Q1.You should run **all** of the search algorithms on the first two problems and record the following information for each combination:
- number of actions in the domain
- number of new node expansions
- time to complete the plan search

Problem 1:

Solving Air Cargo Problem 1 using breadth_first_search...

Actions   Expansions   Goal Tests   New Nodes

  20   43   56   178

Plan length: 6 Time elapsed in seconds: 0.004974200000000001

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

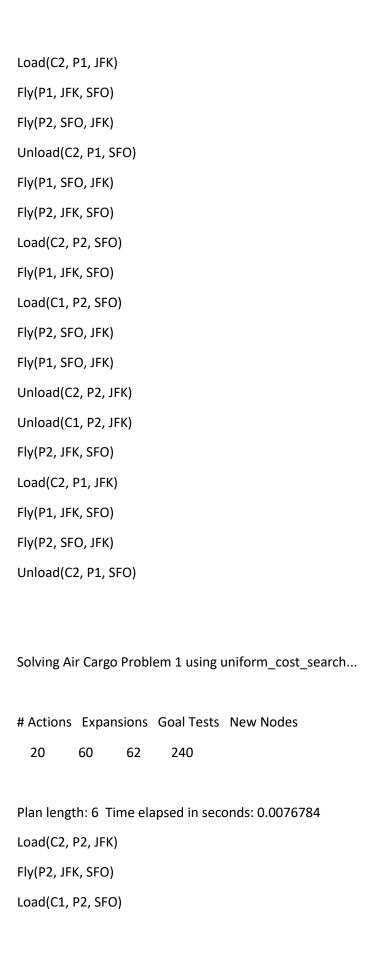Solving Air Cargo Problem 1 using depth_first_graph_search...

Actions   Expansions   Goal Tests   New Nodes

  20   21   22   84

Plan length: 20 Time elapsed in seconds: 0.0027377

Fly(P1, SFO, JFK)

Fly(P2, JFK, SFO)

Load(C2, P1, JFK)

Fly(P1, JFK, SFO)

Fly(P2, SFO, JFK)

Unload(C2, P1, SFO)

Fly(P1, SFO, JFK)

Fly(P2, JFK, SFO)

Load(C2, P2, SFO)

Fly(P1, JFK, SFO)

Load(C1, P2, SFO)

Fly(P2, SFO, JFK)

Fly(P1, SFO, JFK)

Unload(C2, P2, JFK)

Unload(C1, P2, JFK)

Fly(P2, JFK, SFO)

Load(C2, P1, JFK)

Fly(P1, JFK, SFO)

Fly(P2, SFO, JFK)

Unload(C2, P1, SFO)

Solving Air Cargo Problem 1 using uniform_cost_search...

# Actions	Expansions	Goal Tests	New Nodes
20	60	62	240

Plan length: 6 Time elapsed in seconds: 0.0076784

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Load(C1, P2, SFO)

Unload(C2, P2, SFO)

Fly(P2, SFO, JFK)

Unload(C1, P2, JFK)

Solving Air Cargo Problem 1 using greedy_best_first_graph_search with h_unmet_goals...

# Actions	Expansions	Goal Tests	New Nodes
20	7	9	29

Plan length: 6 Time elapsed in seconds: 0.0013483000000000002

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Solving Air Cargo Problem 1 using greedy_best_first_graph_search with h_pg_levelsum...

# Actions	Expansions	Goal Tests	New Nodes
20	6	8	28

Plan length: 6 Time elapsed in seconds: 0.3340624

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Solving Air Cargo Problem 1 using greedy_best_first_graph_search with h_pg_maxlevel...

# Actions	Expansions	Goal Tests	New Nodes
20	6	8	24

Plan length: 6 Time elapsed in seconds: 0.37013029999999997

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Fly(P1, SFO, JFK)

Unload(C2, P2, SFO)

Unload(C1, P1, JFK)

Solving Air Cargo Problem 1 using greedy_best_first_graph_search with h_pg_setlevel...

# Actions	Expansions	Goal Tests	New Nodes
20	6	8	28

Plan length: 6 Time elapsed in seconds: 0.458494

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Solving Air Cargo Problem 1 using astar_search with h_unmet_goals...

# Actions	Expansions	Goal Tests	New Nodes
20	50	52	206

Plan length: 6 Time elapsed in seconds: 0.0075125

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Load(C1, P2, SFO)

Fly(P2, SFO, JFK)

Unload(C1, P2, JFK)

Solving Air Cargo Problem 1 using astar_search with h_pg_levelsum...

# Actions	Expansions	Goal Tests	New Nodes
20	28	30	122

Plan length: 6 Time elapsed in seconds: 0.8186332000000001

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Load(C1, P2, SFO)

Fly(P2, SFO, JFK)

Unload(C1, P2, JFK)

Solving Air Cargo Problem 1 using astar_search with h_pg_maxlevel...

Actions   Expansions   Goal Tests   New Nodes

    20   43   45   180

Plan length: 6 Time elapsed in seconds: 0.9075542

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Load(C1, P2, SFO)

Unload(C2, P2, SFO)

Fly(P2, SFO, JFK)

Unload(C1, P2, JFK)

Solving Air Cargo Problem 1 using astar_search with h_pg_setlevel...

Actions   Expansions   Goal Tests   New Nodes

    20   33   35   138

Plan length: 6 Time elapsed in seconds: 0.986248

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Load(C1, P2, SFO)

Fly(P2, SFO, JFK)

Unload(C1, P2, JFK)

Problem 2:

Solving Air Cargo Problem 2 using breadth_first_search...

Actions   Expansions   Goal Tests   New Nodes

   72   3343   4609   30503

Plan length: 9 Time elapsed in seconds: 1.5728233

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)

Solving Air Cargo Problem 2 using depth_first_graph_search...

Actions   Expansions   Goal Tests   New Nodes

   72   624   625   5602

Plan length: 619 Time elapsed in seconds: 2.1440848

Fly(P3, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P3, SFO, JFK)

Fly(P1, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P3, ATL, SFO)

Load(C2, P1, JFK)

Fly(P2, SFO, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P1, SFO, JFK)

Load(C3, P3, ATL)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Fly(P3, SFO, JFK)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P2, SFO, JFK)

Fly(P1, ATL, SFO)

Unload(C3, P3, JFK)

Fly(P1, SFO, JFK)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, SFO)

Unload(C2, P1, SFO)

Fly(P3, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, JFK)

Fly(P3, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Load(C3, P3, JFK)

Fly(P1, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, JFK)

Fly(P3, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P1, ATL, JFK)

Fly(P2, ATL, SFO)

Fly(P3, SFO, ATL)

Unload(C3, P3, ATL)

Fly(P3, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P3, SFO, JFK)

Fly(P2, ATL, JFK)

Fly(P1, JFK, ATL)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Load(C3, P2, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, JFK)

Fly(P3, ATL, JFK)

Fly(P1, SFO, JFK)

Fly(P2, JFK, SFO)

Unload(C3, P2, SFO)

Fly(P2, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, JFK)

Fly(P3, ATL, SFO)

Load(C2, P3, SFO)

Fly(P3, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P2, SFO, JFK)

Fly(P1, ATL, SFO)

Unload(C2, P3, JFK)

Fly(P1, SFO, JFK)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, SFO)

Load(C3, P2, SFO)

Fly(P3, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, JFK)

Fly(P3, SFO, ATL)

Load(C2, P2, JFK)

Fly(P3, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Unload(C3, P2, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P2, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P1, ATL, SFO)

Fly(P3, ATL, SFO)

Fly(P1, SFO, JFK)

Fly(P2, JFK, ATL)

Fly(P3, SFO, ATL)

Fly(P2, ATL, SFO)

Load(C1, P2, SFO)

Fly(P3, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P3, SFO, JFK)

Fly(P2, ATL, JFK)

Fly(P1, JFK, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, SFO)

Fly(P3, ATL, SFO)

Unload(C2, P2, JFK)

Fly(P1, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P1, ATL, JFK)

Fly(P3, SFO, ATL)

Fly(P2, ATL, SFO)

Fly(P3, ATL, JFK)

Fly(P1, JFK, ATL)

Load(C3, P2, SFO)

Fly(P1, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, JFK)

Fly(P2, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P1, ATL, SFO)

Unload(C3, P2, JFK)

Fly(P3, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P2, SFO, JFK)

Unload(C1, P2, JFK)

Fly(P1, ATL, SFO)

Fly(P2, JFK, ATL)

Fly(P1, SFO, JFK)

Fly(P2, ATL, SFO)

Fly(P3, JFK, ATL)

Fly(P2, SFO, JFK)

Fly(P3, ATL, SFO)

Load(C3, P2, JFK)

Fly(P2, JFK, ATL)

Fly(P3, SFO, ATL)

Fly(P2, ATL, SFO)

Fly(P3, ATL, JFK)

Fly(P1, JFK, ATL)

Fly(P2, SFO, ATL)

Fly(P1, ATL, SFO)

Unload(C3, P2, ATL)

Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P2, SFO, JFK)

Fly(P1, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P2, JFK, SFO)

Fly(P3, ATL, SFO)

Load(C2, P1, JFK)

Fly(P2, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Unload(C2, P1, SFO)

Fly(P2, ATL, JFK)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Load(C2, P3, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P1, ATL, JFK)

Fly(P2, ATL, SFO)

Load(C1, P3, JFK)

Fly(P2, SFO, JFK)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Unload(C2, P3, ATL)

Fly(P3, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, JFK)

Fly(P3, SFO, JFK)

Fly(P2, JFK, ATL)

Unload(C1, P3, JFK)

Fly(P2, ATL, SFO)

Fly(P3, JFK, ATL)

Fly(P2, SFO, JFK)

Fly(P3, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P3, SFO, JFK)

Fly(P1, ATL, SFO)

Load(C1, P2, JFK)

Fly(P1, SFO, JFK)

Fly(P2, JFK, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P3, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P2, SFO, ATL)

Fly(P1, ATL, SFO)

Unload(C1, P2, ATL)

Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, JFK)

Fly(P2, SFO, JFK)

Fly(P1, JFK, ATL)

Fly(P2, JFK, ATL)

Load(C3, P2, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P2, SFO, JFK)

Fly(P1, SFO, JFK)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Unload(C3, P2, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, JFK)

Fly(P1, JFK, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, SFO)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Fly(P1, SFO, ATL)

Load(C3, P3, SFO)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, JFK)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, JFK)

Load(C2, P3, ATL)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Fly(P3, SFO, JFK)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P2, SFO, JFK)

Fly(P1, ATL, SFO)

Unload(C3, P3, JFK)

Fly(P1, SFO, JFK)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P3, SFO, ATL)

Fly(P1, ATL, SFO)

Unload(C2, P3, ATL)

Fly(P3, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, JFK)

Load(C3, P1, JFK)

Fly(P3, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Load(C2, P1, ATL)

Fly(P1, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, JFK)

Fly(P2, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P1, ATL, SFO)

Unload(C3, P1, SFO)

Fly(P3, SFO, ATL)

Fly(P1, SFO, JFK)

Fly(P3, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P3, JFK, ATL)

Load(C3, P2, SFO)

Fly(P3, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P2, ATL, JFK)

Fly(P3, ATL, JFK)

Fly(P1, SFO, ATL)

Unload(C3, P2, JFK)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P1, ATL, SFO)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Load(C1, P1, ATL)

Fly(P1, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P3, SFO, ATL)

Fly(P2, ATL, JFK)

Fly(P1, SFO, JFK)

Fly(P3, ATL, SFO)

Load(C3, P2, JFK)

Fly(P3, SFO, JFK)

Fly(P2, JFK, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P1, JFK, SFO)

Fly(P3, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Unload(C3, P2, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, JFK)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, SFO)

Unload(C2, P1, JFK)

Fly(P2, JFK, ATL)

Fly(P3, SFO, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P3, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, SFO, JFK)

Fly(P2, SFO, ATL)

Load(C3, P2, ATL)

Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P2, SFO, JFK)

Fly(P3, JFK, ATL)

Fly(P1, ATL, SFO)

Fly(P3, ATL, SFO)

Unload(C3, P2, JFK)

Fly(P1, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P1, ATL, JFK)

Fly(P2, ATL, SFO)

Load(C3, P1, JFK)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, JFK)

Fly(P1, JFK, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, SFO)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Fly(P1, SFO, ATL)

Unload(C1, P1, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, JFK)

Unload(C3, P1, SFO)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P2, JFK, ATL)

Load(C1, P3, ATL)

Fly(P3, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, JFK)

Fly(P3, ATL, JFK)

Fly(P1, SFO, ATL)

Fly(P2, JFK, SFO)

Fly(P1, ATL, JFK)

Fly(P2, SFO, ATL)

Unload(C1, P3, JFK)

Fly(P2, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Load(C3, P1, SFO)

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, JFK)

Fly(P3, ATL, SFO)

Fly(P1, ATL, SFO)

Load(C2, P2, JFK)

Fly(P3, SFO, ATL)

Fly(P1, SFO, JFK)

Fly(P3, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Unload(C3, P1, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P3, ATL, SFO)

Fly(P1, ATL, JFK)

Fly(P2, SFO, ATL)

Unload(C2, P2, ATL)

Fly(P2, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, JFK)

Fly(P3, ATL, JFK)

Fly(P1, JFK, ATL)

Fly(P3, JFK, SFO)

Fly(P1, ATL, SFO)

Load(C3, P3, SFO)

Fly(P3, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P1, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P3, JFK, ATL)

Load(C2, P3, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P3, SFO, JFK)

Fly(P2, SFO, JFK)

Fly(P1, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P1, ATL, SFO)

Load(C1, P3, JFK)

Fly(P2, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Unload(C2, P3, ATL)

Fly(P3, ATL, SFO)

Fly(P1, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P1, ATL, JFK)

Fly(P2, ATL, SFO)

Fly(P3, SFO, JFK)

Fly(P1, JFK, ATL)

Unload(C3, P3, JFK)

Fly(P1, ATL, SFO)

Fly(P2, SFO, ATL)

Fly(P1, SFO, JFK)

Fly(P2, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P1, ATL, SFO)

Unload(C1, P3, SFO)

Fly(P3, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P1, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P3, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P3, ATL, SFO)

Load(C3, P1, JFK)

Fly(P2, SFO, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, JFK)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P1, SFO, JFK)

Load(C2, P3, ATL)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Fly(P3, SFO, JFK)

Fly(P2, ATL, SFO)

Fly(P1, JFK, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, SFO)

Fly(P3, ATL, SFO)

Unload(C3, P1, SFO)

Fly(P2, SFO, ATL)

Unload(C2, P3, SFO)

Load(C3, P1, SFO)

Fly(P2, ATL, JFK)

Fly(P3, SFO, ATL)

Fly(P2, JFK, SFO)

Fly(P3, ATL, JFK)

Fly(P1, SFO, ATL)

Fly(P3, JFK, SFO)

Fly(P1, ATL, JFK)

Load(C2, P2, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, JFK)

Fly(P1, JFK, ATL)

Fly(P3, JFK, ATL)

Unload(C3, P1, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, JFK)

Load(C1, P1, SFO)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, JFK)

Fly(P2, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Fly(P3, SFO, JFK)

Unload(C2, P2, SFO)

Fly(P2, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P2, ATL, SFO)

Unload(C1, P1, ATL)

Fly(P1, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, JFK)

Fly(P1, SFO, ATL)

Fly(P3, JFK, ATL)

Fly(P1, ATL, JFK)

Fly(P3, ATL, SFO)

Fly(P2, JFK, ATL)

Load(C3, P2, ATL)

Fly(P2, ATL, SFO)

Fly(P3, SFO, ATL)

Fly(P2, SFO, JFK)

Fly(P3, ATL, JFK)

Fly(P1, JFK, ATL)

Fly(P2, JFK, ATL)

Fly(P3, JFK, ATL)

Load(C1, P3, ATL)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Fly(P3, ATL, JFK)

Fly(P2, SFO, ATL)

Fly(P1, SFO, JFK)

Fly(P2, ATL, JFK)

Fly(P1, JFK, ATL)

Fly(P3, JFK, SFO)

Fly(P1, ATL, SFO)

Unload(C3, P2, JFK)

Fly(P3, SFO, ATL)

Fly(P1, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P3, ATL, JFK)

Fly(P2, ATL, SFO)

Fly(P1, ATL, SFO)

Unload(C1, P3, JFK)

Fly(P2, SFO, ATL)

Fly(P1, SFO, JFK)

Fly(P2, ATL, JFK)

Fly(P3, JFK, ATL)

Fly(P1, JFK, ATL)

Fly(P3, ATL, SFO)

Fly(P1, ATL, SFO)

Load(C3, P2, JFK)

Fly(P3, SFO, ATL)

Fly(P2, JFK, ATL)

Fly(P1, SFO, ATL)

Fly(P2, ATL, SFO)

Fly(P3, ATL, SFO)

Fly(P1, ATL, JFK)

Fly(P3, SFO, JFK)

Unload(C3, P2, SFO)

Solving Air Cargo Problem 2 using uniform_cost_search...

# Actions	Expansions	Goal Tests	New Nodes
72	5154	5156	46618

Plan length: 9 Time elapsed in seconds: 2.7484074

Load(C3, P3, ATL)

Fly(P3, ATL, SFO)

Load(C1, P3, SFO)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C3, P3, SFO)

Fly(P3, SFO, JFK)

Unload(C2, P2, SFO)

Unload(C1, P3, JFK)

Solving Air Cargo Problem 2 using greedy_best_first_graph_search with h_unmet_goals...

Actions   Expansions   Goal Tests   New Nodes

| 72 | 17 | 19 | 170 |

Plan length: 9 Time elapsed in seconds: 0.031599300000000004

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Load(C3, P3, ATL)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Solving Air Cargo Problem 2 using greedy_best_first_graph_search with h_pg_levelsum...

# Actions	Expansions	Goal Tests	New Nodes
72	9	11	86

Plan length: 9 Time elapsed in seconds: 6.6956124

Load(C1, P1, SFO)

Fly(P1, SFO, JFK)

Unload(C1, P1, JFK)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Load(C3, P3, ATL)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

Solving Air Cargo Problem 2 using greedy_best_first_graph_search with h_pg_maxlevel...

Actions   Expansions   Goal Tests   New Nodes
   72   27   29   249

Plan length: 9 Time elapsed in seconds: 13.697749

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Load(C3, P3, ATL)

Fly(P2, JFK, SFO)

Fly(P3, ATL, SFO)

Fly(P1, SFO, JFK)

Unload(C3, P3, SFO)

Unload(C2, P2, SFO)

Unload(C1, P1, JFK)

Solving Air Cargo Problem 2 using greedy_best_first_graph_search with h_pg_setlevel...

Actions   Expansions   Goal Tests   New Nodes
   72   9   11   84

Plan length: 9 Time elapsed in seconds: 9.8989795

Load(C1, P1, SFO)

Load(C2, P2, JFK)

Load(C3, P3, ATL)

Fly(P2, JFK, SFO)

Fly(P3, ATL, SFO)

Fly(P1, SFO, JFK)

Unload(C3, P3, SFO)

Unload(C2, P2, SFO)

Unload(C1, P1, JFK)

Solving Air Cargo Problem 2 using astar_search with h_unmet_goals...

# Actions	Expansions	Goal Tests	New Nodes
72	2467	2469	22522

Plan length: 9 Time elapsed in seconds: 1.7004968

Load(C3, P3, ATL)

Fly(P3, ATL, SFO)

Unload(C3, P3, SFO)

Load(C2, P2, JFK)

Fly(P2, JFK, SFO)

Unload(C2, P2, SFO)

Load(C1, P3, SFO)

Fly(P3, SFO, JFK)

Unload(C1, P3, JFK)

Solving Air Cargo Problem 2 using astar_search with h_pg_levelsum...

Plan length: 9 Time elapsed in seconds: 400,000

Q2. Use the results from the first two problems to determine whether any of the uninformed search algorithms should be excluded for problems 3 and 4. You must run **at least** one uninformed search, two heuristics with greedy best first search, and two heuristics with A* on problems 3 and 4.

Yes uninformed search should be excluded as it be slower for larger domains. We should prefer A* search with heuristics or informed search for better performance.

- **Report includes at least a one paragraph discussion of these results that analyzes the growth trends as the problem size increases**

A. The run time generally increase with the number of actions required for the problem. So a problem 1 with 20 actions consumes more time than problem 2 with 72 actions. In general uninformed search like brute force DFS, BFS, UCS are extremely slow evident from above results for problem 1 and 2 and also on running of problems 3 and 4. However informed searches like A* search with heuristic(astar_search with h_pg_setlevel) perform much better here.

Solving Air Cargo Problem 3 using uniform_cost_search...

# Actions	Expansions	Goal Tests	New Nodes
88	18510	18512	161936

Plan length: 12 Time elapsed in seconds: 12.8313343434439

Solving Air Cargo Problem 3 using greedy_best_first_graph_search with h_pg_levelsum...

# Actions	Expansions	Goal Tests	New Nodes
88	14	16	126

Plan length: 14 Time elapsed in seconds: 0.6654545433707898

Solving Air Cargo Problem 3 using greedy_best_first_graph_search with h_pg_maxlevel...

# Actions	Expansions	Goal Tests	New Nodes
88	21	23	195

Plan length: 13 Time elapsed in seconds: 0.5635418521999
Solving Air Cargo Problem 3 using astar_search with h_unmet_goals...

# Actions	Expansions	Goal Tests	New Nodes
88	7388	7390	65711

Plan length: 12 Time elapsed in seconds: 0.68987059501404839

Solving Air Cargo Problem 3 using astar_search with h_pg_levelsum...

# Actions	Expansions	Goal Tests	New Nodes
88	369	371	3403

Plan length: 12 Time elapsed in seconds: 15.75454754807000006

Solving Air Cargo Problem 4 using uniform_cost_search...

# Actions	Expansions	Goal Tests	New Nodes
104	113339	113341	1066413

Plan length: 14 Time elapsed in seconds: 8.6454545406331999766

Solving Air Cargo Problem 4 using greedy_best_first_graph_search with h_unmet_goals...

# Actions	Expansions	Goal Tests	New Nodes
104	29	31	280

Plan length: 18 Time elapsed in seconds: 0.05443410400010523

Solving Air Cargo Problem 4 using greedy_best_first_graph_search with h_pg_levelsum...

# Actions	Expansions	Goal Tests	New Nodes
104	17	19	165

Plan length: 17 Time elapsed in seconds: 1.408518942000228

Solving Air Cargo Problem 4 using astar_search with h_unmet_goals...

# Actions	Expansions	Goal Tests	New Nodes
104	34330	34332	328509

Plan length: 13 Time elapsed in seconds: 2.9843334343534443

Solving Air Cargo Problem 4 using astar_search with h_pg_levelsum...

# Actions	Expansions	Goal Tests	New Nodes
104	1208	1210	12210

Plan length: 15 Time elapsed in seconds: 84.16787293399982

Q4. 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?

The below algorithms based on runtimes would work best for this situations
astar_search h_pg_levelsum

astar_search h_pg_maxlevel

Q5. 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 below algorithms based on runtimes would work best for this situations
astar_search h_pg_levelsum

astar_search h_pg_maxlevel

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

A* search only if the heuristic is admissible otherwise use uninformed search such as Uniform Cost Search.