Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION(R&S), DECEMBER 2019

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) Consider a DMS with alphabets $\{s_0,s_1,s_2\}$ with probabilities $\{0.7,0.15,0.15\}$ respectively. i) Apply Huffman algorithm to this source and calculate efficiency of the code. ii) Let the source be extended to order 2. Apply Huffman algorithm to the resulting extended source and calculate efficiency of the new code. (7)

b) Consider a source with alphabet, $S=\{x_1, x_2\}$, with respective probabilities 1/4 and 3/4. Determine the entropy, $H(S)$ of the source. Write the symbols of the second-order extension of S, i.e., S^2 and determine its entropy, $H(S^2)$. Verify that $H(S^2) = 2\,H(S)$. (8)

2 a) Describe mutual information along with its properties. (5)

b) Consider two sources X and Y with joint probability distribution, P(X,Y) given as (5)

$$P(X,Y) = \begin{bmatrix} 3/40 & 1/40 & 1/40 \\ 1/20 & 3/20 & 1/20 \\ 1/8 & 1/8 & 3/8 \end{bmatrix}$$

Calculate H(X), H(Y), H(X,Y) and H(Y/ X).

c) Construct a binary code using Shannon – Fano coding technique for a discrete memoryless source with 6 symbols with probabilities {0.3, 0.25, 0.2, 0.12, 0.08, 0.05}. Determine its efficiency and redundancy (5)

3 a) Write the positive and negative statements of Shannon's channel coding theorem. (5)

b) An analog signal band limited to 'B' Hz is sampled at Nyquist rate. The samples are quantized into 4 levels. The quantization levels are assumed to be independent and occur with probabilities: $p_1= p_4 = 1/8$, $p_2 = p_3 = 3/8$. Find the information rate of the source assuming B = 100Hz. (4)

c) Draw the channel model for binary symmetric channel (BSC) and derive an expression for channel capacity of BSC. (6)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Define differential entropy and derive its expression for a Gaussian distributed random variable with zero mean value and variance, σ^2. (6)

b) Construct standard array for (6,3) systematic linear block code with generator (9) matrix, $G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}$.

Check whether the received codeword, r = 010001 is erroneous? If yes, obtain the corrected codeword using standard array.

5 a) A black and white television picture may be viewed as consisting of approximately 3 x 10^5 elements, each of which may occupy one of the 10 distinct brightness levels with equal probability. Assume that the rate of transmission is 30 picture frames per second, and the signal to noise ratio is 30 dB. Determine the minimum bandwidth required to support the transmission of the resulting video signal. (5)

b) Define ring and list its properties. Give an example. (5)

c) Draw the bandwidth-SNR trade off graph and explain. (5)

6 a) Determine the capacity of a channel with infinite bandwidth. (5)

b) Define minimum distance, d_{min} of linear block code (LBC). Explain the error detection and error correction capabilities of (n, k) LBC with respect to its relation with d_{min}. (4)

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

$H = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$. Draw the encoder and decoder circuit of this code.

PART C

Answer any two full questions, each carries 20 marks.

7 a) Draw and explain the encoder circuit of (7,4) systematic cyclic code with generator polynomial, $g(x) = 1 + x + x^3$. Also generate all the codewords corresponding to this code. (10)

b) Draw the tree diagram for a (2,1,2) convolutional encoder with generator sequence, $g^{(1)} = (1\ 1\ 1)$, $g^{(2)} = (1\ 0\ 1)$. Also trace the output for information sequence 11011. (10)

8 a) Consider the generator polynomial of (15, 5) cyclic code as $g(x) = 1 + x + x^2 + x^4 + x^5 + x^8 + x^{10}$. (10)

i. Find the generator matrix and parity check matrix in systematic form.

ii. Determine the error correcting capability of the code.

b) Draw the encoder circuit of (2,1,3) convolutional encoder with feedback polynomials $G^{(1)}(D) = 1 + D^2 + D^3$ and $G^{(2)}(D) = 1 + D + D^2 + D^3$. Also find the codeword polynomial corresponding to information sequence, $u(D) = 1 + D^2 + D^3 + D^4$. (10)

9 a) What is a perfect code? Explain the features of (7,4) Hamming code. (4)

b) Explain the generation of non-systematic (7,4) Hamming code. (6)

c) Draw the state diagram for a (2,1,3) convolutional encoder with generator sequence, $g^{(1)} = (1\ 0\ 1\ 1)$, $g^{(2)} = (1\ 1\ 1\ 1)$. (10)

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