COLLEGE OF COMPUTING TECHNOLOGY - DUBLIN
BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY

DATABASES

CA 2 – Database Design and Implementation

The aim of this assignment is to design and implement a database for a laboratory using a structured approach.

Adelo Vieira
Student Number: 2017279
Lecturer: Greg South
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1 Requirements

We were required to design and implement a database using a structured approach. We are given the following information:

- A laboratory has several chemists who work on one or more projects. While working on these projects a chemist may use different laboratory equipment.
- The laboratory needs to know the following information about its chemists, projects and equipment.
- A chemist has an employee ID, name (first and last) , date of birth, age and several phone numbers.
- A project has a unique project ID (identifier) , name, and a project start, and finish date.
- Equipment information includes a serial number (unique), name, and cost .
- The laboratory wishes to record the date when a given piece of equipment is assigned to and returned by a particular chemist. The laboratory also wishes to record the hours a chemist works on a project.
- The laboratory also has the following business rules:
  - A chemist must be assigned to at least one project and one equipment item.
  - A given piece of equipment need not be assigned, and a given project need not be assigned either to a chemist.

2 Design

The database design will have three phases: conceptual, logical and physical.

2.1 Conceptual

Regular entities: «Chemist», «Project», «Equipment»:

«Chemist»:

c_id: Employee ID (Unique, so primary key).

c_name:

c_fname

c_lname

c_dob: date of birth.

c_age: Derived Attribute. Age can be determined from the current date and the value of that person's Birth_date (c_bod).

c_phone: Multi-value attribute.

«Project»:

p_id: Project ID (primary key).

p_name

p_startdate

p_finishdate

«Equipment»:

equ_serial: Serial number (primary key).

equ_name

equ_cost

- **«chemist»**$_{Total}$ $_{N}$**<works on>**$_{N}$ **«project»**$_{Partial}$
  - A laboratory has several chemists who work on one or more projects.
  - Assumption: A project can have more than one chemist working on.
  - A chemist must be assigned to at least one project: Total participation.
  - A given project need not be assigned to a chemist: Partial participation.
  - The laboratory wishes to record the hours a chemist works on a project: relationship attribute (**hours_worked**).

- **«chemist»**$_{Total}$ $_{1}$**<uses>**$_{N}$ **«equipment»**$_{Partial}$
  - While working on these projects a chemist may use different laboratory equipments.
  - A chemist must be assigned to at least one equipment item: Total participation.
  - A given piece of equipment need not be assigned: Partial participation.
  - The laboratory wishes to record the date when a given piece of equipment is assigned to and returned by a particular chemist: relationship attributes (**assig_date**, **return_date**).

At the beginning of this section we analyzed the requirements shown in Section 1. Then, we were able to make the diagram ER Diagram (CHEN notation) using `https://www.draw.io` tool. In Figure 2.1 we show the ER diagram obtained.

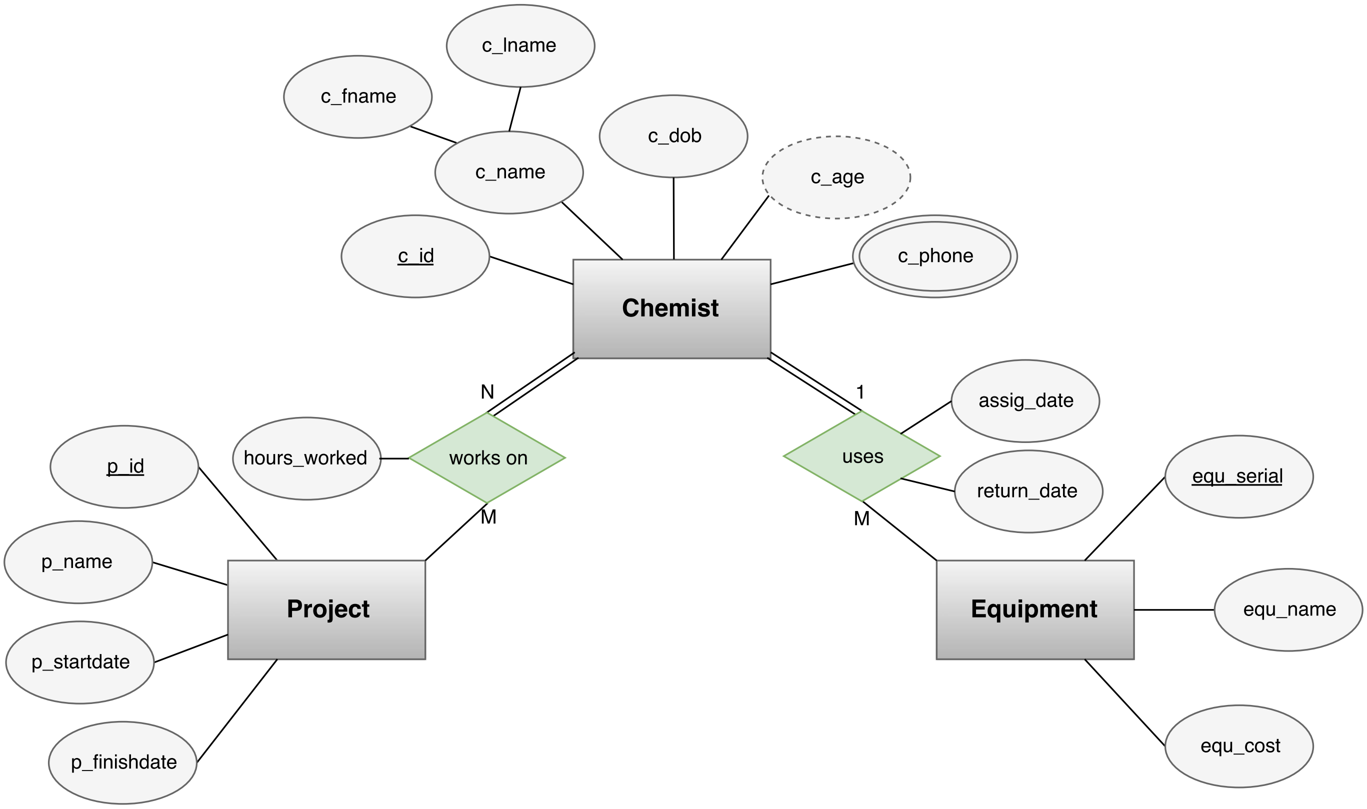


Figure 2.1: ER diagram for the hospital database (CHEN notation)

2.2 Logical

2.2.1 Transformation of the ER Model to Relational Model

In Figure 2.2, notice that we have not included the following attributes:

- **c__phone**: It is a multivalued attributes. It will be added during subsequent steps.
- **c__age**: It is a derived attribute. Age can be determined from the current date and the value of that person's Birth_date (c_bod). For this reason this attribute will not be stored. [CSCI Databases]

Step 1: Mapping of regular entity types

Chemist:

c_id	c_fname	c_lname	c_dob

Project:

p_id	p_name	p_startdate	p_finishdate

Equipment:

equ_serial	equ_name	equ_cost

Figure 2.2: Mapping of regular entity types

Step 2: Mapping of weak entity type

There are not weak entities in this database.

Step 3: Mapping of binary 1:1 relationship types

There are not binary 1:1 relationships in this database.

Step 4: Mapping of binary 1 to N relationship types

For <**uses**> we include we include the primary key **c_id** of the «**Chemist**» relation as foreign key in the «**Equipment**» relation.

We also include the simple attributes **(assig_date, return_date)** of the relationship <**uses**> as attributes of «**Equipment**» (relation on the N side).

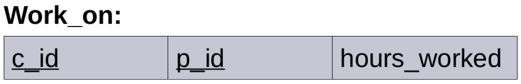
Equipment:

equ_serial	equ_name	equ_cost	c_id	assig_date	return_date
			FK		

Figure 2.3: Mapping of binary 1 to N relationship types

Step 5: Mapping of binary m:n relationship types

We map the M:N relationship type <**work on**> from our the ERD (Figure 2.1) by creating the relation «**Work_on**»:



Work_on:

c_id	p_id	hours_worked

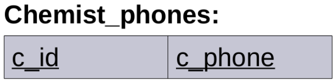
Figure 2.4: Mapping of binary m:n relationship types

- We include the primary keys of the **«Chemist»** and **«Project»** relations as foreign keys in **«Work_on»**.
- We also include the attribute **hours_worked** in **«Work_on»**.
- The primary key of the **«Work_on»** relation is the combination of the foreign key attributes **{c_id, p_id}**.

Step 6: Mapping of multivalued attributes

we create a relation **«Chemist_phones»**:

- The primary key of **«Chemist_phones»** is the combination of **{c_id, c_phone}**.



Chemist_phones:

c_id	c_phone

Figure 2.5: Mapping of the multivalued attribute c_phone

Step 7: Mapping of n-ary relationship types

There are not n-ary relationship (n>2) in this database.

Relational Model obtained

Following the previous steps, we obtained the Relational Model shown in the figure 2.6.

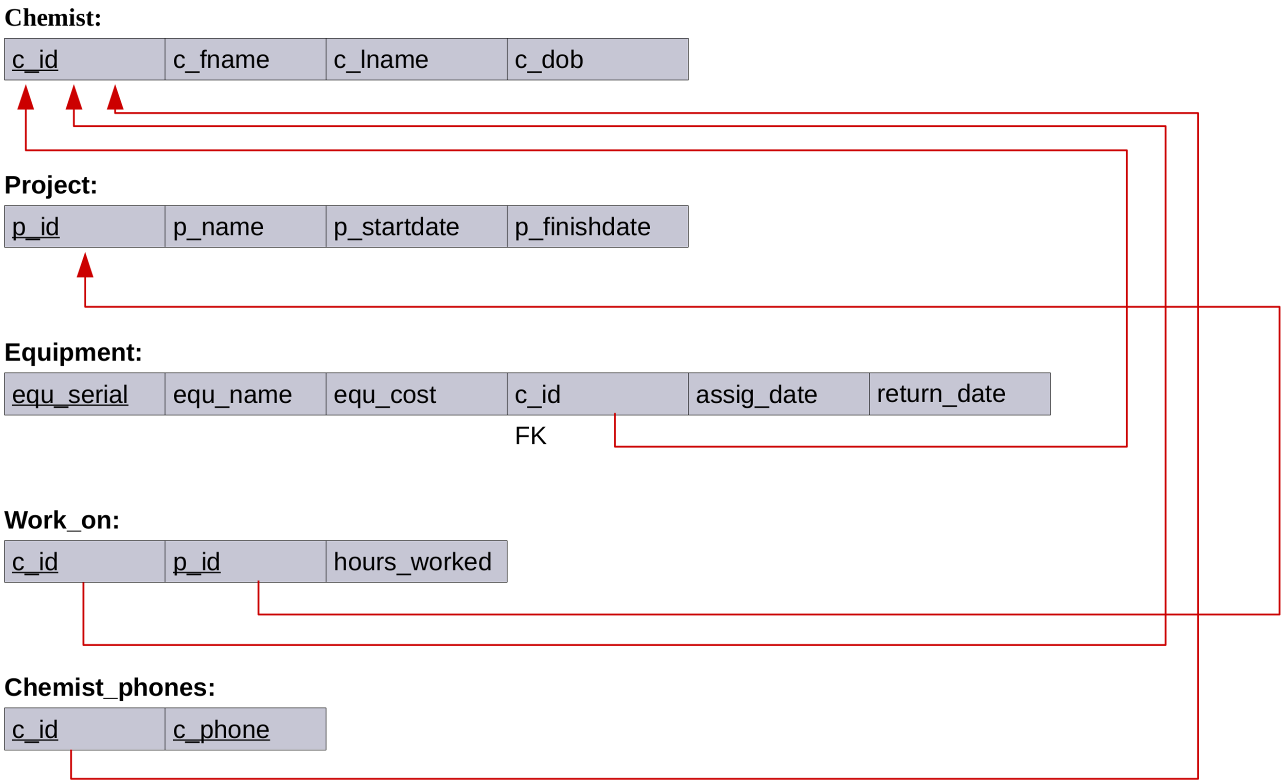


Figure 2.6: Relational Model

2.2.2 Validation of the Relational Model using Normalisation

✓ **1NF - First normal form:**

- There are no repeating groups: In Figure 2.6 we can see that there are no repeating groups in any of the relations of our database.
- Each of our tables contain only atomic values: To show our database meet this condition, we have to refers to the implemetation section. In Figure 3.7 we can see that each of our tables contain only atomic values.

✓ **2NF - Second normal form:**

- From our relational model in Figure 2.6, we can see **«Chemist»**, **«Project»** and **«Equipment»** are automatically in 2NF because their primary keys are a single column (they are not composite).
- For the **«Chemist_phone»** relation it is also easy to notice that is in 2NF because all the columns in the table are part of its composite the primary key.
- In regards to **«Work_on»**, the analysis is a little more complex. This relation contains a composite primary key and an extra attribute. For this attribute (hours_worked)[1] we ask ourselves the following

[1] Hours a chemist works on a project

question: Can we determine the value of hours_worked if we only know part of the primary-key (c_id[2] OR p_id[3])? the answer to this question is NO, we need both (c_id AND p_id) to get the value of hours_worked, so hours_worked is fully functionally dependent: {c_id, p_id} → {hours_worked}[4]. This confirms **«Work_on»** also meet 2NF.

✓ **3NF - Third normal form:**

Now we have to check that each of our relations doesn't have **transitive dependencies**[5]:

- We can easily see that «Work On» and «Chemist_phones» satisfy 3NF because these relations don't have more than one non-key field.
- With regard to «Chemist» and «Project» it is also not difficult to notice that there is not non-key attribute that can be determine from another non-key attribute.
- The analysis is a little more complex for the «Equipment» relation. However, analyzing each column separately, we can notice that none of the non-key values can be determine by another non-key value.

[2] Employee ID

[3] Project ID

[4] This expression is read: "c_id and p_id determine hours_worked" OR "hours_worked depends on c_id and p_id"

[5] A table contains a transitive dependency if a nonkey column's value determines another nonkey column's value [South (a)]

2.2.3 Data Dictionary for each Relation

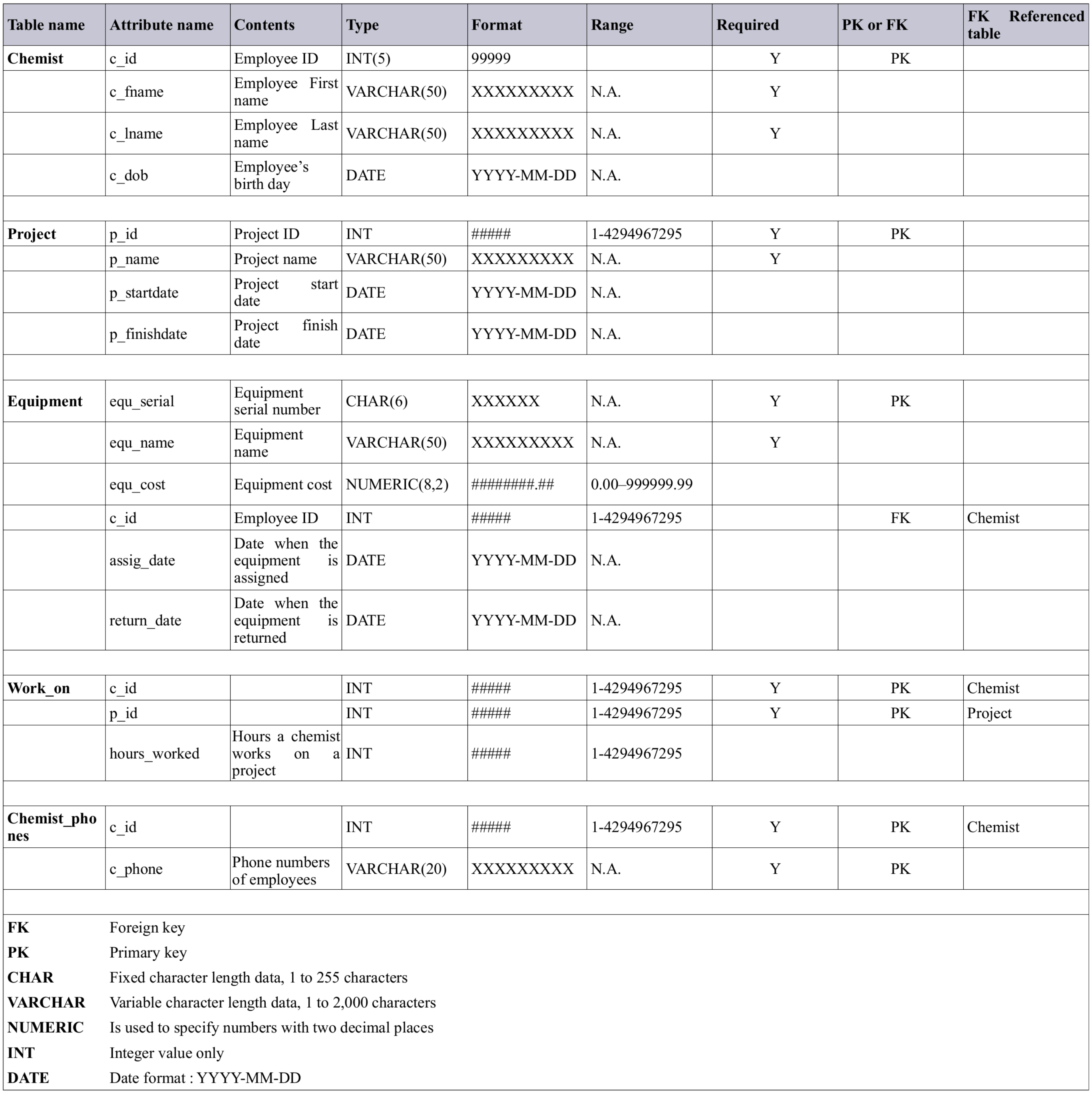
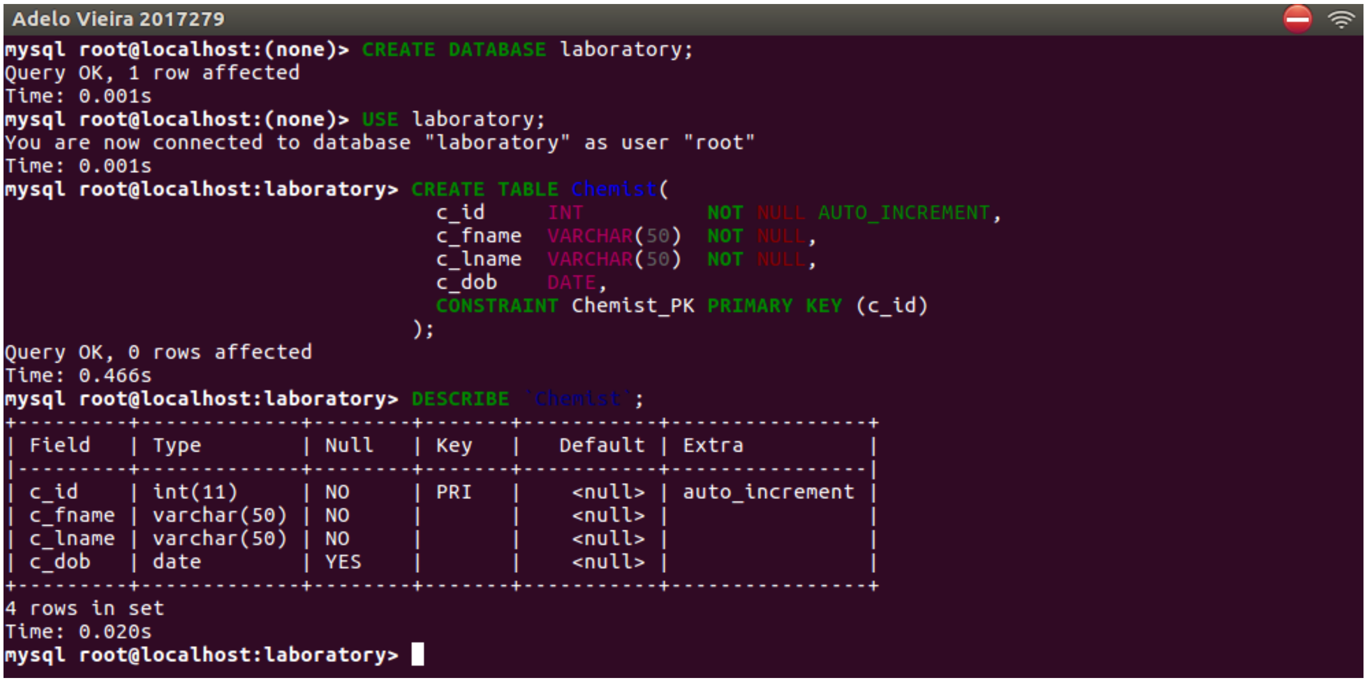


Table name	Attribute name	Contents	Type	Format	Range	Required	PK or FK	FK Referenced table
Chemist	c_id	Employee ID	INT(5)	99999		Y	PK	
	c_fname	Employee First name	VARCHAR(50)	XXXXXXXXX	N.A.	Y		
	c_lname	Employee Last name	VARCHAR(50)	XXXXXXXXX	N.A.	Y		
	c_dob	Employee's birth day	DATE	YYYY-MM-DD	N.A.			
Project	p_id	Project ID	INT	#####	1-4294967295	Y	PK	
	p_name	Project name	VARCHAR(50)	XXXXXXXXX	N.A.	Y		
	p_startdate	Project start date	DATE	YYYY-MM-DD	N.A.			
	p_finishdate	Project finish date	DATE	YYYY-MM-DD	N.A.			
Equipment	equ_serial	Equipment serial number	CHAR(6)	XXXXXX	N.A.	Y	PK	
	equ_name	Equipment name	VARCHAR(50)	XXXXXXXXX	N.A.	Y		
	equ_cost	Equipment cost	NUMERIC(8,2)	########.##	0.00–999999.99			
	c_id	Employee ID	INT	#####	1-4294967295		FK	Chemist
	assig_date	Date when the equipment is assigned	DATE	YYYY-MM-DD	N.A.			
	return_date	Date when the equipment is returned	DATE	YYYY-MM-DD	N.A.			
Work_on	c_id		INT	#####	1-4294967295	Y	PK	Chemist
	p_id		INT	#####	1-4294967295	Y	PK	Project
	hours_worked	Hours a chemist works on a project	INT	#####	1-4294967295			
Chemist_phones	c_id		INT	#####	1-4294967295	Y	PK	Chemist
	c_phone	Phone numbers of employees	VARCHAR(20)	XXXXXXXXX	N.A.	Y	PK	
FK	Foreign key							
PK	Primary key							
CHAR	Fixed character length data, 1 to 255 characters							
VARCHAR	Variable character length data, 1 to 2,000 characters							
NUMERIC	Is used to specify numbers with two decimal places							
INT	Integer value only							
DATE	Date format : YYYY-MM-DD							

Figure 2.7: Data dictionary

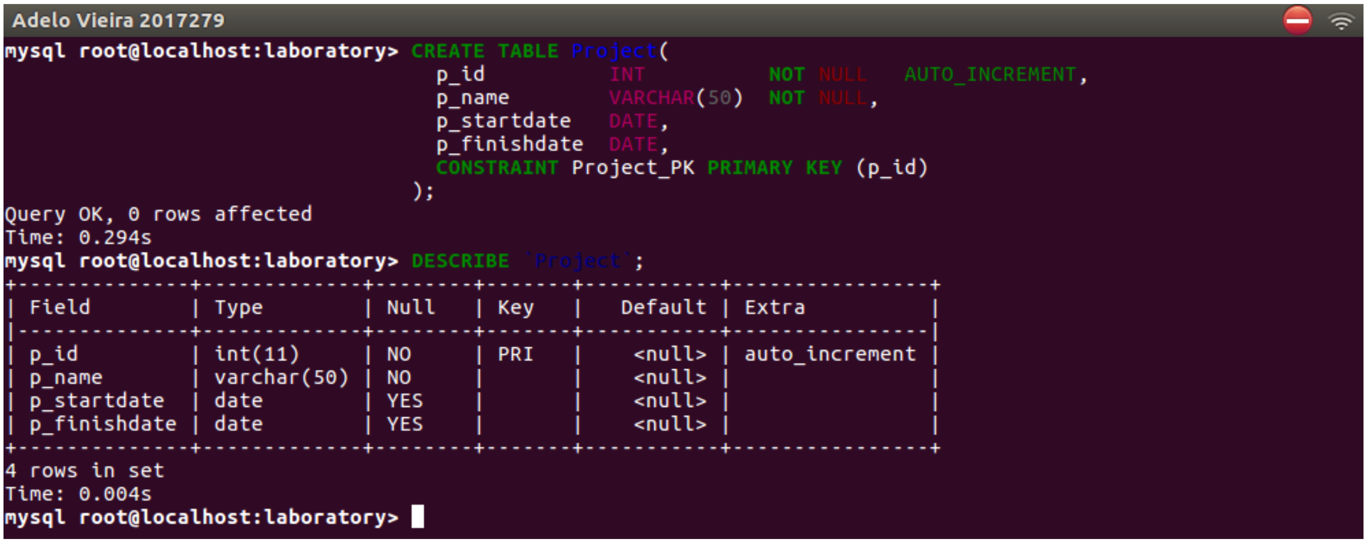
2.3 Physical

After creating the database (CREATE DATABASE laboratory;), we created each of the tables shown in the Relational model (Figure 2.6) in our DBMS MySQL.



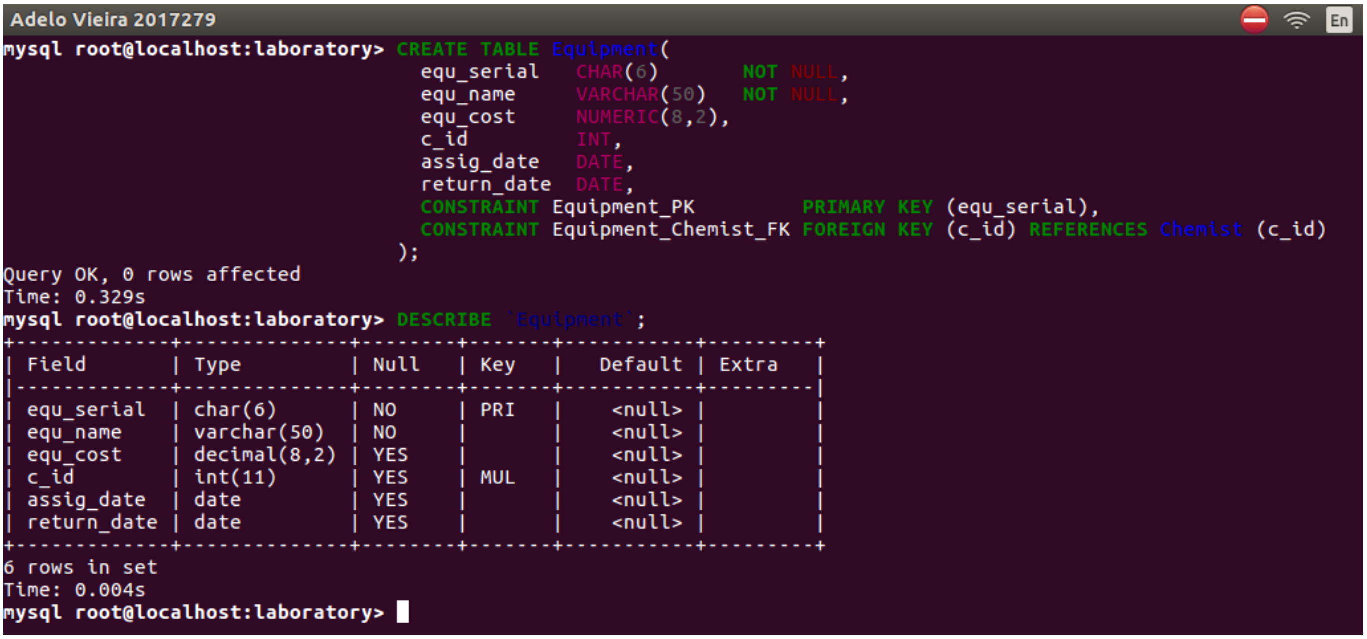
```
mysql root@localhost:(none)> CREATE DATABASE laboratory;
Query OK, 1 row affected
Time: 0.001s
mysql root@localhost:(none)> USE laboratory;
You are now connected to database "laboratory" as user "root"
Time: 0.001s
mysql root@localhost:laboratory> CREATE TABLE Chemist(
                                   c_id      INT          NOT NULL AUTO_INCREMENT,
                                   c_fname   VARCHAR(50)  NOT NULL,
                                   c_lname   VARCHAR(50)  NOT NULL,
                                   c_dob     DATE,
                                   CONSTRAINT Chemist_PK PRIMARY KEY (c_id)
                                 );
Query OK, 0 rows affected
Time: 0.466s
mysql root@localhost:laboratory> DESCRIBE `Chemist`;
+---------+-------------+--------+-------+----------+----------------+
| Field   | Type        | Null   | Key   |  Default | Extra          |
|---------+-------------+--------+-------+----------+----------------|
| c_id    | int(11)     | NO     | PRI   |   <null> | auto_increment |
| c_fname | varchar(50) | NO     |       |   <null> |                |
| c_lname | varchar(50) | NO     |       |   <null> |                |
| c_dob   | date        | YES    |       |   <null> |                |
+---------+-------------+--------+-------+----------+----------------+
4 rows in set
Time: 0.020s
mysql root@localhost:laboratory>
```

Figure 2.8: Creating the «laboratory» database and the «Chemist» table



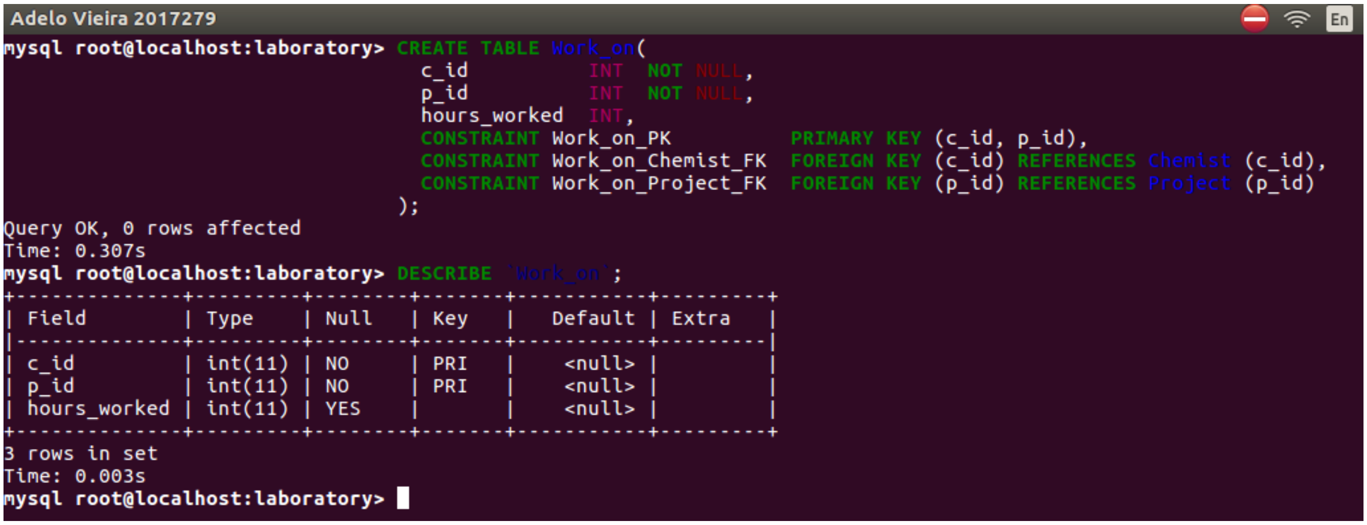
```
mysql root@localhost:laboratory> CREATE TABLE Project(
                                   p_id          INT          NOT NULL   AUTO_INCREMENT,
                                   p_name        VARCHAR(50)  NOT NULL,
                                   p_startdate   DATE,
                                   p_finishdate  DATE,
                                   CONSTRAINT Project_PK PRIMARY KEY (p_id)
                                 );
Query OK, 0 rows affected
Time: 0.294s
mysql root@localhost:laboratory> DESCRIBE `Project`;
+--------------+-------------+--------+-------+----------+----------------+
| Field        | Type        | Null   | Key   |  Default | Extra          |
|--------------+-------------+--------+-------+----------+----------------|
| p_id         | int(11)     | NO     | PRI   |   <null> | auto_increment |
| p_name       | varchar(50) | NO     |       |   <null> |                |
| p_startdate  | date        | YES    |       |   <null> |                |
| p_finishdate | date        | YES    |       |   <null> |                |
+--------------+-------------+--------+-------+----------+----------------+
4 rows in set
Time: 0.004s
mysql root@localhost:laboratory>
```

Figure 2.9: Creating the «Project» table



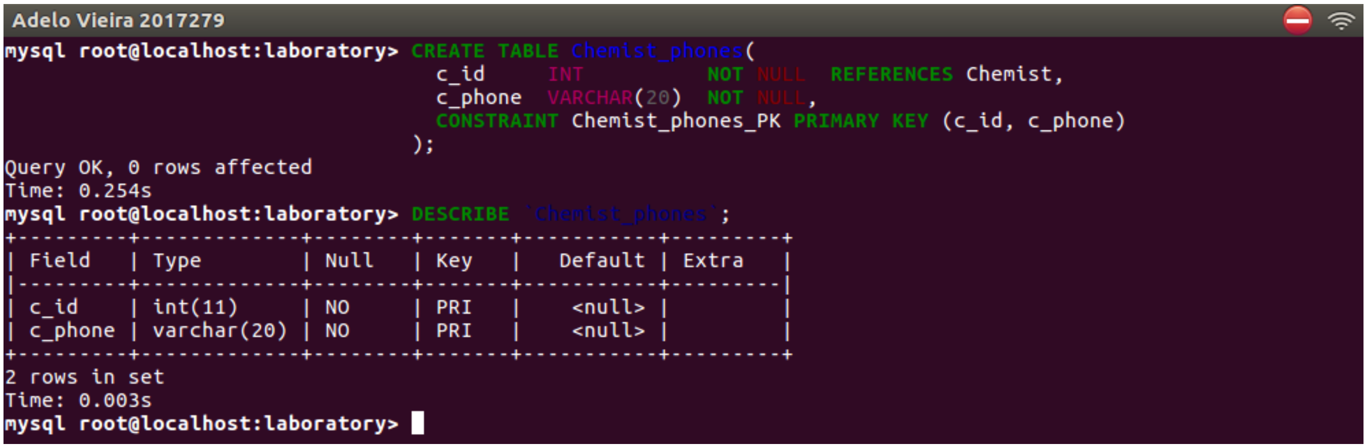
```
mysql root@localhost:laboratory> CREATE TABLE Equipment(
                                   equ_serial   CHAR(6)       NOT NULL,
                                   equ_name     VARCHAR(50)   NOT NULL,
                                   equ_cost     NUMERIC(8,2),
                                   c_id         INT,
                                   assig_date   DATE,
                                   return_date  DATE,
                                   CONSTRAINT Equipment_PK         PRIMARY KEY (equ_serial),
                                   CONSTRAINT Equipment_Chemist_FK FOREIGN KEY (c_id) REFERENCES Chemist (c_id)
                                 );
Query OK, 0 rows affected
Time: 0.329s
mysql root@localhost:laboratory> DESCRIBE `Equipment`;
+-------------+--------------+--------+-------+-----------+---------+
| Field       | Type         | Null   | Key   |   Default | Extra   |
|-------------+--------------+--------+-------+-----------+---------|
| equ_serial  | char(6)      | NO     | PRI   |    <null> |         |
| equ_name    | varchar(50)  | NO     |       |    <null> |         |
| equ_cost    | decimal(8,2) | YES    |       |    <null> |         |
| c_id        | int(11)      | YES    | MUL   |    <null> |         |
| assig_date  | date         | YES    |       |    <null> |         |
| return_date | date         | YES    |       |    <null> |         |
+-------------+--------------+--------+-------+-----------+---------+
6 rows in set
Time: 0.004s
mysql root@localhost:laboratory> █
```

Figure 2.10: Creating the «Equipment» table



```
mysql root@localhost:laboratory> CREATE TABLE Work_on(
                                   c_id          INT  NOT NULL,
                                   p_id          INT  NOT NULL,
                                   hours_worked  INT,
                                   CONSTRAINT Work_on_PK          PRIMARY KEY (c_id, p_id),
                                   CONSTRAINT Work_on_Chemist_FK  FOREIGN KEY (c_id) REFERENCES Chemist (c_id),
                                   CONSTRAINT Work_on_Project_FK  FOREIGN KEY (p_id) REFERENCES Project (p_id)
                                 );
Query OK, 0 rows affected
Time: 0.307s
mysql root@localhost:laboratory> DESCRIBE `Work_on`;
+--------------+---------+--------+-------+-----------+---------+
| Field        | Type    | Null   | Key   |   Default | Extra   |
|--------------+---------+--------+-------+-----------+---------|
| c_id         | int(11) | NO     | PRI   |    <null> |         |
| p_id         | int(11) | NO     | PRI   |    <null> |         |
| hours_worked | int(11) | YES    |       |    <null> |         |
+--------------+---------+--------+-------+-----------+---------+
3 rows in set
Time: 0.003s
mysql root@localhost:laboratory> █
```

Figure 2.11: Creating the «Work_on» table



```
mysql root@localhost:laboratory> CREATE TABLE Chemist_phones(
                                    c_id      INT          NOT NULL  REFERENCES Chemist,
                                    c_phone   VARCHAR(20)  NOT NULL,
                                    CONSTRAINT Chemist_phones_PK PRIMARY KEY (c_id, c_phone)
                                  );
Query OK, 0 rows affected
Time: 0.254s
mysql root@localhost:laboratory> DESCRIBE `Chemist_phones`;
+---------+-------------+--------+-------+-----------+---------+
| Field   | Type        | Null   | Key   |   Default | Extra   |
|---------+-------------+--------+-------+-----------+---------|
| c_id    | int(11)     | NO     | PRI   |    <null> |         |
| c_phone | varchar(20) | NO     | PRI   |    <null> |         |
+---------+-------------+--------+-------+-----------+---------+
2 rows in set
Time: 0.003s
mysql root@localhost:laboratory>
```

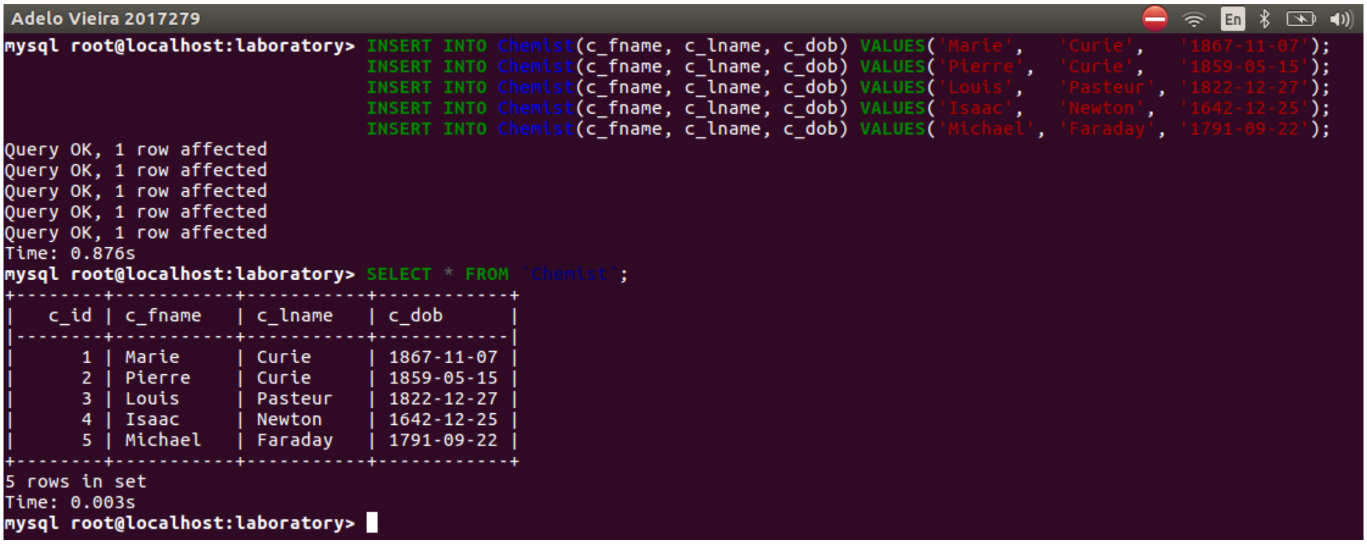
Figure 2.12: Creating the «Chemist_phones» table

3 Implementation

In this section we provide the SQL statements used to insert data into each of the relations generated in Section 2.3.

3.0.1 Chemist relation

```
INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Marie',   'Curie',   '1867-11-07');
INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Pierre',  'Curie',   '1859-05-15');
INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Louis',   'Pasteur', '1822-12-27');
INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Isaac',   'Newton',  '1642-12-25');
INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Michael', 'Faraday', '1791-09-22');
```

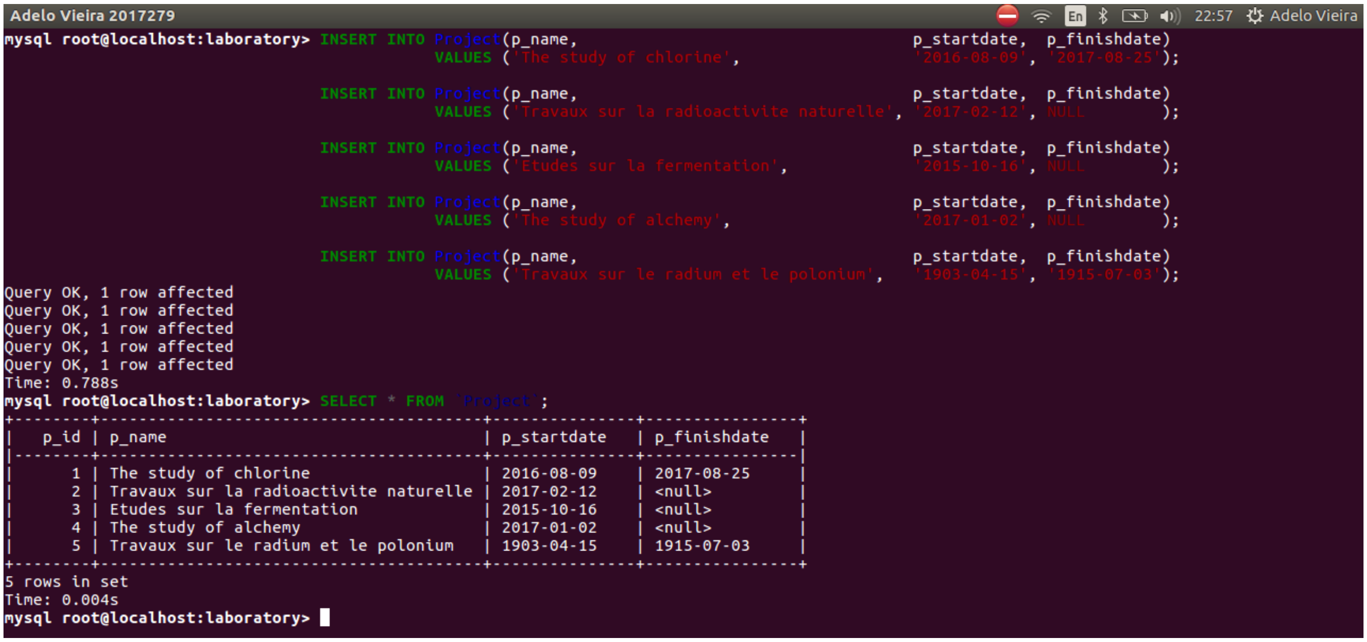


```
mysql root@localhost:laboratory> INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Marie',   'Curie',   '1867-11-07');
                                 INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Pierre',  'Curie',   '1859-05-15');
                                 INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Louis',   'Pasteur', '1822-12-27');
                                 INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Isaac',   'Newton',  '1642-12-25');
                                 INSERT INTO Chemist(c_fname, c_lname, c_dob) VALUES('Michael', 'Faraday', '1791-09-22');
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Time: 0.876s
mysql root@localhost:laboratory> SELECT * FROM `Chemist`;
+--------+----------+----------+------------+
|   c_id | c_fname  | c_lname  | c_dob      |
|--------+----------+----------+------------|
|      1 | Marie    | Curie    | 1867-11-07 |
|      2 | Pierre   | Curie    | 1859-05-15 |
|      3 | Louis    | Pasteur  | 1822-12-27 |
|      4 | Isaac    | Newton   | 1642-12-25 |
|      5 | Michael  | Faraday  | 1791-09-22 |
+--------+----------+----------+------------+
5 rows in set
Time: 0.003s
mysql root@localhost:laboratory>
```

Figure 3.1: Inserting data into the «Chemist» table

3.0.2 Project relation

```
INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
            VALUES ('The study of chlorine',                  '2016-08-09', '2017-08-25');

INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
            VALUES ('Travaux sur la radioactivite naturelle', '2017-02-12', NULL        );

INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
            VALUES ('Etudes sur la fermentation',             '2015-10-16', NULL        );

INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
            VALUES ('The study of alchemy',                   '2017-01-02', NULL        );

INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
            VALUES ('Travaux sur le radium et le polonium',   '1903-04-15', '1915-07-03');
```

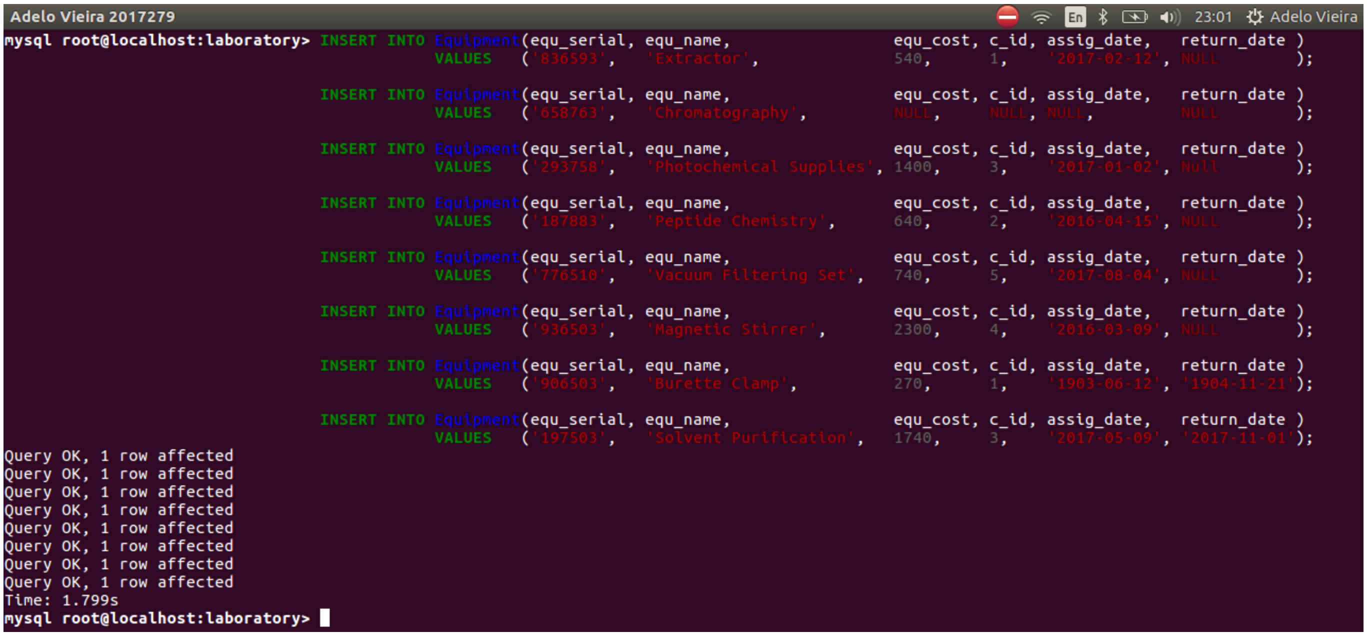


```
mysql root@localhost:laboratory> INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
                                             VALUES ('The study of chlorine',                  '2016-08-09', '2017-08-25');

                                 INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
                                             VALUES ('Travaux sur la radioactivite naturelle', '2017-02-12', NULL        );

                                 INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
                                             VALUES ('Etudes sur la fermentation',             '2015-10-16', NULL        );

                                 INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
                                             VALUES ('The study of alchemy',                   '2017-01-02', NULL        );

                                 INSERT INTO Project(p_name,                                  p_startdate,  p_finishdate)
                                             VALUES ('Travaux sur le radium et le polonium',   '1903-04-15', '1915-07-03');
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Time: 0.788s
mysql root@localhost:laboratory> SELECT * FROM `Project`;
+--------+----------------------------------------+--------------+---------------+
|   p_id | p_name                                 | p_startdate  | p_finishdate  |
|--------+----------------------------------------+--------------+---------------|
|      1 | The study of chlorine                  | 2016-08-09   | 2017-08-25    |
|      2 | Travaux sur la radioactivite naturelle | 2017-02-12   | <null>        |
|      3 | Etudes sur la fermentation             | 2015-10-16   | <null>        |
|      4 | The study of alchemy                   | 2017-01-02   | <null>        |
|      5 | Travaux sur le radium et le polonium   | 1903-04-15   | 1915-07-03    |
+--------+----------------------------------------+--------------+---------------+
5 rows in set
Time: 0.004s
mysql root@localhost:laboratory>
```

Figure 3.2: Inserting data into the «Project» table

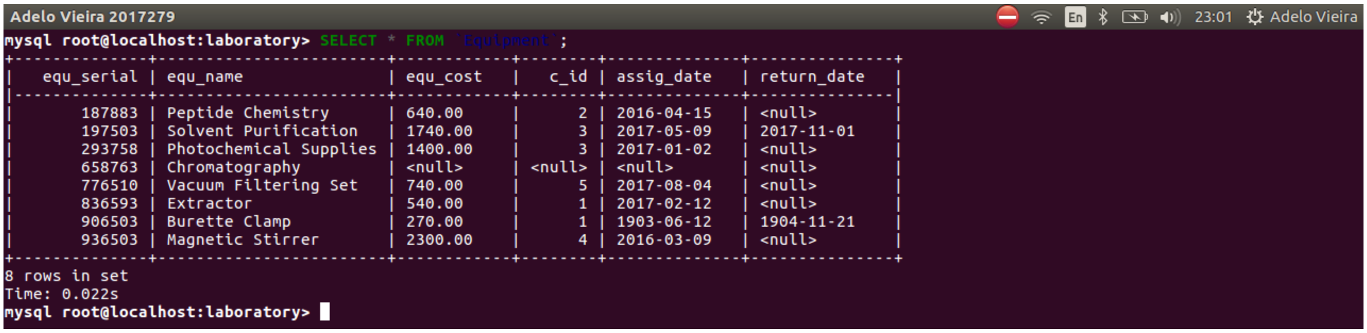
3.0.3 Equipment relation

```
INSERT INTO Equipment(equ_serial, equ_name,                  equ_cost, c_id, assig_date,   return_date )
            VALUES   ('836593',   'Extractor',               540,      1,    '2017-02-12', NULL         );

INSERT INTO Equipment(equ_serial, equ_name,                  equ_cost, c_id, assig_date,   return_date )
            VALUES   ('658763',   'Chromatography',          NULL,     NULL, NULL,         NULL         );

INSERT INTO Equipment(equ_serial, equ_name,                  equ_cost, c_id, assig_date,   return_date )
            VALUES   ('293758',   'Photochemical Supplies', 1400,      3,    '2017-01-02', Null         );

INSERT INTO Equipment(equ_serial, equ_name,                  equ_cost, c_id, assig_date,   return_date )
            VALUES   ('187883',   'Peptide Chemistry',       640,      2,    '2016-04-15', NULL         );

INSERT INTO Equipment(equ_serial, equ_name,                  equ_cost, c_id, assig_date,   return_date )
            VALUES   ('776510',   'Vacuum Filtering Set',    740,      5,    '2017-08-04', NULL         );

INSERT INTO Equipment(equ_serial, equ_name,                  equ_cost, c_id, assig_date,   return_date )
            VALUES   ('936503',   'Magnetic Stirrer',        2300,     4,    '2016-03-09', NULL         );

INSERT INTO Equipment(equ_serial, equ_name,                  equ_cost, c_id, assig_date,   return_date )
            VALUES   ('906503',   'Burette Clamp',           270,      1,    '1903-06-12', '1904-11-21');

INSERT INTO Equipment(equ_serial, equ_name,                  equ_cost, c_id, assig_date,   return_date )
            VALUES   ('197503',   'Solvent Purification',    1740,     3,    '2017-05-09', '2017-11-01');
```



```
Adelo Vieira 2017279                                                                                    23:01  Adelo Vieira
mysql root@localhost:laboratory> INSERT INTO Equipment(equ_serial, equ_name,                     equ_cost, c_id, assig_date,   return_date )
                                             VALUES   ('836593',   'Extractor',                  540,      1,    '2017-02-12', NULL          );

                                 INSERT INTO Equipment(equ_serial, equ_name,                     equ_cost, c_id, assig_date,   return_date )
                                             VALUES   ('658763',   'Chromatography',             NULL,     NULL, NULL,         NULL          );

                                 INSERT INTO Equipment(equ_serial, equ_name,                     equ_cost, c_id, assig_date,   return_date )
                                             VALUES   ('293758',   'Photochemical Supplies',     1400,     3,    '2017-01-02', Null          );

                                 INSERT INTO Equipment(equ_serial, equ_name,                     equ_cost, c_id, assig_date,   return_date )
                                             VALUES   ('187883',   'Peptide Chemistry',          640,      2,    '2016-04-15', NULL          );

                                 INSERT INTO Equipment(equ_serial, equ_name,                     equ_cost, c_id, assig_date,   return_date )
                                             VALUES   ('776510',   'Vacuum Filtering Set',       740,      5,    '2017-08-04', NULL          );

                                 INSERT INTO Equipment(equ_serial, equ_name,                     equ_cost, c_id, assig_date,   return_date )
                                             VALUES   ('936503',   'Magnetic Stirrer',           2300,     4,    '2016-03-09', NULL          );

                                 INSERT INTO Equipment(equ_serial, equ_name,                     equ_cost, c_id, assig_date,   return_date )
                                             VALUES   ('906503',   'Burette Clamp',              270,      1,    '1903-06-12', '1904-11-21');

                                 INSERT INTO Equipment(equ_serial, equ_name,                     equ_cost, c_id, assig_date,   return_date )
                                             VALUES   ('197503',   'Solvent Purification',       1740,     3,    '2017-05-09', '2017-11-01');
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Time: 1.799s
mysql root@localhost:laboratory>
```

Figure 3.3: Inserting data into the «Equipment» table

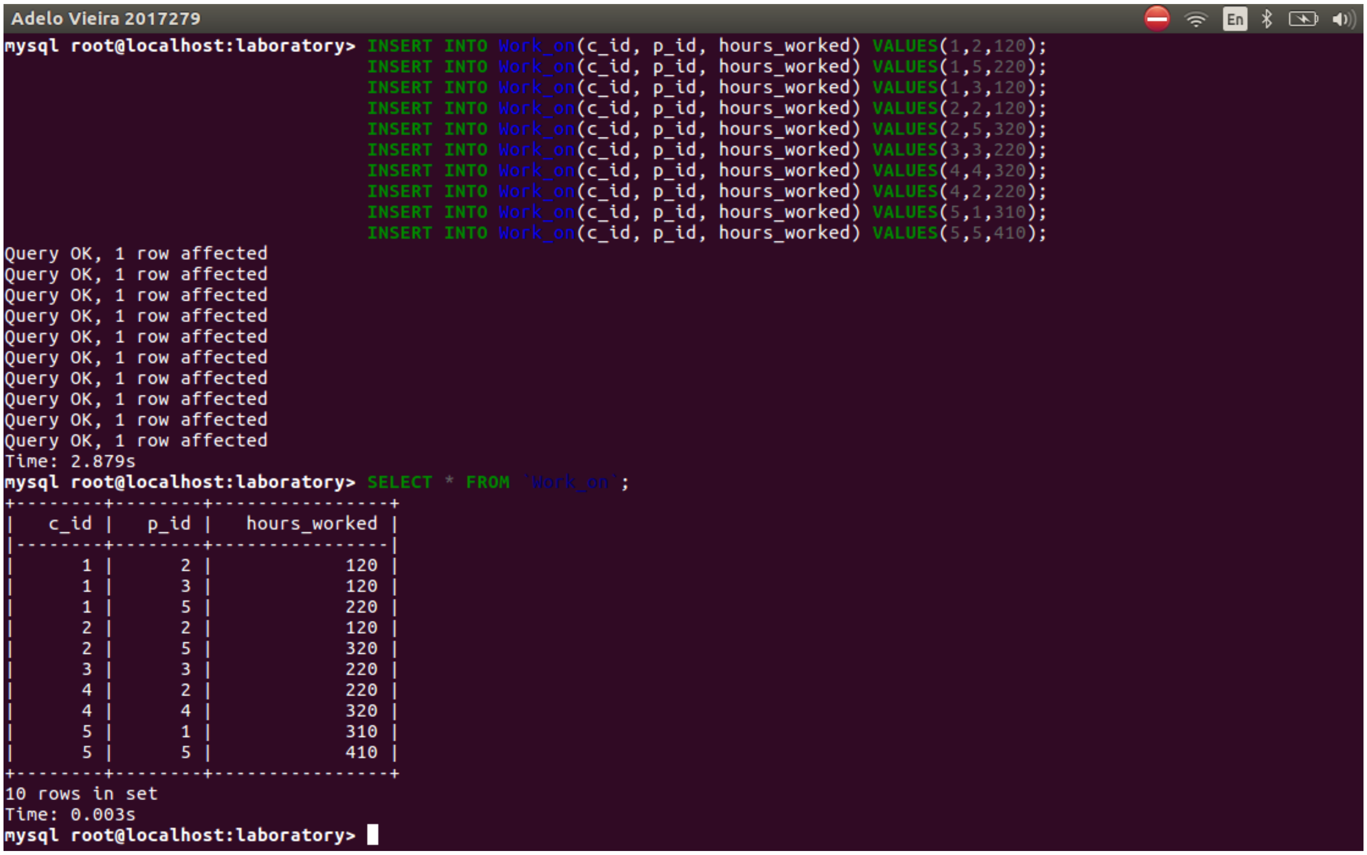


```
Adelo Vieira 2017279                                                                                    23:01  Adelo Vieira
mysql root@localhost:laboratory> SELECT * FROM `Equipment`;
+-------------+------------------------+-----------+--------+--------------+--------------+
|   equ_serial | equ_name               | equ_cost  |   c_id | assig_date   | return_date  |
|-------------+------------------------+-----------+--------+--------------+--------------|
|       187883 | Peptide Chemistry      | 640.00    |      2 | 2016-04-15   | <null>       |
|       197503 | Solvent Purification   | 1740.00   |      3 | 2017-05-09   | 2017-11-01   |
|       293758 | Photochemical Supplies | 1400.00   |      3 | 2017-01-02   | <null>       |
|       658763 | Chromatography         | <null>    | <null> | <null>       | <null>       |
|       776510 | Vacuum Filtering Set   | 740.00    |      5 | 2017-08-04   | <null>       |
|       836593 | Extractor              | 540.00    |      1 | 2017-02-12   | <null>       |
|       906503 | Burette Clamp          | 270.00    |      1 | 1903-06-12   | 1904-11-21   |
|       936503 | Magnetic Stirrer       | 2300.00   |      4 | 2016-03-09   | <null>       |
+-------------+------------------------+-----------+--------+--------------+--------------+
8 rows in set
Time: 0.022s
mysql root@localhost:laboratory>
```

Figure 3.4: Data into «Equipment»

3.0.4 Work_on relation

```sql
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(1,2,120);
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(1,5,220);
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(1,3,120);
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(2,2,120);
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(2,5,320);
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(3,3,220);
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(4,4,320);
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(4,2,220);
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(5,1,310);
INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(5,5,410);
```

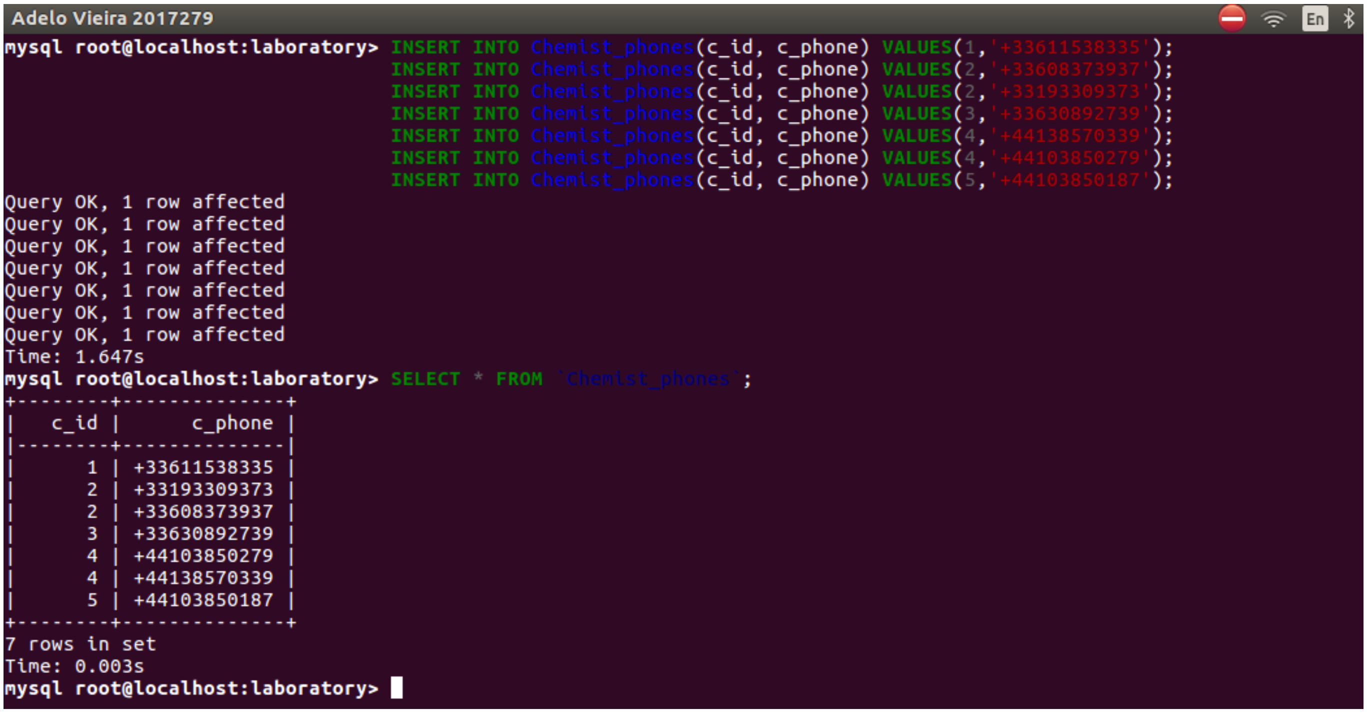


```
mysql root@localhost:laboratory> INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(1,2,120);
                                 INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(1,5,220);
                                 INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(1,3,120);
                                 INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(2,2,120);
                                 INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(2,5,320);
                                 INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(3,3,220);
                                 INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(4,4,320);
                                 INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(4,2,220);
                                 INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(5,1,310);
                                 INSERT INTO Work_on(c_id, p_id, hours_worked) VALUES(5,5,410);
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Time: 2.879s
mysql root@localhost:laboratory> SELECT * FROM `Work_on`;
+--------+--------+----------------+
|   c_id |   p_id |   hours_worked |
|--------+--------+----------------|
|      1 |      2 |            120 |
|      1 |      3 |            120 |
|      1 |      5 |            220 |
|      2 |      2 |            120 |
|      2 |      5 |            320 |
|      3 |      3 |            220 |
|      4 |      2 |            220 |
|      4 |      4 |            320 |
|      5 |      1 |            310 |
|      5 |      5 |            410 |
+--------+--------+----------------+
10 rows in set
Time: 0.003s
mysql root@localhost:laboratory>
```

Figure 3.5: Inserting data into the «Work_on» table

3.0.5 Chemist_phones relation

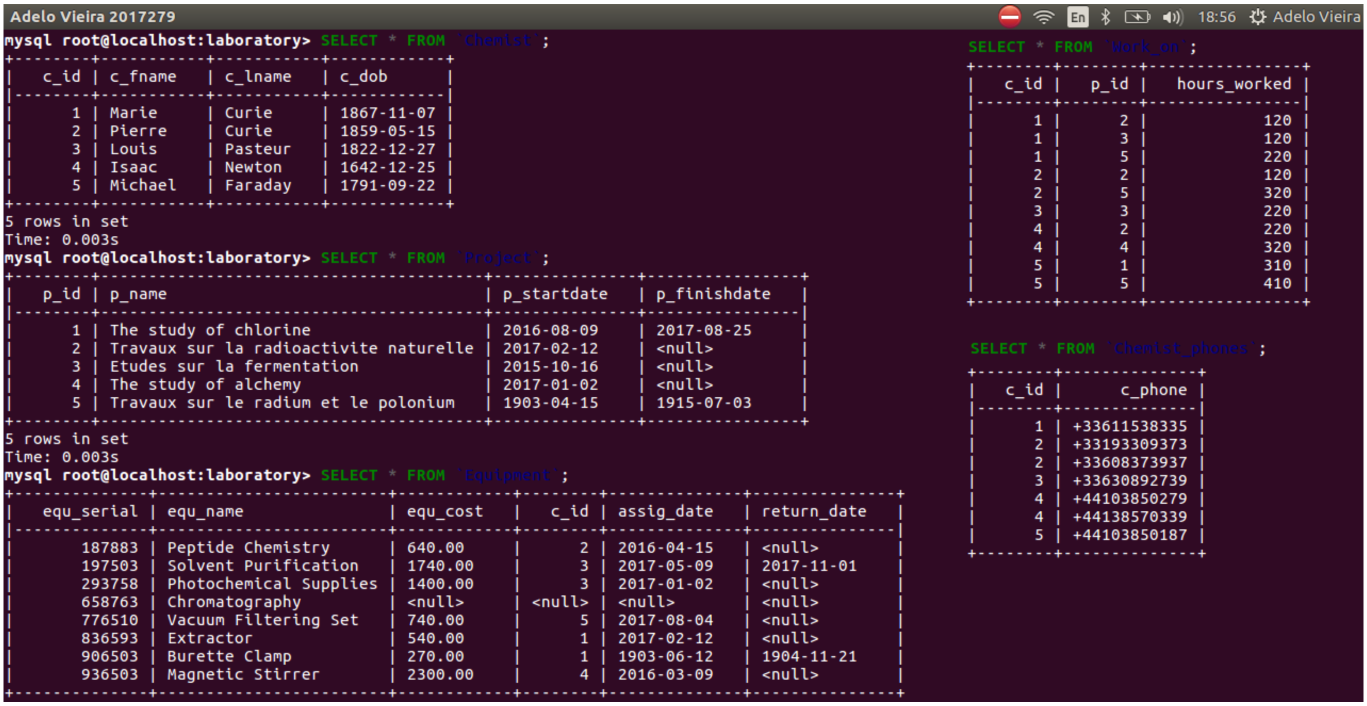
```
INSERT INTO Chemist_phones(c_id, c_phone) VALUES(1,'+33611538335');
INSERT INTO Chemist_phones(c_id, c_phone) VALUES(2,'+33608373937');
INSERT INTO Chemist_phones(c_id, c_phone) VALUES(2,'+33193309373');
INSERT INTO Chemist_phones(c_id, c_phone) VALUES(3,'+33630892739');
INSERT INTO Chemist_phones(c_id, c_phone) VALUES(4,'+44138570339');
INSERT INTO Chemist_phones(c_id, c_phone) VALUES(4,'+44103850279');
INSERT INTO Chemist_phones(c_id, c_phone) VALUES(5,'+44103850187');
```



```
mysql root@localhost:laboratory> INSERT INTO Chemist_phones(c_id, c_phone) VALUES(1,'+33611538335');
                                 INSERT INTO Chemist_phones(c_id, c_phone) VALUES(2,'+33608373937');
                                 INSERT INTO Chemist_phones(c_id, c_phone) VALUES(2,'+33193309373');
                                 INSERT INTO Chemist_phones(c_id, c_phone) VALUES(3,'+33630892739');
                                 INSERT INTO Chemist_phones(c_id, c_phone) VALUES(4,'+44138570339');
                                 INSERT INTO Chemist_phones(c_id, c_phone) VALUES(4,'+44103850279');
                                 INSERT INTO Chemist_phones(c_id, c_phone) VALUES(5,'+44103850187');
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Query OK, 1 row affected
Time: 1.647s
mysql root@localhost:laboratory> SELECT * FROM `Chemist_phones`;
+--------+--------------+
|   c_id |      c_phone |
|--------+--------------|
|      1 | +33611538335 |
|      2 | +33193309373 |
|      2 | +33608373937 |
|      3 | +33630892739 |
|      4 | +44103850279 |
|      4 | +44138570339 |
|      5 | +44103850187 |
+--------+--------------+
7 rows in set
Time: 0.003s
mysql root@localhost:laboratory>
```

Figure 3.6: Inserting data into the «Chemist_phones» table

3.0.6 Laboratory Database



```
mysql root@localhost:laboratory> SELECT * FROM `Chemist`;
+--------+----------+----------+------------+
|   c_id | c_fname  | c_lname  | c_dob      |
|--------+----------+----------+------------|
|      1 | Marie    | Curie    | 1867-11-07 |
|      2 | Pierre   | Curie    | 1859-05-15 |
|      3 | Louis    | Pasteur  | 1822-12-27 |
|      4 | Isaac    | Newton   | 1642-12-25 |
|      5 | Michael  | Faraday  | 1791-09-22 |
+--------+----------+----------+------------+
5 rows in set
Time: 0.003s
mysql root@localhost:laboratory> SELECT * FROM `Project`;
+--------+-------------------------------------+--------------+---------------+
|   p_id | p_name                              | p_startdate  | p_finishdate  |
|--------+-------------------------------------+--------------+---------------|
|      1 | The study of chlorine               | 2016-08-09   | 2017-08-25    |
|      2 | Travaux sur la radioactivite naturelle | 2017-02-12 | <null>        |
|      3 | Etudes sur la fermentation          | 2015-10-16   | <null>        |
|      4 | The study of alchemy                | 2017-01-02   | <null>        |
|      5 | Travaux sur le radium et le polonium | 1903-04-15  | 1915-07-03    |
+--------+-------------------------------------+--------------+---------------+
5 rows in set
Time: 0.003s
mysql root@localhost:laboratory> SELECT * FROM `Equipment`;
+------------+-----------------------+----------+-------+--------------+--------------+
|   equ_serial | equ_name            | equ_cost |  c_id | assig_date   | return_date  |
|------------+-----------------------+----------+-------+--------------+--------------|
|     187883 | Peptide Chemistry     | 640.00   |     2 | 2016-04-15   | <null>       |
|     197503 | Solvent Purification  | 1740.00  |     3 | 2017-05-09   | 2017-11-01   |
|     293758 | Photochemical Supplies | 1400.00 |     3 | 2017-01-02   | <null>       |
|     658763 | Chromatography        | <null>   | <null> | <null>      | <null>       |
|     776510 | Vacuum Filtering Set  | 740.00   |     5 | 2017-08-04   | <null>       |
|     836593 | Extractor             | 540.00   |     1 | 2017-02-12   | <null>       |
|     906503 | Burette Clamp         | 270.00   |     1 | 1903-06-12   | 1904-11-21   |
|     936503 | Magnetic Stirrer      | 2300.00  |     4 | 2016-03-09   | <null>       |
+------------+-----------------------+----------+-------+--------------+--------------+
```

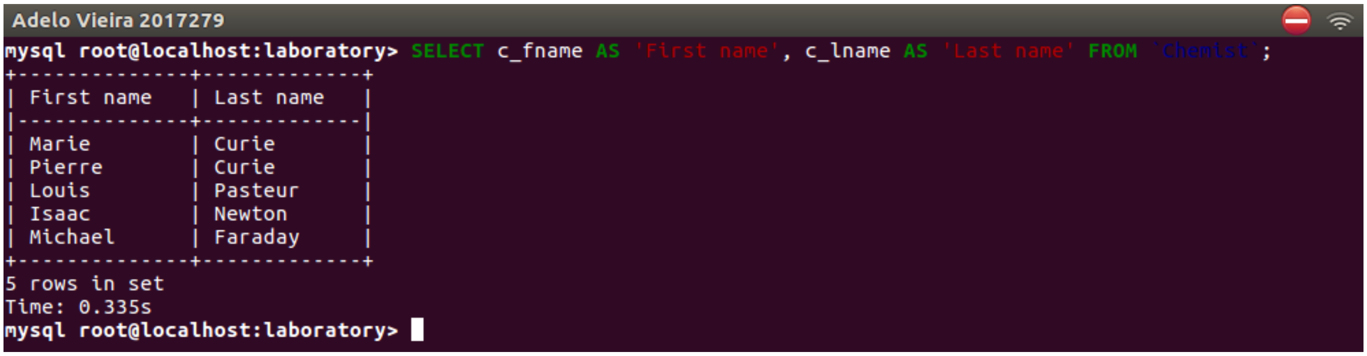
```
SELECT * FROM `Work_on`;
+--------+--------+----------------+
|   c_id |   p_id |   hours_worked |
|--------+--------+----------------|
|      1 |      2 |            120 |
|      1 |      3 |            120 |
|      1 |      5 |            220 |
|      2 |      2 |            120 |
|      2 |      5 |            320 |
|      3 |      3 |            220 |
|      4 |      2 |            220 |
|      4 |      4 |            320 |
|      5 |      1 |            310 |
|      5 |      5 |            410 |
+--------+--------+----------------+

SELECT * FROM `Chemist_phones`;
+--------+--------------+
|   c_id |      c_phone |
|--------+--------------|
|      1 | +33611538335 |
|      2 | +33193309373 |
|      2 | +33608373937 |
|      3 | +33630892739 |
|      4 | +44103850279 |
|      4 | +44138570339 |
|      5 | +44103850187 |
+--------+--------------+
```

Figure 3.7: Laboratory Database

4 Testing

To illustrate how the database has met its aforementioned requirements, we generated the following *SQL queries*:

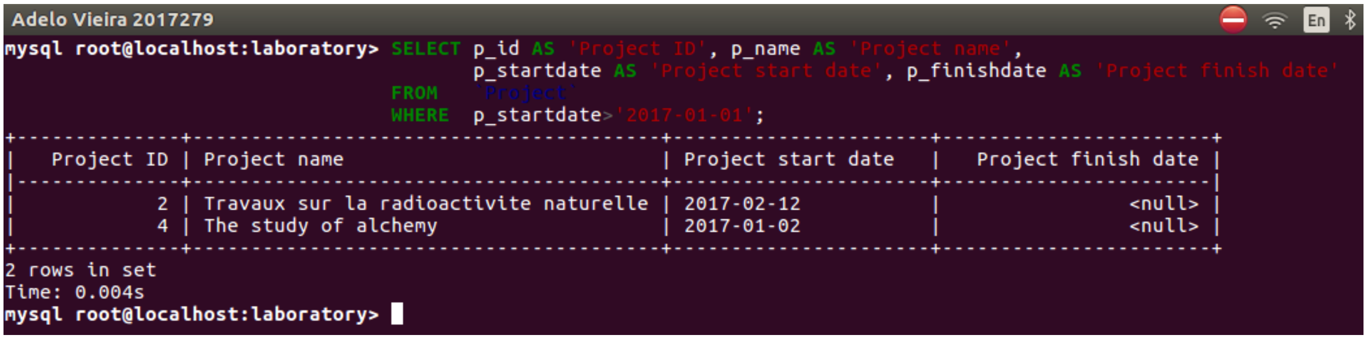
1. A list of all chemists (firstname and lastname only) working in the company:



```
Adelo Vieira 2017279
mysql root@localhost:laboratory> SELECT c_fname AS 'First name', c_lname AS 'Last name' FROM `Chemist`;
+-------------+------------+
| First name  | Last name  |
|-------------+------------|
| Marie       | Curie      |
| Pierre      | Curie      |
| Louis       | Pasteur    |
| Isaac       | Newton     |
| Michael     | Faraday    |
+-------------+------------+
5 rows in set
Time: 0.335s
mysql root@localhost:laboratory> █
```

Figure 4.1: SQL queries: A list of all chemists working in the company

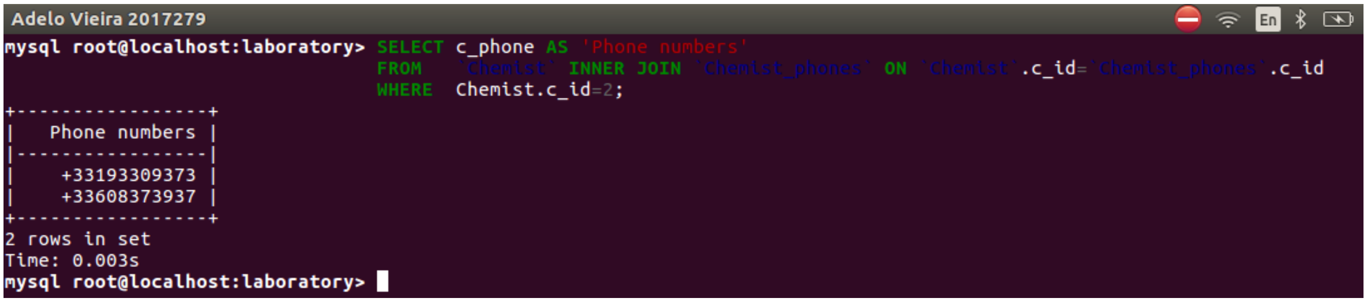
2. A list of all projects that started after 2017-01-01:



```
Adelo Vieira 2017279
mysql root@localhost:laboratory> SELECT p_id AS 'Project ID', p_name AS 'Project name',
                                        p_startdate AS 'Project start date', p_finishdate AS 'Project finish date'
                                 FROM   `Project`
                                 WHERE  p_startdate>'2017-01-01';
+-------------+---------------------------------------+--------------------+---------------------+
|  Project ID | Project name                          | Project start date |  Project finish date |
|-------------+---------------------------------------+--------------------+---------------------|
|           2 | Travaux sur la radioactivite naturelle | 2017-02-12         |              <null> |
|           4 | The study of alchemy                  | 2017-01-02         |              <null> |
+-------------+---------------------------------------+--------------------+---------------------+
2 rows in set
Time: 0.004s
mysql root@localhost:laboratory> █
```

Figure 4.2: SQL queries: A list of all projects that started after $2017-01-01$

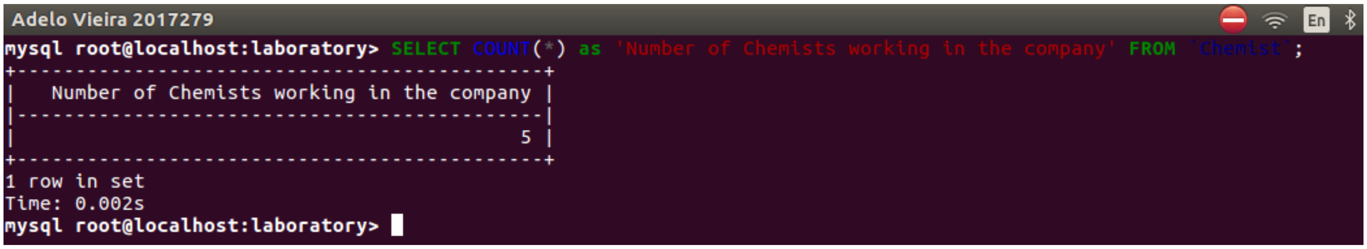
3. The phones numbers for the chemist with Employee ID 2:



```
Adelo Vieira 2017279
mysql root@localhost:laboratory> SELECT c_phone AS 'Phone numbers'
                                 FROM   `Chemist` INNER JOIN `Chemist_phones` ON `Chemist`.c_id=`Chemist_phones`.c_id
                                 WHERE  Chemist.c_id=2;
+----------------+
|  Phone numbers |
|----------------|
|   +33193309373 |
|   +33608373937 |
+----------------+
2 rows in set
Time: 0.003s
mysql root@localhost:laboratory> █
```

Figure 4.3: SQL queries: The phones numbers for the chemist with Employee ID 2

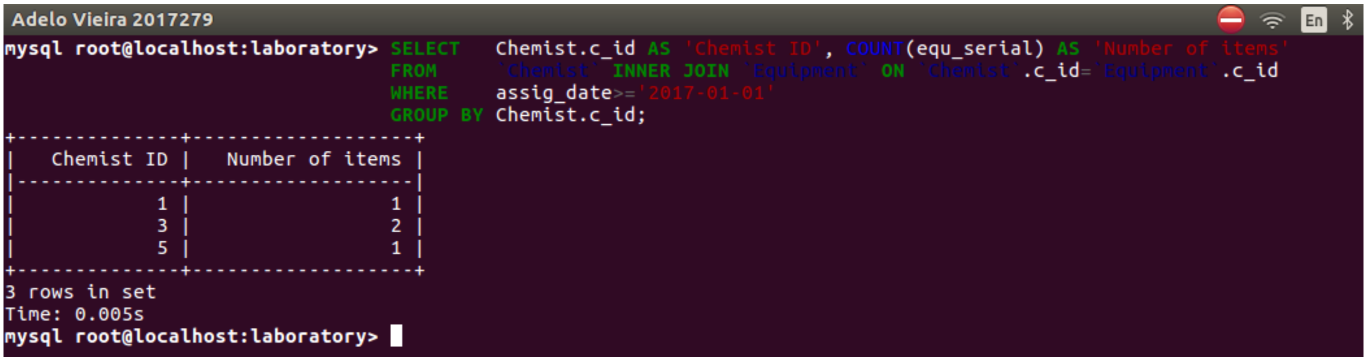
4. How many chemists work in the company:



```
mysql root@localhost:laboratory> SELECT COUNT(*) as 'Number of Chemists working in the company' FROM `Chemist`;
+-------------------------------------------+
|   Number of Chemists working in the company |
|-------------------------------------------|
|                                         5 |
+-------------------------------------------+
1 row in set
Time: 0.002s
mysql root@localhost:laboratory>
```

Figure 4.4: SQL queries: How many chemists work in the company

5. For each chemist, the amount of equipment they have checked out this year:



```
mysql root@localhost:laboratory> SELECT   Chemist.c_id AS 'Chemist ID', COUNT(equ_serial) AS 'Number of items'
                                 FROM     `Chemist` INNER JOIN `Equipment` ON `Chemist`.c_id=`Equipment`.c_id
                                 WHERE    assig_date>='2017-01-01'
                                 GROUP BY Chemist.c_id;
+-------------+------------------+
|   Chemist ID |   Number of items |
|-------------+------------------|
|            1 |                1 |
|            3 |                2 |
|            5 |                1 |
+-------------+------------------+
3 rows in set
Time: 0.005s
mysql root@localhost:laboratory>
```

Figure 4.5: SQL queries: For each chemist, the amount of equipment they have checked out this year

Declaration

I hereby declare that all of the work shown here is my own work.

Student's Name: Adelo Vieira

Student Number: 2017279

Date: December 18, 2017

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Greg South : *Lecture of the database course at CCT: SQL and Data Manipulation.* b.

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