



CRAWFORD UNIVERSITY, FAITH CITY IGBESA
COLLEGE OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF COMPUTER AND MATHEMATICAL SCIENCES
SEMESTER: HARMATTAN **SESSION: 2021/2022**
COURSE CODE: ICT 319 **TITLE: COMMUNICATION AND INFORMATION THEORY**
UNITS: 3 **DURATION: 2.5 HOURS**

INSTRUCTION: ANSWER ANY FOUR QUESTIONS

QUESTION ONE (15 MARKS)

- (A) Define the following:
- i. Communication (2mrks)
 - ii. Information theory (2mrks)
 - iii. Entropy (H)(2mrks)
- (B) (i) Discuss the properties of Entropy in Information Theory (3mrks)
(ii) Describe the basic principles of wave transmission (6mrks)

QUESTION TWO (15 MARKS)

- (A) (i) Describe a general communication system. Explain the functions of each component (5mrks)
(ii) What is Self Information (I)? (2mrks)
(iii) Discuss the properties of Self Information (3mrks)
- (B) (i) According to Shannon's Noisy-Channel Coding Theorem, under what conditions is error-free transmission possible? (2mrks)
(ii) Consider a pack of 32 playing cards, one of which is drawn at random. Calculate the amount of uncertainty of the event $E = \{\text{the card drawn is the king of hearts}\}$. Interpret the result. (3mrks)

QUESTION THREE (15 MARKS)

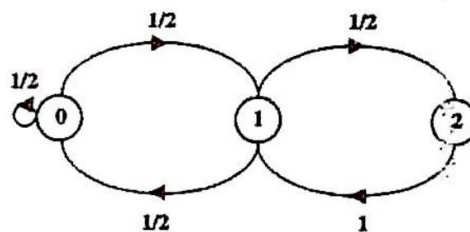
- (A) (i) What is mutual information $I(X;Y)$? (3mrks)
(ii) Identify the properties of mutual information (4mrks)
(iii) Describe with an illustrated diagram the relations between entropy, conditional entropy, joint entropy, and mutual information (3mrks)
- (B) Let $p(x, y)$ be given by:

	Y	
		0 1
X		
0		$\frac{1}{3}$ $\frac{1}{3}$
1		0 $\frac{1}{4}$

- (i) $H(X), H(Y)$ (1mrk) (ii) $H(X|Y), H(Y|X)$ (1mrk) (iii) $H(X;Y)$ (1mrks)
(iv) $H(Y)-H(Y|X)$ (1mrk) (v) $I(X;Y)$ (1mrk)

QUESTION FOUR (15 MARKS)

- (A) (i) Given a Markov chain U taking on values in $\{0, 1, 2\}$ whose transition graph is sketched below:



Derive the transition Matrix and obtain the entropy per symbol of source $U, H_\infty(U)$. (5mrks)

- (B) (i) Consider $C = \{10, 11, 000, 101, 111, 1100, 1101\}$. Show that the code satisfies Kraft's inequality (2mrks)
 (ii) Obtain the prefix code for C (in B (i)) above. (4mrks).
 (iii) What is the chain rule for entropy? (2mrks)
 (iv) Define Relative Entropy (2mrks)

QUESTION FIVE (15 MARKS)

- (A) Let X and Y represent random variables with associated probability distributions $p(x)$ and $p(y)$, respectively. They are not independent. Their conditional probability distributions are $p(x|y)$ and $p(y|x)$, and their joint probability distribution is $p(x, y)$.
- (i) What is the entropy $H(X)$ of variable X , and what is the mutual information of X with itself? (2mrk)
 (ii) In terms of the probability distributions, what are the conditional entropies $H(X|Y)$ and $H(Y|X)$? (2mrks)
 (iii) What is the joint entropy $H(X, Y)$, and what would it be if the random variables X and Y were independent? (1mrk)
 (iv) Give an alternative expression for $H(Y) - H(Y|X)$ in terms of the joint entropy and both marginal entropies. (1mrk)
 (v) What is the mutual information $I(X; Y)$? (1mrk)
- (B) (i) What is Noise in communication? Discuss the types of Noise that can occur (4mrks)
 (ii) Define the following, obtaining expressions where necessary:
- Noise Factor (2mrks)
 - Antenna Gain (2mrks)

QUESTION SIX (15 MARKS)

- (A) Given U as a memoryless source taking values in: $\{A, B, C, D, E, F, G\}$, with the probabilities $\{0.4, 0.2, 0.15, 0.1, 0.05, 0.05, 0.05\}$ respectively.
- (i) What is the entropy of source U ? (3mrks)
 (ii) Show how the data can be compressed using both Shannon-Fano and Huffman algorithms. (4mrks)
- (B) (i) Discuss Transmission impairments in communication (5mrks)
 (ii) Briefly discuss three (3) possible techniques used to correct errors in wave propagation (3mrks)

*checked version
 Calculation in
 12/02/2022*