

**Example 12.24** *Converting Second Normal Form to Third Normal Form*

The relation, ScheduleC, in Table 12.15 on page 755 (and repeated below) is already in second normal form. In Example 12.22 it was demonstrated that  $D = \{\text{Teaching Assistant}\}$  and  $B = \text{Instructor}$  show that ScheduleC is not in third normal form. The conversion algorithm suggests that ScheduleC can be decomposed into ScheduleC[ $D \cup \{B\}$ ] and ScheduleC[ $A - \{B\}$ ].

ScheduleC					
Course	Section	Semester	Instructor	Office	Teaching Assistant
MAT241	1	Fall	Gossett	CC 224	Nielsen
MAT241	2	Fall	Gossett	CC 224	Nielsen
MAT124M	1	Fall	Conrath	CC 225	Dowdey
MAT124M	2	Fall	Kinney	CC 229	Ness
MAT422	2	Fall	Kinney	CC 229	Ness
MAT124M	1	Spring	Conrath	CC 225	Berg

Table 12.15: ScheduleC

Thus, the algorithm suggests the decomposition into ScheduleC[Teaching Assistant, Instructor] (Table 12.24) and ScheduleC[Course, Section, Semester, Office, Teaching Assistant] (Table 12.21).

ScheduleC[Course, Section, Semester, Office, Teaching Assistant]					
Course	Section	Semester	Office	Teaching Assistant	
MAT241	1	Fall	CC 224	Nielsen	
MAT241	2	Fall	CC 224	Nielsen	
MAT124M	1	Fall	CC 225	Dowdey	
MAT124M	2	Fall	CC 229	Ness	
MAT422	2	Fall	CC 229	Ness	
MAT124M	1	Spring	CC 225	Berg	

Table 12.21: ScheduleC[Course, Section, Semester, Office, Teaching Assistant]

ScheduleC[Course, Section, Semester, Office, Teaching Assistant] is not in third normal form. To see this, list the essential functional dependencies.

$$\begin{aligned} \{\text{Course, Section, Semester}\} &\rightarrow \text{Office} \\ \{\text{Course, Section, Semester}\} &\rightarrow \text{Teaching Assistant} \\ \text{Teaching Assistant} &\rightarrow \text{Office} \end{aligned}$$

The functional dependency Teaching Assistant  $\rightarrow$  Office shows that this relation is not in third normal form.

Create two new relations, ScheduleC[Course, Section, Semester, Teaching Assistant] (Table 12.22) and ScheduleC[Teaching Assistant, Office] (Table 12.23).

ScheduleC[Course, Section, Semester, Teaching Assistant]			
Course	Section	Semester	Teaching Assistant
MAT241	1	Fall	Nielsen
MAT241	2	Fall	Nielsen
MAT124M	1	Fall	Dowdey
MAT124M	2	Fall	Ness
MAT422	2	Fall	Ness
MAT124M	1	Spring	Berg

Table 12.22: ScheduleC[Course, Section, Semester, Teaching Assistant]

Both of these new relations are in third normal form. The primary key for the first is {Course, Section, Semester}. There are no other choices for primary key and also no functional dependencies with D not the primary key. The second new relation has only one functional dependency (Teaching Assistant  $\rightarrow$  Office) whose left-hand side is its primary key. They must therefore be in third normal form.

ScheduleC[Teaching Assistant, Office]	
Teaching Assistant	Office
Nielsen	CC 224
Dowdey	CC 225
Ness	CC 229
Berg	CC 225

Table 12.23: ScheduleC[Teaching Assistant, Office]

The relation, ScheduleC[Teaching Assistant, Instructor] in Table 12.24 has only one functional dependency: Teaching Assistant  $\rightarrow$  Instructor. The primary key is therefore Teaching Assistant and this relation is in third normal.

ScheduleC[Teaching Assistant, Instructor]	
Teaching Assistant	Instructor
Nielsen	Gossett
Dowdey	Conrath
Ness	Kinney
Berg	Conrath

Table 12.24: ScheduleC[Teaching Assistant, Instructor]

The three relations, ScheduleC[Course, Section, Semester, Teaching Assistant] (Table 12.22), ScheduleC[Teaching Assistant, Office] (Table 12.23), and ScheduleC[Teaching Assistant, Instructor] (Table 12.24), form a third normal form decomposition for ScheduleC.