INSTITUTO SUPERIOR TÉCNICO

Artificial Intelligence and Decision Systems (IASD)
Final exam, 2009/2010

First date (6 pages)

NAME: ____________________

NUMBER:

- The answers should be given **exclusively** on these sheets
- Read carefully each question before answering
- Justify all your answers (except the multiple choice ones)
- This exam is to be executed **without any** consultation (a small *formulæ* can be found in the last page)
- **Exam duration: 1h30m**

1. [**1 val**] Whose scientific domains **did not** contributed to the Artificial Intelligence area? (more than one answer might be correct)

   ☐ Neurosciences
   ☐ Mathematics
   ☐ Physics
   ☐ Linguistics
   ☐ Chemestry

2. [**1 val**] Concerning the search strategies *breadth-first* and *depth-first*, whose of the following statements are true? (more than one answer might be correct)

   ☐ the spatial complexity of depth-first is lower than the one of breadth-first
   ☐ the temporal complexity of depth-first is lower than the one of breadth-first
   ☐ depth-first is appropriate for problems where the solution is at a known depth (not very high)
   ☐ depth-first is complete
   ☐ depth-first is optimal

3. **[1.5 val]** Consider the problem of fitting a set $\mathcal{S}$ of N Tetris pieces into a M by M grid. Formulate this problem as a constraint satisfaction problems (CSP).

4. **[2.5 val]** For each of the following pair of terms, specify the most general unifier (or specify if not possible):

   (a) $P(x, G(x), G(G(x)))$ and $P(C, z, G(y))$

   (b) $P(y, x, y)$ and $P(B, B, z)$

   (c) $P(x, x)$ and $P(A, B)$

   (d) $P(x, x)$ and $P(G(D), G(z))$

   (e) $P(S(S(0)), S(S(S(0))))$ and $P(x, S(x))$

5. **[1 val]** Whose action definitions[1] are **not** valid STRIPS operators? (more than one answer might be correct)

   - [ ] Action(Rename(x, y), (File(x) ∨ Dir(x)) ∧ NotExists(y), $\neg File(x) \wedge File(y)$)
   - [ ] Action(Rename(x, y), FileOrDir(x) ∧ NotExists(y), $\neg File(x) \wedge File(y)$)
   - [ ] Action(Rename(x, y), (File(x) ∨ Dir(x)) ∧ ¬Exists(y), $\neg File(x) \wedge File(y)$)
   - [ ] Action(Rename(x, y), FileOrDir(x) ∧ ¬Exists(y), $\neg File(x) \wedge File(y)$)
   - [ ] Action(Rename(x, y), (File(x) ∨ Dir(x)) ∧ NotExists(y), $File(y)$)
   - [ ] Action(Rename(x, y), FileOrDir(x) ∧ ¬Exists(y), $File(y)$)

6. Consider three elephants named Virgil, Ovid, and Horace. Assuming that

   - *Virgil is pink*
   - *Ovid is gray and likes Horace*
   - *Horace is either pink or gray (but not both) and likes Virgil*

   (a) **[2 val]** Represent these three facts using first-order logic sentences

[1] Notation: Action(n, p, e) where n is the action designation, p the preconditions and e the effects.

(b) **[2 val]** Convert the obtained sentences into the clausal normal form (CNF)

(c) **[2.5 val]** Prove, using resolution, that *a grey elephant likes a pink elephant*

7. Consider a 1-D grid with four cells, denoted *A, B, C,* and *D*, in which a robot can move from one cell to an adjacent one. Two actions are considered — *Left* and *Right* — to move a single cell in each direction, for which there is a probability of 0.8 of success and 0.2 of staying in the same cell (and probability of 1 of staying in the same place if the movement is not possible). There is a reward of +1 for state *C*, and 0 for the others. Assume that the initial state is *A*.

   (a) **[1 val]** Specify the Markov Decision Process $\langle Q, \sum, T, s_0 \rangle$ that models this problem, where Q is the set of states, $\sum$ the set of actions, T the transition function, and s_0 the initial state.

   (b) **[3 val]** Determine the state utilities using the *value iteration* algorithm (perform two iterations at most, $\gamma = 0.9$)

(c) **[2.5 val]** Determine the optimal policy using the computed utility values (or use the utilities $[0.52, 0.98, 1.73, 0.98]$ if unable to compute them)

Formulæ

$$U(s) = R(s) + \gamma \max_a \sum_{s'} T(s,a,s')U(s')$$

$$U_{i+1}(s) \leftarrow R(s) + \gamma \max_a \sum_{s'} T(s,a,s')U_i(s')$$

$$U^{\pi}(s) = R(s) + \gamma \sum_{s'} T(s,\pi(s),s')U^{\pi}(s')$$

$$\pi^*(s) = \arg\max_a \sum_{s'} T(s,a,s')U(s')$$