INFORMATION THEORY & CODING
(INFO 2111)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The capacity of a binary symmetric channel, given H(P) is binary entropy function is:

(a) 1 - H(P) (b) H(P) – 1
(c) $1 - H(P)^2$ (d) $H(P)^2 - 1$

(ii) For the generation of a cyclic code, the generator polynomial should be the factor of _____

(a) $x^n + 1$ (b) $x^n - 1$
(c) $x^n /2$ (d) $x^{2n/3}$

(iii) In a linear code, the minimum Hamming distance between any two code words is ______minimum weight of any non-zero code word.

(a) less than (b) greater than
(c) equal to (d) not equal

(iv) If the channel bandwidth is 6 kHz & signal to noise ratio is 16, what would be the capacity of the channel?

(a) 15.15 kbps (b) 24.74 kbps
(c) 30.12 kbps (d) 52.18 kbps

(v) Which among the below stated logical circuits are present in encoder and decoder used for the implementation of cyclic codes?

A. Shift Registers
B. Modulo-2 Adders
C. Counters
D. Multiplexers

(a) A & B (b) C & D
(c) A & C (d) B & D

(vi) In Repetition Code, how many information bit/s is/are present in addition to n-1 parity bits?
(a) One (b) Two (c) Four (d) Eight

(vii) For BCH code if the received vector and the computed vector are r(x) and e(x) respectively, then the error free code vector is_______.
(a) r(x) *e(x) (b) r(x)/e(x)
(c) r(x) + e(x) (d) None of these.

(viii) For GF (23) the elements in the set are:
(a) { 1, 2, 3, 4, 5, 6, 7 } (b) { 0,1, 2, 3, 4, 5, 6 }
(c) { 0, 1, 2, 3 } (d) { 0, 1, 2, 3, 4, 5, 6, 7 }

(ix) The syndrome polynomial in a cyclic code solely depends on_________.
(a) generator polynomial (b) parity polynomial
(c) error polynomial (d) code word

(x) Which is not a field element of the polynomial, $p(x) = x^5 + x^2 + 1$ in GF (2^6)?
(a) $\alpha^3 + \alpha$ (b) $\alpha^4 + \alpha^2$ (c) $\alpha^4 + 1$ (d) $\alpha^3 + \alpha + 1$

Group – B

2. Consider that two sources S1 and S2 emit message x1, x2, x3 and y1, y2, y3 with joint probability P(X, Y) as shown in the matrix form.

$$P(X,Y) = \begin{pmatrix} \frac{3}{40} & \frac{1}{40} & \frac{1}{40} \\ \frac{1}{20} & \frac{3}{20} & \frac{1}{20} \\ \frac{1}{8} & \frac{1}{8} & \frac{3}{8} \end{pmatrix}$$

Calculate the entropies H(X), H(Y), H(X, Y), H(X/Y), H (Y/X) and I(X; Y).

(6 × 2) = 12

3. A discrete memory less source X has seven symbols x_1, x_2, x_3, x_4, x_5, x_6 and x_7 with probabilities $p(x_1) = 0.125$, $p(x_2) = 0.0625$, $p(x_3) = 0.25$, $p(x_4) = 0.0625$, $p(x_5) = 0.125$, $p(x_6) = 0.125$ and $p(x_7) = 0.25$. Find the codeword for X using Huffman encoding, and calculate the efficiency of the code.

12

Group – C

4. For (7, 4) Hamming code, H is given below:

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

i. Find the generator matrix.
ii. Find all the code vectors.

iii. Draw the encoder circuit.
iv. What is the d_{min} between the code vectors?
v. How many errors can be detected? How many errors can be corrected?
vi. Calculate syndrome vector for single bit errors.

(6 × 2) = 12

5. (a) Determine the encoded message for data message 100110111001 using CRC generator polynomial $g(x) = x^4 + x^2 + 1$.

(b) Prove that:
(i) $CH^T = 0$ where C is a valid code word and H is the parity check matrix.
(ii) Syndrome is independent of the codeword.

6 + (2 × 3) = 12

Group – D

6. (a) Find the Minimal Polynomial for the field element α^5 in GF (2^3). Use the primitive polynomial $p(x) = x^3 + x + 1$ to construct GF (2^3).

(b) A codeword c(x) of the (15, 5) triple error correcting BCH code incurs errors so as to give $v(x) = x^{13} + x^{10} + x^8 + x^4 + x + 1$. Find the error location polynomial using Reed Solomon Code.

5 + 7 = 12

7. (a) Find the generator polynomial g(x) for a single error correcting binary BCH code of block length 15 over GF (16). Use primitive polynomial $p(x) = x^4+x+1$.

(b) Find (a) $\alpha^7 + \alpha^{11} + \alpha^9$ (b) $\alpha^5 + \alpha^8 + \alpha^{13}$ ·(c) $\alpha^{11} + \alpha^3 + \alpha$ in $GF(2^4)$.

6 + 6 = 12

Group – E

8. A rate 1/3 convolutional coder with constraint length of 3 uses the generating vectors: $g_i^1 = \{1, 0, 0\}$, $g_i^2 = \{1, 1, 1\}$ and $g_i^3 = \{1, 0, 1\}$.
i. Draw the code tree, state diagram and Trellis diagram.
ii. Encode the message m= {10110} using code tree.

(6 + 2 + 2) + 2 =12

9. A rate 1/3 convolutional coder with constraint length of 3 uses the generating vectors $g_i^1 = \{1, 0, 0\}$, $g_i^2 = \{1, 0, 1\}$ and $g_i^3 = \{1, 1, 1\}$.
i. Draw the encoder circuit.
ii. Draw the state diagram for the coder.
iii. Determine the d_{free} of the coder.

(2 + 4 + 6) = 12

Department & Section	Submission Link
IT	https://classroom.google.com/c/MTI1OTk2ODMyMDcz/a/Mjc0NTQ2MTAzMjgw/details