There are 4 problems and they are:

1. Air Cargo 1
2. Air Cargo 2
3. Air Cargo 3
4. Air Cargo 4

There are 11 search Algorithm and they are as follows:

1. Breath First Search
2. Depth First Search Graph
3. Uniform Cost Search
4. Greedy Best First Search Graph - h unmet goals
5. Greedy Best First Search Graph - h PG level sum
6. Greedy Best First Search Graph - h PG Max level
7. Greedy Best First Search Graph - h PG Set level
8. A* Search - h unmet goals
9. A* Search - h PG level sum
10. A* Search - h PG Max level
11. A* Search - h PG Set level

Following tables shows the log values for problem1 to problem 4 for different search algorithms.

Sl.No.	Type	Actions	Expansions	Goal Tests	New Nodes	Plan Length	Elapsed Time (seconds)
1	Breath First Search	20	43	56	178	6	0.0063
2	Depth First Search Graph	20	21	22	84	20	0.0037
3	Uniform Cost Search	20	60	62	240	6	0.0098
4	Greedy Best First Search Graph h unmet goals	20	7	9	29	6	0.003
5	Greedy Best First Search Graph h PG level sum	20	6	8	28	6	0.5092
6	Greedy Best First Search Graph h PG Max level	20	6	8	24	6	0.3566
7	Greedy Best First Search Graph h PG Set level	20	6	8	28	6	0.7381
8	A* Search h unmet goals	20	50	52	206	6	0.0099
9	A* Search h PG level sum	20	28	30	122	6	1.2623

10	A* Search h PG Max level	20	43	45	180	6	1.2881
11	A* Search h PG Set level	20	33	35	138	6	1.7329

Table 1 Log values for Problem 1

Sl.No.	Type	Actions	Expansions	Goal Tests	New Nodes	Plan Length	Elapsed Time (seconds)
1	Breath First Search	72	3343	4609	30503	9	2.1322
2	Depth First Search Graph	72	624	625	5602	619	3.1781
3	Uniform Cost Search	72	5154	5156	46618	9	3.6418
4	Greedy Best First Search Graph h unmet goals	72	17	19	170	9	0.0195
5	Greedy Best First Search Graph h PG level sum	72	9	11	86	9	11.4973
6	Greedy Best First Search Graph h PG Max level	72	27	29	249	9	21.6941
7	Greedy Best First Search Graph h PG Set level	72	9	11	84	9	17.9221
8	A* Search h unmet goals	72	2467	2469	22522	9	2.388
9	A* Search h PG level sum	72	357	359	3426	9	281.8524
10	A* Search h PG Max level	72	2887	2889	26594	9	1610.1934
11	A* Search h PG Set level	72	1037	1039	9605	9	1598.7199

Table 2 Log values for Problem 2

Sl.No.	Type	Actions	Expansions	Goal Tests	New Nodes	Plan Length	Elapsed Time (seconds)
1	Breath First Search	88	14663	18098	129625	12	10.8032
2	Depth First Search Graph	88	408	409	3364	392	1.2231
3	Uniform Cost Search	88	18510	18512	161936	12	14.9147

4	Greedy Best First Search Graph h unmet goals	88	25	27	230	15	0.0375
5	Greedy Best First Search Graph h PG level sum	88	14	16	126	14	24.6941
6	Greedy Best First Search Graph h PG Max level	88	21	23	195	13	29.4289
7	Greedy Best First Search Graph h PG Set level	88	35	37	345	17	98.3256
8	A* Search h unmet goals	88	7388	7390	65711	12	8.6314
9	A* Search h PG level sum	88	369	371	3403	12	445.3575
10	A* Search h PG Max level	88	9580	9582	86312	12	7611.2712
11	A* Search h PG Set level	88	3423	3425	31596	12	8689.7936

Table 3 Log values for Problem 3

Sl.No.	Type	Actions	Expansions	Goal Tests	New Nodes	Plan Length	Elapsed Time (seconds)
1	Breath First Search	104	99736	114953	944130	14	89.1644
2	Depth First Search Graph	104	25174	25175	228849	24132	3485.6532
3	Uniform Cost Search	104	113339	113341	1066413	14	108.0198
4	Greedy Best First Search Graph h unmet goals	104	29	31	280	18	0.058179
5	Greedy Best First Search Graph h PG level sum	104	17	19	165	17	41.51286
6	Greedy Best First Search Graph h PG Max level	104	56	58	580	17	1000.0817
7	Greedy Best First Search Graph h PG Set level	104	107	109	1164	23	408.8075
8	A* Search h unmet goals	104	34330	34332	328509	14	53.8859
9	A* Search h PG level sum	104	1208	1210	12210	15	2307.9066

10	A* Search h PG Max level	104	62077	62079	599376	14	75488.9766
11	A* Search h PG Set level	104	22606	22608	224229	14	86788.5821

Table 4 Log values for Problem 4

Question1:

Analyze the search complexity as a function of domain size, search algorithm, and heuristic:

Table 5 shows the number of nodes expanded against the total actions in the domain for the problems 1 to 4.

Sl.No.	Type	P1 Actions	P1 Expansions	P2 Actions	P2 Expansions	P3 Actions	P3 Expansions	P4 Actions	P4 Expansions
1	Breath First Search	20	43	72	3343	88	14663	104	99736
2	Depth First Search Graph	20	21	72	624	88	408	104	25174
3	Uniform Cost Search	20	60	72	5154	88	18510	104	113339
4	Greedy Best First Search Graph h unmet goals	20	7	72	17	88	25	104	29
5	Greedy Best First Search Graph h PG level sum	20	6	72	9	88	14	104	17
6	Greedy Best First Search Graph h PG Max level	20	6	72	27	88	21	104	56
7	Greedy Best First Search Graph h PG Set level	20	6	72	9	88	35	104	107
8	A* Search h unmet goals	20	50	72	2467	88	7388	104	34330
9	A* Search h PG level sum	20	28	72	357	88	369	104	1208
10	A* Search h PG Max level	20	43	72	2887	88	9580	104	62077
11	A* Search h PG Set level	20	33	72	1037	88	3423	104	22606

Table 5 Actions and expansions for Problem 1 to 4

As the problem size increases, the number of nodes expanded also increases. Uniform Cost search expands more nodes than other searches and Greedy Best First Search Graph h PG level Sum search expands less nodes than other searches.

Question 2:

Analyze search time as a function of domain size, search algorithm, and heuristic.

Table 6 shows the search time in seconds against the total actions in the domain for the problems 1 to 4.

Sl.No.	Type	P1 Actions	P1 time	P2 Actions	P2 time	P3 Actions	P3 time	P4 Actions	P4 time
1	Breath First Search	20	0.0063	72	2.1322	88	10.8032	104	89.1644
2	Depth First Search Graph	20	0.0037	72	3.1781	88	1.2231	104	3485.6532
3	Uniform Cost Search	20	0.0098	72	3.6418	88	14.9147	104	108.0198
4	Greedy Best First Search Graph h unmet goals	20	0.003	72	0.0195	88	0.0375	104	0.058179
5	Greedy Best First Search Graph h PG level sum	20	0.5092	72	11.4973	88	24.6941	104	41.51286
6	Greedy Best First Search Graph h PG Max level	20	0.3566	72	21.6941	88	29.4289	104	1000.0817
7	Greedy Best First Search Graph h PG Set level	20	0.7381	72	17.9221	88	98.3256	104	408.8075
8	A* Search h unmet goals	20	0.0099	72	2.388	88	8.6314	104	53.8859
9	A* Search h PG level sum	20	1.2623	72	281.8524	88	445.3575	104	2307.9066
10	A* Search h PG Max level	20	1.2881	72	1610.1934	88	7611.2712	104	75488.9766
11	A* Search h PG Set level	20	1.7329	72	1598.7199	88	8689.7936	104	86788.5821

Table 6 Actions and search time for Problem 1 to 4

As the problem size increases, the search time also increases. Greedy Best Frist Search Graph h unmet goals search takes less time than other searches and A* Search h PG set Level search takes less time than others.

Question 3:

Analyze the optimality of solution as a function of domain size, search algorithm, and heuristic.

Table 7 shows the plan length for the problems 1 to 4.

Sl.No.	Type	P1 Plan Length	P2 Plan Length	P3 Plan Length	P4 Plan Length
1	Breath First Search	6	9	12	14
2	Depth First Search Graph	20	619	392	24132
3	Uniform Cost Search	6	9	12	14
4	Greedy Best First Search Graph h unmet goals	6	9	15	18
5	Greedy Best First Search Graph h PG level sum	6	9	14	17
6	Greedy Best First Search Graph h PG Max level	6	9	13	17
7	Greedy Best First Search Graph h PG Set level	6	9	17	23
8	A* Search h unmet goals	6	9	12	14
9	A* Search h PG level sum	6	9	12	15
10	A* Search h PG Max level	6	9	12	14
11	A* Search h PG Set level	6	9	12	14

Table 7 Plan Length for Problem 1 to 4

As the problem size increases, the plan length also increases. Depth First Search Graph takes more plan length than other searches and the remaining searches are almost equal.

Question 4:

Report answers all required questions

4.1 Which algorithm or algorithms would be most appropriate for planning in a very restricted domain (i.e., one that has only a few actions) and needs to operate in real time?

All algorithms takes same number of actions. Therefore, it is very difficult to mention the algorithm or algorithms in this case.

4.2 Which algorithm or algorithms would be most appropriate for planning in very large domains (e.g., planning delivery routes for all UPS drivers in the U.S. on a given day)

The A* Search h PG set Level search takes less time than others. Therefore it is appropriate for planning in very large domain.

4.3 Which algorithm or algorithms would be most appropriate for planning problems where it is important to find only optimal plans?

Except DFS Graph all others are optimal plans w.r.t. plan length. Any search can be considered except the DFS Graph.

As the problem size increases, Greedy Best First Search Graph - h unmet goals algorithm performed well with respect to elapsed time. The Depth First Search Graph algorithm has maximum plan length when compared to the other algorithms. A* Search – h PG level sum has minimum expansion, goal tests, and new nodes when compared with other A* search variants but the elapsed time is less A* Search - h PG Max Level and h PG Set level.