Aggregate functions and set operators

- The learning objectives for this week are:
 - Knowing what kind of query problems can aggregate functions solve
 - Knowing how to use the aggregate functions COUNT, SUM, AVG, MIN and
 - Knowing what kind of query problems can set operators solve
 - Knowing how to combine result tables with UNION, EXCEPT and INTERSECT set operators

Aggregate functions

- Performing some calculation for multiple rows so that the end result is a single value is a common query problem
- Example of such query is calculating the count of rows in a certain table
- For example, how can we calculate the number of courses in the Course table?
- Functions that perform such operations are referred to as aggregate functions

The COUNT aggregate function

• The COUNT aggregate function returns the *total number of rows* that match the specified criteria:

```
-- what's the number of courses in the Course table?

SELECT COUNT(*) as number_of_courses FROM Course
```

```
number_of_courses
7
```

The COUNT aggregate function

• We can also filter the rows the aggregate function operates on using the where clause:

```
-- what's the number of courses with more than 3 credits?

SELECT COUNT(*) as number_of_courses FROM Course

WHERE credits > 3
```

```
number_of_courses
2
```

The COUNT aggregate function

• We can also provide a column name for the COUNT aggregate function in which case the function returns the number of the *non-null values* of the given column:

```
-- what's the number of students with an email address?
SELECT COUNT(email) as number_of_students_with_email
FROM Student
```

The SUM aggregate function

• The SUM aggregate function returns the sum of all the values of a column:

```
-- what's the sum of salaries of female teachers?
SELECT SUM(salary) as sum_of_salaries FROM Teacher
WHERE gender = 'F'
```

```
sum_of_salaries
102273.00
```

The AVG aggregate function

• The Avg aggregate function returns the average value of a column:

```
-- what's the average grade from course with code "a730"?
SELECT AVG(grade) as average_grade FROM CourseGrade
WHERE course_code = 'a730'
```

```
average_grade
3
```

The AVG aggregate function

- Calculating the average includes a division operation, which can produce decimal numbers
- To avoid losing the decimal part of the average, we need to cast integer column values to a DECIMAL type:

```
-- multiplying an integer with 1.0 will end up with a DECIMAL type
SELECT AVG(grade * 1.0) as average_grade FROM CourseGrade
WHERE course_code = 'a730'
```

average_grade

3.333333

The AVG aggregate function

• We can limit the number of decimal places in the result by using casting the result to a DECIMAL type with specific precision and scale:

```
-- use scale of 2 in the DECIMAL type to round to two decimals places
SELECT CAST(AVG(grade * 1.0) AS DECIMAL(9, 2)) as average_grade
FROM CourseGrade
WHERE course_code = 'a730'
```

average_grade

3.33

The MIN aggregate function

• The MIN function returns the smallest value of a column

```
-- what's the lowest grade from course with code "a730"?
SELECT MIN(grade) as lowest_grade FROM CourseGrade
WHERE course_code = 'a730'
```

```
lowest_grade
```

The MAX aggregate function

• The MAX function returns the largest value of a column

```
-- what's the highest grade from course with code "a730"?
SELECT MAX(grade) as highest_grade FROM CourseGrade
WHERE course_code = 'a730'
```

```
highest_grade
5
```

Multiple aggregate functions in a single query

• We can have multiple aggregate functions in the same query:

```
-- what's the highest and lowest grade from course with code "a730"?
SELECT MAX(grade) as highest_grade, MIN(grade) as lowest_grade FROM CourseGrade
WHERE course_code = 'a730'
```

The result table contains a single row with two columns:

highest_grade	lowest_grade
5	1

Combining results tables with set operators

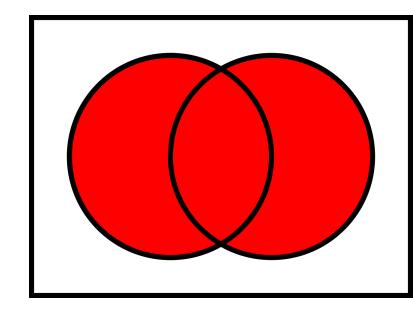
- We can use the results from multiple result tables using the UNION, EXCEPT, and INTERSECT set operators
- For example, the UNION operator returns *all* the rows from two or more result tables *without duplicate values*:

```
-- What are all the surnames among teachers and students?

SELECT surname FROM Teacher

UNION

SELECT surname FROM Student
```



The UNION operator

SELECT surname FROM Teacher

SELECT surname FROM Student

surname

Huhta

Hellerus

surname

Kokki

Kuikka

SELECT surname FROM Teacher UNION
SELECT surname FROM Student

surname

Huhta

Hellerus

Kokki

Kuikka

The EXCEPT operator

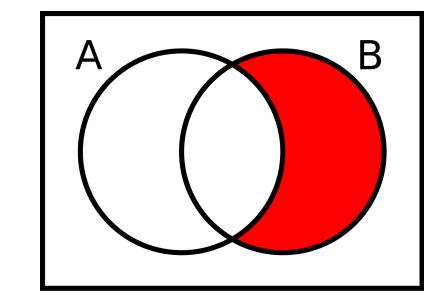
• The EXCEPT operator returns only the rows from the first result table that are *not included* in the second result table *without duplicate values*:

```
-- What are the campus cities that no student lives in?

SELECT city FROM Campus

EXCEPT

SELECT city FROM Student
```



The EXCEPT operator

SELECT city FROM Campus

SELECT city FROM Student

city

Helsinki

Vantaa

city

Helsinki

Espoo

SELECT city FROM Campus EXCEPT SELECT city FROM Student

city

Vantaa

The INTERSECT operator

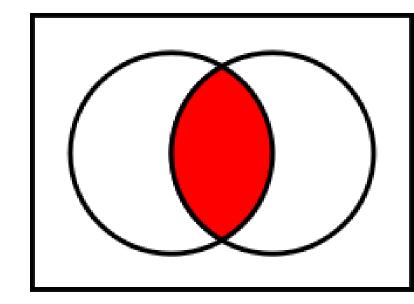
• The INTERSECT operator returns only the rows that exist in both result tables without duplicate values:

```
-- What are the campus cities that have students living in them?

SELECT city FROM Campus

INTERSECT

SELECT city FROM Student
```



The EXCEPT operator

SELECT city FROM Campus

SELECT city FROM Student

city

Helsinki

Vantaa

city

Helsinki

Espoo

SELECT city FROM Campus
INTERSECT
SELECT city FROM Student

city

Helsinki

The set operators

• **!** With set operators, the column names and data types of each statement *must match*:

```
-- X first_name column is missing from the latter SELECT statement.
-- This will lead into an error.

SELECT surname, first_name FROM Teacher

UNION

SELECT surname FROM Student
```

Summary

- We can perform calculations on multiple rows so that the end result is a single row using aggregate functions
- The COUNT aggregate function returns the total number of rows
- The SUM aggregate function returns the sum of all the values of a column
- The Avg aggregate function returns the average of values of a column
- The MIN aggregate function returns the minimum value of a column
- The MAX aggregate function returns the maximum value of a column
- The UNION, EXCEPT and INTERSECT set operators can be used to combine results of multiple result tables