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Paper Code : EC-604 B

INFORMATION THEORY AND CODING

Time Allotted : 3 Hours | *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) The unit of information is

   a) Bit b) Decit

   c) Nat d) all of these.

   ii) For a Lossless channel, the number of non-zero elements in each column is

   a) 0 b) 1

   c) 2 d) 3.

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iii) Entropy is basically a measure of

a) rate of information

b) average information

c) probability of information

d) disorder of information.

iv) An encoder for a (4, 3, 5) convolution code has a memory order of

a) 4 b) 2

c) 3 d) 5.

v) If $I(x_1)$ and $I(x_2)$ is the information carried by the symbols x_1 and x_2 respectively, then $I(x_1, x_2)$ is equal to

a) $I(x_1)^* I(x_2)$ b) $I(x_1) + I(x_2)$

c) $I(x_1) - I(x_2)$ d) $I(x_1) / I(x_2)$.

vi) If L is the average codeword length per symbol and $H(X)$ is the source entropy then which one is more appropriate ?

a) $L = H(X)$ b) $L \leq H(X)$

c) $L \geq H(X)$ d) None of these.

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vii) For (n, k) block code, the minimum distance d_{min} is

a) $d_{min} \le n - k + 1$ b) $d_{min} \le n - k$

c) $d_{min} \le n + k + 1$ d) $d_{min} \le n + k - 1$.

viii) The properties of Cyclic code is/are

a) Linearity b) Cyclic

c) Both (a) and (b) d) None of these.

ix) If m = 4 then what will be the length of BCH code ?

a) 16 b) 15

c) 17 d) None of these.

x) For Hamming Codes of (n, k) linear block codes, the block length (n) will be

a) $2^q - 1$ b) 2^q

c) $2^q + 1$ d) none of these.

xi) Relation between Syndrome Vector (S) and error vector (E) is

a) $S = H^T E$ b) $S = EH^T$

c) Both (a) and (b) d) None of these.

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xii) For GF (2^3) the elements in the set are

a) {1,2,3,4,5,6,7} b) {0,1,2,3,4,5,6}

c) {0,1,2,3} d) {0,1,2,3,4,5,6,7}

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following $3 \times 5 = 15$

2. The generator matrix for a (6, 3) block code is given below. Find the code vector of the message bit 110. Calculate the weight of this code vector.

$$G = \begin{bmatrix} 1 & 0 & 0 & :0 & 1 & 1 \\ 0 & 1 & 0 & :1 & 0 & 1 \\ 0 & 0 & 1 & :1 & 1 & 0 \end{bmatrix} \qquad 4 + 1$$

3. Draw the state diagram for (2, 1, 2) convolutional code and explain.

4. a) What do you mean by Information rate ? Explain.

   b) What is a Discrete Memoryless Channel (DMC) ? Explain. $3 + 2$

5. Find the generator polynomial $g(x)$ for a double error correcting ternary BCH code of block length 8. What is the code rate of the code ?

6. What are Hamming Code and Hamming Bound ? $2 + 3$

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GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Explain the Shannon-Fano coding and Huffman coding with suitable example. 5 + 5

b) Show that the channel capacity of an ideal AWGN channel with infinite bandwidth is given by

$$C_\infty = 1.44\ S/\eta \text{ bit/sec},$$

where S is the average signal power and $\eta/2$ is the power spectral density (psd) of white Gaussian noise. 5

8. a) Verify the following expression :

$$0 \le H(X) \le \log_2 m$$

where m is the size of the alphabet of X. 5

b) A DMS X has five symbols x_1, x_2, x_3, x_4 and x_5 with $P(x_1) = 0.4$, $P(x_2) = 0.19$, $P(x_3) = 0.16$, $P(x_4) = 0.15$ and $P(x_5) = 0.1$.

i) Construct a Shannon-Fano code for X, and calculate the efficiency of the code. 2 + 1

ii) Repeat for the Huffman code and compare the results. 2 + 1

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c) Write short notes on the following : 1 + 1 + 1 + 1

i) Codeword length

ii) Average codeword length

iii) Code efficiency

iv) Code redundancy.

9. Design a (12, 3) systematic convolutional encoder with a constraint length $\upsilon = 3$ and d*> = 3.

i) Construct the trellis diagram for this encoder. 7

ii) What is the d_{free} for the code ? 8

10. a) Let α be a primitive element of the Galois field GF (2^4), such that $1 + \alpha + \alpha^4 = 0$. Generate the triple-error correcting BCH code of length 15. 6

b) Condider a triple-error correcting Reed-Solomon code with symbols from GF (2^4). The generator polynomial of the code is

$$g(x) = (x + \alpha)(x + \alpha^2)(x + \alpha^3)(x + \alpha^4)(x + \alpha^5)(x + \alpha^6).$$

Let the transmitted code vector is an all-zero vector and the received vector is

$$r = (000\ \alpha^7\ 00\ \alpha^3\ 00000\ \alpha^4\ 00)$$

Compute the syndrome decoding. 9

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11. Write short notes on any *three* of the following 3 × 5

a) Viterbi decoding

b) Turbo codes

c) Dual codes

d) Standard array decoding

e) BCH codes.

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