Q1. MCQs

1. c. Quantization

2. c. Low Pass Averaging Pass

3. b. 7

4. c. P1 - P3 - P4 - P2 - P5 - P7 - P10

5. b. Time Reversal

6. c. $u(n) - u(n-1)$

7. a. Low Pass averaging filter.

8. d. 300 Hz

9. d. Circular Convolution of sequences

10. c. 64 and 32.

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Q2 8]

Given :

$$x(n) = \begin{cases} n^2 & ; \; 0 \le n \le 3 \\ 10-n & ; \; 4 \le n \le 6 \\ n & ; \; 7 \le n \le 9 \\ 0 & ; \; \text{otherwise} \end{cases}$$

Formula : i) $\text{Energy } (E) = \sum_{n=-\infty}^{\infty} |x(n)|^2$

ii) $\text{Power } (P) = \lim_{N \to \infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2$

Solution :

$$\text{Energy } (E) = \sum_{n=-\infty}^{\infty} |x(n)|^2$$

$$= \sum_{n=0}^{3} |n^2|^2 + \sum_{n=4}^{6} |10-n|^2 + \sum_{n=7}^{9} |n|^2$$

$$= \sum_{n=0}^{3} n^4 + \sum_{n=4}^{6} (100 - 20n + n^2) + \sum_{n=7}^{9} n^2$$

$$= 1^4 + 2^4 + 3^4 + |100 - 20\times4 + 4^2| + |100 - 20\times5 + 5^2| + |100 - 20\times6 + 6^2| + 7^2 + 8^2 + 9^2$$

$$= 98 + |100-80+16| + |100-100+25| + |100-120+36| + 194$$

$$= 98 + 36 + 25 + 16 + 194$$

$$\text{Energy } (E) = 369$$

[P.T.O]

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Since, Energy of the signal is a finite value, the given signal $x(n)$ is an energy signal.

Since, the signal is an energy signal
Therefore, the power of signal is zero.

$\therefore$ Power $(P) = 0$.

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Q2 c]

DFT Properties

① Shifting property

If $x(n) \leftarrow FT \rightarrow x(k)$ OR $x(n) \leftarrow FT \rightarrow X(\omega)$

Then, $x(n-m) \leftarrow FT \rightarrow W_N^{mk} \cdot x(k)$

i.e. $x(n-m) \leftarrow FT \rightarrow e^{-j\omega k} \, X(\omega)$

& $x(n+m) \leftarrow FT \rightarrow W_N^{-mk} \cdot x(k)$

Shifting property states that when a signal is shifted by m samples then the magnitude spectrum is unchanged but the phase spectrum is changed by amount $(-\omega k)$

② Frequency shifting

$W_N^{mn} \cdot x(k) \leftarrow FT \rightarrow x(k+m)$

$W_N^{-mn} \cdot x(k) \leftarrow FT \rightarrow x(k-m)$

③ Conjugate property

$x(n) \leftarrow FT \rightarrow x(k)$

$x^*(n) \leftarrow FT \rightarrow x^*(-k)$

④ Symmetric Property

$x(n) \leftarrow FT \rightarrow x(k)$

If $x(n) = x(-n)$

Then $x(k) = x^*(N-k)$

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(5) Convolution Property

If $x_1(n) \xleftrightarrow{FT} X_1(k)$ & $x_2(n) \xleftrightarrow{FT} X_2(k)$

Then $x_1(n) * x_2(n) \xleftrightarrow{FT} X_1(k) \cdot X_2(k)$

Convolution of two signals in time domain is equivalent to multiplication in frequency domain.

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Q 3 A]

Histogram

- It is a graphical representation of the intensity distribution of an image
- In simple terms it represents the no. of pixels for each intensity value considered.
- Histogram is not a unique representation of an image
- It is a graph of gray values vs frequency occurences of gray value.
- It depends on the probability or freqrency of gray value.
- So no matter how the grey values are distributed over the image, if the frequency of occurences of gray values is not changed, the histogram will not change
- Therefore, histogram is not unique representation of images
- It means that it is possible that two or more different images have same histograms.

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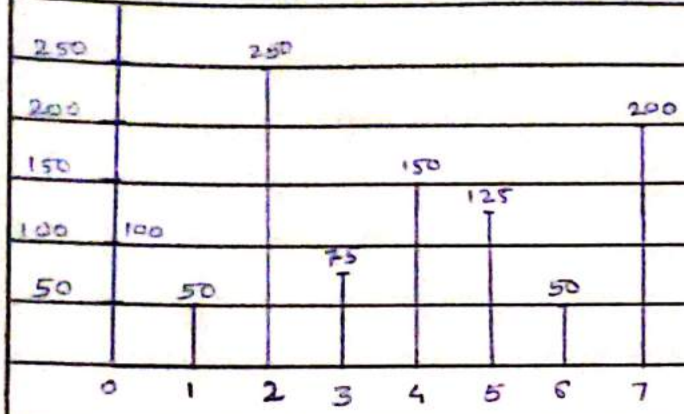
grey level	0	1	2	3	4	5	6	7
No. of Pixels	100	50	250	75	150	125	50	200

L = 8



← Original histogram

grey level	nk	PDF	Sk	L-1 × Sk	Rounding off
0	100	0.1	0.1	0.7	1
1	50	0.05	0.15	1.05	1
2	250	0.025	0.4	2.8	3
3	75	0.075	0.475	3.325	3
4	150	0.15	0.625	4.375	4
5	125	0.125	0.75	5.25	5
6	50	0.05	0.80	5.6	6
7	200	0.2	1	7	7

N = 1000

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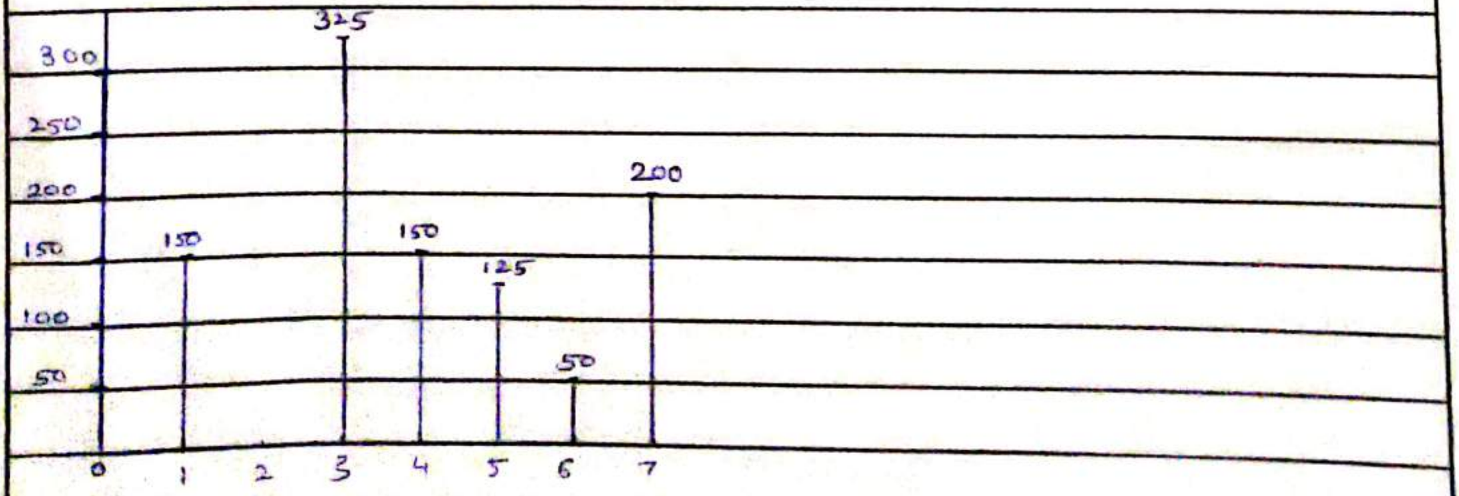
Old grey level	Equalized grey level	New grey level
0	100	1
1	50	1
2	250	3
3	75	3
4	150	4
5	125	5
6	50	6
7	200	7

Equalized grey level	No of Pixels
0	0
1	100 + 50 = 150
2	0
3	250 + 75 = 325
4	150
5	125
6	50
7	200



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Q3 B]

Image segmentation based on discontinuity.

- In this approach the image is partition based on abrupt changes in grey level.
- The principle area of interest within this category is detection of isolated points and detection of lines and edges in an image.

① Point detection
- The detection of points is done by using following mask

-1	-1	-1
-1	8	-1
-1	-1	-1

- If $|R| > T$ then isolated point is detected
- Where T is non-negative point threshold.
- $R = w_1 z_1 + w_2 z_2 + w_3 z_3 + \dots + w_9 z_9$
- The idea is that gray level of an isolated image will be quite different from gray level of its neighbours

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② Line Detection

- Masks for line detection

-1	-1	-1		-1	-1	2
2	2	2		-1	2	-1
-1	-1	-1		2	-1	-1

① Horizontal ② +45°

-1	2	-1		2	-1	-1
-1	2	-1		-1	2	-1
-1	2	-1		-1	-1	2

③ Vertical ④ -45°

- The first mask respond more strongly to line oriented horizontally.
- While third mask respond more strongly to line oriented vertically and 2^{nd} and 4^{th} mask respond more strongly to line oriented +45° & -45°.
- With constant background the maximum response would result when the line is passing through the middle row of the mask

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③ Edge Detection

- It is most common approach for detection of discontinuities in grey level
- Edge detection characterizes the object boundaries
- Edge point can be thought of as pixel location of abrupt gray levels.
- It is the boundary between two regions with relatively distinct gray level properties.
- Types of edges
  ① Step edge
  ② Ramp edge

- Step edges are detected using first order derivative like sobel, Robert, Prewitt.

- Ramp edges are detected using second order derivatives like Laplacian Filter.

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Q4 1]

Zero Memory Point Operations

- It is also known as point processing
- In zero memory point operations, single pixels are used. i.e. T is 1 x 1 operator.
- It means that the new value $f(x, y)$
- For every input image pixel value, Transformation function gives corresponding output image pixel value, no memory location is required to store intermediate results.
- Let r denotes input image pixel value and S denotes output image pixel value.
- Then $s = T(r)$. where T is any zero memory point operation Transformation function

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Dynamic Range Compression

- Most of the times the dynamic range of the image exceeds the capability of the display device
- What happens is that some pixel values are so large that the other low value pixels gets obscured
- A simple example of such is that during daytime we cannot see the stars.
- The reason behind this is that the intensity of sun is so large and that of the stars is so low that the eye cannot adjust to such a large dynamic range.
- In image processing, a classic example of such large difference is the fourier spectrum
- In fourier spectrum, only some of the values are very large while most of the values are too small
- The dynamic range of pixels is of the order of 10^6
- Hence when we plot fourier spectrum, we see only small dots, which represent the large values.

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Bit Plane Slicing

- In this technique we find out the contribution made by each bit to the final image.
- Image is defined as a 256 x 256 x 8 image.
- In this 256 x 256 is the number of pixels present in the image and 8 is the number of bits required to represent each pixel.
- 8 bits simply means 2^8 or 256 grey levels
- Now each pixel will be represented by 8 bits.
- Example,
  Black is represented as 00000000 and white is represented as 11111111 and between them 254 grey levels are accommodated.
- In bit plane slicing we see the importance of each bit in the final image
- This can be follow as: —

1. Consider the LSB value of each pixel and plot image using only LSB
2. Continue doing this for each bit till we come to the MSB
3. Note that we will get 8 different images and all the 8 images will be binary

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Q4 B]

$x(n) = \{1, -2, 3, 2\}$

① Since $x(n)$ is of length 4.

$\therefore$ $N = 4$ we generate a DFT matrix of size 4×4

② $\therefore X(k) = [W_4]_{4\times4} \; x(n)$

$$= \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \begin{bmatrix} 1 \\ -2 \\ 3 \\ 2 \end{bmatrix}$$

$$= \begin{bmatrix} 1 - 2 + 3 + 2 \\ 1 + 2j - 3 + 2j \\ 1 + 2 + 3 - 2 \\ 1 - 2j - 3 - 2j \end{bmatrix}$$

$$= \begin{bmatrix} 4 \\ -2 + 4j \\ 4 \\ -2 - 4j \end{bmatrix}$$

$\therefore X(k) = \{4, -2 + 4j, 4, -2 - 4j\}$

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③ For magnitude and Phase spectrum

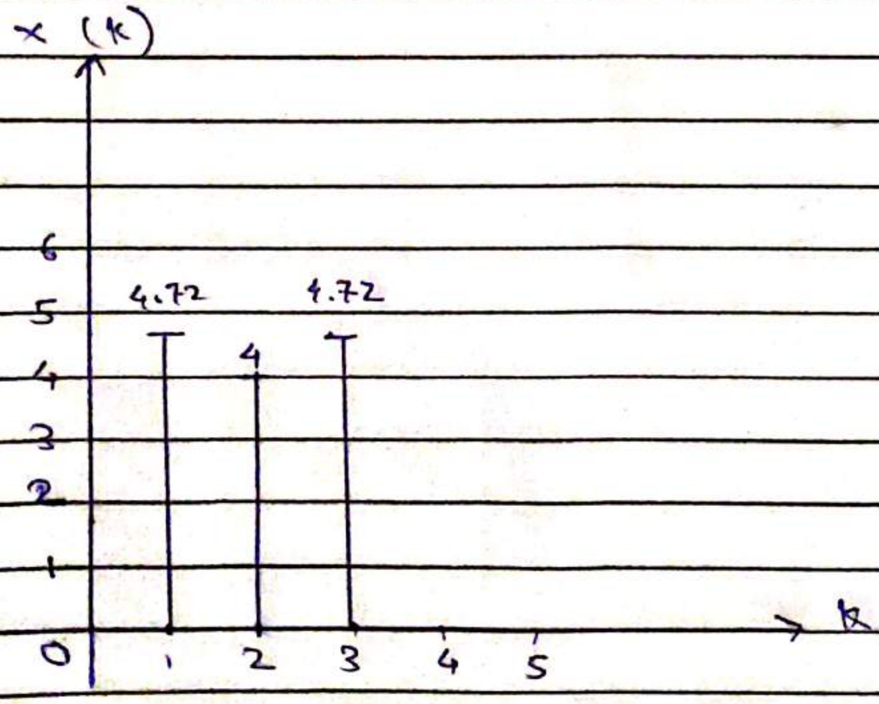
$\therefore |X(k)| = \sqrt{(\text{Real})^2 + (\text{Imaginary})^2}$

$\therefore |X(k)| = \{4, 4.472, 4, 4.472\}$

④ $\therefore \angle X(k) = \tan^{-1}\left(\dfrac{\text{Imaginary}}{\text{Real}}\right)$

$\therefore \angle X(k) = \{0^\circ, -63.43^\circ, 0^\circ, 63.43^\circ\}$

⑤ Magnitude spectrum



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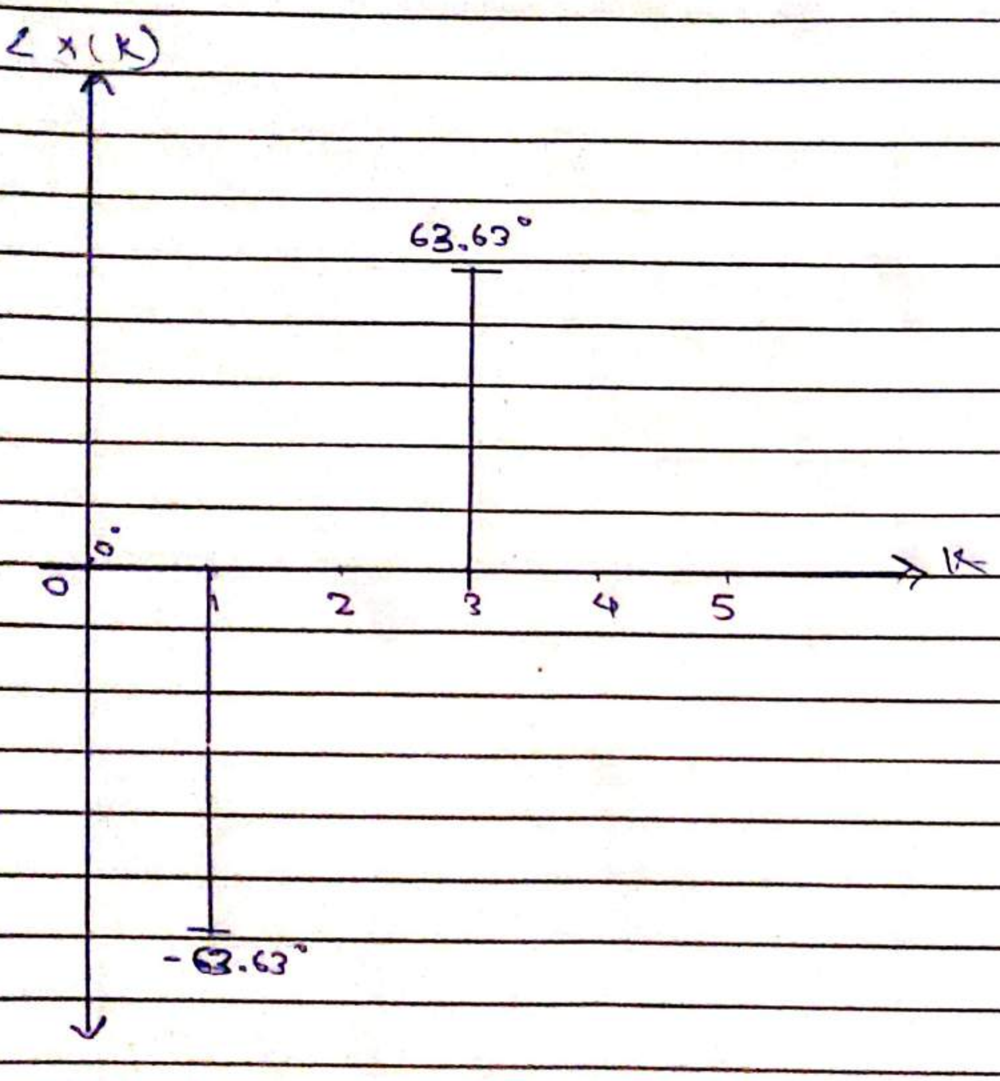
⑥ Phase Spectrum



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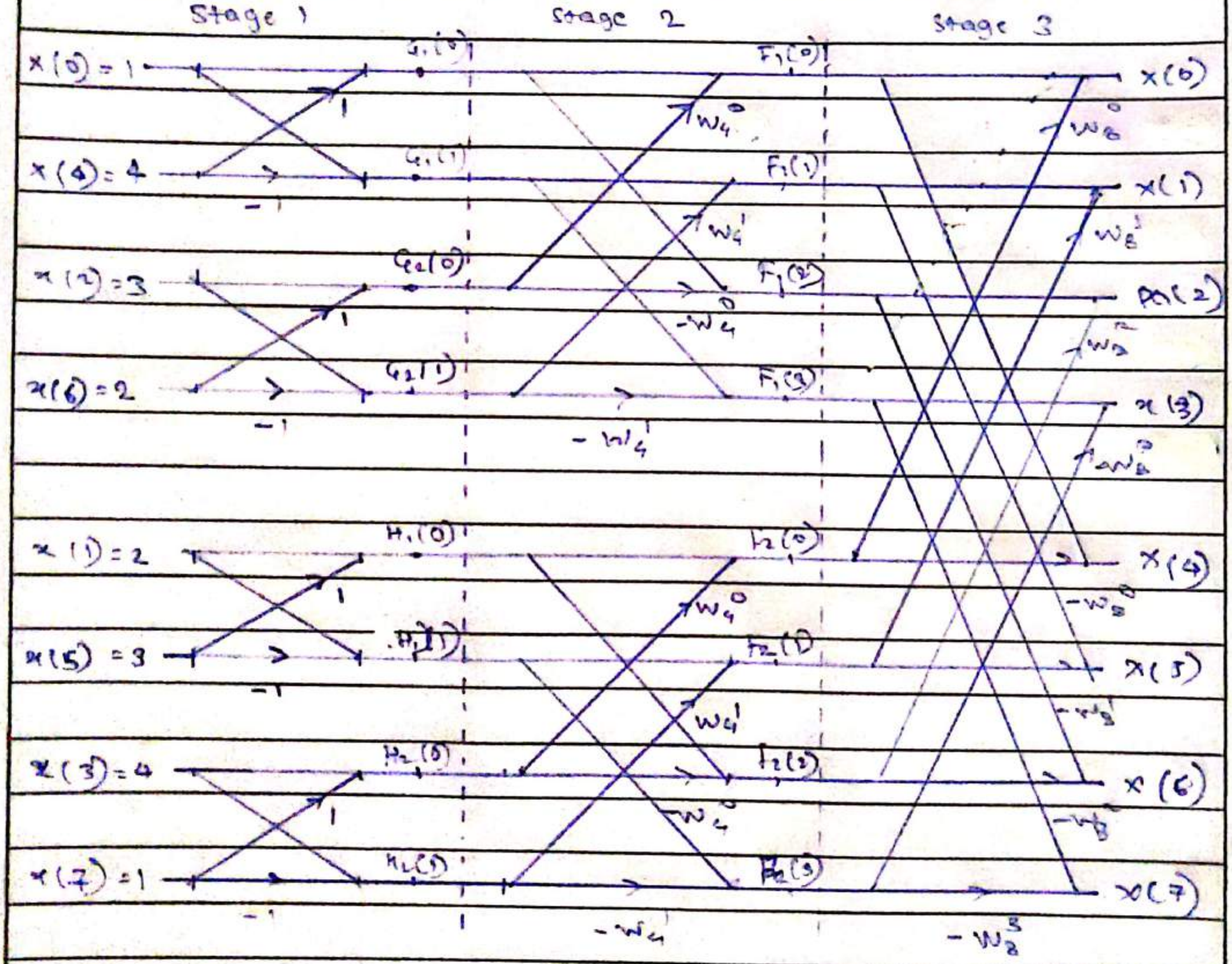
Q4. C]

Solution:

Since N = 8 we draw a 8-point DIT-FFT diagram.

$x(n) = \{1, 2, 3, 4, 4, 3, 2, 1\}$

$x(0)$ $x(1)$ $x(2)$ $x(3)$ $x(4)$ $x(5)$ $x(6)$ $x(7)$



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Stage 1

$G_1(0) = x(0) + x(4) = 1 + 4 = 5$

$G_1(1) = x(0) - x(4) = 1 - 4 = -3$

$G_2(0) = x(2) + x(6) = 3 + 2 = 5$

$G_2(1) = x(2) - x(6) = 3 - 2 = 1$

$H_1(0) = x(1) + x(5) = 2 + 3 = 5$

$H_1(1) = x(1) - x(5) = 2 - 3 = -1$

$H_2(0) = x(3) + x(7) = 4 + 1 = 5$

$H_2(1) = x(3) - x(7) = 4 - 1 = 3$

Stage 2

$F_1(0) = 5 + 5 = 10$	$F_2(0) = 10$
$F_1(1) = -3 - j$	$F_2(1) = -1 - 3j$
$F_1(2) = 5 - 5 = 0$	$F_2(2) = 5 - 5 = 0$
$F_1(3) = -3 + j$	$F_2(3) = -1 + 3j$

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Stage 3

$x(0) = 10 + 10 = 20$

$x(1) = -3 - j + (0.707 - j\,0.707)(-1-3j)$
$= -3 - j + (-0.707 - j2.121 + j0.707 - 2.121)$
$= -3 - j + (-2.828 - 1.414j)$
$= -5.828 - j2.414$

$x(2) = 0$

$x(3) = -3 + j + (-0.707 - 0.707j)(-1 + 3j)$
$= -3 + j + (0.707 - 2.121j + j\,0.707)$
$= -3 + j + (2.828 - j1.414)$
$= -0.172 - j0.414$

$x(4) = 10 - 10 = 0$

$x(5) = -3 - j - (0.707 - j\,0.707)(-1 - j3)$
$= -0.172 + j0.414$

$x(6) = 0 - (-j)(0) = 0$

$x(7) = -3 - j - (-0.707 - j0.707)(-1 + j3)$
$= -5.828 + j2.414$

$x(8) = \{20, -5.828 - j2.414, 0, -0.172 - j0.414, -0.172 + j0.414, 0, -5.828 + j2.414\}$

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