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Examination Answer Books

12 Pages

Instructions to Candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
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8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

Complete, fold and seal
(see note 2 below)

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FORENAME(S): RICHARD

1	Student Number	W0024874535
2	Title of Examination Paper	DSP AND COMMUNICATIONS
3	Module Code	GOEES003
4	Date and Time of Examination	22/05/2025
5	Examination Venue	TY COCH
6	Seat Number	H7
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
Q1	18
Q2	20
Q3	25
Q4	12
Total	75/100

(Gweler yr ochr arall am y fersiwn Cymraeg)

75 %

①

$$(a) \quad y[n] = x[n] - 4$$

$$y_1[n] = x_1[n] - 4 \quad \checkmark$$

$$y_2[n] = x_2[n] - 4 \quad \checkmark$$

$$ay_1[n] + by_2[n] = ax_1[n] - 4 + bx_2[n] - 4$$

$$\text{weighted sum of inputs} = ax_1[n] + bx_2[n] - 8$$

$$H\{ax_1[n] + bx_2[n]\} \rightarrow ???$$

These are not equal ~~since~~ $\therefore$ system is not linear.
show workings

$$(b) \quad y[n] = 2x[n-3]$$

$$\text{delay output by } k; \quad y[n-k] = 2x[n-3-k] \quad (1)$$

$$\text{input } x[n-k]; \quad y[n, k] = 2x[n-k-3] \quad (2)$$

① & ② are equal $\therefore$ system is time invariant.

$$(c) \quad i) \quad y[n] = 4x[n-1] - 3x[n+2] + 2y[n-1]$$

system is causal because $y[n]$ does not rely on future values of x . i.e. there are no " $[n+...]$ " brackets. $\checkmark$

$$ii) \quad y[n] = 6x[n+2] - 7x[n] + y[n+1]$$

system is not causal because $y[n]$ relies on future values of x i.e. $6x[n+2]$. $\checkmark$

①

$$d) y[n] = -0.3y[n-1] + 0.7x[n].$$

Qsd4/7

$$y(n) = -\sum_{i=1}^N a_i y(n-i) + \sum_{j=0}^M b_j x(n-j)$$

$$y(n) = -a_1 y(n-1) - a_2 y(n-2) \dots - a_N y(n-N) + b_0 x(n) + b_1 x(n-1) \dots b_M x(n-M)$$

≡ i) non-recursive as there are no "n+1" term

ii) filter coefficients:

$$a_1 = 0.3$$

$$b_0 = 0.7$$

$$a_0 = ??$$

iii) $x[n] = u[n] = 1$

$$y[n] = -0.3y[n-1] + 0.7(1)$$

$$y[-1] = -0.3y[-2] + 0.7 \quad y[-1] = 0$$

$$y[0] = -0.3y[0-1] + 0.7 = 0.7$$

$$y[1] = -0.3y[1-1] + 0.7 = 0.49$$

$$y[2] = -0.3y[2-1] + 0.7 = 0.553$$

$$y[3] = -0.3y[3-1] + 0.7 = 0.5341$$

$$y[4] = -0.3y[4-1] + 0.7 = 0.53977$$

②

$$a) \quad x(t) = 8 \sin(2\pi f t) u(t)$$

$$f = 1000 \text{ Hz}$$

$$f_s = 10\,000 \text{ Hz}$$

$$x(nT) = 8 \sin\left(2\pi \times 1000 \times \frac{1}{10000} \times n\right) u(n)$$

$$T_s = \frac{1}{10000}$$

$$x(n) = 8 \sin\left(\frac{2\pi \times 1000}{10000} n\right) u(n)$$

$$x(n) = 8 \sin(0.2\pi n) u(n) \quad u(n) = 1$$

$$x(n) = 8 \sin(0.2\pi n)$$

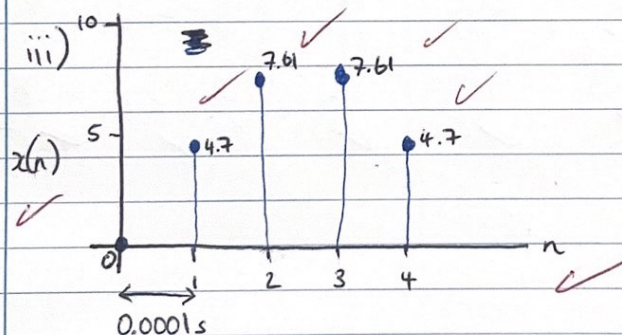
$$ii) \quad x(0) = 8 \sin(0) = 0$$

$$x(1) = 8 \sin(0.2\pi) = 4.70$$

$$x(2) = 8 \sin(0.4\pi) = 7.61$$

$$x(3) = 8 \sin(0.6\pi) = 7.61$$

$$x(4) = 8 \sin(0.8\pi) = 4.70$$



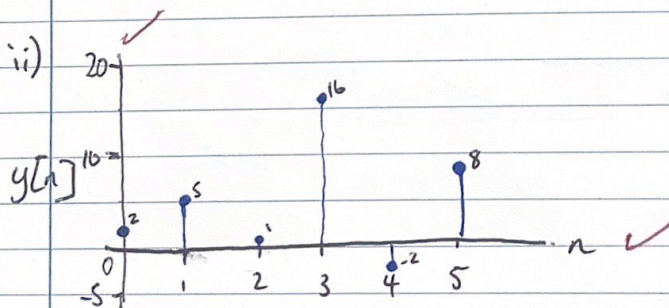
(2)

b)

$$x[n] = 5\delta[n+4] - 3\delta[n+2] + 2\delta[n] - 4\delta[n-1] + 3\delta[n-3] - 2\delta[n-5] + \delta[n-6]$$

$$c) y[n] \text{ terms} = 3 + 4 - 1 = 6$$

n	0	1	2	3	4	5
h[n]	2	-1	4			
x[n]	1	3	0	2		
x[0]h[n]	2	-1	4	0		
x[1]h[n-1]	delay	6	-3	12	0	
x[2]h[n-2]	delay	delay	0	0	0	0
x[3]h[n-3]	delay	delay	delay	4	-2	8
y[n]	2	5	1	16	-2	8



show smaller tick markers

(2)

$$d) x(t) = 4 \cos(6000\pi t) + 2 \cos(16000\pi t) - 2 \cos(8000\pi t)$$

Q201

$$\omega = 2\pi f$$

 ~~$\omega = 2\pi f$~~ 

$$\omega_1 = 6000\pi$$

 $\therefore$ ~~$\omega = 2\pi f$~~ 

$$\omega_2 = 16000\pi$$



$$\omega_3 = 8000\pi$$

0/4

$$f = \frac{\omega}{2\pi}$$

$$f_1 = \frac{6000\pi}{2\pi} = 3000 \text{ Hz}$$

$$f_2 = \frac{16000\pi}{2\pi} = 8000 \text{ Hz}$$

0

$$f_3 = \frac{8000\pi}{2\pi} = 4000 \text{ Hz}$$

Nyquist sampling frequency = ??

P.T.O.

(3) a) $x(n) = (3^n) \cos(0.25\pi n) u(n)$

$$x(n) = a^n \cos(bn) u(n)$$

$$X(z) = \frac{z[z - a \cos(b)]}{z^2 - [2 \cdot a \cos(b)]z + a^2}$$

$$X(z) = \frac{z[z - 3 \cdot \cos(0.25\pi)]}{z^2 - [2 \cdot 3 \cos(0.25\pi)]z + 3^2}$$

$$X(z) = \frac{z[z - 2.121]}{z^2 - [2 \cdot 2.121]z + 9} = \frac{z^2 - 2.121z}{z^2 - 4.243z + 9}$$

b) $3y[n] - 2y[n-1] + y[n-2] - x[n] + 0.5x[n-1] - x[n-2] = 0$

$$3y[n] - 2y[n-1] + y[n-2] = x[n] - 0.5x[n-1] + x[n-2]$$

$$3Y(z) - 2z^{-1}Y(z) + z^{-2}Y(z) = X(z) - 0.5z^{-1}X(z) + z^{-2}X(z)$$

$$Y(z)(3 - 2z^{-1} + z^{-2}) = X(z)(1 - 0.5z^{-1} + z^{-2})$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1 - 0.5z^{-1} + z^{-2}}{3 - 2z^{-1} + z^{-2}}$$

Q3

25/25

Q3a

7/7

Q3b

8/8

③

$$c) y[n] + 0.5y[n-1] - 0.25y[n-2] - x[n] + 0.6x[n-1] - 0.4x[n-2] = 0$$

$$y[n] + 0.5y[n-1] - 0.25y[n-2] = x[n] - 0.6x[n-1] + 0.4x[n-2]$$

$$Y[z] + 0.5z^{-1}Y[z] - 0.25z^{-2}Y[z] = X[z] - 0.6z^{-1}X[z] + 0.4z^{-2}X[z]$$

$$Y[z] (1 + 0.5z^{-1} - 0.25z^{-2}) = X[z] (1 - 0.6z^{-1} + 0.4z^{-2})$$

$$H[z] = \frac{Y[z]}{X[z]} = \frac{1 - 0.6z^{-1} + 0.4z^{-2}}{1 + 0.5z^{-1} - 0.25z^{-2}}$$

$$H(e^{j\omega}) = \frac{Y(e^{j\omega})}{X(e^{j\omega})} = \frac{1 - 0.6e^{-j\omega} + 0.4e^{-2j\omega}}{1 + 0.5e^{-j\omega} - 0.25e^{-2j\omega}}$$

A70

Q3c10/1010

④

a) $L=7$ $L=2M+1$ $7=2M+1$ $6=2M$

$M=3$

$$\omega_c = 2\pi f_c T_s$$

$$f_s = 12000 \text{ Hz}$$

$$T_s = \frac{1}{12000}$$

$$\omega_H = 2\pi f_H T_s$$

$$f_H = 3000 \text{ Hz}$$

$$\omega_H = 2\pi \times 3000 \times \frac{1}{12000} = 1.571 \text{ rad/s}$$

$$\omega_L = 2\pi f_L T_s$$

$$\omega_L = 2\pi \times 800 \times \frac{1}{12000} = 0.419 \text{ rad/s}$$

Bandpass

$$h(k) = \begin{cases} \frac{\omega_H - \omega_L}{\pi} & , k=0 \\ \frac{\sin(\omega_H k)}{\pi k} - \frac{\sin(\omega_L k)}{\pi k} & , -M \leq k \leq M \end{cases}$$

$$\therefore h(k) = \begin{cases} \frac{1.571 - 0.419}{\pi} & , k=0 \\ \frac{\sin(1.571 \times k)}{\pi k} - \frac{\sin(0.419 \times k)}{\pi k} & , -3 \leq k \leq 3 \end{cases}$$

Q4

12/25

Q4a

10/10

$$b_0 = h(0-3) = h(-3) = \frac{\sin(1.571 \times -3)}{\pi(-3)} - \frac{\sin(0.419 \times -3)}{\pi(-3)}$$

$$b_0 = -0.1061 - 0.1009 = -0.207 = h(-3)$$

$$b_1 = h(1-3) = h(-2) = \frac{\sin(1.571 \times -2)}{\pi(-2)} - \frac{\sin(0.419 \times -2)}{\pi(-2)}$$

$$b_1 = -0.1184 = h(-2)$$

$$b_2 = h(2-3) = h(-1) = \frac{\sin(1.571 \times -1)}{\pi(-1)} - \frac{\sin(0.419 \times -1)}{\pi(-1)}$$

$$b_2 = 0.1889 = h(-1)$$

$$b_3 = h(3-3) = h(0) = \frac{1.571 - 0.419}{\pi} = 0.3667$$

$$b_4 = h(4-3) = h(1) = 0.1889$$

$$b_5 = h(5-3) = h(2) = -0.1184$$

$$b_6 = h(6-3) = h(3) = -0.207$$

4

i) Multiplexing - Dividing the baseband into multiple usable frequencies

0Q4b

ii) Analogue Modulation
Converting the baseband to passband for transmission then converting back at the receiver

12/15

iii) ASK digital modulation

Amplitude Shift Keying

Using binary to represent successful carrier connection or unsuccessful carrier connection
i.e. 1 for successful 0 for unsuccessful

1

iv) FSK digital Modulation

Frequency Shift Keying

0

v) Baseband system.

0