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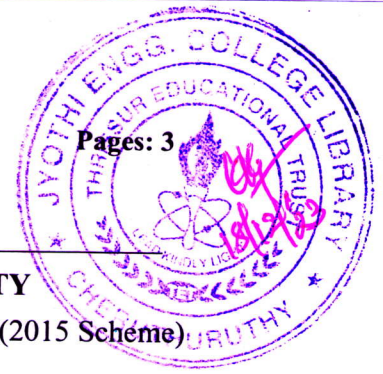
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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S7 (S, FE) / S7 (PT) (S,FE) Examination December 2023 (2015 Scheme)



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 continuous signal is bandlimited to 10 kHz. The signal is quantized in 8 levels of a PCM system with probabilities 0.25, 0.2, 0.2, 0.1, 0.1, 0.05, 0.05, and 0.05. Calculate the entropy and the rate of information. (5)
- b) Prove that mutual information is always non-negative. (5)
- c) Consider a channel with a transition matrix, (5)

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

Identify the type of channel and draw the channel diagram.

- 2 a) Determine the different entropies $H(X)$, $H(Y)$, $H(X, Y)$, $H(X|Y)$, and $H(Y|X)$ for the Joint Probability Matrix given below. Also, verify the relationship between different entropies. (10)

$$P(X, Y) = \begin{bmatrix} 0.3 & 0.05 & 0 \\ 0 & 0.25 & 0 \\ 0 & 0.15 & 0.05 \\ 0 & 0.05 & 0.15 \end{bmatrix}$$

- b) Write the positive and negative statements of Shannon's channel coding theorem. (5)
- 3 a) Consider a set of message symbols $S = \{s_1, s_2, s_3, s_4, s_5\}$ with probabilities $P = \{0.25, 0.25, 0.2, 0.15, 0.15\}$. Construct a binary code using the Shannon-Fano coding procedure and determine the code efficiency. (6)
- b) Derive the capacity of binary erasure channel with the help of channel diagram. (6)
- c) For a DMS source with 2 symbols, if one of the symbol probabilities is α , then determine the entropy of the source. Also plot the entropy graph for different values of α . (3)

PART B

Answer any two full questions, each carries 15 marks.

- 4 a) Given an AWGN channel with 4 kHz bandwidth and the noise power spectral density $N_0/2 = 10^{-9}$ W/Hz. The signal power required at the receiver is 0.1 mW. Calculate the capacity of this channel. (6)

- b) For a systematic linear block code whose generator matrix is given below, (9)

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

Find the error detecting and correcting capabilities of the code. Also draw the syndrome computation circuit.

- 5 a) Derive the expression for differential entropy of a Gaussian distributed random variable with zero mean and variance σ^2 . (8)

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

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

Find the generator and parity check matrix of the code. Determine the code vectors corresponding to the message vectors [0010] and [1010].

- 6 a) Consider the following generator matrix over GF(2) for a linear block code. (8)

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

Construct the standard array for this code.

- b) With the help of graph, explain the SNR trade off graph of Gaussian channel. (7)

PART C

Answer any two full questions, each carries 20 marks.

- 7 a) Consider a convolution encoder, given rate 1/3, constraint length $L = 3$. Given $g^{(1)} = (1 \ 0 \ 0)$, $g^{(2)} = (1 \ 0 \ 1)$, $g^{(3)} = (1 \ 1 \ 1)$. Obtain the codeword sequence corresponding to the information sequence (11001). (8)

- b) Explain the construction of generator matrix and parity check matrix of systematic and non-systematic Hamming code with the help of an example. (7)

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

- 8 a) Draw a (2,1,2) convolutional encoder with the feedback polynomials as $g^{(1)}(D) =$ (10)

$1+D+D^2$ and $g^{(2)}(D) = 1+D^2$. Find the codeword polynomial corresponding to the information sequence, $u(D) = 1+D^3+D^4$. Also draw the state diagram for the given convolutional encoder.

- b) Draw syndrome circuit for a (7,4) cyclic code generated by $g(x) = 1 + x + x^3$. If the received vector r is [0010110], what is the syndrome of r ? Explain the circuit with a table showing the contents of the syndrome register. (10)
- 9 a) Explain the Viterbi algorithm for decoding of convolutional codes. (10)
- b) Generate the codewords corresponding to message vector (1010) and (1100) in systematic and non-systematic form, for a (7, 4) cyclic code with $g(x) = 1 + x + x^3$. (10)
