# REPORT PROJECT 2: CLASSICAL PLANING

| Methods | Expansions | | | | Time (seconds) | | | | Plan length | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P.1 | P.2 | P.3 | P.4 | P.1 | P.2 | P.3 | P.4 | P.1 | P.2 | P.3 | P.4 |
| breadth_first_search | 43 | 3343 | 14663 | 99736 | 0.01 | 2.9248 | 18.61 | 94.4796 | 6 | 9 | 12 | 14 |
| depth_first_graph_search | 21 | 624 | 408 | 25174 | 0 | 4.0348 | 2.1804 | 3633.87 | 20 | 619 | 392 | 24132 |
| uniform_cost_search | 60 | 5154 | 18510 | 113339 | 0.01 | 4.8782 | 38.622 | 102.604 | 6 | 9 | 12 | 14 |
| greedy_best_first_graph_search with h_unmet_goals | 7 | 17 | 25 | 29 | 0 | 0.0274 | 0.0713 | 0.0569 | 6 | 9 | 15 | 18 |
| greedy_best_first_graph_search with h_pg_levelsum | 6 | 9 | 14 | 17 | 0.22 | 5.961 | 20.117 | 12.6115 | 6 | 9 | 14 | 17 |
| greedy_best_first_graph_search with h_pg_maxlevel | 6 | 27 | 21 | 56 | 0.16 | 11.458 | 17.642 | 25.7426 | 6 | 9 | 13 | 17 |
| greedy_best_first_graph_search with h_pg_setlevel | 7 | 26 | 42 | 114 | 0.66 | 25.957 | 166.41 | 319.228 | 7 | 10 | 18 | 24 |
| astar_search with h_unmet_goals | 50 | 2467 | 7388 | 32330 | 0.01 | 3.2667 | 25.081 | 51.8131 | 6 | 9 | 12 | 14 |
| astar_search with h_pg_levelsum | 28 | 357 | 369 | 1208 | 0.54 | 185.07 | 437.59 | 1046.6 | 6 | 9 | 12 | 15 |
| astar_search with h_pg_maxlevel | 43 | 2887 | 9580 | 62077 | 0.56 | 1046.2 | 6675.2 | 18633.5 | 6 | 9 | 12 | 14 |
| astar_search with h_pg_setlevel | 51 | 2102 | 5963 | 37912 | 1.61 | 3306.1 | 10125 | 54027.9 | 6 | 9 | 12 | 14 |
| ***The table analyzes the results after running the search algorithm for the problems*** | | | | | | | | | | | | |

**Note:**

**P.1: Solving Air Cargo Problem 1**

Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(P1, SFO) ∧ At(P2, JFK)
∧ Cargo(C1) ∧ Cargo(C2)
∧ Plane(P1) ∧ Plane(P2)
∧ Airport(JFK) ∧ Airport(SFO))
Goal(At(C1, JFK) ∧ At(C2, SFO))

**P.2: Solving Air Cargo Problem 2**

Init( At(C1, SFO) ∧ At(C2, JFK) ∧ At(C3, ATL) ∧ At(P1, SFO) ∧ At(P2, JFK) ∧ At(P3, ATL)
∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3)
∧ Plane(P1) ∧ Plane(P2) ∧ Plane(P3)
∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ATL))
Goal(At(C1, JFK) ∧ At(C2, SFO) ∧ At(C3, SFO))

**P.3: Solving Air Cargo Problem 3**

Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(C3, ATL) ∧ At(C4, ORD) ∧ At(P1, SFO) ∧ At(P2, JFK)
∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3) ∧ Cargo(C4)
∧ Plane(P1) ∧ Plane(P2)
∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ATL) ∧ Airport(ORD))
Goal(At(C1, JFK) ∧ At(C3, JFK) ∧ At(C2, SFO) ∧ At(C4, SFO))

**P.4: Solving Air Cargo Problem 4**

Init(At(C1, SFO) ∧ At(C2, JFK) ∧ At(C3, ATL) ∧ At(C4, ORD) ∧ At(C5, ORD) ∧ At(P1, SFO) ∧ At(P2, JFK)
∧ Cargo(C1) ∧ Cargo(C2) ∧ Cargo(C3) ∧ Cargo(C4) ∧ Cargo(C5)
∧ Plane(P1) ∧ Plane(P2)
∧ Airport(JFK) ∧ Airport(SFO) ∧ Airport(ATL) ∧ Airport(ORD))
Goal(At(C1, JFK) ∧ At(C2, SFO) ∧ At(C3, JFK) ∧ At(C4, SFO) ∧ At(C5, JFK))

**Question and answer:**

**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?
***=> greedy_best_first_graph_search with h_unmet_goals (based on Time search)***

**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)
***=> astar_search with h_unmet_goals (based on Expansions, Time)***

**3.** Which algorithm or algorithms would be most appropriate for planning problems where it is important to find only optimal plans?
***=> breadth_first_search (based on Expansions, Time and Planing length)***

**The table analyzes the results after running the search algorithm for the problems:**

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| The table analyzes the results after running the search algorithm for the problem 1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Problem** | **Methods** | **Actions** | **Expansions** | **Goal** | **Tests** | **New Nodes** | **Time (seconds)** | **Plan length** |
| Solving Air Cargo Problem 1 | breadth_first_search | 20 | 43 | 56 | | 178 | 0.00840504704017973 | 6 |
| | depth_first_graph_search | 20 | 21 | 22 | | 84 | 0.00409266124679451 | 20 |
| | uniform_cost_search | 20 | 60 | 62 | | 240 | 0.0117554964958366 | 6 |
| | greedy_best_first_graph_search with h_unmet_goals | 20 | 7 | 9 | | 29 | 0.00196119319292421 | 6 |
| | greedy_best_first_graph_search with h_pg_levelsum | 20 | 6 | 8 | | 28 | 0.219256174096481 | 6 |
| | greedy_best_first_graph_search with h_pg_maxlevel | 20 | 6 | 8 | | 24 | 0.15501963292472 | 6 |
| | greedy_best_first_graph_search with h_pg_setlevel | 20 | 7 | 9 | | 31 | 0.655693501518245 | 7 |
| | astar_search with h_unmet_goals | 20 | 50 | 52 | | 206 | 0.0119742880294906 | 6 |
| | astar_search with h_pg_levelsum | 20 | 28 | 30 | | 122 | 0.542085181282081 | 6 |
| | astar_search with h_pg_maxlevel | 20 | 43 | 45 | | 180 | 0.564064167031708 | 6 |
| | astar_search with h_pg_setlevel | 20 | 51 | 53 | | 208 | 1.60505469088581 | 6 |

| The table analyzes the results after running the search algorithm for the problem 2 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Problem** | **Methods** | **Actions** | **Expansions** | **Goal** | **Tests** | **New Nodes** | **Time (seconds)** | **Plan length** |
| Solving Air Cargo Problem 2 | breadth_first_search | 72 | 3343 | 4609 | | 30503 | 2.92475857123996 | 9 |
| | depth_first_graph_search | 72 | 624 | 625 | | 5602 | 4.034848966198341 | 619 |
| | uniform_cost_search | 72 | 5154 | 5156 | | 46618 | 4.878221285477235 | 9 |
| | greedy_best_first_graph_search with h_unmet_goals | 72 | 17 | 19 | | 170 | 0.02742125020934516 | 9 |
| | greedy_best_first_graph_search with h_pg_levelsum | 72 | 9 | 11 | | 86 | 5.961012654920967 | 9 |
| | greedy_best_first_graph_search with h_pg_maxlevel | 72 | 27 | 29 | | 249 | 11.457998789882222 | 9 |
| | greedy_best_first_graph_search with h_pg_setlevel | 72 | 26 | 28 | | 232 | 25.957302062471747 | 10 |
| | astar_search with h_unmet_goals | 72 | 2467 | 2469 | | 22522 | 3.266717609173007 | 9 |
| | astar_search with h_pg_levelsum | 72 | 357 | 359 | | 3426 | 185.07030858936372 | 9 |
| | astar_search with h_pg_maxlevel | 72 | 2887 | 2889 | | 26594 | 1046.220499880341 | 9 |
| | astar_search with h_pg_setlevel | 72 | 2102 | 2104 | | 19395 | 3306.106357410198 | 9 |

| The table analyzes the results after running the search algorithm for the problem 3 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Problem** | **Methods** | **Actions** | **Expansions** | **Goal** | **Tests** | **New Nodes** | **Time (seconds)** | **Plan length** |
| Solving Air Cargo Problem 3 | breadth_first_search | 88 | 14663 | 18098 | | 129625 | 18.610267798213503 | 12 |
| | depth_first_graph_search | 88 | 408 | 409 | | 3364 | 2.1803568837207052 | 392 |
| | uniform_cost_search | 88 | 18510 | 18512 | | 161936 | 38.62150847505466 | 12 |
| | greedy_best_first_graph_search with h_unmet_goals | 88 | 25 | 27 | | 230 | 0.0713168729324849 | 15 |
| | greedy_best_first_graph_search with h_pg_levelsum | 88 | 14 | 16 | | 126 | 20.116822412587332 | 14 |
| | greedy_best_first_graph_search with h_pg_maxlevel | 88 | 21 | 23 | | 195 | 17.642106736679864 | 13 |
| | greedy_best_first_graph_search with h_pg_setlevel | 88 | 42 | 44 | | 405 | 166.40618595028008 | 18 |
| | astar_search with h_unmet_goals | 88 | 7388 | 7390 | | 65711 | 25.081351572574306 | 12 |
| | astar_search with h_pg_levelsum | 88 | 369 | 371 | | 3403 | 437.589407243675 | 12 |
| | astar_search with h_pg_maxlevel | 88 | 9580 | 9582 | | 86312 | 6675.209951792273 | 12 |
| | astar_search with h_pg_setlevel | 88 | 5963 | 5965 | | 54668 | 10125.36043750458 | 12 |

| The table analyzes the results after running the search algorithm for the problem 4 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Problem** | **Methods** | **Actions** | **Expansions** | **Goal** | **Tests** | **New Nodes** | **Time (seconds)** | **Plan length** |
| Solving Air Cargo Problem 4 | breadth_first_search | 104 | 99736 | 114953 | | 944130 | 94.4795746521269 | 14 |
| | depth_first_graph_search | 104 | 25174 | 25175 | | 228849 | 3633.867827464862 | 24132 |
| | uniform_cost_search | 104 | 113339 | 113341 | | 1066413 | 102.60357077589379 | 14 |
| | greedy_best_first_graph_search with h_unmet_goals | 104 | 29 | 31 | | 280 | 0.05689960083009282 | 18 |
| | greedy_best_first_graph_search with h_pg_levelsum | 104 | 17 | 19 | | 165 | 12.611480047634814 | 17 |
| | greedy_best_first_graph_search with h_pg_maxlevel | 104 | 56 | 58 | | 580 | 25.742564922485144 | 17 |
| | greedy_best_first_graph_search with h_pg_setlevel | 104 | 114 | 116 | | 1229 | 319.2276348962473 | 24 |
| | astar_search with h_unmet_goals | 104 | 34330 | 34442 | | 328509 | 51.81310375480916 | 14 |
| | astar_search with h_pg_levelsum | 104 | 1208 | 1210 | | 12210 | 1046.6040979276295 | 15 |
| | astar_search with h_pg_maxlevel | 104 | 62077 | 62079 | | 599376 | 18633.476562229 | 14 |
| | astar_search with h_pg_setlevel | 104 | 37912 | 37914 | | 373328 | 54027.888974003 | 14 |