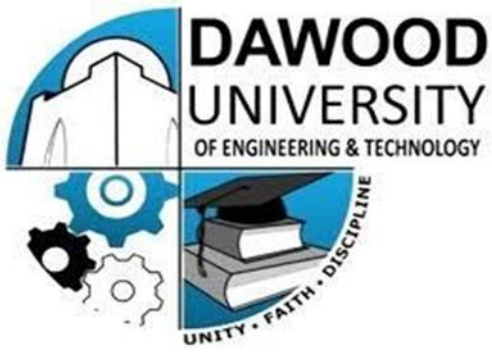
Data Structures & Algorithms

(Practical Manual)



5th Semester, 3rd Year

BATCH -2022

BS ARTIFICIAL INTELLIGENCE

DAWOOD UNIVERSITY OF ENGINEERING & TECHNOLOGY, KARACHI

Dawood University Of Engineering and Technology, Karachi

CERTIFICATE

This is to certify that Mr./Ms. **Muhammad Sohaib** with Roll # **22F-BSAI-40** of Batch 2023 has successfully completed all the labs prescribed for the course "**Data Structures & Algorithms**".

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Lab No. 01

[Introduction to Programming in Python]

Task No. 01

```
Write a program which can generate the following
Input a number: 10
10 x 1 = 10
10 x 2 = 20
10 x 3 = 30
10 x 4 = 40
10 x 5 = 50
10 x 6 = 60
10 x 7 = 70
10 x 8 = 80
10 x 9 = 90
10 x 10 = 100
```

CODE

```
num = int(input('Input a number:'))
for i in range(1,11):
    result = num*i
    print(f"{num} * {i} = {result}")
    i=i+1
```

OUTPUT

```
10 * 1 = 10
10 * 2 = 20
10 * 3 = 30
10 * 4 = 40
10 * 5 = 50
10 * 6 = 60
10 * 7 = 70
10 * 8 = 80
10 * 9 = 90
10 * 10 = 100
```

Task No. 02

```
Write a program to prompt for a score between 0.0 and 1.0. If the score is out of range, print an error message. If the score is between 0.0 and 1.0, print a grade using the following table:

>= 0.9 A
>= 0.8 B
>>= 0.7 C
>= 0.6 D < 0.6 F
Enter score: 0.95 A
Enter score: perfect Bad score
Enter score: 10.0
Bad score
Enter score: 0.75 C
Enter score: 0.5
F
```

CODE

```python
def get_grade(score):
    if score < 0.0 or score > 1.0:
        return "Bad score"
    elif score >= 0.9:
        return "A"
    elif score >= 0.8:
        return "B"
    elif score >= 0.7:
        return "C"
    elif score >= 0.6:
        return "D"
    else:
        return "F"
while True:
    score_input = input("Enter score (or type 'exit' to quit): ")
    if score_input.lower() == "exit":
        break
    if score_input.lower() == "perfect":
        print("Bad score")
        continue
    try:
        score = float(score_input)
        print(get_grade(score))
    except ValueError:
```

```
        print("Bad score")
```

OUTPUT

```
Enter score (or type 'exit' to quit):  0.9
A
Enter score (or type 'exit' to quit):  exit
```

Task No. 03

```
Given an array of integers nums and an integer target, return indices of the two
numbers such that they add up to target. You may assume that each input would
have exactly one solution, and you may not use the same element twice. You can
return the answer in any order.
Example 1:
Input: nums = [2,7,11,15], target = 9
Output: [0,1]
Explanation: Because nums[0] + nums[1] == 9, we return [0, 1].
Example 2:
Input: nums = [3,2,4], target = 6
Output: [1,2]
```

CODE

```
class TwoSum:
    def __init__(self, list1, target):
        self.list1 = list1
        self.target = target
    def solution(self):
        length = len(list1)
        for i in range(length-1):
            for j in range(i+1, length):
                if list1[i]+list1[j] == self.target:
                    new_list = i, j
                    return list(new_list)
        return -1
list1 = [2,7,11,15]
target = 9
obj = TwoSum(list1, target)
print(obj.solution())
```

OUTPUT

```
[0, 1]
```

Lab No. 02

[Implementing Stack Data Structure in Python]

Task No. 01

```
Execute the above code and observe its output
```

Code

```
def create_stack(): # creating a stack
          stack = []
          return stack
# creating an function to check stack is empty or not:
def check_empty(stack):
          return len(stack) == 0
# adding an items into the stack:
def push(stack,item):
          stack.append(item)
          print('pushed item:',item)

# removing an element from the stack:
def pop(stack):
          if(check_empty(stack)):
                    return 'stack is empty'
          else:
                   return stack.pop()

stack = create_stack()
push(stack, str(1))
push(stack, str(2))
push(stack, str(3))
push(stack, str(4))
print("popped item: " + pop(stack))
print("stack after popping an element: " + str(stack))
```

OUTPUT

```
pushed item: 1
pushed item: 2
pushed item: 3
pushed item: 4
popped item: 4
stack after popping an element: ['1', '2', '3']
```

Task No. 02

```
Given a string s containing just the characters '(', ')', '{', '}', '[' and ']',
determine if the input string is valid.

An input string is valid if:

1.  Open brackets must be closed by the same type of brackets.
2.  Open brackets must be closed in the correct order.
3.  Every close bracket has a corresponding open bracket of the same type.

Example 1:
Input: s = "()"
Output: true

Example 2:
Input: s = "()[]{}"
Output: true

Example 3:
Input: s = "(]"
Output: false

Example 4:
Input: s = "([])"
Output: true
```

Code

```
def ispar(s):
    stack = []
    for char in s:
        # Opening bracket
        if char in '({[':
            stack.append(char)
        # Closing Bracket
        elif char in ')}]':
            # closing bracket without opening
            if not stack:
                return False
            # Else pop an item check for matching
            top = stack.pop()
            if (top == '(' and char != ')') or \
               (top == '{' and char != '}') or \
               (top == '[' and char != ']'):
                return False
    # If an opening bracket without closing
    return len(stack) == 0

s = '{()}[]'
if ispar(s):
    print("true")
else:
    print("false")
```

OUTPUT

```
true
```

Lab No. 03

[Building and Utilizing Queues in Python]

Task No. 01

```
Execute the above code and observe its output.
```

Code

```
class Queue:
          def __init__(self):
                    self.queue = []
          # add an element
          def enqueue(self,item):
                    self.queue.append(item)

          # remove an element
          def dequeue(self):
                    if len(self.queue)<1:
                              return None
                    else:
                              return self.queue.pop(0)
          # display the queue
          def display(self):
                    print(self.queue)

          def size(self):
                    return len(self.queue)
q = Queue()

q.enqueue(1)
q.enqueue(2)
q.enqueue(3)
q.enqueue(4)
q.enqueue(5)
q.display()
q.dequeue()
```

```
print("After removing an element")
q.display()
```

OUTPUT

```
[1, 2, 3, 4, 5]
After removing an element
[2, 3, 4, 5]
```

Task No. 02

```
There are n people in a line queuing to buy tickets, where the 0th person is at
the front of the line and the (n - 1)th person is at the back of the line.
You are given a 0-indexed integer array tickets of length n where the number of
tickets that the ith person would like to buy is tickets[i].
Each person takes exactly 1 second to buy a ticket. A person can only buy 1
ticket at a time and has to go back to the end of the line (which happens
instantaneously) in order to buy more tickets. If a person does not have any
tickets left to buy, the person will leave the line.
Return the time taken for the person initially at position k (0-indexed) to
finish buying tickets.

Example 1:
Input: tickets = [2,3,2], k = 2
Output: 6
Explanation:
•   The queue starts as [2,3,2], where the kth person is underlined.
•   After the person at the front has bought a ticket, the queue becomes [3,2,1]
at 1 second.
•   Continuing this process, the queue becomes [2,1,2] at 2 seconds.
•   Continuing this process, the queue becomes [1,2,1] at 3 seconds.
•   Continuing this process, the queue becomes [2,1] at 4 seconds. Note: the
person at the front left the queue.
•   Continuing this process, the queue becomes [1,1] at 5 seconds.
•   Continuing this process, the queue becomes [1] at 6 seconds. The kth person
has bought all their tickets, so return 6.
Example 2:
Input: tickets = [5,1,1,1], k = 0
Output: 8
Explanation:
•   The queue starts as [5,1,1,1], where the kth person is underlined.
•   After the person at the front has bought a ticket, the queue becomes
[1,1,1,4] at 1 second.
```

```
•   Continuing this process for 3 seconds, the queue becomes [4] at 4 seconds.
•   Continuing this process for 4 seconds, the queue becomes [] at 8 seconds. The
kth person has bought all their tickets, so return 8.
```

Code

```
from typing import List
class Solution:
    def timeRequiredToBuy(self, tickets: List[int], k: int) -> int:
        # Initialize the total time required to 0
        total_time = 0

        # Iterate over the ticket queue to simulate the time passing
        for index, tickets_at_this_position in enumerate(tickets):
            # If the current position is before or at the target position k
            if index <= k:
                # Add the minimum of the target tickets and tickets at the
current position
                # It ensures we do not count the extra tickets the target person
doesn't need
                total_time += min(tickets[k], tickets_at_this_position)
            else:
                # After the target person has bought their tickets, they will not
buy more
                # Thus, for the people after the target, we consider one less
ticket for the target
                # Person at position k would have already bought their ticket
when turn comes to later positions
                total_time += min(tickets[k] - 1, tickets_at_this_position)

        # Return the calculated total time
        return total_time
# Example usage:
sol = Solution()
print(sol.timeRequiredToBuy([2, 3, 2], 2))  # This would output 6, the total time
to buy tickets
```

OUTPUT

```
6
```

Lab No. 04

[Working with Linked Lists and Node Insertion]

Task No. 01

```
Implement LinkedList Data Structure in Python.
```

Code

```
class Node: # Creating a node
    def __init__(self, item):
        self.item = item
        self.next = None

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

linked_list = LinkedList()

# Assign item values

linked_list.head = Node(1)
second = Node(2)
third = Node(3)

# Connect nodes
linked_list.head.next = second
second.next = third

# Print the linked list item

while linked_list.head != None:
```

```
    print(linked_list.head.item, end=" ")
    linked_list.head = linked_list.head.next
```

OUTPUT

```
1 2 3
```

Task No. 02

```
Insert a node at Head, and End of the LinkedList
```

Code

```
# Linked List - Python
class Node:
    def __init__(self,data):
        self.data = data
        self.next = None
class LinkedList:
    def __init__(self):
        self.head = None

    def insertHead(self,newNode):
        temporaryNode = self.head
        self.head = newNode
        self.head.next = temporaryNode
        del temporaryNode

    def insertAt(self,newNode,position):
        if position < 0 or position > self.listLength():
            print("Invalid Position")
            return
        if position == 0:
            self.insertHead(newNode)
            previousNode = None
            return
        currentNode = self.head
        currentPosition = 0
        while True:
            if currentPosition == position:
                previousNode.next = newNode
                newNode.next = currentNode
```

```
                break
            previousNode = currentNode
            currentNode = currentNode.next
            currentPosition += 1

    def insertEnd(self,newNode):
        if self.head is None:
            self.head = newNode
        else:
            lastNode = self.head
            while True:
                if lastNode.next is None:
                    break
                lastNode = lastNode.next
            lastNode.next = newNode

    def listLength(self):
        currentNode = self.head
        length = 0
        while currentNode is not None:
            length += 1
            currentNode = currentNode.next
        return length

    def printList(self):
        if self.head is None:
            print("List is empty")
            return
        currentNode = self.head
        while True:
            if currentNode is None:
                break
            print(currentNode.data)
            currentNode = currentNode.next

firstNode = Node(10)
secondNode = Node(20)
thirdNode = Node(30)
fourthNode = Node(40)

linkedList =LinkedList()

# insert at head
```

```
linkedList.insertHead(firstNode)
linkedList.insertHead(secondNode)
# insert at end
linkedList.insertEnd(thirdNode)
linkedList.insertEnd(fourthNode)
linkedList.printList()
```

OUTPUT

```
20
10
30
40
```

Task No. 03

```
Insert a new node in between two nodes passing the index where the new node is to be inserted.
```

Code

```
class Node:
    def __init__(self,data):
        self.data = data
        self.next = None
class LinkedList:
    def __init__(self):
        self.head = None
    def insertHead(self,newNode):
        temporaryNode = self.head
        self.head = newNode
        self.head.next = temporaryNode
        del temporaryNode
    def insertAt(self,newNode,position):
        if position < 0 or position > self.listLength():
            print("Invalid Position")
            return
        if position == 0:
            self.insertHead(newNode)
            previousNode = None
            return
        currentNode = self.head
        currentPosition = 0
        while True:
            if currentPosition == position:
```

```
                previousNode.next = newNode
                newNode.next = currentNode
                break
            previousNode = currentNode
            currentNode = currentNode.next
            currentPosition += 1
    def insertEnd(self,newNode):
        if self.head is None:
            self.head = newNode
        else:
            lastNode = self.head
            while True:
                if lastNode.next is None:
                    break
                lastNode = lastNode.next
            lastNode.next = newNode
    def listLength(self):
        currentNode = self.head
        length = 0
        while currentNode is not None:
            length += 1
            currentNode = currentNode.next
        return length
    def printList(self):
        if self.head is None:
            print("List is empty")
            return
        currentNode = self.head
        while True:
            if currentNode is None:
                break
            print(currentNode.data)
            currentNode = currentNode.next
firstNode = Node(10)
secondNode = Node(20)
thirdNode = Node(30)
fourthNode = Node(40)
linkedList =LinkedList()
# insert at end
linkedList.insertAt(firstNode,0)
linkedList.insertAt(secondNode,1)
# insert at end
linkedList.insertEnd(thirdNode)
linkedList.insertEnd(fourthNode)
```

```
linkedList.printList()
```

OUTPUT

```
10
20
30
40
```

Lab No. 05

[Manipulating Linked Lists: Deletion and Merging]

Task No. 01

```
Implement Deletion of a node from LinkedList using the three ways explained in python.
```

Code

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

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

    def insertHead(self, newNode):
        temporaryNode = self.head
        self.head = newNode
        self.head.next = temporaryNode
        del temporaryNode

    def insertAt(self, newNode, position):
        if position < 0 or position > self.listLength():
            print("Invalid Position")
            return
```

```
        if position == 0:
            self.insertHead(newNode)
            return
        currentNode = self.head
        currentPosition = 0
        while currentNode is not None:
            if currentPosition == position:
                previousNode.next = newNode
                newNode.next = currentNode
                return
            previousNode = currentNode
            currentNode = currentNode.next
            currentPosition += 1

    def insertEnd(self, newNode):
        if self.head is None:
            self.head = newNode
        else:
            lastNode = self.head
            while lastNode.next is not None:
                lastNode = lastNode.next
            lastNode.next = newNode

    def deleteHead(self):
        if self.head is None:
            print("List is empty")
            return
        self.head = self.head.next  # Move head to the next node

    def deleteNode(self, key):
        # Case 1: Deleting the head node
        if self.head is None:
            print("List is empty")
            return
        if self.head.data == key:
            self.head = self.head.next
            return

        # Case 2: Deleting a node from the middle or end
        currentNode = self.head
        while currentNode is not None:
            if currentNode.next and currentNode.next.data == key:
                currentNode.next = currentNode.next.next
                return
```

```
            currentNode = currentNode.next

        print("Node with value", key, "not found.")

    def deleteAt(self, position):
        if position < 0 or position >= self.listLength():
            print("Invalid Position")
            return

        # Case 1: Delete at position 0 (head)
        if position == 0:
            self.deleteHead()
            return

        currentNode = self.head
        currentPosition = 0
        while currentNode is not None:
            if currentPosition == position - 1:
                currentNode.next = currentNode.next.next  # Skip the node to
delete
                return
            currentNode = currentNode.next
            currentPosition += 1

    def listLength(self):
        currentNode = self.head
        length = 0
        while currentNode is not None:
            length += 1
            currentNode = currentNode.next
        return length

    def printList(self):
        if self.head is None:
            print("List is empty")
            return
        currentNode = self.head
        while currentNode is not None:
            print(currentNode.data)
            currentNode = currentNode.next


# Example usage:
```

```
firstNode = Node(10)
secondNode = Node(20)
thirdNode = Node(30)
fourthNode = Node(40)

linkedList = LinkedList()

# Insert nodes
linkedList.insertAt(firstNode, 0)   # Insert first node at the head
linkedList.insertAt(secondNode, 1)  # Insert second node at position 1
linkedList.insertEnd(thirdNode)     # Insert third node at the end
linkedList.insertEnd(fourthNode)    # Insert fourth node at the end

print("Original List:")
linkedList.printList()

# Deleting the head node
linkedList.deleteHead()
print("\nList after deleting head node:")
linkedList.printList()

# Deleting a specific node by value
linkedList.deleteNode(30)
print("\nList after deleting node with value 30:")
linkedList.printList()

# Deleting node at a specific position
linkedList.deleteAt(1)  # Deleting the second node (value 40)
print("\nList after deleting node at position 1:")
linkedList.printList()
```

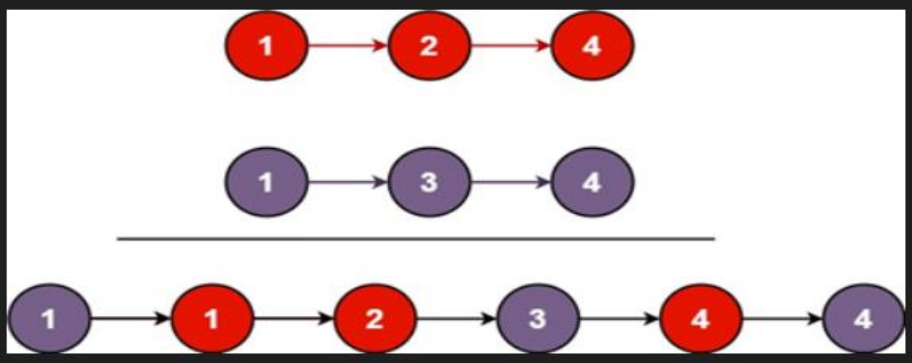
OUTPUT

```
Original List:
10
30
40

List after deleting head node:
30
40

List after deleting node with value 30:
40
Invalid Position

List after deleting node at position 1:
40
```

Task No. 02

```
You are given the heads of two sorted linked lists list1 and list2.
Merge the two lists into one sorted list. The list should be made by splicing
together the nodes of the first two lists.
Return the head of the merged linked list.
```

Example 1:



Input: list1 = [1,2,4], list2 = [1,3,4] Output: [1,1,2,3,4,4]

Example 2: Input: list1 = [], list2 = [] Output: []

Example 3: Input: list1 = [], list2 = [0] Output: [0]

Code

```python
class ListNode:
    def __init__(self, val=0, next=None):
        self.val = val
        self.next = next

class Solution:
    def mergeTwoLists(self, list1, list2):
        if list1 is None or list2 is None:
            return list1 or list2
        if list1.val <= list2.val:
            list1.next = self.mergeTwoLists(list1.next, list2)
            return list1
        else:
            list2.next = self.mergeTwoLists(list1, list2.next)
            return list2

# Helper function to convert a Python list into a linked list
def list_to_linked_list(arr):
    if not arr:
        return None
    head = ListNode(arr[0])
```

```
    current = head
    for val in arr[1:]:
        current.next = ListNode(val)
        current = current.next
    return head

# Helper function to convert a linked list back to a Python list
def linked_list_to_list(head):
    result = []
    while head:
        result.append(head.val)
        head = head.next
    return result

# Test cases
test_cases = [
    ([1, 2, 4], [1, 3, 4]),  # Expected Output: [1,1,2,3,4,4]
    ([], []),                 # Expected Output: []
    ([], [0])                 # Expected Output: [0]
]
# Running the test cases
solution = Solution()
for list1, list2 in test_cases:
    l1 = list_to_linked_list(list1)
    l2 = list_to_linked_list(list2)
    merged_head = solution.mergeTwoLists(l1, l2)
    print(linked_list_to_list(merged_head))
```

OUTPUT

```
[1, 1, 2, 3, 4, 4]
[]
[0]
```

Lab No. 06

[Exploring Recursion for Problem Solving]

Task No. 01

```
Implement python code for factorial of a number.
```

Code

```
# Python also accepts function recursion, which means a defined function can call itself.
def factorial(n):
    if(n==0 or n==1):
        return 1
    else:
        return n * factorial(n-1) #==> called the factorial(n-1) function inside factorial(n)
```

```
print(factorial(5))
# it go inside 'else'.
# It will ne told to calculate 5 * factorial(n==4) so,
# 5 * factorial(4)
# 5 * 4 * factorial(3)
# 5 * 4 * 3 * factorial(2)
# 5 * 4 * 3 * 2 * factorial(1) -> this is n==1 it go inside 'if' & print 1
# 5 * 4 * 3 * 2 * 1
```

OUTPUT

```
120
```

Task No. 02

```
Given an integer n, return true if it is a power of two. Otherwise, return false.
An integer n is a power of two, if there exists an integer x such that n == 2x.

Example 1:
Input: n = 1
Output: true
Explanation: 20 = 1

Example 2:
Input: n = 16
Output: true
Explanation: 24 = 16

Example 3:
Input: n = 3
Output: false
```

Code

```
def ispowerofTwo(n):
    if (n == 0):
        return False
    while (n != 1):
            if (n % 2 != 0):
                return False
            n = n // 2
    return True

ispowerofTwo(3)
```

OUTPUT

```
False
```

Task No. 03

```
Given an integer n, return true if it is a power of three. Otherwise, return
false. An integer n is a power of three, if there exists an integer x such that n
== 3x.

Example 1:
Input: n = 27
Output: true
Explanation: 27 = 33

Example 2:
Input: n = 0
Output: false
Explanation: There is no x where 3x = 0.

Example 3:
Input: n = -1
Output: false
Explanation: There is no x where 3x = (-1).
```

Code

```
def isPowerofThree(n):
    if n <= 0:
        return False
    while n % 3 == 0:
        n /= 3

return n == 1


isPowerofThree(3)
```

OUTPUT

```
True
```

Task No. 04

```
Given an integer n, return true if it is a power of four. Otherwise, return
false. An integer n is a power of four, if there exists an integer x such that n
== 4x.

Example 1:
Input: n = 16
Output: true

Example 2:
Input: n = 5
Output: false

Example 3:
Input: n = 1
Output: true
```

Code

```
def isPowerOfFour(n):
    # Check for non-positive numbers
    if n <= 0:
```

```
        return False
    # Continuously divide by 4 until n is no longer divisible
    while n % 4 == 0:
        n /= 4
    # If n is 1, it's a power of four
    return n == 1
isPowerOfFour(4)
```

OUTPUT

```
True
```

Lab No. 07

[Understanding and Applying Basic Sorting Algorithms]

Task No. 01

```
Develop Python programs for Bubble Sort, Selection Sort, and Insertion Sort.
```

Code

```
# bubble sort
def bubblesort(array):
          n = len(array)
          for i in range(n-1):
                    swapped = False
                    for j in range(n-1- i):
                              if array[j] > array[j+1]:
                                        array[j],array[j+1]=array[j+1],array[j]
                    swapped = True
          if (not swapped):
```

```
                    return

array = [5,4,3,2,1]
bubblesort(array)
print('sorted array in Ascending order:')
print(array)
```

OUTPUT

```
sorted array in Ascending order:
[1, 2, 3, 4, 5]
```

Selection Sort

```
def selection_sort(array):
    length = len(array)

    for i in range(length-1):
        minIndex = i

        for j in range(i+1, length):
            if array[j]<array[minIndex]:
                minIndex = j

        array[i], array[minIndex] = array[minIndex], array[i]
    return array
array = [21,6,9,33,3]

print("The sorted array is: ", selection_sort(array))
```

OUTPUT

```
The sorted array is:  [3, 6, 9, 21, 33]
```

Insertion Sort

```
def insertionSort(array):

    for step in range(1, len(array)):
        key = array[step]
        j = step - 1

        # Compare key with each element on the left of it until an element
smaller than it is found
        # For descending order, change key<array[j] to key>array[j].
        while j >= 0 and key < array[j]:
            array[j + 1] = array[j]
            j = j - 1

        # Place key at after the element just smaller than it.
        array[j + 1] = key


data = [9, 5, 1, 4, 3]
insertionSort(data)
print('Sorted Array in Ascending Order:')
print(data)
```

OUTPUT

```
Sorted Array in Ascending Order:
[1, 3, 4, 5, 9]
```

Task No. 02

```
Given an integer array nums, return true if any value appears at least twice in
the array, and return false if every element is distinct.
 Example 1:
Input: nums = [1,2,3,1]
Output: true
Explanation: The element 1 occurs at the indices 0 and 3.

Example 2:
Input: nums = [1,2,3,4]
Output: false
```

```
Explanation: All elements are distinct.

Example 3:
Input: nums = [1,1,1,3,3,4,3,2,4,2]
Output: true
```

Code

```
def containsDuplicate(nums):
    # Create an empty set to store unique elements
    unique_set = set()
    # Iterate through the array
    for num in nums:
        # If the element is already in the set, it's a duplicate
        if num in unique_set:
            return True
        # Otherwise, add the element to the set
        unique_set.add(num)

    # If the loop completes without returning, there are no duplicates
    return False
containsDuplicate([1,2,22,4])
```

OUTPUT

```
False
```

Task No. 03

```
Given an array nums containing n distinct numbers in the range [0, n], return the
only number in the range that is missing from the array.
Example 1:
Input: nums = [3,0,1]
Output: 2
Explanation: n = 3 since there are 3 numbers, so all numbers are in the range
[0,3]. 2 is the missing number in the range since it does not appear in nums.

Example 2:
Input: nums = [0,1]
Output: 2
Explanation: n = 2 since there are 2 numbers, so all numbers are in the range
[0,2]. 2 is the missing number in the range since it does not appear in nums.
```

```
Example 3:
Input: nums = [9,6,4,2,3,5,7,0,1]
Output: 8
Explanation: n = 9 since there are 9 numbers, so all numbers are in the range
[0,9]. 8 is the missing number in the range since it does not appear in nums.
```

Code

```
from typing import List
class Solution:
    def missingNumber(self, nums: List[int]) -> int:
        nums.sort()
        # ensure n is at the last index
        if nums[-1] != len(nums):
            return len(nums)
        # ensure 0 is at the first index
        elif nums[0] != 0:
            return 0

        # otherwise, the missing number is in the range (0, n)
        for i in range(1, len(nums)):
            expected_num = nums[i - 1] + 1
            if nums[i] != expected_num:
                return expected_num
nums = [3, 0, 1]
solution = Solution()
print(solution.missingNumber(nums))
```

OUTPUT

```
2
```

Lab No. 08

[Applying the Divide-and-Conquer Approach to Sorting]

Task No. 01

```
Write python implementations on Merge Sort & Quick Sort
```

Code

```python
def mergesort(arr):
    if len(arr) <= 1:
        return
    mid = len(arr) // 2 # [1,3,5,2,9,4] (6/2--- mid = 3)
    left = arr[:mid] # 0-(mid-1) or 0-2
    right = arr[mid:] # 3-last tak
    # left = [1,3,5]
    # right = [2,9,4]
    mergesort(left)
    mergesort(right)
    MergeTwosortList(arr, left, right)
```

```
def MergeTwosortList(arr, left, right):
    a = len(left)
    b = len(right)
    i = j = k = 0

    while i < a and j < b:
        if left[i] < right[j]:
            arr[k] = left[i]
            i += 1
        else:
            arr[k] = right[j]
            j += 1
        k += 1

    while i < a:
        arr[k] = left[i]
        i += 1
        k += 1

    while j < b:
        arr[k] = right[j]
        j += 1
        k += 1

arr = [1,3,5,2,9,4]
print('unsorted array',arr)
mergesort(arr)  # Sorting is done in place
print('sorted array',arr)  # Print the sorted array
```

OUTPUT

```
unsorted array [1, 3, 5, 2, 9, 4]
sorted array [1, 2, 3, 4, 5, 9]
```

Code

```
# quick sort
def QuickSort(arr, low, high):
    if low < high:
        pivot = partition(arr, low, high)
        QuickSort(arr, low, pivot - 1)
```

```
        QuickSort(arr, pivot + 1, high)

def partition(arr, low, high):
    pivot = arr[high] #pivot = 5
    i = low - 1 #i=1
    for j in range(low, high):
        if arr[j] < pivot:
            i += 1 # i=0(index)
            arr[i], arr[j] = arr[j], arr[i] #swapping
            # 11  , 1      =  1     ,  11
    i += 1
    arr[i], arr[high] = arr[high], arr[i]
    return i
# [1, 7, 8, 9, 11, 5]
    #  low            high
arr = [11, 7, 8, 9, 1, 5]
print("Original Array:", arr)
QuickSort(arr, 0, len(arr) - 1)
print("Sorted Array:", arr)
```

OUTPUT

```
Original Array: [11, 7, 8, 9, 1, 5]
Sorted Array: [1, 5, 7, 8, 9, 11]
```

Task No. 02

```
You are given an integer array score of size n, where score[i] is the score of
the ith athlete in a competition. All the scores are guaranteed to be unique.
The athletes are placed based on their scores, where the 1st place athlete has
the highest score, the 2nd place athlete has the 2nd highest score, and so on.
The placement of each athlete determines their rank:
•   The 1st place athlete's rank is "Gold Medal".
•   The 2nd place athlete's rank is "Silver Medal".
•   The 3rd place athlete's rank is "Bronze Medal".
•   For the 4th place to the nth place athlete, their rank is their placement
number (i.e., the xth place athlete's rank is "x").
Return an array answer of size n where answer[i] is the rank of the ith athlete.

Example 1:
Input: score = [5,4,3,2,1]
Output: ["Gold Medal","Silver Medal","Bronze Medal","4","5"]
```

```
Explanation: The placements are [1st, 2nd, 3rd, 4th, 5th].

Example 2:
Input: score = [10,3,8,9,4]
Output: ["Gold Medal","5","Bronze Medal","Silver Medal","4"]
Explanation: The placements are [1st, 5th, 3rd, 2nd, 4th].
```

Code

```python
# Given scores of N athletes, find their relative ranks and the people with the top three highest scores, who will be awarded medals: "Gold Medal", "Silver Medal" and "Bronze Medal".
def findrelativeRanks(score):
    sorted_score = sorted(score, reverse=True)
    rank_map = {}
    for i, value in enumerate(sorted_score):
        if i == 0:
            rank_map[value] = "Gold Medal"
        elif i == 1:
            rank_map[value] = "Silver Medal"
        elif i == 2:
            rank_map[value] = "Bronze Medal"
        else:
            rank_map[value] = str(i+1)
    result = []
    for s in score:
        result.append(rank_map[s])

    return result
score = [5,4,3,2,1]
findrelativeRanks(score)
```

OUTPUT

```
['Gold Medal', 'Silver Medal', 'Bronze Medal', '4', '5']
```

Task No. 03

```
Given two strings s and t, return true if t is an anagram of s, and false otherwise.

Example 1:
```

```
Input: s = "anagram", t = "nagaram"
Output: true

Example 2:
Input: s = "rat", t = "car"
Output: false
```

Code

```
from collections import Counter
class Solution:
    def isAnagram(self,s:str,t:str) -> bool:
        if len(s) != len(t):
            return False
        s_dict = Counter(s)
        t_dict = Counter(t)

        return s_dict == t_dict

s1= Solution()
print(s1.isAnagram("anagram","nagaram"))
```

OUTPUT

```
True
```

Task No. 04

```
Given an integer array nums, return the maximum difference between two successive elements in its sorted form. If the array contains less than two elements, return 0.
You must write an algorithm that runs in linear time and uses linear extra space.

Example 1:
Input: nums = [3,6,9,1]
Output: 3
Explanation: The sorted form of the array is [1,3,6,9], either (3,6) or (6,9) has the maximum difference 3.

Example 2:
Input: nums = [10]
Output: 0
Explanation: The array contains less than 2 elements, therefore return 0.
```

Code

```
def maximumGap(nums):
        # sort the array
        nums.sort()
        # find the max gap
        max_gap = 0
        for i in range(1, len(nums)):
            max_gap = max(nums[i] - nums[i-1], max_gap)
        return max_gap

maximumGap([3,6,9,1])
```

OUTPUT

```
3
```

Lab No. 09

[Utilizing HashMaps for Efficient Data Storage and Retrieval]

Task No. 01

```
Implement a Python function for hashing with collision handling using chaining.
```

Code

```
class HashTable:
    def __init__(self, size):
        self.size = size
        self.table = [[] for _ in range(size)]  # Initialize the table with empty
lists (chaining)

    def hash_function(self, key):
        return hash(key) % self.size  # Simple modulo-based hash function
```

```
    def insert(self, key, value):
        index = self.hash_function(key)
        # Check if the key already exists, update it
        for pair in self.table[index]:
            if pair[0] == key:
                pair[1] = value
                return
        # If key doesn't exist, append the new key-value pair
        self.table[index].append([key, value])

    def get(self, key):
        index = self.hash_function(key)
        for pair in self.table[index]:
            if pair[0] == key:
                return pair[1]
        return None  # Key not found

    def remove(self, key):
        index = self.hash_function(key)
        for i, pair in enumerate(self.table[index]):
            if pair[0] == key:
                del self.table[index][i]
                return True
        return False  # Key not found

    def display(self):
        for i, bucket in enumerate(self.table):
            print(f"Index {i}: {bucket}")

# Example Usage
hash_table = HashTable(5)
hash_table.insert("apple", 10)
hash_table.insert("banana", 20)
hash_table.insert("grape", 30)
hash_table.insert("orange", 40)
hash_table.insert("lemon", 50)

print("Hash Table after insertions:")
hash_table.display()

print("\nRetrieving values:")
print("apple:", hash_table.get("apple"))
print("banana:", hash_table.get("banana"))
```

```
print("grape:", hash_table.get("grape"))

print("\nRemoving 'banana':")
hash_table.remove("banana")
hash_table.display()
```

OUTPUT

```
Hash Table after insertions:
Index 0: [['banana', 20], ['orange', 40]]
Index 1: [['lemon', 50]]
Index 2: [['apple', 10]]
Index 3: [['grape', 30]]
Index 4: []

Retrieving values:
apple: 10
banana: 20
grape: 30

Removing 'banana':
Index 0: [['orange', 40]]
Index 1: [['lemon', 50]]
Index 2: [['apple', 10]]
Index 3: [['grape', 30]]
Index 4: []
```

Task No. 02

```
Given two strings s and t, determine if they are isomorphic.
Two strings s and t are isomorphic if the characters in s can be replaced to get
t.
All occurrences of a character must be replaced with another character while
preserving the order of characters. No two characters may map to the same
character, but a character may map to itself.
Example 1:
Input: s = "egg", t = "add"
Output: true
Explanation:
The strings s and t can be made identical by:
•   Mapping 'e' to 'a'.
•   Mapping 'g' to 'd'.
Example 2:
Input: s = "foo", t = "bar"
Output: false
Explanation:
```

```
The strings s and t can not be made identical as 'o' needs to be mapped to both
'a' and 'r'.

Example 3:
Input: s = "paper", t = "title"
Output: true
```

Code

```python
def isIsomorphicHelper(s: str, t: str) -> bool:
    if len(s) != len(t):
        return False
    s_to_t = {}
    t_to_s = {}

    for char_s, char_t in zip(s, t):
        # Check if the current s character is already mapped
        if char_s in s_to_t:
            if s_to_t[char_s] != char_t:
                return False
        else:
            # Check if the current t character is already mapped by another s
character
            if char_t in t_to_s:
                return False
            # Create new mappings
            s_to_t[char_s] = char_t
            t_to_s[char_t] = char_s
    return True
# Main function to call helper
def isIsomorphic(s: str, t: str) -> bool:
    return isIsomorphicHelper(s, t)
# Test cases
print(isIsomorphic("egg", "add"))  # Output: True
print(isIsomorphic("foo", "bar"))  # Output: False
print(isIsomorphic("paper", "title"))  # Output: True
```

OUTPUT

```
True
False
True
```

Lab No. 10

[Implementing Binary Search Trees for Efficient Searching]

Task No. 01

```
Implement Binary Search Trees (BSTs) in Python with Inorder Traversal, a function to add nodes, and a searching function.
```

Code

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

class BST:
    def __init__(self):
        self.root = None

    def insert(self, key):
        new_node = Node(key)
        if self.root is None:
            self.root = new_node
            return
        current = self.root
        while True:
            if key < current.key:
                if current.left is None:
                    current.left = new_node
                    return
                else:
                    current = current.left
            else:
                if current.right is None:
                    current.right = new_node
                    return
                else:
                    current = current.right
```

```
    def search(self, key):
        current = self.root
        while current is not None:
            if key == current.key:
                return True
            elif key < current.key:
                current = current.left
            else:
                current = current.right
        return False

    def inorder_traversal(self):
        result = []
        self._inorder_helper(self.root, result)
        return result

    def _inorder_helper(self, node, result):
        if node is not None:
            self._inorder_helper(node.left, result)
            result.append(node.key)
            self._inorder_helper(node.right, result)

new_node = Node(10)  # Creates a node with key 10
print(new_node.key)  # Output: 10
print(new_node.left)  # Output: None
print(new_node.right)  # Output: None
root = Node(15)  # Root node
root.left = Node(10)  # Left child of root
root.right = Node(20)  # Right child of root

root.left.left = Node(5)  # Left child of 10
root.left.right = Node(12)  # Right child of 10
```

OUTPUT

```
10
None
None
```