Find all professors that are not involved in teaching.

```sql
select name
from professors
where pers-id not in (select held_by from lectures)
```

- operator `in` tests for set membership

Find the students with the largest number of semesters.

```sql
select name
from students
where sem >= all (select sem from students)
```

- With the keyword `all` a comparison is performed with all elements of the set that is parameter of `all`.
- An arbitrary comparison operator can be used with `all` and `some`.
- `all` does not have the functionality of an forall quantifier, since only a comparison of a value with a set can be expressed.
- rather similarity to an aggregate function
- A condition with `some` is satisfied if it is satisfied for at least one element of the set.
Existential quantifier \textit{exists}

- This operator checks whether a set of tuples specified by a subquery is empty. For a non-empty set the \textit{exists} operator yields \textit{true}, otherwise \textit{false}. For the operator \textit{not exists} it is just vice versa.

- Operator \textit{exists} corresponds to the existential quantifier of the relational calculus.

- example: Which professors do not hold lectures?
  
  \begin{verbatim}
  select name
  from professors
  where not exists (select * from lectures where held_by = pers-id)
  \end{verbatim}
The renaming operator

- application of the as-clause
- use:
  - Two relations in the from clause have attributes with the same name, which would appear in the result relation without renaming.
  - If an arithmetic expression is used in the select clause, the result attribute does not have a name.
  - explicit change of an attribute name
example: Which credit line do the customers still have?

```sql
select name, credit-line – debit as rest
from customers
```

**Tuple variables**

- A tuple variable in SQL is bound to a relation.
- Tuple variables are defined in the `from` clause by means of the `as` clause.
- In particular useful in order to compare two tuples of the same relation
- Example: Which students attend which lectures?

```sql
select s.name, v.title
from students as s, attend as a, lectures as l
where s.reg-id = a.reg-id and a.id = l.id
```

**String operations**

- Search patterns are described by
  - A percent sign (%): this represents any substring
  - An underscore (_): this represents any character
distinction between upper and lower case

String patterns in SQL are expressed with the aid of the **like** operator.

example: Find all students with names Meier, Maier, Meyer, etc.

```sql
select reg-id
from students
where name like "M__er"
```

Set operations

- schema compliant relations as operands
- **union, except, intersect**: operands and results are sets of tuples, elimination of duplicates
- **union all, except all, intersect all**: operands and results are multi-relations

number of duplicates for multi-relations $R$ and $S$ ($F(R, x)$ describes the frequency of tuple $x$ in table $R$):

- $\forall x : F(R \text{ union all } S, x) = F(R, x) + F(S, x)$
- $\forall x : F(R \text{ except all } S, x) = \text{if } F(R, x) \geq F(S, x) \text{ then } F(R, x) - F(S, x) \text{ else } 0$
- $\forall x : F(R \text{ intersect all } S, x) = \min(F(R, x), F(S, x))$
Aggregate functions

- Functions **count** (number of tuples), **sum** (sum), **avg** (average), **min** (minimum) and **max** (maximum) can be applied to a set of numbers given as a column of a relation.

- no other aggregate functions in SQL2

- If the keyword **distinct** is used in front of the aggregation attribute, first duplicates are eliminated before the aggregate is computed.

- examples:
  - How many students are there with different names?
    ```sql
    select count (distinct name) from students
    ```
  - How many professors have a name starting with “Sch”?
    ```sql
    select count (*) from professors where name like "Sch%"
    ```
  - What is the average number of semesters of all students?
    ```sql
    select avg (sem) from students
    ```
Grouping

- general form of the select-from-where clause

```
select
from
[where <condition>]
[group by <group-by-expression> [, <group-by-expression>]]
[having <condition>]]
[order by <order-expression>]
```

- group by clause
  - A "group-by-expression" is an expression that refers only to those attributes that are *not* used for computing the aggregate. Tuples with equal values for the specified value are summarized in groups (partitions).
  - For each group the query produces a new tuple in the result relation. Hence, only attributes with one value per group are permitted after the `select` clause.

- having clause
  - choice of groups with respect to a condition which may contain only arguments with one value per group