Reg. No.

Sixth Semester B.E. Degree Examination, August 2001

Telecommunication Engg./Electronics & Communication
Information Theory & Coding

Time: 3 hrs. [Max.Marks : 100

Note: *Answer any FIVE questions.*

1. (a) A binary source is emitting an independent sequence of 0's and 1's with probabilities p and $1-p$ respectively Plot the entropy of the source. **(6 Marks)**

   (b) The output of a DMS consists of the possible letters $x_1, x_2, \ldots, x_n$ which occur with probabilities $p_1, p_2, \ldots, p_n$ respectively. Prove that the entropy of $H(x)$ of the source is atleast $\log_2 n$. **(6 Marks)**

   (c) For a binary communication system, a '0' or '1' is transmitted. Because of noise on the channel, a '0' can be received as '1' and vice-versa. Let m_0 and m_1 represent the events of transmitting '0' and '1' respectively. Let r_0 and r_0 denote the events of receiving '0' and '1' respectively. Let $P(m_0) = 0.5$, $P(r_1/m_0) = p = 0.1$, $P(r_0/m_1) = q = 0.2$

   (i) Find $p(r_0)$ and $p(r_1)$

   (ii) If a '0' was received what is the probability that '0' was sent

   (iii) If a '1' was received what is the probability that '1' was sent.

   (iv) Calculate the probability of error.

   (v) Calculate the probability that the transmitted symbol is read correctly at the receiver. **(8 Marks)**

2. (a) For a discrete memory less source of entropy H(S), show that, the average code-word length for any distortionless source encoding scheme is bounded as $L \geq H(S)$. **(8 Marks)**

   (b) Briefly discuss the classification of codes. **(6 Marks)**

   (c) Show that $H(X,Y) = H(X/Y) + H(Y)$. **(6 Marks)**

3. (a) Show that $I(X,Y) = I(Y,X)$ for a discrete channel. **(8 Marks)**

   (b) Show that for a discrete channel $I(X,Y) \geq 0$ **(6 Marks)**

   (c) Determine the capacity of the channel shown in fig.1

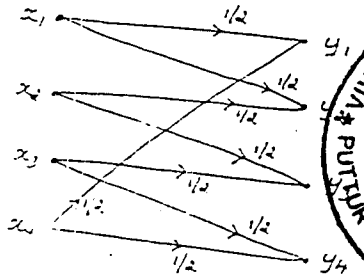
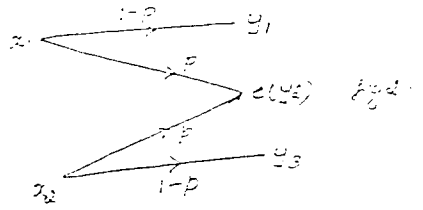


Fig 1.

Contd... 2

4. (a) For a binary erasure channel shown in fig.2, find the following :
   (i) The average mutual information in bits
   (ii) The channel capacity
   (iii) The values of $p(x_1)$ and $p(x_2)$ for maximum mutual information. (8 Marks)



(b) A DMS has an alphabet of seven symbols whose probabilities of occurrences are described here:

Symbol :	S_0	S_1	S_2	S_3	S_4	S_5	S_6
Prob :	0.25	0.125	0.125	0.125	0.125	0.0625	0.0625

Compute the Huffman code for this source, moving a combined symbol as high as possible. Explain why the computed source code has an efficiency of 100% (8 Marks)

(c) Consider a binary block code with 2^n code words of same length n. Show that the Kraft inequality is satisfied for such a code. (4 Marks)

5. (a) Show that for a AWGN channel, $C_\infty = \frac{1.44S}{\eta}$ where $\eta/2$ = noise power spectral density in watts/Hz. (6 Marks)

(b) Consider an AWGN channel with 4kHz bandwidth and noise power spectral density $\frac{\eta}{2} = 10^{-12}$ watts/Hz. The signal power required at the receiver is 0.1mw. Calculate the capacity of the channel. (4 Marks)

(c) If $I(x_i, y_j) = I(x_i) - I(x_i/y_j)$ prove that $I(x_i, y_j) = I(y_j) - I(y_j/x_i)$ (5 Marks)

(d) Consider a continous random variable having a distribution as given below.

$$f_x(x) = \begin{cases} \frac{1}{a} & 0 \le x \le a \\ 0 & \text{otherwise} \end{cases}$$

Find the differential entropy $H(x)$ (5 Marks)

6. (a) Design a single error correcting code with a message block size of 11 and show that by an example that it can correct single error. (8 Marks)

(b) If C_i and C_j an two code vectros in a (n, k) linear block code, show that their sum is also a code vector. (4 Marks)

(c) Show $CH^T = 0$ for a linear block code. (4 Marks)

(d) Prove that the minimum distance of a linear block code is the smallest weight of the non-zero code vector in the code. (4 Marks)

7. (a) The generator polynomial for a (15,7) cyclic code is $g(x) = 1 \oplus x^4 \oplus x^6 \oplus x^7 \oplus x^8$
   (i) Find the code vector in systematic form for the message $D(x) = x^2 \oplus x^3 \oplus x^4$.

Contd.... 3

   (ii) Assume that the first and the last bit of the code vector V(x) for $D(x) = x^2 \oplus x^3 \oplus x^4$ suffer transmission errors.
   Find the syndrome of V(x). (8 Marks)

(b) Consider a (15,9) cyclic code generated by $g(x) = 1 \oplus x^3 \oplus x^4 \oplus x^5 \oplus x^6$. This code has a burst error correcting ability q=3.
Find the burst error correcting efficiency of this code. (6 Marks)

(c) A linear hamming code is described by a generator polynomial $g(D) = 1 \oplus D \oplus D^3$.
   (i) Determine the generator matrix G and parity check matrix.
   (ii) Design an encoder circuit. (6 Marks)

8. (a) Explain briefly the following :
   (a) Golay code
   (b) BCH code. (6 Marks)

(b) Construct the code the assuming the message sequence has length l=2. (14 Marks)

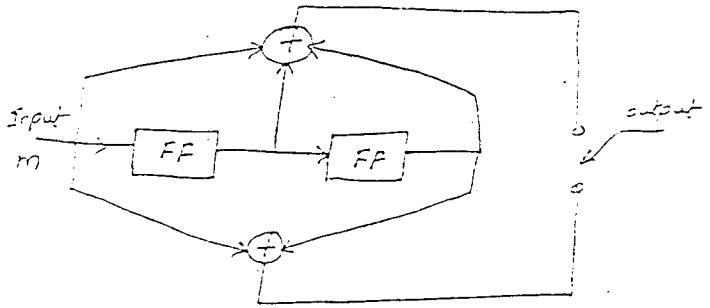


fig 3.

* * *

EC/TE6T1

Reg. No.

Sixth Semester B.E. Degree Examination, July/August 2002
Electronics & Communication/Telecommunication Engg.
Information Theory & Coding

Time: 3 hrs. [Max.Marks: 100]

Note: *Answer any FIVE full questions.*
All questions carry equal marks.

1. (a) Explain the concept of amount information associated with message. Also explain what is infinite information and zero information. **(5 Marks)**

   (b) The collector voltage of a certain circuit is to lie between -5V and -12 Volts. The voltage varies and takes these values : -5V, -6V, -7V, -9V, -11V, -12Volts with respective probabilities of 1/6, 2/6, 1/12, 1/12, 1/6, & $\frac{1}{6}$. This voltage is recorded on plotter. Determine the average information associated with recorded value interms of bits/level. **(5 Marks)**

   (c) The state diagram of mark off source is shown below in Fig.1 **(10 Marks)**
   i) Find the entropy of a source.
   ii) Find $G_1 \& G_2$ and verify $G_1 \geq G_2 \geq H$.

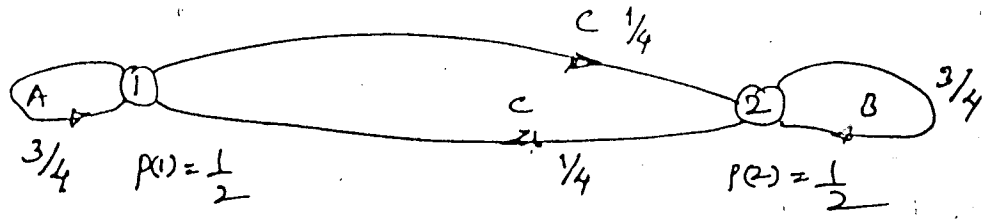


Fig ①

2. (a) Explain shannons - Fano Encoding algorithm. **(6 Marks)**

   (b) The source emits the messages consisting of two symbols each. These messages and their probabilities are given below in Table 1. Design the source encoder using shannons encoding algorithm and also find encoder efficiency. **(10 Marks)**

   (c) Explain the disadvantages of variable length coding. **(4 Marks)**

Table 1

Message Mi	Probability Pi
AA	9/32
AC	3/32
CC	1/16
CB	3/32
CA	3/32
BC	3/32
BB	9/32

Contd.... 2

3. (a) A channel has the following characteristics.

$$P[Y/X] = \begin{array}{c} \\ X_1 \\ X_2 \end{array} \begin{array}{c} \begin{array}{cccc} Y_1 & Y_2 & Y_3 & Y_4 \end{array} \\ \begin{bmatrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{6} & \frac{1}{6} \\ \frac{1}{6} & \frac{1}{6} & \frac{1}{3} & \frac{1}{3} \end{bmatrix} \end{array}$$

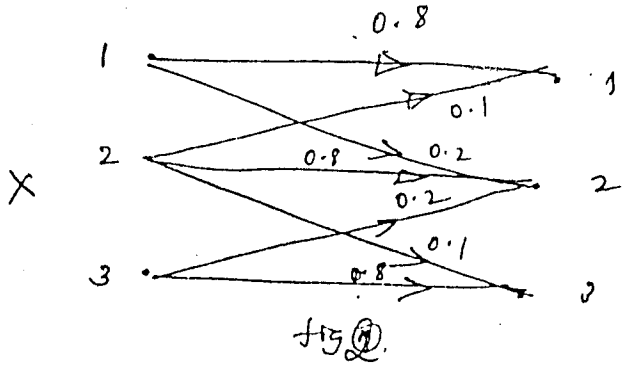
Find $H(x), H(y), H(x,y)$ & channel capacity If γ = 1000 symbols /sec. (10 Marks)

(b) Explain Shannon Hartely - law and its implication & prove that

$$C = \lim_{B \to \infty} C = 1.44 \ S/No.$$ (10 Marks)

4. (a) A friend of yours says that he can design a system for transmitting the output of a micro computer to a line printer operating at a speed of 30 lines/minute over a voice grade telephone line with a band width of $4kHz$ and S/N = 20dBs. Assume that line printer needs eight bits of data per character and prints out 80 character per line. Would you believe him? (6 Marks)

(b) Find the channel capacity of discrete channel shown in fig 2. (10 Marks)



γ_s = 10,000 symbol/sec

fig (2)

(c) State and explain various properties of entropy. (4 Marks)

5. (a) Design a quaternary and binary source code for the source shown using Haffmans coding procedure.

$S = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7\}$

$P = \{9/32, 3/32, 3/32, 2/32, 9/32, 3/32, 3/32\}$

$x = \{0, 1, 2, 3\}$ and $x = \|0, 1\|$

and find coding efficiency. (12 Marks)

(b) For a binary erause channel shown in fig.3 find the following.

i) Average mutual information in bits.

ii) The channel capacity.

Contd.... 3

iii) The values of $p(x_1)$ & $p(x_2)$ for maximum mutual Information. **(8 Marks)**

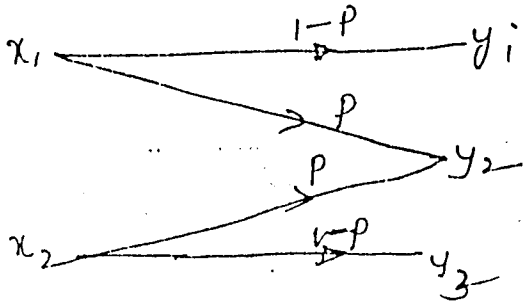


Fig (2)

6. (a) Explain the following terms. **(8 Marks)**

i) Hamming distance ii) Code rate

iii) Free distance iv) Weight of code

(b) Consider a (7,4) linear block code whose generator matrix is given below

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

Find

a) Find all code vectors.

b) Find the party check matrix.

c) Find minimum weight of this code.

d) Draw the decoder circuit. **(12 Marks)**

7. (a) Explain how cyclic codes are generated from the generating polynomials. **(6 Marks)**

(b) The generator polynomial for a (15,7) cyclic code is

$g(x) = 1 \oplus x^4 \oplus x^6 \oplus x^7 \oplus x^8$

i) Find the code vector in systematic form for the message $D(x) = x^2 \oplus x^3 \oplus x^4$.

ii) Assume that first & last bit of the code vector $V(x) for D(x) = x^2 \oplus x^3 \oplus x^4$ suffer transmission effort.

Find the syndrome of v(x). **(14 Marks)**

8. (a) Consider the convolutional encoder shown in fig 4. The message bits are shifted in to the encoder two bits at a time.

a) Find the constraint length and the rate efficiency of the code.

Contd.... 4

b) Assume the initial content of the register to be zero and find the code block for the input message block (110101).

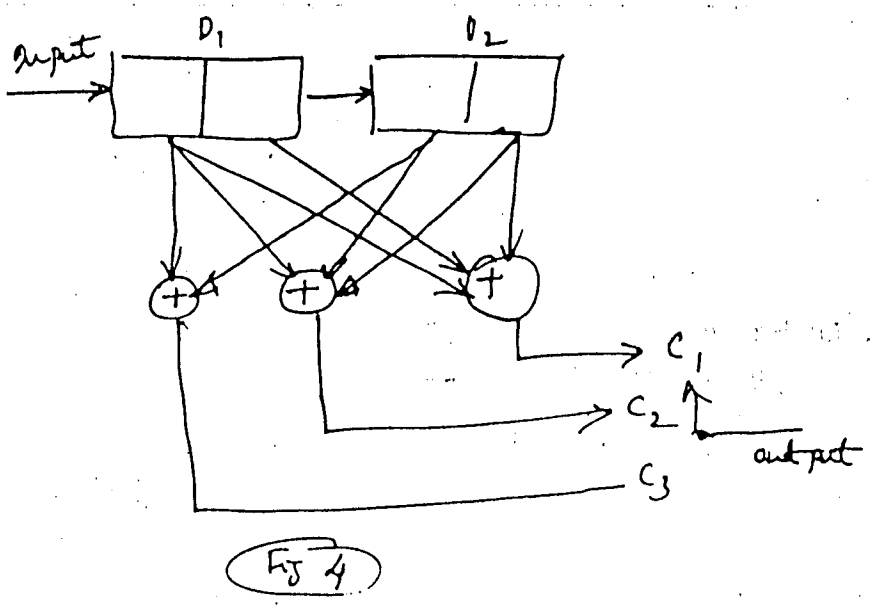


Fig 4

(12 Marks)

(b) Write short notes on :

i) Burst error correcting codes.

ii) Shortened codes. (2 × 4=8 Marks)

** * **

EC/TE6T1

Reg. No.

Sixth Semester B.E. Degree Examination, January/February 2003

Electronics & Communication/Telecommunication Engg.

Information Theory & Coding

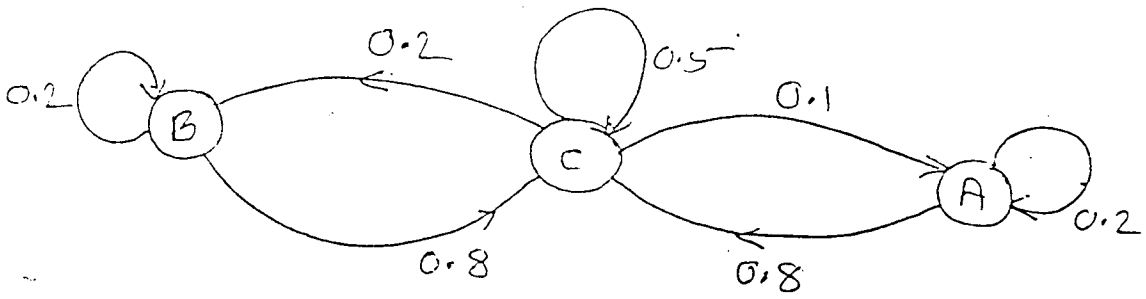
Time: 3 hrs.] [Max.Marks:100

Note: *Answer any FIVE full questions.*
Missing data may suitably be assumed.

1. (a) Derive the expression for entropy of a zero memory discrete source and hence define entropy note, source efficiency and source redundancy. (10 Marks)

   (b) In a facsimile transmission of picture there are about 2.25×10^6 pixels per frame. For a good reproduction, 12 brightness levels are necessary. Assume all these levels are equally likely to occur. Find the rate of information transmission if one picture is to be transmitted every 3 minutes. What is the source efficiency of this facsimile transmitter? (10 Marks)

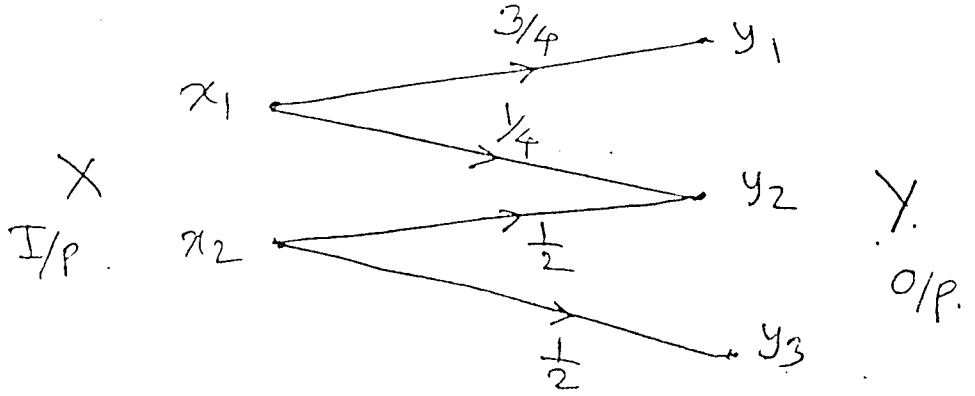
2. (a) For the first order Markov model shown below find the state probabilities, entropy of each state and the entropy of the source. (10 Marks)



   (b) Give different properties of entropy of a zero memory source. Prove the extremal property. (10 Marks)

3. (a) Derive the expression for channel capacity and efficiency of Binary Erasure Channel. (10 Marks)

   (b) Determine the rate of transmission of information through a channel whose noise characteristic is as shown, given $p(x_1) = p(x_2) = \frac{1}{2}$. Assume $r_s = 10,000\ symbols/sec$ (10 Marks)



Contd.... 2

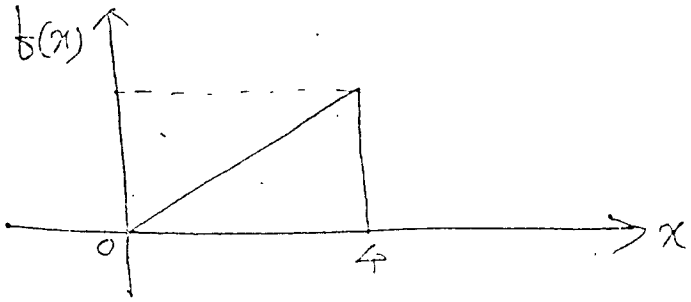
4. (a) Two noisy channels shown below are cascaded. Find $I(x,y)\&I(X,Z)$ (10 Marks)

$$P(Y/X) = \begin{bmatrix} \frac{1}{6} & \frac{1}{6} & \frac{2}{3} \\ \frac{1}{2} & \frac{1}{4} & \frac{1}{4} \end{bmatrix}$$

$$P(Z/Y) = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & 0 \\ \frac{1}{3} & \frac{2}{3} & 0 \\ 0 & \frac{1}{3} & \frac{2}{3} \end{bmatrix}$$

(b) What are the properties of $I(X,Y)$. Show that $I(X,Y) \geq 0$. (10 Marks)

5. (a) A one dimensional random variable has a pdf shown below:



i) Determine the entropy of the source producing this variable.

ii) If the signal is passed through a linear amplifier of gain 16, determine the entropy of the output. (10 Marks)

(b) An analog signal has a 4KHz bandwidth. The signal is sampled at 2.5 times the Nyquist rate and each sample is 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 26dB.

iii) If the output of this source is to be transmitted without errors over an analog channel having S/N ratio of 16dB, compute the bandwidth requirement of the channel. (10 Marks)

6. (a) i) Apply Hoffman encoding procedure for the following set of messages and determine the efficiency of the binary code so formed

Symbols →	x_1	x_2	x_3
Probabilities →	0.7	0.15	0.15

ii) If the same technique is applied to the 2nd order extension for the above messages, how much will the efficiency be improved. (10 Marks)

(b) Derive the expression for capacity of a channel of infinite Bandwidth. (6 Marks)

(c) Explain Bandwidth - SNR trade off. (4 Marks)

Contd.... 3

7 (a) The parity check bits of a (8,4) block code are generated by

$C_5 = d_1 + d_2 + d_4$
$C_6 = d_1 + d_2 + d_3$
$C_7 = d_1 + d_3 + d_4$
$C_8 = d_2 + d_3 + d_4$

Where d_1, d_2, d_3 and d_4 are the message bits and c_1 c_2 c_3 c_4 c_5 c_6 c_7 c_8 are the bits of the transmitted code vector.

i) Find the generator and the parity check matrix for this code.

ii) Find the minimum weight of this code.

iii) Find the error detecting capabilities of this code.

iv) Show through an example that this code can detect 3 errors/code word. (10 Marks)

(b) The generator polynomial for a (15,7) cyclic code is $g(X) = 1 + X^4 + X^6 + X^7 + X^8$.

i) Find the code vector in systematic form for the message polynomial

$$u(X) = X^2 + X^3 + X^4.$$

ii) Assume that the first and the last bits of the code vector $v(X)$ for $u(X)$ given above suffer transmission errors. Find the syndrome of $v(X)$. (10 Marks)

8. (a) Consider the (3,1,2) convolutional code with impulse response.
$g^{(1)} = (110)$, $g^{(2)} = (101)$, $g^{(3)} = (111)$

i) Draw the encoder block diagram.

ii) Find the generator matrix

iii) Find the code word corresponding to the message sequence 11101....

iv) Draw the code tree. (16 Marks)

(b) Define constraint length and the rate efficiency of the convolutional encoder. (4 Marks)

** * **

USN

Sixth Semester B.E. Degree Examination, July/August 2003

Electronics & Communication/Telecommunication Engg.

Information Theory & Coding

Time: 3 hrs.] [Max.Marks : 100

Note: *Answer any FIVE full questions.*

1. (a) Discuss the reasons for using logarithmic measure for measuring the amount of information. **(6 Marks)**

   (b) A fair coin is tossed repeatedly. Let

   A={ event of getting 3 heads out of 5 trials }

   B={ event of getting 5 heads out of 8 trials }

   Which event convey's more information? Support your answers by numerical computation of respective amounts of information. **(6 Marks)**

   (c) A discrete memoryless source produces four symbols with probabilities p_1, p_2, p_3 and p_4. Using partial differentiation method show that the entropy of the source is maximum when all the four symbols occur with equal probability. Compute the value of the maximum entropy. **(8 Marks)**

2. (a) What do you understand by the term 'Extension' of a discrete memoryless source. Show that the entropy of the n-th extension of a DMS is n-times the entropy of the original source. **(8 Marks)**

   (b) For the JPM given below compute individually H(X), H(Y), H(X,Y), H(X/Y), H(Y/X) and I(X,Y). Verify the relation ship among these entropies.

$$P(X,Y) = \begin{bmatrix} 0.05 & 0 & 0.20 & 0.05 \\ 0 & 0.10 & 0.10 & 0 \\ 0 & 0 & 0.20 & 0.10 \\ 0.05 & 0.05 & 0 & 0.10 \end{bmatrix}$$

(12 Marks)

3. (a) What do you understand by the term 'Adjoint' of a Markov source? Consider the ' Adjoint' of the m-th extension of a first order Markov source. Show that

   $H(\overline{S}^m) = H(\overline{S}) + (m-1)H(S)$ **(8 Marks)**

   (b) For the first order Markov source shown in the figure below,

   i) Find the stationary distribution

   ii) Find the entropy of each state and hence the entropy of the source

Contd.... 2

iii) Find the entropy of the adjoint source and verify $H(S) < H(\bar{S})$ (12 Marks)

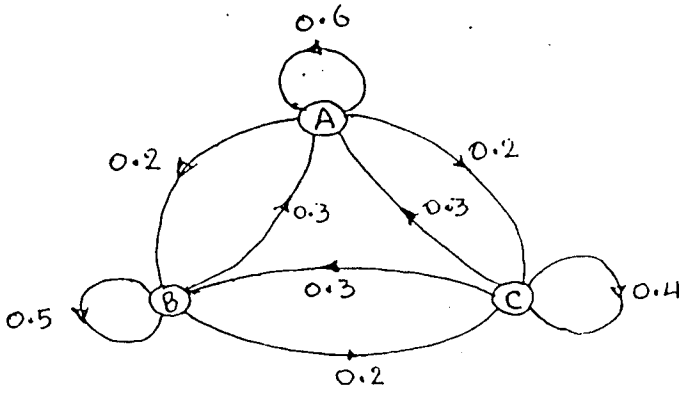


Figure q.3.(b)

4. (a) The noise characteristic of a channel is shown in Fig.Q.4(a). Find the channel capacity. If it were a symmetric channel, recompute the channel capacity. (10 Marks)

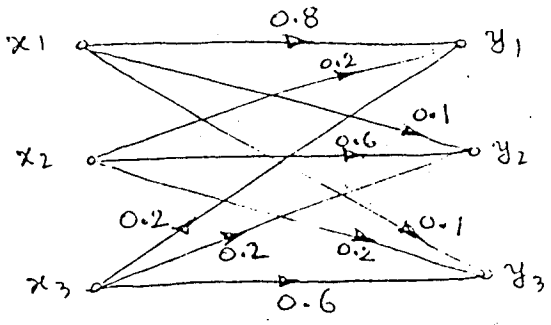


Fig q.4(a)

(b) State Shannon-Hartley law. Derive an expression for the upper limit on channel capacity as the bandwidth tends to infinity. (6 Marks)

(c) A Gaussian channel has a 10 MHz bandwidth and a two sided noise power spectral density $\frac{n}{2}$, of 10^{-14} watts/Hz. The signal power at the receiver has to be maintained at a level less than or equal to $\frac{1}{100}$ of a milliwatt. Calculate the capacity of this channel. (4 Marks)

5. (a) Find the minimum number of symbols, r in the coding alphabet for devising an instantanec code such that $W = \{0, 5, 0, 5, 5\}$. Device such a code (Note : W represents the set of codewords of length 1,2,3...) (5 Marks)

(b) Construct Binary code for the following source using Shannon's binary encoding procedure

$S = \{s_1, s_2, s_3, s_4, s_5\}$

$\underline{P} = \{0.4, 0.25, 0.15, 0.12, 0.08\}$ (5 Marks)

(c) A source produces two symbols 'A' and 'B' with probabilities 0.05 and 0.95 respectively. Construct a suitable binary code such that the efficiency of coding is atleast 65% (10 Marks)

6. (a) For a linear block code with generator matrix $\underline{G}$ and parity check matrix $\underline{H}$, in systematic format, prove that $\underline{G}\,\underline{H}^T = \underline{O}$ (6 Marks)

Contd.... 3

(b) The parity check bits of a (8,4) linear block code are generated using the relation.

$v_1 = u_2 + u_3 + u_4$, $v_2 = u_1 + u_3 + u_4$, $v_3 = u_1 + u_2 + u_3$ and $v_4 = u_1 + u_2 + u_4$

i) Write the generator and parity check matrices.

ii) Find the minimum distance of the code.

iii) What are its error detecting and error correcting capabilities.

iv) Show with an example that this code can detect three errors. (7 Marks)

(c) "Repetition codes" represent the simplest type of linear block codes. The generator matrix of a (5,1) repetition code is given as

$$G = [1 \mid 1\ 1\ 1\ 1]$$

i) Write its parity check matrix.

ii) Write the standard array along with the syndromes of co-set leaders. (7 Marks)

7. (a) Given $n \leq 7$, identify (n,k) values of the cyclic codes generated by the following generator polynomials

i) $g(x) = 1 + x^2 + x^3$

ii) $g(x) = 1 + x + x^2 + x^4$

iii) $g(x) = 1 + x + x^2 + x^3 + x^4$ (8 Marks)

(b) The generator polynomial of a (15,7) cyclic code is $g(X) = 1 + x^4 + x^6 + x^7 + x^8$. Find the code word in systematic form for the message (0101010) clearly explaining all the steps. In particular, list the states of the registers in each step of code computation. Verify your answer by direct hand calculation. (12 Marks)

8. Consider the convolutional encoder given in Fig. Q.8

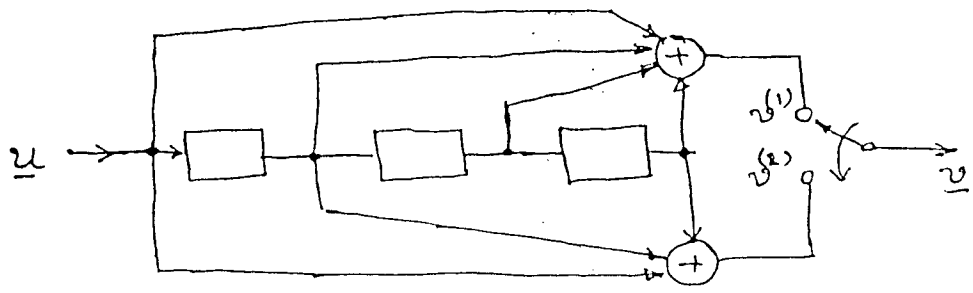


Fig Q.8

a) Construct the tree diagram for the encoder for L=4. (10 Marks)

b) Find the generator matrix G(X) for the encoder. Using the generator matrix find the output code word produced by the sequence $\underline{u} = (1011....)$ (6 Marks)

(c) Verify your answer using code tree. (4 Marks)

** * **

EC/TE6T1

USN

Sixth Semester B.E. Degree Examination, January/February 2004

Electronics and Communication /Telecommunications Engineering

Information Theory & Coding

Time: 3 hrs.] [Max.Marks : 100

Note: *1. Answer any FIVE full questions.*
2. All questions carry equal marks.

1. (a) Define the following :
   i) Information content of a message
   ii) Average information content of symbols
   iii) Maximum entropy for a source with an alphabet of M-symbols.
   iv) Average source information rate. **(5 Marks)**

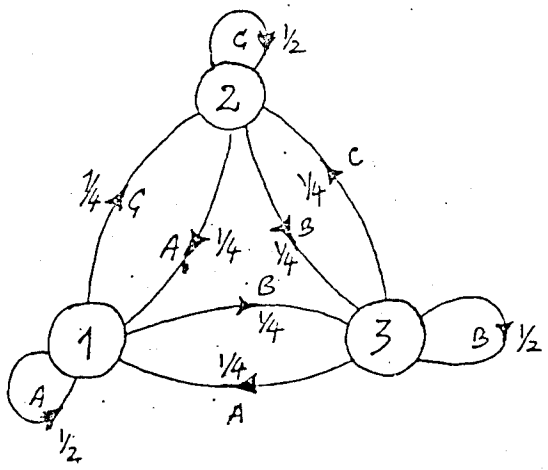
   (b) The output of an information source consists of 128 symbols, sixteen of which occur with a probability of 1/32 and the remaining occur with a probability of 1/224. The source emits 1000 symbols per second. Assuming that the symbols are chosen independently, find the average information rate of this source. **(5 Marks)**

   (c) Discuss the statistical modelling of the symbol sequences emitted by a discrete source with a discrete stationary Markoff random process, How are discrete stationary Markoff sources often represented? Illustrate with an example. **(7+1+2 Marks)**

2. (a) Describe briefly how you would compute the entropy and information rate of Markoff sources. **(6 Marks)**

   (b) The state diagram of a stationary Markoff source is shown in the figure 2(b).
   i) Find the entropy of each state $H_i (i = 1, 2, 3)$
   ii) Find the entropy of the source H,
   iii) Find G_1, G_2, G_3 and verify that,
   $G_1 \geq G_2 \geq G_3 \geq H$

P(State i) = 1/3
i = 1, 2, 3.



(14 Marks)

Contd.... 2

3. (a) What is the meaning of the term communication channel? Indicate the following in the schematic of a practical communication system, when the input to the system and the output from the system are binary :

   i) Data communication channel

   ii) Coding channel and

   iii) Modulation channel. (5 Marks)

   (b) Write the model of an M-ary discrete channel and explain. When do you say that the channel is memory less? Derive the equation for P(error) for this channel. (9 Marks)

   (c) An ideal receiver receives information from a channel of bandwidth 'B' Hertz. Assuming the message to be band limited to f_m hertz, compare the signal-to-noise power ratio at the receiver output to that at its input. Assume that the SNRs of interest are large compared to unity. (6 Marks)

4. (a) What do you mean by source encoding? Name the two functional requirements to be satisfied in the development of an efficient source encoder. (5 Marks)

   (b) A discrete memoryless source has an alphabet of seven symbols whose probabilities of occurrence are as described here :

Symbol :	s_0	s_1	s_2	s_3	s_4	s_5	s_6
Probability :	0.25	0.25	0.125	0.125	0.125	0.0625	0.0625

   Compute the Huffman code for this source moving a combined symbol as high as possible. Evaluate the code efficiency. (15 Marks)

5. (a) Explain the channel matrix 'P' used to conveniently describe a discrete memoryless channel. (5 Marks)

   (b) Prove the following with usual notations: (6 Marks)

$$I(X;Y) = I(Y;X)$$

   (c) Consider a binary symmetric channel characterised by the transition probability 'p'. Plot the mutual information of the channel as a function of p_1, the a priori probability of symbol '1' at the channel input ; do your calculations for the transition probability p=0, 0.1, 0.2, 0.3, 0.5. (9 Marks)

6. (a) What is error control coding? Which are the functional blocks of a communication system that accomplish this? Indicate the function of each block.

   What is the effect of error detection and correction on the performance of the communication system? (8 Marks)

   (b) A (7,4) linear code is generated by the matrix

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

   a transmitted code word is received as 0100110. Show how a decoder using the syndrome look-up table can correct the error using the standard array. (12 Marks)

Contd.... 3

7. (a) What is binary cyclic code? Describe the features of encoder and decoder used for cyclic codes using an (n-k) bit shift register. (10 Marks)

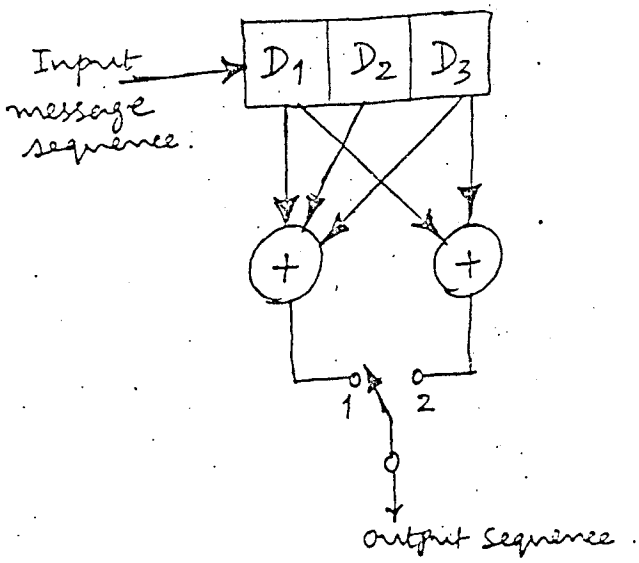
(b) Consider the (15, 11) cyclic code generated by $g(x) = 1 + X + X^4$

i) Device a feedback register encoder for this code.

ii) Illustrate the encoding procedure with the message vector 11001101011 by listing the states of the register (the rightmost bit is the earliest bit). (10 Marks)

8. (a) Briefly describe single error correcting Hamming codes. (7 Marks)

(b) For the convolutional encoder shown in the figure 8(b) find n, k, K and the code rate. Also find the output sequence for the input message sequence 110011. (7 Marks)



(c) Write the features of :

i) BCH codes

ii) Majority logic decodable codes. (6 Marks)

** * **

USN | | | | | | | | | | |

Sixth Semester B.E. Degree Examination, July/August 2004

Electronics and Communication /Telecommunications Engineering

Information Theory & Coding

Time: 3 hrs.] [Max.Marks : 100

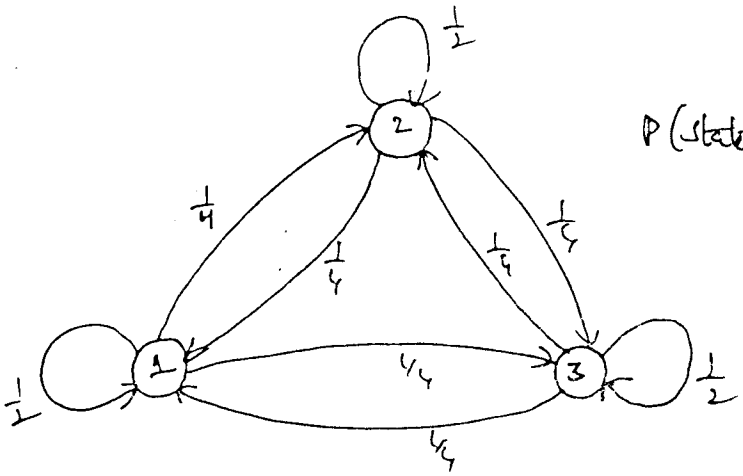
Note: *1. Answer any FIVE full questions.*
2. Normal distribution table can be used.

1. (a) Define i) self information ii) symbol rate and iii) average information as applied to a discrete memoryless source with an example. **(6 Marks)**

   (b) Derive the expression for the maximum entropy of a discrete memoryless source and the conditions to achieve the same. **(6 Marks)**

   (c) A source emits one of the four probable messages M_1, M_2, M_3 and M_4 with probabilities of $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}$ and $\frac{1}{8}$ respectively. Find the entropy of the source. List all the elements for the second extension of this source. Hence show $H(s^2) = 2H(s)$. **(2+4+2=8 Marks)**

2. (a) The state diagram of the Markoff source is given below :



$P(\text{state } i) = \frac{1}{3}$ for $i = 1, 2, 3$

i) Find the entropy of each state Hi

ii) Find the entropy of source H **(8 Marks)**

   (b) What are the important properties of codes while encoding a source. **(5 Marks)**

   (c) A source emits an independent sequence of symbols from an aiphabet consisting of five symbols A, B, C, D and E with probabilities of $\frac{1}{4}, \frac{1}{8}, \frac{1}{8}, \frac{3}{16}$ & $\frac{5}{16}$ respectively. Find the Shannon code for each symbol and efficiency of the coding scheme. **(5+2=7 Marks)**

3. (a) Explain Shannon's source coding theorem. **(5 Marks)**

   (b) Consider a discrete memoryless source with alphabets $(S_0 S_1 S_2)$ and probabilities $(0.70, 0.15, 0.15)$ for its output.

Contd.... 2

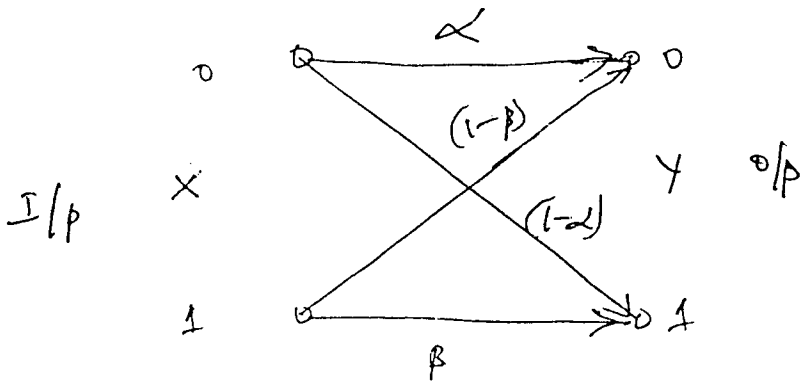
i) Apply Huffman binary coding procedure for the source and find the average length of the codeword.

ii) Consider the second extention of this source. Apply Huffman encoding procedure and find the average length of the codeword.

iii) Find the coding efficiency in the second case. (3+6+2=11 Marks)

(c) List all the properties of mutual information. (4 Marks)

4. (a) A non- symmetric binary channel is given below



i) Find $H(x), H(y), H(x/y)$ and $H(y/x)$ given $p[x=0]=\frac{1}{4}$, $p[x=1]=3/4$ $\alpha=0.75$ and $\beta=0.9$

ii) Find the capacity of the binary symmetric channel $\alpha=\beta=0.75$. (8+2-10 Marks)

(b) Write briefly about Gilbert's model for discrete channels with memory. (5 Marks)

(c) Calculate the capacity of a Gausian channel with a bandwidth of 1 MHz and S/N ratio of 30 dB. (5 Marks)

5. (a) State and explailn Shannon -Hartley law. Derive the upper limit of the channel capacity with increasing bandwidth. What are its implications ? (3+3+2=8 Marks)

(b) An analog signal has a 4 Khz bandwidth. The signal is sampled at 2.5 times the Nyquist rate and each sample quantized to 256 equally likely levels. All samples are statistically independent.

i) What is the information rate of the signal ?

ii) Can the output of this source be transmitted without errors over a Gaussian channel with a bandwidth of 50 khz and S/N ration of 23 dB ?

iii) What will be the bandwidth required for transmitting the output of the signal without erros if the S/N ratio is 10 dB. (3+3+2=8 Marks)

(c) For the channel given in question 4(c), find the time it takes to transmit one million ASCII characters, if each character is considered as 8 bits (No start or stop bts). (4 Marks)

6. (a) Consider the (7, 4) linear block code whose generator matrix is given below.

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

Contd.... 3

i) Find all code vectors

ii) Find parity check mating H.

iii) The minimum weight of this code. (8+2+2=12 Marks)

(b) How do you find the error detecting and correcting capabilities of a linear block code ? Illustrate the same considering a $(6,3)$ code whose 'G' is given by

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

(3+5=8 Marks)

7. The generator polynomial of a $(15,5)$ cyclic code is

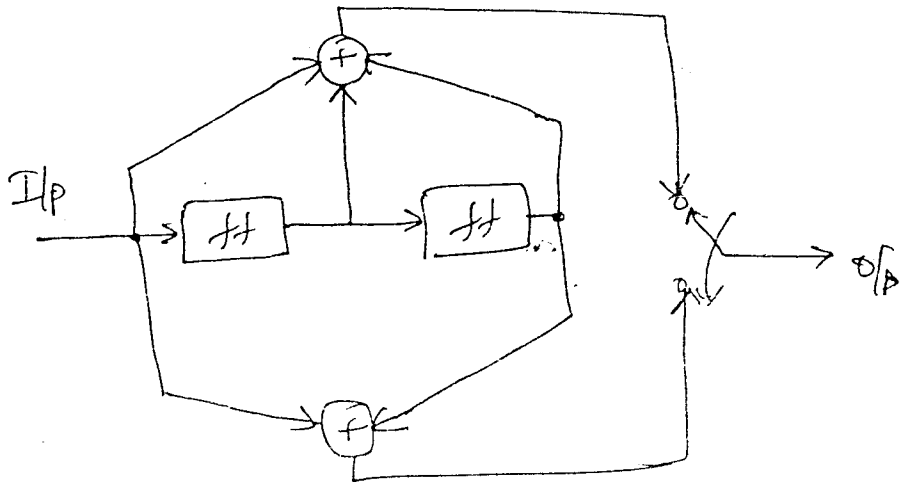
$g(x) = 1 + x + x^2 + x^4 + x^5 + x^8 + x^{10}$

i) Draw the block diagram of encoder and syndrome calculator.

ii) Find the code polynomial for the message polynomial $1 + x^2 + x^4$ in systematic form.

iii) Is $V(x) = 1 + x^4 + x^6 + x^8 + x^{14}$ a code polynomial? If not find the syndrome for $V(x)$. (12+6+2=20 Marks)

8. Consider the convolutional encoder given below.



i) Write the impulse response of the system.

ii) Find the o/p corresponding to input message (10011) using time domain approach.

iii) Write the generator polynomial for this encoder.

iv) Find the output using the generator polynomial for the message. (10111).

v) Write the code tree to calculate the response for the input (101). (2+7+2+4+5=20 Marks)

** * **

NEW SCHEME

EC63

Reg. No. 4PA01EC042

Sixth Semester B.E. Degree Examination, January/February 2006
Electronics & Communication/Telecommunication Engineering
Information Theory and Coding

Time: 3 hrs.) (Max.Marks : 100

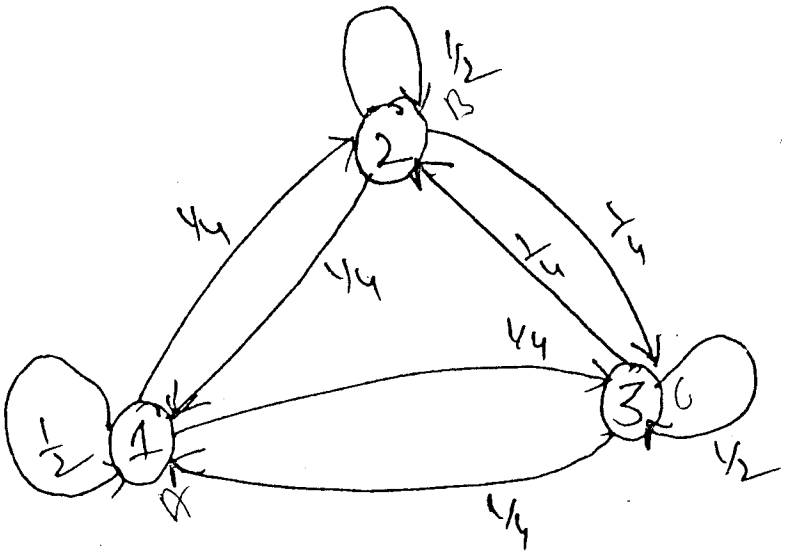
Note: ***Answer any FIVE full questions.***

1. (a) Define :
   i) Amount of information
   ii) Average information and
   iii) Rate of information as applied to a discrete memoryless source. **(6 Marks)**

   (b) Prove that the entropy of a discrete memory less source is maximum, when all the symbols are equally probable and hence plot entropy versus probability of a source with two symbol outputs 0 and 1. **(6+3=9 Marks)**

   (c) In conventional telegraphy we use dots and dashes to transmit messages. A dash is thrice as long as a dot and one third as probable as a dot. Find
   i) Information in a dot and dash
   ii) average information in dot-dash-code
   iii) If a dot takes 2 msec and same time is allowed between symbols the information rate of this code. **(2+1+2 Marks)**

2. (a) The state diagram of a Marleov source is given below :



P (state i) = 1/3 for i = 1, 2, 3

   i) Find the entropy of each state $H_i(i = 1, 2, 3)$.
   ii) Find entropy of the source H.
   iii) Find G_1, G_2 and G_3 and show that $G_1 \geq G_2 \geq G_3 \geq A$ **(3+2+7=12 Marks)**

Contd.... 2

(b) Consider a source S giving out symbols S_1, S_2 *and* S_3 with probabilities of $\frac{1}{2}$, $\frac{1}{4}$ *and* $\frac{1}{4}$ respectively

i) Find the entropy of the source

ii) Write all the symbols of the 2nd extension of S and find its entropy

iii) Hence find relation between $H(s^2)$ & $H(s)$ **(2+4+2 Marks)**

3. (a) What are the properties of codes? State Shannon's source encoding theorem. **(3+3=6 Marks)**

(b) Use Shannon's encoding procedure for the following symbols and find coding efficiency :

Symbol	S_1	S_2	S_3	S_4	S_5
Probability	0.4	0.2	0.2	0.1	0.1

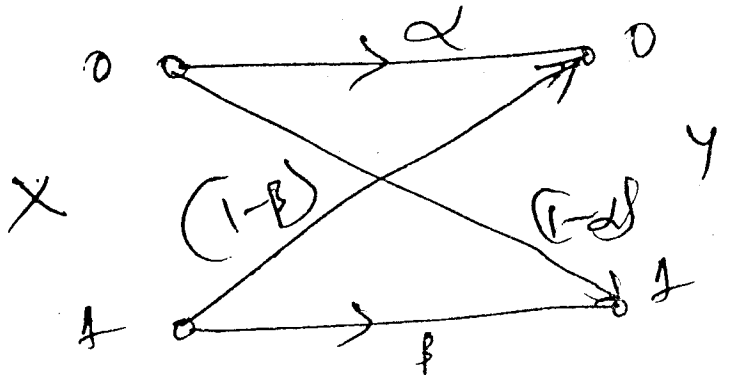
(4+2=6 Marks)

(c) A source has an alphabet of 7 symbols with probabilities as given below :

Symbol	S_1	S_2	S_3	S_4	S_5	S_6	S_7
Probability	1/4	1/4	1/8	1/8	1/8	1/16	1/16

Construct Huffman binary code and find its efficiency. **(6+2 Marks)**

4. (a) A non-symmetric binary channel is given below :



$r_s = 1000/\text{sec}$

i) Find $H(x)$, $H(y)$, $H(xy)$ and $H(y/x)$ given $P[x=0] = \frac{1}{4}$ and $P[x=1] = \frac{3}{4}$. Also $\alpha = 0.75$ and $\beta = 0.9$

ii) Find the capacity of the binary symmetric channel given $\alpha = \beta = 0.9$ **(7+2 Marks)**

(b) Define mutual information and list its properties. **(5 Marks)**

(c) For a channel whose matrix is given below :

$$P[Y/X] = X \begin{matrix} \\ \\ \\ \end{matrix} \overset{Y}{\begin{bmatrix} 0.6 & 0.2 & 0.2 \\ 0.2 & 0.6 & 0.2 \\ 0.2 & 0.2 & 0.6 \end{bmatrix}}$$

Find $I(XY)$ and channel capacity given the I/P symbols occur with equal probability. **(4+2=6 Marks)**

5. (a) State and explain Shannon, Hartley law. Find the upper limit of the channel capacity with increasing bandwidth. Also explain the concept of S/N ratio and bandwidth tradeoff. **(3+3+3 Marks)**

Contd.... 3

(b) An analog signal is band limited as 4 kHz. It is sampled at 2.5 times an Nyquist rate and each sample is quantized to 256 levels. These levels are equally likely to occur. The samples are assumed to be statistically independent. Find

i) Information rate of the sampled signal

ii) can yon transmit the signal without errors on a gaussan channel with 50 kHz bandwidth and S/N rate of 23 dB?

iii) What bandwidth is needed to transmit the signal without errors if S/N ratio is 10 dB?

(3+3+2 Marks)

(c) Write the channel diagram and matrix of binary erasure channel. **(2+1 Marks)**

6. (a) Why do we need error control coding? What are the types of errors and types of coding to combat them? **(2+2+2 Marks)**

(b) The parity check bits of a (8,4) linear block code is given by

$$C_5 = d_1 + d_2 + d_4$$
$$C_6 = d_1 + d_2 + d_3$$
$$C_7 = d_1 + d_3 + d_4$$
$$C_8 = d_2 + d_3 + d_4$$

where d_1, d_2, d_3 *and* d_4 are data bits.

i) Find the generator and parity check matrix of this code

ii) Find the code vectors for all data inputs using the above generator matrix

iii) Find the minimum weight of this coding scheme. **(4+8+2 Marks)**

7. A(15,5) algebraic code is generated using the generator polynomial

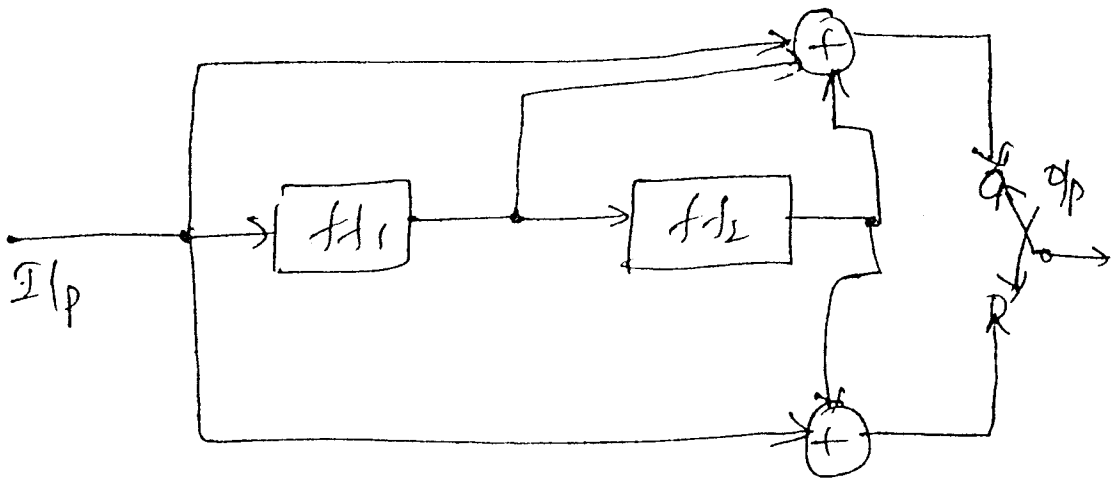
$$g(X) = 1 + X + X^2 + X^4 + X^5 + X^8 + X^{10}$$

(a) Draw the block diagram of encoder and syndrome calculator

(b) Find the code polynomial for the message polynomial $1 + X^2 + X^4$ using the encoder diagram

(c) Is $v(x) = 1 + x^4 + x^6 + x^8 + x^{14}$ a code polynomial or not? **(5+5+7+3=20 Marks)**

8. Consider the convolutional encoder given below :



Contd.... 4

(a) Write the impulse response of this encoder

(b) Find the output for the message (10011) using time domain approach

(c) Find the output for the message in (b) using transform domain approach.

(d) Draw the code tree for the encoder. **(3+5+5+7 Marks)**

** * **

EC 63

USN

NEW SCHEME

Sixth Semester B.E. Degree Examination, July 2006
EC / TC
Information Theory and Coding

Time: 3 hrs.] [Max. Marks:100

Note: ***Answer any FIVE full questions.***

1 a. Discuss the reasons for using logarithmic measure for measuring information **(06 Marks)**

b. The probability that a student passes an examination, given that he has studied, is 0.9. The probability that he passes the examination without studying is 0.2. Assume that the probability of the student studying for the exam is 0.6 (a lazy student indeed).What is the amount of information you have received if you are told that the student has passed the examination? Further, what is the amount of information you receive if you are told that he did study for the exam? **(08 Marks)**

c. Show that the entropy of a discrete memory less source will become maximum when all source symbols are equally probable. What is the maximum value of the entropy? **(06 Marks)**

2 a. Show that the entropy of the source with the following probability distribution is $\left[2 - 1/2^{n-2}\right]$

S	s_1	s_2	s_3	....	s_j	.....	s_{n-1}	s_n
P	1/2	1/4	1/8	....	$1/2^j$	....	$1/2^{n-1}$	$1/2^{n-1}$

(06 Marks)

b. Show that the entropy of the n-th extension. S^n of r zero memory source S, is $H(S^n) = n H(S)$. **(06 Marks)**

c. Consider a second order Markov source shown in fig. 2 (c) . Here S = { 0, 1 } and the states are A = { 0 0 }, B ={0 1 }, C = { 1 0 } and D = { 11 }

i) Compute the probability of states

ii) Compute the entropy of the source. **(08 Marks)**

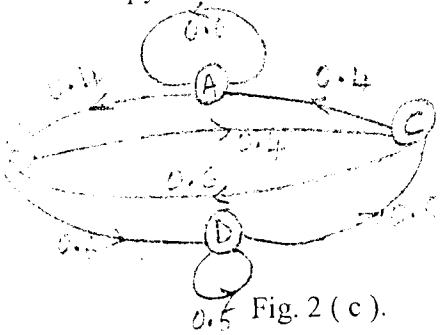


Fig. 2 (c).

3 a. For the Joint probability matrix shown below, find H(x,y), H(x), H(y), H(x/y), H(y/x) and I(x,y)

Contd...2

$$P(X,Y)=\begin{bmatrix} 0.2 & 0 & 0.2 & 0 \\ 0.1 & 0.01 & 0.01 & 0.01 \\ 0 & 0.02 & 0.02 & 0 \\ 0.04 & 0.04 & 0.01 & 0.06 \\ 0 & 0.06 & 0.02 & 0.2 \end{bmatrix}$$ **(09 Marks)**

b. Show that the Mutual Information is always non-negative. **(06 Marks)**

c. State and explain the channel coding theorem with a practical example and diagrams. **(05 Marks)**

4 a. Find the capacity of the discrete channel shown in fig. 4 (a).

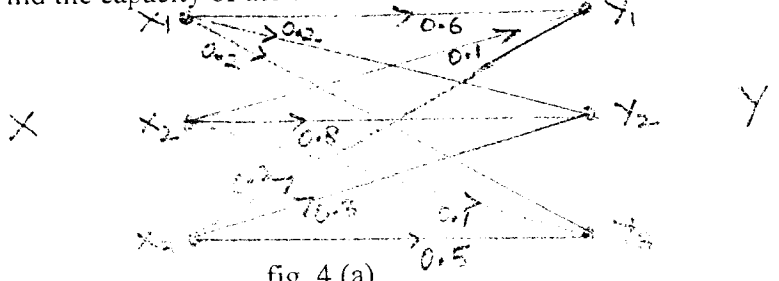


fig. 4 (a) **(06 Marks)**

b. Draw the channel diagram of a Binary Erasure Channel (BEC) and find its channel capacity. **(06 Marks)**

c. A continuous random variable X is constrained to an average value $(1/\alpha)$ and is unidirectional in the interval $(0,\infty)$.
   i) Find the density function that maximizes H(X).
   ii) Find the maximum value of H(X). **(08 Marks)**

5 a. Starting from Shannon – Hartley law, show that $\left(\frac{Eb}{No}\right)$ approaches ln2 = 0.693 as the band width tends to infinity. **(06 Marks)**

b. A voice grade telephone channel has a band width of 3.4 KHz. i) Calculate the channel capacity for a signal-to-noise ratio of 30 dB. ii) calculate the minimum signal-to-noise ratio required to support transmission at the rate of 4800 bits/sec. **(04 Marks)**

c. Given an eight symbol source with probabilities
P = { 0.25, 0.20, 0.15, 0.15, 0.10, 0.05, 0.05, 0.05 } construct two binary Huffman's codes as directed
   i) Place the composite symbol as 'low' as you can
   ii) Move the composite symbol as 'high' as possible.
In each case determine the variance of the word lengths and comment on the results. **(10 Marks)**

6 a. For a (5, 2) linear, systematic block code, choose the generator matrix and parity check matrix with the objective of maximizing d_{min}. For the matrix so chosen , construct the standard array.

b. Determine which of the following polynomials can generate cyclic codes with code word length ≤ 7. Find the (n , k) values for the codes that can be generated.
i) $1 + x^3 + x^4$ ii) $1 + x + x^3 + x^4$ iii) $1 + x^3 + x^5$ iv) $1 + x^2 + x^4$
v) $1 + x + x^2 + x^4$

Contd...3

7 a. A (15, 11) cyclic code is generated by the polynomial $g(x) = 1 + x + x^2 + x^3 + x^4$. Draw the block diagram of a systematic encoder and find the code word for the message u = (1,0,0,1, 0, 0, 0, 1, 0, 0, 1) by tabulating the contents of the shift registers. **(16 Marks)**

For any positive integer $m \geq 3$, what are the parameters for i) BCH codes ii) Reed – Solomon codes. **(04 Marks)**

8 For the convolutional encoder shown in fig. 8 ,

i) Draw the Tree diagram and determine the output produced by a message u = (1011....) **(08 Marks)**

ii) Draw the Trellis diagram and extract the transmitted 'u' , using viterbi algorithm for the received sequence.

r = { 101, 110, 101, 010, 101, 110, 011 } **(12 Marks)**

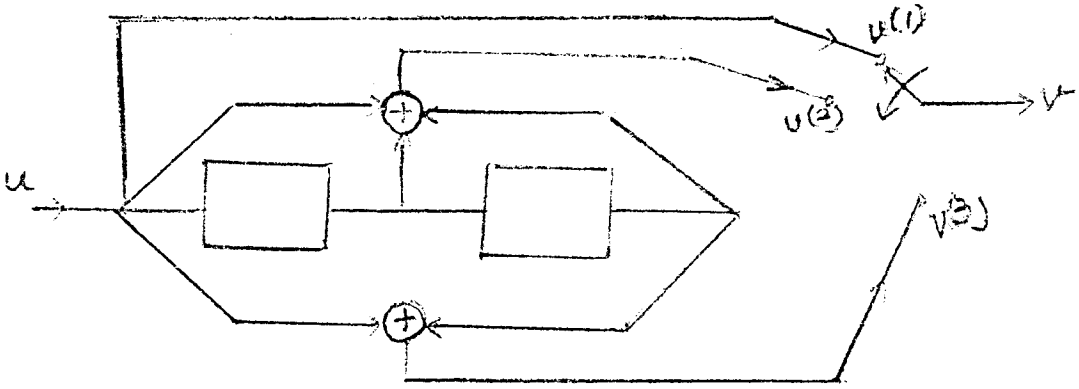


Fig. 8.

*****

EC63

USN

NEW SCHEME

Sixth Semester B.E. Degree Examination, Dec. 06 / Jan. 07
EC / TE
Information Theory and Coding

Time: 3 hrs.] [Max. Marks:100

Note: *1. Answer any FIVE full questions.*

1 a. The information content of a message m_k is given by, $I(m_k) = \log_2\left(\frac{1}{p_k}\right)$ bits, where p_k is the probability of occurrence of message m_k. Justify the above equation. **(06 Marks)**

b. A black and white TV picture consists of 525 lines of picture information. Assuming each line consists of 525 picture elements, each element having 256 brightness levels and the pictures are repeated at the rate of 30 / sec, calculate the average information conveyed by a TV set to a viewer. **(08 Marks)**

c. State and explain Shannon's encoding algorithm. **(06 Marks)**

2 a. Explain 'Rate of information transmission' over a discrete memoryless channel. Justify that this is given $D_i = [H(X) - H(X/Y)]r_s$ bits / sec. **(08 Marks)**

b. Evaluate the mutual information of discrete channel shown in the fig.2(b). Assume $r_s = 10{,}000$ / sec. **(08 Marks)**

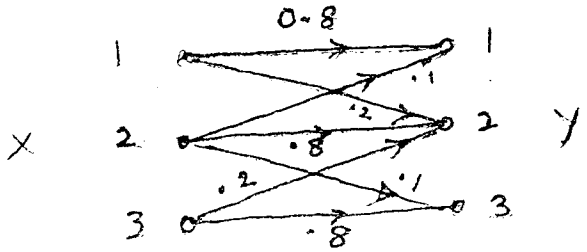


Fig.2(b)

c. Write a brief note on channels (discrete) with memory. **(04 Marks)**

3 a. State and explain Shannon-Hartley theorem for continuous memoryless channel with bandwidth (B) and additive Gaussian band limited white noise. **(08 Marks)**

b. An analog signal having 4 Hz bandwidth is sampled at 2.5 times the Nyquist rate and each sample is quantized into one of the 256 equally likely levels. Assuming the successive samples are statistically independent,

i) Calculate the information rate of this source.

ii) Can the output of this source be transmitted without errors over a Gaussian channel with a bandwidth of 50 kHz and S/N ratio of 23 dB?

iii) What will be the bandwidth requirements of an analog channel for transmitting the output of the source without errors if S/N ratio is 12 dB? **(12 Marks)**

4 a. Develop a Mark-off statistical model for information sources. **(06 Marks)**

b. The state diagram of a stationary Mark-off source is shown in the fig.4(b). Find

i) Entropy of each state

ii) Entropy of the source and

iii) G1 and G2 and verify that $G_1 \geq G_2 \geq H$. **(08 Marks)**

Contd.... 2

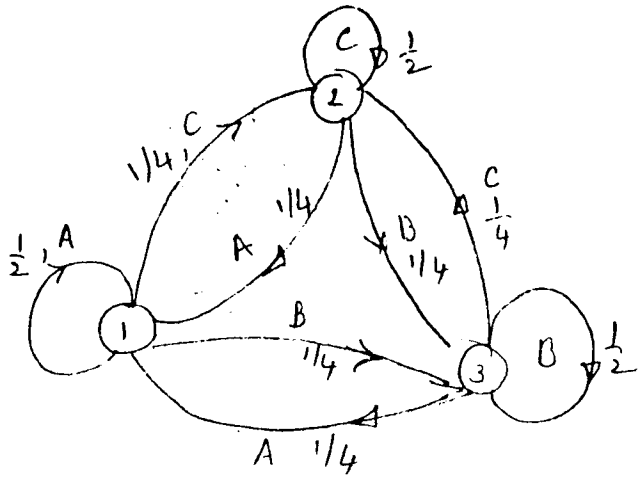


Fig.4(b)

c. A technique used in constructing a source encoder is to arrange the messages in the order of decreasing probability and dividing the message into two almost equal probable groups. The messages in the first group are assigned the bit '0' and the messages in the second group are assigned the bit '1'. The procedure is repeated until no further division is possible. Using this algorithm find the code words for six messages with probabilities $\frac{1}{3},\frac{1}{3},\frac{1}{6},\frac{1}{12},\frac{1}{24},\frac{1}{24}$. **(06 Marks)**

5 a. Explain the term mutual information and state the properties. **(05 Marks)**

b. For an ideal system obtain an expression for plotting the bandwidth-efficiency diagram. Comment on the characteristic. **(08 Marks)**

c. A BSC has an error probability of 0.1. Find its capacities after deriving relevant relation. **(06 Marks)**

6 a. State and explain the channel encoding theorem. **(04 Marks)**

b. Explain the principle of linear block codes for error detection and correction. **(04 Marks)**

c. Consider a (7, 4) linear code whose generator matrix is G,

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

Find: i) All the code vectors of this code
ii) Parity check matrix of this code
iii) The minimum weight of this code. **(12 Marks)**

7 a. Explain the principle and design of binary cyclic codes. **(10 Marks)**

b. A (15, 5) linear cyclic code has a generator polynomial $g(x) = 1+x+x^2+x^4+x^5+x^8+x^{10}$
i) Draw the block diagram of an encoder and syndrome calculator for this code.
ii) Find the code polynomial for the message polynomial $D(x) = (1+x^2+x^4)$.
iii) Find the syndrome of $V(x) = 1+x^4+x^6+x^8+x^{14}$, is V(x) a code polynomial or not? **(10 Marks)**

8 Write explanatory note on the following:

a. Code tree and state diagram for convolution code. **(12 Marks)**

b. Viterbi algorithm. **(08 Marks)**

*****

EC63

USN

NEW SCHEME

Sixth Semester B.E. Degree Examination, July 2007
Electronics and Communication Engineering
Information Theory and Coding

Time: 3 hrs.] [Max. Marks:100

Note : ***Answer any FIVE full questions.***

1 a. Define: i) Self-information ii) Rate of source iii) Entropy of source, with an example. **(06 Marks)**

b. Markoff source is shown below: **(10 Marks)**

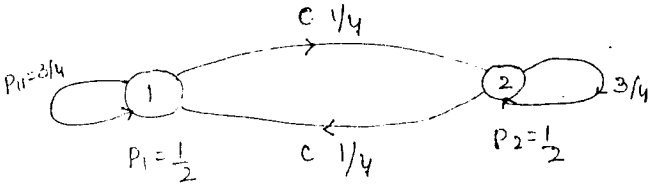


Fig. Q1 (b)

Calculate i) Entropy of source.
ii) Draw tree diagram, for 3 symbol sequences.
iii) Calculate probabilities of messages of length 1, 2 and 3.
iv) Information content of messages of length two.
v) Average information content per symbol in messages of length two.

c. Compare advantages and disadvantages of fixed length codes and variable length codes. **(04 Marks)**

2 a. From the table below, identify prefix codes, instantaneous codes and uniquely decodable codes and give reasons. **(10 Marks)**

Symbols	Code – 1	Code – 2	Code – 3	Code – 4	Code – 5
S_1	00	0	0	0	0
S_2	01	100	10	100	10
S_3	10	110	110	110	110
S_4	11	111	111	11	11

b. Explain how do you test for instantaneous property. **(02 Marks)**

c. Prove that $\underset{n\to\infty}{Lim}\frac{L_n}{n} = H_r(s)$

Where L_n - average length of code for n-order source.

$H_r(s)$ - Entropy of n^{th} extension of source. **(06 Marks)**

d. Define binary symmetric channel and write its channel matrix. **(02 Marks)**

3 a. The source emits messages consisting of 2 symbols each, as per table given below. Design a source encoder using Shannon encoding algorithm and find code efficiency and redundancy. **(08 Marks)**

Symbol	AA	AC	CC	CB	CA	BC	BB
Probability	9/32	3/32	1/16	3/32	3/32	3/32	9/32

b. A discrete memoryless channel is shown below symbols are transmitted every second. Calculate the capacity of this channel in terms of P. **(12 Marks)**

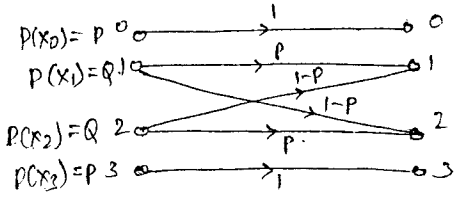


Fig. Q3 (b)

Contd....2

4 a. State Shannon Hartley law and its implications with examples for each. **(08 Marks)**

b. Derive expression for Shannon's limit for $\left(\frac{Eb}{\eta}\right)_{\infty}$ parameter illustrating with Bandwidth – efficiency diagram. Explain this graph of Bandwidth – efficiency. **(12 Marks)**

5 a. State the properties of mutual information. **(04 Marks)**

b. Prove that I (X; Y) ≥ 0. **(05 Marks)**

c. For a given JPM, compute H(X), H(Y), H(X, Y), H(X/Y), H(Y/X) and I(X, Y). Verify relationships among these entropies. **(11 Marks)**

$$P(X,Y)=\begin{bmatrix}0.05 & 0 & 0.20 & 0.05\\ 0 & 0.10 & 0.10 & 0\\ 0 & 0 & 0.20 & 0.10\\ 0.05 & 0.05 & 0 & 0.10\end{bmatrix}$$

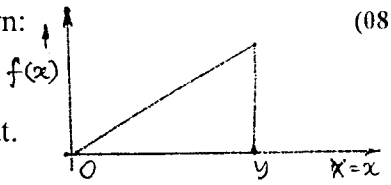
6 a. Prove that channel capacity of a BSC with r_s = 1 msg symbol / second is equal to (1-h) where $h=\sum_{j=1}^{n} p_j \log\frac{1}{p_j}$. **(08 Marks)**

b. Explain continuous channels and how they are dealt with. **(04 Marks)**

c. A continuous random variable has PDF as shown: **(08 Marks)**

i) Determine entropy of source.

ii) If signal is passed through a linear amplifier if gain = 16, find entropy at output.



7 a. If C is a valid code – vector, then prove that $CH^T = 0$ where H^T is transpose of parity check matrix H. **(06 Marks)**

b. For a systematic (6,3) linear block code, $P=\begin{bmatrix}1 & 0 & 1\\ 0 & 1 & 1\\ 1 & 1 & 0\end{bmatrix}$. Find all possible code-vectors. **(06 Marks)**

c. For systematic (6, 3) code with $P=\begin{bmatrix}1 & 0 & 1\\ 0 & 1 & 1\\ 1 & 1 & 0\end{bmatrix}$ the received vector $R=[110010]$. Detect and correct the single error that occurred due to noise. Draw its syndrome calculation grant. **(08 Marks)**

8 a. Consider a (6, 3) linear code whose $G=\begin{bmatrix}1 & 0 & 0 & 1 & 0 & 1\\ 0 & 1 & 0 & 1 & 1 & 0\\ 0 & 0 & 1 & 0 & 1 & 1\end{bmatrix}$

i) Find all code vectors. ii) Find all Hamming weights and distances.

iii) Find minimum weight parity check matrix.

iv) Draw encoder current for above codes. **(10 Marks)**

b. A (15, 5) linear cyclic code has generator polynomial

$g(x)=1+x+x^2+x^4+x^5+x^8+x^{10}$

i) Draw block diagram of encoder and syndrome calculator.

ii) Find code polynomial for message symbol,

$D(x)=1+x^2+x^4$ in systematic form.

iii) Is $\gamma(x)=1+x^4+x^6+x^8+x^{14}$ a code polynomial? **(10 Marks)**

*****

USN | | | | | | | | | | |

EC63

Sixth Semester B.E. Degree Examination, Dec. 07 / Jan. 08
Information Theory and Coding

Time: 3 hrs. Max. Marks:100

Note : ***Answer any FIVE full questions.***

1 a. How is information content of a message measured? Comment on the information content of the following messages :
   i) Tomorrow the sun will rise from the East.
   ii) It will show in Bangalore this winter.
   iii) The phone will ring in the next one hour. **(10 Marks)**

   b. Consider a discrete memoryless source 'C' that outputs two bits at a time. This source comprises two binary sources 'A' and 'B' whose outputs are equally likely to occur and each source contributing one bit. Suppose that the two sources within the source 'C' are independent. What is the information content of each output from the source C? **(06 Marks)**

   c. Consider a binary source which tosses a fair coin and outputs a '1' if a head appears and a '0' if a tail appears. What is the information content of each output from the source? Now, suppose that the source is memory less. What then is the self-information of an m-bit lock from the source? **(04 Marks)**

2 a. Define a Markoff information source. An information source that can remain in one of two states has following property :
   If it is in state-1 during a particular symbol interval having emitted a symbol 'A', then it switches to the second state emitting a symbol 'C' in the following symbol interval with a probability of 0.2. On the other hand, if it is in the second state during a particular symbol interval by emitting a symbol 'B', then the probability that it will go to the first state during the following symbol interval by emitting a symbol 'C' is 0.7. The probability that the system is in state-1 at the beginning of a symbol interval is just as likely as the probability that system is in the second state at the beginning of the symbol interval. Illustrate the above information source in a graph form with your comments in brief. **(07 Marks)**

   b. Design a source encoder using Shannon's encoding algorithm for the information source given below for N = 3.

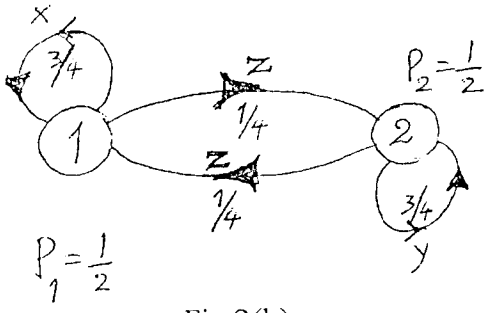


Fig.2(b) **(13 Marks)**

3 a. Which part of a practical communication system is characterized as a data communication channel? What type of channel is the above? Illustrate the above channel by a schematic. **(06 Marks)**

   b. What is a binary symmetric channel? Determine the rate of information transmission over the channel. **(10 Marks)**

   c. Evaluate the capacity of a binary symmetric channel and give the plot of the channel capacity versus the average probability of error 'P' for the independent errors in the transmitted binary sequence caused by the noise in the channel. **(04 Marks)**

4 a. What is a discrete memortyless source? Evaluate the entropy of a binary memoryless source and comment on the variation of the entropy as a function of the symbol probability. (06 Marks)

b. What do you mean by "data compaction" as used in signal processing and what is the outcome of the above operation? (04 Marks)

c. Consider a DMS with three symbols x_i, i = 1, 2, 3 and their respective probabilities P_1 = 0.5, P_2 = 0.3 and P_3 = 0.2. Encode the source symbols using the Huffman encoding algorithm and compute the efficiency of the code suggested. Now group together the symbols, two at a time, and again apply the Huffman encoding algorithm to find the code words. Compute the efficiency of this code. How can the coding efficiency be improved? (10 Marks)

5 a. Consider a binary symmetric channel as shown in the Fig. 5(a). Let the input symbols be equally likely

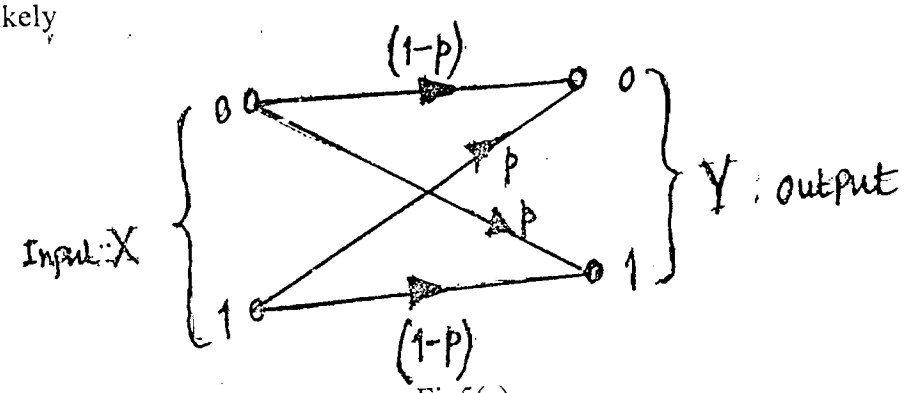


Fig5(a)

i) If the mutual information between x_i and y_j(i = j =0,1) is defined as :

$$I(x_i;y_j) = \log_2\left[\frac{P\left(x_i/y_j\right)}{P(x_i)}\right]$$

Determine I(0;0) and I(1;0).

ii) Suppose the channel is an ideal one, what will be I(0;0) and what do you conclude from the result obtained? (10 Marks)

b. Define the term 'differential entropy' of a continuous random variable 'X'. If the probability density function of a random variable 'X' is

$$f_x(x) = \begin{cases} 1/a, & 0 < x < a \\ 0, & \text{otherwise} \end{cases}$$

Find the differential entropy of 'X'. What do you understand from the result obtained as compared to the entropy of a discrete random variable? (06 Marks)

c. Write a brief note on mutual information between a pair of continuous random variables X and Y. (04 Marks)

6 a. What is a block code? The code 'C' is a block code. Where C = {00000, 10100, 11110, 11001} what is the size of the alphabet presented to the block encoder and which are the uncoded bits of each alphabet? Suppose we have to transmit sequence of 1's and 0's using the above coding scheme, what then is the corresponding code word if the sequence to be encoded is 1001010011...? Comment on the bit redundancy. (06 Marks)

b. For a (7,4) linear block code the generator matrix is given by :

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

Write the parity check matrix. What is the minimum distance for this code? (05 Marks)

c. State and prove the following theorems valid for a linear block code :
   i) Theorem on the minimum distance of a linear block code.
   ii) Theorem on the number of errors which the code can correct and the number of errors which can be detected. (09 Marks)

7 a. Write the scheme of an (n – k) stage shift register encoder, used for an (n, k) binary cyclic code. What are the steps involved in the encoding operation and what are the hardware requirements for implementing the encoding scheme furnished? (10 Marks)

b. Consider the (15, 11) cyclic code generated by, $g(X) = 1 + X + X^4$.
   i) Device a FB registers encoder for this code.
   ii) Illustrate the encoding procedure with the message vector 11001101011 by listing the states of the register (The rightmost bit is the earliest bit) (10 Marks)

8 a. An encoder for a (3, 1) convolutional code is shown in the Fig.8(a), explain the operation of the encoder for an input message sequence of 10110 (take the left most bit as the first bit sent to the encoder)

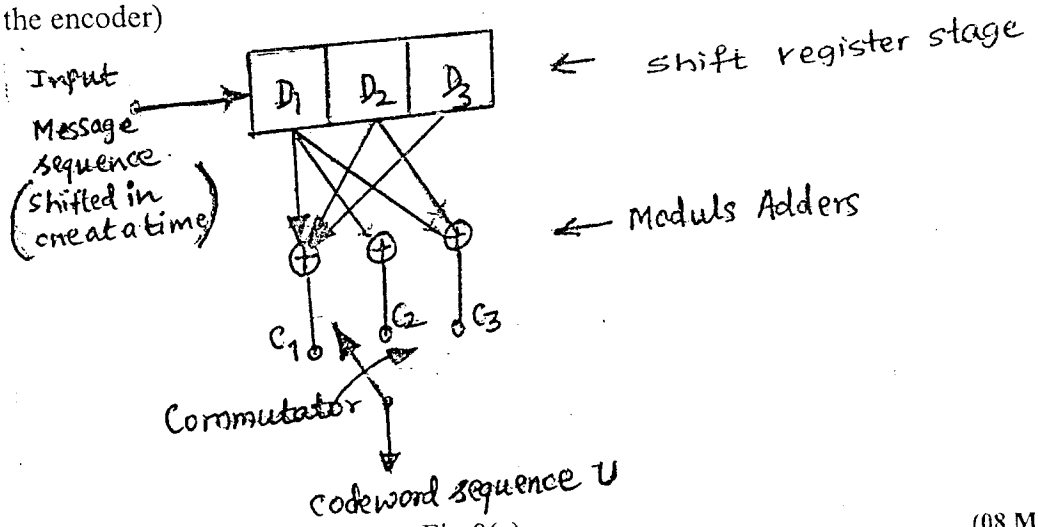


Fig 8(a) (08 Marks)

b. What is viterbi algorithm? For an L – bit message sequence, and an encoder of memory M, how does the algorithm proceed? Comment on the advantage and disadvantage of the viterbi algorithm. (08 Marks)

c. Write a brief note on shortened cyclic code. (04 Marks)

*****

USN | | | | | | | | | | |

06EC65

Sixth Semester B.E. Degree Examination, June-July 2009
Information Theory and Coding

Time: 3 hrs. Max. Marks:100

Note:1. ***Answer any FIVE full questions, selecting at least TWO questions from each part.***
2. Missing data may be suitably assumed.

PART – A

1 a. Find an expression for average information content of symbols in long independent sequences. **(03 Marks)**

b. A source produces symbols A, B, C with equal probabilities at a rate of 100/sec. Due to noise on the channel, the probabilities of correct reception of the various symbols are as shown in Table Q1 (b).

		y_j		
	P(j/i)	A	B	C
x_i	A	3/4	1/4	0
	B	1/4	1/2	1/4
	C	0	1/4	3/4

Table Q1 (b)

Determine the rate at which information is being transmitted. **(07 Marks)**

c. For the second order Markov source Figure Q1 (c) with binary source alphabet (s = 0, 1), find: i) State probabilities. ii) Entropy of each state. iii) Entropy of source. iv) Show that $G_1 > G_2 > H(s)$. **(10 Marks)**

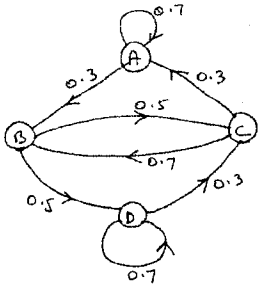


Fig. Q1 (c)

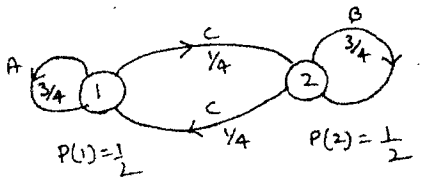


Fig. Q2 (b)

2 a. Explain the steps in the Shannon's Encoding algorithm for generating binary code. **(04 Marks)**

b. Using Shannon's encoding algorithm find the binary code for symbols of length 1 and 2 (i.e. N = 1&2) generated by the information source given in figure Q2 (b). Also compute the average number of bits/symbol and efficiency of the codes for both cases. **(10 Marks)**

c. For the entropy of a zero memory source, prove the extremal property. **(06 Marks)**

3 a. A non symmetric binary channel shown in figure Q3 (a) has a symbol rate of 1000 symbols/sec.

i) Find H(X), H(Y), H(X, Y), H(X/Y), H(Y/X), I(XY). Take P(X=0)=1/4, P(X=1)=3/4, $\alpha = 0.75$, $\beta = 0.9$.

ii) Find the capacity of channel for case (i).

iii) Find the capacity of the binary symmetric channel when $\alpha=\beta=0.75$. **(10 Marks)**

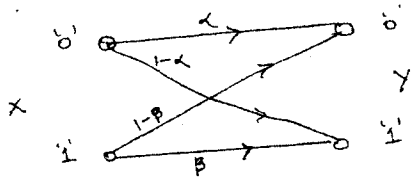


Fig. Q3 (a)

b. Explain mutual information. Find an expression for mutual information in terms of joint probability, probabilities of input and output symbols. **(05 Marks)**

c. Show that mutual information is always positive. **(05 Marks)**

4 a. State and prove Shannon-Hartley law. Derive an expression for the upper limit on channel capacity as bandwidth tends to ∞. **(08 Marks)**

b. Two independent random variables x and y have density functions f(x) and f(y) as shown in Figure Q4 (b).

Fig. Q4 (b)

i) Find the entropy of each signal and the joint entropy.

ii) If the signals are overlapped find f(x, y) and the joint entropy. **(04 Marks)**

c. The output of a DMS consist of letters x_1, x_2, x_3 with probabilities 0.45, 0.35, 0.20 respectively.

i) Compute the Huffman code for this source and also find code efficiency and variance.

ii) If pairs of letter are encoded, compute the Huffman code, code efficiency and variance. **(08 Marks)**

PART – B

5 a. Explain the need and meaning of error control coding. **(05 Marks)**

b. For a linear block code with generator matrix G and parity check matrix H, prove that $GH^T = 0$ in systematic format. **(05 Marks)**

c. For a systematic (6, 3) linear block code the parity matrix, $[P]=\begin{bmatrix}1 & 0 & 1\\ 0 & 1 & 1\\ 1 & 1 & 0\end{bmatrix}$

i) Find all possible code vectors.

ii) Find the minimum weight of the code.

iii) Find the parity check matrix.

iv) For a received code vector R = 1 1 1 1 0 1 detect and correct the error that has occurred due to noise. **(10 Marks)**

6 a. Define cyclic code. Explain how cyclic codes are generated from the generating polynomials. **(06 Marks)**

b. The generator polynomial for a (7, 4) binary cyclic code is $g(x)=1+x+x^3$

i) Find the code vector in systematic form for a message vector 1 1 0 0.

ii) Design an encoder for the above and verify its operation for message vector 1 1 0 0. **(14 Marks)**

7 Consider a (3, 1, 2) convolutional code with $g^{(1)} = 110$, $g^{(2)} = 101$, $g^{(3)} = 111$.

a. Draw the encoder block diagram.

b. Find the generator matrix.

c. Find the code word corresponding to the information sequence (1 1 1 0 0) using time domain and transform domain approach.

d. Draw the state table.

e. Draw the state diagram.

f. Draw the code tree and find encoder output for message sequence (1 1 1 0 0) **(20 Marks)**

8 Write short notes on:

a. RS codes. b. Golay codes. c. Shortened cyclic codes. d. Burst error correcting codes. **(20 Marks)**

* * * * *

USN | | | | | | | | | | |

06EC65

Sixth Semester BE Degree Examination, Dec.09-Jan.10
Information Theory and Coding

Time: 3 hrs. Max. Marks:100

Note: *1. Answer any FIVE full questions, selecting at least TWO questions from each part.*

PART – A

1 a. A source consists of six symbols with probabilities as given below:

$S = \{S_1, S_2, S_3, S_4, S_5, S_6\}$

$P = \left\{\frac{1}{3}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}, \frac{1}{12}, \frac{1}{12}\right\}$

Obtain Huffman i) Binary ; ii) Trinary and iii) Quaternary coding. Find the efficiency and redundancy in each case. **(12 Marks)**

b. Which of the following sets of word lengths are acceptable for the existence of an instantaneous code, given x = {0, 1, 2},Table Q1(b). **(08 Marks)**

Table 1(b).

Number of words of word length l_k			Word length l_k
Code A	Code B	Code C	
2	2	1	1
1	2	4	2
2	2	6	3
4	3	0	4
1	1	0	5

2 a. Explain the properties of entropy and obtain an expression for maximum entropy of a system. **(10 Marks)**

b. Design a system to report the heading of a collection of 400 cars. The heading levels are: heading straight (s), turning left (L) and turning right (R). This information is to be transmitted every second. Construct a model based on the test data given below.

i) On the average during a given reporting interval, 200 cars were heading straight, 100 were turning left and remaining were turning right.

ii) Out of 200 cars that reported heading straight, 100 of them reported going straight during the next reporting period. 50 of them turning left and remaining turning right during the next period.

iii) Out of 100 cars that reported as turning during a signalling period. 50 of them continued their turn and remaining headed straight during the next reporting period.

iv) The dynamics of the cars did not allow them to change their heading from left to right or right to left during subsequent reporting periods.

I) Find the entropy of each state ; II) Find the entropy of the system ; III) Find the rate of transmission. **(10 Marks)**

3 a. With suitable example explain the properties of code. **(06 Marks)**

b. State and explain kraft inequality. **(04 Marks)**

c. For the channel matrix shown in Table 3(c). Find H(A), H(B), H(AB), H(A/B), H(B/A) and I(AB). **(10 Marks)**

Table 3(c).

$$P[AB] = \begin{bmatrix} 0.1 & 0.05 & 0.06 & 0.04 \\ 0.02 & 0.1 & 0.05 & 0.1 \\ 0.1 & 0.05 & 0.02 & 0.01 \\ 0.1 & 0.1 & 0.05 & 0.05 \end{bmatrix}$$

4 a. What is binary erasure channel? Obtain an expression for the channel capacity of the binary erasure channel. **(06 Marks)**

b. State and explain Shannon – Hartley law and derive an expression for maximum capacity of a noisy channel. **(10 Marks)**

c. A Gaussian channel has a bandwidth of 4 kHz and a two sided noise power spectral density $\frac{n}{2} = 10^{-14}$ watts / Hz. Signal power at the receiver has to be maintained at a level less than or equal to 0.1 milli watt. Calculate the capacity of the channel. **(04 Marks)**

PART – B

5 a. Design a linear block code with a minimum distance of three and a message block size of eight bits. **(08 Marks)**

b. In a linear block code the syndrome is given by :

$S_1 = r_1 + r_2 + r_3 + r_5$

$S_2 = r_1 + r_2 + r_4 + r_6$

$S_3 = r_1 + r_3 + r_4 + r_7$

Find :

i) Generator matrix [G] ; ii) Parity check matrix [H]

iii) Write encoder and decoder circuit ; iv) Find the code word for all the messages

v) How many errors it can detect and correct ; vi) Write the standard array.

ii) Find the syndrome for the received data 1011 011. **(12 Marks)**

6 a. In a (15.5) cyclic code the generator polynomial is given by $g(x) = 1 + x + x^2 + x^4 + x^5 + x^8 + x^{10}$.

i) Write the block diagram of encoder and decoder.

ii) Find the codeword for the message 10101

iii) If the received data is 100010101000001 is it a valid code? **(10 Marks)**

b. In a (7.4) binary cyclic code the generator polynomial is given by $g(x) = 1 + x + x^3$. Find the codeword for messages (1001) and (1011). Show the contents of registers at each step. **(10 Marks)**

7 a. For the (3, 2, 1) convolution encoder shown in Fig.7(a). Find the codeword for the input sequence u = [110110], using

i) Time domain approach ; ii) Transfer domain approach ; iii) Using generator matrix. **(10 Marks)**

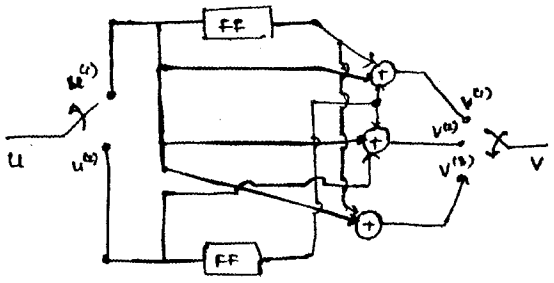


Fig.7(a)

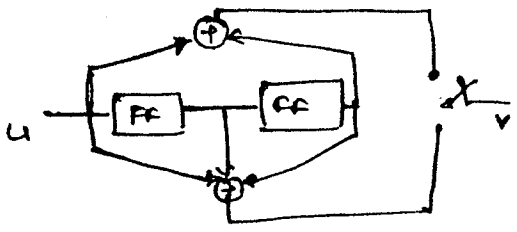


Fig.7(b)

b. For the convolution encoder shown in Fig.7(b)

i) Find the code rate and constraint length

ii) Write tree, state and trellis diagram. **(10 Marks)**

8 Write short notes on:

a. R.S codes b. Shortened cyclic code

c. Burst error correcting codes d. Golay codes. **(20 Marks)**

* * * * *

USN | | | | | | | | | | |

06EC65

Sixth Semester B.E. Degree Examination, May/June 2010
Information Theory and Coding

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. A binary source is emitting an independent sequence of 0's and 1's with the probabilities P and (1 – P) respectively. Plot the entropy of the source versus probability [0 < P < 1]. Write the conclusion. **(04 Marks)**

b. In a facsimile transmission of picture there are about 3.25×10^6 pixels per frame. For a good reproduction, 15 brightness levels are necessary. Assume all these levels are equally likely to occur. Find the rate of information transmission if one picture is to be transmitted every 3 minutes. **(05 Marks)**

c. The state diagram of the Mark off source is as shown in the Fig.Q1(c). P(state i) = $\frac{1}{3}$ for i = 1, 2, 3. Find : i) the entropy of each state Hi, ii) the entropy of source H, iii) G_1, G_2 and H. **(11 Marks)**

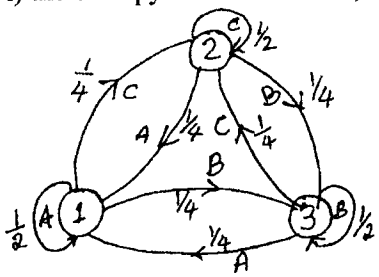


Fig.Q1(c)

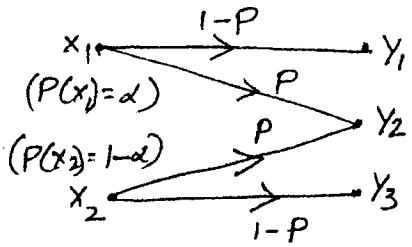


Fig.Q3(b)

2 a. What are the important properties of codes while encoding a source? **(05 Marks)**

b. A source emits an independent sequence of symbols from an alphabet consisting of five symbols A, B, C, D and E with probabilities of $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{8}$, $\frac{3}{16}$ and $\frac{5}{16}$ respectively. Find the Shannon code for each symbol and efficiency and redundancy of the coding scheme. **(06 Marks)**

c. For a channel whose matrix is given below for which $P(x_1) = \frac{1}{2}$, $P(x_2) = P(x_3) = \frac{1}{4}$ and r_s = 10000/sec, find H(x), H(y), $H\left(\frac{y}{x}\right)$, H(x, y), I(x, y) and the capacity.

$$P\left[\frac{y}{x}\right] = \begin{bmatrix} 0.8 & 0.2 & 0 \\ 0.1 & 0.8 & 0.1 \\ 0 & 0.2 & 0.8 \end{bmatrix}$$

(09 Marks)

3 a. Design a quaternary and binary source code for the source shown, using Huffman's coding scheme.

$S = \{S_1, S_2, S_3, S_4, S_5, S_6, S_7\}$; $P = \left\{\frac{9}{32}, \frac{3}{32}, \frac{3}{32}, \frac{2}{32}, \frac{9}{32}, \frac{3}{32}, \frac{3}{32}\right\}$; $X = \{0, 1, 2, 3\}$ and $X = \|0, 1\|$. Find the coding efficiency. **(12 Marks)**

b. For a binary erasure channel shown in Fig.Q3(b), find the following:

i) Average mutual information
ii) Channel capacity
iii) Values of $P(x_1)$ and $P(x_2)$ for maximum mutual information. **(08 Marks)**

4 a. State and explain Shannon Hartley law. Derive the expression for the upper limit of the channel capacity. **(06 Marks)**

b. A voice grade channel of the telephone network has the bandwidth of 3.4 KHz. Calculate:
i) The channel capacity for a SNR of 30 dB
ii) The minimum SNR required to support information transmission at the rate of 4800 bits/sec. **(06 Marks)**

c. Show that : i) $I(x, y) \geq 0$; ii) $I(x, y) = (y, x)$; iii) $I(x, y) = H(x) + H(y) - H(x, y)$. **(08 Marks)**

PART – B

5 a. Consider the (7, 4) LBC whose generator matrix is given below. Find:
i) All code vectors ii) Parity check matrix, H
iii) The minimum weight and distance of this code.

$$[G] = \begin{bmatrix} 1000 & 101 \\ 0100 & 111 \\ 0010 & 110 \\ 0001 & 011 \end{bmatrix}$$ **(10 Marks)**

b. Prove that $CH^T = 0$. **(04 Marks)**

c. Why do we need error control coding? What are the types of errors and types of coding to combat them? **(06 Marks)**

6 a. A (15, 5) linear cyclic code has a generator polynomial, $g(x) = 1 \oplus x \oplus x^2 \oplus x^4 \oplus x^5 \oplus x^8 \oplus x^{10}$.
i) Draw block diagrams of an encoder and syndrome calculator circuit for this code.
ii) Find the code polynomial for the message polynomial $D(x) = 1 \oplus x^2 \oplus x^4$ (in a systematic form).
iii) Is $V(x) = 1 \oplus x^4 \oplus x^6 \oplus x^8 \oplus x^{14}$ a code polynomial? If not, find the syndrome of V(x). **(12 Marks)**

b. What is a binary cyclic code? Discuss the features of encoder and decoder used for cyclic codes using an (n – k) bit shift register. **(08 Marks)**

7 a. Explain briefly the following: **(09 Marks)**
i) Golay code ii) BCH code
iii) Shortened cyclic code iv) Reed Solomon code.

b. Consider a [15, 9] cyclic code generated by $g(x) = 1 \oplus x^3 \oplus x^4 \oplus x^5 \oplus x^6$. Find the burst error correcting efficiency of this code. **(06 Marks)**

c. List the advantages and disadvantages of cyclic codes. **(05 Marks)**

8 Fig.Q8 below shows the convolutional encoder:

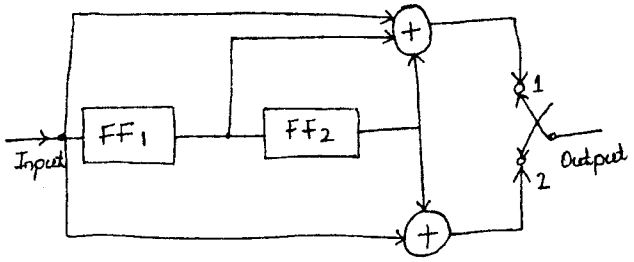


Fig.Q8

a. Write the impulse response of this encoder. **(03 Marks)**

b. Find the output for the message (10011) using time domain approach. **(05 Marks)**

c. Find the output for the message (10011) using transform domain approach. **(05 Marks)**

d. Draw the code tree for the encoder. **(07 Marks)**

* * * * *