LECTURE 4 EXERCISES
RELATIONAL MODEL AND
RELATIONAL DATABASE DESIGN
EXERCISE 1: REDUCE UNIVERSITY SCHEMA

Reduce the university E-R schema to relation schemas. Use schema combination where possible to reduce relationships. Specify all referential integrity constraints.
# EXERCISE 1: REDUCE STRONG ENTITIES

<table>
<thead>
<tr>
<th>Student</th>
<th>Student(studentId, name)</th>
</tr>
</thead>
<tbody>
<tr>
<td>studentId</td>
<td></td>
</tr>
<tr>
<td>name</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Course(courseld, name)</th>
</tr>
</thead>
<tbody>
<tr>
<td>courseld</td>
<td></td>
</tr>
<tr>
<td>name</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Department</th>
<th>Department(code, name)</th>
</tr>
</thead>
<tbody>
<tr>
<td>code</td>
<td></td>
</tr>
<tr>
<td>name</td>
<td></td>
</tr>
</tbody>
</table>

How do we reduce the strong entities?

⇒ Create a relation for each strong entity with the same attribute as the entity.

What are the keys of these relations?  ⇒ Same as the entities.

What are the foreign key constraints?  ⇒ None.

What are the referential integrity actions?  ⇒ None.
EXERCISE 1: REDUCE GENERALIZATIONS

Option 1: Reduce all entities to relation schemas.

- Staff(hkid, name, officeNumber)
- Instructor(hkid, title)
  - foreign key (hkid) references Staff(hkid) on delete cascade
- TA(hkid)
  - foreign key (hkid) references Staff(hkid) on delete cascade

Which option to select?

Option 2: Reduce only subclass entities to relation schemas.

- Instructor(hkid, name, officeNumber, title)
- TA(hkid, name, officeNumber)

Select Option 1 since Staff has a relationship to other entities and some subclass entities have their own attributes.
**EXERCISE 1: REDUCE COMPOSITE/MULTIVALUED ATTRIBUTES**

**Multivalued attributes:** major

<table>
<thead>
<tr>
<th>Student(studentId, name)</th>
<th>StudentMajor(studentId, major)</th>
</tr>
</thead>
<tbody>
<tr>
<td>studentId, name</td>
<td>studentId, major</td>
</tr>
<tr>
<td>(previously reduced)</td>
<td></td>
</tr>
</tbody>
</table>

How do we reduce the multivalued attribute **major**?

⇒ Create a relation `StudentMajor` and include `studentId`, the key of `Student`, and the attribute `major`.

What is the key of this relation?

What is the foreign key constraint?

What is the referential integrity action?
EXERCISE 1: REDUCE WEAK ENTITIES

Offering entity

Since the key of Offering contains several attributes, to simplify the subsequent reductions that involve Offering, it may be helpful to introduce a surrogate key for Offering.

How do we reduce this entity?

⇒ Create a relation from Offering and include courseld, the key of Course, as a foreign key.

What is the key of this relation?

What is the foreign key constraint?

What is the referential integrity action?
EXERCISE 1: REDUCE 1:N RELATIONSHIPS

Offers relationship between Department and Course

How do we reduce this relationship?

⇒ Create a relation, Offers, containing the keys of Department and Course.

What is the key of the relation?
What are the foreign key constraints?
What are the referential integrity actions?
EXERCISE 1: REDUCE 1:N RELATIONSHIPS

Offers relationship between Department and Course (using schema combination)

Department(code, name) (previously reduced)

Course(courseld, name, code)

Department(code) references foreign key (code) on delete cascade

Course(courseId) references foreign key (courseId) on delete cascade

Which relation do we use?

⇒ Course (Add code, the key of Department, as a foreign key.)

What is the foreign key constraint?

What is the referential integrity action?

The referential integrity action is determined by the participation constraint of the entity into which the foreign key is placed.

- partial: on delete set null
- total: on delete cascade
EXERCISE 1: REDUCE 1:N RELATIONSHIPS

Appoints relationship between Department and Staff (using schema combination)

Which relation do we use?
Staff (Add code, the key of Department, as a foreign key.)

What is the foreign key constraint?

What is the referential integrity action?

Department(code, name) (previously reduced)
Staff(hkid, name, officeNumber, code)

foreign key (code) references Department(code) on delete cascade
**EXERCISE 1: REDUCE N:M RELATIONSHIPS**

**AssignedTo** relationship between **Staff** and **Offering**

Staff\((hkid, \text{name, officeNumber})\)  
(previously reduced)

Offering\((\text{courseld, section, semester, year})\)  
(previously reduced)

AssignedTo\((hkid, \text{courseld, section, semester, year})\)

foreign key \((hkid)\) references Staff  
on delete cascade

foreign key \((\text{courseld, section, semester, year})\) references Offering  
on delete cascade

How do we reduce this relationship?  
⇒ Create a relation, **AssignedTo**, containing the keys of the **Staff** and **Offering** relations.

What is the key of the relation?  
What are the foreign key constraints?  
What are the referential integrity actions?

For a relation that represents a relationship, the referential integrity action is always on delete cascade.
**EXERCISE 1: REDUCE N:M RELATIONSHIPS**

**EnrollsIn** relationship between **Student** and **Offering**

- Student(*studentId*, name)
  - (previously reduced)
- Offering(*courseId*, section, semester, year)
  - (previously reduced)
- EnrollsIn(*studentId*, *courseId*, section, semester, year, grade)
  - foreign key (*studentId*) references **Student**(*studentId*)
  - on delete cascade
  - foreign key (*courseId*, section, semester, year) references **Offering**(*courseId*, section, semester, year)
  - on delete cascade

**How do we reduce this relationship?**

⇒ Create a relation, **EnrollsIn**, containing the keys of the **Student** and **Offering** relations.

**Anything else?** ⇒ Add the attribute grade to the relation.
EXERCISE 1: REDUCE N:M RELATIONSHIPS

HasPrerequisite relationship between Course and Course

Course (code, name) (previously reduced)

HasPrerequisite (courseld, prerequisiteId)
  foreign key (courseld) references Course(courseld)
  on delete cascade
  foreign key (prerequisiteId) references Course(courseld)
  on delete cascade

How do we reduce this relationship?

⇒ Create a relation, HasPrerequisite, containing the key of the Course relation (twice).

What is the key of the relation?
EXERCISE 1: UNIVERSITY SCHEMA REDUCTION

Offering(courseld, section, semester, year)  
foreign key (courseld) references Course(courseld)  
on delete cascade

AssignedTo(hkid, courseld, section, semester, year)  
foreign key (hkid) references Staff(hkid)  
on delete cascade  
foreign key (courseld, section, semester, year) references Offering(courseld, section, semester, year)  
on delete cascade

Staff(hkid, name, officeNumber, code)  
foreign key (code) references Department(code)  
on delete cascade

Instructor(hkid, title)  
foreign key (hkid) references Staff(hkid)  
on delete cascade

TA(hkid)  
foreign key (hkid) references Staff(hkid)  
on delete cascade

Student(studentId, name)  
foreign key (studentId) references Student(studentId)  
on delete cascade

Course(courseld, name, code)  
foreign key (code) references Department(code)  
on delete cascade

Department(code, name)  
foreign key (code) references Department(code)  
on delete cascade

EnrollsIn(studentId, courseld, section, semester, year, grade)  
foreign key (studentId) references Student(studentId)  
on delete cascade  
foreign key (courseld, section, semester, year) references Offering(courseld, section, semester, year)  
on delete cascade

HasPrerequisite(courseld, prerequisiteId)  
foreign key (courseld) references Course(courseld)  
on delete cascade  
foreign key (prerequisiteId) references Course(courseld)  
on delete cascade
EXERCISE 2: REDUCE BUS COMPANY SCHEMA

Reduce the bus company E-R schema to relation schemas. Specify all keys and referential integrity constraints. Do not add any surrogate keys. Use schema combination where possible to reduce relationships.
EXERCISE 2: REDUCE ENTITIES

Strong Entities

Driver
- empId
- name
- phoneNo

Bus
- licenseNo
- maxSeating

Route
- routeNo

Station
- name

Weak Entities

Route
- routeNo (previously reduced)

Schedule
- routeNo
- departureTime

- foreign key (routeNo) references Route(routeNo) on delete cascade
**EXERCISE 2: REDUCE 1:N RELATIONSHIPS**

**AssignedTo** relationship between **Driver** and **Schedule** (using schema combination)

Schedule(routeno, departureTime, empId)
foreign key (empId) references Driver(empId)
on delete set null

**Uses** relationship between **Bus** and **Schedule** (using schema combination)

Schedule(routeno, departureTime, licenseNo)
foreign key (licenseNo) references Bus(licenseNo)
on delete set null
**EXERCISE 2: REDUCE 1:N RELATIONSHIPS**

**HasDeparture** relationship between
*Route* and *Station* (using schema combination)

Route\((routeNo, departureStationName)\)
foreign key \((departureStationName)\) references *Station\((name)\) on delete cascade

**HasDestination** relationship between
*Route* and *Station* (using schema combination)

Route\((routeNo, departureStationName, destinationStationName)\)
foreign key \((destinationStationName)\) references *Station\((name)\) on delete cascade
EXERCISE 2: BUS COMPANY SCHEMA REDUCTION

Driver(empId, name, phoneNo)

Bus(licenseNo, maxSeating)

Route(routeNo, departureStationName, destinationStationName)
   foreign key (departureStationName) references Station(name)
      on delete cascade
   foreign key (destinationStationName) references Station(name)
      on delete cascade

Station(name)

Schedule(routeNo, departureTime, empId, licenseNo)
   foreign key (routeNo) references Route(routeNo)
      on delete cascade
   foreign key (empId) references Driver(empId)
      on delete set null
   foreign key (licenseNo) references Bus(licenseNo)
      on delete set null