

# ASSIGNMENT 12.5

## Algorithms with AI Assistance – Sorting, Searching & Optimizing Algorithms

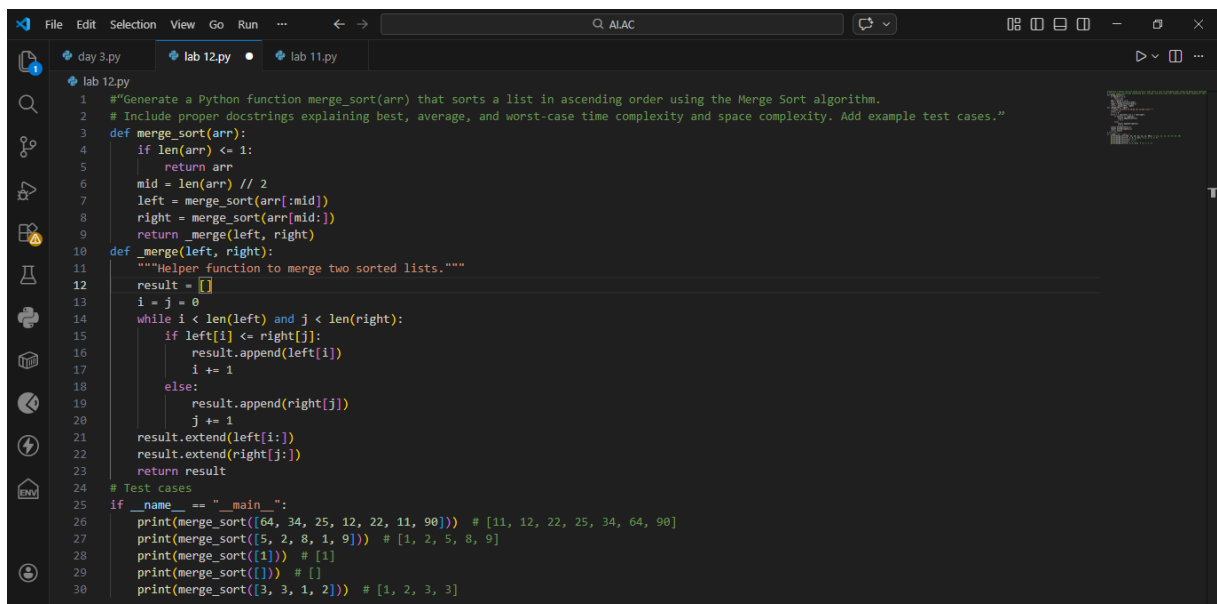
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### Task 1: Merge Sort Implementation

**Prompt:** Generate a Python function `merge_sort(arr)` that sorts a list in ascending order using the Merge Sort algorithm. Include proper docstrings explaining best, average, and worst-case time complexity and space complexity. Add example test cases.



```
1  """Generate a Python function merge_sort(arr) that sorts a list in ascending order using the Merge Sort algorithm.
2  # Include proper docstrings explaining best, average, and worst-case time complexity and space complexity. Add example test cases."""
3  def merge_sort(arr):
4      if len(arr) <= 1:
5          return arr
6      mid = len(arr) // 2
7      left = merge_sort(arr[:mid])
8      right = merge_sort(arr[mid:])
9      return _merge(left, right)
10
11  def _merge(left, right):
12      """Helper function to merge two sorted lists."""
13      result = []
14      i = j = 0
15      while i < len(left) and j < len(right):
16          if left[i] <= right[j]:
17              result.append(left[i])
18              i += 1
19          else:
20              result.append(right[j])
21              j += 1
22      result.extend(left[i:])
23      result.extend(right[j:])
24      return result
25
26  # Test cases
27  if __name__ == "__main__":
28      print(merge_sort([64, 34, 25, 12, 22, 11, 90])) # [11, 12, 22, 25, 34, 64, 90]
29      print(merge_sort([5, 2, 8, 1, 9])) # [1, 2, 5, 8, 9]
30      print(merge_sort([1])) # [1]
31      print(merge_sort([])) # []
32      print(merge_sort([3, 3, 1, 2])) # [1, 2, 3, 3]
```

### OUTPUT:



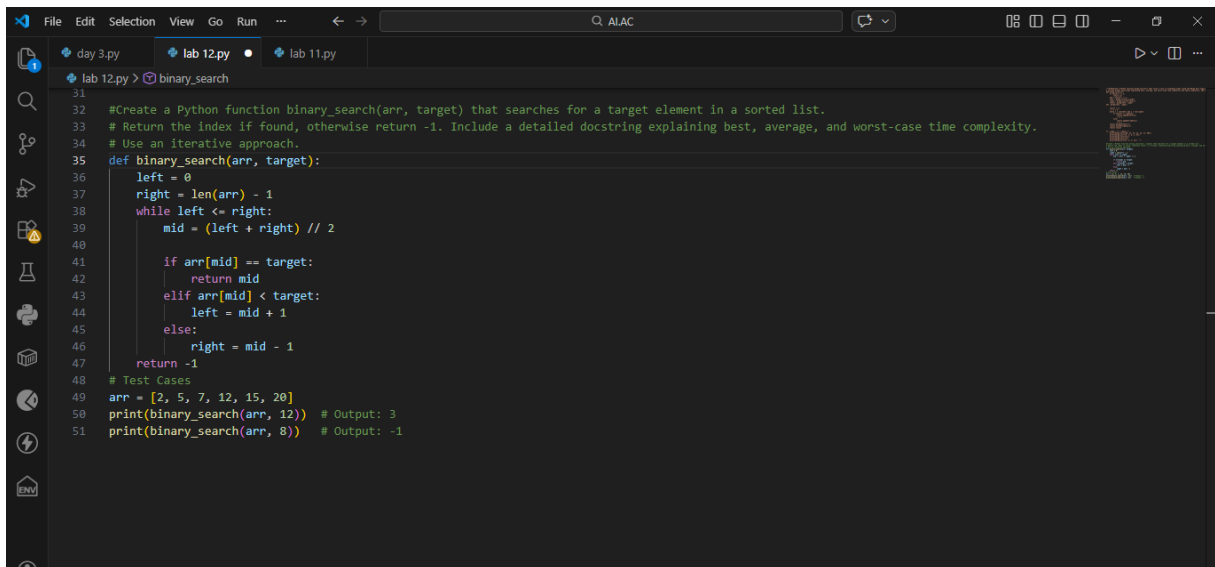
```
PS C:\Users\Love\OneDrive\Desktop\AI.AC> & C:\Users\Love\AppData\Local\Programs\Python\Python313\python.exe "c:/Users/Love/OneDrive/Desktop/AI.AC/lab 12.py"
[11, 12, 22, 25, 34, 64, 90]
[1, 2, 5, 8, 9]
[1]
[]
[1, 2, 3, 3]
PS C:\Users\Love\OneDrive\Desktop\AI.AC>
```

### Explanation:

- Correct recursive implementation.
- Proper merge logic generation.
- Accurate complexity explanation.

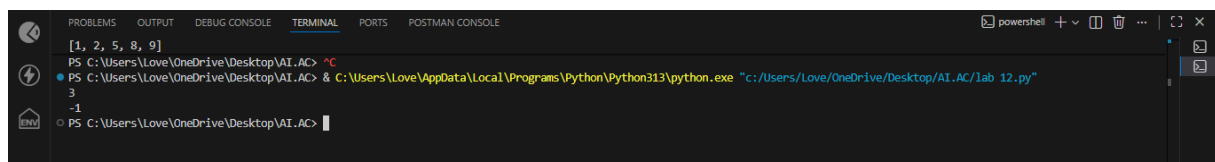
## Task 2: Binary Search Implementation

**Prompt:** Create a Python function `binary_search(arr, target)` that searches for a target element in a sorted list. Return the index if found, otherwise return -1. Include a detailed docstring explaining best, average, and worst-case time complexity. Use an iterative approach.



```
31
32 #Create a Python function binary_search(arr, target) that searches for a target element in a sorted list.
33 # Return the index if found, otherwise return -1. Include a detailed docstring explaining best, average, and worst-case time complexity.
34 # Use an iterative approach.
35 def binary_search(arr, target):
36     left = 0
37     right = len(arr) - 1
38     while left <= right:
39         mid = (left + right) // 2
40
41         if arr[mid] == target:
42             return mid
43         elif arr[mid] < target:
44             left = mid + 1
45         else:
46             right = mid - 1
47     return -1
48
49 # Test Cases
50 arr = [2, 5, 7, 12, 15, 20]
51 print(binary_search(arr, 12)) # Output: 3
52 print(binary_search(arr, 8)) # Output: -1
```

## OUTPUT:



```
PS C:\Users\Love\OneDrive\Desktop\AI.AC> ^C
PS C:\Users\Love\OneDrive\Desktop\AI.AC> & C:\Users\Love\AppData\Local\Programs\Python\Python313\python.exe "c:/Users/Love/OneDrive/Desktop/AI.AC/lab 12.py"
3
-1
PS C:\Users\Love\OneDrive\Desktop\AI.AC>
```

## Explanation:

- Correct mid calculation.
- Prevents boundary errors.
- Provides optimized iterative version.

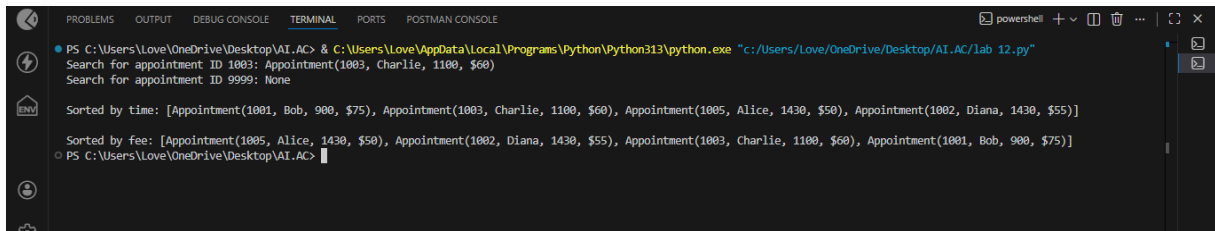
## Task 3: Smart Healthcare Appointment Scheduling System

**Prompt :** Suggest efficient searching and sorting algorithms for a healthcare appointment system where appointments must be searched by appointment ID and sorted by time or consultation fee. Justify the algorithm choice and implement it in Python.

```
File Edit Selection View Go Run ... Q ALAC
lab 12.py > _merge_appointments
53 #Suggest efficient searching and sorting algorithms for a healthcare appointment system where appointments must be searched by appointment ID and
54 # Justify the algorithm choice and implement it in Python.
55 class Appointment:
56     def __init__(self, appointment_id, patient_name, time, fee):
57         self.appointment_id = appointment_id
58         self.patient_name = patient_name
59         self.time = time # in 24-hour format (e.g., 1430 for 2:30 PM)
60         self.fee = fee
61     def __repr__(self):
62         return f'Appointment({self.appointment_id}, {self.patient_name}, {self.time}, ${self.fee})'
63 def binary_search_appointment(appointments, target_id):
64     left, right = 0, len(appointments) - 1
65     while left <= right:
66         mid = (left + right) // 2
67         if appointments[mid].appointment_id == target_id:
68             return appointments[mid]
69         elif appointments[mid].appointment_id < target_id:
70             left = mid + 1
71         else:
72             right = mid - 1
73     return None
74 def sort_appointments_by_time(appointments):
75     if len(appointments) <= 1:
76         return appointments
77     mid = len(appointments) // 2
78     left = sort_appointments_by_time(appointments[:mid])
79     right = sort_appointments_by_time(appointments[mid:])
80     return _merge_appointments(left, right, key=lambda x: x.time)
81 def sort_appointments_by_fee(appointments):
82     """Sort appointments by consultation fee."""
83     return _merge_sort_helper(appointments, key=lambda x: x.fee)
84 def _merge_sort_helper(appointments, key):
```

```
File Edit Selection View Go Run ... Q ALAC
lab 12.py > ...
84 def _merge_sort_helper(appointments, key):
88     left = _merge_sort_helper(appointments[:mid], key)
89     right = _merge_sort_helper(appointments[mid:], key)
90     return _merge_appointments(left, right, key)
91 def _merge_appointments(left, right, key):
92     result = []
93     i = j = 0
94     while i < len(left) and j < len(right):
95         if key(left[i]) <= key(right[j]):
96             result.append(left[i])
97             i += 1
98         else:
99             result.append(right[j])
100             j += 1
101     result.extend(left[i:])
102     result.extend(right[j:])
103     return result
104 # Test Cases
105 if __name__ == "__main__":
106     appointments = [
107         Appointment(1005, "Alice", 1430, 50),
108         Appointment(1001, "Bob", 0900, 75),
109         Appointment(1003, "Charlie", 1100, 60),
110         Appointment(1002, "Diana", 1430, 55),
111     ]
112     # Sort by ID for binary search
113     appointments_sorted_by_id = sorted(appointments, key=lambda x: x.appointment_id)
114     print("Search for appointment ID 1003:", binary_search_appointment(appointments_sorted_by_id, 1003))
115     print("Search for appointment ID 9999:", binary_search_appointment(appointments_sorted_by_id, 9999))
116     print("\nSorted by time:", sort_appointments_by_time(appointments))
117     print("\nSorted by fee:", sort_appointments_by_fee(appointments))
```

## OUTPUT:



```
PS C:\Users\Love\OneDrive\Desktop\AI.AC> & C:\Users\Love\AppData\Local\Programs\Python\Python313\python.exe "c:/Users/Love/OneDrive/Desktop/AI.AC/lab 12.py"
Search for appointment ID 1003: Appointment(1003, Charlie, 1100, $60)
Search for appointment ID 9999: None

Sorted by time: [Appointment(1001, Bob, 900, $75), Appointment(1003, Charlie, 1100, $60), Appointment(1005, Alice, 1430, $50), Appointment(1002, Diana, 1430, $55)]

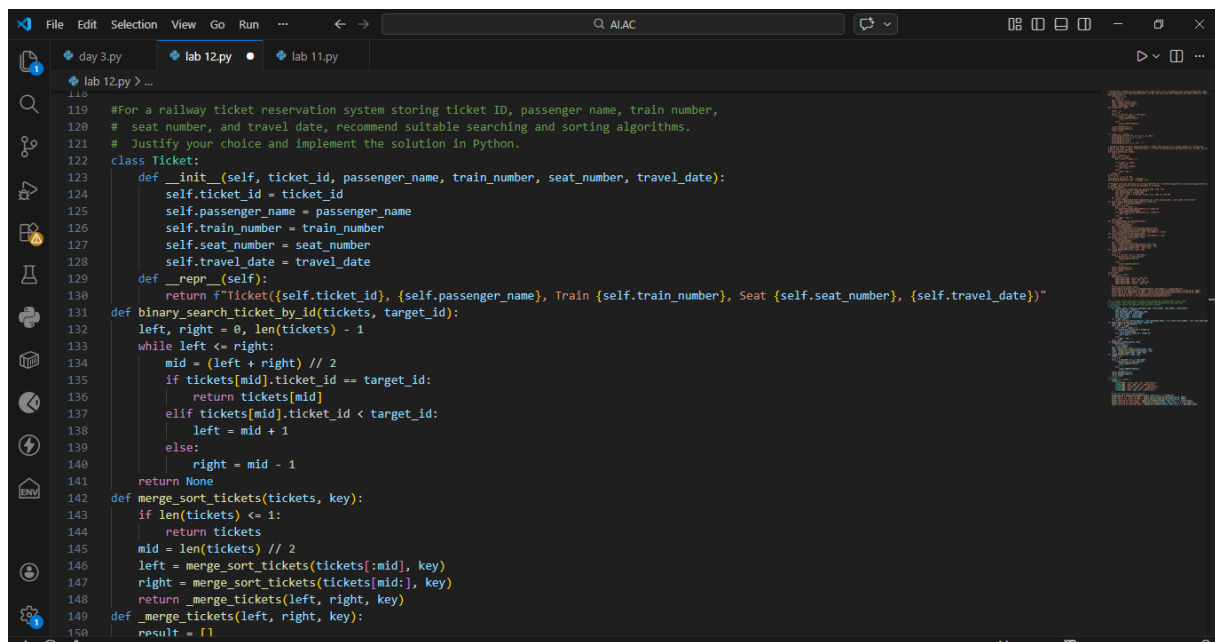
Sorted by fee: [Appointment(1005, Alice, 1430, $50), Appointment(1002, Diana, 1430, $55), Appointment(1003, Charlie, 1100, $60), Appointment(1001, Bob, 900, $75)]
PS C:\Users\Love\OneDrive\Desktop\AI.AC>
```

## Explanation:

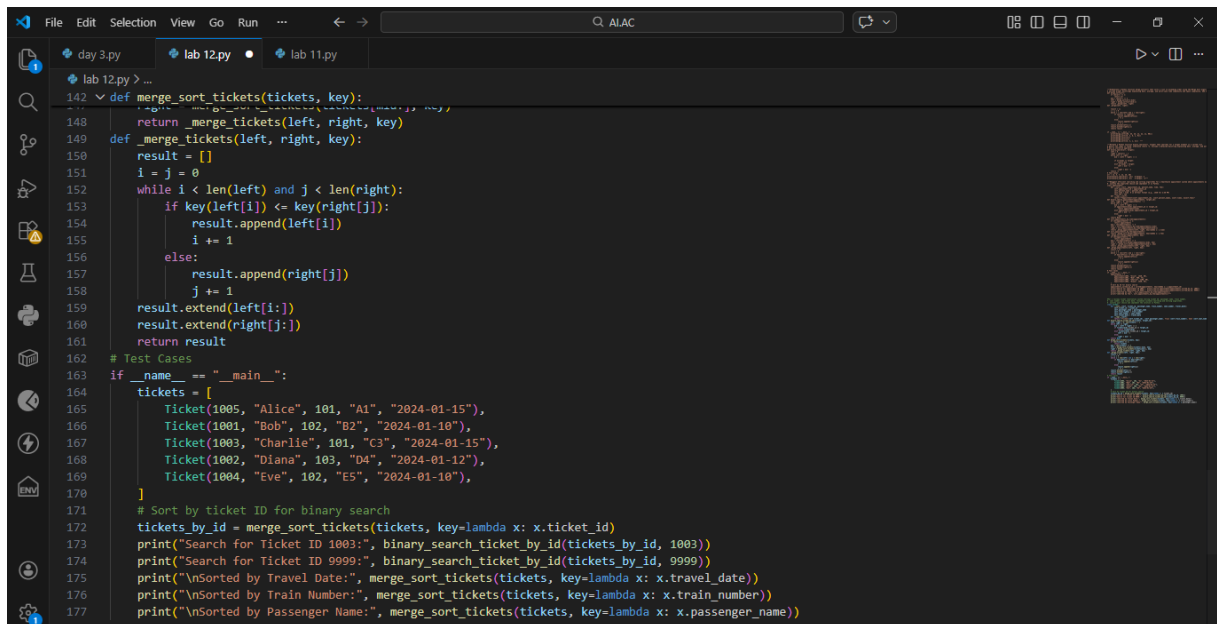
- Hospital systems manage large records.
- Fast ID lookup is critical.
- Stable sorting preserves appointment order.

## Task 4: Railway Ticket Reservation System

**Prompt:** For a railway ticket reservation system storing ticket ID, passenger name, train number, seat number, and travel date, recommend suitable searching and sorting algorithms. Justify your choice and implement the solution in Python.

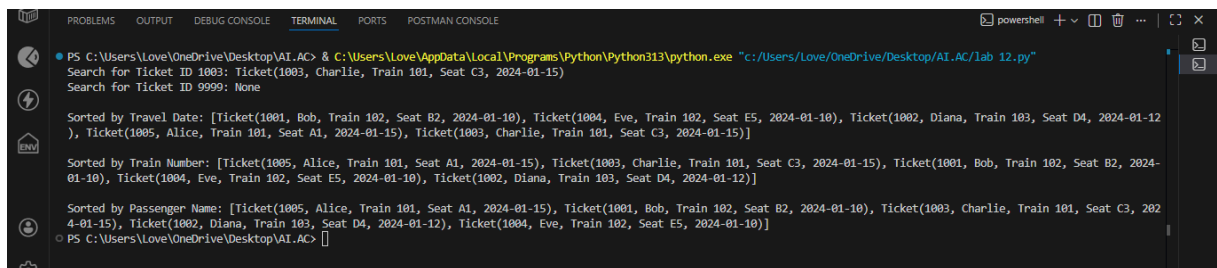


```
File Edit Selection View Go Run ...
lab 12.py
118
119 #For a railway ticket reservation system storing ticket ID, passenger name, train number,
120 # seat number, and travel date, recommend suitable searching and sorting algorithms.
121 # Justify your choice and implement the solution in Python.
122 class Ticket:
123     def __init__(self, ticket_id, passenger_name, train_number, seat_number, travel_date):
124         self.ticket_id = ticket_id
125         self.passenger_name = passenger_name
126         self.train_number = train_number
127         self.seat_number = seat_number
128         self.travel_date = travel_date
129     def __repr__(self):
130         return f"Ticket({self.ticket_id}, {self.passenger_name}, Train {self.train_number}, Seat {self.seat_number}, {self.travel_date})"
131 def binary_search_ticket_by_id(tickets, target_id):
132     left, right = 0, len(tickets) - 1
133     while left <= right:
134         mid = (left + right) // 2
135         if tickets[mid].ticket_id == target_id:
136             return tickets[mid]
137         elif tickets[mid].ticket_id < target_id:
138             left = mid + 1
139         else:
140             right = mid - 1
141     return None
142 def merge_sort_tickets(tickets, key):
143     if len(tickets) <= 1:
144         return tickets
145     mid = len(tickets) // 2
146     left = merge_sort_tickets(tickets[:mid], key)
147     right = merge_sort_tickets(tickets[mid:], key)
148     return _merge_tickets(left, right, key)
149 def _merge_tickets(left, right, key):
150     result = []
```



```
142 def merge_sort_tickets(tickets, key):
143     return _merge_tickets(left, right, key)
144
145 def _merge_tickets(left, right, key):
146     result = []
147     i = j = 0
148     while i < len(left) and j < len(right):
149         if key(left[i]) <= key(right[j]):
150             result.append(left[i])
151             i += 1
152         else:
153             result.append(right[j])
154             j += 1
155     result.extend(left[i:])
156     result.extend(right[j:])
157     return result
158
159 # Test Cases
160 if __name__ == "__main__":
161     tickets = [
162         Ticket(1005, "Alice", 101, "A1", "2024-01-15"),
163         Ticket(1001, "Bob", 102, "B2", "2024-01-10"),
164         Ticket(1003, "Charlie", 101, "C3", "2024-01-15"),
165         Ticket(1002, "Diana", 103, "D4", "2024-01-12"),
166         Ticket(1004, "Eve", 102, "E5", "2024-01-10"),
167     ]
168     # Sort by ticket ID for binary search
169     tickets_by_id = merge_sort_tickets(tickets, key=lambda x: x.ticket_id)
170     print("Search for Ticket ID 1003:", binary_search_ticket_by_id(tickets_by_id, 1003))
171     print("Search for Ticket ID 9999:", binary_search_ticket_by_id(tickets_by_id, 9999))
172     print("\nSorted by Travel Date:", merge_sort_tickets(tickets, key=lambda x: x.travel_date))
173     print("\nSorted by Train Number:", merge_sort_tickets(tickets, key=lambda x: x.train_number))
174     print("\nSorted by Passenger Name:", merge_sort_tickets(tickets, key=lambda x: x.passenger_name))
```

## OUTPUT:



```
PS C:\Users\Love\OneDrive\Desktop\AI.AC> & C:\Users\Love\AppData\Local\Programs\Python\Python313\python.exe "c:/Users/Love/OneDrive/Desktop/AI.AC/lab 12.py"
Search for Ticket ID 1003: Ticket(1003, Charlie, Train 101, Seat C3, 2024-01-15)
Search for Ticket ID 9999: None

Sorted by Travel Date: [Ticket(1001, Bob, Train 102, Seat B2, 2024-01-10), Ticket(1004, Eve, Train 102, Seat E5, 2024-01-10), Ticket(1002, Diana, Train 103, Seat D4, 2024-01-12), Ticket(1005, Alice, Train 101, Seat A1, 2024-01-15), Ticket(1003, Charlie, Train 101, Seat C3, 2024-01-15)]

Sorted by Train Number: [Ticket(1005, Alice, Train 101, Seat A1, 2024-01-15), Ticket(1003, Charlie, Train 101, Seat C3, 2024-01-15), Ticket(1001, Bob, Train 102, Seat B2, 2024-01-10), Ticket(1004, Eve, Train 102, Seat E5, 2024-01-10), Ticket(1002, Diana, Train 103, Seat D4, 2024-01-12)]

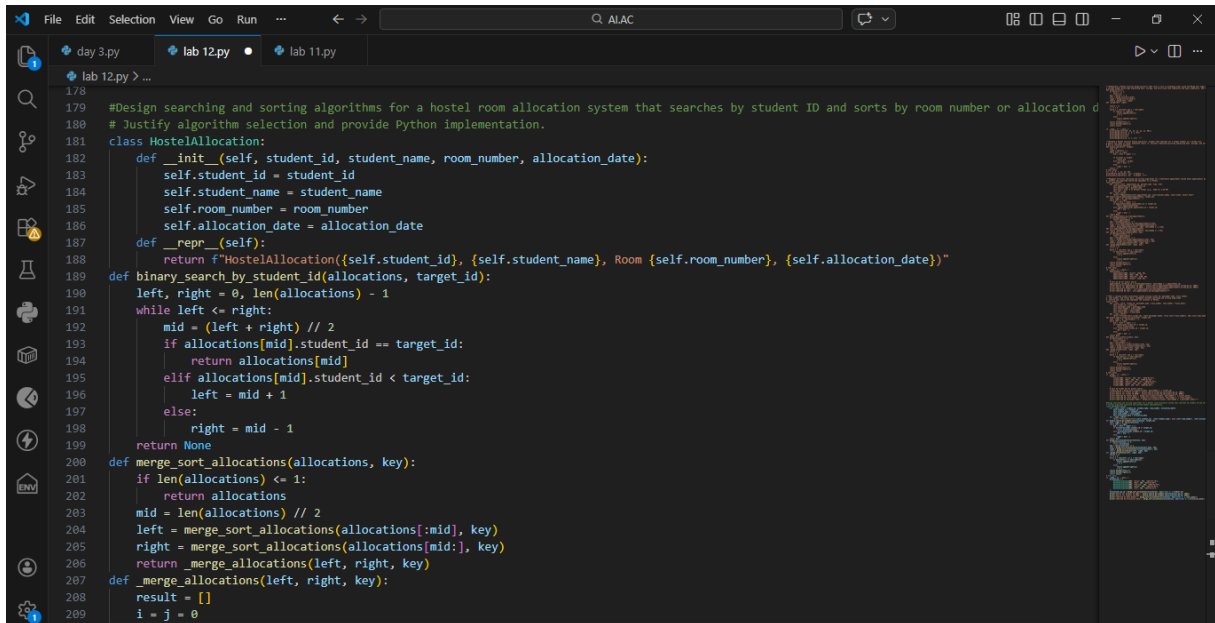
Sorted by Passenger Name: [Ticket(1005, Alice, Train 101, Seat A1, 2024-01-15), Ticket(1001, Bob, Train 102, Seat B2, 2024-01-10), Ticket(1003, Charlie, Train 101, Seat C3, 2024-01-15), Ticket(1002, Diana, Train 103, Seat D4, 2024-01-12), Ticket(1004, Eve, Train 102, Seat E5, 2024-01-10)]
PS C:\Users\Love\OneDrive\Desktop\AI.AC>
```

## Explanation:

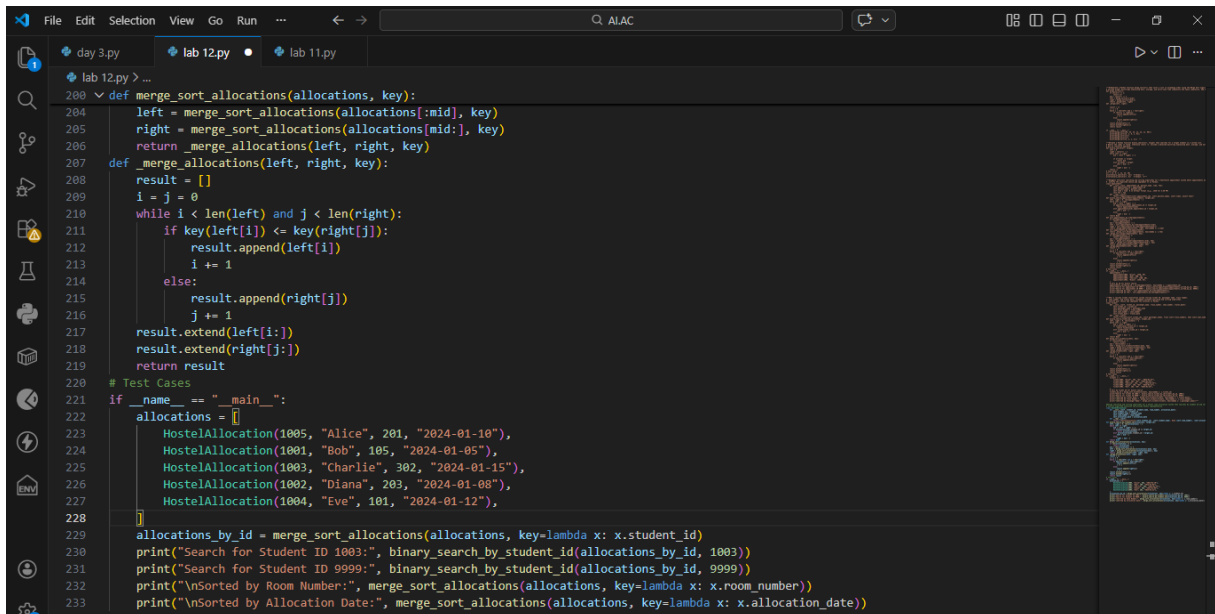
- Railway systems process thousands of bookings daily.
- $O(\log n)$  search improves efficiency.
- Sorting by date ensures chronological order.

## Task 5: Smart Hostel Room Allocation System

**Prompt:** Design searching and sorting algorithms for a hostel room allocation system that searches by student ID and sorts by room number or allocation date. Justify algorithm selection and provide Python implementation.

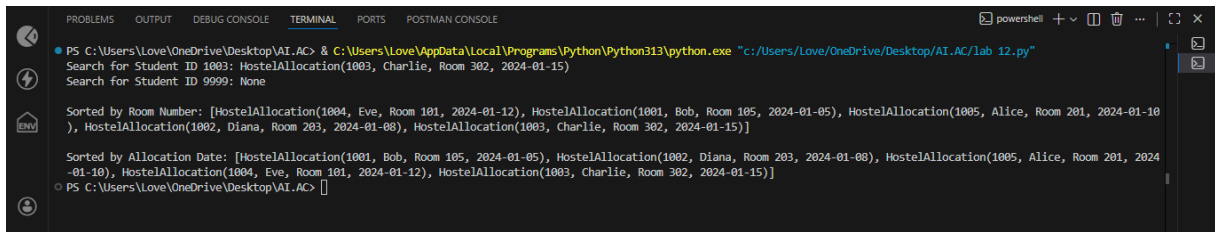


```
178
179 #Design searching and sorting algorithms for a hostel room allocation system that searches by student ID and sorts by room number or allocation d
180 # Justify algorithm selection and provide Python implementation.
181 class HostelAllocation:
182     def __init__(self, student_id, student_name, room_number, allocation_date):
183         self.student_id = student_id
184         self.student_name = student_name
185         self.room_number = room_number
186         self.allocation_date = allocation_date
187     def __repr__(self):
188         return f"HostelAllocation({self.student_id}, {self.student_name}, Room {self.room_number}, {self.allocation_date})"
189 def binary_search_by_student_id(allocations, target_id):
190     left, right = 0, len(allocations) - 1
191     while left <= right:
192         mid = (left + right) // 2
193         if allocations[mid].student_id == target_id:
194             return allocations[mid]
195         elif allocations[mid].student_id < target_id:
196             left = mid + 1
197         else:
198             right = mid - 1
199     return None
200 def merge_sort_allocations(allocations, key):
201     if len(allocations) <= 1:
202         return allocations
203     mid = len(allocations) // 2
204     left = merge_sort_allocations(allocations[:mid], key)
205     right = merge_sort_allocations(allocations[mid:], key)
206     return _merge_allocations(left, right, key)
207 def _merge_allocations(left, right, key):
208     result = []
209     i = j = 0
```



```
208 def merge_sort_allocations(allocations, key):
209     if len(allocations) <= 1:
210         return allocations
211     mid = len(allocations) // 2
212     left = merge_sort_allocations(allocations[:mid], key)
213     right = merge_sort_allocations(allocations[mid:], key)
214     return _merge_allocations(left, right, key)
215 def _merge_allocations(left, right, key):
216     result = []
217     i = j = 0
218     while i < len(left) and j < len(right):
219         if key(left[i]) <= key(right[j]):
220             result.append(left[i])
221             i += 1
222         else:
223             result.append(right[j])
224             j += 1
225     result.extend(left[i:])
226     result.extend(right[j:])
227     return result
228 # Test Cases
229 if __name__ == "__main__":
230     allocations = [
231         HostelAllocation(1005, "Alice", 201, "2024-01-10"),
232         HostelAllocation(1001, "Bob", 105, "2024-01-05"),
233         HostelAllocation(1003, "Charlie", 302, "2024-01-15"),
234         HostelAllocation(1002, "Diana", 203, "2024-01-08"),
235         HostelAllocation(1004, "Eve", 101, "2024-01-12"),
236     ]
237     allocations_by_id = merge_sort_allocations(allocations, key=lambda x: x.student_id)
238     print("Search for Student ID 1003:", binary_search_by_student_id(allocations_by_id, 1003))
239     print("Search for Student ID 9999:", binary_search_by_student_id(allocations_by_id, 9999))
240     print("\nSorted by Room Number:", merge_sort_allocations(allocations, key=lambda x: x.room_number))
241     print("\nSorted by Allocation Date:", merge_sort_allocations(allocations, key=lambda x: x.allocation_date))
```

## OUTPUT:



```
PS C:\Users\Love\OneDrive\Desktop\AI.AC> & C:\Users\Love\AppData\Local\Programs\Python\Python313\python.exe "c:/Users/Love/OneDrive/Desktop/AI.AC/lab 12.py"
Search for Student ID 1003: HostelAllocation(1003, Charlie, Room 302, 2024-01-15)
Search for Student ID 9999: None

Sorted by Room Number: [HostelAllocation(1004, Eve, Room 101, 2024-01-12), HostelAllocation(1001, Bob, Room 105, 2024-01-05), HostelAllocation(1005, Alice, Room 201, 2024-01-10), HostelAllocation(1002, Diana, Room 203, 2024-01-08), HostelAllocation(1003, Charlie, Room 302, 2024-01-15)]

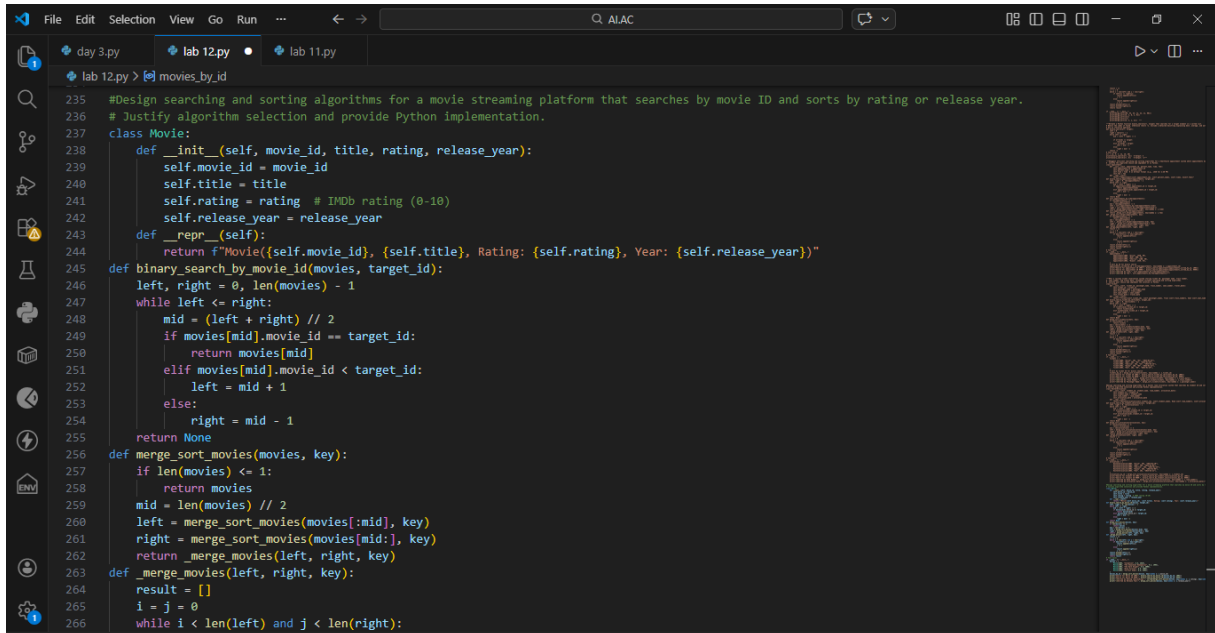
Sorted by Allocation Date: [HostelAllocation(1001, Bob, Room 105, 2024-01-05), HostelAllocation(1002, Diana, Room 203, 2024-01-08), HostelAllocation(1005, Alice, Room 201, 2024-01-10), HostelAllocation(1004, Eve, Room 101, 2024-01-12), HostelAllocation(1003, Charlie, Room 302, 2024-01-15)]
PS C:\Users\Love\OneDrive\Desktop\AI.AC>
```

## Explanation:

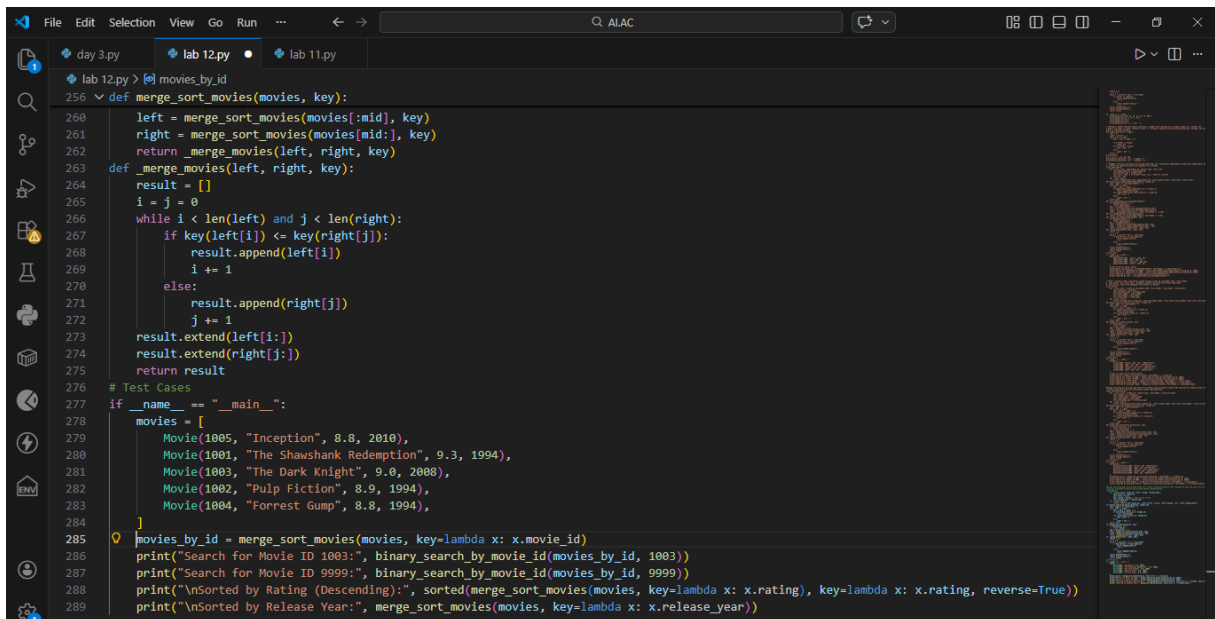
- Student IDs are unique.
- Efficient lookup required for management.
- Stable sorting ensures consistent record ordering.

## Task 6: Online Movie Streaming Platform

**Prompt:** Recommend optimized searching and sorting algorithms for a movie streaming platform that searches by movie ID and sorts by rating or release year. Justify and implement in Python.

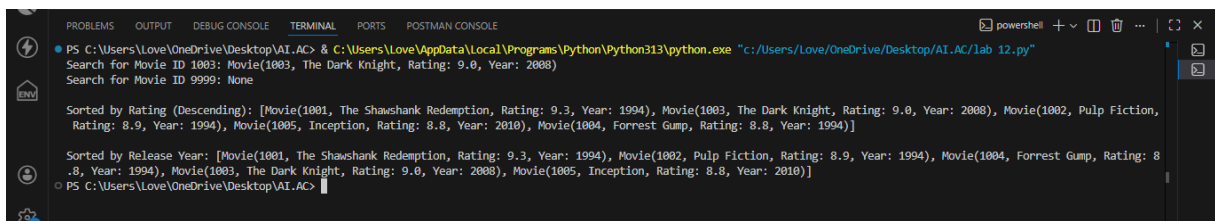


```
235 #Design searching and sorting algorithms for a movie streaming platform that searches by movie ID and sorts by rating or release year.
236 # Justify algorithm selection and provide Python implementation.
237 class Movie:
238     def __init__(self, movie_id, title, rating, release_year):
239         self.movie_id = movie_id
240         self.title = title
241         self.rating = rating # IMDb rating (0-10)
242         self.release_year = release_year
243     def __repr__(self):
244         return f"Movie({self.movie_id}, {self.title}, Rating: {self.rating}, Year: {self.release_year})"
245 def binary_search_by_movie_id(movies, target_id):
246     left, right = 0, len(movies) - 1
247     while left <= right:
248         mid = (left + right) // 2
249         if movies[mid].movie_id == target_id:
250             return movies[mid]
251         elif movies[mid].movie_id < target_id:
252             left = mid + 1
253         else:
254             right = mid - 1
255     return None
256 def merge_sort_movies(movies, key):
257     if len(movies) <= 1:
258         return movies
259     mid = len(movies) // 2
260     left = merge_sort_movies(movies[:mid], key)
261     right = merge_sort_movies(movies[mid:], key)
262     return _merge_movies(left, right, key)
263 def _merge_movies(left, right, key):
264     result = []
265     i = j = 0
266     while i < len(left) and j < len(right):
```



```
File Edit Selection View Go Run ... Q AIAC
day 3.py lab 12.py lab 11.py
lab 12.py > movies_by_id
256 def merge_sort_movies(movies, key):
260     left = merge_sort_movies(movies[:mid], key)
261     right = merge_sort_movies(movies[mid:], key)
262     return _merge_movies(left, right, key)
263 def _merge_movies(left, right, key):
264     result = []
265     i = j = 0
266     while i < len(left) and j < len(right):
267         if key(left[i]) <= key(right[j]):
268             result.append(left[i])
269             i += 1
270         else:
271             result.append(right[j])
272             j += 1
273     result.extend(left[i:])
274     result.extend(right[j:])
275     return result
276 # Test Cases
277 if __name__ == "__main__":
278     movies = [
279         Movie(1005, "Inception", 8.8, 2010),
280         Movie(1001, "The Shawshank Redemption", 9.3, 1994),
281         Movie(1003, "The Dark Knight", 9.0, 2008),
282         Movie(1002, "Pulp Fiction", 8.9, 1994),
283         Movie(1004, "Forrest Gump", 8.8, 1994),
284     ]
285     movies_by_id = merge_sort_movies(movies, key=lambda x: x.movie_id)
286     print("Search for Movie ID 1003:", binary_search_by_movie_id(movies_by_id, 1003))
287     print("Search for Movie ID 9999:", binary_search_by_movie_id(movies_by_id, 9999))
288     print("\nSorted by Rating (Descending):", sorted(merge_sort_movies(movies, key=lambda x: x.rating), key=lambda x: x.rating, reverse=True))
289     print("\nSorted by Release Year:", merge_sort_movies(movies, key=lambda x: x.release_year))
```

## Output:



```
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS POSTMAN CONSOLE
PS C:\Users\Love\OneDrive\Desktop\AI.AC> & C:\Users\Love\AppData\Local\Programs\Python\Python313\python.exe "c:/Users/Love/OneDrive/Desktop/AI.AC/lab 12.py"
Search for Movie ID 1003: Movie(1003, The Dark Knight, Rating: 9.0, Year: 2008)
Search for Movie ID 9999: None

Sorted by Rating (Descending): [Movie(1001, The Shawshank Redemption, Rating: 9.3, Year: 1994), Movie(1003, The Dark Knight, Rating: 9.0, Year: 2008), Movie(1002, Pulp Fiction, Rating: 8.9, Year: 1994), Movie(1005, Inception, Rating: 8.8, Year: 2010), Movie(1004, Forrest Gump, Rating: 8.8, Year: 1994)]

Sorted by Release Year: [Movie(1001, The Shawshank Redemption, Rating: 9.3, Year: 1994), Movie(1002, Pulp Fiction, Rating: 8.9, Year: 1994), Movie(1004, Forrest Gump, Rating: 8.8, Year: 1994), Movie(1003, The Dark Knight, Rating: 9.0, Year: 2008), Movie(1005, Inception, Rating: 8.8, Year: 2010)]
PS C:\Users\Love\OneDrive\Desktop\AI.AC>
```

## Explanation:

- Large movie databases.
- Fast search improves user experience.
- Sorting by rating supports recommendation systems.

## Task 7: Smart Agriculture Crop Monitoring System

**Prompt :** Suggest suitable searching and sorting algorithms for an agriculture crop monitoring system that searches crops by crop ID and sorts by soil moisture or yield estimate. Justify and implement in Python.



```
File Edit Selection View Go Run ... Q AIAC
lab 12.py
lab 12.py > binary_search_by_crop_id
291 #Design searching and sorting algorithms for an agriculture crop monitoring system that searches by crop ID and sorts by soil moisture or yield e
292 # Justify algorithm selection and provide Python implementation.
293 class CropMonitoring:
294     def __init__(self, crop_id, crop_name, soil_moisture, yield_estimate):
295         self.crop_id = crop_id
296         self.crop_name = crop_name
297         self.soil_moisture = soil_moisture # percentage (0-100)
298         self.yield_estimate = yield_estimate # kg/hectare
299     def __repr__(self):
300         return f"CropMonitoring({self.crop_id}, {self.crop_name}, Moisture: {self.soil_moisture}%, Yield: {self.yield_estimate} kg/ha)"
301 def binary_search_by_crop_id(crops, target_id):
302     """Binary search for crop by ID. Time: O(log n), Space: O(1)"""
303     left, right = 0, len(crops) - 1
304     while left <= right:
305         mid = (left + right) // 2
306         if crops[mid].crop_id == target_id:
307             return crops[mid]
308         elif crops[mid].crop_id < target_id:
309             left = mid + 1
310         else:
311             right = mid - 1
312     return None
313 def merge_sort_crops(crops, key):
314     """Merge sort for crops. Time: O(n log n), Space: O(n)"""
315     if len(crops) <= 1:
316         return crops
317     mid = len(crops) // 2
318     left = merge_sort_crops(crops[:mid], key)
319     right = merge_sort_crops(crops[mid:], key)
320     return _merge_crops(left, right, key)
321 def _merge_crops(left, right, key):
322     result = []
```

```
File Edit Selection View Go Run ... Q AIAC
lab 12.py
lab 12.py > binary_search_by_crop_id
313 def merge_sort_crops(crops, key):
318     left = merge_sort_crops(crops[:mid], key)
319     right = merge_sort_crops(crops[mid:], key)
320     return _merge_crops(left, right, key)
321 def _merge_crops(left, right, key):
322     result = []
323     i = j = 0
324     while i < len(left) and j < len(right):
325         if key(left[i]) <= key(right[j]):
326             result.append(left[i])
327             i += 1
328         else:
329             result.append(right[j])
330             j += 1
331     result.extend(left[i:])
332     result.extend(right[j:])
333     return result
334 # Test Cases
335 if __name__ == "__main__":
336     crops = [
337         CropMonitoring(1005, "Wheat", 45, 5200),
338         CropMonitoring(1001, "Rice", 60, 4800),
339         CropMonitoring(1003, "Corn", 50, 6100),
340         CropMonitoring(1002, "Barley", 55, 4500),
341         CropMonitoring(1004, "Soybean", 48, 3900),
342     ]
343     crops_by_id = merge_sort_crops(crops, key=lambda x: x.crop_id)
344     print("Search for Crop ID 1003:", binary_search_by_crop_id(crops_by_id, 1003))
345     print("Search for Crop ID 9999:", binary_search_by_crop_id(crops_by_id, 9999))
346     print("\nSorted by Soil Moisture:", merge_sort_crops(crops, key=lambda x: x.soil_moisture))
347     print("\nSorted by Yield Estimate:", merge_sort_crops(crops, key=lambda x: x.yield_estimate))
```

## Output:

```
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS POSTMAN CONSOLE powershell
PS C:\Users\Love\OneDrive\Desktop\AI.AC> & C:\Users\Love\AppData\Local\Programs\Python\Python313\python.exe "c:\Users\Love\OneDrive\Desktop\AI.AC\lab 12.py"
Search for Crop ID 1003: CropMonitoring(1003, Corn, Moisture: 50%, Yield: 6100 kg/ha)
Search for Crop ID 9999: None

Sorted by Soil Moisture: [CropMonitoring(1005, Wheat, Moisture: 45%, Yield: 5200 kg/ha), CropMonitoring(1004, Soybean, Moisture: 48%, Yield: 3900 kg/ha), CropMonitoring(1003, Corn, Moisture: 50%, Yield: 6100 kg/ha), CropMonitoring(1002, Barley, Moisture: 55%, Yield: 4500 kg/ha), CropMonitoring(1001, Rice, Moisture: 60%, Yield: 4800 kg/ha)]

Sorted by Yield Estimate: [CropMonitoring(1004, Soybean, Moisture: 48%, Yield: 3900 kg/ha), CropMonitoring(1002, Barley, Moisture: 55%, Yield: 4500 kg/ha), CropMonitoring(1001, Rice, Moisture: 60%, Yield: 4800 kg/ha), CropMonitoring(1005, Wheat, Moisture: 45%, Yield: 5200 kg/ha), CropMonitoring(1003, Corn, Moisture: 50%, Yield: 6100 kg/ha)]
PS C:\Users\Love\OneDrive\Desktop\AI.AC>
```

## Explanation:

- Farmers need quick data access.
- Sorting helps decision-making.
- Efficient for large monitoring datasets.

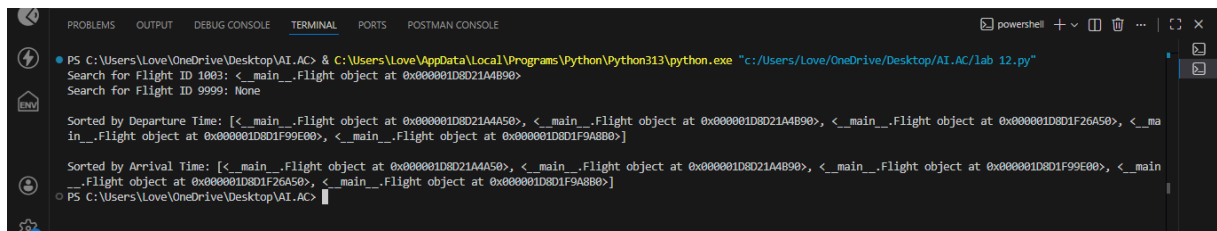
## Task 8: Airport Flight Management System

**Prompt:** Design searching and sorting algorithms for an airport flight management system that searches by flight ID and sorts by departure or arrival time. Provide justification and Python implementation.

```
File Edit Selection View Go Run ... ← → Q ALAC
lab 12.py > ...
349 # Design searching and sorting algorithms for an airport flight management system
350 # that searches by flight ID and sorts by departure or arrival time.
351 # Justify algorithm selection and provide Python implementation.
352 class Flight:
353     def __init__(self, flight_id, airline, departure_time, arrival_time, destination):
354         self.flight_id = flight_id
355         self.airline = airline
356         self.departure_time = departure_time # in 24-hour format (e.g., 1430 for 2:30 PM)
357         self.arrival_time = arrival_time # in 24-hour format
358         self.destination = destination
359     def __repr__(self):
360         return f"Flight({self.flight_id}, {self.airline}, Depart: {self.departure_time}, Arrive: {self.arrival_time}, {self.destination})"
361 def binary_search_by_flight_id(flights, target_id):
362     """Binary search for flight by ID. Time: O(log n), Space: O(1)"""
363     left, right = 0, len(flights) - 1
364     while left <= right:
365         mid = (left + right) // 2
366         if flights[mid].flight_id == target_id:
367             return flights[mid]
368         elif flights[mid].flight_id < target_id:
369             left = mid + 1
370         else:
371             right = mid - 1
372     return None
373 def merge_sort_flights(flights, key):
374     """Merge sort for flights. Time: O(n log n), Space: O(n)"""
375     if len(flights) <= 1:
376         return flights
377     mid = len(flights) // 2
378     left = merge_sort_flights(flights[:mid], key)
379     right = merge_sort_flights(flights[mid:], key)
380     return merge_flights(left, right, key)
```

```
File Edit Selection View Go Run ... ← → Q ALAC
lab 12.py > ...
373 def merge_sort_flights(flights, key):
378     left = merge_sort_flights(flights[:mid], key)
379     right = merge_sort_flights(flights[mid:], key)
380     return merge_flights(left, right, key)
381 def merge_flights(left, right, key):
382     result = []
383     i = j = 0
384     while i < len(left) and j < len(right):
385         if key(left[i]) <= key(right[j]):
386             result.append(left[i])
387             i += 1
388         else:
389             result.append(right[j])
390             j += 1
391     result.extend(left[i:])
392     result.extend(right[j:])
393     return result
394 # Test Cases
395 if __name__ == "__main__":
396     flights = [
397         Flight(1005, "Emirates", 1430, 1800, "Dubai"),
398         Flight(1001, "United", 900, 1200, "New York"),
399         Flight(1003, "Lufthansa", 1100, 1400, "Berlin"),
400         Flight(1002, "Air France", 1430, 1730, "Paris"),
401         Flight(1004, "British Airways", 1800, 2100, "London"),
402     ]
403     flights_by_id = merge_sort_flights(flights, key=lambda x: x.flight_id)
404     print("Search for Flight ID 1003:", binary_search_by_flight_id(flights_by_id, 1003))
405     print("Search for Flight ID 9999:", binary_search_by_flight_id(flights_by_id, 9999))
406     print("\nSorted by Departure Time:", merge_sort_flights(flights, key=lambda x: x.departure_time))
407     print("\nSorted by Arrival Time:", merge_sort_flights(flights, key=lambda x: x.arrival_time))
```

## Output:



```
PS C:\Users\Love\OneDrive\Desktop\AI.AC> & C:\Users\Love\AppData\Local\Programs\Python\Python313\python.exe "c:/Users/Love/OneDrive/Desktop/AI.AC/lab 12.py"
Search for Flight ID 1003: <_main__.Flight object at 0x000001D8D21A4B90>
Search for Flight ID 9999: None

Sorted by Departure Time: [<_main__.Flight object at 0x000001D8D21A4A50>, <_main__.Flight object at 0x000001D8D21A4B90>, <_main__.Flight object at 0x000001D8D1F26A50>, <_main__.Flight object at 0x000001D8D1F99E00>, <_main__.Flight object at 0x000001D8D1F9A8B0>]

Sorted by Arrival Time: [<_main__.Flight object at 0x000001D8D21A4A50>, <_main__.Flight object at 0x000001D8D21A4B90>, <_main__.Flight object at 0x000001D8D1F99E00>, <_main__.Flight object at 0x000001D8D1F26A50>, <_main__.Flight object at 0x000001D8D1F9A8B0>]
PS C:\Users\Love\OneDrive\Desktop\AI.AC>
```

## Explanation:

- Airports manage thousands of flights.
- Fast lookup is critical.
- Time-based sorting must be accurate.