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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	DIGITAL SIGNAL PROCESSING
COURSE CODE	:	BEB 30503 / BEJ 30603
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JANUARY / FEBRUARY 2021
DURATION	:	6 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATION**

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THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

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Q1. (a) As an expert Telecommunication engineer, you have measured an input signal, $x[n]$ and its sampling frequency as shared with you independently in the UTHM Author system.

*(Please login to www.author.uthm.edu.my , go to **Individual Activities** tab and click on your individual folder. Please download the signal.)*

(i) Estimate the magnitude spectrum of the given signal, $x[n]$.

(22 marks)

(ii) Design a low pass filter (LPF) to eliminate the highest frequency of the input signal. Use Bartlett window with length N = 9.

(39 marks)

(iii) Calculate the output signal, $y[n]$ of the HPF. (14 marks)

(iv) Estimate the magnitude spectrum of $y[n]$. (15 marks)

(v) Discuss the result in (iv). (4 marks)

(b) Given a discrete signal $g[n] = \{ \overset{\Downarrow}{2}, 1, 3, 0, 0, 0, 2, -4, -2, 1 \}$. Compute the signal $z[n] = g[n] + 2x[n] - 5$.

(6 marks)

-END OF QUESTIONS -

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Table 1: Properties of the *N*-Sample DFT

Property	Signal	DFT
Shift	$x[n - n_o]$	$X_{DFT}[k]e^{-j2\pi k n_o/N}$
Shift	$x[n-0.5N]$	$(-1)^k X_{DFT}[k]$
Modulation	$x[n]e^{j2\pi n k_o/N}$	$X_{DFT}[k-k_o]$
Modulation	$(-1)^n x[n]$	$X_{DFT}[k-0.5N]$
Folding	$x[-n]$	$X_{DFT}[-k]$
Product	$x[n]y[n]$	$\frac{1}{N} X_{DFT}[k] \otimes Y_{DFT}[k]$
Convolution	$x[n] \otimes y[n]$	$X_{DFT}[k]Y_{DFT}[k]$
Correlation	$x[n] \otimes \otimes y[n]$	$X_{DFT}[k]Y^*_{DFT}[k]$
Central Ordinates	$x[0]=\frac{1}{N}\sum_{k=0}^{N-1} X_{DFT}[k]$, $X_{DFT}[0]=\sum_{n=0}^{N-1} x[n]$	
Central Ordinates	$x\left[\frac{N}{2}\right]=\frac{1}{N}\sum_{k=0}^{N-1}(-1)^k X_{DFT}[k]$ (N even), $X_{DFT}\left[\frac{N}{2}\right]=\sum_{n=0}^{N-1}(-1)^n x[n]$ (N even)	

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Table 2: Windows for FIR filter design.

Window	**Expression** $w_N[n]$, $-0.5(N-1) \le n \le 0.5(N-1)$
Boxcar	1
Cosine	$\cos\left(\frac{n\pi}{N-1}\right)$
Riemann	$\text{sinc}^L\left(\frac{2n}{N-1}\right), L>0$
Bartlett	$1-\frac{2\|n\|}{N-1}$
Von Hann (Hanning)	$0.5+0.5\cos\left(\frac{2n\pi}{N-1}\right)$
Hamming	$0.54+0.46\cos\left(\frac{2n\pi}{N-1}\right)$
Blackman	$0.42+0.5\cos\left(\frac{2n\pi}{N-1}\right)+0.08\cos\left(\frac{4n\pi}{N-1}\right)$
Kaiser	$\frac{I_0\left(\pi\beta\sqrt{1-4\left(\frac{n}{N-1}\right)^2}\right)}{I_0(\pi\beta)}$

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Infinite Impulse Response (FIR) Filter (Bilinear Transformation) Equations

$$\omega_A = C\tan(0.5\Omega_D)$$
$$H(z) = H(s)|_{s=C(z-1)/(z+1)}$$
$$\omega_x = \tan(0.5\Omega_D)$$
$$H_1(s) = H(s)|_{s=s\omega_A/\omega_x}$$
$$H(z) = H_1(s)|_{s=(z-1)/(z+1)}$$

Finite Impulse Response (FIR) Filter Equations

$$h_{LP}[n] = 2F_c\,\mathrm{sinc}(2nF_c)\,w_N[n]$$
$$h_{HP}[n] = \delta[n] - 2F_c\,\mathrm{sinc}(2nF_c)\,w_N[n]$$
$$F_c = 0.5(F_P + F_S)$$

$$h_{HP}[n] = (-1)^n 2F_c\,\mathrm{sinc}(2nF_c)\,w_N[n]$$
$$F_c = 0.5 - 0.5(F_P + F_S)$$

$$h_{BP}[n] = 4F_c\,\mathrm{sinc}(2nF_c)\cos(2\pi nF_0)\,w_N[n]$$
$$h_{BS}[n] = \delta[n] - 4F_c\,\mathrm{sinc}(2nF_c)\cos(2\pi nF_0)\,w_N[n]$$
$$F_0 = 0.5(F_2 + F_3)$$
$$F_c = 0.5(F_3 + F_4) - F_0$$