1 Agents

(a) (i) [3 marks] As an input to the agent, what is “abilities”?

(ii) [5 marks] Suppose Pat claimed that the abilities should not be one of the inputs to the agent, as it
does not affect the actions. Give an example showing why Pat is wrong.

(b) [5 marks] Describe the difference between a fully-observable deterministic system and a partially-
observable stochastic system.

(c) [5 marks] What is the “planning horizon”? Describe the difference between a finite stage and indefi-
nite stage planning horizon.

(d) [5 marks] Give a specific examples of an ordinal preference. How is an ordinal preference different
from a goal?

2 Search

(a) [5 marks] Explain what the frontier is in a graph-search problem, and what it is used for.

(b) [3 marks] Is the worst-case time complexity different for depth-first search and breadth-first search?
(You must be specific about what the complexity is with respect to.) Why or why not?

(c) [5 marks] Consider the following generic search algorithm:

Imagine that this generic algorithm was used as the basis for an implementation of depth-first search
and of breadth-first search. Which line or lines of the pseudocode above must have different imple-
mentations? Briefly, how would those implementations differ?

(d) [4 marks] In what sense is branch and bound better than A*? In what sense is A* better than branch
and bound?

(e) [3 marks] Is the max of two admissible heuristics also admissible? Why or why not?
(f) [3 marks] Consider two admissible heuristics \( h_1 \) and \( h_2 \). Which one of the following options would yield a better heuristic for use with \( A^* \)? Briefly explain your answer.

1. \( \min(h_1, h_2) \)
2. \( \max(h_1, h_2) \)
3. \( \frac{h_1 + h_2}{2} \)
4. \( A^* \) will have the same performance in all cases.

(g) [10 marks] Consider the cyclic delivery graph of Figure 3.7 of the textbook, with the heuristic function of Example 3.13. [Of course, in the exam, we will give you the graph and the heuristic costs.] Suppose the start node is \( b_1 \) and the goal is \( r_{123} \).

For each iteration of \( A^* \), a trace would show the path removed from the frontier and the path(s) added to the frontier to get from \( b_1 \) to \( r_{123} \). We have started the trace, please continue it. You only need to show three iterations: that is, for the next three values selected from the frontier show which paths are added to the frontier (together with their cost-value, \( h \)-value and \( f \)-value). [The path number has no meaning, it is just a number so you can refer to it.]

<table>
<thead>
<tr>
<th>Path Number</th>
<th>Path</th>
<th>cost</th>
<th>( h )</th>
<th>( f )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>( b_1 )</td>
<td>0</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Remove path number 1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>( b_1 \rightarrow b_2 )</td>
<td>6</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>3.</td>
<td>( b_1 \rightarrow b_3 )</td>
<td>4</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>4.</td>
<td>( b_1 \rightarrow c_2 )</td>
<td>3</td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>

(h) [3 marks] For this particular example, when is the first time that multiple-path pruning will prune a path? Be specific about which path is pruned and why.

3 Constraints

(a) [5 marks] Consider the following constraint graph. Note that \((X + Y) \mod 2 = 1\) means that \( X + Y \) is odd.

![Constraint Graph](image)

Is it arc consistent? If it is, explain why. If it isn’t, which domain element(s) that can be pruned? For each domain element(s) that can be pruned, give the arc (or arcs) that can be used to prune it.

(b) [5 marks] Consider the following constraint graph:
Is it arc consistent? If it is, explain why. If it isn’t, which domain element(s) that can be pruned? For each domain element(s) that can be pruned, give the arc (or arcs) that can be used to prune it.

(c) [3 marks] Why does randomization help in local search?

(d) [3 marks] Explain how the next assignment is selected in simulated annealing.

(e) [5 marks] What is a runtime distribution? What is on the x-axis? What is on the y-axis? How is a runtime distribution constructed?

(f) [3 marks] How can a runtime distribution be used to show that one local search algorithm dominates another? If one algorithm dominates another is it always better?

(g) [2 marks] Given a runtime distribution, how can the median runtime be determined?

(h) [3 marks] Why is the mean runtime not a good measure for the performance of a local search algorithm?

4 Logic and Inference

Given the knowledge base $KB$ containing the clauses:

\[
\begin{align*}
  a & \leftarrow b \land c. \\
  b & \leftarrow d. \\
  b & \leftarrow e. \\
  c. \\
  d & \leftarrow h. \\
  e. \\
  f & \leftarrow g \land b. \\
  g & \leftarrow c \land k. \\
  j & \leftarrow a \land b.
\end{align*}
\]

(a) [6 marks] Show how the bottom-up proof procedure works for this example. Show at each step what element is added to $C$, and which clause was used to add it. Give all logical consequences of $KB$.

(b) [4 marks] $f$ is not a logical consequence of $KB$. Explain what this means. Give a model of $KB$ in which $f$ is false.
(c) [4 marks] \( a \) is a logical consequence of \( KB \). Explain what this means. Give a top-down derivation for the query \(?a\).

(d) If, in consistency based diagnosis, there is a singleton diagnosis, \( \{a\} \), what does this tell you about the system?