PART I (SQL). Use the database schema from Assignment 2 to answer the following questions.

1. Write an SQL query to find the name, area, and total population of provinces with a population over 1,000,000 people. The population of a province is the total population of each city in the province.

2. Write an SQL query to find the name and area of provinces that contain at least one city with a population over 1,000,000 people, that are in a country with a higher than average GDP, and that have a higher than average area.

3. Suppose we introduce two new tables to our database:

   CountryMembership(country: string, organization: string)
   Organization(name: string)

where CountryMembership records the international organizations each country participates in, and Organization contains the names of the different international organizations. Thus, CountryMembership.organization is a foreign key to Organization.name. Write a relational algebra query that returns the name, GDP, and inflation of the countries that participate in every organization listed in the Organization table.

PART II (ER). Suppose you have been asked to develop a new database for a world-famous Ski Resort. As a first step, you need to design an ER model (i.e., diagram) that captures the following requirements.

- There are ski lifts (for getting skiers and snowboarders uphill) and ski runs (for skiers and snowboarders to go down). Each lift is identified by a name and has a bottom and top elevation, an opening and closing time, and a capacity (in persons transported per hour). Each run is identified by name and has a start and a finish elevation, a length, and a last patrol time.

- A lift serves one or more runs, i.e., the start of the run is easily and directly reachable from the top of the lift (without intermediate runs or lifts). A run connects-to one or more lifts, i.e., those lifts whose entry points at the bottom are directly reachable from the bottom of a run (without taking any other runs or lifts).
• Lifts may be be connected via the next-lift relation, (i.e., the bottom of the next lift is directly reachable from the top of another lift). Similarly, runs may be connected via the next-run relation (i.e., the top of the next run is directly reachable from the bottom of another run).

4. Create an ER diagram for this scenario based on the given information. Be sure to indicate the key for each entity type. Also, for each relationship type, clearly specify the cardinality constraints using the min..max notation presented in class.

5. Translate your ER schema into a relational schema. For each table, list all attributes, primary keys, and foreign keys.

6. Explain the rational behind both your ER model and the translation from your model to your relational schema.

PART III (ER Relationships). Consider a “Bill of Materials”, i.e., there are Parts (identified by a part number), such that each part has 0 or more sub-parts and each “sub-part” is a part of at most one “super-part”.

7. Model this situation using an ER diagram. Hint: Use a single entity type Part and a binary relationship type HasA and corresponding roles. Describe the cardinalities using the min..max notation from class.

8. Give an example relationship set (i.e., instances of the HasA relation) that satisfies the cardinality constraints.

9. Change the cardinality constraints to capture the new requirement that (i) each part has one or more sub-parts and (ii) each part has exactly one super-part.

10. Give an example entity set that satisfies the new cardinality constraints in (8). What seems to be the problem?