Heuristic Analysis

Problem 1

	Expansions	Goal Tests	New Nodes	Plan Length	Time Elapsed
breadth_first_search	43	56	180	6	0.06
breadth_first_tree_search	1458	1459	5960	6	2.06
depth_first _graph_search	21	22	84	20	0.03
depth_limited_search	101	271	414	50	0.19
uniform_cost_search	55	57	224	6	0.07
recursive_best_first_search h_1	4229	4230	17023	6	5.48
greedy_best_first_graph_search h_1	7	9	28	6	0.01
astar_search h_1	55	57	224	6	0.10
astar_search h_ignore_preconditions	41	43	170	6	0.08
astar_search h_pg_levelsum	11	13	50	6	1.06

Optimal Plan
Load(C1, P1, SFO)
Load(C2, P2, JFK)
Fly(P1, SFO, JFK)
Fly(P2, JFK, SFO)
Unload(C1, P1, JFK)
Unload(C2, P2, SFO)

We observe that the greedy_best_first_graph_search is the most efficient with the fastest execution time, the optimal plan length of 6, and the least number of expansions, goal tests, and new nodes explored out of the non-heuristic searches. A* search with h_ignore_preconditions is the efficient in terms of time spent and expansions.

Problem 2

	Expansions	Goal Tests	New Nodes	Plan Length	Time Elapsed
breadth_first_search	3343	4609	30509	9	10.79
breadth_first_tree_search	-	-	-	-	-
depth_first _graph_search	624	625	5602	619	6.00
depth_limited_search	-	-	-	-	-
uniform_cost_search	4849	4851	44001	9	27.66
recursive_best_first_search h_1	-	-	-	-	-
greedy_best_first_graph_search h_1	966	968	8694	16	4.51
astar_search h_1	4849	4851	44001	9	12.12
astar_search h_ignore_preconditions	1443	1445	13234	9	5.77
astar_search h_pg_levelsum	85	87	831	9	48.93

Optimal Plan
Load(C1, P1, SFO)
Load(C2, P2, JFK)
Load(C3, P3, ATL)
Fly(P2, JFK, SFO)
Unload(C2, P2, SFO)
Fly(P1, SFO, JFK)
Unload(C1, P1, JFK)
Fly(P3, ATL, SFO)
Unload(C3, P3, SFO)

We observe that breadth_first_tree_search, depth_limited_search, and recurisve_best_first_search were unable to find a solution plan within the time frame. According to Figure 3.21 found in pg. 91 in AIMA, we observe that depth-first and depth-limited search are unable to be completed for “finite state searches”. Depth-limited search and depth-first searches will be nonoptimal and incomplete if the depth limit is greater than the the level of the shallowest goal (pg. 87 in AIMA). Again, we observe that greedy_best_first_graph_search_h_1 performed the best plan in speed although not expansions and new nodes. Instead A* search performed the best plan with the least amount of expansions, goal tests, and new nodes.

Problem 3

	Expansions	Goal Tests	New Nodes	Plan Length	Time Elapsed
breadth_first_search	14663	18098	129631	12	80.51
breadth_first_tree_search	-	-	-	-	-
depth_first _graph_search	408	409	3364	392	2.44
depth_limited_search	-	-	-	-	-
uniform_cost_search	18235	18237	159716	12	57.27
recursive_best_first_search h_1	-	-	-	-	-
greedy_best_first_graph_search h_1	5462	5464	48176	21	15.94
astar_search h_1	18235	18237	159716	12	55.47
astar_search h_ignore_preconditions	4945	4947	43991	12	17.12
astar_search h_pg_levelsum	-	-	-	-	-

Optimal Plan

Load(C1, P1, SFO)
Fly(P1, SFO, ATL)
Load(C3, P1, ATL)
Fly(P1, ATL, JFK)
Unload(C1, P1, JFK)
Load(C2, P2, JFK)
Fly(P2, JFK, ORD)
Load(C4, P2, ORD)
Fly(P2, ORD, SFO)
Unload(C2, P2, SFO)
Unload(C3, P1, JFK)
Unload(C4, P2, SFO)

We observe that breadth_first_tree_search, depth_limited_search, and recursive_best_first_search_h_1 could not find a suitable plan for this problem within the time frame. In terms of time, depth_first_graph_search was the most successful by finding a suitable plan in a quick manner. However, its plan length is 392 which is not efficient. Greedy_best_first_graph_search_h_1 proved to be the most efficient with a relatively quick time with the shortest plan among the no heuristic search techniques. A* search h_ignore_preconditions was the most efficient as it found the shortest plan length possible in the quickest manner with the least number of expansions. We observe that informed search strategies with heuristics are able to find solutions more efficiently and our observations match with the conclusions made in the AIMA text (pg. 92).

References

Norvig, P. (2013). *Artificial Intelligence: A Modern Approach* (Third ed.). S.l.: Pearson Education Limited.