INTERMEDIATE SQL

Multiple Tables and Set Theory

Set Theory

{1, 7, 2} = {1, 2, 7} = {2, 1, 2, 7}	set (also: multiset, bags)
$1 \in \{1, 7, 2\}$ $3 \notin \{1, 7, 2\}$	element
$\{2,7\} \subset \{1, 7, 2\}$ $\{7,3\} \not\subset \{1, 7, 2\}$	subset

Set Theory

$\overline{A} = \{x: x \notin A\}$	complement
$A \cup B = \{x: x \in A \text{ or } x \in B\}$	union
$A \cap B = \{x: x \in A \text{ and } x \in B\}$	intersection
$A - B = \{x: x \in A \text{ and } x \notin B\}$	difference
$\wp(A) = \{B: B \text{ is subset of } A\}$	powerset
$A \times B = \{(a,b): a \in A \text{ and } b \in B\}$	Cartesian Product

Inner Joins in SQL

equijoin

```
SELECT S.*, SG.*
FROM student AS S, studentgroup AS SG
WHERE S.SID = SG.PresidentID;
```

Explicit joins

```
SELECT S.*, SG.*
FROM (student AS S JOIN studentgroup AS SG
      ON S.SID = SG.PresidentID);
```

join condition

University
- List students and courses they are enrolled in.

Outer Joins in SQL

```
SELECT S.*, SG.*
FROM (student AS S LEFT OUTER JOIN studentgroup AS SG
      ON S.SID = SG.PresidentID);

SELECT S.*, SG.*
FROM (student AS S RIGHT OUTER JOIN studentgroup AS SG
      ON S.SID = SG.PresidentID);

SELECT S.*, SG.*
FROM (student AS S FULL OUTER JOIN studentgroup AS SG
      ON S.SID = SG.PresidentID);
```

In Oracle
- can drop OUTER
- alternative notation using (+)

Join Examples

University
• List all students who are enrolled in courses.
• List all students and, if they are enrolled in a course, which courses they are enrolled in.
• List all students and what courses they are enrolled in; list students if they are not enrolled in any course and list courses even if there are no enrollments.
• List all students who are not enrolled in a course.
• List student groups without presidents.
• List students who are not president.

Set Operations

UNION	∪	union
INTERSECT	∩	intersection
EXCEPT (MINUS)	-	set difference

Oracle

Intersection and Difference not supported in some systems (Access, SQLServer). Workaround later.

Set Operations Examples

University
• List student members of DeFrag and HerCTI.
• List students that are members of both DeFrag and HerCTI.
• We only allow gaming students to join DeFrag; list students that violate this rule.
• We require that all gaming students are members of DeFrag; list students that violate this rule.
• List students that are not enrolled in any courses.
• List students that are not presidents of any group.

Duplicates with Set Operations

Duplicates are eliminated if we use set operations like

UNION	(union)
INTERSECT	(intersection)
EXCEPT	(set difference)

Adding the keyword ALL retains duplicated:

UNION ALL
INTERSECT ALL
EXCEPT ALL

Only UNION ALL is supported in Oracle.

Set Operations Using Joins

Example:

All employees who are instructors or staff.

```
SELECT E.*
FROM employee AS E, instructor AS I, staff AS S
WHERE E.ID = I.ID or E.ID = S.ID
```

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```

Is E ∩ (I ∪ S) the same as
E x I x S restricted to tuples
where E.ID = I.ID or E.ID = S.ID ?

The IN Operator

Conditions can contain IN for "element of"

```
SELECT LastName, FirstName
FROM student
WHERE started IN (2010, 2013, 2014);
```

```
SELECT LastName, FirstName
FROM student
WHERE started NOT IN (2010, 2013, 2014);
```

```
SELECT Department, CourseName
FROM Course
WHERE Department IN ('CSC' , 'IT', 'IS');
```

The IN Operator

```
SELECT *
FROM enrolled
WHERE (Quarter, Year) in (('Fall', 2012), ('Winter', 2012));
```

This will not work in many systems (e.g. Access).
Can redo as OR of ANDS.

Nesting Queries with IN

```
SELECT LastName, FirstName, SID
FROM student
WHERE SID IN
        (SELECT PresidentID
         FROM studentgroup)
```

In Examples

- List all students enrolled in a computer science course.
- List all students who are members of HerCTI.
- List undergraduate computer science students.
- Presidents who are members of their groups.

Excursion: Using IN for set operations

Set Intersection

Example: Presidents that were enrolled in 2013.

```
SELECT LastName, FirstName, SID
FROM student
WHERE sid IN (SELECT presidentID
              FROM studentgroup)
  AND sid IN (SELECT studentID
              FROM enrolled
              WHERE year = 2013);
```

- Students who enrolled in both 2005 and 2006.

Set Complement

Example: Students who did not enroll in 2013.

```
SELECT LastName, FirstName, SID
FROM student
WHERE sid NOT IN (SELECT studentID
                  FROM enrolled
                  WHERE year = 2013);
```

- Presidents who are not members of their groups.

Set Difference

Example: Students who are presidents but not members of any group.

```
SELECT LastName, FirstName, SID
FROM student
WHERE sid IN (SELECT presidentID
              FROM studentgroup)
  AND sid NOT IN (SELECT studentID
                  FROM memberof);
```

- CS students who are enrolled in a course, but no CS course.

Set UNION and OR

compare to

```
(SELECT studentID
  FROM memberof)
UNION
(SELECT presidentID
  FROM studentgroup);
```

```
(SELECT LastName, FirstName, SID
FROM student
WHERE sid IN (SELECT studentID
                FROM memberof)
   OR sid IN (SELECT presidentID
                FROM studentgroup);
```

Set Operations Examples

- List students who have a mentor who is a president of a studentgroup.
- List courses that exist both as graduate and undergraduate courses.
- List members of HerCTI that are not enrolled in courses.
- Courses not offered in 2013 (i.e. no record of anybody being enrolled).

END of EXCURSION

The ALL and ANY Operators

= ALL	<> ALL
< ALL	<= ALL
> ALL	>= ALL

= ANY	<> ANY
< ANY	<= ANY
> ANY	>= ANY

```
SELECT LastName, FirstName, SID
FROM student
WHERE started >= ALL (SELECT started
                      FROM student);
```

Nesting Queries with ALL

- List the oldest studentgroup.
- List students belonging to the first student cohort.
- List courses that have a unique number.
- For all departments list the highest course number used by that department.

Naming Scope for nested assignments

Correlated Nesting Queries

- List classes for which there is another class with the same name and a higher course number
- List students that started at the university before some group they belong to was founded

Existence

Tests that a set is nonempty

```
SELECT LastName, FirstName, sid
FROM student
WHERE EXISTS (SELECT *
                FROM enrolled
               WHERE sid = studentID);
```

```
SELECT LastName, FirstName, sid
FROM student
WHERE NOT EXISTS (SELECT *
                    FROM enrolled
                   WHERE sid = studentID);
```

Unique Existence

Tests that a set contains one element

```
SELECT LastName, FirstName, sid
FROM student
WHERE UNIQUE (SELECT *
                FROM enrolled
               WHERE sid = studentID);
```

Not supported by Oracle, Access or SQLServer

Examples

- List students who have taken IT, but no CSC courses.
- List students who have taken classes in CSC, IT and GPH.
- List student groups that have both graduate and undergraduate members.
- List courses in which nobody enrolled in 2013.
- List courses in which no student from Chicago ever enrolled.

CONTAINS

- List students who are members of all student groups.
- List students who have taken courses in all departments.
- List students who have enrolled in courses every year that courses were offered.