IS664 Database Programming
Fall 2022

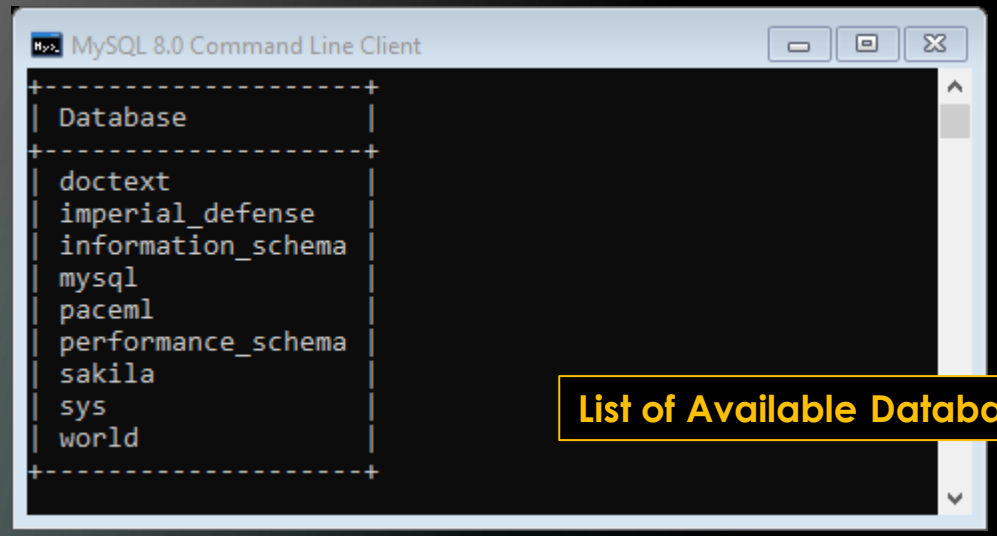
Fundamentals

Database Programming

LECTURE 2: SIMPLE DATABASE CREATION

Seeing Databases

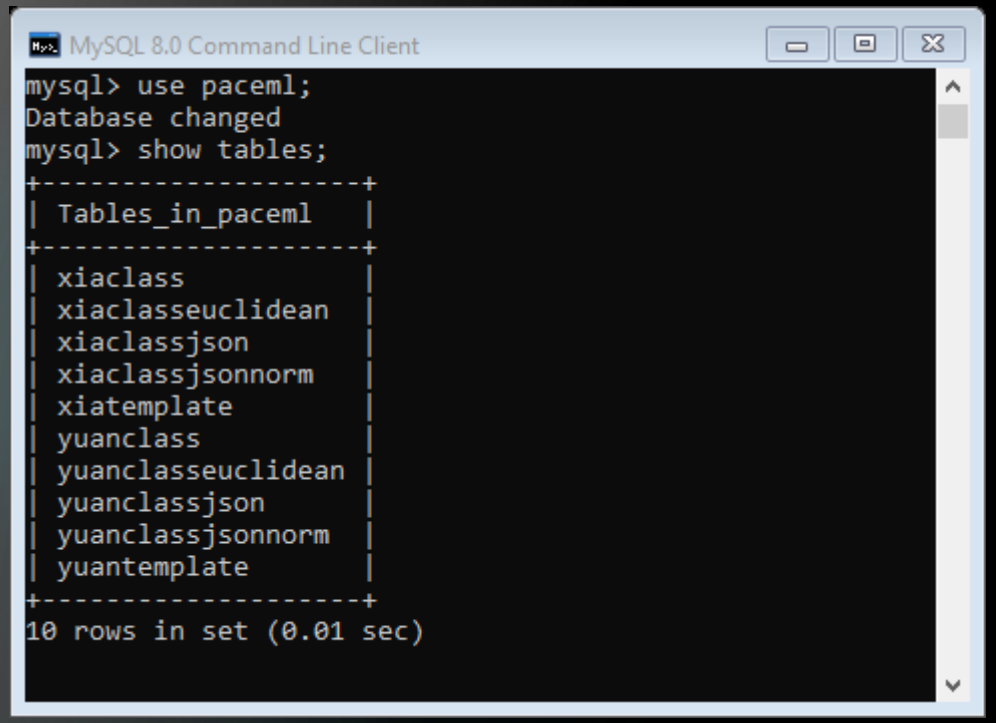
- We can see what databases (namespaces) are available to us on our MySQL Server using the show databases command.



List of Available Databases that you have access to

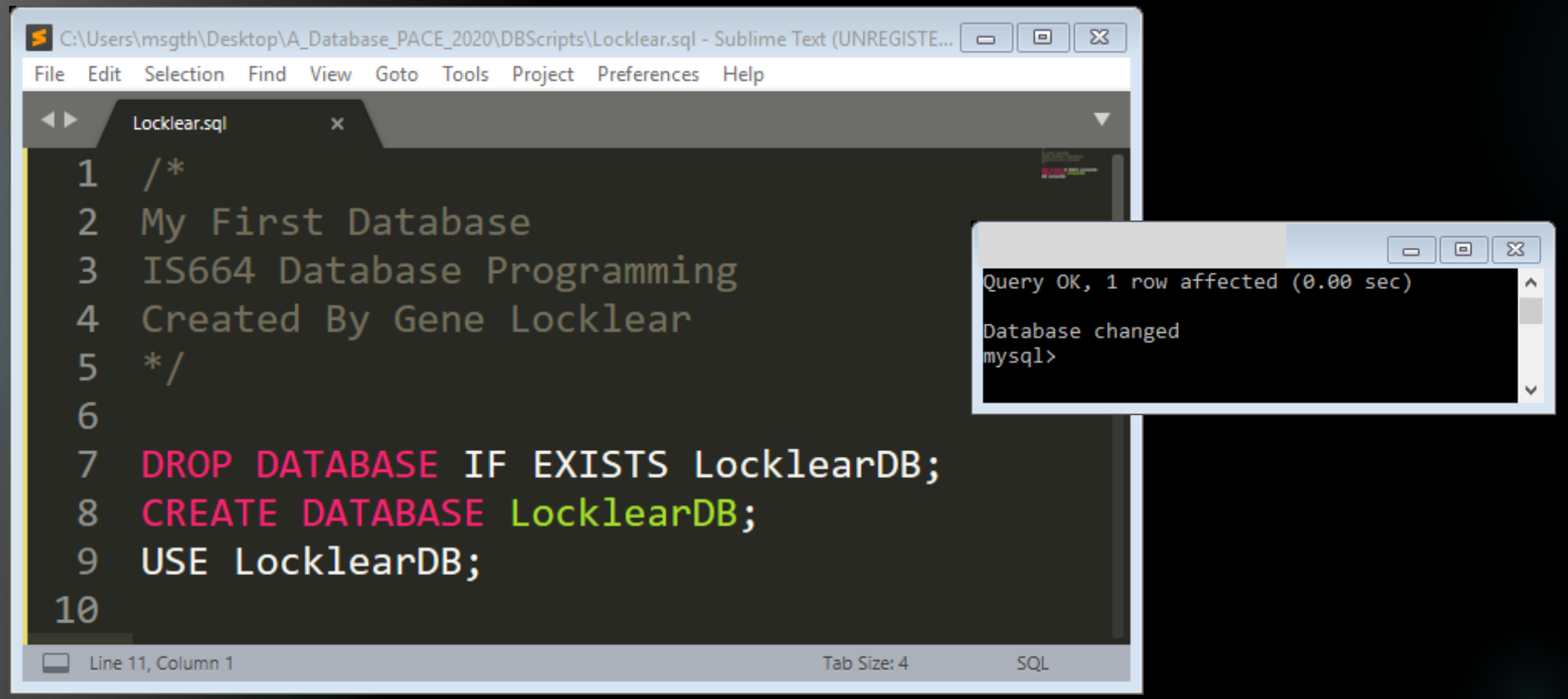
Seeing Tables in a Database

- We can see what relations (tables) are available to us in a specific database by selecting the databases using the USE command and the using the show tables command to see a list of the tables.



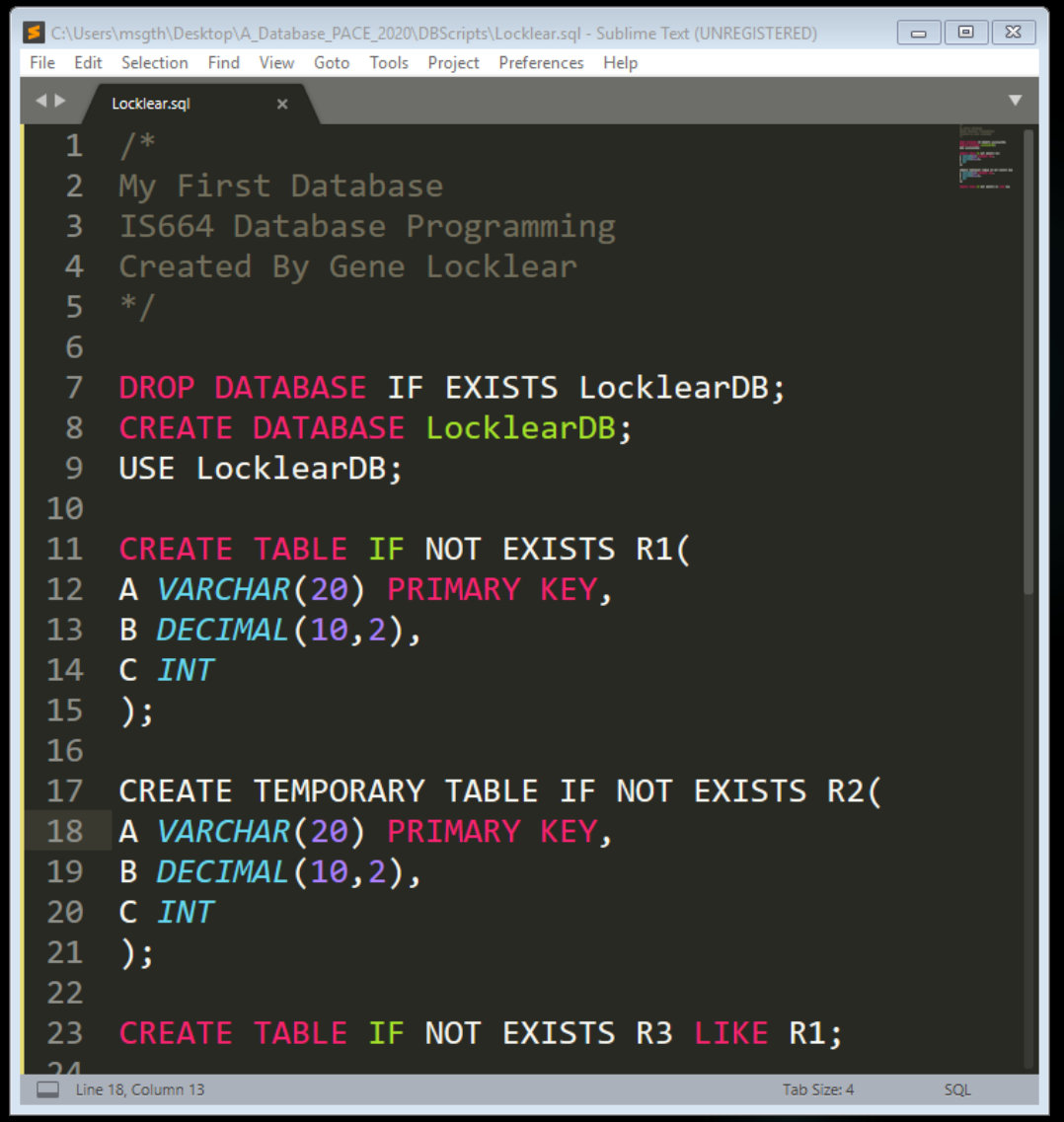
Create and Select a Database

- In order to create a database, we use the **CREATE DATABASE** command.
- Once we have created the database, we can select it using the **USE** [database name] command.



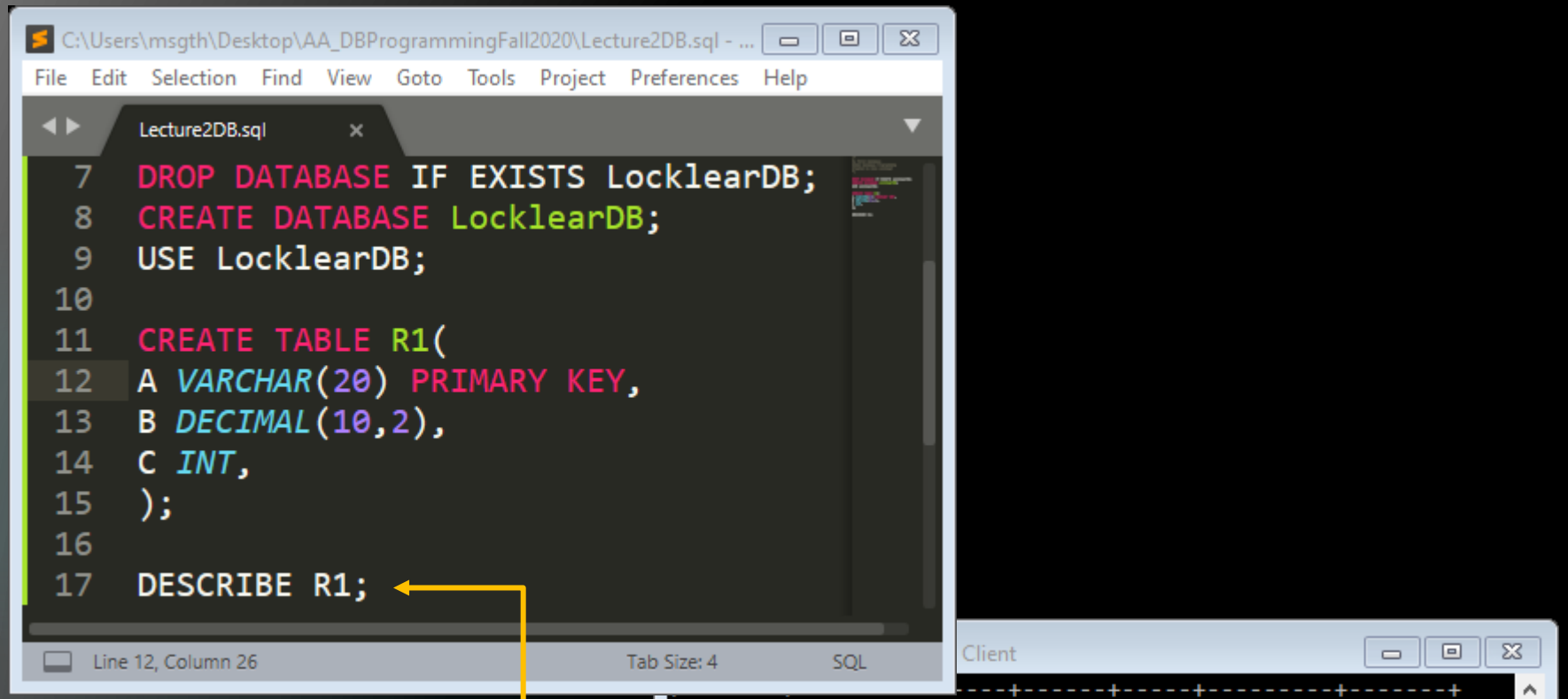
Relation in MySQL

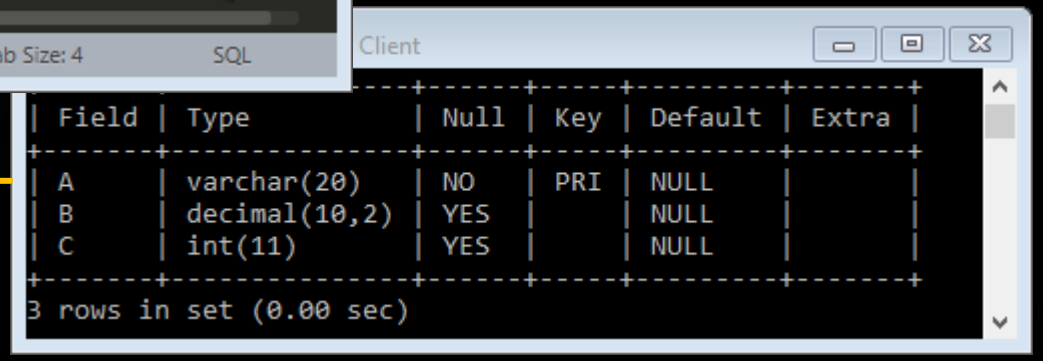
- A maximum of **4096** attributes can be added to a relation.
- Individual storage engines might impose additional restrictions.
- Every relation has a maximum tuple size **65,535** bytes.
- **IF NOT EXISTS** prevents an error when the relation already exists.
- **TEMPORARY** relations are only visible to the current session and dropped automatically when the session is ended.
- **LIKE** is used to create a table based on the definition of another table.



Structure of a Relation

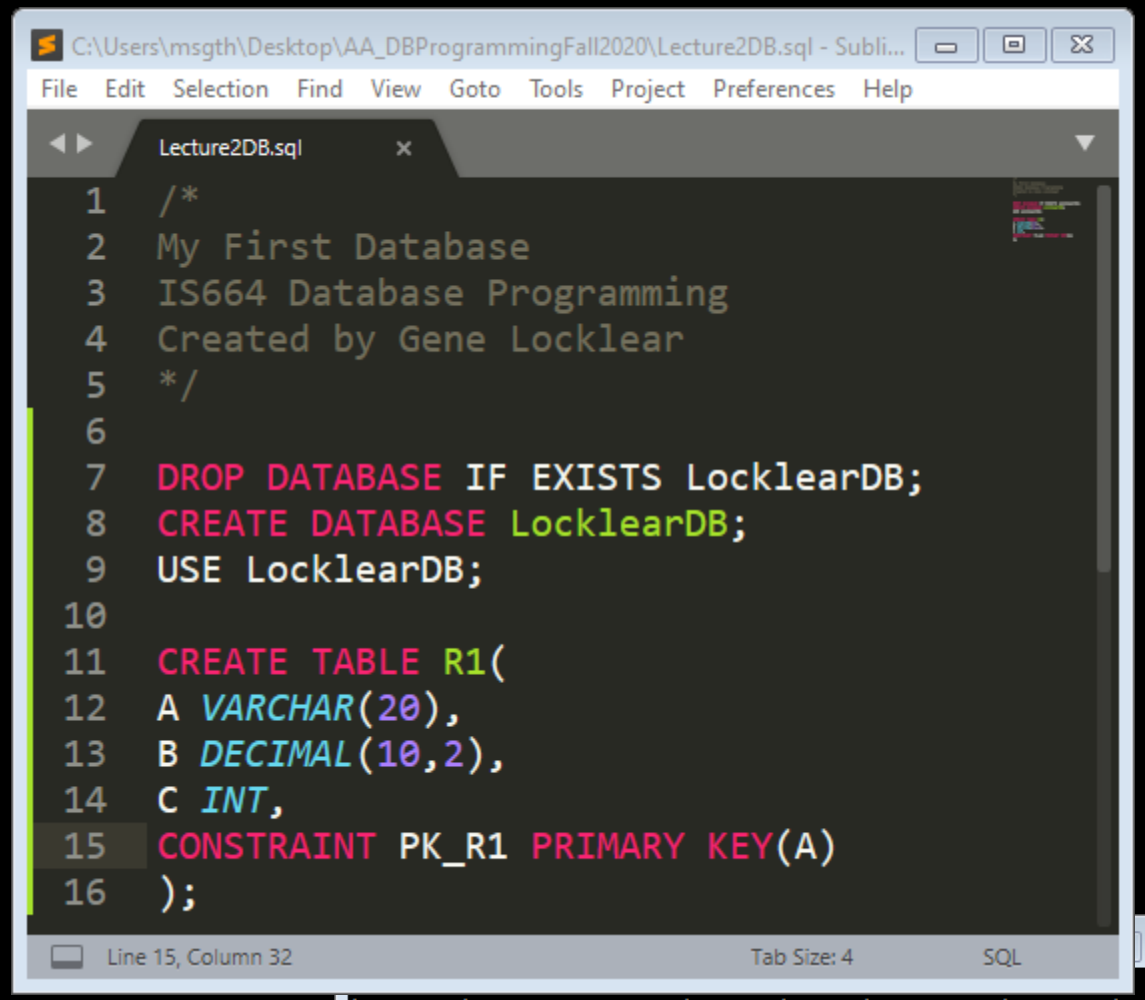
- The **DESCRIBE** command shows the structure of a relation.

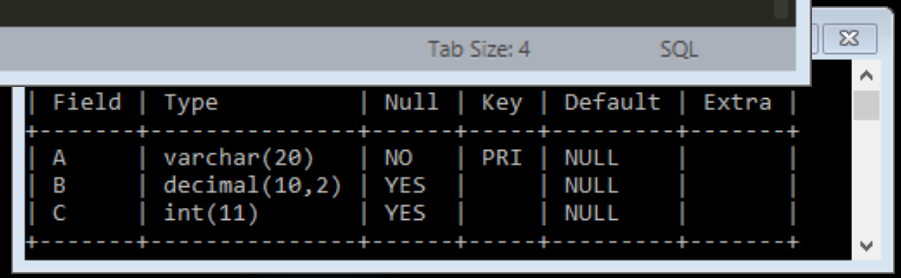




Primary Keys

- A **primary key** uniquely identifies a tuple (row) in a relation.
- A primary key is defined as a **Constraint** on the relation.
- **Primary Keys**
  - By default, are Unique.
  - Cannot be null.
  - Can be only one.
  - Defined on one or more columns.
    - **Composite Key**
- A relation **should always** have a primary key.
- It is preferable to name constraints so that they can be manipulated programmatically.
  - **In the case of the PRIMARY KEY however, we don't need to name it because there is only ever one Primary Key in a Relation.**





Composite Primary Keys

- A **primary key** that is defined on multiple columns is known as a **composite** key.

C:\Users\msgth\Desktop\AA_DBProgrammingFall2020\Lecture2DB.sql - Sublim...

File Edit Selection Find View Goto Tools Project Preferences Help

Lecture2DB.sql

```
1  /*
2  My First Database
3  IS664 Database Programming
4  Created by Gene Locklear
5  */
6
7  DROP DATABASE IF EXISTS LocklearDB;
8  CREATE DATABASE LocklearDB;
9  USE LocklearDB;
10
11 CREATE TABLE R1(
12 A VARCHAR(20),
13 B DECIMAL(10,2),
14 C INT,
15 CONSTRAINT PK_R1 PRIMARY KEY(A,B)
16 );
```

Line 12, Column 15 Tab Size: 4 SQL

Both keys

```
+-------+---------------+------+-----+---------+-------+
| Field | Type          | Null | Key | Default | Extra |
+-------+---------------+------+-----+---------+-------+
| A     | varchar(20)   | NO   | PRI | NULL    |       |
| B     | decimal(10,2) | NO   | PRI | NULL    |       |
| C     | int(11)       | YES  |     | NULL    |       |
+-------+---------------+------+-----+---------+-------+
3 rows in set (0.02 sec)

mysql>
```

Altering Primary Keys

- We can alter the Primary Key programmatically using the **ALTER** command.

C:\Users\msgth\Desktop\AA_DBProgrammingFall2020\Lecture2DB.sql - Sublime Text (UNREGISTERED)

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Lecture2DB.sql

```
7  DROP DATABASE IF EXISTS LocklearDB;
8  CREATE DATABASE LocklearDB;
9  USE LocklearDB;
10
11 CREATE TABLE R1(
12 A VARCHAR(20),
13 B DECIMAL(10,2),
14 C INT,
15 CONSTRAINT PK_R1 PRIMARY KEY(A)
16 );
17
18 DESCRIBE R1;
19
20 ALTER TABLE R1 DROP PRIMARY KEY;
21 ALTER TABLE R1 ADD CONSTRAINT NPK_R1 PRIMARY KEY(B);
22
23 DESCRIBE R1;
```

Line 20, Column 32 Tab Size: 4 SQL

Before

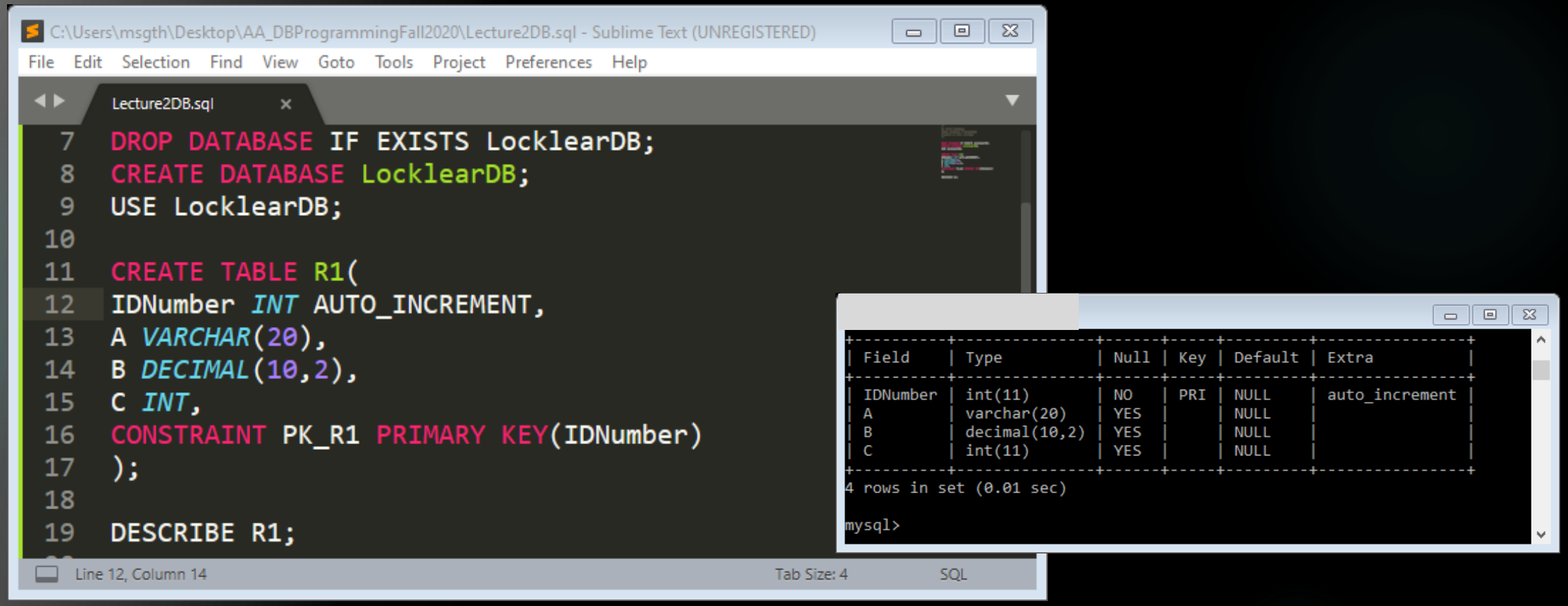
After

mand Line Client

```
+-------+--------------+------+-----+---------+-------+
| Field | Type         | Null | Key | Default | Extra |
+-------+--------------+------+-----+---------+-------+
| A     | varchar(20)  | NO   | PRI | NULL    |       |
| B     | decimal(10,2)| YES  |     | NULL    |       |
| C     | int(11)      | YES  |     | NULL    |       |
+-------+--------------+------+-----+---------+-------+
3 rows in set (0.00 sec)

Query OK, 0 rows affected (1.38 sec)
Records: 0  Duplicates: 0  Warnings: 0

Query OK, 0 rows affected (0.87 sec)
Records: 0  Duplicates: 0  Warnings: 0

+-------+--------------+------+-----+---------+-------+
| Field | Type         | Null | Key | Default | Extra |
+-------+--------------+------+-----+---------+-------+
| A     | varchar(20)  | NO   |     | NULL    |       |
| B     | decimal(10,2)| NO   | PRI | NULL    |       |
| C     | int(11)      | YES  |     | NULL    |       |
+-------+--------------+------+-----+---------+-------+
```

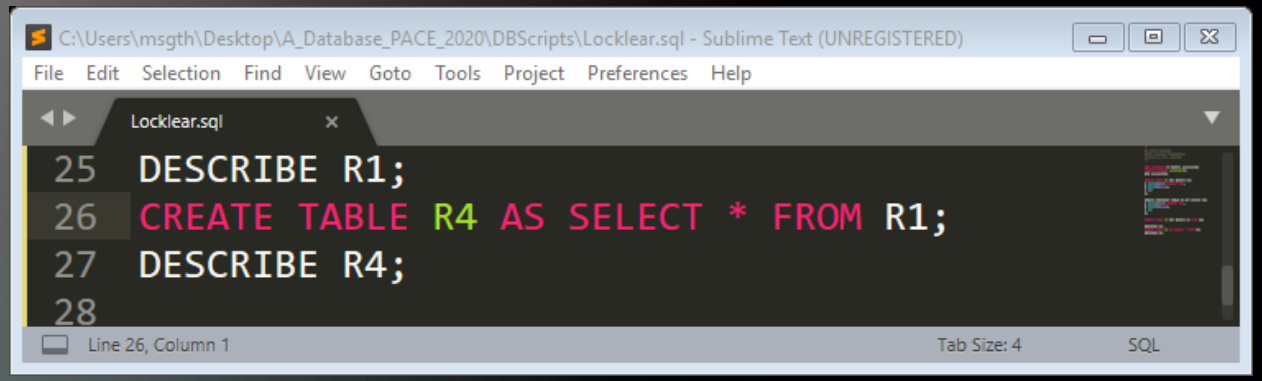
Primary Key: Auto_Increment

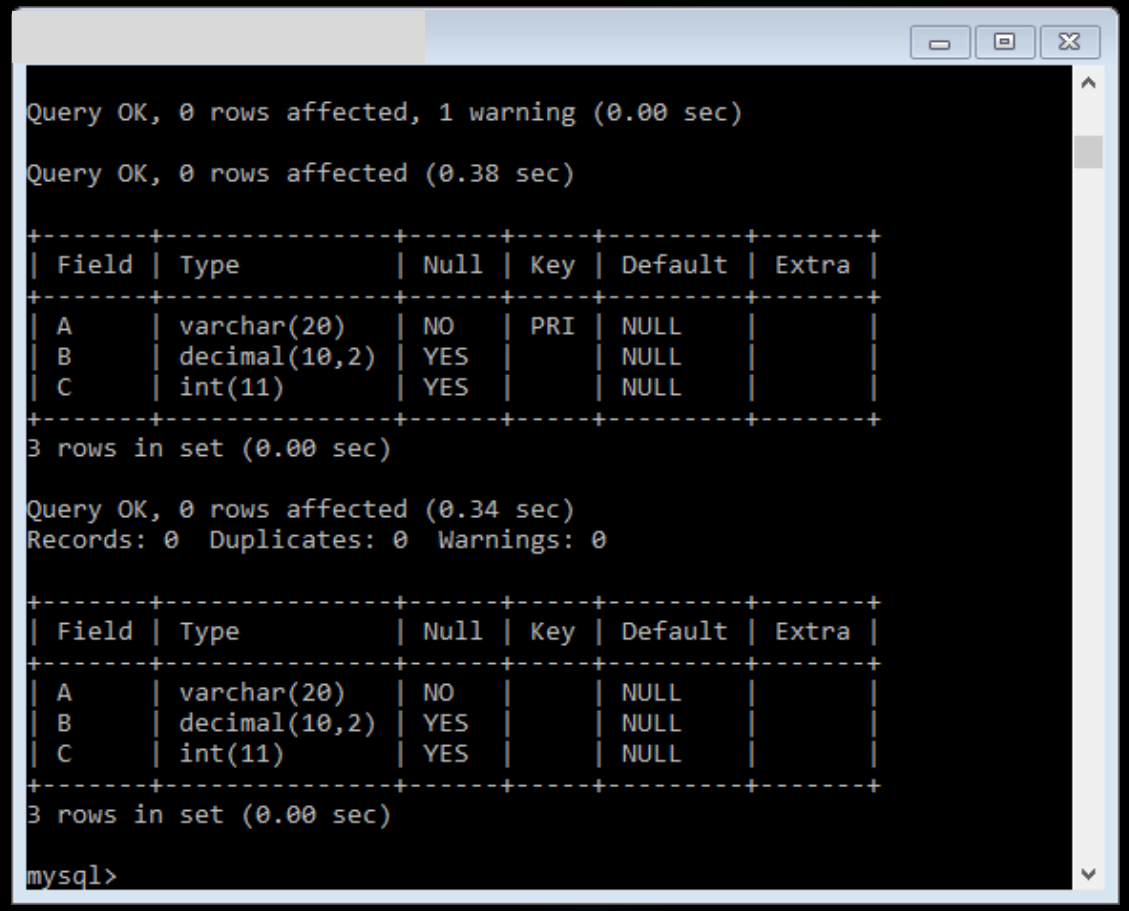
- We can automatically generate a unique identity for each row in a table using the **AUTO_INCREMENT** attribute.



Copy a Relation

- The **AS SELECT * FROM** command allows the data and structure of a table to be copied into another table.





Populate a Relation

- **INSERT INTO [relation] VALUES(v1,v2,…)** allows the relation to be populated with data.

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Lecture2DB.sql | DATA_DB.sql

```
7  DROP DATABASE IF EXISTS LocklearDB;
8  CREATE DATABASE LocklearDB;
9  USE LocklearDB;
10
11 CREATE TABLE R1(
12 A VARCHAR(20),
13 B DECIMAL(10,2),
14 C INT,
15 CONSTRAINT PK_R1 PRIMARY KEY(A)
16 );
17
18 INSERT INTO R1 VALUES('GENE',100.00,54);
19 INSERT INTO R1 VALUES('GEORGE',200.00,45);
20
21 SELECT * FROM R1;
```

Line 19, Column 34 Tab Size: 4 SQL

```
+--------+--------+------+
| GENE   | 100.00 |   54 |
| GEORGE | 200.00 |   45 |
+--------+--------+------+
2 rows in set (0.00 sec)

mysql>
```

Populate a Relation

- If an attribute can be null and we do not have the value for that attribute, **we must specify**, in the insert statement, that we are **only including certain attribute** values.

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Lecture2DB.sql | DATA_DB.sql

```
7  DROP DATABASE IF EXISTS LocklearDB;
8  CREATE DATABASE LocklearDB;
9  USE LocklearDB;
10
11 CREATE TABLE R1(
12 A VARCHAR(20),
13 B DECIMAL(10,2),
14 C INT,
15 CONSTRAINT PK_R1 PRIMARY KEY(A)
16 );
17
18 INSERT INTO R1 (A,C) VALUES('GENE',54);
19 INSERT INTO R1 VALUES('GEORGE',200.00,45);
20
21 SELECT * FROM R1;
```

Specify which attributes are included

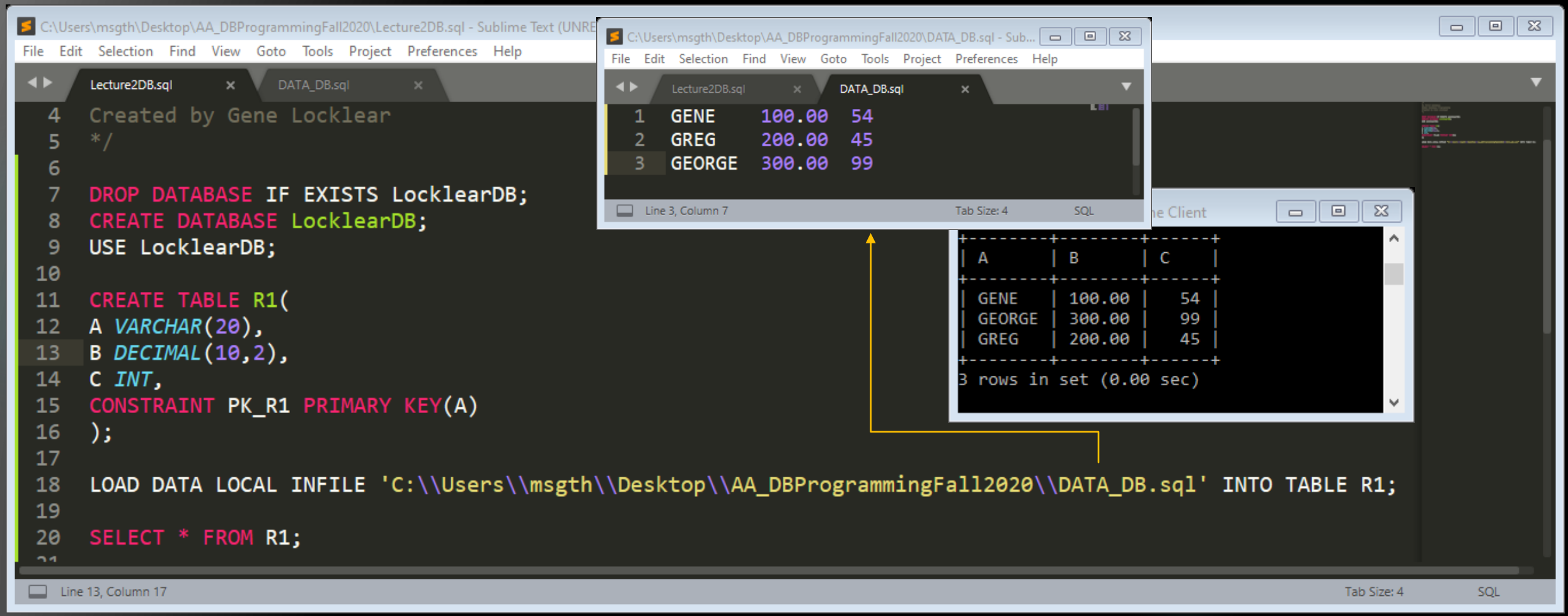
Line 17, Column 1 Tab Size: 4 SQL

```
+--------+--------+------+
| GENE   |   NULL |   54 |
| GEORGE | 200.00 |   45 |
+--------+--------+------+
2 rows in set (0.00 sec)

mysql>
```

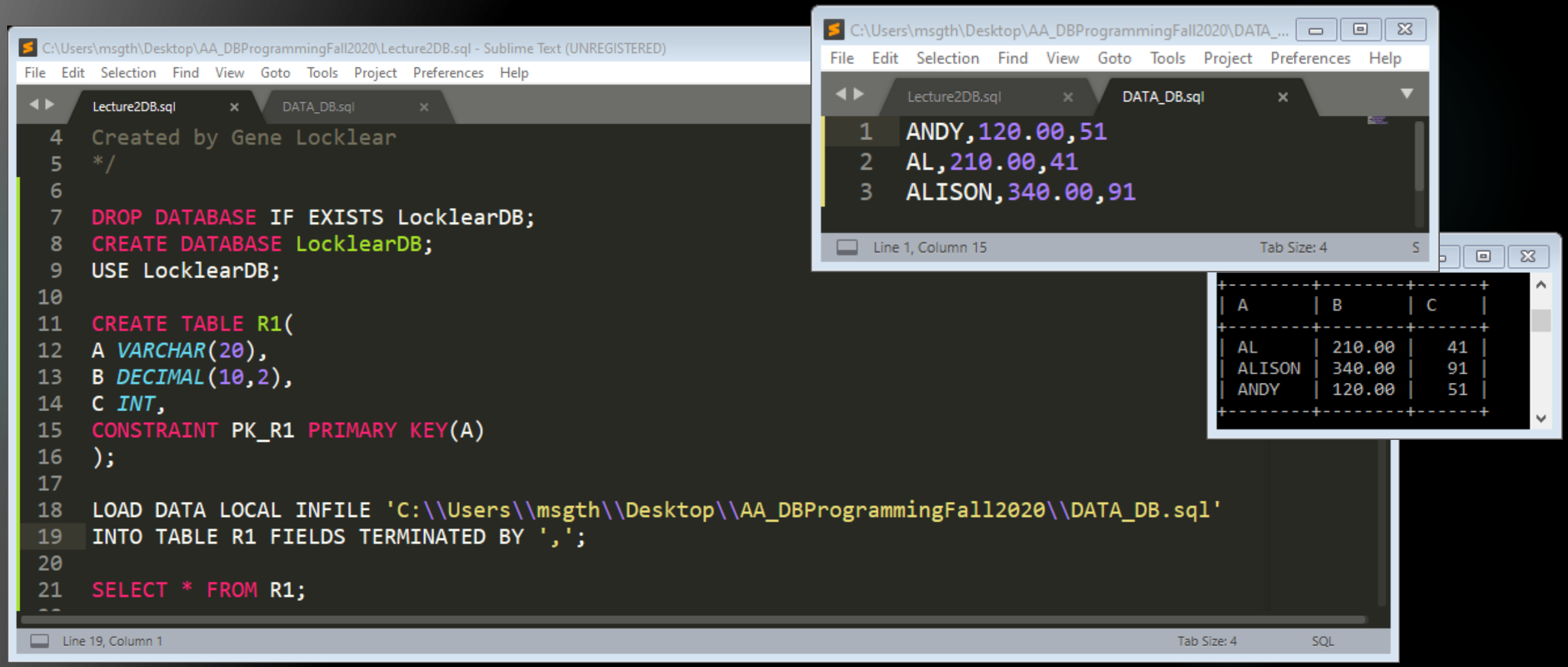
Populate a Relation

- **LOAD DATA LOCAL INFILE [filepath] INTO TABLE [relation]** populates a relation by reading a text file where the attribute values of each tuple are separated by tabs.



Populate a Relation

- We can also specify some other separation when using the **LOAD DATA LOCAL INFILE** command by using **LOCAL DATA LOCAL INFILE [filepath] INTO TABLE [relation] FIELD TERMINATED BY [symbol]**



Generated Columns

- Generated Columns are a way to **compute data for an attribute** based on the values of other attributes.

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Lecture2DB.sql | DATA_DB.sql

```
10
11  CREATE TABLE R1(
12  A VARCHAR(20),
13  B DECIMAL(10,2),
14  C INT,
15  D DECIMAL AS (B * C),
16  CONSTRAINT PK_R1 PRIMARY KEY(A)
17  );
18
19  INSERT INTO R1 (A,B,C) VALUES('GENE',100.00,54);
20  INSERT INTO R1 (A,B,C) VALUES('GEORGE',200.00,45);
21
22  SELECT * FROM R1;
```

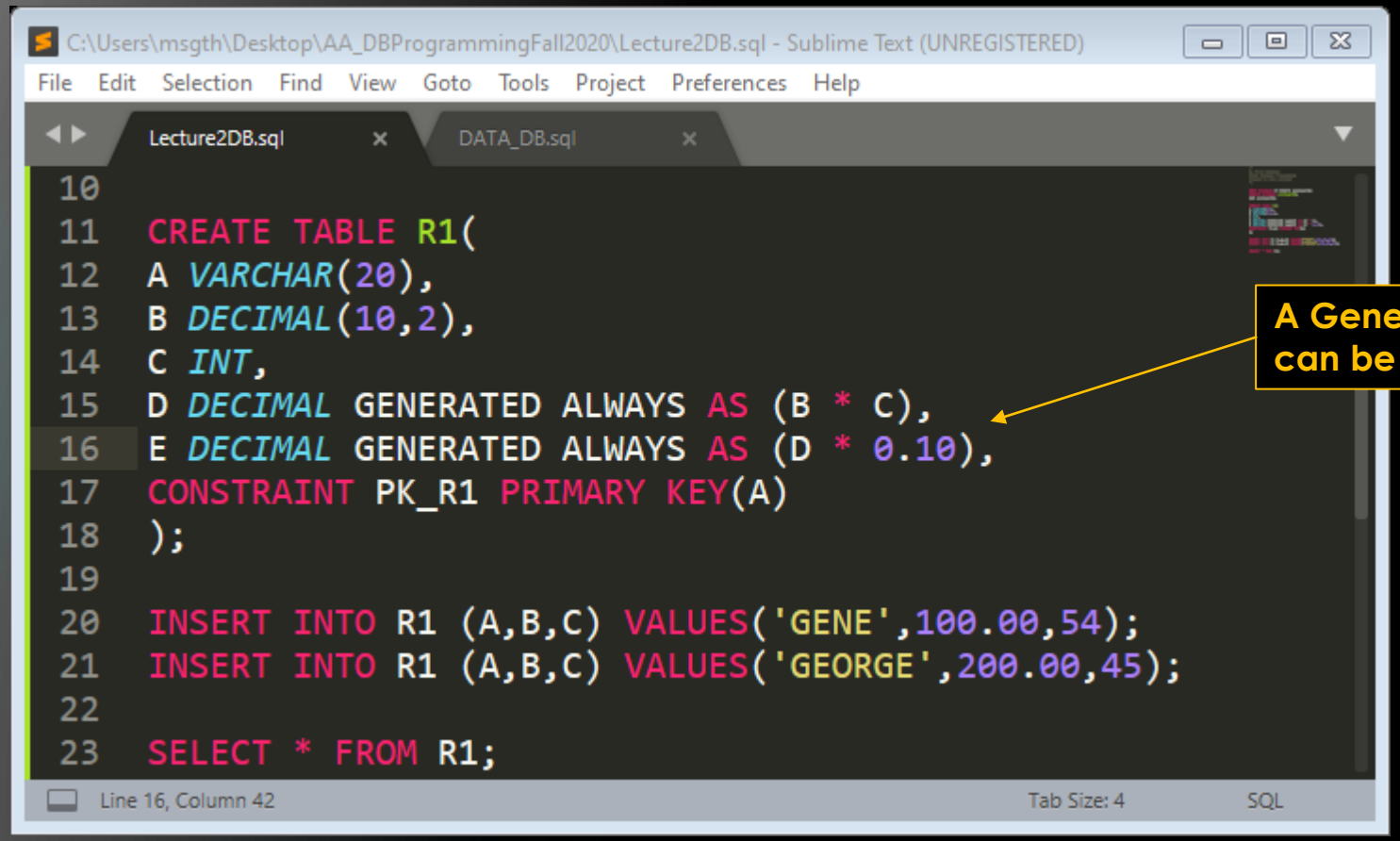
Line 20, Column 24 Tab Size: 4 SQL

Because a generated column's value is unknown and cannot be included in the INSERT statement, we must always specify the attributes that will be included.

```
+--------+--------+------+------+
| GENE   | 100.00 |   54 | 5400 |
| GEORGE | 200.00 |   45 | 9000 |
+--------+--------+------+------+
```

Generated Columns

- Generated Columns can be used in other Generated Columns.
- The use of the **Generated Always** keyword is optional but preferred for clarity.



A Generated Column must be declared before it can be used in another Generated Column

Generated Columns

- Generated Columns can incorporate native MySQL functions.

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Lecture2DB.sql | DATA_DB.sql

```
10
11  CREATE TABLE R2(
12  IDNumber INT(20),
13  FirstName VARCHAR(20),
14  LastName VARCHAR(20),
15  FullName VARCHAR(40) GENERATED ALWAYS AS (CONCAT(FirstName,' ',LastName)),
16  CONSTRAINT PK_R1 PRIMARY KEY(IDNumber)
17  );
18
19  INSERT INTO R2 (IDNumber,FirstName,LastName) VALUES(123,'Gene','Locklear');
20
21  SELECT * FROM R2;
22
23
```

Only native functions can be used

Line 16, Column 38

```
+----------+-----------+----------+---------------+
| IDNumber | FirstName | LastName | FullName      |
+----------+-----------+----------+---------------+
|      123 | Gene      | Locklear | Gene Locklear |
+----------+-----------+----------+---------------+
1 row in set (0.00 sec)
```

Remove a Relation or Attribute

C:\Users\msgth\Desktop\A_Database_PACE_2020\DBScripts\Locklear.sql - Su...

File Edit Selection Find View Goto Tools Project Preferences Help

Locklear.sql

```
25  DROP TABLE R2;
26  SELECT * FROM R2;
27
28  ALTER TABLE R1 DROP B;
29  DESCRIBE R1;
```

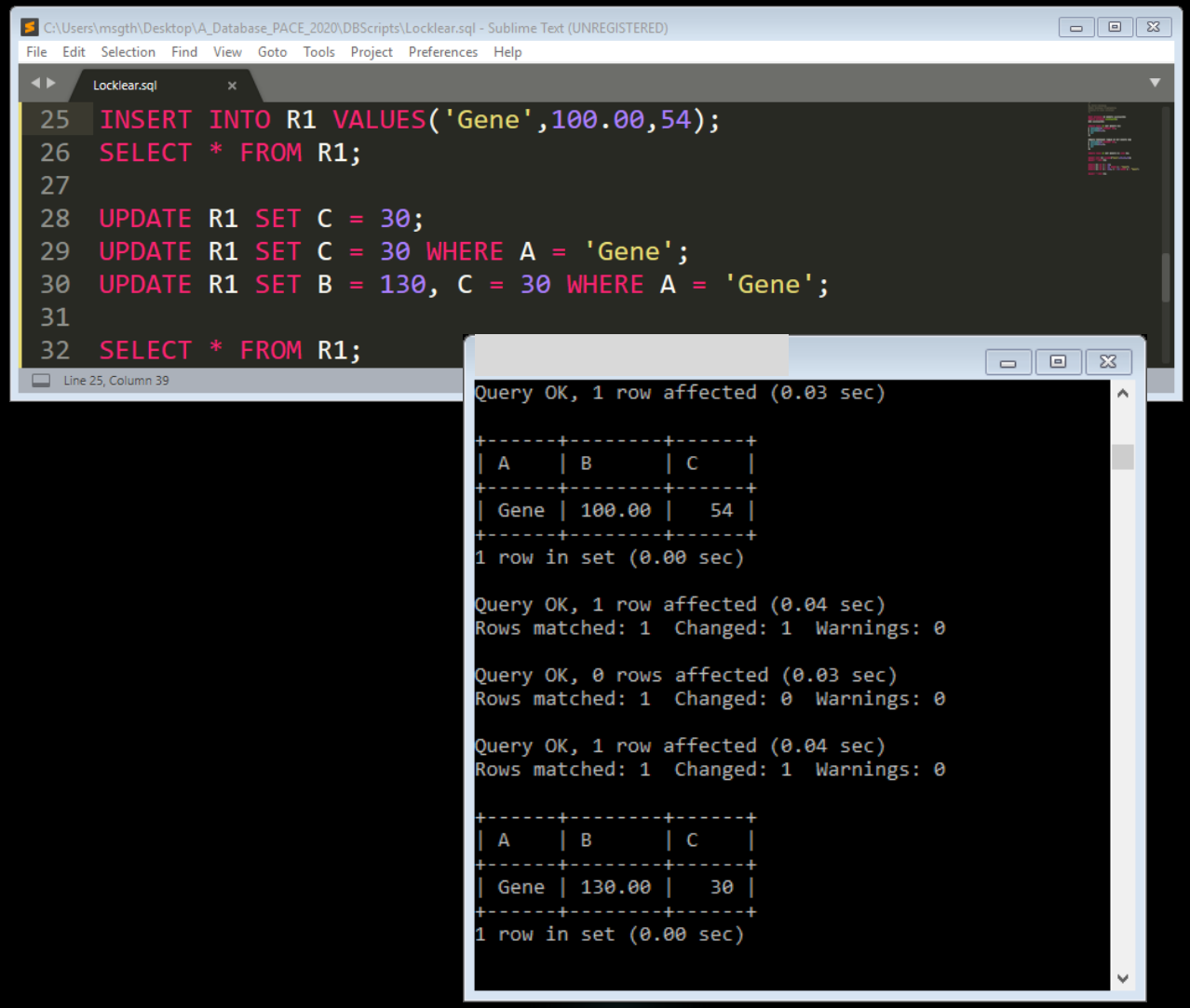
Line 29, Column 13 Tab Size: 4 SQL

```
Query OK, 0 rows affected (0.04 sec)

ERROR 1146 (42S02): Table 'lockleardb.r2' doesn't exist
Query OK, 0 rows affected (0.76 sec)
Records: 0  Duplicates: 0  Warnings: 0

+-------+-------------+------+-----+---------+-------+
| Field | Type        | Null | Key | Default | Extra |
+-------+-------------+------+-----+---------+-------+
| A     | varchar(20) | NO   | PRI | NULL    |       |
| C     | int(11)     | YES  |     | NULL    |       |
+-------+-------------+------+-----+---------+-------+
2 rows in set (0.00 sec)
```

- **DROP** is used to remove a relation from the database.
- **ALTER** in combination with **DROP** is used to remove an attribute from a relation.

Modify a Relation

- For a single relation the **UPDATE** statement modifies the attributes in the relation with new values.
- Specific attributes can be modified using the **SET** clause.
- The **WHERE** clause can be used in conjunction with the **UPDATE** statement to specify the condition which identifies which tuple to modify.
- Without a **WHERE** clause all tuples are updated.
- The **LIMIT** clause specifies a limit on the number of rows that are updated.
- For multiple attributes, **UPDATE** modifies the tuples in each relation named that satisfy the conditions. **ORDER BY** and **LIMIT** cannot be used.



Constraints on a Relation

- In practical terms a **constraint defines a rule to restrict** what values can be stored in the attributes of a relation.
- Constraints are applied at the attribute level and the relation (set of attributes) level.
- It is standard to apply constraints at the time of table creation.

- There are six type of constraints:
  - **NOT NULL** Specifies that an attribute cannot be NULL.
  - **UNIQUE** Specifies that no duplicate value can be assigned to the attribute.
  - **PRIMARY KEY** Specifies that the relation accepts unique values for this attribute and that it can be used to uniquely identify each tuple in the relation.
  - **FOREIGN KEY** Specifies a link between two tables by one specified attribute of both tables.
  - **CHECK** Specifies whether the value of an attribute is valid.
  - **DEFAULT** Specifies a value for an attribute when none is given.

Constraints on a Relation

C:\Users\msgth\Desktop\A_Database_PACE_2020\DBScripts\Locklear.sql - Sublime Text (UNREGISTERED)

File Edit Selection Find View Goto Tools Project Preferences Help

Locklear.sql

```
31
32  CREATE TABLE R5(
33  A VARCHAR(20),
34  B VARCHAR(20),
35  C VARCHAR(20) NOT NULL DEFAULT 'PACE',
36  D VARCHAR(20) CHECK (C IN ('IS','CS','NOT SPECIFIED')),
37  CONSTRAINT pk_r5 PRIMARY KEY(A),
38  CONSTRAINT uk_r5 UNIQUE KEY(B),
39  CONSTRAINT fk_r5 FOREIGN KEY(A) REFERENCES R1(A)
40  );
41
42  DESCRIBE R5;
```

Line 39, Column 48 Tab Size: 4 SQL

```
+-------+-------------+------+-----+---------+-------+
| Field | Type        | Null | Key | Default | Extra |
+-------+-------------+------+-----+---------+-------+
| A     | varchar(20) | NO   | PRI | NULL    |       |
| B     | varchar(20) | YES  | UNI | NULL    |       |
| C     | varchar(20) | NO   |     | PACE    |       |
| D     | varchar(20) | YES  |     | NULL    |       |
+-------+-------------+------+-----+---------+-------+
4 rows in set (0.01 sec)

mysql>
```

Constraints on a Relation

Parent Table

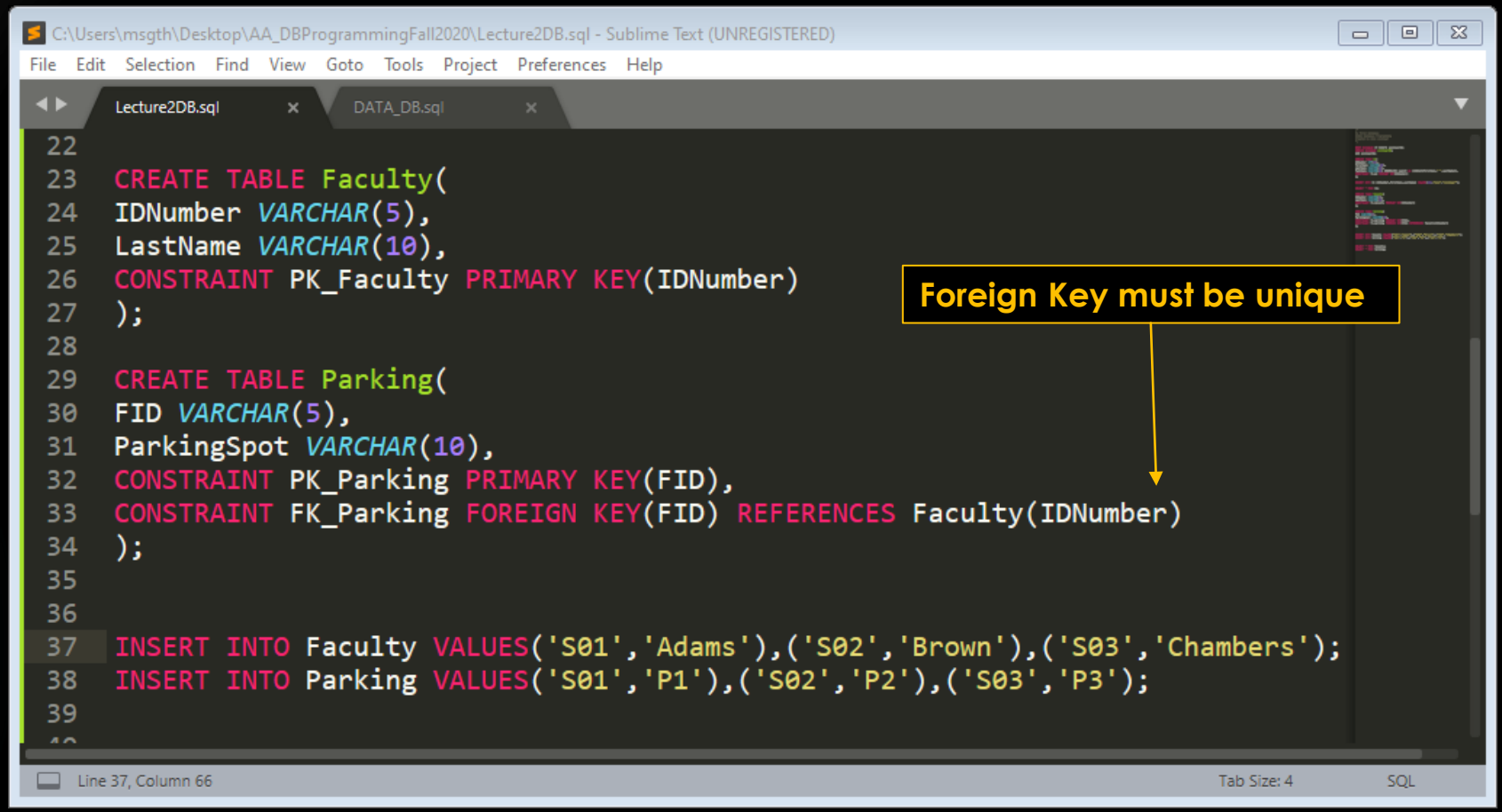
Faculty

IDNumber	LastName
S01	Adams
S02	Brown
S03	Chambers

Child Table

Parking

FID	ParkingSpot
S01	P1
S02	P2
S03	P3



Foreign Key must be unique

Relationship

If there is an IDNumber in the Parking table then there must be a corresponding IDNumber in the Faculty table

Constraints on a Relation

Faculty	
IDNumber	LastName
S01	Adams
S02	Brown
S03	Chambers

Parking	
IDNumber	ParkingSpot
S01	P1
S02	P2
S03	P3
~~S04~~	~~P4~~

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Lecture2DB.sql | DATA_DB.sql

```
22
23  CREATE TABLE Faculty(
24  IDNumber VARCHAR(5),
25  LastName VARCHAR(10),
26  CONSTRAINT PK_Faculty PRIMARY KEY(IDNumber)
27  );
28
29  CREATE TABLE Parking(
30  FID VARCHAR(5),
31  ParkingSpot VARCHAR(10),
32  CONSTRAINT PK_Parking PRIMARY KEY(FID),
33  CONSTRAINT FK_Parking FOREIGN KEY(FID) REFERENCES Faculty(IDNumber)
34  );
35
36
37  INSERT INTO Faculty VALUES('S01','Adams'),('S02','Brown'),('S03','Chambers');
38  INSERT INTO Parking VALUES('S01','P1'),('S02','P2'),('S03','P3');
39  INSERT INTO Parking VALUES('S04','P4');
```

Line 39, Column 39 Tab Size: 4 SQL

ERROR 1452 Message

```
ERROR 1452 (23000): Cannot add o
r update a child row: a foreign
key constraint fails (`lockleard
b`.`parking`, CONSTRAINT `FK_Par
king` FOREIGN KEY (`IDNumber`) R
EFERENCES `faculty` (`IDNumber`)
)
+----------+----------+
| IDNumber | LastName |
+----------+----------+
| S01      | Adams    |
| S02      | Brown    |
| S03      | Chambers |
+----------+----------+
3 rows in set (0.00 sec)

+----------+-------------+
| IDNumber | ParkingSpot |
+----------+-------------+
| S01      | P1          |
| S02      | P2          |
| S03      | P3          |
+----------+-------------+
```

ERROR 1452 occurs because Referential Integrity has been violated

Drop Constraints

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Lecture2DB.sql | DATA_DB.sql

```
28
29  CREATE TABLE Parking(
30  FID VARCHAR(5),
31  ParkingSpot VARCHAR(10),
32  CONSTRAINT PK_Parking PRIMARY KEY(FID),
33  CONSTRAINT FK_Parking FOREIGN KEY(FID) REFERENCES Faculty(IDNumber)
34  );
35
36  ALTER TABLE Parking DROP FOREIGN KEY FK_Parking;
37
38
39  INSERT INTO Faculty VALUES('S01','Adams'),('S02','Brown'),('S03','Chambers');
40  INSERT INTO Parking VALUES('S01','P1'),('S02','P2'),('S03','P3');
41  INSERT INTO Parking VALUES('S04','P4');
42
43
44  SELECT * FROM Faculty;
45  SELECT * FROM Parking;
```

Line 36, Column 49 Tab Size: 4

NO error occurs because we dropped the foreign key

```
+----------+----------+
| IDNumber | LastName |
+----------+----------+
| S01      | Adams    |
| S02      | Brown    |
| S03      | Chambers |
+----------+----------+
3 rows in set (0.00 sec)

+-----+-------------+
| FID | ParkingSpot |
+-----+-------------+
| S01 | P1          |
| S02 | P2          |
| S03 | P3          |
| S04 | P4          |
+-----+-------------+
4 rows in set (0.00 sec)

mysql>
```

Add Constraints

C:\Users\msgth\Desktop\AA_DBProgrammingFall2020\Lecture2DB.sql - Sublime Text (UNREGISTERED)

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Lecture2DB.sql × DATA_DB.sql ×

```
28
29  CREATE TABLE Parking(
30  FID VARCHAR(5),
31  ParkingSpot VARCHAR(10),
32  CONSTRAINT PK_Parking PRIMARY KEY(FID),
33  CONSTRAINT FK_Parking FOREIGN KEY(FID) REFERENCES Faculty(IDNumber)
34  );
35
36  ALTER TABLE Parking ADD CONSTRAINT UK_Parking UNIQUE(ParkingSpot);
37
38  DESCRIBE Parking;
```

Line 38, Column 18 Tab Size: 4 SQL

```
+-------------+-------------+------+-----+---------+-------+
| Field       | Type        | Null | Key | Default | Extra |
+-------------+-------------+------+-----+---------+-------+
| FID         | varchar(5)  | NO   | PRI | NULL    |       |
| ParkingSpot | varchar(10) | YES  | UNI | NULL    |       |
+-------------+-------------+------+-----+---------+-------+
```

Normalization of Relations

- The Normalization of the Relations in a database is designed to **eliminate redundancy** and **prevent data anomalies**.
- Normalization eliminates redundancy by **removing duplicate data** and **reducing data dependency**.
- There are really only 3 forms of Normalization that we are concerned about in general.
- **STEP 1: First Normal Form**
  - All attribute values are atomic.
  - Every record (row) should be unique.
- **STEP 2: Second Normal Form**
  - Must be in First Normal Form
  - All attributes are dependent on the Primary Key (Primary Key may be a Composite Key)
- **STEP 3: Third Normal Form**
  - Must be in Second Normal Form
  - All transitive dependency has been eliminated (R3 is dependent on R2 is dependent on R1)

Normalization of Relations

Multiple candidate keys define a row

Student			
IDNumber	LastName	StudentNumber	Level
S0186	Adams	Pace_001	Freshman
S0213	Brown	Pace_002	Sophomore
S0398	Chambers	Pace_003	Junior

2NF

All attributes are dependent on a single key

3NF

Student	
IDNumber	LastName
S0186	Adams
S0213	Brown
S0398	Chambers

3NF

Student_Year	
StudentNumber	Level
Pace_001	Freshman
Pace_002	Sophomore
Pace_003	Junior

There is no dependency between the two tables

Practical Exercise

- Create the database **pacestudent**.
- Create and populate the relation **Student** in **pacestudent** that contains the following information:

StudentID	LastName	FirstName	Age	Gender	Major
U0001	Anderson	Donald	23	Male	CS
U0002	Baker	Erica	24	Female	IS

- Create and populate the relation **MealPlan** in **pacestudent** that contains the following information and maintains referential integrity with **Student**:

StudentMP	MealPlanCode
U0001	A678
U0002	B789