This is a closed-book closed-notes exam. The only items you are permitted to bring are writing implements. Mark every sheet of paper you use with your name and the string “cs347fs2005 exam1”. If you are caught cheating, you will receive a zero grade for this exam. The max number of points per question is indicated in square brackets after each question. The sum of the max points is 76 (80 including the 4 bonus points). You have 90 minutes to complete this exam. Good luck!

1. List two advantages of the Turing test for deciding whether an artificial entity is intelligent. [4]

Two possible arguments are:

I Simplicity: By utilizing a comparison with a known quantity (i.e., human intelligence) to define intelligence in general, the whole conundrum of defining what precisely intelligence is and how one would measure it is avoided.

II Acceptability: The general public might be very sceptical (and perhaps rightfully so), if one claimed to have created an intelligent artificial entity based on some abstract definition of one’s own design; while fallible, the Turing test is generally perceived as being an acceptable test of intelligence precisely because it compares to a known quantity that the general public can understand: itself.

2. Briefly explain the consequences for AI research if Descartes was right with his theory of dualism. [4]

The consequence would be that all hope of finding a way to create intelligence as an emergent system property would vanish. A new field of science would be born to study what the exact limitations of emergent behavior are versus soul enabled entities.

3. Give a formal description of FreeCell by defining the initial state, successor function, goal test, and path cost function. [8]

Initial State A predetermined configuration of a fifty-two card playing deck. Where the freecells and foundations are empty, the first four tableau piles have seven cards, and the last four have six cards.

Successor Function Returns a list of (action,state) pairs, where the set of actions consists of all legal card moves, where the card is moved from either a tableau pile or a freecell, and the states are the result of applying one of those actions to the current state.

Goal Test All fifty-two cards have been moved to the foundations.

Path Cost Function The path cost can be defined as the number of actions/moves from the initial state to the current state.
All the following questions are about the following state space graph, with A being the start state and C & G being goal states. The order in which successors are generated is counterclockwise, ending at exactly 9 o’clock. Example: C generates first H, then G, then D, and finally B; while E generates first D, then F, and finally A. When sorting by path-cost, nodes with equal path-cost are ordered such that the earlier a node is generated, the higher its priority. Nodes already on the open list have higher priority than newly added nodes with equal path-cost.

4. Give the execution trace of BFTS. [7]

<table>
<thead>
<tr>
<th>open</th>
<th>eval</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>BEH</td>
<td>B</td>
</tr>
<tr>
<td>EHCA</td>
<td>E</td>
</tr>
<tr>
<td>HCADFA</td>
<td>H</td>
</tr>
<tr>
<td>CADFACAG</td>
<td>C</td>
</tr>
</tbody>
</table>

goal found; solution = ABC; path-cost(ABC)=8

5. Give the execution trace of bi-directional DFTS. [10]

<table>
<thead>
<tr>
<th>open forward</th>
<th>open backward</th>
<th>eval forward</th>
<th>eval backward</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CG</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>BEH</td>
<td>HGDBG</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

path found; solution = ABC; path-cost(ABC)=8
6. Give the execution trace of ID-DFGS. [10]

\[
\begin{array}{c|c|c}
\text{depth-limit}=0 \\
\text{open} & \text{closed} & \text{eval} \\
A & - & A \\
\multicolumn{3}{l}{\text{depth-limit reached and no goal found}}
\end{array}
\]

\[
\begin{array}{c|c|c}
\text{depth-limit}=1 \\
\text{open} & \text{closed} & \text{eval} \\
A & - & A \\
BEH & A & B \\
EH & AB & E \\
H & ABE & H \\
\multicolumn{3}{l}{\text{depth-limit reached and no goal found}}
\end{array}
\]

\[
\begin{array}{c|c|c}
\text{depth-limit}=2 \\
\text{open} & \text{closed} & \text{eval} \\
A & - & A \\
BEH & A & B \\
CEH & AB & C \\
\multicolumn{3}{l}{\text{goal found; solution}=ABC; \text{path-cost}(ABC)=8}
\end{array}
\]

7. Give the execution trace of UCGS. [15]

\[
\begin{array}{c|c|c}
\text{open} & \text{closed} & \text{eval} \\
A0 & - & A0 \\
E2B4H8 & A & E2 \\
F3B4D7H8 & AE & F3 \\
B4D4H8G9 & AEF & B4 \\
D4H8C8G9 & AEFBD & D4 \\
C5H8G9 & AEFBD & C5 \\
\multicolumn{3}{l}{\text{goal found; solution }=\text{ AEFDC}; \text{path-cost}(AEFDC)=5}
\end{array}
\]

8. Is UCGS complete for this problem? Explain your answer! [1]

Yes, because it found a solution.


Yes, because the negative step cost from G to H does not cause a negative cycle and the only other possible paths from A either include the step AH or the step FG, both of which would incur a cost greater than the path-cost of the solution found.

10. Is BFTS optimal for this problem? Explain your answer! [2]

No, because it found a solution with higher path-cost than the one found by UCGS.

11. Is bi-directional DFTS optimal for this problem? Explain your answer! [2]

No, because it found a solution with higher path-cost than the one found by UCGS.

12. Is ID-DFGS optimal for this problem? Explain your answer! [2]

No, because it found a solution with higher path-cost than the one found by UCGS.

13. Are there depths \( l \) for which DLTS would be incomplete for this problem? If yes, give those depths; otherwise explain why not. [2]

Yes, for \( l \leq 2 \) DLTS is incomplete for this problem.
14. Is there a step cost associated with a single action that can be changed in the state space graph which would make ID-DFGS not complete? (Note: bidirectional edges represent two separate actions, each with their own step cost). If yes, then give the action and new step cost; otherwise, explain why not. [2]

No, because ID-DFGS does not take step costs into account.

15. Is there a step cost associated with a single action that can be changed in the state space graph which would make UCGS not complete? (Note: bidirectional edges represent two separate actions, each with their own step cost). If yes, then give the action and new step cost; otherwise, explain why not. [2]

No, because UCGS is a graph search algorithm and will therefore not revisit nodes, so negative cycles cannot affect its completeness.

BONUS Are there state spaces for which DLTS with \( l < \text{diameter} \) is optimal? Explain your answer! [4]

Yes. For instance, consider a state space where the start state is a goal and has at least one successor; then the diameter is greater or equal to one and DLTS with \( l = 0 < \text{diameter} \) is optimal. Or, alternatively, consider a state space with branching factor equal to one and positive step costs, which contains three states. If the first state reached from the start state is a goal state, then DLTS with \( l = 1 < 2 = \text{diameter} \) is optimal.