

## CS-171, Intro to A.I. — Mid-term Exam — Winter Quarter, 2014

YOUR NAME: \_\_\_\_\_

YOUR ID: \_\_\_\_\_ ID TO RIGHT: \_\_\_\_\_ ROW: \_\_\_\_\_ SEAT NO.: \_\_\_\_\_

**The exam will begin on the next page. Please, do not turn the page until told.**

**When you are told to begin the exam, please check first to make sure that you have all eight pages, as numbered 1-8 in the bottom-right corner of each page.**

**The exam is closed-notes, closed-book. No calculators, cell phones, electronics.**

**Please clear your desk entirely, except for pen, pencil, eraser, a blank piece of paper (for scratch pad use), and an optional water bottle. Please write your name and ID# on the blank piece of paper and turn it in with your exam.**

This page summarizes the points available for each question so you can plan your time.

**1. (10 pts total, 2 pts each) WUMPUS WORLD MODELS.**

~~**2. (10 pts total) Resolution Proof. (<http://www.braingle.com>)**~~

**3. (10 pts total) DOMINATING HEURISTICS.**

**4. (8 pts total, 2 pts each) TASK ENVIRONMENT.**

**5. (10 pts total, 1/2 pt each) SEARCH PROPERTIES.**

**6. (12 pts total, 1 pt each) LOGIC CONCEPTS.**

**7. (20 points total, 4 pts each) CONSTRAINT SATISFACTION PROBLEM**

**8. (20 pts total, 2 pts each) State-Space Search.**

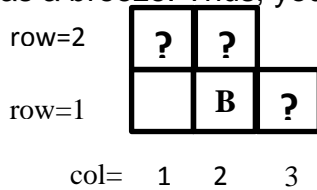


**1. (10 pts total, 2 pts each) WUMPUS WORLD MODELS.**

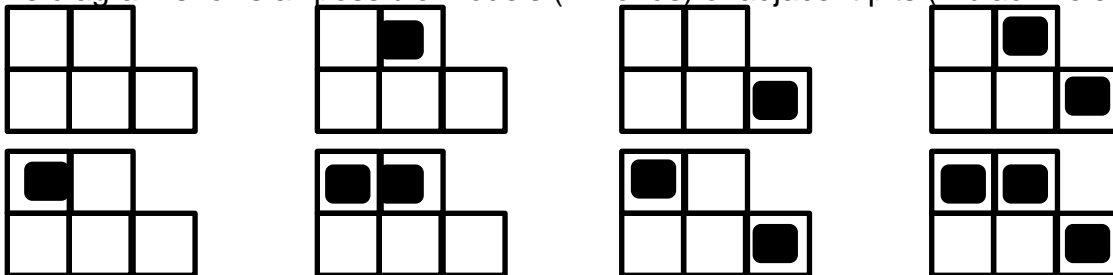
Recall that a knowledge base KB entails a sentence S (written  $KB \models S$ ) just in case the set of models that make the knowledge base true is a subset of the models that make S true (a model is a possible world). If this condition holds, it is impossible for KB to be true and S to be false. In such a case, S must be true in all worlds in which KB is true.

This question will concern only breezes and pits. Squares next to pits are breezy, and breezy squares are next to squares with pits. We ignore the wumpus, gold, etc.

Your agent did not detect a breeze at square [1,1] (row, column). Square [1,2] has a breeze. Thus, your knowledge base  $KB = (\neg B_{1,1}) \wedge (B_{1,2})$ , where B = Breeze.



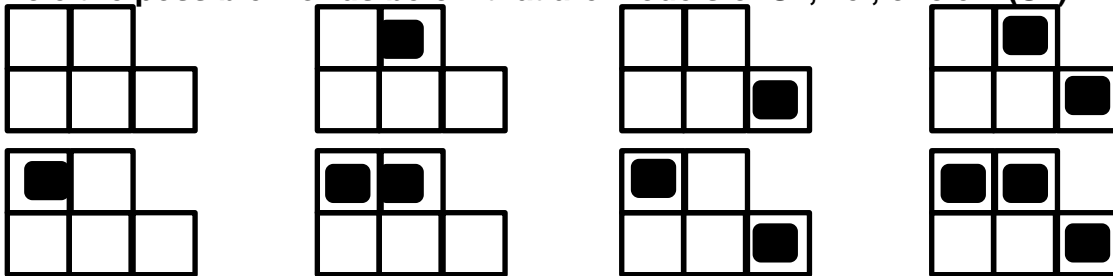
This diagram shows all possible models (= worlds) of adjacent pits (= black holes):



1.a. Circle the possible worlds above that are models of KB, i.e., circle  $M(KB)$ .

1.b. Consider ONLY the sentence  $S1 = \text{“Square [2,1] does not have a pit.”}$

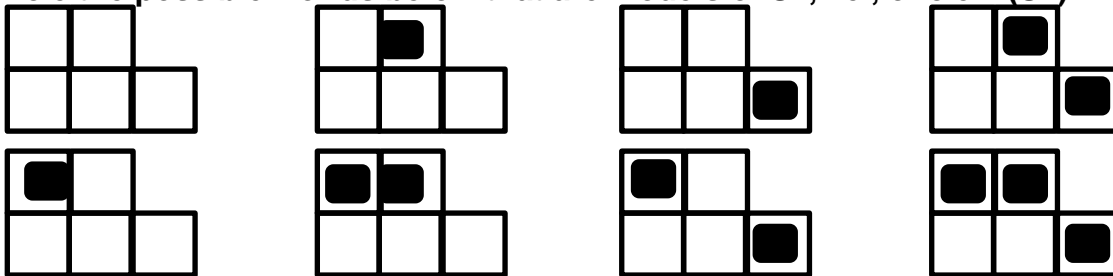
Circle the possible worlds below that are models of  $S1$ , i.e., circle  $M(S1)$ .



1.c. Does  $KB \models S1$ ? (Y = yes, N = no) \_\_\_\_\_

1.d. Consider ONLY the sentence  $S2 = \text{“Square [2,2] does not have a pit.”}$

Circle the possible worlds below that are models of  $S2$ , i.e., circle  $M(S2)$ .

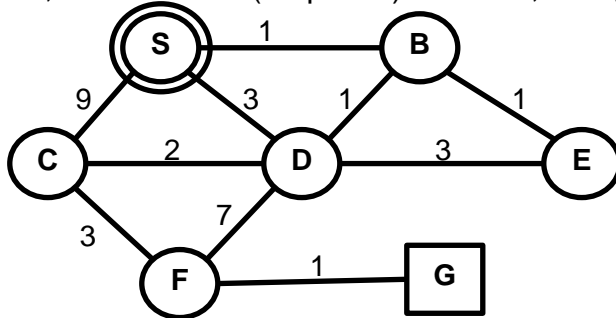


1.e. Does  $KB \models S2$ ? (Y = yes, N = no) \_\_\_\_\_

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**2. CANCELLED (10 pts total) Resolution Proof.**  
**Everyone gets this question correct regardless of your answer.**

**3. (10 pts total) DOMINATING HEURISTICS.** In this question, you are asked to compare different heuristics and to determine which, if any, dominate each other. You are executing Tree Search through this graph (i.e., you do not remember previously visited nodes). The start node (= initial state) is S, and the goal node is G. Actual step costs are shown next to each link. Heuristics are given in the following table. As is usual in your book,  $h^*$  is the true (= optimal) heuristic; here,  $h_i$  are various other heuristics.



Node	h1	h2	h3	$h^*$ (optimal)
S-Start	5	5	5	8
B	4	5	4	7
C	3	2	5	4
D	1	4	3	6
E	3	4	4	8
F	0	1	1	1
G-Goal	0	0	0	0

**3.a. (2 pts)**  
Which heuristic functions are admissible among  $h_1$ ,  $h_2$  and  $h_3$ ? \_\_\_\_\_

**3.b. (2 pt)**  
Which heuristic functions are consistent among  $h_1$ ,  $h_2$  and  $h_3$ ? \_\_\_\_\_

**3.c. (6 pts, 1 pt each)**  
Which of the following statements are true? (write T=True, F=False)

- (a)  $h_1$  dominates  $h_2$ . (T or F) \_\_\_\_\_
- (b)  $h_1$  dominates  $h_3$ . (T or F) \_\_\_\_\_
- (c)  $h_2$  dominates  $h_1$ . (T or F) \_\_\_\_\_
- (d)  $h_2$  dominates  $h_3$ . (T or F) \_\_\_\_\_
- (e)  $h_3$  dominates  $h_1$ . (T or F) \_\_\_\_\_
- (f)  $h_3$  dominates  $h_2$ . (T or F) \_\_\_\_\_

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**4. (8 pts total, 2 pts each) TASK ENVIRONMENT.** Your book defines a task environment as a set of four things, with the acronym PEAS. Fill in the blanks with the names of the PEAS components.

P \_\_\_\_\_ E \_\_\_\_\_ A \_\_\_\_\_ S \_\_\_\_\_

**5. (10 pts total, 1/2 pt each) SEARCH PROPERTIES.**

Fill in the values of the four evaluation criteria for each search strategy shown. Assume a tree search where  $b$  is the finite branching factor;  $d$  is the depth to the shallowest goal node;  $m$  is the maximum depth of the search tree;  $C^*$  is the cost of the optimal solution; step costs are identical and equal to some positive  $\epsilon$ ; and in Bidirectional search both directions using breadth-first search.

Note that these conditions satisfy all of the footnotes of Fig. 3.21 in your book.

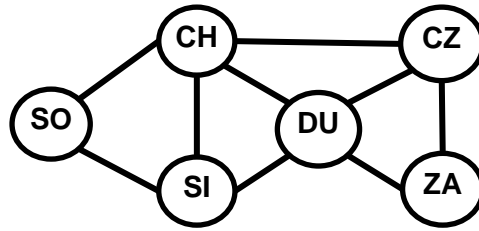
Criterion	Complete?	Time complexity	Space complexity	Optimal?
Breadth-First				
Uniform-Cost				
Depth-First				
Iterative Deepening				
Bidirectional (if applicable)				

**6. (12 pts total, 1 pt each) LOGIC CONCEPTS.** For each of the following terms on the left, write in the letter corresponding to the best answer or the correct definition on the right. The first one is done for you as an example.

<b>A</b>	Agent	A	Perceives environment by sensors, acts by actuators.
	Syntax	B	Chain of inference rule conclusions leading to a desired sentence.
	Semantics	C	Specifies all the sentences in a language that are well formed.
	Entailment	D	Describes a sentence that is true in all models.
	Sound	E	Stands for a proposition that can be true or false.
	Complete	F	Represented as a canonical conjunction of disjunctions.
	Propositional Symbol	G	Possible world that assigns TRUE or FALSE to each proposition.
	Valid	H	Describes a sentence that is false in all models.
	Satisfiable	I	Defines truth of each sentence with respect to each possible world.
	Unsatisfiable	J	An inference procedure that derives only entailed sentences.
	Proof	K	An inference procedure that derives all entailed sentences.
	Model	L	The idea that a sentence follows logically from other sentences.
	Conjunctive Normal Form	M	Describes a sentence that is true in some model.

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**7. (20 points total, 4 pts each) CONSTRAINT SATISFACTION PROBLEMS.**



SO = Sonora  
 CH = Chihuahua  
 CZ = Coahuila de Zaragoza  
 DU = Durango  
 SI = Sinaloa  
 ZA = Zacatecas

You are a map-coloring robot assigned to color this Northwest Mexico map. Adjacent regions must be colored a different color (R=Red, B=Blue, G=Green). The constraint graph is shown.

**7a. (4 pts total) FORWARD CHECKING.** Cross out all values that would be eliminated by Forward Checking, after variable DU has just been assigned value G, as shown:

SO	CH	CZ	DU	SI	ZA
R G B	R G B	R G B	G	R G B	R G B

**7b. (4 pts total) ARC CONSISTENCY.**

SO and CZ have been assigned values, but no constraint propagation has been done. Cross out all values that would be eliminated by Arc Consistency (AC-3 in your book).

SO	CH	CZ	DU	SI	ZA
B	R G B	R	R G B	R G B	R G B

**7c. (4 pts total) MINIMUM-REMAINING-VALUES HEURISTIC.** Consider the assignment below. SI is assigned and constraint propagation has been done. List all unassigned variables that might be selected by the Minimum-Remaining-Values (MRV) Heuristic: \_\_\_\_\_.

SO	CH	CZ	DU	SI	ZA
G B	G B	R G B	G B	R	R G B

**7d. (4 pts total) DEGREE HEURISTIC.** Consider the assignment below. (It is the same assignment as in problem 7c above.) SI is assigned and constraint propagation has been done. List all unassigned variables that might be selected by the Degree Heuristic: \_\_\_\_\_.

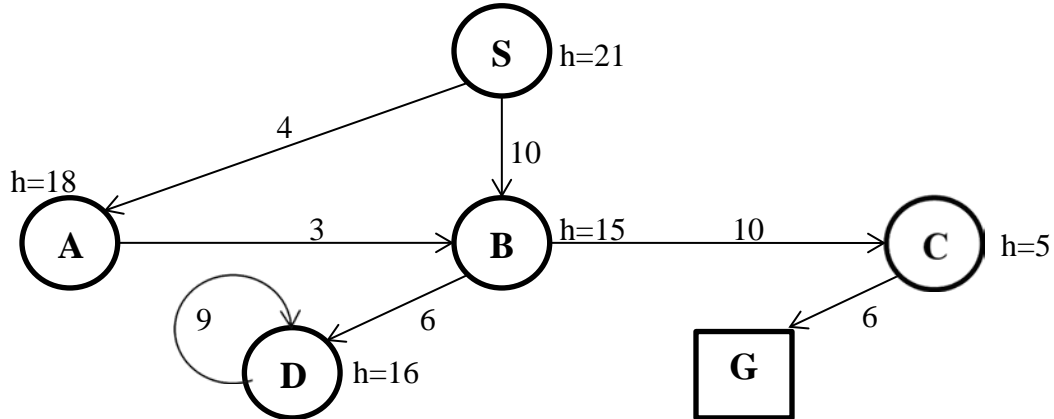
SO	CH	CZ	DU	SI	ZA
G B	G B	R G B	G B	R	R G B

**7e. (4 pts total) MIN-CONFLICTS HEURISTIC.** Consider the complete but inconsistent assignment below. DU has just been selected to be assigned a new value during local search for a complete and consistent assignment. What new value would be chosen below for DU by the Min-Conflicts Heuristic? \_\_\_\_\_.

SO	CH	CZ	DU	SI	ZA
B	G	G	?	G	B

**8. (20 pts total, 2 pts each) State-Space Search.** Execute Tree Search through this graph (do not remember visited nodes, so repeated nodes are possible). It is not a tree, but pretend you don't know that. Step costs are given next to each arc, and heuristic values are given next to each node (as  $h=x$ ). The successors of each node are indicated by the arrows out of that node. (**Note: D is a successor of itself**). As usual, successors are returned in left-to-right order. (The successors of S are A,B; of B are D,C).

The start node is S and the goal node is G. For each search strategy below, indicate (1) **the order** in which nodes are expanded, and (2) **the path** to the goal that was found, if any. Write "None" for the path if the goal was not found. The first one is done for you, as an example.



**8.a. DEPTH-FIRST SEARCH:**

**8.a.(1)** Order of expansion: S A B D D D D ...

**8.a.(2)** Path to goal found: None

**8.b. BREADTH-FIRST SEARCH:**

**8.b.(1)** Order of expansion: \_\_\_\_\_

**8.b.(2)** Path to goal found: \_\_\_\_\_

**8.c. ITERATIVE DEEPENING SEARCH:**

**8.c.(1)** Order of expansion: \_\_\_\_\_

**8.c.(2)** Path to goal found: \_\_\_\_\_

**8.d. UNIFORM COST SEARCH:**

**8.d.(1)** Order of expansion: \_\_\_\_\_

**8.d.(2)** Path to goal found: \_\_\_\_\_

**8.e. GREEDY BEST FIRST SEARCH:**

**8.e.(1)** Order of expansion: \_\_\_\_\_

**8.e.(2)** Path to goal found: \_\_\_\_\_

**8.f. A\* SEARCH:**

**8.f.(1)** Order of expansion: \_\_\_\_\_

**8.f.(2)** Path to goal found: \_\_\_\_\_

\*\*\*\* THIS IS THE END OF THE MID-TERM EXAM \*\*\*\*