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 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. 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. Is the normal form relation in BCNF? Why?

Answer.

1. This relation is in 1 NF because all attribute values are single and atomic. For example attribute J in FD1 is functionally dependent on A only (Not A, B and C)

2. 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)

3. 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,3NFviolations are B→ C, B→ D (Violates 2NF also)
2. R1(BC)R2(BD) R3(BA)

Exercise 6: Check relation is lossless or not.

R (R, N, H ,W, Rm , C , G)

FD = { R->NH , RC->G , RH->Rm , H->w}
Decompositions R1 -> (R,N,H, Rm)
R2 -> (H ,W)
R3 -> (R,C ,G)

ANSWER: lossless

	R	N	H	W	Rm	C	G
R1	a 1	a 2	a 3	~~b 14~~ a4	a 5	b 16	b 17
R2	b 21	b 22	a 3	a 4	b 25	b 26	b 27
R3	a 1	~~b 32~~ a2	~~b 33~~ a3	~~b 34~~ a4	~~b 35~~ a5	a 6	a 7