EC/TE6T1

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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)**

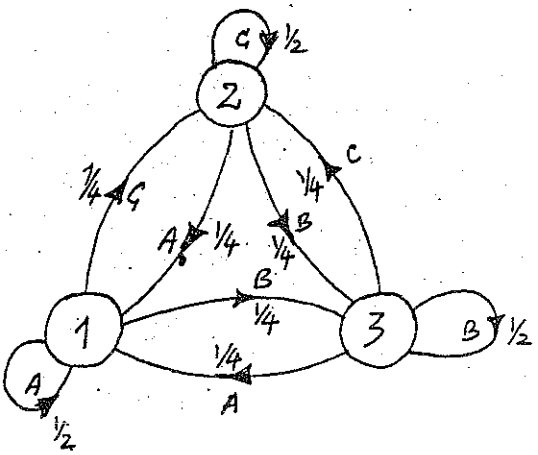
(b) The state diagram of a stationary Markoff source is shown in the figure 2(b).

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:

$$I(X;Y) = I(Y;X)$$ **(6 Marks)**

(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)**

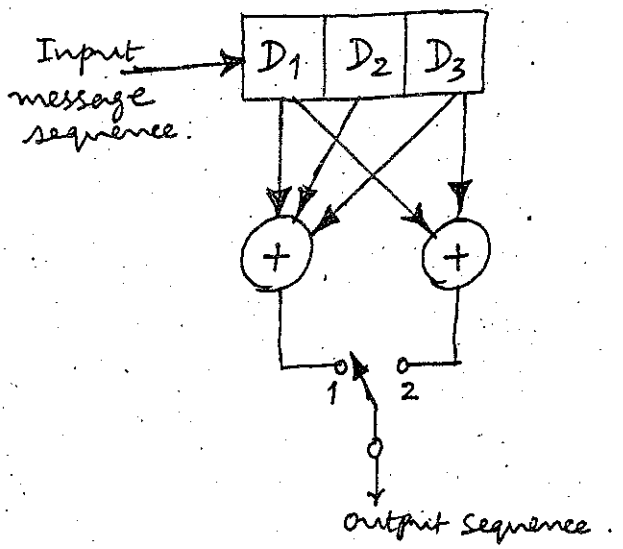
(b) Consider the (15, 11) cyclic code generated by $g(x) = 1 + X + X^4$

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)**

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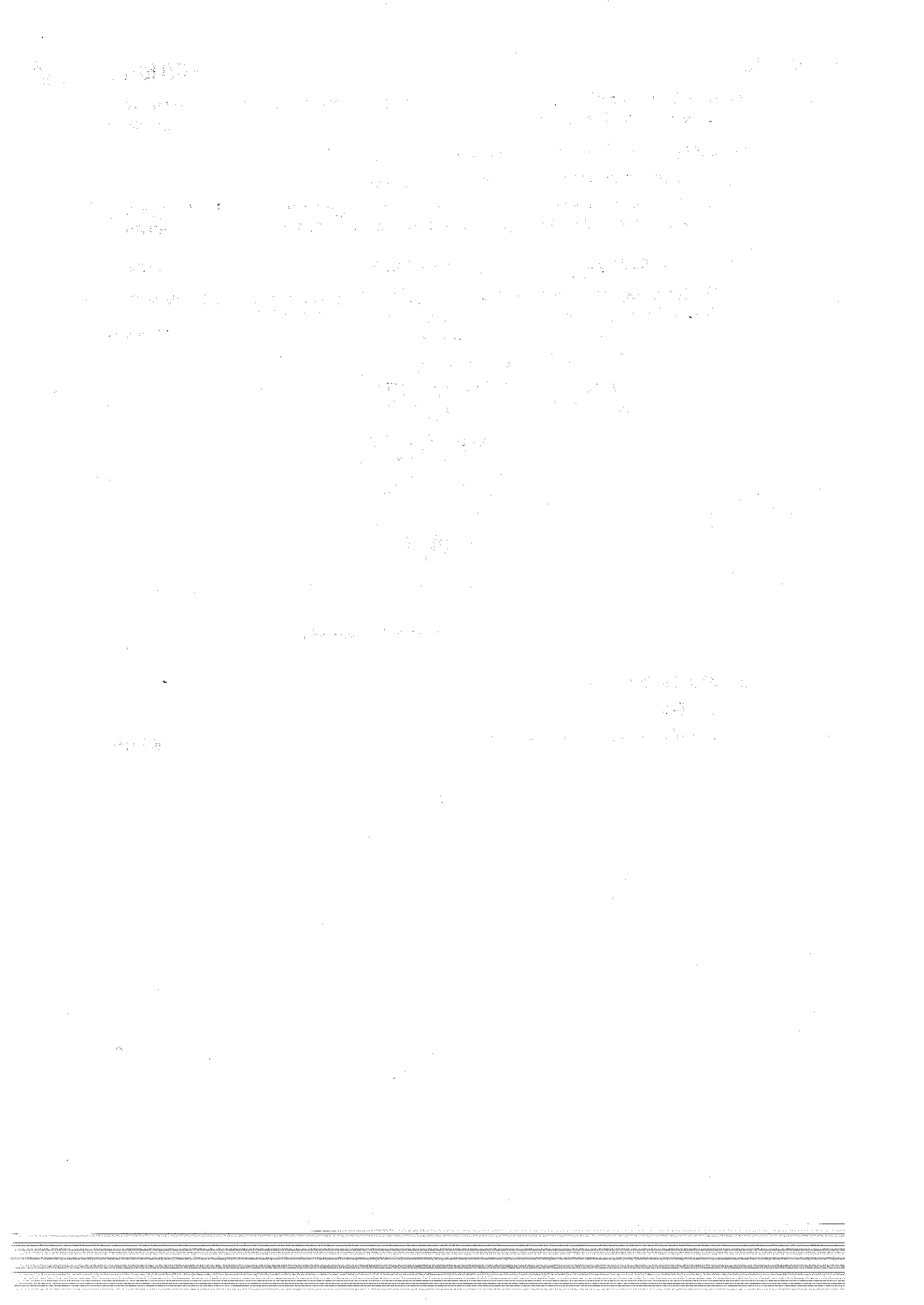

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Sixth Semester B.E. Degree Examination, July/August 2004

Electronics and Communication /Telecommunications Engineering

Information Theory & Coding

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

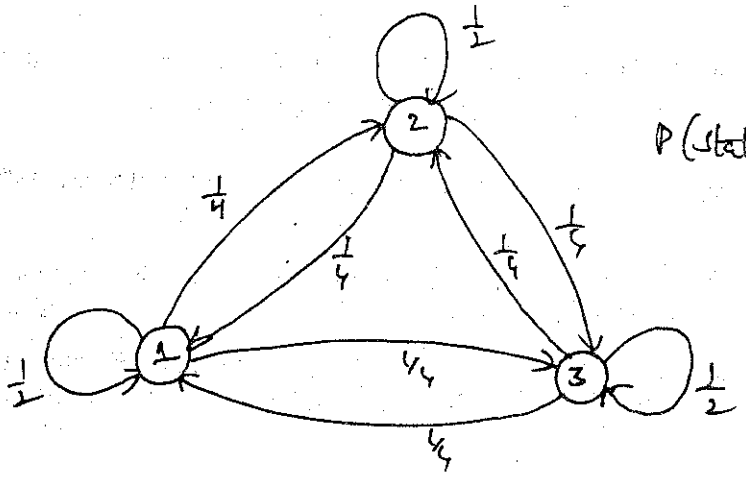
Note: *1. Answer any FIVE full questions.*
2. Normal distribution table can be used.

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 probabililties 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 $i = 1, 2, 3$

$i = 1, 2, 3$

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 alphabet consisting of five symbols A, B, C, D and E with probabilities of $\frac{1}{4}, \frac{1}{8}, \frac{1}{8}, \frac{3}{16}$ & $\frac{5}{16}$ 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

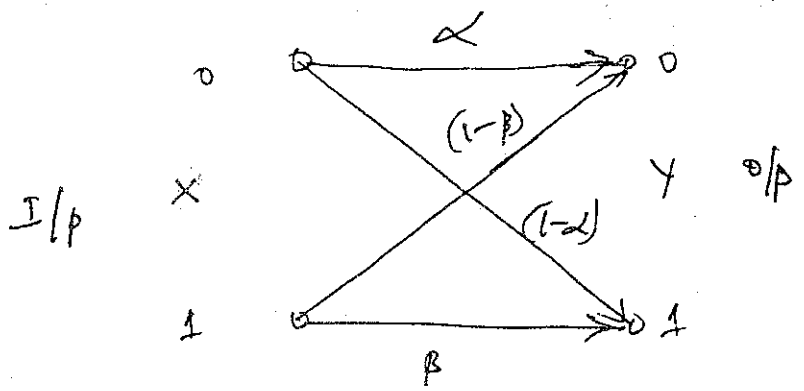
i) Apply Huffman binary coding procedure for the source and find the average length of the codeword.

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

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

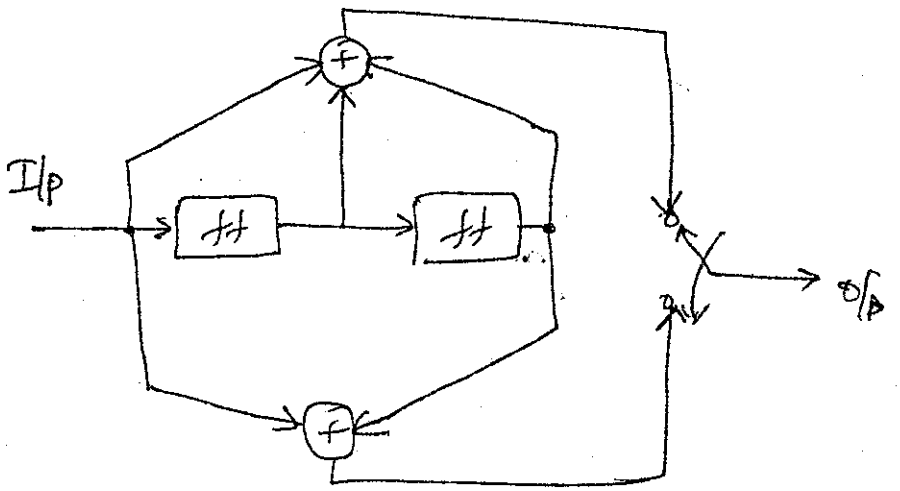
i) Draw the block diagram of encoder and syndrome calculator.

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)

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Sixth Semester B.E. Degree Examination, July/August 2005

Electronics and Communication /Telecommunications Engineering

Information Theory and Coding

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

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

1. (a) Explain why the logarithmic function is used to define a measure of information. Find the information content of a message that consists of a digital word 12 digits long in which each digit may take on one of four possible levels. The probability of sending any of the four levels is assumed to be equal, and the level in any digit does not depend on the values taken on by previous digits. **(6 Marks)**

(b) What is a Markoff information source? What is the use of the tree diagram representation for such a source? Define the terms Entropy and information rate of Markoff sources. **(6 Marks)**

(c) Suppose that it is required to design a system that provides the attitude of the 70 outgoing E and C engineering students of an institute of engineering in the year 2004. The attitude is to be quantised into three levels :

Going for a PG program in a foreign university (F),
Going for a job in a dream company in India (D),
Going for a job in any company (C).

Based on their attitude in the following year given below, construct a first order Markoff model for the source and calculate the entropy

i) 40 students were under category G, 15 students were under category D and 15 students went for category F with assistantship.

ii) Out of 40 students who went for job under C during the said year, 20 of them on the average continued in C during the next year and 10 of them went for a PG program under F and the remaining went for a job in a dream company.

iii) On the average, out of 20 students who were going for a PG program and a dream company, during the next year 10 of them continued in the same direction in the next year and the remaining moved in the direction of acquiring a job in an Indian company in the next year.

iv) For those students under category (ii) and (iii), the administrative policies donot permit them to change from a dream company to a PG programme or from a PG pogramme to a dream company during subsequent years. **(8 Marks)**

2. (a) What is a discrete communication channel? Illustrate the model of a discrete channel. When do you say that the channel is memoryless? Deduce the equation for P(error) for such a channel. **(9 Marks)**

Contd.... 2

NEW SCHEME

EC63

Reg. No.

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

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

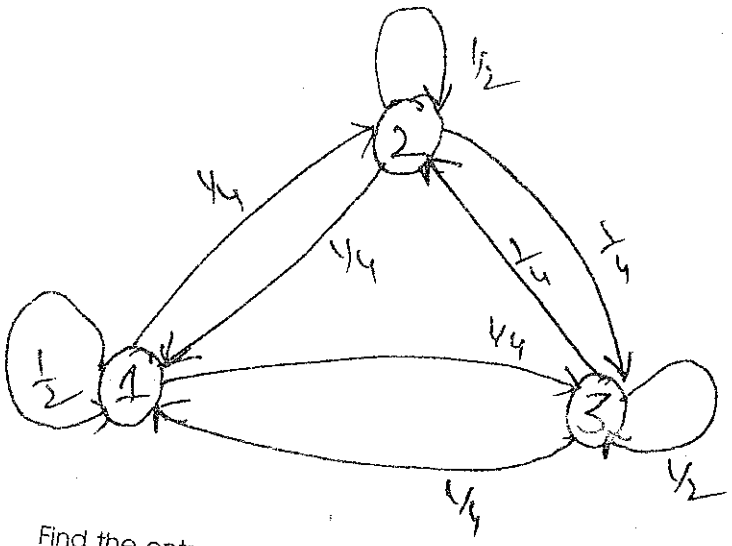
Note: *Answer any FIVE full questions.*

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. (a) The state diagram of a Marleov source is given below : **(2+1+2 Marks)**



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

(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 Mark

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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)**

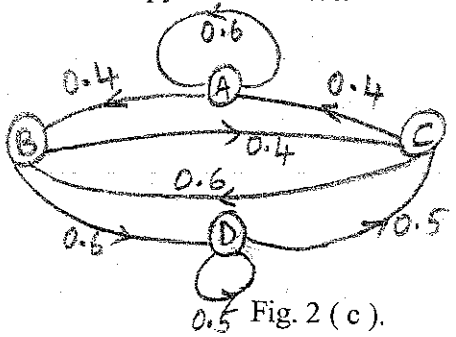

Fig. 2 (c).

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

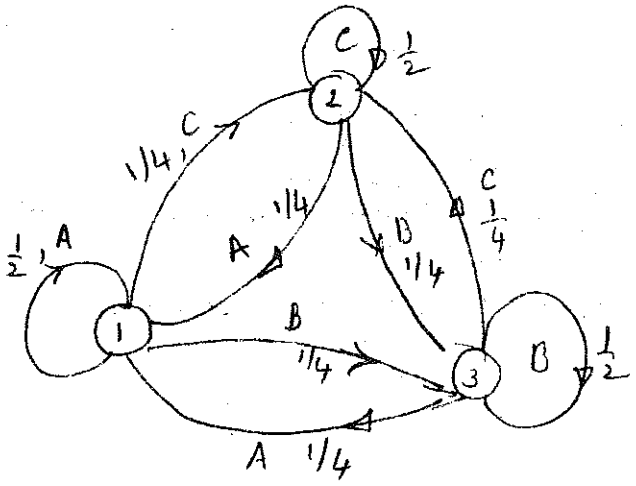

Fig.4(b)

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. **(06 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)**

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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.***

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)**

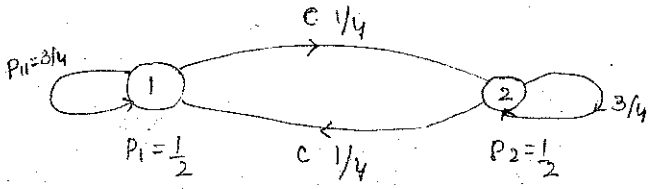


Fig. Q1 (b)

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)**

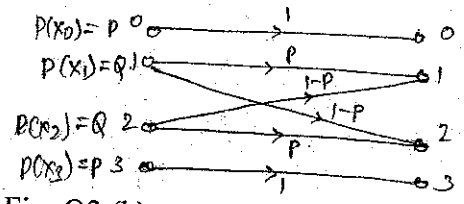


Fig. Q3 (b)

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)**

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)**

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 $I(X; Y) \geq 0$. **(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)**

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

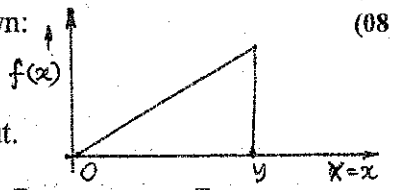
6 a. Prove that channel capacity of a BSC with r_s = 1 msg symbol / second is equal to (1-h) where $h=\sum_{j=1}^{n} p_j \log\frac{1}{p_j}$. **(08 Marks)**

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)**

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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.

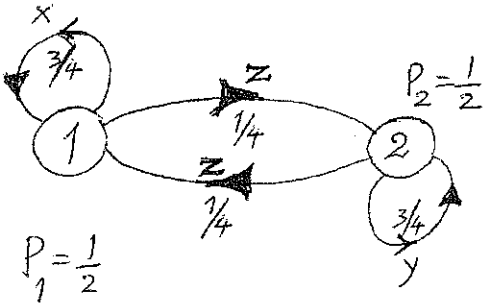

Fig.2(b) **(13 Marks)**

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)**

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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)**

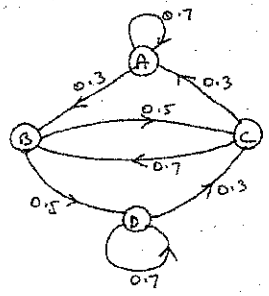

Fig. Q1 (c)

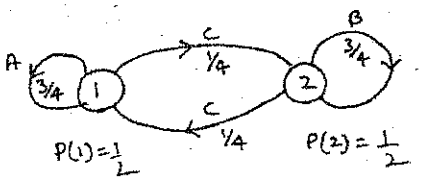

Fig. Q2 (b)

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)**

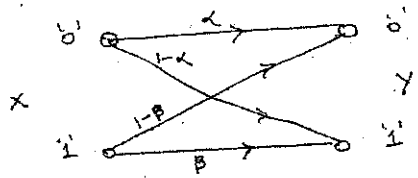

Fig. Q3 (a)

b. Explain mutual information. Find an expression for mutual information in terms of probability, probabilities of input and output symbols. (05 M
c. Show that mutual information is always positive. (05 M

4 a. State and prove Shannon-Hartley law. Derive an expression for the upper limit on cha capacity as bandwidth tends to ∞. (08 Ma
b. Two independent random variables x and y have density functions f(x) and f(y) as show Figure Q4 (b).

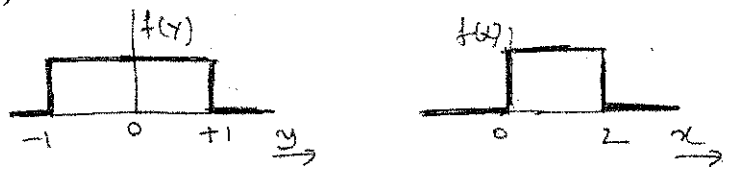

Fig. Q4 (b)

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 Ma
c. The output of a DMS consist of letters x_1, x_2, x_3 with probabilities 0.45, 0.35, (respectively.
i) Compute the Huffman code for this source and also find code efficiency and varian
ii) If pairs of letter are encoded, compute the Huffman code, code efficiency variance. (08 Mar

PART – B

5 a. Explain the need and meaning of error control coding. (05 Mar
b. For a linear block code with generator matrix G and parity check matrix H, prove t $GH^T = 0$ in systematic format. (05 Mar
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 h occurred due to noise. (10 Marl

6 a. Define cyclic code. Explain how cyclic codes are generated from the generati polynomials. (06 Mark
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 Mark

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 doma 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 Mark

8 Write short notes on:
a. RS codes. b. Golay codes. c. Shortened cyclic codes. d. Burst error correcting code (20 Marks

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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 bi erasure channel. (06 M

b. State and explain Shannon – Hartley law and derive an expression for maximum capaci a noisy channel. (10 M

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

PART – B

5 a. Design a linear block code with a minimum distance of three and a message block siz eight bits. (08 Ma

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 Ma

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 Ma

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

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

i) Time domain approach ; ii) Transfer domain approach ; iii) Using generator mat (10 Ma

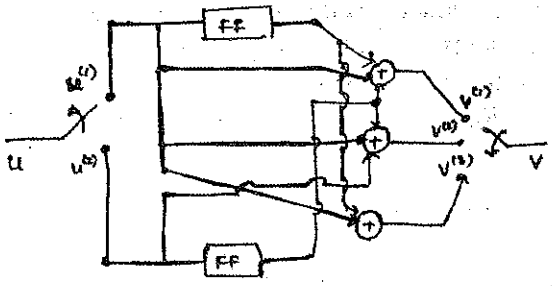

Fig.7(a)

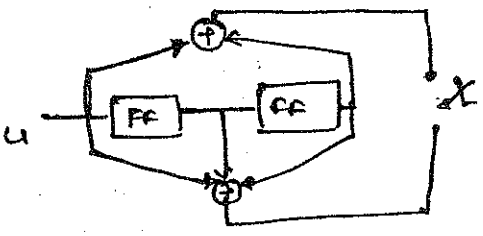

Fig.7(b)

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 Mar

8 Write short notes on:

a. R.S codes b. Shortened cyclic code

c. Burst error correcting codes d. Golay codes. (20 Mar

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2002 SCHEME

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EC63

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

Time: 3 hrs. Max. Marks:100

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

1 a. Justify that the self – information content of a message is a logarithmic function of its probability of emission. **(06 Marks)**

b. Derive an expression for source entropy of long independent sequences and hence define the rate of information, source efficiency and source redundancy. **(07 Marks)**

c. The International Morse Code uses a sequence of symbols of dots and dashes to transmit letters of English alphabet. The dash is represented by a current pulse of duration 3 units and dot one unit. The probability of dash is $1/3^{rd}$ of probability of occurrence of dot.
   i) Calculate information content of dot and dash
   ii) Average information content in dot-dash code
   iii) Assume that dot lasts one milliseconds which is the same time interval as pause between the symbols. Find the rate of information transmission. **(07 Marks)**

2 a. Explain the statistical properties of Markov Sources. **(06 Marks)**

b. The state diagram of a Markov source is shown in Fig.2(b)
   i) Find the state probabilities
   ii) Find the entropy of the state H_i
   iii) Find the entropy of the first order source H(S)
   iv) Find G_1, G_2 and verify that $G_1 \geq G_2 \geq H(S)$
   v) Efficiency of first and second order sources. **(10 Marks)**

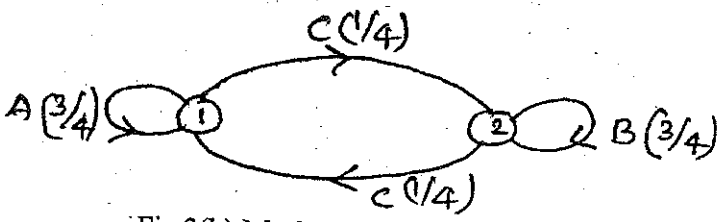

Fig.2(b) Markov Source for Q.2(b).

c. Briefly explain Shannon Encoding Algorithm. **(04 Marks)**

3 a. A source emits a independent sequence of symbols from an alphabet consisting of 5 symbols A, B, C, D and E with probabilities 1/4. 1/8, 1/8, 3/16 and 5/16 respectively. Find the code using Shannon Fano Algorithm for each symbol and efficiency of the coding scheme. **(06 Marks)**

b. Given is a memory less source of source alphabet S = $\{s_1, s_2, s_3, s_4, s_5\}$ and probability statistics P = {0.4, 0.2, 0.2, 0.1, 0.1}. Determine Huffman Code by
   i) Shifting the combined symbol as high as possible
   ii) Shifting the combined symbol as low as possible
   Find coding efficiency and variance of both the codes. **(10 Marks)**

c. For the following prefix code write the decision tree and decode the binary message 010111110010.. into symbol sequence. **(04 Marks)**

S_1	1
S_2	01
S_3	001
S_4	000

4 a. Explain with a neat block diagram the digital communication system indicating the various types of communication channels. Also define the various probabilities and their relationships with respect to coding channel. **(08 Marks)**

b. The input to the channel consists of 5 letters $X = \{x_1, x_2, x_3, x_4, x_5\}$ and output consists of 4 letters $Y = \{y_1, y_2, y_3, y_4\}$. The JPM of this channel is given in Fig.4(b).

	y_1	y_2	y_3	y_4
x_1	0.25	0	0	0
x_2	0.1	0.3	0	0
x_3	0	0.05	0.1	0
x_4	0	0	0.05	0.1
x_5	0	0	0.05	0

i) Compute H(X), H(Y), H(XY), H(Y/X), H(X/Y)

ii) Rate of data transmission and Mutual information

iii) Channel Capacity, Channel Efficiency and Redundancy. **(12 Marks**

5 a. Derive an expression for channel capacity of a Binary Erasure Channel. **(06 Marks**

b. Explain Shannon Hartley Theorem and show that $\lim_{B \to \infty} C = 1.44\, S/\eta$. **(08 Marks**

c. A CRT terminal is used to enter alphanumeric data into a computer. The CRT is connecte through a voice grade telephone line having usable bandwidth of 3 KHz and an output (S/N of 10 dB. Assume that the terminal has 128 characters and data is sent in an independer manner with equal probability.

i) Find the average information per character.

ii) Find channel capacity

iii) Find the maximum rate at which the data can be sent from terminal to comput without error. **(06 Mark**

6 a. Explain matrix representation of Liner Block Codes. **(06 Mark**

b. Consider a (6, 3) linear block code whose generator matrix is

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

i) Find all code vectors

ii) Find all the Hamming weights and distances

iii) Find minimum weight

iv) Find minimum distance

v) Parity check matrix

vi) Draw the encoder circuit for the above codes **(06 Mark**

c. Design a single error correcting code with a message block size of 11 and show that it c correct single error by an example. **(08 Mark**

7 a. A (15, 5) linear cyclic code has a generator polynomial $g(x) = 1 + x + x^2 + x^4 + x^5 + x^8 + x$

i) Draw encoder block diagram

ii) Find Code polynomial for message polynomial $d(x) = 1 + x^2 + x^4$ in systematic form

iii) Is $V(x) = 1 + x^4 + x^6 + x^8 + x^{14}$ a code polynomial? If not find the syndrome of v(**(12 Mark**

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

i) Write the syndrome circuit

ii) Verify the circuit for the message polynomial $d(x) = 1 + x^3$. **(08 Mark**

8 Write short notes on the following:

a. Convolution Codes b. Golay Codes

c. BCH Codes d. Reed Solomon Codes **(20 Mar**

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