STUDENTMAP

VTU B.E/B.TECH QUESTION PAPER SET

CBCS
SEMESTER V

INFORMATION THEORY CODING

Use bookmarks to easily navigate between question papers

CBCS Scheme

USN | | | | | | | | | |

15EC54

Fifth Semester B.E. Degree Examination, Dec.2017/Jan.2018
Information Theory and Coding

Time: 3 hrs. Max. Marks: 80

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

Module-1

1 a. Derive an expression for average information content of symbols in long independent sequence. **(03 Marks)**

b. For the Markov source shown below, find i) The stationary distribution ii) State entropies iii) Source entropy iv) G_1 G_2 and show that $G_1 \geq G_2 \geq H(s)$. **(10 Marks)**

c. Define Self Information, Entropy and Information rate. **(03 Marks)**

OR

2 a. Mention different properties of entropy and prove external property. **(07 Marks)**

b. A source emits one of the four symbols S_1 S_2 S_3 and S_4 with probabilities of $\frac{7}{16}$, $\frac{5}{16}$, $\frac{1}{8}$ & $\frac{1}{8}$. Show that $H(S^2) = 2H(S)$. **(04 Marks)**

c. In a facsimile transmission of a picture, there are about 2.25×10^6 pixels/frame. For a good reproduction at the receiver 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 min. Also compute the source efficiency. **(05 Marks)**

Module-2

3 a. A discrete memory less source has an alphabet of five symbols with their probabilities as given below : **(10 Marks)**

Symbol	S_0	S_1	S_2	S_3	S_4
Probabilities	0.55	0.15	0.15	0.1	0.05

Compute Huffman code by placing composite symbol as high as possible and by placing composite symbol as low as possible. Also find i) The average codeword length ii) The variance of the average code word for both the cases.

b. Using Shannon Fano – coding, find code words for the probability distribution $P = \left\{\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}\right\}$. Find average code word length and efficiency. **(06 Marks)**

OR

4 a. Write a short note on Lempel Ziv algorithm. **(05 Marks)**

b. Derive Source coding theorem. **(05 Marks)**

c. Apply Shannon's encoding algorithm and generate binary codes for the set of messages given below. Also find variance, code efficiency and redundancy. **(06 Marks)**

M_1	M_2	M_3	M_4	M_5
1/8	1/16	3/16	1/4	3/8

Module-3

5 a. Find the capacity of the discrete channel whose noise matrix is **(04 Marks)**

$$P\left(\frac{y}{x}\right) = \begin{bmatrix} 0.8 & 0.2 & 0 \\ 0.1 & 0.8 & 0.1 \\ 0 & 0.2 & 0.8 \end{bmatrix}$$

b. Define Mutual Information. List the properties of Mutual information and prove that $I(x ; y) = H(x) + H(y) - H(xy)$ bits/system. **(06 Marks)**

c. A channel has the following characteristics :

$$P\left(\frac{y}{x}\right) = \begin{bmatrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{6} & \frac{1}{6} \\ \frac{1}{6} & \frac{1}{6} & \frac{1}{3} & \frac{1}{3} \end{bmatrix} \text{ \& } P(x_1) = p(x_2) = \frac{1}{2}$$

Find H(x), H(y), H(x, y) and Channel capacity if r = 1000 symbols/sec. **(06 Marks)**

OR

6 a. A binary symmetric channel has the following noise matrix with source probabilities of

$$P(x_1) = \frac{2}{3} \text{ and } P(x_2) = \frac{1}{3} \text{ and } P\left(\frac{y}{x}\right) = \begin{bmatrix} \frac{3}{4} & \frac{1}{4} \\ \frac{1}{4} & \frac{3}{4} \end{bmatrix}.$$ **(08 Marks)**

i) Determine H(x), H(y), H(x, y), H(y/x), H(x/y) and I(x, y).
ii) Find channel capacity C. iii) Find channel efficiency and redundancy.

b. Derive an expression for channel efficiency for a Binary Erasure channel. **(05 Marks)**

c. Write a note on Differential Entropy. **(03 Marks)**

Module-4

7 a. For a systematic (6.3) linear block code generated by $C_4 = d_1 \oplus d_3$, $C_5 = d_2 \oplus d_3$, $C_6 = d_1 \oplus d_2$.

i) Find all possible code vectors ii) Draw encoder circuit and syndrome circuit
iii) Detect and correct the code word if the received code word is 110010.
iv) Hamming weight for all code vector, min hamming distance. Error detecting and correcting capability. **(14 Marks)**

b. Define the following : i) Block code and Convolutional code ii) Systematic and non – systematic code. **(02 Marks)**

OR

8 a. A linear Hamming code for (7, 4) is described by a generator polynomial $g(x) = 1 + x + x^3$. Determine Generator Matrix and Parity check matrix. **(03 Marks)**

b. A 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 for the message $D(x) = x^2 + x^3 + x^4$. Using cyclic encoder circuit.
ii) Draw syndrome calculation circuit and find the syndrome of the received polynomial $Z(x) = 1 + x + x^3 + x^6 + x^8 + x^9 + x^{11} + x^{14}$. **(13 Marks)**

Module-5

9 a. Consider the (3, 1, 2) convolutional code with $g_1 = 110$, $g_2 = 101$, $g_3 = 111$. **(12 Marks)**
i) Draw the encoder block diagram ii) Find the generator matrix
iii) Find the code word corresponding to the information sequence 11101 using time domain and transform Domain approach.

b. Write short note on BCH code. **(04 Marks)**

OR

10 For a (2,1, 3) convolutional encoder with $g_1 = 1011$, $g_2 = 1101$. **(16 Marks)**

a. Draw the state diagram b. Draw the code tree.
c. Draw trellis diagram and code word for the message 1 1 1 0 1.
d. Using Viterbi decoding algorithm decode the obtained code word if first bit is erroneous.

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CBCS SCHEME

USN | | | | | | | | | | |

15EC54

Fifth Semester B.E. Degree Examination, June/July 2018
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. With neat sketch, explain the block diagram of an information system. **(04 Marks)**

b. Define entropy. State various properties of the entropy. **(04 Marks)**

c. A code is composed of dots and dashes. Assuming a dash is 3 times as long as a dot and has one-third the probability of occurrence. Calculate:

i) The information in a dot and a dash.

ii) The entropy of dot-dash code.

iii) The average rate of information if a dot lasts for 10mili seconds and the same time is allowed between symbols. **(08 Marks)**

OR

2 a. Derive an expression for the entropy of n^{th} extension of a zero memory source. **(06 Marks)**

b. The first order Markoff model shown in Fig.Q.2(b). Find the state probabilities, entropy of each state and entropy of the source. **(10 Marks)**

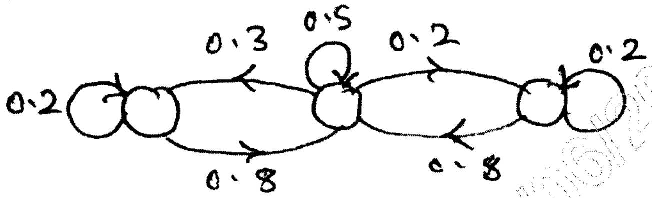

Fig.Q.2(b)

Module-2

3 a. Apply Shannon's binary encoding algorithm to the following set of symbols given in table below. Also obtain code efficiency. **(08 Marks)**

Symbols	A	B	C	D	E
P	1/8	1/16	3/16	1/4	3/8

b. Consider a source S = {s_1, s_2} with probabilities 3/4 and 1/4 respectively. Obtain Shannon-Fano code for source S and its 2^{nd} extension. Calculate efficiencies for each case. Comment on the result. **(08 Marks)**

OR

4 a. Consider a source with 8 alphabets A to H with respective probabilities of 0.22, 020, 018, 015, 0.10, 0.08, 0.05 and 0.02. Construct Huffman's code and determine its efficiency. **(10 Marks)**

b. With an illustrative example, explain arithmetic coding technique. **(06 Marks)**

Module-3

5 a. Define: i) Input entropy ii) Output entropy iii) Equivocation iv) Joint entropy and v) Mutual information with the aid of respective equations. **(04 Marks)**

b. In a communication system, a transmitter has 3 input symbols A = {a_1, a_2, a_3} and receiver also has 3 output symbols B = {b_1, b_2, b_3}. The matrix given below shows JPM. **(08 Marks)**

a_i \ b_j	b_1	b_2	b_3
a_1	$\frac{1}{12}$	*	$\frac{5}{36}$
a_2	$\frac{5}{36}$	$\frac{1}{9}$	$\frac{5}{36}$
a_3	*	$\frac{1}{6}$	*
$P(b_j)$	$\frac{1}{3}$	$\frac{14}{36}$	*

i) Find missing probabilities (*) in the table.

ii) Find $P\left(\frac{b_3}{a_1}\right)$ and $P\left(\frac{a_1}{b_3}\right)$.

c. A transmitter has 5 symbols with probabilities 0.2, 0.3, 0.2, 0.1 and 0.2. Given the channel matrix P(B/A) as shown below, calculate H(B) and H(A, B). **(04 Marks)**

$$P(B/A) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1/4 & 3/4 & 0 & 0 \\ 0 & 1/3 & 2/3 & 0 \\ 0 & 0 & 1/3 & 2/3 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

Fig.Q.5(c)

OR

6 a. A Gaussian channel has a 10MHz bandwidth. If (S/N) ratio is 100, calculate the channel capacity and the maximum information rate. **(04 Marks)**

b. A binary symmetric channel has channel matrix $P(Y/X) = \begin{vmatrix} 3/4 & 1/4 \\ 1/4 & 3/4 \end{vmatrix}$ with source probabilities of $P(X_1) = \frac{2}{3}$ and $P(X_2) = \frac{1}{3}$.

i) Determine H(X), H(Y), H(Y/X) and H(X, Y).

ii) Find the channel capacity. **(06 Marks)**

c. Find the channel capacity of the channel shown in Fig.Q.6(c) using Muroga's method. **(06 Marks)**

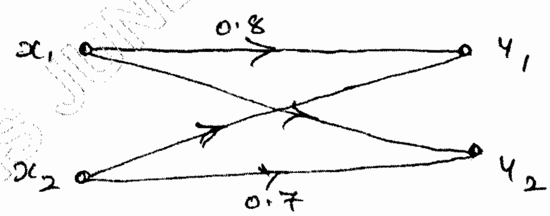

Fig.Q.6(c)

Module-4

7 a. Distinguish between "block codes" and "convolution codes". **(02 Marks)**

b. For a systematic (6, 3) linear block code, the parity matrix is $P = \begin{vmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 0 \end{vmatrix}$. Find all possible code vectors. **(08 Marks)**

c. The parity check bits of a (8, 4) block code are generated by $c_5 = d_1 + d_2 + d_4$, $c_6 = d_1 + d_2 + d_3$, $c_7 = d_1 + d_3 + d_4$ and $c_8 = d_2 + d_3 + d_4$ where d_1, d_2, d_3 and d_4 are message bits. Find the generator matrix and parity check matrix for this code. **(06 Marks)**

OR

8 a. A (7, 4) cyclic code has the generator polynomial $g(x) = 1 + x + x^3$. Find the code vectors both in systematic and nonsystematic form for the message bits (1001) and (1101). **(12 Marks)**

b. Consider a (15, 11) cyclic code generated by $g(x) = 1 + x + x^4$. Device a feed back shift register encoder circuit. **(04 Marks)**

Module-5

9 a. Write a note on BCH codes. **(06 Marks)**

b. Consider the (3, 1, 2) convolutional encoder with $g^{(1)} = (110)$, $g^{(2)} = (101)$ and $g^{(3)} = (111)$.

i) Draw the encoder diagram.

ii) Find the generator matrix.

iii) Find the code word for the message sequence (11101). **(10 Marks)**

OR

10 a. For a (2, 1, 3) convolutional encoder with $g^{(1)} = (1101)$, $g^{(2)} = (1011)$, draw the encoder diagram and code tree. Find the encoded output for the message (11101) by traversing the code tree. **(10 Marks)**

b. Describe the Viterbi decoding algorithm. **(06 Marks)**

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CBCS SCHEME

USN [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] **15EC54**

Fifth Semester B.E. Degree Examination, Dec.2018/Jan.2019
Information Theory and Coding

Time: 3 hrs. Max. Marks: 80

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

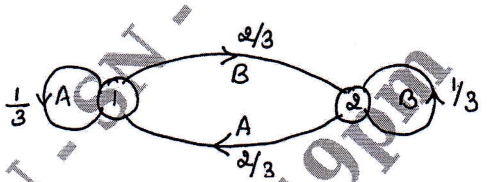
Module-1

1 a. The output of an information source contains 160 symbols, 128 of which occur with a probability of $\frac{1}{256}$ and remaining with a probability of $\frac{1}{64}$ each. Find the average information rate of the source if the source emits 10,000 sym/s. **(02 Marks)**

b. In a facsimile transmission of a picture, there are 4×10^6 pixels/frame. For a good reconstruction of the image atleast eight brightness levels are necessary. Assuming all these levels are equally likely to occur. Find the average information rate if one picture is transmitted every 4s. **(04 Marks)**

c. Consider the following Markov source shown in fig. Q1(c). Find i) State probabilities ii) State entropies iii) Source entropy iv) G_1, G_2 v) Show that $G_1 > G_2 > H$. **(10 Marks)**

Fig.Q1(c)



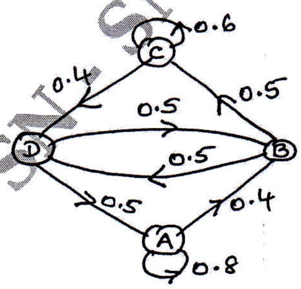
OR

2 a. The international Morse code uses a sequence of symbols of dots and dashes to transmit letters of English alphabet. The dash is represented by a current pulse of duration 2ms and dot of 1ms. The probability of dash is half as that of dot. Consider 1ms duration of gap is given in between the symbols. Calculate i) Self – information of a dot and a dash ii) Average information content of a dot – dash code iii) Average rate of information. **(06 Marks)**

b. State the properties of Entropy. **(04 Marks)**

c. Consider the Markov source shown in fig. Q2(c). find i) State probabilities ii) State entropies iii) Source entropy. **(06 Marks)**

Fig.Q2(c)



Module-2

3 a. With an example, explain Prefix codes. **(04 Marks)**

b. Consider the following source S = {A, B, C, D, E} with probabilities P = {0.5, 0.25, 0.125, 0.0625, 0.0625}. Find the code words for the symbols using Shannon's encoding algorithm. Also, find the source efficiency and redundancy. **(06 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

c. An information source produces a sequence of independent symbols having the following probabilities. Construct binary code using Huffman encoding and find its efficiency. (06 Marks)

A	B	C	D	E	F	G
1/3	1/27	1/3	1/9	1/9	1/27	1/27

OR

4 a. State Kraft McMillan Inequality property. (04 Marks)

b. Consider a discrete memory less source with S = (X, Y, Z) with the corresponding probabilities P = (0.5, 0.3, 0.2). Find the code words for the symbols using Shannon's algorithm. Also, find the source efficiency and redundancy. (06 Marks)

c. Consider a discrete memory less source with S = (X, Y, Z) with respective probabilities P = (0.6, 0.2, 0.2). Find the codeword for the message 'YXZXY' using arithmetic coding. (06 Marks)

Module-3

5 a. A binary channel has the following characteristics

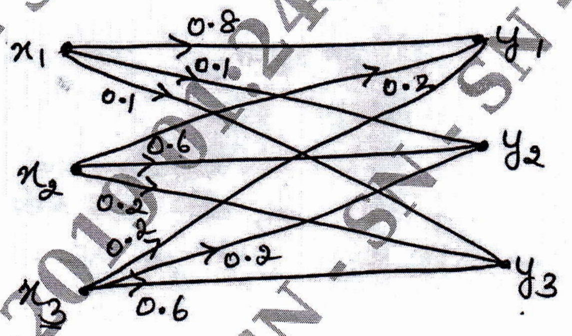
$$P(Y/X) = \begin{bmatrix} 2/3 & 1/3 \\ 1/3 & 2/3 \end{bmatrix}$$

. If input symbols are transmitted with probabilities ¾ and ¼ respectively. Find entropies, H(X), H(X, Y) and H(Y/X). (03 Marks)

b. Prove that the mutual information is always a non - negative entity $I(X ; Y) \geq 0$. (06 Marks)

c. The noise characteristics of a channel are as shown in fig.Q5(c). Find the capacity of the channel using Muroga's method. (07 Marks)

Fig.Q5(c)

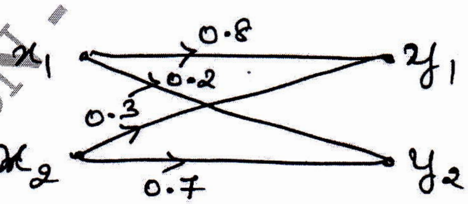


OR

6 a. State the properties of Joint Probability Matrix. (04 Marks)

b. Find the mutual information for the channel shown in fig.6(b). Let $P(x_1) = 0.6$ and $P(x_2) = 0.4$. (06 Marks)

Fig.Q6(b)



c. Derive the expression for the channel capacity of a Binary Symmetric Channel. (06 Marks)

Module-4

7 a. For a (6, 3) code find all the code vectors if the co-efficient matrix P is given by

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

i) Find code vector ii) Implement the encoder iii) Find the syndrome vector (S).
iv) Implement the syndrome circuit. **(08 Marks)**

b. Obtain the generator and parity check matrices for an (n, k) cyclic code with $g(x) = 1+x+x^3$. **(08 Marks)**

OR

8 a. In an LBC, 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 the parity check matrix (H) ii) Draw the encoder circuit
iii) Find the code word for all input sequences.
iv) What is the syndrome for the received data 1011011? **(08 Marks)**

b. In a (15,5) cyclic code, the generator polynomial is given by $g(x) = 1+x+ x^2+x^4+x^5+ x^8+ x^{10}$. Draw the block diagram of an encoder and syndrome calculator for this code. Find whether $r(x) = 1+ x^4+ x^6 + x^8 + x^{14}$ a valid code word. **(08 Marks)**

Module-5

9 a. Design a (15,7) binary BCH code with r = 2. **(06 Marks)**

b. Consider the (3, 1, 2) convolution code with $g^{(1)} = (1\ 1\ 0)$, $g^{(2)} = (1\ 0\ 1)$, $g^{(3)} = (1\ 1\ 1)$.
i) Find the constraint length ii) Find the rate iii) Draw the encoder block diagram
iv) Find the generator matrix v) Find the code word for the message sequence (1 1 1 0 1) using time – domain and transfer – domain approach. **(10 Marks)**

OR

10 a. Explain why (23, 12) Golay code is called as perfect code. **(04 Marks)**

b. Consider the convolution encoder shown in fig. Q10(b).
i) Write the impulse response of the encoder.
ii) Find the output for the message (1 0 0 1 1) using time – domain approach.
iii) Find the output for the message (1 0 0 1 1) using transfer – domain approach. **(12 Marks)**

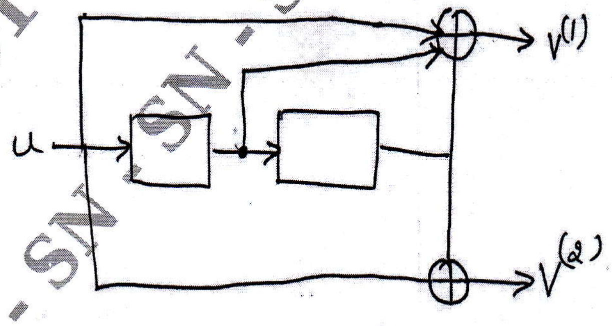


Fig.Q10(b)

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CBCS SCHEME

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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)**

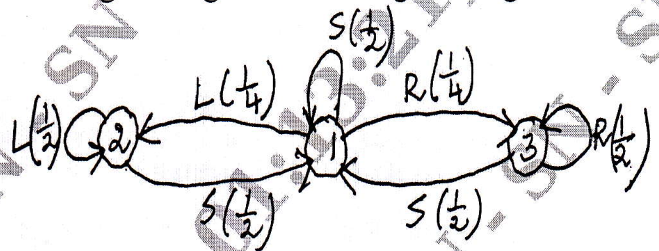

Fig.Q.2(b)

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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CBCS SCHEME

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Fifth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Information Theory and Coding

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

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Module-1

1 a. Define entropy and list the properties of entropy. **(04 Marks)**

b. Consider a zero memory source emitting three symbols s_1, s_2 and s_3 with respective probabilities 0.5, 0.3 and 0.2. Calculate: i) Entropy of the source ii) All symbols and the corresponding probabilities of the second order extension. Also, find entropy of extended source iii) Show that $H(s^2) = 2H(s)$. **(08 Marks)**

c. Show that 1 Nat = 1.443 bits. **(04 Marks)**

OR

2 a. Define Markoff source. Explain with typical transition state diagram. **(06 Marks)**

b. For the Markoff source shown in Fig.Q.2(b), find
i) State probabilities
ii) State entropies
iii) Source entropy.

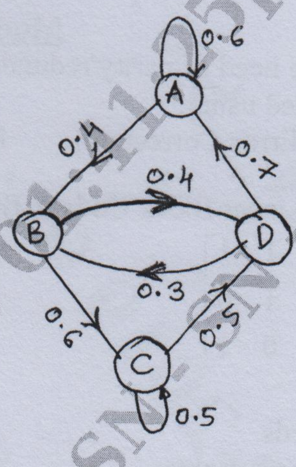

Fig.Q.2(b) **(10 Marks)**

Module-2

3 a. State and prove source coding theorem. **(08 Marks)**

b. Consider a discrete memoryless source with three symbols S = (X, Y, Z) with P = (0.5, 0.35, 0.15)
i) Use Shanon's first encoding technique and find the codewords for the symbols. Also, find the source efficiency and redundancy.
ii) Consider the second order extension of the source. Recompute the codewords, efficiency and redundancy. **(08 Marks)**

OR

4 a. Consider a discrete memoryless source with S = {A, B, C, D} with P = {0.4, 0.3, 0.2, 0.1}. Find the codeword using Huffman coding. Compute efficiency and variance. **(08 Marks)**

b. Write a note on LZ-Algorithm with an example. **(08 Marks)**

Module-3

5 a. Show that **(06 Marks)**

b. For the Joint Probability Matrix (JPM) given, find: i) H(X) ii) H(Y) iii) H(X, Y) iv) H(Y/X) and v) H(X/Y)

$$JPM = P(X,Y) = \begin{array}{c} \\ x_1 \\ x_2 \\ x_3 \\ x_4 \end{array}\begin{array}{c} \begin{matrix} y_1 & y_2 & y_3 & y_4 \end{matrix} \\ \begin{bmatrix} 0.2 & 0 & 0 & 0.05 \\ 0 & 0.15 & 0.15 & 0 \\ 0 & 0 & 0.10 & 0.05 \\ 0.10 & 0.10 & 0 & 0.10 \end{bmatrix} \end{array}$$

(10 Marks)

OR

6 a. State and explain Muroga's theorem. **(04 Marks)**

b. Find the capacity of the channel for the channel matrix P(Y/X):

$$P(Y/X) = \begin{array}{c} \\ x_1 \\ x_2 \\ x_3 \end{array}\begin{array}{c} \begin{matrix} y_1 & y_2 & y_3 \end{matrix} \\ \begin{bmatrix} 0.2 & 0.5 & 0.3 \\ 0.2 & 0.6 & 0.2 \\ 0.1 & 0.1 & 0.8 \end{bmatrix} \end{array}$$

(08 Marks)

c. Briefly explain Differential Entropy. **(04 Marks)**

Module-4

7 a. Briefly explain the need of parity/redundant bits in the data transmission. Also, explain how errors can be tackled using,
i) FEC (Forward Error Correction) ii) ARQ codes (Automatic Repeat Request Codes). **(06 Marks)**

b. Consider a (6, 3) Linear Block Code (LBC) with generator matrix

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

Find:
i) All codewords
ii) All Hamming weights
iii) Minimum Hamming weight and distance
iv) Parity Check Matrix (PCM)
v) Draw the encoder circuit. **(10 Marks)**

OR

8 a. Explain the syndrome calculation and error detection with the help of neat circuit diagram for cyclic codes. **(06 Marks)**

b. Consider a (15, 7) binary cyclic code with $g(x) = 1 + x^4 + x^6 + x^7 + x^8$
i) Draw the encoder circuit
ii) Obtain the codeword for the input (00111)
iii) Draw the syndrome calculating circuit. **(10 Marks)**

Module-5

9 a. Briefly explain: i) Golay codes ii) BCH codes. (06 Marks)

b. Consider the convolution encoder shown in Fig.Q.9(b).

i) Write the impulse response of the encoder.

ii) Find the output for the message (10011) using time-domain approach.

iii) Find the output for the message (10011) using transform domain approach.

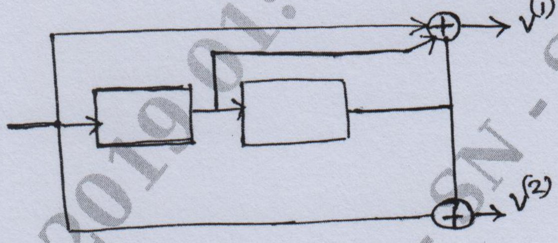

Fig.Q.9(b) (10 Marks)

OR

10 a. Explain various ways to represent convolution codes. (06 Marks)

b. For the convolution encoder $g^{(1)} = 110$, $g^{(2)} = 101$, $g^{(3)} = 111$

i) Draw the encoder block diagram for (3, 1, 2) convolution code

ii) Find generator matrix

iii) Find codewords corresponding to information sequence 11101 using time domain and transform domain approach. (10 Marks)

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CBCS SCHEME

USN | | | | | | | | | |

15EC54

Fifth Semester B.E. Degree Examination, Aug./Sept.2020
Information Theory and Coding

Time: 3 hrs. Max. Marks: 80

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

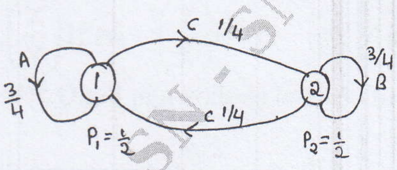
Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Derive an expression for average information content (entropy) of long independent sequence. **(04 Marks)**

b. Consider an information source modeled by a discrete ergodic Markoff random process whose graph is shown in Fig.Q.1(b). Find the source entropy H and the average information content per symbol in messages containing one, two and three symbols that is, find G_1, G_2 and G_3. **(12 Marks)**

Fig.Q.1(b)



OR

2 a. A code is composed of dots and dashes. Assuming that a dash is 3 times as long as a dot and has one third the probability of occurrence. Calculate the information in dot and dash. **(04 Marks)**

b. Design a system to report the heading of a collection of 400 cars. The heading is to be quantized into three levels: heading straight (S), turning left (L), and turning right (R). This information is to be transmitted every second. Based on the test data given below, construct a model for the source and calculate the source entropy and information rate.

i) On the average, during a given reporting interval, 200 cars were heading straight, 100were turning left, and 100 cars were turning right.

ii) Out of 200 cars that reported heading straight during a reporting period, 100 of them (on the average) reported going straight during the next reporting period, 50 of them reported turning left during next period, and 50 of them reported turning right during the next period.

iii) On the average out of 100 cars that reported as turning during a signaling period, 50 of them continued their turn during the next period and the remaining headed straight during the next reporting period.

iv) The dynamics of the cars did not allow them to change their heading from left to right or right to left during subsequent reporting periods. **(12 Marks)**

Module-2

3 a. Consider a source with Alphabet S = (A, B, C, D) with the corresponding probabilities P = (0.1, 0.2, 0.3, 0.4). Find the code words for symbol using Shannons encoding algorithm. Also find the source efficiency and redundancy. **(06 Marks)**

b. Consider the following source:
S = (A, B, C, D, E, F)
P = (0.10, 0.15,0.25, 0.35, 0.08, 0.07)
Find the codewords for the source using Shannon Fano-Algorithm. Also find source efficiency and redundancy. **(06 Marks)**

c. Illustrate with example whether the code is uniquely decodeable or not by applying kraft inequality. **(04 Marks)**

OR

4 a. An information source produces a sequence of independent symbols having the following probabilities:

A	B	C	D	E	F	G
1/3	1/3	1/9	1/9	1/27	1/27	1/27

Construct binary code using Huffman encoding procedure and find its efficiency and redundancies. **(08 Marks)**

b. Discuss the following coding technique with example:
i) Arithmatic coding ii) Lempel-zev algorithm. **(08 Marks)**

Module-3

5 a. The Joint probability matrix of a channel is given by

$$P(xy) = \begin{bmatrix} 0.05 & 0 & 0.20 & 0.05 \\ 0 & 0.1 & 0.10 & 0 \\ 0 & 0 & 0.20 & 0.10 \\ 0.05 & 0.05 & 0 & 0.10 \end{bmatrix}$$

Compute: i) H(X) ii) H(X,Y) iii) $H\left(\frac{Y}{X}\right)$ iv) $H\left(\frac{X}{Y}\right)$ **(08 Marks)**

b. The noise characteristics of channel as shown in Fig.Q.5(b). Find the channel capacity. **(05 Marks)**

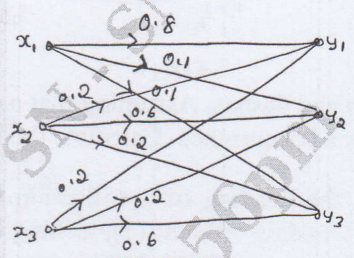


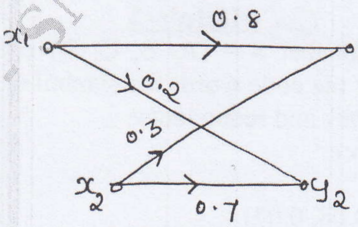
Fig.Q.5(b)

c. State the properties of mutual information. **(03 Marks)**

OR

6 a. A CRT terminal is used to enter alphanumeric data into a computer. The CRT is connected through a voice grad telephone line, usable bandwidth of 3kHz and an output S/N of 10db. Assume that the terminal has 128 characters and data is sent in an independent manner with equal probabilities.
i) Find the average information per character
ii) Find capacity of the channel
iii) Find the maximum rate at which data can be sent from the terminal to the computer without error. **(08 Marks)**

b. Find the mutual information for the channel shown in Fig.Q.6(b). Given that $P(x_1) = 0.6$ and $P(x_2) = 0.4$ **(08 Marks)**



FigQ.6(b)

Module-4

7 a. For a systematic (6, 3) linear block code the parity matrix P is given by

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

Find all possible code vector. **(05 Marks)**

b. Construct the standard array for a (6, 3) linear block code whose generator matrix is given below:

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

Decode the received vector 111100 **(06 Marks)**

c. For a (7, 4) binary cyclic code the generator polynomial is $g(x) = 1 + x + x^3$. Obtain code word for the message 1010 in systematic and non systematic form. **(05 Marks)**

OR

8 a. Design an encoder for the (7, 4) binary cyclic code generated by $g(x) = 1 + x + x^3$ and verify its operation using the message vector (0101). **(06 Marks)**

b. For (7, 4) cyclic code, the received vector $z(x)$ = 1110101 and generator polynomial is $g(x) = 1 + x + x^3$. Draw the syndrome calculation circuit and correct the single error in the received vector. **(06 Marks)**

c. Define Hamming weight, Hamming distance and minimum distance with example. **(04 Marks)**

Module-5

9 a. Write a explanatory note on Golay code. **(04 Marks)**

b. The convolution encoder has the following two generator sequence $g^{(1)} = (111)$, $g^{(2)} = (101)$.

i) Draw the convolution encoder

ii) Find the output for the message 10011 using time domain approach. **(06 Marks)**

c. Explain Viterbi algorithm. **(06 Marks)**

OR

10 a. Consider a (3, 1, 2) convolution encoder with $g^{(1)} = (110)$, $g^{(2)} = (101)$ and $g^{(3)} = (111)$.

i) Draw the encoder block diagram

ii) Draw state table

iii) Draw state transition table

iv) Draw state diagram

v) Find the encoder output by traversing through the state diagram for input message sequence of (11101)

vi) Draw code trellis and obtain the output of the encoder for the same input sequence of (11101). **(12 Marks)**

b. Briefly explain BCH codes. **(04 Marks)**

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CBCS SCHEME

USN | | | | | | | | | | |

17EC54

Fifth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Information Theory and Coding

Time: 3 hrs. Max. Marks: 100

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

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Suppose you are planning a trip to Miami, Florida from Minneapolis in the winter time. You are receiving the following information from Miami Weather bureau:
(i) Mild and Sunny day (ii) Cold day (iii) Possible snow flurries
Explain the amount of information content in each statement. **(06 Marks)**

b. The output of an information source consists of 128 symbols, 16 of which occurs with probability of $\frac{1}{32}$ and the remaining 112 occurs with probability of $\frac{1}{224}$. The source emits 1000 symbols/sec. Assuming that the symbols are chosen independently. Find the Average Information Rate of this source. **(06 Marks)**

c. The state diagram of a stationary Mark off Source is shown in Fig.Q1(c):
(i) Find the entropy of each state
(ii) Find the entropy of the source
(iii) Find G_1 and G_2 and verify that $G_1 \geq G_2 \geq H$.
Assume $P(1) = P(2) = P(3) = \frac{1}{3}$

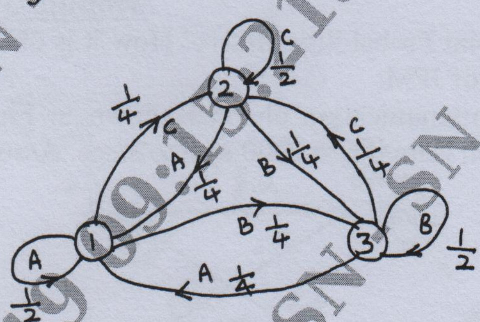

Fig.Q1(c) **(08 Marks)**

OR

2 a. What is self information? Mentions its various measuring units and also mentions the reasons for choosing logarithmic function. **(06 Marks)**

b. A binary source is emitting an independent sequence of 0's 1's with probabilities of P and 1 – P respectively. Plot the entropy of this source versus probability. **(06 Marks)**

c. For the first order Markov statistical model as shown in Fig.Q2(c).
(i) Find the probability of each state (ii) Find H(s) and $H(s^{-2})$

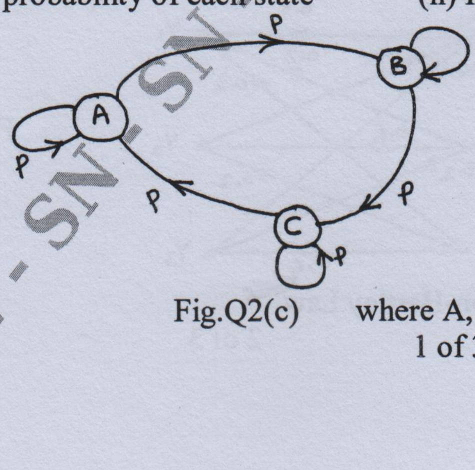

Fig.Q2(c) where A, B, and C are the states. **(08 Marks)**

Module-2

3 a. Identify whether the codes shown in Table.Q3(a) are instantaneous. Justify your answer.

Symbols	Code A	Code B	Code C
S_1	00	1	0
S_2	01	01	100
S_3	10	001	101
S_4	11	00	111

Table.Q3(a) **(06 Marks)**

b. Consider a Discrete Memory Source (DMS) with S = {X, Y, Z} with P = {0.6, 0.2, 0.2}. Find the code word for the message "YXZXY" using Arithmetic code. **(06 Marks)**

c. An information source produces a sequence of independent symbols having the following probabilities. More composite symbol as slow as possible.

Symbol	A	B	C	D	E	F	G
Probabilities	$\frac{1}{3}$	$\frac{1}{27}$	$\frac{1}{3}$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{27}$	$\frac{1}{27}$

Construct Binary Huffman encoding and find its efficiency. **(08 Marks)**

OR

4 a. Write the Shannon's Encoding Algorithms. **(06 Marks)**

b. Consider the following source with probabilities:

S = {A, B, C, D, E, F} P = {0.4, 0.2, 0.2, 0.1, 0.08, 0.02}

Find the code words using Shannon-Fano algorithm and also find its efficiency. **(06 Marks)**

c. Consider the following discrete memoryless source:

$S = \{S_0, S_1, S_2, S_3, S_4\}$ P = {0.55, 0.15, 0.15, 0.1, 0.05}

Compute Huffman code by placing composite symbol as high as possible. Also find average code word length and variance of the code word. **(08 Marks)**

Module-3

5 a. What is Joint Probability Matrix? How it is obtained from Channel Matrix and also mention properties of JPM. **(06 Marks)**

b. For the communication channel shown in Fig.Q5(b), determine Mutual Information and Information Rate if r_s = 1000 symbols/sec. Assume $P(X_1) = 0.6$ and $P(X_2) = 0.4$.

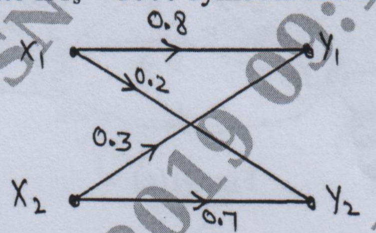

Fig.Q5(b)

(06 Marks)

c. Discuss the Binary Erasure Channel and also prove that the capacity a Binary Erasure Channel is $C = \overline{P} \cdot r_s$ bits/sec. **(08 Marks)**

OR

6 a. What is Mutual Information? Mention its properties. **(06 Marks)**

b. The noise characteristics of a channel shown in Fig.Q6(b). Find the capacity of a channel if r_s = 2000 symbols/sec using Muroga's method.

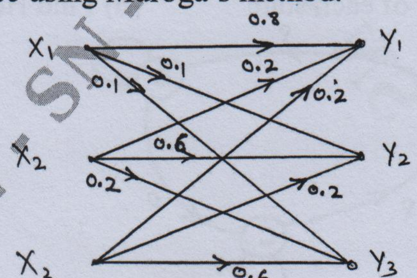

Fig.Q6(b)

(06 Marks)

c. State and prove the Shannon-Hartley Law. **(08 Marks)**

Module-4

7 a. What are the advantages and disadvantages of Error Control Coding? Discuss the methods of controlling Errors. **(06 Marks)**

b. The parity check bits of a (7, 4) Hamming code are generated by

$$C_5 = d_1 + d_3 + d_4$$

$$C_6 = d_1 + d_2 + d_3$$

$$C_7 = d_2 + d_3 + d_4$$

where d_1, d_2, d_3 and d_4 are the message bits.

(i) Find G and H for this code.

(ii) Prove that $GH^T = 0$. **(06 Marks)**

c. Design a syndrome calculating circuit for a (7, 4) cyclic code with $g(X) = 1 + X + X^3$ and also calculate the syndrome of the received vector R = 1110101. **(08 Marks)**

OR

8 a. For a systematic (6, 3) linear block code, the Parity Matrix P is given by

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

(i) Find all possible code words.

(ii) Find error detecting and correcting capability. **(06 Marks)**

b. A (7, 4) cyclic code has the generator polynomial $g(X) = 1 + X + X^3$. Find the code vector both in systematic and non-systematic form for the message bits (1101). **(06 Marks)**

c. Draw the Encoder circuit of a cyclic code using (n – K) bit shift Registers and explain it. **(08 Marks)**

Module-5

9 a. Consider (3, 1, 2) Convolution Encoder with $g^{(1)} = 110$, $g^{(2)} = 101$ and $g^{(3)} = 111$.

(i) Draw the encoder diagram.

(ii) Find the code word for the message sequence (11101) using generator Matrix and Transform domain approach. **(16 Marks)**

b. Discuss the BCH codes. **(04 Marks)**

OR

10 a. Consider the convolution encoder shown in Fig.Q10(a).

(i) Write the impulse response and its polynomial.

(ii) Find the output corresponding to input message (10111) using time and transform domain approach.

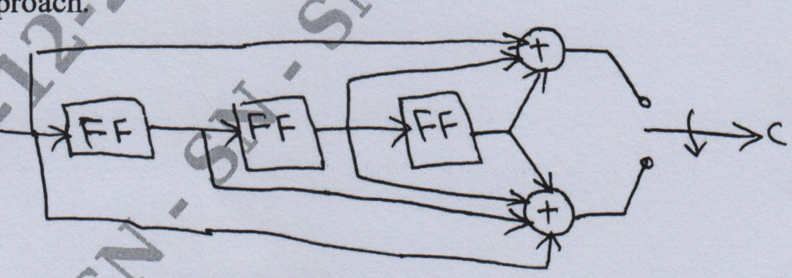

Fig.Q10(a) **(16 Marks)**

b. Write a note on Golay codes. **(04 Marks)**

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