B.TECH/IT/3RD SEM/INFO 2111/2021

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) If I1 is the information carried by message m1 and I2 is the information carried by message m2, then how much amount of information is carried compositely by m1 and m2?
(a) I1 * I2 (b) I1 + I2
(c) I1 - I2 (d) I1 / I2

(ii) The entropy of the source is 0.256 bits/message. Which of the following is true?
(a) 2nd order entropy will be 0.456 bits/message
(b) 3rd order entropy will be 0.512 bits/message
(c) 2nd order entropy will be 0.512 bits/message
(d) 3rd order entropy will be 0.556 bits/message.

(iii) Which of the following statement is not true for variable length coding?
(a) It utilizes the channel inefficiently.
(b) All messages are encoded into variable length codeword.
(c) Output data rate varies continuously.
(d) None of the above.

(iv) Which of the following is true?
(a) $I(X; Y) \leq 0$ (b) $I(X; Y) \neq I(Y; X)$
(c) $I(X; Y) = H(X) - H(Y|X)$ (d) $I(X; Y) \geq 0$

(v) In GF(5), the additive group integer set is {0, 1, 2, 3, 4}. The inverse of element 4 is _____.
(a) 4 (b) 3
(c) 2 (d) 1

(vi) In GF(5), $\frac{1}{4} - \frac{2}{3} =$ _____.
(a) 1 (b) 0
(c) 2 (d) 4

(vii) The t correcting Reed-Soloman code has the minimum distance of _____ symbols.
(a) 2t (b) 2t + 1
(c) (2t + 1)/2 (d) t + 1

(viii) A source emits 40 distinct symbols. The maximum entropy of the source is generated when probabilities are _____.
(a) 1/32 (b) 1/40
(c) 1/64 (d) none of the above.

(ix) In binary source, 0s occur three times as often as 1s. What is the information contained in the 1s?
(a) 4 (b) 3
(c) 2 (d) 1

(x) Two discrete independent sources S1 and S2 have 8 and 16 equally likely messages respectively. Which of the following statement is correct if we compared the sources in terms of entropy?
(a) S1 = S2 (b) S1 < S2
(c) S1 ≥ S2 (d) Depends on rate of symbols.

Group- B

2. (a) What do you mean by code efficiency? [(CO3) (Remember/LOCQ)]
(b) Construct the Huffman tree for the symbols with occurrence probabilities {0.2, 0.25, 0.065, 0.12, 0.115, 0.125, 0.062, 0.063} and also determine the code redundancy and code efficiency. [(CO3) (Apply/IOCQ)]

2 + (7 + 1 + 2) = 12

3. (a) A discrete memory-less source emits six messages with probabilities {0.4, 0.2, 0.2,0.1, 0.1}. Apply the Shannon – Fano – Elias technique to encode the messages and determine its efficiency. [(CO1) (Apply/IOCQ)]
(b) How is mutual information related with relative entropy? [(CO1) (Understand/LOCQ)]
(c) If X and Y are discrete random sources and P(X,Y) is their joint probability distribution given as

P(X, Y)	Y			
X	0.08	0.05	0.02	0.05
	0.15	0.07	0.01	0.12
	0.10	0.06	0.05	0.04
	0.01	0.12	0.01	0.06

Calculate H(X), H(Y), H(X/Y), H(Y/X), H(X, Y) and I(X, Y). [(CO1) (Apply/IOCQ)]

5 + 2 + 5 = 12

Group - C

4. Select the appropriate combination of (n, k) of the cyclic code generated by the following generator polynomials where n ≤ 7.

(i) $g(x) = x^4 + x^3 + x^2 + x + 1$
(ii) $g(x) = x^3 + x^2 + 1$. [(CO2) (Evaluate/HOCQ)]

(6 + 6) = 12

5. (a) What do you mean by hamming distance and burst length? [(CO4) (Remember/LOCQ)]
   (b) In an LBC, the syndrome is given by
   S1 = r1 + r2 + r3 + r5
   S2 = r1 + r2 + r4 + r6
   S3 = r1 + r3 + r4 + r7
   (i) Find the parity check matrix.
   (ii) Draw the encoder circuit.
   (iii) How many errors it can detect and correct?
   (iv) What is the syndrome for the received codeword 1011011?
   [(CO4) (Apply/IOCQ)]

2 + (2 + 2 + 3 + 3) = 12

Group - D

6. (a) Find out irreducible polynomials of degree 2 in GF(3). [(CO6) (Apply/IOCQ)]
   (b) Construct the addition and multiplication table on GF(4). [(CO6) (Apply/IOCQ)]
   (c) In GF(7), calculate $\frac{1}{4} - \frac{3}{5} + 2 - \frac{1}{6}$. [(CO6)(Apply/IOCQ)]

5 + 4 + 3 = 12

7. (a) Compare the BCH codes and Cyclic codes. [(CO6) (Understand/LOCQ)]
   (b) Find the generator polynomial g(x) for a triple error correcting binary BCH code of block length 31 over GF (2^5). Use primitive polynomial $p(x) = x^5+x^2+1$. [(CO6) (Apply/IOCQ)]

3 + 9 = 12

Group - E

8. Construct a (2, 1, 2) convolutional encoder with the feedback polynomials as $g_1(X)=1+X+X^2$ and $g_2(X)= 1+X^2$. Draw the code tree and trace output for input sequence 10011. [(CO5) (Apply/IOCQ)]

(3 + 7 + 2) = 12

9. (a) What do you mean by free distance? [(CO5) (Remember/LOCQ)]
   (b) Construct a (2, 1, 3) convolutional encoder with [1, 0, 1, 1] and [1, 1, 1, 1] as the impulse responses. Find the output of the convolutional encoder for input sequence 11011 using time and transform domain approach. [(CO5)(Apply/IOCQ)]

2 + (2 + 4 + 4) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	11.45%	76.04%	12.51%

Course Outcome (CO):

After the completion of the course students will be able to

1. Derive equations for entropy, mutual information and channel capacity for all types of channels.
2. Compare among different types of error correcting codes.
3. Evaluate the channel performance using Information theory.
4. Formulate the basic equations of linear block codes.
5. Apply convolution codes for performance analysis.
6. Design BCH code for Channel performance improvement.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question

Department & Section	Submission Link
IT	https://classroom.google.com/c/NDAwODkyNDc5OTg2/a/NDY1NzA3NjQyODQy/details