**The Results**

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| **PROBLEM 1** |  |  |  |  |  |
|  | **Actions** | **Expansions** | **Goal Tests** | **New Nodes** | **Time elapsed** |
| 1. breadth\_first\_search | 20 | 43 | 56 | 178 | 0.004302164000000275 |
| 2. depth\_first\_graph\_search | 20 | 21 | 22 | 84 | 0.0028322389999999587 |
| 3. uniform\_cost\_search | 20 | 60 | 62 | 240 | 0.00946672300000001 |
| 4. greedy\_best\_first\_graph\_search h\_unmet\_goals | 20 | 7 | 9 | 29 | 0.0014529329999999896 |
| 5. greedy\_best\_first\_graph\_search h\_pg\_levelsum | 20 | 6 | 8 | 28 | 0.307627335 |
| 6. greedy\_best\_first\_graph\_search h\_pg\_maxlevel | 20 | 6 | 8 | 24 | 0.328304074 |
| 7. greedy\_best\_first\_graph\_search h\_pg\_setlevel | 20 | 13 | 15 | 53 | 1.09167212 |
| 8. astar\_search h\_unmet\_goals | 20 | 50 | 52 | 206 | 0.008700610000000025 |
| 9. astar\_search h\_pg\_levelsum | 20 | 28 | 30 | 122 | 0.755350613 |
| 10. astar\_search h\_pg\_maxlevel | 20 | 43 | 45 | 180 | 0.800117805 |
| 11. astar\_search h\_pg\_setlevel | 20 | 46 | 48 | 192 | 2.1371129663 |

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| **PROBLEM 2** |  |  |  |  |  |
|  | **Actions** | **Expansions** | **Goal Tests** | **New Nodes** | **Time elapsed** |
| 1. breadth\_first\_search | 72 | 3343 | 4609 | 30503 | 1.559270286 |
| 2. depth\_first\_graph\_search | 72 | 624 | 625 | 5602 | 2.207107594 |
| 3. uniform\_cost\_search | 72 | 5154 | 5156 | 46618 | 2.443899133 |
| 4. greedy\_best\_first\_graph\_search h\_unmet\_goals | 72 | 17 | 19 | 170 | 0.012860047 |
| 5. greedy\_best\_first\_graph\_search h\_pg\_levelsum | 72 | 9 | 11 | 86 | 8.067904630000001 |
| 6. greedy\_best\_first\_graph\_search h\_pg\_maxlevel | 72 | 27 | 29 | 249 | 13.285995692 |
| 7. greedy\_best\_first\_graph\_search h\_pg\_setlevel | 72 | 35 | 37 | 321 | 44.1936 |
| 8. astar\_search h\_unmet\_goals | 72 | 2467 | 2469 | 22522 | 2.243313504 |
| 9. astar\_search h\_pg\_levelsum | 72 | 357 | 359 | 3426 | 124.014 |
| 10. astar\_search h\_pg\_maxlevel | 72 | 2887 | 2889 | 26594 | 752.282171 |
| 11. astar\_search h\_pg\_setlevel | 72 | 2671 | 2673 | 24523 | 3034.21919 |

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| **PROBLEM 3** |  |  |  |  |  |
|  | **Actions** | **Expansions** | **Goal Tests** | **New Nodes** | **Time elapsed** |
| 1. breadth\_first\_search | 88 | 14663 | 18098 | 12965 | 8.566245348999999 |
| 2. depth\_first\_graph\_search | 88 | 408 | 409 | 3364 | 0.931719676 |
| 3. uniform\_cost\_search | 88 | 18510 | 18512 | 161936 | 11.045990934 |
| 4. greedy\_best\_first\_graph\_search h\_unmet\_goals | 88 | 25 | 27 | 230 | 0.032268869000000006 |
| 5. greedy\_best\_first\_graph\_search h\_pg\_levelsum | 88 | 14 | 16 | 126 | 14.901587919 |
| 6. greedy\_best\_first\_graph\_search h\_pg\_maxlevel | 88 | 21 | 23 | 195 | 18.387537923 |
| 7. greedy\_best\_first\_graph\_search h\_pg\_setlevel | 88 | 68 | 70 | 722 | 180.282 |
| 8. astar\_search h\_unmet\_goals | 88 | 7388 | 7390 | 65711 | 9.018228374 |
| 9. astar\_search h\_pg\_levelsum | 88 | 369 | 371 | 3403 | 231.956421 |
| 10. astar\_search h\_pg\_maxlevel | 88 | 95080 | 9582 | 86312 | 4329.947494 |
| 11. astar\_search h\_pg\_setlevel | 88 | 101176 | 10178 | 90844 | 14123.0485937 |

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| **PROBLEM 4** |  |  |  |  |  |
|  | **Actions** | **Expansions** | **Goal Tests** | **New Nodes** | **Time elapsed** |
| 1. breadth\_first\_search | 104 | 99736 | 114953 | 944130 | 104.238634514 |
| 2. depth\_first\_graph\_search | 104 | 25174 | 25175 | 228849 | 3254.3905 |
| 3. uniform\_cost\_search | 104 | 113339 | 113341 | 1066413 | 106.6252 |
| 4. greedy\_best\_first\_graph\_search h\_unmet\_goals | 104 | 29 | 31 | 280 | 0.0571 |
| 5. greedy\_best\_first\_graph\_search h\_pg\_levelsum | 104 | 17 | 19 | 165 | 24.6594 |
| 6. greedy\_best\_first\_graph\_search h\_pg\_maxlevel | 104 | 56 | 58 | 580 | 59.2432 |
| 7. greedy\_best\_first\_graph\_search h\_pg\_setlevel | 104 | 1283 | 1285 | 13475 | 4076.94742 |
| 8. astar\_search h\_unmet\_goals | 104 | 34330 | 34332 | 328509 | 58.048492 |
| 9. astar\_search h\_pg\_levelsum | 104 | 1208 | 1210 | 12210 | 1321.0475252 |
| 10. astar\_search h\_pg\_maxlevel | 104 | 62077 | 62079 | 599376 | 46.2323 |
| 11. astar\_search h\_pg\_setlevel | 104 |  |  |  |  |

**1 - Number of nodes expanded versus number of actions**

The graphs show that the higher the number of actions in depth\_first graph the smaller the number of nodes expanded than in the search algorithms. The number of expanded nodes increases significantly as the number of shares increases. The numbers of expanded nodes for the greedy algorithms are virtually the same and are smaller than the uninformed search as well as the astar search.

**2 - Number of actions versus search time**

By analyzing the graphs, the search time increases exponentially in relation to the number of actions. The greedy\_best\_first\_graph\_search h\_unmet\_goals is the quickest to execute in all four air cargo problems.

**3 - Questions**

**A -** 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 Breadth First Search
* Depth First Graph
* Uniform cost search
* Greedy best first graph search with unmet goals

It is the algorithms that take less time to achieve the goals.

**B -** 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
* Greedy\_best\_search with the heuristic suitable

They are the best algorithms to achieve the goals (the domain).

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

* Breadth First Search,
* Depth First Graph,
* Uniform cost search

They are most appropriate when space is finite, but for searching in a space of partial plans, astar is appropriate.