ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

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

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 whereas corresponding CO and PO are written within parentheses.

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1. The cost of flagship mobile phones is significantly higher in Bangladesh than in Singapore. Mr. Gerald, who is traveling from Singapore to Bangladesh next month, has devised a profitable business plan. As he is a greedy individual, he intends to purchase flagship phones in Singapore and sell them in Bangladesh for a profit. 25 (CO3) (PO1)

   For this purpose, Mr. Gerald goes to a local tech store in Singapore. There are N phones on display. For each phone $i(1 \leq i \leq N)$, he has the following information available to him:

   - price in USD (p_i),
   - price in BDT (q_i)
   - type (t_i).

   Assuming $1\ USD = 105\ BDT$, it is guaranteed that $q_i > 105 * p_i$ for each phone i. There are two types of phones: made by Apple (type 0) and made by Samsung (type 1).

   Gerald has a budget of P USD. He can buy as many phones of any type as he likes as long as it does not exceed his budget. But he must ensure to buy at least $\boldsymbol{K}$ $(\boldsymbol{K} \leq \boldsymbol{N})$ Samsung phones as their demands are higher. Gerald wants to know the maximum profit he can achieve while ensuring all the constraints.

   Propose a Dynamic Programming solution for this maximization problem under some constraints. You need to define a set of subproblems, relate the subproblems recursively, provide base cases, construct a solution from the subproblems, and analyze the running time.

2. a) Apply DFS on the following graph and show the order in which order the new vertices are visited. Assume that both the vertices in the adjacency list and neighbors of each individual vertex are ordered alphabetically. 12 (CO1) (PO1)

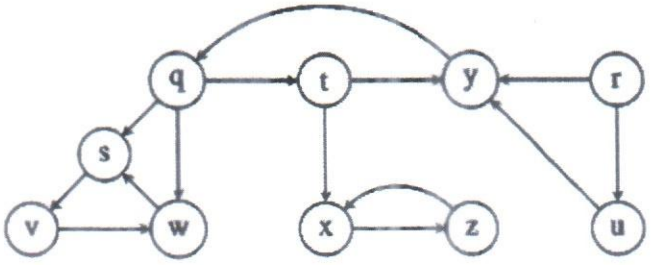

Figure 1: Graph for Question 2(a)

   b) Asses the pros and cons of using adjacency matrix and adjacency list. 8 (CO2) (PO2)

   c) Give a real-life example of a graph where traversing all edges are required. 5 (CO3) (PO1)

3. a) The Omicron variant of the Covid-19 virus was initially detected in South Africa, where it had infected many people. Some people infected with the virus recently arrived in Bangladesh from South Africa. When they arrived in Bangladesh, some of them moved to the Bashundhara Residential Area and started living in various buildings. The virus is infectious, and it infects everyone in a building when one infected person enters. Furthermore, as each day passes, the neighboring building is compromised as well (i.e., if at day 1, building **A** is infected, then at day 2, the virus will be spread at all the neighboring (east, west, north, and south) buildings of **A**. Given a grid map of Bashundhara Residential Area, where each cell with the letter **'X'** indicates an Omicron-infected building and a cell with the letter **'Y'** represents an uninfected building.
Devise an efficient algorithm to determine the number of days it will take the Omicron virus to infect the whole residential area. An example is given for better understanding:

13 (CO3) (PO3)

$$\begin{bmatrix} Y & Y & X & Y \\ Y & X & Y & Y \\ Y & Y & Y & Y \end{bmatrix} \Rightarrow \begin{bmatrix} Y & X & X & X \\ X & X & X & Y \\ Y & X & Y & Y \end{bmatrix} \Rightarrow \begin{bmatrix} X & X & X & X \\ X & X & X & X \\ X & X & Y & Y \end{bmatrix} \Rightarrow \begin{bmatrix} X & X & X & X \\ X & X & X & X \\ X & X & X & X \end{bmatrix}$$

Day 0 ⇒ **Day 1** ⇒ **Day 2** ⇒ **Day 3**

Figure 2: Example demonstration for Question 3(a)

The initial grid contained just two buildings with Omicron infected persons on Day 0, but by the end of Day 3, all the buildings in the grid had been contaminated. Thus, the deadly virus had spread across the residential area in just **three** days.

b) ***Speed in Need*** is a racing video game set in the fictional country, Little America. There are N towns in Little America. The towns are connected by M bidirectional roads. Each town has a unique positive integer difficulty level, $diff$. When you go from town u to town v, you will face obstacles if $diff[u] < diff[v]$. Your car is currently in town X. Assume that the difficulty level of town X is the highest among all.
Determine whether you can traverse all the towns starting from X without facing any obstacle. If so, find the traversal order of the towns with proper justification.

12 (CO2) (PO2)