Artificial Intelligence—Fall 2014

Qualifying Exam (Open Books and Notes)

Question 1 (30 points)

Assume that we have the predicates $Female(X)$, $Male(X)$, $Parent(X, Y)$ (X is a parent of Y), $Wife(X, Y)$ (X is the wife of Y), and $Husband(X, Y)$ (X is the husband of Y) with the obvious meanings; and the constants $John$, Bob, Tom, $Dean$, $Tina$, $Jean$, $Selena$, and $Courtney$.

1. Define the following predicates using the above predicates:

   - *Person*(X): X is a person if X is a male or a female.
   - *Daughter*(X, Y): X is a daughter of Y if X is a female and Y is a parent of X.
   - *Son*(X, Y): X is a son of Y if X is a male and Y is a parent of X.
   - *Siblings*(X, Y): X and Y are siblings if they share a same parent.
   - *Married*(X, Y): X is married to Y if they are husband/wife of each other.

2. Express the following sentences in a first-order logic language consisting of the above predicates and constants.

   - $John$, Bob, Tom, and $Dean$ are males.
   - $Tina$, $Jean$, $Selena$, and $Courtney$ are females.
   - Everyone can be married to at most one person.
   - Bob is the husband of $Jean$.
   - $Jean$ is a parent of $Selena$ and $John$.
   - Bob is a parent of $Tina$ and $John$.

   Let us refer to the resulting theory as the knowledge base KB.

3. Use **resolution** to prove that $Selena$ and $John$ are siblings given the KB. Present the steps in your proof.

4. Are $Tina$ and $Selena$ siblings given the KB? Explain your answer.

5. Express the question "*who is a daughter of Jean*?" as a first-order formula and use KB to answer the question.

Question 2 (35 points)

Consider the logic program Π

$$\begin{aligned} a(X,X) &\leftarrow b(X),\ not\ c(X) \\ d(X) &\leftarrow not\ c(X) \\ c(X) &\leftarrow not\ d(X) \\ p(0) &\leftarrow \end{aligned}$$

1. Compute all answer sets of Π. Justify your answer.
2. Given your answer above, can we say the following
   (a) $\Pi \models p(0)$?
   (b) $\Pi \models c(0)$?
   (c) $\Pi \models d(0)$?
   (d) $\Pi \models \neg a(0,0)$?

   Justify your answer. Note that $\Pi \models a$ means that Π skeptically entails a.

Question 3 (25 points)

The CS department has to create a teaching schedule for every semester. The information about professors, classrooms, and courses is given by a set of facts containing atoms of the following predicates:

- $professor(X)$: X is a professor (e.g., $professor(peter)$);
- $course(Y)$: Y is a course that needs to be offered (e.g., $course(ai)$);
- $room(R)$: R is a classroom;
- $period(S)$: S is a time period (we assume that the a period contains date and time, e.g., $period(mon11\_12)$ denotes the time period from 11 am to noon on Monday).

For example, a set of facts could be

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professor(son). professor(william).
course(ai). course(graphics). course(robotics). course(db).
room(1). room(2). room(3).
period(mon11_12). period(mon1_2).
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The goal is to assign the professors to teach courses in different class rooms at different time periods so that the following constraints are satisfied:

- Every professor teaches exactly two classes;
- Every course is offered by exactly one professor;
- No professor can teach two classes at the same time.

Solve the scheduling problem using answer set programming by developing a program that

- defines the predicate $assign(P, C, R, S)$, which indicates that professor P teaches course C in room R at time period S; and
- contains rules that enforce the above constraints.

Your program needs to satisfy the following properties:

- It returns no answer set if it is impossible to create a schedule.
- It returns all possible solutions if it is possible to create a schedule.

Provide justification for the correctness of your program.

Question 4 (10 points)

Formulate the scheduling problem (see Question 3) as a constraint satisfaction problem (CSP) by specifying the set of variables, the set of domains, and the set of constraints of the problem. Furthermore, describe the relationship (e.g., equivalence) of your CSP with your logic program from Question 3.