PART A [50%]: One answer per question. List your answers here:

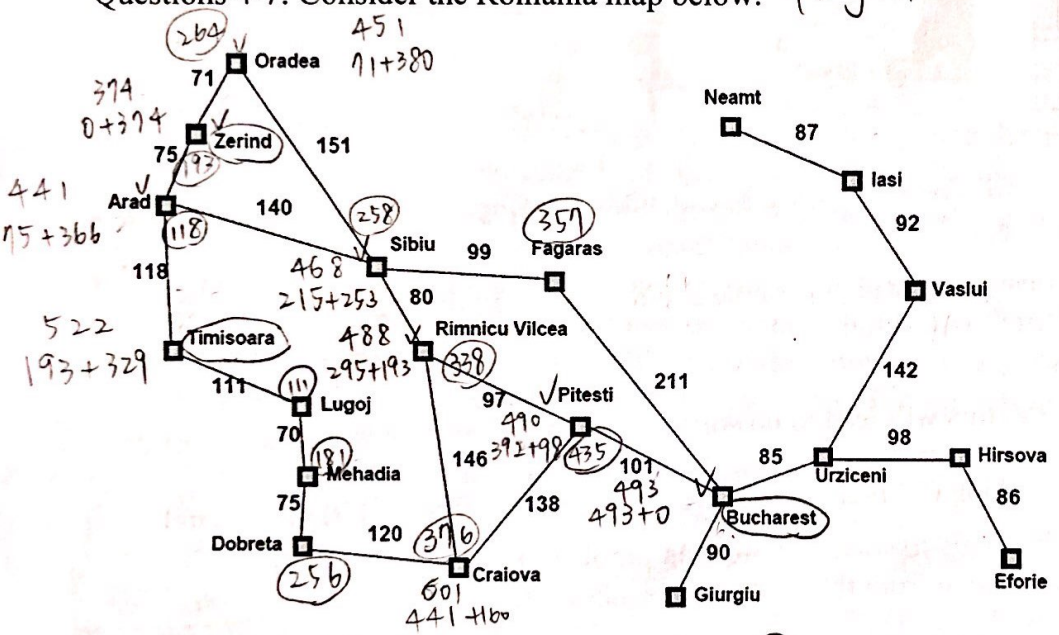
1. C	2. A	3. D	4. A	5. B	6. A	7. BD	8. D	9. C	10. A
11. D	12. B	13. A	14. B	15. B	16. A	17. B	18. D	19. B	20. D

C **1.** For driving a car on a bumpy dirt surface, which of the following best describes the environment?
(A) stochastic and discrete (B) deterministic and discrete
(C) stochastic and continuous (D) deterministic and continuous

A **2.** Letter 'S' in the term "PEAS" description of a task environment represents
(A) sensors (B) speed (C) sources (D) space.

D **3.** Which data structure is suitable for the frontier in a depth-first search?
(A) look-up table (B) FIFO queue (C) priority queue (D) stack

Questions 4-7: Consider the Romania map below: $f = g + h$



Straight-line distance to Bucharest	
Arad	366
Bucharest	0
Craiova	160
Dobreta	242
Eforie	161
Fagaras	178
Giurgiu	77
Hirsova	151
Iasi	226
Lugoj	244
Mehadia	241
Neamt	234
Oradea	380
Pitesti	98
Rimnicu Vilcea	193
Sibiu	253
Timisoara	329
Urziceni	80
Vaslui	199
Zerind	374

A **4.** Which of the following searching strategies is not complete in this problem?
(A) depth-first with tree-search (B) depth-first with graph-search
(C) breadth-first with tree-search (D) breadth-first with graph-search

B **5.** From Timisoara to Bucharest, what is the number of steps of the path found by breadth-first search?
(A) 3 (B) 4 (C) 5 (D) 6

A **6.** To search for a path from Timisoara to Bucharest using uniform-cost search, what is the following is true?
(A) Zerind is expanded before Sibiu.
(B) Zerind is expanded after Dobreta.
(C) The solution path goes through Fagaras.
(D) The path found has the same number of steps as the path found by BFS.

B **7.** How many nodes are expanded by A* search when searching for a path from Zerind to Bucharest?
(A) 5 (B) 6 (C) 7 (D) 8

助教：不管 Zerind

D **8.** Which of the following is true about the relation between IDS and BFS?
(A) IDS involves repeated calls to BFS.

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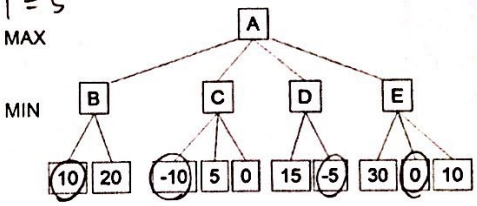
(B) The time complexity of IDS is $O(d)$ times the time complexity of BFS; d is solution depth.
(C) IDS and BFS have the same big-O space complexity.
(D) Tree-search IDS and BFS will find solutions of the same length.

9. In a 2-location vacuum cleaner world where the only percept of the agent is the clean/dirty status of its current position, how many states are in its belief state given the initial percept input and before any action is taken?
(A) 1 (B) 2 (C) 4 (D) 8

10. We are to use hill-climbing to maximize the function $f(x,y)=(3x+3y-2x^2+2xy-y^2)$, where x and y are integers. In each step, the allowed actions are to change x or y (but not both) by ±1. If the current position is (1,0), which of the following is the next position?
(A) (1,1) (B) (1,−1) (C) (0,0) (D) (2,0)

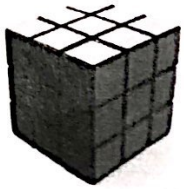
$f(1,0) = 3+0-2+0-0 = 1$
$f(1,1) = 3+3-2+2-1 = 5$
$f(1,-1) = 3-3-2-2-1$ MAX
$f(2,0) = 6-6$

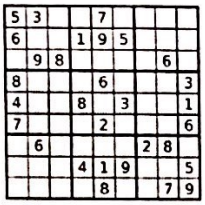
11. Given the game tree to the right, which action should MAX take?
(A) E (B) C (C) D (D) B

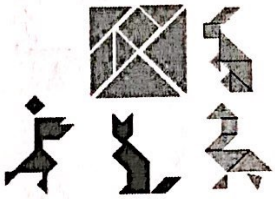


12. To handle stochastic games, what type of nodes is added to the game tree?
(A) random (B) chance (C) evaluation (D) minimax

13. Which of the following game is not a constraint satisfaction problem (CSP)?
(A) magic cube (B) Sudoku (C) word puzzle (D) tangram (七巧板)





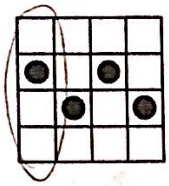


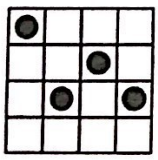
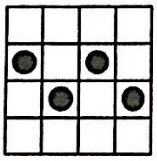
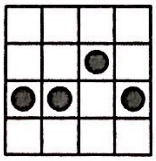
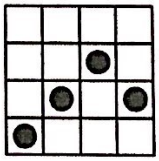
Questions 14-15: This is a CSP problem. The variables a, b, c, d, and e are single-digit integers that satisfy the following constraints: a is even, b>a, c>7, d=2b, e=c-3, e≠a, |d-e|=1

14. After applying only the unary constraints, which variable should we assign first according to the minimum-remaining-value heuristic?
(A) b (B) c (C) e (D) a

15. If the first assigned variable is d=2, this will lead to no solution. What method can we use to detect this failure before any other variable is assigned?
(A) degree heuristic (B) forward checking (C) maintaining-arc-consistency algorithm (D) local search

16. We are using the Min-Conflicts heuristic to solve the 4-queen problem. If we have selected the queen in the leftmost column to move from the current state (shown to the right), which one below is the state after the move?



(A)  (B)  (C)  (D) 

17. Which of the following propositional logic sentences is valid?
(A) $p \Leftrightarrow \neg p$ (B) $p \vee (p \Rightarrow q)$ (C) $(p \vee q) \Rightarrow (p \wedge q)$ (D) $p \wedge q$

18. Truth values of propositional symbols A, B, C and D are related to truth values of P and Q according to the given truth table. Which of them is entailed by P?
(A) A (B) B (C) C (D) D

P	Q	A	B	C	D
F	F	F	F	T	T
F	T	T	T	T	F
T	F	F	T	T	T
T	T	T	F	F	T

19. We start with these sentences in the KB: E, $A \wedge B \Rightarrow C$, $A \wedge F \Rightarrow C$, $F \Rightarrow A$, $B \Rightarrow D$, $E \Rightarrow F$. Which of the following cannot be proved true using forward-chaining?
(A) F (B) D (C) A (D) C

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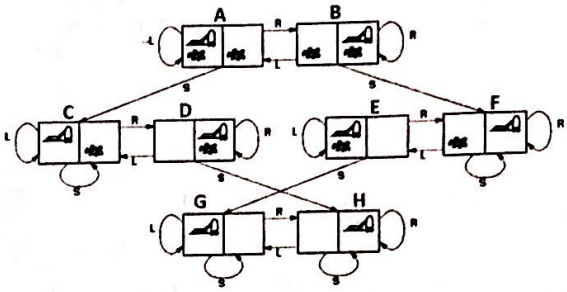
20. In the standard Monte-Carlo Tree Search algorithm, which step is used to update the "goodness" of nodes in the search tree?
(A) selection (B) expansion (C) simulation (D) back-propagation

PART B: Provide all the details

1. [10%] The figure shows the state space of the simple two-cell vacuum cleaner world. G and H are the goal states.

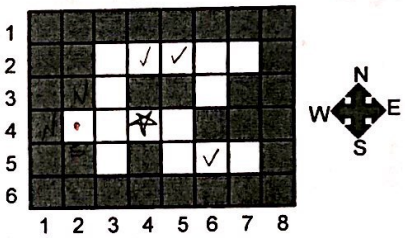


(a) Give the ranges of the numbers of both generated and expanded nodes when searched with tree-search BFS from state A.
(b) Can "the number of dirty cells" be used as an admissible heuristic? Briefly explain.
(c) Apply A* search from state A using the heuristic in (b). List the complete search process. Does it find an optimal path?

2. [10%] We have three variables X, Y, and Z. Their initial domains are digits {0, 1, …, 9}. Given the constraints $X=Y^2$ and $X=Z^3$, use AC-3 to update their domains to make them arc-consistent. Don't just show the results.

3. [10%] A propositional KB contains these sentences:
A, B, P⇒Q, L∧M⇒P, L∧B⇒M, A∧B⇒L, A∧P⇒L
(a) Convert them into CNF.
(b) Use resolution to prove Q.

4. [10%] An agent is equipped with the map. Its state is its location in the map, but it does not know its initial state. It can only be in white cells and it can sense the existence of walls (gray cells) at the four nearest surrounding cells (*N*, *S*, *E*, *W*). For example, the percept is *NSW* at (2,4).



(a) Which states are in the initial belief state? (no percept yet)
(b) Given the initial percept *NS*, which states are in the belief state?
(c) Assume that the agent starts at (4,4), although it does not know this. How many steps does the agent need to take to determine its location? Show your reasoning.

5. [10%] This is about multi-armed bandit problems:

$$UCB(q) = X(q) + c\sqrt{\frac{\log_{10} n}{n(q)}}$$

exploitation / exploration

q: a choice (arm)
X(*q*): current value (reward ratio) of *q*
n(*q*): times of playing *q*
n: times of playing all choices
c: a weighting constant

(a) Briefly describe what a multi-armed bandit problem is.
(b) Describe the purpose of the function UCB in such problems.
(c) Which terms in UCB corresponds to exploration and exploitation, respectively? Explain.
(d) When experiences are accumulated (i.e., as *n* increases) over time, how are the relative contributions of exploration and exploitation in UCB change? Explain.

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