Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S7 (S, FE) Examination May 2024/ S7 (PT) (S,FE) Examination June 2024 (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) Prove that $H(Y) \geq H(Y/X)$, where H(Y) is the marginal entropy and H(Y/X) is the conditional entropy. (6)

b) An event has six possible outcomes with the probabilities p1= 1/2, p2 = 1/4, p3 = 1/8, p4 = 1/16, p5 = 1/32, p6 = 1/32. Find the entropy of the system. Also, find the rate of information if there are 16 outcomes per second. (5)

c) State Shannon's noiseless coding theorem. (4)

2 a) Consider a DMS with 7 symbols, S_1, S_2, …, S_7 with corresponding probabilities 0.37, 0.33, 0.16, 0.07, 0.04, 0.02 and 0.01. Construct the binary Huffman code and determine the efficiency and redundancy of the code. (8)

b) State and prove Kraft's inequality for instantaneous code. (7)

3 a) A binary channel has the following noise characteristics. (10)

$$P(Y/X) = \begin{bmatrix} 2/3 & 1/3 \\ 1/3 & 2/3 \end{bmatrix}$$

Let the input symbols x_1 and x_2 be transmitted with probabilities 3/4 and 1/4 respectively. Calculate the mutual information, channel capacity, and efficiency of the channel.

b) Define mutual information and give any three properties of mutual information. (5)

PART B

Answer any two full questions, each carries 15 marks.

4 a) An analog signal has a bandwidth of 4 kHz. The signal is sampled at 2.5 times the Nyquist rate and each sample quantized into 256 equally likely levels. Assume that successive samples are statistically independent. (10)

i. Can the output of this source be transmitted without errors over a Gaussian

channel of bandwidth 50 kHz and S/N ratio of 20 dB.

ii. If the output of this source is to be transmitted without errors over an analog channel of S/N ratio 10dB, compute the bandwidth requirement of the channel.

b) List any 3 properties of a group. Give 2 examples. (5)

5 a) The parity bits of a (8, 4) linear systematic block code are generated by (8)

c5 = d1+d2+d4

c6 = d1+d2+d3

c7 = d1+d3+d4

c8 = d2+d3+d4

(+ sign denotes modulo-2 addition)

where d1, d2, d3 and d4 are message bits and c5, c6, c7 and c8 are parity bits. Find generator matrix G and parity check matrix H for this code. Draw the encoder circuit.

b) Derive the capacity of the Gaussian channel with infinite bandwidth. (7)

6 a) The parity check matrix of (7,4) linear block code is given as (10)

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

i. Find the minimum distance of the code.

ii. Determine the number of errors this code can detect and correct.

iii. Suppose that the received codeword, r = (1001001). Determine whether the received codeword is in error? If so, obtain the correct codeword.

b) Derive Shannon's Limit (5)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Consider the (7, 4) cyclic code generated by $g(x) = 1 + x^2 + x^3$. Draw the systematic cyclic encoder circuit and explain the computation of the code word in systematic form corresponding to the message $\boldsymbol{u} = 1011$. (10)

b) Draw the code tree for a (2, 1, 2) convolutional encoder with the feedback polynomials as $g^{(1)}(X) = 1+X+X^2$ and $g^{(2)}(X) = 1+X^2$. (10)

8 a) Draw the syndrome computation circuit for a (7, 4) cyclic code with $g(x) = 1 + x + x^3$. (5)

b) Given a (2, 1, 2) convolutional encoder with the feedback polynomials as $g^{(1)}(X)$ (10)

$=1+X+X^2$ and $g^{(2)}(X) = 1+X^2$. Draw a Trellis and find the output sequence for the input sequence [1 0 1 0 1].

c) Explain the features of BCH codes (5)

9 a) Draw a (3,2,1) convolutional encoder with impulse responses given as $g_1^{(1)}$ = [1,1], $g_1^{(2)}$ = [0,1], $g_1^{(3)}$ = [1,1], $g_2^{(1)}$ = [0,1], $g_2^{(2)}$ = [1,0], $g_2^{(3)}$ = [1,0]. Find the output for input sequence $u^{(1)}$ = (101) and $u^{(2)}$ = (110). (10)

b) Consider the generator polynomial $g(X) = 1+ X^3+ X^4+ X^5+ X^6$ of a cyclic code with length 15. Obtain the equivalent generator matrix and parity check matrix of this code. (10)

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