Roll No.											

PRESIDENCY UNIVERSITY

BENGALURU

School of Computer Science and Engineering

Mid - Term Examinations - November 2024

Semester: VII

Course Code: CSE3086

Course Name: Information Theory and Coding

Program: B.Tech(CSE)

Date: 05-11-2024

Time: 2:00pm – 3:30pm

Max Marks: 50

Weightage: 25%

Instructions:

(i) Read all questions carefully and answer accordingly.

(ii) Do not write anything on the question paper other than roll number.

Part A

Answer ALL the Questions. Each question carries 2marks. **5QX2M=10M**

1	Describe what is meant by discrete memoryless sources in information theory?	**2 Marks**	**L2**	**CO1**
2	Explain the Markov statistical model for an information source and its purpose.	**2 Marks**	**L2**	**CO1**
3	Calculate and define the information rate of a Markov source based on transition probabilities.	**2 Marks**	**L3**	**CO1**
4	What is the difference between uniquely decodable codes and instantaneous codes?	**2 Marks**	**L4**	**CO2**
5	What is the significance of the source coding theorem (Shannon's Noiseless Coding Theorem)?	**2 Marks**	**L5**	**CO2**

Part B

Answer ALL Questions. Each question carries 10 marks. **4QX10M=40M**

6	**6a.**	Consider a source that emits symbols A,B,CA, B, CA,B,C with respective probabilities P(A)=0.6P(A) = 0.6P(A)=0.6, P(B)=0.3P(B) = 0.3P(B)=0.3, and P(C)=0.1P(C) = 0.1P(C)=0.1. The next symbol emitted depends on the previous one as per the following transition matrix:	**7 Marks**	**L5**	**CO1**

$$\begin{bmatrix} P(A|A)=0.7 & P(B|A)=0.2 & P(C|A)=0.1 \\ P(A|B)=0.4 & P(B|B)=0.5 & P(C|B)=0.1 \\ P(A|C)=0.3 & P(B|C)=0.4 & P(C|C)=0.3 \end{bmatrix}$$

1. Calculate the entropy of the first-order Markov source.
2. Determine the average information content of a sequence of length 2.

	6b.	A source emits symbols {S1,S2,S3,S4}with probabilities P(S1)=0.5, P(S2)=0.25, P(S3)=0.15 and P(S4)=0.1. Calculate the entropy of the source.	**3 Marks**	**L3**	**CO1**

or

7	**7a.**	A two-state Markov source has the following transition probabilities: • P(A|A)=0.8, P(B|A)=0.2 • P(A|B)=0.4, P(B|B)=0.6 Given that the source emits 200 symbols per second, calculate: 1. The steady-state probabilities of the two states. 2. The entropy and information rate of the source.	**5 Marks**	**L4**	**CO1**
	7b.	Consider a memory-based source where the emission of a symbol depends on the previous two symbols. The following probabilities are given: • P(A|AA)=0.6, P(B|AA)=0.4 • P(A|AB)=0.7, P(B|AB)=0.3 • P(A|BA)=0.5, P(B|BA)=0.5 • P(A|BB)=0.4, P(B|BB)=0.6 Calculate the entropy of this source and the average information content per symbol.	**5 Marks**	**L3**	**CO1**
8		Consider a three-state Markov source with transition probabilities as follows: • P(A|A)=0.7, P(B|A)=0.2, P(C|A)=0.1 • P(A|B)=0.3, P(B|B)=0.5, P(C|B)=0.2 • P(A|C)=0.4, P(B|C)=0.3, P(C|C)=0.3 1. Compute the steady-state probabilities of each state. 2. Calculate the entropy of the source. 3. If the symbol rate is 500 symbols per second, what is the information rate?	**10 Marks**	**L4**	**CO1**

or

9		Consider a non-stationary Markov source that alternates between two modes of operation. In Mode 1, the transition probabilities are defined as follows: P(A|A)=0.9 P(B|A)=0.1 P(A|B)=0.2 P(B|B)=0.8 In Mode 2, the transition probabilities change to: P(A|A)=0.4 P(B|A)=0.6	**10 Marks**	**L5**	**CO1**

$P(A|B)=0.3$ $P(B|B)=0.7$

The source operates in Mode 1 for 60% of the time and in Mode 2 for 40% of the time. The initial probabilities of the states in both modes are:

- In Mode 1: $P(A0)=0.7$, $P(B0)=0.3$
- In Mode 2: $P(A0)=0.5$, $P(B0)=0.5$

1. Compute the steady-state probabilities for each mode.
2. Calculate the overall entropy of the source, considering the time distribution of the modes.
3. Determine the channel capacity for both modes, and then evaluate the average capacity of the source if it transmits data at a rate of 500 symbols per second.

10	A source generates symbols (A, B, C, D, E) with the following probabilities: ($P(A) = 0.1$, $P(B) = 0.2$, $P(C) = 0.3$, $P(D) = 0.25$, $P(E) = 0.15$). 1. Calculate the entropy of the source. 2. Calculate the average code length for a fixed-length code. 3. Assess the implications for coding efficiency if a fixed-length code is used. 4. If the probabilities are changed to ($P(A) = 0.4$, $P(B) = 0.2$, $P(C) = 0.1$, $P(D) = 0.2$, $P(E) = 0.1$), recalculate the entropy and discuss the effect on coding efficiency.	**10 Marks**	**L5**	**CO2**
	or			
11	Construct a Huffman tree for symbols (A, B, C, D, E) with the probabilities $P(A) = 0.1$, $P(B) = 0.15$, $P(C) = 0.25$, $P(D) = 0.3$, $P(E) = 0.2$. 1. Provide a detailed step-by-step construction of the Huffman tree, including the final code assignments. 2. Determine the average length of the codes obtained from the Huffman tree. 3. Analyze the efficiency of the Huffman coding compared to fixed-length coding. 4. If P(C) is increased to 0.35 and all other probabilities are adjusted accordingly, recalculate the Huffman tree and compare the average lengths.	**10 Marks**	**L3**	**CO2**
12	A coding scheme assigns code lengths $A = 1$, $B = 2$, $C = 3$, $D = 3$ for symbols A, B, C, D with respective probabilities $P(A) = 0.5$, $P(B) = 0.25$, $P(C) = 0.15$, $P(D) = 0.1$. 1. Check if the code satisfies Kraft's Inequality. Show the calculations. 2. Calculate the efficiency of the original coding scheme and the proposed scheme. 3. Discuss the practical implications of using an efficient coding scheme in a communication system.	**10 Marks**	**L5**	**CO2**

or

13	A source generates symbols A, B, C, D with probabilities P(A) = 0.4, P(B) = 0.3, P(C) = 0.2, P(D) = 0.1. 1. Construct a Shannon-Fano code for the given symbols. 2. Calculate the average code length of the Shannon-Fano code. 3. Compare the average length of the Shannon-Fano code with the entropy of the source and assess the efficiency. 4. If the probabilities are changed to P(A) = 0.35, P(B) = 0.25, P(C) = 0.25, P(D) = 0.15, recalculate the Shannon-Fano code and average length.	**10 Marks**	**L3**	**CO2**