SECTION 8.2 *n*-ary Relations and Their Applications

2. We have to find all the solutions to this equation, making sure to include all the permutations. The 4-tuples are $(6,1,1,1)$, $(1,6,1,1)$, $(1,1,6,1)$, $(1,1,1,6)$, $(3,2,1,1)$, $(3,1,2,1)$, $(3,1,1,2)$, $(2,3,1,1)$, $(2,1,3,1)$, $(2,1,1,3)$, $(1,3,2,1)$, $(1,3,1,2)$, $(1,2,3,1)$, $(1,2,1,3)$, $(1,1,3,2)$, and $(1,1,2,3)$.

4. Primary keys are the domains that have all different entries.

a) The only primary key is *Course*. **b)** The only primary key is *Caurse_number*.

c) The only primary key is *Course_number*. **d)** The only primary key is *Departure_time*.

6. We see that the *Professar* field by itself is not a key, since there is more than one 5-tuple containing the same professor. We can make the identification of the tuple unique by including the course number as well, or by including the time as well. Thus either *Professor–Caurse_number* or *Professor–Time* will work. Note, however, that either of these might not work if more data are added, since different departments can have the same course number, and a professor can be teaching two courses in the same room at the same time (e.g., a graduate course and the undergraduate version of that same course).

8. **a)** The ISBN is unique for each book, and it is probably the one and only primary key (and certainly the best one in any case).

b) This would work as long as there were not two books published the same year (date is usually given only as a year) with the same title. In practice, this could easily not happen.

c) This would work as long as there were not two books with the same title and the same number of pages. In practice, this could possibly not happen, although it is perhaps less likely than in part **(b)**.

10. The selection operator picks out all the tuples that match the criteria. The 5-tuples in Table 7 that have A100 as their room are (Cruz, Zoology, 335, A100, 9:00 A.M.), (Cruz, Zoology, 412, A100, 8:00 A.M.), and (Farber, Psychology, 501, A100, 3:00 P.M.).

12. The selection operator picks out all the tuples that match the criteria. There is only one 4-tuple in Table 10 that has a quantity of at least 50 and project number 2, namely (9191, 2, 80, 4).

14. We keep only the second, third, and fifth columns, obtaining (b, c, e).

16. The table uses columns 1, 2, and 4 of Table 8. We start by deleting columns 3 and 5 from Table 8. Since no rows are duplicates of earlier rows, this table is the answer.

Airline	*Flight_number*	*Destination*
Nadir	122	Detroit
Acme	221	Denver
Acme	122	Anchorage
Acme	323	Honolulu
Nadir	199	Detroit
Acme	222	Denver
Nadir	322	Detroit

18. By definition, there are $5 + 8 - 3 = 10$ components.

20. Both sides of this equation pick out the subset of R consisting of those n-tuples satisfying both conditions C_1 and C_2. This follows immediately from the definitions of conjunction and the selection operator.

22. Both sides of this equation pick out the set of n-tuples that satisfy condition C, and furthermore are in R or S (or both, of course). This follows immediately from the definitions of union and the selection operator.

24. Both sides of this equation pick out the set of n-tuples that satisfy condition C, and are in R and are not in S. This follows immediately from the definitions of set difference and the selection operator.

26. Note that we lose information when we delete columns. Therefore we might have more in the second set than in the first, since it could be easier to be in the intersection in the second case. A simple example would be to let $R = \{(a, b)\}$ and $S = \{(a, c)\}$, $n = 2$, $m = 1$, and $i_1 = 1$. Then $R \cap S = \emptyset$, so $P_1(R \cap S) = \emptyset$. On the other hand, $P_1(R) = P_1(S) = \{(a)\}$, so $P_1(R) \cap P_1(S) = \{(a)\}$.

28. This is similar to Example 13.

a) We apply the selection operator with the condition "$1000 \leq$ Part_number ≤ 5000" to the 3-tuples given in Table 9, picking out those rows that have a part number in the indicated range. Then we choose the supplier field from those rows, and delete duplicates.

b) Five of the 3-tuples in the joined database satisfy the condition, namely (23, 1092, 1), (23, 1101, 3), (31, 4975, 3), (31, 3477, 2), and (33, 1001, 1). The suppliers appearing here are 23, 31, 33.

30. A primary key is a domain whose value determines the values of all the other domains. For this relation, this does not happen. The first domain is not a primary key, because, for example, the triples (1, 2, 3) and (1, 3, 5) are both in the relation (the terms form an arithmetic progression). Similarly, the triples (1, 3, 5) and (2, 3, 4) are both in the relation, so the second domain is not a key; and the triples (1, 3, 5) and (3, 4, 5) are both in the relation, so the third domain is not a key.

32. The primary key uniquely determines the n-tuple. Thus we can think of the n-tuple as a pair consisting of the primary key (in whichever field it lies) followed by the $(n-1)$-tuple consisting of the values from the other domains. The set of all such pairs is by definition the graph of the function from the subset of the domain of the primary key consisting of those values that appear, to the Cartesian product of the other $n-1$ domains.