CODING & INFORMATION THEORY
(ECEN 4102)

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) Code rate for (15,5) code is
(a) 3 (b) 1/3 (c) 5 (d) 10.

(ii) For a (7,4) cyclic code generated by $g(x)= x^3+x+1$. The syndrome for the error pattern $e(x) = x^3$ is
(a) 101 (b) 111 (c) 110 (d) 011.

(iii) The generator polynomial of a cyclic code is a factor of
(a) $x^n + 1$ (b) $x^{n-1} + 1$ (c) $x^{n+1} + 1$ (d) $x^{n+2} +1$.

(iv) Entropy is
(a) average information per message (b) information in a signal
(c) amplitude of signal (d) all of the above.

(v) For a (7, 4) block code, 7 is the total number of bits and 4 is the number of
(a) redundant bits (b) total bits- information bits
(c) information bits (d) none of the above.

(vi) An encoder for a (4, 3, 5) convolution code has a memory order of
(a) 4 (b) 2 (c) 3 (d) 5.

(vii) While representing the convolutional code by (n, k, m), what does 'm' signify or represent in it?
(a) coded bits (b) message bits
(c) memory (d) none of the above.

(viii) The generator matrix $H = \left[\begin{array}{ccc:ccc} 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 \end{array}\right]$ has a degree of
(a) 2

(ix) The relation between entropy and mutual information is
(a) I(X;Y) = H(X) - H(X/Y) (b) I(X;Y) = H(X/Y) - H(Y/X)
(c) I(X;Y) = H(X) - H(Y) (d) I(X;Y) = H(Y) - H(X).

(x) What is the Hamming distance between 10011 and 11000?
(a) 2 (b) 3 (c) 1 (d) 5.

Group – B

2. (a) Define entropy, mutual information.

(b) Show that $H(X;Y) = H(X) - H(X \mid Y)$ where symbols have their usual meanings.

(c) An analog signal band limited to 10 kHz is quantized in 8 levels of a PCM system with probabilities 1/4, 1/5, 1/5, 1/10, 1/10, 1/20, 1/20, 1/20 respectively. Calculate entropy and the rate of information.

(2 + 2) + 3 + (3 + 2) = 12

3. (a) A discrete memoryless source has five symbols x_1, x_2, x_3, x_4, and x_5 with probabilities of occurrence $P(x_1) = 0.4$, $P(x_2) = 0.19$, $P(x_3) = 0.16$, $P(x_4) = 0.15$, and $P(x_5) = 0.1$.
Construct the Huffman code and determine
(i) entropy
(ii) average code length
(iii) code efficiency.

(b) Draw the block diagram of a typical data transmission system.

(5 + 2 + 2 + 2) + 1 = 12

Group – C

4. (a) For a linear block code, derive that $G.H^T = 0$, where symbols have their usual meanings.

(b) What is an equivalent code?

(c) Define minimum distance of a code-set. If minimum distance of a code is 5, determine the error-detection and error-correction capability of the code.

(d) Parity check matrix of a linear block code is

(i) Determine the generator matrix.

(ii) Assuming that a vector [111011] is received, find the correct data.

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

5. (a) Write down the properties of Linear Block Code.

   (b) The parity check bits of a (7,4) block code are generated by $C_5 = d_1 \oplus d_2 \oplus d_4$; $C_6 = d_1 \oplus d_3$; $C_7 = d_1 \oplus d_3 \oplus d_4$;
   (i) Construct the corresponding Generator Matrix.
   (ii) Find the systematic code corresponding to the information bits [1100] and [1010].
   (iii) If the received words are v_1 = [1011001] and v_2 = [1111011] find the correct code words.

3 + (3 + 3 + 3) = 12

Group – D

6. (a) For a systematic (7, 3) cyclic code determine the generator matrix and parity check matrix if $g(x) = x^4 + x^2 + x + 1$.

   (b) Code word polynomial c(x) belonging to the (7, 4) cyclic code with $g(x) = 1 + x + x^3$ incurs errors so as to produce received polynomial *v*(x). Find c(x) when
   (i) $v(x) = x^5 + x^2 + 1$
   (ii) $v(x) = x^6 + x^3 + 1$

6 + 6 = 12

7. (a) For a (2, 1, 2) convolution code, g^0 = (100) & g^1 = (110). Draw the encoder. Find the state diagram, for this convolution code.

   (b) What is constraint length in convolution code? Compute the same for the above mentioned code.

3 + (7 + 2) = 12

Group – E

8. (a) Determine the Galois Field elements of GF (2^3) for the corresponding polynomial $p(x) = x^3 + x + 1$.

   (b) What do you mean by primitive element? If α^3, α^{12} are field elements of GF(2^4), determine their order and check whether or not they are primitive elements.

   (c) Find the minimal polynomial of α^4 in GF (2^4).

3 + (1 + 4) + 4 = 12

9. Write short notes on (any three):
   (i) Hamming Code
   (ii) Golay Code
   (iii) Turbo Codes
   (iv) Viterbi Decoding.

4 + 4 + 4 = 12