ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

MID SEMESTER EXAMINATION **SUMMER SEMESTER, 2019-2020**

DURATION: 1 Hour 30 Minutes **FULL MARKS: 75**

CSE 4403: Algorithms

Programmable calculators are not allowed.

There are **3 (three)** questions. Answer all **3 (three)** of them.

Figures in the right margin indicate marks.

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1. a) There is a pandemic going on around the world. Numerous people are getting infected each day by an infectious disease that shows no symptoms. The only way to determine whether a person is infected or not is to collect his/her saliva and run a special test on it. Once detected, the affected persons are kept in isolation, so the others remain safe. But due to the ever-rising demands for testing kits, these tests have become very expensive. So you want to perform as fewer tests as possible. [10]

   Assume that there are n people in the world and k of them are affected. Your task is to save the world by designing an algorithm to determine which k of the n people are affected using $O(k \log_2(n))$ experiments.

   b) Professor Aziz specializes in computer networks. He considers the internet as a directed graph, $G(V, E)$ where V represents a set of routers addresses (vertices) and E represents the set of wires connecting them (edges). The time delay caused by the wires passing the message is considered as the edge weight. [15]

   Professor Aziz is working on developing an efficient algorithm to figure out the "Routing Table". The routing table for a router s stores the address of the reachable routers and the delay: the minimum time taken to reach those routers. After working day and night, he discovered that wires are not the only reason for delay. There are significant delays in the routers too. This is because once a message reaches a router, the router takes some time to process it. Only after that, the message is sent to the next router. That means, just like the edges, the vertices have weights associated with them too.

   Propose an efficient solution to help Professor Aziz to find out the routing table for a single vertex and analyze its running time.

2. Horza Forizon is a racing video game set in the fictional country, Little Britain. There are N towns in Little Britain. The towns are connected by M bidirectional roads. The length of the roads can be different. Each town has a unique positive integer difficulty level, $diff$. When you go from town u to town v, you will face obstacles if $diff[u] < diff[v]$. Assume that the difficulty level of town `X` is the highest among all.

   You are given the map of Little Britain containing the difficulty level of each town and the length of each road. For each of the following problems, perform any preprocessing required, provide a solution and also a justification for your solution.

   a) Your car is currently in town `X`. You want to reach town `Y` without facing any obstacle. You want to find the shortest length path from `X` to `Y`. [12]

   b) Your car is currently in town `Y`. You want to reach town `X`. It might be impossible to avoid any obstacles. So you want to go as slow as possible to reduce the damage caused by the obstacles. Assume that it takes 1 minute to go from one town to another. When you face any obstacles in the path from town u to town v, you wait 3 minutes in town v to repair the car and start again. You want to find the minimum time required to go from `Y` to `X`. [13]

3. In Horza Forizon, the racing video game, as you do more and more races, your opponents get more difficult. To cope with them, you need to buy the latest and greatest cars. For this purpose, you go to a car dealership that has N cars on display. Each car $i \in [1, N]$ has a rating r_i and a price p_i USD. There are two types of cars, sports and regular. To challenge different types of opponents, you decide to purchase exactly $Q \in [1, N]$ sports cars, without purchasing the same car twice. Now you want to maximize the sum of the ratings of the purchased cars. But you have a limited budget of P USD.

   Propose a dynamic programming solution to select Q cars so that the sum of the ratings is maximized and the total price of all the purchased cars does not exceed your budget. You need to define a set of subproblems, relate the subproblems recursively, argue that the relation is acyclic, provide base cases, construct a solution from the subproblems, and analyze the running time.