INFORMATION THEORY AND CODING
(ECEN 3105)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) For a noiseless channel I(X;Y) is
(a) H(X) – H(Y) (b) H(X)
(c) H(Y) – H(X) (d) H(X) – H(Y|X).

(ii) A discrete memoryless source entropy H and average codeword length L have the following boundary condition
(a) $L \geq H$ (b) $L<H$
(c) $L \leq H$ (d) $L<H^2$

(iii) The average information contained in a message is
(a) entropy (b) efficiency
(c) coded signal (d) none of the above.

(iv) The received code contains an error if the syndrome vector is
(a) Zero (b) Non zero
(c) Infinity (d) None of the mentioned.

(v) Code rate r, k information bits and n as total bits, is defined as
(a) $r = k/n$ (b) $k = n/r$
(c) $r = k \times n$ (d) $n = r \times k$.

(vi) Let C = 10011100110 be a minimum weight nonzero code word for a linear block code. Maximum number of errors detected by this code is
(a) 3 (b) 4 (c) 5 (d) 6.

(vii) 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) $x^{n+2} + 1$

(viii) Number of elements in GF (2^5) field is
(a) 5 (b) 16 (c) 31 (d) 32.

(ix) In an encoder for a (4, 3, 4) convolution code, maximum number of memories elements present in an individual shift register is
(a) 4 (b) 3 (c) 5 (d) 1.

(x) Which of the following is not a way to represent convolution code?
(a) State diagram (b) Trellis diagram
(c) Tree diagram (d) Linear matrix.

Fill in the blanks with the correct word

(xi) The Hamming distance between 110110110 & 110010011 is _____.

(xii) A channel will be noiseless if it is both _____ and _____.

(xiii) If m = 4, then length (n) of the BCH code _____.

(xiv) The generator polynomial of (9,6) cyclic code must divide the polynomial _____.

(xv) Common decoding technique for convolution code word is _____.

Group - B

2. (a) Summarise the Kraft Inequality. *[(CO1)(Understand/LOCQ)]*
(b) A discrete memoryless source X has 7 messages x_1, x_2, x_3, x_4, x_5, x_6 and x_7 with their probabilities 0.05, 0.15, 0.2, 0.05, 0.15, 0.3 and 0.1 respectively. Construct a Huffman code for X and calculate the efficiency of the code. *[(CO1)(Evaluate/HOCQ)]*

4 + (4 + 4) = 12

3. (a) Given a binary memoryless source X with 2 symbols x_1 and x_2, prove that H(X) is maximum when both x_1 and x_2 are equiprobable. *[(CO3)(Analyse/IOCQ)]*
(b) Given a BSC with $P(x_1) = \alpha$,
(i) Show that mutual information $I(X;Y) = H(Y) + p \log_2 p + (1-p) \log_2(1-p)$
(ii) Calculate I(X:Y) for $\alpha = 0.5$ and $p = 0.1$. *[(CO2)(Evaluate/HOCQ)]*

5 + 7 = 12

Group - C

4. (a) Write down the properties of Linear Block Code. *[(CO3)(Remember/LOCQ)]*
(b) The parity check bits of a (7,4) block code are generated by C5 = d1 ⊕d2 ⊕d4; C6 = d1 ⊕d3; C7 = d1 ⊕d3 ⊕d4;
(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 v1 = [1011001] and v2 = [1111011] find the correct code words. *[(CO3)(Apply/IOCQ)]*

3 + (3 + 3 + 3) = 12

5. (a) Define G and H matrix and prove that $G.H^T = 0$. *[(CO4)(Evaluate/HOCQ)]*
(b) Prove that a block code, with minimum distance of d_{min}, can correct up to $t = \frac{1}{2}(d_{min} - 1)$ number of errors. *[(CO3)(Evaluate/HOCQ)]*

(c) For a block code with minimum distance of 5, find it's error correction and detection capability. *[(CO3)(Evaluate/HOCQ)]*

6 + 4 + 2 = 12

Group - D

6. (a) Determine systematic and non-systematic code words for i = (101) for the (7, 3) code with $g(x) = x^4 + x^2 + x + 1$. *[(CO4)(Analyse/IOCQ)]*

(b) Given that $x^7 + 1 = (x+1)(x^3 + x^2 + 1)(x^3 + x + 1)$, determine the generator polynomials of all the cyclic codes with block length 7. *[(CO4)(Apply/LOCQ)]*

(2 + 4) + 6 = 12

7. (a) Determine the Galois Field elements of GF (2^3) for the corresponding polynomial $f(x) = x^3 + x + 1$ *[(CO5)(Analyse/IOCQ)]*

(b) Find the conjugates of α^5 in GF(2^3). *[(CO4)(Remember/LOCQ)]*

(c) Determine the minimal polynomial of α^5 in GF(2^3). *[(CO5)(Create/HOCQ)]*

4 + 4 + 4 = 12

Group - E

8. (a) For a (2, 1, 2) convolution code, $g_0 = (100)$ & $g_1 = (110)$. Draw the encoder. *[(CO5, CO6)(Apply/IOCQ)]*

(b) State the constraint length in convolution code. Compute the same for this code. Find the state diagram, for the convolution coder mentioned above. *[(CO5, CO6)(Remember/LOCQ)]*

6 + 6 = 12

9. (a) For a (2,1,2) convolution code, $g^0 = (101)$ and $g^1 = (100)$. Draw the encoder. Model the trellis diagram for four successions. *[(CO5,CO6)(Apply/IOCQ)]*

(b) Find the code words for input sequence u = (101) from the trellis diagram constructed above. *[(CO5,CO6)(Analyse/IOCQ)]*

(3 + 7) + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	23.69	43.75	32.29