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(Y) – H(X)
(c) H(X) (d) H(X) – H(Y|X).

(ii) 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.

(iii) A discrete memoryless source entropy H and average code word length L have the following boundary condition
(a) L ≥H (b) L<H
(c) L≤H (d) L< H^2.

(iv) The memory less source refers to
(a) No previous information
(b) No message storage
(c) Emitted message is independent of previous message
(d) None of the above.

(v) Linear codes are used for
(a) forward error correction (b) backward error correction
(c) forward error detection (d) backward error detection.

(vi) If a telephone channel had bandwidth 3000 Hz and SNR 20 dB then chanel capacity is
(a) 3 kbps (b) 1.19 kbps
(c) 2.19 kbps (d) 19.97 kbps.

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

(viii) What is the Hamming distance between 11011 &11001?

(a) 2 (b) 3
(c) 1 (d) 5.

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

(x) For prefixed source coding, the number of bits assigned to the code for the event with less probability is

(a) Higher (b) Lower
(c) Equal (d) Dynamic.

Fill in the blanks with the correct word

(xi) A DMS has 8 messages, the maximum entropy of the source is _____.

(xii) Code rate of (6, 3) block code is ____.

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

(xiv) BCH code is a subclass of _____.

(xv) For a (7, 4) cyclic code generated by $g(x) = x^3+x+1$, the syndrome for the error pattern $e(x) = x^5$ is _____.

Group - B

2. (a) Define Lossless and deterministic channel. *[(CO2)(Understand/LOCQ)]*

(b) Show that for a deterministic channel H (Y|X) =0 where symbols have their usual meanings. Hence justify the relevance of the channel name. *[(CO2)(Analyse/IOCQ)]*

(c) A channel has the following channel matrix:

$$[P(Y \mid X)] = \begin{bmatrix} 0.6 & 0.4 \\ 0.3 & 0.7 \end{bmatrix}$$

(i) Draw the channel diagram.
(ii) Find $P(y_1)$ and $P(y_2)$ when $P(x_1) =0.6$, $P(x_2)=0.4$
(iii) Find the joint probabilities $P(x_1,y_2)$ and $P(x_2,y_1)$ when $P(x_1) = P(x_2)=0.5$.

[(CO2)(Evaluate/HOCQ)]

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

3. (a) Determine the Huffman code for the following messages with their probabilities given as

x_1	x_2	x_3	x_4	x_5	x_6	x_7
0.05	0.15	0.2	0.05	0.15	0.3	0.1

Also calculate the efficiency. *[(CO3)(Analyse/IOCQ)]*

(b) 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) (Analysis/IOCQ)]*

7 + 5 = 12

Group - C

4. (a) 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)(Analyse/IOCQ)]*

   (b) In a linear block code 001010111 is the minimum weight non-zero code word. Find the error correction and detection capability of the linear block code. *[(CO3)(Apply/IOCQ)]*

   (c) The parity check bits of a (7, 4) block code are generated by

   $C_5 = d_1 \oplus d_3 \oplus d_4$; $C_6 = d_2 \oplus d_3$; $C_7 = d_1 \oplus d_2 \oplus d_4$;

   i. Construct the corresponding Generator Matrix.

   ii. Find the systematic code corresponds to the information bits [1001] & [0101].

   iii. If the received words are v_1 = [1011001]. Find the correct code word.

   [(CO4,CO6)(Evaluate/HOCQ)]

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

5. (a) For a systematic (6,3) linear block code, the 3 parity bits c_4, c_5 and c_6 are given by

   $C_4 = m_1 \oplus m_2 \oplus m_3$

   $C_5 = m_1 \oplus m_2$

   $C_6 = m_1 \oplus m_3$

   (i) Construct the generator matrix.

   (ii) Construct the code starting with 110.

   (b) An error control code has the following check matrix

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

   (i) Determine the generator matrix G.

   (ii) Decode the received code word 110110. *[(CO3)(Evaluate/HOCQ)]*

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

Group - D

6. (a) Determine systematic & non-systematic code words for i = (1001) for the (7, 4) code with $g(x) = x^3+x^2+1$. *[(CO4)(Apply/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,CO6)(Evaluate/HOCQ)]*

   (2 + 4) + 6 = 12

7. (a) What is irreducible polynomial? What do you mean by a polynomial over GF(2)? *[(CO5)(Remember/LOCQ)]*

   (b) Prove that $f(x) = 1 + x + x^3$ is a irreducible polynomial over GF(2). *[(CO5)(Remember/LOCQ)]*

   (c) Determine the Galois field elements of GF (2^4) for the corresponding polynomial $p(x) = x^4 + x^3 + 1$. *[(CO2)(Apply/IOCQ)]*

   2 + 3 +7 = 12

Group - E

8. (a) Define constraint length in convolution code. *[(CO5)(Remember/LOCQ)]*

(b) For the given convolution encoder (Fig1), construct the generator sequences.
[(CO3)(Apply/IOCQ)]

(c) Find the state diagram, for this convolution code.

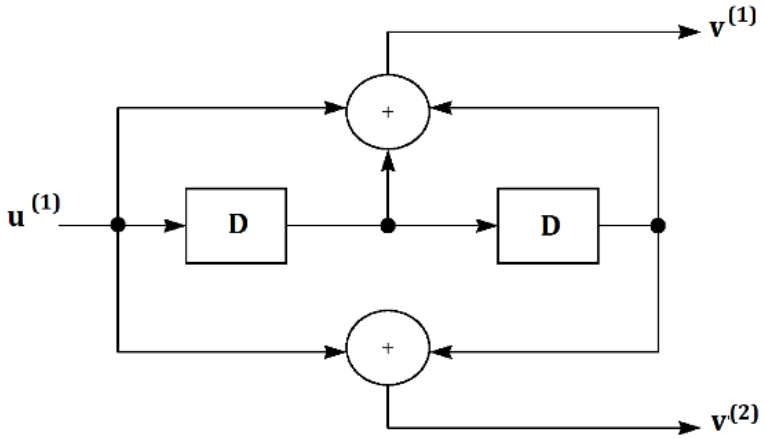

Fig.1

[(CO5,CO6)(Apply/IOCQ)]

2 + 3 + 7 = 12

9. Write short notes on (any three): **(3 × 4) = 12**
   (i) Kraft inequality
   (ii) Shannon Fano Coding
   (iii) Source Coding
   (iv) Trellis diagram
   (v) Galois Field. *[(CO2/CO3)(Remember/LOCQ)]*

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	21.88	45.83	32.29

Course Outcome (CO):

After the completion of the course 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.*