USN | | | | | | | | | | **18EC54**

# Fifth Semester B.E. Degree Examination, July/August 2021
## Information Theory and Coding

Time: 3 hrs. Max. Marks: 100

***Note: Answer any FIVE full questions.***

**1** a. Define the following with respect to information theory:
(i) Self information (ii) Entropy
(iii) Rate of information (iv) Source efficiency **(04 Marks)**

b. Find the relationship between Hartley's nats and bits. **(06 Marks)**

c. Consider the Markov source shown in Fig.Q1(c). Find:
(i) State probabilities (ii) State entropies (iii) Source entropy

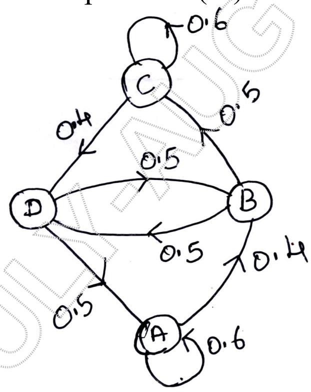


Fig.Q1(c) **(10 Marks)**

**2** a. A source emits one of the four probable messages $m_1$, $m_2$, $m_3$, $m_4$ with probabilities of 7/16, 5/16, 1/8 and 1/8 respectively. Find the entropy of the source. List all the elements for the second extension of this source. Hence show $H(s^2) = 2H(s)$. **(08 Marks)**

b. Prove extremal property of entropy. **(06 Marks)**

c. In a facsimile transmission of picture, there are about $2.25 \times 10^6$ pixel frame. For a good reproduction 12 brightness levels are necessary. Assume all these levels are equally likely to occur. Find the rate of information if one picture is to be transmitted every 3 minitus. What is the source efficiency of this facsimile transmitter? **(06 Marks)**

**3** a. Define non-singular and uniquely decidable codes with an example. **(04 Marks)**

b. A source emits an independent sequence of symbols from an alphabet consisting of five symbols A, B, C, D and E with probabilities of ¼, 1/8, 1/8, 3/16 and 5/16 respectively. Find the Shannon code for each symbol and efficiency of the coding scheme. **(10 Marks)**

c. State and prove Shannon's first theorem. **(06 Marks)**

**4** a. State Prefix and Kraft McMillan inequality property. **(04 Marks)**

b. A source produces nine symbols $x_1$, $x_2$……$x_9$ with respective probabilities of 0.24, 0.23, 0.19, 0.13, 0.08, 0.06, 0.04, 0.02 and 0.01.
(i) Construct a Shannon-Fano ternary code.
(ii) Determine the code-efficiency and redundancy.
(iii) Draw code-tree.
(iv) Determine the probabilities of 0, 1 and 2 when the encoding alphabet is {0, 1, 2}. **(10 Marks)**

c. Find the minimum number of symbols 'r' in the coding alphabet for devising an instantaneous code such that w = {0, 5, 0, 5, 5}. Device such a code.
(Note: w represents the set of code words of length 1, 2, 3….) **(06 Marks)**

**5** a. Show that $H(X,Y) = H\left(\frac{X}{Y}\right) + H(Y)$. **(04 Marks)**

b. A non-symmetric binary channel is given in Fig.Q5(b).

(i) Find H(X), H(Y), $H\left(\frac{X}{Y}\right)$ and $H\left(\frac{Y}{X}\right)$ given $P(X = 0) = \frac{1}{4}$, $P(X = 1) = \frac{3}{4}$, $\alpha = 0.75$, $\beta = 0.9$.

(ii) Find the capacity of the binary symmetric channel if $\alpha = \beta = 0.75$.

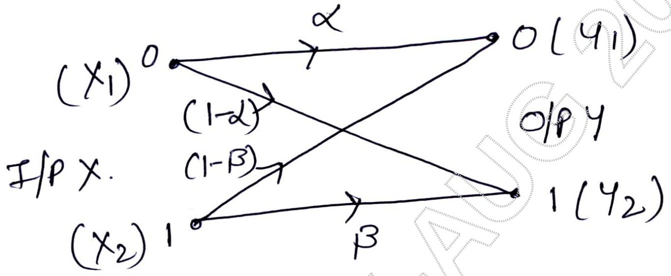


Fig.Q5(b) **(10 Marks)**

c. Show that the mutual information of a discrete channel is symmetric. **(06 Marks)**

**6** a. Derive an expression for channel capacity of binary Erasure channel. **(08 Marks)**

b. For the JPM given below, compute individually H(X), H(Y), H(X, Y), $H\left(\frac{X}{Y}\right)$, $H\left(\frac{Y}{X}\right)$ and I(X, Y).

$$P(X,Y) = \begin{bmatrix} 0.05 & 0 & 0.20 & 0.05 \\ 0 & 0.10 & 0.10 & 0 \\ 0 & 0 & 0.20 & 0.10 \\ 0.05 & 0.05 & 0 & 0.10 \end{bmatrix}$$ **(08 Marks)**

c. What is joint probability matrix? State its properties. **(04 Marks)**

**7** a. Define Hamming weight, Hamming distance and minimum distance of linear block codes (with example). **(06 Marks)**

b. For a systematic (7, 4) linear block code, the parity matrix P is given by

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

(i) Find G and H.
(ii) Draw the encoding circuit.
(iii) Find all possible valid code vectors.
(iv) A single error has occurred each of these received vectors. Detect and correct those errors. (1) RA = [0111110] (2) RB = [1011100]
(v) Draw the syndrome calculation circuit. **(14 Marks)**

8 a. The generator polynomial of a (15, 7) cyclic code is given by $g(x) = 1 + x^4 + x^6 + x^7 + x^8$.
(i) Draw the syndrome calculation circuit.
(ii) Find the syndrome of the received polynomial $z(x) = 1 + x + x^3 + x^6 + x^8 + x^9 + x^{11} + x^{14}$ by listing the states of the register used in syndrome calculation circuit.
(iii) Verify the syndrome obtained in (ii) by using direct hand calculation. **(10 Marks)**

b. Consider the (15, 11) cyclic code generated by $g(x) = 1 + x + x^4$.
(i) Draw the feedback register encoding circuit for this cyclic code.
(ii) Illustrate the encoding procedure with the message vector 01101001011 by listing the state of the register with each input.
(iii) Verify the code polynomial by using the division method. **(10 Marks)**

9 a. What are convolutional codes? How it is different from block codes. **(05 Marks)**

b. Consider the convolutional encodes shown in Fig.Q9(b).
(i) Find the O/P for the message 10011 using time domain approach.
(ii) Find the O/P for the message 10011 using transform domain approach.

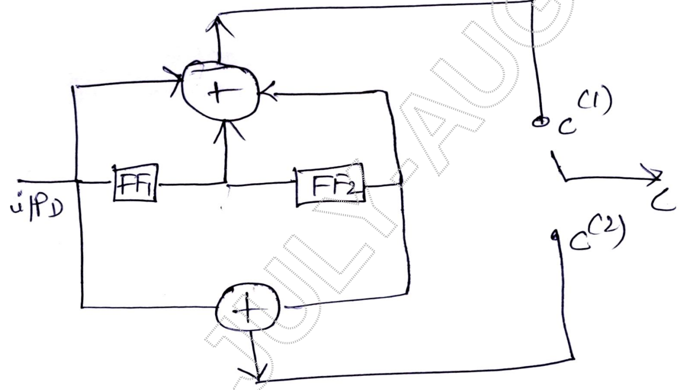


Fig.Q9(b) **(10 Marks)**

c. What do you understand by trellis diagram of a convolutional encodes? Explain clearly. **(05 Marks)**

10 a. For (2, 1, 3) convolution encodes with g(1) = 1011, g(2) = 1101.
(i) Write translation table.
(ii) State diagram.
(iii) Draw the code tree.
(iv) Draw the trellis diagram.
(v) Find the encoded O/P for the message 11101 by traversing the code tree. **(15 Marks)**

b. Explain Viterbi encoding. **(05 Marks)**

* * * * *