1. What is the diameter of this state space? Explain your answer! [2]

4; this is the largest minimal number of steps between any two nodes.
2. Give the execution trace of ID-DFGS. [10]

\[
\begin{array}{ccc}
\text{depth-limit=0} \\
\text{open} & \text{closed} & \text{eval} \\
\text{A} & - & \text{A} \\
\end{array}
\]

depth-limit reached and no goal found

\[
\begin{array}{ccc}
\text{depth-limit=1} \\
\text{open} & \text{closed} & \text{eval} \\
\text{A} & - & \text{A} \\
\text{BCDE} & \text{A} & \text{B} \\
\text{CDE} & \text{AB} & \text{C} \\
\text{DE} & \text{ABC} & \text{D} \\
\text{E} & \text{ABCD} & \text{E} \\
\end{array}
\]

depth-limit reached and no goal found

\[
\begin{array}{ccc}
\text{depth-limit=2} \\
\text{open} & \text{closed} & \text{eval} \\
\text{A} & - & \text{A} \\
\text{BCDE} & \text{A} & \text{B} \\
\text{HFCDE} & \text{AB} & \text{H} \\
\end{array}
\]
goal found; solution=ABH; path-cost(ABH)=10

3. Give the execution trace of UCGS. [10]

\[
\begin{array}{ccc}
\text{open} & \text{closed} & \text{eval} \\
\text{A0} & - & \text{A0} \\
\text{E1B6C7D8} & \text{A} & \text{E1} \\
\text{I2B6F6C7D8} & \text{AE} & \text{I2} \\
\text{D3B6F6C7} & \text{AEI} & \text{D3} \\
\text{C5B6F6C7} & \text{AEID} & \text{G5} \\
\text{B6F6C6} & \text{AEIDG} & \text{B6} \\
\text{F6C6H10} & \text{AEIDGB} & \text{F6} \\
\text{C6H10} & \text{AEIDGBF} & \text{C6} \\
\text{H8} & \text{AEIDGBFC} & \text{H8} \\
\end{array}
\]
goal found; solution = AEIDGCH; path-cost(AEIDGCH)=8

4. Give the execution trace of GBeFGS employing as heuristic \(h(node)\). [6]

\[
\begin{array}{ccc}
\text{open} & \text{closed} & \text{eval} \\
\text{A7} & - & \text{A7} \\
\text{B1C2E2D3} & \text{A} & \text{B1} \\
\text{H0C2E2D3F5} & \text{AB} & \text{H0} \\
\end{array}
\]
goal found; solution=ABH; path-cost(ABH)=10

5. Give the execution trace of A*GS employing as heuristic \(h(node)\). [10]

\[
\begin{array}{ccc}
\text{open} & \text{closed} & \text{eval} \\
\text{A7} & - & \text{A7} \\
\text{E3B7C9D11} & \text{A} & \text{E3} \\
\text{I5B7C9D11F11} & \text{AE} & \text{I5} \\
\text{D6B7C9F11} & \text{AEI} & \text{D6} \\
\text{G6B7C9F11} & \text{AEID} & \text{G6} \\
\text{B7C8F11} & \text{AEIDG} & \text{B7} \\
\text{C8H10F11} & \text{AEIDGB} & \text{C8} \\
\text{H8F11} & \text{AEIDGBC} & \text{H8} \\
\end{array}
\]
goal found; solution=AEIDGCH; path-cost(AEIDGCH)=8
6. Is UCGS optimal for this problem? Explain your answer! [3]

Yes, because the branching factor is finite, the step costs are all positive, and UCGS is always optimal under those conditions.


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

8. Is GBeFGS employing heuristic $h(node)$ optimal for this problem? Explain your answer! [2]

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

9. Is $h(node)$ admissible for this problem? Explain your answer! [4]

Yes, because as can be seen from the following table no node overestimates the remaining path-cost:

<table>
<thead>
<tr>
<th>node</th>
<th>$h(node)$</th>
<th>$C^*(node)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>E</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>F</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>G</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>H</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

10. Is $h(node)$ consistent for this problem? Explain your answer! [4]

No, because $h(A) = 7 > 3 = c(A, E) + h(E)$.

11. Is A*GS employing heuristic $h(node)$ optimal for this problem? Explain your answer! [2]

Yes, because it found a solution with the same path-cost as that found by UCGS which we earlier explained is optimal for this problem.
The questions on this page are about the following adversarial search tree. State evaluation heuristic values for the max player are provided in the form of numbers following the letter labels of the states (e.g., A9 indicates that the heuristic value of state A for the max player is 9). The order in which successors are generated is from left to right. Example: A generates first B, then C, and finally D.

12. Give the execution trace for DLM(A,2). [18]

<table>
<thead>
<tr>
<th>call</th>
<th>open</th>
<th>eval</th>
<th>value</th>
<th>best action, value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLM(A,2)</td>
<td>BCD</td>
<td>B</td>
<td>MinV(B,1)=6</td>
<td>AB,6</td>
</tr>
<tr>
<td></td>
<td>CD</td>
<td>C</td>
<td>MinV(C,1)=7 (SSS)</td>
<td>AC,7</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>D</td>
<td>MinV(D,1)=6</td>
<td>AC,7</td>
</tr>
<tr>
<td></td>
<td>EF</td>
<td>E</td>
<td>MaxV(E,0)=6</td>
<td>BE,6</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>F</td>
<td>MaxV(F,0)=7</td>
<td>BE,6</td>
</tr>
<tr>
<td></td>
<td>HIJ</td>
<td>H</td>
<td>MaxV(H,0)=8</td>
<td>DH,8</td>
</tr>
<tr>
<td></td>
<td>IJ</td>
<td>I</td>
<td>MaxV(I,0)=6</td>
<td>DI,6</td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>J</td>
<td>MaxV(J,0)=9</td>
<td>DI,6</td>
</tr>
</tbody>
</table>

13. What is the Principal Variant (PV) found by DLM(A,2)? [2]
   ACG

14. Give the visual tree trace for ABDLM(A,3,−∞,∞) noting all occurrences of fail-lows, fail-highs and prunes. [20]

15. Which nodes, if any, get pruned by ABDLM(A,3,−∞,∞)? [3]
   J, S, T

16. What is the Principal Variant (PV) found by ABDLM(A,3,−∞,∞)? [2]
   ACGN

17. Given an arbitrary adversarial search tree. How much can the PVs for DLM(root, depth) and ABDLM(root, depth) differ? Explain your answer! [5]
   They can not differ at all, because alpha-beta pruning only prunes nodes that cannot change the result.