CBCS SCHEME

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18EC54

# Fifth Semester B.E. Degree Examination, Dec.2024/Jan.2025
## Information Theory and Coding

Time: 3 hrs. Max. Marks: 100

**Note:** ***Answer any FIVE full questions, choosing ONE full question from each module.***





### Module-1

1 a. Discuss the reasons for using logarithmic measure of measuring the amount of information. **(06 Marks)**

b. A source transmits two independent messages with probabilities of p and (1-p) respectively. Prove that the entropy is maximum when both the messages are equally likely. Plot the variations of entropy (H) as a function of probability 'p' of the messages. **(04 Marks)**

c. Find $G_1$ and $G_2$ and verify that $G_1 > G_2 > H(s)$ for the Fig.Q1(c). **(10 Marks)**

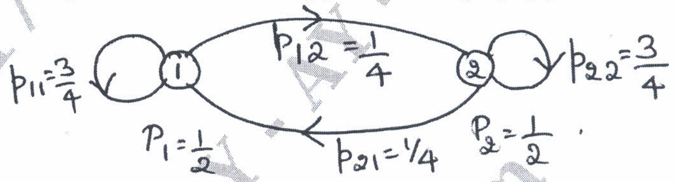


Fig.Q1(c)

**OR**

2 a. Define the following with respect to information theory :
i) Self information
ii) Entropy
iii) Rate of information. **(06 Marks)**

b. An analog signal is band limited to 500 Hz and is sampled at "Nyquist rate". The samples are quantized into 4 levels and each level represent one message. The quantization levels are assumed to be independent. The probabilities of occurrence of 4 levels are $P_1 = P_4 = \frac{1}{8}$ and $P_2 = P_3 = \frac{3}{8}$ find the information rate of the source. **(04 Marks)**

c. The state diagram of the Mark off source is as shown in the Fig.Q2(c). Find :
i) The entropy of each state $H_i$
ii) The entropy of source H
iii) $G_1$, $G_2$ and $H(G_1 > G_2 > H)$. **(10 Marks)**

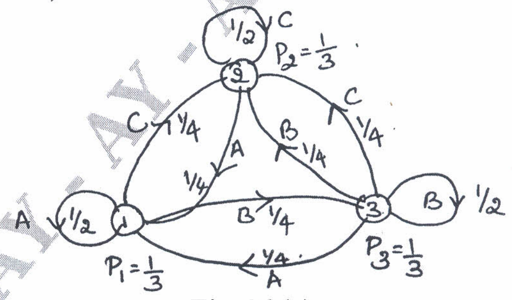


Fig.Q2(c)

### Module-2

3 a. A DMS has an alphabet $S = \{s_0, s_1, s_2, s_3, s_4, s_5, s_6\}$ and source statistics P = {0.125, 0.0625, 0.25, 0.0625, 0.125, 0.125, 0.25}. Construct binary Huffman code. Also find the efficiency and redundancy of coding. **(10 Marks)**

b. Explain prefix coding with an example. Also explain the properties of prefix codes. **(10 Marks)**

**OR**

4 a. Explain Shannon's encoding algorithm. State the properties of Shannon's encoding algorithm. **(10 Marks)**

b. Apply Shannon – Fano encoding algorithm to the following set of messages and obtain the entropy and efficiency.

| Message | $m_1$ | $m_2$ | $m_3$ | $m_4$ | $m_5$ | $m_6$ | $m_7$ | $m_8$ |
|---|---|---|---|---|---|---|---|---|
| Probability of message | $\frac{16}{32}$ | $\frac{4}{32}$ | $\frac{4}{32}$ | $\frac{2}{32}$ | $\frac{2}{32}$ | $\frac{2}{32}$ | $\frac{1}{32}$ | $\frac{1}{32}$ |

**(10 Marks)**

## Module-3

5 a. Prove that the mutual information of the channel is symmetric i.e. $I(X;Y) = (Y;X)$. **(08 Marks)**

b. Two noisy channels are cascaded whose channel matrices are given by,

$$p(y_j \mid x_i) = \begin{bmatrix} \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \\ \frac{1}{2} & \frac{1}{4} & \frac{1}{4} \end{bmatrix} \text{ and } p(z_j \mid y_i) = \begin{bmatrix} \frac{1}{3} & \frac{2}{3} & 0 \\ \frac{2}{3} & 0 & \frac{1}{3} \\ 0 & \frac{1}{3} & \frac{2}{3} \end{bmatrix}$$

With $P(x_1) = P(x_2) = 0.5$. Show that $I(X ; Y) > I(X ; Z)$. **(12 Marks)**

**OR**

6 a. State channel capacity theorem : In the channel capacity equation when the signal power is fixed and white Gaussian noise is present, the channel capacity approaches an upper limit with increase in band width 'B'. Prove that this upper limit is given as,

$$C_\infty = \lim_{B\to\infty} C = 1.44\frac{S}{N_0}.$$ **(10 Marks)**

b. For the channel shown in Fig.Q6(b) the symbols are transmitted at the rate of 10,000 per second. Calculate maximum mutual information of this cannel. **(10 Marks)**

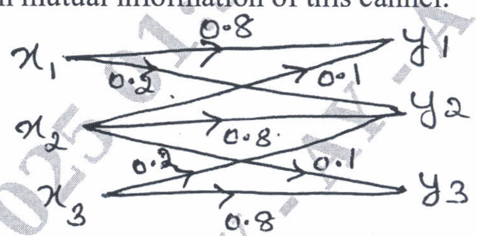


Fig.Q6(b)

## Module-4

7 a. Consider a (7, 4) linear code whose generator matrix is G

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

Find :

i) All the code vectors of this code

ii) Parity check matrix of this code

iii) The maximum weight of this code. **(10 Marks)**

b. The generator polynomial for a(15, 7) cyclic code is $G(x) = 1 + x^4 + x^6 + x^7 + x^8$.

i) Find the code vector in systematic form for the message $D(x) = x^2 + x^3 + x^4$

ii) Assume that the first and last bit of the code vector $V(x)$ for $D(x) = x^2 + x^3 + x^4$ suffer transmission errors. Find the syndrome of $V(x)$. **(10 Marks)**

**OR**

8 a. For a(5, 2) linear, systematic block code, choose the generator matrix and parity check matrix with the objective of maximizing $d_{min}$. For the matrix chosen, construct the standard array. **(10 Marks)**

b. Consider a(6, 3) linear block code whose

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

i) Find all the code vector
ii) Find all Hamming weight and distance
iii) Find minimum weight parity check matrix
iv) Draw encoder circuit for above code. **(10 Marks)**

**Module-5**

9 a. Consider (3, 1, 2) convolution encoder with impulse response

$g_1^{(1)} = \{1\ 1\ 0\}, \quad g_1^{(2)} = \{1\ 0\ 1\}, \quad g_1^{(3)} = \{1\ 1\ 1\}$

i) Draw the encoder block diagram
ii) Find the generator matrix and output code vector for $m = \{1\ \ 1\ \ 1\ \ 0\ 1\}$.
iii) Find the code vector corresponding to the message sequence using time domain approach. **(12 Marks)**

b. Write a note on Viterbi algorithm for decoding of convolutional codes. **(08 Marks)**

**OR**

10 a. For the convolutional encoder of Fig.Q10(a) determine the following :
i) Dimension of the code
ii) Code rate
iii) Constraint length
iv) Generating sequences (impulse responses)
v) Output sequence for message sequence of m = {1 0 0 1 1} using transfer domain approach. **(08 Marks)**

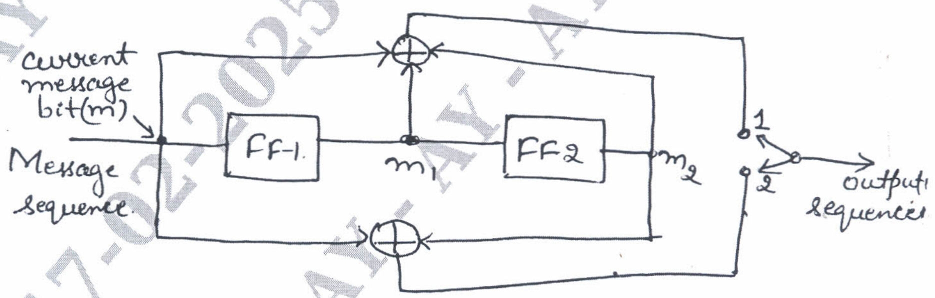


Fig.Q10(a)

b. A rate 1/3 convolution encoder has generating vectors as :
$g_1 = (1\ 0\ 0), \quad g_2 = (1\ \ 1\ \ 1), \quad g_3 = (1\ \ 0,\ \ 1)$
i) Sketch the encoder configuration
ii) State diagram and code tree
iii) If input message sequence is 10110, determine the output sequence of the encoder using code tree. **(12 Marks)**

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