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.

1. Figure 1 shows a flow network where vertex s acts as the source and vertex t acts as the sink. The X/Y value near each edge indicate the current flow (X) and the capacity of the edge (Y), respectively. 10+5 (CO1) (PO1)

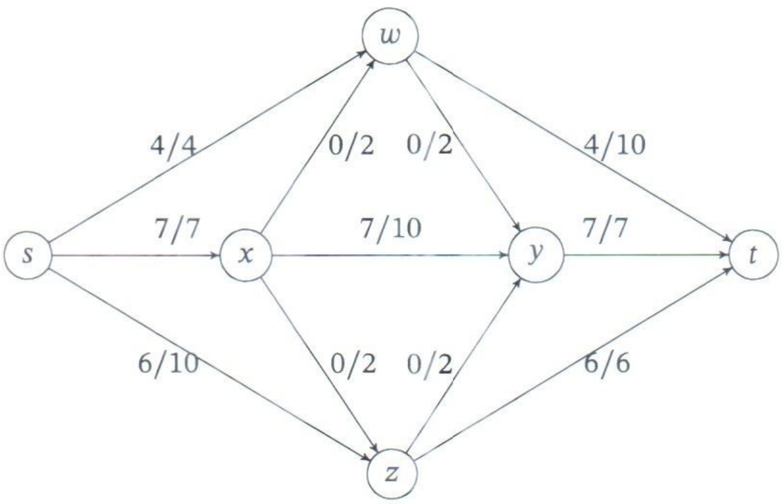

Figure 1: Flow Network Graph for Question 1

   a) Determine the current amount of flow to t. Is this the maximum flow possible from s to t? If not, find the maximum flow.

   b) Determine the set of edges that needs to be discarded to completely isolate s and t, i.e., there will be zero maximum flow from s to t. If there are multiple possible answers, find the one with the minimum sum of capacity of edges.

2. In a game, a solitary chess queen is positioned randomly on an $n \times n$ grid of squares. The game is played between two players: Alice and Bob. Alice goes first and the players take turn alternatively. On each turn, a player can move the queen by any number of cells towards the south (down), west (left), or south-west (down-left) direction. The game ends when one player successfully moves the queen into the lower-left corner and that player is declared as the winner. Both players play optimally.

   a) Assume that $n = 8$. The queen is initially positioned in a cell (r, c), where $1 \leq r, c \leq 8$. If Alice wants to win the game, find out the cells that can be chosen as the initial position of the queen. 14 (CO2) (PO2)

   b) Create a two-player game with two piles of stones, each containing n stones, where the players take turn to remove stones from the piles. The game concludes when a player is unable to remove any more stones from the piles. Design the stone-removal restrictions of the game so that it mimics the chess queen game described in Question 2.a). 6 (CO3) (PO3)

3. Consider the text: "ahishers" and a list of patterns: ['he', 'his', 'she', 'hers', 'hiss'] pose efficient algorithms for the following tasks:

   a) Find the number of patterns from the given list that can be found in the text as a substring.

   b) Find the longest substring from the given text which occurs as a prefix, a suffix, and somewhere in the middle.

4. Northcott's game is played between two players on a checkerboard containing a black and a white piece on each row. Each player is authorized to move pieces of a specific color. A player can move a piece to any vacant square within the same row, as long as the piece does not need to jump over the other players piece. The game concludes when a player is incapable of moving any of his pieces, resulting in his defeat. A sample board configuration for the game is shown in Figure 2.

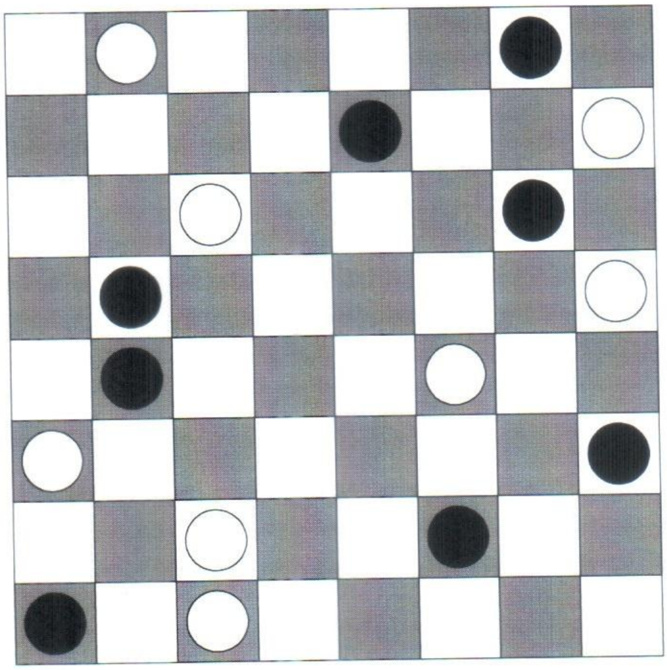

Figure 2: A sample board configuration in a Northcott's Game for Question 4.

   a) Assuming both players will play optimally, argue whether Northcott's game is finite or not. 1((CO2 (PO2

   b) Convert the game to a variation of Nim Game and discuss how to determine the winner of the game by analyzing the initial board configuration. 1((CO3 (PO3

5. In the world of OZ, the currency system is quite unique. Each Emerald City gold coin has an integer number n written on it. The bank allows you to exchange one coin with exactly three different coins worth $\lfloor n/2 \rfloor$, $\lfloor n/3 \rfloor$, and $\lfloor n/4 \rfloor$. You can exchange the gold coins for other currencies, such as US dollars. The exchange rate is 1 : 1. However, you cannot purchase the gold coins with any other currency. 1 (CO3 (PO3

   Suppose that you have a gold coin with the number n on it. Propose a solution strategy that allows you to calculate the maximum amount of US dollars that you can get by exchanging the coin.

The 0-1 Knapsack Problem is the following: in a port, there are n items in total. The i^{th} item is worth v_i dollars and weighs w_i pounds, where v_i and w_i are integers. There is a single cargo ship in the port, which can carry at most W pounds, where W is an integer. We want to load as much valuable items as possible in the ship. Which items should we take? 4 × 4 (CO2) (PO2)

The problem is called "0-1" Knapsack because for each item, we must either take it or leave it behind; we cannot take a fractional amount of an item or take an item more than once.

On the other hand, in the Fractional Knapsack Problem, the setup is similar, but we can take fractions of items, rather than having to make a binary choice for each item.

Now, answer the following questions:

a) Which variant(s) of the Knapsack Problem show optimal substructure property?

b) Can you solve the Fractional Knapsack Problem using a Greedy Approach? Justify your answer.

c) Can you solve the 0-1 Knapsack Problem using a Greedy Approach? Justify your answer.

d) Can you solve the Fractional Knapsack Problem using a Dynamic Programming Approach? Justify your answer.