Subject Name Solutions

1333203 – Winter 2024

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Write names of linear data structures.

Solution

Linear Data Structures
1. Array
2. Stack
3. Queue
4. Linked List

Mnemonic

"All Students Queue Lazily"

Question 1(b) [4 marks]

Define Time and space complexity.

Solution

Complexity Type	Definition	Notation
Time Complexity	Measures how execution time increases as input size grows	O(n), O(1), O(log n)
Space Complexity	Measures how memory usage increases as input size grows	O(n), O(1), O(log n)

Diagram:

```
+---------------+         +----------------+
| INPUT SIZE    |-------->| ALGORITHM      |
| (n)           |         |                |
+---------------+         +----------------+
                                |       |
                                v       v
                    +----------+       +----------+
                    | TIME     |       | SPACE    |
                    | O(n)     |       | O(n)     |
                    +----------+       +----------+
```

Mnemonic

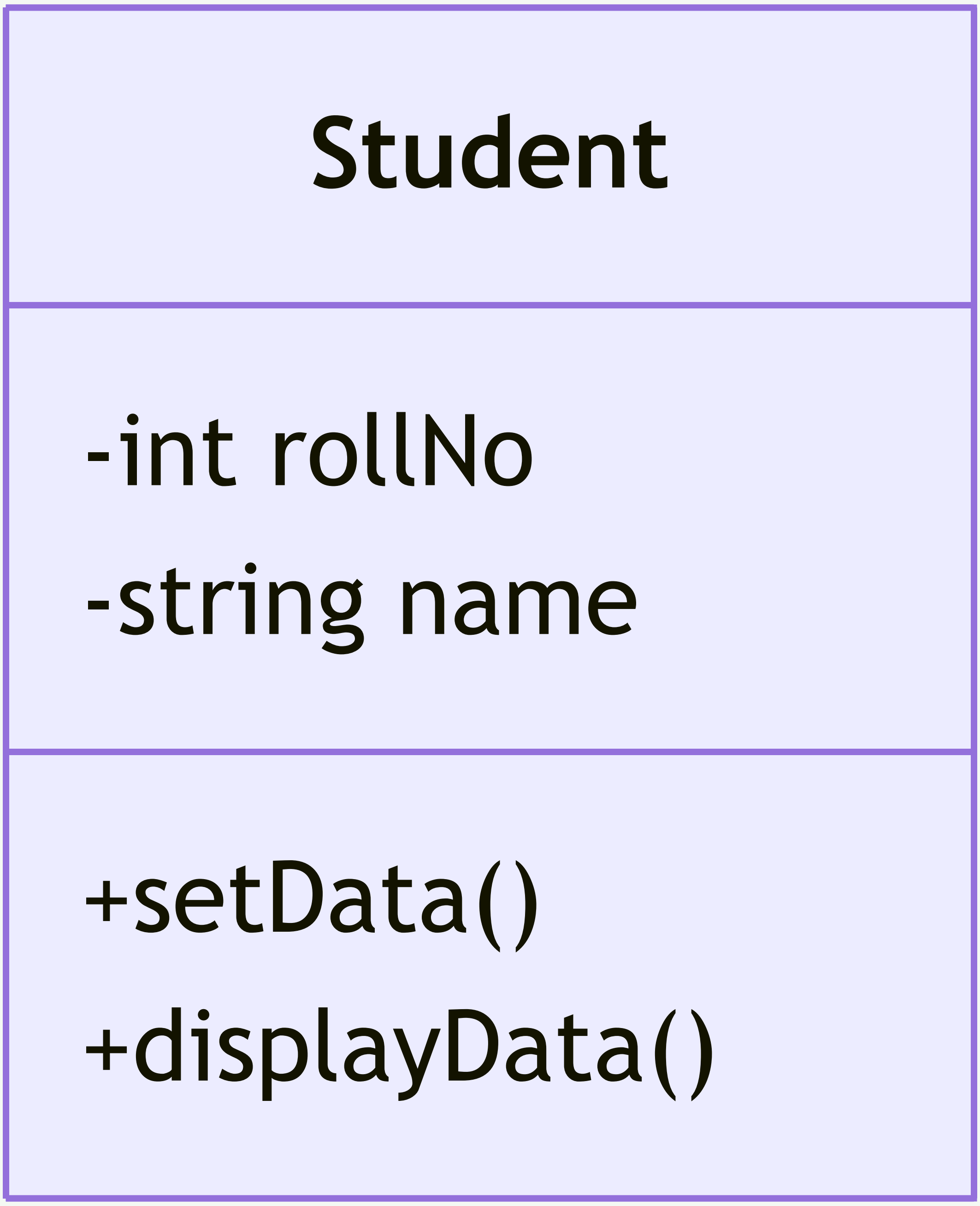
"Time Steps, Space Stores"

Question 1(c) [7 marks]

Explain concept of class & object with example.

Solution

Diagram:



Concept	Definition	Example
Class	Blueprint or template for creating objects	Student class with properties (rollNo, name) and methods (setData, displayData)
Object	Instance of a class with specific values	student1 (rollNo=101, name="Raj")

Code Example:

```python
class Student:
    def __init__(self):
        self.rollNo = 0
        self.name = ""

    def setData(self, r, n):
        self.rollNo = r
        self.name = n

    def displayData(self):
        print(self.rollNo, self.name)

# Creating objects
student1 = Student()
student1.setData(101, "Raj")
```

Mnemonic

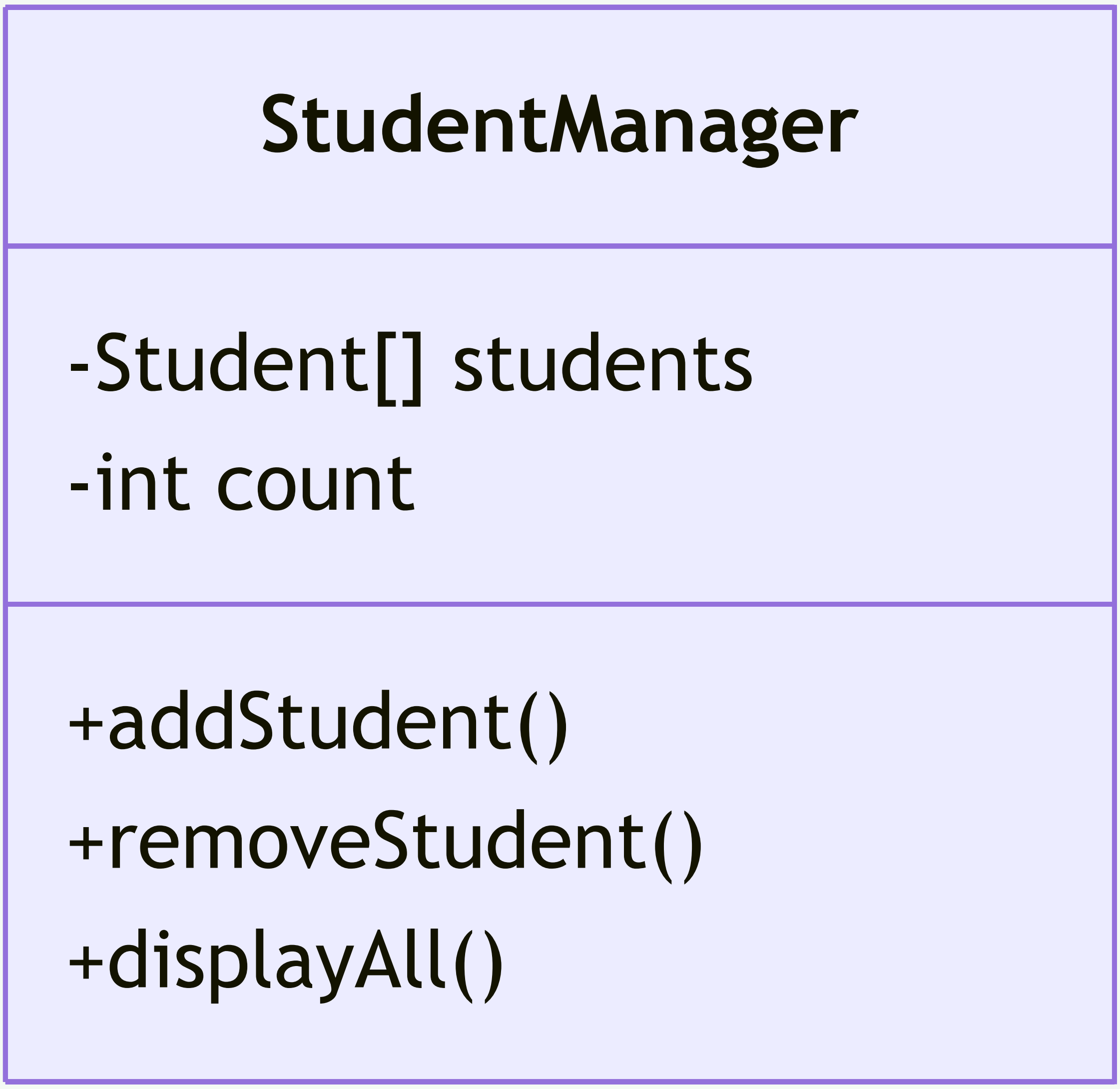
"Class Creates, Objects Operate"

Question 1(c) OR [7 marks]

Develop a class for managing student records with instance methods for adding and removing students from a class.

Solution

Diagram:



Code:

```
class StudentManager:
    def __init__(self):
        self.students = []

    def addStudent(self, roll, name):
        student = Student()
        student.setData(roll, name)
        self.students.append(student)

    def removeStudent(self, roll):
        for i in range(len(self.students)):
            if self.students[i].rollNo == roll:
                self.students.pop(i)
                break

    def displayAll(self):
        for student in self.students:
            student.displayData()
```

Mnemonic

"Add Accumulates, Remove Reduces"

Question 2(a) [3 marks]

Explain the importance of constructor in class.

Solution

Constructor Importance
1. Initializes object's data members
2. Automatically called when object is created
3. Can have different versions (default, parameterized, copy)

Mnemonic

"Initialization Always Creates"

Question 2(b) [4 marks]

Explain different operations on stack.

Solution

Operation	Description	Example
Push	Adds element to top	push(5)
Pop	Removes element from top	x = pop()
Peek/Top	Views top element without removing	x = peek()
isEmpty	Checks if stack is empty	if(isEmpty())

Diagram:

```
    PUSH                     POP
     |                        ^
     v                        |
   +---+                    +---+
   | 5 |                    | 8 |
   +---+                    +---+
   | 7 |  PEEK/TOP ------>  | 7 |
   +---+                    +---+
   | 8 |                    | 2 |
   +---+                    +---+
```

Mnemonic

"Push Pop Peek Properly"

Question 2(c) [7 marks]

Describe evaluation algorithm of postfix expression A B C + * D /

Solution

Diagram:

```
Input: A B C + * D /

+---+---+---+---+---+---+---+---+
```

```
| A | B | C | + | * | D | / |   |
+---+---+---+---+---+---+---+---+
     Read left to right
```

Step	Symbol	Action	Stack
1	A	Push onto stack	A
2	B	Push onto stack	A,B
3	C	Push onto stack	A,B,C
4	+	Pop B,C; Push B+C	A,B+C
5	*	Pop A,B+C; Push A*(B+C)	A*(B+C)
6	D	Push onto stack	A*(B+C),D
7	/	Pop A*(B+C),D; Push A*(B+C)/D*	A*(B+C)/D

Mnemonic

"Read, Push, Pop, Calculate"

Question 2(a) OR [3 marks]

Write difference between stack and queue.

Solution

Feature	Stack	Queue
Principle	LIFO (Last In First Out)	FIFO (First In First Out)
Operations	Push/Pop	Enqueue/Dequeue
Access Points	Single end (top)	Two ends (front, rear)

Mnemonic

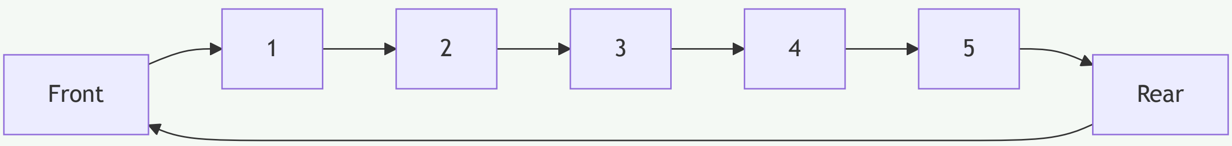
"Stack LIFO, Queue FIFO"

Question 2(b) OR [4 marks]

Explain concept of circular queue.

Solution

Diagram:



Feature	Description
Structure	Linear data structure with connected ends
Advantage	Efficiently uses memory by reusing empty spaces
Operations	Enqueue, Dequeue with modulo arithmetic

Mnemonic

"Circular Connects Front to Rear"

Question 2(c) OR [7 marks]

Describe the procedure for inserting a new node after and before a given node in a singly linked list.

Solution

Diagram:

```
Insert After Node X:
Before: A \rightarrow X \rightarrow B
After:  A \rightarrow X \rightarrow N \rightarrow B

Insert Before Node X:
Before: A \rightarrow X \rightarrow B
After:  A \rightarrow N \rightarrow X \rightarrow B
```

Insertion	Steps
After Node X	1. Create new node N2. Set N's next to X's next3. Set X's next to N
Before Node X	1. Create new node N2. Find node A pointing to X3. Set N's next to X4. Set A's next to N

Mnemonic

"After: Set Next Links, Before: Find Previous First"

Question 3(a) [3 marks]

Explain traversing a linked list.

Solution

Diagram:

```
start \rightarrow [10] \rightarrow [20] \rightarrow [30] \rightarrow NULL
         ^      ^      ^
         |      |      |
       Visit  Visit  Visit
```

Step	Action
1	Initialize pointer to head
2	Access data at current node
3	Move pointer to next node
4	Repeat until NULL

Mnemonic

"Start, Access, Move, Repeat"

Question 3(b) [4 marks]

Explain expression conversion from infix to postfix.

Solution

Diagram:

```
Infix:    A + B * C
Postfix:  A B C * +
```

Step	Action	Stack	Output
1	Scan from left to right		
2	If operand, add to output		A
3	If operator, push if higher precedence	+	A
4	Pop lower precedence operators	+	A B
5	Push current operator	*	A B
6	Continue until expression ends	*	A B C
7	Pop remaining operators		A B C * +

Mnemonic

"Operators Push Pop, Operands Output Directly"

Question 3(c) [7 marks]

Write a program to delete a node at the beginning and end of singly linked list.

Solution

Diagram:

```
Before:  Head \rightarrow [10] \rightarrow [20] \rightarrow [30] \rightarrow NULL
After:   Head \rightarrow [20] \rightarrow NULL
```

Code:

```python
class Node:
    def __init__(self, data):
        self.data = data
        self.next = None

class LinkedList:
    def __init__(self):
        self.head = None

    def deleteFirst(self):
        if self.head is None:
            return
        self.head = self.head.next

    def deleteLast(self):
        if self.head is None:
            return

        # If only one node
        if self.head.next is None:
            self.head = None
            return

        temp = self.head
        while temp.next.next:
            temp = temp.next

        temp.next = None
```

Mnemonic

"Delete First: Shift Head, Delete Last: Find Second-Last"

Question 3(a) OR [3 marks]

Explain searching an element in linked list.

Solution

Diagram:

```
Head \rightarrow [10] \rightarrow [20] \rightarrow [30] \rightarrow NULL
           ^          ^          ^
       Check      Check      Check
```

Step	Description
1	Start from head node
2	Compare current node's data with key
3	If match found, return true
4	Else, move to next node and repeat

Mnemonic

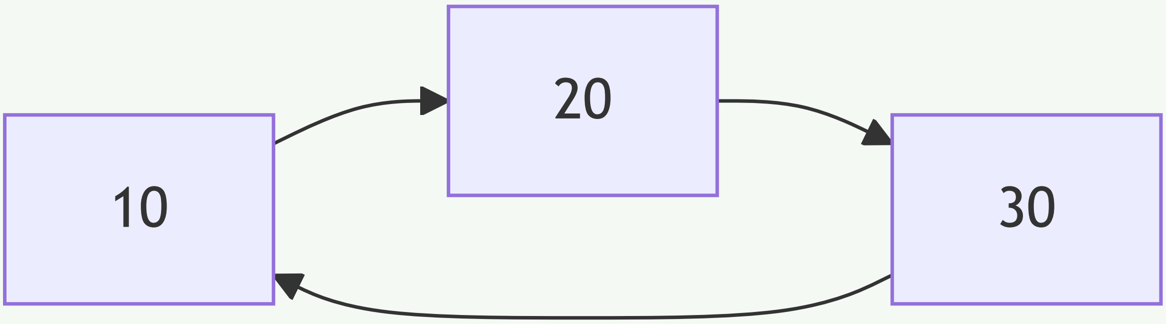
"Start, Compare, Move, Repeat"

Question 3(b) OR [4 marks]

Explain concepts of circular linked lists.

Solution

Diagram:



Feature	Description
Structure	Last node points to first node
Advantage	No NULL pointers, efficient for circular operations
Traversal	Need extra condition to prevent infinite loop

Mnemonic

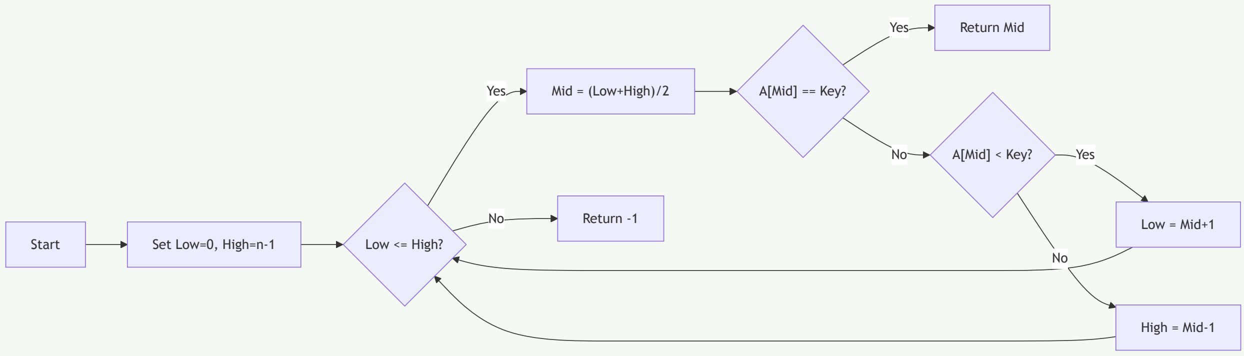
"Last Links to First"

Question 3(c) OR [7 marks]

Explain algorithm to search a particular element from list using Binary Search.

Solution

Diagram:



Code:

```
def binarySearch(arr, key):
    low = 0
    high = len(arr) - 1

    while low <= high:
        mid = (low + high) // 2

        if arr[mid] == key:
            return mid
        elif arr[mid] < key:
            low = mid + 1
        else:
            high = mid - 1

    return -1
```

Mnemonic

"Middle, Compare, Eliminate Half"

Question 4(a) [3 marks]

Write applications of linked list.

Solution

Applications of Linked List
1. Implementation of stacks and queues
2. Dynamic memory allocation
3. Image viewer (next/previous images)

Mnemonic

"Store Data Dynamically"

Question 4(b) [4 marks]

Differentiate between singly linked list and doubly linked list.

Solution

Feature	Singly Linked List	Doubly Linked List
Node Structure	One pointer (next)	Two pointers (next, prev)

Traversal	Forward only	Both directions
Memory	Less memory	More memory
Operations	Simple, less code	Complex, more flexible

Diagram:

```
Singly: [Data|Next] \rightarrow [Data|Next] \rightarrow [Data|Next]

Doubly: [Prev|Data|Next]   [Prev|Data|Next]   [Prev|Data|Next]
```

Mnemonic

"Single Direction, Double Direction"

Question 4(c) [7 marks]

Write a program to sort numbers in ascending order using selection sort algorithm.

Solution

Diagram:

```
Initial: [5, 3, 8, 1, 2]
Pass 1:  [1, 3, 8, 5, 2]  (Swap 5,1)
Pass 2:  [1, 2, 8, 5, 3]  (Swap 3,2)
Pass 3:  [1, 2, 3, 5, 8]  (Swap 8,3)
Pass 4:  [1, 2, 3, 5, 8]  (No swap)
```

Code:

```python
def selectionSort(arr):
    n = len(arr)

    for i in range(n):
        min_idx = i

        for j in range(i+1, n):
            if arr[j] < arr[min_idx]:
                min_idx = j

        # Swap the found minimum element with the first element
        arr[i], arr[min_idx] = arr[min_idx], arr[i]

    return arr

# Example usage
arr = [5, 3, 8, 1, 2]
sorted_arr = selectionSort(arr)
print(sorted_arr)  # Output: [1, 2, 3, 5, 8]
```

Mnemonic

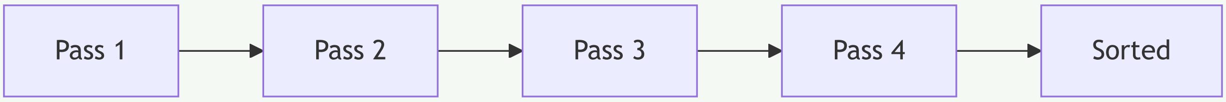
"Find Minimum, Swap Position"

Question 4(a) OR [3 marks]

Explain bubble sort algorithm.

Solution

Diagram:



Key Points
Compare adjacent elements
Swap if they are in wrong order
Largest element bubbles to end in each pass

Mnemonic

"Bubble Bigger Elements Upward"

Question 4(b) OR [4 marks]

Differentiate Linear & Binary search.

Solution

Feature	Linear Search	Binary Search
Working Principle	Sequential checking	Divide and conquer
Time Complexity	O(n)	O(log n)
Data Arrangement	Unsorted or sorted	Must be sorted
Best For	Small datasets	Large datasets

Mnemonic

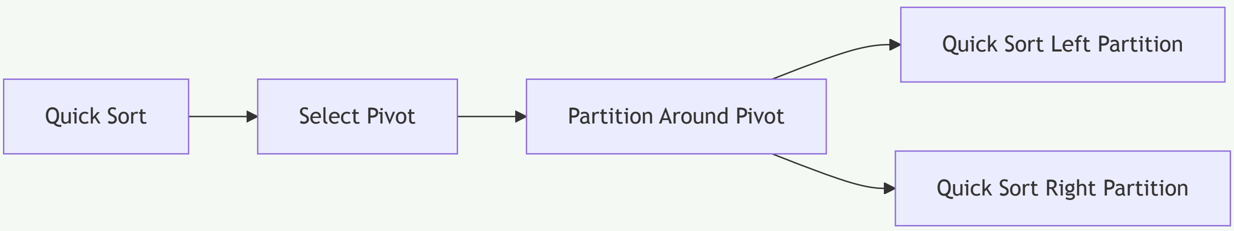
"Linear Looks at All, Binary Breaks in Half"

Question 4(c) OR [7 marks]

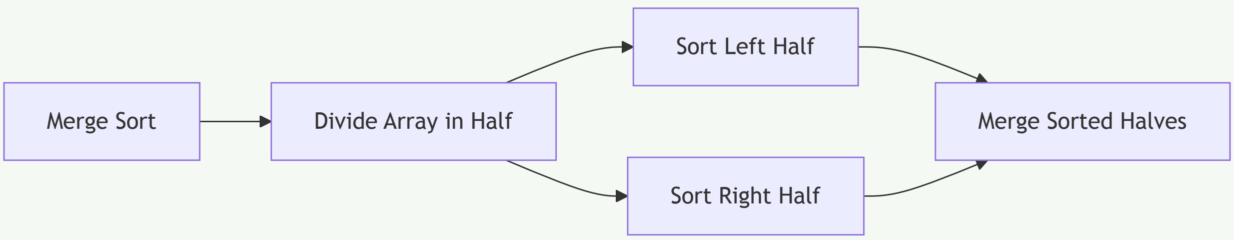
Explain Quick sort & Merge sort algorithm.

Solution

Quick Sort:



Merge Sort:



Algorithm	Principle	Average Time	Space Complexity
Quick Sort	Partitioning around pivot	O(n log n)	O(log n)
Merge Sort	Divide, conquer, combine	O(n log n)	O(n)

Mnemonic

"Quick Partitions, Merge Divides"

Question 5(a) [3 marks]

Define a complete binary tree.

Solution

Diagram:

```
    1
   / \
  2   3
 / \  /
4  5 6
```

Property	Description
All levels filled	Except possibly the last level
Last level filled from left	Nodes added from left to right

Mnemonic

"Fill Left to Right, Level by Level"

Question 5(b) [4 marks]

Explain inorder traversal of a binary tree.

Solution

Diagram:

```
      A
     / \
    B   C
   / \
  D   E

Inorder: D \rightarrow B \rightarrow E \rightarrow A \rightarrow C
```

Step	Action
1	Traverse left subtree
2	Visit root node
3	Traverse right subtree

Code:

```python
def inorderTraversal(root):
    if root:
        inorderTraversal(root.left)
        print(root.data, end=" \rightarrow ")
        inorderTraversal(root.right)
```

Mnemonic

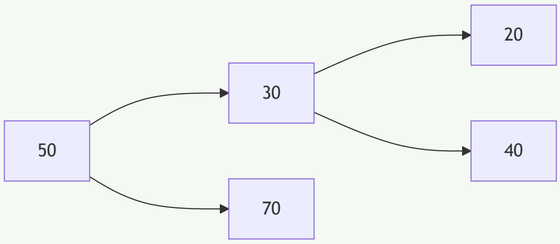
"Left, Root, Right"

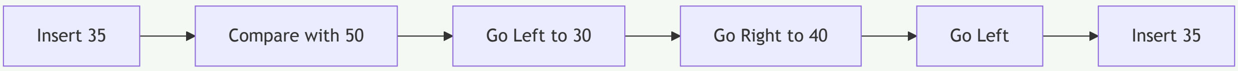
Question 5(c) [7 marks]

Write a program to inserting a node into a binary search tree.

Solution

Diagram:





Code:

```python
class Node:
    def __init__(self, key):
        self.key = key
        self.left = None
        self.right = None

def insert(root, key):
    if root is None:
        return Node(key)

    if key < root.key:
        root.left = insert(root.left, key)
    else:
        root.right = insert(root.right, key)

    return root
```

Mnemonic

"Compare, Move, Insert"

Question 5(a) OR [3 marks]

State the fundamental characteristic of a binary search tree.

Solution

Characteristics of Binary Search Tree
1. Left child nodes < Parent node
2. Right child nodes > Parent node
3. No duplicate values allowed

Mnemonic

"Left Less, Right More"

Question 5(b) OR [4 marks]

Explain postorder traversal of a binary tree.

Solution

Diagram:

```
      A
     / \
    B   C
   / \
  D   E

Postorder: D \rightarrow E \rightarrow B \rightarrow C \rightarrow A
```

Step	Action
1	Traverse left subtree
2	Traverse right subtree
3	Visit root node

Code:

```python
def postorderTraversal(root):
    if root:
        postorderTraversal(root.left)
        postorderTraversal(root.right)
        print(root.data, end=" \rightarrow ")
```

Mnemonic

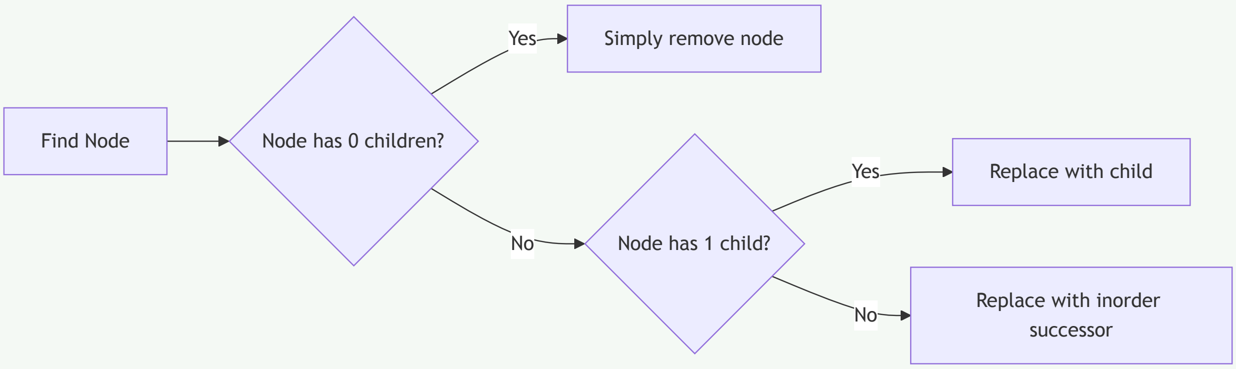
"Left, Right, Root"

Question 5(c) OR [7 marks]

Write a program to delete a node from a binary search tree.

Solution

Diagram:



Code:

```python
def minValueNode(node):
    current = node
```

```python
    while current.left is not None:
        current = current.left
    return current

def deleteNode(root, key):
    if root is None:
        return root

    if key < root.key:
        root.left = deleteNode(root.left, key)
    elif key > root.key:
        root.right = deleteNode(root.right, key)
    else:
        # Node with one or no child
        if root.left is None:
            return root.right
        elif root.right is None:
            return root.left

        # Node with two children
        successor = minValueNode(root.right)
        root.key = successor.key
        root.right = deleteNode(root.right, successor.key)

    return root
```

Mnemonic

"Find, Replace, Reconnect"