



التاريخ: 19/1/2022  
الزمن: ساعة ونصف

Answer two of the following questions

Q1. Write down three example codes, each with the following properties:

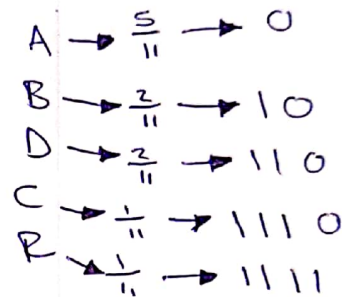
- (i) non distinct.
- (ii) distinct but not instantaneous.
- (iii) instantaneous.

Q2.

Design two codes using Shannon algorithm to encode a memoryless source and calculate its efficiency. Confirm that the codes will have the same efficiency.

A sample of the source output is:

ABRACADABRA  
1 2 3 4 5 6 7 8 9 10 11

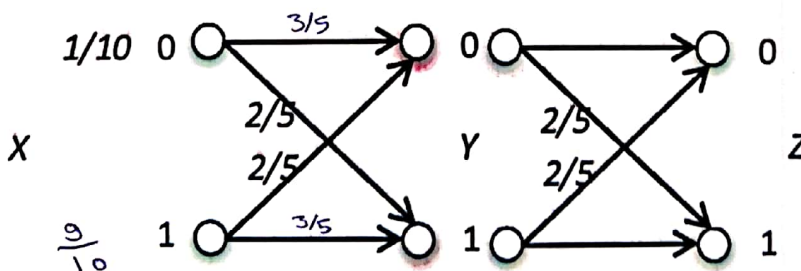


Q3 a. Encode the following messages using the mentioned method:

- (i) 1000000000001100000001000001 (Runlength)
- (ii) BBABABBABCABABDBAD (LZ77)

Q4 A sketch of two binary symmetric channels connected in cascade is given:

- (i) Extract the transition Matrix of the first channel.
- (ii) Compute H(X).
- (iii) At the output of the first channel, find:  $p(Y=1|X=0)$ ,  $p(Y=1, X=0)$ ,  $p(Y=1)$
- (iv) At the output of the second channel, find:  $p(Z=0|X=0)$ ,  $p(Z=1, X=1)$ ,  $p(Z=1)$



تمنياتي للجميع بالتوفيق  
استاذ المادة : أيمن الترهوني

BBABABBABCABABDBAD  
1000000000001100000001000001

30  
30

(184003)

إبراهيم عمورة الأرنؤوط

\* امتحان النصف \*

Q1 Three example codes

i non distinct:-

Code I	Code II	Code III
0	00	110
1	11	110
0	00	010
1	11	010

ii distinct but not instantaneous:-

Code I	Code II	Code III
0	00	1
01	001	10
011	101	100
0111	100	1000

iii instantaneous:-

Code I	Code II	Code III
00	000	0111
10	010	1000
01	011	0101
11	111	1010

Q2

ABRACADABRA

A  $\frac{5}{11}$   
B  $\frac{2}{11}$   
C  $\frac{1}{11}$   
D  $\frac{2}{11}$   
R  $\frac{1}{11}$

A  $\frac{5}{11}$  0  
B  $\frac{2}{11}$  1 0  
D  $\frac{2}{11}$  1 1 0  
C  $\frac{1}{11}$  1 1 1 0  
R  $\frac{1}{11}$  1 1 1 1

A	0
B	10
D	110
C	1110
R	1111

$$L_i = \frac{L_{min}}{L_{avg}} = \frac{H(x) / \log_2(s)}{L_{avg}} = \frac{H(x)}{L_{avg}}$$

$$L_{min} = \frac{H(x)}{\log_2(s)}$$

$$L_{avg} = \sum P_i L_i$$

II

$$L_{min} = H(x) \rightarrow \log_2(2) \leq 1$$

$$H(x) = -\sum P_x \log_2(P_x)$$

$$H(x) = -\left(\frac{5}{11} \log_2\left(\frac{5}{11}\right) + 2\left(\frac{2}{11} \log_2\left(\frac{2}{11}\right)\right) + 2\left(\frac{1}{11} \log_2\left(\frac{1}{11}\right)\right)\right) = 2.04$$

$$L_{avg} = 11\left(\frac{5}{11}\right) + 2\left(\frac{2}{11}\right) + 3\left(\frac{2}{11}\right) + 2 \times 4\left(\frac{1}{11}\right) = 2.09$$

$$\eta_1 = \frac{2.04}{2.09} \times 100$$

$$\eta_1 = 97.61\% \quad \#$$

A	5/11	0		
B	2/11	1	0	0
D	2/11	1	0	1
C	1/11	1	1	0
R	1/11	1	1	1

A	0	5/11
B	1	0
D	1	0
C	1	1
R	1	1

$$L_{avg} = \frac{5}{11} + \frac{2 \times 2 \times 3}{11} + \frac{2 \times 1 \times 3}{11} = 2.09$$

$$\eta_2 = \frac{2.04}{2.09} \times 100$$

$$\eta_2 = 97.61\% \quad \#$$

$$\eta_1 = \eta_2 \quad \#$$

Q3 i) 1000000000000110000000010000001

f) 20327042

0150527151

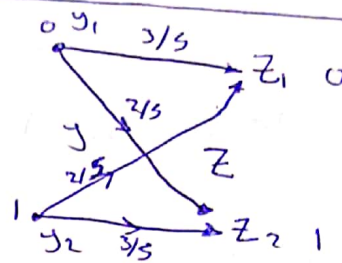
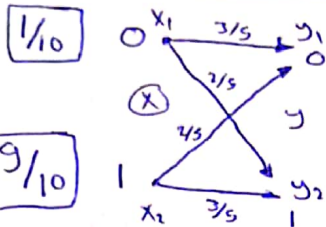
Q3 ii LZ77

BBABABBARCABABDBAD

- (0,0)B
- (1,1)A
- (2,2)B
- (3,3)C
- (8,4)D
- (4,2)D

8

Q4 i



9/10

$$\begin{bmatrix} \frac{3}{5} & \frac{2}{5} \\ \frac{2}{5} & \frac{3}{5} \end{bmatrix}$$

$$\begin{bmatrix} y_1/x_1 & y_2/x_1 \\ y_1/x_2 & y_2/x_2 \end{bmatrix}$$

ii  $H(X) = - \sum P_x \log_2(P_x)$

$$H(X) = \left[ \frac{1}{10} \log_2\left(\frac{1}{10}\right) + \frac{9}{10} \log_2\left(\frac{9}{10}\right) \right]$$

$$H(X) = 0.469 \text{ bits}$$

iii

~~Handwritten scribbles~~

$$P(y=1 | X=0) = \frac{2}{5}$$

$$P(y=1, X=0) = \left(\frac{2}{5} \times \frac{1}{10}\right) = \frac{1}{25} = 0.04$$

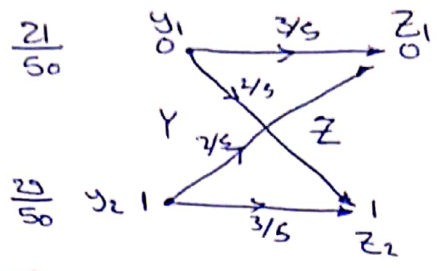
$$P(y=1) = \left(\frac{1}{10} \mid \frac{2}{5}\right) + \left(\frac{9}{10} \mid \frac{3}{5}\right) = \frac{29}{50} = 0.58$$

$$P(y=0) = \frac{21}{50}$$

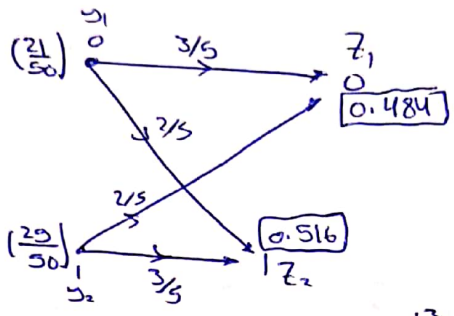
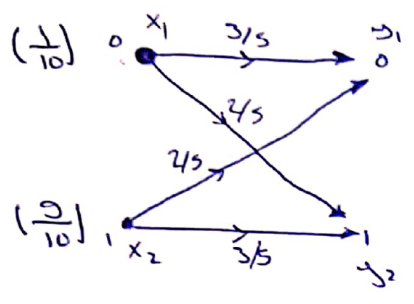
3

iv  $\frac{1-29}{50}$

$\frac{21}{50}$



~~P(Z=0 | X=0) = ...~~



$P(Z=0 | X=0) = \left(\frac{3}{5} \times \frac{3}{5}\right) + \left(\frac{2}{5} \times \frac{2}{5}\right) = \frac{13}{25} = 0.52$

$P(Z=1, X=1) = \left(\frac{3}{10} \times \frac{3}{5} \times \frac{3}{5}\right) + \left(\frac{2}{10} \times \frac{2}{5} \times \frac{2}{5}\right) = 0.468$

$P(Z=1) = \left(\frac{21}{50}\right) \left(\frac{2}{5}\right) + \left(\frac{29}{50}\right) \left(\frac{3}{50}\right) = 0.516$

$\therefore P(Z=0) = 0.484$

8