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

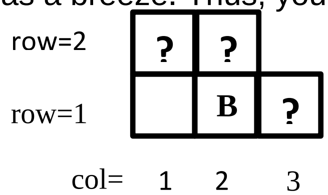
8. (20 pts total, 2 pts each) State-Space Search.

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

Recall that a knowledge base KB entails a sentence S (written KB |= 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.

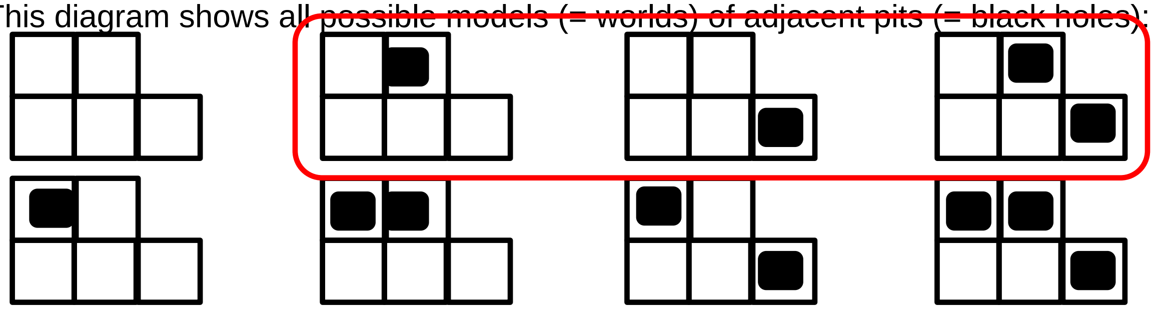
This question will concern only breezes and pits. *Squares next to pits are breezy, and breezy squares are next to squares with pits.* We ignore the wumpus, gold, etc.

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.



See Section 7.3 and Fig. 7.5, p. 241, of your textbook. See also the lecture slides for Propositional Logic A and Review for Mid-term Exam.

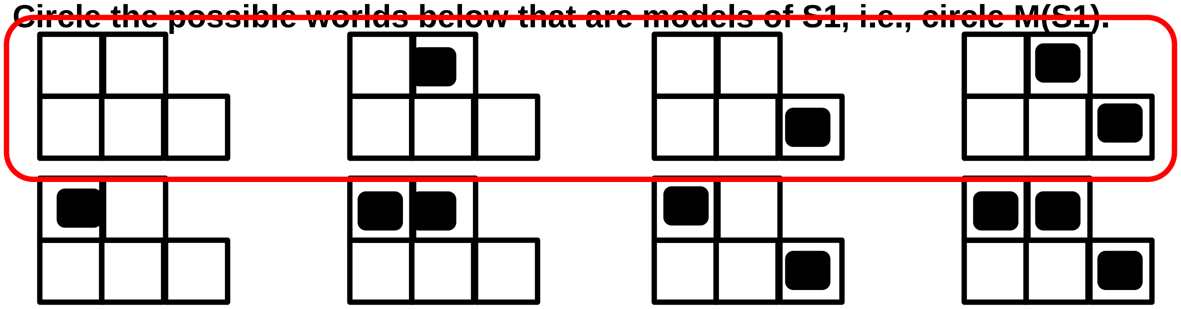
This diagram shows all possible models (= worlds) of adjacent pits (= black holes):



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

1.b. Consider ONLY the sentence S1 = "Square [2,1] does not have a pit."

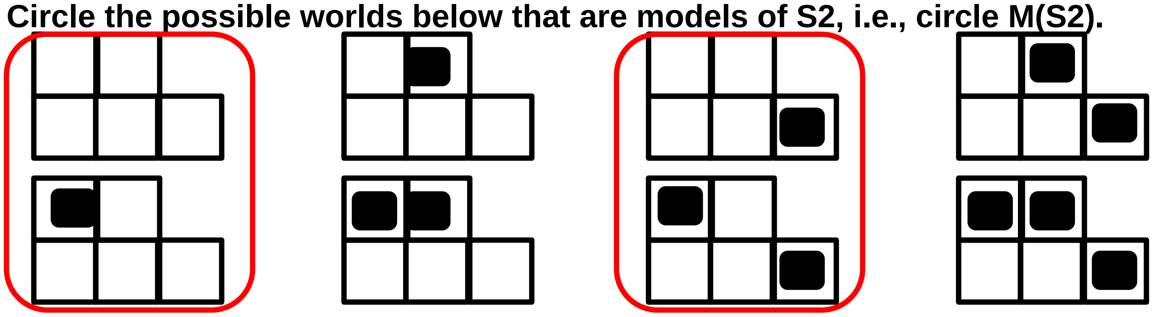
Circle the possible worlds below that are models of S1, i.e., circle M(S1).



1.c. Does KB |= S1? (Y = yes, N = no) ______Y______

1.d. Consider ONLY the sentence S2 = "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 |= S2? (Y = yes, N = no) ______N______

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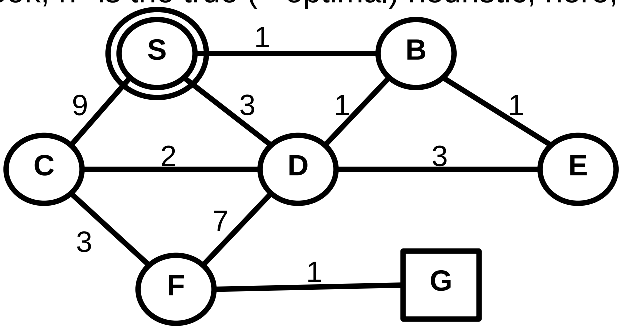
2. CANCELLED (10 pts total) Resolution Proof.
Everyone gets this question correct regardless of your answer.

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.



See Sections 3.5 and 3.6 in your textbook.

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

h3 is not admissible because it may overestimate the true optimal cost (h*). E.g., h3(C) = 5 > h*(C) = 4.

h1 is not consistent because it violates the triangle inequality (i.e., f(n) is not non-decreasing along every path). E.g., h1(B) = 4 > c(B, a, D) + h1(D) = 1+1 = 2.

h3 is not consistent because it violates the triangle inequality. E.g., h3(C) = 5 > c(C, a, F) + h3(F) = 3+1 = 4.

See Section 3.5.2 in your textbook.

3.a. (2 pts)
Which heuristic functions are admissible among h1, h2 and h3? __h1, h2__.

3.b. (2 pt)
Which heuristic functions are consistent among h1, h2 and h3? __h2__.

See Section 3.6.1 in your textbook.

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

(a) h1 dominates h2. (T or F) __F__
(b) h1 dominates h3. (T or F) __F__
(c) h2 dominates h1. (T or F) __F__
(d) h2 dominates h3. (T or F) __F__
(e) h3 dominates h1. (T or F) __T__
(f) h3 dominates h2. (T or F) __F__

(a) E.g., h1(B) < h2(B).
(b) E.g., h1(C) < h3(C).
(c) E.g., h2(C) < h1(C).
(d) E.g., h2(C) < h3(C).
(e) Indeed, h3 dominates h1.
(f) E.g., h3(B) < h2(B).

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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.

See Section 2.3.1.

P<u>erformance (measure)</u> E<u>nvironment</u> Ac<u>tuators</u> S<u>ensors</u>

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 i ... th to the shallowest goal node; m is the maximu ... t of the optimal solution; step costs are identical ... irectional search both directions using breadt ...

Your answer will be considered correct if it differs from that shown below by no more than ±1, e.g., O(b^d) vs. O(b^(d+1)).

See Figure 3.21.

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	Yes	O(b^d)	O(b^d)	Yes
Uniform-Cost	Yes	O(b^(1+floor(C*/ε))) O(b^(d+1)) also OK	O(b^(1+floor(C*/ε))) O(b^(d+1)) also OK	Yes
Depth-First	No	O(b^m)	O(bm)	No
Iterative Deepening	Yes	O(b^d)	O(bd)	Yes
Bidirectional (if applicable)	Yes	O(b^(d/2))	O(b^(d/2))	Yes

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.

See Sections 7.3-4.

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

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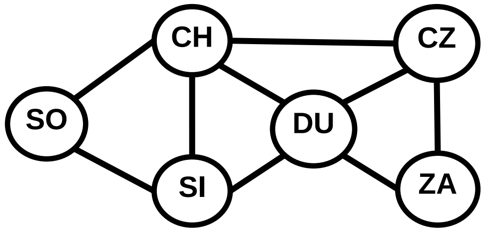
7. (20 points total, 4 pts each) CONSTRAINT SATISFACTION PROBLE

See Chapter 6.



SO = Sonara
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 t[...]nated by Forward Checking, after variable DU has just been assigned value G, as shown:

See Section 6.3.2.

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 propa[...]ne.
Cross out all values that would be eliminated by Arc Consistency [...]k).

See Section 6.2.2.

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 be[...] unassigned variables that might be selected by the Minimum-Remai[...]
Heuristic:______ **SO, CH, DU** ______.

See Section 6.3.1.

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 constra[...] been done. List all unassigned variables that might be selected by the Degree Heuristic:______ **CH, CZ, DU** ______.

See Section 6.3.1.

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[...]al search for a complete and consistent assignment. What new value [...] below for DU by the Min-Conflicts Heuristic?______ **R** ______.

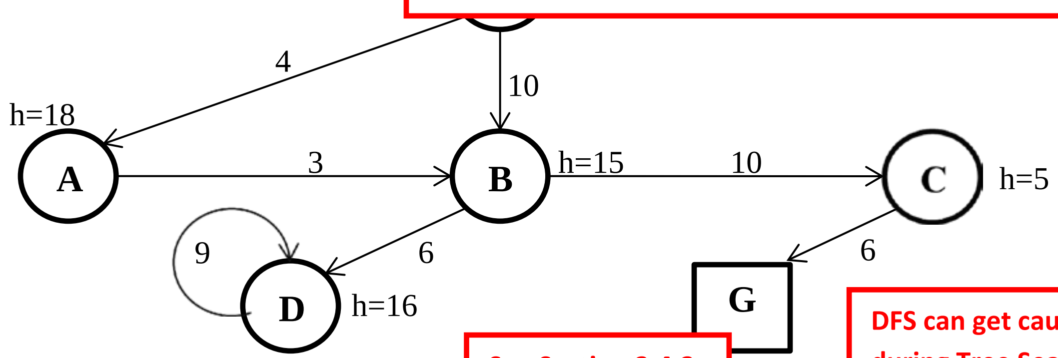
See Section 6.4.

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 n

Please see the lecture slides for Uninformed Search, topic "When to do Goal-Test? When generated? When popped?" for clarification about exactly what to do in practical cases.



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

See Section 3.4.3 and Fig. 3.17.

DFS can get caught in loops during Tree Search (= do not remember visited nodes).

8.b. BREADTH-FIRST SEARCH:

See Section 3.4.1 and Fig. 3.11.

nsion: S A B B D C G
8.b.(2) Path to goal found: S B C G

BFS does the Goal-test before the child is pushed onto the queue. The goal is found when C is expanded.

8.c. ITERATIVE DEEPENING SEARCH:

See Sections 3.4.4-5 and Figs. 3.18-19.

n: S S A B S A B B D C G
8.c.(2) Path to goal found: S B C G

IDS does the Goal-test before the child is pushed onto the queue. The goal is found when C is expanded.

8.d. UNIFORM COST SEARCH:

UCS does goaltest when node is popped off queue.

See Section 3.4.2 and Fig. 3.14.

sion: S A B B D D C C D G
und: S A B C G

8.e. GREEDY BEST FIRST SEARCH

GBFS has the same behavior whether the goaltest is done before node is pushed or after node is popped, because h=0 for a goal node, so goal nodes always sort to the front of the queue anyway.

See Section 3.5.1 and Fig. 3.23.

sion: S B C G
und: S B C G

8.f. A* SEARCH:

A* does goaltest when node is popped off queue.

See Section 3.5.2 and Figs. 3.24-25.

sion: S A B C G
nd: S A B C G

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