

**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) 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.
- (ii) For a (7,4) cyclic code generated by  $g(x) = x^3 + x + 1$ . The syndrome for the error pattern  $e(x) = x^4$  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) If  $m = 3$ , then length (n) of the BCH code  
(a) 6 (b) 5 (c) 7 (d) none of these.
- (v) The properties of cyclic code is /are  
(a) Linear (b) Cyclic (c) both (a) & (b) (d) none of these.
- (vi) An encoder for a (4,3,5) convolution code has input order of  
(a) 4 (b) 2 (c) 3 (d) 5
- (vii) Code word length is  
(a) number of bits (b) distance between bits  
(c) number of parity bits (d) none of the above.
- (viii) The generator polynomial of a (7,4) cyclic code has a degree of  
(a) 2 (b) 3 (c) 4 (d) 5.
- (ix) 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.

- (x) What is the Hamming distance between 11011 & 11001?  
 (a) 2 (b) 3 (c) 1 (d) 5.

**Group - B**

2. (a) Define entropy, channel capacity. [CO1, (Remember/LOCQ)]  
 (b) Show that  $H(X, Y) = H(X/Y) + H(Y)$ . Where symbols have their usual meanings. [CO1, (Analyse/IOCQ)]  
 (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. [CO1, (Apply/IOCQ)]  
**(2 + 2) + 3 + (3 + 1) = 12**
3. (a) A DMS X has five symbols with probabilities of occurrence  $P(x_1) = 0.4$ ;  $P(x_2) = 0.18$ ;  $P(x_3) = 0.17$ ;  $P(x_4) = 0.15$ ;  $P(x_5) = 0.1$ ; Construct the Shannon-Fano coding and determine  
 a> Average code length  
 b> Code efficiency. [CO1, (Create/HOCQ)]
- (b) A channel has the following channel matrix:  $P(Y | X) = \begin{bmatrix} 0.9 & 0.1 \\ 0.2 & 0.8 \end{bmatrix}$   
 a> Draw the channel diagram.  
 b> Find  $P(y_1)$  and  $P(y_2)$  when  $P(x_1) = P(x_2) = 0.5$   
 c> Find the joint probabilities  $P(x_1, y_2)$  and  $P(x_2, y_1)$  when  $P(x_1) = P(x_2) = 0.5$   
 [CO1, (Apply/IOCQ)]  
**(3 + 1 + 3) + (1 + 2 + 2) = 12**

**Group - C**

4. (a) Write down the properties of Linear Block Code. [CO2, (Remember/LOCQ)]  
 (b) The parity check bits of a (7,4) block code are generated by  
 $C_5 = d_1 \oplus d_2 \oplus d_3$ ;  $C_6 = d_1 \oplus d_2$ ;  $C_7 = d_1 \oplus d_3 \oplus d_4$ ;  
 a> Construct the corresponding Generator Matrix.  
 b> Find the systematic code corresponds to the information bits [1110] & [1010].  
 c> If the received words are  $v_1 = [1011001]$  &  $v_2 = [1111011]$ . Find the correct code words. [CO3, CO4, (Create/HOCQ)]  
**3 + (3 + 3 + 3) = 12**
5. (a) For a linear block code derive that  $C.H^T = 0$ , where symbols have their usual meaning. [CO2, (Analyse/IOCQ)]  
 (b) What is an equivalent code? [CO2, (Remember/LOCQ)]  
 (c) Define minimum distance of a code-set. Minimum distance of a code is 7, determine the error-detection & error-correction capability of the code. [CO2, (Apply/IOCQ)]

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

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

a> Determine the generator matrix.

b> Assuming that a vector [110111] is received, find the correct data.

[CO3, CO4, (Evaluate/HOCQ)]

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

### Group - D

6. (a) For a systematic (7, 3) cyclic code determine the generator matrix and parity check matrix if  $g(x) = x^4+x^3+x^2+1$  [CO3, CO4, (Create/HOCQ)]

(b) Determine systematic & nonsystematic code words for  $i = (1101)$  for the (7,4) code with  $g(x) = x^3+x+1$  [CO3, CO4, (Evaluate/HOCQ)]

$$6 + 6 = 12$$

7. (a) For a (2, 1, 2) convolution code,  $g^0 = (101)$  &  $g^1 = (110)$ . Draw the encoder. Find the state diagram, for this convolution code. [CO5, (Create/HOCQ)]

(b) What is constraint length in convolution code? Compute the same for the above mentioned code. [CO5, (Apply/IOCQ)]

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

### Group - E

8. (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?  $\alpha^3, \alpha^{10}$  are field elements of  $GF(2^4)$ , determine their order and check whether or not they are primitive elements. [CO5, (Apply/IOCQ)]

(c) Find the minimal polynomial of  $\alpha^4$  in  $GF(2^4)$ . [CO5, (Apply/IOCQ)]

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

9. Write short notes on (*Any Three*)

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

a> Hamming Code

b> Trellis diagram.

c> Shannon-Fano code.

d> Galois Field

e> Source coding. [CO2, (Remember/LOCQ)]

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	25 %	32 %	43 %

After the completion of the course students will be able to

**Course Outcome (CO):**

➤ Derive equations for entropy mutual information and channel capacity for all types of channels.

## B.TECH/ECE/7<sup>TH</sup> SEM/ECEN 4102(BACKLOG)/2021

- Distinguish between different types of error correcting codes
- Explain various methods of generating and detecting different types of error correcting codes
- Formulate the basic equations of linear block codes, Cyclic codes.
- Learn the basics of convolution code, linear algebra and BCH code.

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

<b>Department &amp; Section</b>	<b>Submission link:</b>
ECE BACKLOG	Join the Backlog classroom using the link: <a href="https://classroom.google.com/c/NDY0NDY3Mjk1NDI1?cjc=dzp3ice">https://classroom.google.com/c/NDY0NDY3Mjk1NDI1?cjc=dzp3ice</a>