VINAYAKA MISSION'S UNIVERSITY

V.M.K.V ENGINEERING COLLEGE, SALEM

DEPARTMENT OF ELECTRONICS & COMMUNICATION

V SEMESTER

INFORMATION THEORY AND CODING
(COMMON TO ECE, ETCE & IT)

QUESTION BANK

UNIT -1

PART - A

1. Define Entropy.
2. Define Self-Information.
3. State the Properties of Entropy Function.
4. State the Condition for entropy to be maximum.
5. Define Joint entropies.
6. Define Conditional entropies.
7. Define Equivocation.
8. State the significance of H(Y/X) and H(X/Y).
9. Define entropy in the continuous case function.
10. State the properties of continuous entropy function.
11. Define mutual information.
12. What is Kraft inequality?
13. Define efficiency of coding.
14. What is purpose of coding?
15. Define the terms encoding and decoding.
16. What do you mean by uniquely decipherable encoding?
17. Define redundancy of coding.
18. What are instantaneous codes?
19. Define average length of a code.
20. State the properties of mutual information.

21. Prove any one property of mutual information.

22. Prove any one property of entropy.

23. State the properties of information rate.

24.find the entropy of an event of throwing a die.

25. a discrete source emits 3000 symbols once every second. The symbol probabilities are {0.5, 0.2, 0.15, 0.1, 0.05} respectively. Determine source entropy and information rate.

PART B

1. What is Entropy? Explain the properties and types of Entropy?
2. Explain about the relationship between Joint and Conditional Entropy.
3. The Joint Probability Matrix is given as

$$\begin{bmatrix} 0.3 & 0.05 & 0 \\ 0 & 0.25 & 0 \\ 0 & 0.15 & 0.05 \\ 0 & 0.05 & 0.15 \end{bmatrix}$$

Find all the Entropies and Mutual Information.

4 Prove that the Upper bound on Entropy is given as $H_{max} \leq \log_2 M$. Here 'M' is the number of messages emitted by the source.

5. Prove that $H(X,Y)=H(X/Y)+H(Y)$

$$=H(Y/X)+H(X)$$

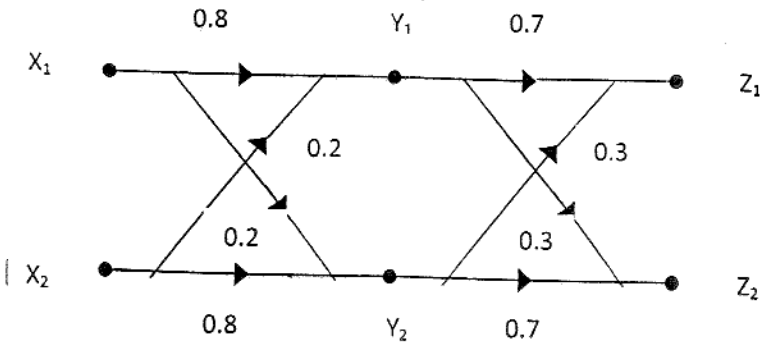
6. (i) A channel has the following Channel matrix.

$$\mathbf{P(Y/X)} = \begin{bmatrix} 1-P & P & 0 \\ 0 & P & 1-P \end{bmatrix}$$

(a)Draw the Channel diagram.

(b)If the source has equally likely outputs, Compute the probabilities associated with the channel outputs for P=0.2 (6 marks)

(ii)Two BSC's are connected in cascade as shown in the figure.



(a)Find the Channel Matrix of the resultant channel.

(b)Find P (Z_1) and P (Z_2), if $P(X_1) = 0.6$, $P(X_2) = 0.4$

7. (i)Prove that the Mutual information of the channel is Symmetric.

$$I(X, Y) = I(Y, X)$$ (6 marks)

(ii)Prove that the mutual information is always positive

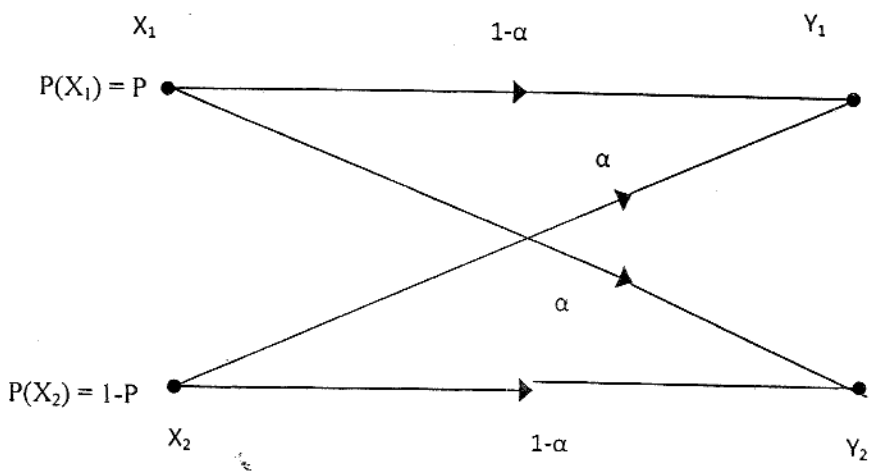
$$I(X, Y) \geq 0$$ (6marks)

8.Prove the following relationships:

a) I(X,Y)=H(X)-H(X/Y)

b) I(X,Y)=H(Y)-H(Y/X)

9.(i) Consider the Binary Symmetric Channel shown in the figure.

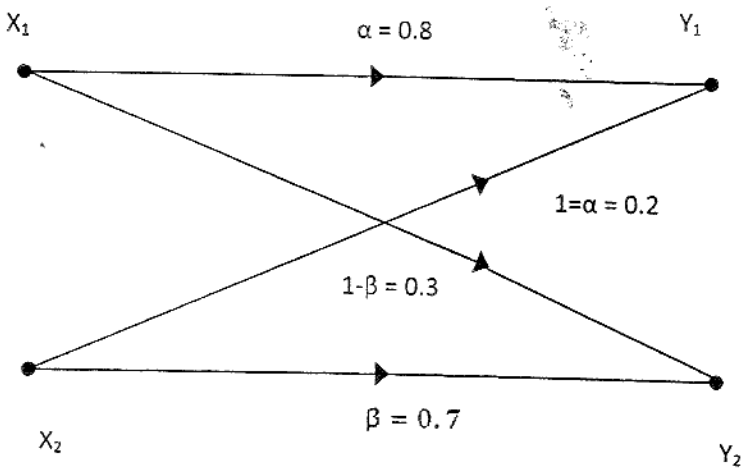


Calculate H(X),H(Y),H(Y/X) and I(X,Y)

(ii)Prove the following

I(X,Y)=H(X)+H(Y)-H(X,Y)

10. (a)Find the Mutual Information and Channel capacity for the channel shown in the figure. Given that $P(X_1) = 0.6$ and $P(X_2) = 0.4$ (6 Marks)



(b)A Binary Channel Matrix is given as:

$$\begin{bmatrix} \frac{2}{3} & \frac{1}{3} \\ \frac{1}{10} & \frac{9}{10} \end{bmatrix}$$

Determine H(X), H(X/Y), H(Y/X) and Mutual Information I(X, Y).

UNIT - 2

PART A

1. What do you mean by memoryless channel?
2. Define a discrete channel.
3. When is a discrete channel said to be memoryless?
4. Define channel matrix D.
5. Distinguish b/w noisy reception & perfect reception.
6. Name the different types of channels.
7. What is a lossless channel?
8. Define a deterministic channel.

9. What is a noiseless channel?

10. When is a channel said to be useless?

11. Define a symmetric channel?

12. Define channel Capacity.

13. What do you understand by BSC and BEC.

14. What is the channel capacity of lossless channel?

15. What is the channel capacity of deterministic channel?

16. What is the channel capacity of noiseless channel?

17. What is the channel capacity of symmetric channel?

18. Define shannon's fundamental theorem?

19. What is decoding schemes?

20. What is useless channel?

21. What is the channel capacity of unsymmetric channel?

22. Define ideal observer.

23. Define fano's inequality.

24. Define maximum likelihood decision scheme.

25. Calculate the capacity of lowpass channel with a usable bandwidth of 3000Hz and S/N = 10^3 at the channel output. Assume the channel noise to be Gaussian and white.

PART-B

1. Explain in detail about Discrete Memory less Channel.

2. Explain the Different types of Channels and Channel Capacity.

3. State and Explain Shannon Hartley theorem.

4. Write Short notes on

i) Decoding Schemes.

ii) Write short notes on Shannon's fundamental theorem.

5. a).Explain in details about Fanon's inequality.

b. Determine the capacity of a ternary channel with the stochastic matrix

$$[p] = \begin{bmatrix} \alpha & 1-\alpha & 0 \\ \frac{1}{2} & 0 & \frac{1}{2} \\ 0 & 1-\alpha & \alpha \end{bmatrix}, 0 \le \alpha \le 1$$

6. Derive the expression for the capacity band limited Gaussian channel

7. A Zero Memory source contains X={x1, x2, x3, x4} with

D(X) = {1/2, 1/4, 1/8, 1/8}

i) Determine entropy of the source

ii) Determine the second order extension of the source and show that $H(X^2) = 2H(X)$

8. Find the capacity of the following three binary channels, given below

a) $P_{11}=P_{22}=1$

b) $P_{11}=P_{12}=P_{21}=P_{22}=1/2$

c) $P_{11}=P_{12}=1/2$; $P_{21}=1/4$; $P_{22}=3/4$

9. i) Find the capacity of the channel with the noise matrix as shown below:

$$\begin{bmatrix} \frac{1}{2} & \frac{1}{4} & 0 & \frac{1}{4} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \frac{1}{4} & 0 & \frac{1}{4} & \frac{1}{2} \end{bmatrix}$$

ii) Derive the expression for channel capacity of a symmetric noise characteristic channel. From the above expression calculate the channel capacity of the given channel noise matrix

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

10. i) Evaluate the channel capacity of the channel whose matrix is given to be

$$\begin{bmatrix} \frac{1-p}{2} & \frac{1-p}{2} & \frac{p}{2} & \frac{p}{2} \\ \frac{p}{2} & \frac{p}{2} & \frac{1-p}{2} & \frac{1-p}{2} \end{bmatrix}$$

ii) a. Evaluate the capacity of the channel whose matrix is given as

$$\begin{bmatrix} 1-\beta & \beta & 0 \\ \beta & 1-\beta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

b. Determine the capacity of a ternary channel with the stochastic matrix

$$[p] = \begin{bmatrix} \alpha & 1-\alpha & 0 \\ \frac{1}{2} & 0 & \frac{1}{2} \\ 0 & 1-\alpha & \alpha \end{bmatrix}, 0 \le \alpha \le 1$$

UNIT III

PART A

1) State information capacity theorem

2) Define differential entropy.

3) Define Shannon limit

4) State Channel coding theorem.

5) Define rate distortion function

6) What is the need for data compression?

7) What are the drawbacks of data compression?

8) Differentiate lossless and lossy compression

9) Define entropy coding

10) What is runlength coding?

11) Define statistical encoding

12) What is differential encoding?

13) Define transform encoding

14) Define data compaction

15) What is prefix coding?

16)what is the need for audio compression?

17)what is the principle of audio coding?

18)what is the need for video compression?

19)write short notes on video compression technique.

20)define rate distortion theory.

21)what is lossless compression?

22) determine the rate of the sampler to digitize an analog signal which has a banwidth of 5hz through to 15Hz.

23)determine the memory required to store a 15-minute passage of speech signal.

24)what is MPEG?

25)define the capacity of colored noise channel.

PART B

1) State and explain information capacity theorem

2) Explain the implications of information capacity theorem

3)Alphanumeric data are entered into a computer from a remote terminal through a Voice grade telephone channel. The channel has a bandwidth of 3.4khz and output signal-to-noise ratio of 20db.The terminal has a total of 128 symbols.Assume that the symbols are equiprobable and the successive transmissions are statistically independent. Calculate the information capacity of the Channel , and the maximum symbol rate for which error free transmisssion over the channel is possible.

4)A voice grade channel of telephone network has a bandwidth of 3.4khz. Calculate the information capacity of the telephone channel for a signal to noise ratio of 30db and the minimum signal – to – noise ratio required to support information transmission through the telephone channel at the rate of 9.6kb/s.

5)An analog signal having 4khz bandwidth is sampled at 1.25 times the Nyquist rate and each sample is quantized into one of 256 equally likely levels.Assume that the successive samples are statistically independent.

(i) What is the information rate of this source ?

(ii) Can the output of the source be transmitted without error an AWGN channel with a bandwidth of 10khz and an S/N ratio of 20db ?

(iii) Find the bandwidth required for an Awgn channel for error-free transmission of the output of this source if the S/N ratio is 25db.

5) Explain rate distortion theory

6) Explain data compression

7) Explain data compaction

8)with the aid of a block diagram explain how digitized pictures are compressed.

9)describe the operation of JPEG decoding stage with a block diagram.

10).list out the compression techniques. Explain any one in detail.

UNIT IV

PART A

1) What are linear codes?

2) What are error correcting codes?

3) What are the properties of syndrome?

4) Define hamming distance

5) What are error correcting codes?

6) What are repetition codes?

7) What are cyclic codes?

8) What are golay codes?

9) What are the advantages and disadvantages of cyclic codes?

10) Consider the (15,9) cyclic code generated by $G(p) = p^6+p^5+p^4+p^3+1$. This code has a burst error correcting ability of q=3. Find the burst error correcting efficiency of this code.

11) Define Convolutional coding.

12) Define code rate of Convolutional encoder.

13) Define constraint length of a convolution code.

14) Compare code tree and trellis diagram

15) What are turbo codes?

16) What are BCH codes?

17) What are RS codes?

18)what is meant by systematic and nonsystematic codes?

19)define code efficiency?

20)what are the important terms of error control coding?

21)define forward acting error correcting?

22)what is meant by channel data rate?

23) what are all the methods of error correcting?

24) give one example of error control coding.

25)give any two properties of cyclic codes.

PART B

1) The generator matrix for a (6,3) block code is given below. Find all the code vectors of this code.

$$G = \left|\begin{array}{ccc:ccc} 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{array}\right|$$

2) Considering (7,4) Code defined by generator polynomial $g(x)=1+x+x^3$ the codeword 0111001 is sent over a noisy Channel producing a received word 0101001 that has a single error. Determine Syndrome Polynomial S(x) and error polynomial e(x).

3) For a (6,3) systematic linear block code, the three parity check bits c_4,c_5,c_6 are formed from the following equations

$C_4 = d1+d3$; $C_5 = d1+d2+d3$; $C_6 = d1+d2$

i) Write down the generator matrix

ii) Construct all possible codewords

iii) Suppose that the received word is 01011.Decode this received word by finding the location of the error and the transmitted data bits.

4)Construct a Convolutional encoder for the following specifications:

Rate efficiency = ½, Constraint length = 4.

The connection from the shift registers to modulo-2 adders are described by the following equations:

$g_1(x) = 1+x$; $g_2(x) = x$

Determine the output codeword for the input message 1110.

5) A generator matrix of (6, 3) linear block code is given as

$$G = \left|\begin{array}{ccc:ccc} 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 \end{array}\right|$$

Determine the d_{min} for the above code. Comment on error correction and detection capabilities. If the received sequence is 1 0 1 1 0 1 , determine the message bit sequence.

6) How is syndrome calculated in cyclic codes?

7) Explain the Viterbi Algorithm with an example

8) The generator polynomial of a (7, 4) cyclic code is $G(p) = p^3 + p + 1$. Find all the code vectors for the code in non systematic form.

9) The generator polynomial of a (7, 4) cyclic code is $G(p) = p^3 + p + 1$. Find all the code vectors for the code in the systematic form.

10) Construct a convolutional encoder whose constraint length (k) is 3 and has modulo-2 adders and an multiplexer. The generator sequences of the encoder are:

$$g^1=(1,0,1);\ g^2=(1,1,0);g^3=(1,1,1)$$

find the encoder output produced by the message sequence 10111.....verify the code word using algorithm.

UNIT V

PART A

1) List the methods for decoding of Convolution codes.
2) Define metric
3) What is surviving path?
4) Define free distance
5) Define coding gain.
6) Give the probability of error with soft decision decoding
7) Give the probability of error with hard decision decoding.
8) Define Noise channel Model
9) Explain Maximum Likelihood Receiver?
10) List out the Characteristics of Viterbi Algorithm
11) List out the practical applications of Viterbi Decoding
12) What is meant by Viterbi Decoding?
13) What is the advantage of Viterbi Decoding?
14) Why Viterbi Algorithm needed?
15) What is meant by forward error correction?
16) Define traceback method of Viterbi Decoding
17) Define the concept of Likelihood
18) List out the Properties of Maximum Likelihood Receiver
19) List out the applications of Maximum Likelihood estimation.
20) Write the expression for Maximum Likelihood Receiver?

21) Define normal distribution.

22) Where convolutional codes are used?

23) How polynomials are selected?

24) Draw the structure of rate-1/2 feed forward convolutional encoder

25) What is meant by path matrix?

PART B

1) Explain Viterbi algorithm for decoding of Convolutional codes

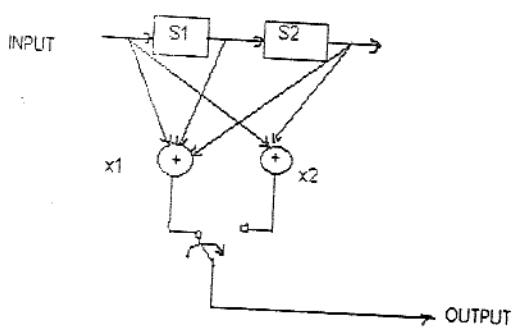
2) Explain sequential decoding for Convolutional codes.

3) Derive the probability of errors for soft and hard decision decoding.

4) Compare hard decision decoding and soft decision decoding

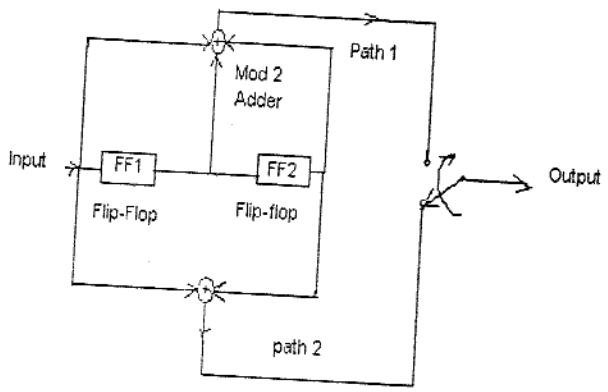
5) An encoder shown below generates an all zero sequence which is sent over a binary symmetric channel. The received sequence 0100100.... There are two errors in this sequence at 2nd and 5th positions. Show that this double error detection is possible with correction by application of viterbi algorithm.

3-160



6. For the Convolutional encoder with Constraint length of 3 and rate ½ as shown in figure, draw the state diagram and trellis diagram. Is the generated code systematic? By using this Viterbi algorithm, decode the sequence 0100010000....

3-162



7.Derive the Transfer function the convolutional code.

8.explain in detail about maximum likelihood decoding.

9.(i) what is meant by channel model?

(ii)write a short notes on

a)binary symmetric channel

b)Gaussian channel

10.let the code word of a coding scheme be

a=000000

b=101010

c=010101

d=111111

if the received sequence over a binary symmetric channel is 111010 and a maximum likelihood decoder is used,what will be the decoded symbol?