28

M.Sc. Engg. /Ph.D. (EE) Date: February 22, 2023 (Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Mid Semester Examination
Course No.: EEE 6409
Course Title: Information Theory

Summer Semester, A.Y.2021-2022
Time: 90 Minutes
Full Marks: 75

There are **4 (four)** questions. Answer **any 3 (three)** questions. All questions carry equal marks. Marks in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper. All symbols bear their usual meanings. Make reasonable approximation(s) for missing information.

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1. a) Show with an example that more uncertainty in message leads towards more information. Find out the amount of information carried by each message if there are 2^{2n-3} number of equally likely messages. 6+6

   b) Consider a discrete memory-less source 'S' that gives output of 3 bits at a time. This source comprises of three binary sources A, B and C. Each of these sources contributes to 1 (one) bit and their outputs are equally likely to occur. Suppose that the sources within 'S' are all independent. Calculate the information content of each output from the original source 'S'. 7

   c) Define and estimate the upper bound of entropy. 6

2. a) A discrete source emits one of four symbols once every 25 μ seconds. The symbol probabilities are 0.45, 0.32, 0.15 and 0.08 respectively. Calculate: 10
      i. Source Entropy,
      ii. Maximum Entropy,
      iii. Source Efficiency,
      iv. Redundancy and
      v. Information rate.

   b) Show how the ambiguity problem can occur in Shannon-Fano algorithm. Apply the Shannon-Fano coding procedure and find the code-word, efficiency and redundancy for the symbols with probabilities 0.35, 0.25, 0.16, 0.1, 0.08, 0.05, 0.01 respectively. 15

3. a) An information source produces 6 symbols with probabilities 0.3, 0.24, 0.2, 0.15, 0.07, 0.04 respectively. Find ternary Huffman coding. Also calculate efficiency and variance of the coding. What changes in the calculation process do you expect to see if you had to do find it for binary and quaternary coding in place of ternary coding? 17

   b) Find an estimate of the maximum channel capacity from Shannon Hartley theorem. Why doesn't having an infinite bandwidth ensure an infinite channel capacity? 8

4. a) Encode the given data sequence by Lempel-Ziv coding: 000101110010100101. 14

   b) Find the value of k from the PDF of a random variable expressed exponentially as ke^{-3x} 4

   c) Average lifespan of a LED bulb is 3 years. Find the probability that it will continue functioning after 4.5 years. 7