B.TECH/IT/4TH SEM/INFO 2203 (BACKLOG)/2023

INFORMATION THEORY & CODING
(INFO 2203)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) When If t is the error correction capability of BCH code, what is the minimum distance of the code?
(a) 2t (b) 2t + 1 (c) 2t-1 (d) None of these.

(ii) The length of the output for a (2, 1, 3) convolution code for the message 1101 is
(a) 12 (b) 14 (c) 10 (d) 16.

(iii) Hamming distance between 1100001011 and 1001101001 is
(a) 1 (b) 5 (c) 4 (d) 3.

(iv) A (7, 4) linear block code has a rate of
(a) 7 (b) 1.75 (c) 4 (d) .57.

(v) For a (2, 1, 2) convolution encoder, impulse response is 1101. The output code word for data 101 is _____.
(a) 01110111 (b) 11011101
(c) 11001110 (d) 01010101.

(vi) Mutual information of the channel is
(a) H(A) + H(A/B) (b) H(A) / H(A/ B)
(c) H(A) - H(A/B) (d) H(A) . H(A/B).

(vii) The mutual information (I) is always _____
(a) 0 (b) > 0 (c) ≥ 0 (d) ≤ 0.

(viii) A (n, k) block code consists of _____ number of check bits added to k number of information bits.
(a) n + k (b) n (c) n/k (d) n - k.

(ix) If R is a codeword and H is a parity check matrix, then which of the following is true for correctly received codeword?
(a) $RH = 0$ (b) $RH^t \neq 0$ (c) $R^tH = 0$ (d) $RH^t = 0$.

(x) What is the mutual information of a channel with independent inputs?
(a) Zero (b) Constant
(c) Variable (d) Infinity.

Group – B

2. Consider a source that, emits nine symbols with the following probabilities – 0.25, 0.15, 0.15, 0.12, 0.10, 0.08, 0.06, 0.05, 0.04.
(i) Find the code word for the symbols using Shannon-Fano algorithm.
(ii) Compare its efficiency with Shannon-Fano-Elias algorithm.

(5 + 1) + (5 + 1) = 12

3. (a) Find Apply the Huffman coding for a DMS with the following source symbols and the given occurrence probabilities:

X	X_1	X_2	X_3	X_4	X_5	X_6	X_7
$P(x_i)$	0.4	0.2	0.12	0.08	0.08	0.06	0.06

(i) Draw the Huffman tree.
(ii) Calculate its efficiency.

(b) Consider a binary memoryless source X with two symbols X1 and X2. Prove that entropy of the source H(X) is maximum when both X1 and X2 are equiprobable
(c) Show that H(X, Y) = H(X|Y) + H(Y).

6 + 3 + 3 = 12

Group – C

4. (a) For systematic (7, 4) cyclic code, determine the generator matrix and parity check matrix, where generator polynomial is G(x) = p3 + p + 1.

(b) A generator matrix of (6, 3) linear block code is given below:

$$H = \begin{bmatrix} 100111 \\ 010110 \\ 001011 \end{bmatrix}$$

(i) Determine the d_{min} for the above code.
(ii) If the received codeword is 101101, determine the message bit sequence.

6 + (3 + 3) = 12

5. For a linear block code, the syndrome is given by:

S1 = m1 + m2 + m3 + m5
S2 = m1 + m2 + m4 + m6
S3 = m1 + m3 + m4 + m7

(i) Find the parity check matrix.
(ii) Draw the encoder circuit.
(iii) Find the code words for a few input sequences.
(iv) How many errors can be detected and corrected?
(v) What is the syndrome for the received data 1011011?

(2 + 3 + 4 + 2 + 1) = 12

Group – D

6. (a) Find the conjugates for the field element α in GF (25).
   (b) Find (i) $\alpha^2 + \alpha^9$ (ii) $\alpha^3 + \alpha^7 + \alpha^{11}$ (iii) $\alpha^{13} + \alpha^2$ in GF(2^4).
   (c) State the properties of Galois Field.

3 + 6 + 3 = 12

7. (a) Find the generator polynomial g(x) for a single error correcting binary BCH code of block length 31 over GF (2^5). Use primitive polynomial $p(x) = x^5 + x^2 + 1$.
   (b) Find the minimal polynomial for the field element α in GF (2^4). Use the primitive polynomial $p(x) = x^4 + x + 1$ to construct GF (2^4).

7 + 5 = 12

Group – E

8. Consider the (3, 1, 2) convolutional encoder with impulse response,
   $g^1 = \{1\ 1\ 0\}$, $g^2 = \{1\ 0\ 1\}$, $g^3 = \{1\ 1\ 1\}$
   (i) Draw the encoder block diagram.
   (ii) Find the generator matrix and output code vector for input message m = {1 1 1 0 1}.

2 + (4 + 2 + 2) + 2 = 12

9. Explain Viterbi Algorithm to decode the convolutional codes with suitable example.

(6 + 6) = 12