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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	DIGITAL SIGNAL PROCESSING
COURSE CODE	:	BEF 35603
PROGRAMME	:	BEV
EXAMINATION DATE	:	JUNE / JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

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Q1 (a) A discrete signal is defined as

$$x(n) = \begin{cases} 2n & for\ 1 \le n \le 3 \\ 0 & for\ else \end{cases}$$

(i) Sketch the signal $w(n)=x(n-1)-3\delta(n-1)$, for $0 \le n \le 4$.

(4 marks)

(ii) Classify and explain whether or not the system for **Q1(a)(i)** is causal system

(2 marks)

(iii) Classify and explain whether or not the system for **Q1(a)(i)** is dynamic system.

(2 marks)

(iv) Sketch the signal $y[n] = x[-n+5]$, for $0 \le n \le 4$.

(2 marks)

(v) Prove whether or not the system for **Q1(a)(iv)** is linear and time invariant.

(6 marks)

(b) State **five (5)** elements in the digital signal processing system.

(4 marks)

Q2 (a) A continuous voltage signal has the following function:

$$v(t) = 12\sin(100\pi t) - 7 \quad volt$$

If the signal is sampled with sampling time of 0.004 *s* and quantized by using truncation technique with quantisation interval of 1 volt,

(i) Explain whether the aliasing sampled signal will occur.

(2 marks)

(ii) Determine digital frequency and digital period of the sampled signal.

(2 marks)

(iii) Calculate the sampled signal $v(n)$ for the first period.

(4 marks)

(iv) Calculate the quantized signal $v(n)$ for one period.

(2 marks)

(v) Analyse the actual quantized signal to noise SNR_Q for one period.

(8 marks)

(b) State any **two (2)** process in the Analog to Digital Converter (ADC) system.
(2 marks)

Q3 (a) A Finite Impulse Response (FIR) filter has an impulse response of:

$$h[n] = 3\delta[n+1] + 2\delta[n-1]; \quad \text{for } -1 \le n \le 1$$

The input is a periodic signal with digital period of N=3,

$$x[n] = \{\overset{\Downarrow}{3},\ 2,\ 1\}$$

Determine output response of the system using one of periodic convolution method.

(5 marks)

(b) Function of the FIR filter is given by

$$h[n] = \{\overset{\Downarrow}{2},\ 2,\ 3\}$$

This function generate a cross-correlation of:

$$r_{xh}[n] = \{3,\ 8,\ \overset{\Downarrow}{9},\ 9,\ 4,\ 2\}$$

Calculate the input functions of the system.

(5 marks)

(c) Determine the Discrete Fourier Transform (DFT) of the four-point sequence of:

$$x[n] = \{\overset{\Downarrow}{2},\ 3,\ 2,\ 1\}$$

(7 marks)

(d) A DFT has function of:

$$X_{DFT}[k] = \{15,\ (2-3j),\ -3,\ (2+3j),\ 15,\ (2-3j)\}$$

Calculate the DFT of $y[n]=x[n-3]$, by using the properties of the DFT.
(3 marks)

Q4 (a) Determine the z-transform and specify its region of convergence (ROC) of the following signal:

$$x_1[n] = \{\overset{\Downarrow}{2},\ 0,\ 4,\ 0,\ 6\}$$

(3 marks)

(b) Determine the z-transform and the ROC of the causal system

$$x[n] = 4^{(n+1)} u[n]$$

(4 marks)

(c) A causal system is described by the following difference equation:

$$y[n] = 0.6y[n-1] + 2x[n]$$

(i) Calculate the transfer function of the system H(z).

(3 marks)

(ii) Estimate the output response of *y[n]* if the input signal is given by:

$$x[n] = 3u[n]$$

(10 marks)

Q5 (a) List **two (2)** classifications of digital filter and state an advantage of each filters

(4 marks)

(b) An analog filter has function of:

$$H(s) = \frac{4}{s+4}$$

(i) Determine function of a digital filter *H(z)*, by using impulse invariant at sampling frequency of *S*=2 Hz.

(6 marks)

(ii) Determine the sampling rate hence the filter is always stable. Solve the digital filter by using mapping based on the backward difference at sampling rate of *S*.

(4 marks)

(c) An analog lowpass filter has transfer function of

$$H(s) = \frac{2}{s^2 - 2s + 2}$$

has cutoff frequency of *1 rad/s*. Use this prototype to design a digital highpass filter with a cutoff frequency of 500 Hz and S=2 kHz.

(6 marks)

– END OF QUESTIONS –

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APPENDIX

$e^{\pm jm\pi} = -1$	m= 1, 3, 5,....
$e^{\pm jm\pi} = 1$	m= 2, 4, 6,....
$e^{jm\pi/2} = j$	m= 1, 5, 9....
$e^{jm\pi/2} = -j$	m= 3, 7, 11,....
$e^{-jm\pi/2} = -j$	m= 1, 5, 9....
$e^{-jm\pi/2} = j$	m= 3, 7, 11,....

TABLE OF NUMERICAL DIFFERENCE ALGORITHMS

Difference	Numerical Algorithm	Mapping for s
Backward	$y(n) = \dfrac{x(n) - x(n-1)}{t_s}$	$s = \dfrac{z-1}{zt_s}$
Forward	$y(n) = \dfrac{x(n+1) - x(n)}{t_s}$	$s = \dfrac{z-1}{t_s}$
Central	$y(n) = \dfrac{x(n+1) - x(n-1)}{t_s}$	$s = \dfrac{z^2-1}{2zt_s}$

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TABLE OF LAPLACE TRANSFORM PAIRS

$f(t)$	$F(s)$
$au(t)$	$\frac{a}{s}$
t^n	$\frac{n!}{s^{n+1}}$
e^{-at}	$\frac{1}{s+a}$
$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$

TABLE OF Z-TRANSFORM PAIRS

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

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TABLE OF D2D FREQUENCY TRASNFORMATION

Form	Band Edge (s)	Mapping z →	Mapping parameters
LP2LP	Ω_C	$\frac{z-\alpha}{1-\alpha z}$	$\alpha = \frac{\sin[0.5(\Omega_D - \Omega_C)]}{\sin[0.5(\Omega_D + \Omega_C)]}$
LP2HP	Ω_C	$\frac{-(z-\alpha)}{1+\alpha z}$	$\alpha = \frac{-\cos[0.5(\Omega_D + \Omega_C)]}{\cos[0.5(\Omega_D - \Omega_C)]}$
LP2BP	Ω_1 , Ω_2	$\frac{-(z^2 + A_1 z + A_2)}{A_2 z^2 + A_1 z + 1}$	$K = \frac{\tan(0.5\Omega_D)}{\tan(0.5(\Omega_2 - \Omega_1))}$ $\alpha = \frac{-\cos[0.5(\Omega_2 + \Omega_1)]}{\cos[0.5(\Omega_2 - \Omega_1)]}$ $A_1 = 2\alpha K/(K+1)$ $A_2 = (K-1)/(K+1)$
LP2BS	Ω_1 , Ω_2	$\frac{z^2 + A_1 z + A_2}{A_2 z^2 + A_1 z + 1}$	$K = \tan(0.5\Omega_D)\tan(0.5(\Omega_2 - \Omega_1))$ $\alpha = \frac{-\cos[0.5(\Omega_2 + \Omega_1)]}{\cos[0.5(\Omega_2 - \Omega_1)]}$ $A_1 = 2\alpha K/(K+1)$ $A_2 = -(K-1)/(K+1)$

Note: The digital lowpass prototype cutoff frequency is Ω_D

All digital frequencies are normalized to $\Omega = 2\pi f/S$

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TABLE OF A2D TRASNFORMATION FOR BILINEAR DESIGN

Form	Band Edge (s)	Mapping s →	Mapping parameters
LP2LP	Ω_C	$\dfrac{z-1}{C(z+1)}$	$C=\tan(0.5\Omega_C)$
LP2HP	Ω_C	$\dfrac{C(z+1)}{(z-1)}$	$C=\tan(0.5\Omega_C)$
LP2BP	$\Omega_1 < \Omega_0 < \Omega_2$	$\dfrac{z^2-2\beta.z+1}{C(z^2-1)}$	$C=\tan(0.5(\Omega_2-\Omega_1))$ $\beta=\cos\Omega_0$ or $\beta=\dfrac{\cos[0.5(\Omega_2+\Omega_1)]}{\cos[0.5(\Omega_2-\Omega_1)]}$
LP2BS	$\Omega_1 < \Omega_0 < \Omega_2$	$\dfrac{C(z^2-1)}{z^2-2\beta.z+1}$	$C=\tan(0.5(\Omega_2-\Omega_1))$ $\beta=\cos\Omega_0$ or $\beta=\dfrac{\cos[0.5(\Omega_2+\Omega_1)]}{\cos[0.5(\Omega_2-\Omega_1)]}$

Note: The analog lowpass prototype prewarped cutoff frequency is 1 rad/s.
All digital frequencies are normalized to $\Omega=2\pi f/S$ but are not prewarped