**REPORT PROJECT 2: Classical Planing**

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| **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*** | | | | | | | | | | | | |

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| **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)) |
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| **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)) |
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| **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)) |
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| **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)*** |
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| **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)*** |
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| **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 |

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| **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 |

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| **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 |

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| **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 |