Roll No											

PRESIDENCY UNIVERSITY
BENGALURU

SET B

SCHOOL OF ENGINEERING
END TERM EXAMINATION – MAY / JUNE 2024

Semester : Semester VI - 2021
Course Code : ECE3012
Course Name : Information Theory and Coding
Program : B.Tech.

Date : Jun 6, 2024
Time : 01.00pm to 04.00pm
Max Marks : 100
Weightage : 50%

Instructions:
(i) Read all questions carefully and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and non-programmable calculator are permitted.
(iv) Do not write any information on the question paper other than Roll Number.

PART A

ANSWER ANY THREE QUESTIONS **(3 Q X 5 M = 15 M)**

1. You are given 4 messages x1, x2, x3 and x4 with respective probabilities 0.1, 0.2,0.3,0.4.
(1) Deduce a code with prefix property (Shannon-Fano code) for these messages.
(2) Calculate code efficiency and redundancy.

(CO1) [Knowledge]

2. An analog signal band limited to 6 KHz is sampled thrice the Nyquist rate and then quantized into 11 levels Q1, Q2,.....Q11. Of these three levels will occur with probability of 1/6 each, four levels will occur with probability of 1/12 and remaining foue levels with probability of 1/24 each. Find the rate of information associated with the analog signal

(CO1) [Knowledge]

3. A transmitter transmits five symbols with probabilities 0.2, 0.3, 0.2, 0.1 and 0.2. Given the channel matrix P(B/A), calculate
(1) H(B) (2) H(A,B).

$$P(B/A) = \begin{matrix} 1 & 0 & 0 & 0 \\ 1/4 & 3/4 & 0 & 0 \\ 0 & 1/3 & 2/3 & 0 \\ 0 & 0 & 1/3 & 2/3 \\ 0 & 0 & 1 & 0 \end{matrix}$$

(CO3) [Knowledge]

4. For a systematic (6,3) linear block Code write all the code vectors with the parity matrix given by

$$p = \begin{matrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 1 \end{matrix}$$

(CO4) [Knowledge]

5. Define the following with respect to information theory

1. Self information
2. Entropy
3. Average rate of information
4. Source efficiency

(CO4) [Knowledge]

PART B

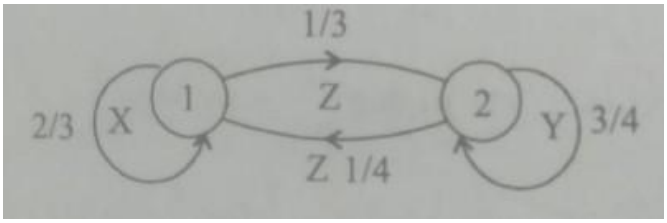
ANSWER ANY TWO QUESTIONS **(2 Q X 20 M = 40 M)**

6.

Markoff model dipicts the different state of symbols and interconnection probabilities. The equation relating these staes is called state equation. The gain in different generations can be obtained by writing tree diagram.The state diagram of a Markoff source is given below

(1) find the entropy of the source

(2) find G1, G2 and G3. Show that G1>G2>G3>H



(CO1) [Comprehension]

7. Joint probability is useful when you want to measure two independent event A and B to determine whether they can happen simultaneously.

The joint probability between any input symbol “ai” and any output symbol “bj” is

P(ai,bj)=p(bj/ai)p(ai) or p(ai/bj)p(bj)

Consider a class of 30 students who took a test and received a grade between 0 and 100 that is normally distributed. Let’s assume that the mean and standard deviation are 80% and 20% respectively; this will be our ground truth data. The joint probability matrix for the data above will look as follows:

Compute individually H(X), H(Y), H(X,Y),H(X/Y),H(Y/X),I(X,Y) and verify the relationship among these entropies.

$$P(x,y) = \begin{bmatrix} 0.05 & 0 & 0.2 & 0.05 \\ 0 & 0.1 & 0.1 & 0 \\ 0 & 0 & 0.2 & 0.1 \\ 0.05 & 0.05 & 0 & 0.1 \end{bmatrix}$$

(CO3) [Comprehension]

8. A generator matrix of order kXn is given by [G] = [Ik | P]. where Ik is an identity matrix of order k and P is an arbitrary matrix called parity Matrix. Consider a (6,3) linear code where generator matrix is

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

(1) Find all code vectors

(2) Find all the Hamming weights and distances.

(3) Find minimum weight parity check matrix.

(4) draw the encoder circuit for the above codes.

(CO4) [Comprehension]

PART C

ANSWER ANY THREE QUESTIONS **(3 Q X 15 M = 45 M)**

9. (a) Entropy of the source is nothing but average information content of different symbols emitted by the source. Consider a source with alphabets m1 and m2 with respective probabilities of 5/6 and 1/6. Determine the entropy of source S and the entropy of its third extension. Hence show that H(S^3) = 3 H(S) [5]

(b) A source produces two symbols S1 and S2 with probabilities 7/8 and 1/8 respectively. Device a coding scheme using Shannon-Fano encoding procedure to get a coding efficiency of at least 75% [10]

(CO1) [Application]

10. In 1948, C.E. Shannon known as Father of Information Theory", devised a coding scheme called Shennon encoding algorithm. A source emits following message symbols. The messages and their probabilities are given in table below. Design a coding scheme using Shannon encoding algorithm and find code efficiency and redundancy

Sl.no	symbol	probability
1	A	9/32
2	B	3/32
3	C	1/16
4	D	3/32
5	E	3/32
6	F	3/32
7	G	9/32

(CO2) [Application]

11. (a) Binary erasure channel is one of the most important channel used in digital communication. It sends Automatic Repeat Request (ARQ) of the transmitted signal till a correct symbol is received at the output and ensures 100% correct data recovery. Estimate the channel capacity for the above channel [10M]

b) Explain the concept of entropy functions in the context of information theory. How does itrelate to equivocation in a communication system? [5M]

(CO3) [Application]

12. (a) Linear Block Code (LBC) is a most widely used code in practical application. In this context, bring out the merits and demerits of "fixed -length codes" and "Variable - length codes. [5]

(b) For a (5,2) LBC, the generator matrix is of the form [Ik | P] where [p] is called parity matrix and is given by [10]

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

I. generator matrix
II. Parity check matrix
III. all possible code vectors

(CO4) [Application]