1. (5') The relational algebra is closed under the operators. Explain what this means and give an example.
2. (5') SQL is a declarative data manipulation language. What are some pros and cons of declarative DMLs relative to procedural ones?
3. (15') Consider the following expressions, which use the result of a relational algebra operation as the input to another operation. For each expression, explain in words what the expression does.

   a. $\sigma_{year \geq 2009}(takes) \bowtie student$

   b. $\sigma_{year \geq 2009}(takes \bowtie student)$

   c. $\Pi_{ID, name, course\_id}(student \bowtie takes)$

4. (15') Consider the relational database of Figure 1. Give an expression in the relational algebra to express each of the following queries:
   a. Find the names of all employees who live in city "Miami".
   b. Find the names of all employees whose salary is greater than $100,000.
   c. Find the names of all employees who live in "Miami" and whose salary is greater than $100,000.

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employee (*person_name*, *street*, *city*)
works (*person_name*, *company_name*, *salary*)
company (*company_name*, *city*)

Fig 1 Employee Database

5. (10') Consider the bank database of Figure 2. Give an expression in the relational algebra for each of the following queries.
   a. Find the names of all branches located in "Chicago".
   b. Find the names of all borrowers who have a loan in branch "Down- town".

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branch(*branch_name*, *branch_city*, *assets*)
customer (*ID*, *customer_name*, *customer_street*, *customer_city*)
loan (*loan_number*, *branch_name*, *amount*)
borrower (*ID*, *loan_number*)
account (*account_number*, *branch_name*, *balance*)
depositor (*ID*, *account_number*)

Fig 2 Bank Database

6. (50') SQL Lab.