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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S6 (S,FE) (FT/WP/PT) Examination December 2025 (2019 Scheme)

Course Code: ECT306

Course Name: INFORMATION THEORY AND CODING

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	A discrete memoryless source emits five symbols in every 2ms. The symbol probabilities are {0.5,0.25,0.125,0.0625,0.0625}. Find the average information rate of the source.	(3)
2	Prove that $H(X,Y) = H(X) + H(Y\|X)$.	(3)
3	Assume a channel that has two inputs and two outputs. The probability of errorless transmission is $2/3$ and the probability of error is $1/3$, for each symbol. Draw the channel diagram and find its capacity.	(3)
4	State the positive and negative statements of Shannon's noisy channel coding theorem.	(3)
5	Define vector space and mention any two axioms.	(3)
6	What are symmetric block codes. Write the general structure of its generator and parity check matrix.	(3)
7	Given $n \leq 7$, identify the dimension (n, k) of the cyclic code generated by the generator polynomial $g(x) = 1 + x + x^2 + x^4$	(3)
8	The generator polynomial of a (7,4) cyclic code is $g(x) = 1 + x + x^3$. Find the generator matrix and corresponding parity check matrix.	(3)
9	Draw the circuit diagram of a convolutional encoder with rate $R = 1/2$, constraint length $L = 3$ and generating sequences $\boldsymbol{g}^{(1)} = [1\ 1\ 1], \boldsymbol{g}^{(2)} = [1\ 0\ 1]$	(3)
10	What are convolutional codes? How is it different from block codes?	(3)

PART B

Answer one full question from each module, each carries 14 marks.

Module I

11 a)	Show that for a random variable X with n elements, the upper bound of entropy is given by $H(X) \leq \log_2 n$ and with equality iff X is uniformly distributed.	(7)

b) A discrete memoryless source has five symbols s_0, s_1, s_2, s_3, s_4 with the probabilities as $\{0.4, 0.2, 0.1, 0.2, 0.1\}$. Construct an Huffman code for the symbols and verify whether it satisfies Kraft's inequality (7)

OR

12 a) Show that for an optimal code, the entropy is bounded as $H(X) \leq L < H(X) + 1$ (7)

b) Given the joint probability densities as, (7)

	x_1	x_2	x_3	x_4
y_1	1/8	1/16	1/32	1/32
y_2	1/16	1/8	1/32	1/32
y_3	1/16	1/16	1/16	1/16
y_4	1/4	0	0	0

Find $H(X), H(Y), H(X,Y), H(Y|X), H(X|Y)$ & $I(X;Y)$.

Module II

13 a) Derive the channel capacity of an AWGN channel with infinite bandwidth. What is the trade-off between bandwidth and SNR for capacity of a Gaussian Channel. Also plot the bandwidth-efficiency graph and mention the regions of operation and Shannon's limit. (8)

b) A voice grade telephone channel has a bandwidth of 3400 Hz. If the SNR on the channel is 30 dB, determine the capacity of the channel. If this channel is to be used to transmit 4.8 $kbps$ of data, determine the minimum SNR required on the channel. (6)

OR

14 a) State and prove the Shannon-Hartley Theorem. (8)

b) Derive the channel capacity of a Binary Erasure channel. Let x_1 and x_2 be the two input symbols over the channel and $p = 0.2$ is the probability of a symbol being erased. Find the probabilities associated with the channel outputs if x_1 and x_2 are equiprobable. (6)

Module III

15 a) Given a primitive polynomial $p(x) = x^3 + x^2 + 1$ defined over $GF(2)$, construct $GF(2^3)$. Represent it in power, polynomial and tuple form. (6)

b) Given the generator matrix of a systematic Linear Block Code as, (8)

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

(i) Find the error correction capability of the code.

(ii) Construct standard array and decode $\boldsymbol{r} = [111110]$.

OR

16 a) Given $F = \{0,1,2,3,4,5,6\}$, write the modulo-7 addition and multiplication table. Verify if F forms a field under modulo-7 addition and multiplication. Using the table find (a)3-6 (b) 3/2. (6)

b) Construct the syndrome lookup table assuming the minimum Hamming weight $w_{min} = 3$, for the (6,3) LBC with parity matrix (*assume bound distance decoding*), (8)

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

(i) Decode the received data $\boldsymbol{r} = [110011]$.

(ii) Draw the syndrome decoder circuit.

Module IV

17 a) For a (7,4) cyclic code in systematic form with generator polynomial $g(x) = 1 + x + x^3$, (8)

(i) Find the codeword in systematic form corresponding to the message vector [1010].

(ii) Find the parity check polynomial.

(iii) Draw the encoder circuit for the systematic code and explain the encoding procedure for [1010] by mentioning the content in the shift register at each clock pulse.

b) Write short note on BCH code. Mention its general structure, error correction capability and applications. (6)

OR

18 a) For a (7,4) Cyclic code, the received vector $\boldsymbol{y}$ is 1011011 and the generator polynomial is $x^3 + x + 1$. Correct the single error in the received vector by drawing the buffer register content at each time shift. Draw the decoder circuit. (8)

b) Explain in detail with necessary diagrams the encoding procedure of a systematic and non-systematic cyclic code. (6)

Module V

19 a) Given a (2,1,2) encoder with the generating polynomials $g^{(1)}(x) = 1 + x + x^2$, and $g^{(2)}(x) = 1 + x^2$, draw the encoding circuit. Assuming the received signal is $\boldsymbol{r} = [1101110001100011]$, decode the received signal using Viterbi algorithm. (8)

b) Write short note on LPDC codes and draw the Tanner graph for the given parity check matrix, (6)

$$\boldsymbol{H} = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

OR

20 a) Given the parity check matrix of an LDPC code as, (8)

$$\boldsymbol{H} = \begin{bmatrix} 1 & 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

Decode the received data $\boldsymbol{r} = [0\ e\ e\ 1\ 0\ e\ 0]$ where the channel is assumed to be binary erasure channel and e is the erased data.

b) Construct a convolutional encoder with generating vectors as $\boldsymbol{g}^{(1)} = [1\ 0\ 0], \boldsymbol{g}^{(2)} = [1\ 0\ 1], \boldsymbol{g}^{(3)} = [1\ 1\ 1]$. Draw the encoder diagram and sketch its state diagram. (6)

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