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Q1 Answers:

```
CREATE TABLE city
(
   id            INTEGER,
   city          CHAR(20),
   state         CHAR(20),
   country       CHAR(20),
   PRIMARY KEY (id)
   )

CREATE TABLE planes
(
   plane-number        CHAR(10),
   model               CHAR(20),
   capacity            INTEGER,
   create-year         INTEGER,
   PRIMARY KEY (plane-number)
   )

CREATE TABLE pilot
(
   ssn                 INTEGER,
   home-city           INTEGER,
   fullname            CHAR(20),
   day-of-birth        DATE,
   month-of-birth      INTEGER,
   year-of-birth       INTEGER,
   salary              DOUBLE,
   PRIMARY KEY (ssn),
   FOREIGN KEY (home-city) REFERENCES city
   )

CREATE TABLE flight
(
   flight-number       CHAR(10),
   captain-ssn         INTEGER,
   plane-number        CHAR(10),
   takeoff-city        INTEGER,
   landing-city        INTEGER,
   time-takeoff        DATE TIME,
   time-landing        DATE TIME,
   PRIMARY KEY (flight-number),
   FOREIGN KEY (captain-ssn)                 REFERENCE pilot,
   FOREIGN KEY (plane-number)                REFERENCE planes,
   FOREIGN KEY (takeoff-city, landing-city)  REFERENCE city
   )
```

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Q2 Answer:

a. Relational algebra equation:

$$\pi_{id,city}(\sigma_{country='Germany'}\ (city))$$

b. SQL query:

```
SELECT id, city
FROM city
WHERE country = 'Germany'
```

Q3 Answer:

a. Relational algebra equation:

$$\pi_{fullname}(\sigma_{country='Germany'}(\ (city) \bowtie_{city.id=pilot.home-city}\ (pilot)))$$

b. SQL query:

```
SELECT p.fullname
FROM city c, pilot p
WHERE c.id = p.home-city AND c.country = 'Germany'
```

Q4 Answer:

a. Relational algebra equation:

$$\pi_{fullname}(\sigma_{country='Germany'}(\ (city) \bowtie_{city.id=flight.takeoff-city}\ (flight) \bowtie_{flight.captain-ssn=pilot.ssn}\ (pilot)) \cup \pi_{fullname}(\sigma_{country='Germany'}(\ (city) \bowtie_{city.id=flight.landing-city}\ (flight) \bowtie_{flight.captain-ssn=pilot.ssn}\ (pilot)))$$

b. SQL query:

```
SELECT p.fullname
FROM city c, pilot p, flight f
WHERE c.id = f.takeoff-city AND c.country = 'Germany' AND f.captain-ssn = p.ssn
UNION
SELECT p.fullname
FROM city c, pilot p, flight f
WHERE c.id = f.landing-city AND c.country = 'Germany' AND f.captain-ssn = p.ssn
```

Q5 Answer:

a. Relational algebra equation:

$$\pi_{model}(flight) \bowtie (planes) \bowtie_{flight.takeoff-city=city.id}\ (\pi_{id}(\sigma_{country='US'}(city)) \bowtie_{flight.takeoff-city=city.id}\ (\pi_{id}\left(\sigma_{country='US'}(city)\right) - (\pi_{model}(flight) \bowtie (planes) \bowtie_{flight.takeoff-city=city.id}\ (\pi_{id}(\sigma_{country<>'US'}(city)) \cup \pi_{model}(flight) \bowtie (planes) \bowtie_{flight.takeoff-city=city.id}\ (\pi_{id}\left(\sigma_{country<>'US'}(city)\right))$$

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b. SQL query:

```
SELECT p.model
FROM flight f, planes p
WHERE p.plane-number = f.plane-number
        AND f.takeoff-city IN (SELECT id FROM city c1 WHERE c1.country = 'US')
        AND f.landing-city IN (SELECT id FROM city c1 WHERE c1.country = 'US')
        AND p.model NOT IN (
                SELECT p.model
                FROM flight f, planes p
                WHERE p.plane-number = f.plane-number
                        AND (f.takeoff-city IN (SELECT id FROM city c3 WHERE
                        c3.country <> 'US') OR f.landing-city IN (SELECT id FROM city
                        c4 WHERE c4.country <> 'US')) )
```

Q6 Answer:

a. Relational algebra equation:

$$(\pi_{model}(flight) \bowtie (planes) \bowtie_{flight.takeoff-city=city.id} (\pi_{id}(\sigma_{country='US'}(city))$$
$$\cup \pi_{model}(flight) \bowtie (planes) \bowtie_{flight.landing-city=city.id} \left(\pi_{id}\left(\sigma_{country='US'}(city)\right)\right)$$
$$\cap (\pi_{model}(flight) \bowtie (planes) \bowtie_{flight.takeoff-city=city.id} (\pi_{id}(\sigma_{country<>'US'}(city))$$
$$\cup \pi_{model}(flight) \bowtie (planes) \bowtie_{flight.landing-city=city.id} \left(\pi_{id}\left(\sigma_{country<>'US'}(city)\right)\right)$$

b. SQL query:

```
SELECT p.model
FROM flight f, planes p
WHERE p.plane-number = f.plane-number
        AND (f.takeoff-city IN (SELECT id FROM city c1 WHERE c1.country = 'US')
        OR f.landing-city IN (SELECT id FROM city c1 WHERE c1.country = 'US'))
INTERSECT
SELECT p.model
FROM flight f, planes p
WHERE p.plane-number = f.plane-number
        AND (f.takeoff-city IN (SELECT id FROM city c1 WHERE c1.country <> 'US')
        OR f.landing-city IN (SELECT id FROM city c1 WHERE c1.country <> 'US'))
```

Q7 Answer:

1) Return the name of pilot and the country where he or she is from
   Answer is b and c
2) Expressions from question that are equivalent
   Answer: a and d is equivalent, and b and c is equivalent.

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Q8 Answer:

1) 15
2) Return the whole information of flights which will takeoff from Pittsburgh
3) Rewrite expression

$$(flight) \bowtie (planes) \bowtie_{flight.takeoff-city=city.id} (\sigma_{city='pittsburgh'}(city))$$

4) Translate into SQL

```
SELECT *
FROM city c, flight f, planes p
WHERE c.city = 'pittsburgh' AND f.takeoff-city = c.id

SELECT *
FROM flight f
JOIN planes p
ON f.plane-number = p.plane-number
JOIN
(SELECT * FROM city temp WHERE temp.city = 'pittsburgh') c
ON f.takeoff-city = c.id
```