UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF MARINE ENGINEERING TECHNOLOGY

FINAL EXAMINATION
JANUARY 2017 SEMESTER

COURSE CODE	:	LEB40403
COURSE NAME	:	DIGITAL SIGNAL PROCESSING
PROGRAMME NAME (FOR MPU: PROGRAMME LEVEL)	:	BACHELOR OF ENGINEERING TECHNOLOGY (HONS) IN MARINE ELECTRICAL AND ELECTRONIC
DATE	:	11/07/2017 TUE
TIME	:	9.00 AM - 12.00 PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read CAREFULLY the instructions given in the question paper.
2. This question paper has information printed on both sides.
3. This question paper consists of FIVE (5) questions. Answer FOUR (4) questions only.
4. Please write yours answers on the answer booklet provided.
5. Write your answers only in BLACK or BLUE ink.
6. Answer all questions in English.

THERE ARE 7 PAGES OF QUESTIONS, EXCLUDING THIS PAGE.

INSTRUCTION: Answer FOUR (4) questions ONLY.
Please use the answer booklet provided.

Question 1(CLO 1 & CLO 2)

(a) Sketch the following sequences:

i. $x(n) = 3\delta(n+2) - 0.5\delta(n) + 5\delta(n-1) - 4\delta(n-5)$

(2 marks)

ii. $x(n) = \delta(n+1) - 2\delta(n-1) + 5u(n-4)$

(2 marks)

(b) Based on Figure Q1, write down the output signals of the adders.

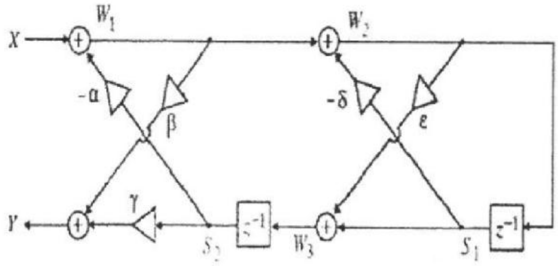

Figure Q1

(4 marks)

(c) A 3-tap FIR-low pass filter has a cut-off frequency of 800Hz and a sampling rate of 8000Hz.

i. Calculate the filter coefficients by using the Fourier transform method.

(4 marks)

ii. Determine the transfer function and difference equation of the designed FIR system.

(4 marks)

iii. Determine the frequency (f), $H(e^{j\Omega})$, $|H(e^{j\Omega})|$, $|H(e^{j\Omega})|dB$, and $\angle H(e^{j\Omega})_{degree}$ and place your answer in Table 1. You are required to copy Table 1 in your answer booklet.

Table 1

Ω(radians)	Frequency(f)	$H(e^{j\Omega})$	$\|H(e^{j\Omega})\|$	$\|H(e^{j\Omega})\|dB$	$\angle H(e^{j\Omega})_{degree}$
0					
3π/4					
π					

(9 marks)

Question 2(CLO 1 , CLO 2 & CLO 3)

(a) Using the sequence definitions, evaluate the digital convolution up to y (4).

$$x(k)=\begin{cases}-2, & k=0,1,2\\ 1, & k=3,4\\ 0 & elsewhere\end{cases} \quad and \quad h(k)=\begin{cases}2, & k=0\\ -1, & k=1,2\\ 0 & elsewhere\end{cases}$$

i. Using the graphical method.

(6 marks)

ii. Using the table method.

(3 marks)

iii. Applying the convolution formula directly.

(6 marks)

(b) Design a Butterworth IIR digital bandpass filter for a given specifications:

$$\omega_{p1}=0.45\pi\ ,\ \omega_{s1}=0.3\pi\ ,\omega_{s2}=0.75\pi\ ,\alpha_p=1\ dB\ \ ,\alpha_s=0.40dB\ ,B_w=0.78$$

(10 marks)

Question 3(CLO 2& CLO 3)

(a) Design a 3-tap FIR low-pass filter with a cut-off frequency of 800Hz and a sampling rate of 8000 Hz using the Hamming window function.

(13 marks)

(b) Determine the frequency (f), $H(e^{j\Omega})$, $|H(e^{j\Omega})|$, $|H(e^{j\Omega})|dB$, and $\angle H(e^{j\Omega})_{\text{degree}}$ and place your answer in Table 2. You are required to copy Table 2 in your answer booklet.

Table 2

Ω(radians)	Frequency(f)	$H(e^{j\Omega})$	$\lvert H(e^{j\Omega})\rvert$	$\lvert H(e^{j\Omega})\rvert dB$	$\angle H(e^{j\Omega})_{\text{degree}}$
0					
π/4					
π/2					
3π/4					
π					

(9 marks)

(c) Sketch the magnitude frequency response and the phase response based on your answer in Q3 (b).

(3 marks)

Question 4(CLO 1 , CLO 2 & CLO 3)

(a) Give a brief comparison between passband and stopband.

(4 marks)

(b) Determine the inverse z-transform for the following transfer function.

i. $X(z) = \frac{1}{(1-z^{-1})(1-0.5z^{-1})}$

(5 marks)

ii. $Y(z) = \frac{z^2(z+1)}{(z-1)(z^2-z+0.5)}$

(6 marks)

(c) A causal LTI IIR digital filter is characterized by a constant coefficient difference equation given by :

$$y[n] = x[n-1] - 1.2x[n-2] + x[n-3] + 1.3y[n-1] - 1.04y[n-2] + 0.222y[n-3]$$

i. Determine the rational function of H(z) in z^{-1} ,z and in the factored form.

(6 marks)

ii. Sketch the pole-zero of the IIR transfer function.

(3 marks)

iii. List the ROC of the transfer function.

(1 marks)

Question 5(CLO 1 , CLO 2 & CLO 3)

(a) Determine the z-transform for each of the following sequences:

i. $x(n) = 10\sin(0.25\pi n)\,u(n)$

(2 marks)

ii. $x(n) = e^{-0.1n}\cos(0.25\pi n)u(n)$

(2 marks)

(b) Design a Type 1 Chebyshev IIR digital high pass filter for a given specifications:

$$F_p = 700Hz\,, F_s = 500Hz\,, \alpha_p = 1dB, \qquad F\alpha_s = 32dB\,, F_T = 2kHz$$

(6 marks)

(c) The realizations of a third-order IIR transfer function is given by:

$$H(z) = \frac{0.44z^2 + 0.362z + 0.02}{z^3 + 0.4z^2 + 0.18z - 0.2}$$

i. Determine the cascade realization based on direct form II realization of each section.

(5 marks)

ii. Determine parallel form II realization.

(5 marks)

iii. Sketch the answer in Q5(c)(ii).

(5 marks)

END OF EXAMINATION PAPER

APPENDIX I

Table of z-transform pairs

x(n)	X(z)	ROC
$-a^n u(-n-1)$	$\frac{1}{1-az^{-1}}$	$\|z\|<\|a\|$
$-na^n u(-n-1)$	$\frac{az^{-1}}{(1-az^{-1})^2}$	$\|z\|<\|a\|$

x(n)	X(z)	ROC
$\delta(n)$	1	$All\ z$
$u(n)$	$\frac{1}{1-z^{-1}}$	$\|z\|>1$
$a^n u(n)$	$\frac{1}{1-az^{-1}}$	$\|z\|>\|a\|$
$na^n u(n)$	$\frac{az^{-1}}{(1-az^{-1})^2}$	$\|z\|>\|a\|$

x(n)	X(z)	ROC
$(\cos\omega_0 n)u(n)$	$\frac{1-z^{-1}\cos\omega_0}{1-2z^{-1}\cos\omega_0+z^{-2}}$	$\|z\|>1$
$(\sin\omega_0 n)u(n)$	$\frac{1-z^{-1}\sin\omega_0}{1-2z^{-1}\cos\omega_0+z^{-2}}$	$\|z\|>1$
$(a^n\cos\omega_0 n)u(n)$	$\frac{1-az^{-1}\cos\omega_0}{1-2az^{-1}\cos\omega_0+a_2z^{-2}}$	$\|z\|>\|a\|$
$(a^n\sin\omega_0 n)u(n)$	$\frac{1-az^{-1}\sin\omega_0}{1-2az^{-1}\cos\omega_0+a_2z^{-2}}$	$\|z\|>\|a\|$

APPENDIX II

TABLE 5.2 Properties of z-transform.

Property	Time Domain	z-Transform
Linearity	$ax_1(n) + bx_2(n)$	$aZ(x_1(n)) + bZ(x_2(n))$
Shift theorem	$x(n-m)$	$z^{-m}X(z)$
Linear convolution	$x_1(n) * x_2(n) = \sum_{k=0}^{\infty} x_1(n-k)x_2(k)$	$X_1(z)X_2(z)$

APPENDIX III

TABLE 7.1 Summary of ideal impulse responses for standard FIR filters.

Filter Type	Ideal Impulse Response $h(n)$ (noncausal FIR coefficients)
Lowpass:	$h(n) = \begin{cases} \frac{\Omega_c}{\pi} & n = 0 \\ \frac{\sin(\Omega_c n)}{n\pi} \text{ for } n \neq 0 & -M \leq n \leq M \end{cases}$
Highpass:	$h(n) = \begin{cases} \frac{\pi - \Omega_c}{\pi} & n = 0 \\ -\frac{\sin(\Omega_c n)}{n\pi} \text{ for } n \neq 0 & -M \leq n \leq M \end{cases}$
Bandpass:	$h(n) = \begin{cases} \frac{\Omega_H - \Omega_L}{\pi} & n = 0 \\ \frac{\sin(\Omega_H n)}{n\pi} - \frac{\sin(\Omega_L n)}{n\pi} \text{ for } n \neq 0 & -M \leq n \leq M \end{cases}$
Bandstop:	$h(n) = \begin{cases} \frac{\pi - \Omega_H + \Omega_L}{\pi} & n = 0 \\ -\frac{\sin(\Omega_H n)}{n\pi} + \frac{\sin(\Omega_L n)}{n\pi} \text{ for } n \neq 0 & -M \leq n \leq M \end{cases}$

Causal FIR filter coefficients: shifting $h(n)$ to the right by M samples.

Transfer function:

$H(z) = b_0 + b_1 z^{-1} + b_2 z^{-2} + \cdots + b_{2M} z^{-2M}$,

where $b_n = h(n - M)$, $n = 0, 1, \ldots, 2M$

APPENDIX IV

TABLE 5.3 Partial fraction(s) and formulas for constant(s).

Partial fraction with the first-order real pole: $\frac{R}{z-p}$	$R = (z-p)\frac{X(z)}{z}\Big\vert_{z=p}$
Partial fraction with the first-order complex poles: $\frac{Az}{(z-P)} + \frac{A^*z}{(z-P^*)}$ P^* = complex conjugate of P A^* = complex conjugate of A	$A = (z-P)\frac{X(z)}{z}\Big\vert_{z=P}$
Partial fraction with mth-order real poles: $\frac{R_m}{(z-p)} + \frac{R_{m-1}}{(z-p)^2} + \cdots + \frac{R_1}{(z-p)^m}$	$R_k = \frac{1}{(k-1)!}\frac{d^{k-1}}{dz^{k-1}}\left((z-p)^m \frac{X(z)}{z}\right)\Big\vert_{z=p}$

APPENDIX V

1. Rectangular window:

$$w_{rec}(n) = 1, \quad -M \le n \le M. \tag{7.15}$$

2. Triangular (Bartlett) window:

$$w_{tri}(n) = 1 - \frac{|n|}{M}, \quad -M \le n \le M. \tag{7.16}$$

3. Hanning window:

$$w_{han}(n) = 0.5 + 0.5\cos\left(\frac{n\pi}{M}\right), \quad -M \le n \le M. \tag{7.17}$$

4. Hamming window:

$$w_{ham}(n) = 0.54 + 0.46\cos\left(\frac{n\pi}{M}\right), \quad -M \le n \le M. \tag{7.18}$$

5. Blackman window:

$$w_{black}(n) = 0.42 + 0.5\cos\left(\frac{n\pi}{M}\right) + 0.08\cos\left(\frac{2n\pi}{M}\right), \quad -M \le n \le M. \tag{7.19}$$