# Tutorial 1 — E-R Model, Basic Queries

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# How to Best Make Use of Tutorials

Treat material presented in these slides as a supplement to Prof. Zarnett's lecture slides, given from a slightly different perspective.

If you notice that this perspective could be wrong, don't hesitate to speak up!

We will also walk through some exercises in tutorial to serve as practice.

# The Entity-Relationship Model

In short, this model lets us represent:

- tables in a database with **mathematical sets**, and
- queries on the database with a language called the **relational algebra**.

# Nouns of the Relational Model (1/2)

A **relation** $R$ is equivalent to a table.

An **attribute** $A$ is equivalent to a column of a table.

We describe the combination of relation and attributes with a **relation schema** of the form $R(A_1, A_2, \ldots, A_n)$.

$Student(student\_number, name, address)$ tells us:

- there is a table called `Student`, and
- it has attributes `name` and `address`.

`name` is an attribute of the relation `Student`.

# Nouns of the Relational Model (2/2)

The **contents** of a relation $R$ are denoted $r(R)$.

$r(R)$ is an (unordered) set of (ordered) **n-tuples**.

Each **n-tuple** of $r(R)$ is equivalent to a row in the relation/table $R$.

The elements of each n-tuple correspond with the attributes $A_1, A_2, \ldots, A_n$ of $R$.

# Nouns of the Entity-Relationship Model (1/5)

An **entity** [table] is equivalent to a relation, which is equivalent to a table.

- `Student` can be an entity in an E-R model.

However, we also use the term **entity** to describe an object in the real world, indistinguishable from other objects.

- A student with student number 20000000 and name Matt is an entity of type `Student`.

In this way, an entity [object] is equivalent to a row of an entity [table].

# Nouns of the Entity-Relationship Model (2/5)

An **entity set** is a set of entities (in the object sense), and is equivalent to the contents of an entity table.

- The set of all students studying at the University of Waterloo might comprise the entity set `Student`.

For instance, `Student` = {(20000000, Matt), (20000001, Josh)}

# Nouns of the Entity-Relationship Model (3/5)

Suppose we have another entity called `Course`, with attributes `course_id` and `title`.

Then the following are two possible entity sets:
`Student` = {(20000000, Matt), (20000001, Josh)}
`Course` = {(CS101, Intro to CS), (CS999, Super Hard CS)}

A **relationship** describes some connection between entities, in both the table sense and the object sense.

- In our E-R model, we can say `Student` takes `Course`.
- An individual student like Matt can take a course like Intro to CS.

# Nouns of the Entity-Relationship Model (4/5)

A **relationship instance** describes how two entity instances are related. The following are each relationship instances:

- Matt takes Intro to CS: $takes_1$ = ((20000000, Matt), (CS101, Intro to CS))
- Josh also takes Intro to CS: $takes_2$ = ((20000001, Josh), (CS101, Intro to CS))
- Intro to CS is taught by Prof. X: $taughtby_1$ = ((CS101, Intro to CS), (1, Prof. X))

A **relationship set** is a set of relationship instances.

- In an E-R model, a relationship set represents how entities (in the table sense) are related.
  - `Students` take `Courses`: *Takes* = {$takes_1$, $takes_2$}
  - `Courses` are taught by `Instructors`: *TaughtBy* = {$taughtby_1$}

In an E-R model, we can use a table to represent a relationship set.
Such a table will have columns to identify which entities are related.

- The `StudentTakesCourse` table might have columns for `student_id` and `course_id`.
- This represents a relationship of **degree** 2, since it relates 2 entities.

# Nouns of the Entity-Relationship Model (5/5)

An **attribute** is data used to describe an entity.

Attributes have a set of legal values called a **domain**, determined by the data type we ascribe to them in our relational schema.

**Simple attributes** contain a single value, e.g. `INT`, `VARCHAR(20)`, `ENUM`.

**Composite attributes** encapsulate other simple or composite attributes. Think someething similar to C `structs`.

- A composite attribute like an `Address` can be composed of the following attributes:
  - lot number,
  - street,
  - nullable apartment/unit number,
  - city,
  - province/state,
  - country, and
  - postal code.

# A Note About `NULL`

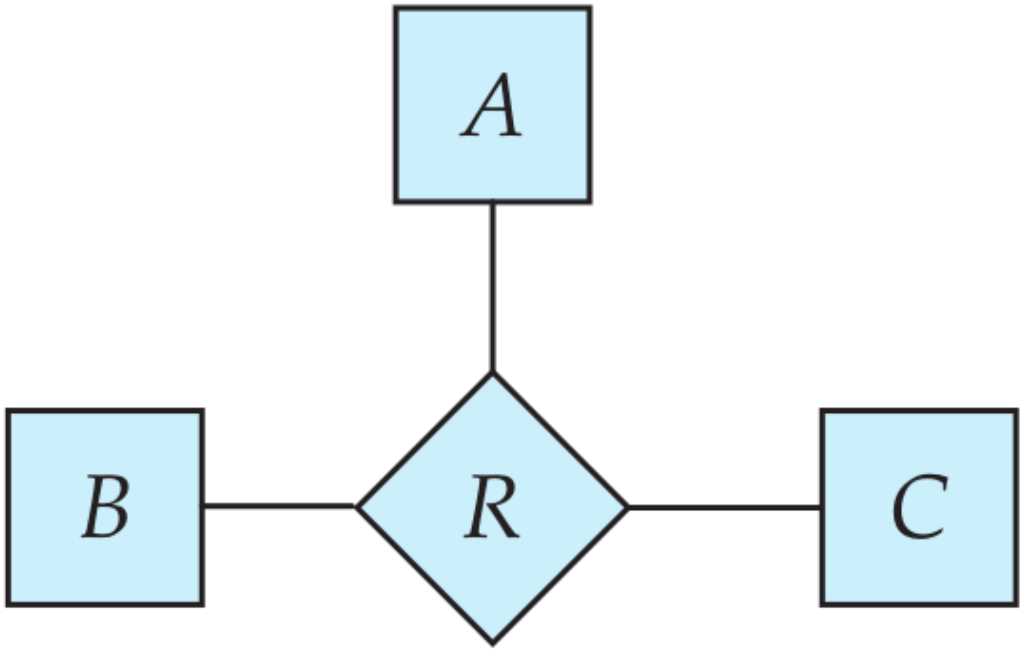
Use <column> `IS NULL` or <column> `IS NOT NULL` to perform null checks.

It typically does not make sense to have any other operators on `NULL` values.

Treat `NULL` as "not having a value", as opposed to an "empty value" like 0 or "".

# Let's get some exercise! - E-R Modeling

Translate the following E-R diagram into a set of database tables by writing relational schemas:



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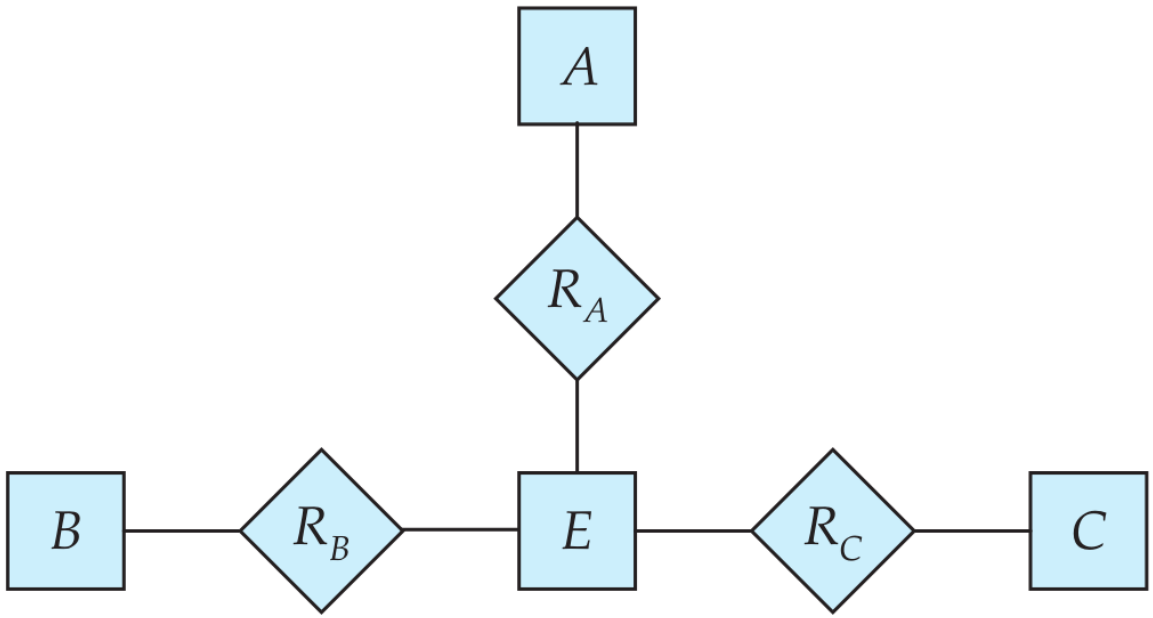


# Let's get some exercise! - E-R Modeling

Draw an E-R diagram to represent the following database specification for a simple Quest-like system:

- Students are identified by student numbers, and have names.
- Courses have course codes and titles.
- Courses are offered in a given term (W, S, F) in a given year.
- Courses are offered in one or more sections.
- Students enroll in sections of a course.
- Students get grades for the sections they are enrolled in at the end of a term.

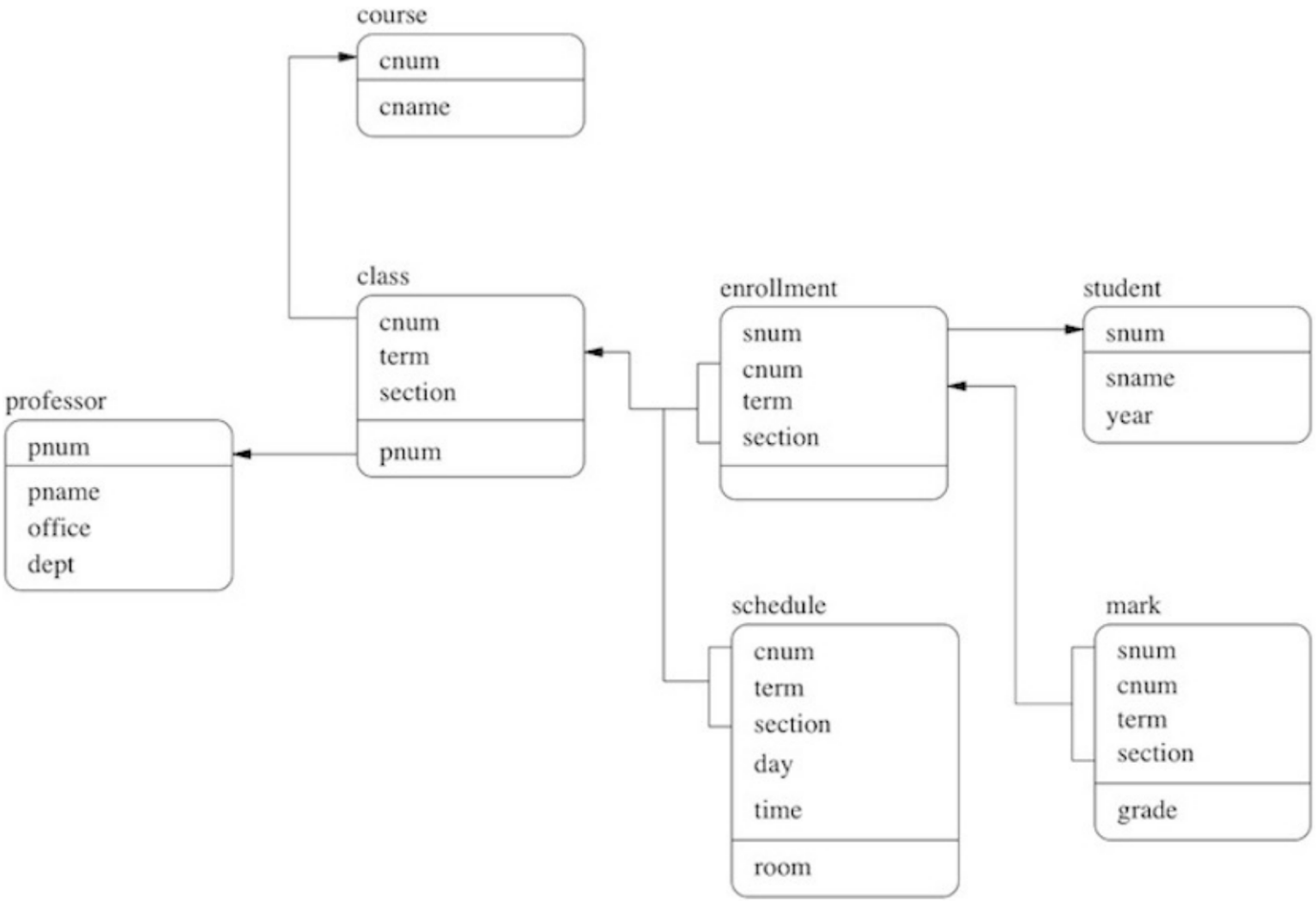
# Let's get some exercise! - E-R Modeling

Sketch out the tables that would implement your E-R diagram for the following specification:

- Students are identified by student numbers, and have names.
- Courses have course codes and titles.
- Courses are offered in a given term (W, S, F) in a given year.
- Courses are offered in one or more sections.
- Students enroll in sections of a course.
- Students get grades for the sections they are enrolled in at the end of a term.

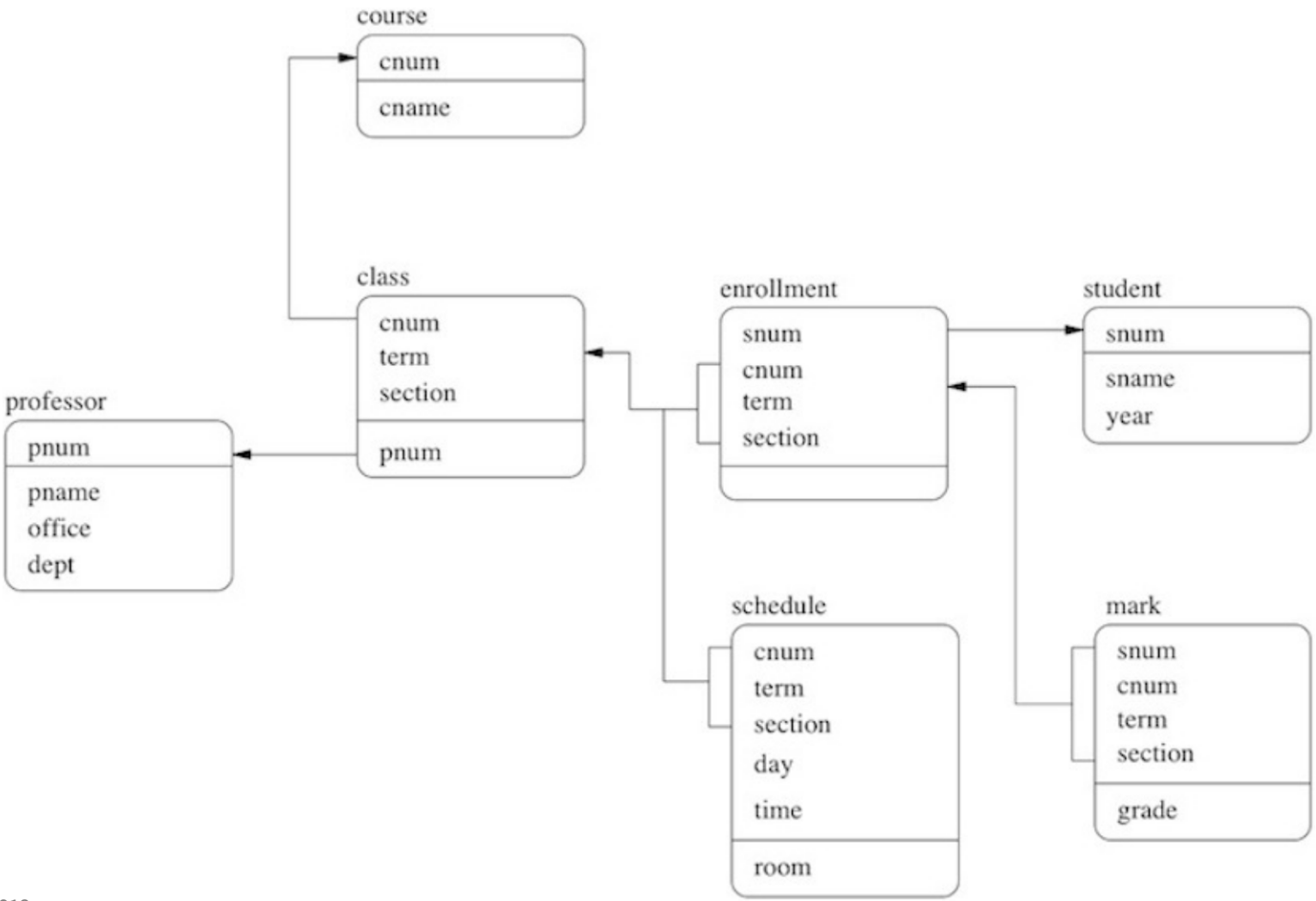
# Let's get some exercise! - Relational Queries

Let's say we're given the following schema for a university database:



# Let’s get some exercise! - Relational Queries

Find the names of all of the students that have not yet been given a grade in a class they have enrolled in.
Try writing the query in SQL, then in relational algebra.



# Let's get some exercise! - Relational Queries

Find all of the course codes along with the names of a student with the top grades in each course.
Try writing the query in SQL, then in relational algebra.