Database Systems

Lecture 5:
Intermediate SQL

Dr. Momtazi
momtazi@aut.ac.ir

based on the slides of the course book

Outline

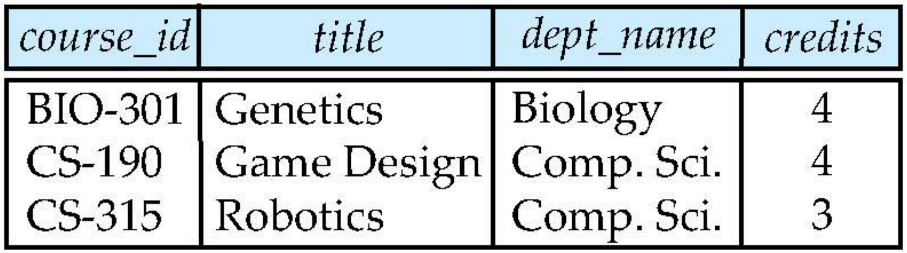
- **Join Expressions**
- Views
- Transactions
- Integrity Constraints
- SQL Data Types and Schemas
- Authorization

Joined Relations

- **Join operations** take two relations and return as a result another relation.
- A join operation is a Cartesian product which requires that tuples in the two relations match (under some condition). It also specifies the attributes that are present in the result of the join
- The join operations are typically used as subquery expressions in the **from** clause

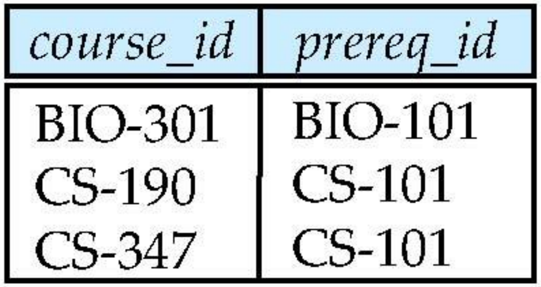
Join operations – Example

- Relation *course*



course_id	*title*	*dept_name*	*credits*
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

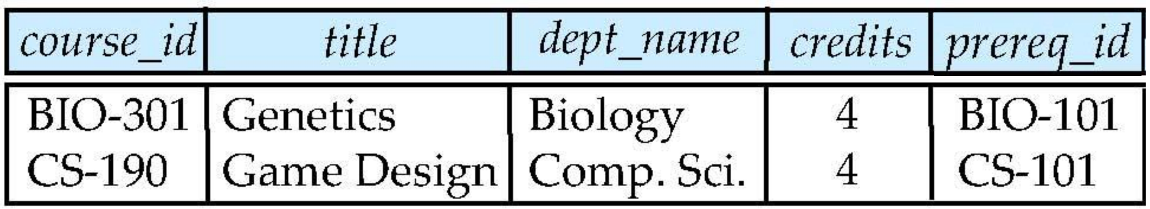
- Relation *prereq*



course_id	*prereq_id*
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

Joined Relations – Examples

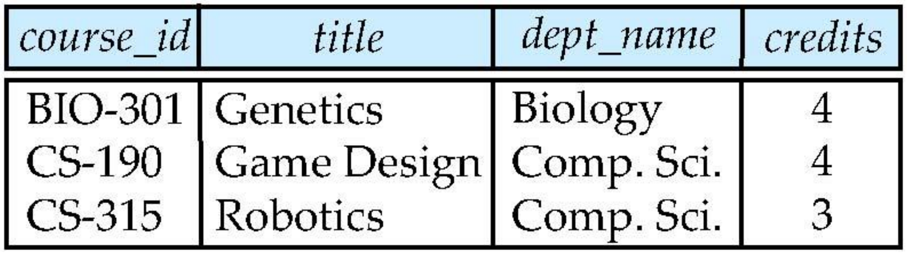
- *course* **natural join** *prereq*



course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101

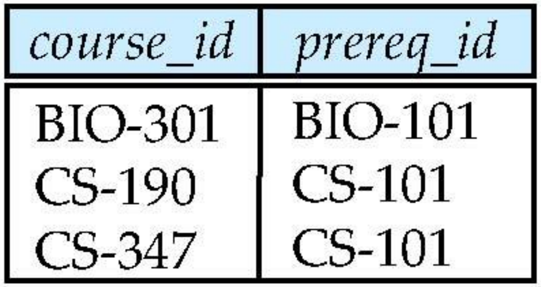
Join operations – Example

- Relation *course*



course_id	*title*	*dept_name*	*credits*
BIO-301	Genetics	Biology	4
CS-190	Game Design	Comp. Sci.	4
CS-315	Robotics	Comp. Sci.	3

- Relation *prereq*



course_id	*prereq_id*
BIO-301	BIO-101
CS-190	CS-101
CS-347	CS-101

- Observe that

  prereq information is missing for CS-315 and

  course information is missing for CS-437

Outer Join

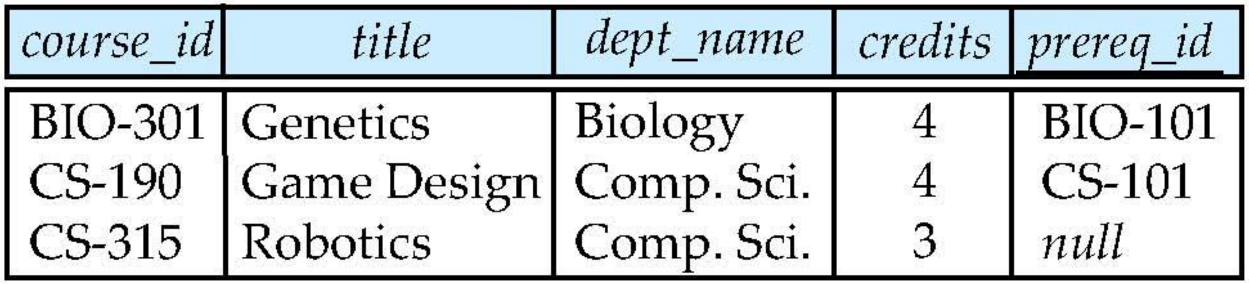
- An extension of the join operation that avoids loss of information.

- Computes the join and then adds tuples from one relation that does not match tuples in the other relation to the result of the join.

- Uses *null* values.

Left Outer Join

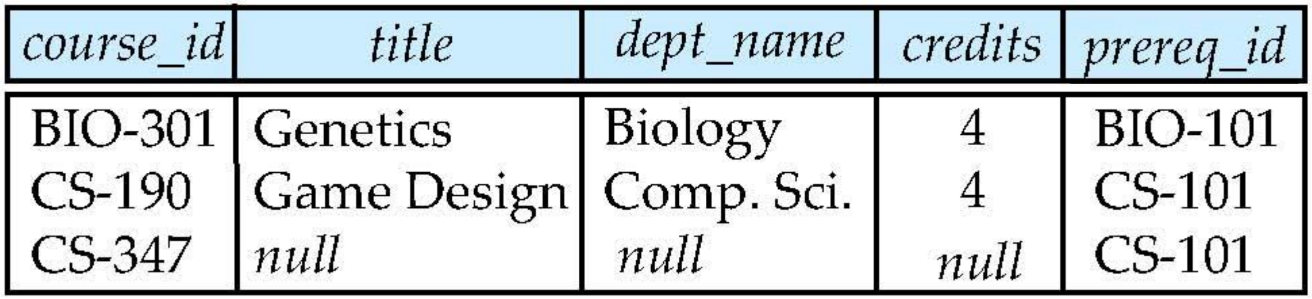
- *course* **natural left outer join** *prereq*



course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	*null*

Right Outer Join

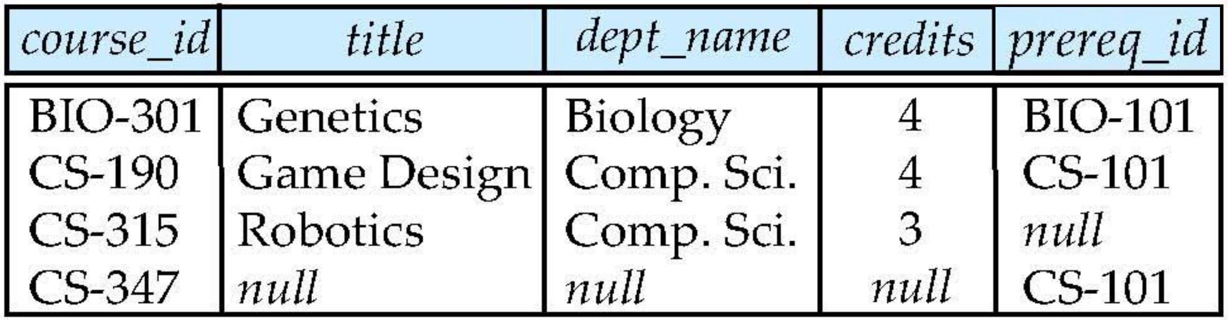
- *course* **natural right outer join** *prereq*



course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-347	*null*	*null*	*null*	CS-101

Full Outer Join

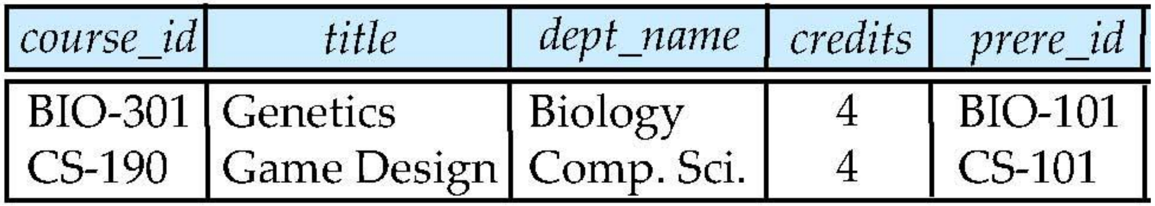
- *course* **natural full outer join** *prereq*



course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	*null*
CS-347	*null*	*null*	*null*	CS-101

Inner Join

- *course* **natural inner join** *prereq*

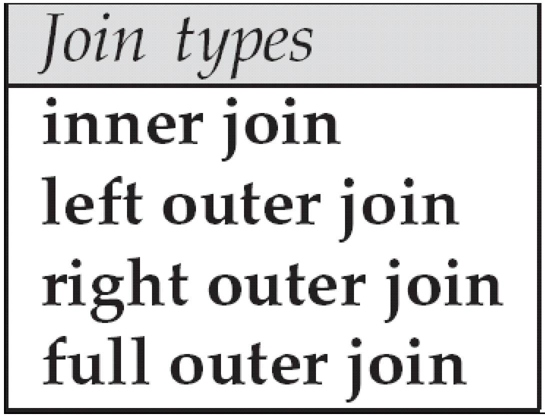


course_id	*title*	*dept_name*	*credits*	*prere_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101

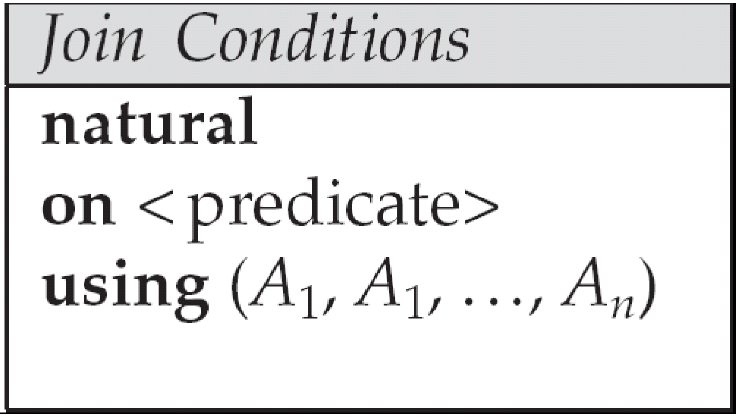
- The default join type, when the join clause is used without the outer prefix is the inner join.

Joined Relations

- **Join operations** take two relations and return as a result another relation.
- These additional operations are typically used as subquery expressions in the **from** clause
- **Join condition** – defines which tuples in the two relations match, and what attributes are present in the result of the join.
- **Join type** – defines how tuples in each relation that do not match any tuple in the other relation (based on the join condition) are treated.



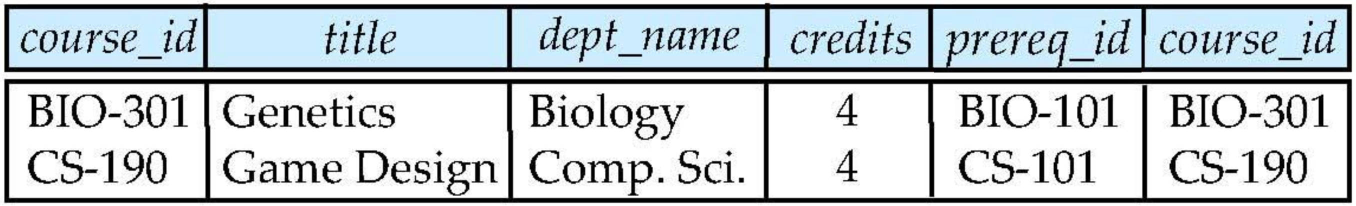
Join types
inner join
left outer join
right outer join
full outer join



Join Conditions
natural
on <predicate>
using $(A_1, A_1, \ldots, A_n)$

Joined Relations – Examples

- *course* **inner join** *prereq* **on**
  course.course_id = prereq.course_id



course_id	*title*	*dept_name*	*credits*	*prereq_id*	*course_id*
BIO-301	Genetics	Biology	4	BIO-101	BIO-301
CS-190	Game Design	Comp. Sci.	4	CS-101	CS-190

- What is the difference between the above, and a natural join?

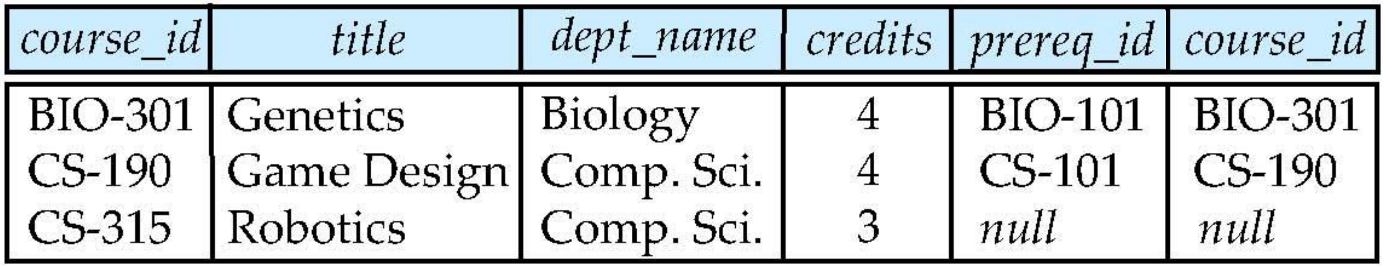
- Alternative:

course, prereq **where**

course.course_id = prereq.course_id

Joined Relations – Examples

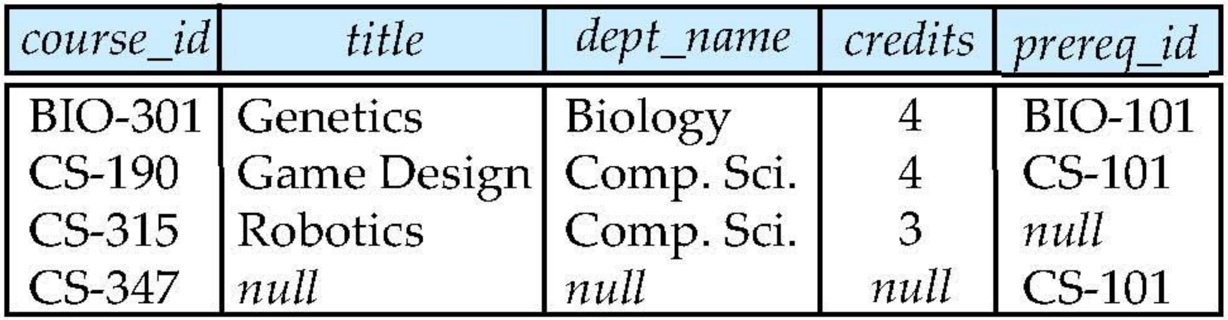
- *course* **left outer join** *prereq* **on**
  course.course_id = prereq.course_id



course_id	*title*	*dept_name*	*credits*	*prereq_id*	*course_id*
BIO-301	Genetics	Biology	4	BIO-101	BIO-301
CS-190	Game Design	Comp. Sci.	4	CS-101	CS-190
CS-315	Robotics	Comp. Sci.	3	*null*	*null*

Joined Relations – Examples

- *course* **full outer join** *prereq* **using** (*course_id*)



course_id	*title*	*dept_name*	*credits*	*prereq_id*
BIO-301	Genetics	Biology	4	BIO-101
CS-190	Game Design	Comp. Sci.	4	CS-101
CS-315	Robotics	Comp. Sci.	3	*null*
CS-347	*null*	*null*	*null*	CS-101

Outline

- Join Expressions
- **Views**
- Transactions
- Integrity Constraints
- SQL Data Types and Schemas
- Authorization

Views

- In some cases, it is not desirable for all users to see the entire logical model (that is, all the actual relations stored in the database.)
- Consider a person who needs to know an instructors name and department, but not the salary. This person should see a relation described, in SQL, by

```
select ID, name, dept_name
from instructor
```

- A **view** provides a mechanism to hide certain data from the view of certain users.
- Any relation that is not of the conceptual model but is made visible to a user as a “virtual relation” is called a **view**.

View Definition

- A view is defined using the **create view** statement which has the form

create view *v* **as** < query expression >

where <query expression> is any legal SQL expression. The view name is represented by *v.*

View Definition

- Once a view is defined, the view name can be used to refer to the virtual relation that the view generates.

- View definition is not the same as creating a new relation by evaluating the query expression
  - Rather, a view definition causes the saving of an expression; the expression is substituted into queries using the view.

Example Views

- A view of instructors without their salary

```
create view faculty as
   select ID, name, dept_name
   from instructor
```

- Using views in SQL queries:
- Find all instructors in the Biology department

```
select name
from faculty
where dept_name = ‘Biology’
```

Example Views

- Create a view of department salary totals

```
create view departments_total_salary(dept_name, total_salary) as
     select dept_name, sum (salary)
     from instructor
    group by dept_name;
```

Views Defined Using Other Views

```
create view physics_fall_2009 as
   select course.course_id, sec_id, building, room_number
   from course, section
   where course.course_id = section.course_id
              and course.dept_name = ’Physics’
              and section.semester = ’Fall’
              and section.year = ’2009’;
```

```
create view physics_fall_2009_watson as
    select course_id, room_number
    from physics_fall_2009
    where building= ’Watson’;
```

View Expansion

- Expand use of a view in a query/another view

```
create view physics_fall_2009_watson as
(select course_id, room_number
from (select course.course_id, building, room_number
        from course, section
        where course.course_id = section.course_id
            and course.dept_name = ’Physics’
            and section.semester = ’Fall’
            and section.year = ’2009’)
where building= ’Watson’;
```

Views Defined Using Other Views

- One view may be used in the expression defining another view
- A view relation v_1 is said to *depend directly* on a view relation v_2 if v_2 is used in the expression defining v_1
- A view relation v_1 is said to *depend on* view relation v_2 if either v_1 depends directly to v_2 or there is a path of dependencies from v_1 to v_2
- A view relation v is said to be *recursive* if it depends on itself.

View Expansion

- A way to define the meaning of views defined in terms of other views.
- Let view v_1 be defined by an expression e_1 that may itself contain uses of view relations.
- View expansion of an expression repeats the following replacement step:

```
repeat
   Find any view relation $v_i$ in $e_1$
   Replace the view relation $v_i$ by the expression defining $v_i$
until no more view relations are present in $e_1$
```

- As long as the view definitions are not recursive, this loop will terminate

Update of a View

- Views present serious problems if we express updates, insertions, or deletions with them.
- The difficulty is that a modification to the database expressed in terms of a view must be translated to a modification to the actual relations in the logical model of the database.

- Add a new tuple to *faculty* view which we defined earlier

  insert into *faculty* **values** ('30765', 'Green', 'Music');

This insertion must be represented by the insertion of the tuple

('30765', 'Green', 'Music', null) into the *instructor* relation

Some Updates cannot be Translated Uniquely

-
  ```
  create view instructor_info as
       select ID, name, building
        from instructor, department
        where instructor.dept_name= department.dept_name;
  ```

- **insert into** *instructor_info* **values** ('69987', 'White', 'Taylor');
  - which department, if multiple departments in Taylor?
  - what if no department is in Taylor?
  - what happen if we add the following tuples to the *instructor* and *department* relations?

  ('69987', 'White', null, null) into *instructor*
  (null, 'Taylor', null) into *department*

Some Updates cannot be Translated Uniquely

- Most SQL implementations allow updates only on simple views
  - The **from** clause has only one database relation.
  - The **select** clause contains only attribute names of the relation, and does not have any expressions, aggregates, or **distinct** specification.
  - Any attribute not listed in the **select** clause can be set to null
  - The query does not have a **group** by or **having** clause.

And Some Not at All

- **create view** *history_instructors* **as**
  select *
  from *instructor*
  where *dept_name*= ’History’;

- What happens if we insert (’25566’, ’Brown’, ’Biology’, 100000) into *history_instructors?*

NOTE:

By default, SQL would allow the above update to proceed. However, views can be defined with a check option clause at the end of the view definition; then, if a tuple inserted into the view does not satisfy the view’s where clause condition, the insertion is rejected by the database system. Updates are similarly rejected if the new value does not satisfy the where clause conditions

Materialized Views

- **Materializing a view**: create a physical table containing all the tuples in the result of the query defining the view
  - Such views called **Materialized view**

- If relations used in the query are updated, the materialized view result becomes out of date
  - Need to **maintain** the view, by updating the view whenever the underlying relations are updated.
  - The process of keeping the materialized view up-to-date is called **materialized view maintenance** (or just **view maintenance**)

Materialized Views Maintenance

- Maintaining a view can be done in different ways
  - View maintenance can be done immediately when any of the relations on which the view is defined is updated.
  - View maintenance can be performed lazily, when the view is accessed.
  - Some systems update materialized views only periodically

Outline

- Join Expressions
- Views
- **Transactions**
- Integrity Constraints
- SQL Data Types and Schemas
- Authorization

Transactions

- Consists of a sequence of query and/or update statements.
- Atomic transaction
- Either fully executed or rolled back as if it never occurred

- Transactions begin implicitly and ended by one of the following
  - **Commit work** commits the current transaction
    - Making the updates performed by the transaction become permanent in the database.
    - After the transaction is committed, a new transaction is automatically started.
  - **Rollback work** causes the current transaction to be rolled back
    - It undoes all the updates performed by the SQL statements in the transaction.
    - Thus, the database state is restored to what it was before the first statement of the transaction was executed.

Transactions

- By default most databases commit each SQL statement automatically as a transaction
  - Can turn off auto commit for a session (e.g. using API)
  - In SQL:1999
    - **begin atomic** …. **end**
    - But not supported on most databases

- Further reading for transactions: Chapter 14

Outline

- Join Expressions
- Views
- Transactions
- **Integrity Constraints**
- SQL Data Types and Schemas
- Authorization

Integrity Constraints

- Integrity constraints guard against accidental damage to the database, by ensuring that authorized changes to the database do not result in a loss of data consistency.
  - A checking account must have a balance greater than $10,000.00
  - A salary of a bank employee must be at least $4.00 an hour
  - A customer must have a (non-null) phone number

Integrity Constraints on a Single Relation

- **not null**
- **primary key**
- **unique**
- **check** (P), where P is a predicate

Not Null and Unique Constraints

- **not null**
  - Declare *name* and *budget* to be **not null**

    name **varchar**(20) **not null**
    budget **numeric**(12,2) **not null**

- **unique** (A_1, A_2, …, A_m)
  - The unique specification states that the attributes *A*1, *A*2, … *A*m
    form a candidate key.
  - Candidate keys are permitted to be null (in contrast to primary keys).

The check clause

- **check** (P)

  where P is a predicate

  Example: ensure that semester is one of fall, winter, spring or summer:

```
create table section (
    course_id varchar (8),
    sec_id varchar (8),
    semester varchar (6),
    year numeric (4,0),
    building varchar (15),
    room_number varchar (7),
    time slot id varchar (4),
    primary key (course_id, sec_id, semester, year),
    check (semester in (’Fall’, ’Winter’, ’Spring’, ’Summer’))
);
```

Referential Integrity

- Ensures that a value that appears in one relation for a given set of attributes also appears for a certain set of attributes in another relation.
  - Example: If “Biology” is a department name appearing in one of the tuples in the *instructor* relation, then there exists a tuple in the *department* relation for “Biology”.

- Let A be a set of attributes. Let R and S be two relations that contain attributes A and where A is the primary key of S. A is said to be a **foreign key** of R if for any values of A appearing in R these values also appear in S.

Cascading Actions in Referential Integrity

-
  ```
  create table course (
      course_id   char(5) primary key,
      title       varchar(20),
      dept_name varchar(20) references department)
  ```

-
  ```
  create table course (
      …
      dept_name varchar(20),
      foreign key (dept_name) references department
                  on delete cascade
                  on update cascade,
      . . . )
  ```

- alternative actions to cascade: **set null**, **set default**

Integrity Constraint Violation During Transactions

- E.g.

```
create table person (
    ID  char(10),
    name char(40),
    mother char(10),
    father  char(10),
    primary key ID,
    foreign key father references person,
    foreign key mother references  person)
```

- How to insert a tuple without causing constraint violation ?
  - insert father and mother of a person before inserting person
  - OR, set father and mother to null initially, update after inserting all persons (not possible if father and mother attributes declared to be **not null**)
  - OR defer constraint checking

Complex Check Clauses

- **check** (*time_slot_id* **in** (**select** *time_slot_id* **from** *time_slot*))
  - should be check by any changes in *time_slot* table as well
- Every section has at least one instructor teaching the section.
  - how to write this?
- **create assertion** <assertion-name> **check** <predicate>;
  - introduce complex overhead
- Unfortunately: subquery in check clause not supported by pretty much any database
  - Alternative: triggers (later)

Outline

- Join Expressions
- Views
- Transactions
- Integrity Constraints
- **SQL Data Types and Schemas**
- Authorization

Built-in Data Types in SQL

- **date:** Dates, containing a (4 digit) year, month and date
  - Example: **date** ‘2005-7-27’
- **time:** Time of day, in hours, minutes and seconds.
  - Example: **time** ‘09:00:30’ **time** ‘09:00:30.75’
- **timestamp**: date plus time of day
  - Example: **timestamp** ‘2005-7-27 09:00:30.75’
- **interval:** period of time
  - Example: interval ‘1’ day
  - Subtracting a date/time/timestamp value from another gives an interval value
  - Interval values can be added to date/time/timestamp values

Default Values

-
  ```
  create table student
  (ID varchar (5),
  name varchar (20) not null,
  dept_name varchar (20),
  tot_cred numeric (3,0) default 0,
  primary key (ID))
  ```

```
insert into student(ID,name,dept_name)
    values('12789', 'Newman', 'Comp. Sci.');
```

Index Creation

-
  ```
  create table student
  (ID varchar (5),
  name varchar (20) not null,
  dept_name varchar (20),
  tot_cred numeric (3,0) default 0,
  primary key (ID))
  ```

```
create index studentID_index on student(ID)
```

Index Creation

- Indices are data structures used to speed up access to records with specified values for index attributes
  - e.g. **select ***
    from *student*
    where *ID* = ‘12345’

  can be executed by using the index to find the required record, without looking at all records of *student*

  More on indices in Chapter 11

Large-Object Types

- Large objects (photos, videos, CAD files, etc.) are stored as a *large object*:
  - **blob**: binary large object -- object is a large collection of uninterpreted binary data (whose interpretation is left to an application outside of the database system)
  - **clob**: character large object -- object is a large collection of character data

book_review **clob**(10KB)

image **blob**(10MB)

movie **blob**(2GB)

Large-Object Types

- When a query returns a large object, a “locator” is returned rather than the large object itself.
- The locator can then be used to fetch the large object in small pieces, rather than all at once
- Much like reading data from an operating system file using a read function call

User-Defined Types

- SQL supports two forms of user-defined data types:
  - distinct types
  - structured data types
    - allows the creation of complex data types with nested record structures, arrays and multisets (Chapter 22)

User-Defined Types

- **create type** construct in SQL creates user-defined type

  create type *Dollars* **as numeric (12,2) final**

  - **create table** *department*
    (*dept_name* **varchar** (20),
    building **varchar** (15),
    budget Dollars);

- NOTE: The keyword final isn’t really meaningful in this context but is required by theSQL:1999 standard; some implementations allow the final keyword to be omitted.

User-Defined Types

- It is possible for several attributes to have the same data type.
  - e.g., the name attributes for student name and instructor (the set of all person names)
  - but not instructor name and dept_name (we would normally not consider the query “Find all instructors who have the same name as a department”)
  - ⇒ assigning an instructor’s name to a department name is probably a programming error
  - Similarly, comparing a monetary value expressed in dollars and pounds

create type *Dollars* **as numeric (12,2) final**
create type *Pounds* **as numeric (12,2) final**

User-Defined Types

- Declaring different types for different attributes results to strong type checking
  - e.g., (department.budget+20) would not be accepted
    - The attribute and the integer constant 20 have different types
- Solution:
  - Values of one type can be cast (converted) to another domain:

cast *(department.budget* **to** *numeric (12,2))*

Domains

- **create domain** construct in SQL-92 creates user-defined domain types

  create domain *person_name* **char**(20) **not null**

- Types and domains are similar. Domains can have constraints, such as **not null**, specified on them.

- **create domain** *degree_level* **varchar**(10)
  constraint *degree_level_test*
  check (**value in** (’Bachelors’, ’Masters’, ’Doctorate’));

Create Table Extensions

- Creating tables that have the same schema as an existing table.

```
create table temp_instructor like instructor
```

```
create table t1 as
        (select *
        from instructor
        where dept_name= 'Music')
with data
```

Create Table Extensions

- **create table … as** statement closely resembles the create view statement and both are defined by using queries.
- The main difference is that the contents of the table are set when the table is created, whereas the contents of a view always reflect the current query result

Outline

- Join Expressions
- Views
- Transactions
- Integrity Constraints
- SQL Data Types and Schemas
- **Authorization**

Authorization

- Forms of authorization on parts of the database:
  - **Read** - allows reading, but not modification of data.
  - **Insert** - allows insertion of new data, but not deletion or updating of existing data.
  - **Update** - allows updating, but not insertion or deletion of data.
  - **Delete** - allows deletion of data, but not insertion or updating.
- Each of these authorization types is called a **privilege**
- A user who creates a new relation is given all privileges on that relation automatically

Authorization

Forms of authorization to modify the database schema

- **Index** - allows creation and deletion of indices.
- **Resources** - allows creation of new relations.
- **Alteration** - allows addition or deletion of attributes in a relation.
- **Drop** - allows deletion of relations.

Authorization Specification in SQL

- The **grant** statement is used to confer authorization

  grant <privilege list>

  on <relation name or view name>

  to <user/role list>

- <user list> is:
  - a user-id
  - **public**, which allows all valid users the privilege granted
- Granting a privilege on a view does not imply granting any privileges on the underlying relations.
- The grantor of the privilege must already hold the privilege on the specified item (or be the database administrator).

Privileges in SQL

- **select:** allows read access to relation,or the ability to query using the view
  - Example: grant users U_1, U_2, and U_3 **select** authorization on the *instructor* relation:

    grant select on *instructor* **to** U_1, U_2, U_3

- **update**:

    grant update on *instructor* **to** *U*1, *U*2, *U*3

Privileges in SQL

- The authorization may be given either on all attributes of the relation or on only some, but not on specific tuples.

- If the list of attributes is omitted, the privilege will be granted on all attributes of the relation.

grant update on *instructor* **to** *U*1, *U*2, *U*3

grant update *(name)* **on** *instructor* **to** *U*1, *U*2, *U*3

Revoking Authorization in SQL

- The **revoke** statement is used to revoke authorization.

  revoke <privilege list>

  on <relation name or view name>

  from <user/role list>

- Example:

  revoke select on *department* **from** U_1, U_2, U_3

  revoke update *(budget)* **on** *department* **from** U_1, U_2, U_3

Roles

- Authorizations can be granted to roles, in exactly the same fashion as they are granted to individual users.
- Each database user is granted a set of roles that he/she is authorized to perform.

create role *lecturer*;

grant *lecturer* **to** U_1**;**

grant select on *takes* **to** *lecturer*;

Roles

- Roles can be granted to users, as well as to other roles

  create role *teaching_assistant*

  grant *teaching_assistant* **to** *lecturer*;

  - *lecturer* inherits all privileges of *teaching_assistant*

- Chain of roles

  create role *dean*;

  grant *instructor* **to** *dean*;

  grant *dean* **to** U_2;

- When a user logs in to the database system, the actions executed by the user during that session have
  - all the privileges granted directly to the user
  - all privileges granted to roles that are granted (directly or indirectly via other roles) to that user

Authorization on Views

- Authorization on view gives us the possibility to define authorization with respect to some specific tuples

```
create view geo_instructor as
(select *
from instructor
where dept_name = ’Geology’);
```

```
grant select on geo_instructor to  geo_staff
```

- Then a *geo_staff* member can issue

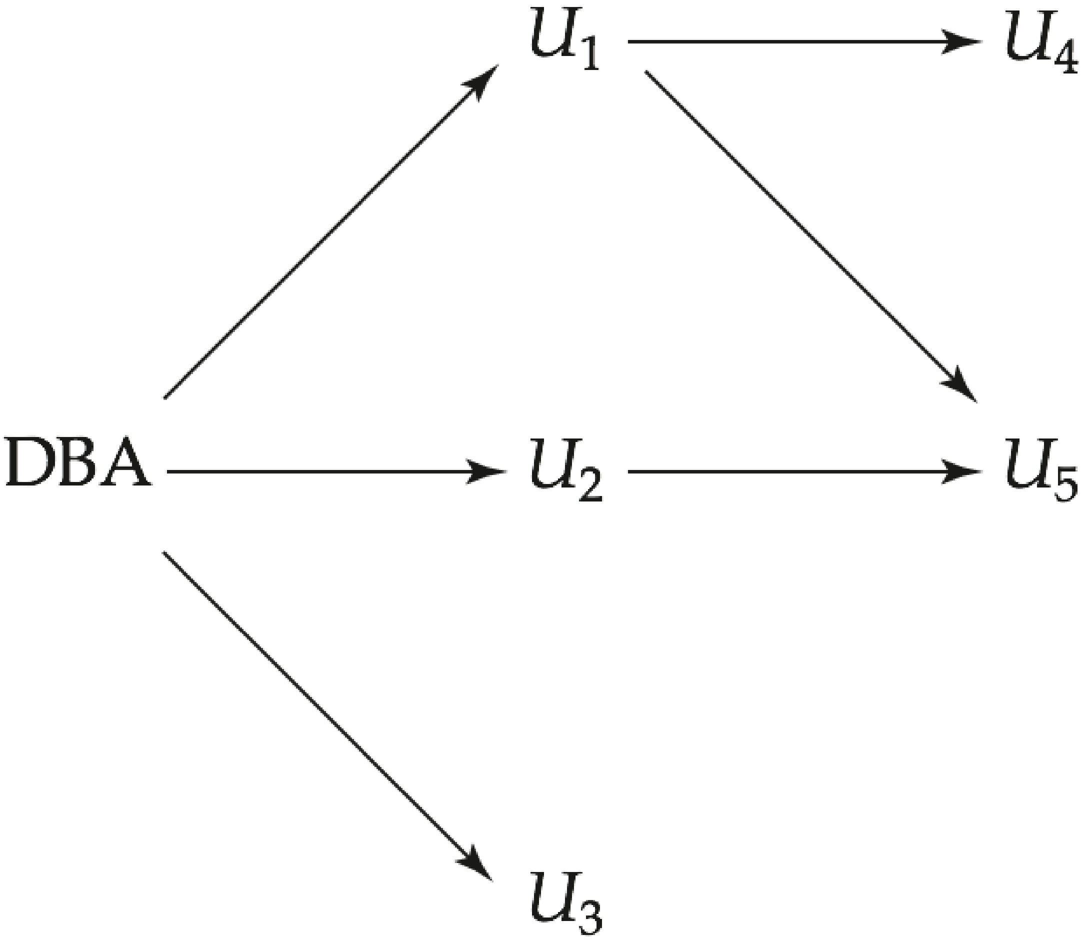
```
  select *
  from geo_instructor;
```

Other Authorization Features

- **references** privilege to create foreign key
  - **grant reference** (*dept_name*) **on** *department* **to** U_1;

- transfer of privileges
  - **grant select on** *department* **to** U_1 **with grant option**;
  - **revoke select on** *department* **from** U_1, U_2 **cascade**;
  - **revoke select on** *department* **from** U_1, U_2 **restrict**;

Transfer of privileges



Questions?