Name: _______________________

CS 331 Midterm
Spring 2016

You have 50 minutes to complete this midterm. You are only allowed to use your textbook, your notes, your assignments and solutions to those assignments during this midterm. If you find that you are spending a large amount of time on a difficult question, skip it and return to it when you’ve finished some of the easier questions. Total marks for this midterm is 44.

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Section I: Agents (8 points)
1. Consider the agent AlphaGo, which recently beat a human expert at the game Go. Recall that in the game of Go, two players take turns placing stones on a 19x19 board. The objective is to capture territory and/or the other player’s stones by surrounding them. This question refers to a setting in which AlphaGo plays a single game (not a tournament) without timed moves.

For each part below, circle the choice which best describes this environment for AlphaGo:

a) **Fully observable** or **Partially observable** [1 point]

b) **Deterministic** or **Stochastic** [1 point]

c) **Episodic** or **Sequential** [1 point]

d) **Static** or **Dynamic** [1 point]

e) **Discrete** or **Continuous** [1 point]

f) Single agent or **Multi-agent** [1 point]

2. What type of agent is AlphaGo? Choose from simple reflex agent, model-based reflex agent, goal-based agent and utility-based agent. Explain your answer. [2 points]

Goal or utility based. The terminal states can be described as goal or non-goal for win/loss, or with a territory-based value for a utility to describe winning by a lot vs. a little.
II. Search [10 points]
4. We saw that hill climbing was not optimal because it can get stuck in local optima. Explain how simulated annealing addresses this weakness. What role does the temperature parameter $T$ play? [3 points]

Simulated annealing introduces random downhill moves to explore more of the search space than just the local optimum near the initial state (as hill climbing does). $T$ adjusts the probability of accepting random downhill moves, decreasing over time.

5. Recall the Cannibals & Missionaries problem from Programming Assignment 1, in which the problem is to transport some cannibals and missionaries from the right bank to the left bank of a river using a boat with capacity 2, while never allowing the cannibals to outnumber the missionaries on either bank. Assume there are at least one cannibal and at least one missionary in the problem. At any given state, let $C$ be the number of cannibals and $M$ be the number of missionaries remaining on the right bank. Consider using A* tree-search to solve this problem with one of the following admissible heuristics:

1) $\frac{C + M}{2}$
2) $C + M - 1$

a) Which of these heuristics dominates the other? Which expands more nodes during the search? Explain your answer. [3 points]

(2) dominates because its value is always greater than or equal to that of (1). (1) will therefore expand more nodes (all that (2) does plus some).
b) Give an example to show that $C + M$ is not an admissible heuristic. The example should be a fully-specified state in the state space. Explain why we can conclude from the example that $C + M$ is not admissible. [4 points]

With one cannibal and one missionary on the right bank, the goal is achievable in one move, but the heuristic has a value of 2. This is an overestimate, so the heuristic is not admissible.

III. Games [11 points]
6. Calculate the expectiminimax value of the root node in the game tree below. Show your work for partial credit. [7 points]
7. The order in which successors are evaluated affects the behavior of the alpha-beta algorithm. For the game tree below, the values of the unlabeled leaf nodes are 1, 3, and 5. List these values in the order that produces the maximum amount of pruning from the alpha-beta algorithm. [4 points]

5, 3, 1. (Really the 3 and 1 don’t matter as long as 5 is first.)

**IV. Propositional Logic [15 points]**

8. Consider the following KB consisting of two clauses:

\[ A \lor B \lor \neg C \]
\[ \neg B \lor D \lor A \]

Perform resolution on these two clauses. What new clause is generated? [2 points]

\[ A \lor D \lor \neg C \]
9. I am planting a garden in a limited amount of space. Based on my vegetable preferences, I have decided that:
I will plant tomatoes or eggplant or both.
If I plant tomatoes, then I will plant both basil and garlic.
If I plant garlic, then I will plant eggplant.
I will not plant both basil and eggplant.

a) Convert these English sentences into propositional logic. [4 points]

\[ T \lor E \]
\[ T \implies B \land G \]
\[ G \implies E \]
\[ \neg(B \land E) \]

b) Convert the propositional logic sentences from part (a) into CNF. [4 points]

1. \[ T \lor E \]
2. \[ \neg T \lor B \]
3. \[ \neg T \lor G \]
4. \[ \neg G \lor E \]
5. \[ \neg B \lor \neg E \]

c) Does the knowledge base entail that I will plant eggplant? Show the resolution steps to justify your answer. [5 points]

6. \[ \neg E \]
7. \[ T (6 + 1) \]
8. \[ G (7 + 3) \]
9. \[ E (8 + 4) \]
10. \[ \} (9 + 6) \]

Therefore, I will plant eggplant.