Exercise 3 - Solution

Q1.

No, AB+ = {A,B,C},a proper subset of {A,B,C,D,E}

Yes, ABD+ = {A,B,C,D,E}

Q2.

Let us use the following shorthand notation:

C = CourseNo, SN = SecNo, OD = OfferingDept, CH = CreditHours, CL = CourseLevel,

I = InstructorSSN, S = Semester, Y = Year, D = Days_Hours, RM = RoomNo,

NS = NoOfStudents

Hence, R = {C, SN, OD, CH, CL, I, S, Y, D, RM, NS}, and the following functional dependencies hold:

{C} -> {OD, CH, CL}

{C, SN, S, Y} -> {D, RM, NS, I}

{RM, D, S, Y} -> {I, C, SN}

First, we can calculate the closures for each left hand side of a functional dependency, since these sets of attributes are the candidates to be keys:

(1) {C}+ = {C, OD, CH, CL}

(2) Since {C, SN, S, Y} -> {D, RM, NS, I}, and {C}+ = {C, OD, CH, CL}, we get:

{C, SN, S, Y}+ = {C, SN, S, Y, D, RM, NS, I, OD, CH, CL} = R

(3) Since {RM, D, S, Y} -> {I, C, SN}, we know that {RM, D, S, Y}+ contains {RM, D, S, Y, I, C, SN}. But {C}+ contains {OD, CH, CL} so these are also contained in {RM, D, S, Y}+ since C is already there. Finally, since {C, SN, S, Y} are now all in {RM, D, S, Y}+ and {C, SN, S, Y}+ contains {NS} (from (2) above), we get:

{RM, D, S, Y}+ = {RM, D, S, Y, I, C, SN, OD, CH, CL, NS} = R

Hence, both K1 = {C, SN, S, Y} and K2 = {RM, D, S, Y} are (candidate) keys of R.

Q3.

Given relations

Order(O#, Odate, Cust#, Total_amt)

Order_Item(O#, I#, Qty_ordered, Total_price, Discount%),

the schema of Order * Order_Item looks like

T1(O#,I#,Odate, Cust#, Total_amount, Qty_ordered, Total_price, Discount%)

and its key is O#,I#.

It is not in 2NF, as attributes Odate, Cut#, and Total_amount are only partially dependent on the primary key, O#I#

Nor is it in 3NF, as a 2NF is a requirement for 3NF.

Q4.

(a)The key for this relation is Book_title,Authorname. This relation is in 1NF and not in 2NF as no attributes are FFD on the key. It is also not in 3NF.

(b)

3NF decomposition:

Book0(Book_title, Authorname)

Book1-1(Book_title, Publisher, Book_type)

Book1-2(Book_type, Listprice)

Book2(Authorname, Author_affil)

Q5.

(a)

- {M} IS NOT a candidate key since it does not functionally determine attributes Y or P.

- {M, Y} IS a candidate key since it functionally determines the remaining attributes P, MP, and C.

- {M, C} IS NOT a candidate key since it does not functionally determine attributes Y or P.

(b)

REFRIG is not in 2NF, due to the partial dependency {M, Y} -> MP (since {M} -> MP holds). Therefore REFRIG is neither in 3NF nor in BCNF.

Alternatively: BCNF can be directly tested by using all of the given dependencies and finding out if the left hand side of each is a superkey (or if the right hand side is a prime attribute). In the two fields in REFRIG: M -> MP and MP -> C. Since neither M nor MP is a superkey, we can conclude that REFRIG is is neither in 3NF nor in BCNF.

(c) Yes. Please follow the algorithm provided in the lecture notes.

Q6.

1) List the candidate keys for R.

EH/ABH/BDH/CDH

2) Determine the highest normal form of R with respect to F.

1NF. Non-prime attribute G is functionally determined by D.

Q7.

1) Is the decomposition $\{ABCD, DEGH\}$ (with the same FD set F) of R lossless-join?

No.

Decomposition	A	B	C	D	E	G	H
$R_1(A,B,C,D)$	a	a	a	**a**	b	b	b
$R_2(D,E,G,H)$	b	b	b	**a**	a	a	a

Decomposition	A	B	C	D	E	G	H
$R_1(A,B,C,D)$	a	a	a	a	b	**a**	b
$R_2(D,E,G,H)$	**a**	b	b	a	a	a	a

2) Find a minimal cover F_m for F.

$F_m = \{AB \to C, D \to A, D \to G, E \to B, AB \to D, E \to A, CD \to E\}$

Q8.

1) Decompose into a set of 3NF relations if it is not in 3NF. Make sure your decomposition is dependency-preserving and lossless-join.

For $F_m = \{AB \to C, D \to A, D \to G, E \to B, AB \to D, E \to A, CD \to E\}$:

From $AB \to C, AB \to D$, derive $R_1\{A,B,C,D\}$

From $D \to A, D \to G$, derive $R_2\{A,D,G\}$

From $E \to B, E \to A$, derive $R_3\{A,B,E\}$

From $CD \to E$, derive $R_4\{C,D,E\}$

None of the relation schemas contains a key of R, add one relation schema $R_5\{E,H\}$

2) Decompose it into a collection of BCNF relations if it is not in BCNF. Make sure your decomposition is lossless-join.

For $= \{AB \to CD, E \to D, ABC \to DE, E \to AB, D \to AG, ACD \to BE\}$:

Consider $AB \to CD$, AB is not a superkey, split R into $R_1\{A,B,C,D\}$ and $R_2\{A,B,E,G,H\}$

Consider $D \to A$ in $R_1\{A,B,C,D\}$, D is not a superkey, split R_1into $R_{11}\{A,D\}$ and $R_{12}\{B,C,D\}$

Consider $E \to AB$, E is not a superkey, split R_2 into $R_2\{A,B,E\}$ and $R_3\{E,G,H\}$

One of the possible lossless-join decompositions to BCNF is: R_{11}, R_{12}, R_2, R_3

Q9.

1) solution:

$F_m = \{A \to H, G \to A, E \to D, D \to G, E \to I, AB \to C, AB \to E, CD \to K\}$

2) solution:

ABJ, BDJ, BEJ, BGJ (any one is correct)

3) solution:

No.

Decomposition	A	B	C	D	E	K	G	H	I	J
$R_1(A,B,C)$	a	a	a	b	b	b	b	b	b	b
$R_2(D,E,K,G)$	b	b	b	a	a	a	a	b	b	b
$R_3(H,I,J)$	b	b	b	b	b	b	b	a	a	a

4) solution:

1NF.

Partial dependency: $A \xrightarrow{P} H$

Q10.

(1)

$F_m = \{A \to H, G \to A, E \to D, D \to G, E \to I, AB \to C, AB \to E, CD \to K\}$

From $A \to H$, derive $R_1(A,H)$

From $G \to A$, derive $R_2(A,G)$

From $E \to D, E \to I$, derive $R_3(E,D,I)$

From $D \to G$, derive $R_4(D,G)$

From $AB \to C, AB \to E$, derive $R_5(A,B,C,E)$

From $CD \to K$, derive $R_6(C,D,K)$

None of the relation schemas contains a key of R, add one relation schema $R_7(A,B,J)$

(2)

$F_m = \{A \rightarrow H, G \rightarrow A, E \rightarrow D, D \rightarrow G, E \rightarrow I, AB \rightarrow C, AB \rightarrow E, CD \rightarrow K\}$

Consider $A \rightarrow H$ for F_m： $R_1(A, H), R_2'(A, B, C, D, E, K, G, I, J)$

Consider $G \rightarrow A$ for R_2'： $R_2(A, G), R_3'(B, C, D, E, K, G, I, J)$

Consider $E \rightarrow D$ for R_3'： $R_3(E, D), R_4'(B, C, E, K, G, I, J)$

Consider E → I for R_4'： $R_4(E, I), R_5(B, C, E, K, G, J)$

One of the possible lossless-join decompositions is： R_1~R_5