ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION   SUMMER SEMESTER, 2020-2021
DURATION: 3 Hours   FULL MARKS: 100

CSE 4809: Algorithm Engineering

Programmable calculators are not allowed. Do not write anything on the question paper.
There are **6 (six)** questions. Answer **all** of them. Figures in the right margin indicate marks.

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1. a) Prove that the expected running time of a randomized select algorithm is $O(n)$.
    5
    (CO5)
    (PO2)

    b) Prove that the expected number of comparisons in a randomized quicksort is **nlgn**.
    5
    (CO5)
    (PO2)

    c) Prove that randomized MAX-3-CNF algorithm is an **8/7 -approximation** algorithm.
    6
    (CO5)
    (PO2)

2. a) i.   Knowing Hamiltonian Circuit problem is NPC, confirm TSP problem is also NPC.
        ii. Name two decision problems and two optimization problems that are NPC.
        iii. iii. Why are we interested in approximation algorithms?
    3x2
    (CO3)
    (PO1)

    b) Proof that 2-CNF SAT is in P.
    5
    (CO3)
    (PO1)

    c) Write the approximation algorithm for TSP problem using Triangle inequality.
    5
    (CO3)
    (PO1)

3. a) i.   What is a balanced tree? Write two applications of balanced tree.
        ii. Why memory based balanced tree could not be used in disk based searching/indexing?
        iii. How does Red-Black Tree maintain the balance in the tree?
        iv. How does B-Tree maintain the balance in the tree?
    4x2
    (CO4)
    (PO1,
    PO2)

    b) Prove that the maximum height of a B-Tree is $log_t (n + 1)/2$, where t is the minimum degree and n is the total number of keys.
    4
    (CO4)
    (PO2)

    c) Insert the following keys in a B-tree (assume t is 3):
    G M P X A C D E J K N O R S T U V Y Z B Q L F
    8
    (CO4)
    (PO1)

4. a) i. Greedy and Dynamic Programming are applied to problems with similar properties; what are those properties? 3x2 (CO2) (PO1, PO2)

ii. How does Johnson's algorithm use Dijkstra Algorithm to solve all pair shortest path?

iii. Can Johnson's Algorithm solve shortest path problem with negative loops in the graph? Explain your answer.

b) Write an algorithm to solve the fractional knapsack problem in $O(n)$ time. 5 (CO2) (PO2)

c) Write the optimal substructure property of Optimal Prefix Coding problem. What is the greedy heuristic applied by Huffman Coding Algorithm to find the optimal prefix coding? 5 (CO2) (PO2)

5. a) i. What is the greedy heuristic for Dijkstra Algorithm? Why does the heuristic work? 3x2 (CO2) (PO1, PO2)

ii. What is the greedy heuristic for Activity Selection problem? Why does the heuristic work?

iii. What is the graph property that Bellman Algorithm exploit? Is it a greedy or a dynamic programming algorithm?

b) What do you understand by topological sorting? What is the role of topological sorting in finding shortest paths in DAG? 5 (CO2) (PO1)

c) Suppose there are cells in a rectangular mining field. Each cell may contain gold as reward, or may have bug that reduces the reward earned. We want to find the minimum number of squares in the mining field that will provide the maximum possible reward. Devise an algorithm or pseudo code for the purpose using greedy or dynamic programming technique. 5 (CO2) (PO3)

6. a) i. Write two possible applications of Block Chain other than its use in crypto-currency. 3x2
   ii. What are the applications of Merkle Tree? (CO4)
   iii. How can block chain be hacked? (PO1, PO2)

b) How is double spending restricted in a Block Chain-based crypto-currency? 5 (CO4) (PO1)

c) Explain the role of mining in Block Chain-based crypto-currency. How is the Proof of Work (PoW) ensured? 5 (CO4) (PO2)