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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: VI**

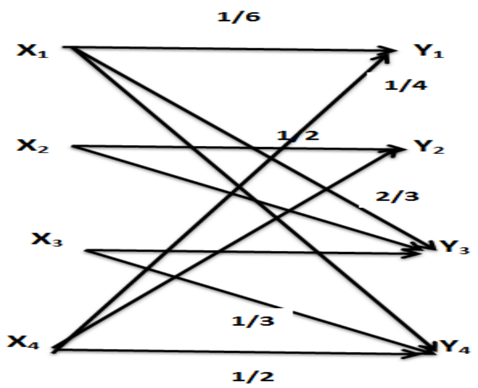
Branch: Electronics and Telecommunication Engineering **Duration: 3 hrs.**

Course Code: 23ET6PCITC **Max Marks: 100**

Course: Information Theory and Coding

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	***CO***	***PO***	**Marks**
1	a)	Prove that the Entropy attains a maximum value when all the source symbols are Equiprobable	*CO2*	*PO1*	**06**
	b)	The channel diagram of the source is given. Compute the missing probabilities and obtain the channel matrix. Calculate H(X), H(Y), H(X,Y) and I(X,Y) given $P(X_1) = P(X_3) = 0.3$ and $P(X_2) = P(X_4) = 0.2$, $P(Y_1/X_1)= 1/6$, $P(Y_3/X_1)= 2/3$, $P(Y_2/X_2)= 1/2$, $P(Y_4/X_3)= 1/3$ $P(Y_4/X_4)= 1/2$ and $P(Y_1/X_4) = P(Y_2/X_4)$ 	*CO2*	*PO1*	**10**
	c)	Show that H(X, Y) = H(X/Y) + H(Y)	*CO2*	*PO1*	**04**
		OR			
2	a)	Two six sided balanced dice are thrown. Find the probabilities and measure of information of each of the following events (i) One roll is 2 given that sum is 5. (ii) Value of second roll subtracted from the value of the first roll is 3. (iii) Only 5 or 6 appears on both dies.	*CO2*	*PO1*	**04**
	b)	Arrive at the input probabilities for the given state equations. Obtain the code tree at the end of the first symbol interval and prove that G_1>H(S), the entropy of the Source. P(A)= P P(A) + P P(C) P(B) = P P(B) + P P(A) P(C) = P P(C) + P P(B)	*CO2*	*PO1*	**10**

		c)	A source has a Source alphabet $S = \{S_1, S_2, S_3\}$ with $P = \{1/2, 1/4, 1/4\}$. Find the entropy of this source. Also determine the entropy of its 2nd extension and verify that $H(S^2) = 2\,H(S)$	*CO2*	*PO1*	**06**
			UNIT - II			
	3	a)	The source emits 5 symbols A, B, C, D and E. The probability of Occurrence of the symbol A is (6/16). The following sequences are given $\alpha_1 = 0,\ \alpha_2 = \frac{6}{16},\ \alpha_3 = \frac{10}{16},\ \alpha_4 = \frac{13}{16},\ \alpha_5 = \frac{15}{16}$ and $\alpha_6 = 1$. Compute the probabilities of B, C, D and E. Obtain the Shannon binary encoding algorithm for the source and calculate the efficiency of the source and redundancy.	*CO2*	*PO1*	**08**
		b)	Consider a source with 7 alphabets as shown below with the probability of occurrence. Construct a binary Huffman code by placing the composite symbols as low as you can. Determine the efficiency and Redundancy of the code so formed	*CO2*	*PO1*	**07**
		c)	Discuss the various properties of codes	*CO1*		**05**
			OR			
	4	a)	A discrete memory less source has an alphabet of 7 symbols with probabilities for its output as described below. Compute Shannon-Fano code for this source. Find the code efficiency and redundancy.	*CO2*	*PO1*	**08**
		b)	State and Prove Noise less Coding Theorem	*CO2*	*PO1*	**06**
		c)	Find the smallest number of letters in the alphabet 'r' for devising a code with prefix property such that W=[0,3,0,5] where W is the set of number of words with word lengths 1,2,3……	*CO2*	*PO1*	**06**
			UNIT - III			
	5	a)	Derive the expression for channel capacity of Symmetric channel.	*CO2*	*PO1*	**06**
		b)	Two channels are cascaded whose channel matrices are given below with $P(X_1) = P(X_2) = 0.5$. Find the overall mutual Information I(X,Z)	*CO2*	*PO1*	**09**

Table for Q3 b):

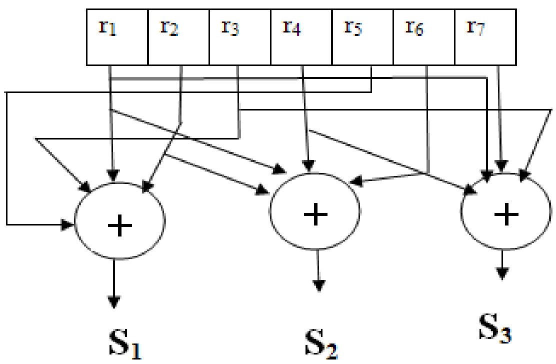
Symbol	A	B	C	D	E	F	G
Probabilities	0.4	0.2	0.1	0.1	0.1	0.05	0.05

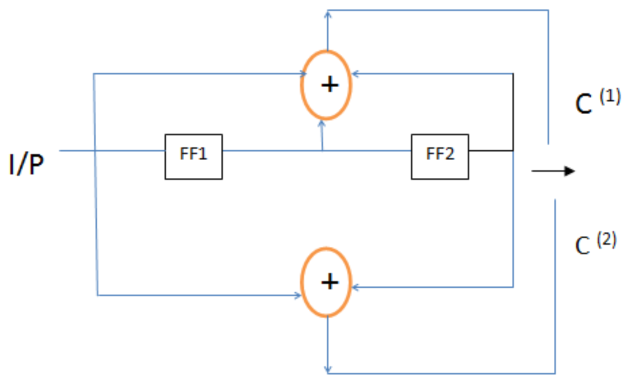
Table for Q4 a):

Symbol	A	B	C	D	E	F	G
Probabilities	0.25	0.25	0.125	0.125	0.125	0.0625	0.0625

Matrices for Q5 b):

$$P\left(\frac{Y}{X}\right) = \begin{bmatrix} \frac{1}{5} & \frac{1}{5} & \frac{3}{5} \\ \frac{1}{2} & \frac{1}{3} & \frac{1}{6} \end{bmatrix} \qquad P\left(\frac{Z}{Y}\right) = \begin{bmatrix} 0 & 3/5 & 2/5 \\ 1/3 & 2/3 & 0 \\ 1/2 & 0 & 1/2 \end{bmatrix}$$

		c)	A continuous random variable X is uniformly distributed in the interval (0, 4). Find the differential entropy H(X). If X is a voltage which is applied to an amplifier whose gain is 8. Find the differential entropy of the output of amplifier.	*CO2*	*PO1*	**05**
			OR			
	6	a)	A channel has the characteristics as shown below. Find H(X), H(Y), H(X, Y) and Channel capacity if r=1000sym/sec and draw the channel diagram. $P\left(\frac{Y}{X}\right)= \begin{bmatrix} 1/3 & 1/3 & 1/6 & 1/6 \\ 1/6 & 1/6 & 1/3 & 1/3 \end{bmatrix}$	*CO2*	*PO1*	**07**
		b)	An analog signal has a 4KHz bandwidth. The signal is sampled at 2.5 times the Nyquist rate and each sample quantized into 256 equally likely levels. Assume that the successive samples are statistically 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 of 20db? (iii) If the output of this source is to be transmitted without errors over an analog channel having (S/N) of 10 dB, Compute the bandwidth requirement of the channel.	*CO2*	*PO1*	**06**
		c)	Show that the conditional differential entropy of Y is H(Y/X)= H(N), where H(N) is the differential entropy of N	*CO2*	*PO1*	**07**
			UNIT - IV			
	7	a)	Prove that the minimum distance of a Linear Block code is equal to the minimum Hamming weight of a non-zero cod vector.	*CO3*	*PO2*	**05**
		b)	Design an encoder for the given syndrome calculation circuit and obtain its Parity matrix, Parity check matrix and the Generator matrix. Determine the 'n' and 'k' values of the linear block code. Obtain the code vectors. Construct the standard array for the code and obtain the decoding circuit. 	*CO3*	*PO2*	**10**
		c)	A linear hamming code is described by the generator polynomial g (D) = $1+D+D^3$. Determine the Generator and the Parity check matrix.	*CO3*	*PO2*	**05**
			OR			

	8	a)	The generator matrix for a (5, 1) Linear block code is given below. Obtain the parity check matrix and evaluate the syndrome for all five possible single error patterns. $G = [1 \quad 1 \quad 1 \quad 1 \mid \quad 1]$	*CO3*	*PO2*	**05**
		b)	A (15, 5) linear cyclic code has a generator polynomial $g(x) = 1+x+x^2+x^4+x^5+x^8+x^{10}$.draw the block diagram of the encoder and find the code polynomial for the message $D(X) = 1+X^2+X^4$ in systematic form. Is $V(X) = 1+X^4+X^6+X^8+X^{14}$ a code polynomial?	*CO3*	*PO2*	**09**
		c)	For the (7,4) cyclic code, $D(x)= d_0+d_1X+d_2X^2+d_3X^3$ and $X^n+1 = X^7+1= (1+X+X^3)(1+X+X^2+X^4)$. Using the generator polynomial $g(x) = 1+X+X^3$, find the code vectors for the message 1001 both in systematic and nonsystematic form	*CO3*	*PO2*	**06**
			UNIT - V			
	9	a)	For the binary convolutional encoder (2, 1, 2) given below. Draw the state transition table, trellis diagram. Using the trellis structure. If the received vector is [11 11 10 01 10 01 11] decode the input sequence using Viterbi Decoding.  	*C03*	*PO2*	**12**
		b)	For the convolutional encoder, if the generator coefficients are $g^{(1)} = 111$ and $g^{(2)} =101$. Draw the encoder block diagram and find the output sequence using Time and Transform domain approach	*CO3*	*PO2*	**08**
			OR			
	10	a)	For the (2,1,2) convolutional encoder, if the generator coefficients are $g^{(1)} = 111$ and $g^{(2)} =101$. Draw the state table, state transition table, state diagram and the code tree. Using the code tree find the encoded sequence for the message 10111. Verify using transform domain approach.	*CO3*	*PO2*	**12**
		b)	For the (3, 2, 1) convolutional encoder, the generator coefficients are $g_1^{(1)} = 10$, $g_1^{(2)} = 01$, $g_1^{(3)} = 00$, $g_2^{(1)} = 11$, $g_2^{(2)} = 10$ and $g_3^{(2)} = 01$. Draw the encoder block diagram and obtain the codeword corresponding to the information sequences d (1) = 010 and d (2) = 011 using time and transform domain approach	*CO3*	*PO2*	**08**

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