Exercise 1

Consider the relational schema R ={A, B, C, D} and F ={AB → C, B → D}. Let the following be an instance of the relational schema R.

r(R):

A	B	C	D
a1	b1	c1	d1
a2	b2	c2	d2
a3	b3	c3	d3

(a) What is the candidate key for R?

(b) Are the following operations valid? (Explain).

i) insert (a1, b4, c4, d4)?

ii) insert (a3, b4, c3, d4)?

iii) insert (a4, b4, c2, d5)?

(c) Is R in 2NF? If the answer is no, briefly explain why.

(d) Is R in BCNF? If the answer is no, briefly explain why.

Answer.

(a) The candidate key is the union of all attributes present in the left side of FDs:

AB is the only candidate key for R.

(b)

i) Yes

ii) Yes

iii) No, violates FD: B → D

(c) No. B is not a superkey in B → D

(d) No. AB is a candidate key, and B (in B → D) is included in the candidate key AB.

Exercise 2

Assume we have this relation and the following functional dependencies for the relational schema R:

R = { A , B , C , D , E , F , G , H , I , J , K , M }

FD1: A → { J , K }
FD2: B → { D , E }
FD3: F → { G , H }
FD4: I → { C }

1. What is the normal form of this relation? Why?
2. Decompose relation R until satisfying the highest normal form.

Answer.
1. This relation is in 1 NF because all attribute values are single and atomic.
FD1 and FD2 are partial dependencies; hence the relation is not in 2NF. For example attribute J in FD1 is functionally dependent on A only (Not A, B and C)

2. A decomposition to 2 NF is
R11(A, J, K)
R12(B, D, E)
R13(A, B, C, F, G, H, I, M)

3. FD3 violates 3NF as it is a transitive FD. Note that FD4 does not violate 3 NF because C is part of the PK.
A decomposition to 3NF is
R21(A, B, C, F, I, M)
R22(F, G, H)

4. FD4 violates BCNF as I is not a superkey. (R21(A, B, C, F, I, M))
A decomposition into BCNF is
R31(A, B, F, I, M)
R32(I, C)

The resulting decomposition of the relation R is:
R11(A, J, K)
R12(B, D, E)
R22(F, G, H)
R31(A, B, F, I, M) attribute I becomes part of the PK as I determines C that is removed
R32(I, C).

Exercise 3: If the set of functional dependencies F = {A → BC, CD → E, E → C, D → AEH, ABH → BD, DH → BC }, then what is the canonical cover of F?

Answer. {A → BC, E → C, D → AEH, AH → D}

Exercise 4: Consider a relation R with five attributes ABCDE. You are given the following dependencies: A → B, BC → E, and ED → A.

1. List all keys for R.
2. Is R in 3NF?
3. Is R in BCNF?

Answer.

1. ACD, BCD, ECD
2. Yes (All attributes belong to some superkey, hence it satisfies 3NF)
3. No (A, BC, ED are not superkeys in the relation R:Multiple overlapping Candidate Keys)

Exercise 5: For the following relation schema and set of FD's:

R(A,B,C,D) with FD's B → C, and B → D.

1. Indicate all 3 NF violations.
2. Decompose the relations, as necessary, into collections of relations that are in 3 NF.

Answer. R(A,B,C,D) with FD's B→ C and B→ D

1. Key is AB, 3NF violations are B→ C, B→ D (Violates 2NF also)

2. R1(BC) R2(BD) R3(BA)