



UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA
FIRST SEMESTER EXAMINATIONS, MAY, 2019

COURSE NO: CE 472
COURSE NAME: INFORMATION THEORY
CLASS: CE IV **TIME:** 3 HRS

Name: _____ Index Number: _____

Answer all questions in Section A and any other two in Section B. Circle your answers in Section A.

1. Self information should be
 - a. Neutral
 - b. Negative
 - c. Positive
 - d. Positive and Negative
2. Following is not a unit of information
 - a. Hz
 - b. nat
 - c. bit
 - d. decit
3. The channel capacity of a noise free channel having M symbols is given by
 - a. $\log M$
 - b. 2
 - c. M
 - d. None
4. Binary Huffman coding is a
 - a. Suffix Condition Coding
 - b. Prefix and Suffix Condition Coding
 - c. Condition Coding
 - d. Prefix Condition Coding
5. When X and Y are statistically independent, then $I(x,y)$ is
 - a. 0
 - b. 1
 - c. $\ln 2$
 - d. None of the above
6. Entropy represents
 - a. Information Signal
 - b. Amplitude of Information
 - c. Average Information per Message
 - d. All of the above
7. Coded system are inherently capable of better transmission efficiency than the uncoded system
 - a. True
 - b. False
8. The channel capacity is a measure

- a. Entropy rate
b. Maximum rate of information a channel can handle
- c. Information contents of messages transmitted in a channel
d. None of the above
9. The probability of a message is 1/16. The information in bits is
- a. 1 bit
b. 2 bits
c. 3 bits
d. 4 bits
10. The channel Capacity is
- a. Bandwidth of the demand
b. Amount of Information per second
c. Noise rate in the demand
d. None of the above
11. The probability density function of a Markov process is
- a. $p(x_1, x_2, x_3, \dots, x_n) = p(x_1)p(x_2/x_1)p(x_3/x_2) \dots p(x_n/x_{n-1})$
b. $p(x_1, x_2, x_3, \dots, x_n) = p(x_1)p(x_1/x_2)p(x_2/x_3) \dots p(x_{n-1}/x_n)$
c. $p(x_1, x_2, x_3, \dots, x_n) = p(x_1)p(x_2)p(x_3) \dots p(x_n)$
d. $p(x_1, x_2, x_3, \dots, x_n) = p(x_1)p(x_2 * x_1)p(x_3 * x_2) \dots p(x_n * x_{n-1})$
12. For M equally likely messages, the average amount of information H is
- a. $H = \log_{10}M$
b. $H = \log_2M$
c. $H = \log_{10}M^2$
d. $H = 2\log_{10}M$
13. The maximum Entropy is
- a. 0
b. 0.5
c. P
d. 1
14. Information Rate
- a. Information per Unit Time
b. Average Number of bits of Information Per Second
c. rH
d. All of the above
15. Information rate basically gives an idea about the generated information per _____ by source
- a. Minute
b. Second
c. bit
d. hour
16. For a binary symmetric channel, the random bits are given as
- a. Logic 1 given by probability P and logic 0 by (1-P)
b. Logic 1 given by probability 1-P and logic 0 by P
c. Logic 1 given by probability P² and logic 0 by 1-P
d. Logic 1 given by probability P and logic 0 by (1-P)²
17. The mutual information

- a. Is symmetric
 - b. Always non negative
 - c. Both a and b are correct
 - d. None of the above
18. The relation between entropy and mutual information is
- a. $I(X;Y) = H(X) - H(X/Y)$
 - b. $I(X;Y) = H(X/Y) - H(Y/X)$
 - c. $I(X;Y) = H(X) - H(Y)$
 - d. $I(X;Y) = H(Y) - H(X)$
19. The memory less source refers to
- a. No previous information
 - b. No message storage
 - c. Emitted message is independent of previous message
 - d. None of the above
20. The information I contained in a message with probability of occurrence is given by (k is constant)
- a. $I = k \log_2 1/P$
 - b. $I = k \log_2 P$
 - c. $I = k \log_2 1/2P$
 - d. $I = k \log_2 1/P^2$
21. When the base of the logarithm is 2, then the unit of measure of information is
- a. Bits
 - b. Bytes
 - c. Nats
 - d. None of the above
22. The technique that may be used to increase average information per bit is
- a. Shannon-Fano Coding
 - b. ASK
 - c. FSK
 - d. None of the above
23. The entropy for a fair coin toss is exactly
- a. 5 bits
 - b. 3 bits
 - c. 2 bits
 - d. 1 bit
24. Huffman Code produces a code which uses a minimum number of bits to represent each symbol
- a. True
 - b. False
25. For which value(s) of p is the binary entropy function $H(p)$ maximized?
- a. 0
 - b. 0.5
 - c. 1
 - d. 2
26. The more one learns, the more the uncertainty is
- a. True
 - b. False
27. The followings are the applicable areas of Information Theory
- a. Data Compression
 - b. Cryptography
 - c. DSL Modem
 - d. All of the above

28. The order of Commutation System is:

Source to Encoder to Channel to Decoder to Destination

- a. True
- b. False

29. The major primary concern of Information Theory

- a. Source and Destination
- b. Channel
- c. Encoder and Decoder
- d. All of the above

30. The long quest of finding computationally-efficient codes include:

- a. Lossless Source Coding (Huffman Code)
- b. Noisy Channel Coding (Polar Code)
- c. Lossy Channel Coding (Polar Code)
- d. All of the above

SECTION B

1. Consider two random variables $X_1, X_2 \in \{0, 1\}$ with joint p.m.f

(X_1, X_2)	(0, 0)	(0, 1)	(1, 0)	(1, 1)
$p(X_1, X_2)$	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{6}$

- a. Compute $H(X_1)$, $H(X_2)$, and $H(X_1, X_2)$
- b. Compute $H(X_1|X_2 = 0)$, $H(X_1|X_2 = 1)$, $H(X_1|X_2)$, and $H(X_2|X_1)$.
- c. Compute $I(X_1; X_2)$

2a. A source emits symbols X_i , $1 \leq i \leq 6$, in the BCD format with probabilities $P(X_i)$ as given in Table 1, at a rate $R_s = 9.6$ kbaud (baud=symbol/second).

X_i	$P(X_i)$	BCD WORD
A	0.30	000
B	0.10	001
C	0.02	010
D	0.15	011
E	0.40	100
F	0.03	101

State (i) the information rate and (ii) the data rate of the source

- b. Apply Shannon-Fano coding to the source signal characterised in Table 1. Are there any disadvantages in the resulting code words?
- c. What is the original symbol sequence of the Shannon-Fano coded signal 110011110000110101100?
- d. What is the data rate of the signal after Shannon-Fano coding? What compression factor has been achieved?
- e. Derive the coding efficiency of both the uncoded BCD signal as well as the Shannon-Fano coded signal
- f. Repeat parts b to e but this time with Huffman coding.

3a. A digital communication system uses a 4-ary signaling scheme. Assume that 4 symbols $-3, -1, 1, 3$ are chosen with probabilities 18, 14, 12, 18, respectively. The

channel is an ideal channel with AWGN, the transmission rate is 2 Mbaud (2×10^6 symbols/s), and the channel signal to noise ratio is known to be 15.

- i. Determine the source information rate.
 - ii. If you are able to employ some capacity-approaching error-correction coding technique and would like to achieve error-free transmission, what is the minimum channel bandwidth required
- b. A predictive source encoder generates a bit stream, and it is known that the probability of a bit taking value 0 is $P(0) = p = 0.95$. The bit stream is then encoded by a Run Length Encoder (RLC) with a code word length of $n = 5$ bits.
- i. Determine the compression ratio of the RLC
 - ii. Find the encoder input patterns that produce the following encoder output code words: 11111 11110 11101 11100 11011 ... 00001 0000.
 - iii. What is the encoder input sequence of the RLC coded signal 110110000011110?