heuristic_analysis

1. The optimal plan for Problem 1, 2, and 3 are as follow:

```
Solving Air Cargo Problem 1 using astar_search with h_ignore_preconditions...

Expansions   Goal Tests   New Nodes
    41          43         170

Plan length: 6  Time elapsed in seconds: 0.04533852700114949
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 2 using astar_search with h_ignore_preconditions...

Expansions   Goal Tests   New Nodes
   1450        1452       13303

Plan length: 9  Time elapsed in seconds: 4.348901558005309
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, P1, SFO)
Fly(P1, SFO, JFK)
Unload(C1, P1, JFK)

(aind) D-10-18-218-212:AIND-Planning David$
```

```
(aind) D-10-18-218-212:AIND-Planning David$ python run_search.py -p 3 -s 9

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

Expansions   Goal Tests   New Nodes
   5040        5042       44944

Plan length: 12  Time elapsed in seconds: 16.754045623994898
Load(C2, P2, JFK)
Fly(P2, JFK, ORD)
Load(C4, P2, ORD)
Fly(P2, ORD, SFO)
Unload(C4, P2, SFO)
Load(C1, P1, SFO)
Fly(P1, SFO, ATL)
Load(C3, P1, ATL)
Fly(P1, ATL, JFK)
Unload(C3, P1, JFK)
Unload(C2, P2, SFO)
Unload(C1, P1, JFK)

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```

2. Non-heuristic search result metrics VS heuristic methods
Problem 1, 2, and 3:
We compared breadth_first_tree_search, depth_first_graph_search, depth_first_graph_search, and h_ignore_preconditions methods.

	Expansions	Goal Tests	New Nodes	Plan Length
BFS	43	56	180	6
DFS	12	13	48	12
BFTS	1458	1459	5960	6
h_ignore_preconditions	41	43	170	6
level sum	11	13	50	6

	Expansions	Goal Tests	New Nodes	Plan Length
BFS	3343	4609	30509	9
DFS	582	583	5211	575
BFTS	>10min	>10min	>10min	>10min
h_ignore_preconditions	1450	1452	13303	9
level sum	86	88	841	9

	Expansions	Goal Tests	New Nodes	Plan Length
BFS	14663	18098	129631	12
DFS	627	628	5176	596
BFTS	>10min	>10min	>10min	>10min
h_ignore_preconditions	5040	5042	44944	12
level sum	316	318	2912	12

3. Compare and contrast heuristic search result metrics using A* with the "ignore preconditions" and "level-sum" heuristics for Problems 1, 2, and 3.

Also shown in the tables above. The level sum explore less node but takes more time than h ignore precondition method.

4. What was the best heuristic used in these problems? Was it better than non-heuristic search planning methods for all problems? Why or why not?

The best one is, level sum.
 It is not better than non-heuristic for all problems. For examples, in problem 1, DFS behaves better than heuristic method. When the search space is not very big and we are lucky enough, we are likely finding that DFS may better than heuristic methods.