Problem 1 (example solution)

a)

[Diagram showing an entity-relationship model with entities such as 'Automobile', 'Sellar', 'Dealer', 'Insurance Report', 'Damage', 'Location', 'Time', 'Date', 'Make', 'Model', 'Year', 'Name', 'Address', 'Email', 'Author', 'Review', and 'Review ID'.]
b)
Primary Keys:
- Automobile: VIN
- Seller: Seller ID
- Type: {Model, Make, Year}

Weak Entities:
- Review (Discriminator: Review ID)
- Accident (Discriminator: Location, Date, Time)

Cardinalities:
- Sold By:
  - Many-to-One (Automobile has total participation):
    - Each registered automobile must have one seller.
    - Each seller can sell more than one automobiles.
    - Each registered automobile can be sold by only one seller.

- Is Of:
  - Many-to-One (Automobile has total participation):
    - Each automobile must have a type.
    - Each automobile is of only one type.
    - Each type can have many automobiles.
• Written:
  ■ Many-to-One (Review has total participation).
  ■ Each review must have a type.
  ■ Each review is only for one type.
  ■ Each type can have many reviews.

• Involved:
  ■ One-to-Many
  ■ Each automobile may have many accidents.
  ■ Each accident is associated with one automobile.

c) Relational Model:

• Dealer (Seller ID, Phone #, Name, Company, Address)
• Individual (Seller ID, Phone #, Email)
• Automobile (VIN, color, mileage, body style, Seller ID, model, make, year)
• Review (Review ID, model, make, year, review, author)
• Type (model, make, year)
• Accident (Date, Time, Location, VIN, Damage, Insurance Report)
• Cars (Date, Time, Location, VIN, VIN2)

d) Keys are indicated in the tables. No other candidate keys.
Problem 2

a)
b)

Relational Model:

- Model (Model No, Capacity, Weight)
- Plane_Type (Reg No, Model No)
- Expertise(Model No, SSN)
- Employee (SSN, Union No)
- Technician (SSN, Name, Salary, Address, Phone No)
- Traffic Controller (SSN, Exam Date)
- Test (FAA No, Name, Max Score)
- Test Info(Reg No, SSN, FAA No, Hour, Date, Score)

SQL Statement:

- CREATE TABLE Model ( Model_No CHAR(5),
  Capacity INTEGER,
  Weight INTEGER,
  PRIMARY KEY (Model_No));

- CREATE TABLE Plane_Type ( Reg_No INTEGER,
  Model_No CHAR(5),
  PRIMARY KEY (Reg_No)
  FOREIGN KEY (Model_No) REFERENCES Model);
CREATE TABLE Employee (
  SSN CHAR(9),
  Union_No INTEGER,
  PRIMARY KEY (SSN));

CREATE TABLE Technician (
  SSN CHAR(9),
  Name VARCHAR(60),
  Salary INTEGER,
  Address VARCHAR(120),
  Phone_No CHAR(10),
  PRIMARY KEY (SSN),
  FOREIGN KEY (SSN) REFERENCES Employee ON DELETE CASCADE);

CREATE TABLE Traffic_Controller (
  SSN CHAR(9),
  Exam_Date DATE,
  PRIMARY KEY (SSN),
  FOREIGN KEY (SSN) REFERENCES Employee ON DELETE CASCADE);

CREATE TABLE Expertise (
  SSN CHAR(9) NOT NULL,
  Model_No CHAR(5),
  PRIMARY KEY (SSN, Model_No),
  FOREIGN KEY (SSN) REFERENCES Technician,
  FOREIGN KEY (Model_No) REFERENCES Model);
CREATE TABLE Test ( FAA_No INTEGER, Name VARCHAR(60), Max_Score INTEGER, PRIMARY KEY (FAA_No));

CREATE TABLE Test_Info ( SSN CHAR(9) NOT NULL, Reg_No INTEGER NOT NULL, FAA_No INTEGER NOT NULL, Hour INTEGER, Date DATE, Score INTEGER, PRIMARY KEY (SSN, Reg_No, FAA_No), FOREIGN KEY (SSN) REFERENCES Technician, FOREIGN KEY (Reg_No) REFERENCES Plane_Type, FOREIGN KEY (FAA_No) REFERENCES Test);
Problem 3

In the following relational algebra expressions BL stands for Bank_Location, IS stands for Issuer and ML for Max_limits.

1. \( \pi \ \text{card} (\sigma \ \text{Location} = 'Boston' (BL) \bowtie IS) \)

2. \( \pi \ \text{card} (IS) - \pi \ \text{card} (\sigma \ \text{Location} = 'NY' (BL) \bowtie IS) \)

3. \( \pi \ \text{Bank} (\sigma \ \text{Max_limits} < 100,000 (ML) \bowtie IS) \)

4. \( (\pi \ \text{Bank} (\sigma \ \text{Card} = 'MasterCard' (IS)) \cap \pi \ \text{Bank} (\sigma \ \text{Card} = 'Visa' (IS))) - \pi \ \text{Bank} (\sigma \ \text{Card} != 'MasterCard' \land \text{Card} != 'Visa' (IS)) \)

5. \( \text{IS} / \pi \ \text{card} (ML) \) or \( \text{IS} / \pi \ \text{card} (IS) \)

Note: != denotes not equal
**Problem 4**

In the following relational algebra expressions Empl stands for Employee.

1. \( \pi \ SSN, \ name \ (\sigma \ \text{hours} > 100 \land \text{location} = 'Boston' \ (\text{Empl} \bowtie \text{HourLog} \bowtie \text{Project})) \)

2. \( \pi \ SSN, \ name \ (\sigma \ \text{DNo} = 1 \land \text{PNo} = 2 \ (\text{Empl} \bowtie \text{HourLog})) \)

3. \( \pi \ SSN, \ name \ (\text{Empl} \bowtie \pi \ SSN \ (\sigma \ \text{HourLog.SSN} = \text{d.SSN} \land \text{HourLog.PNo} \neq \text{d.PNo} \ (\text{HourLog} \times \rho \ (\text{d, HourLog})))) \)

4. \( \pi \ SSN, \ name \ (\text{Empl} \bowtie (\pi \ SSN, \ PNo \ (\text{HourLog}) / \pi \ PNo \ (\text{Project}))) \)