INFORMATION THEORY AND CODING
(ECEN 3105)

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) Purpose of the source coding is to
(a) increase the information transmission rate
(b) decrease the information transmission rate
(c) decrease the S/N ratio
(d) decrease the probability of error.

(ii) When X and Y are statistically independent, then I(X ; Y) is
(a) 1 (b) 0.5 (c) 0 (d) undecided.

(iii) The technique that may be used to increase average information per bit is
(a) Shannon-Fano algorithm (b) ASK
(c) FSK (d) Digital modulation techniques.

(iv) Let C = 10001100110 be a minimum weight nonzero code word for a linear block code. Maximum number of errors detected by this code is
(a) 5,6 (b) 2,5 (c) 2,4 (d) 4,2.

(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) none of the above (d) information bits.

(vi) 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) $x^{n+2}+1$.

(vii) A BCH code constructed over GF (2^5). The code word length
(a) 6 (b) 31 (c) 32 (d) 64.

(viii) Huffman coding technique is adopted for constructing the source code with _____ redundancy.
(a) maximum (b) constant (c) minimum (d) logic unpredictable.

(ix) Which among the following represents the code in which codeword consists of message bits and parity bits separately?
(a) Block Codes (b) Systematic Codes (c) Code Rate (d) Hamming Distance.

(x) The generator polynomial of a (7,5) cyclic code has a degree of
(a) 2 (b) 3 (c) 4 (d) 5.

Group – B

2. (a) Define mutual information, channel capacity. [CO2(Remember/LOCQ)]
(b) Show that for a lossless channel H(X|Y) = 0, where, symbols have their usual meanings. [CO2(Analyse/IOCQ)]
(c) An analog signal band limited to 5 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. What may be the maximum entropy of this source? [CO2,(Apply/IOCQ)]

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

3. (a) Explain the term and their significance: Mutual Information, Channel Capacity, and Conditional Probability. [CO2,(Remember/LOCQ)]
(b) If $I(x_1)$ is the information carried by symbol x_1 and $I(x_2)$ is the information carried by message x_2. Then prove that the amount of information carried compositely due to x_1 and x_2 is $I(x_1, x_2)=I(x_1)+I(x_2)$. [CO2(Analyse/IOCQ)]

(2 + 2 + 2) + 6 = 12

Group – C

4. (a) The parity check matrix of a (7,4) Hamming code is as under:

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

Calculate the syndrome vector for single bit errors. [CO3(Create/HOCQ)]
(b) For the code X_1 = (000,111) how many errors can be successfully detected and corrected? [CO4(Evaluate/HOCQ)]

8 + (2 + 2) = 12

5. (a) For a linear block code show that error syndrome solely depends on the error pattern not on the original code word. [CO3,CO6(Analyse/IOCQ)]
(b) Define Hamming weight of a block code. What is minimum Hamming distance of a code set? For a linear block code, how you can determine the minimum Hamming distance. [CO3, (Remember/LOCQ)]
(c) Parity check matrix of a linear block code is

$$H = \left| \begin{array}{ccc:ccc} 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 \end{array} \right|$$

(i) Determine the generator matrix.
(ii) Assuming that a vector [110111] is received, find the correct data.
[CO3,CO4,CO6(Evaluate/HOCQ)]

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

Group – D

6. (a) Determine the systematic and non-systematic codeword polynomial, for the (7, 4) code, given I = (1001) and G(p)= $1+p+p^3$. [CO4,CO6(Evaluate/HOCQ)]
   (b) For a systematic (7, 4) cyclic code determine the generator matrix and parity check matrix if $g(x) = 1 + x + x^3$. [CO4(Evaluate/HOCQ)]

(3 + 3) + 6 = 12

7. (a) Determine the Galois Field elements of GF (2^4) for the corresponding polynomial $p(x) = x^4+x+1$. [CO5(Apply/IOCQ)]
   (b) What do you mean by primitive element? α^3, α^{10} are field elements of GF(2^4), determine their order and check whether or not they are primitive elements. [CO5,CO6(Apply/IOCQ)]
   (c) Find the minimal polynomial of α^4 in GF (2^4). [CO5(Apply/IOCQ)]

3 + (1 + 4) + 4 = 12

Group – E

8. (a) For a (2, 1, 3) convolution code, g^1 = (1011) & g^2 = (1101). Draw the encoder. Find the state diagram, for this convolution code. [CO5,CO6(Create/HOCQ)]
   (b) What is constraint length in convolution code? Compute the same for the above mentioned code. [CO5(Apply/IOCQ)]

(3 + 7) + (1 + 1) = 12

9. Write short notes on (*any three*). **(3 × 4) = 12**
   (i) Viterbi decoder
   (ii) Discrete memory-less source
   (iii) Hamming code
   (iv) BCH code
   (v) Source coding. [CO2,CO5(Remember/LOCQ)]

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	26	32.3	41.7

Course Outcome (CO):

After completing the course the students will be able to:

1. Distinguish between different types of source codes.
2. Figure out equations for entropy, mutual information and channel capacity for all types of channels, utilizing their knowledge on the elements.

3. Explain and estimate the merit of various methods for generating and detecting different types of error correcting codes.
4. Formulate the basic equations of linear block codes, cyclic codes.
5. Outline the basics of convolution code, linear algebra and BCH code.
6. Develop overall understanding about different types of codes applied to both source and channel end during data transmission.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question