ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION **SUMMER SEMESTER, 2021-2022**

DURATION: 3 HOURS **FULL MARKS: 100**

CSE 4809: Algorithm Engineering

Programmable calculators are not allowed. Do not write anything on the question paper.

Answer **all 6 (six)** questions. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses.

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1. a) Write the rationale for the three cases of master method. 6 (CO2) (PO1)

   b) How is GPU parallelism used to speed up the training of a single batch data in Deep Learning? 4 (CO2) (PO1)

   c) Discuss the greedy heuristic in Dijkstra's single source shortest path algorithm. Why does the heuristic work? 4 (CO2) (PO1)

   d) Answer the following questions in short: 2×3 (CO2) (PO1)
      i. Why does quick sort not need a merging algorithm like merge sort?
      ii. Why does longest simple path finding problem not have a dynamic programming solution like a shortest path finding problem?
      iii. How does B+ Tree maintain balance?

2. a) Prove that any comparison sort requires $\Omega(n \lg n)$ comparisons in the worst case. 3 (CO1) (PO1)

   b) Prove that the expected running time of a randomized quicksort is $O(n \lg n)$ 4 (CO1) (PO1)

   c) Write Randomized-Select algorithm to find any order statistics. Prove that expected running time of Randomized-Select algorithm to find any order statistics (particularly the median) is $O(n)$. 3+6 (CO1) (PO1)

3. a) With an example scenario, describe the game of Prisoner's Dilemma with its importance in social science. Give an analysis of how Dominant Strategy helps to find the equilibrium. 3+3 (CO2) (PO2)

   b) Two coffee shops selling their coffees at different prices (High, Competitive, Low) yield the profits as shown in Table 1. Use Iterated Elimination of Strictly Dominated Strategy to solve the game instance. 5 (CO3) (PO1)

Table 1: Profits of Two Coffee Shops for Question 3. b).

		Coffee Shop 2		
	Price	High	Competitive	Low
Coffee Shop 1	High	13,3	1,4	7,3
	Competitive	4,2	3,3	6,1
	Low	-1,9	2,8	8,-1

c) Use appropriate game strategy to solve the following game given in Table 2 and provide reasoning behind your choice. 5 (CO3) (PO1)

Table 2: A game instance for Question 3.c).

		Player 2	
		Choice 1	Choice2
Player 1	Choice 1	4,3	1,1
	Choice 2	1,-2	3,4

4. a) Briefly describe blockchain and its application domains. 4 (CO2) (PO1)

b) Ethereum has recently switched from Proof of Work (PoW) to Proof of Stake (PoS) consensus mechanism for creating Blocks though Bitcoin is still continuing with PoW. Describe the PoW and PoS with their pros and cons. 6 (CO2) (PO1)

c) Answer the following questions in short: 2×3 (CO2) (PO1)

i. How are Nonce calculated in parallel using GPU even though a mining node proposes only one Block in one competition round of PoW?

ii. When you add your personal GPU to a mining node in Bitcoin, what are the tasks that you perform and what reward do you get in return?

iii. Why do we not ask solution to any NP problem instance as a challenge in PoW?

5. a) In graph theory, a vertex cover of a graph is a set of vertices that includes at least one endpoint of every edge of the graph. Finding minimum vertex cover is NP-Complete.

i. Write a 2-approximation algorithm for Minimum-Vertex-Cover problem with its proof. 3+3 (CO4) (PO1)

ii. Can you think of any improvement of the 2-approximation algorithm for Minimum-Vertex-Cover? 3 (CO4) (PO2)

b) Greedy-Set-Cover is a polynomial-time $\rho(n) = H(\max\{|S|: S \in F\})$ approximation algorithm. Explain the complexity in plain language. You do not need to show any proof. 3 (CO2) (PO1)

c) Prove (trivially) that Travelling Salesman Problem (TSP) and Boolean-SAT are NP-Complete. 2+2 (CO2) (PO1)

6. a) Argue that $P \subseteq NP$ 3 (CO2) (PO1)

b) Formally define NP-Hard and NP-Complete problem. 3 (CO2) (PO2)

c) Answer the following questions:

i. Prove that 2-CNF SAT is in P. 4+2 (CO2) (PO1)

ii. If 2-CNF SAT is solvable, why is 3-CNF SAT not assumed to be solved?

d) Briefly describe Reduction and Reducibility in the context of NP-Completeness. 4 (CO2) (PO1)