Object-Oriented Programming: Inheritance, Solutions

9

Say not you know another entirely,
till you have divided an inheritance with him.
—Johann Kasper Lavater

This method is to define as the number of a class the class of all classes similar to the given class.
—Bertrand Russell

Objectives

In this chapter you'll learn:

- How inheritance promotes software reusability.
- The notions of superclasses and subclasses and the relationship between them.
- To use keyword `extends` to create a class that inherits attributes and behaviors from another class.
- To use access modifier `protected` to give subclass methods access to superclass members.
- To access superclass members with `super`.
- How constructors are used in inheritance hierarchies.
- The methods of class `Object`, the direct or indirect superclass of all classes.

Self-Review Exercises

9.1 Fill in the blanks in each of the following statements:

a) __________ is a form of software reusability in which new classes acquire the members of existing classes and embellish those classes with new capabilities.

ANS: Inheritance.

b) A superclass's __________ members can be accessed in the superclass declaration *and in* subclass declarations.

ANS: `public` and `protected`.

c) In a(n) __________ relationship, an object of a subclass can also be treated as an object of its superclass.

ANS: *is-a* or inheritance.

d) In a(n) __________ relationship, a class object has references to objects of other classes as members.

ANS: *has-a* or composition.

e) In single inheritance, a class exists in a(n) __________ relationship with its subclasses.

ANS: hierarchical.

f) A superclass's __________ members are accessible anywhere that the program has a reference to an object of that superclass or to an object of one of its subclasses.

ANS: `public`.

g) When an object of a subclass is instantiated, a superclass __________ is called implicitly or explicitly.

ANS: constructor.

h) Subclass constructors can call superclass constructors via the __________ keyword.

ANS: `super`.

9.2 State whether each of the following is *true* or *false*. If a statement is *false*, explain why.

a) Superclass constructors are not inherited by subclasses.

ANS: True.

b) A *has-a* relationship is implemented via inheritance.

ANS: False. A *has-a* relationship is implemented via composition. An *is-a* relationship is implemented via inheritance.

c) A `Car` class has an *is-a* relationship with the `SteeringWheel` and `Brakes` classes.

ANS: False. This is an example of a *has-a* relationship. Class `Car` has an *is-a* relationship with class `Vehicle`.

d) When a subclass redefines a superclass method by using the same signature, the subclass is said to overload that superclass method.

ANS: False. This is known as overriding, not overloading—an overloaded method has the same name, but a different signature.

Exercises

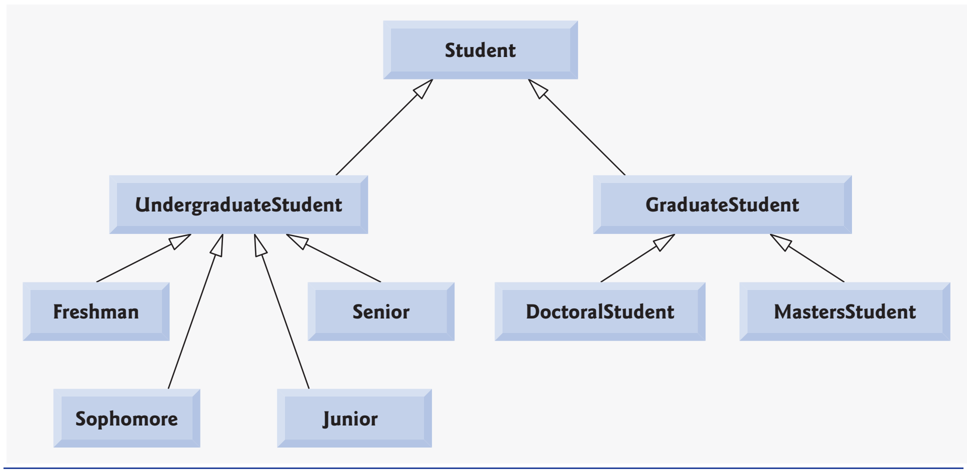
NOTE: Solutions to the programming exercises are located in the* `ch09solutions` *folder. Each exercise has its own folder named* `ex09_##` *where* `##` *is a two-digit number representing the exercise number. For example, exercise 9.3's solution is located in the folder* `ex09_03`*.

9.4 Discuss the ways in which inheritance promotes software reuse, saves time during program development and helps prevent errors.

ANS: Inheritance allows developers to create subclasses that reuse code declared already in a superclass. Avoiding the duplication of common functionality between several classes by building a class inheritance hierarchy can save developers a considerable amount of time. Similarly, placing common functionality in a single superclass, rather than duplicating the code in multiple unrelated classes, helps prevent the same errors from appearing in multiple source-code files. If errors occur in the common functionality of the superclass, the software developer needs to modify only the superclass's.

9.5 Draw an inheritance hierarchy for students at a university similar to the hierarchy shown in Fig. 9.2. Use `Student` as the superclass of the hierarchy, then extend `Student` with classes `UndergraduateStudent` and `GraduateStudent`. Continue to extend the hierarchy as deep (i.e., as many levels) as possible. For example, `Freshman`, `Sophomore`, `Junior` and `Senior` might extend `UndergraduateStudent`, and `DoctoralStudent` and `MastersStudent` might be subclasses of `GraduateStudent`. After drawing the hierarchy, discuss the relationships that exist between the classes. [*Note:* You do not need to write any code for this exercise.]

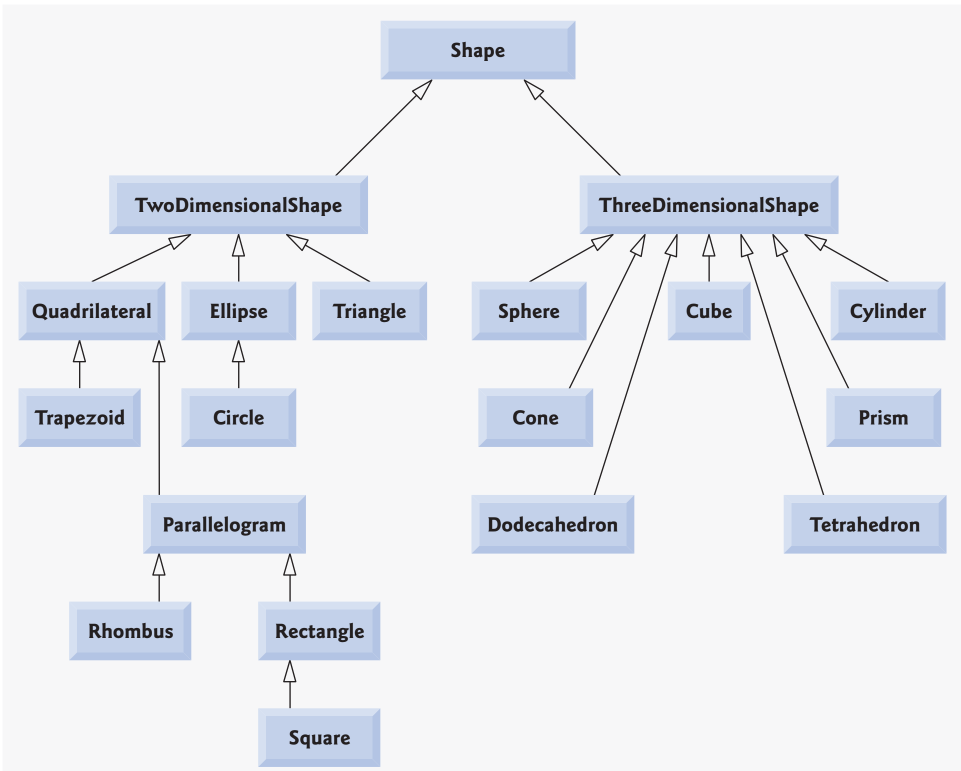
ANS:



This hierarchy contains many *is-a* (inheritance) relationships. An `UndergraduateStudent` *is a* `Student`. A `GraduateStudent` *is a* `Student`, too. Each of the classes `Freshman`, `Sophomore`, `Junior` and `Senior` *is an* `UndergraduateStudent` and *is a* `Student`. Each of the classes `DoctoralStudent` and `MastersStudent` *is a* `GraduateStudent` and *is a* `Student`. Note that there could be *many* more classes. For example, `GraduateStudent` could have subclasses like `LawStudent`, `BusinessStudent`, `MedicalStudent`, etc.

9.6 The world of shapes is much richer than the shapes included in the inheritance hierarchy of Fig. 9.3. Write down all the shapes you can think of—both two-dimensional and three-dimensional—and form them into a more complete `Shape` hierarchy with as many levels as possible. Your hierarchy should have class `Shape` at the top. Classes `TwoDimensionalShape` and `ThreeDimensionalShape` should extend `Shape`. Add additional subclasses, such as `Quadrilateral` and `Sphere`, at their correct locations in the hierarchy as necessary.

ANS: [*Note:* Solutions may vary.]



9.7 Some programmers prefer not to use `protected` access, because they believe it breaks the encapsulation of the superclass. Discuss the relative merits of using `protected` access vs. using `private` access in superclasses.

ANS: `private` instance variables are hidden in the subclass and are accessible only through the `public` or `protected` methods of the superclass. Using `protected` access enables the subclass to manipulate the `protected` members without using the access methods of the superclass. This makes the code more brittle, because changes to the superclass might require changes to the subclasses. If the superclass instance variables are `private`, the methods of the superclass must be used to access the data. This encapsulation makes the code easier to maintain, modify and debug.