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# Database Concepts

8th Edition

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David M. Kroenke • David J. Auer • Scott L. Vandenberg • Robert C. Yoder

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## Instructor's Manual

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Prepared by Robert C. Yoder

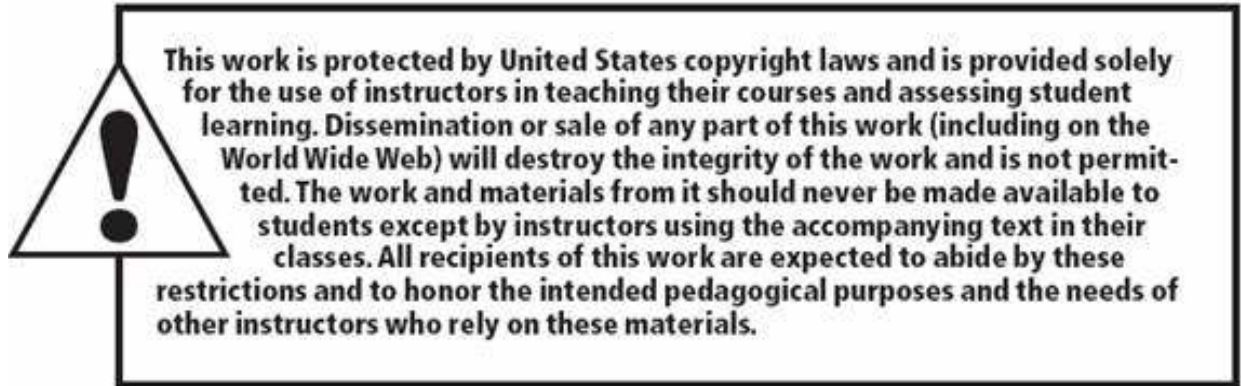
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### Chapter Two

### The Relational Model



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Instructor's Manual to accompany:

## ***Database Concepts (8th Edition)***

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**David M. Kroenke • David J. Auer • Scott L. Vandenberg • Robert C. Yoder**

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### ▶ CHAPTER OBJECTIVES

- Learn the conceptual foundation of the relational model
- Understand how relations differ from nonrelational tables
- Learn basic relational terminology
- Learn the meaning and importance of keys, foreign keys, and related terminology
- Understand how foreign keys represent relationships
- Learn the purpose and use of surrogate keys
- Learn the meaning of functional dependencies
- Learn to apply a process for normalizing relations

### ▶ CHAPTER ERRATA

There are no known errors at this time. Any errors that are discovered in the future will be reported and corrected in the Online DBC e08 Errata document, which will be available at <http://www.pearsonhighered.com/kroenke>.

### ▶ THE ACCESS WORKBENCH

Solutions to the *Access Workbench* exercises may be found in *Solutions to all Sections: The Access Workbench*, which is a separate document within the Instructor's Manual.

### ▶ TEACHING SUGGESTIONS

- The Art Course database discussed in Chapter 1 is a good database to use for an in-class demo of the concepts in this chapter. The DBMS screenshots in Chapter 2 use that database as the example database. See the list, data and database files supplied, and use the following:
  - Microsoft Access 2016:
    - “Art Course List” in DBC-e08-Lists-And-Data.xlsx
    - DBC-e08-Art-Course-Database-CH01.accdb
  - Microsoft SQL Server 2016 Developer Edition:
    - DBC-e08-MSSQL-Art-Course-Database-Create-Tables.sql
    - DBC-e08-MSSQL-Art-Course-Database-Insert-Data.sql
    - NOTE: Create a database diagram for the database

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- Oracle Database Express Edition (XE) 11g Release 2:
  - DBC-e08-ODB-Art-Course-Database-Create-Tables.sql
  - DBC-e08-ODB-Art-Course-Database-Insert-Data.sql
  - DBC-e08-ODB-Art-Course-Database-SQL-Queries-CH01.sql
- MySQL 5.7:
  - DBC-e08-MySQL-Art-Course-Database-Create-Tables.sql
  - DBC-e08-MySQL-Art-Course-Database-Insert-Data.sql
- The goal of this chapter is to present an overview of the major elements of the relational model. This includes the definition of a relation, important terminology, the use of surrogate keys, and basic design principles.
- Students often misconstrue the statement that only a single element is allowed in a cell to mean that the cells must be fixed in length. One can have a variable length memo in a cell but that is considered, semantically, to be one thing. By the way, there are a number of reasons for this restriction. Perhaps the easiest to explain is that SQL has no means for addressing sub-elements in a cell.
- When students execute SQL SELECTs, they may generate relations with duplicate rows. Such results do not fit the definition of relations, but they are considered relations nonetheless. This is a good example of “theory versus practice”.
- You may want to emphasize that foreign keys and the primary key that they reference need not have the same name. They must, however, have the same underlying set of values (domain). This means that the values not just look the same; it means that the values mean the same thing. A foreign key of CatName and a foreign key of ValentineNickName might look the same, but they do not mean the same thing. Using ValentineNickName as a foreign key to Name in the relation CAT would result in some weird results.
- Referential integrity constraints are important. You might ask the students to think of an example when a foreign key does not have a referential integrity constraint (answer: whenever a parent row is optional, say, STUDENTs need not have an ADVISER).
- We favor the use of surrogate keys. Unless there is a natural, numeric ID (like PartNumber), we almost always add a surrogate key to our database designs. Sometimes a surrogate key will be added even if there is a natural, numeric ID for consistency. Surrogate keys can cause problems (primarily patching up foreign keys) if the database imports data from other databases that either do not employ a surrogate key or use a different one. In some cases, institutions have developed policies for ensuring that surrogate keys are unique globally. It’s probably best for the students to get into the habit of using them and consider not using them as an exception. Professional opinions vary on this, however.

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- If you're using Oracle Database, then you'll need to teach the use of **sequences** to implement surrogate keys. Sequences are an awkward solution to this problem, however, and may be why surrogate keys are less used in the Oracle-world. Maybe there will be a better solution to them from Oracle in the future.
- The discussion of functional dependencies is critical—maybe the most important in the book. If students can understand that all tables do is record “data points” of functional dependencies, then normalization will be easier and seem more natural.
- In physics, because there are formulae like  $F = ma$ , we need not store tables and tables of data recording data points for force, mass, and acceleration. The formula suffices for all data points. However, there is no formula for computing how much a customer of, say, American Airlines, owes for his or her ticket from New York to Houston. If we could say the cost of an airline ticket was \$.05 per mile, then we could compute the cost of a ticket, and tables of airline flight prices would be unnecessary. But, we cannot; it all depends on ... So, we store the data points for functional dependencies in tables.
- If we use domain/key normal form as the ultimate, then, insofar as functional dependencies are concerned, the domain/key definition that “every constraint is a logical consequence of domains and keys,” comes down to Boyce-Codd Normal Form. Therefore, we proceed on good theoretical ground with the discussion as presented in this chapter.
- Students should understand the three ambiguities in a null value. This understanding will help them comprehend the issues addressed by INNER and OUTER joins in the next chapter.
- Exercises 2.40 and 2.41 deal with multivalued dependencies and fourth normal form (4NF). These are instructive as they show students how to deal with situations where the value of one column in a table is associated with several values of another attribute in (at least initially) the same table. This is an important concept, and after BCNF it is the next important concept students need to understand about normalization.

### ▶ ANSWERS TO REVIEW QUESTIONS

#### 2.1 *Why is the relational model important?*

It is the single most important standard in database processing and is used for the design and implementation of almost every commercial database worldwide.

#### 2.2 *Define the term **entity** and give an example of an entity (other than the one from this chapter).*

**Entity** is the formal name for a “thing” that is being tracked in a database, and is defined as something of importance to the user that needs to be represented in the database.

**Example:** TEXTBOOK

#### 2.3 *List the characteristics a table must have to be considered a relation. Define the term **domain**, and explain the significance of the **domain integrity constraint** to a relation.*

- Rows contain data about an entity.
- Columns contain data about attributes of the entity.
- Cells of the table hold a single value.
- All entries in a column are of the same kind.
- Each column has a unique name.
- The order of the columns is unimportant.
- The order of the rows is unimportant.

A domain is a set of data that is of the same data type, and further, has the domain integrity constraint in that they must come from a set of allowed values, like the set of player positions on a baseball team.

#### 2.4 *Give an example of a relation (other than one from this chapter).*

**Example:** TEXTBOOK (ISBN, Title, Publisher, Copyright)

#### 2.5 *Give an example of a table that is not a relation (other than one from this chapter).*

**Example:** TEXTBOOK (ISBN, Title, Publisher, Copyright, Authors)

A table is not a relation when there are multiple author names in the Authors column.

#### 2.6 *Under what circumstances can an attribute of a relation be of variable length?*

It can be of a variable length, if that attribute is considered to be a single thing like a memo or other variable length data item.

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2.7 *Explain the use of the terms **file**, **record**, and **field**.*

These terms are synonyms for table, row, and column. These terms, however, generally refer to pre-relational bases.

2.8 *Explain the use of the terms **relation**, **tuple**, and **attribute**.*

These terms are synonyms for table, row, and column. These terms, however, are the ones used in relational database theory.

2.9 *Under what circumstances can a relation have duplicate rows?*

When manipulating a relation with a DBMS we may end up with duplicate rows. Although in theory we should eliminate the duplicates, in practice this is often not done.

2.10 *Define the term **unique key** and give an example.*

A unique key is a column whose values identify one and only one row.

**Example:** TEXTBOOK (ISBN, Title, Publisher, Copyright)

where **ISBN** is a unique identifier.

2.11 *Define the term **nonunique key** and give an example.*

A nonunique key not only identifies a row, but it potentially identifies more than one row.

**EXAMPLE:** TEXTBOOK (ISBN, Title, Publisher, Copyright)

**Publisher** is a nonunique identifier.

2.12 *Give an example of a relation with a unique composite key.*

**EXAMPLE:** APARTMENT (BuildingNumber, ApartmentNumber, NumberOfBedrooms, Rent)

where (**BuildingNumber, ApartmentNumber**) is a unique composite key.

2.13 *Define the terms **candidate key** and **primary key**. Explain the difference between a **primary key** and a **candidate key**. Explain the significance of the **entity integrity constraint** to a primary key.*

All candidate keys are unique identifiers. Any of the candidate keys could be the primary key, but one of the candidate keys is chosen to be the primary key for the relation and for foreign keys based on the relation. The other candidate keys will remain in the relation as alternate keys. The *entity integrity constraint* simply means that each value in a primary key must be unique with respect to the other values of the primary key in the relation.



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### 2.14 Describe four uses of a primary key.

A primary key can be used

- to identify a row.
- to represent the row in foreign keys.
- to organize storage for the relation.
- as a basis for indexes and other structures to facilitate searching in storage.

### 2.15 What is a **surrogate key**, and under what circumstances would you use one?

A surrogate key is a unique, numeric identifier that is appended to a relation to serve as the primary key. Surrogate keys are convenient and may improve database performance particularly when the candidate keys are composite and have long fields in them.

### 2.16 How do surrogate keys obtain their values?

They are supplied automatically by the DBMS.

### 2.17 Why are the values of surrogate keys normally hidden from users on forms, queries, and reports?

Surrogate keys are normally hidden because they usually have no meaning to the users.

### 2.18 Explain the term **foreign key** and give an example.

A foreign key creates the relationship between the tables; its key value corresponds to a primary key in a relation other than the one where the key is a primary key.

**EXAMPLE:**     **TEXTBOOK** (ISBN, Title, *Publisher*, Copyright)

**PUBLISHER** (PublisherName, Street, City, State, Zip)

**Publisher** in TEXTBOOK is a foreign key that references the primary key **PublisherName** in PUBLISHER.

### 2.19 Explain how primary keys and foreign keys are denoted in this book.

Primary keys are underlined and foreign keys are in italics.

### 2.20 Define the term **referential integrity constraint** and give an example of one. How does the referential integrity constraint contribute to database integrity?

The **referential integrity constraint** is a rule specifying that every value of a foreign key matches a value of the primary key. It contributes to database integrity by ensuring that every row in a “child” relation connects to a “parent” relation, preventing errors in data entry.

**Example:** **Publisher** in TEXTBOOK must exist in PublisherName in PUBLISHER.

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2.21 *Explain three possible interpretations of a null value.*

Three possible interpretations are:

- No value is appropriate for that attribute
- The value is known to be blank for that attribute
- Some value or values are appropriate but we don't know which one it is yet

2.22 *Give an example of a null value (other than one from this chapter), and explain each of the three possible interpretations for that value.*

An example of null value would be: Null value for the attribute DeceasedDate in the table SUBSCRIBER.

- The subscriber may be a corporation and a value is inappropriate.
- The subscriber may be alive, and the value is known to be blank.
- The subscriber may be dead, but the date of death is unknown, and the value is appropriate, but not none.

2.23 *Define the terms **functional dependency** and **determinant**, using an example not from this book.*

A functional dependency is a logical relationship in which the value of one item in the relationship can be determined by knowing the value of the other item.

**EXAMPLE: ISBN → Title**

This means that if the ISBN (of a textbook) is known, then we will also know (can determine) the only title for that ISBN. The item on the left—the one whose value is known—is called the **determinant**.

2.24 *In the following equation, name the functional dependency and identify the determinant(s):*

$$\text{Area} = \text{Length} \times \text{Width}$$

The functional dependency is:

$$(\text{Length}, \text{Width}) \rightarrow \text{Area}$$

(Length, Width) is the determinant.

Note this is different than saying “Length and Width are the determinants” because we need both.

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2.25 Explain the meaning of the following expression:

$$A \rightarrow (B, C)$$

Given this expression, tell if it is also true that:

$$A \rightarrow B$$

and

$$A \rightarrow C$$

Answer: the functional dependency:

$$A \rightarrow (B, C)$$

means that a value of A determines the value of both B and C.

We can say that  $A \rightarrow B$  and  $A \rightarrow C$

2.26 Explain the meaning of the following expression:

$$(D, E) \rightarrow F$$

Given this expression, tell if it is also true that:

$$D \rightarrow F$$

and

$$E \rightarrow F$$

The functional dependency:

$$(D, E) \rightarrow F$$

means that values of the pair (D, E) determine the value of F, since we need both values.

We **cannot** say that

$$D \rightarrow F \text{ and } E \rightarrow F$$

2.27 Explain the differences in your answers to questions 2.25 and 2.26.

$A \rightarrow (B, C)$  is just shorthand for  $A \rightarrow B$  and  $A \rightarrow C$

However,  $(D, E) \rightarrow F$  means that the composite, as a whole, identifies F.

For example:  $\text{EmployeeNumber} \rightarrow (\text{FirstName}, \text{LastName})$

This means that  $\text{EmployeeNumber} \rightarrow \text{FirstName}$

and that  $\text{EmployeeNumber} \rightarrow \text{LastName}$ .

But:  $(\text{FirstName}, \text{LastName}) \rightarrow \text{HireDate}$

does *not* mean that  $\text{FirstName} \rightarrow \text{HireDate}$  (There could be lots of employees named “Bob”.)

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2.28 Define the term **primary key** in terms of functional dependencies.

A primary key is one or more attributes that functionally determines all of the other attributes in the relation.

2.29 If you assume that a relation has no duplicate data, how do you know there is always at least one primary key?

Because the collection of **all** the attributes in the relation can identify a unique row.

2.30 How does your answer to question 2.29 change if you allow a relation to have duplicate data?

It doesn't work—such tables do not have a primary key.

2.31 In your own words, describe the nature and purpose of the normalization process.

The purpose of the normalization process is to prevent update problems in the tables (relations) in the database. The nature of the normalization process is that we break up relations as necessary to ensure that every determinant is a candidate key. Each relation will only have one theme in it.

2.32 Examine the data in the Veterinary Office List—Version One in Figure 1-34 (see page 63), and state assumptions about functional dependencies in that table. What is the danger of making such conclusions on the basis of sample data?

**PetName** → (PetType, PetBreed, PetDOB, OwnerLastName, OwnerFirstName, OwnerPhone, OwnerEmail)

**OwnerEmail** → (OwnerLastName, OwnerFirstName, OwnerPhone)

**OwnerPhone** → (OwnerLastName, OwnerFirstName, OwnerEmail)

The danger is that there may be valid possibilities not apparent from sample data. For example, two owners might have pets with the same name.

2.33 Using the assumptions you stated in your answer to question 2.32, what are the determinants of this relation? What attribute(s) can be the primary key of this relation?

Attributes that can be the primary key are called candidate keys.

**Determinants:** PetName, OwnerEmail, OwnerPhone

**Candidate keys:** PetName

2.34 Describe a modification problem that occurs when changing data in the relation in question 2.32 and a second modification problem that occurs when deleting data in this relation.

Changes to owner data may need to be made in several rows.

Deleting data for the last pet of an owner deletes owner data as well.

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- 2.35 Examine the data in the Veterinary Office List—Version Two in Figure 1-35 (see page 63), and state assumptions about functional dependencies in that table.

**PetName** → (PetType, PetBreed, PetDOB, OwnerLastName, OwnerFirstName, OwnerPhone, OwnerEmail)

**OwnerEmail** → (OwnerLastName, OwnerFirstName, OwnerPhone)

**OwnerPhone** → (OwnerLastName, OwnerFirstName, OwnerEmail)

**(PetName, Date)** → (Service, Charge)

The last functional dependency assumes a pet is seen at most on one day and that there is no standard charge for a service.

- 2.36 Using the assumptions you stated in your answer to question 2.35, what are the determinants of this relation? What attribute(s) can be the primary key of this relation?

**Determinants:** PetName, OwnerEmail, OwnerPhone, (PetName, Date)

**Candidate keys:** (PetName, Date)

- 2.37 Explain a modification problem that occurs when changing data in the relation in question 2.35 and a second modification problem that occurs when deleting data in this relation.

Same as 2.34:

Changes to owner data may need to be made in several rows.

Deleting data for the last pet of an owner deletes owner data as well.



### ANSWERS TO EXERCISES

- 2.38 Apply the normalization process to the Veterinary Office List—Version One relation shown in Figure 1-34 (see page 63) to develop a set of normalized relations. Show the results of each of the steps in the normalization process.

#### **STEP ONE:**

**PET-AND-OWNER** (PetName, PetType, PetBreed, PetDOB, OwnerLastName, OwnerFirstName, OwnerPhone, OwnerEmail)

#### **Functional Dependencies:**

**PetName** → (PetType, PetBreed, PetDOB, OwnerLastName, OwnerFirstName, OwnerPhone, OwnerEmail)

**OwnerEmail** → (OwnerLastName, OwnerFirstName, OwnerPhone)

**OwnerPhone** → (OwnerLastName, OwnerFirstName, OwnerEmail)

**PET-AND-OWNER Candidate Keys:** PetName

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*Is every determinant a candidate key?*

NO—OwnerEmail and OwnerPhone are NOT candidate keys.

**STEP TWO:**

Break into two relations: OWNER and PET

OWNER (OwnerLastName, OwnerFirstName, OwnerPhone, OwnerEmail)

PET (PetName, PetType, PetBreed, PetDOB, {Foreign Key})

**FOR OWNER:**

*Functional Dependencies:*

OwnerEmail → (OwnerLastName, OwnerFirstName, OwnerPhone)

OwnerPhone → (OwnerLastName, OwnerFirstName, OwnerEmail)

**OWNER Candidate Keys:** OwnerPhone, OwnerEmail

*Is every determinant a candidate key?*

YES—OwnerEmail and OwnerPhone are candidate keys—Normalization complete!

We can choose either candidate key as primary key.

(A) IF WE USE OwnerPhone as primary key, THEN:

OWNER (OwnerPhone, OwnerLastName, OwnerFirstName, OwnerEmail)

PET (PetName, PetType, PetBreed, PetDOB, OwnerPhone)

*Functional Dependencies:*

PetName → (PetType, PetBreed, PetDOB, OwnerPhone)

**PET Candidate Keys:** PetName

*Is every determinant a candidate key?*

YES—PetName is a candidate key—Normalization complete!

**FINAL NORMALIZED RELATIONS:**

OWNER (OwnerPhone, OwnerLastName, OwnerFirstName, OwnerEmail)

PET (PetName, PetType, PetBreed, PetDOB, OwnerPhone)

(B) IF WE USE OwnerEmail as primary key, THEN:

OWNER (OwnerPhone, OwnerLastName, OwnerFirstName, OwnerEmail)

PET (PetName, PetType, PetBreed, PetDOB, OwnerEmail)

*Functional Dependencies:*

PetName → (PetType, PetBreed, PetDOB, OwnerEmail)

**PET Candidate Keys:** PetName

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*Is every determinant a candidate key?*

YES—PetName is a candidate key—Normalization complete! However, it may be unreasonable to require that PetName be unique.

**FINAL NORMALIZED REALTIONS:**

**OWNER** (OwnerPhone, OwnerLastName, OwnerFirstName, OwnerEmail)

**PET** (PetName, PetType, PetBreed, PetDOB, OwnerEmail)

- 2.39 Apply the normalization process to the Veterinary Office List—Version Two relation shown in Figure 1-35 (see page 63) to develop a set of normalized relations. Show the results of each of the steps in the normalization process.

**STEP ONE:**

**PET-AND-OWNER** (PetName, PetType, PetBreed, PetDOB, OwnerLastName, OwnerFirstName, OwnerPhone, OwnerEmail, Service, Date, Charge)

**Functional Dependencies:**

PetName → (PetType, PetBreed, PetDOB, OwnerLastName, OwnerFirstName, OwnerPhone, OwnerEmail)

OwnerEmail → (OwnerLastName, OwnerFirstName, OwnerPhone)

OwnerPhone → (OwnerLastName, OwnerFirstName, OwnerEmail)

(PetName, Date) → (Service, Charge)

The last functional dependency assumes a pet is seen at most on one day and that there is no standard charge for a service.

**PET-AND-OWNER Candidate Keys:** (PetName, Date)

*Is every determinant a candidate key?*

NO—PetName, OwnerEmail and OwnerPhone are NOT candidate keys.

**STEP TWO:**

Break into two relations: OWNER and PET-SERVICE

**OWNER** (OwnerLastName, OwnerFirstName, OwnerPhone, OwnerEmail)

**PET-SERVICE** (PetName, PetType, PetBreed, PetDOB, {Foreign Key}, Service, Date, Charge)

**FOR OWNER:**

**Functional Dependencies:**

OwnerEmail → (OwnerLastName, OwnerFirstName, OwnerPhone)

OwnerPhone → (OwnerLastName, OwnerFirstName, OwnerEmail)

**OWNER Candidate Keys:** OwnerPhone, OwnerEmail

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*Is every determinant a candidate key?*

**YES—OwnerEmail and OwnerPhone are candidate keys—Normalization complete!**

**We can choose either candidate key as primary key. We will use OwnerPhone.**

If a student chooses OwnerEmail, the steps will be similar as shown in Exercise 2.38.

**IF WE USE OwnerPhone as primary key, THEN:**

**OWNER (OwnerPhone, OwnerLastName, OwnerFirstName, OwnerEmail)**

**PET-SERVICE (PetName, PetType, PetBreed, PetDOB, *OwnerPhone*, Service, Date, Charge)**

**FOR PET-SERVICE:**

**Functional Dependencies:**

**PetName → (PetType, PetBreed, PetDOB, OwnerPhone)**

**(PetName, Date) → (Service, Charge)**

The last functional dependency assumes a pet is seen at most on one day and that there is no standard charge for a service.

**PET-AND-SERVICE Candidate Keys: (PetName, Date)**

*Is every determinant a candidate key?*

**NO—PetName is NOT a candidate key.**

**STEP THREE:**

**Break PET-SERVICE into two relations:           PET and SERVICE**

**OWNER (OwnerPhone, OwnerLastName, OwnerFirstName, OwnerEmail)**

**PET (PetName, PetType, PetBreed, PetDOB, *OwnerPhone*)**

**SERVICE (PetName, Date, Service, Charge)**

**PET Functional Dependencies:**

**PetName → (PetType, PetBreed, PetDOB, OwnerPhone)**

**PET Candidate Keys:                           PetName**

*Is every determinant a candidate key?*

**YES—PetName is a candidate key—Normalization complete!**

**SERVICE Functional Dependencies:**

**(PetName, Date) → (Service, Charge)**

The functional dependency assumes a pet is seen at most on one day and that there is no standard charge for a service.

**SERVICE Candidate Keys:                   (PetName, Date)**



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*Is every determinant a candidate key?*

YES—(PetName, Date) is a candidate key—Normalization complete!

FINAL NORMALIZED REALTIONS:

OWNER (OwnerPhone, OwnerLastName, OwnerFirstName, OwnerEmail)

PET (PetName, PetType, PetBreed, PetDOB, OwnerPhone)

SERVICE (PetName, Date, Service, Charge)

- 2.40 *What is the **multivalued, multicolumn problem**? What is a **multivalued dependency** and how is it resolved in 4NF? To answer these questions, consider the following relation:*

STUDENT (StudentNumber, StudentName, SiblingName, Major)

*Assume that the values of SiblingName are the names of all of a given student's brothers and sisters; also assume that students have at most one major.*

- A. *Define and discuss the **multivalued, multicolumn problem**. Define and discuss a **multivalued dependency**.*

The multivalued, multicolumn problem is basically a one-to-many relationship embedded in a single relation. A multivalued dependency is when a determinant is associated with a set of values. For example, suppose we want to store the names of children for each employee. We might be tempted to add a child1, child2, and perhaps a child3 attribute in the EMPLOYEE relation, or to duplicate the employee row for each child. This causes several problems. Duplicating data in rows will cause update anomalies. In addition, many employees may have less than three children, so many child attributes will remain blank. Suppose we hire a new employee with twelve children! We would have to add nine new child attributes to the EMPLOYEE relation AND change all SQL queries that display the children for each employee. It is best to split the relation so that the EMPLOYEE-CHILD relation is in a separate relation.

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- B. Show an example of this relation for two students, one of whom has three siblings and the other of whom has only two siblings.

StudentNumber	StudentName	SiblingName	Major
100	Mary Jones	Victoria	Accounting
100	Mary Jones	Slim	Accounting
100	Mary Jones	Reginald	Accounting
200	Fred Willows	Rex	Finance
200	Fred Willows	Billy	Finance

- C. List the candidate keys in this relation.

**STUDENT Candidate Keys:** (StudentNumber, SiblingName)

This assumes that StudentName is not unique.

- D. State the functional dependencies in this relation.

StudentNumber → (StudentName, Major)

(StudentNumber, SiblingName) → (StudentName, Major)

- E. Explain why this relation does not meet the relational design criteria set out in this chapter (i.e., why this is not a well-formed relation).

Some attributes are functionally dependent on a part of the composite primary key.

- F. Define and discuss 4NF and how 4NF can be used to allow a set of well-formed relations.

Multi-valued dependencies are directly handled by 4NF. The multiple values for each row in the original relation are split into a separate relation with a composite key consisting of the multi-value dependency attributes. Since StudentNumber multidetermines SiblingName, those two attributes should be placed into a new relation with the composite key (StudentNumber, SiblingName), and also the attribute SiblingName should be removed from the original relation.

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- G. Divide this relation into a set of relations that meet the relational design criteria (that is, that are well formed).

Break into two relations:      **STUDENT** and **STUDENT-SIBLING**

**STUDENT** (StudentNumber, StudentName, Major)

**STUDENT-SIBLING** (StudentNumber, SiblingName)

**FOR STUDENT-SIBLING:**

**Functional Dependencies:**

(StudentNumber, SiblingName) → (StudentNumber)

(StudentNumber, SiblingName) → (SiblingName)

**STUDENT-SIBLING Candidate Keys:**      (StudentNumber, SiblingName)

*Is every determinant a candidate key?*

**YES—(StudentNum, SiblingName) is a candidate key—Normalization complete!**

**FOR STUDENT:**

**STUDENT** (StudentNumber, StudentName, Major)

**Functional Dependencies:**

StudentNumber → (StudentName, Major)

**STUDENT Candidate Keys:**      StudentNumber

*Is every determinant a candidate key?*

**YES—StudentNumber is a candidate key—Normalization complete!**

**FINAL NORMALIZED REALTIONs:**

**STUDENT** (StudentNumber, StudentName, Major)

**STUDENT-SIBLING** (StudentNumber, SiblingName)

- 2.41 Alter question 2.40 to allow students to have multiple majors. In this case, the relational structure is:

**STUDENT** (StudentNumber, StudentName, SiblingName, Major)

- A. Define and discuss the **multivalued, multicolumn problem**. Define and discuss a **multivalued dependency**.

See the answer to Part A of Question 2.40 above.

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- B. Show an example of this relation for two students, one of whom has three siblings and the other of whom has one sibling. Assume that each student has a single major.

StudentNumber	StudentName	SiblingName	Major
100	Mary Jones	Victoria	Accounting
100	Mary Jones	Slim	Accounting
100	Mary Jones	Reginald	Accounting
200	Fred Willows	Rex	Finance

- C. Show the data changes necessary to add a second major for only the first student.

StudentNumber	StudentName	SiblingName	Major
100	Mary Jones	Victoria	Accounting
100	Mary Jones	Slim	Accounting
100	Mary Jones	Reginald	Accounting
200	Fred Willows	Rex	Finance
100	Mary Jones	Victoria	InfoSystems
100	Mary Jones	Slim	InfoSystems
100	Mary Jones	Reginald	InfoSystems

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- D. Based on your answer to part C, show the data changes necessary to add a second major for the second student.

StudentNumber	StudentName	SiblingName	Major
100	Mary Jones	Victoria	Accounting
100	Mary Jones	Slim	Accounting
100	Mary Jones	Reginald	Accounting
200	Fred Willows	Rex	Finance
100	Mary Jones	Victoria	InfoSystems
100	Mary Jones	Slim	InfoSystems
100	Mary Jones	Reginald	InfoSystems
200	Fred Willows	Rex	Accounting

- E. Explain the differences in your answers to parts C and D. Comment on the desirability of this situation.

We had to add three rows in the first case—one major for each of the siblings of the student. If we didn't do that, it would appear the student has a sibling with one major, but doesn't have the sibling as a second major. We only had to add a single row for the student with only one sibling. You can see how the redundant data is rapidly growing.

- F. Define and discuss 4NF and how 4NF can be used to allow a set of well-formed relations.

See the answer to Part F of Question 2.40 above.

- G. Divide this relation into a set of well-formed relations.

If we split STUDENT into two relations, STUDENT and STUDENT-SIBLING, then we get:

**STUDENT** (StudentNumber, StudentName, Major)

**STUDENT-SIBLING** (StudentNumber, SiblingName)

The relation is identical to the STUDENT-SIBLING relation in 2.40 above, and is properly normalized. Now we need to check STUDENT-MAJOR.

**FOR STUDENT:**

**STUDENT** (StudentNumber, StudentName, Major)

**Functional Dependencies:**

**StudentNumber** → (StudentName)

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$(\text{StudentNumber}, \text{Major}) \rightarrow \text{StudentName}$

**STUDENT Candidate Keys:**  $(\text{StudentNumber}, \text{Major})$

*Is every determinant a candidate key?*

NO—StudentNumber is NOT a candidate key.

Break into two relations: **STUDENT-2** and **STUDENT-MAJOR**

**STUDENT-2** (StudentNumber, StudentName)

**STUDENT-MAJOR** (StudentNumber, Major)

**FOR STUDENT-2:**

**Functional Dependencies:**

$\text{StudentNumber} \rightarrow \text{StudentName}$

**STUDENT\_2 Candidate Keys:** **StudentNumber**

*Is every determinant a candidate key?*

YES—StudentNumber is a candidate key—Normalization complete!

**FOR STUDENT-MAJOR:**

**Functional Dependencies:**

$(\text{StudentNumber}, \text{Major}) \rightarrow \text{StudentNumber}$

$(\text{StudentNumber}, \text{Major}) \rightarrow \text{Major}$

**STUDENT\_2 Candidate Keys:**  $(\text{StudentNumber}, \text{Major})$

*Is every determinant a candidate key?*

YES— $(\text{StudentNumber}, \text{Major})$  is a candidate key—Normalization complete!

**FINAL NORMALIZED REALTIONS:**

**STUDENT-2** (StudentNumber, StudentName)

**STUDENT-MAJOR** (StudentNumber, Major)

**STUDENT-SIBLING** (StudentNumber, SiblingName)

- 2.42 *The text states that you can argue that “the only reason for having relations is to store instances of functional dependencies.” Explain, in your own words, what this means.*

In a properly normalized relation, each row of the relation consists of a primary key value (which is a determinant) and attribute values (which are all functionally dependent on the primary key). Thus, properly normalized relations store instances of functional dependencies, and only instances of functional dependencies. So we can say that the purpose of relations is to store instances of functional dependencies.

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2.43 Consider a table named *ORDER\_ITEM*, with data as shown in Figure 2-26. The schema

	OrderNumber	SKU	Quantity	Price
1	1000	201800	1	300.00
2	1000	202800	1	130.00
3	2000	101100	4	50.00
4	2000	101200	2	50.00
5	3000	103200	1	300.00
6	3000	101100	2	50.00
7	3000	101200	1	50.00

for *ORDER\_ITEM* is:

**ORDER\_ITEM (OrderNumber, SKU, Quantity, Price)**

Where SKU is a “Stock Keeping Unit” number, which is similar to a part number. Here it indicates which product was sold on each line of the table. Note that one OrderNumber must have at least one SKU associated with it, and may have several. Use this table and the detailed discussion of normal forms on pages 99-100 to answer the following questions.

- A. Define 1NF. Is *ORDER\_ITEM* in 1NF? If not, why not, and what would have to be done to put it into 1NF? Make any changes necessary to put *ORDER\_ITEM* into 1NF. If this step requires you to create an additional table, make sure that the new table is also in 1NF.

First Normal Form is any table that meets the definition of a relation (Figure 2.1 below). *ORDER\_ITEM* is in 1NF.

1. Rows contain data about an entity
2. Columns contain data about attributes of the entity
3. Cells of the table hold a single value
4. All entries in a column are of the same kind
5. Each column has a unique name
6. The order of the columns is unimportant
7. The order of the rows is unimportant
8. No two rows may hold identical sets of data values

- B. Define 2NF. Now that *ORDER\_ITEM* is in 1NF, is it also in 2NF? If not, why not, and what would have to be done to put it into 2NF? Make any changes necessary to put *ORDER\_ITEM* into 2NF. If this step requires you to create an additional table, make sure that the new table is also in 2NF.

Second Normal Form is any table that 1) is in First Normal Form, and 2) all nonkey attributes are determined by the entire primary key. In this case, the Primary Key is OrderNumber, SKU. Because SKU alone determines Price (SKU → Price), *ORDER\_ITEM* is NOT in 2NF. This is solved by creating another table (PRODUCT), where SKU is both the Primary Key and Foreign Key in PRODUCT, and Price is moved out of *ORDER\_ITEM* and into the PRODUCT Table.

**ORDER\_ITEM (OrderNumber, SKU, Quantity)**

**PRODUCT (SKU, Price)**

- C. *Define 3NF. Now that ORDER\_ITEM is in 2NF, is it also in 3NF? If not, why not, and what would have to be done to put it into 3NF? Make any changes necessary to put ORDER\_ITEM into 3NF. If this step requires you to create an additional table, make sure that the new table and any other tables created in previous steps are also in 3NF.*

Third Normal Form is any table that 1) is in Second Normal Form, and 2) and no nonkey attributes are determined by any other nonkey attributes. Because the original question was not in Second Normal Form, it was NOT in Third Normal Form. The solution in B fixes this problem, and then both ORDER\_ITEM and PRODUCT are in Third Normal Form, and no nonkey attribute determines another nonkey attribute.

- D. *Define BCNF. Now that ORDER\_ITEM is in 3NF, is it also in BCNF? If not, why not, and what would have to be done to put it into BCNF? Make any changes necessary to put ORDER\_ITEM into BCNF. If this step requires you to create an additional table, make sure that the new table and any other tables created in previous steps are also in BCNF.*

BCNF is any table that 1) is in Third Normal Form, and 2) and **all** determinants are candidate keys. Because the original question was not in Second Normal Form, it was NOT in BCNF. The solution in B fixes this problem, and then both ORDER\_ITEM and PRODUCT are in BCNF, and all determinants are candidate keys.

### ▶ ANSWERS TO REGIONAL LABS CASE QUESTIONS

*Regional Labs is a company that conducts research and development work on a contract basis for other companies and organizations. Figure 2-33 shows data that Regional Labs collects about projects and the employees assigned to them.*

*This data is stored in a relation (table) named PROJECT:*

#### PROJECT (ProjectID, EmployeeName, EmployeeSalary)

FIGURE 2-33

Sample Data for  
Regional Labs

ProjectID	EmployeeName	EmployeeSalary
100-A	Eric Jones	64,000.00
100-A	Donna Smith	70,000.00
100-B	Donna Smith	70,000.00
200-A	Eric Jones	64,000.00
200-B	Eric Jones	64,000.00
200-C	Eric Parks	58,000.00
200-C	Donna Smith	70,000.00
200-D	Eric Parks	58,000.00



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A. Assuming that all functional dependencies are apparent in this data, which of the following are true?

1. **ProjectID** → **EmployeeName** **FALSE**
2. **ProjectID** → **EmployeeSalary** **FALSE**
3. **(ProjectID, EmployeeName)** → **EmployeeSalary**  
**TRUE**, but only if **EmployeeName** → **EmployeeSalary**
4. **EmployeeName** → **EmployeeSalary** **TRUE**
5. **EmployeeSalary** → **ProjectID** **FALSE**
6. **EmployeeSalary** → **(ProjectID, EmployeeName)** **FALSE**

B. What is the primary key of PROJECT?

**(ProjectID, EmployeeName)**

C. Are all the nonkey attributes (if any) dependent on the primary key?

**NO**, EmployeeSalary is dependent only on EmployeeName

D. In what normal form is PROJECT?

**1NF ONLY**

E. Describe two modification anomalies that affect PROJECT.

The two modification anomalies that affect PROJECT are:

**INSERTION:** To give an employee a salary, we must first assign the employee to a project.

**MODIFICATION:** If we change a Salary, we have to change it in multiple places and may create inconsistent data.

F. Is ProjectID a determinant? If so, based on which functional dependencies in part A?

**NO**

G. Is EmployeeName a determinant? If so, based on which functional dependencies in part A?

**YES** **EmployeeName** → **EmployeeSalary**

H. Is (ProjectID, EmployeeName) a determinant? If so, based on which functional dependencies in part A?

**YES** **(ProjectID, EmployeeName)** → **EmployeeSalary**

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I. *Is EmployeeSalary a determinant? If so, based on which functional dependencies in part A?*

**NO** Actually, for the data in Figure 2-33, it is a determinant. However, the dataset is **too small** to validate this determinant, and logically EmployeeSalary is *not* a determinant!

J. *Does this relation contain a transitive dependency? If so, what is it?*

**NO**

K. *Redesign the relation to eliminate modification anomalies.*

The following seems workable:

**ASSIGNMENT** (ProjectID, EmployeeName)

**SALARY** (EmployeeName, EmployeeSalary)



### ANSWERS TO GARDEN GLORY PROJECT QUESTIONS

*Garden Glory is a partnership that provides gardening and yard maintenance services to individuals and organizations. Garden Glory is owned by two partners. They employ two office administrators and a number of full- and part-time gardeners. Garden Glory will provide one-time garden services, but it specializes in ongoing service and maintenance. Many of its customers have multiple buildings, apartments, and rental houses that require gardening and lawn maintenance services.*

Figure 2-34 shows data that Garden Glory collects about properties and services.

FIGURE 2-34

Sample Data for Garden Glory

PropertyName	Type	Street	City	ZIP	ServiceDate	Description	Amount
Lastlake Building	Office	123 Lastlake	Seattle	98119	5/5/2014	Lawn Mow	\$ 72.50
Lim St Apts	Apartment	4 East Lim	Lynnwood	98223	5/8/2014	Lawn Mow	\$ 120.50
Jefferson Hill	Office	42 West 7th St	Bellevue	98003	5/9/2014	Careen Service	\$ 50.00
Lastlake Building	Office	123 Lastlake	Seattle	98119	5/10/2014	Lawn Mow	\$ 72.50
Firstlake Building	Office	123 Firstlake	Seattle	98119	5/12/2014	Lawn Mow	\$ 42.50
Lim St Apts	Apartment	4 East Lim	Lynnwood	98223	5/15/2014	Lawn Mow	\$ 120.50
Firstlake Building	Office	123 Firstlake	Seattle	98119	5/19/2014	Lawn Mow	\$ 42.50

A. *Using these data, state assumptions about functional dependencies among the columns of data. Justify your assumptions on the basis of these sample data and also on the basis of what you know about service businesses.*

From the data it appears that there are many functional dependencies that could be defined. Some examples are:

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PropertyName → PropertyType

(PropertyName, Street) → (PropertyType, City, Zip)

(PropertyName, City) → (PropertyType, Street, Zip)

(PropertyName, Zip) → (PropertyType, Street, City)

(PropertyName, Description, ServiceDate) → Amount

None of these seem to be more than just coincidence, however. It would seem, for example, that an “Elm St Apts” could exist in more than one city—there are certainly enough cities with a street named Elm Street! There is simply not enough data to rely on it. Logically, it seems that we need one ID column—a surrogate key will be required here.

With regard to services, it would seem likely that a given service could be given to the same property, but on different dates. So, if we had a good determinant for property, then the last functional dependency would be true. So, the following seems workable:

PropertyID → (PropertyName, PropertyType, Street, City, Zip)

(PropertyID, Description, ServiceDate) → Amount

B. Given your assumptions in part A, comment on the appropriateness of the following designs:

1. PROPERTY (PropertyName, PropertyType, Street, City, Zip, ServiceDate, Description, Amount)

**NOT GOOD:** For example, PropertyName does not determine ServiceDate.

2. PROPERTY (PropertyName, PropertyType, Street, City, Zip, ServiceDate, Description, Amount)

**NOT GOOD:** There may be more than one service on a given date.

3. PROPERTY (PropertyName, PropertyType, Street, City, Zip, ServiceDate, Description, Amount)

**NOT GOOD:** For example, (PropertyName, ServiceDate) does not determine Description since there may be more than one service at a property on a given date.

4. PROPERTY (PropertyID, PropertyName, PropertyType, Street, City, Zip, ServiceDate, Description, Amount)

**NOT GOOD:** For example, PropertyID does not determine ServiceDate.

5. PROPERTY (PropertyID, PropertyName, PropertyType, Street, City, Zip, ServiceDate, Description, Amount)

**NOT GOOD:** For example, (PropertyID, ServiceDate) does not determine Description since there may be more than one service at a property on a given.

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6. PROPERTY (PropertyID, PropertyName, PropertyType, Street, City, Zip, ServiceDate)

and

SERVICE (ServiceDate, Description, Amount)

**BETTER:** ServiceDate is properly set up as a foreign key in PROPERTY. HOWEVER, this will limit the system to only one service per property—the foreign key is in the wrong table!

7. PROPERTY (PropertyID, PropertyName, PropertyType, Street, City, Zip, ServiceDate)

and:

SERVICE (ServiceID, ServiceDate, Description, Amount)

NOT GOOD: ServiceDate is supposedly a foreign key in PROPERTY, but isn't even a primary key in SERVICE. This simply doesn't work!

8. PROPERTY (PropertyID, PropertyName, PropertyType, Street, City, Zip, ServiceID)

and:

SERVICE (ServiceID, ServiceDate, Description, Amount, PropertyID)

**NOT GOOD:** ServiceID is properly used as a foreign key in PROPERTY, but we also have PropertyID as a foreign key in SERVICE. This simply doesn't work; there cannot be two foreign keys like this! The question then becomes: Which one should we keep?

9. PROPERTY (PropertyID, PropertyName, PropertyType, Street, City, Zip)

and:

SERVICE (ServiceID, ServiceDate, Description, Amount, PropertyID)

**GOOD!** Finally the relationship is set up correctly. Now we can have many services (even on the same date) for one property.

C. Suppose Garden Glory decides to add the following table:

**SERVICE-FEE (PropertyID, ServiceID, Description, Amount)**

*Add this table to what you consider to be the best design in your answer to part B. Modify the tables from part B as necessary to minimize the amount of data duplication. Will this design work for the data in Figure 2-34? If not, modify the design so that this data will work. State the assumptions implied by this design.*

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Here's the best design from part B:

**PROPERTY**(PropertyID, PropertyName, PropertyType, Street, City, Zip)

**SERVICE**(ServiceID, ServiceDate, Description, Amount, *PropertyID*)

Adding

**SERVICE-FEE** (PropertyID, ServiceID, ServiceDate, Amount)

means that we need to take PropertyID, ServiceDate, and Amount out of SERVICE.

Note that PropertyID of SERVICE-FEE is a foreign key in PROPERTY. Now, for this design to make sense, we need to allow for multiple services on a property by making (ServiceID, PropertyID, ServiceDate) the key in SERVICE-FEE.

**PROPERTY**(PropertyID, PropertyName, PropertyType, Street, City, Zip)

**SERVICE** (ServiceID, Description)

**SERVICE-FEE** (PropertyID, ServiceID, ServiceDate, Amount)

This means that a service can be applied to a property on different, but multiple, dates and that a property can have multiple, but different, services on the same date. This also means that a service can be applied to multiple, but different, properties on the same date. However, a property may not have the same service on the same date. All of this seems reasonable and will work with the data in Figure 2-34. Now we need to check with the users.



### ANSWERS TO JAMES RIVER JEWELRY PROJECT QUESTIONS

*[NOTE: The James River Jewelry Project Questions are available online for Appendix D, which can be downloaded from the textbook's Web site:*

*[www.pearsonhighered.com/kroenke](http://www.pearsonhighered.com/kroenke). The solutions for these questions will be included in the Instructor's Manual for each chapter]*

James River Jewelry is a small jewelry shop. While James River Jewelry does sell typical jewelry purchased from jewelry vendors, including such items as rings, necklaces, earrings, and watches, it specializes in hard-to-find Asian jewelry. Although some Asian jewelry is manufactured jewelry purchased from vendors in the same manner as the standard jewelry is obtained, many of the Asian jewelry pieces are often unique single items purchased directly from the artisan who created the piece (the term "manufactured" would be an inappropriate description of these pieces). James River Jewelry has a small but loyal clientele, and it wants to further increase customer loyalty by creating a frequent buyer program. In this program, after every 10 purchases, a customer will receive a credit equal to 50 percent of the sum of his or her 10 most recent purchases. This credit must be applied to the next (or "11<sup>th</sup>") purchase.

Figure D-1 shows data that James River Jewelry collects for its frequent buyer program.

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Name	Phone	EmailAddress	InvoiceNumber	InvoiceDate	PreTaxAmount
Elizabeth Stanley	555-236-7789	Elizabeth.Stanley@somewhere.com	1001	5/5/2017	\$ 155.00
Fred Price	555-236-0070	Fred.Price@somewhere.com	1002	5/7/2017	\$ 200.00
Linda Becky	555-236-0892	Linda.Becky@somewhere.com	1003	5/11/2017	\$ 75.00
Pamela Buch	555-236-0491	Pamela.Buch@somewhere.com	1004	5/15/2017	\$ 67.00
Richard Romeo	555-236-3334	Richard.Romeo@somewhere.com	1005	5/15/2017	\$ 330.00
Elizabeth Stanley	555-236-7789	Elizabeth.Stanley@somewhere.com	1006	5/18/2017	\$ 75.00
Linda Becky	555-236-0892	Linda.Becky@somewhere.com	1007	5/25/2017	\$ 45.00
Elizabeth Stanley	555-236-7789	Elizabeth.Stanley@somewhere.com	1008	5/6/2017	\$ 145.00
Samantha Jackson	555-236-1095	Samantha.Jackson@somewhere.com	1009	6/7/2017	\$ 72.00

- A. *Using these data, state assumptions about functional dependencies among the columns of data. Justify your assumptions on the basis of these sample data and also on the basis of what you know about retail sales.*

From the data it would appear:

Name → (Phone, EmailAddress)

Phone → (Name, EmailAddress)

EmailAddress → (Name, Phone)

However, these are based on a very limited dataset and cannot be trusted. For example, name is not a good determinant in a retail application; there may be many customers with the same name. It's also possible that some customers could have the same phone, even though they do not in this example.

Another functional dependency is:

InvoiceNumber → (Name, Phone, EmailAddress, InvoiceDate, PreTaxAmount)

- B. *Given your assumptions in part A, comment on the appropriateness of the following designs:*

1. CUSTOMER (Name, Phone, EmailAddress, InvoiceNumber, InvoiceDate, PreTaxAmount)

**NOT GOOD:** For example, Name does not determine InvoiceNumber because one customer may have made more than one purchase.

2. CUSTOMER (Name, Phone, EmailAddress, InvoiceNumber, InvoiceDate, PreTaxAmount)

**TRUE, but not normalized.** For example, EmailAddress → Phone. And why is InvoiceNumber the key for data about a customer?

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3. CUSTOMER (Name, Phone, EmailAddress, InvoiceNumber, InvoiceDate, PreTaxAmount)

**GOOD FOR CUSTOMERS, BUT NOT INVOICES:** Given a unique Email address, Email works as a key for customer data. Unfortunately, EmailAddress does *not* determine InvoiceNumber and therefore is not a sufficient key.

4. CUSTOMER (CustomerID, Name, Phone, EmailAddress, InvoiceNumber, InvoiceDate, PreTaxAmount)

**GOOD FOR CUSTOMERS, BUT NOT INVOICES:** A unique ID column is a good idea, and works as a key for customer data. Unfortunately, CustomerID does *not* determine InvoiceNumber and therefore is not a sufficient key.

5. CUSTOMER (Name, Phone, EmailAddress)

and

PURCHASE (InvoiceNumber, InvoiceDate, PreTaxAmount)

**GETTING BETTER, BUT INCOMPLETE.** We cannot be sure Name is unique, and the relationship between CUSTOMER and PURCHASE is not defined.

6. CUSTOMER (Name, Phone, EmailAddress)

and

PURCHASE (InvoiceNumber, InvoiceDate, PreTaxAmount, *EmailAddress*)

**GOOD.** The design breaks up the themes and has a proper foreign key. However, the use of EmailAddress as a primary key may be a problem if two customers share an Email address.

7. CUSTOMER (Name, EmailAddress)

and

PURCHASE (InvoiceNumber, Phone, InvoiceDate, PreTaxAmount, *EmailAddress*)

**A GOOD DESIGN WAS JUST MADE BAD AGAIN.** The design breaks up the themes and has a proper foreign key. However, why was Phone moved? It should have been left in CUSTOMER where it will only be entered once and where:

**EmailAddress → Phone**

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- C. *Modify what you consider to be the best design in part B to include a column called AwardPurchaseAmount. The purpose of this column is to keep a balance of the customers' purchases for award purposes. Assume that returns will be recorded with invoices having a negative PreTaxAmount.*

The best design in part B was number 6, so we'll put AwardPurchaseAmount in CUSTOMER. The result is:

**CUSTOMER (Name, Phone, EmailAddress, AwardPurchaseAmount)**

**PURCHASE (InvoiceNumber, InvoiceDate, PreTaxAmount, EmailAddress)**

However, the problem with this design is that there's no history of prior AwardPurchaseAmounts.

- D. *Add a new AWARD table to your answer to part C. Assume that the new table will hold data concerning the date and amount of an award that is given after a customer has purchased 10 items. Ensure that your new table has appropriate primary and foreign keys.*

The new table is:

**AWARD (AwardID, AwardDate, AwardAmount, AwardPurchaseAmount, EmailAddress)**

The other tables need to be adjusted, and the final design will be:

**CUSTOMER (Name, Phone, EmailAddress)**

**PURCHASE (InvoiceNumber, InvoiceDate, PreTax Amount, EmailAddress, AwardID)**

**AWARD (AwardID, AwardDate, AwardAmount, AwardPurchaseAmount, EmailAddress)**

Placing AwardID into PURCHASE as a foreign key allows for each purchase to be allocated to a particular award. Business rules need to be in place to ensure that the count of the number of PURCHASEs having a positive PreTaxAmount minus the count of the number having a negative PreTaxAmount never exceeds 10 for any given AWARD row.



### **ANSWERS TO THE QUEEN ANNE CURIOSITY SHOP PROJECT QUESTIONS**

*The Queen Anne Curiosity Shop sells both antiques and current-production household items that complement or are useful with the antiques. For example, the store sells antique dining room tables and new tablecloths. The antiques are purchased from both individuals and wholesalers, and the new items are purchased from distributors. The store's customers include individuals, owners of bed-and-breakfast operations, and local interior designers who work with both individuals and small businesses. The antiques are unique, although some multiple items, such as dining room chairs, may be available as a set (sets are never broken). The new items are not unique, and an item may be reordered if it is out of stock. New items are also available in various sizes and colors (for example, a particular style of tablecloth may be available in several sizes and in a variety of colors).*



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Figure 2-35 shows typical sales data for the Queen Anne Curiosity Shop, and Figure 2-36 shows typical purchase data.

**FIGURE 2-35**

Sample Sales Data for The Queen Anne Curiosity Shop

LastName	FirstName	Phone	InvoiceDate	InvoiceItem	Price	Tax	Total
Shire	Robert	206-524-2433	14-Dec-16	Antique Desk	3,000.00	249.00	3,249.00
Shire	Robert	206-524-2433	14-Dec-16	Antique Desk Chair	500.00	41.50	541.50
Goodyear	Katherine	206-524-3544	15-Dec-16	Dining Table Linens	1,000.00	83.00	1,083.00
Bancroft	Chris	425-635-9788	15-Dec-16	Candles	50.00	4.15	54.15
Griffith	John	206-524-4655	23-Dec-16	Candles	45.00	3.74	48.74
Shire	Robert	206-524-2433	5-Jan-17	Desk Lamp	250.00	20.75	270.75
Tierney	Doris	425-635-8677	10-Jan-17	Dining Table Linens	750.00	62.25	812.25
Anderson	Donna	360-538-7566	12-Jan-17	Book Shelf	250.00	20.75	270.75
Goodyear	Katherine	206-524-3544	15-Jan-17	Antique Chair	1,250.00	103.75	1,353.75
Goodyear	Katherine	206-524-3544	15-Jan-17	Antique Chair	1,750.00	145.25	1,895.25
Tierney	Doris	425-635-8677	25-Jan-17	Antique Candle Holders	350.00	29.05	379.05

**FIGURE 2-36**

Sample Purchase Data for The Queen Anne Curiosity Shop

PurchaseItem	PurchasePrice	PurchaseDate	Vendor	Phone
Antique Desk	1,800.00	7-Nov-16	European Specialties	206-325-7866
Antique Desk	1,750.00	7-Nov-16	European Specialties	206-325-7866
Antique Candle Holders	210.00	7-Nov-16	European Specialties	206-325-7866
Antique Candle Holders	200.00	7-Nov-16	European Specialties	206-325-7866
Dining Table Linens	600.00	14-Nov-16	Linens and Things	206-325-6755
Candles	50.00	14-Nov-16	Linens and Things	206-325-6755
Desk Lamp	150.00	14-Nov-16	Lamps and Lighting	206-325-8977
Floor Lamp	300.00	14-Nov-16	Lamps and Lighting	206-325-8977
Dining Table Linens	450.00	21-Nov-16	Linens and Things	206-325-6755
Candles	27.00	21-Nov-16	Linens and Things	206-325-6755
Book Shelf	150.00	21-Nov-16	Harrison, Denise	425-746-4522
Antique Desk	1,000.00	28-Nov-16	Lee, Andrew	425-746-5433
Antique Desk Chair	300.00	28-Nov-16	Lee, Andrew	425-746-5433
Antique Chair	750.00	28-Nov-16	New York Brokerage	206-325-9088
Antique Chair	1,050.00	28-Nov-16	New York Brokerage	206-325-9088

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- A. *Using these data, state assumptions about functional dependencies among the columns of data. Justify your assumptions on the basis of these sample data and also on the basis of what you know about retail sales.*

From the sample sales data it would appear:

**LastName → (FirstName, Phone)**

**FirstName → (LastName, Phone)**

**Phone → (LastName, FirstName)**

**Price → (Tax, Total)**

**(LastName, InvoiceDate, InvoiceItem) → (Price, Tax, Total)**

**(FirstName, InvoiceDate, InvoiceItem) → (Price, Tax, Total)**

**(PhoneName, InvoiceDate, InvoiceItem) → (Price, Tax, Total)**

However, these are based on a very limited dataset and cannot be trusted. For example, name is not a good determinant in a retail application; there may be many customers with the same name. It's also possible that some customers could have the same phone, even though they do not in this example. The one trustable functional dependency here is:

**Price → (Tax, Total)**

From the sample purchase data it would appear:

**(PurchaseItem, PurchasePrice) → (PurchaseDate, Vendor, Phone)**

**(PurchaseItem, PurchasePrice, PurchaseDate) → (Vendor, Phone)**

**(PurchasePrice, PurchaseDate) → (PurchaseItem, Vendor, Phone)**

**Vendor → Phone**

**Phone → Vendor**

However, these are based on a very limited dataset and cannot be trusted. For example, PurchaseItem is not a good determinant in a retail application; there may be many items with the same designator. It's also possible that multiple purchases on the same purchase date will be for the purchase price. The most trustworthy functional dependencies here are:

**Vendor → Phone**

**Phone → Vendor**

But, the first of these may fail if the vendor has multiple phone numbers.

- B. *Given your assumptions in part A, comment on the appropriateness of the following designs:*

1. CUSTOMER (LastName, FirstName, Phone, InvoiceDate, InvoiceItem, Price, Tax, Total)

**NOT GOOD.** There may be many customers with the same last name.

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## Chapter Two – The Relational Model

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2. CUSTOMER (LastName, FirstName, Phone, InvoiceDate, InvoiceItem, Price, Tax, Total)  
**NOT GOOD.** There may be many customers with the same last name and first name.
  3. CUSTOMER (LastName, FirstName, Phone, InvoiceDate, InvoiceItem, Price, Tax, Total)  
**NOT GOOD.** Phone will be fairly unique, and combined with FirstName may overcome the problem of two people with the same phone number being in the customer list (but not necessarily—what if three students are sharing an apartment, and two of them are Bill Smith and Bill Jones?). However, this will not determine the purchase information of purchase date, etc.
  4. CUSTOMER (LastName, FirstName, Phone, InvoiceDate, InvoiceItem, Price, Tax, Total)  
**NOT GOOD.** There may be many customers with the same last name and first name, and some of them may make a purchase on the same date. The only good thing about this is that it is starting to address the purchase information. If (LastName, FirstName) was unique, then customers would be limited to one purchase per day.
  5. CUSTOMER (LastName, FirstName, Phone, InvoiceDate, InvoiceItem, Price, Tax, Total)  
**NOT GOOD.** We're still trying to make the unworkable actually work. Same objections as above in 4, except that now customers would be limited to one of a particular item per day. For example, a customer could not purchase two antique chairs on the same day!
  6. CUSTOMER (LastName, FirstName, Phone)  
and:  
SALE (InvoiceDate, InvoiceItem, Price, Tax, Total)  
**NOT GOOD.** Finally the customer and purchase data is effectively broken up, but there is no foreign key to link the two tables. In CUSTOMER, using (LastName, FirstName) is still a problem. In SALE, with InvoiceDate as the primary key there can only be one purchase per day!
  7. CUSTOMER (LastName, FirstName, Phone, *InvoiceDate*)  
and:  
SALE (InvoiceDate, InvoiceItem, Price, Tax, Total)  
**NOT GOOD.** We've got a foreign key of InvoiceDate in CUSTOMER. But everything else that was wrong in design 6 above is still a problem. Moreover, by using InvoiceDate as the foreign key, we limit the customer to only one purchase!
-

## Chapter Two – The Relational Model

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8. CUSTOMER (LastName, FirstName, Phone)

and:

SALE (InvoiceDate, InvoiceItem, Price, Tax, Total, *LastName*, *FirstName*)

**GOOD.** The customer can have lots of purchases, but not two of the same thing on the same day. Also, LastName and FirstName may not be the best choice for a primary key in CUSTOMER.

C. *Modify what you consider to be the best design in part B to include surrogate ID columns called CustomerID and SaleID. How does this improve the design?*

The best design in part B was number 8, so we'll put in the ID columns. These columns will become the new primary keys, and we'll need to adjust the foreign key so that it is in SALE. The result is:

**CUSTOMER** (CustomerID, LastName, FirstName, Phone)

**SALE** (SaleID, *CustomerID*, InvoiceDate, InvoiceItem, Price, Tax, Total)

We now have a clean design, and CUSTOMER is in BCNF. SALE is not in BCNF because

**Price** → (Tax, Total)

We could further normalize SALE, but we will intentionally leave it this way. This is called **denormalization**, and is discussed in Chapter 5. The point is that creating the extra table (PRICE\_TAX\_TOTAL) is more trouble than it is worth. (Can you imagine what the data for that table would look like?)

The primary key problems with both tables are resolved, and now a customer can purchase as many of an item on the same date as he or she wants to!

D. *Modify the design in part C by breaking SALE into two relations named SALE and SALE\_ITEM. Modify columns and add additional columns as you think necessary. How does this improve the design?*

The main problem with the design in part C is that only one item can be included in each sale. Moving items into a SALE\_ITEM table linked SALE will allow multiple items to be purchased as part of one sale. We'll need to include SaleID as part of a composite primary key so that the sale items are grouped according to their corresponding SALE. SaleID will also be the foreign key linking to SALE. Item and Price now belong in SALE\_ITEM, and we'll need to add a PreTaxTotal to SALE—tax will now only be calculated on the pretax total value of the sale. The result is:

**CUSTOMER** (CustomerID, LastName, FirstName, Phone)

**SALE** (SaleID, *CustomerID*, InvoiceDate, PreTaxTotal, Tax, Total)

**SALE\_ITEM** (SaleID, SaleItemID, InvoiceItem, Price)

## Chapter Two – The Relational Model

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We now have an improved clean design, and the CUSTOMER and SALE\_ITEM tables are in BCNF. SALES is still denormalized as discussed in part C.

We have good primary and foreign keys, and now a customer can purchase as many of an item on the same date as he or she wants to and all items can be part of just one sale!

E. Given your assumptions, comment on the appropriateness of the following designs:

1. PURCHASE (PurchaseItem, PurchasePrice, PurchaseDate, Vendor, Phone)

**NOT GOOD.** There may be many purchases of the same item (“Candles”).

2. PURCHASE (PurchaseItem, PurchasePrice, PurchaseDate, Vendor, Phone)

**NOT GOOD.** There may be many purchases of the same item that cost the same amount of money (“Candles, \$30.00”).

3. PURCHASE (PurchaseItem, PurchasePrice, PurchaseDate, Vendor, Phone)

**NOT GOOD.** This limits purchases of a particular item to one per day.

4. PURCHASE (PurchaseItem, PurchasePrice, PurchaseDate, Vendor, Phone)

**NOT GOOD.** This limits purchases of a particular item to one per vendor.

5. PURCHASE (PurchaseItem, PurchasePrice, PurchaseDate)

and:

VENDOR (Vendor, Phone)

**NOT GOOD.** It does, however separate the two themes of PURCHASE and VENDOR. However, there is no foreign key to link the tables. Moreover, this design still limits purchases of a particular item to one per day.

6. PURCHASE (PurchaseItem, PurchasePrice, PurchaseDate, Vendor)

and:

VENDOR (Vendor, Phone)

**BETTER, BUT STILL NOT GOOD.** It separates the two themes of PURCHASE and VENDOR, but they are *not* properly linked by a foreign key.

## Chapter Two – The Relational Model

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7. PURCHASE (PurchaseItem, PurchasePrice, PurchaseDate, Vendor)

and:

VENDOR (Vendor, Phone)

**GOOD, but could be BETTER.** It separates the two themes of PURCHASE and VENDOR, which are now properly linked by a foreign key. However, this design still limits purchases of a particular item to one per day.

That said, this is the best design of the bunch.

F. *Modify what you consider to be the best design in part E to include surrogate ID columns called PurchaseID and VendorID. How does this improve the design?*

The best design in part E was number 7, so we'll put in the ID columns. These columns will become the new primary keys, and we'll need to adjust the foreign key in PURCHASE. The result is:

PURCHASE (PurchaseID, Item, PurchasePrice, PurchaseDate, VendorID)

VENDOR (VendorID, Vendor, Phone)

We now have a clean design, and PURCHASE is in BCNF. VENDOR is not in BCNF because

Vendor → (VendorID, Phone)

Phone → (VendorID, Vendor)

We could further normalize VENDOR, but we will intentionally leave it this way. As discussed in part D, this is called denormalization and is discussed in Chapter 5. The point is that creating the extra table (VENDOR\_PHONE) is more trouble than it is worth.

The primary key problems with both tables are resolved, and now the Queen Anne Curiosity Shop can purchase as many of an item on the same date as needed.

## Chapter Two – The Relational Model

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- G. *The relations in your design from part D and part F are not connected. Modify the database design so that sales data and purchase data are related.*

The connection between the two parts of the database design is the item being first purchased and then sold. Thus, we can create an integrated design by replacing InvoiceItem in SALE\_ITEM with PurchaseID as a foreign key. We will rename Price in SALE\_ITEM as SalePrice. Our final design will be:

**CUSTOMER** (CustomerID, LastName, FirstName, Phone)

**SALE** (SaleID, CustomerID, InvoiceDate, PreTaxTotal, Tax, Total)

**SALE\_ITEM** (SaleID, SaleItemID, PurchaseID, SalePrice)

**PURCHASE** (PurchaseID, PurchaseItem, PurchasePrice, PurchaseDate, VendorID)

**VENDOR** (VendorID, Vendor, Phone)

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# Database Concepts

8th Edition

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David M. Kroenke • David J. Auer • Scott L. Vandenberg • Robert C. Yoder

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## Instructor's Manual

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Prepared by David J. Auer

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### Appendix A

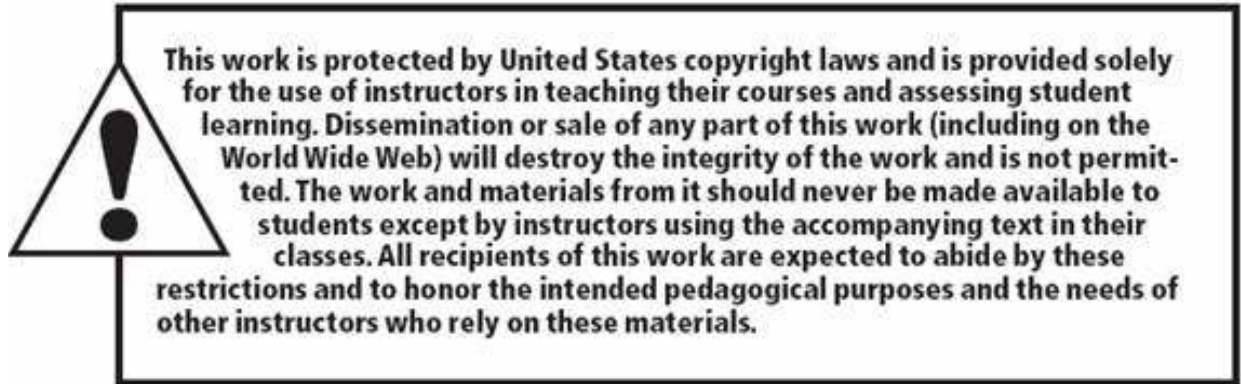
### Getting Started with Microsoft SQL Server 2016

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Instructor's Manual to accompany:

## ***Database Concepts (8th Edition)***

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**David M. Kroenke • David J. Auer • Scott L. Vandenberg • Robert C. Yoder**

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## ▶ CHAPTER OBJECTIVES

- Learn how to install SQL Server 2016
- Learn how to install SQL Server Management Studio
- Learn how to create a database in SQL Server 2016
- Learn how to submit SQL commands to create table structures
- Learn how to submit SQL commands to insert database data
- Learn how to submit SQL commands to query a database
- Learn how to install the Microsoft SQL Server 2016 ODBC Client
- Learn how to import Microsoft Excel worksheet data into a database

## ▶ CHAPTER ERRATA

These are no known errors at this time. Any errors that are discovered in the future will be reported and corrected in the online [DBC e08 Errata](#) document, which will be available at <http://www.pearsonhighered.com/kroenke>.

## ▶ THE ACCESS WORKBENCH

Solutions to the *Access Workbench* exercises may be found in *Solutions to all Sections: The Access Workbench*, which is a separate document within the Instructor's Manual.

There is no section of *The Access Workbench* associated with this appendix.

## ▶ NOTES ON MICROSOFT WINDOWS 10

This book uses the Microsoft Windows 10 operating system as the basis for screenshots and step-by-step instructions. However, with Windows 10, Microsoft has introduced a continuous update system that has already resulted in some fundamental differences in how different versions of Windows 10 look and operate.

For example, in the original version of Microsoft Windows 10, clicking the **Windows Start** button (or pressing the Windows key on the keyboard) displayed the menu shown in Figure 1. In this menu, we need to click the **All apps button** in order to see the **All apps menu** shown in Figure 2.

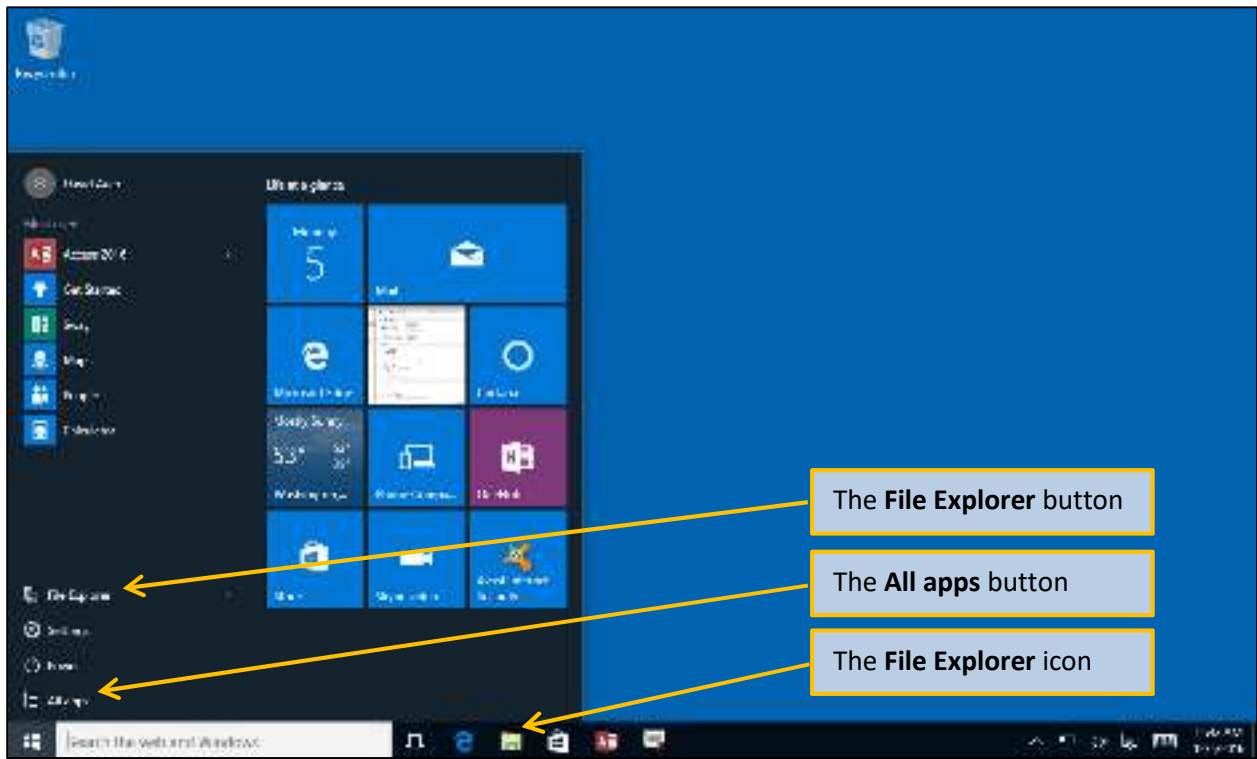


Figure 1 – Windows 10 Main Menu

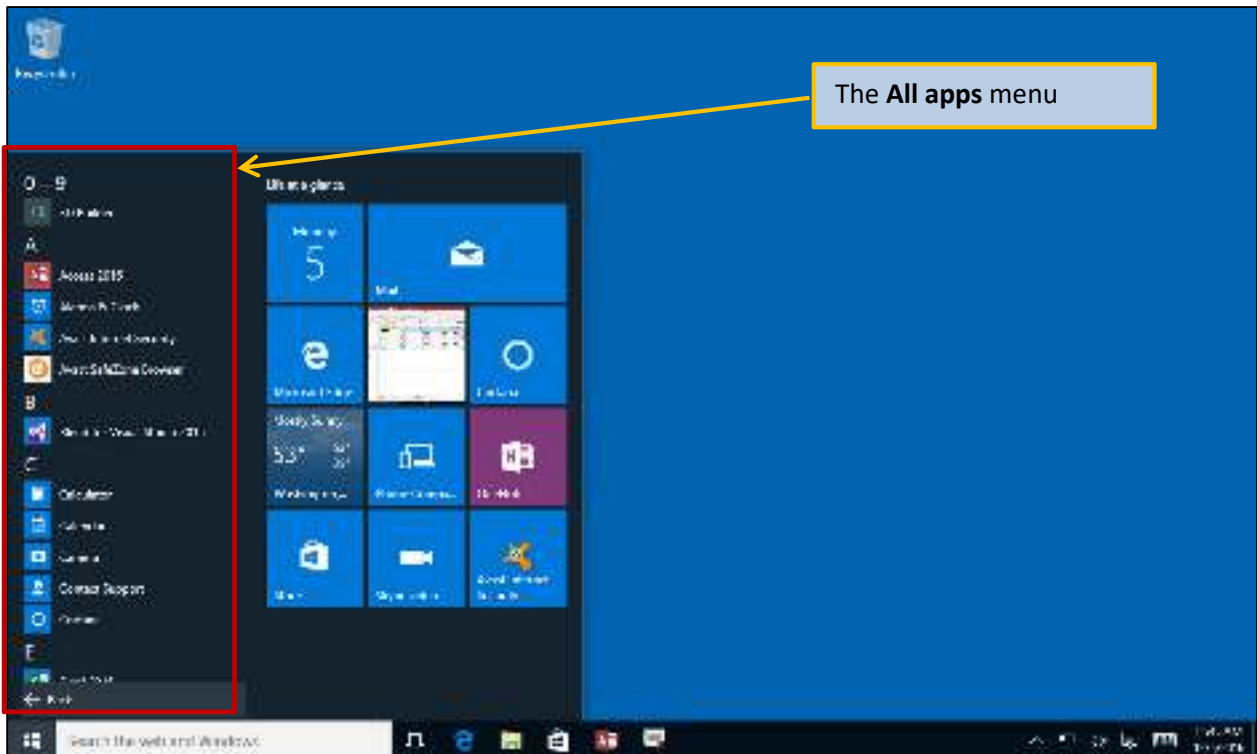


Figure 2 – Windows 10 All Apps Menu

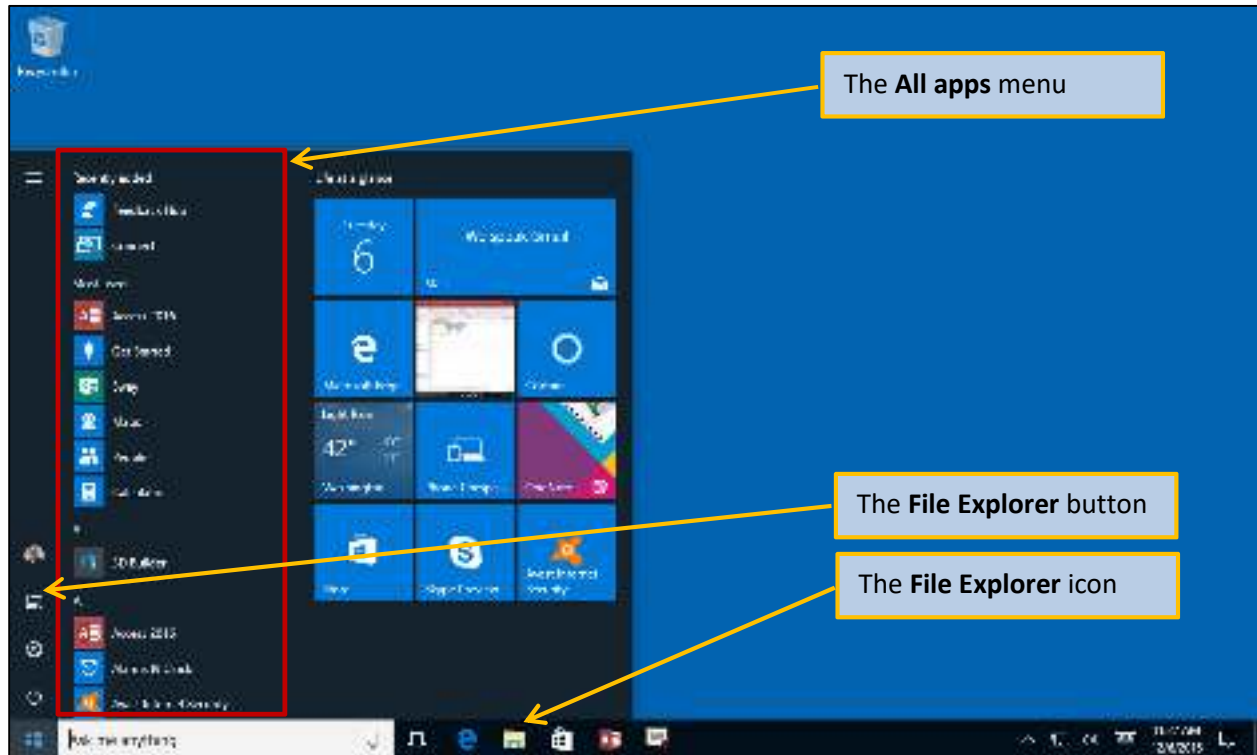


Figure 3 – Windows 10 Anniversary Update Main Menu with All Apps Menu Included

Microsoft then released the Windows 10 Anniversary Update (Feature update to Windows 10, version 1607) (see the blog discussion at <https://blogs.windows.com/windowsexperience/2016/08/02/how-to-get-the-windows-10-anniversary-update/#K1CZuiw4aiiuE9A5.97> ). One of the changes introduced in the Anniversary Update was a major change to the menu system. Now, as shown in Figure 3, the **All apps menu** is immediately available when the Start button is used (or when the keyboard Windows key is pressed).

Therefore, note that the step by step instructions in this book may need to be altered for your use depending upon which version of Microsoft Windows 10 you or your students are using!

We recommend that you update Windows 10 to the Windows 10 Anniversary Update (Feature update to Windows 10, version 1607), and make sure it is patched with all updates to that version (at a minimum patched to Windows 10 Version 1607 update for August 23, 2016 (KB3176936), and the Windows 10 Version 1607 cumulative update for September 29, 2016 (KB3194496). We also recommend using the 32-bit version of Microsoft Office. This insures that all the examples discussed in this book will function properly.

 **TEACHING SUGGESTIONS**

- For individual student personal use on their own computer, we recommend (and use in this book) Microsoft SQL Server 2016 Developer edition. Microsoft SQL Server 2016 Express Advanced edition can be used as an alternative.
- When you are using Microsoft SQL Server 2016, the best text editor to use is the text editor built into the Microsoft SQL Server Management Studio. Take some time to show you students how to use it.
- Make sure that your students work through Appendix A in conjunction with other material presented in the text by working through Appendix A in the following sequence:
  - ❖ Before starting Chapter 3 on SQL, install Microsoft SQL Server 2016 and Microsoft SQL Server Management Studio by working through this appendix up to and including “How Do I Install the Microsoft SQL Server Management Studio?”
  - ❖ When studying the Chapter 3 sections on how to create and populate database tables, work up to and including “How Do I Use SQL Statements to Insert Database Data?” Both Chapter 3 and this appendix use the same WP database, and this work will show you how to create your own copy of the WP database.
  - ❖ When studying the Chapter 3 sections on how to use SQL Data Manipulation Language (DML) and SQL Data Definition Language (DDL), work through the section named “How Do I Work with SQL Queries in Microsoft SQL Server?” Both Chapter 3 and this appendix use the same WP database, and you can run the SQL Statements shown in Chapter 3 yourself, and see the results.
  - ❖ When studying the Appendix E material on SQL Views, you can run the SQL Statements shown in Appendix E yourself and see the results.
  - ❖ When studying the Appendix E material on SQL Persistent Stored Modules (SQL/PSM), you can run the SQL Statements shown in Appendix E yourself and see the results.
  - ❖ Work through the section “How Do I Import Microsoft Excel Data into a Microsoft SQL Server Database Table?” in this appendix to understand how to import Microsoft Excel data in a database table.
  - ❖ Work through the section “How Do I Create an ODBC Connection from Microsoft Access 2016 to an SQL Server 2016 Database?” in this appendix to understand how to use Microsoft Access as a development environment for a Microsoft SQL Server database.

▶ **ANSWERS TO REVIEW QUESTIONS**

A.1 *What is SQL Server 2016 Developer edition? What is SQL Server 2016 Express edition? What are the differences between these two editions of SQL Server 2016?*

**Developer Edition** is a free, single-user version of the Enterprise Edition, and it has the complete feature set of the Enterprise Edition. It is intended, as the name implies, for use by a single user who is doing database and application development work.

**Enterprise Edition** is a powerful and feature-laden commercial version. It handles up to the maximum number of CPUs or CPU cores allowed by the operating system, the maximum memory supported by the operating system, and a maximum database size of 524 Petabytes (PBytes). It includes full data warehouse capabilities and business intelligence capabilities.

**Express Edition** is free, feature-limited version is available for download. It supports 4 CPU cores, 1,410 MByte of memory, and a maximum database size of 10 GBytes. Despite its limitations, it is a great learning tool when the **Express Advanced** version, which includes the SQL Server 2016 reporting services package, is used.

The differences are:

- ❖ Developer edition can be used by only one person in a non-production environment, while Express edition can be used in a multi-user, production environment.
- ❖ Developer edition supports more CPUs or core, larger computer memory and storage.
- ❖ Developer edition is full featured, while Express (and even Express Advanced) has feature limitations.

A.2 *What is the primary advantage of using SQL Server 2016 instead of Microsoft Access?*

SQL Server 2016 handles SQL much better than Microsoft Access.

A.3 *What is the set of Microsoft programs that are recommended as a necessary set of prerequisites to the actual installation of SQL Server 2016? In what order should you install these products?*

1. Microsoft .NET Framework 3.5 SP 1
2. Microsoft .NET Framework 4.6.1
3. Oracle Java Runtime Environment (JRE) 7 Update 51 or higher
4. Update for Visual C++ 2013, Visual C++ Redistributable Package, and KB3164398
5. Microsoft SQL Server 2016 Developer Edition
6. Microsoft SQL Server Management Studio
7. Critical update for SQL Server 2016 MSVCRT prerequisites.

Install these in the order listed. As Microsoft incorporates updates into SQL Server 2016, it may become unnecessary to separately install the *Critical update for SQL Server 2016 MSVCRT prerequisites*.

### A.4 *How do you install Microsoft SQL Server 2016 Developer edition?*

Install Microsoft SQL Server 2016 Developer as follows (this is an outline – we will not repeat the full set of instructions contained in the Appendix). Note that we are actually downloading SQL Server 2016 with Service Pack 1:

1. Download **SQLServer2016-SSEI-Dev.exe**, which is a stub that starts the download of the actual installation file.
2. Download **SQLServer2016SP1-FullSlipStream-x64-ENU-DEV.iso**, which is the actual installation file in a format that is used to burn a DVD or be mounted as a DVD for installation.
3. Mount **SQLServer2016SP1-FullSlipStream-x64-ENU-DEV.iso**.
4. In the mounted file set, right-click the **setup.exe** file, and then click the **Run as administrator** command,
5. In the **SQL Server Installation Center** dialog box, click the **Installation** button.
6. In the Installation screen, click **New SQL Server standalone installation or add features to an existing installation**.
7. When the **SQL Server 2016 Setup** dialog box is displayed, follow the steps detailed in the text and Figure A-8.

### A.5 *What is the purpose of Microsoft SQL Server Management Studio?*

The Microsoft SQL Server Management Studio is the graphical management utility for SQL Server 2016. Using SQL Server Management Studio makes it much easier to work with SQL Server 2016. It is used to create databases and SQL scripts, and to run SQL scripts and commands.

### A.6 *How do you install the Microsoft SQL Server Management Studio?*

Install the Microsoft SQL Server Management Studio as follows (this is an outline – we will not repeat the full set of instructions contained in the Appendix). Note that SQL Server Management Studio now requires a separate download:

1. Open the **SQL Server Installation Center** dialog box, click the **Installation** button.
2. In the Installation screen, click **Install SQL Server Management Tools**.
3. When the **Download SQL Server Management Studio (SSMS) Web page** is displayed, click the **Download SQL Server Management Studio {VersionNumber}** button and download the file to the **This PC | Downloads** folder.

4. Open File Explorer and browse to the **This PC | Downloads** folder. Right-click the **SMSS-Setup-ENU.exe** file to display the shortcut menu, and then click the **Run as administrator** command. When the User Account Control dialog box for this file is displayed, click the **Yes** button.
5. The **Microsoft SQL Server Management Studio installation** dialog box is displayed. Click the **Install** button to begin the installation process.
6. When the installation is complete, the Setup Completed page is displayed. Click the **Close** button to complete the installation process.
7. Close the **SQL Server Installation Center** Dialog Box.

*A.7 If you experience a problem starting the Microsoft SQL Server Management Studio, what steps should you take to resolve this problem?*

Microsoft SQL Server 2016 may either take a long time to start the required services, or may fail to start the at all (we do *not* know why this occurs, and hope that Microsoft will fix this glitch soon!)

To fix this problem if it occurs, click the **OK** button to close the error message, and then use the **Windows key + X key** combination on the keyboard to display a short cut menu. In the menu, click the **Task Manager** command to display the Task Manager. In Task Manager, click the **Services** tab and scroll down until you see the *MSSQLSERVER* service. Right-click the **MSSQLSERVER** service to bring up a shortcut menu and click the **Start** command. Also, start the **MSSQLLaunchpad** and **SQLSERVERAGENT** services. After these services are started, close the Task Manager and then log into Microsoft SQL Server 2016.

*A.8 How do you create a new database in SQL Server 2016?*

To create an SQL Server database, right-click the object in the Object Explorer to display the shortcut menu, and then click **New Database**.

*A.9 How do you specify the active database in SQL Server 2016?*

Specify the database in the SQL Query Toolbar by selecting the database name from the drop-down list.

*A.10 What is a SQL script? What types of SQL statements and commands can you run more efficiently as scripts?*

A SQL script is a related group of SQL statements intended to be run at the same time. Scripts are efficient for processing groups of SQL statements such as:

1. A set of **CREATE TABLE** commands to build a new database structure.
2. A set of **INSERT** commands when data needs to be added to a table.



**A.11** *What tool(s) can be used to create a script?*

Scripts can be created in Microsoft SQL Server Management Studio or in any other ASCII text editor, such as the Windows Notepad text editor. Microsoft SQL Server Management Studio is the recommended tool for script creation and editing.

**A.12** *What file extension should you use for SQL scripts?*

The file extension `.sql` should be used so that such files are recognizable by the Microsoft SQL Server Management Studio and SQL Server 2016.

**A.13** *How do you open and run a script in SQL Server?*

To open a script in SQL Server Management Studio Express, use the **File | Open | File . . .** menu command. In the **Open File** dialog box, select the **script file name** and then click the **Open** button. At this point, SQL Server *may* ask you to authenticate again. If so, a dialog box named **Connect to Database Engine** will appear, and you will have to click the **Connect** button. The script appears in a tabbed window labeled with the name of the script. To run the script, first specify the database to be used, and then click the **Execute** button in the **SQL Editor toolbar**.

After the script is executed, a Message window appears below the script window indicating success (or displaying appropriate error messages).

**A.14** *How do you create database tables in SQL Server?*

To create database tables, create an SQL script containing the necessary SQL CREATE TABLE statements. Save and name the script. Be sure the correct database has been selected in the drop-down database list, and/or include the following code at the start of your script:

```
USE {DatabaseName}  
GO
```

Run the script.

**A.15** *How do you populate database tables in SQL Server?*

To create populate database tables, create an SQL script containing the necessary SQL INSERT statements. Save and name the script. Be sure the correct database has been selected in the drop-down database list, and/or include the following code at the start of your script:

```
USE {DatabaseName}  
GO
```

Run the script.

**A.16** *How do you create and run an SQL query in SQL Server?*

To run a query, first specify the database you want to query by clicking on the database name in the Database folder in the Object Browser to select it (alternatively, select it in the database drop-down list). Next, click the **New Query** button in the **Standard toolbar**. A tabbed window will appear along with the SQL Editor toolbar. In the new window, type the text of the SQL query you want to run, and then click the **Execute** button in the SQL Editor toolbar.

The results appear in a tabbed **Results** window below the query window in a spreadsheet style display. The size of the query window and the results window can be adjusted, and the column widths in the results display can be modified using the standard Windows drag-and-drop technique to help make more data visible. You can run multiple queries at the same time—clicking the New Query button again will open another tabbed query window.

**A.17** *How do you install the Microsoft SQL Server 2016 ODBC client? Which ODBC software is installed in the process?*

For SQL Server 2016, you do not have to take any extra steps to install ODBC support. The ODBC Driver 13 for SQL Server (and the older SQL Server Native Client 11.0) is automatically installed and available for use.

**A.18** *How do you import Microsoft Excel data into an SQL Server table?*

The first step is to normalize the data in the Microsoft Excel worksheet into one or more correctly formatted worksheets. The worksheets should not have titles, but should include the proper column headings.

We then use the **SQL Server Import and Export Wizard** as our tool for data import. This tool, however, has some glitches, and we must use some “work arounds.”

**A.19** *Why should imported data be initially stored in a temporary table and then moved into a different SQL Server table? How do you do this?*

Because the **SQL Server Import and Export Wizard** has some glitches, and we must use some “work arounds.” One of these is storing data in a temporary table, creating a properly structured table, and then moving (or copying) the data to the properly structured table. The steps are:

1. Import the Microsoft Excel data into a temporary table.
2. Use an SQL CREATE TABLE statement—written and saved in an SQL Script—to create the needed properly structured table.
3. Use an SQL bulk INSERT statement—written and saved in an SQL Script—to populate the new table. Bulk INSERT statements use an SQL SELECT statement within the INSERT statement to determine what data will be selected for insertion into the new table.
4. [Optional] Delete the temporary table.

**A.20** *How do you create user accounts in SQL Server 2016? How do you give them appropriate permissions to a specific database?*

SQL Server user accounts are created and user permissions are managed in the SQL Server Management Studio.

1. In the Object Explorer, right-click the **Security | Logins** folder to display a shortcut menu.
2. In the shortcut menu, click the **New Login** command to display the **Login – New** dialog box.
3. In the Login – New dialog box, enter the necessary data for the new user.
4. To grant permissions, click the **User Mapping** button. Assign specific database permissions on the User Mapping page.
5. Click the **OK** button to create the new user account.

**A.21** *Why would you want to create an ODBC connection to link a Microsoft Access 2016 to an SQL Server Database?*

While SQL Server 2016 is an excellent enterprise-class DBMS, it does not provide any application development tools. Microsoft Access 2016 does provide a set of application development tools such as forms, reports, stored queries, and menu systems (see Appendix H, “The Access Workbench—Section H—Microsoft Access 2016 Switchboards”). Thus, it would be useful to have a way to use Microsoft Access 2016 as the application development frontend for an SQL Server 2016 database.

We can connect Microsoft Access 2016 to SQL Server via an **Open Database Connectivity (ODBC)** link between the two.

**A.22** *What is an ODBC DSN? Why is one needed?*

An ODBC DSN is data source, and DSN stands for data source name. The DSN stores the actual data, such as the specific database to be used, and the user login name and password, needed to establish a ODBC link to a database.

**A.23** *How do you create an ODBC connection to link a Microsoft Access 2016 database to an SQL Server Database?*

A DSN may be created independently of a specific use by using the Microsoft **ODBC Data Source Administrator** utility provided with the Windows operating system. We describe how to do this in Chapter 7.

However, when connecting a Microsoft Access 2016 database to an SQL Server database, we use the Microsoft Access 2106 **Get External Data – ODBC Database** Wizard. The Wizard includes the steps necessary to create the needed ODBC DSN to connect to the SQL Server database as part of the process. Thus, we create the ODBC connection during the connection process, and no separate DSN creation is needed.

▶ **ANSWERS TO EXERCISES**

A.24 *If you haven't already done so, download and install SQL Server 2016 Developer edition as described in the text. Use the default settings for the installation. Be sure that the Microsoft SQL Server 2016 Management Studio is correctly installed.*

Installation is easy and straightforward. The complete instructions on how to download and install SQL Server 2016 Developer edition are in Appendix A, and will not be repeated here.

A.25 *If you haven't already done so, work through the steps described in this appendix to create and populate the WP database.*

For table creation, use the file: **DBC-e08-MSSQL-WP-Create-Tables.sql**

For data entry, use the file: **DBC-e08-MSSQL-WP-Insert-Data.sql**

A.26 *Using SQL Server 2016 and the Microsoft SQL Server Management Studio, run the SQL queries in Chapter 3.*

*SQL-Query-CH03-01 through SQL-Query-CH03-32*

*Skip SQL-Query-CH03-33 and SQL-Query-CH03-34 as they result in errors!*

*SQL-Query-CH03-35 through SQL-Query-CH03-51*

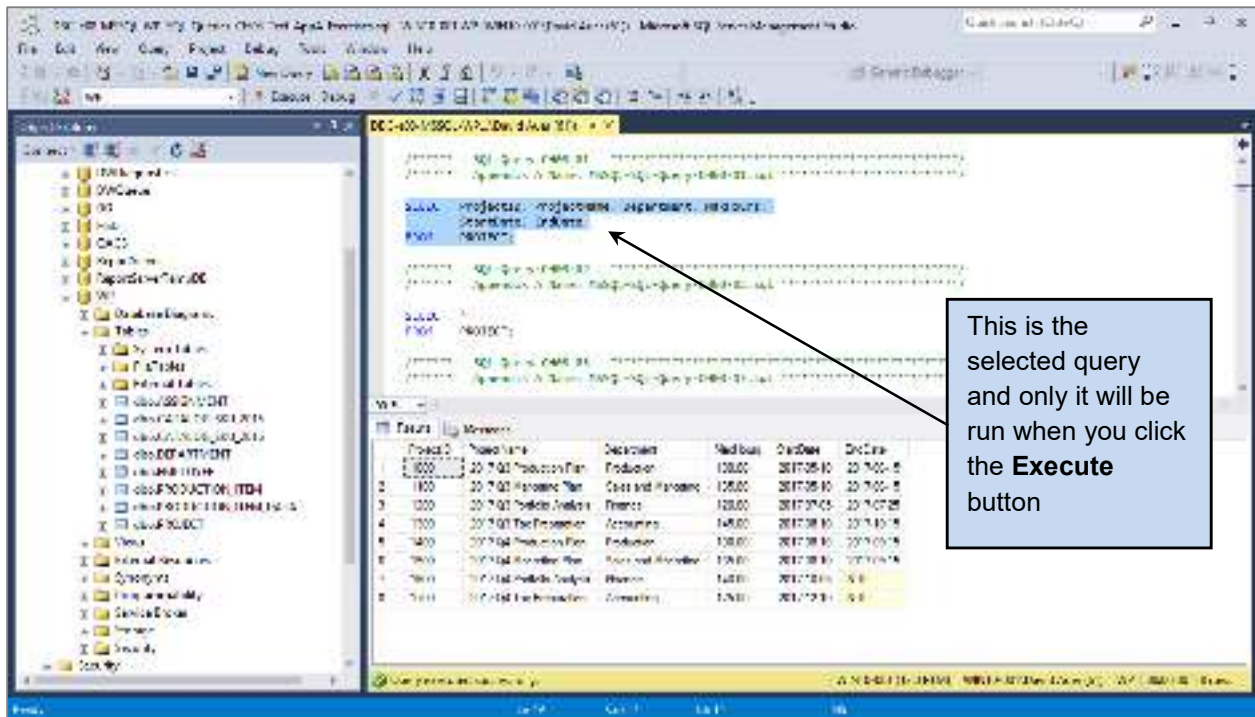
*Save each query as follows:*

- *Create and run each query in SQL Server Management Studio.*
- *After you have run each query, use the **File | Save SQLQuery#.sql As** command to save the query. (The # sign in the name changes as you create different queries. By default, SQL Server saves each file as an SQL file with the file extension \*.sql. Use this default setting unless your instructor tells you to use a different extension. Name your queries in numerical sequence, starting with the file name MSSQL-SQL-Query-CH03-01.sql.*

The solutions are in the script file:

**DBC-e08-MSSQL-WP-SQL-Queries-CH03-Text-AppA-Exercises.sql**

**DO NOT RUN THIS FILE AS A SCRIPT!** You can run individual queries from the script file by highlighting them and then clicking the Execute button, as shown in the screen shot on the next page.



A.27 Use Microsoft SQL Server Management Studio to run one or more of the saved SQL queries you created in question A.14:

- Open a query using the **Open File** button (or by selecting the **File | Open File** menu command). Note that the query is opened in a tabbed query window. Run the query.
- Use the **Open File** button (or the **File | Open File** menu command) to open and run another query in another tabbed window.
- Experiment with opening and closing windows and running various queries in these windows.

These questions are self-explanatory and do not require separate solutions.

A.28 If needed, complete exercise 3.58. Complete exercise 3.59 using SQL Server 2016 and the Microsoft SQL Server Management Studio. Start each saved query name with **MSSQL-** and use the default **.sql** file extension. (The first saved query name should be **MSSQL-SQL-Query-AWE-3-1-A.sql**.)

The solution for this Exercise is the same as the solution to Exercise 3.59. See the Instructor's Manual for Chapter 3 and the solutions in the file:

**DBC-e08-MSSQL-WP-SQL Queries-CH03-Exercises.sql**

- A.29 *If needed, complete exercise 3.58. Complete Exercise 3.60 using SQL Server 2016 and the Microsoft SQL Server Management Studio. Start the saved query name with MSSQL- and use the default .sql file extension. The saved query name will be MSSQL-SQL-Query-AWE-3-3-E.sql.*

The solution for this Exercise is the same as the solution to Exercise 3.60. See the Instructor's Manual for Chapter 3 and the solutions in the file:

**DBC-e08-MSSQL-WP-SQL Queries-CH03-Exercises.sql**

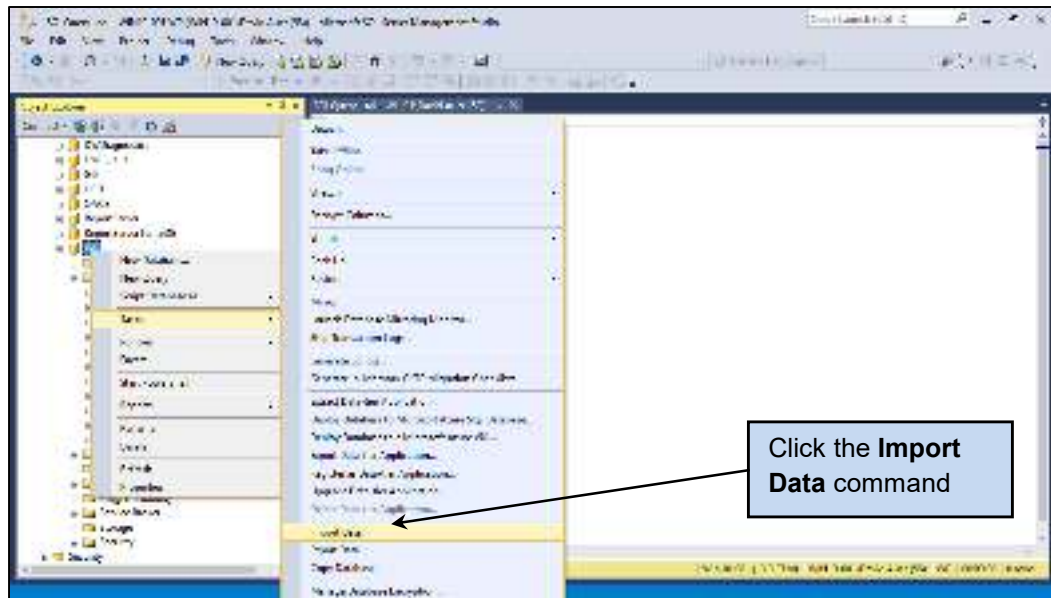
- A.30 *If you have not already done so, import the COMPUTER table from Microsoft Excel in the SQL Server 2016 WP database as explained in the text.*

This is self-explanatory. This exercise is intended to make sure that the student is prepared to answer exercise A.31.

- A.31 *Import the COMPUTER\_ASSIGNMENT table from Microsoft Excel in the SQL Server 2016 WP database as explained in the text. How should this table be linked to the EMPLOYEE table and the COMPUTER table by foreign keys? Be sure to include these foreign keys in your final COMPUTER\_ASSIGNMENT table structure when you create it in SQL Server 2016.*

To Import the COMPUTER\_ASSIGNMENT table:

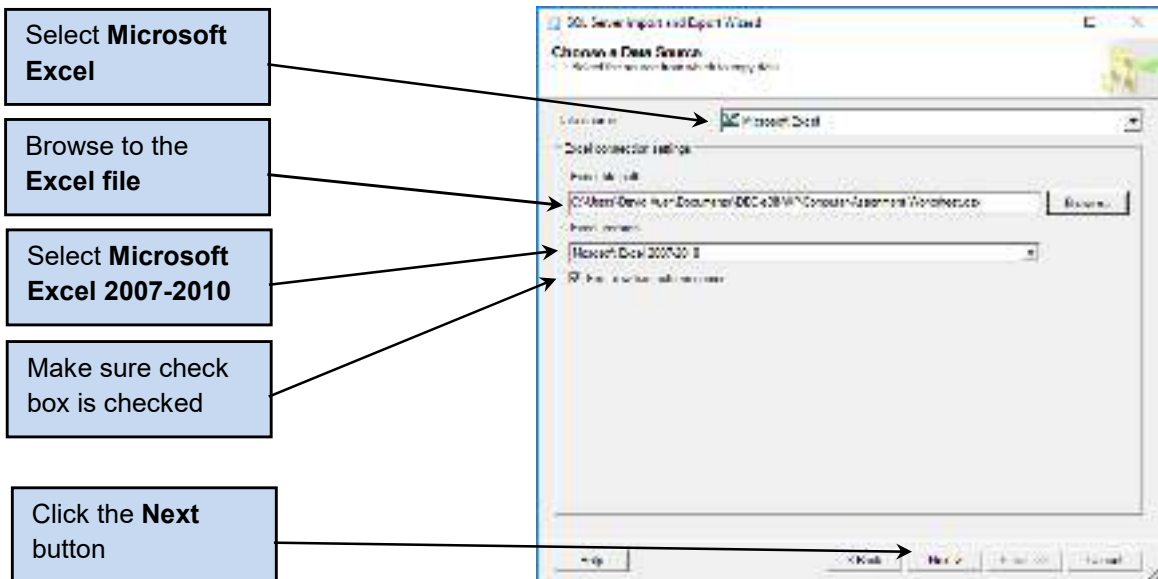
1. In the Microsoft SQL Server Management Studio, expand the **WP** database.
2. Right-click on the WP database object to display a shortcut menu, and in the shortcut menu click on the **Tasks** command to display the Tasks menu.
3. In the Task menu, click the **Import Data** command to launch the SQL Server Import and Export Wizard.



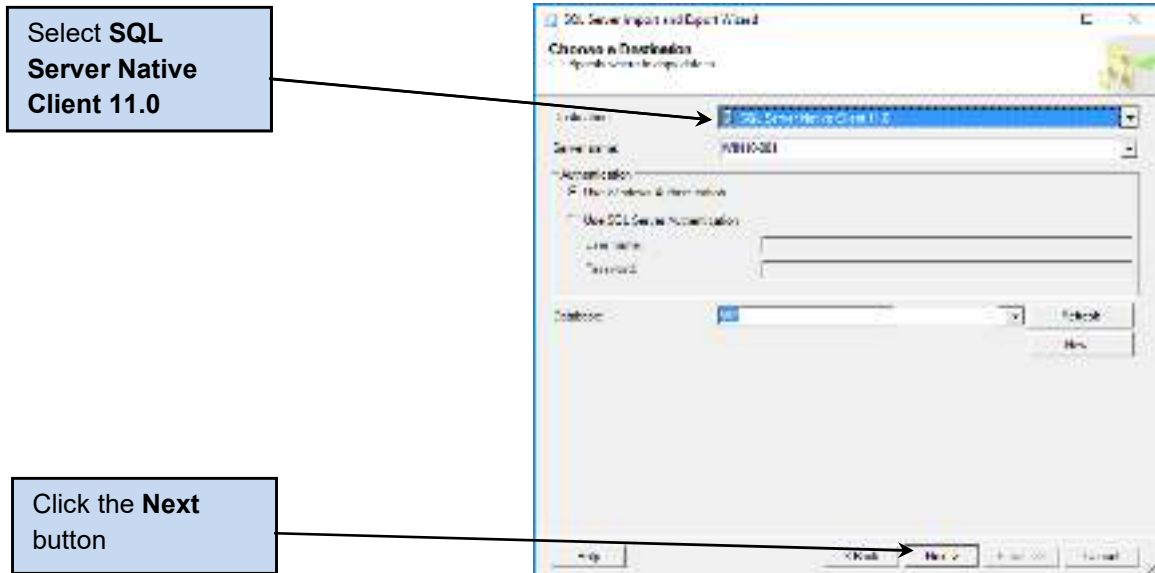
4. On the **Welcome to SQL Server Import and Export Wizard** page, click the **Next** button to display the Choose a Data Source page.



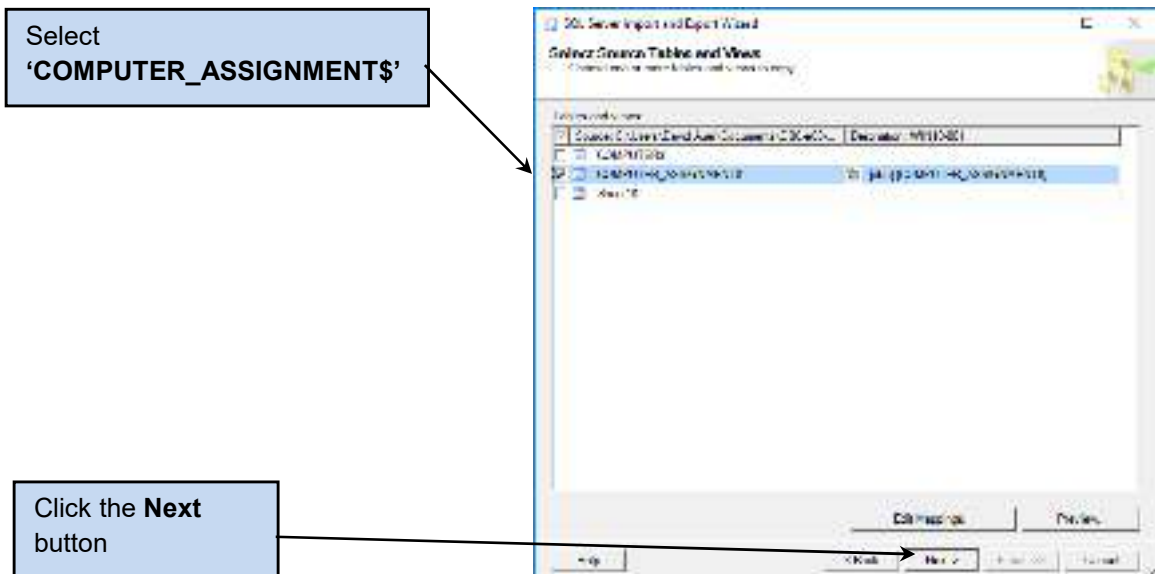
5. On the **Choose a Data Source** page select **Microsoft Excel** as the data source.
6. On the **Choose a Data Source** page, browse to the location of the Microsoft Excel file, select **Microsoft Excel 2007-2010** as the Excel version (there is a glitch if Excel 2013 or Excel 2016 is used) from the drop-down list, and make sure the check box for **First row has column names** is checked.



- Click the **Next** button to display the Choose a Destination page, and select SQL Server Native Client 11 as the destination. The WP database values are automatically supplied, and there is nothing to change.



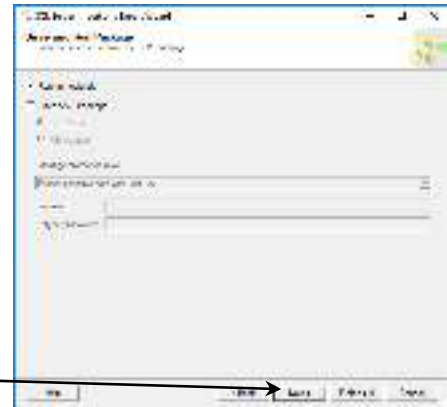
- Click the **Next** button to display the **Specify Table Copy or Query** page. The defaults are correct here.
- Click the **Next** button to display the **Select Source Tables and Views** page, and check the **'COMPUTER\_ASSIGNMENT\$'** check box in the Source column. The table name **[dbo].[COMPUTER\_ASSIGNMENT\$]** is generated and displayed in the Destination column. This is the name we will use for the temporary table in the WP database.





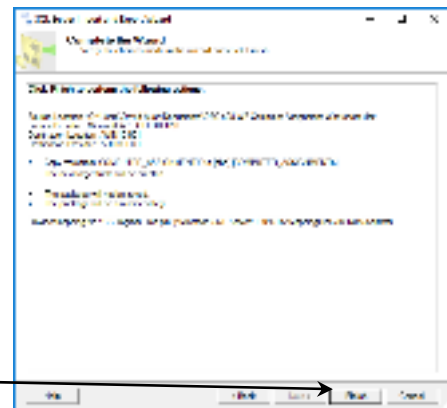
10. Click the **Next** button to display the **Save and Run Package** page. The defaults are correct.

Click the **Next** button



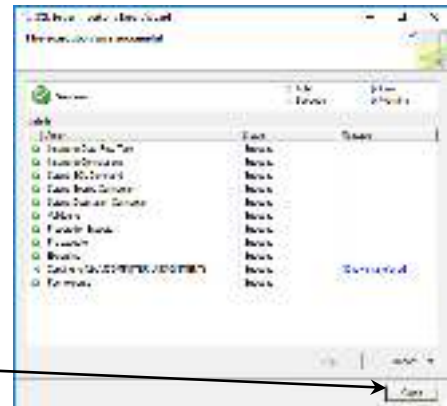
11. Click the **Next** button to display the **Complete the Wizard** page. This is a summary page. Click the **Finish** button.

Click the **Finish** button



12. The SQL Server Import and Export Wizard runs the actual import, and then displays the **The execution was successful** page. Note that there are no errors in the process. Click the **Close** button to close the Wizard.

Click the **Close** button



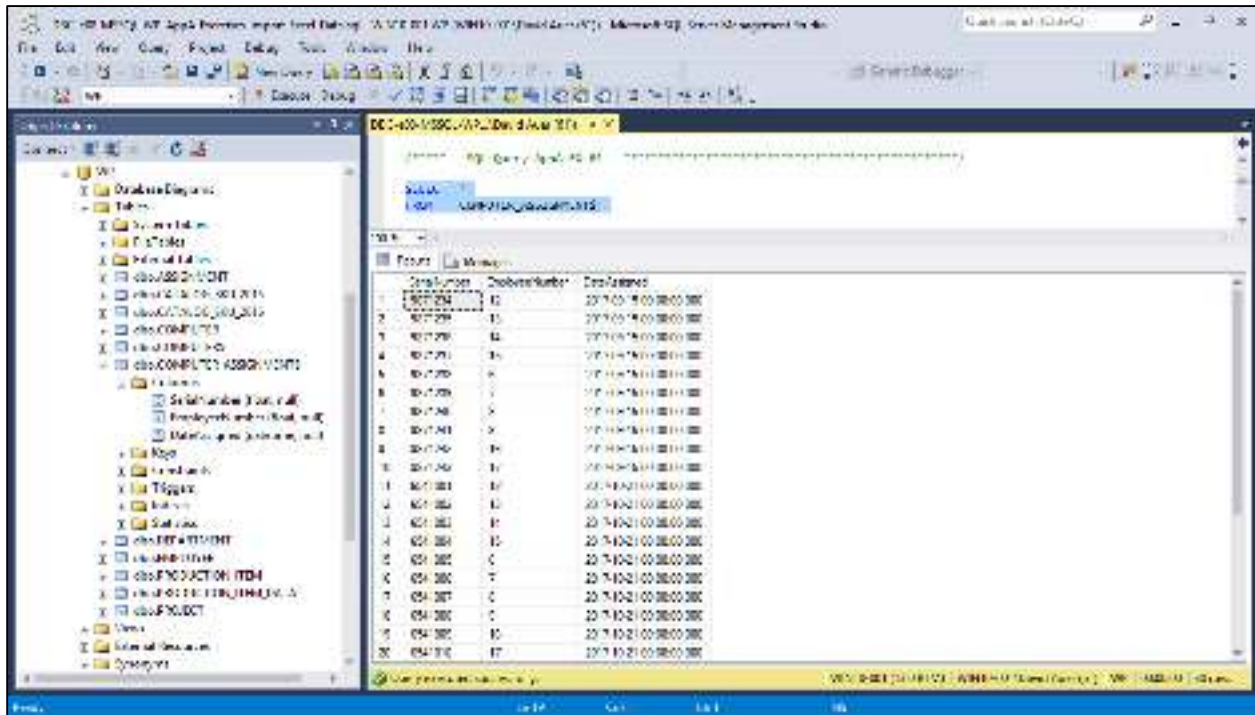
Now we created the actual COMPUTER\_ASSIGNMENT table and copy the data to it.

1. In SQL Server Management Studio, refresh the **WP** database. In Object Explorer, expand the WP database, then expand the Tables object, then expand the **dbo.COMPUTER\_ASSIGNMENT\$** object, and finally expand the Columns object.
2. Open a New Query window, and run SQL-Query-AppA-EX-01:  

```

/* *** SQL-Query-AppA-EX-01 *** */
SELECT *
FROM COMPUTER_ASSIGNMENT$;

```



3. Now we have to create the final COMPUTER\_ASSIGNMENT table in the WP database. In the Microsoft SQL Server Management Studio, write the SQL CREATE TABLE statement for the COMPUTER\_ASSIGNMENT table based on the column characteristics in Figure A-65 (these are Microsoft Access 2016 specifications).

Database Column Characteristics for the WP COMPUTER\_ASSIGNMENT Table

Column Name	Type	Key	Required	Remarks
SocialNumber	Number	Primary Key, Foreign Key	Yes	Long Integer
EmployeeNumber	Number	Primary Key, Foreign Key	Yes	Long Integer
DateAssigned	Date/Time	Primary Key	Yes	Medium Date

Figure A-65 — Database Column Characteristics for the WP COMPUTER\_ASSIGNMENT Table

One important consideration here is foreign key constraints. Note that we link to both the EMPLOYEE table using EmployeeNumber and to the COMPUTER table using SerialNumber. What referential integrity constraints should we use?

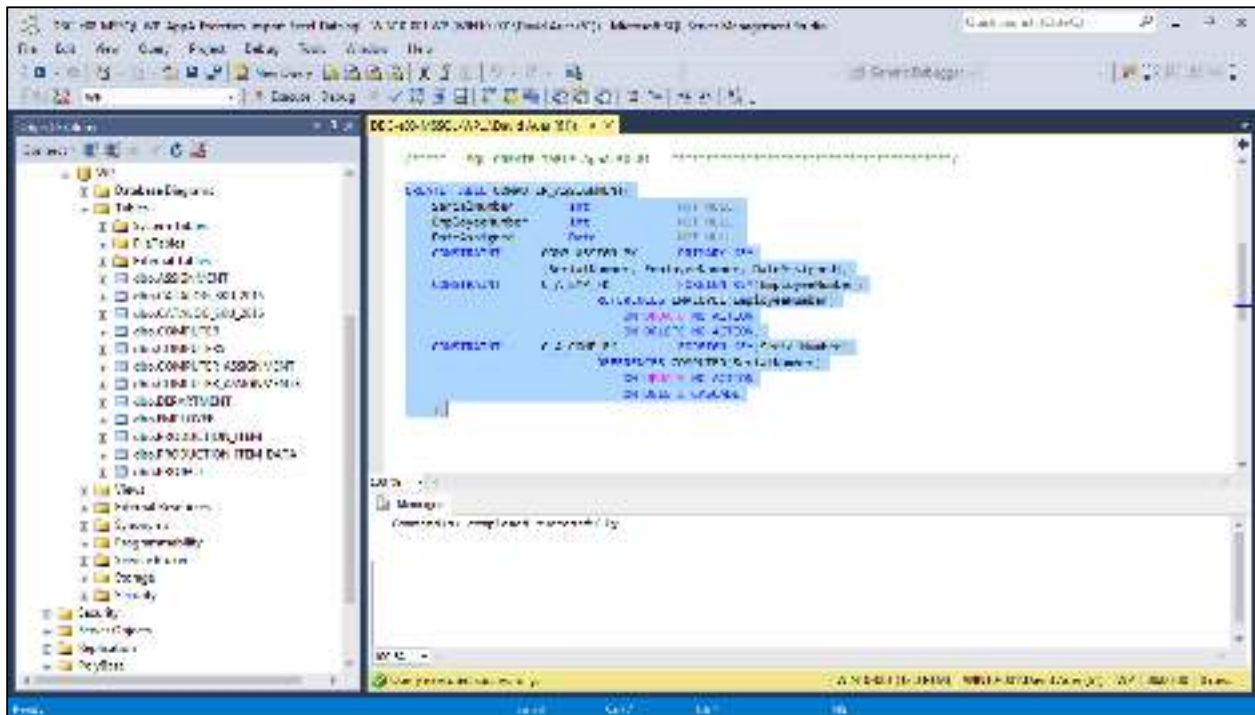
For EMPLOYEE, EmployeeNumber is a surrogate key and is never updated. Further, WP never drops employee records because of record keeping requirements. Therefore, we will never cascade updates or deletes for this primary key.

FOR COMPUTER, SerialNumber never changes. However, when we remove a computer from the WP computer inventory, we do not need to keep historical records of having had that computer. Therefore, while we do not cascade updates, we will cascade deletions for this primary key.

Here is the final SQL statement to create the COMPUTER\_ASSIGNMENT table:

```
/* *** SQL-CREATE-TABLE-AppA-EX-01 *** */
CREATE TABLE COMPUTER_ASSIGNMENT (
    SerialNumber      Int          NOT NULL,
    EmployeeNumber    Int          NOT NULL,
    DateAssigned      Date        NOT NULL,
    CONSTRAINT        COMP_ASSIGN_PK  PRIMARY KEY
                        (SerialNumber, EmployeeNumber, DateAssigned),
    CONSTRAINT        C_A_EMP_FK      FOREIGN KEY (EmployeeNumber)
                        REFERENCES EMPLOYEE (EmployeeNumber)
                        ON UPDATE NO ACTION
                        ON DELETE NO ACTION,
    CONSTRAINT        C_A_COMP_FK     FOREIGN KEY (SerialNumber)
                        REFERENCES COMPUTER (SerialNumber)
                        ON UPDATE NO ACTION
                        ON DELETE CASCADE
);
```

4. Run the SQL-CREATE-TABLE-AppA-EX-01 statement. The result is shown in the screen shot on the next page.



- To copy the imported data from the temporary COMPUTER\_ASSIGNMENT\$ table to the final COMPUTER\_ASSIGNMENT table, use the SQL bulk INSERT statement SQL-INSERT-AppA-EX-01. Note that we use an ORDER BY clause in the SELECT statement to order the data inserted into the COMPUTER\_ASSIGNMENT table:

```

/* *** SQL-INSERT-AppA-EX-01 *** */
INSERT INTO dbo.COMPUTER_ASSIGNMENT
    (SerialNumber, EmployeeNumber, DateAssigned)
SELECT     SerialNumber, EmployeeNumber, DateAssigned
FROM       COMPUTER_ASSIGNMENT$
ORDER BY   SerialNumber, EmployeeNumber, DateAssigned;

```

- After running the SQL-INSERT-AppA-EX-01 statement, run SQL-Query-AppA-EX-02. The result is shown in the screen shot on the next page.

```

/* *** SQL-Query-AppA-EX-02 *** */
SELECT *
FROM   COMPUTER_ASSIGNMENT;

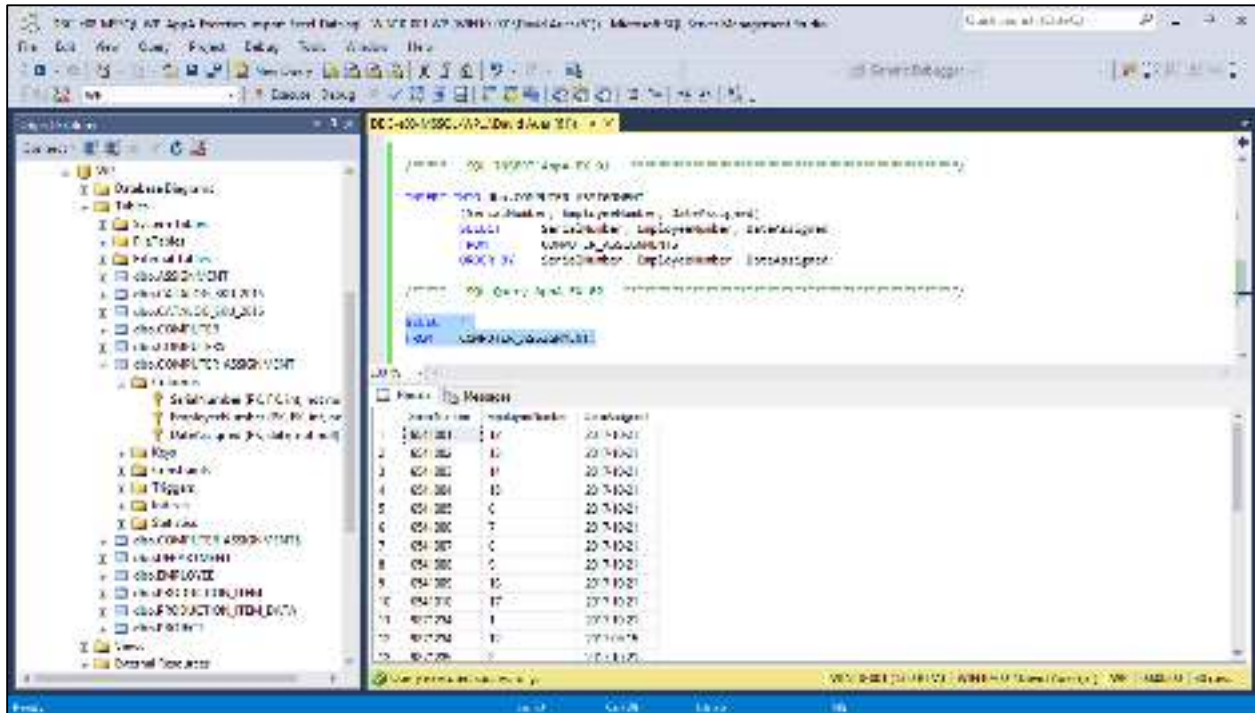
```

- Dropping the temporary COMPUTER\_ASSIGNMENT\$ table is optional—if you drop it, be sure you drop the right table!

```

/* *** SQL-DROP-TABLE-AppA-EX-01 *** */
DROP TABLE COMPUTER_ASSIGNMENT$;

```



Because we were able to put all needed constraints, including PRIMARY KEY and the FOREIGN KEY constraints, into the SQL CREATE TABLE statement, the COMPUTER\_ASSIGNMENT table does not require any modifications and is ready to use.

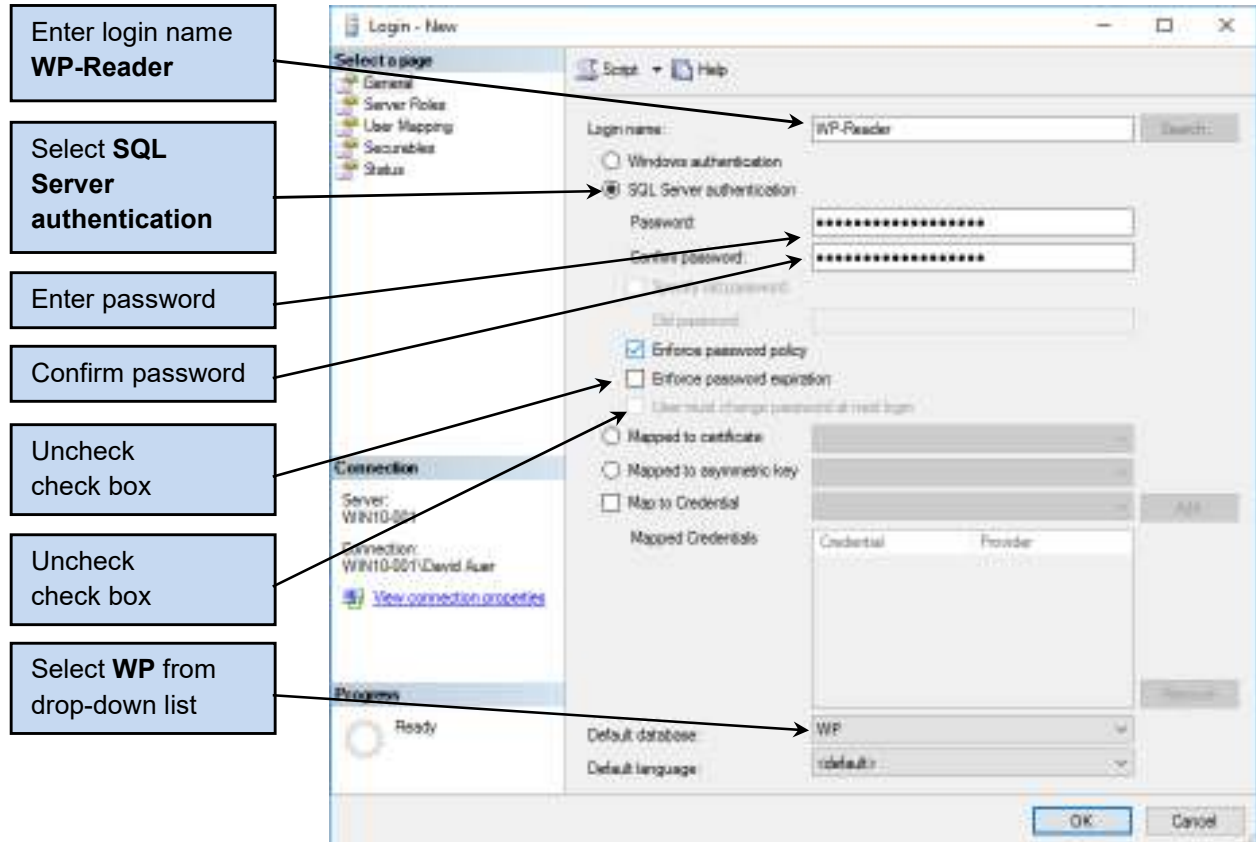
A.32 *If you have not already done so, create the **WP-User** user account and associated permissions in the SQL Server 2016 WP database as explained in the text.*

This is self-explanatory. This exercise is intended to make sure that the student is prepared to answer exercise A.33.

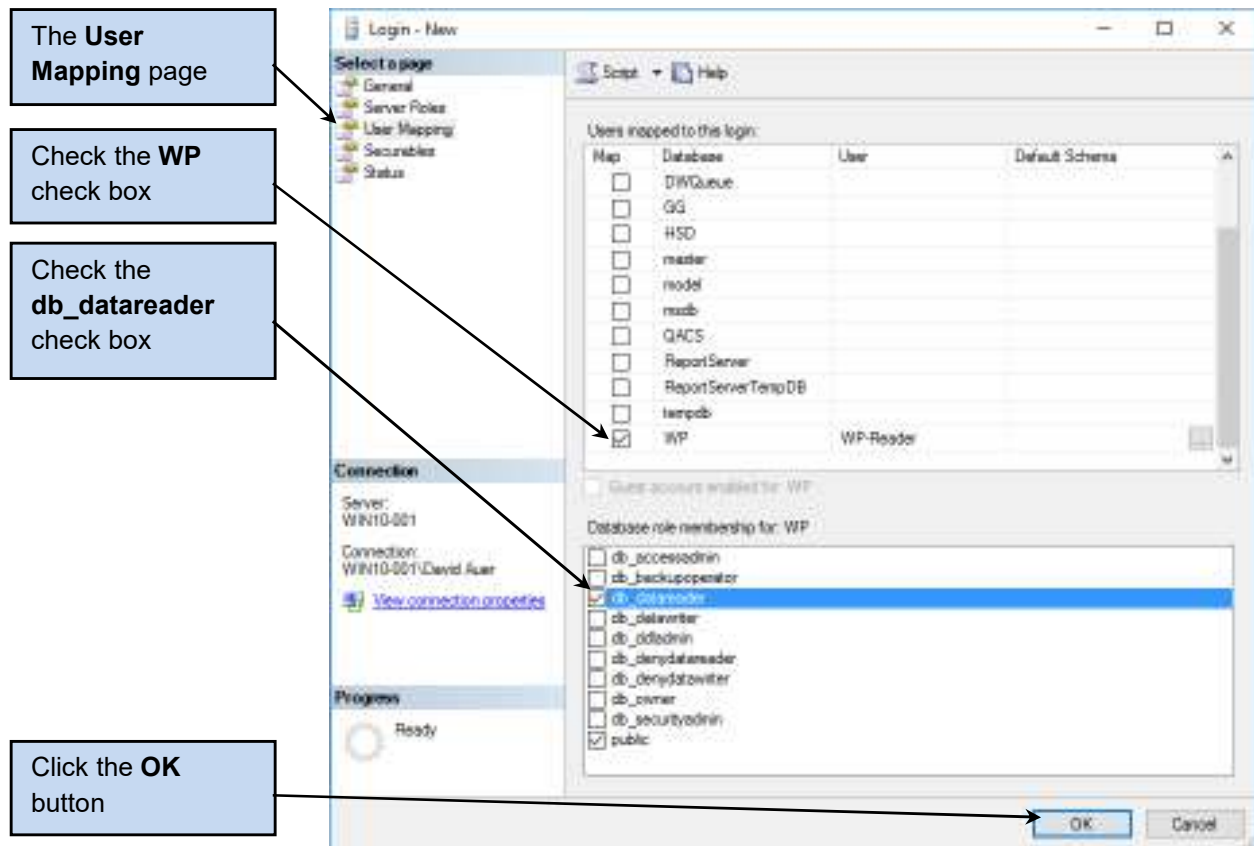
A.33 *Create a user account in the SQL Server 2016 WP database named **WP-Reader**. Give this user **SQL Server authentication** with the password of **WP-Reader+password** and with other password settings to match those shown in Figure A-44. Give WP-Reader a user mapping to the WP database with **public** and **db\_datareader** permissions only.*

1. In the Microsoft SQL Server Management Studio, expand the **Security** folder so that the **Logins** folder and its contents are visible.
2. Right-click the Logins folder to display a shortcut menu, and click the **New Login** command.
3. The **General** page of the Login - New dialog box is displayed.
4. In the Login - New dialog box General page, type in the login name **WP-Reader**.
5. Click the **SQL Server authentication** radio button.
6. Uncheck the **User must change password at next login** password setting.

7. Uncheck the **Enforce password expiration** password setting.
8. Type in the password **WP-Reader+password** in both the Password and Confirm password text boxes.
9. Select **WP** as the Default database from the Default database drop-down list.



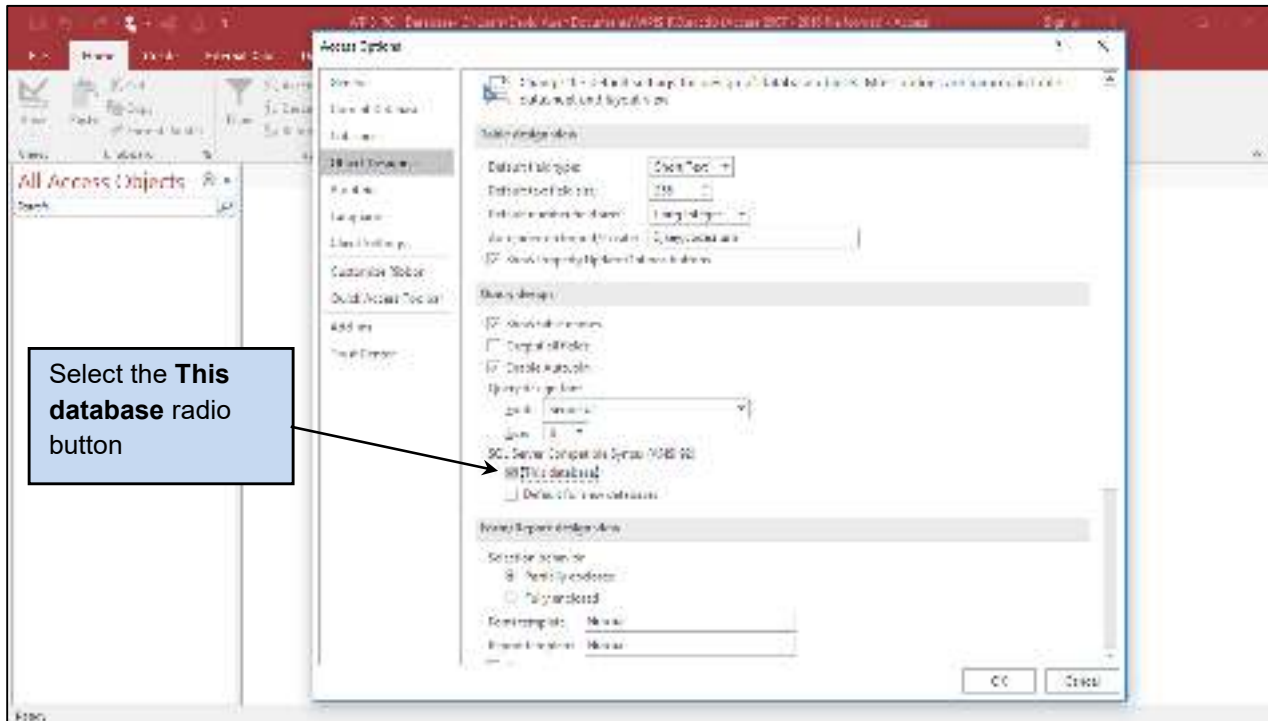
10. Double check your settings, and then click the **User Mapping** button shown to display the User Mapping page of the Login – New dialog box.
11. On the User Mapping page, scroll down the **Users mapped to this login** list until you can see the **WP** database settings, and click the check box in the **Map** column.
12. In the **Database role memberships for: WP** list, leave already checked the public role selected and additionally check the check box for the db\_datareader database roles. These permissions give WP-User the necessary rights to read data from the WP database tables, but do not grant permission to write new or revised data to the WP database tables.



13. Double check your settings, and then click the **OK** button.
14. The new user login WP-Reader is created, and assigned the specified set of permissions to the WP database.

A.34 Create a Microsoft Access 2016 database named **WPIS\_RO.accdb** where RO stands for “read-only.” This database will be a read-only application for the SQL Server 2016 WP database, which will allow users to read and query the data in the WP database but not to make any updates to the data or to insert new data. Then:

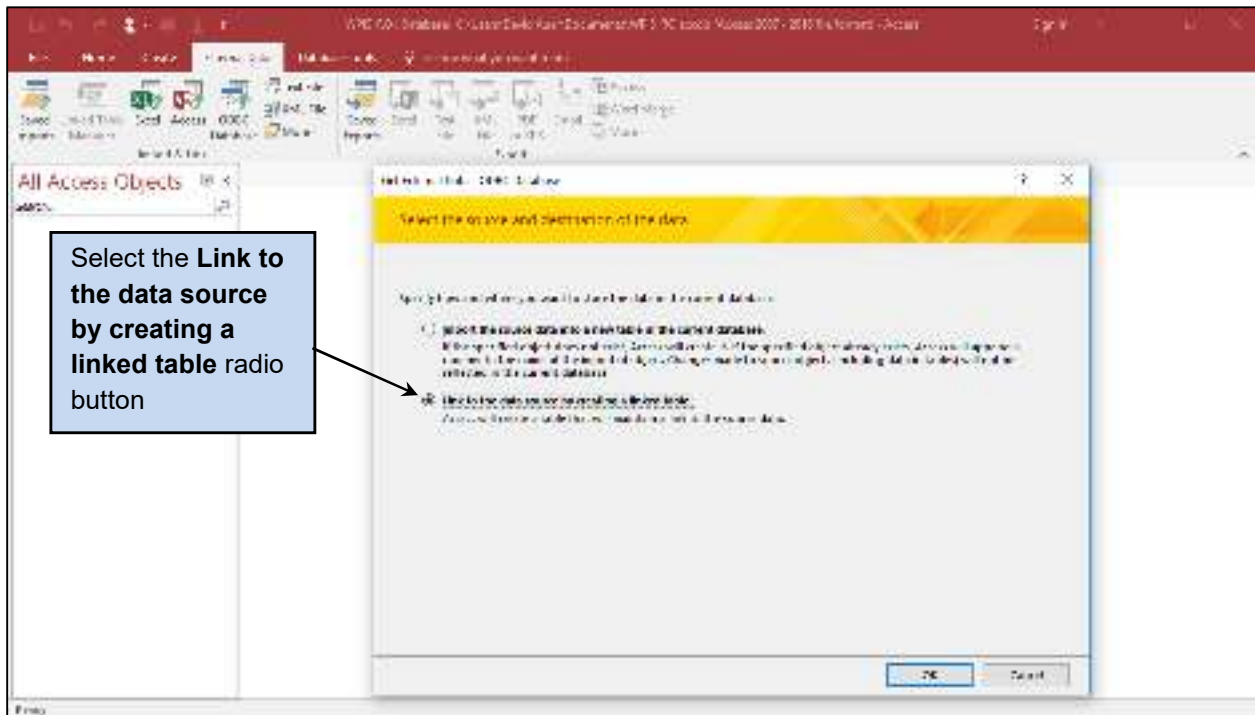
1. Set the **WPIS\_RO.accdb** database to use **SQL Server Compatible Syntax (ANSI 92)**.



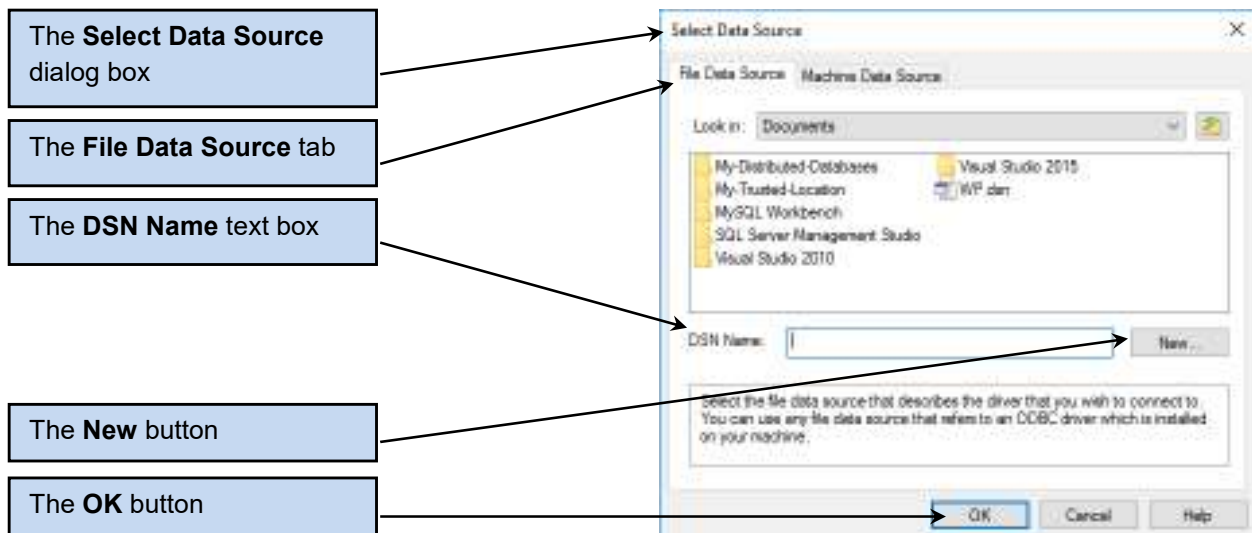
2. Link the **WPIS\_RO.accdb** database to the SQL Server 2016 WP database. When you create your File Data Source DSN, name the DSN **WPRO**, and use the WP-Reader user account (as detailed in Exercise A.33) for SQL Server authentication.

1. In the Microsoft Access 2016 **WPIS.accdb** database, click the **External Data** command tab, and then click the **ODBC Database** button in the Import & Link commands section.
2. The **Get External Data - ODBC Database** Wizard dialog box is displayed.
3. In the Get External Data – ODBC Database Wizard dialog box, the **Select the source and destination of the data** page is displayed. Click the **Link to the data source by creating a linked table** radio button, as shown in the screen shot on the next page.

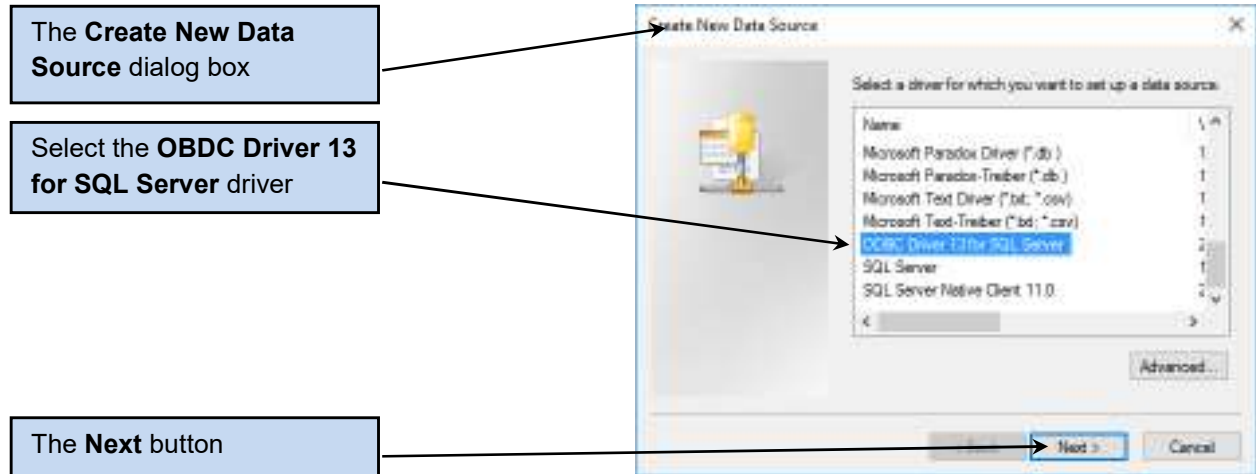




4. Click the **OK** button.
5. The **Select Data Source** dialog box is displayed. This is the dialog box that we will use to create the needed ODBC DSN. In the **Select Data Source** dialog box, make sure the **File Data Source** tab is selected.



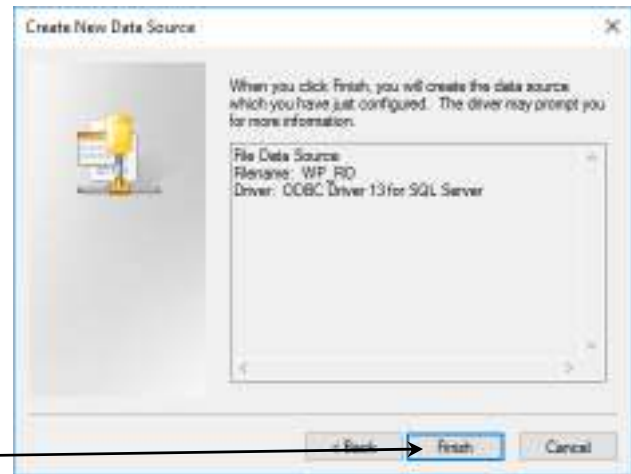
6. Click the **New** button to display the **Create New Data Source**.
7. In the Create New Data Source dialog box, scroll down through the list of drivers until you can see the driver named ODBC Driver 13 for SQL Server. Click this driver name to select it.



8. Click the **Next** button.
9. The next page of the Create New Data Source dialog box provides a text box for naming the new DSN. Type in **WP\_RO**.



10. Click the **Next** button.
11. The next page of the Create New Data Source dialog box provides a summary of the settings that will be used to create the new DSN.



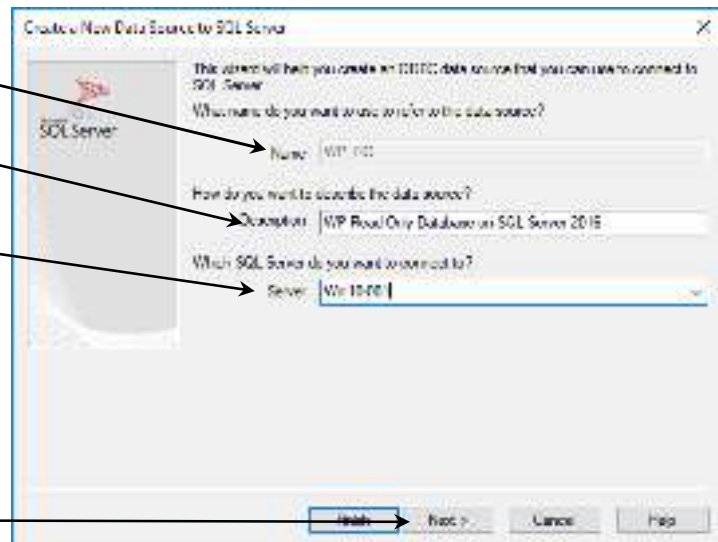
The **Finish** button

10. Click the **Finish** button.
11. The **Create a New Data Source to SQL Server** Wizard dialog box is displayed, and the DSN name of WP is already assigned.
12. In the **Description** text box enter the text **WP Read Only Database on SQL Server 2016**.
13. In the **Server** text box, type in the SQL Server name exactly as it appears at the top of the Object Explorer window in the SQL Server Management Studio. In Figure A-42, you can see that our server name is **WIN10-001**, so this is what we will enter. This name may consist of two parts—a *computer name* (in our case WIN10-001) and an *SQL Server 2016 instance name*. If you have only one instance of SQL Server 2016 on your computer, and it was installed with the default instance name of MSSQLSERVER, then no instance name appears in Object Explorer, and no instance name is needed in the **Server** text box. This is what has happened in our case. The dialog box now appears as shown here.

The DSN **WP\_RO**

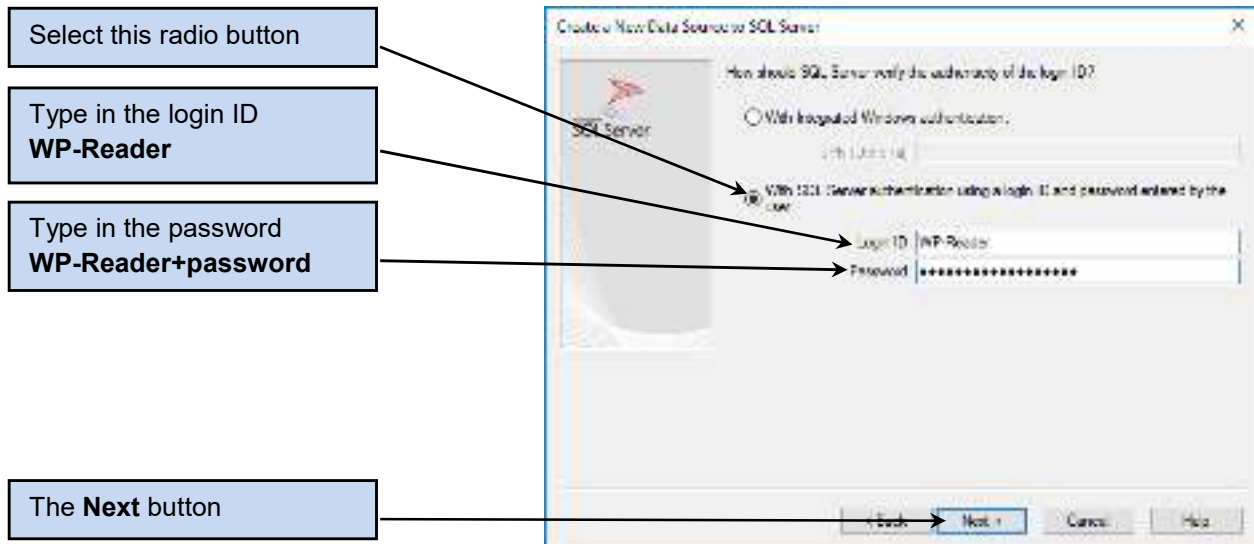
Type in the description

Type in the **SQL Server** name

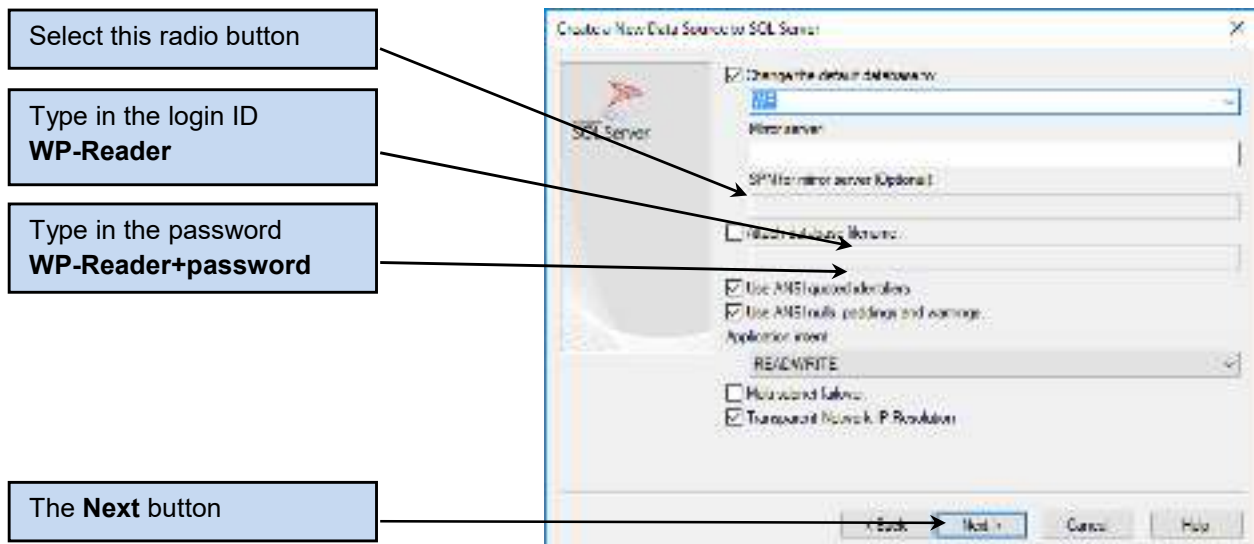


The **Next** button

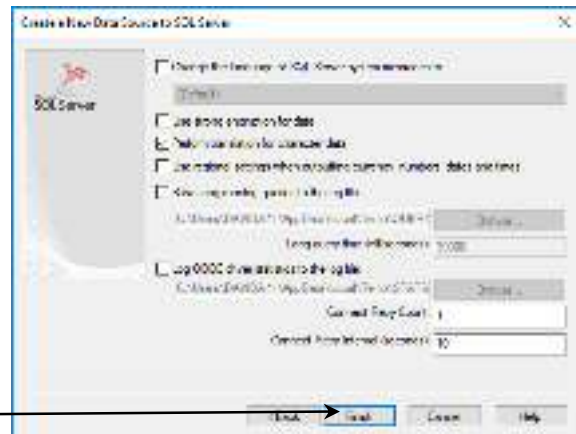
- Click the **Next** button. The Login settings page is displayed. Click the **With SQL Server authentication using a login ID and password entered by the user** radio button, and then enter the login ID **WP-Reader** and the password **WP-Reader+password**.



- Click the **Next** button. A database settings page is displayed. Set the default database to **WP**, but leave all the other setting as they are.



- Click the **Next** button. An additional set of database settings page is displayed. The defaults shown here are correct.



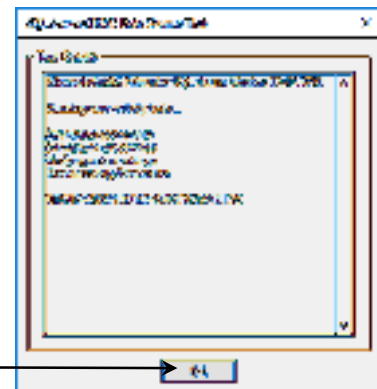
The **Finish** button

18. Click the **Finish** button. The **ODBC Microsoft SQL Server Setup** dialog box is displayed, showing the settings that will be used to create the DSN. Additionally, the dialog box has a **Test Data Source** button that can be used to test the DSN before it is created.
19. Click the **Test Data Source** button.



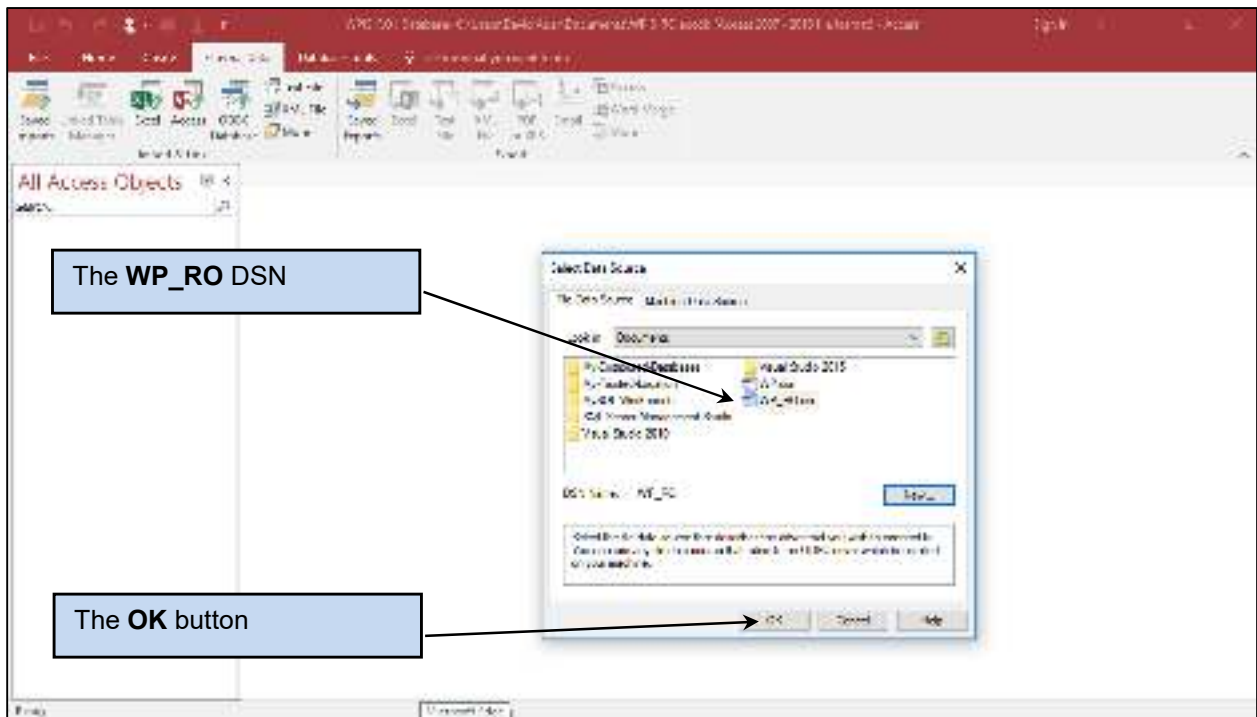
The **Test Data Source** button

20. If all the settings are correct, the **SQL Server ODBC Data Source Test** dialog box is displayed with the message "TESTS COMPLETED SUCCESSFULLY". In the SQL Server ODBC Data Source Test dialog box, click the **OK** button.



The **OK** button

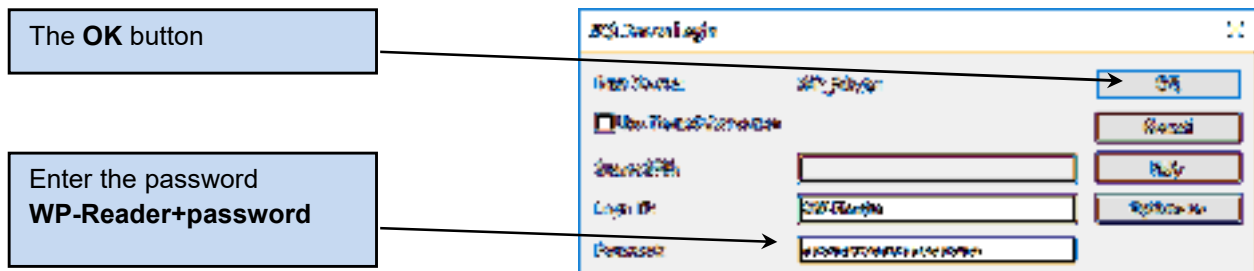
21. The **ODBC Microsoft SQL Server Setup** dialog box is displayed. Click the **OK** button.
22. The **WP\_RO DSN** file data source is created and displayed in the **Select Data Source**. Now that the DSN is completed, we can finish linking the Microsoft Access 2016 database to the SQL Server database. In the Select Data Source dialog box, click the **OK** button.



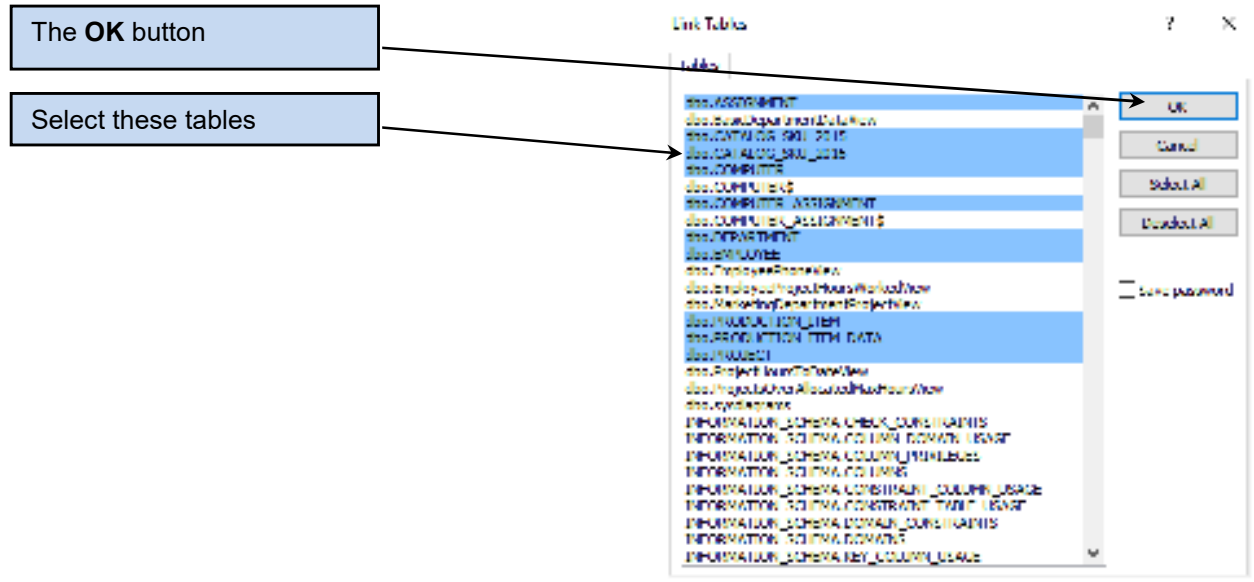
3. *Import all existing tables (including the COMPUTER and COMPUTER\_AUTHENTICATION tables if they have been imported as detailed in Exercises A.30 and A.31).*

**Note that the steps in this question are a continuation of the steps in question 2—the Microsoft Access 2016 Get External Data – ODBC Database Wizard continues to run after we close the Select Data Source dialog box!**

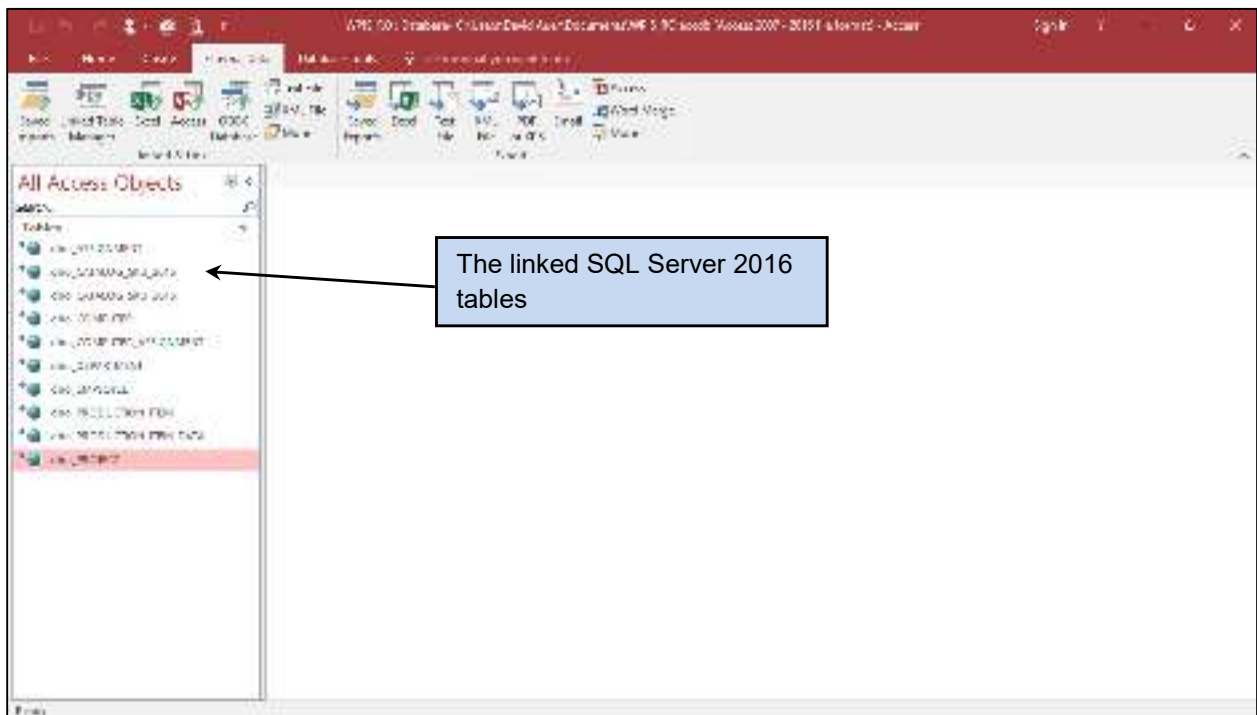
1. The **SQL Server Login** dialog box is displayed. Enter the password **WP-Reader+password** in the Password text box, and then click the **OK** button.



- The **Link Tables** dialog box is displayed. Select the ten tables in the WP database as shown. To select the **dbo.ASSIGNMENT** table, click on it. To add each additional table to the selection, **press the Ctrl key and then click on the table name**. **dbo** stands for database owner and is commonly shown in SQL Server object names (technically, it is a schema name).

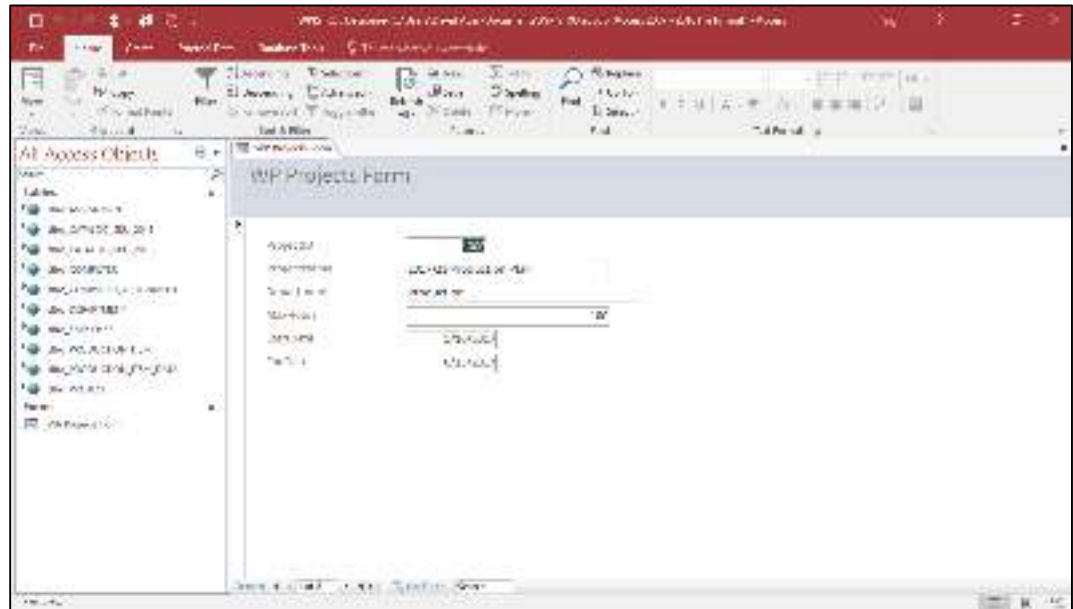


- Click the **OK** button. The ODBC links between the WP\_RO.accdb Microsoft Access 2016 and the WP database in SQL Server 2016 are completed.



## Appendix A - Getting Started with Microsoft SQL Server 2016

4. **Create a form to show all the data in PROJECT table named *WP Projects Form*.**  
This is done using Microsoft Access 2016 techniques as discussed the Chapter 1 section of “The Access Workbench.”



5. **Create a report to show all the data in the PROJECT table named *WP Projects Report*.**

This is done using Microsoft Access 2016 techniques as discussed in the Chapter 4 section of “The Access Workbench.”

