ERROR CONTROL CODING FOR SECURE DATA TRANSMISSION
(ECE3123)

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) 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) $L<H^2$

(ii) Which type of channel does not represent any correlation between input and output symbols?
(a) Noiseless channel (b) Lossless channel
(c) Useless channel (d) Deterministic channel

(iii) How many redundant bits are added in block codes for k information bits and n code bits?
(a) n+k (b) n-k (c) k^2 (d) n^2

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

(v) For a (7, 4) block code, 7 is the total number of bits and 4 is the number of
(a) redundant bits (b) check bits
(c) information bits (d) none of the above

(vi) If m = 3, then block length n of the BCH code
(a) 6 (b) 5 (c) 7 (d) none of these

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

(viii) In decoding of cyclic code, which among the following is also regarded as "Syndrome Polynomial"?
(a) Generator polynomial (b) Received codeword polynomial
(c) Quotient polynomial (d) Remainder polynomial

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

(x) Viterbi algorithm applies the
(a) maximum likelihood principle (b) minimum likelihood principle
(c) maximum entropy principle (d) minimum entropy principle

Fill in the blanks with the correct word

(xi) The _____of the codeword is the number of non-zero elements.

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

(xiii) One example of entropy coding is _____.

(xiv) 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 _____.

(xv) Constraint length of a convolution code is _____ the number of input bits that affect the current output _____.

Group - B

2. (a) Apply the Shannon-Fano coding procedure for the 8 message ensemble $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8$ with probabilities $\frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{16}, \frac{1}{16}, \frac{1}{4}, \frac{1}{16}, \frac{1}{8}$ respectively. Show that the code efficiency is 100%. *[(CO1)(Evaluate/HOCQ)]*

(b) Explain conditional probability? *[(CO2)(Understand/LOCQ)]*

8 + 4 = 12

3. (a) Verify the following expression $0 \leq H(X) \leq \log_2 m$, where m is the size of the alphabet of X. *[(CO3)(Analyse/HOCQ)]*

(b) If $I(x_1)$ is the information carried by the symbols x_1 and $I(x_2)$ is the information carried by message x_2, then prove that amount of information carried compositely due to x_1 and x_2 is $I(x_1,x_2) = I(x_1) + I(x_2)$. *[(CO4)(Remember/LOCQ)]*

6 + 6 = 12

Group - C

4. (a) Consider a systematic (8, 4) code whose parity-check equations are

$v_0 = u_1 + u_2 + u_3$
$v_1 = u_0 + u_1 + u_2$
$v_2 = u_0 + u_1 + u_3$
$v_3 = u_0 + u_2 + u_3$

where u_0, u_1, u_2, u_3 are message digits and v_0, v_1, v_2, v_3 are parity check digits. Find the generator and parity check matrices for this code. If the minimum distance of this code is 4, calculate its error detection and correction capability.

[(CO4) (Evaluate/HOCQ)]

(b) Prove that (4,3) even parity code is Linear Block code. *[(CO3) (Analyse/IOCQ)]*

8 + 4 = 12

5. (a) Determine the parity check matrix H for the (5, 3) code for the given G- matrix. Show that $GH^T = 0$ and $cH^T = 0$ for c= (11010).

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

[(CO4)(Evaluate/HOCQ)]

(b) For source coding, define the terms code length and code rate and mention the boundary of code rate. *[(CO3)(Understand/LOCQ)]*

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

Group - D

6. (a) Given that $x^9 + 1 = (x^6 + x^3 + 1)(x^2 + x + 1)(x + 1)$. Determine the cyclic codes with block length 9. *[(CO4)(Create/HOCQ)]*

(b) Codeword 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. $v(x) = x^6 + x^3 + 1$. *[(CO4)(Apply/IOCQ)]*

6 + 6 = 12

7. (a) Determine the Galois Field elements of GF (2^4) for the corresponding polynomial $f(p) = p^4 + p + 1$. *[(CO5)(Analyse/HOCQ)]*

(b) Find the conjugates of α^6, α^4 in GF (2^4). *[(CO5)(Apply/IOCQ)]*

4 + (4 + 4) = 12

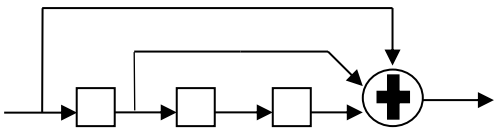
Group - E

8. Write short notes on:- Trellis Diagram, Turbo Codes, Viterbi Decoding, and Golay Code. *[(CO5,CO6) (Remember/LOCQ)]*

(3 + 3 + 3 + 3) = 12

9. (a) For a (2,1,3) convolution code $g_0 = (1011)$ and $g_1 = (1001)$. Draw the encoder. Determine the complete code bits (until registers reach zero state) for the input sequence u = (0110). *[(CO5, CO6)(Apply/IOCQ)]*

(b) For the given encoder circuit, formulate the generator polynomial.



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

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution			