



Mini Project

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1 REQUIREMENT ANALYSIS

1.1 DATA REQUIREMENTS

Financial service company is included of several entities which is having the need of maintaining all the requirements for the company. They have been identified with the essential attributes for each entity.

The company is consisting of several branches and each branch contains sectors. Employees from different sectors may work in different branches and for the employees they are having a employer for the whole company. If an employee has children, the company follow a method to maintain the details of them for instances when some difficulties happen to an employee the company is bonded to take the responsibility of that children.

Customer many register to any branch in the company and he/she registered by an employee. Customer can take the facilities of pawning, leasing and loaning. For pawning there should be articles with customer and for leasing there should be vehicles owned to them.

Customer pays back the facilities taken through instalments.

Entity	Attributes
Customer	Customer ID, Full Name, Address, Date Of Birth, NIC, Email, Phone Number,
Employee	Employee ID, Full Name, Address, Date Of Birth, NIC, Email, Phone Number, Designation, Salary

Child	Name, Date Of Birth, Address
Sector	Sector ID, Sector Name
Branch	Branch ID, Branch Name, Branch Address
Vehicle	Registration No Chasis No Engine No Class Make Estimated Value Lease Residual Percentage <i>Lease Residual</i>
Article	Type Condition Mass KT Amount Market Value Pawning Percentage <i>Pawning Amount</i>
Leasing	Reference No Date Term Length Interest Rate Facility <i>Monthly Rental</i>
Loan	Reference No, Date Term Length, Loan Amount Interest Rate <i>Monthly Rental</i>

Pawning	Reference No Date Term Length, Loan Amount, Interest Rate, <i>Total Amount</i>
Installment	Reference No, Installment No, Paid Date, Paid Amount

*Derived attributes are mentioned in *italic*.

1.2 FUNCTIONAL REQUIREMENTS

In this project, the goal is to define the functional requirements that specify the capabilities of the database system. These functional requirements encompass various tasks and responsibilities for the database system. They include:

- **Data Retrieval:** The database system should be capable of efficiently retrieving data as needed.
- **Data Modification:** The system should allow authorized users to modify the content of the database when necessary.
- **Data Gap Handling:** It should provide the ability to fill in any gaps or missing data within the database.
- **Data Update:** Users should be able to update previously entered data in the database to ensure accuracy.
- **Commenting On Data:** The system should enable users to add comments to the data, especially when the data is missing or questionable, for documentation and clarification purposes.
- **Performance Improvement:** The system should be optimized to supply data with improved performance, ensuring that tasks are executed efficiently at all functional levels."

This schema has been designed to represent a database for a financial service company. The entities chosen to populate this schema include customers, employees, loans, pawning, leasing, installments, articles, vehicles, branches, and sectors. The schema encompasses various aspects of the financial service company's operations, allowing data related to these entities to be efficiently stored and retrieved. Furthermore, the functional requirements outlined earlier are fully satisfied by this database schema.

2 CONCEPTUAL DIAGRAM

2.1 ER DIAGRAM

Assumptions for ER Diagram:

1. Customer can register for the company only one time but they can do transactions from any branch.
2. There can be any branches without customers.
3. A customer can be stay without paying any installment.
4. When taking a pawning, customer can only use one article.

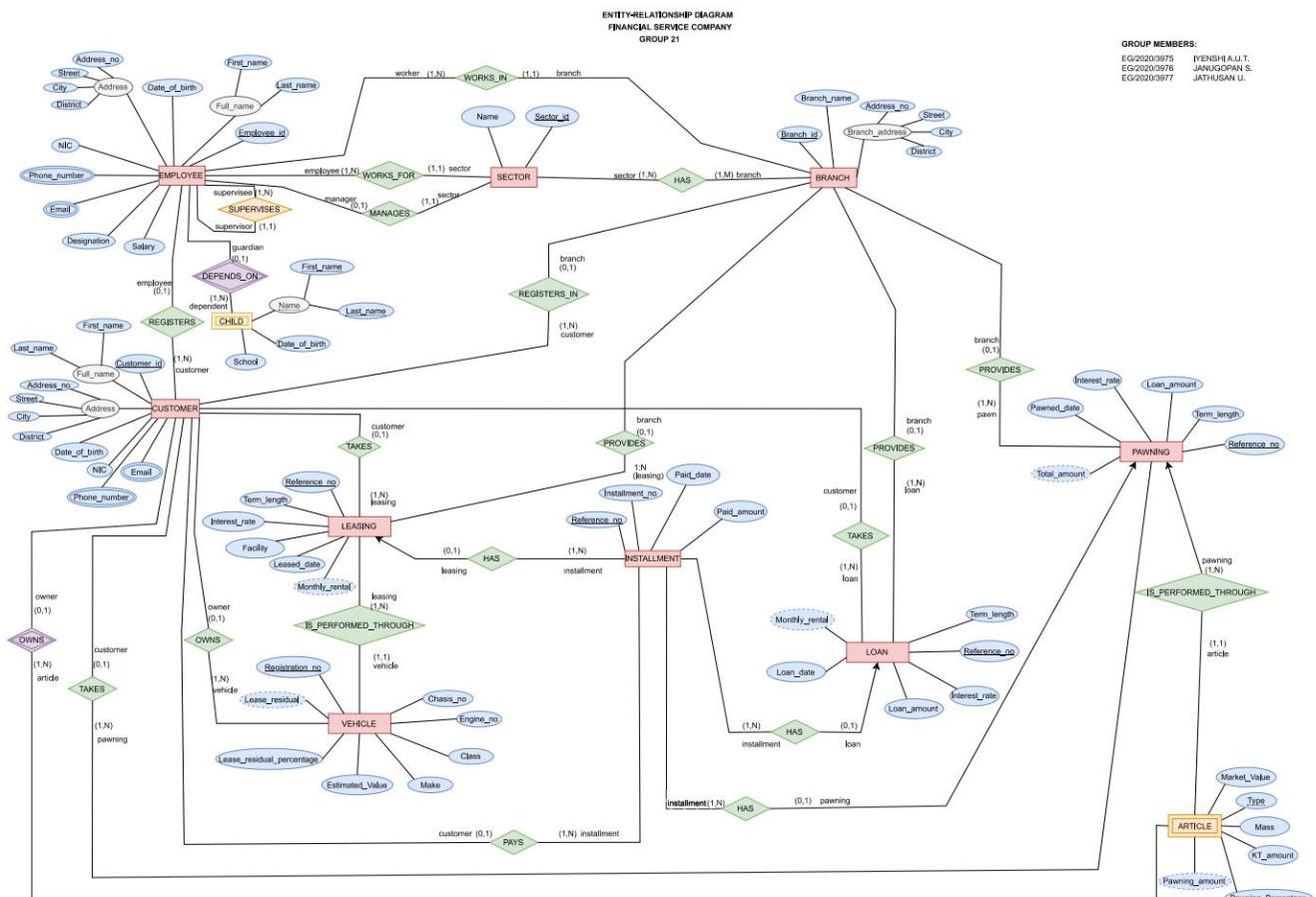


Figure 1 : ER Diagram

Google Uploaded Link:[ER Diagram Group21](#)

2.2 UML DIAGRAM

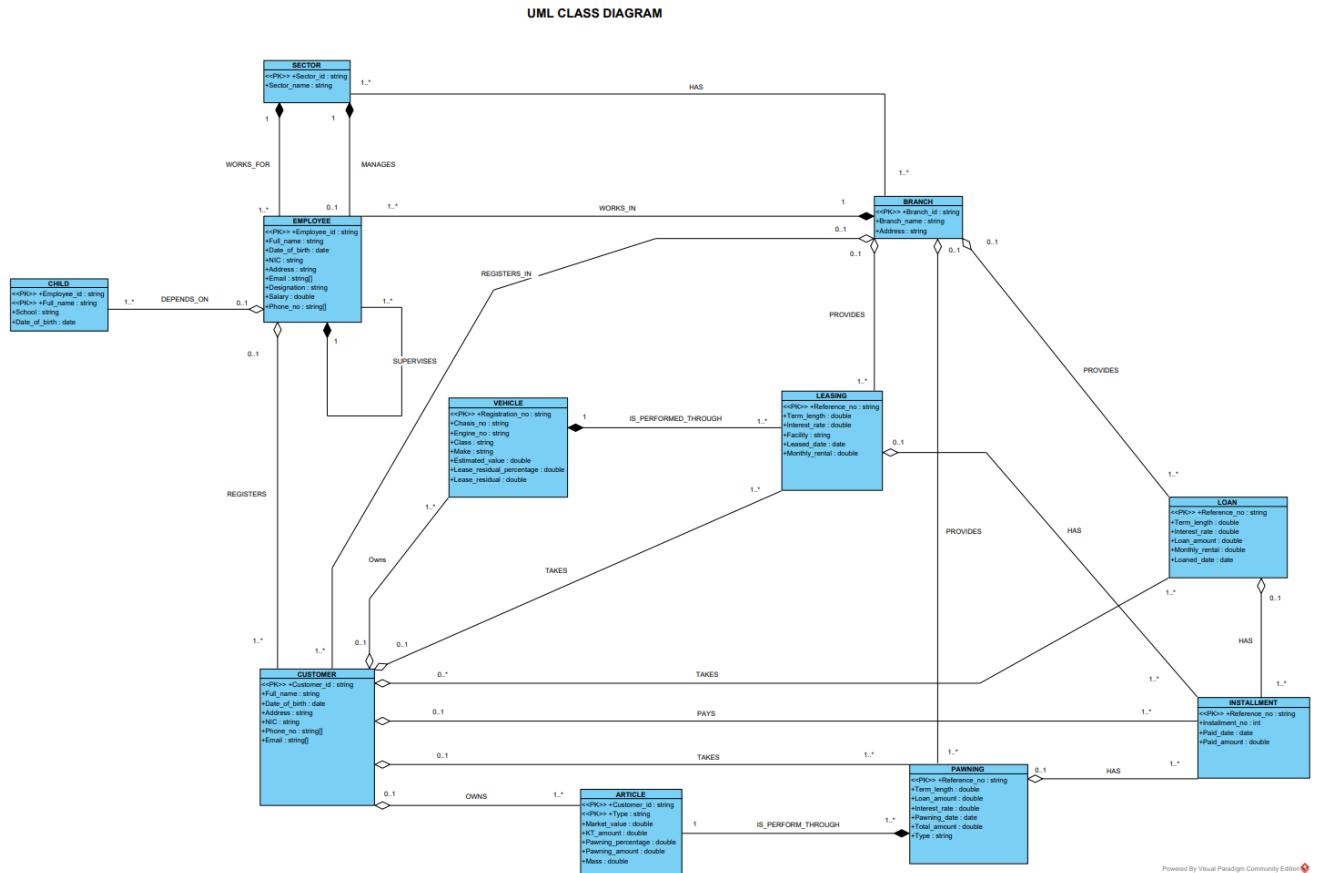


Figure 2 : UML Diagram

Google Uploaded Link: [UML Diagram](#)

3 IMPLEMENTATION

3.1 NORMALIZATION

3.1.1 Before Normalization

EMPLOYEE											
Employee_id	Full_name	Date_of_birth	Address	NIC	Designation	Salary	Phone_number	Email	Head	Sector_id	Branch_id
CUSTOMER											
Customer_id	Full_name	Date_of_birth	Address	NIC	Phone_number	Email	Registered_employee				
BRANCH											
Branch_id	Branch_name	Address									
CHILD											
Parent_employ	Full_name	Date_of_birth	School								
BRANCH_SECTOR											
Branch_id	Sector_id										
SECTOR											
Sector_id	Sector_name	Head									
LOAN											
Reference_no	Term_length	Loaned_date	Interest_rate	Loan_amount	Monthly_rental	Customer_id	Branch_id				
LEASING											
Reference_no	Term_lenth	Interest_rate	Facility	Lesed_date	Monthly_rental	Customer_id	Vehicle_id	Branch_id			
VEHICLE											
Registration_no	Chasis_no	Engine_no	Class	Make	Estimated_value	Lease_residual	Customer_id				
ARTICLE											
Customer_id	Article_type	Mass	Market_value	KT_amount	Pawanin_percentage		Pawning_amount				
INSTALLMENT											
Reference_no	Paid_date	Paid_amount	Customer_id	Loan_id	Leasing_id	Pawning_id					
PAWNING											
Reference_no	Term_length	Loan_amount	Interest_rate	Pawning_date	Customer_id	Article_type	Branch_id				

3.1.2 First Normalization

In employee table Full_name and Address are composite attributes. Phone_number and Email are multivalued attributes.

After taking to the first normalization,

EMPLOYEE												
Employee_id	First_name	Last_name	Date_of_birth	Address_no	Street	District	NIC	Designation	Salary	Head	Sector_id	Branch_id
EMPLOYEE_EMAIL												
Employee_id	Email											
EMPLOYEE_PHONE_NUMBER												
Employee_id	Phone_number											

In CUSTOMER table also, Full_name and address are composite attributes. Phone_number and Email are multivalued attributes.

CUSTOMER										
Customer_id	First_name	Last_name	Date_of_birth	Address_no	Street	City	District	NIC	Registered_employee	Registered_branch
CUSTOMER_PHONE_NUMBER										
Customer_id	Phone_number									
CUSTOMER_EMAIL										
Customer_id	Email									

In BRANCH table Branch_address is a composite key. By taking it into First Normalized Form,

BRANCH					
Branch_id	Branch_name	Address_no	Street	City	District

Other tables are already in first normal form.

CHILD							
Parent_employee	First_name	Last_name	Date_of_birth	School			
SECTOR							
Sector_id	Sector_name	Head					
BRANCH_SECTOR							
Branch_id	Sector_id						
LEASING							
Reference_no	Term_length	Interest_rate	Facility	Lesed_date	Monthly_rental	Customer_id	Vehicle_id
VEHICLE							
Registration_no	Chasis_no	Engine_no	Class	Make	Estimated_value	Lease_residual	Owned_customer
LOAN							
Reference_no	Term_length	Loaned_date	Interest_rate	Loan_amount	Monthly_rental	Loanee	Branch_id
ARTICLE							
Owned_customer	Article_type	Mass	Market_value	KT_amount	Pawarin_percentage	Pawning_amount	
INSTALLMENT							
Reference_no	Paid_date	Paid_amount	Customer_id	Loan_id	Leasing_id	Pawning_id	
PAWNING							
Reference_no	Term_length	Loan_amount	Interest_rate	Pawning_date	Customer_id	Article_type	Branch_id

3.1.3 SECOND NORMAL FORM

As there are no tables with multiple candidate key, tables are already in second normal form.

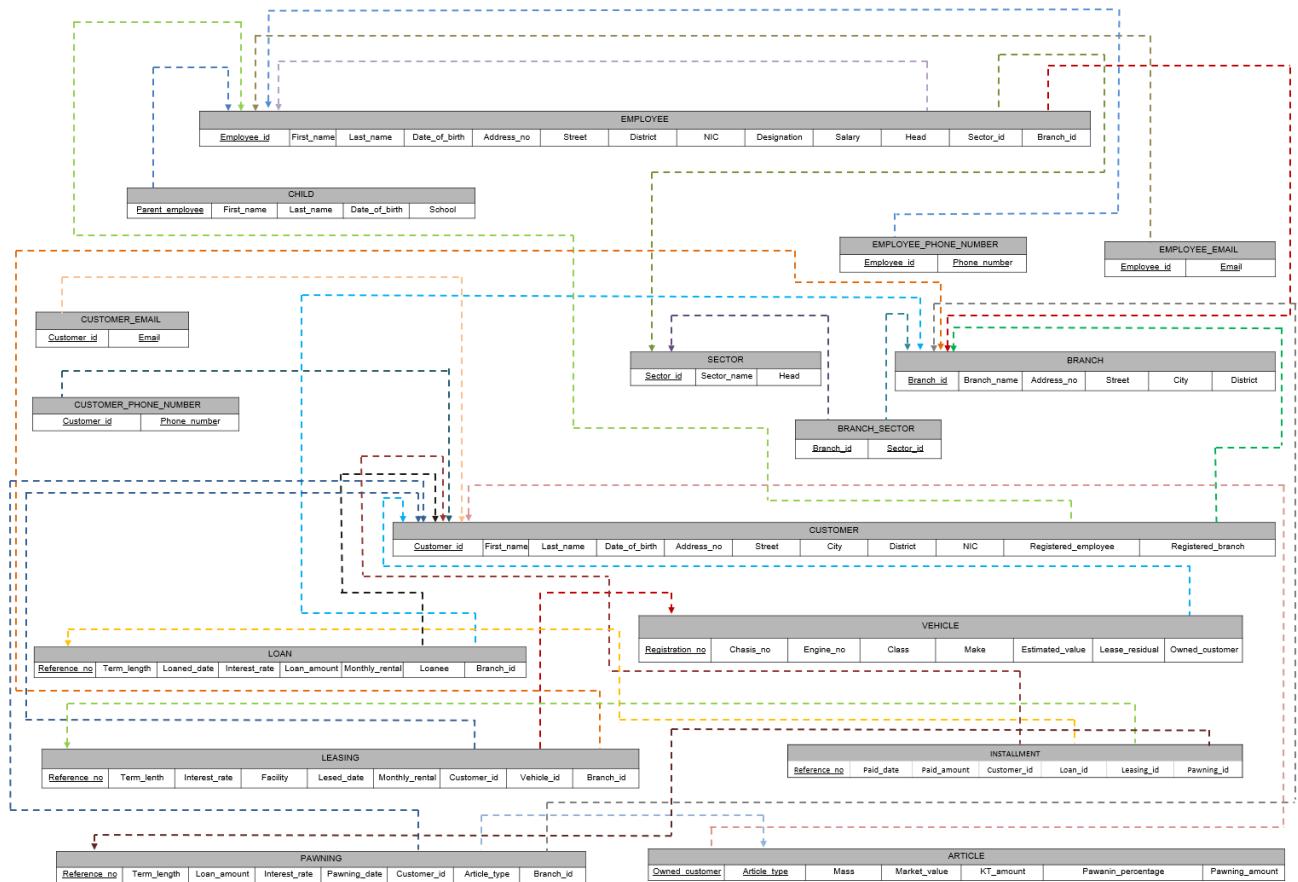


Figure 3 : All the Relations with Foreign Keys

Google Uploaded Link: [Relations With Foreign Keys](#)

3.2 CREATION OF TABLES

This part contains how the tables were created and the finally checking whether all the tables have been created.

```
MySQL 8.0 Command Line Client
mysql> create table SECTOR(Sector_id varchar(10) not null, Sector_name varchar(25), Head varchar(5), primary key(Sector_ID));
Query OK, 0 rows affected (0.01 sec)

mysql> create table BRANCH(Branch_id varchar(10) not null, Branch_name varchar(15), Address_No varchar(5), Street varchar(20), City varchar(15), char(15), primary key(Branch_id));
Query OK, 0 rows affected (0.01 sec)

mysql> create table BRANCH_SECTOR(Branch_id varchar(10) not null, Sector_id varchar(10) not null, primary key(Branch_id,Sector_id), constraint fk_branch_sec foreign key(Branch_id) references BRANCH(Branch_id), constraint fk_br_sec_sec foreign key(Sector_id) references SECTOR(Sector_id));
Query OK, 0 rows affected (0.02 sec)

mysql> CREATE table EMPLOYEE(Employee_id varchar(5) NOT NULL, First_name varchar(10), Last_name varchar(10), Date_of_birth date, Address_no varchar(20), City varchar(15), District varchar(15), NIC varchar(12) not null, Designation varchar(25) default null, Salary decimal(10,2), 10, Sector_id varchar(10), Branch_id varchar(10), primary key(Employee_id), constraint fk_em_branch foreign key(Branch_id) references BRANCH(Branch_id) on delete set null on update cascade, constraint fk_em_sector foreign key(Sector_id) references SECTOR(Sector_id) on delete set null on update cascade);
Query OK, 0 rows affected (0.03 sec)

mysql> create table EMPLOYEE_PHONE_NUMBER(Employee_id varchar(5) NOT NULL, Phone_number varchar(10) not null, primary key(Phone_number,Employee_id), emp_phn Foreign key(Employee_id) references EMPLOYEE(Employee_id));
Query OK, 0 rows affected (0.02 sec)

mysql> create table EMPLOYEE_EMAIL(Employee_id varchar(5) NOT NULL, Email varchar(25) not null, primary key>Email,Employee_id), constraint fk_emp_email foreign key(Employee_id) references EMPLOYEE(Employee_id));
Query OK, 0 rows affected (0.03 sec)

mysql> create table CHILD(Parent_employee varchar(5) NOT NULL, First_name varchar(10) not null, Last_name varchar(10) not null, Date_of_birth date, ar(25), primary key(Parent_employee, First_name, Last_name), constraint fk_emp_ch Foreign key(Parent_employee) references EMPLOYEE(Employee_id));
Query OK, 0 rows affected (0.02 sec)

mysql> CREATE table CUSTOMER(Customer_id varchar(5) NOT NULL, First_name varchar(10), Last_name varchar(10), Date_of_birth date, Address_no varchar(20), City varchar(15), District varchar(20), NIC varchar(12) not null, Registered_employee varchar(5), Registered_branch varchar(10), y(Customer_id), constraint fk_cus_emp foreign key(Registered_employee) references EMPLOYEE(Employee_id), constraint fk_cus_branch foreign key(Registered_Branches BRANCH(Branch_id) on delete set null on update cascade);
Query OK, 0 rows affected (0.04 sec)

mysql> create table CUSTOMER_PHONE_NUMBER(Customer_id varchar(5) NOT NULL, Phone_number varchar(10) not null, primary key(Phone_number,Customer_id), cuspn Foreign key(Customer_id) references CUSTOMER(Customer_id));
15 rows in set (0.00 sec)
```

```
MySQL 8.0 Command Line Client
mysql> create table CUSTOMER_PHONE_NUMBER(Customer_id varchar(5) NOT NULL, Phone_number varchar(10) not null, primary key(Phone_number,Customer_id), cuspn Foreign key(Customer_id) references CUSTOMER(Customer_id));
Query OK, 0 rows affected (0.02 sec)

mysql> create table CUSTOMER_EMAIL(Customer_id varchar(5) NOT NULL, Email varchar(25) not null, primary key>Email,Customer_id), constraint fk_cusem_F tomer_id) references CUSTOMER(Customer_id));
Query OK, 0 rows affected (0.04 sec)

mysql> create table LOAN(Reference_no varchar(10) not null, Term_length int, Loaned_date date, Interest_rate decimal(4,2), Loan_amount decimal(10,2), t decimal(8,2), Loanee varchar(5), Branch_id varchar(10), primary key(Reference_No), constraint fk_loan_cus Foreign key(Loanee) references CUSTOMER(Loanee), constraint fk_loan_branch Foreign key(Branch_ID) references BRANCH(Branch_id) on delete set null on update cascade);
Query OK, 0 rows affected (0.02 sec)

mysql> create table VEHICLE(Registration_no varchar(15) not null, Chassis_no varchar(15), Engine_no varchar(15), Class varchar(10) default null, Ma default null, Estimated_value decimal(10,2), Lease_residual_percentage decimal(4,2), Lease_residual decimal, Owned_customer varchar(25), primary action_no), constraint fk_vh_cus foreign key(Owned_customer) references CUSTOMER(Customer_id));
Query OK, 0 rows affected (0.02 sec)

mysql> create table LEASING(Reference_no varchar(10) not null, Term_length int, Interest_rate decimal(4,2), Facility decimal, Leased_date date, l decimal(8,2), Customer_id varchar(5), Vehicle_id varchar(15), Branch_id varchar(10), primary key(Reference_no), constraint fk_lease_cus Foreign k ) references CUSTOMER(Customer_id), constraint fk_lease_branch Foreign key(Branch_id) references BRANCH(Branch_id), constraint fk_leas vh Foreign key(Vehicle_id) re LE(Registration_no));
Query OK, 0 rows affected (0.02 sec)

mysql> create table ARTICLE(Owned_customer varchar(5) not null, Article_type varchar(10) not null, Mass decimal, Market_value decimal(10,2), KT_am awning_percentage decimal(4,2), Pawning_amount decimal(10,2), primary key(Article_type,Owned_customer), constraint fk_ar_cus Foreign key(Owned_custom CUSTOMER(Customer_id));
Query OK, 0 rows affected (0.02 sec)

mysql> create table PAWNING(Reference_No varchar(10) not null, Term_length decimal, Loan_amount decimal(10,2), Interest_rate decimal(4,2), Pawned_Total_amount decimal, Owned_customer varchar(5), Article_type varchar(10), Branch_id varchar(10), primary key(Reference_no), constraint fk_paw_cus (Owned_customer) references CUSTOMER(Customer_id), constraint fk_paw_ar foreign key(Article_type) references ARTICLE(Article_type), constraint fk_pawbr Foreign() references BRANCH(Branch_id) on delete set null on update cascade);
Query OK, 0 rows affected (0.03 sec)

mysql> create table INSTALLMENT(Reference_no varchar(8) not null, Installment_no int, Paid_date date, Paid_amount decimal, Customer_id varchar(15) archar(10), Leasing_id varchar(10), Pawning_id varchar(10), primary key(Reference_no), constraint fk_ins_cus Foreign key(Customer_id) references C 15 rows in set (0.00 sec)
```

```
MySQL 8.0 Command Line Client

mysql> create table INSTALLMENT(Reference_no varchar(8) not null,    Installment_no int,    Paid_date date,    Paid_amount decimal,    Customer_id varchar(15)
      ,    Leasing_id varchar(10),    Pawning_id varchar(10),    primary key(Reference_no),    constraint fk_ins_cus Foreign key(Customer_id) references C
      er_id,    constraint fk_ins_lo Foreign key(Loan_id) references LOAN(Reference_no),    constraint fk_ins_les Foreign key(Leasing_id) references LEASING(Refere
      nstraint fk_ins_paw Foreign key(Pawning_id) references PAWNING(Reference_no));
Query OK, 0 rows affected (0.02 sec)

mysql> show tables
-> ;
+-----+
| Tables_in_financial_service_company |
+-----+
| article
| branch
| branch_sector
| child
| customer
| customer_email
| customer_phone_number
| employee
| employee_email
| employee_phone_number
| installment
| leasing
| loan
| pawning
| sector
| vehicle
+-----+
16 rows in set (0.00 sec)

mysql>
```

3.3 INSERT, UPDATE AND DELETE DATA INTO TABLES

This part contains CRUD operations performed on each tables.

3.3.1 Branch Table

```
MySQL 8.0 Command Line Client
mysql> insert into BRANCH value('BR001','Galle','12','High-level Road','Galle','Galle'),('BR002','Kiribathgoda','25','High-level Road','Kiribathgoda','Gampaha'),('BR003','Grandpass','35','High-level Road','Colombo','Colombo'),('BR004','Malabe','43','Borella Road','Malabe','Colombo'),('BR005','Anuradhapura','51','Main Road','Matara','Matara');
Query OK, 6 rows affected (0.02 sec)
Records: 6  Duplicates: 0  Warnings: 0

mysql> update BRANCH set Address_Nos='12',Street='High-level Road' where Branch_id='BR005';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> update BRANCH set Street='Piliyandala Road',City='Moratuwa' where Branch_id='BR004';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> delete from Branch where Branch_id='BR006';
Query OK, 1 row affected (0.00 sec)

mysql> select * from branch;
+-----+-----+-----+-----+-----+
| Branch_id | Branch_name | Address_No | Street | City | District |
+-----+-----+-----+-----+-----+
| BR001 | Galle | 12 | High-level Road | Galle | Galle |
| BR002 | Kiribathgoda | 25 | High-level Road | Kiribathgoda | Gampaha |
| BR003 | Grandpass | 35 | High-level Road | Colombo | Colombo |
| BR004 | Malabe | 43 | Piliyandala Road | Moratuwa | Colombo |
| BR005 | Anuradhapura | 12 | High-level Road | Anuradhapura | Anuradhapura |
+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

3.3.2 Sector Table

```
MySQL 8.0 Command Line Client
mysql> insert into SECTOR value('SE001','Finance','EM002'), ('SE002','Registration','EM002'), ('SE003','Pawning','EM002'), ('SE004','Leasing','EM002'), ('SE005','Loaning','EM002'), ('SE006','Management','EM002');
Query OK, 6 rows affected (0.01 sec)
Records: 6  Duplicates: 0  Warnings: 0

mysql> update SECTOR set Sector_name='Vehicle Leasing' where Sector_id='SE00';
Query OK, 0 rows affected (0.00 sec)
Rows matched: 0  Changed: 0  Warnings: 0

mysql> update SECTOR set Sector_name='Customer Registration',Head='EM003' where Sector_id='SE002';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> delete from SECTOR where Sector_id='SE006';
Query OK, 1 row affected (0.00 sec)

mysql> select * from sector;
+-----+-----+-----+
| Sector_id | Sector_name | Head |
+-----+-----+-----+
| SE001 | Finance | EM002 |
| SE002 | Customer Registration | EM003 |
| SE003 | Pawning | EM002 |
| SE004 | Leasing | EM002 |
| SE005 | Loaning | EM002 |
+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

3.3.3 Branch_Sector Table

```
MySQL 8.0 Command Line Client
mysql> insert into BRANCH_SECTOR value('BR001','SE001'),('BR001','SE002'),('BR001','SE003'),('BR002','SE001'),('BR002','SE002'),('BR003','SE001');
Query OK, 6 rows affected (0.00 sec)
Records: 6 Duplicates: 0 Warnings: 0

mysql> update BRANCH_SECTOR set Sector_id='SE004' where Branch_id='BR002' and Sector_id='SE002';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update BRANCH_SECTOR set Branch_id='BR005' where Branch_id='BR002' and Sector_id='SE001';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> delete from BRANCH_SECTOR where Branch_id='BR002' and Sector_id='SE001';
Query OK, 0 rows affected (0.00 sec)

mysql> select * from BRANCH_SECTOR;
+-----+-----+
| Branch_id | Sector_id |
+-----+-----+
| BR001    | SE001   |
| BR003    | SE001   |
| BR005    | SE001   |
| BR001    | SE002   |
| BR001    | SE003   |
| BR002    | SE004   |
+-----+-----+
6 rows in set (0.00 sec)

mysql>
```



3.3.4 Employee Table

```
MySQL 8.0 Command Line Client
mysql> insert into EMPLOYEE values('EM001','John','Smith','2000-02-04','12','MainStreet','Hapugala','Galle','200012345678','Loanofficer',100000.00,'EM001','SE001','BR001'), ('EM002','Jane','Doe','1995-05-14','13','MainStreet','Karapitiya','Galle','199512345671','Manager',750000.00,'EM002','SE001','BR001'), ('EM003','Michael','Jackson','1990-06-10','17','MainStreet','Karapitiya','Galle','199012345671','Loanofficer',750000.00,'EM002','SE001','BR001'), ('EM004','Maria','Garcia','1991-12-12','19','MainStreet','Vakvella','Galle','199112345671','Financialanalyst',2000000.00,'EM002','SE001','BR001'), ('EM005','Jennifer','White','1989-02-08','20','MainStreet','Hapugala','Galle','1989112345671','Riskmanager',800000.00,'EM002','SE001','BR001'), ('EM006','William','Anderson','1985-12-08','122','MainStreet','Hapugala','Galle','198512345671','Marketingmanager',90000.00,'EM002','SE001','BR001');
Query OK, 6 rows affected (0.01 sec)
Records: 6 Duplicates: 0 Warnings: 0

mysql> update EMPLOYEE set First_name='Elizabeth',Salary='120000.00' where Employee_id='EM004';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update EMPLOYEE set District='Colombo',Address_no='155' where Employee_id='EM005';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> Delete from EMPLOYEE where Employee_id = 'EM006';
Query OK, 1 row affected (0.01 sec)

mysql> select * from employee;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Employee_id | First_name | Last_name | Date_of_birth | Address_no | Street      | City       | District | NIC      | Designation | Salary     | Head      | Sector_id | Branch_id |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| EM001    | John      | Smith     | 2000-02-04   | 12        | MainStreet | Hapugala  | Galle     | 200012345678 | Loanofficer | 100000.00 | EM001    | SE001   |
| BR001    | Jane      | Doe       | 1995-05-14   | 13        | MainStreet | Karapitiya | Galle     | 199512345671 | Manager    | 750000.00 | EM002    | SE001   |
| EM003    | Michael   | Jackson   | 1990-06-10   | 17        | MainStreet | Karapitiya | Galle     | 199012345671 | Loanofficer | 750000.00 | EM002    | SE001   |
| EM004    | Elizabeth | Garcia   | 1991-12-12   | 19        | MainStreet | Vakvella  | Galle     | 199112345671 | Financialanalyst | 2000000.00 | EM002    | SE001   |
| BR001    | Jennifer | White    | 1989-02-08   | 155      | MainStreet | Hapugala  | Colombo  | 1989112345671 | Riskmanager | 800000.00 | EM002    | SE001   |
| EM006    | William   | Anderson | 1985-12-08   | 122      | MainStreet | Hapugala  | Galle     | 198512345671 | Marketingmanager | 90000.00  | EM002    | SE001   |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)
```



3.3.5 Employee_Phone_Number Table

```
MySQL 8.0 Command Line Client
mysql> insert into EMPLOYEE_PHONE_NUMBER value('EM001', '0751234567'), ('EM001', '0751234554'), ('EM002', '0751231561'), ('EM003', '0711235527'), ('EM003', '0765354569'), ('EM004', '0721253568'), ('EM005', '0721253587');
Query OK, 7 rows affected (0.01 sec)
Records: 7  Duplicates: 0  Warnings: 0

mysql> update EMPLOYEE_PHONE_NUMBER set Phone_number='0701251555' where Employee_id='EM002';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> update EMPLOYEE_PHONE_NUMBER set Phone_number='0741533547' where Employee_id='EM004';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> delete from EMPLOYEE_PHONE_NUMBER where Employee_id='EM005';
Query OK, 1 row affected (0.00 sec)

mysql> select * from EMPLOYEE_PHONE_NUMBER;
+-----+-----+
| Employee_id | Phone_number |
+-----+-----+
| EM001       | 0751234554 |
| EM001       | 0751234567 |
| EM002       | 0701251555 |
| EM003       | 0711235527 |
| EM003       | 0765354569 |
| EM004       | 0741533547 |
+-----+-----+
6 rows in set (0.00 sec)

mysql>
```

3.3.6 Employee_Email Table

```
MySQL 8.0 Command Line Client
mysql> insert into EMPLOYEE_EMAIL value('EM001', 'john@gmail.com'), ('EM001', 'smith@gmail.com'), ('EM002', 'jane@gmail.com'), ('EM002', 'doe@gmail.com'), ('EM003', 'micheal@gmail.com'), ('EM004', 'maria@gmail.com'), ('EM004', 'gartia@gmail.com'), ('EM005', 'anderson@gmail.com');
Query OK, 8 rows affected (0.02 sec)
Records: 8  Duplicates: 0  Warnings: 0

mysql> update EMPLOYEE_EMAIL set Email='abcd105@gmail.com' where (Employee_id='EM004' and Email='gartia@gmail.com');update EMPLOYEE_EMAIL set Email='habcd5@gmail.com' where Employee_id='EM003';delete from EMPLOYEE_EMAIL where Employee_id='EM005';
Query OK, 1 row affected (0.02 sec)
Rows matched: 1  Changed: 1  Warnings: 0

Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

Query OK, 1 row affected (0.00 sec)

mysql> select * from EMPLOYEE_EMAIL;
+-----+-----+
| Employee_id | Email      |
+-----+-----+
| EM001       | john@gmail.com |
| EM001       | smith@gmail.com |
| EM002       | doe@gmail.com |
| EM002       | jane@gmail.com |
| EM003       | habcd5@gmail.com |
| EM004       | abcd105@gmail.com |
| EM004       | maria@gmail.com |
+-----+-----+
7 rows in set (0.00 sec)

mysql>
```

3.3.7 Child Table

```
MySQL 8.0 Command Line Client
mysql> insert into CHILD value('EM001','Vimal','John','2010-03-04','Richmond College'),('EM002','Kamal','Jane','2012-05-04','Mahinda College'),('EM002','Sunil','Jane','2013-07-14','Mahinda College'),('EM003','Aarav','Michael','2009-10-24','St. Aloysius College'),('EM004','Nimal','Maria','2014-06-04','Richmond College'),('EM005','Rajan','Jennifer','2017-03-04','Richmond College');
Query OK, 6 rows affected (0.00 sec)
Records: 6 Duplicates: 0 Warnings: 0

mysql> update CHILD set School='St. Aloysius College' where Parent_employee='EM004';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update CHILD set Date_of_birth='2010-11-13' where Parent_employee='EM003';
Query OK, 1 row affected (0.02 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update CHILD set Date_of_birth='2010-11-13' where Parent_employee='EM003';delete from CHILD where Parent_employee='EM005';
Query OK, 0 rows affected (0.00 sec)
Rows matched: 1 Changed: 0 Warnings: 0

Query OK, 1 row affected (0.00 sec)

mysql> select * from child;
+-----+-----+-----+-----+-----+
| Parent_employee | First_name | Last_name | Date_of_birth | School
+-----+-----+-----+-----+-----+
| EM001           | Vimal      | John       | 2010-03-04   | Richmond College
| EM002           | Kamal      | Jane       | 2012-05-04   | Mahinda College
| EM002           | Sunil      | Maria      | 2013-07-14   | Mahinda College
| EM003           | Aarav      | Michael    | 2009-10-24   | St. Aloysius College
| EM004           | Nimal      | Maria      | 2014-06-04   | St. Aloysius College
+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

3.3.8 Customer Table

```
Select MySQL 8.0 Command Line Client
mysql> insert into CUSTOMER value('CUS01','Nimal','Perera','1996-06-04','1','Main Road','Galle','Galle','199612256678','EM001','BR001'),('CUS02','Ajith','Kumar','1990-03-04','2','Main Road','Colombo','Colombo','199096225678','EM001','BR003'),('CUS03','Kamal','Hassan','1991-04-04','3','Main Road','Batticaloa','Batticaloa','199189225678','EM002','BR002'),('CUS04','Rajini','Kanth','1986-05-04','4','HL Road','Kandy','Kandy','198625225678','EM004','BR001'),('CUS05','Vijay','Kumar','1987-12-04','5','Wakwella Road','Hapugala','Galle','19871235678','EM001','BR004');
Query OK, 6 rows affected (0.02 sec)
Records: 6 Duplicates: 0 Warnings: 0

mysql> update CUSTOMER set Date_of_birth='1987-12-14' where Customer_id='CUS05';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update CUSTOMER set Address_no='5',Date_of_birth='1991-12-14',District='Colombo' where Customer_id='CUS03';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> delete from CUSTOMER where Customer_id='CUS06';
Query OK, 1 row affected (0.01 sec)

mysql> select * from customer;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Customer_id | First_name | Last_name | Date_of_birth | Address_no | Street | City | District | NIC | Registered_employee | Registered_branch |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| CUS01       | Nimal      | Perera    | 1996-06-04   | 1          | Main Road | Galle | Galle     | 199612256678 | EM001      | BR001
| CUS02       | Ajith      | Kumar     | 1990-03-04   | 2          | Main Road | Colombo | Colombo   | 199096225678 | EM001      | BR003
| CUS03       | Kamal      | Hassan    | 1991-12-14   | 5          | Main Road | Batticaloa | Batticaloa | 199189225678 | EM002      | BR002
| CUS04       | Rajini     | Kanth     | 1986-05-04   | 4          | HL Road   | Kandy  | Kandy     | 198625225678 | EM004      | BR001
| CUS05       | Vijay      | Kumar     | 1987-12-04   | 5          | Wakwella Road | Hapugala | Galle     | 19871235678 | EM001      | BR004
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

3.3.9 Customer_Phone_Number Table

```
MySQL 8.0 Command Line Client
mysql> insert into CUSTOMER_PHONE_NUMBER value('CUS01','0755864567'),('CUS01','0751753554'),('CUS02','0751231591'),('CUS03','0711428527'),('CUS03','0765396769'),('CUS04','072125359'),('CUS05','0721247235');
Query OK, 7 rows affected (0.01 sec)
Records: 7  Duplicates: 0  Warnings: 0

mysql> update CUSTOMER_PHONE_NUMBER set Phone_number='0701211355' where Customer_id='CUS02';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> update CUSTOMER_PHONE_NUMBER set Phone_numbers='0747598547' where Customer_id='CUS04';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> delete from CUSTOMER_PHONE_NUMBER where Customer_id='CUS05';
Query OK, 1 row affected (0.00 sec)

mysql> select * from CUSTOMER_PHONE_NUMBER;
+-----+-----+
| Customer_id | Phone_number |
+-----+-----+
| CUS01       | 0751753554 |
| CUS01       | 0755864567 |
| CUS02       | 0761211355 |
| CUS03       | 0711428527 |
| CUS03       | 0765396769 |
| CUS04       | 0747598547 |
+-----+-----+
6 rows in set (0.00 sec)

mysql>
```

3.3.10 Customer_Email Table

```
MySQL 8.0 Command Line Client
mysql> insert into CUSTOMER_EMAIL value('CUS01','cabcd001@gmail.com'),('CUS01','cabcd002@gmail.com'),('CUS02','cabcd0013@gmail.com'),('CUS02','cabcd0014@gmail.com'),('CUS03','cabcd0015@gmail.com'),('CUS04','cabcd0016@gmail.com'),('CUS04','cabcd0017@gmail.com'),('CUS05','cabcd0018@gmail.com');
Query OK, 8 rows affected (0.02 sec)
Records: 8  Duplicates: 0  Warnings: 0

mysql> update CUSTOMER_EMAIL set Email='cabcad105@gmail.com' where (Customer_id='CUS04' and Email='cabcd0017@gmail.com');
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> update CUSTOMER_EMAIL set Email='chabcd5@gmail.com' where Customer_id='CUS03';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> delete from CUSTOMER_EMAIL where Customer_id='CUS05';
Query OK, 1 row affected (0.00 sec)

mysql> select * from customer_email;
+-----+-----+
| Customer_id | Email      |
+-----+-----+
| CUS01       | cabcd001@gmail.com |
| CUS01       | cabcd002@gmail.com |
| CUS02       | cabcd0013@gmail.com |
| CUS02       | cabcd0014@gmail.com |
| CUS03       | chabcd5@gmail.com |
| CUS04       | cabcad105@gmail.com |
| CUS04       | cabcd0016@gmail.com |
+-----+-----+
7 rows in set (0.00 sec)

mysql>
```

3.3.11 Loan Table

```
MySQL 8.0 Command Line Client
mysql> insert into LOAN value('L0001',6,'2023-06-14',3,100000.00,17667.00,'CUS01','BR001'),('L0002',6,'2023-07-22',3,300000.00,53000.00,'CUS02','BR002'),('L0003',12,'2023-08-18',2,100000.00,9334.00,'CUS03','BR003'),('L0004',6,'2023-09-16',3,150000.00,51500.00,'CUS03','BR003'),('L0005',18,'2023-05-04',1,170000.00,11145.00,'CUS04','BR004'),('L0006',6,'2023-04-24',3,350000.00,618334.00,'CUS05','BR001');
Query OK, 6 rows affected (0.00 sec)
Records: 6 Duplicates: 0 Warnings: 0

mysql> update LOAN set Loaned_date='2022-06-14',Branch_id='BR005' where Reference_no='L0005';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update LOAN set Loaned_date='2023-05-27',Loanee='CUS01' where Reference_no='L0004';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> delete from LOAN where Reference_no='L0006';
Query OK, 1 row affected (0.00 sec)

mysql> select * from loan;
+-----+-----+-----+-----+-----+-----+-----+
| Reference_no | Term_length | Loaned_date | Interest_rate | Loan_amount | Monthly_rental | Loanee | Branch_id |
+-----+-----+-----+-----+-----+-----+-----+
| L0001 | 6 | 2023-06-14 | 3.00 | 100000.00 | 17667.00 | CUS01 | BR001 |
| L0002 | 6 | 2023-07-22 | 3.00 | 300000.00 | 53000.00 | CUS02 | BR002 |
| L0003 | 12 | 2023-08-18 | 2.00 | 100000.00 | 9334.00 | CUS03 | BR003 |
| L0004 | 6 | 2023-05-27 | 3.00 | 150000.00 | 51500.00 | CUS01 | BR003 |
| L0005 | 18 | 2022-06-14 | 1.00 | 170000.00 | 11145.00 | CUS04 | BR005 |
+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

3.3.12 Vehicle Table

```
MySQL 8.0 Command Line Client
mysql> insert into VEHICLE value('VEH001','CHA001','ENG001','Car','Prius',1000000.00,55.50,5500000.00,'CUS01'),('VEH002','CHA002','ENG002','Van','Nissan',2875000.00,45.50,1308125.00,'CUS02'),('VEH003','CHA003','ENG003','Car','Audi',2000000.00,65.00,13000000.00,'CUS02'),('VEH004','CHA004','ENG004','Lorry','Hyundai',1500000.00,55.50,832500.00,'CUS03'),('VEH005','CHA005','ENG005','Car','Alto',2300000.00,65.50,1506500.00,'CUS04'),('VEH006','CHA006','ENG006','Threewheel','Bajaj',450000.00,65.50,294750.00,'CUS04');
Query OK, 6 rows affected (0.01 sec)
Records: 6 Duplicates: 0 Warnings: 0

mysql> update VEHICLE set Chasis_no='CHA007',Engine_no='ENG008' where Registration_no='VEH004';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update VEHICLE set Chasis_no='CHA009',Engine_no='ENG009' where Registration_no='VEH004';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> delete from VEHICLE where Registration_no='VEH006';
Query OK, 1 row affected (0.00 sec)

mysql> select * from vehicle;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Registration_no | Chasis_no | Engine_no | Class | Make | Estimated_value | Lease_residual_percentage | Lease_residual | Owned_customer |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| VEH001 | CHA001 | ENG001 | Car | Prius | 1000000.00 | 55.50 | 5500000 | CUS01 |
| VEH002 | CHA002 | ENG002 | Van | Nissan | 2875000.00 | 45.50 | 1308125 | CUS02 |
| VEH003 | CHA003 | ENG003 | Car | Audi | 2000000.00 | 65.00 | 13000000 | CUS02 |
| VEH004 | CHA009 | ENG009 | Lorry | Hyundai | 1500000.00 | 55.50 | 832500 | CUS03 |
| VEH005 | CHA005 | ENG005 | Car | Alto | 2300000.00 | 65.50 | 1506500 | CUS04 |
+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

3.3.13 Leasing Table

```
MySQL 8.0 Command Line Client
mysql> insert into LEASING value('LE001',24,10.05,5500000.00,'2021-06-14',253230.00,'CUS01','VEH001','BR001'),('LE002',24,10.50,1308125.00,'2021-07-14',1500.00,'CUS02','VEH002','BR002'),('LE003',36,12.55,13000000.00,'2022-05-14',406430.00,'CUS02','VEH003','BR003'),('LE004',24,9.60,832500.00,'2022-04-14',38018.00,'CUS03','VEH004','BR003'),('LE005',36,15.60,1506500.00,'2023-03-14',48376.00,'CUS04','VEH005','BR004'),('LE006',48,20.05,1506500.00,'2023-06-14',37679.00,'CUS04','VEH005','BR001');
Query OK, 6 rows affected (0.02 sec)
Records: 6 Duplicates: 0 Warnings: 0

mysql> update LEASING set Leased_date='2023-10-14',Monthly_rental=10.25,Vehicle_id='VEH002' where Reference_no='LE004';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update LEASING set Branch_id='BR004',Monthly_rental=17.25 where Reference_no='LE002';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> delete from LEASING where Reference_no='LE002';
Query OK, 1 row affected (0.00 sec)

mysql> select * from leasing;
+-----+-----+-----+-----+-----+-----+-----+-----+
| Reference_no | Term_length | Interest_rate | Facility | Leased_date | Monthly_rental | Customer_id | Vehicle_id | Branch_id |
+-----+-----+-----+-----+-----+-----+-----+-----+
| LE001 | 24 | 10.05 | 5500000 | 2021-06-14 | 253230.00 | CUS01 | VEH001 | BR001 |
| LE003 | 36 | 12.55 | 13000000 | 2022-05-14 | 406430.00 | CUS02 | VEH003 | BR003 |
| LE004 | 24 | 9.60 | 832500 | 2023-10-14 | 10.25 | CUS03 | VEH002 | BR003 |
| LE005 | 36 | 15.60 | 1506500 | 2023-03-14 | 48376.00 | CUS04 | VEH005 | BR004 |
| LE006 | 48 | 20.05 | 1506500 | 2023-06-14 | 37679.00 | CUS04 | VEH005 | BR001 |
+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

3.3.14 Article Table

```
MySQL 8.0 Command Line Client
mysql> insert into ARTICLE value('CUS01','Ring',20,50000.00,24,50.00,25000),('CUS02','Chain',15,120000.00,22,50.00,56000),('CUS03','Ring',25,40000.00,22,50.00,20000),('CUS04','Bracelet',10,60000.00,24,50.00,30000),('CUS05','Bracelet',10,75000.00,24,50.00,37500),('CUS05','Chain',15,100000.00,22,50.00,50000);
Query OK, 6 rows affected (0.00 sec)
Records: 6 Duplicates: 0 Warnings: 0

mysql> update ARTICLE set Market_value=50000.00,Pawning_amount=25000.00 where Owned_customer='CUS05' and Article_type='Bracelet';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update ARTICLE set Market_value=150000.00,Pawning_amount=75000 where Owned_customer='CUS04';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> delete from ARTICLE where Owned_customer='CUS05' and Article_type='Chain';
Query OK, 1 row affected (0.00 sec)

mysql> select * from article;
+-----+-----+-----+-----+-----+-----+-----+
| Owned_customer | Article_type | Mass | Market_value | KT_amount | Pawnning_percentage | Pawnning_amount |
+-----+-----+-----+-----+-----+-----+-----+
| CUS04 | Bracelet | 10 | 150000.00 | 24 | 50.00 | 75000.00 |
| CUS05 | Bracelet | 10 | 50000.00 | 24 | 50.00 | 25000.00 |
| CUS02 | Chain | 15 | 120000.00 | 22 | 50.00 | 56000.00 |
| CUS01 | Ring | 20 | 50000.00 | 24 | 50.00 | 25000.00 |
| CUS03 | Ring | 25 | 40000.00 | 22 | 50.00 | 20000.00 |
+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

3.3.15 Pawning Table

```
MySQL 8.0 Command Line Client
mysql> insert into PAWNING value('PAW001',12,5000.00,15.05,'2021-10-12',57525.00,'CUS02','Chain','BR002'),('PAW002',12,20000.00,10.05,'2021-11-12',22010.00,'CUS01','Ring','BR002'),('PAW003',6,18000.00,20.50,'2022-09-12',21690.00,'CUS03','Ring','BR002'),('PAW004',12,28000.00,15.00,'2022-05-12',32200.00,'CUS04','Bracelet','BR003'),('PAW006',12,18000.00,12.00,'2023-07-12',20160.00,'CUS03','Ring','BR002'),('PAW007',12,18000.00,12.00,'2023-07-12',20160.00,'CUS01','Chain','BR001');
Query OK, 7 rows affected (0.01 sec)
Records: 7 Duplicates: 0 Warnings: 0

mysql> update PAWNING set Term_length=24,Pawned_date='2022-05-15' where Reference_No='PAW004';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update PAWNING set Branch_id='BR003' where Reference_No='PAW003';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> delete from PAWNING where Reference_No='PAW006';
Query OK, 1 row affected (0.00 sec)

mysql> select * from pawning;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Reference_No | Term_length | Loan_amount | Interest_rate | Pawned_date | Total_amount | Owned_customer | Article_type | Branch_id |
+-----+-----+-----+-----+-----+-----+-----+-----+
| PAW001      | 12          | 5000.00    | 15.05        | 2021-10-12  | 57525       | CUS02         | Chain        | BR002      |
| PAW002      | 12          | 20000.00   | 10.05        | 2021-11-12  | 22010       | CUS01         | Ring        | BR002      |
| PAW003      | 6           | 18000.00   | 20.50        | 2022-09-12  | 21690       | CUS03         | Ring        | BR003      |
| PAW004      | 24          | 28000.00   | 15.00        | 2022-05-15  | 32200       | CUS04         | Bracelet    | BR003      |
| PAW005      | 6           | 25000.00   | 10.00        | 2023-07-12  | 27500       | CUS04         | Bracelet    | BR003      |
| PAW007      | 12          | 18000.00   | 12.00        | 2023-07-12  | 20160       | CUS01         | Chain        | BR001      |
+-----+-----+-----+-----+-----+-----+-----+-----+
6 rows in set (0.00 sec)

mysql>
```

3.3.16 Installment Table

```
MySQL 8.0 Command Line Client
mysql> insert into INSTALLMENT value('INS001',1,'2023-08-02',10000.00,'CUS01','L0001',null,null),('INS002',2,'2023-09-22',20000.00,'CUS01',null,'LE001',null),('INS003',3,'2023-05-15',15000.00,'CUS02',null,null,'PAW001'),('INS004',4,'2023-07-13',30000.00,'CUS03','L0003',null,null),('INS005',5,'2023-01-27',12000.00,'CUS04',null,null,'PAW004'),('INS006',6,'2023-04-05',11000.00,'CUS03',null,'LE004',null);
Query OK, 6 rows affected (0.00 sec)
Records: 6 Duplicates: 0 Warnings: 0

mysql> update INSTALLMENT set Paid_amount=15550.00,Paid_date='2023-07-04' where Reference_no='INS005';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> update INSTALLMENT set Installment_no=3,Paid_amount=25550.00,Paid_date='2022-12-04' where Reference_no='INS004';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> delete from INSTALLMENT where Reference_no='INS006';
Query OK, 1 row affected (0.00 sec)

mysql> select * from installment;
+-----+-----+-----+-----+-----+-----+-----+-----+
| Reference_no | Installment_no | Paid_date | Paid_amount | Customer_id | Loan_id | Leasing_id | Pawning_id |
+-----+-----+-----+-----+-----+-----+-----+
| INS001       | 1             | 2023-08-02 | 10000     | CUS01       | L0001   | NULL       | NULL       |
| INS002       | 2             | 2023-09-22 | 20000     | CUS01       | NULL    | LE001     | NULL       |
| INS003       | 3             | 2023-05-15 | 15000     | CUS02       | NULL    | NULL       | PAW001    |
| INS004       | 3             | 2022-12-04 | 25550     | CUS03       | L0003   | NULL       | NULL       |
| INS005       | 5             | 2023-07-04 | 15550     | CUS04       | NULL    | NULL       | PAW004    |
+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

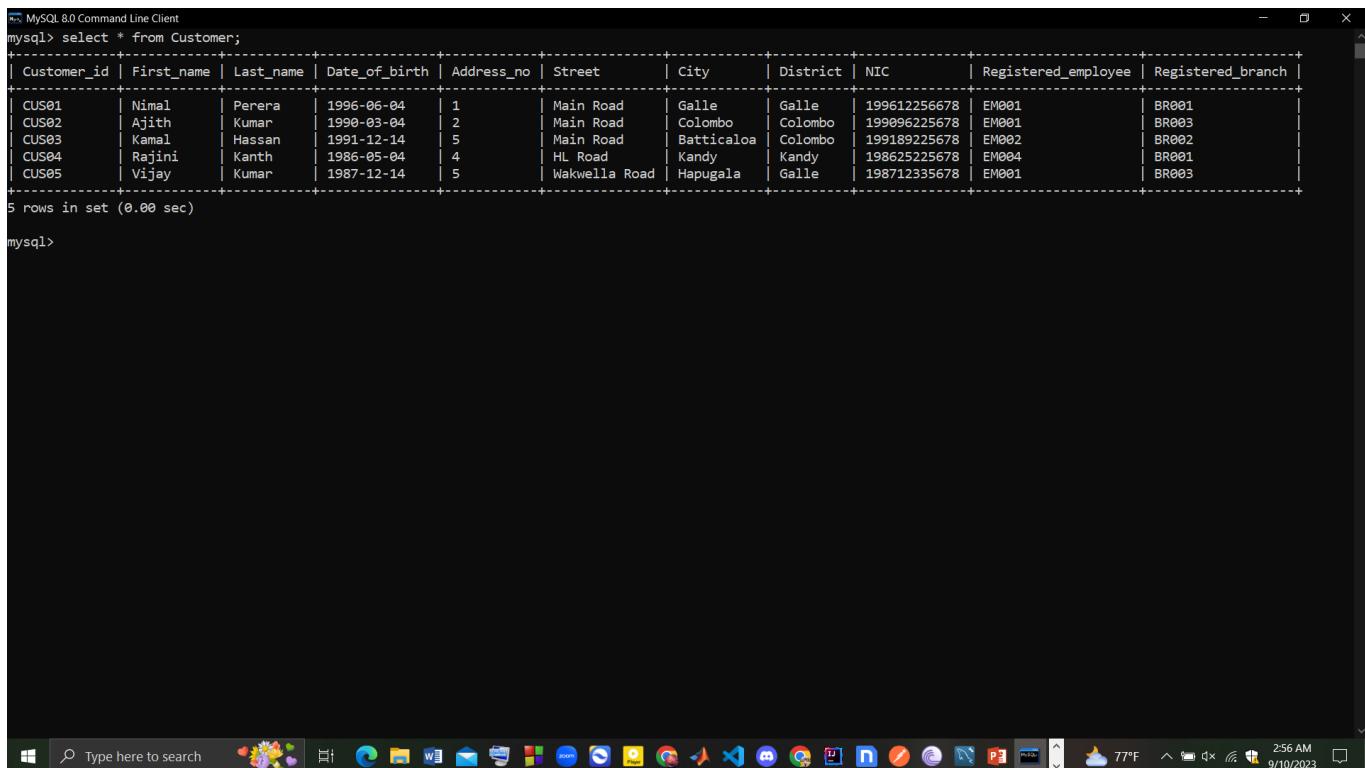
mysql>
```

4 TRANSACTIONS

4.1 SIMPLE QUERIES

This part contains the simple queries which were made based on select, project, Cartesian product, creating user view, rename and one aggregation.

4.1.1 Select Operation



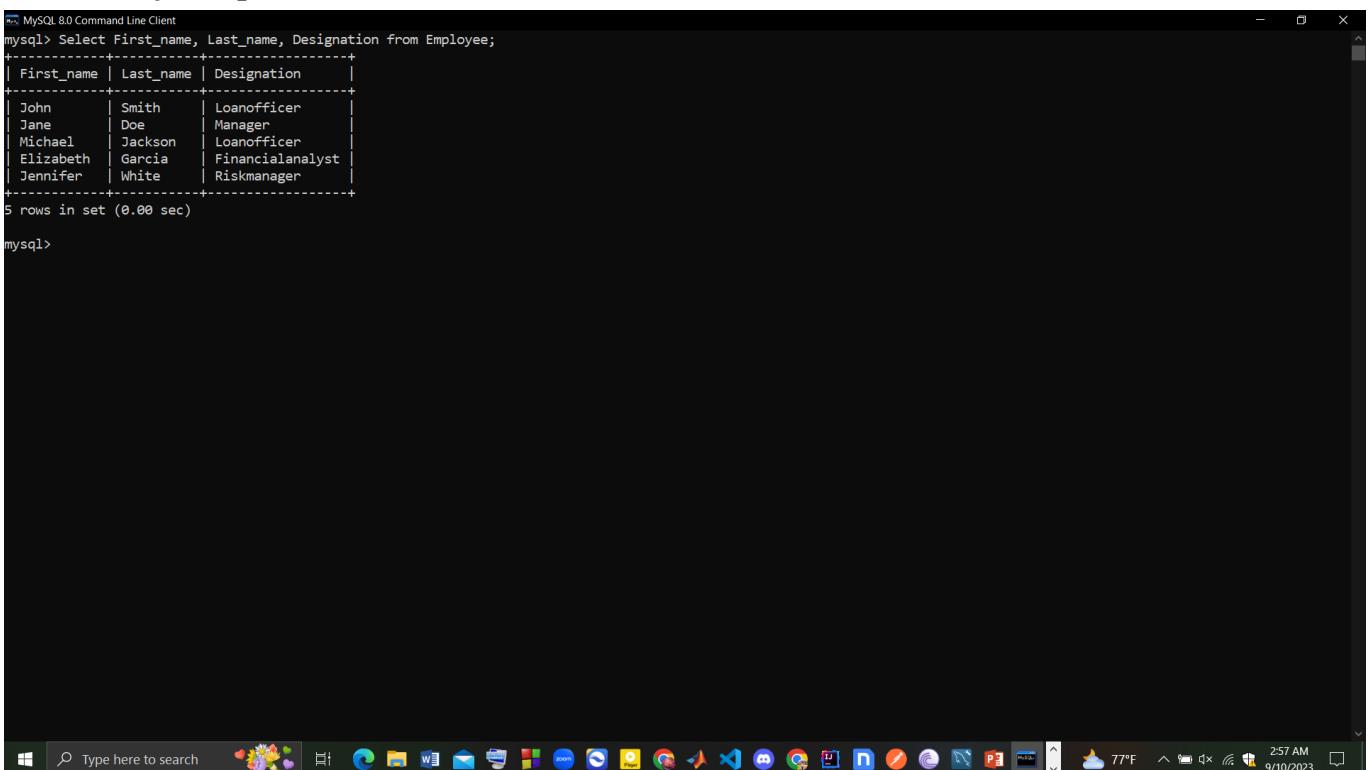
MySQL 8.0 Command Line Client
mysql> select * from Customer;

Customer_id	First_name	Last_name	Date_of_birth	Address_no	Street	City	District	NIC	Registered_employee	Registered_branch
CUS01	Nimal	Perera	1996-06-04	1	Main Road	Galle	Galle	199612256678	EM001	BR001
CUS02	Ajith	Kumar	1990-03-04	2	Main Road	Colombo	Colombo	199096225678	EM001	BR003
CUS03	Kamal	Hassan	1991-12-14	5	Main Road	Batticaloa	Colombo	199189225678	EM002	BR002
CUS04	Rajini	Kanth	1986-05-04	4	HL Road	Kandy	Kandy	198625225678	EM004	BR001
CUS05	Vijay	Kumar	1987-12-14	5	Wakwella Road	Hapugala	Galle	198712335678	EM001	BR003

5 rows in set (0.00 sec)

mysql>

4.1.2 Project Operation



MySQL 8.0 Command Line Client
mysql> Select First_name, Last_name, Designation from Employee;

First_name	Last_name	Designation
John	Smith	Loanofficer
Jane	Doe	Manager
Michael	Jackson	Loanofficer
Elizabeth	Garcia	Financialanalyst
Jennifer	White	Riskmanager

5 rows in set (0.00 sec)

mysql>

4.1.3 Cartesian Product Operation

```
MySQL 8.0 Command Line Client
mysql> select * from employee cross join installment;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Employee_id | First_name | Last_name | Date_of_birth | Address_no | Street | City | District | NIC | Designation | Salary | Head | Sector_id |
| Branch_id | Reference_no | Installment_no | Paid_date | Paid_amount | Customer_id | Loan_id | Leasing_id | Pawning_id |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| EM001 | John | Smith | 2000-02-04 | 12 | MainStreet | Mapugala | Galle | 200012345678 | Loanofficer | 100000.00 | EM001 | SE001 | | |
| BR001 | INS005 | 5 | 2023-07-04 | 15550 | CUS04 | NULL | NULL | PAW004 | 200012345678 | Loanofficer | 100000.00 | EM001 | SE001 |
| EM001 | John | Smith | 2000-02-04 | 12 | MainStreet | Mapugala | Galle | 200012345678 | Loanofficer | 100000.00 | EM001 | SE001 |
| BR001 | INS004 | 3 | 2022-12-04 | 25550 | CUS03 | L0003 | NULL | NULL | 200012345678 | Loanofficer | 100000.00 | EM001 | SE001 |
| EM001 | John | Smith | 2000-02-04 | 12 | MainStreet | Mapugala | Galle | 200012345678 | Loanofficer | 100000.00 | EM001 | SE001 |
| BR001 | INS003 | 3 | 2023-05-15 | 15000 | CUS02 | NULL | NULL | PAW001 | 200012345678 | Loanofficer | 100000.00 | EM001 | SE001 |
| EM001 | John | Smith | 2000-02-04 | 12 | MainStreet | Mapugala | Galle | 200012345678 | Loanofficer | 100000.00 | EM001 | SE001 |
| BR001 | INS002 | 2 | 2023-09-22 | 200000 | CUS01 | NULL | LE001 | NULL | 200012345678 | Loanofficer | 100000.00 | EM001 | SE001 |
| EM001 | John | Smith | 2000-02-04 | 12 | MainStreet | Mapugala | Galle | 200012345678 | Loanofficer | 100000.00 | EM001 | SE001 |
| BR001 | INS001 | 1 | 2023-08-02 | 10000 | CUS01 | L0001 | NULL | NULL | PAW004 | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| EM002 | Jane | Doe | 1995-05-14 | 13 | MainStreet | Karapitiya | Galle | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| BR001 | INS005 | 5 | 2023-07-04 | 15550 | CUS04 | NULL | NULL | PAW004 | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| EM002 | Jane | Doe | 1995-05-14 | 13 | MainStreet | Karapitiya | Galle | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| BR001 | INS004 | 3 | 2022-12-04 | 25550 | CUS03 | L0003 | NULL | NULL | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| EM002 | Jane | Doe | 1995-05-14 | 13 | MainStreet | Karapitiya | Galle | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| BR001 | INS003 | 3 | 2023-05-15 | 15000 | CUS02 | NULL | NULL | PAW001 | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| EM002 | Jane | Doe | 1995-05-14 | 13 | MainStreet | Karapitiya | Galle | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| BR001 | INS002 | 2 | 2023-09-22 | 200000 | CUS01 | NULL | LE001 | NULL | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| EM002 | Jane | Doe | 1995-05-14 | 13 | MainStreet | Karapitiya | Galle | 199512345671 | Manager | 750000.00 | EM002 | SE001 |
| BR001 | INS001 | 1 | 2023-08-02 | 10000 | CUS01 | L0001 | NULL | NULL | PAW004 | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| EM003 | Michael | Jackson | 1990-06-10 | 17 | MainStreet | Karapitiya | Galle | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| BR001 | INS005 | 5 | 2023-07-04 | 15550 | CUS04 | NULL | NULL | PAW004 | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| EM003 | Michael | Jackson | 1990-06-10 | 17 | MainStreet | Karapitiya | Galle | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| BR001 | INS004 | 3 | 2022-12-04 | 25550 | CUS03 | L0003 | NULL | NULL | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| EM003 | Michael | Jackson | 1990-06-10 | 17 | MainStreet | Karapitiya | Galle | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| BR001 | INS003 | 3 | 2023-05-15 | 15000 | CUS02 | NULL | NULL | PAW001 | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| EM003 | Michael | Jackson | 1990-06-10 | 17 | MainStreet | Karapitiya | Galle | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| BR001 | INS002 | 2 | 2023-09-22 | 200000 | CUS01 | NULL | LE001 | NULL | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| EM003 | Michael | Jackson | 1990-06-10 | 17 | MainStreet | Karapitiya | Galle | 199012345671 | Loanofficer | 750000.00 | EM002 | SE001 |
| BR001 | INS001 | 1 | 2023-08-02 | 10000 | CUS01 | L0001 | NULL | NULL | PAW004 | 199112345671 | Financialanalyst | 120000.00 | EM002 | SE001 |
| EM004 | Elizabeth | Garcia | 1991-12-12 | 19 | MainStreet | Vakkella | Galle | 199112345671 | Financialanalyst | 120000.00 | EM002 | SE001 |
| BR001 | INS005 | 5 | 2023-07-04 | 15550 | CUS04 | NULL | NULL | PAW004 | 199112345671 | Financialanalyst | 120000.00 | EM002 | SE001 |
| EM004 | Elizabeth | Garcia | 1991-12-12 | 19 | MainStreet | Vakkella | Galle | 199112345671 | Financialanalyst | 120000.00 | EM002 | SE001 |
| BR001 | INS004 | 3 | 2022-12-04 | 25550 | CUS03 | L0003 | NULL | NULL | 199112345671 | Financialanalyst | 120000.00 | EM002 | SE001 |

```

4.1.4 Creating User View

```
MySQL 8.0 Command Line Client
mysql> create view UV1 as select distinct designation from employee;
Query OK, 0 rows affected (0.01 sec)

mysql> select * from UV1;
+-----+
| designation |
+-----+
| Loanofficer |
| Manager |
| Financialanalyst |
| Riskmanager |
+-----+
4 rows in set (0.00 sec)

mysql>
```

4.1.5 Renaming Operation

```
MySQL 8.0 Command Line Client
mysql> create view Child_Details as select First_name, Last_name, School from child;
Query OK, 0 rows affected (0.01 sec)

mysql> select * from Child_details;
+-----+-----+-----+
| First_name | Last_name | School
+-----+-----+-----+
| Vimal      | John       | Richmond College
| Kamal      | Jane       | Mahinda College
| Sunil      | Jane       | Mahinda College
| Aarav      | Michael    | St. Aloysius College
| Nimal      | Maria      | St. Aloysius College
+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```



4.1.6 Aggregation Operation

```
MySQL 8.0 Command Line Client
mysql> Select MAX(estimated_value) as large_leasing from vehicle;
+-----+
| large_leasing |
+-----+
| 20000000.00 |
+-----+
1 row in set (0.00 sec)

mysql>
```



4.1.7 LIKE Operation

```
MySQL 8.0 Command Line Client
mysql> Select * from pawning where Pawned_date like '2022-__-__';
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Reference_No | Term_length | Loan_amount | Interest_rate | Pawned_date | Total_amount | Owned_customer | Article_type | Branch_id |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| PAW003 | 6 | 18000.00 | 20.50 | 2022-09-12 | 21690 | CUS03 | Ring | BR003 |
| PAW004 | 24 | 28000.00 | 15.00 | 2022-05-15 | 32200 | CUS04 | Bracelet | BR003 |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql>
```

4.2 COMPLEX QUIRIES

This part includes queries based on 4 set operations, different joins and 3 nested queries.

4.2.1 Union Operation

```
MySQL 8.0 Command Line Client
mysql> (select Chasis_no, Engine_no, Estimated_value, Lease_residual_percentage from Vehicle where Estimated_value>1000000.00)union(select Chasis_no, Engine_no,Estimated_value, Lease_residual_percentage from vehicle where Lease_residual_percentage>50);
+-----+-----+-----+-----+
| Chasis_no | Engine_no | Estimated_value | Lease_residual_percentage |
+-----+-----+-----+-----+
| CHA001 | ENG001 | 10000000.00 | 55.50 |
| CHA002 | ENG002 | 2875000.00 | 45.50 |
| CHA003 | ENG003 | 20000000.00 | 65.00 |
| CHA009 | ENG009 | 1500000.00 | 55.50 |
| CHA005 | ENG005 | 2300000.00 | 65.50 |
+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

4.2.2 Intersection Operation

```
MySQL 8.0 Command Line Client - 9/10/2023 6:34 AM
mysql> (select L.Reference_no, L.Customer_id, L.Vehicle_id from Leasing as L inner join Vehicle as V where Estimated_value > 1500000.00 ^ and Lease_residual_percentage > 50);
+-----+-----+-----+
| Reference_no | Customer_id | Vehicle_id |
+-----+-----+-----+
| LE001        | CUS01      | VEH001    |
| LE001        | CUS01      | VEH001    |
| LE001        | CUS01      | VEH001    |
| LE003        | CUS02      | VEH003    |
| LE004        | CUS03      | VEH002    |
| LE005        | CUS04      | VEH005    |
| LE006        | CUS04      | VEH005    |
+-----+-----+-----+
15 rows in set (0.00 sec)

mysql>
```

4.2.3 Set Difference Operation

```
MySQL 8.0 Command Line Client - 9/10/2023 6:35 AM
mysql> (select Chassis_no, Engine_no, Estimated_value, Lease_residual_percentage from vehicle where Lease_residual_percentage > 50)
   -> except
   -> (select Chassis_no, Engine_no, Estimated_value, Lease_residual_percentage from vehicle where Lease_residual_percentage < 60);
+-----+-----+-----+-----+
| Chassis_no | Engine_no | Estimated_value | Lease_residual_percentage |
+-----+-----+-----+-----+
| CHA003     | ENG003    | 20000000.00    | 65.00                  |
| CHA005     | ENG005    | 23000000.00    | 65.50                  |
+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql>
```

4.2.4 Division Operation

```
mysql> create view ViewPaw1 as select Owned_customer,Branch_id from pawning;
Query OK, 0 rows affected (0.02 sec)

mysql> create view ViewAr1 as select Owned_customer from Article where Owned_customer='CUS04' or owned_customer='CUS03';
Query OK, 0 rows affected (0.02 sec)

mysql> SELECT * FROM ViewPaw1;
+-----+-----+
| Owned_customer | Branch_id |
+-----+-----+
| CUS02          | BR002    |
| CUS01          | BR002    |
| CUS03          | BR003    |
| CUS04          | BR003    |
| CUS04          | BR003    |
| CUS01          | BR001    |
+-----+-----+
6 rows in set (0.00 sec)

mysql> SELECT * FROM ViewAr1;
+-----+
| Owned_customer |
+-----+
| CUS03          |
| CUS04          |
+-----+
2 rows in set (0.00 sec)

mysql> select distinct Branch_id from ViewPaw1 as VP
   -> where not exists ((select distinct Owned_customer  from ViewPaw1 where Owned_customer='CUS04')
   -> Except
   -> (select VA.Owned_customer from ViewAr1 as VA where VP.Owned_customer=VA.Owned_customer));
+-----+
| Branch_id |
+-----+
| BR003     |
+-----+
1 row in set (0.00 sec)

mysql>
```

4.2.5 Inner Join

4.2.6 Natural Join

```
MySQL 8.0 Command Line Client
mysql> create view UV_NaturalJoin as Select * from Vehicle natural join Leasing where leased_date<'2022-01-31' ;
Query OK, 0 rows affected (0.01 sec)

mysql> select * from UV_NaturalJoin;
+-----+-----+-----+-----+-----+-----+-----+-----+
| Registration_no | Chasis_no | Engine_no | Class | Make | Estimated_value | Lease_residual_percentage | Lease_residual | Owned_custc
| Monthly_rental | Customer_id | Vehicle_id | Branch_id |
+-----+-----+-----+-----+-----+-----+-----+-----+
| VEH001          | CUS01    | ENG001   | Car    | Prius  | 10000000.00 | 55.50      | 5500000  | CUS01
| 253230.00       |          | VEH001   | BR001  |        |             |             |             |
| VEH002          | CUS01    | ENG002   | Van    | Nissan | 2875000.00 | 45.50      | 1308125  | CUS02
| 253230.00       |          | VEH001   | BR001  |        |             |             |             |
| VEH003          | CUS01    | ENG003   | Car    | Audi   | 20000000.00 | 65.00      | 13000000 | CUS02
| 253230.00       |          | VEH001   | BR001  |        |             |             |             |
| VEH004          | CUS01    | ENG009   | Lorry  | Hyundai | 1500000.00 | 55.50      | 832500   | CUS03
| 253230.00       |          | VEH001   | BR001  |        |             |             |             |
| VEH005          | CUS01    | ENG005   | Car    | Alto   | 2300000.00 | 65.50      | 1506500  | CUS04
| 253230.00       |          | VEH001   | BR001  |        |             |             |             |
+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

4.2.7 Left Outer Join

```
MySQL 8.0 Command Line Client
mysql> Create view UV_LeftOJoin as (select * from vehicle as V left outer join leasing as L on V.owned_customer=L.customer_id where L.Mc
Query OK, 0 rows affected (0.01 sec)

mysql> select * from UV_LeftOJoin;
+-----+-----+-----+-----+-----+-----+-----+-----+
| Registration_no | Chasis_no | Engine_no | Class | Make   | Estimated_value | Lease_residual_percentage | Lease_residual | Owned_customer
Monthly_rental | Customer_id | Vehicle_id | Branch_id |
+-----+-----+-----+-----+-----+-----+-----+-----+
| VEH001          | CHA001    | ENG001    | Car   | Prius  | 10000000.00     | 55.50           | 5500000 | CUS01
| 253230.00      | CUS01    | VEH001    | BR001 |         |                 |                 |             |
| VEH002          | CHA002    | ENG002    | Van   | Nissan | 2875000.00      | 45.50           | 1308125 | CUS02
| 406430.00      | CUS02    | VEH003    | BR003 |         |                 |                 |             |
| VEH003          | CHA003    | ENG003    | Car   | Audi   | 20000000.00     | 65.00           | 1300000 | CUS02
| 406430.00      | CUS02    | VEH003    | BR003 |         |                 |                 |             |
| VEH005          | CHA005    | ENG005    | Car   | Alto   | 2300000.00      | 65.50           | 1506500 | CUS04
| 48376.00        | CUS04   | VEH005    | BR004 |         |                 |                 |             |
| VEH005          | CHA005    | ENG005    | Car   | Alto   | 2300000.00     | 65.50           | 1506500 | CUS04
| 37679.00        | CUS04   | VEH005    | BR001 |         |                 |                 |             |
+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

4.2.8 Right Outer Join

```
MySQL 8.0 Command Line Client
mysql> create view UV_RightOJoin as(select * from installment as I right outer join article as A on I.customer_id=A.owned_customer wher
Query OK, 0 rows affected (0.01 sec)

mysql> select * from UV_RightOJoin;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Reference_no | Installment_no | Paid_date | Paid_amount | Customer_id | Loan_id | Leasing_id | Pawning_id | Owned_customer | Article_
t |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| NULL         | NULL       | NULL     | NULL       | NULL       | NULL    | NULL     | NULL     | CUS05       | Bracelet
0 |
| INS003       | 3          | 2023-05-15 | 15000     | CUS02     | NULL    | NULL     | PAW001   | CUS02       | Chain
0 |
| INS001       | 1          | 2023-08-02 | 10000     | CUS01     | L001    | NULL     | NULL     | CUS01       | Ring
0 |
| INS002       | 2          | 2023-09-22 | 20000     | CUS01     | LE001   | NULL     | NULL     | CUS01       | Ring
0 |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql>
```

4.2.9 Full Outer Join

```
MySQL 8.0 Command Line Client
mysql> create view UV3_FullOJoin as (select * from UV1_FullOjoin union select * from UV2_FullOJoin);
Query OK, 0 rows affected (0.01 sec)

mysql> create view UV3_FullOJoin as (select * from UV1_FullOjoin union select * from UV2_FullOJoin);select * from UV3_FullOJoin;
ERROR 1050 (42S01): Table 'UV3_FullOJoin' already exists
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Reference_no | Term_length | Loaned_date | Interest_rate | Loan_amount | Monthly_rental | Loanee | Branch_id | Customer_id | First_name | Last_name | Date_of_birth | Address_no | Street | City | District | NIC | Registered_employee | Registered_branch |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| L0002 | 6 | 2023-07-22 | 3.00 | 300000.00 | 53000.00 | CUS02 | BR002 | CUS02 | Ajith | Kumar | 1990-03-04 | 2 | Main Road | Colombo | Colombo | 199096225678 | EM001 | BR003 |
| L0005 | 18 | 2022-06-14 | 1.00 | 170000.00 | 11145.00 | CUS04 | BR005 | CUS04 | Rajini | Kanth | 1986-05-04 | 4 | HL Road | Kandy | Kandy | 198625225678 | EM004 | BR001 |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql>
```

4.2.10 Outer Join

```
MySQL 8.0 Command Line Client
mysql> select * from sector;
+-----+-----+-----+
| Sector_id | Sector_name | Head |
+-----+-----+-----+
| SE001 | Finance | EM002 |
| SE002 | Customer Registration | EM003 |
| SE003 | Pawning | EM002 |
| SE004 | Leasing | EM002 |
| SE005 | Loaning | EM002 |
+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> select * from branch_sector;
+-----+-----+
| Branch_id | Sector_id |
+-----+-----+
| BR001 | SE001 |
| BR003 | SE001 |
| BR005 | SE001 |
| BR001 | SE002 |
| BR001 | SE003 |
| BR002 | SE004 |
+-----+-----+
6 rows in set (0.02 sec)

mysql> create view OUnion as((select * from sector as s natural join branch_sector as bs)union(select S.Sector_id, s.Sector_name, s.Head, null from sector as s));
Query OK, 0 rows affected (0.01 sec)

mysql> select * from OUnion;
+-----+-----+-----+-----+
| Sector_id | Sector_name | Head | Branch_id |
+-----+-----+-----+-----+
| SE001 | Finance | EM002 | BR001 |
+-----+-----+-----+-----+
806 PM 9/10/2023
```

```
MySQL 8.0 Command Line Client
mysql> select * from OUnion;
+-----+-----+-----+-----+
| Sector_id | Sector_name      | Head   | Branch_id |
+-----+-----+-----+-----+
| SE001     | Finance          | EM002  | BR001   |
| SE001     | Finance          | EM002  | BR003   |
| SE001     | Finance          | EM002  | BR005   |
| SE002     | Customer Registration | EM003 | BR001   |
| SE003     | Pawning           | EM002  | BR001   |
| SE004     | Leasing            | EM002  | BR002   |
| SE001     | Finance          | EM002  | NULL    |
| SE002     | Customer Registration | EM003 | NULL    |
| SE003     | Pawning           | EM002  | NULL    |
| SE004     | Leasing            | EM002  | NULL    |
| SE005     | Loaning            | EM002  | NULL    |
+-----+-----+-----+-----+
11 rows in set (0.00 sec)

mysql>
```

4.2.11 Complex Query 1

```
MySQL 8.0 Command Line Client
mysql> create view VC1 as(select V.Owned_customer, V.Class, V.Make from Vehicle as V where class='car'AND V.Owned_customer in (select C.Customer_id from Customer as C where C.District='Colombo'));select * from VC1;
Query OK, 0 rows affected (0.01 sec)

+-----+-----+-----+
| Owned_customer | Class | Make |
+-----+-----+-----+
| CUS02          | Car   | Audi  |
+-----+-----+-----+
1 row in set (0.00 sec)

mysql>
```

4.2.12 Complex Query 2

```
MySQL 8.0 Command Line Client
mysql> create view VC2 as(select Designation, Sector_id  from Employee where Designation in(select Designation from employee where branch_id='BR001'));select * from VC2;
Query OK, 0 rows affected (0.01 sec)

+-----+-----+
| Designation | Sector_id |
+-----+-----+
| Loanofficer | SE001      |
| Manager     | SE001      |
| Loanofficer | SE001      |
| Financialanalyst | SE001      |
| Riskmanager | SE001      |
+-----+-----+
5 rows in set (0.00 sec)

mysql>
```

4.2.13 Complex Query 3

```
MySQL 8.0 Command Line Client
mysql> create view VC3 as(select first_name, last_name, date_of_birth from customer where customer_id in  (select customer_id from ins_talment where date_of_birth>'1990-01-01')); select * from VC3;
Query OK, 0 rows affected (0.01 sec)

+-----+-----+-----+
| first_name | last_name | date_of_birth |
+-----+-----+-----+
| Nimal     | Perera    | 1996-06-04   |
| Ajith     | Kumar     | 1990-03-04   |
| Kamal     | Hassan    | 1991-12-14   |
+-----+-----+-----+
3 rows in set (0.00 sec)

mysql>
```

5 DATABASE TUNING

In the process of query optimization for the ten selected complex queries outlined in here comprehensive tuning approach was applied, primarily focusing on indexing techniques. The optimization process for each complex query involved the following steps to ensure clarity and effectiveness:

1. **Initial Index Assessment:** Initially the indexes which were already there was identified.
2. **Initial Performance Assessment:** Then the default performance of the query was evaluated.
3. **Index Creation:** A suitable index was created to optimize the query's execution.
4. **Index Assessment:** Again the indexes which were available at that moment was identified.
5. **Performance Assessment:** Then again performance of the query was evaluated
6. **Performance Improvement:** The number of accessed rows was once more assessed using the 'explain' command, post-index creation, to evaluate the query's improved performance.

The success of query tuning was demonstrated by comparing the number of accessed rows in the 'EXPLAIN' output before and after index creation. A reduction in the number of accessed rows after index implementation indicated that the query had been effectively tuned.

When comparing the indexes and tuning process if a query is used with only attributes which are with indexes already (ex: Primary Key, Foreign Key) they cannot be further tuned according to the observation.

Others can be tuned.

5.1 TUNING QUERY 1

```
MySQL 8.0 Command Line Client
mysql> show index from vehicle;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| vehicle |          0 | PRIMARY |          1 | Registration_no | A           |      5 |       NULL |       NULL |       BTREE |           |           |           | YES    |       NULL |
| vehicle |          1 | fk_vh_cus |          1 | Owned_customer | A           |      4 |       NULL |       NULL |       YES  | BTREE   |           |           | YES    |       NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql> explain( (select Chasis_no, Engine_no, Estimated_value, Lease_residual_percentage from Vehicle where Estimated_value>1000000.00)union(select Chasis_no, Engine_no,Estimated_value, Leas
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table     | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | PRIMARY     | Vehicle   |        ALL | NULL  |        ALL | NULL |       NULL |       NULL |      5 |      33.33 | Using where |
| 2 | UNION        | vehicle   |        ALL | NULL  |        ALL | NULL |       NULL |       NULL |      5 |      33.33 | Using where |
| 3 | UNION RESULT | <union1,2> |        ALL | NULL  |        ALL | NULL |       NULL |       NULL |      NULL |      NULL | Using temporary |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set, 1 warning (0.00 sec)

mysql> create index LRP_Index using BTREE on Vehicle(Lease_residual_percentage);
Query OK, 0 rows affected (0.05 sec)
Records: 0  Duplicates: 0  Warnings: 0

mysql> show index from vehicle;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| vehicle |          0 | PRIMARY |          1 | Registration_no | A           |      5 |       NULL |       NULL |       BTREE |           |           |           | YES    |       NULL |
| vehicle |          1 | fk_vh_cus |          1 | Owned_customer | A           |      4 |       NULL |       NULL |       YES  | BTREE   |           |           | YES    |       NULL |
| vehicle |          1 | LRP_Index |          1 | Lease_residual_percentage | A           |      4 |       NULL |       NULL |       YES  | BTREE   |           |           | YES    |       NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)

mysql> explain( (select Chasis_no, Engine_no, Estimated_value, Lease_residual_percentage from Vehicle where Estimated_value>1000000.00)union(select Chasis_no, Engine_no,Estimated_value, Leas
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table     | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | PRIMARY     | Vehicle   |        ALL | NULL  |        ALL | NULL |       NULL |       NULL |      5 |      33.33 | Using where |
| 2 | UNION        | vehicle   |        ALL | range |        LRP_Index | LRP_Index |       NULL |       NULL |      4 |     100.00 | Using index condition |
| 3 | UNION RESULT | <union1,2> |        ALL | NULL  |        ALL | NULL |       NULL |       NULL |      NULL |      NULL | Using temporary |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set, 1 warning (0.00 sec)

mysql> drop index LRP_Index on vehicle;
Query OK, 0 rows affected (0.01 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

5.2 TUNING QUERY 2

```
MySQL 8.0 Command Line Client
mysql> show index from vehicle;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| vehicle | 0 | PRIMARY | 1 | Registration_no | A | 5 | NULL | NULL | BTREE | | YES | NULL |
| vehicle | 1 | fk_vh_cus | 1 | Owned_customer | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql> explain (select L.Reference_no, L.Customer_id, L.Vehicle_id from Leasing as L inner join Vehicle as V where Estimated_value > 1500000.00 and Lease_residual_percentage > 50);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | V | NULL | ALL | NULL | NULL | NULL | NULL | 5 | 20.00 | Using where |
| 1 | SIMPLE | L | NULL | ALL | NULL | NULL | NULL | NULL | 6 | 100.00 | Using join buffer (hash join) |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> create index LRP_Index using BTree on Vehicle(Lease_residual_percentage);
Query OK, 0 rows affected (0.04 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> create index EV_Index using BTree on Vehicle(Estimated_value);
Query OK, 0 rows affected (0.04 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> show index from vehicle;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| vehicle | 0 | PRIMARY | 1 | Registration_no | A | 5 | NULL | NULL | BTREE | | YES | NULL | |
| vehicle | 1 | fk_vh_cus | 1 | Owned_customer | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| vehicle | 1 | LRP_Index | 1 | Lease_residual_percentage | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| vehicle | 1 | EV_Index | 1 | Estimated_value | A | 5 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> explain (select L.Reference_no, L.Customer_id, L.Vehicle_id from Leasing as L inner join Vehicle as V where Estimated_value > 1500000.00 and Lease_residual_percentage > 50);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | V | NULL | range | LRP_Index,EV_Index | LRP_Index | 3 | NULL | 4 | 80.00 | Using index condition; Using where |
| 1 | SIMPLE | L | NULL | ALL | NULL | NULL | NULL | NULL | 6 | 100.00 | Using join buffer (hash join) |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> drop index LRP_Index on vehicle;drop index EV_Index on vehicle;
Query OK, 0 rows affected (0.01 sec)
Records: 0 Duplicates: 0 Warnings: 0
```

5.3 TUNING QUERY 3

```
MySQL 8.0 Command Line Client
mysql> show index from loan;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| loan | 0 | PRIMARY | 1 | Reference_no | A | 5 | NULL | NULL | BTREE | | YES | NULL | |
| loan | 1 | fk_loan_cus | 1 | Loanee | A | 5 | NULL | NULL | YES | BTREE | | YES | NULL |
| loan | 1 | fk_loan_br | 1 | Branch_id | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.02 sec)

mysql> explain(select * from UV3_FullJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | PRIMARY | <derived2> | NULL | ALL | NULL | NULL | NULL | NULL | 4 | 100.00 | NULL |
| 2 | DERIVED | l | NULL | ALL | NULL | NULL | NULL | NULL | 5 | 33.33 | Using where |
| 2 | DERIVED | c | NULL | eq_ref | PRIMARY | PRIMARY | 22 | financial_service_company.l.Loanee | 1 | 100.00 | NULL |
| 3 | UNION | l | NULL | ALL | fk_loan_cus | NULL | NULL | NULL | 5 | 33.33 | Using where |
| 3 | UNION | c | NULL | eq_ref | PRIMARY | PRIMARY | 22 | financial_service_company.l.Loanee | 1 | 100.00 | NULL |
| 4 | UNION RESULT | <union2,3> | NULL | ALL | NULL | NULL | NULL | NULL | NULL | NULL | Using temporary |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
6 rows in set, 1 warning (0.00 sec)

mysql> create index LAmount using BTree on Loan(Loan_amount);
Query OK, 0 rows affected (0.04 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> show index from loan;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| loan | 0 | PRIMARY | 1 | Reference_no | A | 5 | NULL | NULL | BTREE | | YES | NULL | |
| loan | 1 | fk_loan_cus | 1 | Loanee | A | 5 | NULL | NULL | YES | BTREE | | YES | NULL |
| loan | 1 | fk_loan_br | 1 | Branch_id | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| loan | 1 | LAmount | 1 | Loan_amount | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> explain(select * from UV3_FullJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | PRIMARY | <derived2> | NULL | ALL | NULL | NULL | NULL | NULL | 4 | 100.00 | NULL |
| 2 | DERIVED | l | NULL | range | LAmount | LAmount | 6 | NULL | 2 | 100.00 | Using index condition |
| 2 | DERIVED | c | NULL | eq_ref | PRIMARY | PRIMARY | 22 | financial_service_company.l.Loanee | 1 | 100.00 | NULL |
| 3 | UNION | l | NULL | range | fk_loan_cus,LAmount | LAmount | 6 | NULL | 2 | 100.00 | Using index condition; Using where |
| 3 | UNION | c | NULL | eq_ref | PRIMARY | PRIMARY | 22 | financial_service_company.l.Loanee | 1 | 100.00 | NULL |
| 4 | UNION RESULT | <union2,3> | NULL | ALL | NULL | NULL | NULL | NULL | NULL | NULL | Using temporary |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
```

5.4 TUNING QUERY 4

```
MySQL 8.0 Command Line Client
mysql> show index from loan;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| loan | 0 | PRIMARY | 1 | Reference_no | A | 5 | NULL | NULL | BTREE | | | YES | NULL | |
| loan | 1 | fk_loan_cus | 1 | Loanee | A | 5 | NULL | NULL | YES | BTREE | | | YES | NULL |
| loan | 1 | fk_loan_br | 1 | Branch_id | A | 4 | NULL | NULL | YES | BTREE | | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)

mysql> explain(select * from UV_InnerJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | l | NULL | ALL | fk_loan_cus | NULL | NULL | NULL | 5 | 33.33 | Using where |
| 1 | SIMPLE | c | NULL | eq_ref | PRIMARY | PRIMARY | 22 | financial_service_company.l.Loanee | 1 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> create index IRate_Index using BTree on Loan(Interest_rate);
Query OK, 0 rows affected (0.04 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> show index from loan;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| loan | 0 | PRIMARY | 1 | Reference_no | A | 5 | NULL | NULL | BTREE | | | YES | NULL | |
| loan | 1 | fk_loan_cus | 1 | Loanee | A | 5 | NULL | NULL | YES | BTREE | | | YES | NULL |
| loan | 1 | fk_loan_br | 1 | Branch_id | A | 4 | NULL | NULL | YES | BTREE | | | YES | NULL |
| loan | 1 | IRate_Index | 1 | Interest_rate | A | 3 | NULL | NULL | YES | BTREE | | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> explain(select * from UV_InnerJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | c | NULL | ALL | PRIMARY | NULL | NULL | NULL | 5 | 100.00 | NULL |
| 1 | SIMPLE | l | NULL | ref | fk_loan_cus,IRate_Index | fk_loan_cus | 23 | financial_service_company.c.Customer_id | 1 | 60.00 | Using where |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> drop index IRate_Index on Loan;
Query OK, 0 rows affected (0.01 sec)
Records: 0 Duplicates: 0 Warnings: 0

```

5.5 TUNING QUERY 5

```
MySQL 8.0 Command Line Client
mysql> show index from loan;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| loan | 0 | PRIMARY | 1 | Reference_no | A | 5 | NULL | NULL | BTREE | | | YES | NULL | |
| loan | 1 | fk_loan_cus | 1 | Loanee | A | 5 | NULL | NULL | YES | BTREE | | | YES | NULL |
| loan | 1 | fk_loan_br | 1 | Branch_id | A | 4 | NULL | NULL | YES | BTREE | | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)

mysql> explain(select * from UV_LeftJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | l | NULL | ALL | fk_lease_cus | NULL | NULL | NULL | 6 | 33.33 | Using where |
| 1 | SIMPLE | v | NULL | ref | fk_vh_cus | fk_vh_cus | 103 | financial_service_company.l.Customer_id | 1 | 100.00 | Using index condition |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> create index MREntal_Index using BTree on Loan(Monthly_rental);
Query OK, 0 rows affected (0.03 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> show index from loan;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| loan | 0 | PRIMARY | 1 | Reference_no | A | 5 | NULL | NULL | BTREE | | | YES | NULL | |
| loan | 1 | fk_loan_cus | 1 | Loanee | A | 5 | NULL | NULL | YES | BTREE | | | YES | NULL |
| loan | 1 | fk_loan_br | 1 | Branch_id | A | 4 | NULL | NULL | YES | BTREE | | | YES | NULL |
| loan | 1 | MREntal_Index | 1 | Monthly_rental | A | 5 | NULL | NULL | YES | BTREE | | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> explain(select * from UV_LeftJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | l | NULL | ALL | fk_lease_cus | NULL | NULL | NULL | 6 | 33.33 | Using where |
| 1 | SIMPLE | v | NULL | ref | fk_vh_cus | fk_vh_cus | 103 | financial_service_company.l.Customer_id | 1 | 100.00 | Using index condition |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> drop index MREntal_Index on Loan;
Query OK, 0 rows affected (0.01 sec)
Records: 0 Duplicates: 0 Warnings: 0

```

5.6 TUNING QUERY 6

```
MySQL 8.0 Command Line Client
mysql> show index from article;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| article | 0 | PRIMARY | 1 | Article_type | A | 3 | NULL | NULL | BTREE | | YES | NULL |
| article | 0 | PRIMARY | 2 | Owned_customer | A | 5 | NULL | NULL | BTREE | | YES | NULL |
| article | 1 | fk_ar_cus | 1 | Owned_customer | A | 5 | NULL | NULL | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)

mysql> explain(select * from UV_RightJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | a | NULL | ALL | NULL | NULL | NULL | financial_service_company.a.Owned_customer | 5 | 20.00 | Using where |
| 1 | SIMPLE | i | NULL | ref | fk_ins_cus | fk_ins_cus | 63 | financial_service_company.a.Owned_customer | 1 | 100.00 | Using where |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> create index MValue_Index using BTree on Article(Market_value);
Query OK, 0 rows affected (0.03 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> show index from article;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| article | 0 | PRIMARY | 1 | Article_type | A | 3 | NULL | NULL | BTREE | | YES | NULL | |
| article | 0 | PRIMARY | 2 | Owned_customer | A | 5 | NULL | NULL | BTREE | | YES | NULL |
| article | 1 | fk_ar_cus | 1 | Owned_customer | A | 5 | NULL | NULL | BTREE | | YES | NULL |
| article | 1 | MValue_Index | 1 | Market_value | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.01 sec)

mysql> explain(select * from UV_RightJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | a | NULL | range | MValue_Index | MValue_Index | 6 | NULL | 3 | 100.00 | Using index condition |
| 1 | SIMPLE | i | NULL | ref | fk_ins_cus | fk_ins_cus | 63 | financial_service_company.a.Owned_customer | 1 | 100.00 | Using where |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> drop index MValue_Index on Article;
Query OK, 0 rows affected (0.01 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql>
```

5.7 TUNING QUERY 7

```
MySQL 8.0 Command Line Client
mysql> show index from customer;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| customer | 0 | PRIMARY | 1 | Customer_id | A | 5 | NULL | NULL | BTREE | | YES | NULL | |
| customer | 1 | fk_cus_emp | 1 | Registered_employee | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| customer | 1 | fk_cus_br | 1 | Registered_branch | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)

mysql> explain(select * from VC1);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | v | NULL | ALL | fk_vh_cus | NULL | NULL | NULL | 5 | 20.00 | Using where |
| 1 | SIMPLE | c | NULL | eq_ref | PRIMARY | PRIMARY | 22 | financial_service_company.v.Owned_customer | 1 | 20.00 | Using where |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> create index District_Index using BTree on Customer(District);
Query OK, 0 rows affected (0.04 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> show index from customer;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| customer | 0 | PRIMARY | 1 | Customer_id | A | 5 | NULL | NULL | BTREE | | YES | NULL | |
| customer | 1 | fk_cus_emp | 1 | Registered_employee | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| customer | 1 | fk_cus_br | 1 | Registered_branch | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| customer | 1 | District_Index | 1 | District | A | 3 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> explain(select * from VC1);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | v | NULL | ALL | fk_vh_cus | NULL | NULL | NULL | 5 | 20.00 | Using where |
| 1 | SIMPLE | c | NULL | eq_ref | PRIMARY,District_Index | PRIMARY | 22 | financial_service_company.v.Owned_customer | 1 | 40.00 | Using where |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> drop index District_Index on Customer;
Query OK, 0 rows affected (0.02 sec)
Records: 0 Duplicates: 0 Warnings: 0
```

5.8 TUNING QUERY 8

```
MySQL 8.0 Command Line Client
mysql> show index from Employee;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| employee | 0 | PRIMARY | 1 | Employee_id | A | 6 | NULL | NULL | BTREE |  | YES | NULL | |
| employee | 1 | fk_emp_em | 1 | Head | A | 2 | NULL | NULL | BTREE |  | YES | NULL |
| employee | 1 | fk_emp_br | 1 | Branch_id | A | 1 | NULL | NULL | YES | BTREE |  | YES | NULL |
| employee | 1 | fk_emp_sec | 1 | Sector_id | A | 1 | NULL | NULL | YES | BTREE |  | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> explain(select * from VC2);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | employee | NULL | ALL | NULL | <auto_distinct_keys> | NULL | NULL | financial_service_company.employee.Designation | 6 | 100.00 | Using where |
| 1 | SIMPLE | <subquery3> | NULL | eq_ref | <auto_distinct_key> | fk_emp_br | 43 | const | fk_emp_br | 1 | 100.00 | NULL |
| 3 | MATERIALIZED | employee | NULL | ref | fk_emp_br | fk_emp_br | 43 | const |  | 5 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set, 1 warning (0.00 sec)

mysql> create index Designation_Index using BTREE on Employee(Designation);
Query OK, 0 rows affected (0.04 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> show index from Employee;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| employee | 0 | PRIMARY | 1 | Employee_id | A | 6 | NULL | NULL | BTREE |  | YES | NULL | |
| employee | 1 | fk_emp_em | 1 | Head | A | 2 | NULL | NULL | BTREE |  | YES | NULL |
| employee | 1 | fk_emp_br | 1 | Branch_id | A | 1 | NULL | NULL | YES | BTREE |  | YES | NULL |
| employee | 1 | fk_emp_sec | 1 | Sector_id | A | 1 | NULL | NULL | YES | BTREE |  | YES | NULL |
| employee | 1 | Designation_Index | 1 | Designation | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> explain(select * from VC2);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | employee | NULL | ALL | Designation_Index | NULL | NULL | financial_service_company.employee.Designation | 6 | 100.00 | Using where | |
| 1 | SIMPLE | <subquery3> | NULL | eq_ref | <auto_distinct_key> | fk_emp_br | 43 | const | fk_emp_br | 1 | 100.00 | NULL |
| 3 | MATERIALIZED | employee | NULL | ref | fk_emp_br,Designation_Index | fk_emp_br | 43 | const |  | 5 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set, 1 warning (0.00 sec)

mysql> drop index Designation_Index on Employee;
Query OK, 0 rows affected (0.02 sec)
Records: 0 Duplicates: 0 Warnings: 0

```

5.9 TUNING QUERY 9

```
MySQL 8.0 Command Line Client
mysql> show index from Leasing;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| leasing | 0 | PRIMARY | 1 | Reference_no | A | 6 | NULL | NULL | BTREE |  | YES | NULL | |
| leasing | 1 | fk_lease_cus | 1 | Customer_id | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| leasing | 1 | fk_lease_br | 1 | Branch_id | A | 3 | NULL | NULL | YES | BTREE |  | YES | NULL |
| leasing | 1 | fk_leas_vh | 1 | Vehicle_id | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.01 sec)

mysql> explain(select * from UV_NaturalJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | leasing | NULL | ALL | NULL | NULL | NULL | NULL | 6 | 33.33 | Using where |
| 1 | SIMPLE | vehicle | NULL | ALL | NULL | NULL | NULL | NULL | 5 | 100.00 | Using join buffer (hash join) |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> create index LeasedDate_Index using BTREE on Leasing(Leased_date);
Query OK, 0 rows affected (0.03 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> show index from Leasing;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| leasing | 0 | PRIMARY | 1 | Reference_no | A | 6 | NULL | NULL | BTREE |  | YES | NULL | |
| leasing | 1 | fk_lease_cus | 1 | Customer_id | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| leasing | 1 | fk_lease_br | 1 | Branch_id | A | 3 | NULL | NULL | YES | BTREE |  | YES | NULL |
| leasing | 1 | fk_leas_vh | 1 | Vehicle_id | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| leasing | 1 | LeasedDate_Index | 1 | Leased_date | A | 5 | NULL | NULL | YES | BTREE |  | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> explain(select * from UV_NaturalJoin);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | leasing | NULL | range | LeasedDate_Index | LeasedDate_Index | 4 | NULL | 1 | 100.00 | Using index condition |
| 1 | SIMPLE | vehicle | NULL | ALL | NULL | NULL | NULL | NULL | 5 | 100.00 | Using join buffer (hash join) |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> drop index LeasedDate_Index on Leasing;
Query OK, 0 rows affected (0.03 sec)
Records: 0 Duplicates: 0 Warnings: 0

```

5.10 TUNING QUERY 10

```
MySQL 8.0 Command Line Client
mysql> show index from customer;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| customer | 0 | PRIMARY | 1 | Customer_id | A | 5 | NULL | NULL | BTREE | | YES | NULL | |
| customer | 1 | fk_cus_emp | 1 | Registered_employee | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| customer | 1 | fk_cus_br | 1 | Registered_branch | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.02 sec)

mysql> explain( select * from VC3);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | customer | NULL | ALL | PRIMARY | NULL | NULL | NULL | 5 | 33.33 | Using where |
| 1 | SIMPLE | installment | NULL | ref | fk_ins_cus | fk_ins_cus | 63 | financial_service_company.customer.Customer_id | 1 | 100.00 | Using where; Using index; FirstMatch(customer) |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 2 warnings (0.00 sec)

mysql> create index DOB_Index using BTREE on Customer(date_of_birth);
Query OK, 0 rows affected (0.05 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> show index from customer;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| customer | 0 | PRIMARY | 1 | Customer_id | A | 5 | NULL | NULL | BTREE | | YES | NULL | |
| customer | 1 | fk_cus_emp | 1 | Registered_employee | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| customer | 1 | fk_cus_br | 1 | Registered_branch | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| customer | 1 | DOB_Index | 1 | Date_of_birth | A | 5 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> explain( select * from VC3);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | customer | NULL | range | PRIMARY,DOB_Index | DOB_Index | 4 | NULL | | 3 | 100.00 | Using index condition |
| 1 | SIMPLE | installment | NULL | ref | fk_ins_cus | fk_ins_cus | 63 | financial_service_company.customer.Customer_id | 1 | 100.00 | Using where; Using index; FirstMatch(customer) |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 2 warnings (0.00 sec)

mysql> drop index DOB_Index on customer;
```