Artificial Intelligence—Fall 2011

Qualification Exam (Open Book and Notes)

Question 1

(20 points) For each pair of atomic sentences, give the most general unifier if it exists:

- $p(a, b, b)$, $p(X, Y, Z)$
- $q(Y, g(a, b))$, $q(g(X, X), Y)$
- $older(father(Y), Y)$, $older(father(X), john)$
- $knows(father(Y), Y)$, $knows(X, X)$

Note that we adopt the convention of logic programming (strings with an upper-case letter represent variables). Show the steps.

Question 2

(10 points) Given that $\forall x \exists y P(x, y)$ holds, it is said that we cannot conclude that $\exists q P(q, q)$. Prove this conclusion by finding an example where the first formula is true but the second formula is false.

Question 3

(30 points) Represent the following sentences in first-order logics suitable for use with resolution:

- Emily is either a surgeon or a lawyer.
- Joe is an actor, but he also holds another job.
- All surgeons are doctors.
- Joe does not have a lawyer (i.e., is not a customer of any lawyer).
- Emily has a boss who is a lawyer.

- There exists a lawyer all of whose customers are doctors.
- Every surgeon has a lawyer.

Use the following vocabulary in your representation:

- $o(P, O)$: predicate, person P has occupation O.
- $c(P_1, P_2)$: predicate, person P_1 is a customer of person P_2.
- $b(P_1, P_2)$: predicate, person P_1 is a boss of person P_2.
- $doctor,\ surgeon,\ lawyer,\ actor$: constants denoting occupations.
- $emily,\ joe$: constants denoting people.

Using resolution show that your knowledge base entails $\neg o(joe, surgeon)$.

Question 4

(25 points) Suppose that we have the logic program

$$P = \begin{cases} p & \leftarrow \\ a & \leftarrow \quad not\ \ b \\ b & \leftarrow \quad not\ \ a \end{cases}$$

Answer the following:

- What is the Herbrand base B_P of the program? In the following, we refer to a literal as either an atom $l \in B_P$ or its negation as failure atom $not\ \ l$.
- What are the answer sets of P? Compute them, if any exists.
- It is said that if we add one literal to the body of one of the rules of P, we can create a new program P' that does not have an answer set. Show that we can achieve this.
- It is said that if we add one literal to the body of one of the rules of P, we can create a new program P' that has a unique answer set. Show that we can achieve this.

Justify your answer.

Question 5

(15 points) Suppose that we have the following STRIPS planning problem: $P = \langle F, A, I, G \rangle$ where

- $F = \{f, g, h\}$.
- $A = \{(a, \{f\}, \emptyset), (b, \{g\}, \{f\}), (c, \{h\}, \emptyset)\}$ with $pre(a) = \{h\}$, $pre(b) = \{f\}$, and $pre(c) = \emptyset$.
- $I = \emptyset$.
- $G = \{g\}$.

Answer the following:

- Draw the planning graph for the problem until the graph is saturated.
- From the planning graph, draw an estimation of the shortest solution of the problem. Does this number correspond to the real shortest solution of the problem?
- What will be your answer for the previous questions (Item 2) if the goal G changes to $\{g, f\}$?

Justify your answer.