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.

(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)

Q4.

(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.

Q5.

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.

3) 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

4) Find a minimal cover F_m for F.

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

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

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

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

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

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

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

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

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

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

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

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

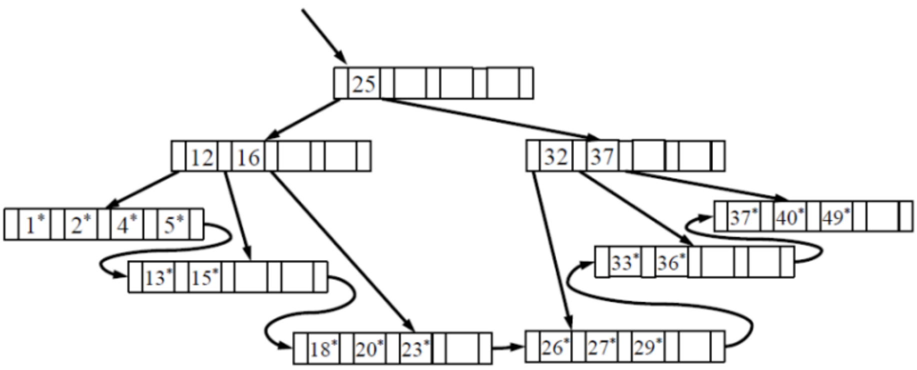
Consider $E \rightarrow AB$, E is not a superkey, split R_2 into $\boldsymbol{R_2\{A, B, E\}}$ and $R_3\{E, G, H\}$

Consider $E \rightarrow G$, E is not a superkey, split R_3 into $\boldsymbol{R_{31}\{E, G\}}$and $\boldsymbol{R_{32}\{E, H\}}$

One of the possible lossless-join decompositions to BCNF is: $R_{11}, R_{12}, R_2, R_{31}, R_{32}$

Q6.

1)



2) According to the definition of B+-tree, the biggest B+-tree for the same set of index entries will be the tree where every node is just "half full". Note that the answer is not unique.