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) 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.

(ii) The information I contained in a message with probability of occurrence is given by (k is constant)
(a) $I = k \log_2 P$ (b) $I = k \log_2 1/P$
(c) $I = k \log_2 1/2P$ (d) $I = k \log_2 1/P2$.

(iii) 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

(iv) The average information contained in a message is
(a) entropy (b) efficiency
(c) coded signal (d) none of the above.

(v) Basically, Galois field consists of _____ number of elements.
(a) Finite (b) Infinite
(c) Both (a) and (b) (d) None of above.

(vi) 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.

(vii) According to linearity property, the _____ of two code words in a cyclic code is also a valid code word.
(a) sum (b) difference (c) product (d) division.

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

(ix) In digital communication system, smaller the code rate, _____ are the redundant bits.
(a) less (b) more (c) equal (d) unpredictable.

(x) While representing the convolutional code by (n,k,m), what does 'm' signify or represent in it?
(a) Coded bits (b) Message bits
(c) Memory order (d) All of the above.

Group – B

2. (a) Explain the terms and their significance: Entropy, Mutual information, Self information and Channel capacity. [(CO2) (Remember/LOCQ)]
(b) An analog signal is band-limited to f_m Hz and sampled at Nyquist rate. The samples are quantized into 4 levels. Each level represent one symbols. Thus there are 4 symbols. The probability of occurrence of these 4 levels (symbols) are P(x1)=P(x4)=1/8 and P(x2)=P(x3)=3/8. Obtain the information rate of the source. [(CO2) (Evaluate/HOCQ)]

(2 × 4) + 4 = 12

3. (a) Summarize the Kraft inequality. [(CO1) (Understand/LOCQ)]
(b) A discrete memoryless source X has *five* equally likely symbols. Construct a Shannon-Fano code for X, and calculate the efficiency of the code. [(CO1)(Evaluate/HOCQ)]

4 + (4 + 4) = 12

Group – C

4. (a) Define G and H matrix and prove that $G.H^T = 0$. [(CO4)(Analyze/IOCQ)]
(b) Prove that a block code, with minimum distance of d_{min}, can correct up to $t = ½(d_{min} - 1)$ number of errors. [(CO3)(Analyze/LOCQ)]
(c) For a block code with minimum distance of 5, find it's error correction and detection capability. [(CO3)(Evaluate/HOCQ)]

6 + 4 + 2 = 12

5. (a) An error control code has the following parity 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/IOCQ)]

(b) For a systematic linear block code, the three 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. [(CO4) (Evaluate/HOCQ)]

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

Group – D

6. (a) A message 101101 is to be transmitted in cyclic code with a generator polynomial $G(p)= p^4+p^3+1$. Obtain the transmitted code word. How many check bits (i.e., parity bits) does the encoded message contain? Draw the encoding arrangement for the same. [(CO4) (Analyze/IOCQ)]
(b) State the advantages of cyclic codes. [(CO4) (Remember/LOCQ)]

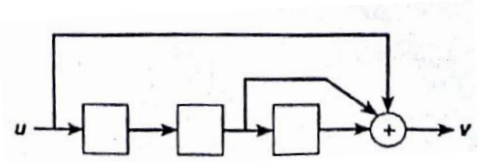
(6 + 1 + 3) + 2 = 12

7. (a) (i) What is irreducible polynomial? What do you mean by a polynomial over GF(2)?
(ii) Prove that $f(x) = 1 + x + x^3$ is a irreducible polynomial over GF(2). [(CO5)(Remember/LOCQ)]
(b) Let α be a primitive element of the Galois field $GF(2^4)$ such that $1 + \alpha + \alpha^4 = 0$. Generate the triple error correcting BCH code of length 15.
[(CO5) (Evaluate/HOCQ)]

(2 + 3) + 7 = 12

Group – E

8. (a) Determine the output sequence given the input sequence u=(1001) for the figure. According to the figure a shift register consist of 3 stages where $g_0=1$, $g_1=0$, $g_2=1$, and $g_3=1$, respectively. [(CO5)(Evaluate/HOCQ)]



(b) Find out the advantages and disadvantages of convolution code? [(CO5)(Analyze/IOCQ)]

8 + 4 = 12

9. (a) Illustrate the Generator polynomial of cyclic code. [(CO4,6)(Remember/LOCQ)]
(b) Briefly explain the discrete memory less source (DMS).
[(CO6) (Understand /LOCQ)]
(c) Verify the following expression: $C_s=\log_2 m$, where C_s is the channel capacity of a lossless channel and m is the number of symbols in X. [(CO6)(Analyze/IOCQ)]

4 + 3 + 5 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	26.04%	38.54%	35.41%

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

Department & Section	Submission Link
ECE A	https://classroom.google.com/w/NDA0NjYwODQ3NjYy/tc/NDY0MDA3NjU5MDQy
ECE B	https://classroom.google.com/w/NDA1MzU1NTEzODMz/tc/NDYzOTE4NTI2MzU5
ECE C	https://classroom.google.com/w/NDE5MTIwMjgzOTEz/tc/NDU1MTU1MzY0MjUx
Backlog	https://classroom.google.com/c/MTI2NDI2OTE2ODYz?cjc=kizxg6b