X[5] = -3.1 + j8.2$$
$$X[8] = 4.5 + j1.6$$

Determine the remaining 4 samples. **[5 marks]**

(b) Compute the DFT of two real sequences each of length-4 below:

$$g[n] = \{\ 2, -1,\ 3,\ 0\}; \quad 0 \leq n \leq 3$$

$$h[n] = \{-2,\ 4,\ 2, -1\}; \quad 0 \leq n \leq 3$$

[10 marks]

QUESTION 4 [20 MARKS]

(a) When selecting filters for an application, compare between finite impulse response (FIR) and infinite impulse response (IIR) filters. Your discussion should focus on the phase response and the number of coefficients.

[4 marks]

(b) Several electrical motors in your building has been malfunctioning lately. One of your engineers analysed some readings from a spectrum analyser and discovered that there are noise in the power supply which may have caused these malfunctions. Your engineer proposes to install a highpass digital filter with a stopband magnitude of $|H(e^{j\omega})| \le 0.02$ for frequencies from DC until 40 Hz, and a passband magnitude of $0.95 \le |H(e^{j\omega})| \le 1.05$ for frequencies 50 Hz and above. The digital filter has a sampling frequency of 200 Hz.

(i) According to the specifications mentioned above, sketch the expected graph / tolerance diagram of its magnitude response $|H(e^{j\omega})|$ versus normalized angular frequency ω. Carefully label the gains, passband edge frequency, stopband edge frequency, passband and stopband frequency range. **[4 marks]**

(ii) Select a suitable window type that complies with the filter requirements. Then design a linear phase FIR filter to meet these specifications. **[12 marks]**

QUESTION 5 [10 MARKS]

Draw the realization for the IIR filter with the transfer function $H(z)$ in the following two forms. Maximum marks are awarded for implementation with the least number of components.

$$H(z) = \frac{(1 - z^{-1} + 0.2z^{-2})(1 - 0.6z^{-1})}{(1 - 0.25z^{-1})(1 + 0.5z^{-1} - 0.1z^{-2})}$$

(a) Direct form. **[5 marks]**

(b) Cascade form. **[5 marks]**

QUESTION 6 [20 MARKS]

(a) An LTI system has the transfer function:

$$H(z) = \frac{2}{1 - 0.9\, e^{j\frac{\pi}{4}} z^{-1}} + \frac{2}{1 - 0.9\, e^{-j\frac{\pi}{4}} z^{-1}} + \frac{3}{1 - 2\, z^{-1}}$$

(i) Sketch the poles and zeros of the system above on a z-plane. **[3 marks]**

(ii) If the system above is **STABLE**, find the impulse response. **[4 marks]**

(iii) If the system above is **CAUSAL**, find the impulse response. **[4 marks]**

(iv) Can this system be both stable and causal? Explain. **[2 marks]**

(b) The impulse response of an LTI system is:

$$h[n] = \{\ 0.5, -0.5, 0.8, 0.1, 0.8, -0.5, 0.5\ \}; \qquad 0 \le n \le 6$$

(i) Is this system causal? Is it linear-phase? Explain your answer. **[2 marks]**

(ii) Determine the group delay of this system. **[3 marks]**

(iii) Determine the poles of this system. **[2 marks]**

-END OF QUESTION PAPER-