UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2010/2011

COURSE	:	DIGITAL SIGNAL PROCESSING
COURSE CODE	:	BEE 3213
PROGRAMME	:	BEE
EXAMINATION DATE	:	APRIL / MAY 2011
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY.

THIS PAPER CONSISTS OF THIRTEEN (13) PAGES

Q1 (a) List down FOUR advantages of digital signal processing.

(4 marks)

(b) Let $x[n] = \frac{5}{2}(0.5)^n u[n]$ in the range of $0 \le n \le 4$. Illustrate the signal and calculate its even and odd parts.

(10 marks)

(c) Given, $x[n] = \{2, -5, 3, 0, 8, -2\}$, $-2 \le n \le 3$. Evaluate $y[n] = x\left[2n - \frac{7}{4}\right]$ by applying step interpolation and represent $y[n]$ as sum of impulses.

(6 marks)

Q2 (a) Apply an impulse response of $h[n] = (2n+3)(u[n-3] - u[n]) - 4\delta[n-3]$ to a Finite Impulse Response (FIR) filter and evaluate its response $y[n]$ to the input $x[n]$ by using sum-by-column method where,

$$x[n] = \begin{Bmatrix} 4^n + 1, & -2 < n \le 2 \\ 0, & elsewhere \end{Bmatrix}.$$

(13 marks)

(b) Assume that $x[n]$ and $h[n]$ are periodic signals. Calculate the convolution for $x[n]$ and $h[n]$ by using cyclic method.

(7 marks)

Q3 (a) Sampling and quantization is a part of process in Analog to Digital Converter (ADC). Briefly explain:

(i) Sampling theorem.
(ii) Nyquist Rate.
(iii) Nyquist interval.

(6 marks)

(b) Figure Q3 shows a block diagram of ADC. If an analog signal $x[n] = 5/6\sin[8\pi/f] + 1/7\sin(11\,\pi\,t) + \cos(5\pi/f)$ is sampled at a sampling rate of 20Hz. Construct:

(i) Signal at point (a) in Figure Q3.

(4 marks)

(ii) Signal at point (b) in Figure Q3 with 4 quantization level and full scale range ± 2V by using rounding technique ($0 \le n \le 2$).

(9 marks)

(iii) Quantization error, $\varepsilon[n]$ for Q3 (b) (ii).

(1 marks)

Q4 (a) Given $y[n] = \{\underset{\Downarrow}{5}, 3, 1, 0\}$. Calculate the Discrete Fourier Transformation (DFT) of given discrete signal.

(6 marks)

(b) The DFT of a discrete signal, $y[n]$ is given by $Y_{DFT}[k] = \{\overset{\Downarrow}{6}, 3-j, -8, 3+j\}$. Apply Decimation in Time (DIT) Fast Fourier Transformation (FFT) algorithm to determine its discrete signal, $y[n]$.

(14 marks)

Q5 (a) Calculate the z-transform and its region of convergence for the following discrete signal:

(i) $x(n) = \{1, 2, \overset{\Downarrow}{3}, 2, 1\}$

(ii) $x(n) = \{-1, 2, \overset{\Downarrow}{0}, -2, 1\}$

(4 marks)

(iii) $x(n) = (2)^{n+2} u(n)$

(iv) $x(n) = (n-1)(2)^{n+2} u(n)$

(6 marks)

(b) Calculate the inverse z-transform for the following discrete signal:

(i) $X(z) = 2 - z^{-1} + 3z^{-3}$

(ii) $X(z) = (z - z^{-1})^2$

(5 marks)

(c) Calculate the transfer function and difference equation for the following causal system. Investigate the stability of the system, using each system representation.

$$h(n) = (2)^n\, u(n)$$

(5 marks)

Q6 (a) Design the Infinite Impulse Transform (IIR) digital filter using step invariance transform with given analog transfer function, $H(s)$ of $\dfrac{-3}{(s+2)(s+3)}$.

(12 marks)

(b) Use an analog lowpass filter, $H(s) = \dfrac{1}{s(s+1)}$ to design a notch filter with band edges of 1 kHz and 6 kHz that operates at sampling frequency of 20 kHz.

(8 marks)

Q7 (a) Design Finite Impulse Response (FIR) filters system of Figure Q7 using Boxcar window. The specifications of the filters are:

Filter 1:	*Filter 2:*
Pass frequency = 3 kHz	Pass frequency = 10 kHz
Stop frequency = 7 kHz	Stop frequency = 8 kHz

The sampling frequency, $S = 25$ kHz and the filter length, $N = 5$.

(14 marks)

(b) Draw the simplify version of the FIR filter system of Q7 (a) and calculate its impulse response.

(6 marks)

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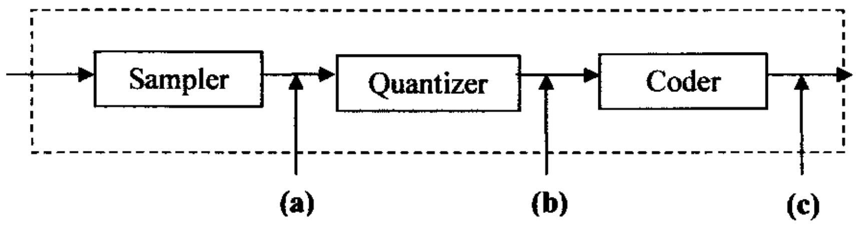

FIGURE Q3

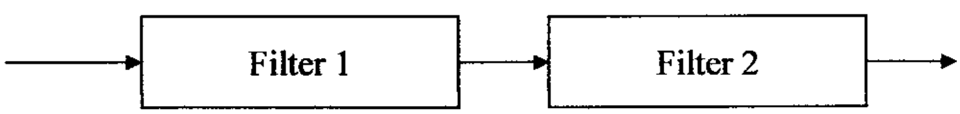

FIGURE Q7

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Finite Summation Formula

$$\sum_{k=0}^{n} \alpha = \frac{n(n+1)}{2}$$

$$\sum_{k=0}^{n} \alpha^2 = \frac{n(n+1)(2n+1)}{6}$$

$$\sum_{k=0}^{n} \alpha^3 = \frac{n^2(n+1)^2}{4}$$

$$\sum_{k=0}^{n} \alpha^k = \frac{1-\alpha^{n+1}}{1-\alpha}, \quad \alpha \neq 1$$

$$\sum_{k=0}^{n} k\alpha^k = \frac{\alpha\left[1-(n+1)\alpha^n + n\alpha^{n+1}\right]}{(1-\alpha)^2}$$

$$\sum_{k=0}^{n} k^2\alpha^k = \frac{\alpha\left[(1+\alpha)-(n+1)^2\alpha^n + (2n^2+2n-1)\alpha^{n+1} - n^2\alpha^{n+2}\right]}{(1-\alpha)^3}$$

Infinite Summation Formula

$$\sum_{k=0}^{\infty} \alpha^k = \frac{1}{1-\alpha}, \qquad |\alpha| < 1$$

$$\sum_{k=1}^{\infty} \alpha^k = \frac{\alpha}{1-\alpha}, \qquad |\alpha| < 1$$

$$\sum_{k=1}^{\infty} k\alpha^k = \frac{\alpha}{(1-\alpha)^2}, \qquad |\alpha| < 1$$

$$\sum_{k=1}^{\infty} k^2\alpha^k = \frac{\alpha^2+\alpha}{(1-\alpha)^3}, \qquad |\alpha| < 1$$

$$\sum_{k=-\infty}^{\infty} e^{-\alpha|k|} = \frac{1+e^{-\alpha}}{1-e^{-\alpha}}, \qquad \alpha > 0$$

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Table 1

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

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Table 2

Signal	**z-transform**
$a_1 x_1(n) + a_2 x_2(n)$	$a_1 X_1(z) + a_2 X_2(z)$
$x(-n)$	$X(z^{-1})$
i) $x(n-k)$ ii) $x(n+k)$	i) $z^{-k} X(z)$ ii) $z^{k} X(z)$
$x_1(n) * x_2(n)$	$X_1(z) X_2(z)$
$r_{x_1 x_2}(l) = \sum_{n=-\infty}^{\infty} x_1(n) x_2(n-l)$	$R_{x_1 x_2}(z) = X_1(z) X_2(z^{-1})$
$a^n x(n)$	$X(a^{-1}z)$
$n x(n)$	$z^{-1} \frac{dX(z)}{dz^{-1}}$ or $-z \frac{dX(z)}{dz}$
$x(n) - x(n-1)$	$X(z)(1 - z^{-1})$
$\sum_{k=0}^{\infty} X(k)$	$X(z) = \left(\frac{z}{z-1}\right)$
$\lim_{n \to 0} x(n)$	$\lim_{\lvert z \rvert \to \infty} X(z)$
$\lim_{n \to \infty} x(n)$	$\lim_{\lvert z \rvert \to 1} \left(\frac{z-1}{z}\right) X(z)$

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Table 3

Signal $x(t)$	**Laplace Transform $X(s)$**
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
$r(t) = tu(t)$	$\frac{1}{s^2}$
$t^2 u(t)$	$\frac{2}{s^3}$
$t^n u(t)$	$\frac{n!}{s^{n+1}}$
$e^{-\alpha t} u(t)$	$\frac{1}{s+\alpha}$
$te^{-\alpha t} u(t)$	$\frac{1}{(s+\alpha)^2}$
$t^n e^{-\alpha t} u(t)$	$\frac{n!}{(s+\alpha)^{n+1}}$

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Table 4

Form	Band Edges	Mapping $z \rightarrow$	Parameters
Lowpass to lowpass	Ω_C	$\dfrac{z-\alpha}{1-\alpha z}$	$\alpha = \dfrac{\sin[0.5(\Omega_D - \Omega_C)]}{\sin[0.5(\Omega_D + \Omega_C)]}$
Lowpass to highpass	Ω_C	$\dfrac{-(z+\alpha)}{1+\alpha z}$	$\alpha = \dfrac{-\cos[0.5(\Omega_D + \Omega_C)]}{\cos[0.5(\Omega_D - \Omega_C)]}$
Lowpass to bandpass	$[\Omega_1, \Omega_2]$	$\dfrac{-(z^2 + A_1 z + A_2)}{A_2 z^2 + A_1 z + 1}$	$K = \dfrac{\tan(0.5\Omega_D)}{\tan[0.5(\Omega_2 - \Omega_1)]}$ $\alpha = \dfrac{-\cos[0.5(\Omega_2 + \Omega_1)]}{\cos[0.5(\Omega_2 - \Omega_1)]}$ $A_1 = \dfrac{2\alpha K}{K+1}$, $A_2 = \dfrac{K-1}{K+1}$
Lowpass to bandstop	$[\Omega_1, \Omega_2]$	$\dfrac{(z^2 + A_1 z + A_2)}{A_2 z^2 + A_1 z + 1}$	$K = \tan(0.5\,\Omega_D)\tan[0.5(\Omega_2 - \Omega_1)]$ $\alpha = \dfrac{-\cos[0.5(\Omega_2 + \Omega_1)]}{\cos[0.5(\Omega_2 - \Omega_1)]}$ $A_1 = \dfrac{2\alpha}{K+1}$, $A_2 = \dfrac{1-K}{1+K}$