# ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION SUMMER SEMESTER, 2022-2023

DURATION: 3 HOURS FULL MARKS: 150

## CSE 4403: Algorithms

**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 with corresponding COs and POs in parentheses.

---

1. You need to buy a cow for the Goru Party and have $N$ markets to choose from, reachable from IUT. Each market is connected to IUT by a unique path with bi-directional roads. There is a fixed transportation fee collected at some stops on the route. Your goal is to calculate how many markets you can reach without exceeding the budget for the transportation fee $M$, provided the information about which stops on the way collect the transportation fee.

   a) Analyze the above-mentioned problem and propose a suitable algorithm to solve it. 10 (CO3) (PO3)

   b) Justify the reason for choosing your solution. 5 (CO2) (PO2)

   c) Formulate the worst-case time complexity for your proposed algorithm. 3 (CO2) (PO2)

   d) Will your solution still work if the path between IUT and the market is not unique? If your answer is yes, justify. Otherwise, propose the modification required in your previous solution to solve the updated problem. 7 (CO3) (PO3)

2. For the Goru Party, a number of dishes are planned to cook. Each dish has its own cooking duration and must be prepared within a fixed timeframe (i.e., each dish has a fixed start and end time). With just one cook who can handle one dish at a time, your aim is to determine the maximum number of dishes you can cook within their time constraints.
   Now, answer the following questions:

   a) Design a Greedy Algorithm to solve the problem described above and estimate its worst runtime complexity. 8 + 2 (CO3) (PO3)

   b) Prove the optimality of your proposed algorithm. 5 (CO1) (PO1)

   c) Design a Greedy Algorithm to calculate the minimum number of chefs required, if you want to cook all of the dishes. Estimate the worst runtime complexity. 8 + 2 (CO3) (PO3)

3. Students want to decorate IUT using lighting during the Goru Party. For easier maintenance, the whole IUT campus is divided into multiple sectors. Given the cable required to connect different sectors, your goal is to calculate the shortest amount of cable required to connect all the sectors.

   a) Mention two algorithms, which can be used to solve the problem described above and estimate their worst runtime complexity. — 6 (CO2) (PO2)

   b) Write a suitable algorithm to solve the problem described above. — 7 (CO1) (PO1)

   c) Consider that, IUT is divided into seven sectors. The amount of cable required to connect various sectors is represented by 3 integer values, where the first 2 integers indicate the sector number and the third integer indicates the amount of required cable to connect them. Assume that the following values are given: — 12 (CO3) (PO3)

   1 2 6
   1 4 4
   2 3 7
   2 4 8
   2 5 6
   3 5 4
   4 5 14
   4 6 5
   5 6 7
   5 7 8
   6 7 10

   Apply your selected algorithm to solve the problem for the aforementioned scenario.

4. Some sweets are planned to be served after the Goru Party. You have a line of sweet boxes, each containing a number written on top of it, indicating how many sweets you can take. Some boxes have negative numbers, meaning instead of taking, you must deposit sweets. Your task is to find the maximum number of sweets you can collect by choosing consecutive boxes strategically.
   For example: if the numbers on top of the boxes are: [-2, -1, 5, 0, -1, 3, 4, -2], then the maximum number of sweets you can collect is 11, which can be obtained by choosing the 3rd to 7th boxes.
   Now answer the following questions:

   a) Explain the naive brute force solution for the problem and discuss why this solution is not practical. — 5 (CO3) (PO3)

   b) Design a solution using the divide and conquer approach to solve the problem. — 10 (CO3) (PO3)

   c) Estimate the runtime of your solution using the recurrence relation and verify your result using the master theorem. — 5 (CO1) (PO1)

   d) Is the divide-and-conquer solution the most efficient solution for this problem? If your answer is yes, justify. Otherwise, provide a better solution. — 5 (CO3) (PO3)

5. After the Goru Party, outgoing students are giving out candies standing in a line. You can not take candy from two consecutive people. Your task is to calculate the maximum total candy you can collect provided the number of candies each person will give. For instance, if there are 5 people with candies: [3, 10, 3, 1, 2], you can collect a maximum of 12 candies.

a) Explain why this problem can be solved using dynamic programming. 5 (CO1) (PO1)

b) Design a top-down or bottom-up algorithm for solving this problem. 10 (CO3) (PO3)

c) Determine the worst-case time complexity for your proposed algorithm. 3 (CO2) (PO2)

d) Construct a memorization table for the following input: [ 1, 2, 3, 4, 5, 1, 2, 3, 4, 5 ]. 7 (CO2) (PO2)

6. a) What is Monte-Carlo simulation? Write down the pros and cons of this method. Using Monte-Carlo simulation estimate the value of PI. 3 + 5 (CO1) (PO1)

b) Show the steps of finding Huffman Encoding for the string representing your full name. 7 (CO3) (PO3)

c) Apply the Ford-Fulkerson algorithm to the network flow graph provided in the Figure 1 to find the maximum flow possible from node $S$ to $T$. Show each step of your operation. 10 (CO3) (PO3)

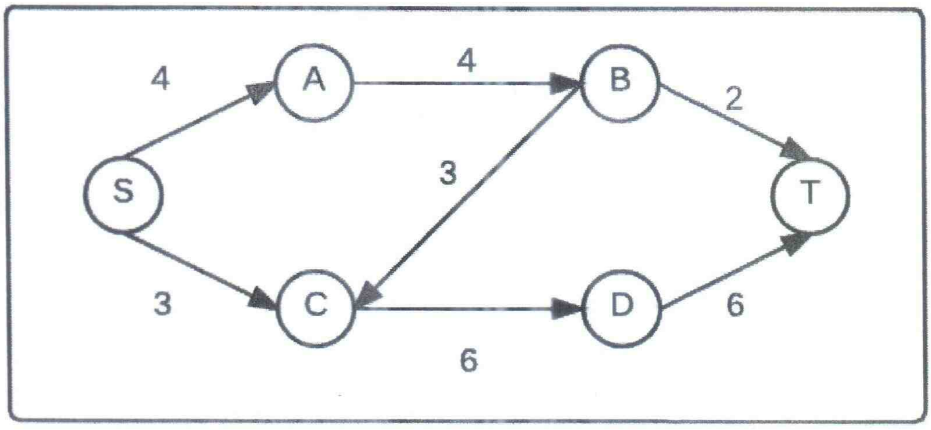


**Figure 1**: A network flow graph for Question 6.c