Adwait Parag 202130010

Assignment 5

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Q1

INDIA

Size = 5 characters = 5 bytes = 40 bits

Symbol	Probability
I	0.4
N	0.2
D	0.2
A	0.2

① Interval for I

lower range = 0 upper range = 1

No. of sub-intervals = 5

Step value = $\frac{1-0}{5} = 0.2$

Interval for char 'I' is [0 to 0.4]

② Interval for 'N'

low range = 0 upper range = 0.4

No. of sub-intervals = 5

Step value = $\frac{0.4-0}{5} = 0.08$

Interval for char 'N' is [0.16 to 0.24]

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③ Interval for 'D'

Lower range = 0.16 upper range = 0.24

No. of sub-intervals = 5

$$\text{Step value} = \frac{0.24 - 0.16}{5} = \frac{0.08}{5} = 0.016$$

Interval for char 'D' is [0.208 to 0.224]

④ 'I'

Range : [0.208 to 0.224]

$$\text{Step value} = \frac{0.224 - 0.208}{5}$$

$$= 0.0032$$

Interval : [0.208 to 0.2144]

⑤ 'A'

Range [0.208 to 0.2144]

Step value = 0.00128

Interval : [0.21312 to 0.2144]

0.21312 < Arithmetic Codeword < 0.2144

Arithmetic Codeword : 0.21313

$$\text{BPP} = \frac{\text{Size of compressed message in bits}}{\text{Total no. of characters}}$$

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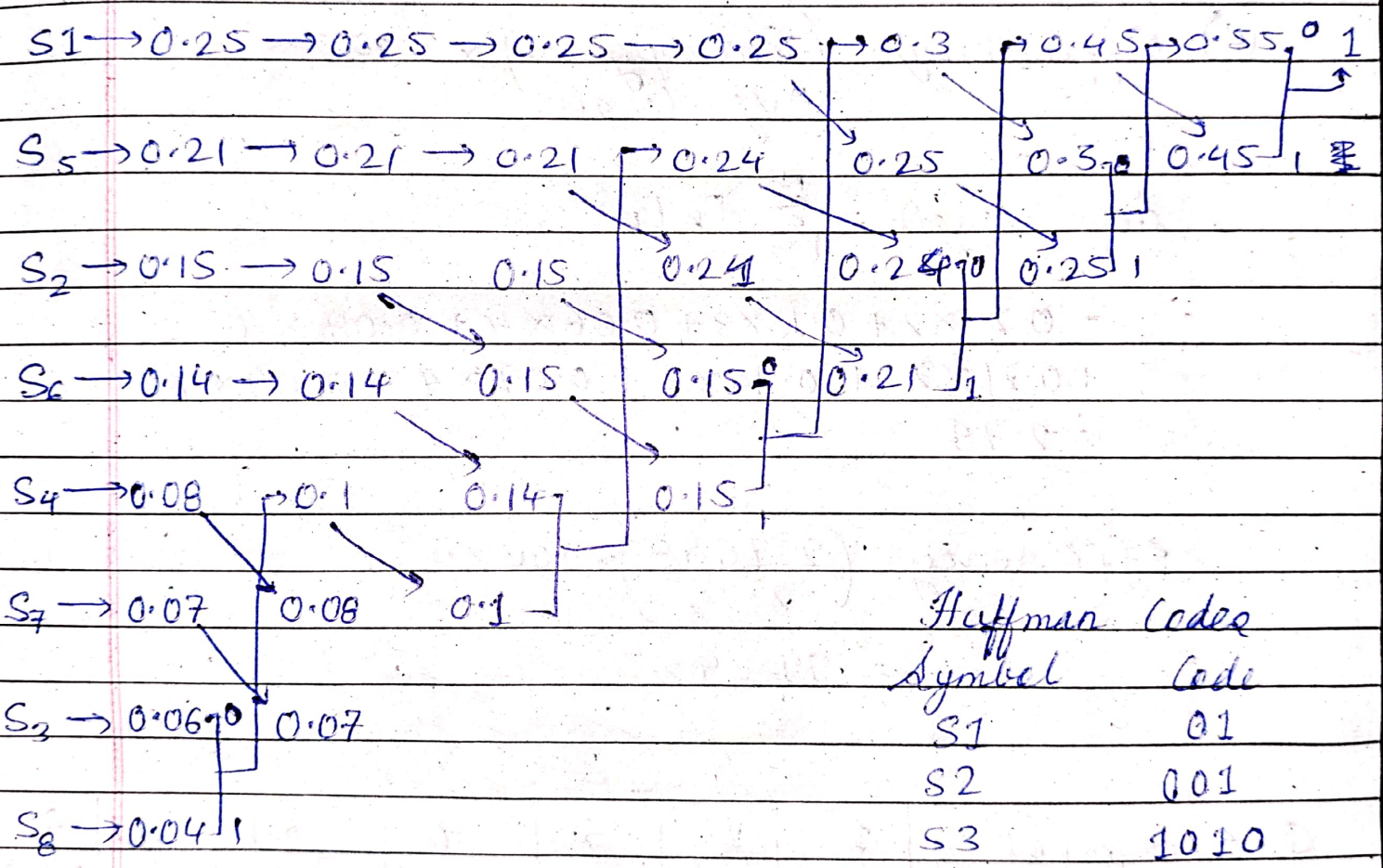
BPP = 6.2

$$\text{Compression} = \left(\frac{\text{Original size} - \text{Compressed size}}{\text{Original size}}\right) \times 100\%$$

Compression = 20%

Q2. (a) Huffman tree



Huffman Codes	
Symbol	Code
S1	01
S2	001
S3	1010
S4	0000
S5	11
S6	100
S7	0001
S8	1011

(b) Min. no. of average bits of seq. per symbol = Entropy

$$= \sum_{k=1}^{N} P_k \log\left(\frac{1}{P_k}\right)$$

$$= 2.7698$$

(c) Effeceency $\propto$ $\left(\frac{\text{Entropy}}{\text{Avg. length}}\right) \times 100\%$

Avg. length $= \sum_{k=1}^{N} P_k L_k$

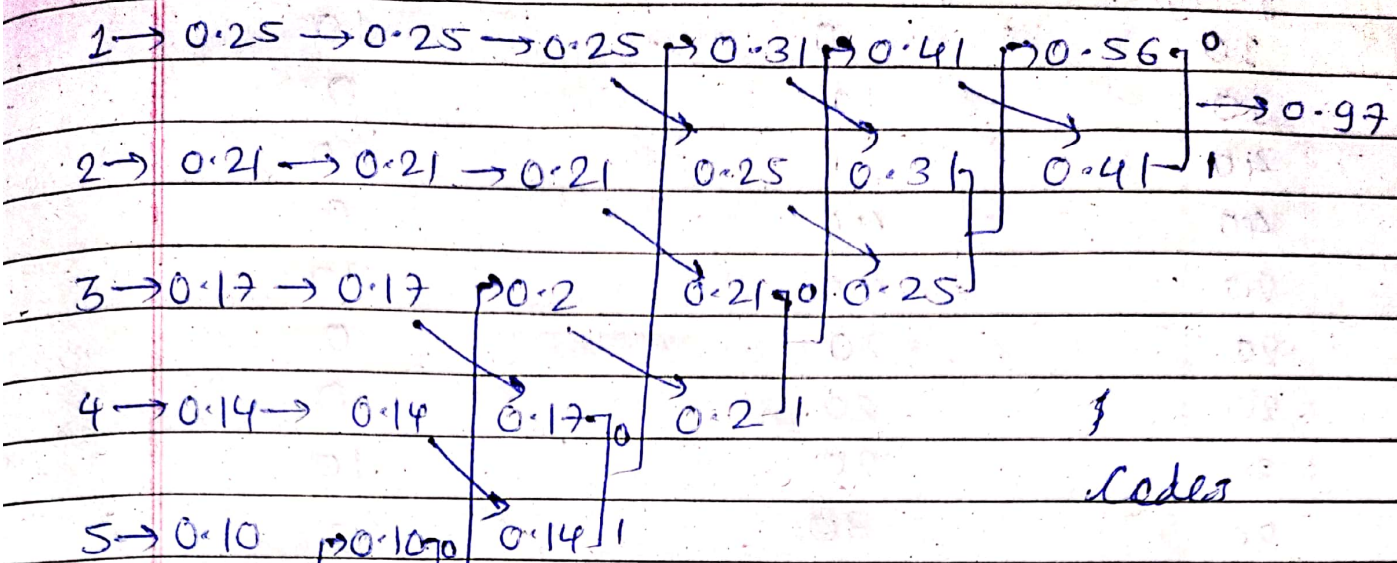
$= 0.25\times2 + 0.15\times3 + 0.06\times4 + 0.08\times4$
$+ 0.21\times2 + 0.14\times3 + 0.07\times4 + 0.04\times4$
$= 2.79$

Effeceency $= \left(\frac{2.7698}{2.79}\right) \times 100\%$

$= 99.24\%$

Q.3

Symbol	1	2	3	4	5	6	7
Probability	0.25	0.21	0.17	0.14	0.10	0.07	0.03



Codes

1	01
2	10
3	000
4	001
5	111
6	1100
7	1101

Q.4

$$F = \begin{bmatrix} 10 & 10 & 90 & 40 \\ 20 & 20 & 20 & 30 \\ 30 & 30 & 40 & 40 \\ 50 & 50 & 60 & 80 \end{bmatrix}$$

DPCM Encoding

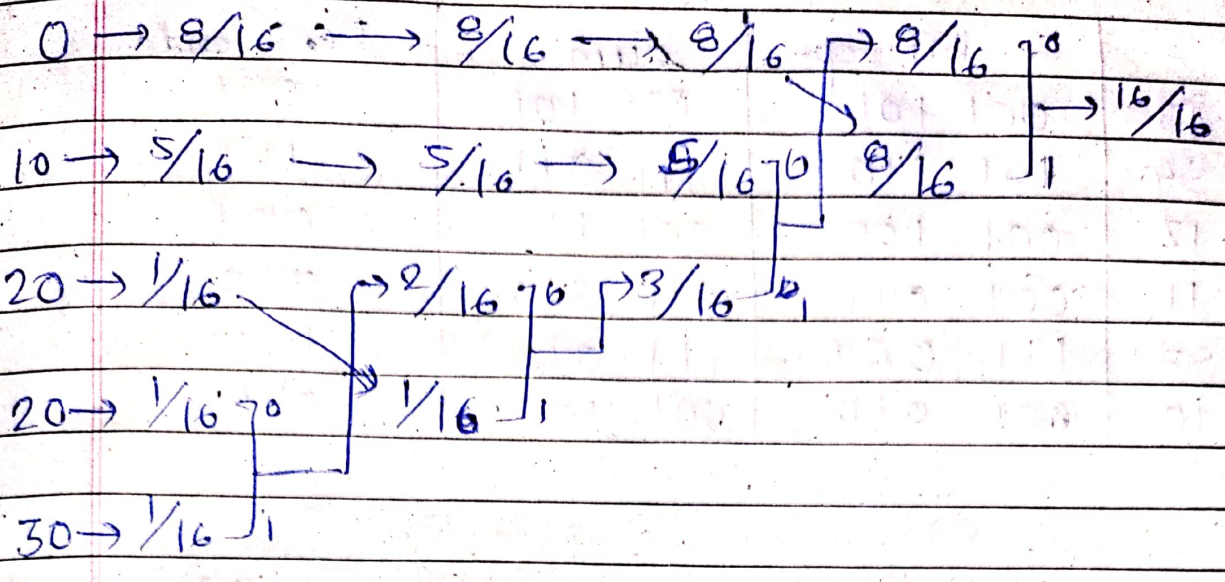
f(x,y)	f^(x,y)	e(x,y)=f(x,y)-f^(x,y)
10	0	10
10	10	0
40	10	30
40	40	0
20	40	-20
20	20	0
20	20	0
30	20	10
30	30	0
30	30	0
40	30	10
40	40	0
50	40	10
50	50	0
60	50	10
80	60	20

Coded Image =
$$\begin{bmatrix} 10 & 0 & 30 & 0 \\ -20 & 0 & 0 & 10 \\ 0 & 0 & 10 & 0 \\ 10 & 0 & 10 & 20 \end{bmatrix}$$

Q.5

$$\begin{bmatrix} 10 & 0 & 30 & 0 \\ -20 & 0 & 0 & 10 \\ 0 & 0 & 10 & 0 \\ 10 & 0 & 10 & 20 \end{bmatrix}$$

Sym.	Prob.
0	8/16
10	5/16
20	1/16
-20	1/16
30	2/16



Symbol	Code
0	1
10	00
20	011
-20	0100
30	0101

Encoded Image =

00	1	0101	1
0100	1	1	00
1	1	00	1
00	1	00	011

$$BPP = \frac{\text{Size of compressed Image}}{\text{No. of pixel}} = \frac{29}{16} = 1.81$$

~~Sample~~

Compression ratio $= \left(\frac{96-29}{96}\right) \times 100\% = 69.79\%$

Q.6

$$F = \begin{bmatrix} 13 & 54 & 12 \\ 13 & 11 & 57 \\ 11 & 10 & 12 \end{bmatrix}$$

(a)

	6 bit rep.	Sum	IGS code
13	001 101	001 101	001
54	101 110	111 011	111
12	001 100	001 111	001
11	001 011	010 010	010
57	111 001	111 011	111
10	001 010	001 101	001

Encoded Image = $\begin{bmatrix} 001 & 111 & 001 \\ 001 & 010 & 111 \\ 010 & 001 & 001 \end{bmatrix}$

$B = \frac{27}{9} = 3$

Compression factor $= \left(\frac{54-27}{54}\right) \times 100$

(b)

IGS (3-bit)	Decoded	O/p pixel value
001	001 000	8
111	111 000	56
001	001 000	8
010	010 000	16
111	111 000	56
001	001 000	8

Decoded Image = $\begin{bmatrix} 8 & 56 & 8 \\ 8 & 16 & 56 \\ 16 & 8 & 8 \end{bmatrix}$

$$MSE = \frac{1}{MXN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} [f(x,y) - \hat{f}(x,y)]^2$$

$$MSE = \frac{1}{9} [25+4+16+25+25+1+25+4+16]$$

$$\boxed{MSE = 15.67}$$

$$PSNR = \frac{(57)^2}{15.67} = 207.3$$

Q.7

(i) All image compression techniques are invertible - False

(ii) Runlength coding is less than but may not give data compression always - True

(iii) Runlength coding always gives data compression - False

(iv) Lossy is not suitable for compressing executable files - True

(v) Variable length coding procedure can be used to compress a histogram equalized image with 2^n gray levels - True

(vi) Shrinking of an image is lossy compression - True

(vii) Compression of an image is only possible if pixel values are occurring consecutively - False