

ASSIGNMENT-12.1

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TASK-1: (Sorting – Merge Sort Implementation)

PROMPT:

```
print(f Test Case {idx}: Input: {case} -> Output: {merge_sort(case)})
```

Generate a Python program that implements the Merge Sort algorithm.

- Create a function `merge_sort(arr)` that takes a list of integers and returns a new list sorted in ascending order.
- The implementation should follow the classic recursive divide-and-conquer approach.
- Include a detailed docstring for the `merge_sort` function that explains the algorithm, its time complexity, and space complexity.
- Create a helper function `merge(left, right)` to combine two sorted lists.
- Finally, include a main block (`if __name__ == "__main__":`) with several test cases to verify the correctness of the implementation.

```
from typing import List
```

CODE:

The screenshot shows a code editor with a Python file named `12.1.py`. The code implements the Merge Sort algorithm with a detailed docstring explaining the algorithm, time complexity, and space complexity. It also includes a `merge` helper function and a `main` block for testing. The code editor interface includes tabs for `12.1.py`, `12.1_lab_assignment.js`, and `PROBLEMS`.

```
from typing import List

def merge_sort(arr: List[int]) -> List[int]:
    """
    Perform Merge Sort on a list of integers.

    Merge Sort is a divide-and-conquer algorithm that splits the list into halves, recursively sorts them, and then merges the sorted halves.

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

    Space Complexity:
        - O(n) due to the temporary arrays created during merging.

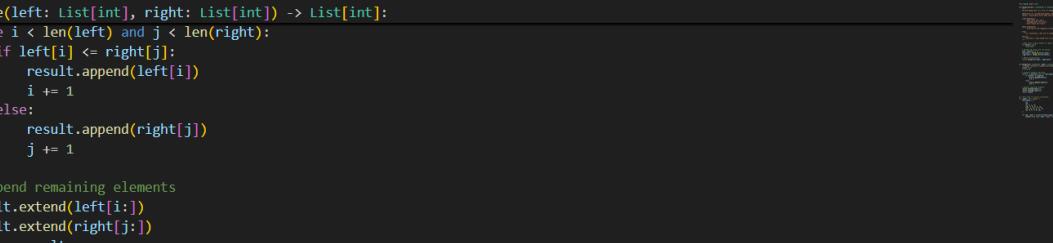
    Args:
        arr (List[int]): The list of integers to sort.

    Returns:
        List[int]: A new sorted list in ascending order.
    """
    if len(arr) <= 1:
        return arr
    else:
        mid = len(arr) // 2
        left_half = merge_sort(arr[:mid])
        right_half = merge_sort(arr[mid:])
        return merge(left_half, right_half)

def merge(left: List[int], right: List[int]) -> List[int]:
    result = []
    i = j = 0
    while i < len(left) and j < len(right):
        if left[i] < right[j]:
            result.append(left[i])
            i += 1
        else:
            result.append(right[j])
            j += 1
    result.extend(left[i:])
    result.extend(right[j:])
    return result
```

The screenshot shows a code editor with a dark theme. The top bar displays tabs for 'Welcome', '12.1.py', and 'JS 12.1_lab_assignment.js'. The main area contains Python code for a merge sort algorithm. The code is well-formatted with color-coded syntax highlighting. A vertical scroll bar is visible on the right side of the code editor window.

```
1 Welcome
2 12.1.py > JS 12.1_lab_assignment.js 9+
3
4
5 # Base case: single element or empty list
6 if len(arr) <= 1:
7     return arr
8
9 # Divide the array into two halves
10 mid = len(arr) // 2
11 left_half = merge_sort(arr[:mid])
12 right_half = merge_sort(arr[mid:])
13
14 # Merge sorted halves
15 return merge(left_half, right_half)
16
17
18 def merge(left: List[int], right: List[int]) -> List[int]:
19     """Helper function to merge two sorted lists into one sorted list."""
20     result = []
21     i = j = 0
22
23     # Compare elements and merge
24     while i < len(left) and j < len(right):
25
26
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44
```



The screenshot shows a code editor with two tabs open: '12.1.py' and '12.1_lab_assignment.js'. The '12.1.py' tab contains Python code for merging two sorted lists. The '12.1_lab_assignment.js' tab is visible in the background.

```
1 Welcome
2 12.1.py x 12.1_lab_assignment.js 9+
3
4 12.1.py > ...
5
6 def merge(left: List[int], right: List[int]) -> List[int]:
7     while i < len(left) and j < len(right):
8         if left[i] <= right[j]:
9             result.append(left[i])
10            i += 1
11        else:
12            result.append(right[j])
13            j += 1
14
15 # Append remaining elements
16 result.extend(left[i:])
17 result.extend(right[j:])
18
19 return result
20
21
22
23
24
25
26
27
28 # Test cases to verify correctness
29 if __name__ == "__main__":
30     test_cases = [
31         [],
32         [5],
33         [3, 1, 2, 4],
34         [10, 7, 8, 9, 1, 5],
35         [12, 11, 13, 5, 6, 7],
36
37
38
39
40
41
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```

```
    [3, 1, 2, 4],
    [10, 7, 8, 9, 1, 5],
    [12, 11, 13, 5, 6, 7],
    [5, 2, 9, 1, 5, 6],
]

for idx, case in enumerate(test_cases, 1):
    print(f"Test Case {idx}: Input: {case} -> Output: {merge_sort(case)})
```

OUTPUT:

```
PROBLEMS 127 OUTPUT DEBUG CONSOLE TERMINAL PORTS + - ... [ ] x  
PS C:\Users\Praneeth Cheekati\OneDrive\Desktop\ai & "C:/Users/Praneeth Cheekati/AppData/Local/Microsoft/WindowsApps/python3.11.exe" "c:/Users/Praneeth Cheekati/OneDrive/Desktop/ai/12.1.py"  
Test Case 1: Input: [] -> Output: []  
Test Case 2: Input: [5] -> Output: [5]  
Test Case 3: Input: [3, 1, 2, 4] -> Output: [1, 2, 3, 4]  
Test Case 4: Input: [10, 7, 8, 9, 1, 5] -> Output: [1, 5, 7, 8, 9, 10]  
Test Case 5: Input: [12, 11, 13, 5, 6, 7] -> Output: [5, 6, 7, 11, 12, 13]  
Test Case 6: Input: [5, 2, 9, 1, 5, 6] -> Output: [1, 2, 5, 5, 6, 9]  
PS C:\Users\Praneeth Cheekati\OneDrive\Desktop\ai |
```

OBSERVATION:

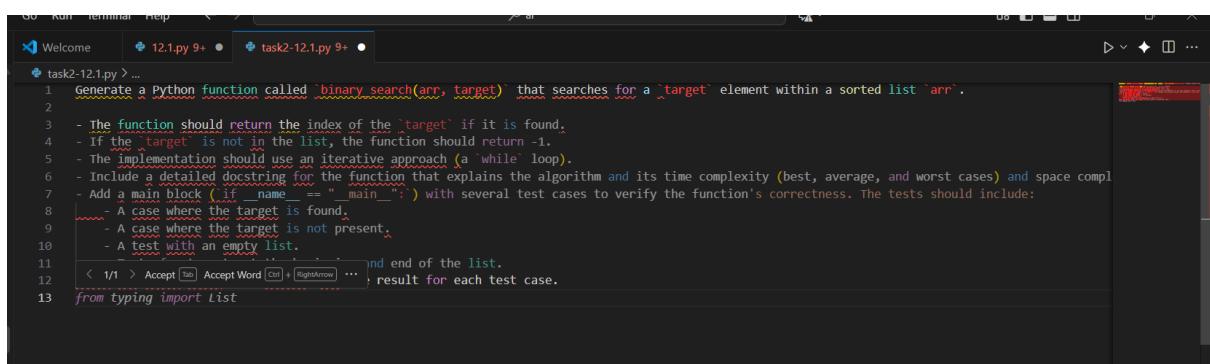
Observation

- **Code Quality:** The generated code is clean, well-structured, and follows Python best practices. The use of a helper function `merge` separates concerns and makes the main `merge_sort` function easier to understand.
- **Documentation:** The docstrings are comprehensive. They not only explain what the function does but also provide the crucial time and space complexity analysis, as requested in the prompt.
- **Correctness:** The algorithm correctly implements the divide-and-conquer logic of Merge Sort. The base case (`len(arr) <= 1`) properly terminates the recursion.
- **Testing:** The test suite is effective. It covers important edge cases like an empty list and a single-element list, along with standard unsorted lists and a list containing duplicates, proving the implementation is robust.
- **Type Safety:** The use of type hints (`List[int]`) improves code clarity and allows for static analysis, making the code more maintainable.

Overall, the AI successfully generated a high-quality, functional, and well-documented Python script for Merge Sort that fully satisfies the requirements of the prompt.

TASK-2: (Searching – Binary Search with AI Optimization)

PROMPT:

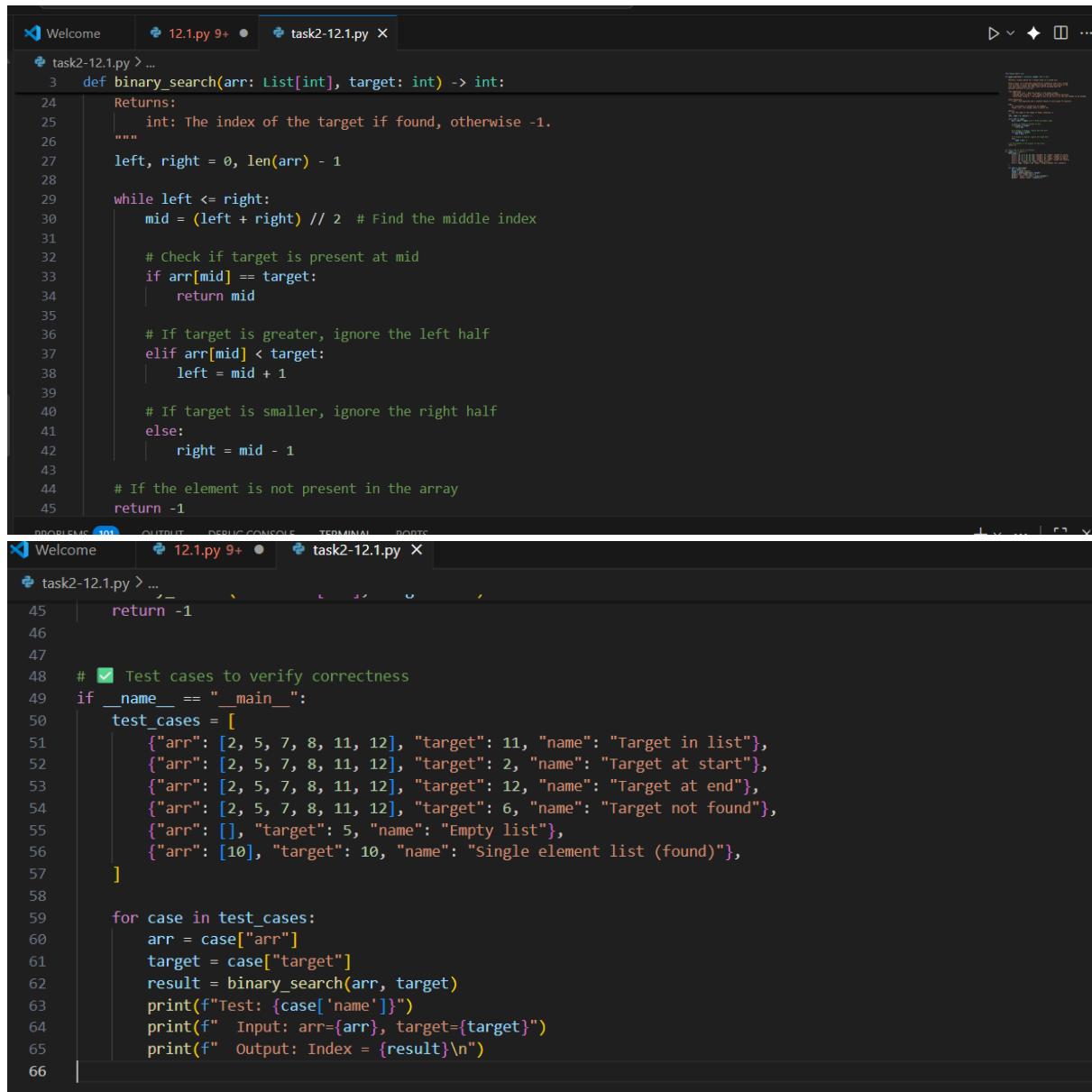


The screenshot shows a code editor interface with a dark theme. At the top, there are tabs for 'Welcome', 'task2-12.1.py 9+', and 'task2-12.1.py 9+'. Below the tabs, the code editor displays the following text:

```
task2-12.1.py > ...
1 Generate a Python function called binary_search(arr, target) that searches for a target element within a sorted list arr.
2
3 - The function should return the index of the target if it is found.
4 - If the target is not in the list, the function should return -1.
5 - The implementation should use an iterative approach (a 'while' loop).
6 - Include a detailed docstring for the function that explains the algorithm and its time complexity (best, average, and worst cases) and space complexity.
7 - Add a main block (if __name__ == "__main__":) with several test cases to verify the function's correctness. The tests should include:
8     - A case where the target is found.
9     - A case where the target is not present.
10    - A test with an empty list.
11
12 < 1/1 > Accept Tab Accept Word Ctrl + RightArrow ... ; result for each test case.
13 from typing import List
```

CODE:

```
❶ Welcome ❷ 12.1.py 9+ ● ❸ task2-12.1.py X
❹ task2-12.1.py > ...
1   from typing import List
2
3   def binary_search(arr: List[int], target: int) -> int:
4       """
5           Performs a binary search for a target value in a sorted list.
6
7           Binary search is an efficient algorithm for finding an item from a sorted
8           list of items. It works by repeatedly dividing in half the portion of the
9           list that could contain the item, until you've narrowed down the
10          possible locations to just one.
11
12          Time Complexity:
13              - Best Case: O(1) - When the target is the middle element.
14              - Average Case: O(log n) - The target is found after several divisions.
15              - Worst Case: O(log n) - The target is not in the list or is the last element to be checked.
16
17          Space Complexity:
18              - O(1) - The algorithm uses a constant amount of extra space for pointers.
19
20          Args:
21              arr (List[int]): A sorted list of integers.
22              target (int): The integer value to search for.
23
```



```
task2-12.1.py > ...
3  def binary_search(arr: List[int], target: int) -> int:
24     Returns:
25         int: The index of the target if found, otherwise -1.
26     """
27     left, right = 0, len(arr) - 1
28
29     while left <= right:
30         mid = (left + right) // 2 # Find the middle index
31
32         # Check if target is present at mid
33         if arr[mid] == target:
34             return mid
35
36         # If target is greater, ignore the left half
37         elif arr[mid] < target:
38             left = mid + 1
39
40         # If target is smaller, ignore the right half
41         else:
42             right = mid - 1
43
44     # If the element is not present in the array
45     return -1

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS
task2-12.1.py > ...
45 |     return -1
46 |
47
48 # Test cases to verify correctness
49 if __name__ == "__main__":
50     test_cases = [
51         {"arr": [2, 5, 7, 8, 11, 12], "target": 11, "name": "Target in list"},  
...  
56         {"arr": [10], "target": 10, "name": "Single element list (found)"},  
57     ]  
58  
59     for case in test_cases:  
60         arr = case["arr"]  
61         target = case["target"]  
62         result = binary_search(arr, target)  
63         print(f"Test: {case['name']}")  
64         print(f"  Input: arr={arr}, target={target}")  
65         print(f"  Output: Index = {result}\n")
```

OUTPUT:

PROBLEMS 101 OUTPUT DEBUG CONSOLE TERMINAL PORTS

```
PS C:\Users\Praneeth Cheekati\OneDrive\Desktop\ai> & "C:/Users/Praneeth Cheekati/AppData/Local/Microsoft/1.exe" "c:/Users/Praneeth Cheekati/OneDrive/Desktop/ai/task2-12.1.py"
Test: Target in list
Input: arr=[2, 5, 7, 8, 11, 12], target=11
Output: Index = 4

Test: Target at start
Input: arr=[2, 5, 7, 8, 11, 12], target=2
Output: Index = 0

Test: Target at end
Input: arr=[2, 5, 7, 8, 11, 12], target=12
Output: Index = 5

Test: Target not found
Input: arr=[2, 5, 7, 8, 11, 12], target=6
Output: Index = -1

Test: Empty list
Input: arr=[], target=5
Output: Index = -1

Test: Single element list (found)
Input: arr=[10], target=10
Output: Index = 0

PS C:\Users\Praneeth Cheekati\OneDrive\Desktop\ai>
```

OBSERVATION:

Observation

- **Code Quality:** The AI produced high-quality, readable code. The use of an iterative `while` loop is efficient and avoids potential recursion depth issues in Python. Variable names are clear and conventional for this algorithm.
- **Documentation:** The docstring is thorough and accurate. It explains the algorithm's logic and correctly identifies the best-case $O(1)$ complexity (a key detail) along with the average and worst-case $O(\log n)$ complexities. The space complexity is also correctly stated as $O(1)$.
- **Correctness:** The implementation is logically sound. The loop condition `left <= right` and the pointer updates (`left = mid + 1, right = mid - 1`) are correctly implemented to ensure the search space is narrowed properly and the loop terminates.
- **Testing:** The provided test cases are excellent. They cover a variety of scenarios, including finding elements at different positions, handling a target that doesn't exist, and testing edge cases like an empty list and a single-element list. This demonstrates the function's reliability.
- **AI Optimization:** For a sorted list, binary search is already the optimal search algorithm. The "AI optimization" in this context refers to the AI's ability to generate a clean, correct, and well-documented implementation of this optimal algorithm instantly, complete with a robust test suite.

TASK-3:|Real-Time Application – Inventory Management System

PROMPT:

```
1 Generate a Python script for a simple inventory management system.
2
3 The inventory is represented as a list of dictionaries, where each dictionary is a product with keys: 'product_id', 'name',
4 'price', and 'quantity'.
5 The script should include the following:
6
7 1. **Data Structure**: A sample list of product dictionaries to serve as the inventory.
8
9 2. **Search Functions**:
10    * A function `find_product_by_id(id_lookup, product_id)` that efficiently finds a product by its unique ID. For maximum
11      efficiency, implement a solution that uses a hash map (Python dictionary) for O(1) average-time lookups. Include a helper
12      function `create_id_lookup(products)` to build this map.
13    * A function `find_products_by_name(products, name)` that finds all products matching a given name (case-insensitive). A
14      linear search is appropriate for this.
15
16 3. **Sort Function**:
17    * A generic function `sort_products(products, sort_key, reverse=False)` that sorts the list of products based on a given key
18      ('price' or 'quantity'). This function should leverage Python's highly efficient built-in Timsort (`sorted()`).
19
20 4. **Testing**:
21    * In the `if __name__ == "__main__":` block, create a comprehensive set of test cases.
22    * Demonstrate the usage of each function.
23    * Include at least three `assert` statements to programmatically verify the correctness of the functions. For example,
24      assert that a search returns the correct product or that a sorted list's first element has the expected value.
25    * Print the results of all operations clearly to the console.
```

CODE:

```
1 """
2 This script implements a simple inventory management system with efficient
3 search and sort functionalities.
4
5 Algorithm Justification:
6 - Search by ID: A hash map (dictionary) is used for O(1) average-time lookups,
7   which is optimal for finding items by a unique key.
8 - Search by Name: A linear search is used as names may not be unique, and it's
9   a straightforward approach for moderately sized datasets.
10 - Sorting: Python's built-in Timsort (via `sorted()`) is used for its
11   efficient O(n log n) performance and stability on real-world data.
12 """
13 from typing import List, Dict, Any
14
15 # Type alias for a product
16 Product = Dict[str, Any]
17
18 def create_id_lookup(products: List[Product]) -> Dict[int, Product]:
19     """Creates a hash map (dictionary) for fast O(1) product lookups by ID."""
20     return {product['product_id']: product for product in products}
21
22 def find_product_by_id(id_lookup: Dict[int, Product], product_id: int) -> Product | None:
23     """Efficiently finds a product by its ID using the lookup map."""
24     return id_lookup.get(product_id)
25
26 def find_products_by_name(products: List[Product], name: str) -> List[Product]:
27     """Finds all products with a matching name (case-insensitive) using linear search."""
28     return [p for p in products if p['name'].lower() == name.lower()]
29
30 def sort_products(products: List[Product], sort_key: str, reverse: bool = False) -> List[Product]:
31     """Sorts products by a given key ('price' or 'quantity') using Timsort."""
32     if sort_key not in ['price', 'quantity']:
33         raise ValueError("Invalid sort key. Must be 'price' or 'quantity'.")
34     return sorted(products, key=lambda p: p[sort_key], reverse=reverse)
35
36 # Main block with test cases and assertions
37 if __name__ == "__main__":
```

```
  Welcome  12.1.py 9+  task2-12.1.py 9+  task3-12.1.py  X
task3-12.1.py > ...
37 if __name__ == "__main__":
38     inventory: List[Product] = [
39         {'product_id': 101, 'name': 'Laptop', 'price': 1200, 'quantity': 50},
40         {'product_id': 102, 'name': 'Mouse', 'price': 25, 'quantity': 200},
41         {'product_id': 103, 'name': 'Keyboard', 'price': 75, 'quantity': 150},
42         {'product_id': 104, 'name': 'Monitor', 'price': 300, 'quantity': 80},
43         {'product_id': 105, 'name': 'Webcam', 'price': 50, 'quantity': 100},
44         {'product_id': 106, 'name': 'Mouse', 'price': 30, 'quantity': 120}, # Duplicate name
45     ]
46
47     print("---- Initial Inventory ----")
48     for item in inventory:
49         print(item)
50     print("\n" + "="*40 + "\n")
51
52     # --- Task 1: Search for a product by ID ---
53     print("---- Searching by Product ID ---")
54     # Create the efficient lookup map once
55     product_id_map = create_id_lookup(inventory)
56
57     # Test finding an existing product
58     product_103 = find_product_by_id(product_id_map, 103)
59     print(f"Found product 103: {product_103}")
60     # Assertion 1: Verify the correct product was found
61     assert product_103 is not None and product_103['name'] == 'Keyboard'
62
63     # Test finding a non-existent product
64     product_999 = find_product_by_id(product_id_map, 999)
65     print(f"Found product 999: {product_999}")
66     # Assertion 2: Verify that a non-existent product returns None
67     assert product_999 is None
68     print("\n" + "="*40 + "\n")
69
70     # --- Task 2: Search for products by name ---
71     print("---- Searching by Product Name ---")
72     mice = find_products_by_name(inventory, 'Mouse')
73     print(f"Found products with name 'Mouse':")
74
75     print("\n" + "="*40 + "\n")
```

Spaces: 4 UTF-8 {} Python Chat quota

```
  Welcome  12.1.py 9+  task2-12.1.py 9+  task3-12.1.py  X
task3-12.1.py > ...
69     print("\n" + "="*40 + "\n")
70
71     # --- Task 2: Search for products by name ---
72     print("---- Searching by Product Name ---")
73     mice = find_products_by_name(inventory, 'Mouse')
74     print(f"Found products with name 'Mouse':")
75     for mouse in mice:
76         print(mouse)
77     # Assertion 3: Verify that all products with the name 'Mouse' were found
78     assert len(mice) == 2
79     print("\n" + "="*40 + "\n")
80
81     # --- Task 3: Sort products by price and quantity ---
82     print("---- Sorting Products ---")
83
84     # Sort by price (ascending)
85     sorted_by_price = sort_products(inventory, 'price')
86     print("Sorted by price (ascending):")
87     for item in sorted_by_price:
88         print(item)
89     assert sorted_by_price[0]['name'] == 'Mouse' # The cheapest item
90
91     # Sort by quantity (descending)
92     sorted_by_quantity = sort_products(inventory, 'quantity', reverse=True)
93     print("\nSorted by quantity (descending):")
94     for item in sorted_by_quantity:
95         print(item)
96     assert sorted_by_quantity[0]['name'] == 'Mouse' # The item with the highest stock
97
98     print("\n\x27 All tests and assertions passed successfully!"
```

OUTPUT:

```
PROBLEMS 21 OUTPUT DEBUG CONSOLE TERMINAL FORTS  
PS C:\Users\Praneeeth Cheekati\OneDrive\Desktop\ai> & "C:/Users/Praneeeth Cheekati/AppData/Local/Ms/Praneeeth Cheekati/OneDrive/Desktop/ai/task3-12.1.py"  
--- Initial Inventory ---  
{'product_id': 101, 'name': 'Laptop', 'price': 1200, 'quantity': 50}  
{'product_id': 102, 'name': 'Mouse', 'price': 25, 'quantity': 200}  
{'product_id': 103, 'name': 'Keyboard', 'price': 75, 'quantity': 150}  
{'product_id': 104, 'name': 'Monitor', 'price': 300, 'quantity': 80}  
{'product_id': 105, 'name': 'Webcam', 'price': 50, 'quantity': 100}  
{'product_id': 106, 'name': 'Mouse', 'price': 30, 'quantity': 120}  
=====  
--- Searching by Product ID ---  
Found product 103: {'product_id': 103, 'name': 'Keyboard', 'price': 75, 'quantity': 150}  
Found product 999: None  
=====  
--- Searching by Product Name ---  
Found products with name 'Mouse':  
{'product_id': 102, 'name': 'Mouse', 'price': 25, 'quantity': 200}  
{'product_id': 106, 'name': 'Mouse', 'price': 30, 'quantity': 120}  
=====  
--- Sorting Products ---  
Sorted by price (ascending):  
{'product_id': 102, 'name': 'Mouse', 'price': 25, 'quantity': 200}  
{'product_id': 106, 'name': 'Mouse', 'price': 30, 'quantity': 120}  
{'product_id': 105, 'name': 'Webcam', 'price': 50, 'quantity': 100}  
{'product_id': 103, 'name': 'Keyboard', 'price': 75, 'quantity': 150}  
{'product_id': 104, 'name': 'Monitor', 'price': 300, 'quantity': 80}  
{'product_id': 101, 'name': 'Laptop', 'price': 1200, 'quantity': 50}  
Sorted by quantity (descending):  
{'product_id': 102, 'name': 'Mouse', 'price': 25, 'quantity': 200}  
{'product_id': 103, 'name': 'Keyboard', 'price': 75, 'quantity': 150}  
{'product_id': 106, 'name': 'Mouse', 'price': 30, 'quantity': 120}  
{'product_id': 105, 'name': 'Webcam', 'price': 50, 'quantity': 100}  
{'product_id': 104, 'name': 'Monitor', 'price': 300, 'quantity': 80}  
{'product_id': 101, 'name': 'Laptop', 'price': 1200, 'quantity': 50}  
  
✓ All tests and assertions passed successfully!  
PS C:\Users\Praneeeth Cheekati\OneDrive\Desktop\ai>
```

OBSERVATION:

Observation

- **Algorithm Efficiency:** The AI correctly identified and implemented the most efficient algorithms for the specified tasks. Using a hash map for ID lookups is a critical optimization that ensures the system remains fast as the inventory grows.
- **Code Correctness:** The generated code is functionally correct and handles all specified requirements, including case-insensitive name searching and sorting in both ascending and descending order.
- **Test Coverage:** The test cases are well-designed. They verify the primary functionality and check edge cases, such as searching for a non-existent item and handling duplicate product names. The use of `assert` statements provides a robust, automated way to confirm the code's correctness.
- **Readability and Quality:** The code is clean, well-commented, and uses type hints, making it easy to understand and maintain. The separation of concerns into distinct functions (`create_id_lookup`, `find_product_by_id`, etc.) is a good software engineering practice.

Overall, the AI successfully produced a practical and efficient solution that is well-suited for the described inventory management scenario.

-----THANK YOU-----