Database Systems

Project: Design, development and implementation of a relational database

A relational database should be developed following the subsequent steps for the case study described in this PDF. All questions must be answered in the order described here; answers should be preceded by the question number. Answers must be typed-in and diagrams must be created using the appropriate software, **no handwritten** parts will be accepted.

1. Develop a conceptual data model reflecting the following requirements:

a. Identify the main entity types.

Entity	Clinic, Staff, Owner, Pet, Examination

b. Identify the main relationship types between the entity types identified in "a".

Relationship	**Descriptions**
Has	Clinic has Staff
Manages	Staff manages Clinic
Owns	Owner owns Pet
Registers	Clinic registers pet
Conducts	Staff member conducts Examination
Receives	Pet receives Exam

c. Determine the multiplicity constraints for each relationship identified in "b".

Entity	**M_1**	**Relationship**	**M_2**	**Entity**
Clinic	1..1	Has ▶️ 1:*	1..*	Staff
Staff	1..1	Manages ▶️	0..1	Clinic

		1:1		
Owner	1..1	Owns ▶️ 1:*	1..*	Pet
Clinic	1..1	Registers ▶️ 1:*	0..*	Pet
Staff	1..1	Conducts ▶️ 1:*	0..*	Examination
Pet	1..1	Receives ▶️ 1:*	1..*	Examination

Assumptions:

- Every staff member is associated with exactly one clinic, assuming every staff member works at a clinic.
- A clinic must have at least one staff member, with no upper limit to the number of staff members a clinic can employ.
- Each clinic is managed by at most one staff member, but some clinics might not have a manager.
- A pet that has visited the clinic has one or more examinations recorded.

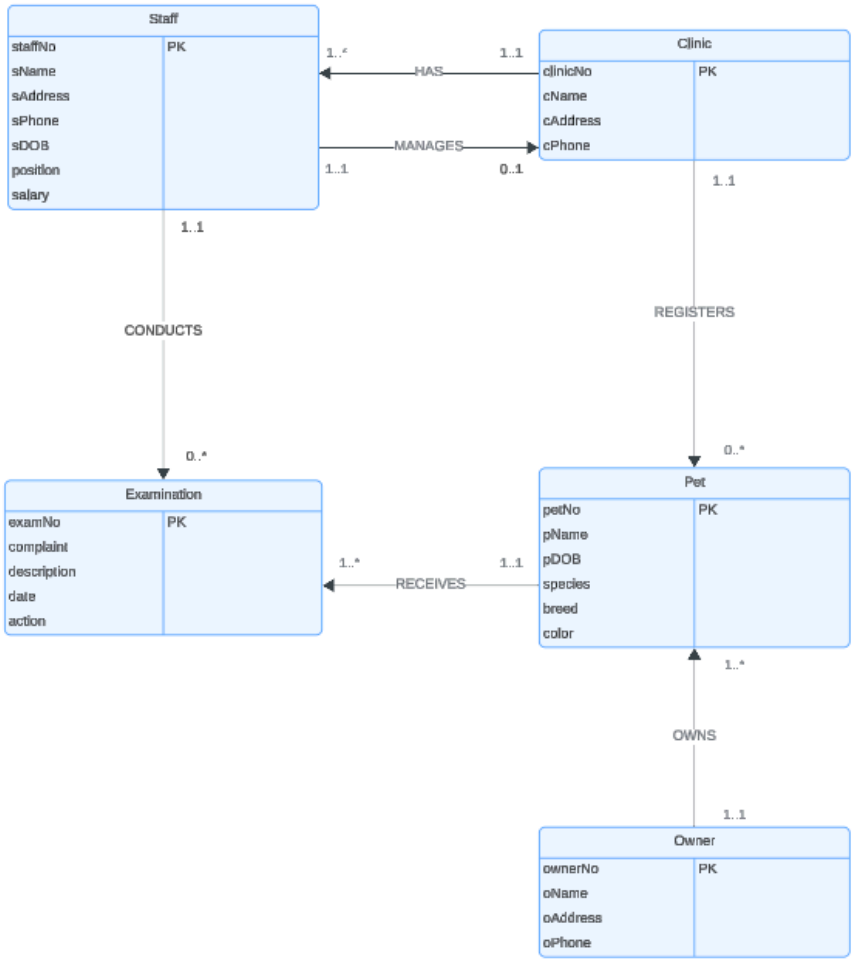
d. Identify attributes and associate them with entity or relationship types.

Entity	**Attributes**
Clinic	clinicNo, cName, cAddress, cPhone
Staff	staffNo, sName, sAddress, sPhone, sDOB, Position, salary
Owner	ownerNo, oName, oAddress, oPhone
Pet	petNo, pName, pDOB, species, breed, color
Examination	examNo, complaint, description, date, action

e. Determine candidate and primary key attributes for each (strong) entity type.

Entity	Attributes
Clinic	clinicNo(PK=CK), cName, cAddress, cPhone
Staff	staffNo(PK=CK), sName, sAddress, sPhone, sDOB, position, salary
Owner	ownerNo(PK=CK), oName, oAddress, oPhone
Pet	petNo(PK=CK), pName, pDOB, species, breed, color
Examination	examNo(PK=CK), complaint, description, date, action

f. Generate the E-R diagram for the conceptual level (no FKs as attributes).
See next page.



Develop a logical data model based on the following requirements:
a. Derive relations from the conceptual model.

Summary of Relationships

- **Clinic Has Staff**: 1:* → clinicNo FK in Staff.
- **Staff Manages Clinic**: 1:1 → staffNo FK in Clinic.
- **Owner Owns Pet**: 1:* → ownerNo FK in Pet.
- **Clinic Registers Pet**: 1:* → clinicNo FK in Pet.
- **Staff Conducts Examination**: 1:* → staffNo FK in Examination.
- **Pet Receives Examination**: 1:* → petNo FK in Examination.

Final Relations:

1. **Clinic**(clinicNo, cName, cAddress, cPhone, staffNo)
   Primary Key clinicNo
   Foreign key staffNo references Staff(staffNo)
2. **Staff**(staffNo, sName, sAddress, sPhone, sDOB, position, salary, clinicNo)
   Primary Key staffNo
   Foreign key clinicNo references Clinic(clinicNo)
3. **Owner**(ownerNo, oName, oAddress, oPhone)
   Primary Key ownerNo
4. **Pet**(petNo, pName, pDOB, species, breed, color, ownerNo, clinicNo)
   Primary Key petNo
   Foreign key ownerNo references Owner(ownerNo); clinicNo references Clinic(clinicNo)
5. **Examination**(examNo, complaint, description, date, action, petNo, staffNo)
   Primary Key examNo
   Foreign key petNo references Pet(petNo); staffNo references Staff(staffNo)

Appendix:

Relationship	Types	Reasoning	Derive Relation
Clinic Has Staff	1:*	This relationship introduces a foreign key.	**Staff**(staffNo PK, sName, sAddress, sPhone, sDOB, position, salary, clinicNo FK)

		The entity on the "one side" is Clinic, and its primary key (clinicNo) is added as a foreign key in the **Staff** relation.	- clinicNo references Clinic.clinicNo. - Enforces that all staff are linked to a specific clinic.
Staff Manages Clinic	1:1	**Partial Participation for Clinic**: • Some clinics might not have a staff, so the staffNo attribute in the Clinic table can be **NULL**. **Partial Participation for Staff**: • Some staff members might not manage a clinic, so there's no need to enforce a mandatory participation for all Staff in the **Manages** relationship. **Disjoint Constraint**: • staffs are a subset of all staff, but this subset is implicit in the schema. Only those Staff whose staffNo appears as staffNo in Clinic are staffs.	**Clinic**(clinicNo PK, cName, cAddress, cPhone, staffNo FK NULL) - staffNo references Staff.staffNo. - NULL allowed for staffNo to represent clinics without staffs. - UNIQUE constraint ensures one staff per clinic.
Owner Owns Pet	1:*	This relationship introduces a foreign key. - Each pet belongs to exactly one owner, and each owner can own one or more pets. - This ensures proper tracking of ownership between owners and their pets.	**Pet**(petNo PK, pName, pDOB, species, breed, color, ownerNo FK) - ownerNo references Owner.ownerNo. - Enforces that every pet is owned by a valid owner.
Clinic Registers Pet	1:*	This relationship introduces a foreign key. - Each pet is registered at exactly one clinic, and each clinic can register multiple pets. - This ensures that every pet is linked to a specific clinic.	Pet(petNo PK, pName, pDOB, species, breed, color, ownerNo FK, clinicNo FK) - clinicNo references Clinic.clinicNo. - Enforces that all pets are registered to valid clinics.
Staff Conducts Examination	1:*	This relationship introduces a foreign key. - Each examination is conducted by	Examination(examNo PK, complaint, description, date, action, petNo FK, staffNo FK)

		exactly one staff member, and a staff member can conduct one or more examinations. - This ensures proper accountability for staff members conducting exams.	- staffNo references Staff.staffNo. - Enforces that every examination is linked to a valid staff member.
Pet Receives Examination	1:*	This relationship introduces a foreign key. - Each examination is conducted for exactly one pet, and a pet can have one or more examinations. - This ensures that all examinations are associated with a specific pet.	Examination(examNo PK, complaint, description, date, action, petNo FK, staffNo FK) - petNo references Pet.petNo. - Enforces that every examination is linked to a valid pet.

b. Validate the logical model using normalization to 3NF.

Normalization Process

1. First Normal Form (1NF)

Requirement: Data must be atomic, and there should be no repeating groups or multi-valued attributes.

Validation:

- All attributes in each relation (Clinic, Staff, Owner, Pet, Examination) are atomic.
- There are no repeating groups or multi-valued attributes in the relations.
- **Conclusion**: All relations are in **1NF**.

2. Validation of 2NF and 3NF

Requirement for 2NF:

- Ensure all non-prime attributes depend entirely on the whole primary key (no partial dependencies).

Requirement for 3NF:

- Ensure all non-prime attributes depend only on the primary key, with no transitive dependencies.

Validation Across Relations:

1. **Clinic**:
    - Attributes (cName, cAddress, cPhone) depend entirely and directly on the

primary key (clinicNo).
    - No partial or transitive dependencies exist.
2. **Staff**:
    - Attributes (sName, sAddress, sPhone, sDOB, position, salary) depend entirely and directly on the primary key (staffNo).
    - Foreign key (clinicNo) ensures proper association with the clinic.
    - No partial or transitive dependencies.
3. **Owner**:
    - Attributes (oName, oAddress, oPhone) depend entirely and directly on the primary key (ownerNo).
    - No partial or transitive dependencies.
4. **Pet**:
    - Attributes (pName, pDOB, species, breed, color) depend entirely and directly on the primary key (petNo).
    - Foreign keys (ownerNo, clinicNo) link pets to their owner and clinic without introducing partial or transitive dependencies.
5. **Examination**:
    - Attributes (complaint, description, date, action) depend entirely and directly on the primary key (examNo).
    - Foreign keys (petNo, staffNo) ensure association with valid pets and staff members without introducing partial or transitive dependencies.

Conclusion:

- All relations meet the requirements for both **2NF** (no partial dependencies) and **3NF** (no transitive dependencies).

c. Validate the logical model against 5 user transactions. (Note: These will be then implemented in 3c).

Transaction	Steps	Validation
Add a New Pet	Insert a new record into the Pet table with attributes: petNo, pName, pDOB, species, breed, color, ownerNo, clinicNo.	ownerNo FK ensures valid owner; clinicNo FK ensures valid clinic; Required attributes enforce integrity.
Record an Examination	Insert a new record into the Examination table with attributes: examNo, complaint, description, date, action, petNo, staffNo.	petNo FK ensures valid pet; staffNo FK ensures valid staff member; Required attributes enforce integrity.
Assign a Staff Member to a Clinic	Insert a new record into the Staff table with attributes: staffNo, sName, sAddress, sPhone, sDOB, position,	clinicNo FK ensures valid clinic; Required attributes (e.g., sName, clinicNo) ensure proper data entry for staff.

	salary, clinicNo.	
Change Clinic staff	Update the staffNo attribute in the Clinic table for a specific clinicNo.	staffNo FK ensures valid staff; UNIQUE constraint on staffNo prevents multiple clinics from sharing the same staff.
Retrieve a Pet's Examination History	Execute a query joining Pet and Examination tables to retrieve all examinations for a specific pet.	petNo FK ensures valid pet; staffNo FK ensures valid staff; Schema supports efficient joins for accurate data retrieval.

d. Define integrity constraints:

i. Primary key constraints.

All the PKs identified in a. must be unique, and must not be NULL.

ii. Referential integrity/Foreign key constraints.

Relation	FK	References	FK Constraints
Staff	clinicNo	Clinic(clinicNo)	- Ensures every staff member is associated with a valid clinic. - Must not be NULL.
Clinic	staffNo	Staff(staffNo)	- Ensures a clinic's staff is a valid staff member. - Can be NULL to allow clinics without a staff.
Pet	ownerNo	Owner(ownerNo)	- Ensures every pet is owned by a valid owner. - Must not be NULL.
Pet	clinicNo	Clinic(clinicNo)	- Ensures every pet is registered at a valid clinic. - Must not be NULL.
Examination	petNo	Pet(petNo)	- Ensures each examination is linked to a valid pet. - Must not be NULL.
Examination	staffNo	Staff(staffNo)	- Ensures each examination is conducted by a valid staff member. - Must not be NULL.

iii. Alternate key constraints (if any).

Alternate key: None.

iv. Required data.

Relation	Attributes	Required Data Constraints

Clinic	clinicNo, cName, cAddress, cPhone	- These attributes must not be NULL. - Each clinic must have valid identification and contact information.
Staff	staffNo, sName, sAddress, sPhone, sDOB, position, salary, clinicNo	- All attributes must not be NULL. - clinicNo ensures that every staff member is linked to a clinic.
Owner	ownerNo, oName, oAddress, oPhone	- These attributes must not be NULL. - Ensures every owner is fully identifiable.
Pet	petNo, pName, pDOB, species, breed, color, ownerNo, clinicNo	- All attributes must not be NULL. - Ensures every pet is fully described and associated with an owner and clinic.
Examination	examNo, complaint, description, date, action, petNo, staffNo	- All attributes must not be NULL. - Ensures that every examination has valid details, is linked to a pet, and is conducted by a staff member.

v. Attribute domain constraints.

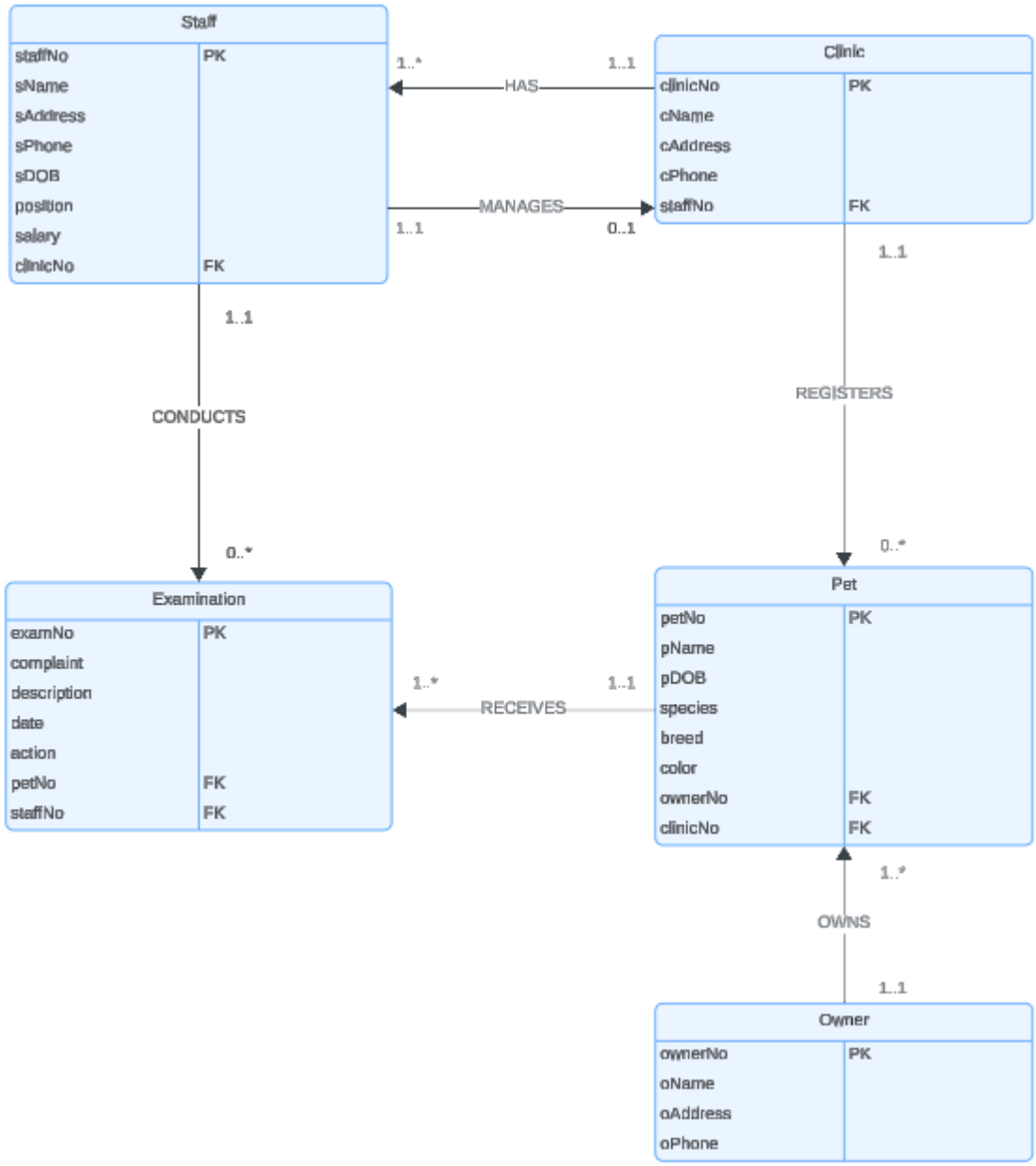
Relation	Attribute	Domain Constraints
Clinic	clinicNo	Integer, positive, unique, not NULL.
	cName	String, length ≤ 100, not NULL.
	cAddress	String, length ≤ 200, not NULL.
	cPhone	String, valid phone number format (length 10, contains digits only), not NULL.
Staff	staffNo	Integer, positive, unique, not NULL.
	sName	String, length ≤ 100, not NULL.
	sAddress	String, length ≤ 200, not NULL.
	sPhone	String, valid phone number format (length 10, contains digits only), not NULL.
	sDOB	Date, must be a valid date in the past, not NULL.
	position	String, length ≤ 50, not NULL.
	salary	Decimal, positive, not NULL.
	clinicNo	Integer, references Clinic.clinicNo, not NULL.
Owner	ownerNo	Integer, positive, unique, not NULL.
	oName	String, length ≤ 100, not NULL.
	oAddress	String, length ≤ 200, not NULL.

	oPhone	String, valid phone number format (e.g., length 10, contains digits only), not NULL.
Pet	petNo	Integer, positive, unique, not NULL.
	pName	String, length ≤ 100, not NULL.
	pDOB	Date, must be a valid date in the past, not NULL.
	species	String, length ≤ 50, not NULL.
	breed	String, length ≤ 50, not NULL.
	color	String, length ≤ 50, not NULL.
	ownerNo	Integer, references Owner.ownerNo, not NULL.
	clinicNo	Integer, references Clinic.clinicNo, not NULL.
Examination	examNo	Integer, positive, unique, not NULL.
	complaint	String, length ≤ 500, not NULL.
	description	String, length ≤ 1000, not NULL.
	date	Date, must be a valid date (past or current date), not NULL.
	action	String, length ≤ 500, not NULL.
	petNo	Integer, references Pet.petNo, not NULL.

vi. General constraints (if any).

Constraint	Description
Unique staff for Each Clinic	A staff member (staffNo) can manage at most one clinic. Enforced with a UNIQUE constraint on staffNo in the Clinic table.
Mandatory Clinic for Staff	Every staff member must be associated with exactly one clinic. Enforced by making clinicNo in the Staff table NOT NULL and referencing Clinic.clinicNo.
Mandatory Ownership for Pets	Every pet must belong to one owner. Enforced by making ownerNo in the Pet table NOT NULL and referencing Owner.ownerNo.
Mandatory Registration for Pets	Every pet must be registered to one clinic. Enforced by making clinicNo in the Pet table NOT NULL and referencing Clinic.clinicNo.
Mandatory Examination Links	Every examination must be linked to one valid pet (petNo) and one valid staff member (staffNo). Enforced by making petNo and staffNo in the Examination table NOT NULL and referencing their respective primary keys.
Valid Dates	sDOB (Staff Date of Birth) and pDOB (Pet Date of Birth) must be valid dates in the past. date in Examination must be a valid date, not in the future.
Valid Phone Numbers	All phone number fields (cPhone, sPhone, oPhone) must follow a standard format (length 10, digits only).
Salary Constraint	The salary attribute in the Staff table must be a positive decimal value.

e. Generate the E-R diagram for the logical level (contains FKs as attributes).



3. Translate the logical data model for the SQLite DBMS.

a. Develop SQL code to create the entire database schema, reflecting the constraints identified in previous steps.

b. Create at least 5 tuples for each relation in your database.

```
Data from Clinic:
(1, 'Happy Tails', '123 Pet Lane', '1234567890', None)
(6, 'Paws Miami', '101 Ocean Dr, Miami, FL', '3051234567', None)
(7, 'Pet Paradise', '202 Beach Ave, Miami, FL', '3052345678', None)
(8, 'Miami Paw Care', '303 Biscayne Blvd, Miami, FL', '3053456789', None)
(9, 'Happy Pets Miami', '404 Sunset Rd, Miami, FL', '3054567890', None)
(10, 'VetCare Miami', '505 Brickell Ave, Miami, FL', '3055678901', None)

Data from Staff:
(1, 'Alice', '456 Elm St', '1234567890', '1985-05-10', 'Veterinarian', 75000.0, 1)
(6, 'Carlos Mendez', '123 Ocean Dr, Miami, FL', '3051234567', '1980-11-10', 'Veterinarian', 85000.0, 6)
(7, 'Sofia Martinez', '234 Beach Ave, Miami, FL', '3052345678', '1992-06-15', 'Receptionist', 40000.0, 7)
(8, 'Daniela Garcia', '345 Biscayne Blvd, Miami, FL', '3053456789', '1995-03-05', 'Technician', 50000.0, 8)
(9, 'Ricardo Lopez', '456 Sunset Rd, Miami, FL', '3054567890', '1987-09-25', 'Veterinarian', 80000.0, 9)
(10, 'Maria Perez', '567 Brickell Ave, Miami, FL', '3055678901', '1990-01-18', 'Technician', 55000.0, 10)

Data from Owner:
(1, 'Jane Doe', '789 Oak St', '0987654321')
(6, 'Ana Rodriguez', '789 Bay Rd, Miami, FL', '7861234567')
(7, 'Juan Torres', '890 Coral Way, Miami, FL', '7862345678')
(8, 'Luis Alvarez', '567 Flagler St, Miami, FL', '7863456789')
(9, 'Elena Sanchez', '345 Little Havana, Miami, FL', '7864567890')
(10, 'Miguel Diaz', '123 Coconut Grove, Miami, FL', '7865678901')

Data from Pet:
(1, 'Buddy', '2020-05-01', 'Dog', 'Golden Retriever', 'Golden', 1, 1)
(6, 'Rocky', '2018-12-10', 'Dog', 'Bulldog', 'Brown', 6, 6)
(7, 'Luna', '2019-04-22', 'Cat', 'Sphynx', 'Beige', 7, 7)
(8, 'Max', '2021-08-05', 'Dog', 'Beagle', 'Tri-color', 8, 8)
(9, 'Milo', '2020-01-15', 'Rabbit', 'Holland Lop', 'White', 9, 9)
(10, 'Chloe', '2022-02-28', 'Bird', 'Parrot', 'Green', 10, 10)

Data from Examination:
(1, 'Limping', 'Examined leg; X-ray performed', '2023-11-01', 'Prescribed medication', 1, 1)
(6, 'Limping', 'Checked leg; no fracture found', '2023-01-15', 'Prescribed rest and pain relief', 6, 6)
(7, 'Hair Loss', 'Examined skin and conducted allergy test', '2023-02-10', 'Prescribed special shampoo', 7, 7)
(8, 'Coughing', 'Checked throat and chest X-ray', '2023-03-20', 'Prescribed antibiotics', 8, 8)
(9, 'Weight Loss', 'Blood tests and physical examination', '2023-04-25', 'Prescribed vitamins and diet plan', 9, 9)
(10, 'Broken Wing', 'X-ray and bandage applied', '2023-05-15', 'Scheduled follow-up', 10, 10)
```

c. Develop the 5 SQL queries that correspond to 2c using embedded SQL.

```
New pet added successfully.
New examination recorded successfully.
New staff member assigned to a clinic successfully.
Clinic staff changed successfully.

Examination history for Pet 6:
(6, 'Limping', 'Checked leg; no fracture found', '2023-01-15', 'Prescribed rest and pain relief')
(11, 'Skin Rash', 'Applied ointment and prescribed medication', '2023-11-28', 'Follow-up in 2 weeks')
```

d. Upload all the code and documentation to GitHub.

https://github.com/Lizi0630/DataScienceProject2024