Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Seventh Semester B.Tech Degree Supplementary Examination June 2022 (2015 Scheme)

Course Code: EC401

Course Name: INFORMATION THEORY & CODING

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two full questions, each carries 15 marks. Marks

1 a) What do you mean by Binary Erasure Channel (BEC)? Derive its expression for channel capacity. (3)

b) You are given four messages a, b, c and d with probabilities 0.1, 0.2, 0.3 and 0.4 (7)

i) Derive Shannon – Fano code for these messages and draw code tree

ii) Calculate efficiency and redundancy

iii) Calculate the probabilities of 0's and 1's

c) What is entropy of a source? What are the properties of entropy? (5)

2 a) Demonstrate instantaneous code with an example. (5)

b) Determine the different entropies i.e H(X), H(Y), H(X,Y), H(X|Y) and H(Y|X) for the Joint Probability Matrix given below (10)

$$P(X,Y) = \begin{bmatrix} 0.2 & 0 & 0.2 & 0 \\ 0.1 & 0.01 & 0.01 & 0.01 \\ 0 & 0.02 & 0.02 & 0 \\ 0.04 & 0.04 & 0.01 & 0.06 \\ 0 & 0.06 & 0.02 & 0.2 \end{bmatrix}$$

3 a) State and prove Shannon's first theorem. (5)

b) Consider a source with 8 alphabets A to H with respective probabilities of 0.22, 0.20, 0.18, 0.15, 0.10, 0.08, 0.05, 0.02. Construct a ternary compact code (Huffman code) and determine efficiency. (10)

PART B

Answer any two full questions, each carries 15 marks.

4 a) A Continuous Random Variable X is uniformly distributed in the interval (0,4). Find the differential entropy of X. Suppose that X is a voltage which is applied to an amplifier whose gain is 16. Find the differential entropy of the output of the amplifier. Explain why the entropy at the output of the amplifier is greater than the input. (6)

b) A communication system employs a continuous source. The channel noise is White and Gaussian. The bandwidth of the source output is 20MHz and signal to noise ratio at receiver is 1000. (5)

i) Determine channel capacity

ii) If signal to noise ratio drops to 100, how much bandwidth is needed to achieve the same channel capacity as in (i)

iii) If the bandwidth is decreased to 10MHz, what is the signal to noise ratio required to maintain the same channel capacity as in (i)

c) If C is a valid code word generated by an (n, k) linear block code with parity check matrix H, prove that $CH^T = 0$. (4)

5 a) What is mutual information of a continuous channel? What are its properties? (3)

b) What is Shannon's limit? Derive its value. (4)

c) For the (6,3) Linear Block Code with parity check matrix P is given by (8)

$P = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 0 \end{bmatrix}$. Find all possible codewords. Let received vector R = [101101]. Detect and correct the single error due to noise in R.

6 a) Identify whether the set of whole numbers is an Abelian group under addition. (3)

b) For a systematic linear block code, the three parity check bits C_4, C_5 and C_6 are given by (7)

$C_4 = d_1 + d_3$

$C_5 = d_1 + d_2 + d_3$

$C_6 = d_1 + d_2$

i) Construct generator matrix

ii) Construct all codes

iii) Determine error detecting and error correcting capability

iv) Prepare suitable decoding table

v) Decode the received vector 111100 using syndrome table

c) State and prove Shannon Hartley Law. (5)

PART C

Answer any two full questions, each carries 20 marks.

7 a) A rate 1/3 non-systematic code is given by the sub generators g(1) = (1,1,0,1), g(2) = (1,0,0,1) and g(3) = (1,1,1,0) (10)

i) Construct the coder

ii) Draw the tree graph, trellis and state diagrams

iii) Tabulate the survivor paths for given vector R = (001,010,101,000)

b) A (15,5) linear cyclic code has a generator polynomial $g(x) = x^{10} + x^8 + x^5 + x^4 + x^2 + x + 1$. (10)

i) Draw the block diagram of the encoder and syndrome calculation circuit for the code

ii) Find the code polynomial for the message polynomial $d(x) = x^4 + x^2 + 1$ in systematic form

iii) Is $V(x) = x^{14} + x^8 + x^6 + x^4 + 1$, a valid code polynomial? If not, find the syndrome of V(x).

8 a) What is Viterbi algorithm? For an L bit message sequence and an encoder of memory m, how does the algorithm proceed? (7)

b) Compare block codes and convolutional codes (3)

c) The generator polynomial for a cyclic code is $g(x) = 1 + x^4 + x^6 + x^7 + x^8$

i) Show that its length is 15

ii) Find the generator matrix and parity check matrix in systematic form (10)

iii) Device encoder circuit

iv) Find the code vector min systematic form for the message polynomial $U(X) = 1 + x^2 + x^3 + x^4$

9 a) What are BCH codes and Reed Solomon codes? Give the parameters of both. (10)

b) For a convolutional encoder the generator polynomials are given by $g^{(1)} = [1,0,0]$, $g^{(2)} = [1,0,1]$ and $g^{(3)} = [1,1,0]$ (10)

i) Sketch the encoder configuration

ii) Draw the state diagram, code tree and trellis diagram

iii) Determine the output for the input 1 1 0 1 0 1 0 0.

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