

**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) The expected information contained in a message is called
 - (a) entropy
 - (b) efficiency
 - (c) coded signal
 - (d) none of the above.
 - (ii) 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.
 - (iii) The rate of a block code is the ratio of
 - (a) Block length to message length
 - (b) Message length to block length
 - (c) Message weight to block length
 - (d) None.
 - (iv) Linear Codes are used for
 - (a) Forward Error Correction
 - (b) Backward Error Correction
 - (c) Forward Error Detection
 - (d) Backward Error Detection.
 - (v) If a telephone channel has bandwidth 3000 Hz and SNR 20 dB then channel capacity is
 - (a) 3 kbps
 - (b) 1.19 kbps
 - (c) 2.19 kbps
 - (d) 19.97 kbps.
 - (vi) For GF(2³) the elements in the set are
 - (a) { 1,2,3,4,5,6,7,8 }
 - (b) { 0,1,2,3,4,5,6,7 }
 - (c) { 0,1,2,3,4,5,6 }
 - (d) { 1,2,3,4 }

- (vii) Block length is the _____ in the code word
 - (a) number of bits
 - (b) distance between bits
 - (c) number of parity bits
 - (d) none of the above.
- (viii) In Repetition Code, how many information bit/s is/are present in addition to n-1 parity bits
 - (a) One
 - (b) Two
 - (c) Four
 - (d) Eight.
- (ix) Which among the following represents the code in which code words consists of message bits and parity bits separately?
 - (a) Block Codes
 - (b) Systematic Codes
 - (c) Code Rate
 - (d) Hamming Distance.
- (x) In a linear code, the minimum Hamming distance between any two code words is _____ minimum weight of any non-zero code word
 - (a) less than
 - (b) greater than
 - (c) equal to
 - (d) none of the above.

Group – B

2. (a) Why is Huffman code called optimum code?
 (b) A DMS 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 $P(x_5)=0.1$. Construct a Shanon Fano code and calculate the code efficiency.
 (c) What is conditional entropy?
3 + (5 + 2) + 2 = 12
3. (a) A discrete source emits one of 5 symbols once every millisecond with probabilities 1/2, 1/4, 1/8, 1/16 and 1/16 respectively. Determine the source entropy and information rate.
 (b) Determine the channel capacity of a noiseless channel.
 (c) Show that $H(X, Y) = H(X/Y) + H(Y)$.
5 + 3 + 4 = 12

Group – C

4. (a) Define G and H matrix and show that $G \cdot H^T = 0$
 (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. For a block code with minimum distance of 5, find it's error correction and detection capability.
6 + (4 + 2) = 12

5. (a) (i) Construct the parity-check matrix for the (7, 4) systematic Hamming Code.
 (ii) Construct the generator matrix for the above Hamming Code.
- (b) Consider a (6, 3) linear block code whose generator matrix is given by
- $$\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$
- (i) Find the parity check matrix
 (ii) Find the minimum distance of the code.

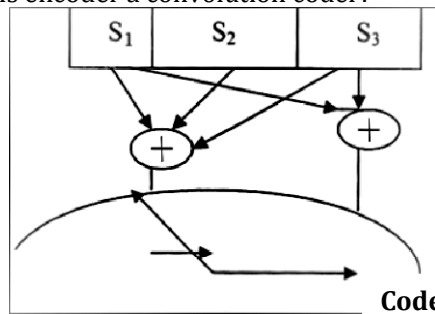
$$(3 + 3) + (2 + 4) = 12$$

Group - D

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

$$6 + (3 + 3) = 12$$

7. (a) What are the advantages and disadvantages of convolution code?
- (b) For the convolution coder shown below, find the value of the constraint length and code rate. If a message sequence 11101 is applied at the input, what will be the output? What is the justification of calling this encoder a convolution coder?



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

Group - E

8. (a) Determine the Galois field elements of $GF(2^4)$ for the corresponding polynomial $p(x) = x^4 + x + 1$.
- (b) What do you mean by primitive element? α^{10}, α^7 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^8 in $GF(2^4)$.

$$3 + 1 + 2 + 2 + 4 = 12$$

9. Write short notes on (*any three*):

$$(3 \times 4) = 12$$

- (i) Source Coding
 (ii) Golay Code
 (iii) Trellis diagram
 (iv) Factor of $x^n + 1$ in cyclic code.