

School of Computer Science and Artificial Intelligence

Lab Assignment # 12.2

Program : B. Tech (CSE)

Specialization :AIML

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Lab 12: Algorithms with AI Assistance – Sorting, Searching, and Optimizing Algorithms

Lab Objectives:

- Apply AI-assisted programming to implement and optimize sorting and searching algorithms.
- Compare different algorithms in terms of efficiency and use cases.

Week6 -

Tuesday

- Understand how AI tools can suggest optimized code and complexity improvements.

Task Description -1 (Data Structures – Stack Implementation with AI Assistance)

➤ Task: Use AI assistance to generate a Python program that implements a Stack data structure.

Instructions:

Prompt AI to create a Stack class with the following methods:

- push(element)
- pop()
- peek()
- is_empty()
- Ensure proper error handling for stack underflow.
- Ask AI to include clear docstrings for each method.

```
## Task 1: Stack Implementation using AI Assistance # Prompt Given to AI
Create a Python class Stack with methods: push(element), pop(), peek(), is_empty(). Include proper error handling for stack underflow and clear docstrings.

class Stack:
    """
    Stack Data Structure Implementation using Python list.
    A stack follows the LIFO (Last In First Out) principle.
    """
    def __init__(self):
        """Initialize an empty stack."""
        self.items = []

    def push(self, element):
        """
        Push an element onto the stack.
        :param element: The element to be added to the stack.
        """
        self.items.append(element)

    def pop(self):
        """
        Remove and return the top element of the stack.
        :raises IndexError: If the stack is empty (stack underflow).
        :return: The top element of the stack.
        """
        if self.is_empty():
            raise IndexError("Stack Underflow: Cannot pop from empty stack.")
        return self.items.pop()

    def peek(self):
        """
        Return the top element without removing it.
        :raises IndexError: If the stack is empty.
        :return: The top element.
        """
        if self.is_empty():
            raise IndexError("Stack is empty.")
        return self.items[-1]

    def is_empty(self):
        """
        Check whether the stack is empty.
        :return: True if stack is empty, otherwise False.
        """
        return len(self.items) == 0

## Task 2: Linear Search vs Binary Search # Prompt Given to AI
Generate linear_search(arr, target) and binary_search(arr, target). Include docstrings explaining working principle and complexity.
```

Task Description -2 (Algorithms – Linear vs Binary Search

Analysis)

➤ Task: Use AI to implement and compare Linear Search and Binary Search algorithms in Python.

Instructions:

- Prompt AI to generate:
- linear_search(arr, target)
- binary_search(arr, target)
- Include docstrings explaining:
- Working principle
- Test both algorithms using different input sizes.

Task 2: Linear Search vs Binary Search # * Prompt Given to AI

Generate linear_search(arr, target) and binary_search(arr, target). Include docstrings explaining working principle and complexity.

```
def linear_search(arr, target):
    """
    Perform Linear Search on a list.

    Working Principle:
    - Traverse each element sequentially.
    - Compare each element with the target.

    Time Complexity:
    - Best Case: O(1)
    - Worst Case: O(n)

    Space Complexity: O(1)
    """
    for i in range(len(arr)):
        if arr[i] == target:
            return i
    return -1

def binary_search(arr, target):
    """
    Perform Binary Search on a sorted list.

    Working Principle:
    - Repeatedly divide the search space in half.
    - Compare middle element with target.

    Time Complexity:
    - Best Case: O(1)
    - Worst Case: O(log n)

    Space Complexity: O(1)

    Note: Array must be sorted.
    """
    low = 0
    high = len(arr) - 1

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

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

    return -1
```

♦ Analysis

Linear Search checks each element → slower for large datasets.

Binary Search divides search space → much faster for sorted data.

Binary Search is preferred for large sorted datasets.

Task Description -3 (Test Driven Development – Simple Calculator Function)

➤ Task:

Apply Test Driven Development (TDD) using AI assistance to develop a calculator function.

Instructions:

- Prompt AI to first generate unit test cases for addition and subtraction.
- Run the tests and observe failures.
- Ask AI to implement the calculator functions to pass all tests.
- Re-run the tests to confirm success.

Expected Output:

- Separate test file and implementation file.

- Test cases executed before implementation.
- Final implementation passing all test cases.

```
## Task 3: Test Driven Development (TDD) - Calculator • Step 1: Generate Unit Tests First

import unittest
from calculator import add, subtract

class TestCalculator(unittest.TestCase):

    def test_add(self):
        self.assertEqual(add(5, 3), 8)
        self.assertEqual(add(-1, 1), 0)

    def test_subtract(self):
        self.assertEqual(subtract(5, 3), 2)
        self.assertEqual(subtract(0, 4), -4)

if __name__ == "__main__":
    unittest.main()

-----
ModuleNotFoundError: Traceback (most recent call last)
/tmp/ipython-input-718294899.py in <cell line: 0>()
      1 import unittest
----> 2 from calculator import add, subtract
      3
      4 class TestCalculator(unittest.TestCase):
      5

ModuleNotFoundError: No module named 'calculator'

-----
NOTE: If your import is failing due to a missing package, you can
manually install dependencies using either !pip or !apt.

To view examples of installing some common dependencies, click the
"Open Examples" button below.
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• Run Tests (Before Implementation)
✗ Tests fail because functions are not implemented.

• Step 2: Implement Functions
```

```
def add(a, b):
    """
    Return the sum of two numbers.

    Time Complexity: O(1)
    """
    return a + b

def subtract(a, b):
    """
    Return the difference between two numbers.
    """
```

```
• Run Tests (Before Implementation)
✗ Tests fail because functions are not implemented.

• Step 2: Implement Functions

def add(a, b):
    """
    Return the sum of two numbers.

    Time Complexity: O(1)
    """
    return a + b

def subtract(a, b):
    """
    Return the difference between two numbers.

    Time Complexity: O(1)
    """
    return a - b
```

Task Description -4 (Data Structures – Queue Implementation with AI Assistance)

➤ Task:

Use AI assistance to generate a Python program that implements a Queue data structure.

Instructions:

- Prompt AI to create a Queue class with the following methods:
 - enqueue(element)

- dequeue()
 - front()
 - is_empty()
- Handle queue overflow and underflow conditions.
- Include appropriate docstrings for all methods.

Expected Output:

- A fully functional Queue implementation in Python.
- Proper error handling and documentation.

```
## ✅ Task 4: Queue Implementation # Prompt Given to AI
Create Queue class with enqueue(), dequeue(), front(), is_empty(). Handle overflow and underflow. Include docstrings.

class Queue:
    """
    Queue Data Structure implementation using list.
    Follows FIFO (First In First Out) principle.
    """

    def __init__(self, capacity=None):
        """
        Initialize queue.

        :param capacity: Maximum size of queue (optional).
        """
        self.items = []
        self.capacity = capacity

    def enqueue(self, element):
        """
        Add element to the rear of queue.

        :raises OverflowError: If queue exceeds capacity.
        """
        if self.capacity and len(self.items) >= self.capacity:
            raise OverflowError("Queue Overflow: Cannot add element.")
        self.items.append(element)

    def dequeue(self):
        """
        Remove and return front element.

        :raises IndexError: If queue is empty.
        """
        if self.is_empty():
            raise IndexError("Queue Underflow: Cannot dequeue.")
        return self.items.pop(0)

    def front(self):
        """
        Return front element without removing it.
        """
        if self.is_empty():
            raise IndexError("Queue is empty.")
        return self.items[0]

    def is_empty(self):
        """
        Check if queue is empty.
        """
        return len(self.items) == 0
```

Task Description -5 (Algorithms – Bubble Sort vs Selection Sort)

➤ Task:

Use AI to implement Bubble Sort and Selection Sort algorithms and compare their behavior.

Instructions:

➤ Prompt AI to generate:

- `bubble_sort(arr)`
- `selection_sort(arr)`

➤ Include comments explaining each step.

➤ Add docstrings mentioning time and space complexity.

Expected Output:

- Correct Python implementations of both sorting algorithms.
- Complexity analysis in docstrings.

```
## 🟢 Task 5: Bubble Sort vs Selection Sort

• Bubble Sort

def bubble_sort(arr):
    """
    Sort list using Bubble Sort.

    Working:
    - Repeatedly swap adjacent elements if in wrong order.

    Time Complexity:
    - Best Case: O(n)
    - Worst Case: O(n^2)

    Space Complexity: O(1)
    """
    n = len(arr)
    for i in range(n):
        for j in range(0, n-i-1):
            if arr[j] > arr[j+1]:
                arr[j], arr[j+1] = arr[j+1], arr[j]
    return arr

• Selection Sort

def selection_sort(arr):
    """
    Sort list using Selection Sort.

    Working:
    - Repeatedly find minimum element and place at correct position.

    Time Complexity:
    - Best Case: O(n^2)
    - Worst Case: O(n^2)

    Space Complexity: O(1)
    """
    n = len(arr)
    for i in range(n):
        min_index = i
        for j in range(i+1, n):
            if arr[j] < arr[min_index]:
                min_index = j
        arr[i], arr[min_index] = arr[min_index], arr[i]
    return arr
```

♦ Comparison

Algorithm	Best Case	Worst Case	Stable	Use Case
Bubble Sort	$O(n)$	$O(n^2)$	Yes	Small datasets
Selection Sort	$O(n^2)$	$O(n^2)$	No	Simple implementation

🚀 Conclusion

- AI assistance helps generate optimized and well-documented code quickly.
- Binary Search is significantly more efficient than Linear Search for large sorted datasets.
- TDD improves code reliability.
- Bubble and Selection Sort are simple but inefficient for large data.
- Proper error handling improves robustness of Stack and Queue implementations.