Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech/CSE/NEW/SEM-6/CS-604A/2013

2013

INFORMATION THEORY AND CODING

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) The binary symbols 0 and 1 are transmitted with probabilities $\frac{1}{4}$ and $\frac{3}{4}$ respectively. The corresponding self information are

   a) 2 bits & 0.415 bits b) 0 & 1 bits

   c) 1 & 0 bits d) 0 & 0 bits.

   ii) A source $X = \{ x_1, x_2, x_3 \}$ emits symbols with $P = \left\{ \frac{1}{2}, \frac{1}{4}, \frac{1}{4} \right\}$ The total information of all the messages is

   a) 2 bits b) 3 bits

   c) 4 bits d) 5 bits.

iii) A Gaussian channel has a 10 MHz bandwidth of $S/N = 100$. The channel capacity is

a) 66.59×10^6 bits/s

b) 77.60×10^6 bits/s

c) 55.48×10^7 bits/s

d) 44.37×10^6 bits/s.

iv) Which of the following statements is true regarding the Hamming weight of a code word ?

a) It is the total number of elements in the code words.

b) It is the total number of zero elements in the code words.

c) It is the total number of non-zero elements in the code words.

d) None of these.

v) A Linear Block Code will always contain

a) a negative code word.

b) all zero code word.

c) all one code word.

d) variable length individual code words.

vi) A monic polynomial means

a) its leading term coefficient is unity.

b) it is having all non-zero coefficients.

c) it is having degree one.

d) at least one coefficient of it is zero.

vii) Which of the following statements is true regarding the cyclic code '*C*' ?

a) '*C*' always contains variable length codes.

b) '*C*' is also a linear code.

c) '*C*' will not contain all one code word.

d) '*C*' will not contain all zero code word.

viii) The minimum distance of a RS code is

a) $n + k + 1$ b) $n - k + 1$

c) $n + k - 1$ d) $n - k - 1$.

ix) A primitive polynomial is a/an

a) odd polynomial b) even polynomial

c) prime polynomial d) none of these.

x) The constraint length of a shift register encoder is defined as

a) the number of symbols input

b) the number of symbols it can store in its memory

c) the number of symbols output

d) none of these.

xi) A (n, k) convolutional code has the word length

a) $k = (m - 1) k_0$ b) $k = (1 - m) k_0$

c) $k = (m + 1) k_0$ d) none of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Define the efficiency of a prefix code. Calculate the efficiency of a source X which generates four symbols with probabilities $P(x_1) = 0.5$, $P(x_2) = 0.2$, $P(x_3) = 0.2$ and $P(x_4) = 0.1$. 2 + 3

3. Discuss some of the properties for a linear block code. What do you mean by Hamming Distance ? 3 + 2

4. What are the properties for a cyclic code ? Explain with example. Write one polynomial representing binary cyclic codes. 3 + 2

5. Consider a convolutional encoder described by its Generator Polynomial Matrix, defined over GF (2) :

$$G(D) = \begin{bmatrix} D & O & 1 & D^2 & D + D^2 \\ D^2 & 0 & 0 & 1 + D & 0 \\ 1 & 0 & D^2 & 0 & D^2 \end{bmatrix}$$

   i) Draw the circuit realization of this encoder using shift registers. What is the value of v ? 2 + 1

   ii) Is this a Catastrophic Code ? Why ? 2

6. Find the generator polynomial $g(x)$ for a double error correcting ternary BCH code of block length 8. What is the code rate of the code ?

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Discuss the Matrix representation of a (3, 2) Linear Block Code using your own chosen Generator Matrix. 5

   b) Briefly discuss the idea of Parity Check Matrix for the Linear Block Code. 5

   c) Explain the 'Nearest Neighbour Decoding' concept for the Linear Block Code. 5

8. a) Write down the division algorithm for the polynomials. Consider the two polynomials $f(x) = 1 + x^2$ and $g(x) = 1 + x + x^2$ over GF (2), now calculate $f(x) + g(x)$. 3 + 2

   b) Discuss a method for generating Cyclic Codes with suitable example. 5

   c) Let $f(x)$ is a polynomial in $f[x]$. Now discuss the reducibility or factorization concept of $f(x)$. Give suitable example to justify your answer. 5

9. a) State and prove the theorem on Kraft inequality. 5

b) Consider a DMS with source probabilities { 0.35, 0.25, 0.20, 0.15, 0.05 }.

i) Determine the Huffman code for this source. 5

ii) Determine the average length R of the code words. 3

iii) What is the efficiency η of the code ? 2

10. a) Define channel capacity. 2

b) State and prove channel capacity theorem. 1 + 5

c) Explain the importance of Shanon limit. 3

d) A telephone channel has a bandwidth of 3000 Hz and the SNR = 20 dB. Determine the channel capacity. If the SNR is increased to 25 dB, determine the increased capacity. 2 + 2

11. Design a (12, 3) systematic convolutional encoder with a constraint length $v = 3$ and $d^* >= 8$.

i) Construct the Trellis Diagram for this encoder. 7

ii) What is the d_{free} for this code ? 8