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**Foundations of Query Languages**  
**Summer semester 2010**  
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### 3. Exercise Set: FOL and Conjunctive Queries

#### Exercise 1

Consider the following database schema Prof(PName), Course(CName), GivesCourse(PName,CName), Student(SName), Attends(SName,CName), Grades(PName,SName). Write down in the relational calculus:

- What professors offer no courses?
- What students are graded by a professor who offer no courses?
- What pairs of students attend a common course?
- What professors offer a course and also grades all students in that course?

#### Exercise 2

Consider the following pairs of conjunctive queries and decide for each pair  $q_i, q'_i$  if  $q_i \sqsubseteq q'_i$ ,  $q'_i \sqsubseteq q_i$ , and  $q_i \equiv q'_i$  holds. If such relationships hold provide the corresponding containment mappings. Otherwise, give a database that provides a counterexample

- $q_1: \text{ans}(X,Y) \leftarrow R(X,Z), R(Z,T), S(T,Y)$  and  $q'_1: \text{ans}(X,Z) \leftarrow R(X,X), S(X,Z)$
- $q_2: \text{ans}(X) \leftarrow R(X,Y), S(Y,Z), S(Y',Z')$  and  $q'_2: \text{ans}(Y) \leftarrow S(A,B), R(Y,A), R(Y',A)$
- $q_3: \text{ans}(U,Z) \leftarrow R(U,V), R(X,Y), S(Y,Z), S(V,X)$  and  $q'_3: \text{ans}(U,V) \leftarrow R(Y,U), R(U,X), S(U,V), S(X,Y)$

#### Exercise 3

Consider the following pairs of conjunctive queries and decide if  $q_i \sqsubseteq q'_i$ ,  $q'_i \sqsubseteq q_i$ , and  $q_i \equiv q'_i$  hold using the method of the canonical instance.

- $q_1: \text{ans}(X) \leftarrow R(X,Y,X), R(X,Z,Y), S(Y,X)$  and  $q'_1: \text{ans}(X) \leftarrow R(X,Y,Z), S(Y,Z)$
- $q_2: \text{ans}(X) \leftarrow R(X,Y), R(Y,Z), R(Z,X)$  and  $q'_2: \text{ans}(X) \leftarrow R(X,Y), R(Y,Z), R(Z,U), R(U,V)$

#### Exercise 4

Let  $Q, Q'$  be conjunctive queries. Prove or disprove the following statements:

- Every conjunctive query  $Q$  is satisfiable, i.e. for every conjunctive query  $Q$  there is a database instance  $I$  such that  $Q(I) \neq \emptyset$ .
- $Q(I) \subseteq Q'(I)$  for all finite database instances  $I$  iff it holds that  $Q(J) \subseteq Q'(J)$  for all (possibly infinite) database instances  $J$ .

Due by: May 12, 2010 before the tutorial starts.