Question 3)

b) For the public test cases, paths found by Iterative Deepening Search (IDS) and Bidirectional Search (BBFS) are similar. However, this is not guaranteed. In unweighted graphs, both algorithms yield the shortest path in terms of edge count, resulting in similar paths. In contrast, for weighted graphs, these algorithms do not necessarily find the optimal path, which is based on path cost rather than edge count. Therefore, in our case , the paths found by IDS and BBFS might differ.

c) The time and memory for IDS and BBFS are:
(As the code was taking a lot of time for all the pairs, it is calculated only for 1225 pairs. The total time and memory is recorded)

```
Total Iterative Deepening Search time: 102.541554 seconds
Total Iterative Deepening Search memory: 0.483505 MB
Total Bidirectional Heuristic Time: 9.779656 seconds
Total Bidirectional Heuristic memory: 0.552379 MB
```

It is clearly observed that:

- The time required by Iterative Deepening Search is greater than time required by Bidirectional Breadth-First Search
- THe memory utilized by Iterative Deepening Search is less than memory utilized by Bidirectional Breadth-First Search in terms of space complexity.

e) For the public test cases, the paths received in A* and Bidirectional Heuristic Search is different, mainly due to two reasons:

- Heuristic Influence: A*'s path depends on the heuristic in the question, optimizing based on the f-score estimates. Bidirectional Heuristic Search's path depends on meeting the two searches from start and goal, influenced by how well each search direction's heuristic directs the search.
- Path Optimality: A* provides an optimal path if the heuristic is ideal. Bidirectional Heuristic Search finds a path that meets in the middle, which may not be the globally optimal path.

When both the algorithms are run for all pairs the total time and memory is reported.

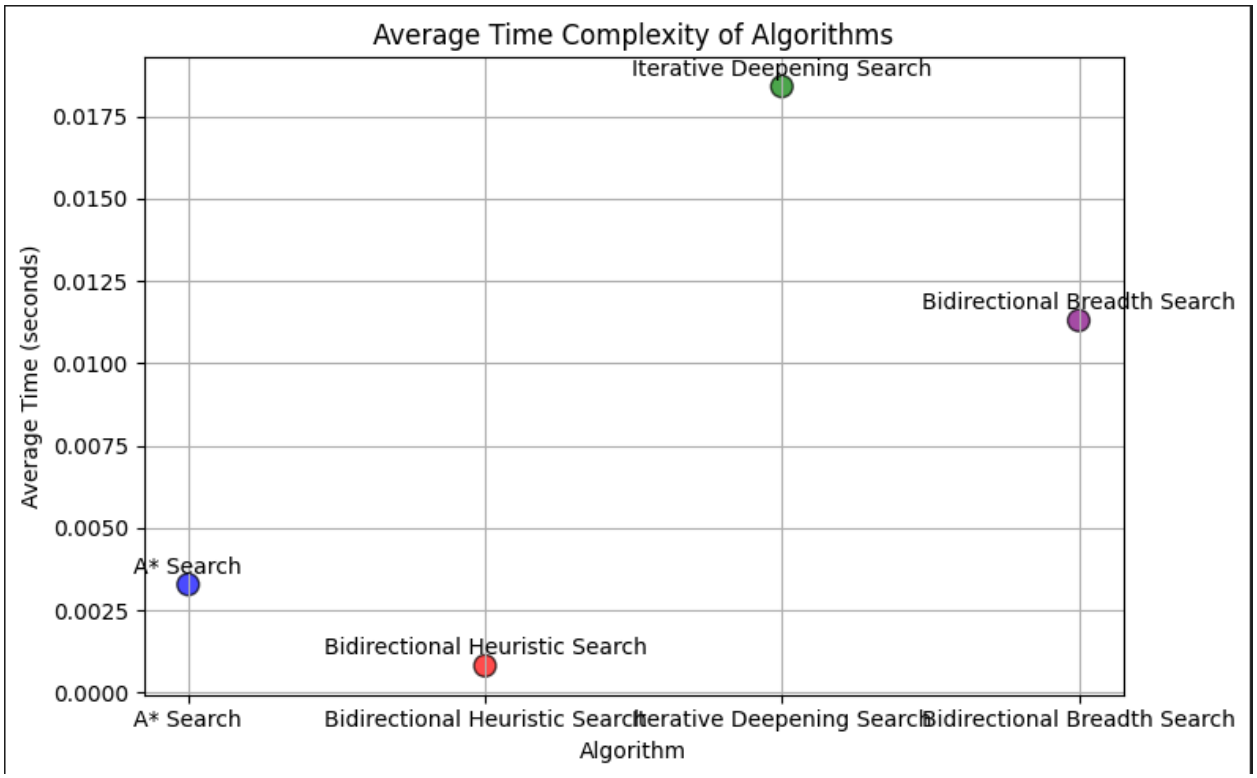
```
A* Search total time: 100.647804 seconds
A* Search total memory: 22.313979 MB
Bidirectional Heuristic Search total time: 32.457171 seconds
Bidirectional Heuristic Search total memory: 9.753134 MB
```

It is clearly observed that:

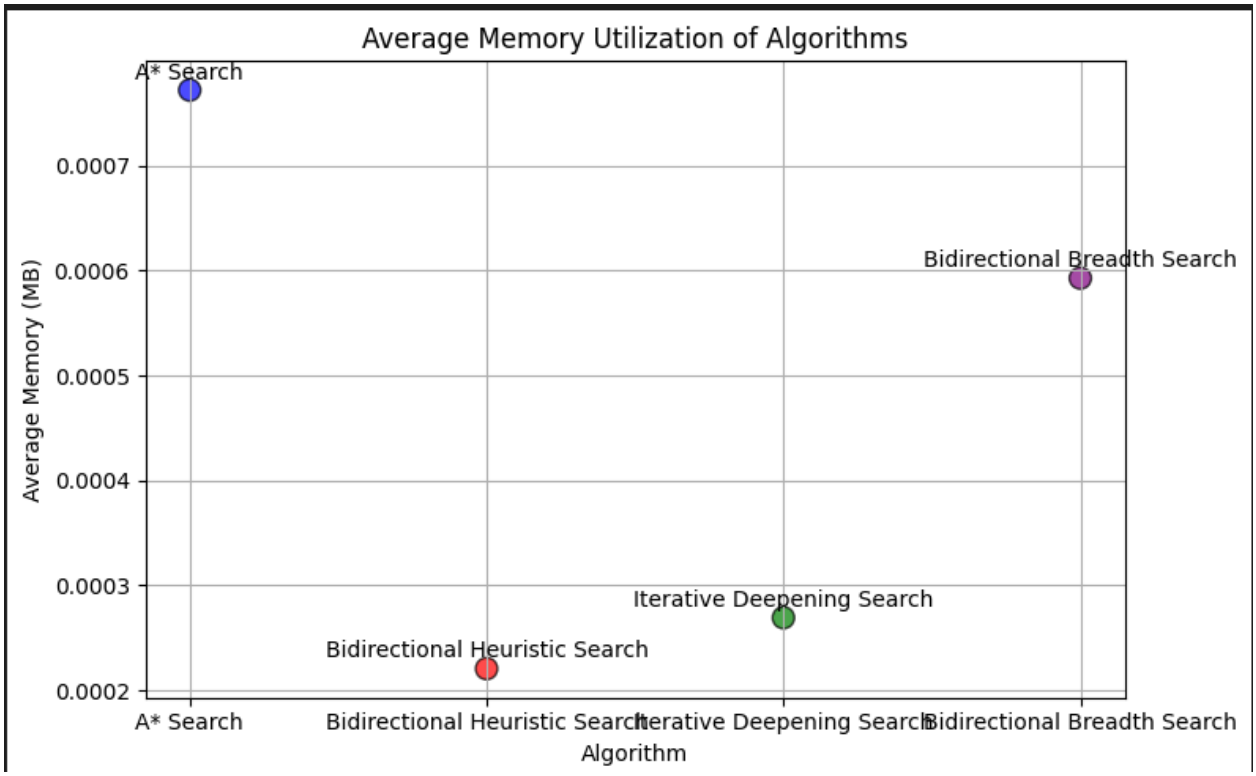
- The time required by A* (O(b^d)) is greater than the time required by Bidirectional Heuristic Search (O(b^d/2)) .

- The memory utilized by A* (O(b^d)) is greater than the memory utilized by Bidirectional Heuristic Search (O(b^d/2)) .

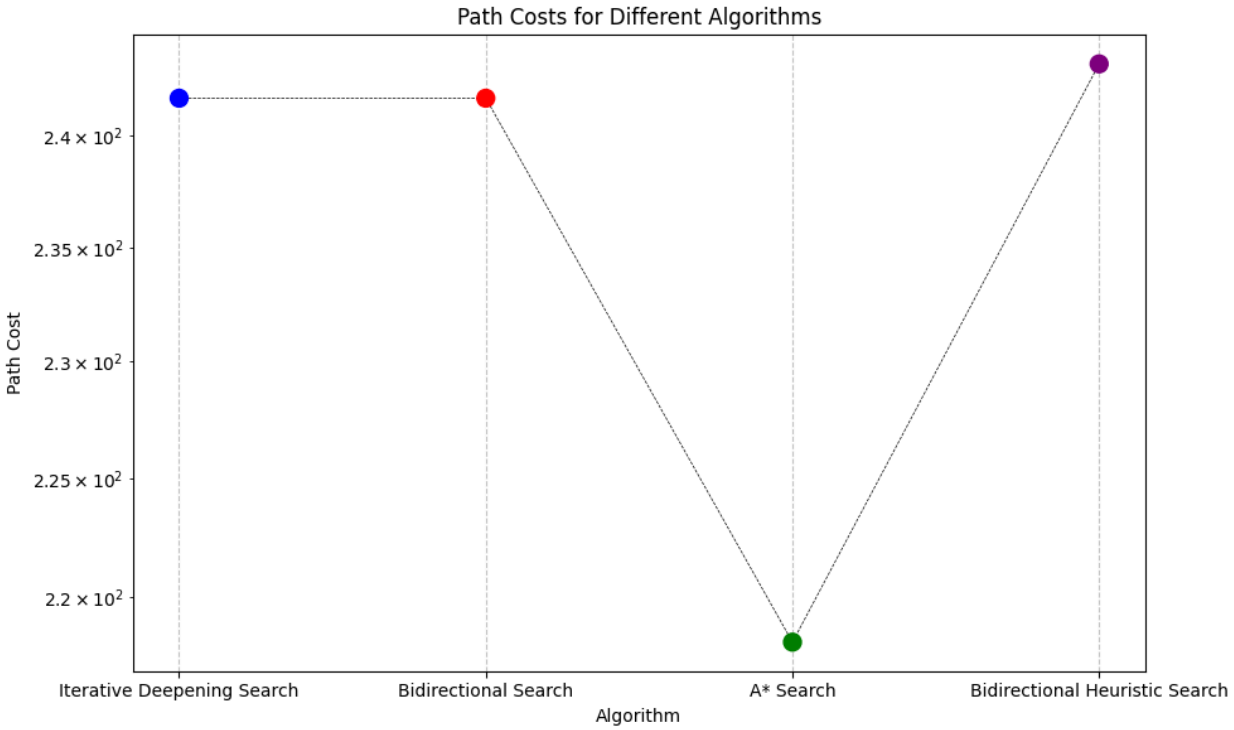
f) The average over a randomly selected 400 points is taken for time and space calculations
Scatter plot showcasing the time complexity of four algorithms:



Scatter plot showcasing the space complexity of four algorithms:



Scatter plot showing the optimality of the algorithms by calculating the path cost of the optimal path found. The path cost is found for start node = 1 and end node = 2



Informed search algorithms are better than uninformed ones mainly because:

- Informed search algorithms, such as A* and Bidirectional Heuristic Search, use heuristics to guide the search process, often leading to faster discovery of solutions compared to uninformed algorithms.
- By focusing the search on promising areas, informed algorithms explore fewer nodes, reducing the overall search space and speeding up the process.
- Algorithms like A* can guarantee finding the optimal path if the heuristic used is admissible (i.e., it never overestimates the true cost).

However, informed search algorithms have their own drawbacks:

- Algorithms like A* often require substantial memory to store nodes and their associated information (e.g., cost estimates), which can be a disadvantage in memory-constrained environments.
- The overhead of calculating and managing heuristic values can sometimes outweigh the benefits, especially when the heuristic computation is complex.