Internal Assessment Test - 1

1) Construct a codeword for the data 1011 using (7.4) Hamming code where parity equations are $P1 = d_2 \oplus d_3 \oplus d_4$, $P2 = d_1 \oplus d_3 \oplus d_4$, $P3 = d_1 \oplus d_2 \oplus d_4$. Decode the data assuming no error during transmission. Decode the data assuming the 3^{rd} bit is received in error due to noise in the channel.

$\longrightarrow$ Given $P = \begin{bmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \end{bmatrix}$

$(n-k)$

$7-4$

$\Rightarrow 3$

$2^3 = 8$

$$G = [I_{K-1} \quad P_{Kn}]$$

$$= \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$C = D \cdot G$$

$$[1\ 0\ 1\ 1] \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$C = [1\,0\,1\,1\,0\,1\,0]$

$H^T = [P \mid I]$

$$H = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}$$

$$H^T = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$S = [1\,0\,1\,1\,0\,1\,0] \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$S = [0\ 0\ 0]$$

∴ if syndrome $S = rH^T$ is equal to zero, there will be no error in received data bit

Lets, check the error in 3rd bit (r)

$$r = [1\,0\,0\,1\,0\,1\,0]$$

$$= [1\,0\,0\,1\,0\,1\,0] \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ \boxed{1 \quad 1 \quad 1} \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \rightarrow 3^{rd}$$

hence 3rd bit $S = [1\ 1\ 0]$ is error in received data.

2.) Define

i) Entropy

-> it is a measure of uncertainity or random associated with the possible outcome of a message signal higher entropy indicator greater uncertainity.

Mathematical Formula

$$H(x) = -\sum_{i} P(x_i) * \log_2 (P(x_i))$$

where

-> $H(x)$ is entropy of random variable x

-> $P(x_i)$ is the probability of x

-> $\log_2$ is the logarithm for base 2.

ii) Hamming weight

-> Hamming weight of a binary string (or codeword) is the number of non-zero bits (or 1) in the string its a fundamental concept in correction oding and information theory.

ex: Binary string (10 11 0)

.hamming weight of the binary one in 3

$$\boxed{hw = 3}$$

) Self Information

> Self information is a measure of the informatio ontent associated with a specific eventful sym quantifier the suprise or uncertainity associat ith the occurence of that event.

Ex: $I(x) = -\log_2 (p(x))$

where $I(x)$ self Information

$P(x)$ exponentially on event x

iv) Information rate

-> which measures the rate at which information is transmitted over a communication channel in bits per second (bytes)

it's often compared

relationship between bitrate, symbol rate,

Information rate.

Information rate (bqn) = symbol rate (symbol / sec)

v) Joint probability matrix

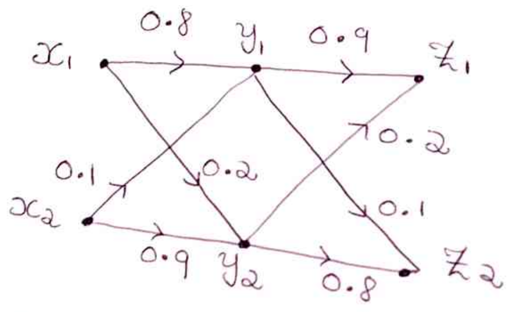
-> A joint probability matrix is a table that shows the probabilities at two vevents occuring simultaneously

-> In digital Communication, we often use it to represent relationship between

-> The transmitted symbols (X)

-> The received symbols (Y)

3.) Two noisy channels are cascaded as shown below, find $H(x)$, $H(Y)$, & $H(Z)$, $H(X,Z)$, $H(Z|X)$ and $H(X|Z)$ given the probability of $p(x_1) = p(x_2) = 0.5$



-> $P(x_1) = P(x_2) = 0.5$

Probabilities from x to z

$P(y_1 | x_1) = 0.8$ and $P(y_2 / x_1) = 0.2$

$P(y_1 | x_2) = 0.1$ and $P(y_2 | x_2) = 0.9$

Transition probabilities from Y to Z

$P(Z_1/Y_1)=0.9$ and $P(Z_2|Y_1)=0.1$

$P(Z_1|Y_2)=0.2$ and $P(Z_2|Y_2)=0.8$

$P(y_1)=P(y_1|X_1)\cdot P(X_1)+P(Y_1|X_2)\cdot P(X_2)=0.45$

$P(y_2)=P(y_2|X_1)\cdot P(X_1)+P(y_2|X_2)\cdot P(X_2)=0.55$

$P(Z_1)=P(Z_1|Y_1)\cdot P(Y_1)+P(Z_1|Y_2)\cdot P(Y_2)=0.525$

$P(Z_2)=P(Z_2|Y_1)\cdot P(Y_1)+P(Z_2|Y_2)\cdot P(Y_2)=0.425$

(x_1, Z_1)

$$P(x_1, Z_1)=P(Z_1|y_1)\cdot P(y_1|x_1)\cdot P(x_1)+P(Z_1, y_2)\cdot P(y|x)\cdot P(x)$$

$$=0.38$$

$$P(x_1, Z_2)=P(Z_2|y_1)\cdot P(y_1|x_1)\cdot P(x_1)+P(Z_2|y_2)+P(y_2|x_1)$$

$$P(x_1)=0.12$$

$$P(x_2, Z_1)=P(Z_1|Y_1)\cdot P(Y_1|X_2)\cdot P(X_2)+P(Z_1|Y_1)\cdot P(Y_2|Z_1)\cdot P(x_1)$$

$$=0.135$$

$$P(x_2, Z_2)=P(Z_2|Y_1)\cdot P(Y_1|x_2)\cdot P(X_2)+P(Z_2|Y_2)\cdot P(Y_2|Z_2)$$

$$P(X_2)=0.365$$

To calculate Entropy

$$H(x)=-[P(x_1)\log_2 P(x_1)+P(x_2)\log_2(P(x))]$$

$$=-[0.5\log_2 0.5+0.5\log_2 0.5]=1.0 \text{ bits}$$

$$H(Y)=-[P(Y_1)\log_2 P(Y_1)+P(Y_2)\log_2 P(Y_2)]$$

$$\approx 0.995 \text{ bits}$$

$H(X,Z) = -\sum_{i} P(x, z_1)\log_2 P(x_1, z_1)$

$H(x,z) \approx 1.818$ bits

$H(Z) = -[P(z_1)\log_2 P(z_1) + P(z_2)\log_2 P(z_2)]$

≈ 1.0 bits

$S = H(Z, R)$

$= (Z|\alpha) + H(x,z) - H(x)$

$\approx 1.818 - 1.0$

$\boxed{\gamma = 0.818 \text{ bits}}$

4.) Consider a (6,3) Linear block code whose geometric matrix is given by

$$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

a.) Find all codewords

b.) Draw encoder circuit

c.) Draw syndrome computation circuit

$\longrightarrow$ $G = [I_K | P_K]$

$$= \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 1 \end{bmatrix}$$

$\underbrace{\quad\quad}_{I}$

$K \Rightarrow 6-3$

$\Rightarrow 3$

$2^3 \Rightarrow 8$

ii)

$C = D \cdot G$

$$= \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

$C_1 = [0\,0\,0\,0\,0\,0]$ $\quad C_4 = [0\,1\,1\,1\,0\,1]$ $\quad C_7 = [1\,1\,0\,0\,1\,1]$

$C_2 = [0\,0\,1\,0\,1\,1]$ $\quad C_5 = [1\,0\,0\,1\,0\,1]$ $\quad C_8 = [1\,1\,1\,0\,0\,0]$

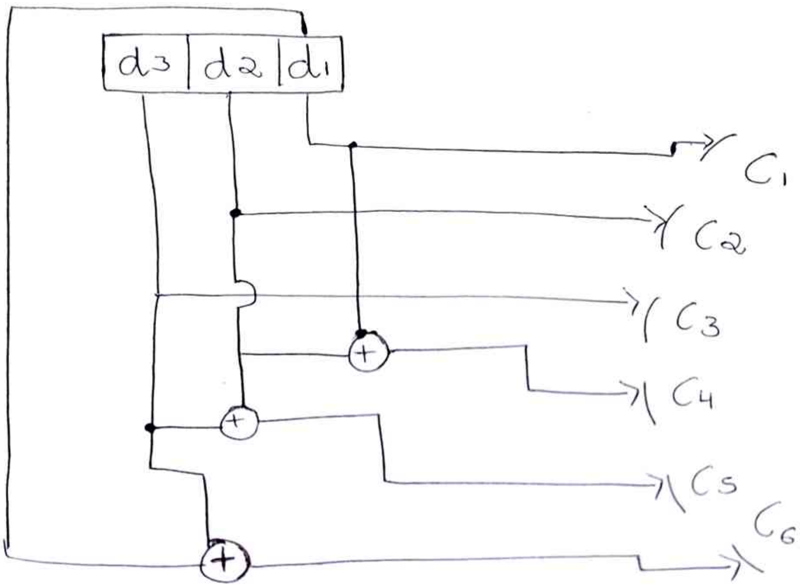
$C_3 = [0\,1\,0\,1\,1\,0]$ $\quad C_6 = [1\,0\,1\,1\,1\,0]$

$C_1 = d_1$ $\quad C_4 = d_1 \oplus d_2$

$C_2 = d_2$ $\quad C_5 = d_2 \oplus d_3$

$C_3 = d_3$ $\quad C_6 = d_1 \oplus d_3$

ii)

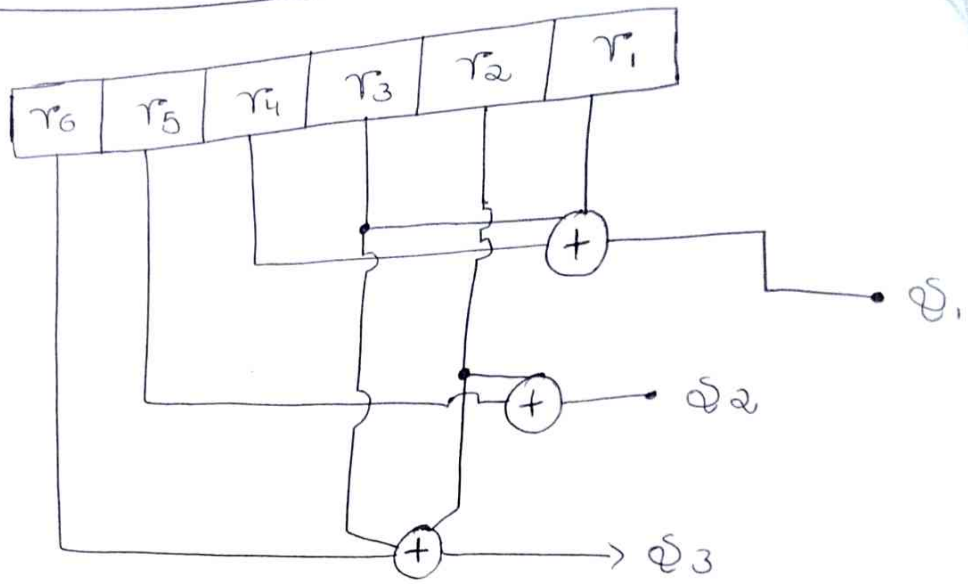


c.) Syndrom Computation circuit

$$S = rH^T$$

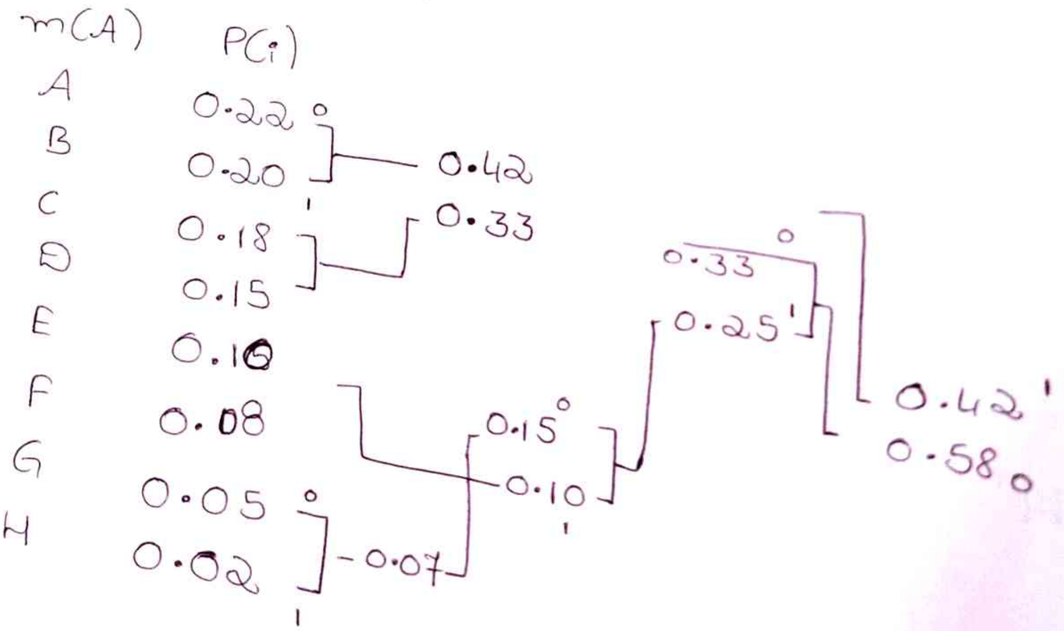
$$H^T = H = \begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

$$H^T = \begin{array}{c} \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \end{array}$$



5.) Consider a source with 8 alphabets A to H with respective probabilities of 0.22, 0.20, 0.18, 0.15, 0.10, 0.08, 0.05, 0.02, Construct huffman code and determine it's efficiency.

⟶ Huffman's code



A	01	2
B	11	2
C	000	3
D	101	3
E	110	3
F	001	3
G	01010	5
H	01010	5

$$H(S) = 0.22 \log\left(\frac{1}{0.22}\right) + 0.20 \log\left(\frac{1}{0.22}\right) + 0.18 \lg\left(\frac{1}{0.8}\right)$$

$$+ 0.15 \lg\left(\frac{1}{0.15}\right) + 0.10 \lg\left(\frac{1}{0.10}\right) + 0.08\left(\frac{1}{0.08}\right)$$

$$+ 0.05 \lg\left(\frac{1}{0.05}\right) + 0.02 \lg\left(\frac{1}{0.02}\right)$$

$$= 0.48 + 0.46 + 0.44 + 0.41 + 0.33 + 0.29 + 0.11$$

$$= 2.73$$

$$L = \sum_{i=0}^{m-1} (n \times P_i)$$

$$= 0.44 + 0.40 + 0.54 + 0.45 + 0.30 + 0.24 + 0.15 + 0.1$$

$$= \underline{\underline{2.62}}$$

$$\eta = \frac{H(S)}{L}$$

$$= \frac{2.62}{2.73} = \underline{\underline{0.95}}$$

$$\boxed{\eta = 95\%}$$

7.) Apply shannon's binary encoding algorithm to the following set of symbols given below along with thier probabilities. Also obtain code efficiency. symbols A, B, C, D, E corresponding probabilities 1/8, 1/16, 3/4, 1/4, 3/8.

A = 0.25, B = 0.62, C = 0.18, D = 0.25, E = 0.35

→

mi	P(i)	no of bits	Fi	Binary	Code word
E	0.37	2	0	0	0
A	0.25	2	0.37	0.01	01
D	0.25	2	0.62	0.10	10
C	0.18	3	0.37	0.110	110
B	0.062	5	1.05	1001	1001

Step 3: finding the number of bits

1) $\lg(1/P_i) = n_1 < 1 + \lg(1/P_1)$

$1.43 \le n_i < 2.43$

2) $2 \le n_1 \le 3$

3) $2 \le n_1 < 3$

4) $2.7 \le n_1 \le 3.47$

5) $4.0 \le n_3 < 5.02$

Step 3: fraction is calculate

$$F_i = \sum_{K=1}^{i-1} P_K \qquad K = 0$$

$$F_1 = \sum_{K=1}^{i-1} P_K = 0$$

$F_2 = \sum_{K=2}^{2-1} P_K = P_1$, $F_3 = P_2 + P_1$, $P_4 = P_3 \oplus P_2 \oplus P_1$

3/4 Efficiency :

$$H(\xi) = \sum_{i=1}^{5} P_i \lg(1/P_i)$$

$$= \sum_{i=1}^{6} n_i p_i$$

$$= 0.37 \lg(1/0.37) + 0.25 \lg(1/0.25) + 0.25 \lg\left(\frac{1}{0.25}\right)$$

$$+ 0.18 \lg\left(\frac{1}{0.18}\right) + 0.62 \lg\left(\frac{1}{0.62}\right)$$

$$= 0.53 + 0.5 + 0.5 + 0.44 + 0.2487$$

$$H(\xi) = 2.2187$$

$$H(\xi) = (2 \times 0.37) + (2 \times 0.25) + (2 \times 0.25) + (3 \times 0.18)$$
$$+ (5 \times 0.062)$$

$$= 0.74 + 0.5 + 0.5 + 0.54 + 0.31$$

$$= \underline{\underline{2.59}} \qquad \eta =$$

8.) A (7, 4) Liner block code has the tamperse A parity check matrix given by

$$H^T = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

a.) Construct all codewords & thier linear block

b.) Show that thier code is Hamming code.

$\longrightarrow$

$$H = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

$$P = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 0 & 1 & 1 & 1 \end{bmatrix}$$

WKT $\quad [I_k \mid P_k]$

$$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$$

$2^3 = 16$

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$C = D * G \Rightarrow \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$C_1 = [0\,0\,0\,0\,0\,0\,0]$ $C_9 = [1\,0\,0\,0\,1\,1\,0]$

$C_2 = [0\,0\,0\,1\,1\,1\,1]$ $C_{10} = [1\,0\,0\,1\,0\,0\,1]$

$C_3 = [0\,0\,1\,0\,1\,0\,1]$ $C_{11} = [1\,0\,1\,0\,0\,1\,1]$

$C_4 = [0\,0\,1\,1\,0\,1\,0]$ $C_{12} = [1\,0\,1\,1\,1\,0\,0]$

$C_5 = [0\,1\,0\,0\,0\,1\,1]$ $C_{13} = [1\,1\,0\,0\,1\,0\,1]$

$C_6 = [0\,1\,0\,1\,1\,0\,0]$ $C_{14} = [1\,1\,0\,1\,0\,1\,0]$

$C_7 = [0\,1\,1\,0\,1\,1\,0]$ $C_{15} = [1\,1\,1\,0\,0\,0\,0]$

$C_8 = [0\,1\,1\,1\,0\,0\,1]$ $C_{16} = [1\,1\,1\,1\,1\,1\,1]$

6.) Construct a ternary code using Huffman encoding algorithm for the source A, B, C, D, E, F and G with probabilities 1/3, 1/27, 1/3, 1/9, 1/9, 1/27 and 1/27 respectively and move the composite symbol as low as possible.

→ ~~A B C D E F G~~
~~0.33 0.03~~

A	B	C	D	E	F	G
0.333	0.037	0.333	0.111	0.111	0.037	0.037

mi	Pi		
A	0.333^{0}	0.333^{0}	0.333^{0}
C	0.333^{1}	0.333^{1}	0.333^{1}
D	0.111^{20}	0.111^{20}	0.333^{2}
E	0.111^{21}	0.111^{21}	
B	0.037^{220}	0.111^{22}	
F	0.037^{221}		
G	0.037^{222}		

a.

A	0	1
B	220	3
C	0	1
D	20	2
E	21	2
F	221	3
G	222	3

$$H(S) = \sum_{i=1}^{M} P_i \lg\left(\frac{1}{P_i}\right)$$

$$= 0.333 \lg\left(\frac{1}{0.333}\right) + 0.333 \lg\left(\frac{1}{0.333}\right) +$$

$$0.111 \lg\left(\frac{1}{0.111}\right) + 0.037 \lg\left(\frac{1}{0.037}\right) + 0.037 \lg\left(\frac{1}{0.037}\right)$$

$$0.037 \lg\left(\frac{1}{0.037}\right)$$

$$=$$

$$n = \sum_{i=1}^{M} n_i \times P_i$$

$$= (1 \times 0.333) + (3 \times 0.037) + (1 \times 0.333)$$

$$+ (2 \times 0.111) + (2 \times 0.111) + (3 \times 0.037) + (3 \times 0.037)$$

$$=$$

$$\eta = \frac{H(S)}{n}$$

4.) a.)

-> Lempel Ziv coding refers to a family of lossless data compression algorithms developed data compression algorithms devcloved by Abraham lempel and Jacob Ziv. These algorithms form the basis of many modern compression schmes and are widely used in applications like file compression (Zip files), data storage and communication systems.

Key features.

i) Dictionary based compression

-> Lempel Ziv methods rely on building a dictionary (explicitly or implicitly) of recurring patterns in the input data.

ii) Lossless Compression

-> The original data can be perfectly reconstructed from the compressed data, making it suitable for applications like text and executable files where accuracy is critical.

Advantages

-> Effecient and Versatile

-> Adaptable to many types of data

Applications

-> File compression

-> Communication Protocols

-> Multimedia

b.) Erron Control Coding (ECC) is a technique used in communication systems to detect and correct errors that occur during data transmission or storage.

Advantages

i) Error detection and Correction

-> ECC an identify and correct errors in transmitt data, ensuring data Integrity

ii) Improved Reliability

-> Enhances realibility of data transmission, even over noisy or unreliable channels, such as wireless networks.

iii) Efficient Resource utilization

-> Reduces the need for retransmissions, saving bandwidth and time

iv) Adaptability :

-> Different coding techniques cater to varying levels of error resilience and data requirements.

v) Improved data Security

-> Some error control codes can also provide an additional layer of security by making the data harder to decode.

Disadvantages

i) Increased Complexity

-> Implementing ECC algorithms require additional processing power and memory, increasing system Complex

ii) Redundancy overhead

-> Extra parity or redundancy bits are added

iii) Processing Delay

-> Error Correction involves encoding and decoding processes, which may introduce latency in real time systems

iv) Cost

-> EEC hardware can be expensive especially in high Performance systems.

b.) $g(x) = 1 + x + x^3$ — ①

Given $(7, 4)$

$[1101000]$

multiply with x

$x \cdot g(x) = x + x^2 + x^4$

$\cancel{x^2 \cdot g(x)} = \begin{bmatrix} 0 & 1 & 1 & 0 & 1 & 0 & 0 \end{bmatrix}$

$x^2 \cdot g(x) = x^2 + x^3 + x^6$

$= \begin{bmatrix} 0 & 0 & 1 & 1 & 0 & 1 & 0 \end{bmatrix}$

$x^3 \cdot g(x) = x^3 + x^4 + x^6$

$= \begin{bmatrix} 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$

$$G = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

$R_3 \longrightarrow R_1 \oplus R_3$

$$G = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

$R_4 \longrightarrow R_1 \oplus R_2 \oplus R_4$

$$G = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ \cancel{0} & \cancel{0} & \cancel{0} & \cancel{0} & \cancel{0} & \cancel{0} & \cancel{1} \end{bmatrix}$$

$1 \; 0 \; 1 \; 0 \; 0 \; 0 \; 1$

$V = D * G$

$$D = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Codeword

$V = E$

00000000
1010001
1110010
0100011
0110100
1100101
1000110
0010111
1101000
1101000
1001011
0011010
0101110
1111111