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Examination Answer Books

12 Pages

Instructions to Candidates

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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.
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6	Seat Number	
7	Number of Answer Books handed in	1

Complete, fold and seal
(see note 2 below)

SURNAME: Pesarillo

FORENAME(S): Ronan

List the numbers of the questions you have attempted	Office Use
1)	
2)	
3)	
4)	
Q1	5
Q2	13
Q3	27
Q4	26
Total	71/100

G.M.

Question No.

1)

i) Is it "Linear"? $y[n] = x[2n] + 8$ ← Discrete Time System

$$x_1 = \{1, 2, 3, 4\}$$

$$x_2 = \{2, 4, 6, 8\}$$

T, H $x_1 + x_2 = x_3 = \{3, 6, 9, 12\}$

$$H\{x_1\} = \{6+8, 12+8, 18+8, 24+8\}$$

$$= \{14, 20, 26, 32\}$$

x_1, x_2

$$H\{a_1 x_1 + a_2 x_2\} \rightarrow 2a_1 x_1 + 2a_2 x_2$$

not linear

H, T $H\{x_1\} = \{2+8, 4+8, 6+8, 8+8\}$

$$= \{10, 12, 14, 16\}$$

$H\{x_1\} \downarrow x_2$

$H\{x_2\} = \{4+8, 8+8, 12+8, 16+8\}$

$$= \{12, 16, 20, 24\}$$

$a_1^2 x_1 + 2a_1 x_1 a_2 x_2 + a_2^2 x_2$

$$2a_1 x_1 + 4a_1 x_1 a_2 x_2 + 2a_2 x_2$$

$H\{x_1\} + H\{x_2\} = \{22, 28, 34, 40\}$

$$\neq \{14, 20, 26, 32\}$$

Therefore $y[n] = x[2n] + 8$ is NOT Linear.

ii) Is it "Causal"? 'n' into all, or something...

If $x[0] = 0$, $y[0] = 8$; what will be of $x[2]$ then?

Start $\rightarrow y[-1] = x[-2] + 8$

$y[0] = x[0] + 8$ — We don't have $y[2]$ before $y[1]$.

$y[1] = x[2] + 8$

$y[2] = x[4] + 8$

'y' depends on an 'x' that has not been defined before its 'y' develops an answer.

If $y[n] = x[n] - x[n-1]$, then that will be "Causal".

iii) Is it "Time-Invariant"?

$-k, H = "H, -k"$

$-k, H$ $y[n] = x[2n] + 8$

$$y[n-k] = x[2n-k] + 8$$

$$y[2n-k] = ?$$

$H, -k$ $y[n] = x[2n] + 8$

$$y[2n] = x[2n-2k] + 8$$

$$y[2n-k] = ?$$

Therefore is time-varying.

* not properly written

Please Turn Over for Question 2)

2)

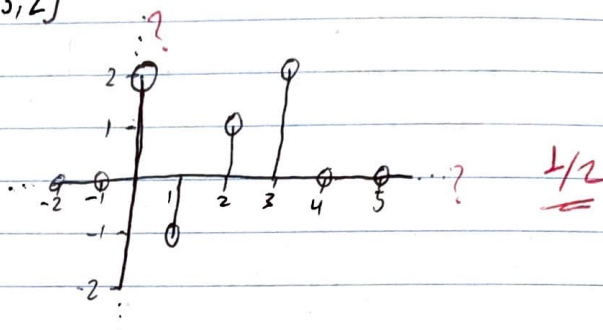
Causal Discrete Time (Linear Time Invariant) phase Finite Response Impulse Response describes:

$$h[n] = [2, -1, 1, 2]$$

System Input: (↑ if no indication where the sequence starts at $n=0$)

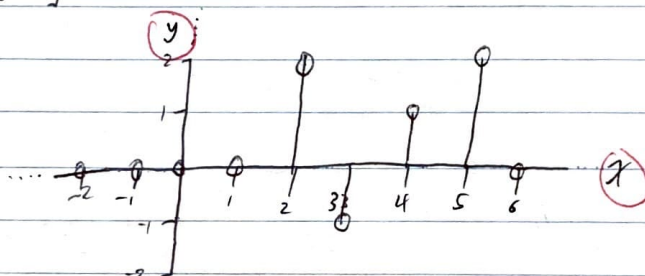
$$x[n] = [1, -2, 3, 2]$$

a) Illustration of $h[n]$:



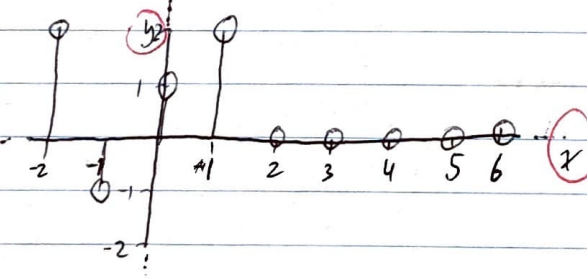
b) Signals of $h[n-2]$ and $h[n+2]$

$h[n-2]$



$h[n+2]$

($h[n]+k$ makes the results go up by k .)



c) See next page for tabulate time domain convolution for $h[n] \otimes x[n]$...

Question No.

2) a) $h[n] = [2, -1, 1, 2]$ $h[n] \otimes x[n] = x[n] \otimes h[n]$
 $x[n] = [1, -2, 3, 2]$

$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$ or $y[n] = \sum_{k=-\infty}^{\infty} h[k]x[n-k]$

k	0	1	2	3	4	5	6
$h[k]$	2	-1	1	2			
$x[n-0]$	1	-1	1	2			
$x[n-1]$		-4	2	-2	-4		
$x[n-2]$			6	-3	3	6	
$x[n-3]$				4	-2	2	4
Result	2	-5	9	1	-3	8	4

Therefore $h[n] \otimes x[n] = [2, -5, 9, 1, -3, 8, 4]$ because it's an FIR filter. $y[n] = \sum_{k=0}^6 h[k]x[n-k]$

3) a) Z-Transform of the following sequence:
 $x[n] = 25 \sin\left(\frac{1}{6}\pi n\right) U(n)$

$\frac{1}{6} = 0.16$ or 0.167 by 3d.p.

Or in-given $x[n] = 25 \sin(0.167\pi n) U(n)$

$\frac{z \sin(a)}{z^2 - 2z \cos(a) + 1}$

$25 \times \sin(0.167\pi n) U(n)$; $0.167\pi = a$

$\sin(an) U(n)$

$\frac{25 \cdot z \sin(0.167\pi)}{z^2 + 2z \cos(0.167\pi) + 1}$

Region of Convergence: $|z| > 1$

b) See next page for Transfer Function conversion.

Q2c

~~12/12~~

9/9

Q3

27/30

Q3a

3/6

3) b) Transfer Function of: $y[n] + 1.2y[n-1] + 0.3y[n-2] - x[n-1] + x[n-3] = 0$

Discrete Time

$$Y(z) = \sum_{n=-\infty}^{\infty} y[n] z^{-n}$$

$$X(z) = \sum_{n=-\infty}^{\infty} x[n] z^{-n}$$

$$y[n] + 1.2y[n-1] + 0.3y[n-2] = x[n-1] - x[n-3]$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1z^{-1} - 1z^{-3}}{1z^0 + 1.2z^{-1} + 0.3z^{-2}}$$

$$X(z)z^{-1} - X(z)z^{-3} = Y(z)z^0 + 1.2Y(z)z^{-1} + 0.3Y(z)z^{-2}$$

$$X(z)(z^{-1} - z^{-3}) = Y(z)(1 + 1.2z^{-1} + 0.3z^{-2}) \Rightarrow H(z) = \frac{z^{-1} - z^{-3}}{1 + 1.2z^{-1} + 0.3z^{-2}}$$

c) Frequency Response of: $y[n] - \frac{1}{2}y[n-1] + \frac{1}{16}y[n-2] - x[n] = 0$

$$y[n] - \frac{1}{2}y[n-1] + \frac{1}{16}y[n-2] = x[n]$$

Continuous Time

$$Y(z)(1z^0 - \frac{1}{2}z^{-1} + \frac{1}{16}z^{-2}) = X(z)z^0 = X(z) \cdot 1$$

$$Y(z)z^0 - \frac{1}{2}Y(z)z^{-1} + \frac{1}{16}Y(z)z^{-2} = X(z)z^0$$

DTFT - Discrete Time Fourier Transform

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1}{1 - \frac{1}{2}z^{-1} + \frac{1}{16}z^{-2}}$$

$$X(\omega) = \sum_{n=-\infty}^{\infty} x[n] e^{-j\omega n}$$

Frequency Response

$$H(e^{j\omega}) = \sum_{n=-\infty}^{\infty} h[n] e^{-j\omega n}$$

 $e^{j\omega}$

$$H(e^{j\omega}) = \frac{1}{1 - \frac{1}{2}e^{-j\omega} + \frac{1}{16}e^{-2j\omega}}$$

Quadratic Form

$$1 \div (1 + 2(-\frac{1}{4}e^{-j\omega}) + (-\frac{1}{4}e^{-j\omega})^2)$$

$$H(e^{j\omega}) = \frac{1}{e^{-j\omega}(e^{j\omega} - \frac{1}{2} + \frac{1}{16}e^{j\omega})}$$

$$H(e^{j\omega}) = \frac{1}{(1 - \frac{1}{4}e^{-j\omega})^2}$$

See next page for Question 4).

Q4
26/30
Q4a
8/10

Question No.

- 4) a) Calculating filter coefficients.
3-TAP, Low-Pass.
Cutoff Freq: 1000 Hz
Sampling Rate: 10,000 Hz

Normalised Cutoff Freq. $\omega_c = 2\pi f_c \cdot T_s$
Filter length 'L' = $2M+1$
 $f_c \div f_{sr}$

$$2\pi \cdot \frac{1000}{10000} = 2\pi \cdot 0.1 = 0.2\pi = \omega_c$$

3-TAP, $2M+1$
2 $2M$
1 M
 $b_k = h(k-M)$
for $k=0,1,2$
 $H(z) = b_0 + b_1 z^{-1} + b_2 z^{-2} + \dots + b_{2M} z^{-2M}$

Lowpass Filter Formulae

$$h(k) = \begin{cases} \frac{\omega_c}{\pi} & \text{if } k=0 \\ \frac{-\sin(\omega_c k)}{\pi k} & \text{if } -M \leq k \leq M \end{cases}$$

3. $h(1) = \frac{-\sin(0.2\pi \cdot 1)}{\pi \cdot 1} = -0.187097856$

1. $h(0) = \frac{0.2\pi}{\pi} = 0.2$

2. $h(1) = \frac{-\sin(0.2\pi \cdot 1)}{\pi \cdot 1} = -0.187097856$

$h(-1) = h(1)$

$b_0, b_1, b_2 = ?$

- b) 5-TAP, Bandpass
Cutoff Freq. Low: 1000
High: 1,250
Sampling Rate: 5000

Normalised Cutoff Freq. formula still applies.

5-TAP, $2M+1$
4 $2M$
2 M

$$2\pi \cdot 1000 \div 5000 = 2\pi \cdot 0.2 = 0.4\pi = \omega_L$$

$$2\pi \cdot 1250 \div 5000 = 2\pi \cdot 0.25 = 0.5\pi = \omega_H$$

Bandpass Formulae

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

$$h(2) = \frac{\sin(0.5\pi \cdot 2)}{\pi \cdot 2} - \frac{\sin(0.4\pi \cdot 2)}{\pi \cdot 2} = -0.0935489283$$

$$h(1) = \frac{\sin(0.5\pi \cdot 1)}{\pi \cdot 1} - \frac{\sin(0.4\pi \cdot 1)}{\pi \cdot 1} = 0.0155791947$$

$$h(0) = \frac{0.5\pi - 0.4\pi}{\pi} = 0.1$$

$$h(1) = \frac{\sin(0.5\pi \cdot 1) - \sin(0.4\pi \cdot 1)}{\pi \cdot 1} = 0.0155791947$$

$$h(2) = \frac{\sin(0.5\pi \cdot 2) - \sin(0.4\pi \cdot 2)}{\pi \cdot 2} = -0.0935489283$$

$$h(2) = -0.0935489283 \approx -0.0935$$

$$h(1) = 0.0155791947 \approx 0.0156$$

$$h(0) = 0.1000000000 \approx 0.1000$$

$$h(1) = 0.0155791947 \approx 0.0156$$

$$h(2) = -0.0935489283 \approx -0.0935$$

$h(-1) = h(1)$

$h(-2) = h(2)$

$b_0, b_1, b_2, b_3 = ?$

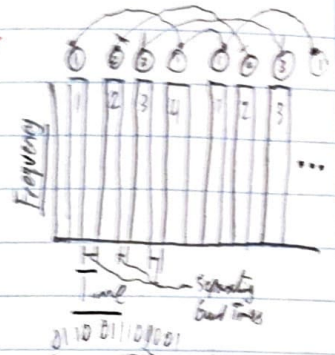
Please Turn over for 4) c)

Q4b
12/15

4) c) Brief Explanations of the following terminology:-

i) Time Division Multiplexing

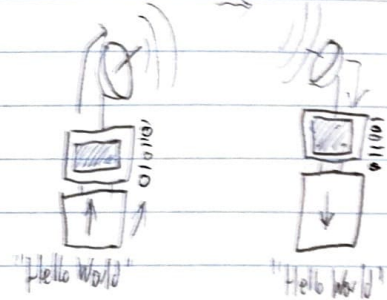
Time Division Multiplexing is where set of ~~data~~ ^{multiple} ~~can't~~ ^{can} ~~means~~ ^{means} a set of separate ~~time~~ ^{resources} used data is split into time frames per user, usually separated by guard times where compensation against data collision is facilitated. What can be interesting about this method of ~~time~~ ^{communication} is that a user can take multiple sets of time frames.



Q4c
6/15

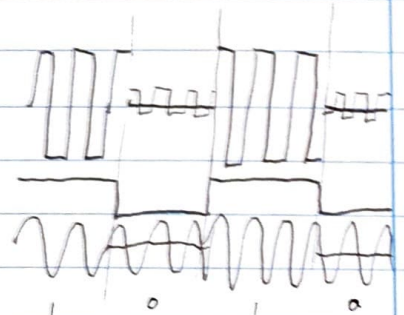
ii) Modulation and Demodulation

Modulation is the ~~encoding~~ ^{conversion} and sending of data whereas Demodulation is the ~~receiving~~ ^{recovery} and decoding of sent data into a readable format.



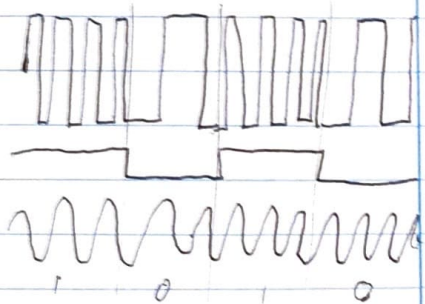
iii) ASK Digital Modulation

"Amplitude Shift Key" digital modulation is when a sequence of data is being represented as amplitude sizes that manipulate the ~~carrier~~ ^{resulting} signal that is to be sent to a recipient device to demodulate and read.



iv) FSK Digital Modulation

"Frequency Shift Key" digital modulation is ~~often~~ ^{similar} like ASK Digital Modulation, but the frequency is what manipulates the process of the ~~carrier~~ ^{resulting} signal, later sending it to some recipient device to demodulate and read.



v) Baseband System

A baseband system is where the input and other such set of data comprise of frequencies of a relatively small number (that can include 0Hz).

They can be separate from passband system that uses filters to modify the signal to artificial ~~IT~~ ^{initially} unrecognizable sets.

~ 20Hz - 4kHz. ☒ 0
1MHz - 60MHz. X

