University of Toronto
CSC343, Fall 2014

Relational Algebra Exercises

These are solutions to some of the exercises we worked on in class. The remaining solutions will be posted once we have finished the exercises. **Important:** There are other good answers to each of these queries.

Schema

A note about the domain: A course may or may not satisfy the "breadth" requirement.

Student(<u>sID</u>, surName, firstName, campus, email, cgpa)

Course(<u>dept, cNum</u>, name, breadth)

Offering(<u>oID</u>, dept, cNum, term, instructor)

Took(<u>sID, oID</u>, grade)

Offering[dept, cNum] $\subseteq$ Course[dept, cNum]

Took[sID] $\subseteq$ Student[sID]

Took[oID] $\subseteq$ Offering[oID]

Queries

Write a query for each of the following:

1. Student number of all students who have taken csc343.

   Answer:

   $\Pi_{sID}\sigma_{dept=\text{“}csc\text{”}\wedge cNum=343}(Took \bowtie Offering)$

2. Student number of all students who have taken csc343 and earned an A+ in it.

   Answer:

   $Good343(sID) := \Pi_{sID}\sigma_{dept=\text{“}csc\text{”}\wedge cNum=343\wedge grade\geq 90}(Took \bowtie Offering)$

3. The names of all such students.

   Answer:

   Here we reuse relation Good343 from the previous question.

   $\Pi_{surName,firstName}(Good343 \bowtie Student)$

4. The names of all students who have passed a breadth course with Professor Picky.

Answer:

$PickyBreadth(sID) := \Pi_{sID}\sigma_{breadth=true \wedge instructor=\text{“}Picky\text{”}}(Course \bowtie Offering)$

$Passers(sID) := \Pi_{sID}\sigma_{grade \geq 50}(PickyBreadth \bowtie Took)$

$Answer(surName, firstName) := \Pi_{surName,firstName}(Passers \bowtie Student)$

5. sID of all students who have earned some grade over 80 and some grade below 50.

   Answer:

   $(\Pi_{sID}\sigma_{grade>80}Took) \cap (\Pi_{sID}\sigma_{grade<50}Took)$

6. Terms when Cook and Pitassi were both teaching something.

   Answer:

   $(\Pi_{term}\sigma_{instructor=\text{“}Cook\text{”}}\, Offering) \cap (\Pi_{term}\sigma_{instructor=\text{“}Pitassi\text{”}}\, Offering)$

7. Terms when either of them was teaching csc363.

   Answer:

   $\Pi_{term}(\sigma_{dept=\text{“}csc\text{”} \wedge cNum=363 \wedge (instructor=\text{“}Cook\text{”} \vee instructor=\text{“}Pitassi\text{”})}\, Offering)$

8. sID of students who have earned a grade of 85 or more, or who have passed a course taught by Atwood.

   Answer:

   $HaveHighGrade(sID) = \Pi_{sID}\sigma_{grade \geq 90}Took$

   $PassedAtwood(sID) = \Pi_{sID}\sigma_{instructor=\text{“}Atwood\text{”} \wedge grade \geq 50}(Took \bowtie Offering)$

   $Answer(sID) := HaveHighGrade \cup PassedAtwood$

9. Terms when csc369 was not offered.

   Answer:

   $(\Pi_{term}\, Offering) - (\Pi_{term}\sigma_{dept=\text{“}csc\text{”} \wedge cNum=369}\, Offering)$

10. Department and course number of courses that have never been offered.

    Answer:

    $(\Pi_{dept,cNum}\, Course) - (\Pi_{dept,cNum}\, Offering)$

11. SIDs and surnames of all pairs of students who've taken a course together. (The original question asked for just names, but we're including SIDs also in this solution. Having names alone would be fine if that is what one wants, but of course two individuals with the same name would be indistinguishable by name only.)

    Answer:

    $Pairs(sID1, sID2) := \Pi_{T1.sID,T2.sID}\sigma_{T1.sID<T2.sID \wedge T1.oID=T2.oID}[(\rho_{T1}Takers)\times(\rho_{T2}Takers)]$

    $OneName(sID1, sID2, name1) := \Pi_{sID1,sID2,surName}\sigma_{sID1=sID}(Pairs \times Student)$

    $Answer(sID1, sID2, name1, name2) :=$

    $\Pi_{sID1,sID2,name1,surName}\sigma_{sID2=sID}(OneName \times Student)$

    Rather than getting the surnames in two steps we could have done it all at once. To do so, we'd have to bring in two copies of Student, and therefore would need to do some renaming.

12. sID of student(s) with the highest grade in csc343, in term 20099.

    Answer:

    This works except for one wrinkle discussed below:

    $Takers(sID, grade) := \Pi_{sID,grade}[(\sigma_{dept=\text{“}csc\text{”} \wedge cNum=343 \wedge term=20099}Offering) \bowtie Took]$

    $NotTop(sID) := \Pi_{T1.sID}\sigma_{T1.grade<T2.grade}[(\rho_{T1}Takers) \times (\rho_{T2}Takers)]$

    $Answer(sID) := (\Pi_{sID}Takers) - NotTop$

    Notice that the schema doesn't disallow having two different offerings of csc343 in 20099, and this makes sense in our domain. For instance, we have a day and an evening section of csc343 this term. The schema also does not prevent a student from being in the Took relation for both of them, even though this probably doesn't make sense in our domain. If such a student were to get the top mark for one and a non-top mark for the other, they would appear in NotTop and therefore not in Answer. To prevent that, we can keep the oID until the very end:

    $Takers(sID, oID, grade) := (\sigma_{dept=\text{“}csc\text{”} \wedge cNum=343 \wedge term=20099}Offering) \bowtie Took$

    $NotTop(sID, oID, grade) := \Pi_{T1.sID,T1.oID,T1.grade}\sigma_{T1.grade<T2.grade}[(\rho_{T1}Takers)\times(\rho_{T2}Takers)]$

    $Answer(sID) := \Pi_{sID}(Takers - NotTop)$

    Notice that the final projection onto sID has moved. Make sure you know why. These small matters often make the difference between a correct and an incorrect or even syntically ill-formed query.

13. sID of students who have a grade of 100 at least twice.

    Answer:

    $AtLeastTwice(sID) :=$

    $\Pi_{T1.sID}\sigma_{T1.oID \neq T2.oID \wedge T1.sID=T2.sID \wedge T1.grade=100 \wedge T2.grade=100}[(\rho_{T1}Takers)\times(\rho_{T2}Takers)]$

14. sID of students who have a grade of 100 exactly twice.

    Answer:

$$AtLeastThrice(sID) :=$$
$$\Pi_{T1.sID}$$
$$\sigma_{T1.oID \neq T2.oID \wedge T2.oID \neq T3.oID \wedge T1.oID \neq T3.oID \wedge T1.sID = T2.sID = T3.sID \wedge T1.grade = T2.grade = T3.grade = 100}$$
$$[(\rho_{T1} Takers) \times (\rho_{T2} Takers) \times (\rho_{T3} Takers)]$$
$$ExactlyTwice(sID) := atLeastTwice - AtLeastThrice$$

Notice that, since $\neq$ is not transitive, we must compare the three oIDs all three ways.

15. sID of students who have a grade of 100 at most twice.

    Answer:

    $$(\Pi_{sID} Student) - AtLeastThrice$$

16. Department and cNum of all courses that have been taught in every term when csc448 was taught.

    Answer:

    $$448Terms(term) := \Pi_{term}(\sigma_{dept = \text{“csc”} \wedge cNum = 448} Offering)$$
    $$CourseTerms(dept, cNum, term) := \Pi_{dept, cNum, term} Offering$$
    $$ShouldHaveBeen(dept, cNum, term) := \Pi_{dept, cNum} Course \times 448Terms$$
    $$WereNotAlways(dept, cNum, term) := ShouldHaveBeen - CourseTerms$$
    $$Answer(dept, cNum) := (\Pi_{dept, cNum} Course) - (\Pi_{dept, cNum} WereNotAlways)$$

17. Name of all students who have taken, at some point, every course Gries has taught (but not necessarily taken them from Gries).

    Answer:

    Try this one on your own. It is great practise for the “every” strategy.