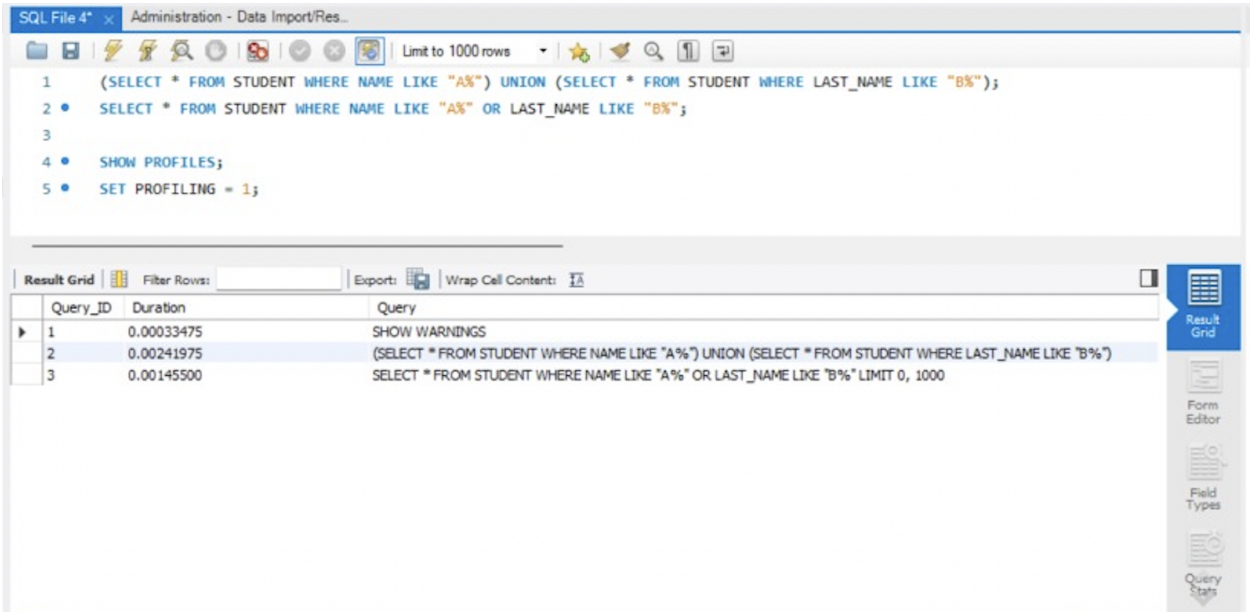
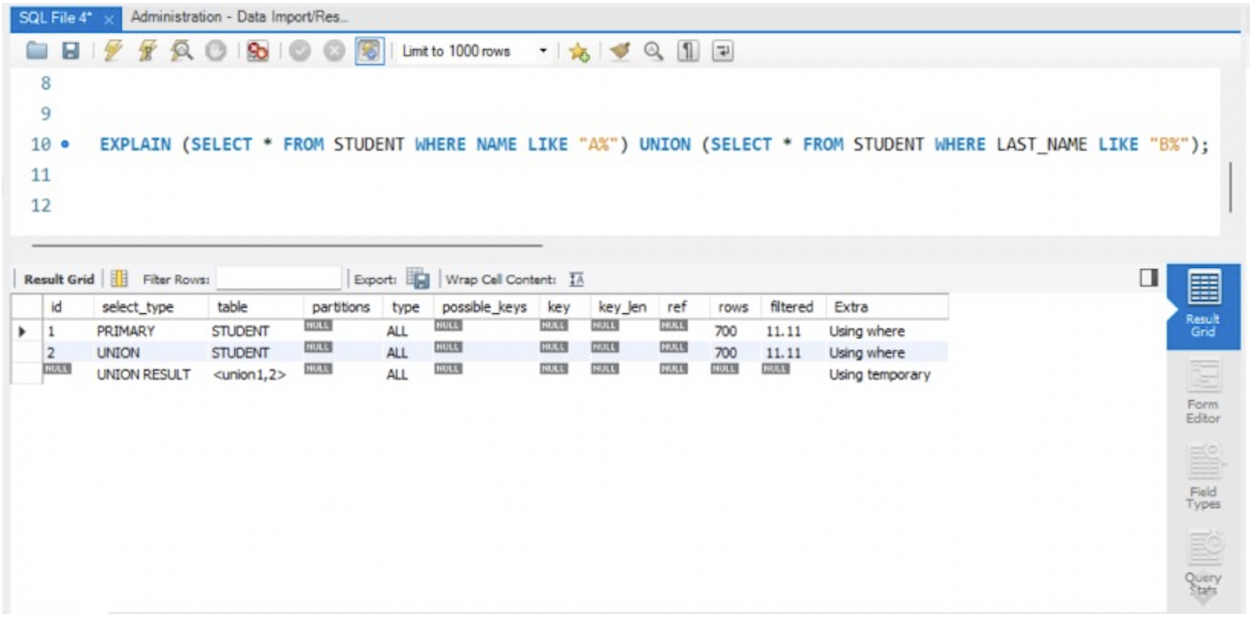
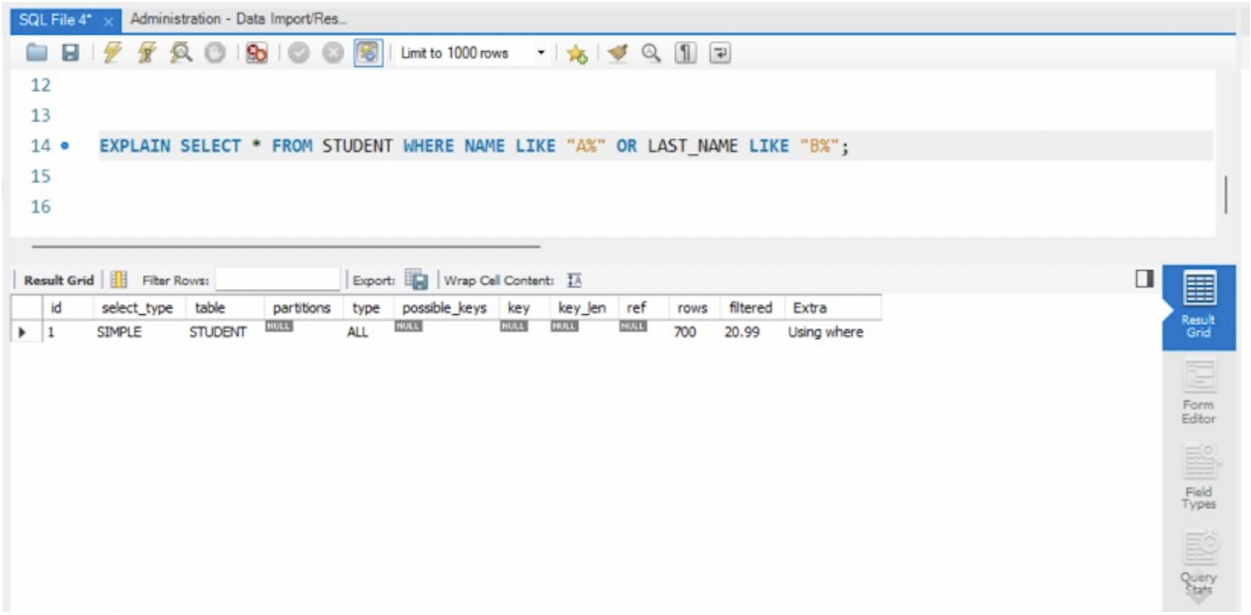
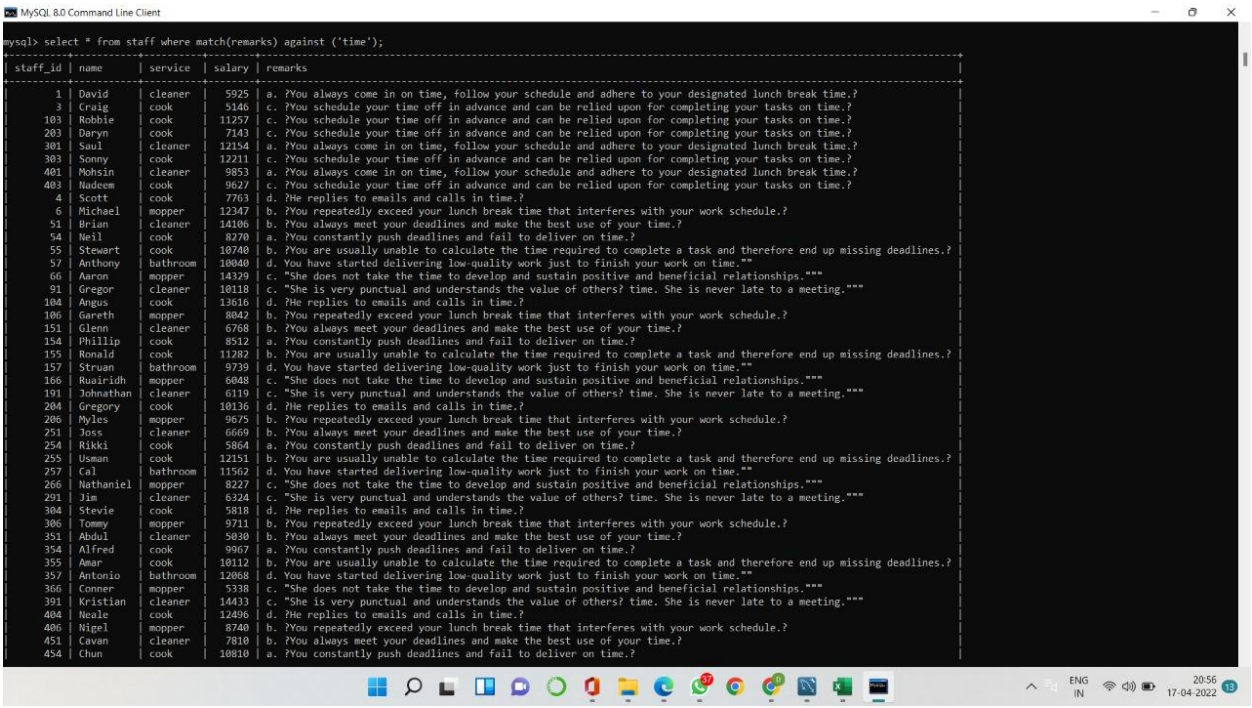
1. The query (having Like statement) for searching in the text-type column with the clause *UNION* is optimized using the *OR* clause.
   We infer from the following figure that query with *OR* clause takes *0.001455* units which is less than that of query with union clause (*0.00241975* units). This is because the first query scans each record in the table twice while the second scans only once.







2. *select * from staff where remarks like '%time%';*
   *select * from staff where match(remarks) against ('time');*
   Unlike the first query, the second one uses a full text index against the column and thus takes much less time than the first one.



```
mysql> show profiles;
+----------+------------+-----------------------------------------------------------------+
| Query_ID | Duration   | Query                                                           |
+----------+------------+-----------------------------------------------------------------+
|        1 | 0.00013275 | select * from staff where remarks like '%time%'                 |
|        2 | 0.00020275 | show database                                                   |
|        3 | 0.06217000 | show databases                                                  |
|        4 | 0.00020850 | SELECT DATABASE()                                               |
|        5 | 0.00181775 | select * from staff where remarks like '%time%'                 |
|        6 | 0.00115200 | select * from staff where match(remarks) against ('time')       |
|        7 | 0.00160625 | select * from staff where remarks like '%time%'                 |
|        8 | 0.00104200 | select * from staff where match(remarks) against ('time')       |
+----------+------------+-----------------------------------------------------------------+
8 rows in set, 1 warning (0.00 sec)
```

```
mysql> explain select * from staff where match(remarks) against ('time');
+----+-------------+-------+------------+----------+---------------+------------+---------+-------+------+----------+-----------------------------+
| id | select_type | table | partitions | type     | possible_keys | key        | key_len | ref   | rows | filtered | Extra                       |
+----+-------------+-------+------------+----------+---------------+------------+---------+-------+------+----------+-----------------------------+
|  1 | SIMPLE      | staff | NULL       | fulltext | remarks_ft    | remarks_ft | 0       | const |    1 |   100.00 | Using where; Ft_hints: sorted |
+----+-------------+-------+------------+----------+---------------+------------+---------+-------+------+----------+-----------------------------+
1 row in set, 1 warning (0.00 sec)

mysql> explain select * from staff where remarks like '%time%';
+----+-------------+-------+------------+------+---------------+------+---------+------+------+----------+-------------+
| id | select_type | table | partitions | type | possible_keys | key  | key_len | ref  | rows | filtered | Extra       |
+----+-------------+-------+------------+------+---------------+------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | staff | NULL       | ALL  | NULL          | NULL | NULL    | NULL |  499 |    11.11 | Using where |
+----+-------------+-------+------------+------+---------------+------+---------+------+------+----------+-------------+
1 row in set, 1 warning (0.00 sec)
```

3. Modified the roll_no datatype from *'INT'* to *'TINYINT'*. This decreased the execution time. This is because smaller data types are usually faster, because they use less space on the disk, in memory, and in the CPU cache. They also generally require fewer CPU cycles to process. Same reason can be applied to mediumint.

```
mysql> SHOW PROFILES;
+----------+------------+-----------------------------------------------------------------------------------+
| Query_ID | Duration   | Query                                                                             |
+----------+------------+-----------------------------------------------------------------------------------+
|       10 | 0.04021625 | show tables                                                                       |
|       11 | 0.00095600 | explain select * from staff where match(remarks) against ('time')                 |
|       12 | 0.00043350 | explain select * from staff where remarks like '%time%'                           |
|       13 | 0.00158500 | describe student_hostel_payment                                                   |
|       14 | 0.03785000 | SELECT * FROM information_schema.columns WHERE table_schema = 'finalhostel'       |
|       15 | 0.47299925 | ALTER TABLE STUDENT_HOSTEL_PAYMENT MODIFY TRANSACTION_ID MEDIUMINT(50)            |
|       16 | 0.00132300 | ALTER TABLE STUDENT_HOSTEL_PAYMENT MODIFY TRANSACTION_ID MEDIUMINT                |
|       17 | 0.37439150 | ALTER TABLE TRANSACTION MODIFY TRANSACTION_ID MEDIUMINT                           |
|       18 | 0.26193000 | ALTER TABLE TRANSACTION MODIFY TRANSACTION_ID MEDIUMINT()                         |
|       19 | 0.00013850 | SET PROFILING                                                                     |
|       20 | 0.06792775 | SET PROFILING=1                                                                   |
|       21 | 0.28855750 | SELECT * FROM STUDENT LIMIT 5                                                     |
|       22 | 0.02267700 | SELECT ROLL_NO FROM STUDENT_HOSTEL_PAYMENT                                        |
|       23 | 0.03129800 | SELECT DATABASE()                                                                 |
|       24 | 0.02922075 | SELECT ROLL_NO FROM STUDENT_HOSTEL_PAYMENT                                        |
+----------+------------+-----------------------------------------------------------------------------------+
15 rows in set, 1 warning (0.00 sec)
```

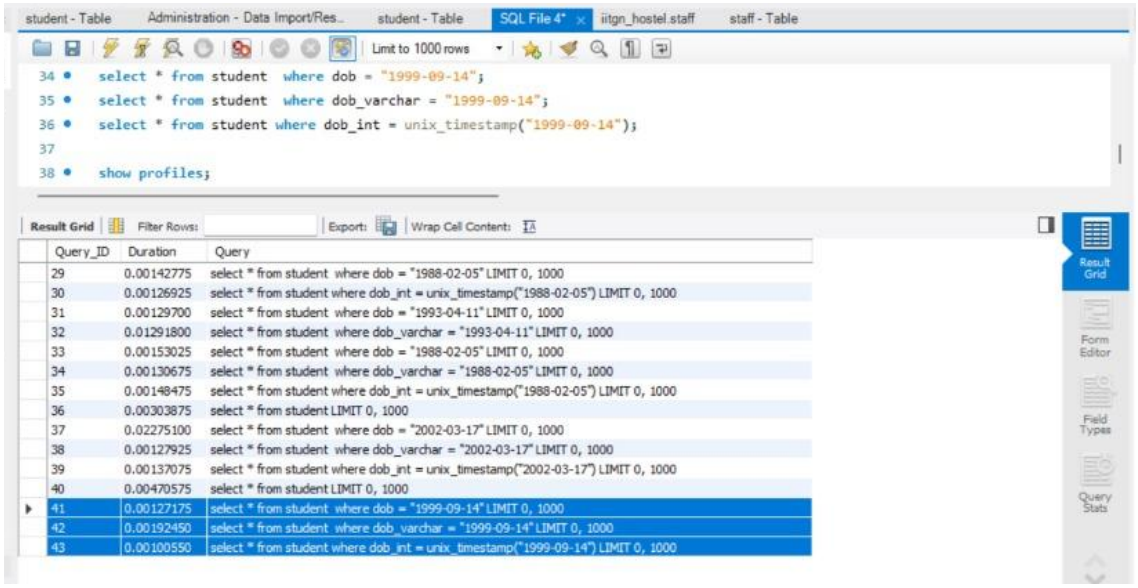
```
mysql> show profiles;
+----------+-------------+-----------------------------------------------+
| Query_ID | Duration    | Query                                         |
+----------+-------------+-----------------------------------------------+
|       24 | 0.00043600 | select roll_no from student_hostel_payment |
+----------+-------------+-----------------------------------------------+
1 row in set, 1 warning (0.00 sec)
```

```
mysql> explain select roll_no from student_hostel_payment;
+----+-------------+-------------------------+------------+-------+---------------+-------------+---------+------+------+----------+-------------+
| id | select_type | table                   | partitions | type  | possible_keys | key         | key_len | ref  | rows | filtered | Extra       |
+----+-------------+-------------------------+------------+-------+---------------+-------------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | student_hostel_payment | NULL       | index | NULL          | roll_no_idx | 1       | NULL |   32 |   100.00 | Using index |
+----+-------------+-------------------------+------------+-------+---------------+-------------+---------+------+------+----------+-------------+
1 row in set, 1 warning (0.00 sec)
```

```
mysql> show profiles;
+----------+-------------+-----------------------------------------------------------------------+
| Query_ID | Duration    | Query                                                                 |
+----------+-------------+-----------------------------------------------------------------------+
|       31 | 0.03050150 | alter table student_hostel_payment modify roll_no MEDIUMINT(50) |
|       32 | 0.00183800 | select roll_no from student_hostel_payment                      |
+----------+-------------+-----------------------------------------------------------------------+
2 rows in set, 1 warning (0.00 sec)
```

```
mysql> explain select roll_no from student_hostel_payment;
+----+-------------+-------------------------+------------+-------+---------------+-------------+---------+------+------+----------+-------------+
| id | select_type | table                   | partitions | type  | possible_keys | key         | key_len | ref  | rows | filtered | Extra       |
+----+-------------+-------------------------+------------+-------+---------------+-------------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | student_hostel_payment | NULL       | index | NULL          | roll_no_idx | 3       | NULL |   32 |   100.00 | Using index |
+----+-------------+-------------------------+------------+-------+---------------+-------------+---------+------+------+----------+-------------+
1 row in set, 1 warning (0.00 sec)
```

4. We altered the table by adding two new columns dob_varchar(with dob as varchar data type) and dob_int (with dob as int data type)) to the students table. The values have to be taken from the dob(stored as *date* data type) column. We infer from the following that *int* comparisons are faster, for the simple fact that ints take up much less space than *varchar* and *date* data types.



5. Searching with isnull works faster than without explicitly writing not null.

```
mysql> SELECT COUNT(SALARY) FROM STAFF;
+---------------+
| COUNT(SALARY) |
+---------------+
|           443 |
+---------------+
1 row in set (0.00 sec)

mysql> SELECT COUNT(SALARY) FROM STAFF WHERE SALARY IS NOT NULL;
+---------------+
| COUNT(SALARY) |
+---------------+
|           443 |
+---------------+
1 row in set (0.00 sec)

mysql> SHOW PROFILES;
+----------+------------+-----------------------------------------------------------------+
| Query_ID | Duration   | Query                                                           |
+----------+------------+-----------------------------------------------------------------+
|       17 | 0.37439150 | ALTER TABLE TRANSACTION MODIFY TRANSACTION_ID MEDIUMINT          |
|       18 | 0.26193000 | ALTER TABLE TRANSACTION MODIFY TRANSACTION_ID MEDIUMINT()        |
|       19 | 0.00013850 | SET PROFILING                                                   |
|       20 | 0.06792775 | SET PROFILING=1                                                 |
|       21 | 0.28855750 | SELECT * FROM STUDENT LIMIT 5                                   |
|       22 | 0.02267700 | SELECT ROLL_NO FROM STUDENT_HOSTEL_PAYMENT                      |
|       23 | 0.03129800 | SELECT DATABASE()                                               |
|       24 | 0.02922075 | SELECT ROLL_NO FROM STUDENT_HOSTEL_PAYMENT                      |
|       25 | 0.19772825 | SELECT COUNT(*) FROM STAFF                                      |
|       26 | 0.00070025 | SELECT COUNT(SALARY) FROM STAFF                                 |
|       27 | 0.01663100 | SELECT COUNT(SALARY) FROM STAFF WHERE SALARY NOT NULL           |
|       28 | 0.00062875 | SELECT COUNT(SALARY) FROM STAFF WHERE SALARY IS  NOT NULL       |
|       29 | 0.07104075 | UPDATE STAFF SET SALARY = NULL WHERE SALARY < 6000              |
|       30 | 0.00080000 | SELECT COUNT(SALARY) FROM STAFF                                 |
|       31 | 0.00063450 | SELECT COUNT(SALARY) FROM STAFF WHERE SALARY IS NOT NULL        |
+----------+------------+-----------------------------------------------------------------+
15 rows in set, 1 warning (0.00 sec)
```

6. mysql caches the select query as well as the result set, allowing identical selects to run faster as data is fetched from the memory cache. We are not able to perform caching because the mysql version 8.0 does not support it.
7. We performed *JOIN* on warden and furniture tables and compared it with a subquery. We infer that retrieval time of the query using joins is faster than that of a subquery thus helps better in the optimization. This is because the subquery runs the internal queries first and then from the resulting table again filters out the actual results while *JOIN*

produces the result in one go.

```
mysql> show profiles;
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------+
| Query_ID | Duration   | Query                                                                                                                       |
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------+
|        7 | 0.00076600 | select warden_id from warden where block_name in (select block_name from furniture where block_name='A')                   |
|        8 | 0.00194200 | select warden.block_name from warden natural join furniture where furniture.block_name = 'A'                               |
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------+
2 rows in set, 1 warning (0.00 sec)
```

```
mysql> explain select warden_id from warden where block_name in (select block_name from furniture where block_name='A');
+----+-------------+------------+------------+-------+--------------------+--------------------+---------+-------------------------+------+----------+-------------
------------+
| id | select_type  | table       | partitions | type   | possible_keys       | key                | key_len | ref                     | rows | filtered | Extra
           |
+----+-------------+------------+------------+-------+--------------------+--------------------+---------+-------------------------+------+----------+-------------
------------+
|  1 | SIMPLE       | warden      | NULL       | ref    | block_name_idx      | block_name_idx      | 83      | const                   |   49 |   100.00 | Using where;
 Using index |
|  1 | SIMPLE       | <subquery2> | NULL       | eq_ref | <auto_distinct_key> | <auto_distinct_key> | 83      | final.warden.block_name |    1 |   100.00 | Using where
           |
|  2 | MATERIALIZED | furniture   | NULL       | ref    | block_name          | block_name          | 83      | const                   |   49 |   100.00 | Using index
           |
+----+-------------+------------+------------+-------+--------------------+--------------------+---------+-------------------------+------+----------+-------------
------------+
3 rows in set, 1 warning (0.00 sec)
```

```
mysql> explain select warden.block_name from warden natural join furniture where furniture.block_name = 'A';
+----+-------------+-----------+------------+------+---------------+---------------+---------+-------+------+----------+-------------+
| id | select_type | table     | partitions | type | possible_keys | key           | key_len | ref   | rows | filtered | Extra       |
+----+-------------+-----------+------------+------+---------------+---------------+---------+-------+------+----------+-------------+
|  1 | SIMPLE      | warden    | NULL       | ref  | block_name_idx | block_name_idx | 83      | const |   49 |   100.00 | Using index |
|  1 | SIMPLE      | furniture | NULL       | ref  | block_name     | block_name     | 83      | const |   49 |   100.00 | Using index |
+----+-------------+-----------+------------+------+---------------+---------------+---------+-------+------+----------+-------------+
2 rows in set, 1 warning (0.00 sec)
```

However, more joins in a query means the database server has to do more work, which means that it is a more time consuming process to retrieve data.

```
mysql> show profiles;
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------+
| Query_ID | Duration   | Query                                                                                                                       |
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------+
|        9 | 0.00286850 | select warden.id from warden natural join furniture natural join hostel where hostel.block_name='A'                         |
|       10 | 0.01692025 | select warden.block_name from warden natural join furniture natural join hostel where hostel.block_name='A'                 |
|       11 | 0.00085725 | explain select warden.block_name from warden natural join furniture natural join hostel where hostel.block_name='A'         |
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------+
3 rows in set, 1 warning (0.00 sec)
```

```
mysql> explain select warden.block_name from warden natural join furniture natural join hostel where hostel.block_name='A';
+----+-------------+-----------+------------+------+---------------+---------------+---------+-------+------+----------+-------------+
| id | select_type | table     | partitions | type | possible_keys | key           | key_len | ref   | rows | filtered | Extra       |
+----+-------------+-----------+------------+------+---------------+---------------+---------+-------+------+----------+-------------+
|  1 | SIMPLE      | hostel    | NULL       | const | PRIMARY       | PRIMARY       | 82      | const |    1 |   100.00 | Using index |
|  1 | SIMPLE      | warden    | NULL       | ref   | block_name_idx | block_name_idx | 83      | const |   49 |   100.00 | Using index |
|  1 | SIMPLE      | furniture | NULL       | ref   | block_name     | block_name     | 83      | const |   49 |   100.00 | Using index |
+----+-------------+-----------+------------+------+---------------+---------------+---------+-------+------+----------+-------------+
3 rows in set, 1 warning (0.00 sec)
```

8. The execution time is decreased as we used natural join instead of subqueries. This is because Subquery runs the internal queries first and then from the result set again filters out the actual results. Wherein join runs the and produces the result in one go.

```
mysql> show profiles;
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
| Query_ID | Duration   | Query                                                                                                                                                                                               |
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
|       19 | 0.42159175 | select name from student where roll_no in (select roll_no from postgrad where block_name in (select block_name from furniture where room_no in (select room_no from hostel_rooms where sharing_type ='Double'))) |
|       20 | 0.01484350 | select student.name from student natural join postgrad natural join furniture natural join hostel_rooms where sharing_type='Double'                                                                  |
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
2 rows in set, 1 warning (0.00 sec)
```

```
mysql> explain select name from student where roll_no in (select roll_no from postgrad where block_name in (select block_name from furniture where room_no in (select room_no from hostel_rooms where sharing_type ='Double')));
+----+-------------+--------------+------------+--------+------------------------+---------------+---------+--------------------------------------------------+------+----------+------------------------------------------+
| id | select_type | table        | partitions | type   | possible_keys          | key           | key_len | ref                                              | rows | filtered | Extra                                    |
+----+-------------+--------------+------------+--------+------------------------+---------------+---------+--------------------------------------------------+------+----------+------------------------------------------+
|  1 | SIMPLE      | postgrad     | NULL       | index  | PRIMARY,block_name_idx | block_name_idx | 83     | NULL                                             |  352 |   100.00 | Using where; Using index; Start temporary |
|  1 | SIMPLE      | student      | NULL       | eq_ref | PRIMARY                | PRIMARY       | 4       | final.postgrad.roll_no                           |    1 |   100.00 | NULL                                     |
|  1 | SIMPLE      | hostel_rooms | NULL       | ALL    | PRIMARY                | NULL          | NULL    | NULL                                             |  499 |    10.00 | Using where; Using join buffer (hash join) |
|  1 | SIMPLE      | furniture    | NULL       | ref    | block_name             | block_name    | 88      | final.postgrad.block_name,final.hostel_rooms.room_no |    1 |   100.00 | Using index; End temporary               |
+----+-------------+--------------+------------+--------+------------------------+---------------+---------+--------------------------------------------------+------+----------+------------------------------------------+
4 rows in set, 1 warning (0.00 sec)
```

```
mysql> explain select student.name from student natural join postgrad natural join furniture natural join hostel_rooms where sharing_type='Double';
+----+-------------+--------------+------------+--------+------------------------+----------------+---------+-----------------------------------------------------+------+----------+--------------------------+
| id | select_type | table        | partitions | type   | possible_keys          | key            | key_len | ref                                                 | rows | filtered | Extra                    |
+----+-------------+--------------+------------+--------+------------------------+----------------+---------+-----------------------------------------------------+------+----------+--------------------------+
|  1 | SIMPLE      | furniture    | NULL       | index  | block_name             | block_name     | 88      | NULL                                                |  388 |   100.00 | Using where; Using index |
|  1 | SIMPLE      | hostel_rooms | NULL       | eq_ref | PRIMARY,block_name     | PRIMARY        | 86      | final.furniture.room_no,final.furniture.block_name  |    1 |    10.00 | Using where              |
|  1 | SIMPLE      | postgrad     | NULL       | ref    | PRIMARY,block_name_idx | block_name_idx | 83      | final.furniture.block_name                          |   35 |   100.00 | Using index              |
|  1 | SIMPLE      | student      | NULL       | eq_ref | PRIMARY                | PRIMARY        | 4       | final.postgrad.roll_no                              |    1 |   100.00 | NULL                     |
+----+-------------+--------------+------------+--------+------------------------+----------------+---------+-----------------------------------------------------+------+----------+--------------------------+
4 rows in set, 1 warning (0.00 sec)
```

On the web app server of the database,”SEARCH” option has been added on the “Student” table page to be able to search the names of students starting from a certain alphabet and the last names starting from a certain alphabet. This helps in accessing required information easily.

Group G1 Contribution (out of 50%)

Shubham Ghosh 21120017- 12.5%
Pranav Ninawe 21120015 - 12.5%
Rovin Singh 21120016 - 12.5%
Darshan Patil 21120006 - 12.5%
(Equal participation of all group members)

Group G2 Contribution (out of 50%)

Iram Nawab 21250011 - 12.5%
Manasvi Kothari 21120011 - 12.5%
Hardik Mahur 19110086 - 12.5%
Shoaib Alam 21250024 - 12.5%
(Equal participation of all group members)