EECS 492, Winter 2010
Introduction to Artificial Intelligence
Midterm 2 (75 points)

Name: _____

Uniqname: _____

This exam is closed book: you may not use the textbook, lecture slides, notes, or any type of computing device. Write your name at the top of every page.

"I have neither given nor received aid on this examination,
nor have I concealed any violations of the honor code."

signed _____

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Problem 1. Quickies

1.1. (4 points) Which of the sentences below are equivalent to "-(A ^ (B v -C))" ? (Circle all that apply.)

A) -A v -(B v -C)
B) -A ^ -(B v -C)
C) (-A v -B) ^ (-A v C)
D) -A ^ (-B ^ C)
E) (-A ^ -B ^ -C) v (-A ^ -B ^ C) v (-A ^ B ^ -C) v (-A ^ B ^ C) v (A ^ -B ^ C)

1.2. (2 points) Suppose a world consists of *five* propositions, A, B, C, D, and E. How many models are there for A<=>B<=>C?

1.3. (4 points) Which of the following statements are true? (Circle all that apply)

A) Producing no new knowledge in an iteration of forward chaining proves an inconsistency.
B) Any sentence of propositional logic can be written as an equivalent CNF sentence.
C) Skolemization replaces existential quantifications with functions of zero arguments.
D) The standard inference method used by Prolog is complete.

1.4. (2 points) Consider the DPLL algorithm for inference on propositional logic. Recall that it is essentially a constraint satisfaction algorithm that tries to find a world model that satisfies the KB. Suppose the KB contains the usual Wumpus rules, along with the sentence "-S11 ^ B11". You wish to know whether it is safe to proceed to square (2,1), or whether the square might contain a pit. (Assume that your agent does not take risks.)

A) Add -P21 to the KB; if DPLL returns true, it is safe to proceed to square (2,1).
B) Add -P21 to the KB; if DPLL returns false, it is safe to proceed to square (2,1).
C) Add P21 to the KB; if DPLL returns true, it is safe to proceed to square (2,1).
D) Add P21 to the KB; if DPLL returns false, it is safe to proceed to square (2,1).

1.5. (3 points) Recall that forward chaining is complete for Horn clauses. Which of the following are Horn clauses? (Circle all that apply).

A) A ^ B => C
B) -A ^ -B => C
C) A v B => C
D) A v B => C v D

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Problem 2. First Order Logic

2.1. (4 points) Which of the following are true? (Circle all that apply).

A) When correctly translated, each English sentence has exactly one FOL translation.
B) In the FOL sentence "FORALL x A(B(x))", B(x) represents a predicate with one argument.
C) "Bill" and "Roger" cannot be the same object using standard semantics.
D) Every PL sentence can be converted into an FOL sentence.

2.2. (6 points) What substitutions, if any, unify the pairs of sentences below? *You may standardize-apart as useful.*

a) Sentence 1: A(x) ^ B(x,y) ^ C(Bob, y)
Sentence 2: A(Bob) ^ B(x, Roger) ^ C(z, Roger)

b) Sentence 1: A(x) ^ B(Bob)
Sentence 2: A(y) ^ B(Roger)

c) Sentence 1: A(Bob) ^ -B(x)
Sentence 2: A(x) ^ -B(Charlie)

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Problem 3. FOL Inference

Consider the FOL sentences below.

1. IsLion(x) => IsFeline(x)
2. IsFeline(x) ^ -IsLion(x) => IsCuddly(x)
3. IsFeline(Simba) ^ IsFeline(Baghira)
4. -IsCuddly(Simba)
5. -Equals(x,y) ^ IsLion(x) => -IsLion(y)
6. -Equals(Baghira, Simba)

3.1. (4 points). Convert each sentence into CNF, numbering your sentences the way we have in class. (SXa would be the first CNF sentence derived from sentence X.) Write your answers in the space to the right of each sentence. You can abbreviate (if you wish) propositions and constants with the first letter, i.e., IsCuddly(x) can be written "C(x)", Baghira can be written "B".

3.1. (3 points). Translate sentence 5 into *everyday* English. (It should not sound like something a 492 student would say!)

3.2. (8 points). Prove that Baghira is not a Lion by using unit resolution and refutation to derive an empty sentence. At each step, identify which sentences you are unifying and the substitution(s) that allow it, and uniquely number the resulting sentence. *Find a short proof: three points will be deducted for every step beyond six, not counting the refutation. Your proof should be neat and easy to read; there is additional space on the back page.*

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Problem 4. Probability Basics

Consider the conditional and marginal probability tables below:

	A ^ B	A ^ -B	-A ^ B	-A ^ -B
P(C | ...)	0.8	0.2	0.9	0.4

	A	-A
P(B | ...)	0.7	0.7

P(A)	0.2

4.1. (2 points) Draw the Bayes net representing the factorization of the joint probability P(A, B, C) in terms of the conditional probability tables given above.

4.2. (1 point) What is P(-C | -A, B) ? (Answer in the form of a number.)

4.3. (1 point) What is P(A, -B, C)? (Answer in the form of a number.)

4.4. (1 points) What is the marginal probability P(B)? (Answer in the form a number.)

4.5. (3 points) What is the conditional probability P(C | A)? (Answer in the form of a number.)

4.6. (2 points) Write down the independences and conditional independences satisfied by the distributions.

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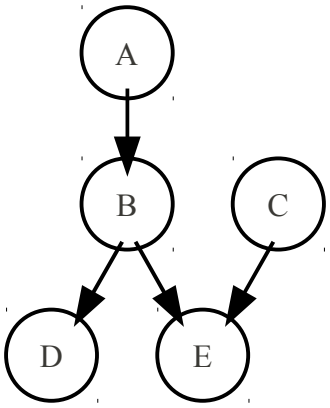
Problem 5. Bayesian Networks

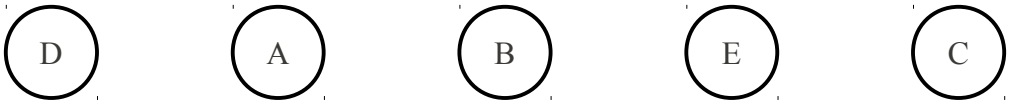
Consider the Bayesian network below.



5.1. (1 point) Write the joint distribution in terms of the conditional distributions described by the graph.

5.2. (2 points) How many numbers are required to specify the conditional probability tables used by the Bayesian network?

5.3. (5 points) Rewrite the Bayesian network by introducing the variables in the order D, A, B, E, C. Add arrows to the variables below, minimizing the number of edges while remaining inferentially equivalent to the original net.



5.4. (2 points) What is the minimum number of numbers required to specify the conditional probability tables used when introducing the variables in the order above?

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Problem 6. Matching

6.1. (15 points, -1 for each wrong.) Match the terms (letters on left) with the most appropriate phrase on the right:

_____ A) Constant (in FOL)
_____ B) Conditional Distribution
_____ C) Complete Inference
_____ D) Forward Chaining
_____ E) A proposition (in FOL)
_____ F) Backward Chaining
_____ G) Marginal Distribution
_____ H) Sound Inference
_____ I) Joint Distribution

1. A non-conditional distribution for a subset of variables
2. A complete description of the probabilistic relationships between one or more random variables.
3. A predicate with zero arguments.
4. A probability given evidence.
5. Criticized for producing irrelevant conclusions
6. All true facts can be derived.
7. A function with zero arguments.
8. No untrue facts are ever derived.
9. Semi-Decidable
10. Regressive inference.

_____ A) Resolution
_____ B) Conditional Independence
_____ C) Contrapositive
_____ D) Modus Ponens
_____ E) Product Rule
_____ F) DeMorgan's rule

1. (A => B) => (A => -B)
2. -(A v B) => (-A ^ -B)
3. (A v -B) ^ (B v -C) => (A v -C)
4. (A=>B) => (-B => -A)
5. A ^ (A => B) => B
6. P(A, B | C) = P(A|C) P(B|C)
7. P(-A) = 1 - P(A)
8. P(A, B) = P(A | B) P(B)
9. P(A v B) = P(A) + P(B) - P(A^B)

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This page may be used for scratch work, but it will not be graded unless you specifically refer to this area in the main question area.