ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

MID SEMESTER EXAMINATION SUMMER SEMESTER, 2022-2023

DURATION: 1 HOUR 30 MINUTES FULL MARKS: 75

CSE 4403: Algorithms

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

Answer **all 3 (three)** questions. Figures in the right margin indicate full marks of questions with corresponding COs and POs in parentheses.

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1. a) Calculate the worst time complexity using Big O notation of the following algorithms: 2 × 5 (CO1) (PO1)

   i. Breath-First Search algorithm
   ii. Floyd-Warshall's algorithm
   iii. Bellman Ford's algorithm
   iv. Prim's algorithm
   v. Kruskal's algorithm

   b) Analyze the following code segments and find the upper bound runtime in Big O notation. 3 × 2 (CO1) (PO1)

   i.
```
queue<int> g;
for (int i = 0; i < N; i++)
    for (int j = 0; j < 10; j++)
        g.push(i*j);
```

Code Snippet 1: A code snippet for Question 1.b)i

   ii.
```
for (int i = 0; i < N; i++)
    for (int j = 0; j < 10*M; j++)
        cout << "Hello";
```

Code Snippet 2: A code snippet for Question 1.b)ii

   iii.
```
int ar[N];
for (int i = 0; i < N; i++)
    cin >> ar[i];
sort(ar, ar+N);
for (int i = 0; i < 10; i++)
    for (int j = 0; j < N; j++)
        cout << ar[j];
```

Code Snippet 3: A code snippet for Question 1.b)iii

   c) Calculate the space requirement for Counting sort applied to sort an integer (8 bytes) array of size 1000. 3 + 6 (CO1) (PO1)
   Consider the array given in Table 1, where XX = the last 2 digits of your student ID. Show the step-by-step sorting procedure of this array using radix sort.

Table 1: An array for Question 1.c

12	23	5	18	53	XX

2. a) There are n cities and m roads in a country. Each road connecting two cities is bi-directional. The cost to travel through each road may vary. Each city has a tourist fee. Every time a tourist visits a city, they need to pay the fee for that city. A group of three tourists start their journey from city 1 and want to finish their journey at city n. None of the tourists are allowed to use the same path to reach the destination. We consider two paths as different if they differ by at least one vertex. Given the description of each road (connecting cities and cost) and the tourist fee of each city, your goal is to find the most optimal travel paths for all the tourists to reach the destination minimizing the total expense of the group.

   i. Design a suitable algorithm to solve the problem. 10 (CO3) (PO3)

   ii. Justify why your proposed solution will find the optimal solution. 5 (CO2) (PO2)

   iii. Calculate the worst time complexity of your proposed solution. 3 (CO3) (PO1)

   b) Will your solution still work, if the cities provide rewards for the tourists instead of tourist fees? If your answer is yes, justify. Otherwise, propose the solution for the updated scenario. 7 (CO2) (PO2)

3. a) Explain how path compression is used to flatten the tree in union-find operation. Apply Kruskal's algorithm to the graph provided in Figure 1 to find the minimum spanning tree. Show the content of the parent array in each step of the union-find operation. 10 (CO2) (PO2)

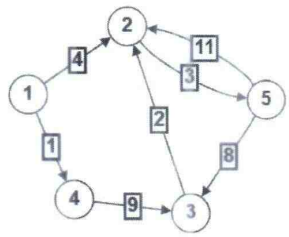

Figure 1: A directed graph for Question 3.a

   b) The intra-department cricket tournament of IUT is going to be held. A team gets 2 points if they win a match and they get 1 point if they lose a match. In case of a tie, a coin toss is used to decide the winner. Given the target point (P), your goal is to calculate in how many different ways a team can obtain the target points.
   For example: If the target point $P = 4$, then the team can obtain the point in 5 different ways:

   - L L L L
   - L L W
   - L W L
   - W L L
   - W W

   i. Explain whether this problem can be solved using Dynamic Programming (DP) or not. Justify your answer. 5 (CO3) (PO1)

   ii. Design a bottom-up algorithm for solving this problem and find the initial values for the DP table. 5 (CO3) (PO3)

   iii. Formulate the worst-case time complexity for your proposed algorithm and construct a DP table for $P = 10$. 5 (CO3) (PO2)