CSCD48: Artificial Intelligence

Sample Midterm Exam – Z Minutes

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Date:

UTORid:
First and Last Name:

Instructions.

- This test has X questions. Make sure to skim through all the questions before starting. This will help you pace yourself. This exam has Y points in total, and you have Z Minutes.
- This exam is closed book and closed notes, and no calculator is allowed.
- Write your answers on this questions paper. Make sure to put your name and UTORid on every page.
- Show your reasoning clearly. If your reasoning is correct, but your final answer is wrong, you will receive most of the credit. If you just show the answer without reasoning, and your answer is wrong, you may receive no points at all.

Question	**Score**
Question 1	/15
Question 2	/10
Question 3	/5
Question 4	/5
Question 5	/10
Total	/45

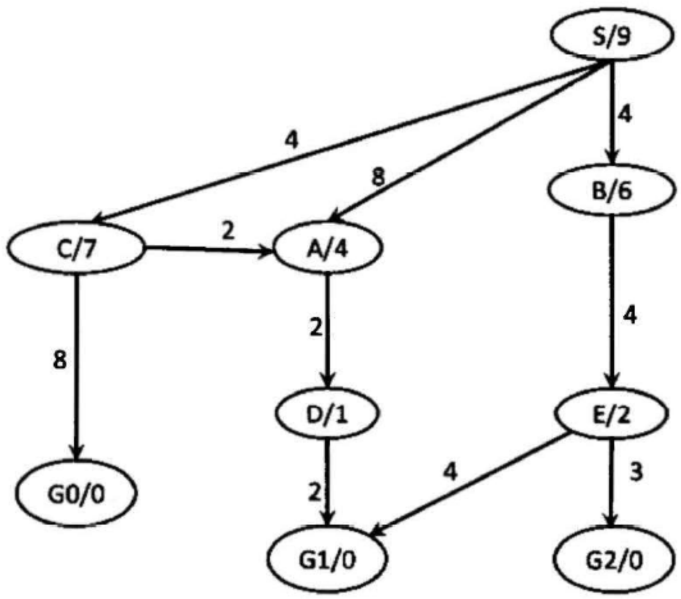
Question 1. [Search – 15 points]

(a) Consider the search graph below, where S is the start node and G0, G1, and G2 are goal states. Arcs are labeled with the cost of traversing them and heuristic estimate of the cost to a goal is shown inside the nodes. For each of the tree search strategies below, indicate which of the three goal states is reached.

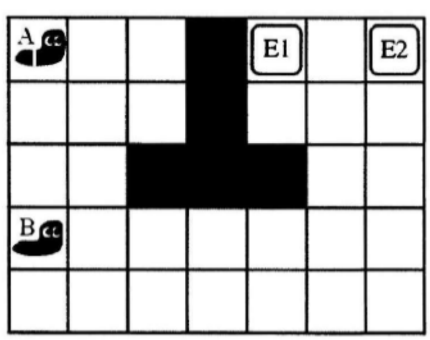
i. **[2 points]** Breadth-first search:

ii. **[2 points]** Uniform Cost search:

iii. **[2 points]** A* search:



(b) As shown in figure below, two slugs A and B want to exit a maze via exists E_1 and E_2. At each time step, each slug can either stay in place or move to an adjacent free square. A slug cannot move into a square that the other slug is moving into. Either slug may use either exit, but they cannot both use the same exit.



You wish to pose a search problem that will allow slugs to get to exit in as few time steps as possible. Let $d(c_1, c_2)$ denote Manhattan Distance between locations c_1 and c_2 (all locations consist of pair of numbers (x, y)). Consider three different search heuristics, defined in terms of the location of slug A and slug B and exit locations E_1 and E_2. Remember that either slug can use either exit, but they must use different exists.

Definition	Explanation
$h_1 = \max_{s \in \{A,B\}} \min\{d(s, E_1), d(s, E_2)\}$	Return the maximum, over the two slugs, of the distance from the slug to its closest exit.
$h_2 = \max\{d(A, E_1), d(B, E_2)\}$	Assign slug A to exit E_1 and B to E_2; then return the maximum distance from either slug to its assigned exit.
$h_3 = \min_{(e,e') \in \{(E_1,E_2),(E_2,E_1)\}} \max\{d(A, e), d(B, e')\}$	Return the max distance from a slug to its assigned exit, under the assignment of slugs to distinct exits which minimizes this quality.

i. **[4 points]** Which of these three heuristics are admissible? Mark all admissible heuristics.

☐ h_1 ☐ h_2 ☐ h_3

ii. **[5 points]** For two heuristics h_1 and h_2 we say that h_1 **dominates** h_2 if $h_1(s) \geq h_2(s)$ for all states. Note that the heuristics need not be admissible. For each pair of heuristics, mark the box that correctly describes their dominance relationship.

☐ h_1 dominates h_2 ☐ h_2 dominates h_1 ☐ $h_1 = h_2$ ☐ none

☐ h_1 dominates h_3 ☐ h_3 dominates h_1 ☐ $h_1 = h_3$ ☐ none

☐ h_2 dominates h_3 ☐ h_3 dominates h_2 ☐ $h_2 = h_3$ ☐ none

3	A2	A3	A4
B1	B2	B3	B4
C1	**3**	C3	C4
D1	D2	D3	**4**

Question 2. [CSP – 10 points]

The objective of the Sudoku game that is illustrated above is to place numbers $1, 2, 3, 4$ on the 4×4 grid such that each row, column, and 2×2 box constrains each number only once. In the illustration, some cells have assigned values; those that do not are labelled with letters (*e.g.*, A1, A2, etc.). Assume you are solving this puzzle as a CSP that contains only binary not-equals constraints.

a) **[2 points]** Assume you have been using forward checking and A3 is chosen for assignment. List all values (in any order) that might be selected by the least Constraining Value (LCV) Heuristic.

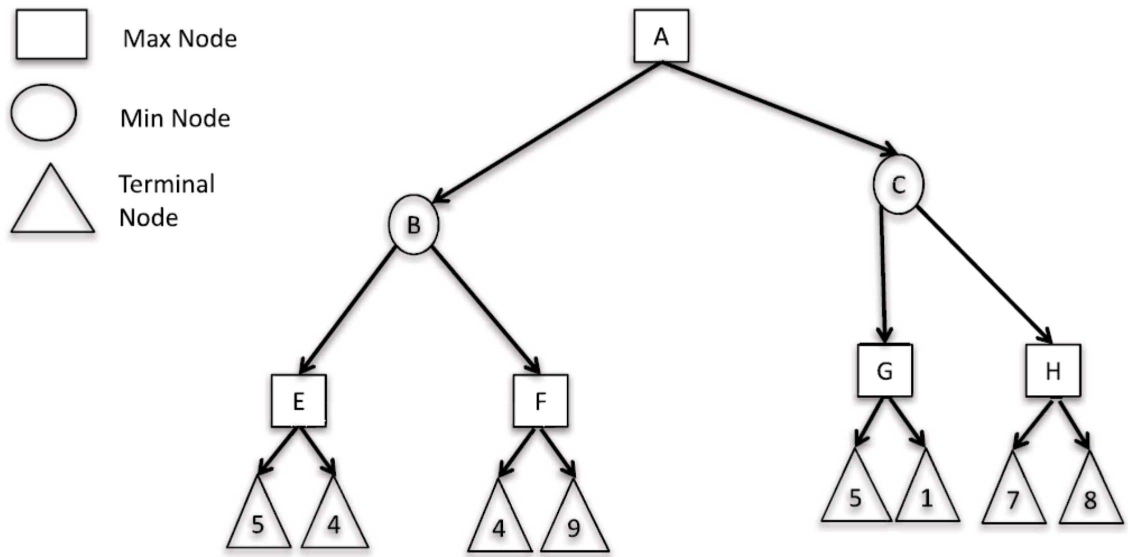
b) **[3 points]** Assume you have been using forward checking and no variables has been chosen for assignment. List all unassigned variables (in any order) that might be selected by Minimum Remaining Values (MRV) Heuristic.

c) **[2 points]** What does it mean for a CSP to be "arc consistent"?

d) **[3 points]** Given the current assignment, the cell labelled D3 cannot be a 1 or 2. If we run AC3 to enforce Arc-Consistency on the current CSP, will these values be pruned?

Question 3. [Game Tree Search – 5 points]

Consider the following simple game search tree.



(a) **[1 point]** Mark the moves that would be corect for Max when Max is at position A and Max is following minimax strategy.

☐ Move to B ☐ Move to C

(b) **[1 point]** What is the value that Max would expect to obtain if both Max and Min follow a minimax strategy.

(c) **[3 point]** On the diagram draw a line across the edges that would be pruned by alpha-beta pruning. **You do not need to mark the edges in the subtree, just the edge leading to the pruned subtree.**

Question 4. [Game Theory – 5 points]

Consider the following two-player game in which each player has three strategies.

Player A \ Player B	L	M	R
U	(1, 1)	(2, 3)	(1, 6)
M	(3, 4)	(5, 5)	(2, 2)
D	(1, 10)	(4, 7)	(0, 4)

Find all the pure strategy Nash equilibria for this game.

Question 5. [MDP – 10 points]

Suppose Sam wanted to make an informed decision about whether to party or relax over the weekend. Sam prefers to party, but is worried about getting sick. Such a problem can be modeled as an MDP with two states, *healthy* and *sick*, and two actions, *relax* and *party*. Based on experience, Sam estimates that the dynamics $P(s' \mid s, a)$ is given by

S	A	Probability of $s' =$ *healthy*
healthy	relax	0.95
healthy	party	0.7
sick	relax	0.5
sick	party	0.1

Sam estimates the rewards to be the following, irrespective of the resulting state:

S	A	Reward
healthy	relax	7
healthy	party	10
sick	relax	0
sick	party	2

(a) **[2 point]** Explain why the the total reward for all of these policies is infinite when decay factor is $\gamma = 1$.

(b) **[8 point]** Prove that when $\gamma = 0.8$, the optimal policy is to party when healthy and relax when sick.