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**PRESIDENCY UNIVERSITY
BENGALURU**

**SCHOOL OF ENGINEERING
END TERM EXAMINATION - JUN 2023**

Semester : Semester VI - 2020

Course Code : ECE3012

Course Name : Sem VI - ECE3012 - Information Theory and Coding

Program : ECE

Date : 7-JUN-2023

Time : 9.30AM - 12.30PM

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.*
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PART A

ANSWER ALL THE QUESTIONS

(5 X 2 = 10M)

1. The output of an information source contains 160 symbols, 128 of which occurs with a probability of $1/256$ and remaining occur with a probability of $1/64$ each. Find the information rate of source if the source emits 10000 symbol/sec
(CO2,CO3,CO4) [Knowledge]
2. Average rate of Information, popularly known as Entropy and it has various properties and one among those is code efficiency. Define the same.
(CO3,CO4,CO2) [Knowledge]
3. Error control codes are divided into two broad categories namely block code and convolution codes. State the difference between them.
(CO4,CO3,CO2) [Knowledge]
4. The capacity of a discrete memoryless channel is defined as the maximum possible rate of information transmission over the channel. Share the insight of Shannon, father of Information theory on Channel capacity with appropriate equation
(CO4,CO3,CO2) [Knowledge]
5. There are several special channels which are of great interest in the field of communication systems. Among them BSC (Binary Symmetric Channel) is one of the most important channels. Define Channel Capacity for this channel with suitable equation.
(CO3,CO4,CO2) [Knowledge]

PART B

ANSWER ALL THE QUESTIONS

(2 X 15 = 30M)

6. a) Reliability and security are two essential components of any communication system. Reliability is provided by using channel coding while security is provided by using cryptography. McEliece cryptosystem is one of the public key cryptosystem which uses Linear block codes and encryption is done using the key p, it is given below for the plain text d= [101] with length k=3. Find encoded valid vector with the average length n= 6. [10M]

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

- b) Error correcting codes are a fundamental tool for protecting data from noise and these are considered as one of the most fundamental aspects of digital communication which is responsible for the validity of real-time interactions. List and define such error correcting codes. [5M]

(CO4) [Comprehension]

7. A channel is said to be symmetric if the second and subsequent rows of the channel matrix contain the same elements as that of first row but in different order. Assuming the input probabilities $P(x_1) = 1/2$ and $P(x_2) = 1/2$, Consider the Symmetric channel with following characteristics.

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

Find the following Values for the above mentioned Symmetric channel

- Joint Probability Matrix P (x, y)
- Input entropy H(x)
- Output Entropy H(y)
- Mutual Entropy H(X, Y)

[15M]

(CO1) [Comprehension]

PART C

ANSWER ALL THE QUESTIONS

(3 X 20 = 60M)

8. a) Hamming code is an error correction system that can detect and correct errors when data is stored or transmitted. It requires adding additional parity bits with the data. It is commonly used in error correction code (ECC). For such a hamming code Hamming weight can be defined as the number of non zero components in C. For a (6,3) liner systematic code find all the hamming weight by calculating valid code vectors. Generator matrix for the same code is given below. [15M]

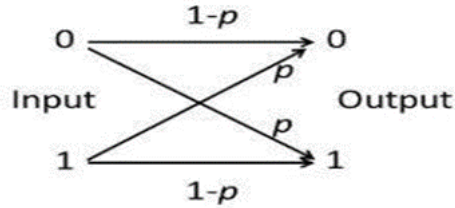
$$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

- b) A Shannon-Fano code is simply a method of encoding information as a data compression technique and popularly performed as a "method of obtaining codes using probability." Construct a binary shannon fano code for the following symbols s1,s2,s3,s4 with probabilities 9/16,3/16,3/16,1/16 respectively. [5M]

(CO4) [Application]

9. a) The binary Symmetric channel (BSC) is one of the communication channel model in Information Theory and Coding. In this model, a transmitter wishes to send a bit(a zero or a one), and the receiver will receive a bit. The bit will be "flipped" with a "crossover probability" of p or otherwise is received correctly. Consider a binary symmetric channel with probabilities as plotted in figure? Derive the expression for Channel Capacity of the Binary Symmetric Channel? [10M]

Binary symmetric channel (BSC) model



$$P[Y = 0 | X = 1] = P[Y = 1 | X = 0] = p$$

$$P[Y = 1 | X = 1] = P[Y = 0 | X = 0] = 1-p$$

b) Shannon–Hartley theorem gives information that the maximum rate at which information can be transmitted over a communications channel of a specified bandwidth in the presence of noise. An Analog signal has a 4 KHz bandwidth. The Signal is sampled at 2 times the Nyquist rate and each sample quantized into 128 equally likely levels. Consider the successive samples are statically independent.

i) Find the information rate of this source?

ii) Can the output of this source be transmitted without errors over a Gaussian channel of bandwidth 50 KHz and S/N ratio is 100 watts? [10M]

(CO3) [Application]

10. Huffman coding is a simple and systematic way to design good variable-length codes for the given probabilities of the symbols. The resulting code is both uniquely decodable and instantaneous (prefix-free). For the zero memory source with Probabilities $P = \{0.4, 0.3, 0.2, 0.1\}$

a. Construct the binary Huffman Code by placing the composite symbol as low as possible and high as possible. [10M]

b. Determine the average length (L) and efficiency. [10M]

(CO2) [Application]