Roll Number:_____

***Thapar Institute of Engineering & Technology***

Department of Computer Science and Engineering

**END SEMESTER EXAMINATION**

B. E. **(2nd Yr. COE/CSE)**
27th May, 2024
Monday, Time-9:00 To 12:00 PM
Time: 3 Hours
Max Marks: 60 (Weightage: 40)

Course Code: UCS415
Course Name: Design and Analysis of Algorithms
Name of Faculty: Tarunpreet Bhatia, Sumit Sharma, Manisha Singh, Swati Sharma, Mansi Sharma, Shubhra Dwivedi, Shruti Aggarwal

**Note: Attempt any 4 questions. Assume missing data (if any).**

| Q.No | Questions | Marks | CO | BL |
|---|---|---|---|---|
| Q.1 | (a) You are a team member responsible for enhancing the efficiency and reliability of an urban bike-sharing system. The city is represented as a graph, with bike stations serving as vertices and bike lanes connecting them as edges. Your primary objective is to design an algorithm for bike lane maintenance that ensures every bike lane is traversed exactly once by a maintenance crew, which conducts station checks for maintenance needs and redistributes bikes if necessary. | (5) | CO3 | L6 |
| | (b) Suppose you are flying by Vistara Airlines from New Delhi to Tokyo, and you know the weight restriction for cabin baggage, which is 7 kg. Additionally, the items you carry are unique, each with different weights and values, as shown in **Table 1**. However, the combined weight of all the items exceeds 7 kg, so you must inform the customs officer to retain the items with less weight but higher value. Each item is either allowed to be taken in baggage or not carried. Your primary objective is to carry the items with maximum value in your cabin baggage without surpassing the baggage limit.<br>**Table 1**<br>Items \| Smartphone \| Tablet \| Power bank \| Laptop<br>Weights \| 3 \| 4 \| 2 \| 5<br>Values \| 40 \| 50 \| 10 \| 70<br>i) Which items will be carried in your cabin bag? Write the recursive equation and show your calculations with the help of dynamic programming.<br>ii) How would your answer vary if greedy programming is used to select the items for filling your cabin bag? Justify your answer with proper reasoning. | (7+3) | CO2 | L3 |
| Q.2 | (a) You are organizing a fundraising event for your local charity. You have a list of potential donors, each willing to contribute a certain amount of money. The potential donor contributions are {5K, 6K, 10K, 11K, 16K}. However, you want to find out all the possible combinations of donors whose contributions sum up to a target amount of 21K to efficiently reach your fundraising goal. Show the state space tree to find all possible combinations of donors whose contributions sum up to the target amount using the backtracking technique by clearly specifying the pruning conditions on the state space tree. | (8) | CO2 | L3 |
| | (b) Given a wall of length $W$ and two shelves of length $m$ and $n$, we are tasked with fitting the wall of length $W$ with shelves of length $m$ and $n$ so that the space left empty (which can't be filled with shelf) is to be minimized, and if possible the solution having larger number of longer shelves is preferred as longer shelves are the cheaper ones. However, cost is still secondary in our adventure of minimizing the cost, we should be more worried about minimizing the empty space (if possible it should be zero). Design a greedy algorithm for this problem. | (3) | CO1 | L4 |
| | (c) Differentiate between Las Vegas and Monte Carlo randomized algorithms with the help of an example. | (4) | CO4 | L1 |

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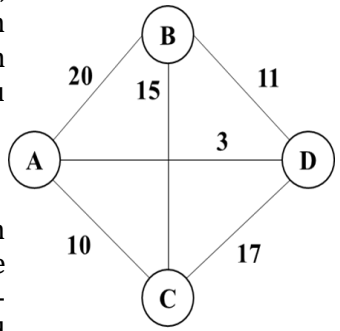
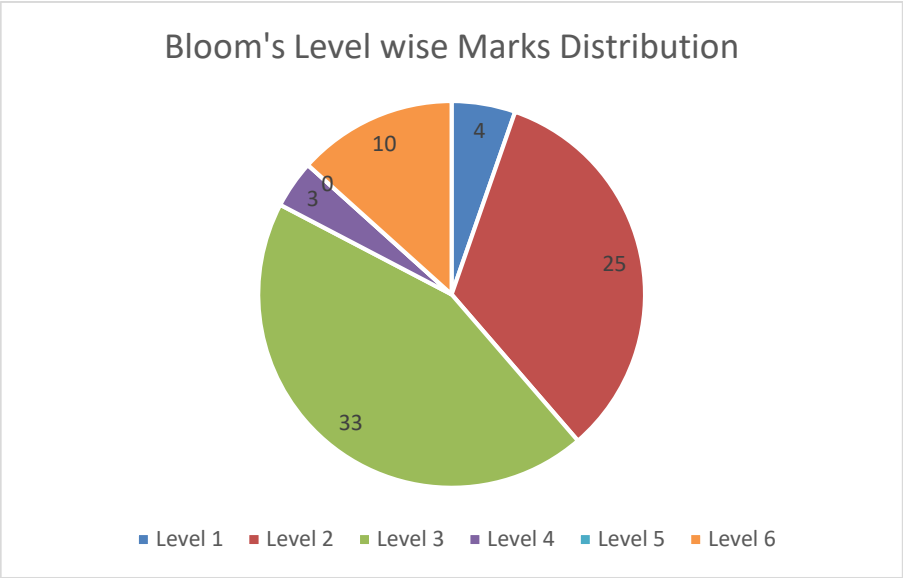
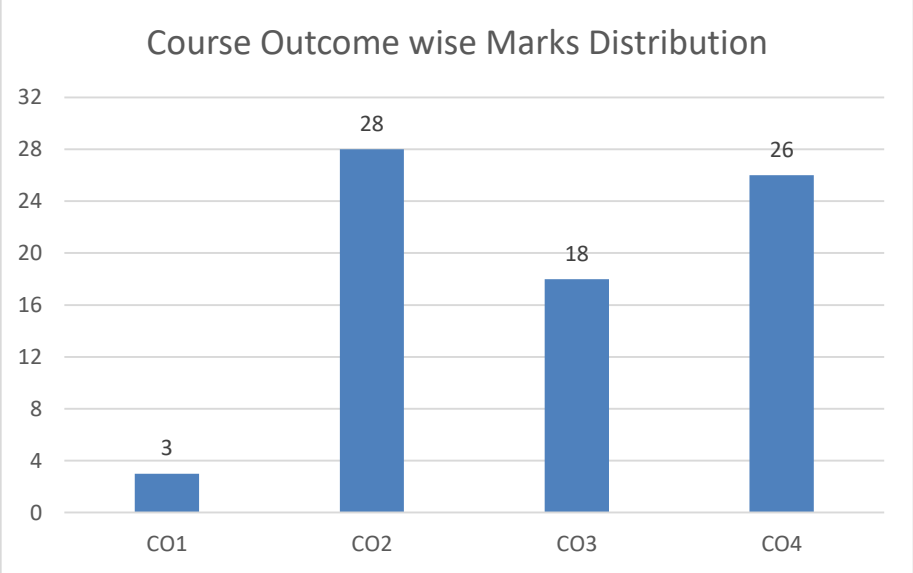
| Q.3 | (a) Imagine a warehouse floor laid out in a grid pattern, awaiting the deployment of N autonomous robots assigned to collect items from various locations and deliver them to designated destinations. The challenge here is to ensure that no two robots collide or interfere with each other's paths while navigating the warehouse. The two robots collide if they occupy the same row, column, or diagonal. Each cell in the grid represents a possible position for a robot. To tackle this logistical puzzle, you decide to use the Backtracking approach to find a valid arrangement for the N robots within the warehouse. Design a pseudo code or algorithm for this problem using the Backtracking approach. Also, apply your algorithm to find one of the possible solutions for $N = 4$. You need to show the function calls while applying your algorithm. What will be the worst-case time complexity of your algorithm?<br><br>(b) TIET has a summer school session that offers eight courses (A-H). An "X" in **Table 2** shows which courses have students in common. There are time slots available (9:00 to 12:00 p.m.) each day (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday) to schedule final exams. TIET wishes to schedule the eight final exams over as few days as possible without creating conflicts for the students scheduled to take them. Having more than one exam scheduled on the same day is fine as long as the courses do not have any students in common. Find the complete schedule of the exams. Show the steps involved in finding the schedule. Is it P or NP problem?<br><br>**Table 2**<br>\| \| A \| B \| C \| D \| E \| F \| G \| H \|<br>\| A \| \| X \| X \| X \| \| \| \| \|<br>\| B \| X \| \| X \| \| X \| X \| \| \|<br>\| C \| X \| X \| \| X \| X \| X \| X \| \|<br>\| D \| X \| \| X \| \| \| X \| X \| \|<br>\| E \| \| X \| X \| \| \| X \| \| X \|<br>\| F \| \| X \| X \| X \| X \| \| X \| X \|<br>\| G \| \| \| X \| X \| \| X \| \| X \|<br>\| H \| \| \| \| \| X \| X \| X \| \| | (10)<br><br>(5) | CO2<br><br>CO3 | L2<br><br>L6 |
| Q.4 | (a) Given a text "ABCCDDGCDD" along with a pattern "CDD", determine the location(s) of the pattern within the text by utilizing the Rabin Karp algorithm. Let $d$ be the number of characters in the input set {A, B, C, .., J}. Further, choose $q$ as 13 in the computation to ensure that all calculations can be carried out using single-precision arithmetic. Assign a numerical value to the characters in the input set {A, B, C, .., J} as {1, 2, 3, .., 10}. Show all the intermediate calculations.<br><br>(b) Goods will be transported from a warehouse to 4 distribution centers: Ahmedabad, Bombay, Chennai, and Delhi, and finally to the market. The maximum number of goods that can be transferred from the warehouse to Ahmedabad is 7 units, and to Delhi is 4 units; from Ahmedabad to Bombay is 5 units; from Ahmedabad to Chennai is 3 units; from Delhi to Ahmedabad is 3 units; from Delhi to Chennai is 2 units; from Chennai to Bombay is 3 units; from Chennai to market is 5 units, and from Bombay to market is 8 units. This network configuration facilitates the efficient flow of goods from the central warehouse through the distribution centers to the final market destination. You need to find the maximum units of goods that can be transported from the warehouse to the market, showing all the intermediate stages of the residual graph. You need to select warehouse → Delhi → Ahmedabad → Chennai → market as the first augmented path in the flow network. | (7)<br><br>(8) | CO4<br><br>CO3 | L3<br><br>L3 |
| Q.5 | Imagine you are tasked with surveying a set of 4 landmarks in a national park. A graph of these landmarks is shown in **Figure 1**, where the graph edges represent the distance between each landmark. You need to determine the most efficient route to visit each landmark exactly once and return to the starting point 'A.' You decided to apply two different algorithmic approaches:<br>i) Least Cost Branch-and-Bound (LCBB)<br>ii) 2-Approximation<br>You need to calculate the tour's total cost and path for both approaches by showing all the intermediate steps and state space tree for LCBB. Also, compare and contrast both LCBB and the 2-Approximation algorithms in terms of solution optimality and computational complexity (P, NP, NP-hard or NP-complete problems).<br><br>  <br><br>**Figure 1** | (10+3 +2) | CO4 | L2 |


Bloom's Level wise Marks Distribution
4
25
33
3
0
10
Level 1
Level 2
Level 3
Level 4
Level 5
Level 6


Course Outcome wise Marks Distribution
32
28
24
20
16
12
8
4
0
3
28
18
26
CO1
CO2
CO3
CO4