

CS-171, Intro to A.I. — Final Exam — Winter Quarter, 2016

YOUR NAME: _____

YOUR ID: _____ ID TO RIGHT: _____ ROW: _____ SEAT: _____

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 14 pages, as numbered 1-14 in the bottom-right corner of each page (including scratch paper at the end). We wish to avoid copy problems. We will supply a new exam for any copy problems.

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

Please turn off all cell phones now. No electronics are allowed at any point of the exam.

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 for each question, so you can plan your time.

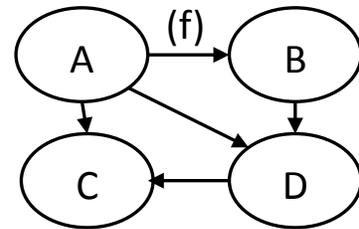
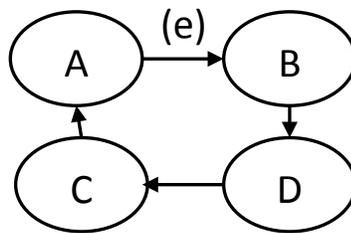
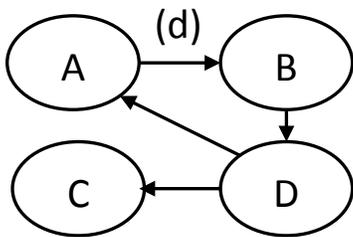
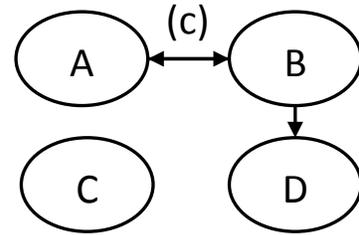
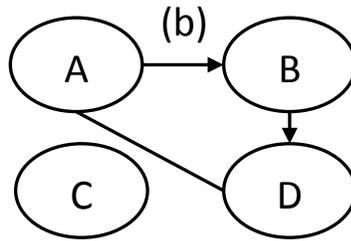
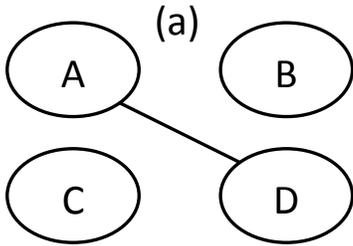
1. (10 pts total, -1 for each error, but not negative) Mini-Max, Alpha-Beta Pruning.
2. (10 pts total, -1 pt each wrong answer, but not negative) Search Properties.
3. (4 pts total, 1 pt each) TASK ENVIRONMENT.
4. (15 pts total) Bayesian Networks.
5. (15 pts total) Decision Tree Learning.
6. (15 pts total; full credit for a correct proof, else 2 pts each useful resolution up to 10 pts) Easter Bunny Resolution Theorem Proving in Propositional Logic.
7. (15 points total, 3 pts each) Constraint Satisfaction Problems.
8. (16 pts total, 2 pts each) English and FOL correspondence.

The Exam is printed on both sides to save trees! Work both sides of each page!

4. (15 pts total) Bayesian Networks.

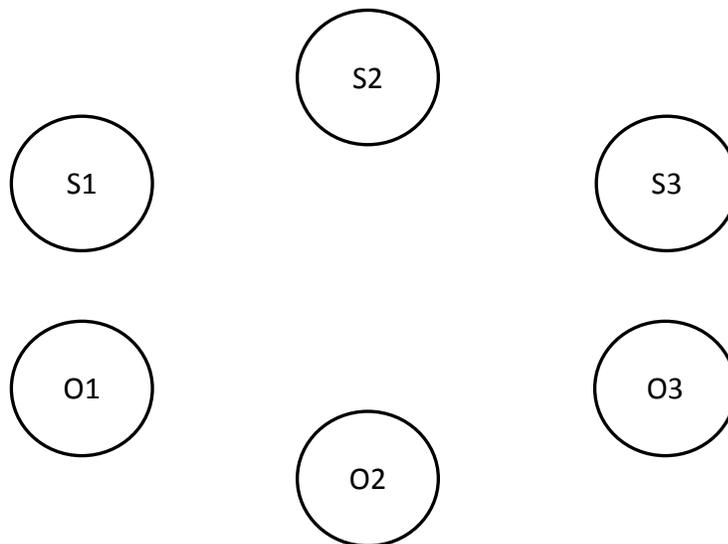
4.a. (2 pts total, -1 for each error, but not negative) Circle the letters that correspond to all valid Bayesian Networks in the following figure. (If there is not any valid Bayesian Network, circle None.)

Bayesian Networks: None (a) (b) (c) (d) (e) (f)



4.b. (3 pts, -1 for each error, but not negative) Draw the Bayesian Network that corresponds to the following probability distribution. (It is a Hidden Markov Model, popular in speech recognition, etc. By convention, S_i = state_i, O_i = observation_i.)

$$P(S_1, S_2, S_3, O_1, O_2, O_3) = P(S_1) P(S_2|S_1) P(S_3|S_2) P(O_1|S_1) P(O_2|S_2) P(O_3|S_3)$$



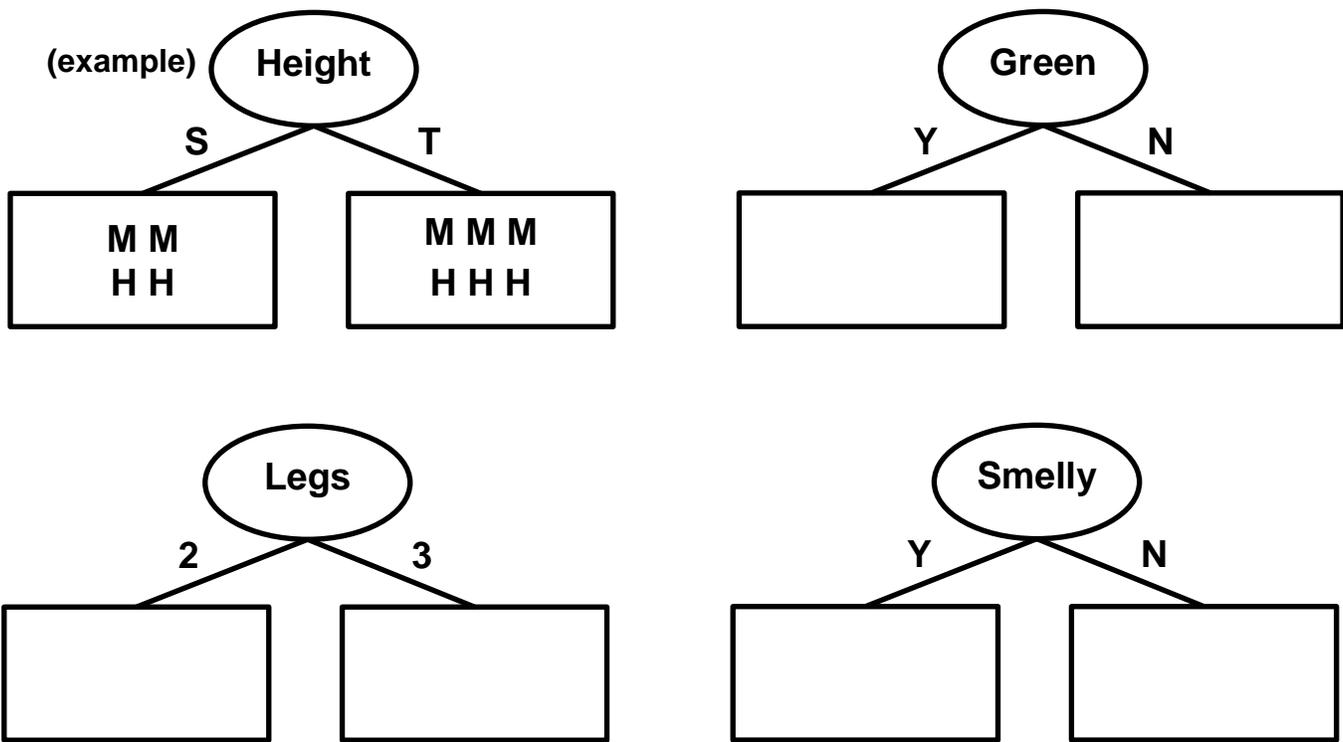
**** PROBLEM CONTINUES ON THE NEXT PAGE ****

5. (15 pts total) Decision Tree Learning. (Adapted from Prof. Ziv-Bar Joseph, Carnegie Mellon University, Course 10-701 Machine Learning materials.) NASA wants to discriminate Martians (M) from Humans (H) based on these features (attributes): Green $\in \{N, Y\}$, Legs $\in \{2, 3\}$, Height $\in \{S, T\}$, Smelly $\in \{N, Y\}$. Your available training data is as follows (N = No, Y = Yes, S = Small, T = Tall):

Example Number	Height	Green	Legs	Smelly	Target: Species
1	S	Y	3	Y	M
2	T	Y	3	N	M
3	S	Y	3	N	M
4	T	Y	3	N	M
5	T	N	2	Y	M
6	T	Y	2	Y	H
7	S	N	2	N	H
8	T	N	3	N	H
9	S	N	3	N	H
10	T	N	3	N	H

Please note: A human might be green or have three legs for many possible reasons, e.g., if they were an actor playing a Martian as a role in a film or play. Anyway, it's a made-up problem for the test.

5.a. (6 pts total, 3 pts each) For each possible choice of root feature (attribute) below, show the resulting species distribution. Give your answer as M* over H*. The first one is done for you, as an example.

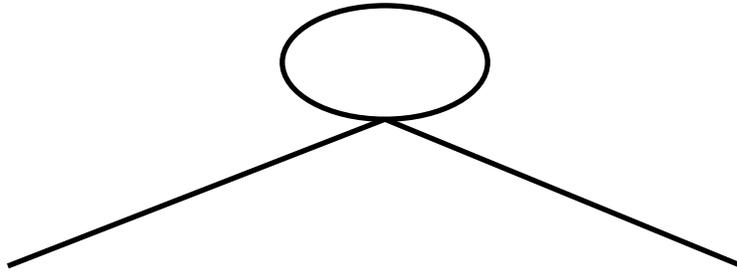


5.b. (4 pts) Which root feature (attribute) would information gain select as the “best” root feature (i.e., the highest information gain)? (No calculator is needed; the numbers have been chosen to be obvious.)

Circle one of: Height Green Legs Smelly

**** PROBLEM CONTINUES ON THE NEXT PAGE ****

5.c. (5 pts) Draw the decision tree that results from your choice of root feature (attribute) in 5.b above.
(No calculator is needed; the numbers have been chosen to be obvious.) Your tree will be considered correct if it is correct for the root feature you chose in 5.b above, even if that answer was wrong.



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6. (15 pts total; full credit for a correct proof, else 2 pts each useful resolution up to 10 pts) Easter Bunny Resolution Theorem Proving in Propositional Logic. (Adapted from <http://brainden.com/logic-puzzles.htm>.)

Four bunny rabbits played together in the bushes. Two were brown bunny rabbits and two were white bunny rabbits. You translate this fact into Propositional Logic (in prefix form) as:

/* Bi means bunny i is brown. */

(or (and B1 B2 (¬ B3) (¬ B4)) (and B1 (¬ B2) B3 (¬ B4))
 (and B1 (¬ B2) (¬ B3) B4) (and (¬ B1) B2 B3 (¬ B4))
 (and (¬ B1) B2 (¬ B3) B4) (and (¬ B1) (¬ B2) B3 B4)))

However, none of them could see each other very clearly, and their views were obscured by branches

Bunny 1 reported, "One of bunnies 2 & 3 is brown and one is white, but I can't tell which."

Bunny 2 reported, "One of bunnies 3 & 4 is brown and one is white, but I can't tell which."

Bunny 3 reported, "Bunny 4 is brown."

You translate these facts into Propositional Logic (in prefix form) as:

(or (and B2 (¬ B3)) (and (¬ B2) B3)) (or (and B3 (¬ B4)) (and (¬ B3) B4)) B4

Bunny 1 asks, "Is it true that I am a white bunny rabbit?"

You translate this query into Propositional Logic as "(¬ B1)" and form the negated goal as "B1." Your knowledge base (KB) in CNF plus negated goal (in clausal form) is:

(B1 B2 B3) ((¬ B1) (¬ B2) (¬ B3))
 (B1 B2 B4) ((¬ B1) (¬ B2) (¬ B4))
 (B1 B3 B4) ((¬ B1) (¬ B3) (¬ B4))
 (B2 B3 B4) ((¬ B2) (¬ B3) (¬ B4))
 (B2 B3) ((¬ B2) (¬ B3))
 (B3 B4) ((¬ B3) (¬ B4))
 B4 B1

Write a resolution proof that Bunny 1 is a white bunny rabbit.

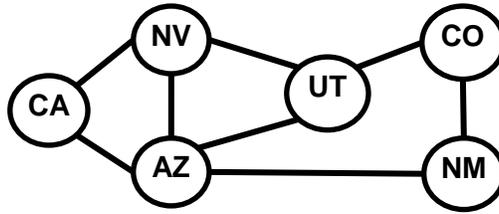
For each step of the proof, fill in the first two blanks with CNF sentences from KB that will resolve to produce the CNF result that you write in the third (resolvent) blank. The resolvent is the result of resolving the first two sentences. Add the resolvent to KB, and repeat. Use as many steps as necessary, ending with the empty clause.

The shortest proof I know of is only four lines long. (A Bonus Point for a shorter proof.)

Resolve _____ with _____ to produce: _____

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7. (15 points total, 3 pts each) Constraint Satisfaction Problems.



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

7.a. (3 pts total, -1 each wrong answer, but not negative) **FORWARD CHECKING**. Cross out all values that would be eliminated by Forward Checking, after variable AZ has just been assigned value R as shown:

CA	NV	AZ	UT	CO	NM
R G B	R G B	R	R G B	R G B	R G B

7.b. (3 pts total, -1 each wrong answer, but not negative) **ARC CONSISTENCY**.

CA and AZ 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).

CA	NV	AZ	UT	CO	NM
B	R G B	R	R G B	R G B	R G B

7.c. (3 pts total, -1 each wrong answer, but not negative) **MINIMUM-REMAINING-VALUES HEURISTIC**.

Consider the assignment below. NV is assigned and constraint propagation has been done. List all unassigned variables that might be selected by the Minimum-Remaining-Values (MRV) Heuristic: _____.

CA	NV	AZ	UT	CO	NM
R B	G	R B	R B	R G B	R G B

7.d. (3 pts total, -1 each wrong answer, but not negative) **DEGREE HEURISTIC**.

Consider the assignment below. (It is the same assignment as in problem 7.c above.) NV is assigned and constraint propagation has been done. List all unassigned variables that might be selected by the Degree Heuristic: _____.

CA	NV	AZ	UT	CO	NM
R B	G	R B	R B	R G B	R G B

7.e. (3 pts total) **MIN-CONFLICTS HEURISTIC**.

Consider the complete but inconsistent assignment below. AZ 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 AZ by the Min-Conflicts Heuristic? _____.

CA	NV	AZ	UT	CO	NM
B	G	?	G	G	B

8. (16 pts total, 2 pts each) English and FOL correspondence. For each English sentence below, write the letter corresponding to its best or closest FOPC (FOL) sentence (wff, or well-formed formula).

8.a (2 pts) _____ “Every person plays some game.”

- A. $\forall x \forall y \text{ Person}(x) \wedge \text{Game}(y) \wedge \text{Plays}(x, y)$
- B. $\forall x \exists y \text{ Person}(x) \wedge \text{Game}(y) \wedge \text{Plays}(x, y)$
- C. $\forall x \forall y \text{ Person}(x) \Rightarrow (\text{Game}(y) \wedge \text{Plays}(x, y))$
- D. $\forall x \exists y \text{ Person}(x) \Rightarrow (\text{Game}(y) \wedge \text{Plays}(x, y))$

8.b (2 pts) _____ “All games are fun.”

- A. $\forall x \text{ Game}(x) \wedge \text{Fun}(x)$
- B. $\forall x \text{ Game}(x) \Rightarrow \text{Fun}(x)$
- C. $\exists x \text{ Game}(x) \wedge \text{Fun}(x)$
- D. $\exists x \text{ Game}(x) \Rightarrow \text{Fun}(x)$

8.c (2 pts) _____ “For every game, there is a person that plays that game.”

- A. $\forall x \exists y \text{ Game}(x) \wedge \text{Person}(y) \wedge \text{Plays}(y, x)$
- B. $\forall x \exists y [\text{Game}(x) \wedge \text{Person}(y)] \Rightarrow \text{Plays}(y, x)$
- C. $\forall x \exists y \text{ Game}(x) \Rightarrow [\text{Person}(y) \wedge \text{Plays}(y, x)]$
- D. $\forall x \forall y \text{ Game}(x) \wedge \text{Person}(y) \wedge \text{Plays}(y, x)$

8.d (2 pts) _____ “Every person plays every game.”

- A. $\forall x \forall y [\text{Person}(x) \wedge \text{Game}(y)] \Rightarrow \text{Plays}(x, y)$
- B. $\forall x \forall y \text{ Person}(x) \Rightarrow [\text{Game}(y) \wedge \text{Plays}(x, y)]$
- C. $\forall x \forall y \text{ Person}(x) \wedge \text{Game}(y) \wedge \text{Plays}(x, y)$
- D. $\forall x \exists y [\text{Person}(x) \wedge \text{Game}(y)] \Rightarrow \text{Plays}(x, y)$

8.e (2 pts) _____ “There is some person in Irvine who is smart.”

- A. $\forall x \text{ Person}(x) \wedge \text{In}(x, \text{Irvine}) \wedge \text{Smart}(x)$
- B. $\exists x \text{ Person}(x) \wedge \text{In}(x, \text{Irvine}) \wedge \text{Smart}(x)$
- C. $\forall x [\text{Person}(x) \wedge \text{In}(x, \text{Irvine})] \Rightarrow \text{Smart}(x)$
- D. $\exists x \text{ Person}(x) \Rightarrow [\text{In}(x, \text{Irvine}) \wedge \text{Smart}(x)]$

8.f (2 pts) _____ “Every person in Irvine is smart.”

- A. $\forall x \text{ Person}(x) \wedge \text{In}(x, \text{Irvine}) \wedge \text{Smart}(x)$
- B. $\exists x \text{ Person}(x) \wedge \text{In}(x, \text{Irvine}) \wedge \text{Smart}(x)$
- C. $\forall x [\text{Person}(x) \wedge \text{In}(x, \text{Irvine})] \Rightarrow \text{Smart}(x)$
- D. $\exists x \text{ Person}(x) \Rightarrow [\text{In}(x, \text{Irvine})] \wedge \text{Smart}(x)$

8.g (2 pts) _____ “Some person plays every game.”

- A. $\exists x \forall y [\text{Person}(x) \wedge \text{Game}(y)] \Rightarrow \text{Plays}(x, y)$
- B. $\exists x \forall y \text{ Person}(x) \wedge \text{Game}(y) \wedge \text{Plays}(x, y)$
- C. $\forall x \forall y \text{ Person}(x) \wedge \text{Game}(y) \wedge \text{Plays}(x, y)$
- D. $\exists x \forall y \text{ Person}(x) \wedge [\text{Game}(y) \Rightarrow \text{Plays}(x, y)]$

8.h (2 pts) _____ “Some person plays some game.”

- A. $\exists x \exists y \text{ Person}(x) \wedge \text{Game}(y) \wedge \text{Plays}(x, y)$
- B. $\exists x \exists y [\text{Person}(x) \wedge \text{Game}(y)] \Rightarrow \text{Plays}(x, y)$
- C. $\exists x \exists y \text{ Person}(x) \Rightarrow [\text{Game}(y) \wedge \text{Plays}(x, y)]$
- D. $\forall x \forall y \text{ Person}(x) \wedge \text{Game}(y) \wedge \text{Plays}(x, y)$

****** THIS IS THE END OF THE FINAL EXAM. HAPPY SPRING BREAK!! ******

Scratch Paper

YOUR NAME: _____

Your ID: _____

Scratch Paper

YOUR NAME: _____

Your ID: _____

Scratch Paper

YOUR NAME: _____

Your ID: _____

Scratch Paper

YOUR NAME: _____

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