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CSC 421
Assignment 1

Notes:

The PrintTree method can be commented and uncommented on line 249 of Search.java

The cannibal heuristic can be commented and uncommented just below line 150 of ProblemCannibals.java

Results are below from 1 run of each question.

Question 1:

```
TreeSearch------------------------
BreadthFirstTreeSearch:          (cost=568.0, expansions=39) Timisoara Arad Sibiu Fagaras Bucharest
UniformCostTreeSearch:           (cost=536.0, expansions=93) Timisoara Arad Sibiu Rimnicu Pitesti Bucharest
DepthFirstTreeSearch:            (cost=568.0, expansions=4)  Timisoara Arad Sibiu Fagaras Bucharest
GreedyBestFirstTreeSearch: (cost=615.0, expansions=6)  Timisoara Lugoj Mehadia Drobeta Craiova Pitesti Bucharest
AstarTreeSearch:           (cost=536.0, expansions=11) Timisoara Arad Sibiu Rimnicu Pitesti Bucharest


GraphSearch----------------------
BreadthFirstGraphSearch:   (cost=568.0, expansions=11) Timisoara Arad Sibiu Fagaras Bucharest
UniformCostGraphSearch:          (cost=536.0, expansions=12) Timisoara Arad Sibiu Rimnicu Pitesti Bucharest
DepthFirstGraphSearch:           (cost=723.0, expansions=8)  Timisoara Arad Sibiu Rimnicu Craiova Pitesti Bucharest
GreedyBestGraphSearch:           (cost=615.0, expansions=6)  Timisoara Lugoj Mehadia Drobeta Craiova Pitesti Bucharest
AstarGraphSearch:          (cost=536.0, expansions=10) Timisoara Arad Sibiu Rimnicu Pitesti Bucharest


IterativeDeepening----------------------
```

```
IterativeDeepeningTreeSearch:       (cost=568.0, expansions=47) Timisoara Arad Sibiu Fagaras Bucharest
IterativeDeepeningGraphSearch:      (cost=568.0, expansions=4)  Timisoara Arad Sibiu Fagaras Bucharest
```

Question 2:

```
TreeSearch------------------------
 Timisoara (g=0.0, h=329.0, f=329.0) order=0
  Arad (g=118.0, h=366.0, f=484.0) order=3
   Zerind (g=193.0, h=374.0, f=567.0) order=-1
   Sibiu (g=258.0, h=253.0, f=511.0) order=6
    Oradea (g=409.0, h=380.0, f=789.0) order=-1
    Arad (g=398.0, h=366.0, f=764.0) order=-1
    Fagaras (g=357.0, h=176.0, f=533.0) order=8
     Bucharest (g=568.0, h=0.0, f=568.0) order=-1
     Sibiu (g=456.0, h=253.0, f=709.0) order=-1
    Rimnicu (g=338.0, h=193.0, f=531.0) order=7
     Craiova (g=484.0, h=160.0, f=644.0) order=-1
     Sibiu (g=418.0, h=253.0, f=671.0) order=-1
     Pitesti (g=435.0, h=100.0, f=535.0) order=9
      Craiova (g=573.0, h=160.0, f=733.0) order=-1
      Bucharest (g=536.0, h=0.0, f=536.0) order=-1
      Rimnicu (g=532.0, h=193.0, f=725.0) order=-1
   Timisoara (g=236.0, h=329.0, f=565.0) order=-1
  Lugoj (g=111.0, h=244.0, f=355.0) order=1
   Mehadia (g=181.0, h=241.0, f=422.0) order=2
    Drobeta (g=256.0, h=242.0, f=498.0) order=5
     Craiova (g=376.0, h=160.0, f=536.0) order=10
      Drobeta (g=496.0, h=242.0, f=738.0) order=-1
      Rimnicu (g=522.0, h=193.0, f=715.0) order=-1
      Pitesti (g=514.0, h=100.0, f=614.0) order=-1
     Mehadia (g=331.0, h=241.0, f=572.0) order=-1
    Lugoj (g=251.0, h=244.0, f=495.0) order=4
     Mehadia (g=321.0, h=241.0, f=562.0) order=-1
     Timisoara (g=362.0, h=329.0, f=691.0) order=-1
   Timisoara (g=222.0, h=329.0, f=551.0) order=-1
AstarTreeSearch:              (cost=536.0, expansions=11) Timisoara Arad Sibiu Rimnicu Pitesti Bucharest
```

```
GraphSearch----------------------
 Timisoara (g=0.0, h=329.0, f=329.0) order=0
```

```
    Arad (g=118.0, h=366.0, f=484.0) order=3
      Zerind (g=193.0, h=374.0, f=567.0) order=-1
      Sibiu (g=258.0, h=253.0, f=511.0) order=5
        Oradea (g=409.0, h=380.0, f=789.0) order=-1
        Arad (g=398.0, h=366.0, f=764.0) order=-1
        Fagaras (g=357.0, h=176.0, f=533.0) order=7
          Bucharest (g=568.0, h=0.0, f=568.0) order=-1
          Sibiu (g=456.0, h=253.0, f=709.0) order=-1
        Rimnicu (g=338.0, h=193.0, f=531.0) order=6
          Craiova (g=484.0, h=160.0, f=644.0) order=-1
          Sibiu (g=418.0, h=253.0, f=671.0) order=-1
          Pitesti (g=435.0, h=100.0, f=535.0) order=8
            Craiova (g=573.0, h=160.0, f=733.0) order=-1
            Bucharest (g=536.0, h=0.0, f=536.0) order=-1
            Rimnicu (g=532.0, h=193.0, f=725.0) order=-1
      Timisoara (g=236.0, h=329.0, f=565.0) order=-1
    Lugoj (g=111.0, h=244.0, f=355.0) order=1
      Mehadia (g=181.0, h=241.0, f=422.0) order=2
        Drobeta (g=256.0, h=242.0, f=498.0) order=4
          Craiova (g=376.0, h=160.0, f=536.0) order=9
            Drobeta (g=496.0, h=242.0, f=738.0) order=-1
            Rimnicu (g=522.0, h=193.0, f=715.0) order=-1
            Pitesti (g=514.0, h=100.0, f=614.0) order=-1
          Mehadia (g=331.0, h=241.0, f=572.0) order=-1
        Lugoj (g=251.0, h=244.0, f=495.0) order=-1
      Timisoara (g=222.0, h=329.0, f=551.0) order=-1
AstarGraphSearch:               (cost=536.0, expansions=10) Timisoara Arad Sibiu Rimnicu Pitesti
Bucharest
```

Question 3:

```
TreeSearch------------------------
BreadthFirstTreeSearch:          (cost=11.0, expansions=9505)       3 3 1 0 0 0  2 2 0 1 1
1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3
1  1 1 1 2 2 0  0 0 0 3 3 1
UniformCostTreeSearch:           (cost=11.0, expansions=9595)       3 3 1 0 0 0  2 2 0 1 1
1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3
1  1 1 1 2 2 0  0 0 0 3 3 1
DepthFirstTreeSearch:            (cost=203.0, expansions=203)       3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  2 2 0 1 1
1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1
1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  0 3 0 3 0
1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  0 3 0 3 0
```

```
1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  1 3 0 2 0
1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  1 3 0 2 0
1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0
1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  1 1 0 2 2 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3
1  2 2 1 1 1 0  2 0 0 1 3 1  2 2 1 1 1 0  1 1 0 2 2 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3
1  2 2 1 1 1 0  1 1 0 2 2 1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0 1  3 3 1 0 0 0  1 3 0 2 0
1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  2 2 0 1 1
1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0
1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  1 3 1 2 0 0  0 3 0 3 0
1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  1 3 0 2 0 1  3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  1 3 0 2 0 1  3 3 1 0 0 0  1 3 0 2 0 1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 2 0 1 1
1  3 3 1 0 0 0  1 3 0 2 0 1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0
1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  1 1 0 2 2 1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0
1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0 1  3 3 1 0 0 0  1 3 0 2 0
1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  1 3 1 2 0 0  0 3 0 3 0
1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0
1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  1 1 0 2 2
1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  1 1 1 2 2 0  1 0 0 2 3 1  1 1 1 2 2 0  1 0 0 2 3
1  1 1 1 2 2 0  0 0 0 3 3 1
GreedyBestFirstTreeSearch: (cost=47.0, expansions=93)    3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0
2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0 1  3 3 1 0 0 0
1 3 0 2 0 1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0
2 2 0 1 1 1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0
0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  2 2 1 1 1 0  1 1 0 2 2 1  2 2 1 1 1 0
2 0 0 1 3 1  2 2 1 1 1 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  2 0 0 1 3 1  3 0 1 0 3 0
1 0 0 2 3 1  1 1 1 2 2 0  1 0 0 2 3 1  2 0 1 1 3 0  0 0 0 3 3 1
AstarTreeSearch:                  (cost=11.0, expansions=8362)          3 3 1 0 0 0  2 2 0 1 1 1  2 3 1
1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  2 0 1
1 3 0  0 0 0 3 3 1



GraphSearch----------------------
BreadthFirstGraphSearch:     (cost=11.0, expansions=14)    3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0
0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  2 0 1 1 3 0
0 0 0 3 3 1
UniformCostGraphSearch:               (cost=11.0, expansions=14)    3 3 1 0 0 0  1 3 0 2 0 1  2 3 1
1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  2 0 1
1 3 0  0 0 0 3 3 1
```

```
DepthFirstGraphSearch:                (cost=11.0, expansions=12)   3 3 1 0 0 0  1 3 0 2 0 1  2 3 1
1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  1 1 1
2 2 0  0 0 0 3 3 1
GreedyBestGraphSearch:                (cost=11.0, expansions=13)   3 3 1 0 0 0  1 3 0 2 0 1  2 3 1
1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  2 0 1
1 3 0  0 0 0 3 3 1
AstarGraphSearch:             (cost=11.0, expansions=14)   3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0
0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  1 1 1 2 2 0
0 0 0 3 3 1
```

```
IterativeDeepening----------------------
IterativeDeepeningTreeSearch:        (cost=11.0, expansions=10879)        3 3 1 0 0 0  1 3 0 2 0
1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3
1  1 1 1 2 2 0  0 0 0 3 3 1
IterativeDeepeningGraphSearch:      (cost=11.0, expansions=12)   3 3 1 0 0 0  1 3 0 2 0 1  2 3 1
1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  2 0 1
1 3 0  0 0 0 3 3 1
```

Question 4:

```
TreeSearch------------------------
BreadthFirstTreeSearch:               (cost=5.0, expansions=2228)  0 0 0  0 8 0  3 5 0  0 5 0  2 2
0  3 1 0
UniformCostTreeSearch:                (cost=5.0, expansions=1459)  0 0 0  0 8 0  3 5 0  0 5 0  2 2
0  3 2 1
DepthFirstTreeSearch:                 (cost=847.0, expansions=847)          0 0 0  0 0 12  0 0 12
0 0 12  0 8 12  0 8 0  0 8 0  3 8 5  3 8 12  3 8 0  3 0 0  0 0 0  0 0 12  3 0 12  3 8 12  3 8 0  3 8 0
0 8 0  0 0 0  0 8 0  0 8 0  0 8 0  0 8 12  3 8 12  0 8 12  3 8 5  3 8 8  3 8 3  3 8 8  3 8 8  3 8 3  0 8
3  0 8 0  0 8 12  3 8 12  3 0 12  0 0 12  0 0 12  3 0 12  3 0 0  0 0 0  3 0 0  3 0 0  3 8 0  3 8 3  3 0
3  3 0 0  0 0 0  0 8 0  3 8 5  3 8 8  3 8 3  3 8 12  3 8 8  0 8 8  0 8 12  0 0 12  0 8 12  0 8 12  3 8
12  3 0 12  0 0 12  0 0 0  0 0 12  3 0 12  3 0 12  0 0 12  0 8 12  0 8 0  3 5 0  3 5 5  3 5 12  0 5 12
0 5 12  0 0 12  3 0 12  3 0 0  0 0 0  0 0 12  0 8 12  0 0 12  3 0 12  3 0 0  3 0 0  3 0 0  3 0 12  3 0
0  3 0 12  3 8 12  3 8 0  3 0 0  3 0 0  3 8 0  3 0 0  3 8 0  3 8 12  3 0 12  0 0 12  0 0 12  0 0 12  0 0
12  0 8 12  0 8 12  0 0 12  0 8 12  3 8 12  3 8 3  0 8 3  3 8 5  3 8 0  3 8 0  3 8 0  3 8 3  3 8 8  3 8
8  3 8 12  3 8 8  3 0 8  3 8 8  0 8 8  3 8 8  3 8 0  3 8 0  0 8 0  3 5 0  3 0 0  0 0 0  0 8 0  0 8 12  0 0
12  0 0 0  0 0 12  0 0 0  0 0 0  0 0 0  0 0 0  0 8 0  3 8 5  3 0 5  3 0 0  3 0 12  3 8 12  3 8 3  3 8 12
3 8 8  3 8 0  3 0 0  0 0 0  3 0 0  0 0 0  0 8 0  3 5 0  3 5 0  3 5 0  3 8 0  3 8 12  3 8 0  3 8 3  3 0 3
3 0 3  3 0 3  3 8 3  3 8 8  3 0 8  3 0 8  3 0 8  0 0 8  0 8 8  0 8 8  0 0 8  0 0 8  0 0 12  3 0 12  3 8
12  0 8 12  0 8 0  0 8 12  3 5 12  3 0 12  3 0 12  3 0 0  3 0 12  3 8 12  3 0 12  3 0 0  3 8 0  3 0 0
3 0 0  3 8 0  3 8 12  0 8 12  3 8 5  3 8 0  3 8 0  3 8 3  0 8 3  3 8 3  3 8 3  3 8 3  3 8 8  3 8 3  3 8 3
3 8 3  3 8 8  3 0 8  3 0 0  3 0 12  3 0 0  3 8 0  3 8 0  3 8 12  3 8 8  3 8 8  3 0 8  3 8 8  0 8 8  0 8
12  0 8 12  3 8 12  3 8 12  3 0 12  3 0 0  3 0 0  3 0 12  0 0 12  3 0 12  0 0 12  0 8 12  0 0 12  0 0
```

```
0  0 0 0  0 0 0  0 0 0  3 0 0  3 0 0  0 0 0  3 0 0  3 0 12  3 8 12  3 8 3  3 0 3  3 8 3  0 8 3  3 8 3  3 8
8  3 8 8  3 8 12  3 8 8  0 8 8  3 8 8  3 8 8  0 8 8  0 8 12  3 8 12  3 8 12  3 8 12  3 8 12  3 8 0  3 0
0  0 0 0  0 0 0  0 8 0  0 8 0  0 8 0  3 8 0  3 8 0  0 8 0  3 5 0  3 8 0  3 8 8  3 0 8  3 0 0  0 0 0  3 0 0
3 8 0  3 8 0  3 8 0  0 8 0  3 8 5  3 8 0  3 8 8  3 8 8  3 8 12  0 8 12  3 8 5  3 8 3  3 8 3  3 8 12  3 8
3  3 8 12  0 8 12  3 5 12  3 0 12  3 0 12  3 8 12  3 0 12  3 0 0  3 0 12  3 8 12  3 0 12  0 0 12  0 0
12  0 8 12  3 5 12  3 0 12  3 0 12  3 0 12  3 0 0  3 0 12  3 0 12  3 0 0  3 8 0  3 8 0  3 8 8  0 8 8  3
8 8  3 8 12  3 8 3  3 0 3  0 0 3  0 8 3  0 0 3  0 0 3  0 0 12  0 0 0  3 0 0  3 0 12  0 0 12  3 0 12  3 0
0  3 8 0  3 8 12  3 8 3  3 8 3  3 8 3  3 0 3  3 8 3  3 0 3  3 0 3  3 0 3  3 0 12  3 0 0  0 0 0  0 8 0  0 0
0  0 0 0  3 0 0  3 0 12  3 0 0  3 0 12  0 0 12  0 0 12  0 0 12  3 0 12  3 0 12  3 8 12  3 0 12  3 8 12
3 8 12  0 8 12  0 0 12  0 0 12  0 0 0  0 8 0  3 8 5  3 8 12  3 0 12  3 8 12  3 8 0  3 8 3  3 8 8  3 0 8
3 0 0  3 0 0  3 0 0  3 8 0  3 8 0  3 8 3  3 8 12  3 8 8  3 8 8  0 8 8  3 8 5  3 8 5  3 8 3  3 8 3  3 0 3
3 0 0  3 8 0  3 8 0  3 8 3  3 8 12  3 8 0  3 0 0  0 0 0  0 0 12  3 0 12  0 0 12  0 0 12  0 0 0  3 0 0  3
8 0  3 8 12  3 8 3  3 8 3  3 0 3  0 0 3  0 0 0  0 8 0  0 0 0  0 0 12  0 0 0  0 8 0  0 8 0  0 0 0  0 0 12
3 0 12  0 0 12  3 0 12  0 0 12  0 8 12  0 0 12  0 0 0  0 8 0  3 8 5  3 8 12  3 8 8  0 8 8  0 0 8  0 8 8
3 8 5  0 8 5  0 8 12  0 8 0  3 8 0  3 8 12  3 8 3  0 8 3  3 5 3  0 5 3  0 0 3  3 0 3  3 8 3  3 8 8  0 8 8
0 8 12  3 5 12  3 0 12  3 0 0  0 0 0  3 0 0  3 0 12  3 0 12  3 0 0  3 0 0  3 8 0  3 8 0  3 8 12  3 8 0
3 8 0  3 8 8  0 8 8  0 0 8  0 0 0  3 0 0  3 0 12  3 0 12  0 0 12  0 0 0  3 0 0  0 0 0  0 0 0  0 0 12  0 0
0  0 8 0  0 8 0  0 8 12  0 0 12  3 0 12  3 8 12  3 8 3  3 8 3  3 8 3  0 8 3  3 8 5  3 8 3  3 8 0  0 8 0
0 8 0  3 8 0  3 8 3  3 0 3  3 8 3  3 0 3  3 8 3  3 8 3  3 8 8  3 8 0  3 8 12  3 8 0  3 8 0  0 8 0  0 0 0
0 0 12  0 0 0  3 0 0  3 0 12  3 0 12  3 0 0  3 0 0  3 0 0  3 0 12  0 0 12  0 8 12  0 8 12  3 8 12  3 8
3  3 8 12  3 8 12  3 8 12  3 8 12  3 8 12  3 8 3  3 0 3  3 8 3  3 0 3  0 0 3  0 8 3  0 8 12  0 0 12  0 8
12  3 8 5  3 0 5  0 0 5  0 0 5  0 0 12  0 0 12  0 0 12  0 0 0  0 8 0  3 5 0  3 5 12  3 5 0  3 8 0  3 8
12  3 8 12  0 8 12  3 8 5  0 8 5  0 8 0  0 8 0  3 8 0  3 8 3  3 8 3  3 8 0  3 0 0  3 0 12  0 0 12  3 0
12  3 0 0  0 0 0  0 8 0  0 8 12  3 8 5  3 8 8  3 0 8  3 8 8  3 8 0  3 8 8  3 0 8  3 0 8  3 0 12  0 0 12
0 0 12  3 0 12  0 0 12  0 0 12  0 0 12  0 0 12  0 0 0  3 0 0  3 8 0  3 8 0  3 8 8  3 8 0  3 8 8  3 8 3
3 8 0  3 0 0  3 0 0  3 0 0  0 0 0  0 0 0  0 0 0  0 0 0  0 0 12  0 8 12  3 5 12  3 0 12  3 0 12  3 8 12
3 8 0  3 8 8  0 8 8  0 8 0  0 8 12  0 8 12  3 8 5  3 8 12  0 8 12  3 8 5  3 8 3  0 8 3  0 8 12  0 8 12
3 5 12  3 8 12  3 0 12  3 0 0  0 0 0  3 0 0  3 0 0  3 0 12  0 0 12  0 8 12  3 5 12  3 8 12  3 8 12  3 8
3  0 8 3  0 8 12  0 8 12  3 8 12  3 8 8  3 8 3  3 0 3  3 0 3  0 0 3  0 0 3  0 0 0  0 0 0  0 8 0  3 8 0  3
0 0  3 0 0  0 0 0  0 0 12  3 0 12  3 0 0  0 0 0  3 0 0  3 0 12  3 0 0  0 0 0  3 0 0  3 0 0  0 0 0  0 0 0
0 0 0  3 0 0  0 0 0  0 0 12  0 0 0  0 8 0  3 5 0  3 5 0  3 5 0  3 5 5  3 5 12  0 5 12  3 5 12  0 5 12  0
8 12  3 8 5  3 8 12  3 8 8  3 8 0  3 8 12  3 8 3  3 8 0  3 8 3  3 8 0  3 8 0  3 0 0  3 8 0  3 8 3  3 8 3
3 8 3  3 8 12  3 0 12  3 0 12  3 0 12  0 0 12  3 0 12  3 0 0  3 0 0  0 0 0  0 0 0  0 8 0  0 8 0  3 5 0
0 5 0  0 5 12  0 5 12  0 0 12  0 0 0  0 0 12  0 0 0  3 0 0  3 0 0  3 8 0  3 0 0  0 0 0  0 0 0  0 0 12  0
8 12  3 8 5  0 8 5  0 8 0  0 8 0  0 8 0  3 8 0  0 8 0  3 5 0  3 5 5  3 5 5  0 5 5  0 0 5  0 0 12  0 0 0  0
8 0  0 0 0  0 0 12  3 0 12  3 8 12  3 8 3  3 8 12  0 8 12  0 0 12  0 0 0  0 0 0  0 0 12  3 0 12  3 0 0
3 8 0  3 8 0  0 8 0  0 0 0  0 0 12  0 0 0  3 0 0  3 0 12  0 0 12  0 8 12  0 8 0  3 5 0  0 5 0  0 5 12  0
5 0  0 5 12  2 5 2  3 5 2  3 0 2  3 0 0  3 0 0  3 0 0  0 0 0  0 0 12  0 0 0  0 0 12  3 0 12  0 0 12  0 8
12  3 8 12  3 8 8  3 0 8  3 0 8  3 8 8  3 8 12  3 0 12  3 8 12  0 8 12  3 5 12  3 5 0  3 5 12  3 8 12
3 8 12  3 8 3  3 8 0  3 8 3  3 8 0  3 8 3  3 8 0  3 8 3  3 8 12  3 8 8  0 8 8  3 8 8  3 8 3  3 8 12  3 8
8  3 8 0  3 8 12  0 8 12  3 8 12  3 8 3  0 8 3  0 0 3  0 0 3  3 0 3  3 0 12  0 0 12  0 8 12  0 8 0  3 8
5  0 8 5  0 8 5  0 0 5  0 0 5  0 8 5  3 8 5  3 0 5  3 0 12  3 0 0  3 8 0  3 0 0  3 8 0  0 8 0  3 8 0  3 8
```

```
3  3 0 3  3 0 0  3 8 0  0 8 0  0 8 0  0 8 12  0 0 12  0 8 12  0 0 12  0 0 0  0 0 0  0 8 0  3 5 0  0 5 0
0 5 0  2 2 0  2 2 0  3 2 1
GreedyBestFirstTreeSearch: (cost=33.0, expansions=65)    0 0 0  3 0 0  3 8 0  3 8 3  3 8 3  3 0
3  3 0 12  3 0 12  3 0 12  3 0 12  0 0 12  0 8 12  0 8 12  0 8 0  0 8 12  3 5 12  0 5 12  0 8 12  3 8
5  3 0 5  0 0 5  3 0 5  0 0 5  3 0 5  3 0 12  0 0 12  3 0 12  3 8 12  0 8 12  3 5 12  3 5 12  0 5 12  2
2 12  3 1 12
AstarTreeSearch:                (cost=5.0, expansions=1376)  0 0 0  0 8 0  3 5 0  0 5 0  2 2 0  3 1
0
```

```
GraphSearch----------------------
BreadthFirstGraphSearch:     (cost=5.0, expansions=29)     0 0 0  0 8 0  3 5 0  0 5 0  2 2 0  3 1
0
UniformCostGraphSearch:              (cost=5.0, expansions=30)     0 0 0  0 8 0  3 5 0  0 5 0  2 2
0  3 2 1
DepthFirstGraphSearch:               (cost=33.0, expansions=46)    0 0 0  0 8 0  0 8 12  3 5 12  3
8 12  3 8 3  0 8 3  0 0 3  3 0 3  3 0 12  3 0 0  3 8 0  3 8 8  0 8 8  3 5 8  3 5 5  3 5 0  0 5 0  2 5 2  0
5 2  2 2 2  2 8 2  3 7 2  3 7 12  3 7 0  0 7 0  3 7 4  3 7 7  2 8 7  0 8 7  3 5 7  0 5 7  2 2 7  3 1 7
GreedyBestGraphSearch:               (cost=34.0, expansions=61)    0 0 0  0 8 0  3 8 5  3 0 5  0 0
5  0 8 5  3 5 5  0 5 5  2 5 2  2 8 2  0 8 2  3 5 2  0 5 2  0 5 12  2 2 12  2 2 0  2 0 0  2 8 0  2 8 12  3
8 7  3 8 3  0 8 3  3 5 3  0 5 3  2 2 3  2 0 3  2 8 3  3 7 3  3 7 7  2 8 7  0 8 7  3 5 7  0 5 7  2 2 7  3 1
7
AstarGraphSearch:               (cost=5.0, expansions=37)     0 0 0  0 8 0  3 5 0  0 5 0  2 2 0  3 1
0
```

```
IterativeDeepening----------------------
IterativeDeepeningTreeSearch:        (cost=5.0, expansions=2247)  0 0 0  0 8 0  3 5 0  0 5 0  2 2
0  3 2 1
IterativeDeepeningGraphSearch:       (cost=5.0, expansions=14)     0 0 0  0 8 0  3 5 0  0 5 0  2 2
0  3 2 1
```

Question 5:

```
TreeSearch------------------------
BreadthFirstTreeSearch:              (cost=11.0, expansions=9505)         3 3 1 0 0 0  2 2 0 1 1
1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3
1  1 1 1 2 2 0  0 0 0 3 3 1
UniformCostTreeSearch:               (cost=11.0, expansions=9595)         3 3 1 0 0 0  2 2 0 1 1
1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3
1  1 1 1 2 2 0  0 0 0 3 3 1
DepthFirstTreeSearch:                (cost=203.0, expansions=203)         3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  2 2 0 1 1
```

```
1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1
1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  0 3 0 3 0
1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  0 3 0 3 0
1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  1 3 0 2 0
1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  1 3 0 2 0
1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0
1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  1 1 0 2 2 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3
1  2 2 1 1 1 0  2 0 0 1 3 1  2 2 1 1 1 0  1 1 0 2 2 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3
1  2 2 1 1 1 0  1 1 0 2 2 1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0 1  3 3 1 0 0 0  1 3 0 2 0
1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  2 2 0 1 1
1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0
1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  1 3 1 2 0 0  0 3 0 3 0
1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0 1  2 3 1 1 0 0  1 3 0 2 0 1  3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  1 3 0 2 0 1  3 3 1 0 0 0  1 3 0 2 0 1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 2 0 1 1
1  3 3 1 0 0 0  1 3 0 2 0 1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0
1  3 3 1 0 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 3 0 1 0 1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0
1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  1 1 0 2 2 1  1 3 1 2 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0
1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  0 3 0 3 0 1  2 3 1 1 0 0  1 3 0 2 0 1  3 3 1 0 0 0  1 3 0 2 0
1  3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  1 3 1 2 0 0  0 3 0 3 0
1  2 3 1 1 0 0  2 2 0 1 1 1  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0  2 2 0 1 1 1  2 3 1 1 0 0  0 3 0 3 0
1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  1 1 0 2 2
1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  1 1 1 2 2 0  1 0 0 2 3 1  1 1 1 2 2 0  1 0 0 2 3
1  1 1 1 2 2 0  0 0 0 3 3 1
GreedyBestFirstTreeSearch: (cost=11.0, expansions=16)    3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0
0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  1 1 1 2 2 0
0 0 0 3 3 1
AstarTreeSearch:                (cost=11.0, expansions=570)  3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0
0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  1 1 1 2 2 0
0 0 0 3 3 1



GraphSearch---------------------
BreadthFirstGraphSearch:     (cost=11.0, expansions=14)    3 3 1 0 0 0  1 3 0 2 0 1  2 3 1 1 0 0
0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  2 0 1 1 3 0
0 0 0 3 3 1
UniformCostGraphSearch:              (cost=11.0, expansions=14)    3 3 1 0 0 0  1 3 0 2 0 1  2 3 1
1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  2 0 1
1 3 0  0 0 0 3 3 1
DepthFirstGraphSearch:               (cost=11.0, expansions=12)    3 3 1 0 0 0  1 3 0 2 0 1  2 3 1
1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  1 1 1
2 2 0  0 0 0 3 3 1
```

```
GreedyBestGraphSearch:              (cost=11.0, expansions=12)    3 3 1 0 0 0  2 2 0 1 1 1  2 3 1
1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  1 1 1
2 2 0  0 0 0 3 3 1
AstarGraphSearch:              (cost=11.0, expansions=13)    3 3 1 0 0 0  2 2 0 1 1 1  2 3 1 1 0 0
0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  2 0 1 1 3 0
0 0 0 3 3 1


IterativeDeepening----------------------
IterativeDeepeningTreeSearch:        (cost=11.0, expansions=10125)         3 3 1 0 0 0  1 3 0 2 0
1  2 3 1 1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3
1  2 0 1 1 3 0  0 0 0 3 3 1
IterativeDeepeningGraphSearch:      (cost=11.0, expansions=12)    3 3 1 0 0 0  1 3 0 2 0 1  2 3 1
1 0 0  0 3 0 3 0 1  1 3 1 2 0 0  1 1 0 2 2 1  2 2 1 1 1 0  2 0 0 1 3 1  3 0 1 0 3 0  1 0 0 2 3 1  1 1 1
2 2 0  0 0 0 3 3 1
```