

CS589 Principles of Database Systems
Spring 2016, Homework 1
Due: Thursday, 21 April 2016

You may do this assignment with a partner. If you do so, turn in a single submission with both names. You may seek help from your partner, the instructor and the class mailing list, but not other sources.

1. (10 points) Exercise 3.2 from Levene and Loizu. Give a general form of the translation, plus a specific example.
2. (15 points) Prove that there are SPJU– (select, project, join, union, difference) queries that cannot be expressed by any SPJU query. Hint: Find a property of SPJU queries that is not necessarily shared by queries involving difference.

Questions 3. – 5. involve the following database schema:

UnivReq(Course, Degree) university requirements for degrees
MajorReq(Course, Major) department requirements for majors
Prereq(PCourse, Course) prerequisites of courses

3. (5 points) For each Datalog rule below, state whether it is safe or unsafe. If unsafe, explain the problem.
 - i. `Result(C) :- MajorReq(E, 'CS'), Prereq(C, E), ¬CsReq(C).`
 - ii. `Result(C) :- MajorReq(E, 'CS'), ¬Prereq(C, E), CsReq(C).`
 - iii. `Result(C) :- ¬MajorReq(E, 'CS'), ¬Prereq(C, E), CsReq(C).`
 - iv. `Result(C) :- ¬MajorReq(E, 'CS'), Prereq(C, E), CsReq(C).`
 - v. `Result(C) :- MajorReq(E, 'CS'), Prereq('Mth114', E),
¬CsReq('Mth114').`
4. Give queries in a) relational algebra, b) tuple calculus, c) domain calculus, and d) Datalog for the following:
 - i. (8 points) List all prerequisites of prerequisites of 'Mth427'.
 - ii. (12 points) Which majors include all university requirements for the 'BA' degree in their own requirements?
5. i. (5 points) Give a relational algebra expression equivalent to Result(C) in the Datalog program below. (Note: You do not have to use the conversion of the theorem.)

```
CsReq(A) :- UnivReq(A, 'BS').
CsReq(B) :- MajorReq(B, 'CS').
Result(C) :- MajorReq(E, 'CS'), Prereq(C, E), ¬CsReq(C).
```

ii. (5 points) Give a Datalog program equivalent to the following relational algebra expression.

$$\rho_{\text{Course} \rightarrow \text{PCourse}}(\pi_{\text{Course}}(\sigma_{\text{Degree}='BA'}(\text{UnivReq})) \cup \pi_{\text{Course}}(\sigma_{\text{Major}='EE'}(\text{MajorReq}))) \bowtie \sigma_{\text{Course}='CS302'}(\text{Prereq})$$

6. i. (20 points) Show that SPJ relational algebra (with just Select, Project and Join) is equivalent to safe 1-rule Datalog without negation, if we limit each Select to a single condition. (Describe a procedure for conversion in each direction, plus give a specific example for each way.)
- ii. (10 points) Show that SPJ– relational algebra (SPJ plus difference) is *not* equivalent to safe 1-rule Datalog with negation. (Find a query in one language that has no equivalent in the other. Be sure to explain why it has no equivalent.)