(i) retrieving each individual table from the database and printing

1. Database

Script: show tables;

```
mysql> use airport;
Database changed
mysql> show tables;
+-------------------+
| Tables_in_airport |
+-------------------+
| airport           |
| flight            |
| flight_leg        |
| leg_instance      |
+-------------------+
4 rows in set (0.00 sec)
```

2. Tables

2.1 airport

2.1.1 Structure

Script: desc airport;

```
mysql> desc airport;
+--------------+--------------+------+-----+---------+-------+
| Field        | Type         | Null | Key | Default | Extra |
+--------------+--------------+------+-----+---------+-------+
| Airport_code | varchar(10)  | NO   | PRI | NULL    |       |
| Name         | varchar(255) | NO   |     | NULL    |       |
| City         | varchar(255) | NO   |     | NULL    |       |
| State        | varchar(255) | NO   |     | NULL    |       |
+--------------+--------------+------+-----+---------+-------+
4 rows in set (0.01 sec)

mysql>
```

2.1.2 Data

Script: select * from airport;

```
mysql> select * from airport;
+--------------+-----------------------------------------+--------------+---------------------+
| Airport_code | Name                                    | City         | State               |
+--------------+-----------------------------------------+--------------+---------------------+
| BDL          | Bradley International Airport           | Hartford     | Connecticut         |
| DTW          | Detroit Metropolitan Wayne County Airport | Detroit    | State of Michigan   |
| IAH          | George Bush Intercontinental Airport    | Houston      | Texas               |
| JFK          | John F. Kennedy International Airport   | New York     | New York            |
| LAX          | Los Angeles International Airport       | Los Angeles  | State of California |
| MSP          | Minneapolis-Saint Paul International Airport | Minneapolis | Minnesota       |
| SAN          | San Diego International Airport         | San Diego    | State of California |
| SFO          | San Francisco International Airport     | San Francisco | State of California |
+--------------+-----------------------------------------+--------------+---------------------+
8 rows in set (0.00 sec)

mysql>
```

2.2 flight

2.2.1 Structure

Script: desc flight;

```
mysql> desc flight;
+---------------+-----------------------------------------------------------------------------------------+------+-----+---------+-------+
| Field         | Type                                                                                    | Null | Key | Default | Extra |
+---------------+-----------------------------------------------------------------------------------------+------+-----+---------+-------+
| Flight_number | varchar(36)                                                                             | NO   | PRI | NULL    |       |
| Airline       | varchar(255)                                                                            | NO   |     | NULL    |       |
| Weekdays      | enum('Monday','Tuesday','Wednesday','Thursday','Friday','Saturday','Sunday')            | NO   |     | NULL    |       |
+---------------+-----------------------------------------------------------------------------------------+------+-----+---------+-------+
3 rows in set (0.01 sec)

mysql>
```

2.2.2 Data

Script: select * from flight;

```
mysql> select * from flight;
+---------------+----------------------+-----------+
| Flight_number | Airline              | Weekdays  |
+---------------+----------------------+-----------+
| AA201         | American Airlines    | Monday    |
| AA202         | American Airlines    | Wednesday |
| AA203         | American Airlines    | Friday    |
| TWA023        | Trans World Airlines | Tuesday   |
+---------------+----------------------+-----------+
4 rows in set (0.00 sec)

mysql>
```

2.3 flight_leg

2.3.1 Structure

Script: desc flight_leg;

```
mysql> desc flight_leg;
+--------------------------+-------------+------+-----+---------+-------+
| Field                    | Type        | Null | Key | Default | Extra |
+--------------------------+-------------+------+-----+---------+-------+
| Flight_number            | varchar(36) | NO   | PRI | NULL    |       |
| Leg_number               | int(11)     | NO   | PRI | NULL    |       |
| Departure_airport_code   | varchar(10) | NO   | MUL | NULL    |       |
| Sheduled_departure_time  | time(4)     | NO   |     | NULL    |       |
| Arrival_airport_code     | varchar(10) | NO   | MUL | NULL    |       |
| Sheduled_arrival_time    | time(4)     | NO   |     | NULL    |       |
+--------------------------+-------------+------+-----+---------+-------+
6 rows in set (0.01 sec)

mysql>
```

2.3.2 Data

Script: select * from flight_leg;

```
mysql> select * from flight_leg;
+---------------+------------+------------------------+-------------------------+----------------------+-------------------------+
| Flight_number | Leg_number | Departure_airport_code | Sheduled_departure_time | Arrival_airport_code | Sheduled_arrival_time   |
+---------------+------------+------------------------+-------------------------+----------------------+-------------------------+
| AA201         |          1 | BDL                    | 08:00:00.0000           | DTW                  | 09:30:00.0000           |
| AA201         |          2 | DTW                    | 10:30:00.0000           | MSP                  | 11:30:00.0000           |
| AA201         |          3 | MSP                    | 12:30:00.0000           | SFO                  | 14:30:00.0000           |
| TWA023        |          1 | IAH                    | 09:30:00.0000           | SAN                  | 11:00:00.0000           |
| TWA023        |          2 | SAN                    | 12:00:00.0000           | LAX                  | 13:00:00.0000           |
+---------------+------------+------------------------+-------------------------+----------------------+-------------------------+
5 rows in set (0.00 sec)

mysql>
```

2.4 leg_instance

2.4.1 Structure

Script: desc leg_instance;

```
mysql> desc leg_instance;
+---------------------------+-------------+------+-----+---------+-------+
| Field                     | Type        | Null | Key | Default | Extra |
+---------------------------+-------------+------+-----+---------+-------+
| Flight_number             | varchar(36) | NO   | PRI | NULL    |       |
| Leg_number                | int(11)     | NO   | PRI | NULL    |       |
| Date                      | date        | NO   | PRI | NULL    |       |
| Number_of_available_seats | int(11)     | NO   |     | NULL    |       |
| Airplane_id               | varchar(36) | NO   |     | NULL    |       |
| Departure_airport_code    | varchar(10) | NO   | MUL | NULL    |       |
| Departure_time            | time(4)     | NO   |     | NULL    |       |
| Arrival_airport_code      | varchar(10) | NO   | MUL | NULL    |       |
| Arrival_time              | time(4)     | NO   |     | NULL    |       |
+---------------------------+-------------+------+-----+---------+-------+
9 rows in set (0.01 sec)

mysql>
```

2.4.2 Data

Script: select * from leg_instance;

```
mysql> select * from leg_instance;
+---------------+------------+------------+---------------------------+-------------+----------------------+----------------+----------------------+----------------+
| Flight_number | Leg_number | Date       | Number_of_available_seats | Airplane_id | Departure_airport_code | Departure_time | Arrival_airport_code | Arrival_time   |
+---------------+------------+------------+---------------------------+-------------+----------------------+----------------+----------------------+----------------+
| AA201         |          1 | 2019-09-02 |                         6 | B1234       | BDL                  | 08:15:00.0000  | DTW                  | 09:32:00.0000  |
| AA201         |          2 | 2019-09-02 |                        10 | B1234       | DTW                  | 10:35:00.0000  | MSP                  | 11:30:00.0000  |
| AA201         |          3 | 2019-09-02 |                        21 | B1234       | MSP                  | 13:02:00.0000  | SFO                  | 14:45:00.0000  |
| TWA023        |          1 | 2019-09-03 |                        20 | A3301       | IAH                  | 09:25:00.0000  | SAN                  | 10:45:00.0000  |
| TWA023        |          2 | 2019-09-03 |                        17 | A3301       | SAN                  | 11:45:00.0000  | LAX                  | 12:51:00.0000  |
+---------------+------------+------------+---------------------------+-------------+----------------------+----------------+----------------------+----------------+
5 rows in set (0.00 sec)

mysql>
```

(ii) showing appropriate section of the system catalog

1. information_schema.KEY_COLUMN_USAGE

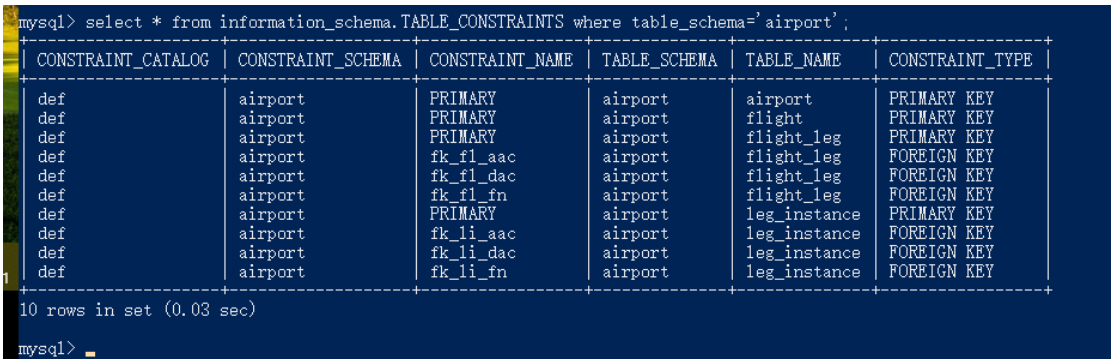
Script: select CONSTRAINT_SCHEMA, CONSTRAINT_NAME, TABLE_NAME, COLUMN_NAME, ORDINAL_POSITION, POSITION_IN_UNIQUE_CONSTRAINT, REFERENCED_TABLE_SCHEMA, REFERENCED_TABLE_NAME, REFERENCED_COLUMN_NAME from INFORMATION_SCHEMA.KEY_COLUMN_USAGE where `TABLE_SCHEMA` = 'airport';

```
mysql> select CONSTRAINT_SCHEMA, CONSTRAINT_NAME, TABLE_NAME, COLUMN_NAME, ORDINAL_POSITION, POSITION_IN_UNIQUE_CONSTRAINT, REFERENCED_TABLE_SCHEMA, REFERENCED_TABLE_NAME, REFERENCED_COLUMN_NAME from INFORMATION_SCHEMA.KEY_COLUMN_USAGE
where `TABLE_SCHEMA` = 'airport';
+-------------------+-----------------+---------------+---------------------------+------------------+-----------------------------+-------------------------+-----------------------+------------------------+
| CONSTRAINT_SCHEMA | CONSTRAINT_NAME | TABLE_NAME    | COLUMN_NAME               | ORDINAL_POSITION | POSITION_IN_UNIQUE_CONSTRAINT | REFERENCED_TABLE_SCHEMA | REFERENCED_TABLE_NAME | REFERENCED_COLUMN_NAME |
+-------------------+-----------------+---------------+---------------------------+------------------+-----------------------------+-------------------------+-----------------------+------------------------+
| airport           | PRIMARY         | airport       | Airport_code              |                1 |                        NULL | NULL                    | NULL                  | NULL                   |
| airport           | PRIMARY         | flight        | Flight_number             |                1 |                        NULL | NULL                    | NULL                  | NULL                   |
| airport           | PRIMARY         | flight_leg    | Flight_number             |                1 |                        NULL | NULL                    | NULL                  | NULL                   |
| airport           | PRIMARY         | flight_leg    | Leg_number                |                2 |                        NULL | NULL                    | NULL                  | NULL                   |
| airport           | fk_fl_aac       | flight_leg    | Arrival_airport_code      |                1 |                           1 | airport                 | airport               | Airport_code           |
| airport           | fk_fl_dac       | flight_leg    | Departure_airport_code    |                1 |                           1 | airport                 | airport               | Airport_code           |
| airport           | fk_fl_fn        | flight_leg    | Flight_number             |                1 |                           1 | airport                 | flight                | Flight_number          |
| airport           | PRIMARY         | leg_instance  | Flight_number             |                1 |                        NULL | NULL                    | NULL                  | NULL                   |
| airport           | PRIMARY         | leg_instance  | Leg_number                |                2 |                        NULL | NULL                    | NULL                  | NULL                   |
| airport           | PRIMARY         | leg_instance  | Date                      |                3 |                        NULL | NULL                    | NULL                  | NULL                   |
| airport           | fk_li_aac       | leg_instance  | Arrival_airport_code      |                1 |                           1 | airport                 | airport               | Airport_code           |
| airport           | fk_li_dac       | leg_instance  | Departure_airport_code    |                1 |                           1 | airport                 | airport               | Airport_code           |
| airport           | fk_li_fn        | leg_instance  | Flight_number             |                1 |                           1 | airport                 | flight_leg            | Flight_number          |
| airport           | fk_li_fn        | leg_instance  | Leg_number                |                2 |                           2 | airport                 | flight_leg            | Leg_number             |
+-------------------+-----------------+---------------+---------------------------+------------------+-----------------------------+-------------------------+-----------------------+------------------------+
14 rows in set (0.00 sec)

mysql>
```

2. information_schema.TABLE_CONSTRAINTS

Script: select * from information_schema.TABLE_CONSTRAINTS where table_schema='airport';



```
mysql> select * from information_schema.TABLE_CONSTRAINTS where table_schema='airport';
+--------------------+-------------------+-----------------+--------------+--------------+-----------------+
| CONSTRAINT_CATALOG | CONSTRAINT_SCHEMA | CONSTRAINT_NAME | TABLE_SCHEMA | TABLE_NAME   | CONSTRAINT_TYPE |
+--------------------+-------------------+-----------------+--------------+--------------+-----------------+
| def                | airport           | PRIMARY         | airport      | airport      | PRIMARY KEY     |
| def                | airport           | PRIMARY         | airport      | flight       | PRIMARY KEY     |
| def                | airport           | PRIMARY         | airport      | flight_leg   | PRIMARY KEY     |
| def                | airport           | fk_fl_aac       | airport      | flight_leg   | FOREIGN KEY     |
| def                | airport           | fk_fl_dac       | airport      | flight_leg   | FOREIGN KEY     |
| def                | airport           | fk_fl_fn        | airport      | flight_leg   | FOREIGN KEY     |
| def                | airport           | PRIMARY         | airport      | leg_instance | PRIMARY KEY     |
| def                | airport           | fk_li_aac       | airport      | leg_instance | FOREIGN KEY     |
| def                | airport           | fk_li_dac       | airport      | leg_instance | FOREIGN KEY     |
| def                | airport           | fk_li_fn        | airport      | leg_instance | FOREIGN KEY     |
+--------------------+-------------------+-----------------+--------------+--------------+-----------------+
10 rows in set (0.03 sec)

mysql>
```

(iii) problems

1. Check constraints

   Since MySQL does not implement the check constraint function, I use enum and trigger to replace it. I used enum to limit the values of the weekdays column in the table “flight” to 'Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday', or 'Sunday'.

   I used triggers to check for “Sheduled_departure_time” and “Sheduled_arrival_time” in table “flight_leg”, and “Departure_time” and “Arrival_time” in table “leg_instance”, and restricted the former to be smaller than the latter, otherwise exceptions are thrown.

## Appendix I SQL Script to create database and tables and insert data

```
-- create database
DROP DATABASE IF EXISTS `airport`;
CREATE DATABASE `airport`;
USE `airport`;

-- create tables
DROP TABLE IF EXISTS `airport`;
CREATE TABLE `airport`  (
  `Airport_code` varchar(10) NOT NULL,
  `Name` varchar(255) NOT NULL,
  `City` varchar(255) NOT NULL,
  `State` varchar(255) NOT NULL,
  PRIMARY KEY (`Airport_code`)
);

DROP TABLE IF EXISTS `flight`;
CREATE TABLE `flight`  (
  `Flight_number` varchar(36) NOT NULL,
  `Airline` varchar(255) NOT NULL,
  `Weekdays` enum('Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday', 'Sunday')
NOT NULL,
  PRIMARY KEY (`Flight_number`)
```

```
);

DROP TABLE IF EXISTS `flight_leg`;
CREATE TABLE `flight_leg`  (
  `Flight_number` varchar(36) NOT NULL,
  `Leg_number` int(11) NOT NULL,
  `Departure_airport_code` varchar(10) NOT NULL,
  `Sheduled_departure_time` time(4) NOT NULL,
  `Arrival_airport_code` varchar(10) NOT NULL,
  `Sheduled_arrival_time` time(4) NOT NULL,
  PRIMARY KEY (`Flight_number`, `Leg_number`),
  CONSTRAINT `fk_fl_aac` FOREIGN KEY (`Arrival_airport_code`) REFERENCES `airport` (`Airport_code`) ON DELETE CASCADE ON UPDATE CASCADE,
  CONSTRAINT `fk_fl_dac` FOREIGN KEY (`Departure_airport_code`) REFERENCES `airport` (`Airport_code`) ON DELETE CASCADE ON UPDATE CASCADE,
  CONSTRAINT `fk_fl_fn` FOREIGN KEY (`Flight_number`) REFERENCES `flight` (`Flight_number`) ON DELETE CASCADE ON UPDATE CASCADE,
  CONSTRAINT `ck_fl_sdsa` CHECK(Sheduled_departure_time <= Sheduled_arrival_time)
);

DROP TABLE IF EXISTS `leg_instance`;
CREATE TABLE `leg_instance`  (
  `Flight_number` varchar(36) NOT NULL,
  `Leg_number` int(11) NOT NULL,
  `Date` date NOT NULL,
  `Number_of_available_seats` int(11) NOT NULL,
  `Airplane_id` varchar(36) NOT NULL,
  `Departure_airport_code` varchar(10) NOT NULL,
  `Departure_time` time(4) NOT NULL,
  `Arrival_airport_code` varchar(10) NOT NULL,
  `Arrival_time` time(4) NOT NULL,
  PRIMARY KEY (`Flight_number`, `Leg_number`, `Date`),
  CONSTRAINT `fk_li_aac` FOREIGN KEY (`Arrival_airport_code`) REFERENCES `airport` (`Airport_code`) ON DELETE CASCADE ON UPDATE CASCADE,
  CONSTRAINT `fk_li_dac` FOREIGN KEY (`Departure_airport_code`) REFERENCES `airport` (`Airport_code`) ON DELETE CASCADE ON UPDATE CASCADE,
  CONSTRAINT `fk_li_fn` FOREIGN KEY (`Flight_number`, `Leg_number`) REFERENCES `flight_leg` (`Flight_number`, `Leg_number`) ON DELETE CASCADE ON UPDATE CASCADE,
  CONSTRAINT `ck_li_da` CHECK(Departure_time <= Arrival_time)
);

-- Use triggers instead of check constraints
DROP TRIGGER IF EXISTS `tri_fl_before_insert_time`;
CREATE TRIGGER `tri_fl_before_insert_time` BEFORE INSERT ON flight_leg FOR EACH
```

```
ROW
BEGIN
    DECLARE msg VARCHAR(200);
    IF new.Sheduled_departure_time > new.Sheduled_arrival_time
    THEN
        SET msg = CONCAT('Invalid Time: ', NEW.Sheduled_departure_time, '>',
NEW.Sheduled_arrival_time);
        SIGNAL SQLSTATE 'HY000' SET MESSAGE_TEXT = msg;
    END IF;
END;

DROP TRIGGER IF EXISTS `tri_fl_before_update_time`;
CREATE TRIGGER `tri_fl_before_update_time` BEFORE UPDATE ON flight_leg FOR EACH
ROW
BEGIN
    DECLARE msg VARCHAR(200);
    IF new.Sheduled_departure_time > new.Sheduled_arrival_time
    THEN
        SET msg = CONCAT('Invalid Time: ', NEW.Sheduled_departure_time, '>',
NEW.Sheduled_arrival_time);
        SIGNAL SQLSTATE 'HY000' SET MESSAGE_TEXT = msg;
    END IF;
END;

DROP TRIGGER IF EXISTS `tri_li_before_insert_time`;
CREATE TRIGGER `tri_li_before_insert_time` BEFORE INSERT ON leg_instance FOR EACH
ROW
BEGIN
    DECLARE msg VARCHAR(200);
    IF new.Departure_time > new.Arrival_time
    THEN
        SET msg = CONCAT('Invalid Time: ', NEW.Departure_time, '>', NEW.Arrival_time);
        SIGNAL SQLSTATE 'HY000' SET MESSAGE_TEXT = msg;
    END IF;
END;

DROP TRIGGER IF EXISTS `tri_li_before_update_time`;
CREATE TRIGGER `tri_li_before_update_time` BEFORE UPDATE ON leg_instance FOR EACH
ROW
BEGIN
    DECLARE msg VARCHAR(200);
    IF new.Departure_time > new.Arrival_time
    THEN
        SET msg = CONCAT('Invalid Time: ', NEW.Departure_time, '>', NEW.Arrival_time);
```

```
            SIGNAL SQLSTATE 'HY000' SET MESSAGE_TEXT = msg;
        END IF;
END;

-- insert data
INSERT INTO `airport` VALUES ('BDL', 'Bradley International Airport', 'Hartford', 'Connecticut');
INSERT INTO `airport` VALUES ('IAH', 'George Bush Intercontinental Airport', 'Houston', 'Texas');
INSERT INTO `airport` VALUES ('JFK', 'John F. Kennedy International Airport', 'New York', 'New York');
INSERT INTO `airport` VALUES ('DTW', 'Detroit Metropolitan Wayne County Airport', 'Detroit', 'State of Michigan');
INSERT INTO `airport` VALUES ('MSP', 'Minneapolis-Saint Paul International Airport', 'Minneapolis', 'Minnesota');
INSERT INTO `airport` VALUES ('SFO', 'San Francisco International Airport', 'San Francisco', 'State of California');
INSERT INTO `airport` VALUES ('SAN', 'San Diego International Airport', 'San Diego', 'State of California');
INSERT INTO `airport` VALUES ('LAX', 'Los Angeles International Airport', 'Los Angeles', 'State of California');

INSERT INTO `flight` VALUES ('AA201', 'American Airlines', 'Monday');
INSERT INTO `flight` VALUES ('AA202', 'American Airlines', 'Wednesday');
INSERT INTO `flight` VALUES ('AA203', 'American Airlines', 'Friday');
INSERT INTO `flight` VALUES ('TWA023', 'Trans World Airlines', 'Tuesday');

INSERT INTO `flight_leg` VALUES ('AA201', 1, 'BDL', '08:00', 'DTW', '09:30');
INSERT INTO `flight_leg` VALUES ('AA201', 2, 'DTW', '10:30', 'MSP', '11:30');
INSERT INTO `flight_leg` VALUES ('AA201', 3, 'MSP', '12:30', 'SFO', '14:30');
INSERT INTO `flight_leg` VALUES ('TWA023', 1, 'IAH', '09:30', 'SAN', '11:00');
INSERT INTO `flight_leg` VALUES ('TWA023', 2, 'SAN', '12:00', 'LAX', '13:00');

INSERT INTO `leg_instance` VALUES ('AA201', 1, '2019-09-02', 6, 'B1234', 'BDL', '08:15', 'DTW', '09:32');
INSERT INTO `leg_instance` VALUES ('AA201', 2, '2019-09-02', 10, 'B1234', 'DTW', '10:35', 'MSP', '11:30');
INSERT INTO `leg_instance` VALUES ('AA201', 3, '2019-09-02', 21, 'B1234', 'MSP', '13:02', 'SFO', '14:45');
INSERT INTO `leg_instance` VALUES ('TWA023', 1, '2019-09-03', 20, 'A3301', 'IAH', '09:25', 'SAN', '10:45');
INSERT INTO `leg_instance` VALUES ('TWA023', 2, '2019-09-03', 17, 'A3301', 'SAN', '11:45', 'LAX', '12:51');
```