CBCS SCHEME

USN | | | | | | | | | |  **15EC54**

## Fifth Semester B.E. Degree Examination, June/July 2019
# Information Theory and Coding

Time: 3 hrs. Max. Marks: 80

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



### Module-1

1 a. Define information content, entropy and information rate. **(03 Marks)**

b. A card is selected at random from a deck of playing cards. If you are told that it is in red colour, how much information is conveyed? How much additional information is needed to completely specify a card? **(05 Marks)**

c. Prove the maximal property of entropy. **(08 Marks)**

**OR**

2 a. A DMS has an alphabet X = {$x_1$, $x_2$, $x_3$, $x_4$} with probability statistics $\left\{\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}\right\}$ show that $H(X^2) = 2.H(x)$. **(06 Marks)**

b. For the Markov source shown in Fig.Q.2(b). Find state probability, state entropy and source entropy. Also, write tree diagram to generate message of length 2. **(10 Marks)**

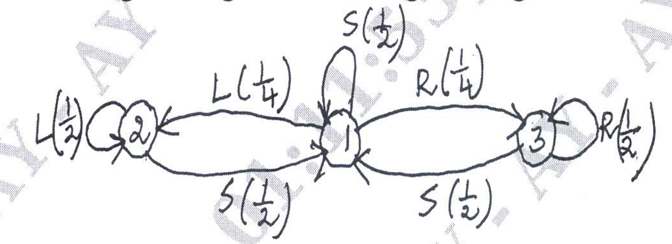


Fig.Q.2(b)

### Module-2

3 a. Apply Shannon encoding algorithm and generation codes for the set of symbols S = {$s_1$, $s_2$, $s_3$, $s_4$, $s_5$, $s_6$} with probability P = {0.3, 0.25, 0.20, 0.12, 0.08, 0.05}. Find code efficiency and variance. **(08 Marks)**

b. Using Shannon Fano algorithm, encode the following set of symbols and find the P(0) and P(1) {Probability of Zeros and ones}. **(05 Marks)**

| Symbol | a | b | c | d | e | f | g |
|---|---|---|---|---|---|---|---|
| P | 0.5 | 0.25 | 0.125 | 0.0625 | 0.03125 | 0.015625 | 0.015625 |

c. Write the decision tree for the following set of codes and check for KMI property:

| | |
|---|---|
| $S_1$ | 1 |
| $S_2$ | 01 |
| $S_3$ | 001 |
| $S_4$ | 0001 |
| $S_5$ | 00001 |

**(03 Marks)**

**OR**

4 a. A DMS has an alphabet of seven symbols with probability statistics as given below:
$S = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7\}$
$$P = \left\{\frac{1}{4}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}, \frac{1}{8}, \frac{1}{16}, \frac{1}{16}\right\}$$
Compute Huffman code for these set of symbols by moving the combined symbols as high as possible. Explain why the efficiency of the coding is 100%. **(08 Marks)**

b. Write a note on Lempel – Ziv Algorithm. **(04 Marks)**

c. Design compact Huffman code by taking the code alphabet $X = \{0, 1, 2\}$ for the set of symbols $S = \{s_1, s_2, s_3, s_4, s_5, s_6\}$, $P = \left\{\frac{1}{3}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}, \frac{1}{12}, \frac{1}{12}\right\}$. Find efficiency. **(04 Marks)**

## Module-3

5 a. The TPM of a channel is given below. Compute H(x), H(y), H(x/y) and H(y/x)
$$P(xy) = \begin{bmatrix} 0.48 & 0.12 \\ 0.08 & 0.32 \end{bmatrix}$$
**(05 Marks)**

b. A binary symmetric channel has the following noise matrix. Compute mutual information, data transmission rate and channel capacity if $r_s = 10$ sym/sec
$$P(y/x) = \begin{bmatrix} 1/4 & 3/4 \\ 3/4 & 1/4 \end{bmatrix}$$
$$P(x) = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} \end{bmatrix}$$
**(06 Marks)**

c. Derive an expression for the data transmission rate of binary Erasure channel. **(05 Marks)**

**OR**

6 a. An engineer says that he can design a system for transmitting computer output to a line printer operating at a speed of 30 lines/minute over a cabel having bandwidth of 3.5 kHz and $\frac{S}{N} = 30\text{dB}$. Assume that the printer needs 8 bits of data/character and prints out 80 characters/line. Would you believe the engineer? **(06 Marks)**

b. Write a note on differential entropy. **(05 Marks)**

c. Consider a binary symmetric channel whose channel matrix is given by $P(y/x) = \begin{bmatrix} 0.8 & 0.2 \\ 0.4 & 0.6 \end{bmatrix}$. Find channel capacity. **(05 Marks)**

## Module-4

7 a. State error detecting and correcting capability of block codes. **(02 Marks)**

b. Consider a linear block code (6, 3). The check bits of this code are derived using the following relations:
$c_4 = d_1 + d_2$
$c_5 = d_1 + d_2 + d_3$
$c_6 = d_2 + d_3$
i) find generator matrix G
ii) find all code words of linear block code
iii) compute error detecting and correcting ability
iv) also find H and $H^T$.
**(07 Marks)**

c. For a linear block code, the syndrome is given by:
$S_1 = r_1 + r_2 + r_3 + r_5$ $S_2 = r_1 + r_2 + r_4 + r_6$ $S_3 = r_1 + r_3 + r_4 + r_7$
i) Find H matrix ii) Draw syndrome calculator circuit iii) Draw encoder circuit. **(07 Marks)**

**OR**

8 a. A (7, 3) Hamming code is generated using $g(x) = 1 + x + x^2 + x^4$. Design a suitable encoder to generate systematic cyclic codes. Verify the circuit operation for D = [110]. Also, generate the code using mathematical computation. **(08 Marks)**

b. Design a syndrome calculator circuit for (7, 4) cyclic code having the generator polynomial $g(x) = 1 + x + x^3$. Verify the circuit operation using R = [1101001]. Also, perform the relevant mathematical computations. **(08 Marks)**

## Module-5

9 a. Write an explanatory note on BCH codes. **(05 Marks)**

b. Consider the (3, 1, 2) convolutional encoder with $g^{(1)} = (110)$ $g^{(2)} = (101)$, $g^{(3)} = (111)$
   i) Find constraint length
   ii) Find rate efficiency
   iii) Draw encoder diagram
   iv) Find the generator matrix
   v) Find the code for the message sequence (11101) using matrix and frequency domain approach. **(11 Marks)**

**OR**

10 a. For (2, 1, 3) convolutional encoder with $g^{(1)} = (1101)$, $g^{(2)} = (1011)$.
   i) Write state transition table
   ii) State diagram
   iii) Draw the code tree
   iv) Draw the trellis diagram
   v) Find the encoded output for the message (11101) by traversing the code tree. **(10 Marks)**

b. Explain Viterbi decoding. **(06 Marks)**

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