1) For rules on collaboration and late policies, please see the course web page. The final problem involves programming.

a. On what sorts of graphs will DFS outperform BFS? On what sorts of graphs will BFS outperform DFS?

DFS will outperform BFS on thickly connected graphs with high branching factor, because BFS experiences an exponential blowup in nodes expanded as the branching factor increases. BFS will outperform DFS on sparse graphs with low branching factor, where DFS can get stuck following long, irrelevant chains.

b. When would bi-directional BFS not be available as a search method? Give an example.

In practice, bi-directional BFS is rarely available. This is because in the real world most of our problems are solved online, where we have a simple test to determine whether a state is a goal or not, but not an actual goal state we can work back from.

c. Consider a general search problem in which every node has:

- Depth $d(n)$: the length of the path (number of edges) to the node.
- $g(n)$: the cost of getting to the node.
- $h(n)$: the estimated cost of getting to the goal.

If you search using a function $f(n)$ to evaluate the "goodness" of n, and to decide which node to expand next, write expressions for $f(n)$ for the following types of search:

1. BFS $= d(n)$
2. DFS $= -d(n)$
3. UCS $= g(n)$
4. A* $= g(n) + h(n)$

(Take the minimum node each time, as in the A* definition).

2) Alice wants to run UCS on a graph where she knows some costs are negative or zero.

a. Why doesn't UCS work on Alice's graph?

UCS will no longer be optimal on the graph, but will be complete. With negative weights, UCS may miss a longer path to get to a node that has negative overall weight, lowering its cost.

b. Now assume that Alice knows the cost on any edge is bounded below by $\underline{c}$. She proposes running UCS on the graph, but modifying the algorithm to add $\underline{c} + 1$ to the cost of each edge, transforming the graph into one where all the edges are positive. Is this complete? Is it optimal? Why or why not?

It is complete and optimal in the modified graph, but not in the original graph.

c. Does your answer change if $\underline{c}$ is exactly equal to the minimum cost edge?

No.