EECS-317 Data Management and Information Processing

Lecture 11 – Defining Databases and Adding Data

Steve Tarzia

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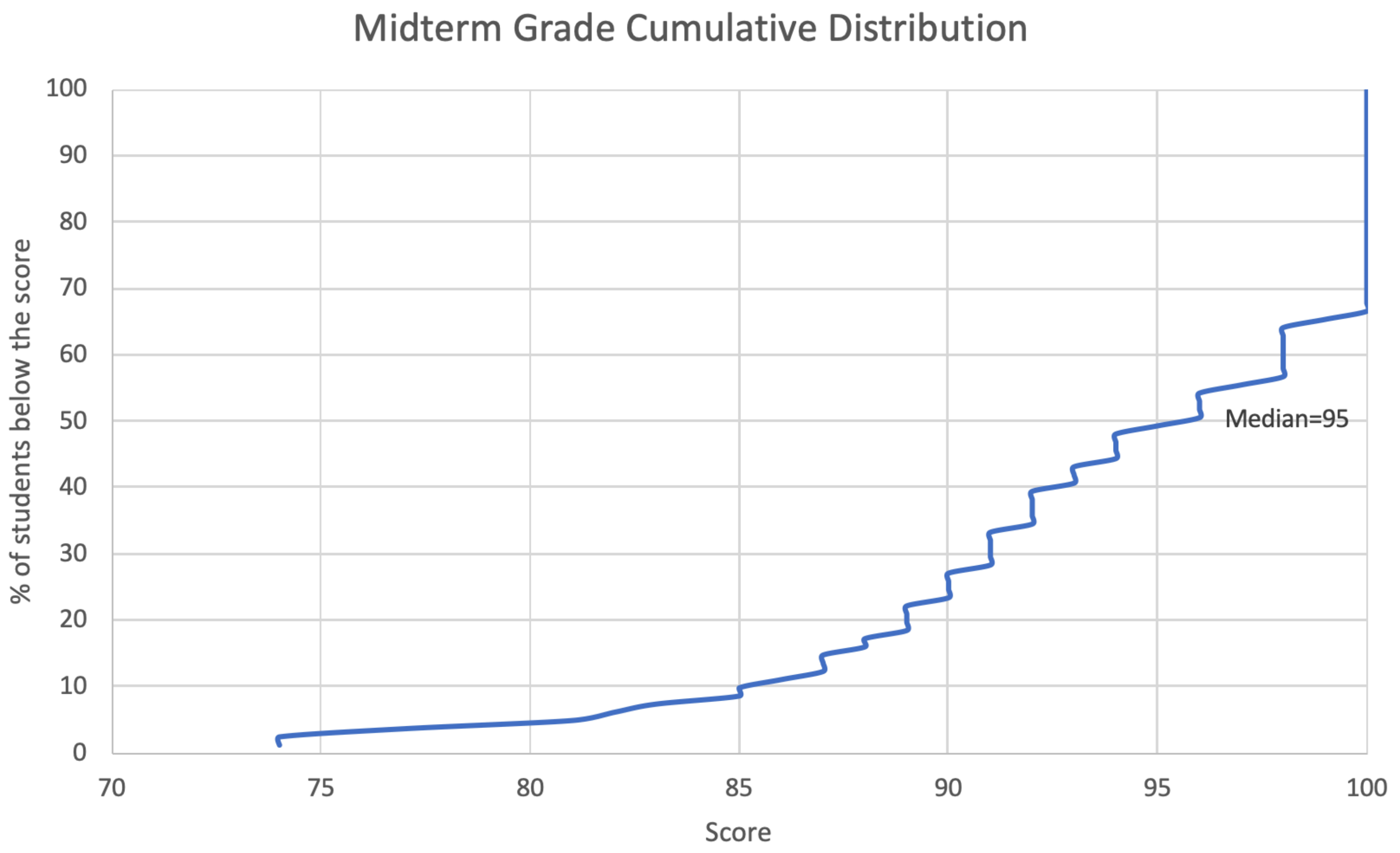
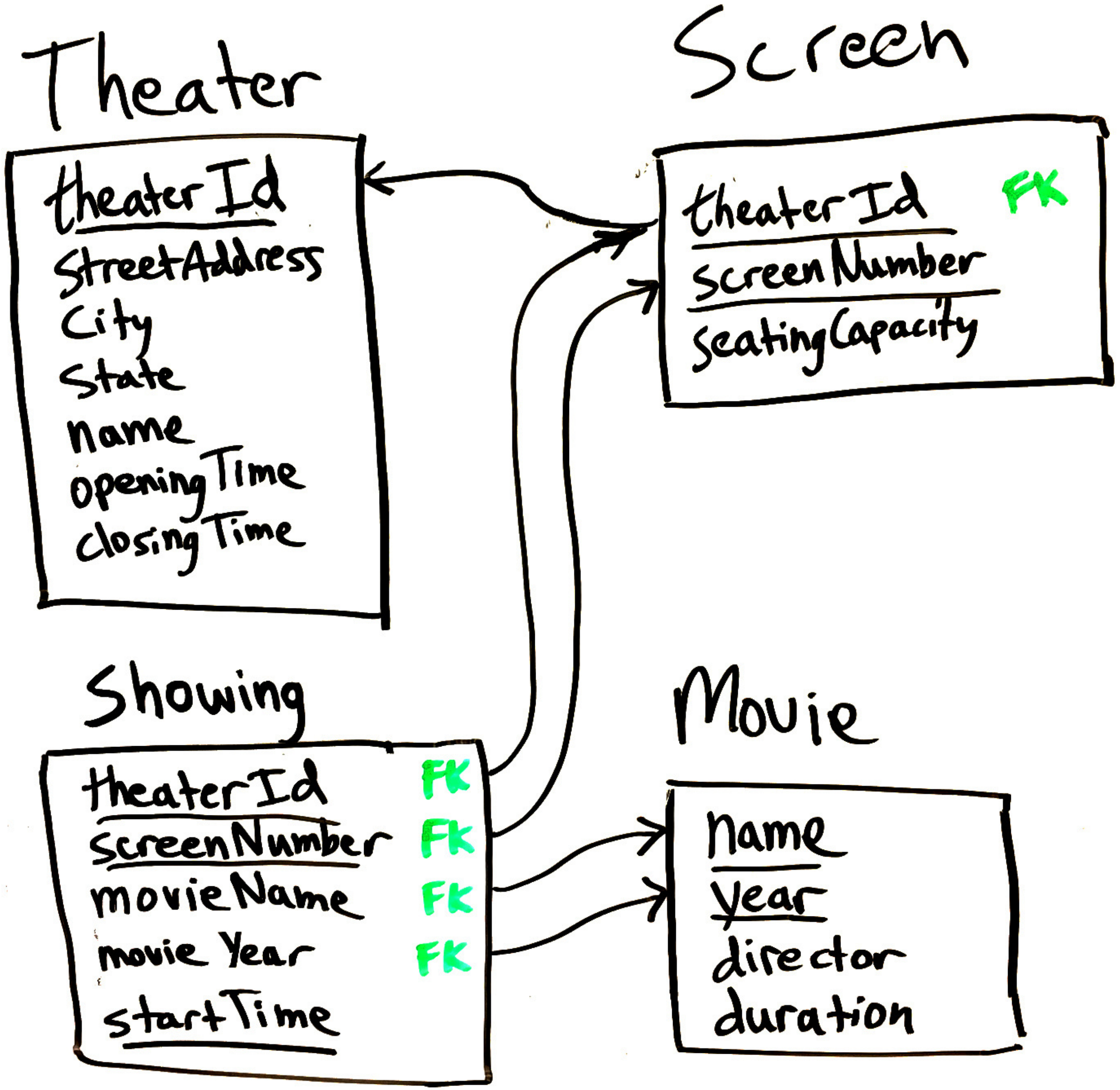
Northwestern

Announcements

- HW4 is due on Monday.



Movie Theater

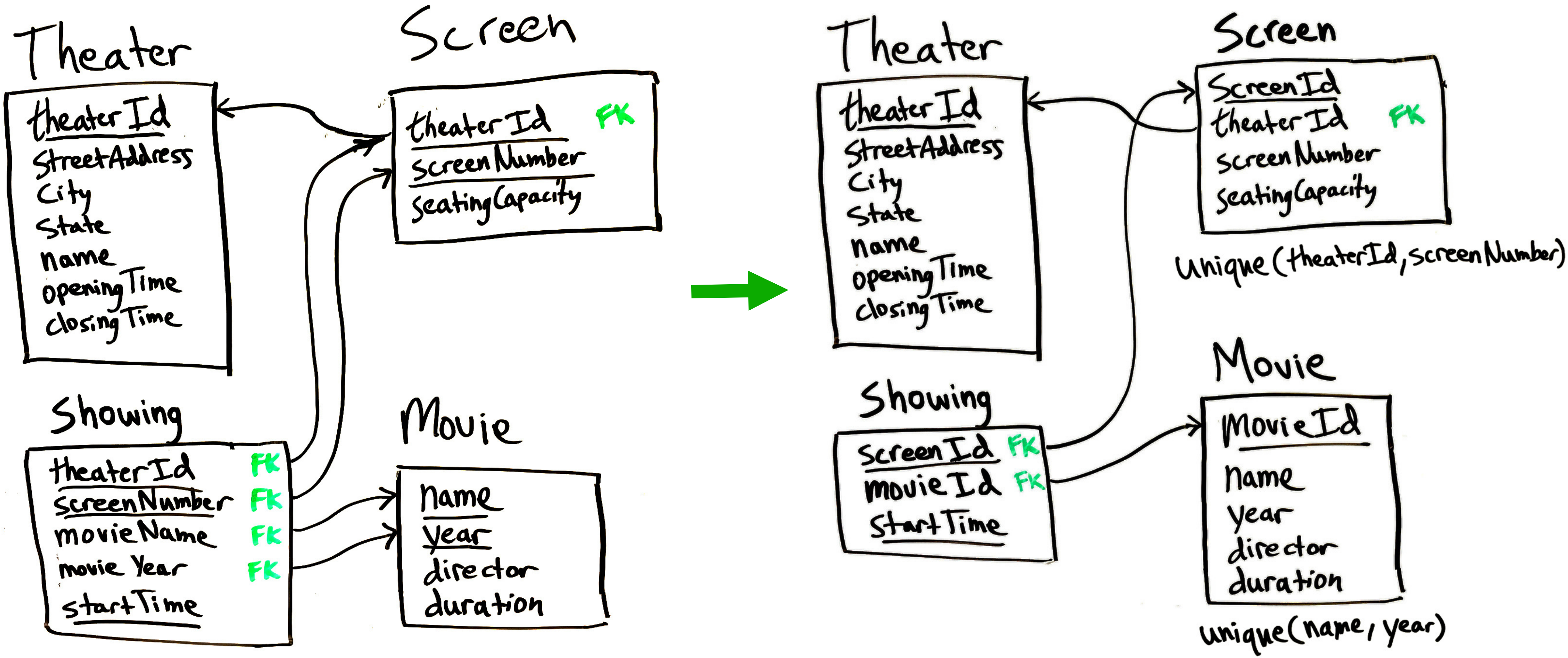


Composite Primary Keys

- Primary Keys uniquely identify rows
  - Used as *indexes* to find a row of interest
  - Prevent duplication
- Often we need more than one column to uniquely identify rows
  - Eg., a Screen is uniquely identified by theaterId *and* screenNumber.
  - theaterId alone cannot be a primary key because it's OK for multiple screens to exist at the same theater, as long as they have different screenNumber.
  - screenNumber alone cannot be a primary key because different theaters can use the same screen numbers (1, 2, 3 …).
- However, composite primary keys make foreign keys and parent-child relationships messy.

Adding a **ScreenId** and **MovieId** simplifies the schema.

Showing table becomes smaller and JOINs are simpler



Non-primary/Unique Keys

- When a table is a parent, it is common to create a meaningless "ID" column for the primary key, then add a non-primary composite key to enforce the integrity constraint.
- For example, in the movie theater example:
  - movieId is meaningless, but it is a convenient way for other tables to refer to movies in foreign keys.
  - add a *unique key* on (name, year) to prevent two instances of the same movie
  - Showing table can have just a single column movieId as a foreign key instead of two columns (name, year).

Unique Keys

- Unique keys are also sometimes needed when you want to add additional constraints beyond those enforced by the primary key.
- In the Music Festival example we needed both:
  - ***primary key*** (time, artist)
    - an artist cannot play on two Stages the same time
  - ***unique key*** (time, stage)
    - a stage cannot host two Artists at the same time

Primary key (time, artist)

Artist	Stage	Time
Beyoncé	1	1
Beyoncé	2	2
~~Beyoncé~~	~~1~~	~~2~~
Bieber	1	2
Bieber	2	1
~~Bieber~~	~~1~~	~~1~~

- This unique key prevents an artist from being on two stages at the same time
- The two crossed-out rows are not allowed because they duplicate a previous (time, artist) combination.

Unique key (time, stage)

Artist	Stage	Time
Beyoncé	1	1
Beyoncé	2	2
Beyoncé	1	2
~~Bieber~~	~~1~~	~~2~~
Bieber	2	1
~~Bieber~~	~~1~~	~~1~~

- This unique key prevents a stage from being used by two artists at the same time
- The two crossed-out rows are not allowed because they duplicate a previous (time, stage) combination.

Why not make a key on a single column?

Artist	Stage	Time
Beyoncé	1	1
Beyoncé	2	2
Beyoncé	1	2
Bieber	1	2
Bieber	2	1
Bieber	1	1

- Key (artist) would prevent an artist from performing twice (even at different times)
- Key (stage) would prevent a stage from ever being used twice.
- Key (time) would prevent two artists from performing at the same time (on different stages).

Modifying SQL databases

- Define tables
- Add rows to tables
- Delete rows from tables
- Update columns in a row
- Alter tables by adding or removing:
  - Columns
  - Indexes
  - Foreign keys
- … and much more

- `CREATE TABLE` …
- `INSERT INTO` …
- `DELETE FROM` …
- `UPDATE` …
- `ALTER TABLE` …

I'll be showing the SQLite dialect in these slides. For the final project, look up the detailed syntax online:

https://sqlite.org/lang.html

Deleting rows

- **DELETE** command deletes rows in a table matching some criterion.
- Very similar to the SELECT statements you're familiar with.
- Just replace SELECT with DELETE and don't specify any columns
- This deletes all the rows in the Classes table for classes in a certain room:

```
DELETE FROM Classes WHERE ClassRoomID=12;
```

- If you don't include a WHERE clause, all the rows in that tables will be deleted: 🚷😰

```
DELETE FROM Classes;
```

- To be safe, run a SELECT query first to see what will be deleted:

```
SELECT * FROM Classes WHERE ClassRoomID=12;
```

Foreign Keys affect deletions

- In the SchoolScheduling database, there is a foreign key in the table which refers to the *Class_Rooms* table.
  - What happens if we try to delete a classroom that has several associated classes?
- If you try to delete a row that is a parent to another row there are several possible results, depending on the particular foreign key settings:
  - `RESTRICT` is the default behavior it it would block the deletion
    - You would have to delete the classes first, then the classrooms
  - `CASCADE` causes the child rows to be deleted as well
    - Classes would be deleted
  - `SET NULL` causes the child rows to have the column set to null
    - Classes would remain, but with a NULL ClassRoomId

Updating rows

- **UPDATE** command is used to change one or more columns in rows matching some criterion.

```
UPDATE Departments SET DeptName="Social Studies"
  WHERE DeptName="History";
```

- Just like DELETE, a single UPDATE command can affect many rows and it can use subqueries:

```
UPDATE Students SET StudMajor=
  (SELECT MajorID FROM Majors WHERE Major="English");
```

- Can also refer to existing column values and use math functions:

```
UPDATE Student_Schedules SET Grade=Grade+5
WHERE ClassID=1500;
```

Updating multiple columns

- Use a comma-separated list to update multiple columns at once:

```
UPDATE my_table
  SET column1=value1,
      column2=value2,
      column3=value3
  WHERE id=123;
```

Inserting new rows

- INSERT command creates one row with the column values specified.
- List the column values in same order that the columns were defined:

```
INSERT INTO Buildings VALUES ("FD", "Ford", 5, 1, 0);
```

- Or, explicitly list the columns being set (this is more clear):

```
INSERT INTO Buildings (BuildingName, BuildingCode,
     NumberOfFloors, ElevatorAccess, SiteParkingAvailable)
  VALUES ("Ford", "FD", 5, 1, 0);
```

- Unspecified columns will get the default value specified when the table was created (more on this later).

Bulk loading data

Three options for inserting lots of rows:

1. Write code in a programming language like R or Python to read the source data and run lots of `INSERT` statements or one really big `INSERT` statement:

   ```
   INSERT INTO animals VALUES (1, "cat", 5), (2, "dog", 2),
       (3, "mouse", 9), (4, "rat", 3) …
   ```

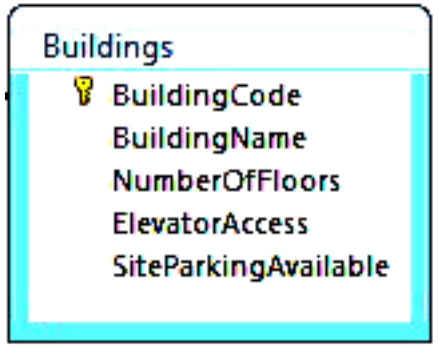
2. Import a CSV file:
   - CSV (**C**omma **S**eparated **V**alues) is a very simple, standard spreadsheet format.
   - Exact import steps are different for each DBMS.
   - In DB Browser for SQLite use *File* → *Import* → *Table from CSV file*
3. Use an ETL software package (Extract, Transform, Load)

Creating tables

- `CREATE TABLE` command defines:
  - Table name
  - Column names
  - Column types (int, float, text, etc.)
  - Whether columns are optional or required (NOT NULL)
  - Primary key
  - Foreign keys
  - Unique keys
  - Indexes (non-unique keys)
- In other words, everything that we drew in the data model diagrams

CREATE TABLE Syntax examples

from SchoolScheduling.sqlite



Buildings

- BuildingCode
- BuildingName
- NumberOfFloors
- ElevatorAccess
- SiteParkingAvailable

Table name

Required column, not optional

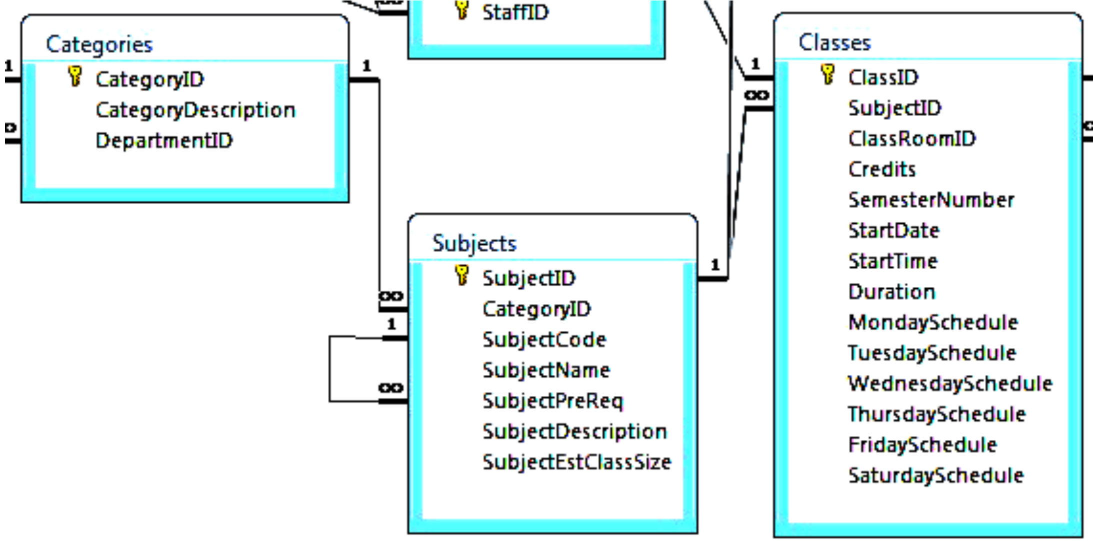
```
CREATE TABLE Buildings (
  BuildingCode nvarchar(3) NOT NULL,
  BuildingName nvarchar(25),
  NumberOfFloors smallint,
  ElevatorAccess bit NOT NULL DEFAULT 0,
  SiteParkingAvailable bit NOT NULL DEFAULT 0,
  PRIMARY KEY (BuildingCode)
);
```

Columns

← *Text with at most 25 characters*

Column cannot be NULL, but it will take a value of zero if none is specified.

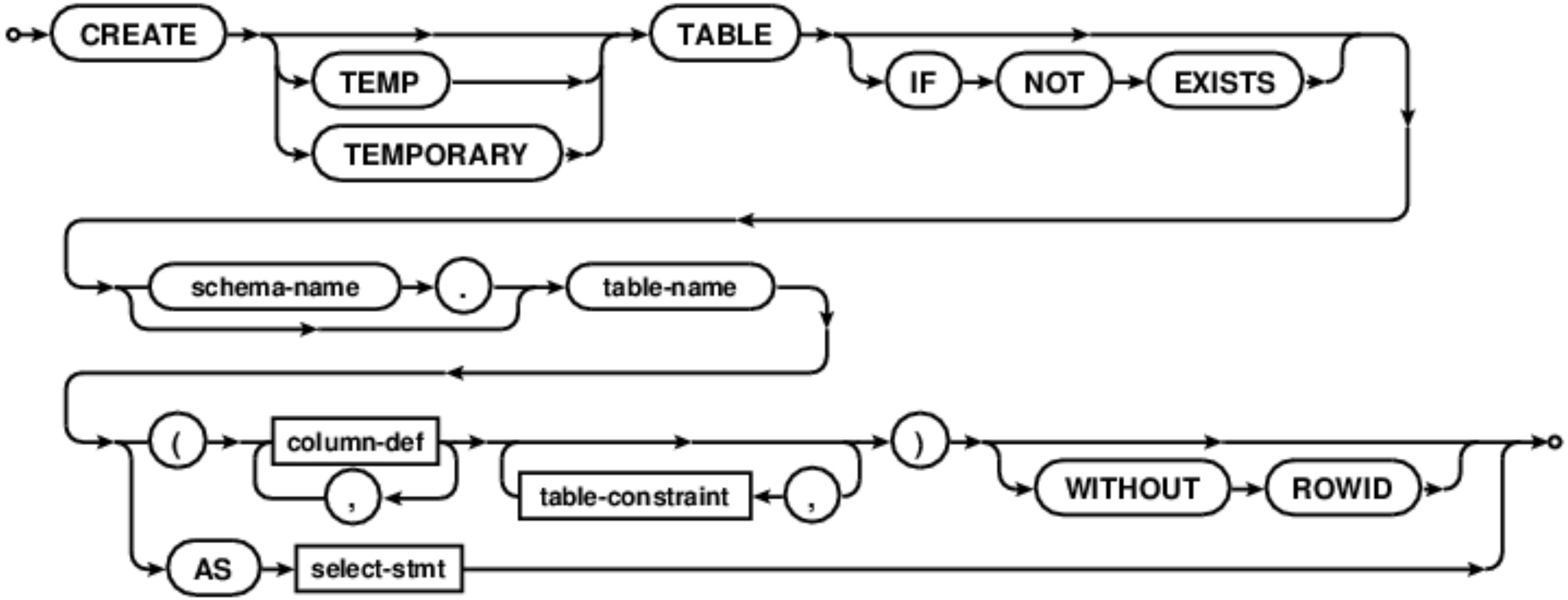
Each column has a data type, like nvarchar(3) *or* smallint



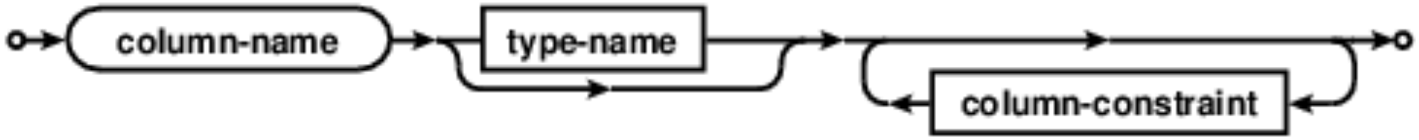
```
CREATE TABLE Subjects (
  SubjectID int NOT NULL DEFAULT 0 ,
  CategoryID nvarchar (10) NULL
      REFERENCES Categories(CategoryID),
  SubjectCode nvarchar (8) NULL ,
  SubjectName nvarchar (50) NULL ,
  SubjectPreReq nvarchar (8) NULL DEFAULT NULL
      REFERENCES Subjects(SubjectCode),
  SubjectDescription text NULL ,
  SubjectEstClassSize smallint NOT NULL DEFAULT 0,
  PRIMARY KEY (SubjectID),
  UNIQUE (SubjectCode)
);
```

Foreign keys

CREATE TABLE syntax diagram



column-def:



column-constraint:

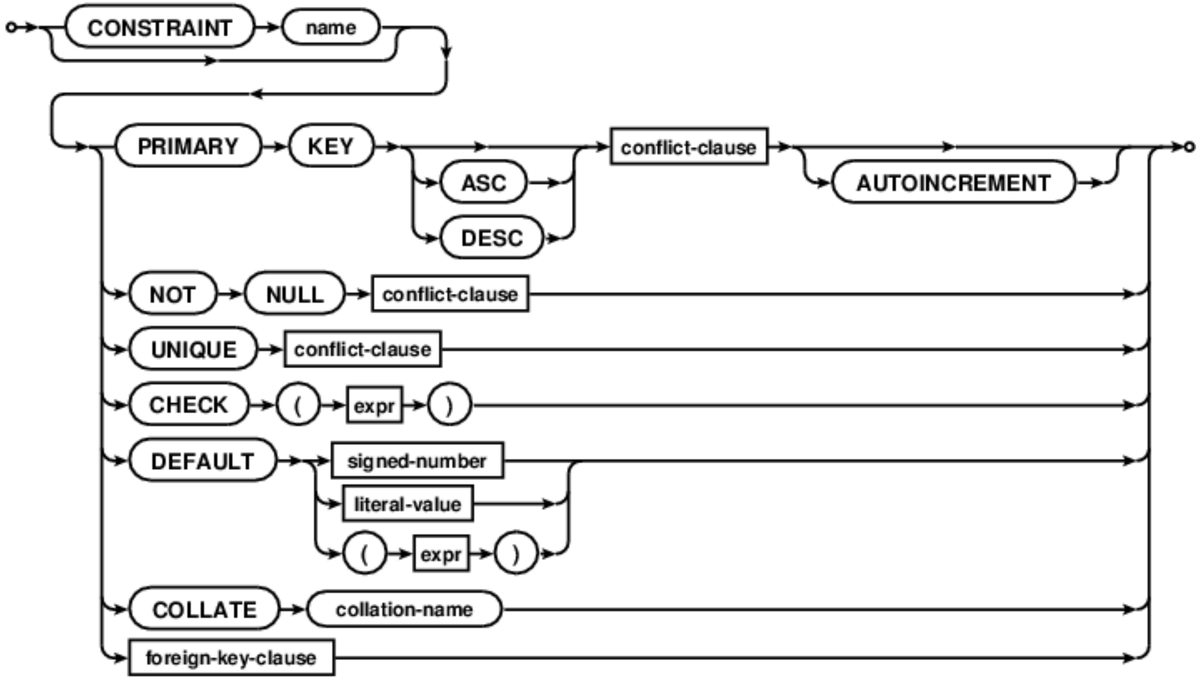
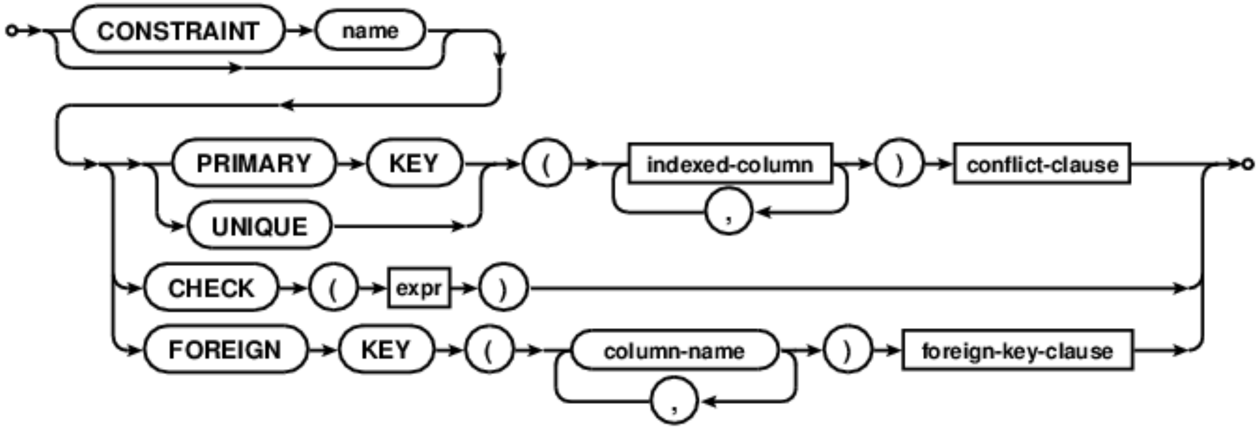


table-constraint:



Using SQLite within Python

- https://docs.python.org/2/library/sqlite3.html
- Can use similar syntax to connect to MySQL, etc.

Also possible to use SQL within R or practically any other language:

- https://db.rstudio.com/databases/sqlite/

Debugging a data import

- If data fails to import completely, try loading it into a *temporary text table*
  - Don't enforce key constraints and use large text types for every column
- Query the text table to look for unexpected values in the source data

This table has strict constraints on what kind of data can be inserted:

```
CREATE TABLE person (
  SSN int NOT NULL,
  firstName varchar(30) NOT NULL,
  lastName varchar(30) NOT NULL,
  birthDate char(10) NOT NULL,
  PRIMARY KEY (SSN)
);
```

This **temporary table** relaxes those constraints:

```
CREATE TABLE _import_person (
  SSN varchar(1000) NOT NULL,
  firstName varchar(1000) NOT NULL,
  lastName varchar(1000) NOT NULL,
  birthDate varchar(1000) NOT NULL,
);
```

Using queries to fill tables

- You can transfer data from the temporary to permanent tables by putting a SELECT in an INSERT query. For example:

  -
    ```
    INSERT INTO orders (col1, col2)
    SELECT col1, col2 FROM tmp_orders;
    ```
- Above query copies data from `tmp_orders` to `orders` table.

- Note that DB Browser to sqlite does not always work well with very large CSV files. You may have to be import big files using the commandline version of sqlite.

CSV data import demo

- LA County Restaurant Inspections and Violations
- https://www.kaggle.com/meganrisdal/la-county-restaurant-inspections-and-violations/home

Recap

- Showed how introducing a single identifier column can make foreign keys simpler.
- Looked in detail at an example needing two unique composite keys.
- Gave SQL syntax for creating and altering tables, and modifying data:
    - `CREATE TABLE` …
    - `INSERT INTO` …
    - `DELETE FROM` …
    - `UPDATE` …
    - `ALTER TABLE` …
- Showed how SQL can be used inside of another language (like Python) to build a database programmatically.