Exercise 1
Consider a relation R(A, B, C, D, E) with the following dependencies:

\[ AB \rightarrow C \quad CD \rightarrow E \quad DE \rightarrow B \]

Is AB a candidate key of this relation?

No, \( AB^+ = \{ A, B, C \} \).

If not, is ABD?

Yes, \( ABD^+ = \{ A, B, C, D, E \} \).

Exercise 2
Consider the following relation:

\[ \text{CAR\_SALE(Car\#, DateSold, Salesman\#, Commission\%, DiscountAmount)} \]

Assume that a car may be sold by multiple salesmen, and hence \( \{\text{Car\#, Salesman\#}\} \) is the primary key. Additional dependencies are:

\[ \text{Car\# } \rightarrow \text{DateSold} \]
\[ \text{Car\# } \rightarrow \text{DiscountAmount} \]
\[ \text{DateSold } \rightarrow \text{DiscountAmount} \]
\[ \text{Salesman\# } \rightarrow \text{Commission\%} \]

Based on the given primary key, is the relation in 1NF, 2NF, 3NF?

Why or why not?

How would you successively normalize it completely?

Solution:

- The relation is in 1NF because all attribute values are single atomic values.
- The relation is not in 2NF because:
  - \( \text{Car\# } \rightarrow \text{DateSold} \)
  - \( \text{Car\# } \rightarrow \text{DiscountAmount} \)
  - \( \text{Salesman\# } \rightarrow \text{Commission\%} \)

Thus, these attributes are not fully functionally dependent on the primary key.
- 2NF decomposition:
  - \( \text{CAR\_SALE1(Car\#, DateSold, DiscountAmount)} \)
  - \( \text{CAR\_SALE2(Car\#, Salesman\#)} \)
  - \( \text{CAR\_SALE3(Salesman\#, Commission\%)} \)
- The relations are not in 3NF because:
  - \( \text{Car\# } \rightarrow \text{DateSold } \rightarrow \text{DiscountAmount} \)

Thus, DateSold is neither a key itself nor a subset of a key and DiscountAmount is not a prime attribute.
Exercise 3
Consider the following relation for published books:
BOOK(BookTitle, AuthorName, BookType, ListPrice, AuthorAffiliation, Publisher)
Suppose the following dependencies exist:
BookTitle → BookType, Publisher
BookType → ListPrice
AuthorName → AuthorAffiliation
What normal form is the relation in? explain your answer.
Apply normalization until you cannot decompose the relations further. State the reasons behind each decomposition.

Solution:
• The relation is in 1NF and not in 2NF as no attributes are fully functionally dependent on the key (BookTitle and AuthorName). It is also not in 3NF.
  • The relation is not in 2NF because:
    • BookTitle → Publisher, BookType
    • BookType → ListPrice
    • AuthorName → AuthorAffiliation
  Thus, these attributes are not fully functionally dependent on the primary key. The 2NF decomposition will eliminate the partial dependencies.
  • 2NF decomposition:
    • Book1(BookTitle, AuthorName)
    • Book2(BookTitle, BookType, ListPrice, Publisher)
    • Book3(AuthorName, AuthorAffiliation)

• The relations are not in 3NF because:
  • BookTitle → BookType → ListPrice
Thus, BookType is neither a key itself nor a subset of a key and ListPrice is not a prime attribute. The 3NF decomposition will eliminate the transitive dependency of Listprice.
• 3NF decomposition:
  • Book1(BookTitle, AuthorName)
  • Book2A(BookTitle, BookType, Publisher)
  • Book2B(BookType, ListPrice)
  • Book3(AuthorName, AuthorAffiliation)