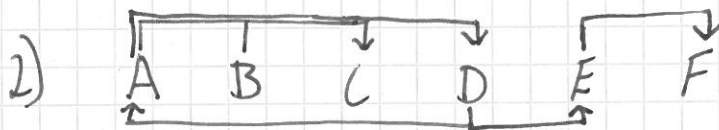


### Lab 3

1) a)  $R(A, B, C, D)$  where  $AB \rightarrow C$   
but  $A \rightarrow D$ . The latter does not  
fulfill 2NF.

b)  $R(A, B, C, D)$  where  $AB \rightarrow C$   
and  $C \rightarrow D$ . Again, the latter does  
not fulfill 3NF, as  $C$  is determinant for  $D$ .

c)  $R(A, B, C, D)$  where  $ABC \rightarrow D$   
but  $D \rightarrow C$ .



a)  $A \rightarrow D, D \rightarrow AE \models A \rightarrow AE$  transitive  
 $A \rightarrow AE \models A \rightarrow E$  reflexive

$A \rightarrow E, E \rightarrow F \models A \rightarrow F$  transitive

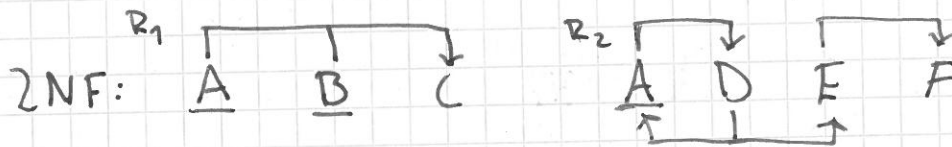
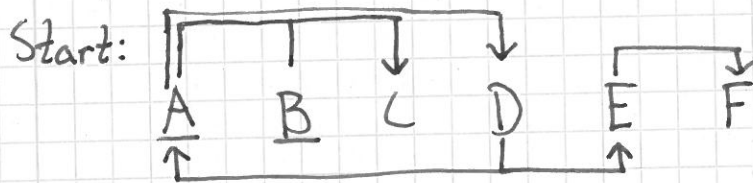
$A \rightarrow E, A \rightarrow F, A \rightarrow D \models A \rightarrow DEF$  union

$A \geq AB \models AB \rightarrow A$  reflexive

$AB \rightarrow A, A \rightarrow DEF \models AB \rightarrow DEF$  transitive

$AB \rightarrow DEF, AB \rightarrow C \models AB \rightarrow CDEF$  union

2) b)



For  $R_2$ , we have  $F = \{ \{A \rightarrow D\}, \{D \rightarrow AE\}, \{E \rightarrow F\} \}$

$A \rightarrow D, D \rightarrow AE \models A \rightarrow AE$  transitive

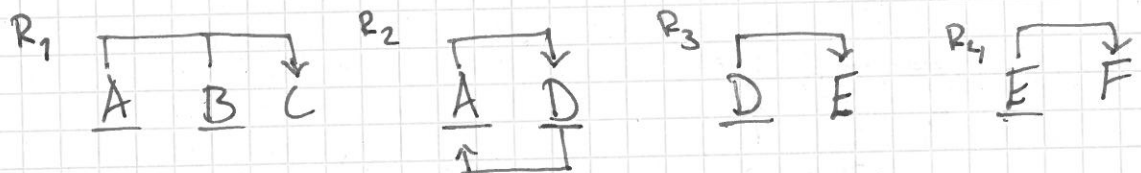
$A \rightarrow AE \models A \rightarrow E$  reflexive

$A \rightarrow E, E \rightarrow F \models A \rightarrow F$  transitive

$A \rightarrow D, A \rightarrow E, A \rightarrow F \models A \rightarrow DEF$  union

A becomes the primary key. Through similar reasoning, D could have been PK, making it an alternative key.

c.) 3NF



d) Already BCNF

3) a) BOOK(Title#, Title, Author#, BookType, Price, AuthorName, Publisher)

$\{ \{ \text{Title\#} \rightarrow \text{Title, BookType, Publisher} \}, \{ \text{Author\#} \rightarrow \text{AuthorName} \}, \{ \text{BookType} \rightarrow \text{Price} \} \}$

Title# and Author# are candidate keys.

b) No attribute depends on both key attributes, meaning we split the table, and make Author# a foreign key.

2NF: BOOK(Title#, Title, Author#, BookType, Price, Publisher)

AUTHOR(Author#, AuthorName)

3NF: BOOK(Title#, Title, Author#, BookType, Publisher)

AUTHOR(Author#, AuthorName)

BOOKTYPE(BookType, Price)

BCNF: No changes for BCNF

## 2) a) Komplettierung

In the previous hand-in, we only had AB. In addition to this, there should also be BD:

$$D \rightarrow AE \models D \rightarrow A \quad (\text{decomposition})$$

$$D \rightarrow AE \models D \rightarrow E \quad (\text{decomposition})$$

$$D \rightarrow E, E \rightarrow F \models D \rightarrow F \quad (\text{transitive})$$

$$D \rightarrow A, AB \rightarrow C \models BD \rightarrow C \quad (\text{psuedotransitive})$$

$$D \rightarrow A, D \rightarrow E, D \rightarrow F \models D \rightarrow AEF \quad (\text{union})$$

$$D \supseteq BD \models BD \rightarrow D \quad (\text{reflexive})$$

$$BD \rightarrow D, D \rightarrow AEF \models BD \rightarrow AEF \quad (\text{transitive})$$

$$BD \rightarrow AEF, BD \rightarrow C \models BD \rightarrow ALEF \quad (\text{union})$$

This gives A, B and D as prime attributes, and the remaining C, E and F as non-prime.

- 2) b) As we now know D to be prime, it can remain in  $R_1$  even though it is only dependent on part of the key.

$R = (A, B, C, D, E, F)$ , where candidate keys are AB, BD. As E depends on D, it is dependent on part of a CK and violates 2NF.

$$R_1 = (A, B, C, D) \quad R_2 = (D, E, F)$$

$$CK: AB, BD \quad CK: D$$

$$\{\{AB \rightarrow C\}, \{A \rightarrow D\}, \{D \rightarrow A\}\} \quad \{\{D \rightarrow E\}, \{E \rightarrow F\}\}$$

Now in 2NF

- c)  $R_1$  is already in 3NF.

$R_2$  must be broken up.

$$R_2 = (D, E) \quad R_3 = (E, F)$$

$$CK: D \quad CK: E$$

$$\{\{D \rightarrow E\}\} \quad \{\{E \rightarrow F\}\}$$

Now in 3NF

- d)  $R_2$  and  $R_3$  already in BCNF

$R_1$  must be broken up, as D is determined only by A.

$$R_1 = (A, B, C) \quad R_4 = (A, D)$$

$$CK: AB \quad CK: A$$

$$\{\{AB \rightarrow C\}\} \quad \{\{A \rightarrow D\}\}$$

3) b) As author# does not depend on title#, it was incorrect to make author# a foreign key of the BOOK entity. More correct would have been to split the entity into two completely disjunct entities, meaning we initially have three tables for 2NF:

BOOK = (Title#, Title, BookType, Publisher)

AUTHOR = (Author#, AuthorName)

PUBLICATION = (Title#, Author#)

For 3NF, move out BookType and Price.

BOOK = (Title#, Title, BookType)

BOOKTYPE = (BookType, Price)

Other two tables as in 2NF

No changes for BCNF.