

SCHOOL OF COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE		DEPARTMENT OF COMPUTER SCIENCE ENGINEERING	
Program Name: B. Tech		Assignment Type: Lab	
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Course Code	24CS002PC215	Course Title	AI Assisted Coding
Year/Sem	II/I	Regulation	R24
Date and Day of Assignment	Week6 - Monday	Time(s)	
Duration	2 Hours	Applicable to Batches	
AssignmentNumber: 12.1 (Present assignment number)/ 24 (Total number of assignments)			
Q.No.	Question		Expected Time to complete
1	Lab 12: Algorithms with AI Assistance – Sorting, Searching, and Optimizing Algorithms Lab Objectives: <ul style="list-style-type: none"> • Apply AI-assisted programming to implement and optimize sorting and searching algorithms. 		Week6 - Monday

- Compare different algorithms in terms of efficiency and use cases.
- Understand how AI tools can suggest optimized code and complexity improvements.

Task Description #1 (Sorting – Merge Sort Implementation)

- Task: Use AI to generate a Python program that implements the Merge Sort algorithm.
- Instructions:
 - Prompt AI to create a function `merge_sort(arr)` that sorts a list in ascending order.
 - Ask AI to include time complexity and space complexity in the function docstring.
 - Verify the generated code with test cases.
- Expected Output:
 - A functional Python script implementing Merge Sort with proper documentation.

PROMPT: "Implement merge sort in Python with docstring (time/space complexity), helper merge function, and test cases."

CODE:

```
▶ def merge(left, right):
    """Merges two sorted lists into a single sorted list.

    Args:
        left: The left sorted list.
        right: The right sorted list.

    Returns:
        A new list containing elements from left and right in sorted order.

    Time Complexity: O(n), where n is the total number of elements in both lists.
    Space Complexity: O(n), where n is the total number of elements in both lists (for the new merged list).
    """
    merged_list = []
    i, j = 0, 0

    while i < len(left) and j < len(right):
        if left[i] < right[j]:
            merged_list.append(left[i])
            i += 1
        else:
            merged_list.append(right[j])
            j += 1

    # Append remaining elements from left and right (if any)
    merged_list.extend(left[i:])
    merged_list.extend(right[j:])

    return merged_list
```

```

❶ def merge_sort(arr):
    """Sorts a list using the merge sort algorithm.

    Args:
        arr: The list to be sorted.

    Returns:
        A new list containing elements from arr in sorted order.

    Time Complexity: O(n log n), where n is the number of elements in the list. This is because the list is divided in half at each step (log n levels), and merging takes linear time (n) at each level.
    Space Complexity: O(n), where n is the number of elements in the list. This is due to the space required for the temporary lists created during the merge process.
    """
    if len(arr) <= 1:
        return arr

    mid = len(arr) // 2
    left_half = arr[:mid]
    right_half = arr[mid:]

    left_half = merge_sort(left_half)
    right_half = merge_sort(right_half)

    return merge(left_half, right_half)

❷ # Test cases
test_cases = [
    ([3, 1, 4, 1, 5, 9, 2, 6], [1, 1, 2, 3, 4, 5, 6, 9]),
    ([], []),
    ([1], [1]),
    ([5, 4, 3, 2, 1], [1, 2, 3, 4, 5]),
    ([1, 2, 3, 4, 5], [1, 2, 3, 4, 5]),
    ([1, 5, 2, 4, 3], [1, 2, 3, 4, 5]),
]

for input_arr, expected_output in test_cases:
    actual_output = merge_sort(input_arr)
    assert actual_output == expected_output, f"Input: {input_arr}, Expected: {expected_output}, Got: {actual_output}"
    print(f"Test case passed for input: {input_arr}")

❸ Test case passed for input: [3, 1, 4, 1, 5, 9, 2, 6]
Test case passed for input: []
Test case passed for input: [1]
Test case passed for input: [5, 4, 3, 2, 1]
Test case passed for input: [1, 2, 3, 4, 5]
Test case passed for input: [1, 5, 2, 4, 3]

```

OBSERVATION: This code implements the merge sort algorithm with a helper function and includes test cases to verify its correctness. The execution output shows that all provided test cases passed successfully.

Task Description #2 (Searching – Binary Search with AI Optimization)

- Task: Use AI to create a binary search function that finds a target element in a sorted list.
- Instructions:
 - Prompt AI to create a function `binary_search(arr, target)` returning the index of the target or -1 if not found.
 - Include docstrings explaining best, average, and worst-case complexities.

- Test with various inputs.
- Expected Output:
 - Python code implementing binary search with AI-generated comments and docstrings.

PROMPT: Write a Python function `binary_search(arr, target)` that returns the index of target in a sorted list or -1 if not found.

Add a docstring explaining best, average, and worst-case complexities.

Include AI-generated comments in the code and test it with different inputs.

CODE:

```
▶ def binary_search(arr, target):
    """
    Performs binary search on a sorted list to find a target element.

    Args:
        arr: A sorted list of elements.
        target: The element to search for.

    Returns:
        The index of the target element if found, otherwise -1.

    Time Complexity Analysis:
        - Best Case: O(1) - When the target element is the middle element in the first comparison.
        - Average Case: O(log n) - On average, the search space is halved in each step.
        - Worst Case: O(log n) - When the target element is at the beginning or end of the list, or not present.
            The number of comparisons is logarithmic with respect to the size of the list (n).
    """
    left, right = 0, len(arr) - 1

    while left <= right:
        mid = (left + right) // 2
        if arr[mid] == target:
            return mid
        elif arr[mid] < target:
            left = mid + 1
        else:
            right = mid - 1

    return -1

# Test cases
sorted_list = [2, 5, 8, 12, 16, 23, 38, 56, 72, 91]
target1 = 23
target2 = 5
target3 = 100
target4 = 91

print(f"Index of {target1}: {binary_search(sorted_list, target1)}")
print(f"Index of {target2}: {binary_search(sorted_list, target2)}")
print(f"Index of {target3}: {binary_search(sorted_list, target3)}")
print(f"Index of {target4}: {binary_search(sorted_list, target4)}")
```

Index of 23: 5
 Index of 5: 1
 Index of 100: -1
 Index of 91: 9

OBSERVATION: The binary search function successfully finds the target element in a sorted list using a divide-and-conquer approach.

Its best case is **O(1)** when the target is at the middle, and average/worst case is **O(log n)**. Testing with different inputs shows correct results for both found and not found cases.

Task Description #3 (Real-Time Application – Inventory Management System)

- Scenario: A retail store's inventory system contains thousands of products, each with attributes like product ID, name, price, and stock quantity. Store staff need to:
 1. Quickly search for a product by ID or name.
 2. Sort products by price or quantity for stock analysis.
- Task:
 - Use AI to suggest the most efficient search and sort algorithms for this use case.
 - Implement the recommended algorithms in Python.
 - Justify the choice based on dataset size, update frequency, and performance requirements.
- Expected Output:
 - A table mapping operation → recommended algorithm → justification.
 - Working Python functions for searching and sorting the inventory.

PROMPT: Scenario: A retail store's inventory system contains thousands of products, each with attributes like product ID, name, price, and stock quantity. Store staff need to: Quickly search for a product by ID or name. Sort products by price or quantity for stock analysis. now suggest the most efficient search and sort algorithms for this use case. Implement the recommended algorithms in Python. Justify the choice based on dataset size, update frequency, and performance requirements. The output should be in the form of table mapping operation → recommended algorithm → justification.

CODE:

```
▶ # 1. Create a dictionary named inventory with sample data.  
inventory = {  
    'PROD001': {'name': 'Laptop', 'price': 1200.00, 'quantity': 50},  
    'PROD002': {'name': 'Mouse', 'price': 25.00, 'quantity': 200},  
    'PROD003': {'name': 'Keyboard', 'price': 75.00, 'quantity': 150},  
    'PROD004': {'name': 'Monitor', 'price': 300.00, 'quantity': 30},  
    'PROD005': {'name': 'Webcam', 'price': 50.00, 'quantity': 100},  
    'PROD006': {'name': 'Printer', 'price': 200.00, 'quantity': 20},  
    'PROD007': {'name': 'Speakers', 'price': 100.00, 'quantity': 75},  
    'PROD008': {'name': 'Desk Lamp', 'price': 35.00, 'quantity': 120}  
}  
  
# 2. Write a Python function named search_product_by_id.  
def search_product_by_id(inventory_dict, product_id):  
    """Searches for a product by its ID using direct dictionary lookup."""  
    return inventory_dict.get(product_id)  
  
# 3. Write a Python function named search_product_by_name.  
def search_product_by_name(inventory_dict, product_name):  
    """Searches for a product by its name using linear search through values."""  
    for product_details in inventory_dict.values():  
        if product_details['name'].lower() == product_name.lower():  
            return product_details  
    return None  
  
# 4. Write a Python function named sort_inventory_by_price.  
def sort_inventory_by_price(inventory_dict):  
    """Sorts the inventory by product price."""  
    # Extract product details (values) into a list and sort  
    sorted_products = sorted(inventory_dict.values(), key=lambda x: x['price'])  
    return sorted_products  
  
# 5. Write a Python function named sort_inventory_by_quantity.  
def sort_inventory_by_quantity(inventory_dict):  
    """Sorts the inventory by product quantity."""  
    # Extract product details (values) into a list and sort  
    sorted_products = sorted(inventory_dict.values(), key=lambda x: x['quantity'])  
    return sorted_products
```

```

→ --- Search by ID ---
Searching for ID 'PROD003': {'name': 'Keyboard', 'price': 75.0, 'quantity': 150}
Searching for ID 'PROD999': None

--- Search by Name ---
Searching for name 'Monitor': {'name': 'Monitor', 'price': 300.0, 'quantity': 30}
Searching for name 'Tablet': None

--- Sort by Price ---
Inventory sorted by price:
{'name': 'Mouse', 'price': 25.0, 'quantity': 200}
{'name': 'Desk Lamp', 'price': 35.0, 'quantity': 120}
{'name': 'Webcam', 'price': 50.0, 'quantity': 100}
{'name': 'Keyboard', 'price': 75.0, 'quantity': 150}
{'name': 'Speakers', 'price': 100.0, 'quantity': 75}
{'name': 'Printer', 'price': 200.0, 'quantity': 20}
{'name': 'Monitor', 'price': 300.0, 'quantity': 30}
{'name': 'Laptop', 'price': 1200.0, 'quantity': 50}

--- Sort by Quantity ---
Inventory sorted by quantity:
{'name': 'Printer', 'price': 200.0, 'quantity': 20}
{'name': 'Monitor', 'price': 300.0, 'quantity': 30}
{'name': 'Laptop', 'price': 1200.0, 'quantity': 50}
{'name': 'Speakers', 'price': 100.0, 'quantity': 75}
{'name': 'Webcam', 'price': 50.0, 'quantity': 100}
{'name': 'Desk Lamp', 'price': 35.0, 'quantity': 120}
{'name': 'Keyboard', 'price': 75.0, 'quantity': 150}
{'name': 'Mouse', 'price': 25.0, 'quantity': 200}

```

► # 6. Include example calls to each function and print outputs.

```

print(""\n--- Search by ID ---")
# Test case: ID found
product_id_found = 'PROD003'
found_product_id = search_product_by_id(inventory, product_id_found)
print(f"Searching for ID '{product_id_found}': {found_product_id}")

# Test case: ID not found
product_id_not_found = 'PROD999'
not_found_product_id = search_product_by_id(inventory, product_id_not_found)
print(f"Searching for ID '{product_id_not_found}': {not_found_product_id}")

print("\n--- Search by Name ---")
# Test case: Name found
product_name_found = 'Monitor'
found_product_name = search_product_by_name(inventory, product_name_found)
print(f"Searching for name '{product_name_found}': {found_product_name}")

# Test case: Name not found
product_name_not_found = 'Tablet'
not_found_product_name = search_product_by_name(inventory, product_name_not_found)
print(f"Searching for name '{product_name_not_found}': {not_found_product_name}")

print("\n--- Sort by Price ---")
sorted_by_price = sort_inventory_by_price(inventory)
print("Inventory sorted by price:")
for product in sorted_by_price:
    print(product)

print("\n--- Sort by Quantity ---")
sorted_by_quantity = sort_inventory_by_quantity(inventory)
print("Inventory sorted by quantity:")
for product in sorted_by_quantity:
    print(product)

```

OBSERVATION:

Based on the analysis and implementation, the key observation is that using a dictionary with product ID as the key provides highly efficient $O(1)$ average time complexity for searching by ID, which is crucial for frequent lookups in a retail inventory system. Sorting operations, while less frequent, are efficiently handled by Python's built-in Timsort with $O(n \log n)$ complexity. Searching by name is less efficient ($O(n)$), highlighting the importance of ID-based lookups for performance.

Deliverables (For All Tasks)

1. AI-generated prompts for code and test case generation.
2. At least 3 assert test cases for each task.
3. AI-generated initial code and execution screenshots.
4. Analysis of whether code passes all tests.
5. Improved final version with inline comments and explanation.
6. Compiled report (Word/PDF) with prompts, test cases, assertions, code, and output.