

DATA STRUCTURES

LAB MANUAL

(R22A0583)

**B.TECH
(II YEAR – I SEM)
(2023-24)**



Prepared By Dr.K.SURESH

DEPARTMENT OF INFORMATION TECHNOLOGY

**MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)**

Recognized under 2(f) and 12 (B) of UGC ACT 1956

(Affiliated to JNTUH, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015 Certified)

Maisammaguda, Dhulapally (Post Via. Hakimpet), Secunderabad – 500100, Telangana State, India

DEPARTMENT OF INFORMATION TECHNOLOGY

Vision & Mission

Vision

- To acknowledge quality education and instill high patterns of discipline making the students technologically superior and ethically strong which involves the improvement in the quality of life in human race.

Mission

- To achieve and impart holistic technical education using the best of infrastructure, outstanding technical and teaching expertise to establish the students in to competent and confident engineers.
- Evolving the center of excellence through creative and innovative teaching learning practices for promoting academic achievement to produce internationally accepted competitive and world class professionals.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1 – ANALYTICAL SKILLS

- To facilitate the graduates with the ability to visualize, gather information, articulate, analyze, solve complex problems, and make decisions. These are essential to address the challenges of complex and computation intensive problems increasing their productivity.

PEO2 – TECHNICAL SKILLS

- To facilitate the graduates with the technical skills that prepare them for immediate employment and pursue certification providing a deeper understanding of the technology in advanced areas of computer science and related fields, thus encouraging to pursue higher education and researchbased on their interest.

PEO3 – SOFT SKILLS

- To facilitate the graduates with the soft skills that include fulfilling the mission, setting goals, showing self-confidence by communicating effectively, having a positive attitude, get involved in team-work, being a leader, managing their career and their life.

PEO4 – PROFESSIONAL ETHICS

- To facilitate the graduates with the knowledge of professional and ethical responsibilities by paying attention to grooming, being conservative with style, following dress codes, safety codes, and adapting themselves to technological advancements.

PROGRAM SPECIFIC OUTCOMES (PSOs)

After the completion of the course, B. Tech Computer Science and Engineering, the graduates will have the following Program Specific Outcomes:

1. Fundamentals and critical knowledge of the Computer System:- Able to Understand the working principles of the computer System and its components , Apply the knowledge to build, asses, and analyze the software and hardware aspects of it .
2. The comprehensive and Applicative knowledge of Software Development: Comprehensive skills of Programming Languages, Software process models, methodologies, and able to plan, develop, test, analyze, and manage the software and hardware intensive systems in heterogeneous platforms individually or working in teams.
3. Applications of Computing Domain & Research: Able to use the professional, managerial, interdisciplinary skill set, and domain specific tools in development processes, identify the research gaps, and provide innovative solutions to them.

PROGRAM OUTCOMES (POs)

Engineering Graduates should possess the following:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design / development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi disciplinary environments.
12. **Life- long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.



MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

Maisammaguda, Dhulapally Post, Via Hakimpet, Secunderabad – 500100

Department of Information Technology

GENERAL LABORATORY INSTRUCTIONS

1. Students are advised to come to the laboratory at least 5 minutes before (to the starting time), those who come after 5 minutes will not be allowed into the lab.
2. Plan your task properly much before to the commencement, come prepared to the lab with the synopsis / program / experiment details.
3. Student should enter into the laboratory with:
 - a. Laboratory observation notes with all the details (Problem statement, Aim, Algorithm, Procedure, Program, Expected Output, etc.,) filled in for the lab session.
 - b. Laboratory Record updated up to the last session experiments and other utensils (if any) needed in the lab.
 - c. Proper Dress code and Identity card.
4. Sign in the laboratory login register, write the TIME-IN, and occupy the computer system allotted to you by the faculty.
5. Execute your task in the laboratory, and record the results / output in the lab observation note book, and get certified by the concerned faculty.
6. All the students should be polite and cooperative with the laboratory staff, must maintain the discipline and decency in the laboratory.
7. Computer labs are established with sophisticated and high end branded systems, which should be utilized properly.
8. Students / Faculty must keep their mobile phones in SWITCHED OFF mode during the lab sessions. Misuse of the equipment, misbehaviors with the staff and systems etc., will attract severe punishment.
9. Students must take the permission of the faculty in case of any urgency to go out; if anybody found loitering outside the lab / class without permission during working hours will be treated seriously and punished appropriately.
10. Students should LOG OFF/ SHUT DOWN the computer system before he/she leaves the lab after completing the task (experiment) in all aspects. He/she must ensure the system / seat is kept properly.

HEAD OF THE DEPARTMENT

PRINCIPAL

INDEX

S.No	Name of the program	Page No
1.	Write a Python program for class, Flower, that has three instance variables of type str, int, and float that respectively represent the name of the flower, its number of petals, and its price. Your class must include a constructor method that initializes each variable to an appropriate value, and your class should include methods for setting the value of each type, and retrieving the value of each type.	1
2.	Develop an inheritance hierarchy based upon a Polygon class that has abstract methods area() and perimeter(). Implement classes Triangle, Quadrilateral, Pentagon, that extend this base class, with the obvious meanings for the area() and perimeter() methods. Write a simple program that allows users to create polygons of the various types and input their geometric dimensions, and the program then outputs their area and perimeter.	5
3.	Write a python program to implement Method Overloading and Method Overriding.	9
4.	Write a Python program to illustrate the following comprehensions: a) List Comprehensions b) Dictionary Comprehensions c) Set Comprehensions d) Generator Comprehensions	14
5.	Write a Python program to generate the combinations of n distinct objects taken from the elements of a given list. Example: Original list: [1, 2, 3, 4, 5, 6, 7, 8, 9] Combinations of 2 distinct objects: [1, 2] [1, 3] [1, 4] [1, 5] [7, 8] [7, 9] [8, 9].	21
6.	Write a program for Linear Search and Binary search.	24
7.	Write a program to implement Bubble Sort and Selection Sort.	28
8.	Write a program to implement Merge sort and Quick sort.	31
9.	Write a program to implement Stacks and Queues.	35
10.	Write a program to implement Singly Linked List.	43
11.	Write a program to implement Doubly Linked list.	51
12.	Write a program to implement Binary Search Tree.	59

1. Write a Python program for class, Flower, that has three instance variables of type str, int, and float, that respectively represent the name of the flower, its number of petals, and its price. Your class must include a constructor method that initializes each variable to an appropriate value, and your class should include methods for setting the value of each type, and retrieving the value of each type.

Program:

```
class Flower:
#Common base class for all Flowers
    def __init__(self, petalName, petalNumber, petalPrice):
        self.name = petalName
        self.petals = petalNumber
        self.price = petalPrice

    def setName(self, petalName):
        self.name = petalName

    def setPetals(self, petalNumber):
        self.petals = petalNumber

    def setPrice(self, petalPrice):
        self.price = petalPrice

    def getName(self):
        return self.name

    def getPetals(self):
        return self.petals

    def getPrice(self):
        return self.price

#This would create first object of Flower class
f1 = Flower("Sunflower", 2, 1000)
print ("Flower Details:")
print ("Name: ", f1.getName())
print ("Number of petals:", f1.getPetals())
print ("Price:", f1.getPrice())

print ("\n")

#This would create second object of Flower class
f2 = Flower("Rose", 5, 2000)
f2.setPrice(3333)
f2.setPetals(6)
print ("Flower Details:")
print ("Name: ", f2.getName())
print ("Number of petals:", f2.getPetals())
print ("Price:", f2.getPrice())
```


Output:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

2. Develop an inheritance hierarchy based upon a Polygon class that has abstract methods `area()` and `perimeter()`. Implement classes `Triangle`, `Quadrilateral`, `Pentagon`, that extend this base class, with the obvious meanings for the `area()` and `perimeter()` methods. Write a simple program that allows users to create polygons of the various types and input their geometric dimensions, and the program then outputs their area and perimeter.

Program:

```
from abc import abstractmethod, ABCMeta
import math

class Polygon(metaclass = ABCMeta):
    def __init__(self, side_lengths = [1,1,1], num_sides = 3):
        self._side_lengths = side_lengths
        self._num_sides = 3

    @abstractmethod
    def area(self):
        pass

    @abstractmethod
    def perimeter(self):
        pass

    def __repr__(self):
        return (str(self._side_lengths))

class Triangle(Polygon):
    def __init__(self, side_lengths):
        super().__init__(side_lengths, 3)
        self._perimeter = self.perimeter()
        self._area = self.area()

    def perimeter(self):
        return(sum(self._side_lengths))

    def area(self):

        #Area of Triangle
        s = self._perimeter/2
        product = s
        for i in self._side_lengths:
            product*=(s-i)
        return product**0.5

class Quadrilateral(Polygon):
    def __init__(self, side_lengths):
        super().__init__(side_lengths, 4)
        self._perimeter = self.perimeter()
```

```

        self._area = self.area()

def perimeter(self):
    return(sum(self._side_lengths))

def area(self):

    # Area of an irregular Quadrilateral
    semiperimeter = sum(self._side_lengths) / 2
    return math.sqrt((semiperimeter - self._side_lengths[0]) *
                     (semiperimeter - self._side_lengths[1]) *
                     (semiperimeter - self._side_lengths[2]) *
                     (semiperimeter - self._side_lengths[3]))

class Pentagon(Polygon):
    def __init__(self, side_lengths):
        super().__init__(side_lengths, 5)
        self._perimeter = self.perimeter()
        self._area = self.area()

    def perimeter(self):
        return((self._side_lengths) * 5)

    def area(self):

        # Area of a regular Pentagon
        a = self._side_lengths
        return (math.sqrt(5 * (5 + 2 * (math.sqrt(5))))) * a * a) / 4

#object of Triangle
t1 = Triangle([1,2,2])
print(t1.perimeter(), t1.area())

#object of Quadrilateral
q1 = Quadrilateral([1,1,1,1])
print(q1.perimeter(), q1.area())

#object of Pentagon
p1 = Pentagon(1)
print(p1.perimeter(), p1.area())

```

Output:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

3. Write a python program to implement method overloading and method overriding.

Method Overloading

Method overloading is an OOPS concept which provides ability to have several methods having the same name with in the class where the methods differ in types or number of arguments passed.

Method overloading in Python

Method overloading in its traditional sense (as defined above) as exists in other languages like method overloading in Java doesn't exist in Python.

In Python if you try to overload a function by having two or more functions having the same name but different number of arguments only the last defined function is recognized, calling any other overloaded function results in an error.

Achieving method overloading

Since using the same method name again to overload the method is not possible in Python, so achieving method overloading in Python is done by having a single method with several parameters. Then you need to check the actual number of arguments passed to the method and perform the operation accordingly.

Program:

```
class OverloadDemo:
    # sum method with default as None for parameters
    def sum(self, a=None, b=None, c=None):
        # When three params are passed
        if a!=None and b!=None and c!=None:
            s = a + b + c
            print('Sum = ', s)
        # When two params are passed
        elif a!=None and b!=None:
            s = a + b
            print('Sum = ', s)

od = OverloadDemo()
od.sum(7, 8)
od.sum(7, 8, 9)
```

Output:

Method overriding - Polymorphism through inheritance

Method overriding provides ability to change the implementation of a method in a child class which is already defined in one of its super class. If there is a method in a super class and method having the same name and same number of arguments in a child class then the child class method is said to be overriding the parent class method.

When the method is called with parent class object, method of the parent class is executed. When method is called with child class object, method of the child class is executed. So the appropriate overridden method is called based on the object type, which is an example of Polymorphism.

Program:

```
class Person:
    def __init__(self, name, age):
        self.name = name
        self.age = age

    def displayData(self):
        print('In parent class displayData method')
        print(self.name)
        print(self.age)

class Employee(Person):
    def __init__(self, name, age, id):
        # calling constructor of super class
        super().__init__(name, age)
        self.empId = id

    def displayData(self):
        print('In child class displayData method')
        print(self.name)
        print(self.age)
        print(self.empId)

#Person class object
person = Person('Karthik Shaurya', 26)
person.displayData()
#Employee class object
emp = Employee('Karthik Shaurya', 26, 'E317')
emp.displayData()
```

Output:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

4. Write a Python program to illustrate the following comprehensions:
- a) List Comprehensions
 - b) Dictionary Comprehensions
 - c) Set Comprehensions
 - d) Generator Comprehensions

Comprehensions in Python

Comprehensions in Python provide us with a short and concise way to construct new sequences (such as lists, set, dictionary etc.) using sequences which have been already defined. Python supports the following 4 types of comprehensions:

- a) List Comprehensions
- b) Dictionary Comprehensions
- c) Set Comprehensions
- d) Generator Comprehensions

a) List Comprehensions:

List Comprehensions provide an elegant way to create new lists. The following is the basic structure of a list comprehension:

output_list = [output_exp for var in input_list if (var satisfies this condition)]

Note that list comprehension may or may not contain an if condition. List comprehensions can contain multiple **for** (nested list comprehensions).

Example: Suppose we want to create an output list which contains only the even numbers which are present in the input list. Let's see how to do this using *for loop* and *list comprehension* and decide which method suits better.

Using Loop:

```
#Constructing output list WITHOUT using List comprehensions
input_list = [1, 2, 3, 4, 4, 5, 6, 7, 7]

output_list = []

#Using loop for constructing output list
for var in input_list:
    if var % 2 == 0:
        output_list.append(var)

print("Output List using for loop:", output_list)
```

Output:

Using List Comprehension:

```
# Using List comprehensions
# for constructing output list

input_list = [1, 2, 3, 4, 4, 5, 6, 7, 7]

list_using_comp = [var for var in input_list if var % 2 == 0]

print("Output List using list comprehensions:", list_using_comp)
```

Output:

b) Dictionary Comprehensions:

Extending the idea of list comprehensions, we can also create a dictionary using dictionary comprehensions. The basic structure of a dictionary comprehension looks like below.

output_dict = {key:value for (key, value) in iterable if (key, value satisfy this condition)}

Example 1: Suppose we want to create an output dictionary which contains only the odd numbers that are present in the input list as keys and their cubes as values. Let's see how to do this using for loops and dictionary comprehension.

Using Loop:

```
input_list = [1, 2, 3, 4, 5, 6, 7]

output_dict = {}

# Using loop for constructing output dictionary
for var in input_list:
    if var % 2 != 0:
        output_dict[var] = var**3

print("Output Dictionary using for loop:", output_dict)
```

Output:

Using Dictionary Comprehension:

```
# Using Dictionary comprehensions
# for constructing output dictionary

input_list = [1,2,3,4,5,6,7]

dict_using_comp = {var:var ** 3 for var in input_list if var % 2 != 0}

print("Output Dictionary using dictionary comprehensions:",
dict_using_comp)
```

Output:

Example 2: Given two lists containing the names of states and their corresponding capitals, construct a dictionary which maps the states with their respective capitals. Let's see how to do this using for loops and dictionary comprehension.

Using Loop:

```
state = ['Gujarat', 'Maharashtra', 'Rajasthan']
capital = ['Gandhinagar', 'Mumbai', 'Jaipur']

output_dict = {}

# Using loop for constructing output dictionary
for (key, value) in zip(state, capital): output_dict[key] = value

print("Output Dictionary using for loop:", output_dict)
```

Output:

Using Dictionary Comprehension:

```
# Using Dictionary comprehensions
# for constructing output dictionary

state = ['Gujarat', 'Maharashtra', 'Rajasthan']
capital = ['Gandhinagar', 'Mumbai', 'Jaipur']

dict_using_comp = {key:value for (key, value) in zip(state, capital)}

print("Output Dictionary using dictionary
comprehensions:",dict_using_comp)
```

Output:

c) Set Comprehensions:

Set comprehensions are pretty similar to list comprehensions. The only difference between them is that set comprehensions use curly brackets { }. Let's look at the following example to understand set comprehensions.

Example : Suppose we want to create an output set which contains only the even numbers that are present in the input list. Note that set will discard all the duplicate values. Let's see how we can do this using for loops and set comprehension.

Using Loop:

```
input_list = [1, 2, 3, 4, 4, 5, 6, 6, 6, 7, 7]

output_set = set()

# Using loop for constructing output set
for var in input_list:
    if var % 2 == 0:
        output_set.add(var)

print("Output Set using for loop:", output_set)
```

Output:

Using Set Comprehension:

```
# Using Set comprehensions
# for constructing output set

input_list = [1, 2, 3, 4, 4, 5, 6, 6, 6, 7, 7]

set_using_comp = {var for var in input_list if var % 2 == 0}

print("Output Set using set comprehensions:", set_using_comp)
```

Output:

d) Generator Comprehensions:

Generator Comprehensions are very similar to list comprehensions. One difference between them is that generator comprehensions use circular brackets whereas list comprehensions use square brackets. The major difference between them is that generators don't allocate memory for the whole list. Instead, they generate each value one by one which is why they are memory efficient. Let's look at the following example to understand generator comprehension:

```
input_list = [1, 2, 3, 4, 4, 5, 6, 7, 7]
output_gen = (var for var in input_list if var % 2 == 0)
print("Output values using generator comprehensions:", end = ' ')
for var in output_gen:
    print(var, end = ' ')
```

Output:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

5. Write a Python program to generate the combinations of n distinct objects taken from the elements of a given list. **Example:** Original list: [1, 2, 3, 4, 5, 6, 7, 8, 9] Combinations of 2 distinct objects: [1, 2] [1, 3] [1, 4] [1, 5] [7, 8] [7, 9] [8, 9].

Program:

```
def combination(n, n_list):
    if n<=0:
        yield []
        return
    for i in range(len(n_list)):
        c_num = n_list[i:i+1]
        for a_num in combination(n-1, n_list[i+1:]):
            yield c_num + a_num
n_list = [1,2,3,4,5,6,7,8,9]
print("Original list:")
print(n_list)
n = 2
result = combination(n, n_list)
print("\nCombinations of",n,"distinct objects:")
for e in result:
    print(e)
```

Output:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

6. Write a program for Linear Search and Binary search

Linear Search Program:

```
def linearSearch(target, List):
    position = 0
    global iterations
    iterations = 0
    while position < len(List):
        iterations += 1
        if target == List[position]:
            return position
        position += 1
    return -1

if __name__ == '__main__':
    List = [1, 2, 3, 4, 5, 6, 7, 8]
    target = 3
    answer = linearSearch(target, List)
    if answer != -1:
        print('Target found at index :', answer, 'in',
              iterations, 'iterations')
    else:
        print('Target not found in the list')
```

Output:

Binary Search Program:

```
def binarySearch(target, List):  
  
    left = 0  
    right = len(List) - 1  
    global iterations  
    iterations = 0  
  
    while left <= right:  
        iterations += 1  
        mid = (left + right) // 2  
        if target == List[mid]:  
            return mid  
        elif target < List[mid]:  
            right = mid - 1  
        else:  
            left = mid + 1  
    return -1  
  
if __name__ == '__main__':  
    List = [1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14]  
    target = 12  
    answer = binarySearch(target, List)  
    if (answer != -1):  
        print('Target',target,'found at position', answer, 'in',  
              iterations,'iterations')  
    else:  
        print('Target not found')
```

Output:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

7. Write a program to implement Bubble Sort and Selection Sort

Bubble Sort Program:

```
def bubble_sort(alist):
    for i in range(len(alist) - 1, 0, -1):
        no_swap = True
        for j in range(0, i):
            if alist[j + 1] < alist[j]:
                alist[j], alist[j + 1] = alist[j + 1], alist[j]
                no_swap = False
        if no_swap:
            return

alist = input('Enter the list of numbers: ').split()
alist = [int(x) for x in alist]
bubble_sort(alist)
print('Sorted list: ', alist)
```

Output:

Selection Sort Program:

```
def selection_sort(alist):
    for i in range(0, len(alist) - 1):
        smallest = i
        for j in range(i + 1, len(alist)):
            if alist[j] < alist[smallest]:
                smallest = j
        alist[i], alist[smallest] = alist[smallest], alist[i]

alist = input('Enter the list of numbers: ').split()
alist = [int(x) for x in alist]
selection_sort(alist)
print('Sorted list: ', alist)
```

Output:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

8. Write a program to implement Merge sort and Quick sort

Merge Sort Program:

```
def merge_sort(alist, start, end):
    '''Sorts the list from indexes start to end - 1 inclusive.'''
    if end - start > 1:
        mid = (start + end)//2
        merge_sort(alist, start, mid)
        merge_sort(alist, mid, end)
        merge_list(alist, start, mid, end)

def merge_list(alist, start, mid, end):
    left = alist[start:mid]
    right = alist[mid:end]
    k = start
    i = 0
    j = 0
    while (start + i < mid and mid + j < end):
        if (left[i] <= right[j]):
            alist[k] = left[i]
            i = i + 1
        else:
            alist[k] = right[j]
            j = j + 1
        k = k + 1
    if start + i < mid:
        while k < end:
            alist[k] = left[i]
            i = i + 1
            k = k + 1
    else:
        while k < end:
            alist[k] = right[j]
            j = j + 1
            k = k + 1

alist = input('Enter the list of numbers: ').split()
alist = [int(x) for x in alist]
merge_sort(alist, 0, len(alist))
print('Sorted list: ', alist)
```

Output:

Quick Sort Program:

```
def quicksort(alist, start, end):
    '''Sorts the list from indexes start to end - 1 inclusive.'''
    if end - start > 1:
        p = partition(alist, start, end)
        quicksort(alist, start, p)
        quicksort(alist, p + 1, end)

def partition(alist, start, end):
    pivot = alist[start]
    i = start + 1
    j = end - 1

    while True:
        while (i <= j and alist[i] <= pivot):
            i = i + 1
        while (i <= j and alist[j] >= pivot):
            j = j - 1

        if i <= j:
            alist[i], alist[j] = alist[j], alist[i]
        else:
            alist[start], alist[j] = alist[j], alist[start]
            return j

alist = input('Enter the list of numbers: ').split()
alist = [int(x) for x in alist]
quicksort(alist, 0, len(alist))
print('Sorted list: ', alist)
```

Output:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

9. Write a program to implement Stacks and Queues

Stack Program:

```
# Custom stack implementation in Python
class Stack:

    # Constructor to initialize the stack
    def __init__(self, size):
        self.arr = [None] * size
        self.capacity = size
        self.top = -1

    # Function to add an element `x` to the stack
    def push(self, x):
        if self.isFull():
            print("Stack Overflow!! Calling exit()...")
            exit(1)

        print("Inserting", x, "into the stack...")
        self.top = self.top + 1
        self.arr[self.top] = x

    # Function to pop a top element from the stack
    def pop(self):
        # check for stack underflow
        if self.isEmpty():
            print("Stack Underflow!! Calling exit()...")
            exit(1)

        print("Removing", self.peak(), "from the stack")

        #decrease stack size by 1 and (optionally) return the popped element
        top = self.arr[self.top]
        self.top = self.top - 1
        return top

    # Function to return the top element of the stack
    def peek(self):
        if self.isEmpty():
            exit(1)
        return self.arr[self.top]

    # Function to return the size of the stack
    def size(self):
        return self.top + 1

    # Function to check if the stack is empty or not
    def isEmpty(self):
        return self.size() == 0
```

```
# Function to check if the stack is full or not
def isFull(self):
    return self.size() == self.capacity

if __name__ == '__main__':

    stack = Stack(3)

    stack.push(1)      # Inserting 1 in the stack
    stack.push(2)      # Inserting 2 in the stack

    stack.pop()        # removing the top element (2)
    stack.pop()        # removing the top element (1)

    stack.push(3)      # Inserting 3 in the stack

    print("Top element is", stack.peek())
    print("The stack size is", stack.size())

    stack.pop()        # removing the top element (3)

    # check if the stack is empty
    if stack.isEmpty():
        print("The stack is empty")
    else:
        print("The stack is not empty")
```

Output:

Queue Program:

```
# Custom queue implementation in Python
class Queue:

    # Initialize queue
    def __init__(self, size):
        self.q = [None] * size          # list to store queue elements
        self.capacity = size            # maximum capacity of the queue
        self.front = 0                  # front points to the front element in the queue
        self.rear = -1                  # rear points to the last element in the queue
        self.count = 0                  # current size of the queue

    # Function to dequeue the front element
    def pop(self):
        # check for queue underflow
        if self.isEmpty():
            print("Queue Underflow!! Terminating process.")
            exit(1)

        print("Removing element...", self.q[self.front])

        self.front = (self.front + 1) % self.capacity
        self.count = self.count - 1

    # Function to add an element to the queue
    def append(self, value):
        # check for queue overflow
        if self.isFull():
            print("Overflow!! Terminating process.")
            exit(1)

        print("Inserting element...", value)

        self.rear = (self.rear + 1) % self.capacity
        self.q[self.rear] = value
        self.count = self.count + 1

    # Function to return the front element of the queue
    def peek(self):
        if self.isEmpty():
            print("Queue UnderFlow!! Terminating process.")
            exit(1)

        return self.q[self.front]

    # Function to return the size of the queue
    def size(self):
        return self.count
```

```
# Function to check if the queue is empty or not
def isEmpty(self):
    return self.size() == 0

# Function to check if the queue is full or not
def isFull(self):
    return self.size() == self.capacity

if __name__ == '__main__':

    # create a queue of capacity 5
    q = Queue(5)

    q.append(1)
    q.append(2)
    q.append(3)

    print("The queue size is", q.size())
    print("The front element is", q.peek())
    q.pop()
    print("The front element is", q.peek())

    q.pop()
    q.pop()

    if q.isEmpty():
        print("The queue is empty")
    else:
        print("The queue is not empty")
```

Output:

Exercise Programs:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

10. Write a program to implement Singly Linked List

Program:

```
import os
from typing import NewType

class _Node:
    '''
    Creates a Node with two fields:
    1. element (accessed using ._element)
    2. link (accessed using ._link)
    '''
    __slots__ = '_element', '_link'

    def __init__(self, element, link):
        '''
        Initialises ._element and ._link with element and link respectively.
        '''
        self._element = element
        self._link = link

class LinkedList:
    '''
    Consists of member funtions to perform different
    operations on the linked list.
    '''

    def __init__(self):
        '''
        Initialises head, tail and size with None, None and 0 respectively.
        '''
        self._head = None
        self._tail = None
        self._size = 0

    def __len__(self):
        '''
        Returns length of linked list
        '''
        return self._size

    def isempty(self):
        '''
        Returns True if linked list is empty, otherwise False.
        '''
        return self._size == 0

    def addLast(self, e):
        '''
```

```

        Adds the passed element at the end of the linked list.
        '''
        newest = _Node(e, None)

        if self.isempty():
            self._head = newest
        else:
            self._tail._link = newest

        self._tail = newest
        self._size += 1

    def addFirst(self, e):
        '''
        Adds the passed element at the beginning of the linked list.
        '''
        newest = _Node(e, None)

        if self.isempty():
            self._head = newest
            self._tail = newest
        else:
            newest._link = self._head
            self._head = newest
        self._size += 1

    def addAnywhere(self, e, index):
        '''
        Adds the passed element at the passed index position of the linked list.
        '''
        newest = _Node(e, None)

        i = index - 1
        p = self._head

        if self.isempty():
            self.addFirst(e)
        else:
            for i in range(i):
                p = p._link
            newest._link = p._link
            p._link = newest
            print(f"Added Item at index {index}!\n\n")
        self._size += 1

    def removeFirst(self):
        '''
        Removes element from the beginning of the linked list.
        Returns the removed element.
        '''
        if self.isempty():
            print("List is Empty. Cannot perform deletion operation.")
            return

```

```

    e = self._head._element
    self._head = self._head._link
    self._size = self._size - 1

    if self.isempty():
        self._tail = None

    return e

def removeLast(self):
    '''
    Removes element from the end of the linked list.
    Returns the removed element.
    '''
    if self.isempty():
        print("List is Empty. Cannot perform deletion
              operation.")
        return

    p = self._head
    if p._link == None:
        e = p._element
        self._head = None
    else:
        while p._link._link != None:
            p = p._link
        e = p._link._element
        p._link = None
        self._tail = p

    self._size = self._size - 1
    return e

def removeAnywhere(self, index):
    '''
    Removes element from the passed index position of the linked list.
    Returns the removed element.
    '''
    p = self._head
    i = index - 1

    if index == 0:
        return self.removeFirst()
    elif index == self._size - 1:
        return self.removeLast()
    else:
        for x in range(i):
            p = p._link
        e = p._link._element
        p._link = p._link._link

    self._size -= 1
    return e

def display(self):
    '''

```

```

        Utility function to display the linked list.
        '''
        if self.isempty() == 0:
            p = self._head
            while p:
                print(p._element, end='-->')
                p = p._link
            print("NULL")
        else:
            print("Empty")

    def search(self, key):
        '''
        Searches for the passed element in the linked list.
        Returns the index position if found, else -1.
        '''
        p = self._head
        index = 0
        while p:
            if p._element == key:
                return index
            p = p._link
            index += 1
        return -1

#####

def options():
    '''
    Prints Menu for operations
    '''
    options_list = ['Add Last', 'Add First', 'Add Anywhere',
                    'Remove First', 'Remove Last', 'Remove Anywhere',
                    'Display List', 'Print Size', 'Search', 'Exit']

    print("MENU")
    for i, option in enumerate(options_list):
        print(f'{i + 1}. {option}')

    choice = int(input("Enter choice: "))
    return choice

def switch_case(choice):
    '''
    Switch Case for operations
    '''
    if choice == 1:
        elem = int(input("Enter Item: "))
        L.addLast(elem)
        print("Added Item at Last!\n\n")

    elif choice == 2:
        elem = int(input("Enter Item: "))
        L.addFirst(elem)
        print("Added Item at First!\n\n")

```

```

elif choice == 3:
    elem = int(input("Enter Item: "))
    index = int(input("Enter Index: "))
    L.addAnywhere(elem, index)

elif choice == 4:
    print("Removed Element from First:", L.removeFirst())

elif choice == 5:
    print("Removed Element from last:", L.removeLast())

elif choice == 6:
    index = int(input("Enter Index: "))
    print(f"Removed Item: {L.removeAnywhere(index)} !\n\n")

elif choice == 7:
    print("List: ", end='')
    L.display()
    print("\n")

elif choice == 8:
    print("Size:", len(L))
    print("\n")

elif choice == 9:
    key = int(input("Enter item to search: "))
    if L.search(key) >= 0:
        print(f"Item {key} found at index position {L.search(key)}\n\n")
    else:
        print("Item not in the list\n\n")

elif choice == 10:
    import sys
    sys.exit()

#####

if __name__ == '__main__':
    L = LinkedList()
    while True:
        choice = options()
        switch_case(choice)

```

Output:

Signature of the Faculty

Exercise Programs:

Exercise Programs:

11. Write a program to implement Doubly Linked list

Program:

```
import os

class _Node:
    '''
    Creates a Node with three fields:
    1. element (accessed using ._element)
    2. link (accessed using ._link)
    3. prev (accessed using ._prev)
    '''
    __slots__ = '_element', '_link', '_prev'

    def __init__(self, element, link, prev):
        '''
        Initialises ._element, ._link and ._prev with element, link and prev respectively.
        '''
        self._element = element
        self._link = link
        self._prev = prev

class DoublyLL:
    '''
    Consists of member funtions to perform different
    operations on the doubly linked list.
    '''

    def __init__(self):
        '''
        Initialises head, tail and size with None, None and 0 respectively.
        '''
        self._head = None
        self._tail = None
        self._size = 0

    def __len__(self):
        '''
        Returns length of linked list
        '''
        return self._size

    def isempty(self):
        '''
        Returns True if doubly linked list is empty, otherwise False.
        '''
        return self._size == 0

    def addLast(self, e):
        '''
        Adds the passed element at the end of the doubly linked list.
        '''
```

```

newest = _Node(e, None, None)

if self.isempty():
    self._head = newest
else:
    self._tail._link = newest
    newest._prev = self._tail
self._tail = newest
self._size += 1

def addFirst(self, e):
    '''
    Adds the passed element at the beginning of the doubly linked list.
    '''
    newest = _Node(e, None, None)

    if self.isempty():
        self._head = newest
        self._tail = newest
    else:
        newest._link = self._head
        self._head._prev = newest
    self._head = newest
    self._size += 1

def addAnywhere(self, e, index):
    '''
    Adds the passed element at the passed index position of the
    doubly linked list.
    '''
    if index >= self._size:
        print(f'Index value out of range, it should be between
              0 - {self._size - 1}')
    elif self.isempty():
        print("List was empty, item will be added at the end")
        self.addLast(e)
    elif index == 0:
        self.addFirst(e)
    elif index == self._size - 1:
        self.addLast(e)
    else:
        newest = _Node(e, None, None)
        p = self._head
        for _ in range(index - 1):
            p = p._link
        newest._link = p._link
        p._link._prev = newest
        newest._prev = p
        p._link = newest
        self._size += 1

def removeFirst(self):
    '''
    Removes element from the beginning of the doubly linked list.
    Returns the removed element.'''

```

```

    if self.isempty():
        print('List is already empty')
        return
    e = self._head._element
    self._head = self._head._link
    self._size -= 1

    if self.isempty():
        self._tail = None
    else:
        self._head._prev = None
    return e

def removeLast(self):
    '''
    Removes element from the end of the doubly linked list.
    Returns the removed element.
    '''
    if self.isempty():
        print("List is already empty")
        return
    e = self._tail._element
    self._tail = self._tail._prev
    self._size -= 1

    if self.isempty():
        self._head = None
    else:
        self._tail._link = None

    return e

def removeAnywhere(self, index):
    '''
    Removes element from the passed index position of the
    doubly linked list.
    Returns the removed element.
    '''
    if index >= self._size:
        print(f'Index value out of range, it should be between
              0 - {self._size - 1}')
    elif self.isempty():
        print("List is empty")
    elif index == 0:
        return self.removeFirst()
    elif index == self._size - 1:
        return self.removeLast()
    else:
        p = self._head
        for _ in range(index - 1):
            p = p._link
        e = p._link._element
        p._link = p._link._link
        p._link._prev = p
        self._size -= 1
    return e

```

```

def display(self):
    '''
    Utility function to display the doubly linked list.
    '''
    if self.isempty():
        print("List is Empty")
        return

    p = self._head
    print("NULL<-->", end='')
    while p:
        print(p._element, end="<-->")
        p = p._link
    print("NULL")

    print(f"\nHead : {self._head._element}, Tail :
          {self._tail._element}")

#####

def options():
    '''
    Prints Menu for operations
    '''
    options_list = ['Add Last', 'Add First', 'Add Anywhere',
                    'Remove First', 'Remove Last', 'Remove Anywhere',
                    'Display List', 'Exit']

    print("MENU")
    for i, option in enumerate(options_list):
        print(f'{i + 1}. {option}')

    choice = int(input("Enter choice: "))
    return choice

def switch_case(choice):
    '''
    Switch Case for operations
    '''
    os.system('cls')
    if choice == 1:
        elem = int(input("Enter Item: "))
        DL.addLast(elem)
        print("Added Item at Last!\n\n")

    elif choice == 2:
        elem = int(input("Enter Item: "))
        DL.addFirst(elem)
        print("Added Item at First!\n\n")

    elif choice == 3:
        elem = int(input("Enter Item: "))
        index = int(input("Enter Index: "))
        DL.addAnywhere(elem, index)

```

```

elif choice == 4:
    print("Removed Element from First:", DL.removeFirst())

elif choice == 5:
    print("Removed Element from last:", DL.removeLast())

elif choice == 6:
    index = int(input("Enter Index: "))
    print(f"Removed Item: {DL.removeAnywhere(index)} !\n\n")

elif choice == 7:
    print("List:")
    DL.display()
    print("\n")

elif choice == 8:
    import sys
    sys.exit()

#####

if __name__ == '__main__':
    DL = DoublyLL()
    while True:
        choice = options()
        switch_case(choice)

```

Output:

Signature of the Faculty

Exercise Programs:

12. Write a program to implement Binary Search Tree

Program:

```
# # # Binary Search Tree
class binarySearchTree:
    def __init__(self, val=None):
        self.val = val
        self.left = None
        self.right = None

    def insert(self, val):
        # check if there is no root
        if (self.val == None):
            self.val = val
        # check where to insert
        else:
            # check for duplicate then stop and return
            if val == self.val: return 'no duplicates allowed in binary search tree'
            # check if value to be inserted < currentNode's value
            if (val < self.val):
                # check if there is a left node to currentNode if true then recurse
                if(self.left):
                    self.left.insert(val)
                # insert where left of currentNode when currentNode.left=None
                else: self.left = binarySearchTree(val)

            # same steps as above here the condition we check is value to be
            # inserted > currentNode's value
            else:
                if(self.right):
                    self.right.insert(val)
                else: self.right = binarySearchTree(val)

    def breadthFirstSearch(self):
        currentNode = self
        bfs_list = []
        queue = []
        queue.insert(0, currentNode)
        while(len(queue) > 0):
            currentNode = queue.pop()
            bfs_list.append(currentNode.val)
            if(currentNode.left):
                queue.insert(0, currentNode.left)
            if(currentNode.right):
                queue.insert(0, currentNode.right)

        return bfs_list

    # In order means first left child, then parent, at last right child
    def depthFirstSearch_INorder(self):
        return self.traverseInOrder([])
```

```

# Pre order means first parent, then left child, at last right child
def depthFirstSearch_PREorder(self):
    return self.traversePreOrder([])

# Post order means first left child, then right child , at last parent
def depthFirstSearch_POSTorder(self):
    return self.traversePostOrder([])

def traverseInOrder(self, lst):
    if (self.left):
        self.left.traverseInOrder(lst)
    lst.append(self.val)
    if (self.right):
        self.right.traverseInOrder(lst)
    return lst

def traversePreOrder(self, lst):
    lst.append(self.val)
    if (self.left):
        self.left.traversePreOrder(lst)
    if (self.right):
        self.right.traversePreOrder(lst)
    return lst

def traversePostOrder(self, lst):
    if (self.left):
        self.left.traversePostOrder(lst)
    if (self.right):
        self.right.traversePostOrder(lst)
    lst.append(self.val)
    return lst

def findNodeAndItsParent(self, val, parent = None):
    # returning the node and its parent so we can delete the
    # node and reconstruct the tree from its parent
    if val == self.val: return self, parent
    if (val < self.val):
        if (self.left):
            return self.left.findNodeAndItsParent(val, self)
        else: return 'Not found'
    else:
        if (self.right):
            return self.right.findNodeAndItsParent(val, self)
        else: return 'Not found'

# deleting a node means we have to rearrange some part of the tree
def delete(self, val):
    # check if the value we want to delete is in the tree
    if (self.findNodeAndItsParent(val) == 'Not found'): return 'Node is not in tree'
    # we get the node we want to delete and its parent-node
    # from findNodeAndItsParent method
    deleting_node, parent_node = self.findNodeAndItsParent(val)
    # check how many children nodes does the node we are going
    # to delete have by traversePreOrder from the deleting_node
    nodes_affected = deleting_node.traversePreOrder([])

```

```

# if len(nodes_effected)==1 means, the node to be deleted doesn't
# have any children
# so we can just check from its parent node the position(left or
# right) of node we want to delete
# and point the position to 'None' i.e node is deleted

if (len(nodes_effected)==1):
    if (parent_node.left.val == deleteing_node.val) : parent_node.left = None
    else: parent_node.right = None
    return 'Successfully deleted'
# if len(nodes_effected) > 1 which means the node we are
# going to delete has 'children',
# so the tree must be rearranged from the deleteing_node
else:
    # if the node we want to delete doesn't have any parent
    # means the node to be deleted is 'root' node
    if (parent_node == None):
        nodes_effected.remove(deleteing_node.val)
        # make the 'root' node i.e self value,left,right to None,
        # this means we need to implement a new tree again without
        # the deleted node
        self.left = None
        self.right = None
        self.val = None

        #construction of new tree
        for node in nodes_effected:
            self.insert(node)
        return 'Successfully deleted'

    # if the node we want to delete has a parent
    # traverse from parent_node
    nodes_effected = parent_node.traversePreOrder([])

    # deleting the node
    if (parent_node.left == deleteing_node) : parent_node.left = None
    else: parent_node.right = None

    # removeing the parent_node, deleteing_node and inserting
    # the nodes_effected in the tree
    nodes_effected.remove(deleteing_node.val)
    nodes_effected.remove(parent_node.val)
    for node in nodes_effected:
        self.insert(node)

return 'Successfully deleted'

```

```

bst = binarySearchTree()
bst.insert(7)
bst.insert(4)
bst.insert(9)
bst.insert(0)
bst.insert(5)
bst.insert(8)
bst.insert(13)

```

```

#
#      7
#    /  \
#   /    \
#  4      9
# /  \   /  \
# 0   5 8   13

# IN order - useful in sorting the tree in ascending order
print('IN order: ',bst.depthFirstSearch_INorder())

# PRE order - useful in reconstructing a tree
print('PRE order:' ,bst.depthFirstSearch_PREorder())

# POST order - useful in finding the leaf nodes
print('POST order:', bst.depthFirstSearch_POSTorder())

print(bst.delete(5))
print(bst.delete(9))
print(bst.delete(7))

# after deleting
print('IN order: ',bst.depthFirstSearch_INorder())
print('PRE order:' ,bst.depthFirstSearch_PREorder())
print('POST order:', bst.depthFirstSearch_POSTorder())

```

Output:

Signature of the Faculty



Exercise Programs:

