UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
CS 440/ECE 448 Artificial Intelligence
Spring 2019

EXAM 1 REVIEW

Tuesday, February 26, 2019

- This is a CLOSED BOOK exam. No calculators are permitted. You need not simplify explicit numerical expressions.
- This review includes many problems. Exam is typically 8 T/F questions, 8 short answer questions, and 3 long questions.

Name: ______________________________

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Section: ______________________________

1. (2 points) An unknown environment is also unobservable.

   ◯ True

   ◯ False

   Explain:

2. (2 points) In a fully observable, known, static, single-agent, sequential, stochastic environment, an internal-state agent has no more information available to it than a reflex agent.

   ◯ True

   ◯ False

   Explain:

3. (2 points) Suppose you are given a "perfect" heuristic function that gives the correct minimum cost from each node to the goal. True or false: greedy best-first search with this heuristic always returns the solution with the lowest cost.

   ◯ True

   ◯ False

   Explain:

4. (2 points) The GRAPHPLAN algorithm develops a planning graph until it reaches a level at which no pair of goal predicates is mutex, and then stops.

   ◯ True

   ◯ False

   Explain:

5. (2½ points) Give one reason why a test of intelligence should evaluate action rather than thought. Give one reason why such a test should evaluate thought rather than action.

6. (2½ points) Can an environment be both known and unobservable? Give an example.

7. (2½ points) What is the difference between a goal-directed agent and a utility-directed agent? Given

an example of each, from among the software agents that you have written for machine problems in this course.

8. ($2\frac{1}{2}$ points) Discuss the relative strengths and weaknesses of breadth-first search vs. depth-first search for AI problems.

9. ($2\frac{1}{2}$ points) In the tree search formulation, why do we restrict step costs to be non-negative?

10. ($2\frac{1}{2}$ points) What is the distinction between a world state and a search tree node?

11. ($2\frac{1}{2}$ points) How do we avoid repeated states during tree search?

12. ($2\frac{1}{2}$ points) How can randomness be incorporated into a game tree? How about partial observability (imperfect information)?

13. ($2\frac{1}{2}$ points) What are the main challenges of adversarial search as contrasted with single-agent search? What are some algorithmic similarities and differences?

14. ($2\frac{1}{2}$ points) What additional difficulties does dice throwing or other sources of uncertainty introduce into a game?

15. ($2\frac{1}{2}$ points) What is local search for CSPs? For which kinds of CSPs might local search be better than backtracking search? What about the other way around?

16. ($2\frac{1}{2}$ points) Explain why it is a good heuristic to choose the variable that is *most* constrained but the value that is *least* constraining in a CSP search.

17. ($2\frac{1}{2}$ points) Use the axioms of probability to prove that $P(\neg A) = 1 - P(A)$.

18. ($2\frac{1}{2}$ points) Consider the following joint probability distribution:

$$
\begin{aligned}
P(A, B) &= 0.12 \\
P(A, \neg B) &= 0.18 \\
P(\neg A, B) &= 0.28 \\
P(\neg A, \neg B) &= 0.42
\end{aligned}
$$

What are the marginal distributions of A and B? Are A and B independent and why?

19. ($2\frac{1}{2}$ points) 20% of students at U of I are part of the Greek system. Amongst these students, 10% study engineering. Furthermore, 15% of the entire student body studies engineering. Given that we know that a student studies engineering, what is the probability that the student is not part of the Greek system?

20. ($2\frac{1}{2}$ points) Give an example of a coordination game and an anti-coordination game. For each game, write down its payoff matrix, list dominant strategies, Pareto optimal solutions, and pure strategy Nash equilibria (if any).

21. ($2\frac{1}{2}$ points) In the lectures, we covered dominant strategies, Nash equilibria, and Pareto optimal solutions of simultaneous move games. We can also consider minimax strategies for such games, defined in the same way as for multi-player alternating games. What would be the minimax strategies in the Prisoners Dilemma, Stag Hunt, and Game of Chicken? If both players follow the minimax strategy, does the game outcome differ from the Nash equilibria? When/why would one prefer to choose a minimax strategy rather than a Nash equilibrium?

22. (7 points) Suppose you have to design an agent to play the game of Scrabble. Write a PEAS specification for the agent and characterize the task environment according to the seven relevant categories.

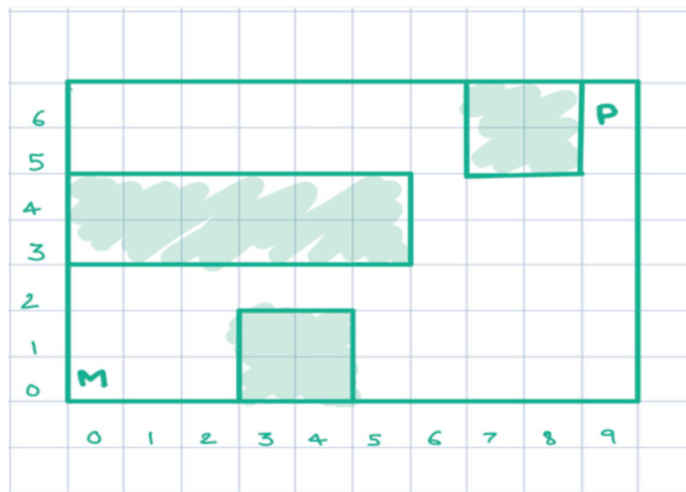
23. (6 points) For each type of maze described below, specify the typical-case time complexity and space complexity of both breadth-first-search (BFS) and depth-first-search (DFS). Assume that both BFS and DFS return the first solution path they find.

    (a) The Albuquerque maze has $b = 3$ possible directions that you can take at each intersection. No path is longer than $m = 25$ steps. There is only one solution, which is known to require exactly $d = 25$ steps.

(b) The Belmont maze has $b = 3$ possible directions that you can take at each intersection. No path is longer than $m = 25$ steps. About half of all available paths are considered solutions to the maze.

(c) The Crazytown maze has $b = 3$ possible directions that you can take at each intersection. The maze is infinite in size, so some paths have infinite length. There is only one solution, which is known to require $d = 25$ steps.

24. (8 points) Refer to the maze shown below. Here, M represents Mario, P represents Peach, and the goal of the game is to get Mario and Peach to find each other. In each move, both Mario and Peach take turns. For example, one move would consist of Peach moving a block to the bottom from her current position, and Mario moving one block to the left from his current position. Standing still is also an option.



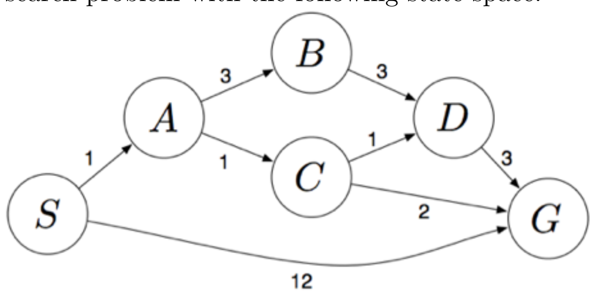
(a) Describe state and action representations for this problem.

(b) What is the branching factor of the search tree?

(c) What is the size of the state space?

(d) Describe an admissible heuristic for this problem.

25. (8 points) Consider the search problem with the following state space:



S denotes the start state, G denotes the goal state, and step costs are written next to each arc. Assume that ties are broken alphabetically (i.e., if there are two states with equal priority on the frontier, the state that comes first alphabetically should be visited first).

(a) What path would BFS return for this problem?

(b) What path would DFS return for this problem?

(c) What path would UCS return for this problem?

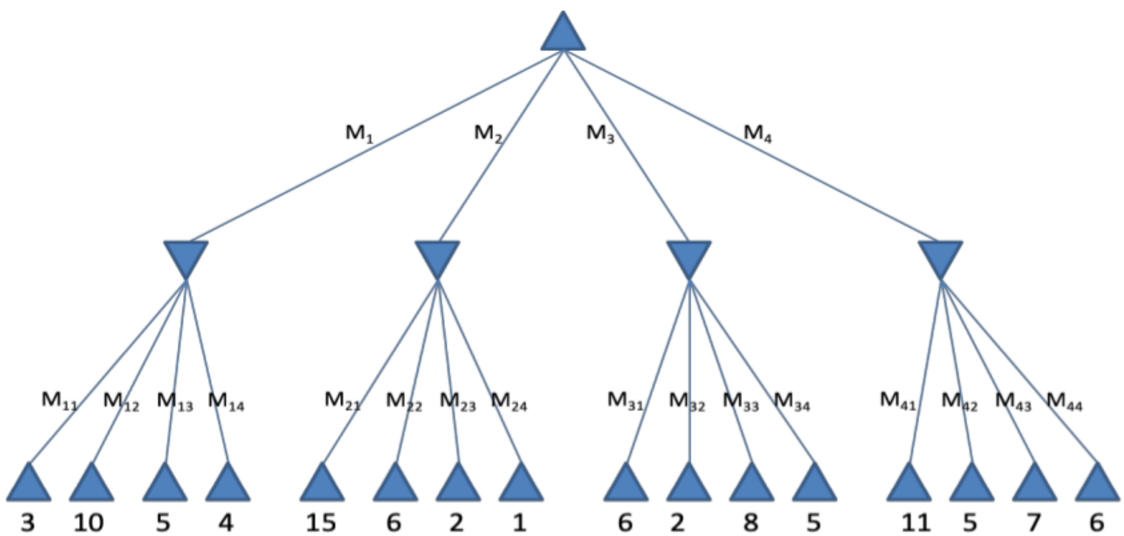
(d) Consider the heuristics for this problem shown in the table below.

State	h_1	h_2
S	5	4
A	3	2
B	6	6
C	2	1
D	3	3
G	0	0

i. Is h1 admissible? Is it consistent?

ii. Is h2 admissible? Is it consistent?

26. (8 points) Consider the following game tree (MAX moves first):



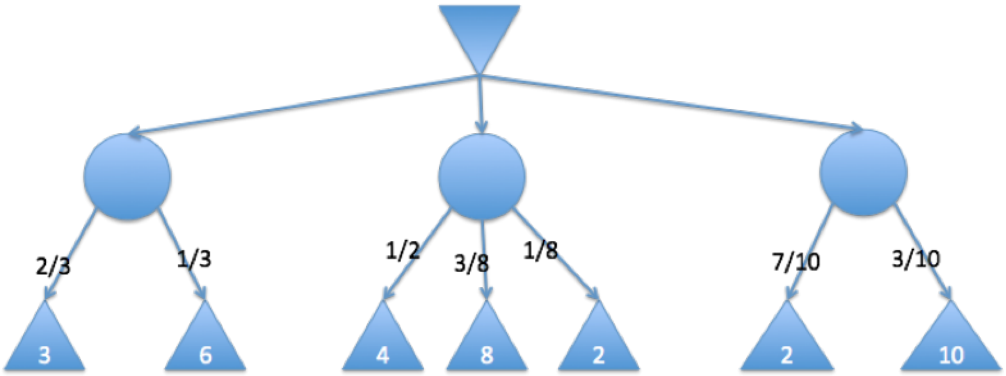
(a) Write down the minimax value of every non-terminal node next to that node.

(b) How will the game proceed, assuming both players play optimally?

(c) Cross out the branches that do not need to be examined by alpha-beta search in order to find the minimax value of the top node, assuming that moves are considered in the non-optimal order shown.

(d) Suppose that a heuristic was available that could re-order the moves of both max (M_1, M_2, M_3, M_4) and min $(M_{11}, \ldots, M_{44})$ in order to force the alpha-beta algorithm to prune as many nodes as possible. Which max move would be considered first: M_1, M_2, M_3, or M_4? Which of the min moves $(M_{11}, \ldots, M_{44})$ would have to be considered?

27. (8 points) Consider the following expectiminimax tree:



Circle nodes are chance nodes, the top node is a min node, and the bottom nodes are max nodes.

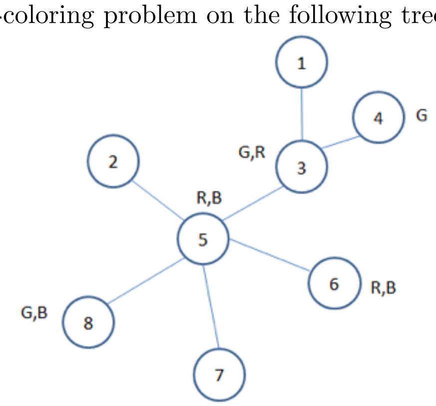
(a) For each circle, calculate the node values, as per expectiminimax definition.

(b) Which action should the min player take?

28. (8 points) Consider the following game, called "High/Low." There is an infinite deck of cards, half of which are 2s, one quarter are 3s, and one quarter are 4s. The game starts with a 3 showing. After each card, you say "High" or "Low," and a new card is flipped. If you are correct (e.g., you say "High" and then the next card is higher than the one showing), you win the points shown on the new card. If there is a tie (the next card equals the one showing), you get zero points. If you are wrong (e.g., you say "High" and then the next card is lower than the one showing), then you lose the amount of the card that was already showing.

    Draw the expectimax tree for the first round of this game and write down the expected utility of every node. What is the optimal policy assuming the game only lasts one round?

29. (6 points) Consider the graph-coloring problem on the following tree-structured CSP:



We assume there are three available colors (R,G,B) and some nodes are constrained to use only a subset of these colors, as indicated above. Show all the steps for applying the tree-structured CSP algorithm for finding a solution to this problem.

30. (5 points) For each of the following problems, determine whether an algorithm to optimally solve the problem requires worst-case computation time that is polynomial or exponential in the parameters d and m (assuming that P $\neq$ NP).

    (a) A map has d regions. Colors have been applied to all m regions, drawing from a set of m possible colors. Your algorithm needs to decide whether or not any two adjacent regions have the same color.

    (b) b. A map has d regions. Your algorithm needs to assign colors to all d regions, drawing colors from a set of m possible colors, in order to guarantee that no two adjacent regions have the same color.

(c) Your algorithm needs to find its way out of a maze drawn on a d-by-d grid.

(d) Your algorithm needs to find the shortest path in a d-by-d maze while hitting m waypoints (equivalent to dots in MP1 part 1.2).

(e) Your algorithm needs to solve a planning problem in a blocks world consisting of d blocks.

31. (7 points) Let A and B be independent binary random variables with $p(A = 1) = 0.1$, $p(B = 1) = 0.4$. Let C denote the event that at least one of them is 1, and let D denote the event that exactly one of them is 1.

    (a) What is $P(C)$?

    (b) What is $P(D)$?

    (c) What is $P(D|A = 1)$?

(d) Are A and D independent? Why?

32. (12 points) Consider the following game:

	Player A: Action 1	Player A: Action 2
Player B: Action 1	A=3 B=2	A=0 B=0
Player B: Action 2	A=1 B=1	A=2 B=3

(a) Find dominant strategies (if any).

(b) Find pure strategy equilibria (if any).

33. (12 points) In each square, the first number refers to payoff for the player whose moves are shown on the row-label, the second number refers to payoff for the player shown on the column label.

	A	B	C
A	0, 0	25, 40	5, 10
B	40, 25	0, 0	5, 15
C	10, 5	15, 5	10, 10

(a) Are there any dominant strategies? If so, what are they? If not, why not?

(b) Are there any pure-strategy Nash equilibria? If so, what are they? If not, why not?

(c) Are there any Pareto-optimal solutions? If so, what are they? If not, why not?

34. (12 points) Suppose that both Alice and Bob want to go from one place to another. There are two routes R1 and R2. The utility of a route is inversely proportional to the number of cars on the road. For instance, if both Alice and Bob choose route R1, the utility of R1 for each of them is 1/2.

    (a) Write out the payoff matrix.

    (b) Is this a zero-sum game?

    (c) Find dominant strategies, if any. If there are no dominant solution, explain why not.

(d) Find pure strategy equilibria, if any. If there are no pure strategy equilibria, explain why not.

(e) Find the mixed strategy equilibrium.