Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

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) A source emits one of four symbols S_0, S_1, S_2 and S_3 with probabilities 1/3, 1/6, 1/4, 1/4 respectively. The successive symbols emitted by the source are statistically independent. Calculate the entropy of the source. (3)

b) If X and Y are discrete random sources and P(X,Y) is their joint probability distribution and is given as (12)

P(X,Y)=0.08 0.05 0.02 0.05

0.15 0.07 0.01 0.12

0.10 0.06 0.05 0.04

0.01 0.12 0.01 0.06

Calculate H(X), H(Y), H(X/Y), H(Y/X), H(X, Y) and I(X,Y).
Verify the formula H(X, Y) = H(X)+H(Y/X).

2 a) State Shannon's channel coding theorem. Give its positive and negative statements. (5)

b) An information source produces sequences of independent symbols A,B,C,D,E,F,G with corresponding probabilities 1/3,1/27,1/3,1/9,1/9,1/27,1/27. Construct a binary code and determine its efficiency and redundancy using (10)

i) Shannon –Fano coding procedure

ii) Huffman coding procedure.

3 a) What is meant by a symmetric channel? How do we find the capacity? (5)

b) Discuss binary symmetric and binary erasure channel? Draw the channel diagrams and derive the expressions for their channel capacities. (10)

PART B

Answer any two full questions, each carries 15 marks.

4 a) The parity matrix of a (6,3) linearsystematic block code is given below. (7)

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

Construct standard array.

b) State and derive Shannon-Hartley theorem. Explain the implications. (8)

5 a) Derive the expression for channel capacity when bandwidth becomes infinite. (7)

b) A voice grade channel of the telephone network has a bandwidth of 3.4 KHz. (8)

(a) Calculate channel capacity of the telephone channel for signal to noise ratio of 30 dB.

(b) Calculate the minimum SNR required to support information transmission through the telephone channel at the rate of 4800 bits/sec.

6 a) Define ring and field. Discuss properties. (5)

b) The parity matrix for a (7,4) linear block code is given below: (10)

$$[P] = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$$

i) Find generator and parity check matrices

ii) Draw the encoder circuit.

iii) Sketch the syndrome calculation circuit

iv) Illustrate the decoding of the received vector corresponding to the message vector 1001, if it is received with 5th bit in error.

PART C

Answer any two full questions, each carries 20 marks.

7 a) Draw a (2, 1,3) convolutional encoder with [1, 0, 1, 1] and [1, 1, 1, 1] as the impulse responses. Find the output of the convolutional encoder for input sequence 11011 using transform domain approach (8)

b) Given $G(D) = [\ 1,\ 1 + D + D^{3}]$, design a (2, 1, 3) convolutional encoder of rate = ½. (7)

c) Discuss properties of Hamming codes. (5)

8 a) Construct a convolution encoder, given rate 1/3, constraint length L = 3. Given $g^{(1)} = (1\ 0\ 0)$, $g^{(2)} = (1\ 0\ 1)$, $g^{(3)} = (1\ 1\ 1)$. Sketch state diagram and trellis diagram of this encoder. (15)

b) Discuss syndrome decoding of cyclic code. Draw syndrome decoder circuit for a (15, 9) cyclic code with generator polynomial $g(X)= 1+ X^3+ X^4+ X^5+ X^6$ (5)

9 a) Draw a (2,1,2) convolutional encoder with the feedback polynomials as $g_1(X)=1+X+X^2$ and $g_2(X)= 1+X^2$. Draw the code tree and trace output for input sequence 10011. (8)

b) Discuss generation of Hamming codes. (7)

c) What is minimum free distance of a convolutional code? (5)

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Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION(S), MAY2019

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) Define the term: Amount of information. Find out the information conveyed by one of the two equally probable messages. (3)

b) Joint probability matrix of a discrete channel is given by, (12)

P(X,Y)= 0.05	0.05	0.02	0.05
0.15	0.16	0.01	0.09
0.12	0.03	0.02	0.05
0.01	0.12	0.01	0.06

Compute marginal, conditional and joint entropies and verify their relation.

2 a) Given an AWGN channel with 5 K Hz bandwidth and the noise power spectral density $\eta/2 = 10^{-9}$ W/Hz. The signal power required at the receiver is 1mW.Calculate the capacity of this channel. (5)

b) Given a telegraph source having two symbols, dot and dash. The dot duration is 0.6 sec. The dash duration is half the dot duration. The probability of the dots occurrence is thrice that of the dash and the time between symbols is 0.1 sec. Calculate the information rate of the telegraph source. (6)

c) What is the joint entropy H(X, Y), and what would it be if the random variables X and Y were independent? (4)

3 a) State and establish Kraft's inequality. (7)

b) Determine the Huffman coding for the following message with their probabilities given $p(x_1)$ =0.05, $p(x_2)$=0.15, $p(x_3)$ =0.2, $p(x_4)$ =0.05, $p(x_5)$ =0.15, $p(x_6)$ =0.3, $p(x_7)$ =0.1. Find the efficiency and redundancy of the code. (8)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Draw the bandwidth –SNR trade off graph and explain. (7)

b) The parity bits of a (7,4) linear systematic block code are generated by (8)

$c_5 = d_1+d_3+d_4$

$c_6=d_1+d_2+d_3$

$c_7=d_2+d_3+d_4$

(+ sign denotes modulo-2 addition)

where d_1, d_2, d_3 and d_4 are message bits and c_5, c_6, c_7 are parity bits. Find generator matrix G and parity check matrix H for this code. Draw the encoder circuit.

5 a) Find the capacity of a channel with infinite bandwidth. Discuss Shannon's limit. (7)

b) The parity matrix of a (6, 3) linear systematic block code is given below. (8)

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

Find all the possible code vectors.

a) Find out the minimum distance of the code.
b) How many errors can be detected and corrected by this code?

6 a) Explain the properties of a field. Cite any two examples. (5)

b) Alphanumeric data are entered into a computer from a remote terminal through a voice grade telephone channel. The channel has a bandwidth of 3.4 KHz and output signal to noise power ratio of 20 dB. The terminal has a total of 128 symbols which may be assumed to occur with equal probability and that the successive transmissions are statistically independent. (10)

a) Calculate the channel capacity.
b) Calculate the maximum symbol rate for which error free transmission over the channel is possible.

PART C

Answer any two full questions, each carries 20 marks.

7 Draw a (2, 1, 2) convolutional encoder with the feedback polynomials as $g_1(X)=1+X+X^2$ and $g_2(X)= 1+X^2$. Draw Trellis and find the output sequence for input sequence [1 0 0 1 1]. Do Viterbi decoding on this trellis for the received sequence {01, 10, 10, 11, 01, 01, 11} and obtain the estimate of the transmitted sequence and the message sequence. (20)

8 a) A channel encoder uses a (7, 4) linear systematic cyclic code in the systematic form, generator polynomial being $X^3 + X + 1$. Determine the correct codeword transmitted if the received word is (8)

(i) 1011011 (ii) 1101111

b) Draw a (3,2,1) convolutional encoder with impulse responses given as $g_1^{(1)}=[1,1]$, $g_1^{(2)}=[1,0]$, $g_1^{(3)}=[1,0]$, $g_2^{(1)}=[0,1]$, $g_2^{(2)}=[1,1]$, $g_2^{(3)}=[0,0]$. (7)

c) Mention the parameters of BCH codes. (5)

9 a) Discuss the procedure for generation of a systematic cyclic code. Draw and explain the systematic cyclic encoder circuit for a (15, 9) cyclic code with generator polynomial $g(X)= 1+ X^3+ X^4+ X^5+ X^6$. (8)

b) Draw a (2,1,2) convolutional encoder with the feedback polynomials as $g_1(X)=1+X+X^2$ and $g_2(X)= 1+X^2$. Draw the code tree and trace output for input sequence 10011. (7)

c) What are Reed Solomon Codes? Discuss properties. (5)

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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 3×10^5 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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Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech S7 (S) Examination Sept 2020

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) Explain the necessary and sufficient conditions for a code to be instantaneous. Give examples. (3)

b) A zero memory source has a source alphabet, $S = \{s_1, s_2, s_3\}$ with $P = \{0.5, 0.3, 0.2\}$. Find the entropy of the source. Find the entropy of its second extension and verify. (5)

c) Explain the properties of mutual information. (7)

2 a) Prove that the entropy of a discrete memory less source S is upper bounded by average code word length L for any distortion less source encoding scheme. (5)

b) Given a binary source with two symbols x_1 and x_2. Given x_2 is twice as long as x_1 and half as probable. The duration of x_1 is 0.3 seconds. Calculate the information rate of the source. (4)

c) Consider a source with 8 alphabets, ***a*** to ***h*** with respective probabilities 0.2, 0.2, 0.18, 0.15, 0.12, 0.08, 0.05 and 0.02. Construct a minimum redundancy code and determine the code efficiency. (6)

3 a) Consider a message ensemble $S = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7\}$ with probabilities $P = \{0.45, 0.15, 0.12, 0.08, 0.08, 0.08, 0.04\}$. Construct a binary code and determine its efficiency using Shannon – Fano coding procedure. (5)

b) Given a binary symmetric channel with $P(Y/X) = \begin{bmatrix} 3/4 & 1/4 \\ 1/4 & 3/4 \end{bmatrix}$ and $P(x_1) = 2/3; P(x_2) = 1/3$. Calculate the mutual information and channel capacity. (10)

PART B

Answer any two full questions, each carries 15 marks.

4 a) Explain the significance of Shannon-Hartley’s theorem. (5)

b) Define standard array. How is it used in syndrome decoding? Explain with an example. (10)

5 a) What are the properties to be satisfied by a linear block code? (2)

b) The parity matrix for a (6,3) systematic linear block code is given by (8)

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

(i) Find all code words. (ii) Find generator and parity check matrix. (iii) Draw encoding circuit. (iv) Draw syndrome circuit.

c) A communication system employs a continuous source. The channel noise is white and Gaussian. The bandwidth of the source output is 10 MHz and signal to noise power ratio at the receiver is 100. (5)

(i) Determine the channel capacity.

(ii) If the signal to noise ratio drops to 10, how much bandwidth is needed to achieve the same channel capacity as in (i).

(iii) If the bandwidth is decreased to 1 MHz, what S/N ratio is required to maintain the same channel capacity as in (i).

6 a) Define the minimum distance of a code. How is it important in error detection and correction? (5)

b) Derive Shannon Limit. (5)

c) What is the capacity of a channel of infinite bandwidth? (5)

PART C

Answer any two full questions, each carries 20 marks.

7 a) What is a perfect code? Explain the features of (7,4) Hamming code. (5)

b) Consider the (7, 4) cyclic code generated by $g(x) = 1 + x + x^3$. Suppose the message $\boldsymbol{u}$ = 1111 is to be encoded. Compute the code word in systematic form. Draw the encoder circuit. (7)

c) Draw a (2, 1, 3) encoder, if the generator sequences are (1 0 0 0) and (1 1 0 1) respectively. Also find the code vector for the input $\boldsymbol{u}$ = 1101 using transform domain approach. (8)

8 a) Draw a convolutional encoder with generator sequences $g^{(1)} = 100$ and $g^{(2)} = 101$. Draw state and Trellis diagrams. (10)

b) Write H matrix for (15, 11) cyclic code using $g(x) = 1 + x + x^4$. Calculate the code polynomial for a message polynomial $d(x) = 1 + x^3 + x^7 + x^{10}$. (10)

9 a) Explain maximum likelihood decoding of convolutional codes. (6)

b) What is free distance of a convolutional code? (6)

c) Explain decoder for cyclic code with the help of a block diagram. (8)

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Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Seventh Semester B.Tech Degree Examination (Regular and Supplementary), December 2020

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)	Find the self information of two messages with respective probabilities 0.1 and 0.9. Comment on the results.	(3)
	b)	Prove that mutual information of a channel is symmetric and always non-negative.	(5)
	c)	Joint probability matrix of a discrete channel is given below: $P(X,Y) = \begin{bmatrix} 0.3 & 0.2 & 0.1 \\ 0.1 & 0.1 & 0.2 \end{bmatrix}$ Determine the different entropies and verify their relationships.	(7)
2	a)	State and prove noiseless coding theorem.	(5)
	b)	An analog signal is band limited to 3.4 kHz and is sampled at Nyquist rate. The samples are quantized into 4 levels. The quantization levels are assumed to be independent and occur with probabilities $p_1 = 1/2; p_2 = 1/4; p_3 = p_4 = 1/8$. Find the information rate of the source.	(4)
	c)	Find binary Huffman code for random variable S = {s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8} with probabilities (0.4, 0.25, 0.15, 0.06, 0.05, 0.04, 0.03, 0.02}. Move the combined symbol as high as possible. Find average code word length and efficiency.	(6)
3	a)	Consider a message ensemble S = {s_1, s_2, s_3, s_4, s_5, s_6} with probabilities P = {1/3, 1/4, 1/8, 1/8, 1/12, 1/12}. Construct a binary code and determine its efficiency using Shannon – Fano coding procedure.	(5)
	b)	Explain binary symmetric and binary erasure channels. Derive the expression for their channel capacities.	(10)

PART B

Answer any two full questions, each carries 15 marks.

4	a)	What are the properties to be satisfied by a linear block code? Illustrate with an example.	(5)
	b)	What is the capacity of a channel of infinite bandwidth?	(5)
	c)	Define the terms Hamming weight, Hamming distance and minimum Hamming distance with suitable example.	(5)
5	a)	Explain band width – SNR trade off in a Gaussian channel.	(5)

b) For a systematic (7,4) linear block code, the parity matrix P is given by (10)

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

(i) Find all possible valid code vectors. (ii) Draw the encoder circuit. (iii) Draw the syndrome calculation circuit.

6 a) If V is a valid code vector, prove that $VH^T = 0$, where H is parity check matrix. (5)

b) State and prove Shannon – Hartley theorem. (10)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Draw a (2,1,3) encoder with impulse sequences $g^{(1)} = 1011$ and $g^{(2)} = 1111$. Find the generator matrix for the given encoder. Also find the code vector for the message 11010 by time and frequency domain approaches. (12)

b) What is a BCH code? Find the generator polynomial for single, double and triple error correcting BCH code of block length, n = 15. (8)

8 a) What are the properties to be satisfied by a cyclic code? (5)

b) For a non-systematic rate ½ code given by $g^{(1)} = 111$ and $g^{(2)} = 101$. Draw the graph, trellis and state diagram. (10)

c) What are the features of Reed-Solomon codes? (5)

9 a) Explain how systematic encoding is achieved in cyclic codes. For a systematic (7, 4) cyclic code, find the code vector corresponding to message $u(x) = 1 + x^3$, generated by $g(x) = 1 + x + x^3$. (10)

b) For a convolutional encoder with generator sequences $g^{(1)} = 100$ and $g^{(2)} = 101$, if the received code word is 00100000010000, find the transmitted code word using Viterbi algorithm. (10)

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