Relational Algebra *(35 points)*

First, you will write the relational algebra expressions for different operations on the database.

Relational Algebra Guidelines

Feel free to hand-write your answers to the relational algebra problems. Make sure your work is neat and readable. Unreadable work will lose points. Submit your RA problems on Canvas in a file **`midterm-ra.pdf`**. You can also use this .doc file as a starter file for your RA problems (but only include the Relational Algebra part - you may include the 7 problem descriptions, which will make grading easier if you provide your answers under each problem description).

For multiple-step operations that modify data, make sure to respect all referential integrity constraints. You will lose points if you are not careful to do this.

If you get stuck on a problem, you may include a description of your problem-solving process for partial credit.

Relational Algebra Problems

1. You Can't Put a Price on Pets... But Shelters Don't Run Themselves. Write a query to retrieve the average adoption price for each animal type registered in the database.

$$animal\_type\,G_{avg(adoption\_price)\ as\ avg\_adoption\_price}(animals)$$

2. They Dream of Doggos. Write a query to retrieve the name, gender, estimated age, and breed of all dogs with applications having a status of 'Submitted'.

$$\Pi_{name,\ gender,\ age\_est,\ breed}(\sigma_{\ status\ =\ 'Submitted'\ \wedge\ animal\_type\ =\ 'Dog'}\ (animals \bowtie applications))$$

3. The Wait Begins. Write a query that returns the name and phone number of all applicants who have an application with status 'Submitted', as well as the animal id of different animals they have applied to adopt.

$$\Pi_{name,\ phone,\ animal\_id}(\sigma_{\ status\ =\ 'Submitted'}\ (applicants \bowtie applications))$$

4. New Additions to Small Homes. Retrieve the name and animal type of all animals who *only* have applications from applicants who have 3 or fewer individuals living in the household.

$$household\_animal\_count \leftarrow_{animal\_id} G_{max(household\_size)\ as\ biggest\_household}\ (applicants \bowtie applications)$$

$$\Pi_{animals.name,\ animal\_type}(\sigma_{\ biggest\_household\ <=\ 3}\ (\ household\_animal\_count \bowtie animals))$$

5. And You Said It Was Only Volunteering... Write a query which returns the name of all employees who have applied to adopt an animal at the shelter, as well as the id, name, and animal type of each animal they have applied for. Note that employee ids and applicants ids have different meanings - assume that the name and phone number uniquely identifies an individual, so you'll want to look for records that match on these values between *employees* and *applicants*.

$$\Pi_{employees.name,\ applications.animal\_id,\ animals.name,\ animal\_type}(\sigma_{applications.animal\_id\ =\ animals.animal\_id}\ (applicants \bowtie employees \bowtie applications \times animals))$$

6. Spam-Filtering. Let's make sure that we don't have any applicants that have spammed applications for every shelter in the database. Write a query which returns the name and phone-number of any applicant who has an application <u>for every</u> shelter currently in the *shelters* relation. *Hint: What extended relational algebra operation can be useful here?*

$$list\_of\_applicants \leftarrow \Pi_{applicants.name,applicants.\ phone,\ shelter\_id}(\sigma_{applications.animal\_id\ =\ animals.animal\_id}(applicants \bowtie applications \times animals))$$

$$list\_of\_shelters \leftarrow \Pi_{shelter\_id}(shelters)$$

$$(list\_of\_applicants\ /\ list\_of\_shelters)$$

7. Rocket Science? Through some recent ground-breaking marketing research, surveys show that animal shelters offering pet rocks result in decreased trust from potential applicants in the legitimacy of the shelter. Write the series of relational algebra operations necessary to remove all records that refer to pet rocks (where *animal_type* is 'Rock') from all tables in the database. Don't worry, they'll go to good homes.

$$applications \leftarrow applications\ - \Pi_{app\_id,\ applicant\_id,\ animal\_id,\ status,\ application\_date}(\sigma_{animal\_type\ =\ 'Rock'}(applications \bowtie animals))$$

$$animals \leftarrow animals\ -\ \sigma_{animal\_type\ =\ 'Rock'}(animals)$$