CHAPTER

14

JAVAFX BASICS

Objectives

- To distinguish between JavaFX, Swing, and AWT (§14.2).
- To write a simple JavaFX program and understand the relationship among stages, scenes, and nodes (§14.3).
- To create user interfaces using panes, UI controls, and shapes (§14.4).
- To update property values automatically through property binding (§14.5).
- To use the common properties `style` and `rotate` for nodes (§14.6).
- To create colors using the `Color` class (§14.7).
- To create fonts using the `Font` class (§14.8).
- To create images using the `Image` class and to create image views using the `ImageView` class (§14.9).
- To layout nodes using `Pane`, `StackPane`, `FlowPane`, `GridPane`, `BorderPane`, `HBox`, and `VBox` (§14.10).
- To display text using the `Text` class and create shapes using `Line`, `Circle`, `Rectangle`, `Ellipse`, `Arc`, `Polygon`, and `Polyline` (§14.11).
- To develop the reusable GUI component `ClockPane` for displaying an analog clock (§14.12).

14.1 Introduction

JavaFX is an excellent pedagogical tool for learning object-oriented programming.

JavaFX is a new framework for developing Java GUI programs. The JavaFX API is an excellent example of how the object-oriented principles are applied. This chapter serves two purposes. First, it presents the basics of JavaFX programming. Second, it uses JavaFX to demonstrate object-oriented design and programming. Specifically, this chapter introduces the framework of JavaFX and discusses JavaFX GUI components and their relationships. You will learn how to develop simple GUI programs using layout panes, buttons, labels, text fields, colors, fonts, images, image views, and shapes.

14.2 JavaFX vs Swing and AWT

Swing and AWT are replaced by the JavaFX platform for developing rich Internet applications.

AWT

When Java was introduced, the GUI classes were bundled in a library known as the *Abstract Windows Toolkit (AWT)*. AWT is fine for developing simple graphical user interfaces, but not for developing comprehensive GUI projects. In addition, AWT is prone to platform-specific bugs. The AWT user-interface components were replaced by a more robust, versatile, and flexible library known as *Swing components*. Swing components are painted directly on canvases using Java code. Swing components depend less on the target platform and use less of the native GUI resources. Swing is designed for developing desktop GUI applications. It is now replaced by a completely new GUI platform known as *JavaFX*. JavaFX incorporates modern GUI technologies to enable you to develop rich Internet applications. A rich Internet application (RIA) is a Web application designed to deliver the same features and functions normally associated with deskop applications. A JavaFX application can run seemlessly on a desktop and from a Web browser. Additionally, JavaFX provides a multi-touch support for touch-enabled devices such as tablets and smart phones. JavaFX has a built-in 2D, 3D, animation support, video and audio playback, and runs as a stand-alone application or from a browser.

Swing

JavaFX

why teaching JavaFX?

This book teaches Java GUI programming using JavaFX for two reasons. First, JavaFX is much simpler to learn and use for new Java programmers. Second, Swing is essentially dead, because it will not receive any further enhancement. JavaFX is the new GUI tool for developing cross-platform-rich Internet applications on desktop computers, on hand-held devices, and on the Web.

14.1 Explain the evolution of Java GUI technologies.

14.2 Explain why this book teaches Java GUI using JavaFX.

14.3 The Basic Structure of a JavaFX Program

The abstract `javafx.application.Application` *class defines the essential framework for writing JavaFX programs.*

We begin by writing a simple JavaFX program that illustrates the basic structure of a JavaFX program. Every JavaFX program is defined in a class that extends `javafx.application.Application`, as shown in Listing 14.1:

LISTING 14.1 MyJavaFX.java

```
1 import javafx.application.Application;
2 import javafx.scene.Scene;
3 import javafx.scene.control.Button;
4 import javafx.stage.Stage;
```

```
5
6  public class MyJavaFX extends Application {                          extend Application
7    @Override // Override the start method in the Application class
8    public void start(Stage primaryStage) {                            override start
9      // Create a scene and place a button in the scene
10     Button btOK = new Button("OK");                                   create a button
11     Scene scene = new Scene(btOK, 200, 250);                          create a scene
12     primaryStage.setTitle("MyJavaFX"); // Set the stage title         set stage title
13     primaryStage.setScene(scene); // Place the scene in the stage     set a scene
14     primaryStage.show(); // Display the stage                         display stage
15   }
16
17   /**
18    * The main method is only needed for the IDE with limited
19    * JavaFX support. Not needed for running from the command line.
20    */
21   public static void main(String[] args) {                           main method
22     Application.launch(args);                                        launch application
23   }
24 }
```

You can test and run your program from a command window or from an IDE such as NetBeans or Eclipse. A sample run of the program is shown in Figure 14.1. Supplements II.F–H give the tips for running JavaFX programs from a command window, NetBeans, and Eclipse. A JavaFX program can run stand-alone or from a Web browser. For running a JavaFX program from a Web browser, see Supplement II.I.

JavaFX on NetBenas and Eclipse

FIGURE 14.1 A simple JavaFX displays a button in the window.

The `launch` method (line 22) is a static method defined in the `Application` class for launching a stand-alone JavaFX application. The `main` method (lines 21–23) is not needed if you run the program from the command line. It may be needed to launch a JavaFX program from an IDE with a limited JavaFX support. When you run a JavaFX application without a main method, JVM automatically invokes the `launch` method to run the application.

`launch`

The main class overrides the `start` method defined in `javafx.application.Application` (line 8). After a JavaFX application is launched, the JVM constructs an instance of the class using its `no-arg` constructor and invokes its `start` method. The `start` method normally places UI controls in a scene and displays the scene in a stage, as shown in Figure 14.2a.

construct application

start application

Line 10 creates a `Button` object and places it in a `Scene` object (line 11). A `Scene` object can be created using the constructor `Scene(node, width, height)`. This constructor specifies the width and height of the scene and places the node in the scene.

`scene`

A `Stage` object is a window. A `Stage` object called *primary stage* is automatically created by the JVM when the application is launched. Line 13 sets the scene to the primary stage and line 14 displays the primary stage. JavaFX names the `Stage` and `Scene` classes using the analogy from the theater. You may think stage as the platform to support scenes and nodes as actors to perform in the scenes.

primary stage

You can create additional stages if needed. The JavaFX program in Listing 14.2 displays two stages, as shown in Figure 14.2b.

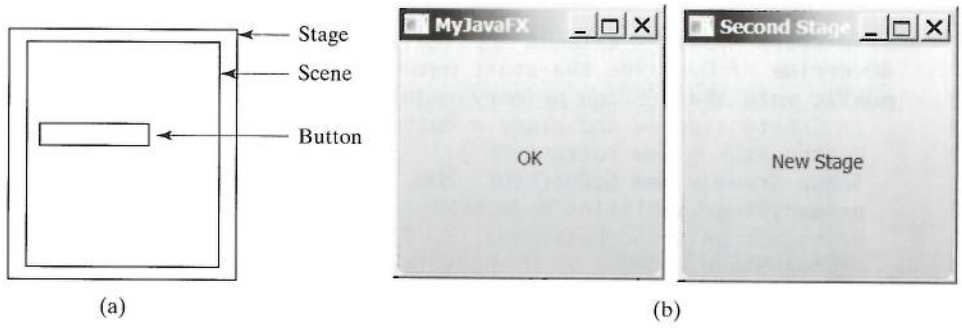


FIGURE 14.2 (a) Stage is a window for displaying a scene that contains nodes. (b) Multiple stages can be displayed in a JavaFX program.

LISTING 14.2 MultipleStageDemo.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.control.Button;
4  import javafx.stage.Stage;
5
6  public class MultipleStageDemo extends Application {
7    @Override // Override the start method in the Application class
8    public void start(Stage primaryStage) {
9      // Create a scene and place a button in the scene
10     Scene scene = new Scene(new Button("OK"), 200, 250);
11     primaryStage.setTitle("MyJavaFX"); // Set the stage title
12     primaryStage.setScene(scene); // Place the scene in the stage
13     primaryStage.show(); // Display the stage
14
15     Stage stage = new Stage(); // Create a new stage
16     stage.setTitle("Second Stage"); // Set the stage title
17     // Set a scene with a button in the stage
18     stage.setScene(new Scene(new Button("New Stage"), 100, 100));
19     stage.show(); // Display the stage
20   }
21 }
```

primary stage in start

display primary stage

create second stage

display second stage

main method omitted

main method omitted

Note that the main method is omitted in the listing since it is identical for every JavaFX application. From now on, we will not list the `main` method in our JavaFX source code for brevity.

prevent stage resizing

By default, the user can resize the stage. To prevent the user from resizing the stage, invoke `stage.setResizable(false)`.

Check Point

14.3 How do you define a JavaFX main class? What is the signature of the `start` method? What is a stage? What is a primary stage? Is a primary stage automatically created? How do you display a stage? Can you prevent the user from resizing the stage? Can you replace `Application.launch(args)` by `launch(args)` in line 22 in Listing 14.1?

14.4 Show the output of the following JavaFX program.

```
import javafx.application.Application;
import javafx.stage.Stage;

public class Test extends Application {
  public Test() {
    System.out.println("Test constructor is invoked");
  }
```

```
  @Override // Override the start method in the Application class
  public void start(Stage primaryStage) {
    System.out.println("start method is invoked");
  }

  public static void main(String[] args) {
    System.out.println("launch application");
    Application.launch(args);
  }
}
```

14.4 Panes, UI Controls, and Shapes

Panes, UI controls, and shapes are subtypes of `Node`.

When you run MyJavaFX in Listing 14.1, the window is displayed as shown in Figure 14.1. The button is always centered in the scene and occupies the entire window no matter how you resize it. You can fix the problem by setting the position and size properties of a button. However, a better approach is to use container classes, called *panes*, for automatically laying out the nodes in a desired location and size. You place nodes inside a pane and then place the pane into a scene. A *node* is a visual component such as a shape, an image view, a UI control, or a pane. A *shape* refers to a text, line, circle, ellipse, rectangle, arc, polygon, polyline, etc. A *UI control* refers to a label, button, check box, radio button, text field, text area, etc. A scene can be displayed in a stage, as shown in Figure 14.3a. The relationship among `Stage`, `Scene`, `Node`, `Control`, and `Pane` is illustrated in the UML diagram, as shown in Figure 14.3b. Note that a `Scene` can contain a `Control` or a `Pane`, but not a `Shape` or an `ImageView`. A `Pane` can contain any subtype of `Node`. You can create a `Scene` using the constructor `Scene(Parent, width, height)` or `Scene(Parent)`. The dimension of the scene is automatically decided in the latter constructor. Every subclass of `Node` has a no-arg constructor for creating a default node.

pane

node

shape

UI control

Listing 14.3 gives a program that places a button in a pane, as shown in Figure 14.4

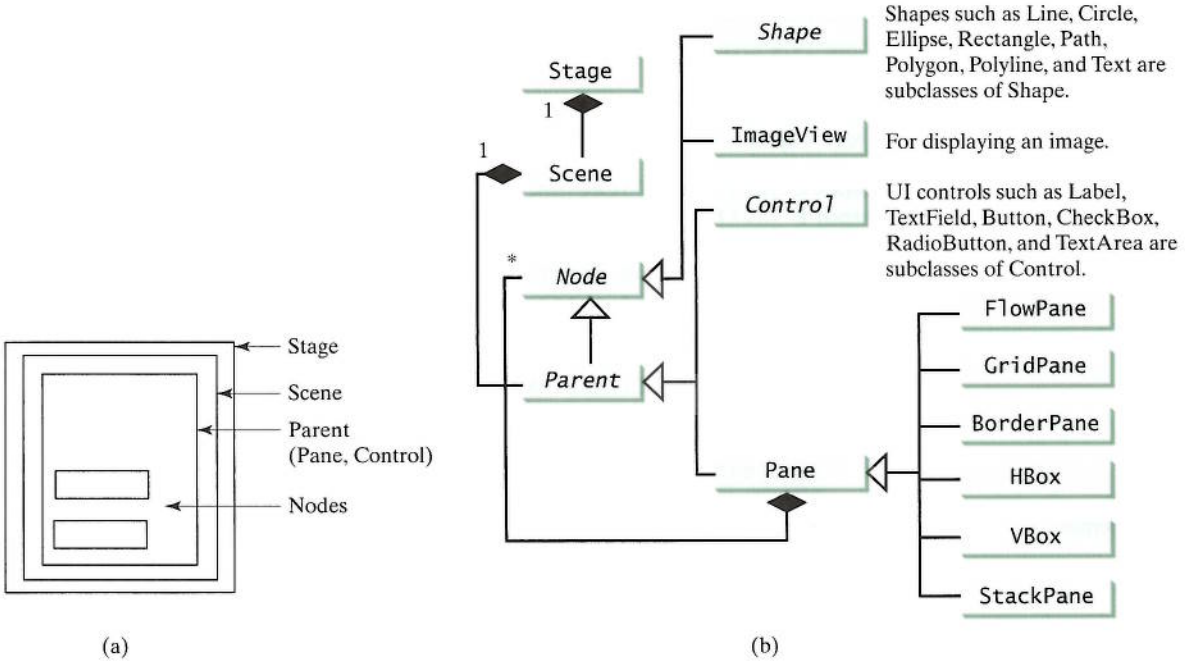


FIGURE 14.3 (a) Panes are used to hold nodes. (b) Nodes can be shapes, image views, UI controls, and panes.

LISTING 14.3 ButtonInPane.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.control.Button;
4  import javafx.stage.Stage;
5  import javafx.scene.layout.StackPane;
6
7  public class ButtonInPane extends Application {
8    @Override // Override the start method in the Application class
9    public void start(Stage primaryStage) {
10     // Create a scene and place a button in the scene
11     StackPane pane = new StackPane();
12     pane.getChildren().add(new Button("OK"));
13     Scene scene = new Scene(pane, 200, 50);
14     primaryStage.setTitle("Button in a pane"); // Set the stage title
15     primaryStage.setScene(scene); // Place the scene in the stage
16     primaryStage.show(); // Display the stage
17   }
18 }
```

create a pane
add a button
add pane to scene
display stage
main method omitted

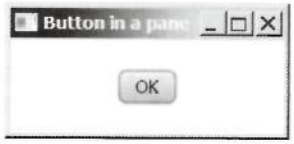


FIGURE 14.4 A button is placed in the center of the pane.

The program creates a `StackPane` (line 11) and adds a button as a child of the pane (line 12). The `getChildren()` method returns an instance of `javafx.collections.ObservableList`. `ObservableList` behaves very much like an `ArrayList` for storing a collection of elements. Invoking `add(e)` adds an element to the list. The `StackPane` places the nodes in the center of the pane on top of each other. Here, there is only one node in the pane. The `StackPane` respects a node's preferred size. So you see the button displayed in its preferred size.

ObservableList

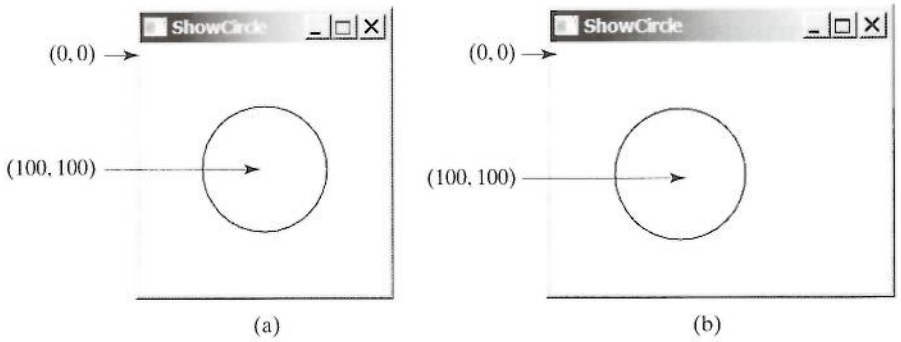
Listing 14.4 gives an example that displays a circle in the center of the pane, as shown in Figure 14.5a.

LISTING 14.4 ShowCircle.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.layout.Pane;
4  import javafx.scene.paint.Color;
5  import javafx.scene.shape.Circle;
6  import javafx.stage.Stage;
7
8  public class ShowCircle extends Application {
9    @Override // Override the start method in the Application class
10   public void start(Stage primaryStage) {
11     // Create a circle and set its properties
12     Circle circle = new Circle();
13     circle.setCenterX(100);
14     circle.setCenterY(100);
15     circle.setRadius(50);
16     circle.setStroke(Color.BLACK);
17     circle.setFill(Color.WHITE);
18
19     // Create a pane to hold the circle
20     Pane pane = new Pane();
```

create a circle
set circle properties
create a pane

```
21      pane.getChildren().add(circle);                          add circle to pane
22
23      // Create a scene and place it in the stage
24      Scene scene = new Scene(pane, 200, 200);                 add pane to scene
25      primaryStage.setTitle("ShowCircle"); // Set the stage title
26      primaryStage.setScene(scene); // Place the scene in the stage
27      primaryStage.show(); // Display the stage                 display stage
28    }
29  }                                                            main method omitted
```



(a) (b)

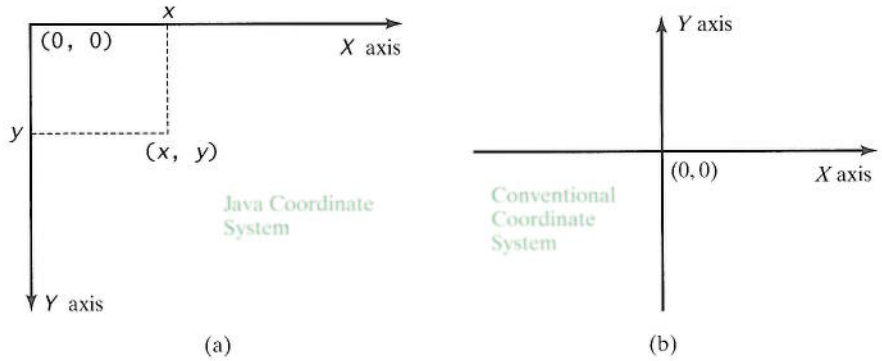
FIGURE 14.5 (a) A circle is displayed in the center of the scene. (b) The circle is not centered after the window is resized.

The program creates a `Circle` (line 12) and sets its center at (100, 100) (lines 13–14), which is also the center for the scene, since the scene is created with the width and height of 200 (line 24). The radius of the circle is set to 50 (line 15). Note that the measurement units for graphics in Java are all in *pixels*. pixels

The stroke color (i.e., the color to draw the circle) is set to black (line 16). The fill color (i.e., the color to fill the circle) is set to white (line 17). You may set the color to `null` to specify that no color is set. set color

The program creates a `Pane` (line 20) and places the circle in the pane (line 21). Note that the coordinates of the upper left corner of the pane is (0, 0) in the Java coordinate system, as shown in Figure 14.6a, as opposed to the conventional coordinate system where (0, 0) is at the center of the window, as shown in Figure 14.6b. The *x*-coordinate increases from left to right and the *y*-coordinate increases downward in the Java coordinate system.

The pane is placed in the scene (line 24) and the scene is set in the stage (line 26). The circle is displayed in the center of the stage, as shown in Figure 14.5a. However, if you resize the window, the circle is not centered, as shown in Figure 14.5b. In order to display the circle centered as the window resizes, the *x*- and *y*-coordinates of the circle center need to be reset to the center of the pane. This can be done by using property binding, introduced in the next section.



(a) (b)

FIGURE 14.6 The Java coordinate system is measured in pixels, with `(0, 0)` at its upper-left corner.

Check Point

14.5 How do you create a `Scene` object? How do you set a scene in a stage? How do you place a circle into a scene?

14.6 What is a pane? What is a node? How do you place a node in a pane? Can you directly place a `Shape` or an `ImageView` into a `Scene`? Can you directly place a `Control` or a `Pane` into a `Scene`?

14.7 How do you create a `Circle`? How do you set its center location and radius? How do you set its stroke color and fill color?

14.5 Property Binding

Key Point

You can bind a target object to a source object. A change in the source object will be automatically reflected in the target object.

target object
source object
binding object
binding property
bindable object
observable object

JavaFX introduces a new concept called *property binding* that enables a *target object* to be bound to a *source object*. If the value in the source object changes, the target object is also changed automatically. The target object is called a *binding object* or a *binding property* and the source object is called a *bindable object* or *observable object*. As discussed in the preceding listing, the circle is not centered after the window is resized. In order to display the circle centered as the window resizes, the *x*- and *y*-coordinates of the circle center need to be reset to the center of the pane. This can be done by binding the `centerX` with pane's `width/2` and `centerY` with pane's `height/2`, as shown in Listing 14.5.

VideoNote
Understand property binding

LISTING 14.5 ShowCircleCentered.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.layout.Pane;
4  import javafx.scene.paint.Color;
5  import javafx.scene.shape.Circle;
6  import javafx.stage.Stage;
7
8  public class ShowCircleCentered extends Application {
9    @Override // Override the start method in the Application class
10   public void start(Stage primaryStage) {
11     // Create a pane to hold the circle
12     Pane pane = new Pane();
13
14     // Create a circle and set its properties
15     Circle circle = new Circle();
16     circle.centerXProperty().bind(pane.widthProperty().divide(2));
17     circle.centerYProperty().bind(pane.heightProperty().divide(2));
18     circle.setRadius(50);
19     circle.setStroke(Color.BLACK);
20     circle.setFill(Color.WHITE);
21     pane.getChildren().add(circle); // Add circle to the pane
22
23     // Create a scene and place it in the stage
24     Scene scene = new Scene(pane, 200, 200);
25     primaryStage.setTitle("ShowCircleCentered"); // Set the stage title
26     primaryStage.setScene(scene); // Place the scene in the stage
27     primaryStage.show(); // Display the stage
28   }
29 }
```

create a pane
create a circle
bind properties
add circle to pane
add pane to scene
display stage

The `Circle` class has the `centerX` property for representing the *x*-coordinate of the circle center. This property like many properties in JavaFX classes can be used both as target and source in a property binding. A target listens to the changes in the source and automatically

updates itself once a change is made in the source. A target binds with a source using the `bind` method as follows:

```
target.bind(source);
```

the `Property` interface

The `bind` method is defined in the `javafx.beans.property.Property` interface. A binding property is an instance of `javafx.beans.property.Property`. A source object is an instance of the `javafx.beans.value.ObservableValue` interface. An `ObservableValue` is an entity that wraps a value and allows to observe the value for changes.

the `ObservableValue` interface

common binding properties

JavaFX defines binding properties for primitive types and strings. For a `double`/`float`/`long`/`int`/`boolean` value, its binding property type is `DoubleProperty`/`FloatProperty`/`LongProperty`/`IntegerProperty`/`BooleanProperty`. For a string, its binding property type is `StringProperty`. These properties are also subtypes of `ObservableValue`. So they can also be used as source objects for binding properties.

common `ObservableValue` objects

By convention, each binding property (e.g., `centerX`) in a JavaFX class (e.g., `Circle`) has a getter (e.g., `getCenterX()`) and setter (e.g., `setCenterX(double)`) method for returning and setting the property's value. It also has a getter method for returning the property itself. The naming convention for this method is the property name followed by the word `Property`. For example, the property getter method for `centerX` is `centerXProperty()`. We call the `getCenterX()` method as the *value getter method*, the `setCenterX(double)` method as the *value setter method*, and `centerXProperty()` as the *property getter method*. Note that `getCenterX()` returns a `double` value and `centerXProperty()` returns an object of the `DoubleProperty` type. Figure 14.7a shows the convention for defining a binding property in a class and Figure 14.7b shows a concrete example in which `centerX` is a binding property of the type `DoubleProperty`.

value getter method

value setter method

property getter method

```
public class SomeClassName {

  private PropertyType x;

  /** Value getter method */
  public propertyValueType getX() { ... }

  /** Value setter method */
  public void setX(propertyValueType value) { ... }

  /** Property getter method */
  public PropertyType
    xProperty() { ... }
}
```

(a) `x` is a binding property

```
public class Circle {

  private DoubleProperty centerX;

  /** Value getter method */
  public double getCenterX() { ... }

  /** Value setter method */
  public void setCenterX(double value) { ... }

  /** Property getter method */
  public DoubleProperty centerXProperty() { ... }
}
```

(b) `centerX` is binding property

FIGURE 14.7 A binding property has a value getter method, setter method, and property getter method.

The program in Listing 14.5 is the same as in Listing 14.4 except that it binds `circle`'s `centerX` and `centerY` properties to half of `pane`'s width and height (lines 16–17). Note that `circle.centerXProperty()` returns `centerX` and `pane.widthProperty()` returns `width`. Both `centerX` and `width` are binding properties of the `DoubleProperty` type. The numeric binding property classes such as `DoubleProperty` and `IntegerProperty` contain the `add`, `subtract`, `multiply`, and `divide` methods for adding, subtracting, multiplying, and dividing a value in a binding property and returning a new observable property. So, `pane.widthProperty().divide(2)` returns a new observable property that represents half of the `pane`'s width. The statement

```
circle.centerXProperty().bind(pane.widthProperty().divide(2));
```

is same as

```
centerX.bind(width.divide(2));
```

Since `centerX` is bound to `width.divide(2)`, when `pane`'s width is changed, `centerX` automatically updates itself to match `pane`'s width / 2.

Listing 14.6 gives another example that demonstrates bindings.

LISTING 14.6 BindingDemo.java

```
1  import javafx.beans.property.DoubleProperty;
2  import javafx.beans.property.SimpleDoubleProperty;
3
4  public class BindingDemo {
5    public static void main(String[] args) {
6      DoubleProperty d1 = new SimpleDoubleProperty(1);
7      DoubleProperty d2 = new SimpleDoubleProperty(2);
8      d1.bind(d2);
9      System.out.println("d1 is " + d1.getValue()
10       + " and d2 is " + d2.getValue());
11     d2.setValue(70.2);
12     System.out.println("d1 is " + d1.getValue()
13       + " and d2 is " + d2.getValue());
14   }
15 }
```

create a DoubleProperty
create a DoubleProperty
bind property
set a new source value

```
d1 is 2.0 and d2 is 2.0
d1 is 70.2 and d2 is 70.2
```

The program creates an instance of `DoubleProperty` using `SimpleDoubleProperty(1)` (line 6). Note that `DoubleProperty`, `FloatProperty`, `LongProperty`, `IntegerProperty`, and `BooleanProperty` are abstract classes. Their concrete subclasses `SimpleDoubleProperty`, `SimpleFloatProperty`, `SimpleLongProperty`, `SimpleIntegerProperty`, and `SimpleBooleanProperty` are used to create instances of these properties. These classes are very much like wrapper classes `Double`, `Float`, `Long`, `Integer`, and `Boolean` with additional features for binding to a source object.

The program binds `d1` with `d2` (line 8). Now the values in `d1` and `d2` are the same. After setting `d2` to `70.2` (line 11), `d1` also becomes `70.2` (line 13).

The binding demonstrated in this example is known as *unidirectional binding*. Occasionally, it is useful to synchronize two properties so that a change in one property is reflected in another object, and vice versa. This is called a *bidirectional binding*. If the target and source are both binding properties and observable properties, they can be bound bidirectionally using the `bindBidirectional` method.

unidirectional binding

bidirectional binding

14.8 What is a binding property? What interface defines a binding property? What interface defines a source object? What are the binding object types for `int`, `long`, `float`, `double`, and `boolean`? Are `Integer` and `Double` binding properties? Can `Integer` and `Double` be used as source objects in a binding?

14.9 Following the JavaFX binding property naming convention, for a binding property named `age` of the `IntegerProperty` type, what is its value getter method, value setter method, and property getter method?

14.10 Can you create an object of `IntegerProperty` using `new IntegerProperty(3)`? If not, what is the correct way to create it? What will the output if line 8 is replaced by `d1.bind(d2.multiply(2))` in Listing 14.6? What will the output if line 8 is replaced by `d1.bind(d2.add(2))` in Listing 14.6?

14.11 What is a unidirectional binding and what is bidirectional binding? Are all binding properties capable of bidirectional binding? Write a statement to bind property `d1` with property `d2` bidirectionally.

14.6 Common Properties and Methods for Nodes

The abstract `Node` *class defines many properties and methods that are common to all nodes.*

Nodes share many common properties. This section introduces two such properties `style` and `rotate`.

JavaFX style properties are similar to cascading style sheets (CSS) used to specify the styles for HTML elements in a Web page. So, the style properties in JavaFX are called *JavaFX CSS*. In JavaFX, a style property is defined with a prefix `-fx-`. Each node has its own style properties. You can find these properties from http://docs.oracle.com/javafx/2/api/javafx/scene/doc-files/cssref.html. For information on HTML and CSS, see Supplements V.A and V.B. If you are not familiar with HTML and CSS, you can still use JavaFX CSS.

JavaFX CSS

The syntax for setting a style is `styleName:value`. Multiple style properties for a node can be set together separated by semicolon (`;`). For example, the following statement

```
circle.setStyle("-fx-stroke: black; -fx-fill: red;");
```

setStyle

sets two JavaFX CSS properties for a circle. This statement is equivalent to the following two statements.

```
circle.setStroke(Color.BLACK);
circle.setFill(Color.RED);
```

If an incorrect JavaFX CSS is used, your program will still compile and run, but the style is ignored.

The `rotate` property enables you to specify an angle in degrees for rotating the node from its center. If the degree is positive, the rotation is performed clockwise; otherwise, it is performed counterclockwise. For example, the following code rotates a button 80 degrees.

```
button.setRotate(80);
```

Listing 14.7 gives an example that creates a button, sets its style, and adds it to a pane. It then rotates the pane 45 degrees and set its style with border color red and background color light gray, as shown in Figure 14.8.

LISTING 14.7 NodeStyleRotateDemo.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.control.Button;
4  import javafx.stage.Stage;
5  import javafx.scene.layout.StackPane;
6
7  public class NodeStyleRotateDemo extends Application {
8    @Override // Override the start method in the Application class
9    public void start(Stage primaryStage) {
10     // Create a scene and place a button in the scene
11     StackPane pane = new StackPane();
12     Button btOK = new Button("OK");
13     btOK.setStyle("-fx-border-color: blue;");
14     pane.getChildren().add(btOK);
15
16     pane.setRotate(45);                                    rotate the pane
17     pane.setStyle(                                         set style for pane
18       "-fx-border-color: red; -fx-background-color: lightgray;");
19
20     Scene scene = new Scene(pane, 200, 250);
21     primaryStage.setTitle("NodeStyleRotateDemo"); // Set the stage title
22     primaryStage.setScene(scene); // Place the scene in the stage
```

```
23      primaryStage.show(); // Display the stage
24    }
25  }
```

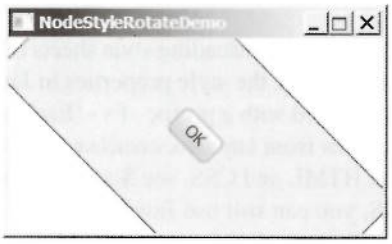


FIGURE 14.8 A pane's style is set and it is rotated 45 degrees.

As seen in Figure 14.8, the rotate on a pane causes all its containing nodes rotated too.

`contains` method

The `Node` class contains many useful methods that can be applied to all nodes. For example, you can use the `contains(double x, double y)` method to test where a point (x, y) is inside the boundary of a node.

14.12 How do you set a style of a node with border color red? Modify the code to set the text color for the button to red.

14.13 Can you rotate a pane, a text, or a button? Modify the code to rotate the button 15 degrees counterclockwise?

14.7 The `Color` Class

The `Color` class can be used to create colors.

JavaFX defines the abstract `Paint` class for painting a node. The `javafx.scene.paint.Color` is a concrete subclass of `Paint`, which is used to encapsulate colors, as shown in Figure 14.9.

The getter methods for property values are provided in the class, but omitted in the UML diagram for brevity.

javafx.scene.paint.Color

-red: double	The red value of this Color (between 0.0 and 1.0).
-green: double	The green value of this Color (between 0.0 and 1.0).
-blue: double	The blue value of this Color (between 0.0 and 1.0).
-opacity: double	The opacity of this Color (between 0.0 and 1.0).
+Color(r: double, g: double, b: double, opacity: double)	Creates a Color with the specified red, green, blue, and opacity values.
+brighter(): Color	Creates a Color that is a brighter version of this Color.
+darker(): Color	Creates a Color that is a darker version of this Color.
+color(r: double, g: double, b: double): Color	Creates an opaque Color with the specified red, green, and blue values.
+color(r: double, g: double, b: double, opacity: double): Color	Creates a Color with the specified red, green, blue, and opacity values.
+rgb(r: int, g: int, b: int): Color	Creates a Color with the specified red, green, and blue values in the range from 0 to 255.
+rgb(r: int, g: int, b: int, opacity: double): Color	Creates a Color with the specified red, green, and blue values in the range from 0 to 255 and a given opacity.

FIGURE 14.9 `Color` encapsulates information about colors.

A color instance can be constructed using the following constructor:

```
public Color(double r, double g, double b, double opacity);
```

in which `r`, `g`, and `b` specify a color by its red, green, and blue components with values in the range from `0.0` (darkest shade) to `1.0` (lightest shade). The `opacity` value defines the transparency of a color within the range from `0.0` (completely transparent) to `1.0` (completely opaque). This is known as the RGBA model, where RGBA stands for red, green, blue, and alpha. The alpha value indicates the opacity. For example,

RBGA model

```
Color color = new Color(0.25, 0.14, 0.333, 0.51);
```

The `Color` class is immutable. Once a `Color` object is created, its properties cannot be changed. The `brighter()` method returns a new `Color` with a larger red, green, and blue values and the `darker()` method returns a new `Color` with a smaller red, green, and blue values. The `opacity` value is the same as in the original `Color` object.

You can also create a `Color` object using the static methods `color(r, g, b)`, `color(r, g, b, opacity)`, `rgb(r, g, b)`, and `rgb(r, g, b, opacity)`.

Alternatively, you can use one of the many standard colors such as `BEIGE`, `BLACK`, `BLUE`, `BROWN`, `CYAN`, `DARKGRAY`, `GOLD`, `GRAY`, `GREEN`, `LIGHTGRAY`, `MAGENTA`, `NAVY`, `ORANGE`, `PINK`, `RED`, `SILVER`, `WHITE`, and `YELLOW` defined as constants in the `Color` class. The following code, for instance, sets the fill color of a circle to red:

```
circle.setFill(Color.RED);
```

14.14 How do you create a color? What is wrong about creating a `Color` using `new Color(1.2, 2.3, 3.5, 4)`? Which of two colors is darker, `new Color(0, 0, 0, 1)` or `new Color(1, 1, 1, 1)`? Does invoking `c.darker()` change the color value in `c`?

14.15 How do you create a `Color` object with a random color?

14.16 How do you set a circle object `c` with blue fill color using the `setFill` method and using the `setStyle` method?

14.8 The **Font** Class

A `Font` describes font name, weight, and size.

You can set fonts for rendering the text. The `javafx.scene.text.Font` class is used to create fonts, as shown in Figure 14.10.

A `Font` instance can be constructed using its constructors or using its static methods. A `Font` is defined by its name, weight, posture, and size. Times, Courier, and Arial are the examples of the font names.You can obtain a list of available font family names by invoking the static `getFamilies()` method. `List` is an interface that defines common methods for a list. `ArrayList` is a concrete implmentation of `List`. The font postures are two constants: `FontPosture.ITALIC` and `FontPosture.REGULAR`. For example, the following statements create two fonts.

```
Font font1 = new Font("SansSerif", 16);
Font font2 = Font.font("Times New Roman", FontWeight.BOLD,
  FontPosture.ITALIC, 12);
```

Listing 14.8 gives a program that displays a label using the font (Times New Roman, bold, italic, and size 20), as shown in Figure 14.11.

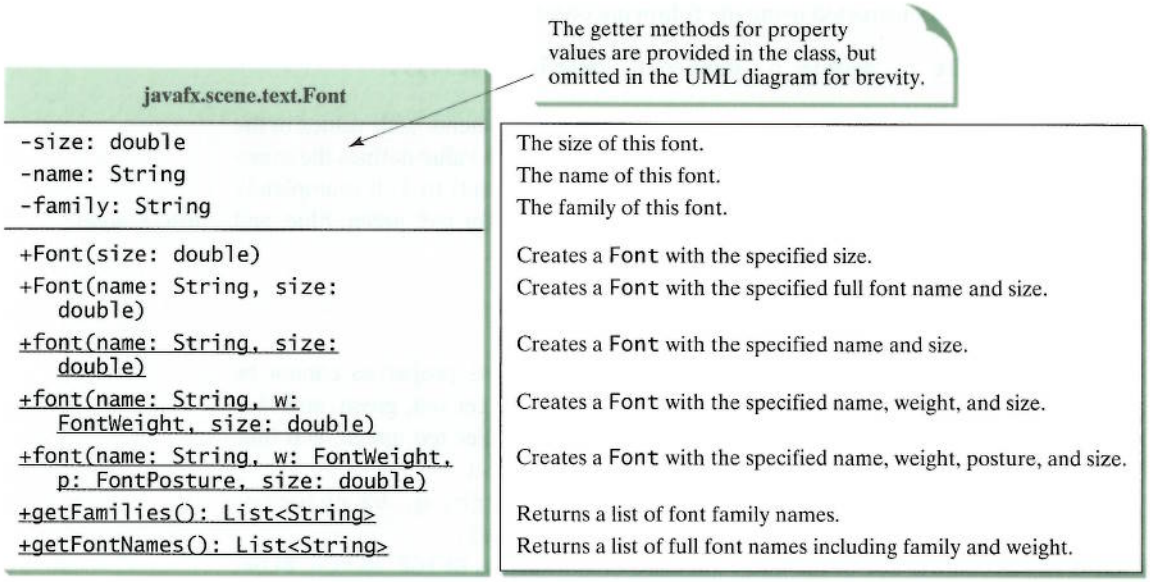


FIGURE 14.10 `Font` encapsulates information about fonts.

LISTING 14.8 FontDemo.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.layout.*;
4  import javafx.scene.paint.Color;
5  import javafx.scene.shape.Circle;
6  import javafx.scene.text.*;
7  import javafx.scene.control.*;
8  import javafx.stage.Stage;
9
10 public class FontDemo extends Application {
11   @Override // Override the start method in the Application class
12   public void start(Stage primaryStage) {
13     // Create a pane to hold the circle
14     Pane pane = new StackPane();
15
16     // Create a circle and set its properties
17     Circle circle = new Circle();
18     circle.setRadius(50);
19     circle.setStroke(Color.BLACK);
20     circle.setFill(new Color(0.5, 0.5, 0.5, 0.1));
21     pane.getChildren().add(circle); // Add circle to the pane
22
23     // Create a label and set its properties
24     Label label = new Label("JavaFX");
25     label.setFont(Font.font("Times New Roman",
26       FontWeight.BOLD, FontPosture.ITALIC, 20));
27     pane.getChildren().add(label);
28
29     // Create a scene and place it in the stage
30     Scene scene = new Scene(pane);
31     primaryStage.setTitle("FontDemo"); // Set the stage title
32     primaryStage.setScene(scene); // Place the scene in the stage
```

create a StackPane
create a Circle
create a Color
add circle to the pane
create a label
create a font
add label to the pane

```
33      primaryStage.show(); // Display the stage
34    }
35  }
```

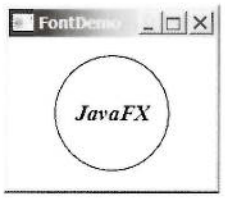


FIGURE 14.11 A label is on top of a circle displayed in the center of the scene.

The program creates a `StackPane` (line 14) and adds a circle and a label to it (lines 21, 27). These two statements can be combined using the following one statement:

```
pane.getChildren().addAll(circle, label);
```

A `StackPane` places the nodes in the center and nodes are placed on top of each other. A custom color is created and set as a fill color for the circle (line 20). The program creates a label and sets a font (line 25) so the text in the label is displayed in Times New Roman, bold, italic, and 20 pixels.

As you resize the window, the circle and label are displayed in the center of the window, because the circle and label are placed in the stack pane. Stack pane automatically places nodes in the center of the pane.

A `Font` object is immutable. Once a `Font` object is created, its properties cannot be changed.

14.17 How do you create a `Font` object with font name `Courier`, size `20`, and weight `bold`?

14.18 How do you find all available fonts on your system?

14.9 The **Image** and **ImageView** Classes

The `Image` class represents a graphical image and the `ImageView` class can be used to display an image.

The `javafx.scene.image.Image` class represents a graphical image and is used for loading an image from a specified filename or a URL. For example, `new Image("image/us.gif")` creates an `Image` object for the image file `us.gif` under the directory `image` in the Java class directory and `new Image("http://www.cs.armstrong.edu/liang/image/us.gif")` creates an `Image` object for the image file in the URL on the Web.

VideoNote
Use `Image` and `ImageView`

The `javafx.scene.image.ImageView` is a node for displaying an image. An `ImageView` can be created from an `Image` object. For example, the following code creates an `ImageView` from an image file:

```
Image image = new Image("image/us.gif");
ImageView imageView = new ImageView(image);
```

Alternatively, you can create an `ImageView` directly from a file or a URL as follows:

```
ImageView imageView = new ImageView("image/us.gif");
```

The UML diagrams for the `Image` and `ImageView` classes are illustrated in Figures 14.12 and 14.13.

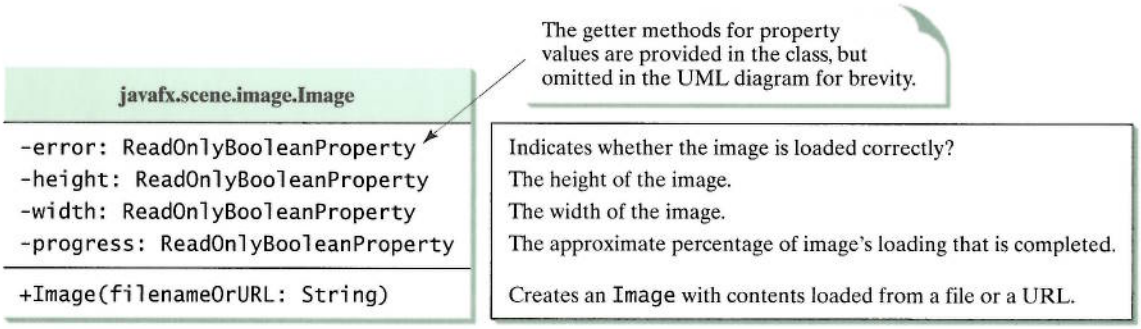


FIGURE 14.12 `Image` encapsulates information about images.

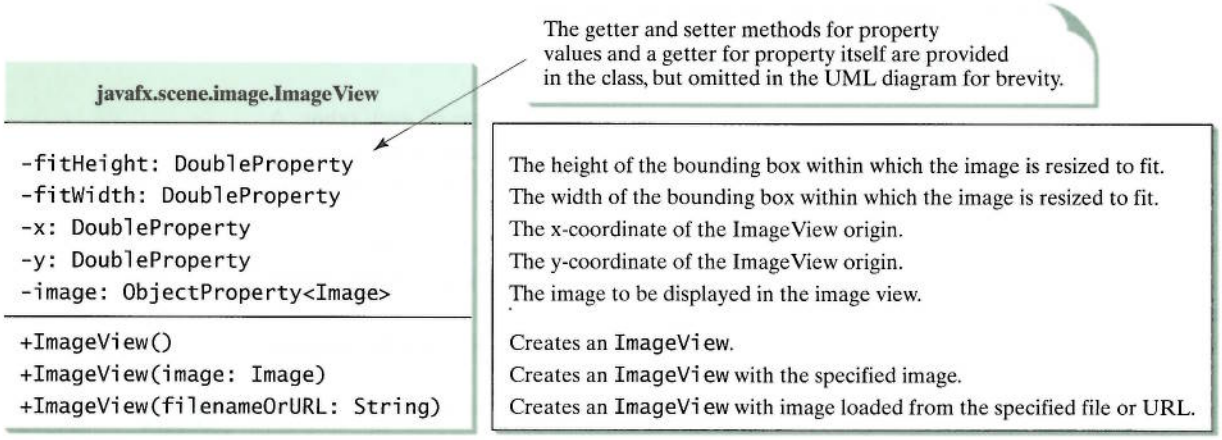


FIGURE 14.13 `ImageView` is a node for displaying an image.

Listing 14.9 displays an image in three image views, as shown in Figure 14.14.

LISTING 14.9 ShowImage.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.layout.HBox;
4  import javafx.scene.layout.Pane;
5  import javafx.geometry.Insets;
6  import javafx.stage.Stage;
7  import javafx.scene.image.Image;
8  import javafx.scene.image.ImageView;
9
10 public class ShowImage extends Application {
11   @Override // Override the start method in the Application class
12   public void start(Stage primaryStage) {
13     // Create a pane to hold the image views
14     Pane pane = new HBox(10);                                  create an HBox
15     pane.setPadding(new Insets(5, 5, 5, 5));
16     Image image = new Image("image/us.gif");                   create an image
17     pane.getChildren().add(new ImageView(image));              add an image view to pane
18
19     ImageView imageView2 = new ImageView(image);               create an image view
20     imageView2.setFitHeight(100);                              set image view properties
21     imageView2.setFitWidth(100);
```

```
22      pane.getChildren().add(imageView2);                    add an image to pane
23
24      ImageView imageView3 = new ImageView(image);           create an image view
25      imageView3.setRotate(90);                              rotate an image view
26      pane.getChildren().add(imageView3);                    add an image to pane
27
28      // Create a scene and place it in the stage
29      Scene scene = new Scene(pane);
30      primaryStage.setTitle("ShowImage"); // Set the stage title
31      primaryStage.setScene(scene); // Place the scene in the stage
32      primaryStage.show(); // Display the stage
33    }
34  }
```

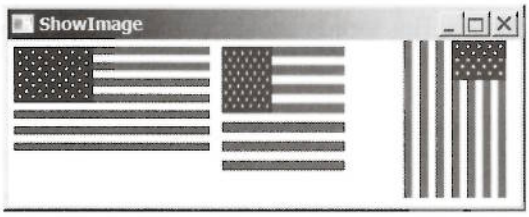
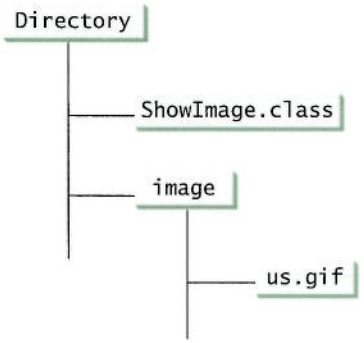


FIGURE 14.14 An image is displayed in three image views placed in a pane.

The program creates an `HBox` (line 14). An `HBox` is a pane that places all nodes horizontallly in one row. The program creates an `Image`, and then an `ImageView` for displaying the iamge, and places the `ImageView` in the `HBox` (line 17).

The program creates the second `ImageView` (line 19), sets its `fitHeight` and `fitWidth` properties (lines 20–21) and places the `ImageView` into the `HBox` (line 22). The program creates the third `ImageView` (line 24), rotates it 90 degrees (line 25), and places it into the `HBox` (line 26). The `setRotate` method is defined in the `Node` class and can be used for any node. Note that an `Image` object can be shared by multiple nodes. In this case, it is shared by three `ImageView`. However, a node such as `ImageView` cannot be shared. You cannot place an `ImageView` multiple times into a pane or scene.

Note that you must place the image file in the same directory as the class file, as shown in the following figure.



If you use the URL to locate the image file, the URL protocal http:// must be present. So the following code is wrong.

```
new Image("www.cs.armstrong.edu/liang/image/us.gif");
```

It must be replaced by

```
new Image("http://www.cs.armstrong.edu/liang/image/us.gif");
```

Check Point

14.19 How do you create an `Image` from a URL or a filename?

14.20 How do you create an `ImageView` from an `Image`, or directly from a file or a URL?

14.21 Can you set an `Image` to multiple `ImageView`? Can you display the same `ImageView` multiple times?

14.10 Layout Panes

Key Point

JavaFX provides many types of panes for automatically laying out nodes in a desired location and size.

VideoNote
Use layout panes

JavaFX provides many types of panes for organizing nodes in a container, as shown in Table 14.1. You have used the layout panes `Pane`, `StackPane`, and `HBox` in the preceding sections for containing nodes. This section introduces the panes in more details.

TABLE 14.1 Panes for Containing and Organizing Nodes

Class	*Description*
`Pane`	Base class for layout panes. It contains the `getChildren()` method for returning a list of nodes in the pane.
`StackPane`	Places the nodes on top of each other in the center of the pane.
`FlowPane`	Places the nodes row-by-row horizontally or column-by-column vertically.
`GridPane`	Places the nodes in the cells in a two-dimensional grid.
`BorderPane`	Places the nodes in the top, right, bottom, left, and center regions.
`HBox`	Places the nodes in a single row.
`VBox`	Places the nodes in a single column.

You have used the `Pane` in Listing 14.4, ShowCircle.java. A `Pane` is usually used as a canvas for displaying shapes. `Pane` is the base class for all specialized panes. You have used a specialized pane `StackPane` in Listing 14.3, ButtonInPane.java. Nodes are placed in the center of a `StackPane`. Each pane contains a list for holding nodes in the pane. This list is an instance of `ObservableList`, which can be obtained using pane's `getChildren()` method. You can use the `add(node)` method to add an element to the list, use `addAll(node1, node2, ...)` to add a variable number of nodes to the pane.

`ObservableList`
`getChildren()`

14.10.1 FlowPane

`FlowPane` arranges the nodes in the pane horizontally from left to right or vertically from top to bottom in the order in which they were added. When one row or one column is filled, a new row or column is started. You can specify the way the nodes are placed horizontally or vertically using one of two constants: `Orientation.HORIZONTAL` or `Orientation.VERTICAL`. You can also specify the gap between the nodes in pixels. The class diagram for `FlowPane` is shown in Figure 14.15.

Data fields `alignment`, `orientation`, `hgap`, and `vgap` are binding properties. Each binding property in JavaFX has a getter method (e.g., `getHgap()`) that returns its value, a setter method (e.g., `setHGap(double)`) for setting a value, and a getter method that returns the property itself (e.g., `hGapProperty()`). For a data field of `ObjectProperty<T>` type, the value getter method returns a value of type `T` and the property getter method returns a property value of type `ObjectProperty<T>`.

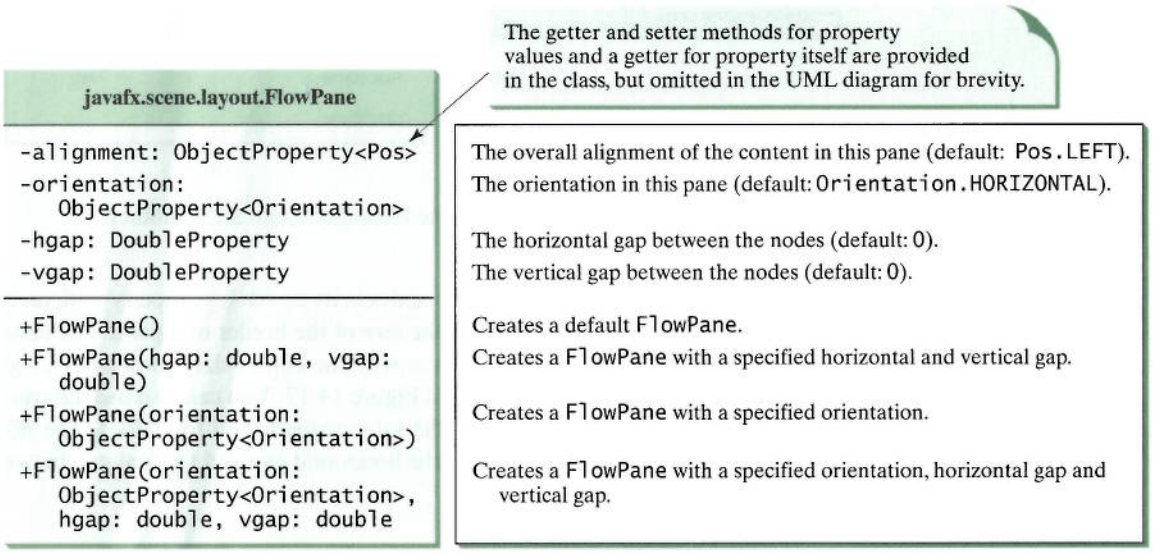
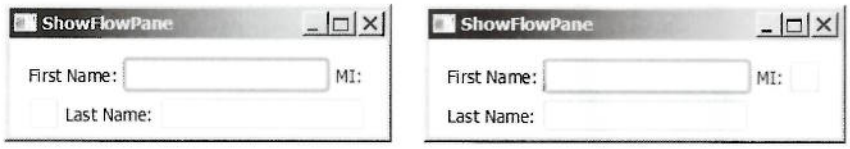


FIGURE 14.15 FlowPane lays out nodes row by row horizontally or column by column vertically.

Listing 14.10 gives a program that demonstrates FlowPane. The program adds labels and text fields to a FlowPane, as shown in Figure 14.16.

LISTING 14.10 ShowFlowPane.java

```
1  import javafx.application.Application;
2  import javafx.geometry.Insets;
3  import javafx.scene.Scene;
4  import javafx.scene.control.Label;
5  import javafx.scene.control.TextField;
6  import javafx.scene.layout.FlowPane;
7  import javafx.stage.Stage;
8
9  public class ShowFlowPane extends Application {                    extend Application
10   @Override // Override the start method in the Application class
11   public void start(Stage primaryStage) {
12     // Create a pane and set its properties
13     FlowPane pane = new FlowPane();                                 create FlowPane
14     pane.setPadding(new Insets(11, 12, 13, 14));
15     pane.setHgap(5);
16     pane.setVgap(5);
17
18     // Place nodes in the pane
19     pane.getChildren().addAll(new Label("First Name:"),             add UI controls to pane
20       new TextField(), new Label("MI:"));
21     TextField tfMi = new TextField();
22     tfMi.setPrefColumnCount(1);
23     pane.getChildren().addAll(tfMi, new Label("Last Name:"),
24       new TextField());
25
26     // Create a scene and place it in the stage
27     Scene scene = new Scene(pane, 200, 250);                        add pane to scene
28     primaryStage.setTitle("ShowFlowPane"); // Set the stage title
29     primaryStage.setScene(scene); // Place the scene in the stage   place scene to stage
30     primaryStage.show(); // Display the stage                       display stage
31   }
32 }
```



(a) (b)

FIGURE 14.16 The nodes fill in the rows in the `FlowPane` one after another.

The program creates a `FlowPane` (line 13) and sets its `padding` property with an `Insets` object (line 14). An `Insets` object specifies the size of the border of a pane. The constructor `Insets(11, 12, 13, 14)` creates an `Insets` with the border sizes for top (11), right (12), bottom (13), and left (14) in pixels, as shown in Figure 14.17. You can also use the constructor `Insets(value)` to create an `Insets` with the same value for all four sides. The `hGap` and `vGap` properties are in lines 15–16 to specify the horizontal gap and vertical gap between two nodes in the pane, as shown in Figure 14.17.

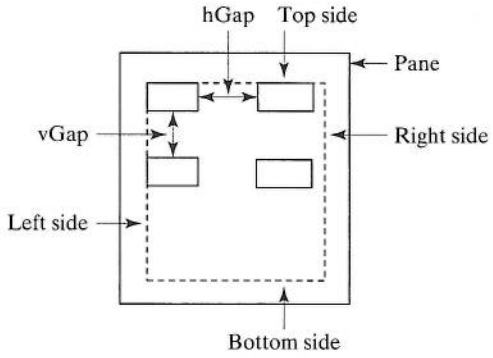


FIGURE 14.17 You can specify `hGap` and `vGap` between the nodes in a `FlowLPane`.

Each `FlowPane` contains an object of `ObservableList` for holding the nodes. This list can be obtained using the `getChildren()` method (line 19). To add a node into a `FlowPane` is to add it to this list using the `add(node)` or `addAll(node1, node2, ...)` method. You can also remove a node from the list using the `remove(node)` method or use the `removeAll()` method to remove all nodes from the pane. The program adds the labels and text fields into the pane (lines 19–24). Invoking `tfMi.setPrefColumnCount(1)` sets the preferred column count to `1` for the MI text field (line 22). The program declares an explicit reference `tfMi` for a `TextField` object for MI. The explicit reference is necessary, because we need to reference the object directly to set its `prefColumnCount` property.

The program adds the pane to the scene (line 27), sets the scene in the stage (line 29), and displays the stage (line 30). Note that if you resize the window, the nodes are automatically rearranged to fit in the pane. In Figure 14.16a, the first row has three nodes, but in Figure 14.16b, the first row has four nodes, because the width has been increased.

Suppose you wish to add the object `tfMi` to a pane ten times; will ten text fields appear in the pane? No, a node such as a text field can be added to only one pane and once. Adding a node to a pane multiple times or to different panes will cause a runtime error.

Note

A node can be placed only in one pane. Therefore, the relationship between a pane and a node is the composition denoted by a filled diamond, as shown in Figure 14.3b.

14.10.2 GridPane

A `GridPane` arranges nodes in a grid (matrix) formation. The nodes are placed in the specified column and row indices. The class diagram for `GridPane` is shown in Figure 14.18.

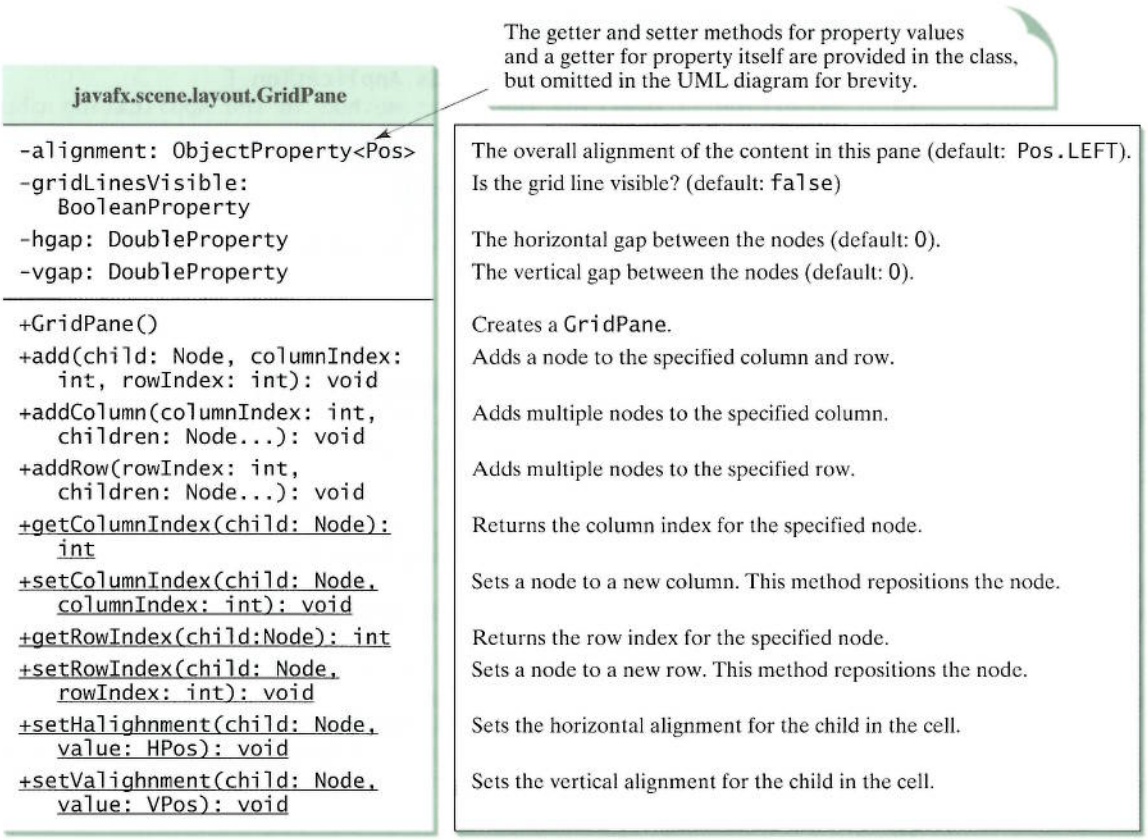


FIGURE 14.18 `GridPane` lays out nodes in the specified cell in a grid.

Listing 14.11 gives a program that demonstrates `GridPane`. The program is similar to the one in Listing 14.10, except that it adds three labels and three text fields, and a button to the specified location in a grid, as shown in Figure 14.19.

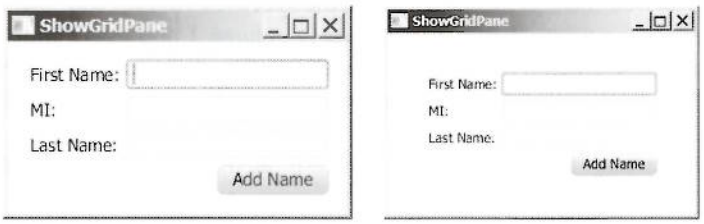


FIGURE 14.19 The `GridPane` places the nodes in a grid with a specified column and row indices.

LISTING 14.11 ShowGridPane.java

```
1 import javafx.application.Application;
2 import javafx.geometry.HPos;
3 import javafx.geometry.Insets;
```

```
 4  import javafx.geometry.Pos;
 5  import javafx.scene.Scene;
 6  import javafx.scene.control.Button;
 7  import javafx.scene.control.Label;
 8  import javafx.scene.control.TextField;
 9  import javafx.scene.layout.GridPane;
10  import javafx.stage.Stage;
11
12  public class ShowGridPane extends Application {
13    @Override // Override the start method in the Application class
14    public void start(Stage primaryStage) {
15      // Create a pane and set its properties
16      GridPane pane = new GridPane();
17      pane.setAlignment(Pos.CENTER);
18      pane.setPadding(new Insets(11.5, 12.5, 13.5, 14.5));
19      pane.setHgap(5.5);
20      pane.setVgap(5.5);
21
22      // Place nodes in the pane
23      pane.add(new Label("First Name:"), 0, 0);
24      pane.add(new TextField(), 1, 0);
25      pane.add(new Label("MI:"), 0, 1);
26      pane.add(new TextField(), 1, 1);
27      pane.add(new Label("Last Name:"), 0, 2);
28      pane.add(new TextField(), 1, 2);
29      Button btAdd = new Button("Add Name");
30      pane.add(btAdd, 1, 3);
31      GridPane.setHalignment(btAdd, HPos.RIGHT);
32
33      // Create a scene and place it in the stage
34      Scene scene = new Scene(pane);
35      primaryStage.setTitle("ShowGridPane"); // Set the stage title
36      primaryStage.setScene(scene); // Place the scene in the stage
37      primaryStage.show(); // Display the stage
38    }
39  }
```

create a grid pane
set properties
add label
add text field
add button
align button right
create a scene
display stage

The program creates a `GridPane` (line 16) and sets its properties (line 17–20). The alignment is set to the center position (line 17), which causes the nodes to be placed in the center of the grid pane. If you resize the window, you will see the nodes remaining in the center of the grid pane.

The program adds the label in column `0` and row `0` (line 23). The column and row index starts from `0`. The `add` method places a node in the specified column and row. Not every cell in the grid needs to be filled. A button is placed in column 1 and row 3 (line 30), but there are no nodes placed in column 0 and row 3. To remove a node from a `GridPane`, use `pane.getChildren().remove(node)`. To remove all nodes, use `pane.getChildren().removeAll()`.

remove nodes

The program invokes the static `setHalignment` method to align the button right in the cell (line 31).

Note that the scene size is not set (line 34). In this case, the scene size is automatically computed according to the sizes of the nodes placed inside the scene.

14.10.3 BorderPane

A `BorderPane` can place nodes in five regions: top, bottom, left, right, and center, using the `setTop(node)`, `setBottom(node)`, `setLeft(node)`, `setRight(node)`, and `setCenter(node)` methods. The class diagram for `GridPane` is shown in Figure 14.20.

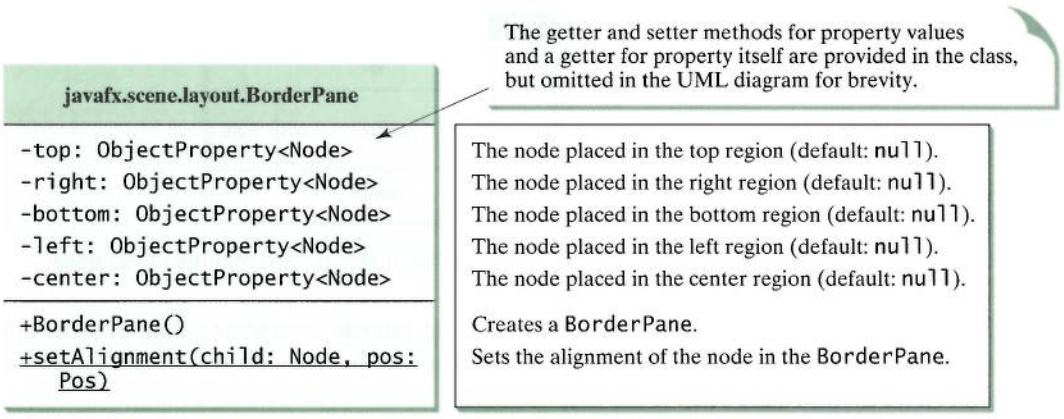


FIGURE 14.20 `BorderPane` places the nodes in top, bottom, left, right, and center regions.

Listing 14.12 gives a program that demonstrates `BorderPane`. The program places five buttons in the five regions of the pane, as shown in Figure 14.21.

LISTING 14.12 ShowBorderPane.java

```
1  import javafx.application.Application;
2  import javafx.geometry.Insets;
3  import javafx.scene.Scene;
4  import javafx.scene.control.Label;
5  import javafx.scene.layout.BorderPane;
6  import javafx.scene.layout.StackPane;
7  import javafx.stage.Stage;
8
9  public class ShowBorderPane extends Application {
10   @Override // Override the start method in the Application class
11   public void start(Stage primaryStage) {
12     // Create a border pane
13     BorderPane pane = new BorderPane();                          create a border pane
14
15     // Place nodes in the pane
16     pane.setTop(new CustomPane("Top"));                          add to top
17     pane.setRight(new CustomPane("Right"));                      add to right
18     pane.setBottom(new CustomPane("Bottom"));                    add to bottom
19     pane.setLeft(new CustomPane("Left"));                        add to left
20     pane.setCenter(new CustomPane("Center"));                    add to center
21
22     // Create a scene and place it in the stage
23     Scene scene = new Scene(pane);
24     primaryStage.setTitle("ShowBorderPane"); // Set the stage title
25     primaryStage.setScene(scene); // Place the scene in the stage
26     primaryStage.show(); // Display the stage
27   }
28 }
29
30 // Define a custom pane to hold a label in the center of the pane
31 class CustomPane extends StackPane {                            define a custom pane
32   public CustomPane(String title) {
33     getChildren().add(new Label(title));                         add a label to pane
34     setStyle("-fx-border-color: red");                           set style
35     setPadding(new Insets(11.5, 12.5, 13.5, 14.5));              set padding
36   }
37 }
```

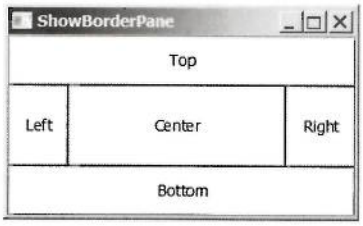


FIGURE 14.21 The `BorderPane` places the nodes in five regions of the pane.

The program defines `CustomPane` that extends `StackPane` (line 31). The constructor of `CustomPane` adds a label with the specified title (line 33), sets a style for the border color, and sets a padding using insets (line 35).

The program creates a `BorderPane` (line 13) and places five instances of `CustomPane` into five regions of the border pane (lines 16–20). Note that a pane is a node. So a pane can be added into another pane. To remove a node from the top region, invoke `setTop(null)`. If a region is not occupied, no space will be allocated for this region.

14.10.4 HBox and VBox

An `HBox` lays out its children in a single horizontal row. A `VBox` lays out its children in a single vertical column. Recall that a `FlowPane` can lay out its children in multiple rows or multiple columns, but an `HBox` or a `VBox` can lay out children only in one row or one column. The class diagrams for `HBox` and `VBox` are shown in Figures 14.22 and 14.23.

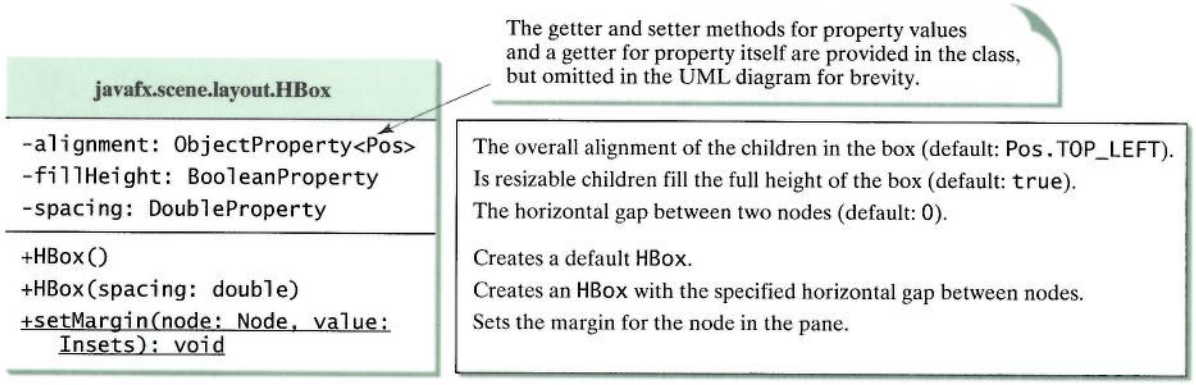


FIGURE 14.22 `HBox` places the nodes in one row.

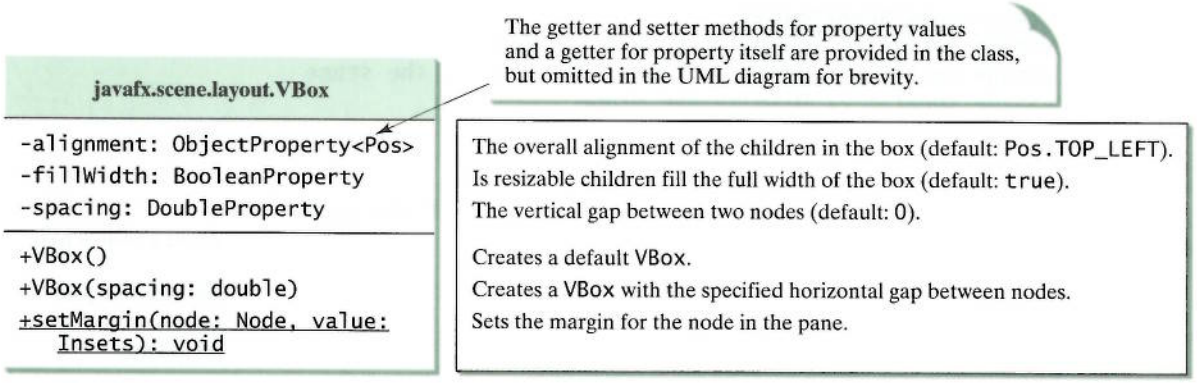


FIGURE 14.23 `VBox` places the nodes in one column.

Listing 14.12 gives a program that demonstrates HBox and VBox. The program places two buttons in an HBox and five labels in a VBox, as shown in Figure 14.24.

LISTING 14.13 ShowHBoxVBox.java

```
1  import javafx.application.Application;
2  import javafx.geometry.Insets;
3  import javafx.scene.Scene;
4  import javafx.scene.control.Button;
5  import javafx.scene.control.Label;
6  import javafx.scene.layout.BorderPane;
7  import javafx.scene.layout.HBox;
8  import javafx.scene.layout.VBox;
9  import javafx.stage.Stage;
10 import javafx.scene.image.Image;
11 import javafx.scene.image.ImageView;
12
13 public class ShowHBoxVBox extends Application {
14   @Override // Override the start method in the Application class
15   public void start(Stage primaryStage) {
16     // Create a border pane
17     BorderPane pane = new BorderPane();                          create a border pane
18
19     // Place nodes in the pane
20     pane.setTop(getHBox());                                      add an HBox to top
21     pane.setLeft(getVBox());                                     add a VBox to left
22
23     // Create a scene and place it in the stage
24     Scene scene = new Scene(pane);                               create a scene
25     primaryStage.setTitle("ShowHBoxVBox"); // Set the stage title
26     primaryStage.setScene(scene); // Place the scene in the stage
27     primaryStage.show(); // Display the stage                    display stage
28   }
29
30   private HBox getHBox() {                                       getHBox
31     HBox hBox = new HBox(15);
32     hBox.setPadding(new Insets(15, 15, 15, 15));
33     hBox.setStyle("-fx-background-color: gold");
34     hBox.getChildren().add(new Button("Computer Science"));      add buttons to HBox
35     hBox.getChildren().add(new Button("Chemistry"));
36     ImageView imageView = new ImageView(new Image("image/us.gif"));
37     hBox.getChildren().add(imageView);
38     return hBox;                                                 return an HBox
39   }
40
41   private VBox getVBox() {                                       getVBox
42     VBox vBox = new VBox(15);
43     vBox.setPadding(new Insets(15, 5, 5, 5));
44     vBox.getChildren().add(new Label("Courses"));                add a label
45
46     Label[] courses = {new Label("CSCI 1301"), new Label("CSCI 1302"),
47         new Label("CSCI 2410"), new Label("CSCI 3720")};
48
49     for (Label course: courses) {
50       VBox.setMargin(course, new Insets(0, 0, 0, 15));           set margin
51       vBox.getChildren().add(course);                            add a label
52     }
53
54     return vBox;                                                 return vBox
55   }
56 }
```

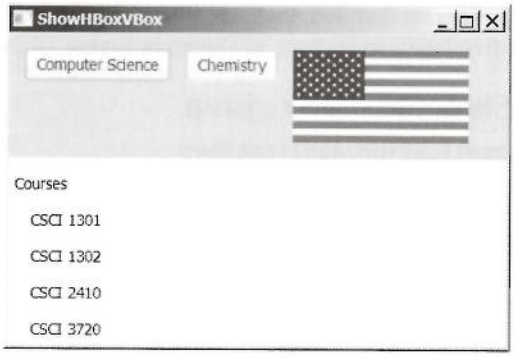


FIGURE 14.24 The `HBox` places the nodes in one row and the `VBox` places the nodes in one column.

The program defines the `getHBox()` method. This method returns an `HBox` that contains two buttons and an image view (lines 30–39). The background color of the `HBox` is set to gold using Java CSS (line 33). The program defines the `getVBox()` method. This method returns a `VBox` that contains five labels (lines 41–55). The first label is added to the `VBox` in line 44 and the other four are added in line 51. The `setMargin` method is used to set a node's margin when placed inside the `VBox` (line 50).

Check Point

14.22 How do you add a node to a `Pane`, `StackPane`, `FlowPane`, `GridPane`, `BorderPane`, `HBox`, and `VBox`? How do you remove a node from these panes?

14.23 How do you set the alignment to right for nodes in a `FlowPane`, `GridPane`, `HBox`, and `VBox`?

14.24 How do you set the horizontal gap and vertical hap between nodes in 8 pixels in a `FlowPane` and `GridPane` and set spacing in 8 pixels in an `HBox` and `VBox`?

14.25 How do you get the column and row index of a node in a `GridPane`? How do you reposition a node in a `GridPane`?

14.26 What are the differences between a `FlowPane` and an `HBox` or a `VBox`?

14.11 Shapes

Key Point

JavaFX provides many shape classes for drawing texts, lines, circles, rectangles, ellipses, arcs, polygons, and polylines.

VideoNote
Use shapes

The `Shape` class is the abstract base class that defines the common properties for all shapes. Among them are the `fill`, `stroke`, and `strokeWidth` properties. The `fill` property specifies a color that fills the interior of a shape. The `stroke` property specifies a color that is used to draw the outline of a shape. The `strokeWidth` property specifies the width of the outline of a shape. This section introduces the classes `Text`, `Line`, `Rectangle`, `Circle`, `Ellipse`, `Arc`, `Polygon`, and `Polyline` for drawing texts and simple shapes. All these are subclasses of `Shape`, as shown in Figure 14.25.

14.11.1 Text

The `Text` class defines a node that displays a string at a starting point (`x`, `y`), as shown in Figure 14.27a. A `Text` object is usually placed in a pane. The pane's upper-left corner point is (`0`, `0`) and the bottom-right point is (`pane.getWidth()`, `pane.getHeight()`). A string may be displayed in multiple lines separated by `\n`. The UML diagram for the `Text` class is shown in Figure 14.26. Listing 14.13 gives an example that demonstrates text, as shown in Figure 14.27b.

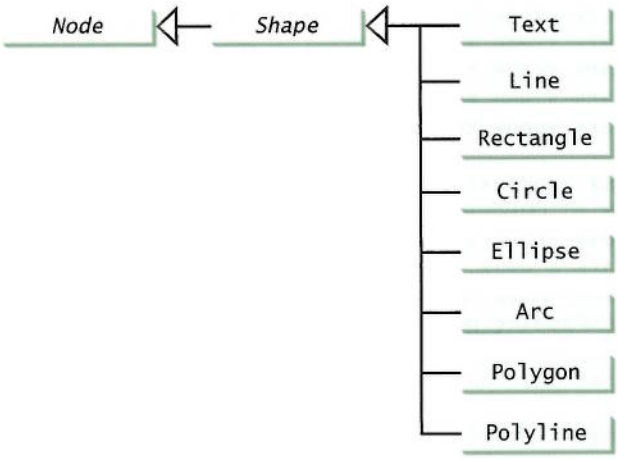


FIGURE 14.25 A shape is a node. The Shape class is the root of all shape classes.

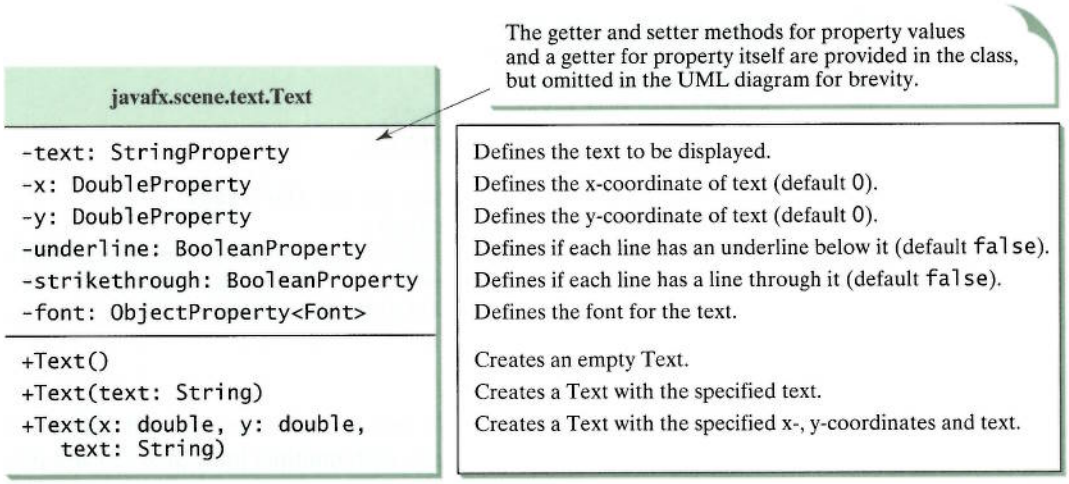
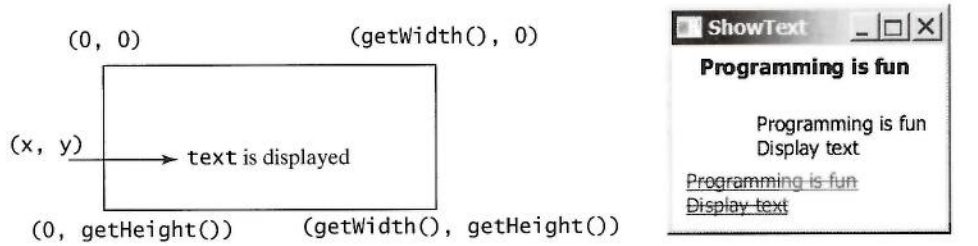


FIGURE 14.26 Text defines a node for displaying a text.



(a) Text(x, y, text)

(b) *Three* Text *objects are displayed*

FIGURE 14.27 A Text object is created to display a text.

LISTING 14.14 ShowText.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.layout.Pane;
4  import javafx.scene.paint.Color;
5  import javafx.geometry.Insets;
```

```
 6 import javafx.stage.Stage;
 7 import javafx.scene.text.Text;
 8 import javafx.scene.text.Font;
 9 import javafx.scene.text.FontWeight;
10 import javafx.scene.text.FontPosture;
11
12 public class ShowText extends Application {
13   @Override // Override the start method in the Application class
14   public void start(Stage primaryStage) {
15     // Create a pane to hold the texts
16     Pane pane = new Pane();
17     pane.setPadding(new Insets(5, 5, 5, 5));
18     Text text1 = new Text(20, 20, "Programming is fun");
19     text1.setFont(Font.font("Courier", FontWeight.BOLD,
20       FontPosture.ITALIC, 15));
21     pane.getChildren().add(text1);
22
23     Text text2 = new Text(60, 60, "Programming is fun\nDisplay text");
24     pane.getChildren().add(text2);
25
26     Text text3 = new Text(10, 100, "Programming is fun\nDisplay text");
27     text3.setFill(Color.RED);
28     text3.setUnderline(true);
29     text3.setStrikethrough(true);
30     pane.getChildren().add(text3);
31
32     // Create a scene and place it in the stage
33     Scene scene = new Scene(pane);
34     primaryStage.setTitle("ShowText"); // Set the stage title
35     primaryStage.setScene(scene); // Place the scene in the stage
36     primaryStage.show(); // Display the stage
37   }
38 }
```

create a pane
create a text
set text font
add text to pane
create a two-line text
add text to pane
create a text
set text color
set underline
set strike line
add text to pane

The program creates a `Text` (line 18), sets its font (line 19), and places it to the pane (line 21). The program creates another `Text` with multiple lines (line 23) and places it to the pane (line 24). The program creates the third `Text` (line 26), sets its color (line 27), sets an underline and a strike through line (lines 28–29), and places it to the pane (line 30).

14.11.2 Line

A line connects two points with four parameters `startX`, `startY`, `endX`, and `endY`, as shown in Figure 14.29a. The `Line` class defines a line. The UML diagram for the `Line` class is shown in Figure 14.28. Listing 14.15 gives an example that demonstrates text, as shown in Figure 14.29b.

LISTING 14.15 ShowLine.java

```
 1 import javafx.application.Application;
 2 import javafx.scene.Scene;
 3 import javafx.scene.layout.Pane;
 4 import javafx.scene.paint.Color;
 5 import javafx.stage.Stage;
 6 import javafx.scene.shape.Line;
 7
 8 public class ShowLine extends Application {
 9   @Override // Override the start method in the Application class
10   public void start(Stage primaryStage) {
11     // Create a scene and place it in the stage
```

```
12      Scene scene = new Scene(new LinePane(), 200, 200);          create a pane in scene
13      primaryStage.setTitle("ShowLine"); // Set the stage title
14      primaryStage.setScene(scene); // Place the scene in the stage
15      primaryStage.show(); // Display the stage
16    }
17  }
18
19  class LinePane extends Pane {                                   define a custom pane
20    public LinePane() {
21      Line line1 = new Line(10, 10, 10, 10);                      create a line
22      line1.endXProperty().bind(widthProperty().subtract(10));
23      line1.endYProperty().bind(heightProperty().subtract(10));
24      line1.setStrokeWidth(5);                                    set stroke width
25      line1.setStroke(Color.GREEN);                               set stroke
26      getChildren().add(line1);                                   add line to pane
27
28      Line line2 = new Line(10, 10, 10, 10);                      create a line
29      line2.startXProperty().bind(widthProperty().subtract(10));
30      line2.endYProperty().bind(heightProperty().subtract(10));
31      line2.setStrokeWidth(5);
32      line2.setStroke(Color.GREEN);
33      getChildren().add(line2);                                   add line to pane
34    }
35  }
```

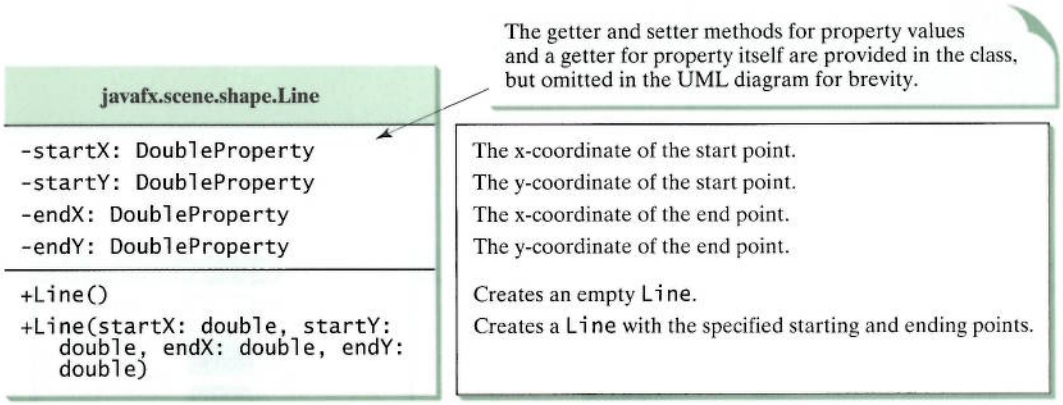


FIGURE 14.28 The `Line` class defines a line.

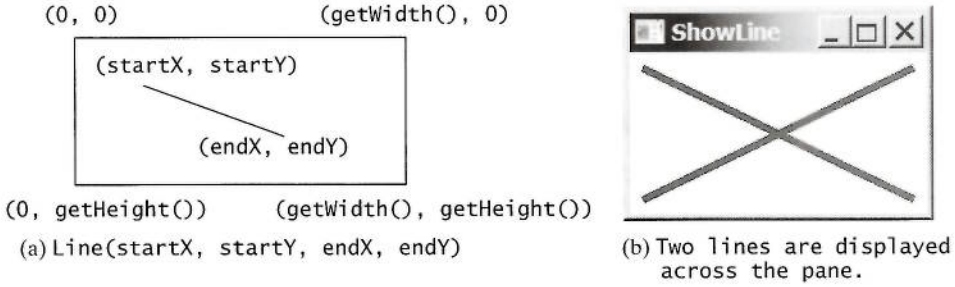


FIGURE 14.29 A `Line` object is created to display a line.

The program defines a custom pane class named `LinePane` (line 19). The custom pane class creates two lines and binds the starting and ending points of the line with the width and height of the pane (lines 22–23, 29–30) so that the two points of the lines are changed as the pane is resized.

14.11.3 Rectangle

A rectangle is defined by the parameters `x`, `y`, `width`, `height`, `arcWidth`, and `arcHeight`, as shown in Figure 14.31a. The rectangle's upper-left corner point is at (`x`, `y`) and parameter `aw` (`arcWidth`) is the horizontal diameter of the arcs at the corner, and `ah` (`arcHeight`) is the vertical diameter of the arcs at the corner.

The `Rectangle` class defines a rectangle. The UML diagram for the `Rectangle` class is shown in Figure 14.30. Listing 14.15 gives an example that demonstrates rectangles, as shown in Figure 14.31b.

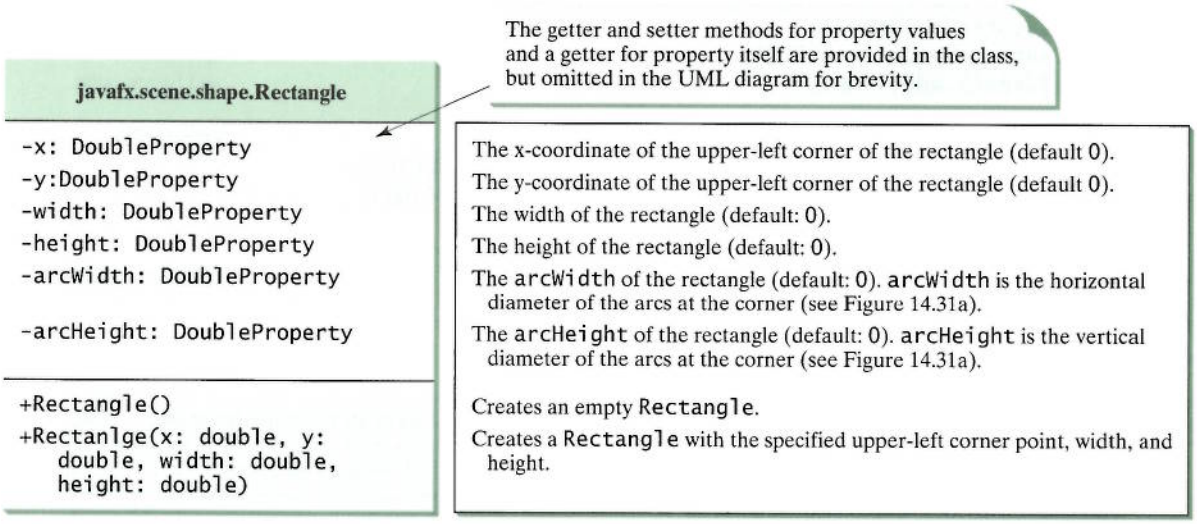
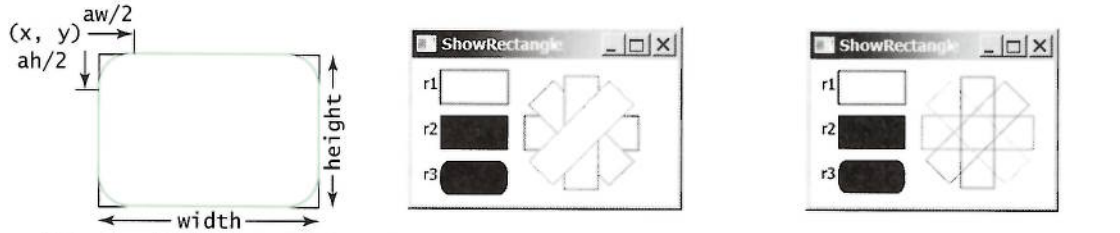


FIGURE 14.30 The `Rectangle` class defines a rectangle.



(a) `Rectangle(x, y, w, h)` (b) Multiple rectangles are displayed (c) Transparent rectangles are displayed

FIGURE 14.31 A `Rectangle` object is created to display a rectangle.

LISTING 14.16 ShowRectangle.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.layout.Pane;
4  import javafx.scene.paint.Color;
5  import javafx.stage.Stage;
6  import javafx.scene.text.Text;
7  import javafx.scene.shape.Rectangle;
8
9  public class ShowRectangle extends Application {
10   @Override // Override the start method in the Application class
11   public void start(Stage primaryStage) {
12     // Create a pane
```

```
13      Pane pane = new Pane();                                          create a pane
14
15      // Create rectangles and add to pane
16      Rectangle r1 = new Rectangle(25, 10, 60, 30);                    create a rectangle r1
17      r1.setStroke(Color.BLACK);                                       set r1's properties
18      r1.setFill(Color.WHITE);
19      pane.getChildren().add(new Text(10, 27, "r1"));
20      pane.getChildren().add(r1);                                      add r1 to pane
21
22      Rectangle r2 = new Rectangle(25, 50, 60, 30);                    create rectangle r2
23      pane.getChildren().add(new Text(10, 67, "r2"));
24      pane.getChildren().add(r2);                                      add r2 to pane
25
26      Rectangle r3 = new Rectangle(25, 90, 60, 30);                    create rectangle r3
27      r3.setArcWidth(15);                                              set r3's arc width
28      r3.setArcHeight(25);                                             set r3's arc height
29      pane.getChildren().add(new Text(10, 107, "r3"));
30      pane.getChildren().add(r3);
31
32      for (int i = 0; i < 4; i++) {
33        Rectangle r = new Rectangle(100, 50, 100, 30);                 create a rectangle
34        r.setRotate(i * 360 / 8);                                      rotate a rectangle
35        r.setStroke(Color.color(Math.random(), Math.random(),
36            Math.random()));
37        r.setFill(Color.WHITE);
38        pane.getChildren().add(r);                                     add rectangle to pane
39      }
40
41      // Create a scene and place it in the stage
42      Scene scene = new Scene(pane, 250, 150);
43      primaryStage.setTitle("ShowRectangle"); // Set the stage title
44      primaryStage.setScene(scene); // Place the scene in the stage
45      primaryStage.show(); // Display the stage
46    }
47  }
```

The program creates multiple rectangles. By default, the fill color is black. So a rectangle is filled with black color. The stroke color is white by default. Line 17 sets stroke color of rectangle `r1` to black. The program creates rectangle `r3` (line 26) and sets its arc width and arc height (lines 27–28). So `r3` is displayed as a rounded rectangle.

The program repeatedly creates a rectangle (line 33), rotates it (line 34), sets a random stroke color (lines 35–36), its fill color to white (line 37), and adds the rectangle to the pane (line 38).

If line 37 is replaced by the following line

```
r.setFill(null);
```

the rectangle is not filled with a color. So they are displayed as shown in Figure 14.31c.

14.11.4 `Circle` and `Ellipse`

You have used circles in several examples early in this chapter. A circle is defined by its parameters `centerX`, `centerY`, and `radius`. The `Circle` class defines a circle. The UML diagram for the `Circle` class is shown in Figure 14.32.

An ellipse is defined by its parameters `centerX`, `centerY`, `radiusX`, and `radiusY`, as shown in Figure 14.34a. The `Ellipse` class defines an ellipse. The UML diagram for the `Ellipse` class is shown in Figure 14.33. Listing 14.17 gives an example that demonstrates ellipses, as shown in Figure 14.34b.

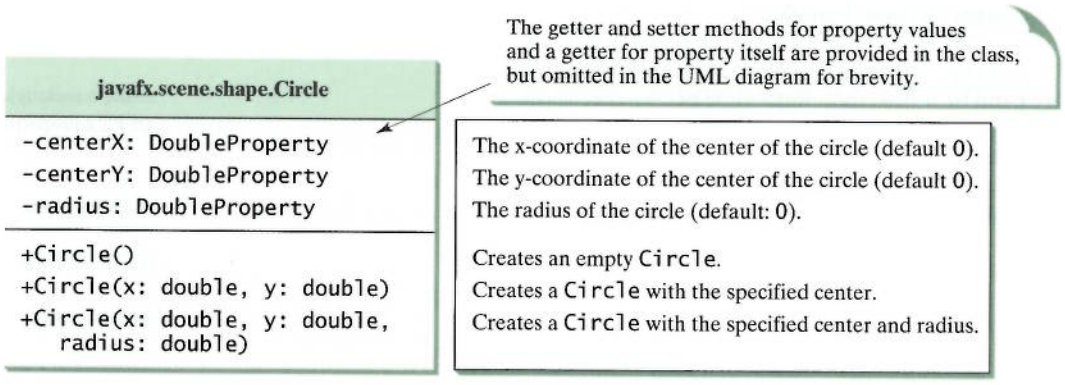


FIGURE 14.32 The `Circle` class defines circles.

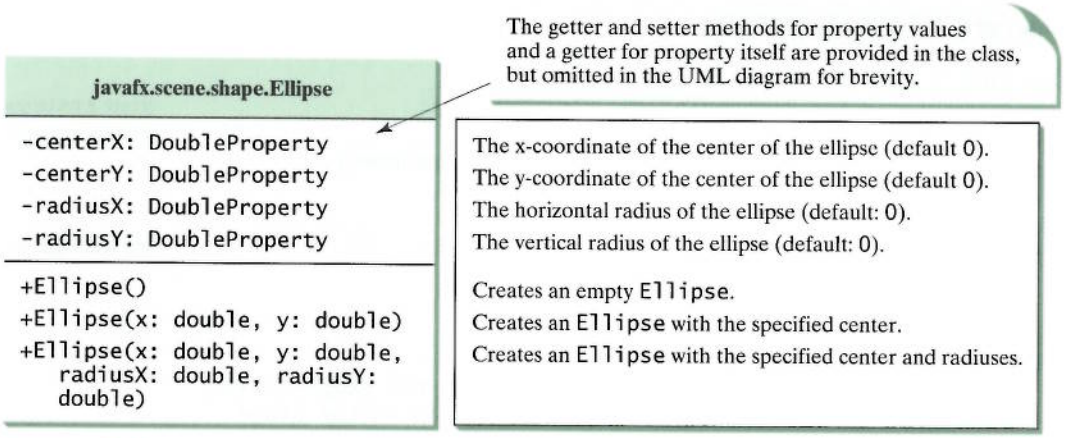
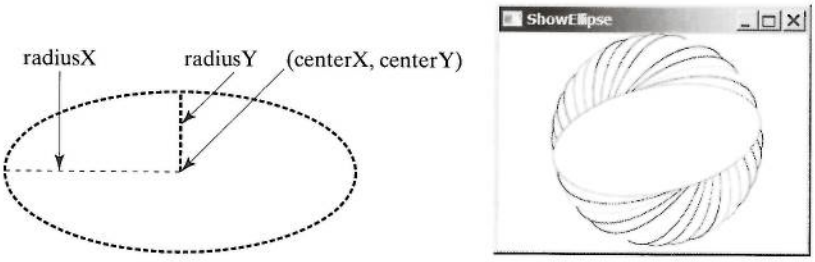


FIGURE 14.33 The `Ellipse` class defines ellipses.



(a) `Ellipse(centerX, centerY, radiusX, radiusY)`

(b) Multiple ellipses are displayed.

FIGURE 14.34 An `Ellipse` object is created to display an ellipse.

LISTING 14.17 ShowEllipse.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.layout.Pane;
4  import javafx.scene.paint.Color;
5  import javafx.stage.Stage;
6  import javafx.scene.shape.Ellipse;
7
8  public class ShowEllipse extends Application {
9    @Override // Override the start method in the Application class
```

```
10    public void start(Stage primaryStage) {
11      // Create a pane
12      Pane pane = new Pane();                                    create a pane
13
14      for (int i = 0; i < 16; i++) {
15        // Create an ellipse and add it to pane
16        Ellipse e1 = new Ellipse(150, 100, 100, 50);             create an ellipse
17        e1.setStroke(Color.color(Math.random(), Math.random(),   set random color for stroke
18          Math.random()));
19        e1.setFill(Color.WHITE);                                 set fill color
20        e1.setRotate(i * 180 / 16);                              rotate ellipse
21        pane.getChildren().add(e1);                              add ellipse to pane
22      }
23
24      // Create a scene and place it in the stage
25      Scene scene = new Scene(pane, 300, 200);
26      primaryStage.setTitle("ShowEllipse"); // Set the stage title
27      primaryStage.setScene(scene); // Place the scene in the stage
28      primaryStage.show(); // Display the stage
29    }
30  }
```

The program repeatedly creates an ellipse (line 16), sets a random stroke color (lines 17–18), sets its fill color to white (line 19), rotates it (line 20), and adds the rectangle to the pane (line 21).

14.11.5 Arc

An arc is conceived as part of an ellipse, defined by the parameters `centerX`, `centerY`, `radiusX`, `radiusY`, `startAngle`, `length`, and an arc type (`ArcType.OPEN`, `ArcType.CHORD`, or `ArcType.ROUND`). The parameter `startAngle` is the starting angle; and `length` is the spanning angle (i.e., the angle covered by the arc). Angles are measured in degrees and follow the usual mathematical conventions (i.e., 0 degrees is in the easterly direction, and positive angles indicate counterclockwise rotation from the easterly direction), as shown in Figure 14.36a.

The `Arc` class defines an arc. The UML diagram for the `Arc` class is shown in Figure 14.35. Listing 14.18 gives an example that demonstrates ellipses, as shown in Figure 14.36b.

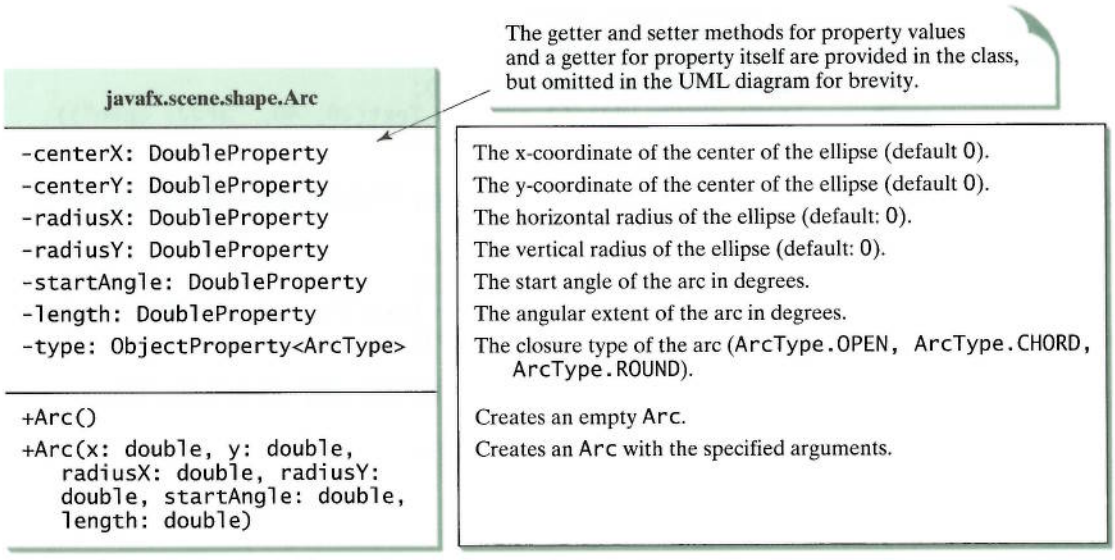
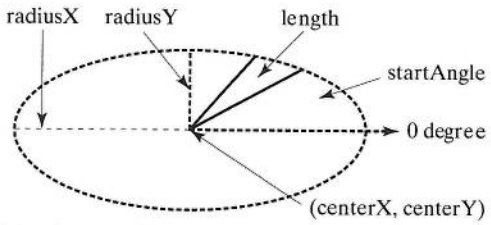
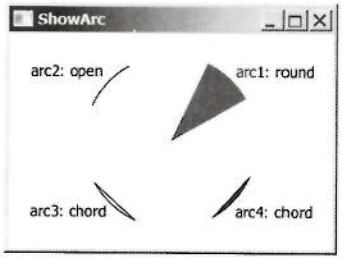


FIGURE 14.35 The `Arc` class defines an arc.



(a) `Arc(centerX, centerY, radiusX, radiusY, startAngle, length)`



(b) Multiple ellipses are displayed

FIGURE 14.36 An `Arc` object is created to display an arc.

LISTING 14.18 ShowArc.java

```
1  import javafx.application.Application;
2  import javafx.scene.Scene;
3  import javafx.scene.layout.Pane;
4  import javafx.scene.paint.Color;
5  import javafx.stage.Stage;
6  import javafx.scene.shape.Arc;
7  import javafx.scene.shape.ArcType;
8  import javafx.scene.text.Text;
9
10 public class ShowArc extends Application {
11   @Override // Override the start method in the Application class
12   public void start(Stage primaryStage) {
13     // Create a pane
14     Pane pane = new Pane();
15
16     Arc arc1 = new Arc(150, 100, 80, 80, 30, 35); // Create an arc
17     arc1.setFill(Color.RED); // Set fill color
18     arc1.setType(ArcType.ROUND); // Set arc type
19     pane.getChildren().add(new Text(210, 40, "arc1: round"));
20     pane.getChildren().add(arc1); // Add arc to pane
21
22     Arc arc2 = new Arc(150, 100, 80, 80, 30 + 90, 35);
23     arc2.setFill(Color.WHITE);
24     arc2.setType(ArcType.OPEN);
25     arc2.setStroke(Color.BLACK);
26     pane.getChildren().add(new Text(20, 40, "arc2: open"));
27     pane.getChildren().add(arc2);
28
29     Arc arc3 = new Arc(150, 100, 80, 80, 30 + 180, 35);
30     arc3.setFill(Color.WHITE);
31     arc3.setType(ArcType.CHORD);
32     arc3.setStroke(Color.BLACK);
33     pane.getChildren().add(new Text(20, 170, "arc3: chord"));
34     pane.getChildren().add(arc3);
35
36     Arc arc4 = new Arc(150, 100, 80, 80, 30 + 270, 35);
37     arc4.setFill(Color.GREEN);
38     arc4.setType(ArcType.CHORD);
```

create a pane

create `arc1`
set fill color for `arc1`
set `arc1` as round arc

add `arc1` to pane

create `arc2`
set fill color for `arc2`
set `arc2` as round arc

add `arc2` to pane

create `arc3`
set fill color for `arc3`
set `arc3` as chord arc

add `arc3` to pane

create `arc4`

```
39      arc4.setStroke(Color.BLACK);
40      pane.getChildren().add(new Text(210, 170, "arc4: chord"));
41      pane.getChildren().add(arc4);                                    add arc4 to pane
42
43      // Create a scene and place it in the stage
44      Scene scene = new Scene(pane, 300, 200);
45      primaryStage.setTitle("ShowArc"); // Set the stage title
46      primaryStage.setScene(scene); // Place the scene in the stage
47      primaryStage.show(); // Display the stage
48    }
49  }
```

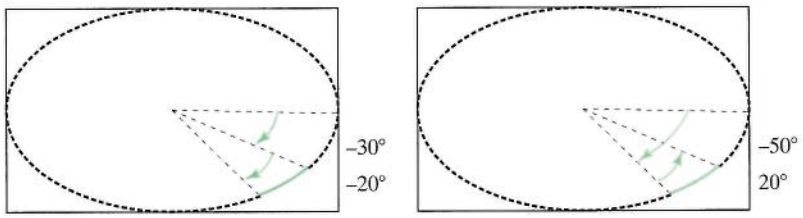
The program creates an arc `arc1` centered at (150, 100) with `radiusX 80` and `radiusY 80`. The starting angle is `30` with `length 35` (line 15). `arc1`'s arc type is set to `ArcType.ROUND` (line 18). Since `arc1`'s fill color is red, `arc1` is displayed filled with red round.

The program creates an arc `arc3` centered at (150, 100) with `radiusX 80` and `radiusY 80`. The starting angle is `30+180` with `length 35` (line 29). `Arc3`'s arc type is set to `ArcType.CHORD` (line 31). Since `arc3`'s fill color is white and stroke color is black, `arc3` is displayed with black outline as a chord.

Angles may be negative. A negative starting angle sweeps clockwise from the easterly direction, as shown in Figure 14.37. A negative spanning angle sweeps clockwise from the starting angle. The following two statements define the same arc: negative degrees

```
new Arc(x, y, radiusX, radiusY, -30, -20);
new Arc(x, y, radiusX, radiusY, -50, 20);
```

The first statement uses negative starting angle `-30` and negative spanning angle `-20`, as shown in Figure 14.37a. The second statement uses negative starting angle `-50` and positive spanning angle `20`, as shown in Figure 14.37b.



(a) Negative starting angle –30° and negative spanning angle –20°

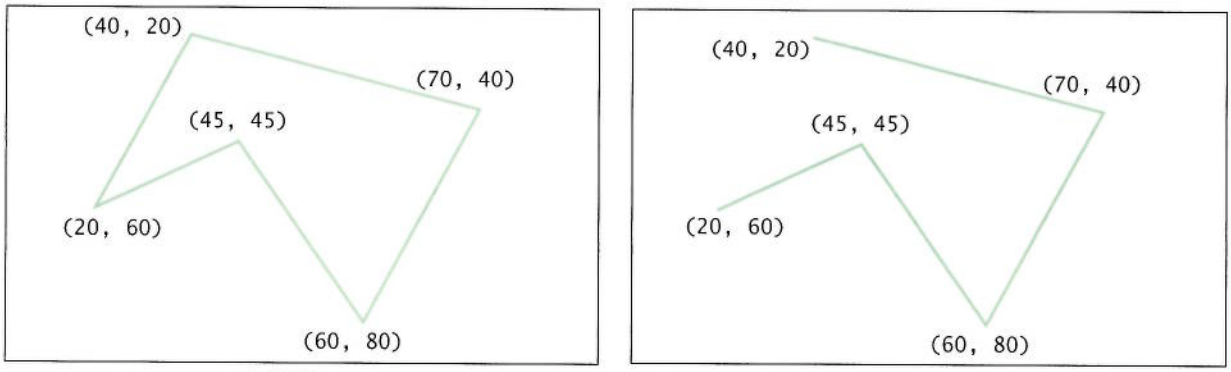
(b) Negative starting angle –50° and positive spanning angle 20°

FIGURE 14.37 Angles may be negative.

Note that the trigonometric methods in the `Math` class use the angles in radians, but the angles in the `Arc` class are in degrees.

14.11.6 `Polygon` and `Polyline`

The `Polygon` class defines a polygon that connects a sequence of points, as shown in Figure 14.38a. The `Polyline` class is similar to the `Polygon` class except that the `Polyline` class is not automatically closed, as shown in Figure 14.38b.



(a) Polygon (b) Polyline

FIGURE 14.38 `Polygon` is closed and `Polyline` is not closed.

The UML diagram for the `Polygon` class is shown in Figure 14.39. Listing 14.19 gives an example that creates a hexagon, as shown in Figure 14.40.

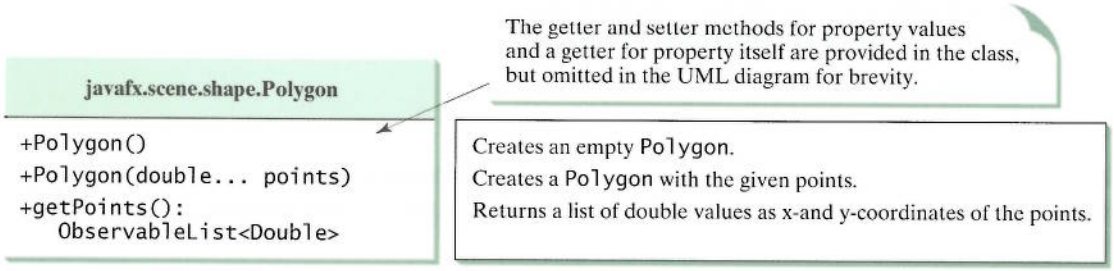
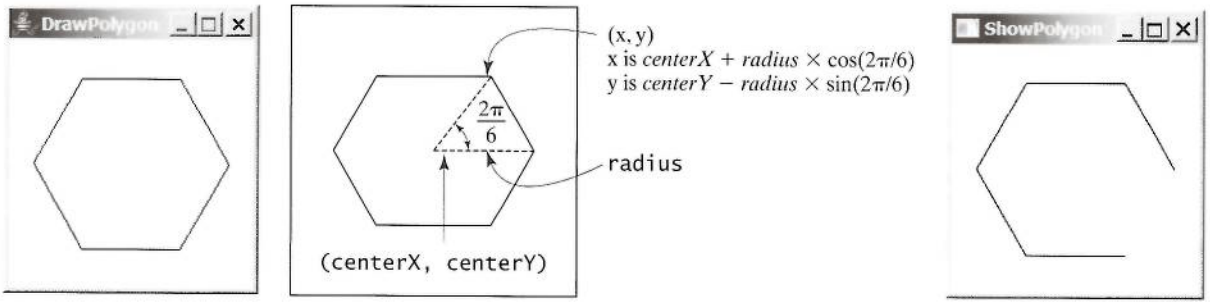


FIGURE 14.39 `Polygon` defines a polygon.



(a) (b)

FIGURE 14.40 (a) A `Polygon` is displayed. (b) A `Polyline` is displayed.

LISTING 14.19 ShowPolygon.java

```
1  import javafx.application.Application;
2  import javafx.collections.ObservableList;
3  import javafx.scene.Scene;
4  import javafx.scene.layout.Pane;
5  import javafx.scene.paint.Color;
6  import javafx.stage.Stage;
7  import javafx.scene.shape.Polygon;
```

```
8
9  public class ShowPolygon extends Application {
10   @Override // Override the start method in the Application class
11   public void start(Stage primaryStage) {
12     // Create a pane, a polygon, and place polygon to pane
13     Pane pane = new Pane();                                          create a pane
14     Polygon polygon = new Polygon();                                 create a polygon
15     pane.getChildren().add(polygon);                                 add polygon to pane
16     polygon.setFill(Color.WHITE);
17     polygon.setStroke(Color.BLACK);
18     ObservableList<Double> list = polygon.getPoints();               get a list of points
19
20     final double WIDTH = 200, HEIGHT = 200;
21     double centerX = WIDTH / 2, centerY = HEIGHT / 2;
22     double radius = Math.min(WIDTH, HEIGHT) * 0.4;
23
24     // Add points to the polygon list
25     for (int i = 0; i < 6; i++) {
26       list.add(centerX + radius * Math.cos(2 * i * Math.PI / 6));    add x-coordinate of a point
27       list.add(centerY - radius * Math.sin(2 * i * Math.PI / 6));    add y-coordinate of a point
28     }
29
30     // Create a scene and place it in the stage
31     Scene scene = new Scene(pane, WIDTH, HEIGHT);                    add pane to scene
32     primaryStage.setTitle("ShowPolygon"); // Set the stage title
33     primaryStage.setScene(scene); // Place the scene in the stage
34     primaryStage.show(); // Display the stage
35   }
36 }
```

The program creates a polygon (line 14) and adds it to a pane (line 15). The `polygon.getPoints()` method returns an `ObservableList<Double>` (line 18), which contains the `add` method for adding an element to the list (lines 26–27). Note that the value passed to `add(value)` must be a `double` value. If an `int` value is passed, the `int` value would be automatically boxed into an `Integer`. This would cause an error because the `ObservableList<Double>` consists of `Double` elements.

The loop adds six points to the polygon (lines 25–28). Each point is represented by its x- and y-coordinates. For each point, its x-coordinate is added to the polygon's list (line 26) and then its y-coordinate is added to the list (line 27). The formula for computing the x- and y-coordinates for a point in the hexagon is illustrated in Figure 14.40a.

If you replace `Polygon` by `Polyline`, the program displays a polyline as shown in Figure 14.40b. The `Polyline` class is used in the same way as `Polygon` except that the starting and ending point are not connected in `Polyline`.

14.27 How do you display a text, line, rectangle, circle, ellipse, arc, polygon, and polyline?

14.28 Write code fragments to display a string rotated 45 degrees in the center of the pane.

14.29 Write code fragments to display a thick line of 10 pixels from (10, 10) to (70, 30).

14.30 Write code fragments to fill red color in a rectangle of width 100 and height 50 with the upper-left corner at (10, 10).

14.31 Write code fragments to display a round-cornered rectangle with width 100, height 200 with the upper-left corner at (10, 10), corner horizontal diameter 40, and corner vertical diameter 20.

14.32 Write code fragments to display an ellipse with horizontal radius 50 and vertical radius 100.

14.33 Write code fragments to display the outline of the upper half of a circle with radius 50.

14.34 Write code fragments to display the lower half of a circle with radius 50 filled with the red color.

14.35 Write code fragments to display a polygon connecting the following points: (20, 40), (30, 50), (40, 90), (90, 10), (10, 30), and fill the polygon with green color.

14.36 Write code fragments to display a polyline connecting the following points: (20, 40), (30, 50), (40, 90), (90, 10), (10, 30).

14.12 Case Study: The `ClockPane` Class

This case study develops a class that displays a clock on a pane.

The contract of the `ClockPane` class is shown in Figure 14.41.

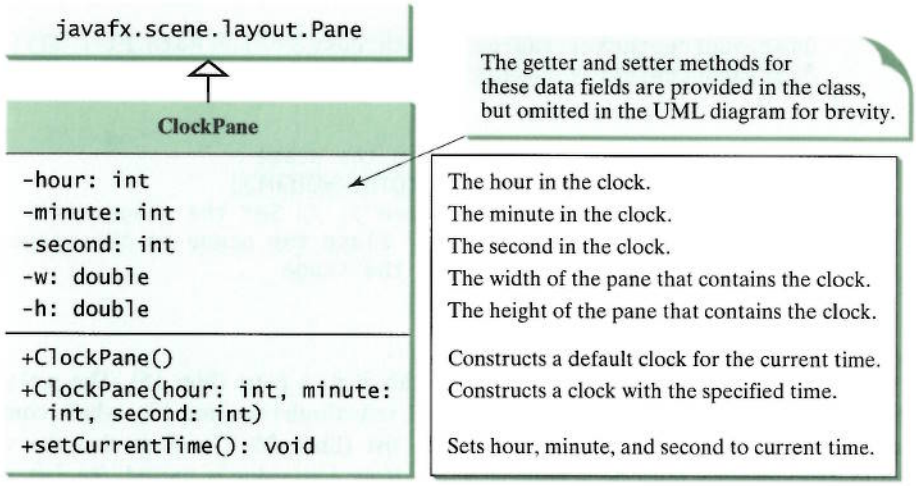


FIGURE 14.41 `ClockPane` displays an analog clock.

Assume `ClockPane` is available; we write a test program in Listing 14.20 to display an analog clock and use a label to display the hour, minute, and second, as shown in Figure 14.42.

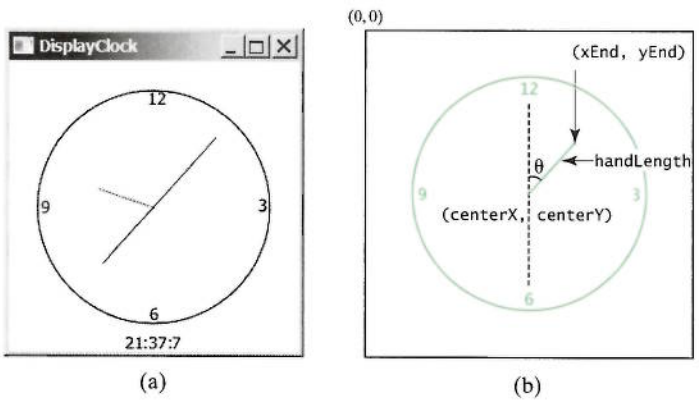


FIGURE 14.42 (a) The `DisplayClock` program displays a clock that shows the current time. (b) The endpoint of a clock hand can be determined, given the spanning angle, the hand length, and the center point.

LISTING 14.20 DisplayClock.java

```
1  import javafx.application.Application;
2  import javafx.geometry.Pos;
3  import javafx.stage.Stage;
4  import javafx.scene.Scene;
5  import javafx.scene.control.Label;
6  import javafx.scene.layout.BorderPane;
7
8  public class DisplayClock extends Application {
9    @Override // Override the start method in the Application class
10   public void start(Stage primaryStage) {
11     // Create a clock and a label
12     ClockPane clock = new ClockPane();                          create a clock
13     String timeString = clock.getHour() + ":" + clock.getMinute()
14       + ":" + clock.getSecond();
15     Label lblCurrentTime = new Label(timeString);               create a label
16
17     // Place clock and label in border pane
18     BorderPane pane = new BorderPane();
19     pane.setCenter(clock);                                      add a clock
20     pane.setBottom(lblCurrentTime);                             add a label
21     BorderPane.setAlignment(lblCurrentTime, Pos.TOP_CENTER);
22
23     // Create a scene and place it in the stage
24     Scene scene = new Scene(pane, 250, 250);
25     primaryStage.setTitle("DisplayClock"); // Set the stage title
26     primaryStage.setScene(scene); // Place the scene in the stage
27     primaryStage.show(); // Display the stage
28   }
29 }
```

The rest of this section explains how to implement the `ClockPane` class. Since you can use the class without knowing how it is implemented, you may skip the implementation if you wish.

skip implementation?
implementation

To draw a clock, you need to draw a circle and three hands for the second, minute, and hour. To draw a hand, you need to specify the two ends of the line. As shown in Figure 14.42b, one end is the center of the clock at `(centerX, centerY)`; the other end, at `(endX, endY)`, is determined by the following formula:

$$endX = centerX + handLength \times \sin(\theta)$$
$$endY = centerY - handLength \times \cos(\theta)$$

Since there are 60 seconds in one minute, the angle for the second hand is

$$second \times (2\pi/60)$$

The position of the minute hand is determined by the minute and second. The exact minute value combined with seconds is `minute + second/60`. For example, if the time is 3 minutes and 30 seconds, the total minutes are 3.5. Since there are 60 minutes in one hour, the angle for the minute hand is

$$(minute + second/60) \times (2\pi/60)$$

Since one circle is divided into 12 hours, the angle for the hour hand is

$$(hour + minute/60 + second/(60 \times 60)) \times (2\pi/12)$$

For simplicity in computing the angles of the minute hand and hour hand, you can omit the seconds, because they are negligibly small. Therefore, the endpoints for the second hand, minute hand, and hour hand can be computed as:

```
secondX = centerX + secondHandLength × sin(second × (2π/60))
secondY = centerY - secondHandLength × cos(second × (2π/60))
minuteX = centerX + minuteHandLength × sin(minute × (2π/60))
minuteY = centerY - minuteHandLength × cos(minute × (2π/60))
hourX = centerX + hourHandLength × sin((hour + minute/60) × (2π/12))
hourY = centerY - hourHandLength × cos((hour + minute/60) × (2π/12))
```

The ClockPane class is implemented in Listing 14.21.

LISTING 14.21 ClockPane.java

```
1  import java.util.Calendar;
2  import java.util.GregorianCalendar;
3  import javafx.scene.layout.Pane;
4  import javafx.scene.paint.Color;
5  import javafx.scene.shape.Circle;
6  import javafx.scene.shape.Line;
7  import javafx.scene.text.Text;
8
9  public class ClockPane extends Pane {
10   private int hour;
11   private int minute;
12   private int second;
13
14   // Clock pane's width and height
15   private double w = 250, h = 250;
16
17   /** Construct a default clock with the current time*/
18   public ClockPane() {
19     setCurrentTime();
20   }
21
22   /** Construct a clock with specified hour, minute, and second */
23   public ClockPane(int hour, int minute, int second) {
24     this.hour = hour;
25     this.minute = minute;
26     this.second = second;
27     paintClock();
28   }
29
30   /** Return hour */
31   public int getHour() {
32     return hour;
33   }
34
35   /** Set a new hour */
36   public void setHour(int hour) {
37     this.hour = hour;
38     paintClock();
39   }
40
41   /** Return minute */
42   public int getMinute() {
43     return minute;
44   }
45
```

clock properties

no-arg constructor

constructor

set a new hour

paint clock

```
46    /** Set a new minute */
47    public void setMinute(int minute) {                          set a new minute
48      this.minute = minute;
49      paintClock();                                              paint clock
50    }
51
52    /** Return second */
53    public int getSecond() {
54      return second;
55    }
56
57    /** Set a new second */
58    public void setSecond(int second) {                          set a new second
59      this.second = second;
60      paintClock();                                              paint clock
61    }
62
63    /** Return clock pane's width */
64    public double getW() {
65      return w;
66    }
67
68    /** Set clock pane's width */
69    public void setW(double w) {                                 set a new width
70      this.w = w;
71      paintClock();                                              paint clock
72    }
73
74    /** Return clock pane's height */
75    public double getH() {
76      return h;
77    }
78
79    /** Set clock pane's height */
80    public void setH(double h) {                                 set a new height
81      this.h = h;
82      paintClock();                                              paint clock
83    }
84
85    /* Set the current time for the clock */
86    public void setCurrentTime() {                               set current time
87      // Construct a calendar for the current date and time
88      Calendar calendar = new GregorianCalendar();
89
90      // Set current hour, minute and second
91      this.hour = calendar.get(Calendar.HOUR_OF_DAY);
92      this.minute = calendar.get(Calendar.MINUTE);
93      this.second = calendar.get(Calendar.SECOND);
94
95      paintClock(); // Repaint the clock                          paint clock
96    }
97
98    /** Paint the clock */
99    protected void paintClock() {                                paint clock
100     // Initialize clock parameters
101     double clockRadius = Math.min(w, h) * 0.8 * 0.5;           get radius
102     double centerX = w / 2;                                    set center
103     double centerY = h / 2;
104
105     // Draw circle
```

create a circle

create texts

create second hand

create minute hand

create hour hand

clear pane
add to pane

```
106       Circle circle = new Circle(centerX, centerY, clockRadius);
107       circle.setFill(Color.WHITE);
108       circle.setStroke(Color.BLACK);
109       Text t1 = new Text(centerX - 5, centerY - clockRadius + 12, "12");
110       Text t2 = new Text(centerX - clockRadius + 3, centerY + 5, "9");
111       Text t3 = new Text(centerX + clockRadius - 10, centerY + 3, "3");
112       Text t4 = new Text(centerX - 3, centerY + clockRadius - 3, "6");
113
114       // Draw second hand
115       double sLength = clockRadius * 0.8;
116       double secondX = centerX + sLength *
117         Math.sin(second * (2 * Math.PI / 60));
118       double secondY = centerY - sLength *
119         Math.cos(second * (2 * Math.PI / 60));
120       Line sLine = new Line(centerX, centerY, secondX, secondY);
121       sLine.setStroke(Color.RED);
122
123       // Draw minute hand
124       double mLength = clockRadius * 0.65;
125       double xMinute = centerX + mLength *
126         Math.sin(minute * (2 * Math.PI / 60));
127       double minuteY = centerY - mLength *
128         Math.cos(minute * (2 * Math.PI / 60));
129       Line mLine = new Line(centerX, centerY, xMinute, minuteY);
130       mLine.setStroke(Color.BLUE);
131
132       // Draw hour hand
133       double hLength = clockRadius * 0.5;
134       double hourX = centerX + hLength *
135         Math.sin((hour % 12 + minute / 60.0) * (2 * Math.PI / 12));
136       double hourY = centerY - hLength *
137         Math.cos((hour % 12 + minute / 60.0) * (2 * Math.PI / 12));
138       Line hLine = new Line(centerX, centerY, hourX, hourY);
139       hLine.setStroke(Color.GREEN);
140
141       getChildren().clear();
142       getChildren().addAll(circle, t1, t2, t3, t4, sLine, mLine, hLine);
143     }
144   }
```

The program displays a clock for the current time using the no-arg constructor (lines 18–20) and displays a clock for the specified hour, minute, and second using the other constructor (lines 23–28). The current hour, minute, and second is obtained by using the `GregorianCalendar` class (lines 86–96). The `GregorianCalendar` class in the Java API enables you to create a `Calendar` instance for the current time using its no-arg constructor. You can then use its methods `get(Calendar.HOUR)`, `get(Calendar.MINUTE)`, and `get(Calendar.SECOND)` to return the hour, minute, and second from a `Calendar` object.

The class defines the properties `hour`, `minute`, and `second` to store the time represented in the clock (lines 10–12) and uses the `w` and `h` properties to represent the width and height of the clock pane (line 15). The initial values of `w` and `h` are set to 250. The `w` and `h` values can be reset using the `setW` and `setH` methods (lines 69, 80). These values are used to draw a clock in the pane in the `paintClock()` method.

The `paintClock()` method paints the clock (lines 99–143). The clock radius is proportional to the width and height of the pane (line 101). A circle for the clock is created at the center of the pane (line 106). The text for showing the hours 12, 3, 6, 9 are created in lines 109–112.

The second hand, minute hand, and hour hand are the lines created in lines 114–139. The `paintClock()` method places all these shapes in the pane using the `addAll` method in a list (line 142). Because the `paintClock()` method is invoked whenever a new property (`hour`, `minute`, `second`, `w`, and `h`) is set (lines 27, 38, 49, 60, 71, 82, 95), before adding new contents into the pane, the old contents are cleared from the pane (line 141).

Key Terms

AWT 536
bidirectional binding 544
bindable object 542
binding object 542
binding property 542
JavaFX 536
node 539
observable object 542
pane 539
property getter method 543
primary stage 537
shape 539
Swing 536
value getter method 543
value setter method 543
UI control 539
unidirectional binding 544

Chapter Summary

1. JavaFX is the new framework for developing rich Internet applications. JavaFX completely replaces Swing and AWT.

2. A main JavaFX class must extend `javafx.application.Application` and implement the `start` method. The primary stage is automatically created by the JVM and passed to the `start` method.

3. A stage is a window for displaying a scene. You can add nodes to a scene. Panes, controls, and shapes are nodes. Panes can be used as the containers for nodes.

4. A binding property can be bound to an observable source object. A change in the source object will be automatically reflected in the binding property. A binding property has a value getter method, value setter method, and property getter method.

5. The `Node` class defines many properties that are common to all nodes. You can apply these properties to panes, controls, and shapes.

6. You can create a `Color` object with the specified red, green, blue components, and opacity value.

7. You can create a `Font` object and set its name, size, weight, and posture.

8. The `javafx.scene.image.Image` class can be used to load an image and this image can be displayed in an `ImageView` object.

9. JavaFX provides many types of panes for automatically laying out nodes in a desired location and size. The `Pane` is the base class for all panes. It contains the `getChildren()` method to return an `ObservableList`. You can use `ObservableList`'s `add(node)` and `addAll(node1, node2, ...)` methods for adding nodes into a pane.

10. A `FlowPane` arranges the nodes in the pane horizontally from left to right or vertically from top to bottom in the order in which they were added. A `GridPane` arranges nodes in a grid (matrix) formation. The nodes are placed in the specified column and row indices. A `BorderPane` can place nodes in five regions: top, bottom, left, right, and center. An `HBox` lays out its children in a single horizontal row. A `VBox` lays out its children in a single vertical column.

11. JavaFX provides many shape classes for drawing texts, lines, circles, rectangles, ellipses, arcs, polygons, and polylines.

Quiz

Answer the quiz for this chapter online at www.cs.armstrong.edu/liang/intro10e/quiz.html.

MyProgrammingLab™

Programming Exercises

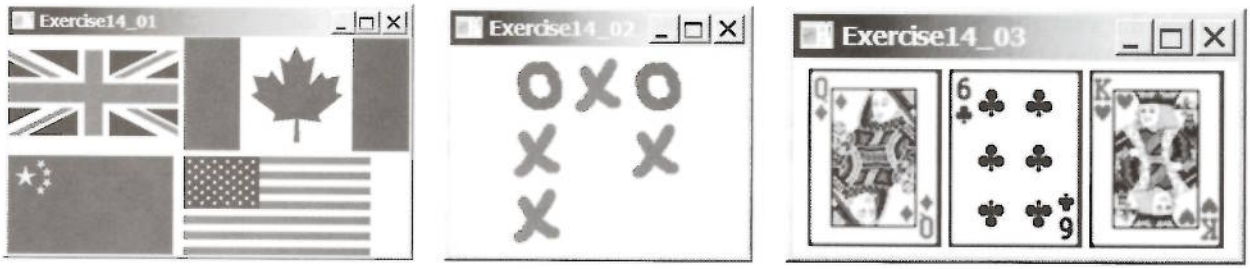
download image files

Note

The image files used in the exercises can be obtained from www.cs.armstrong.edu/liang/intro10e/book.zip under the image folder.

Sections 14.2–14.9

14.1 (*Display images*) Write a program that displays four images in a grid pane, as shown in Figure 14.43a.



(a) (b) (c)

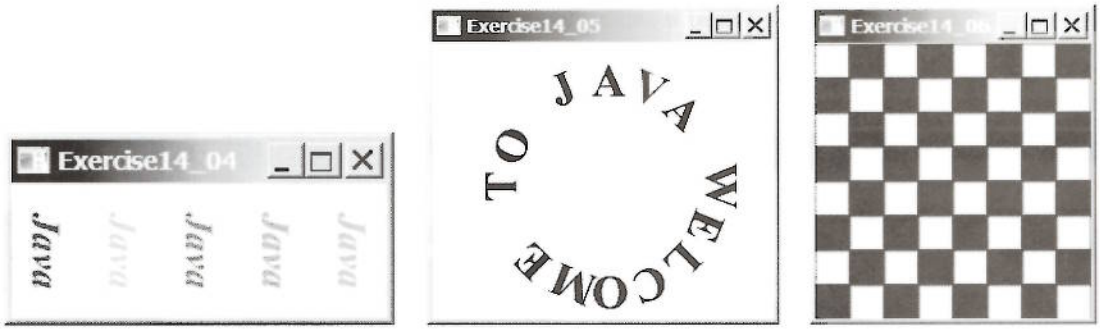
Figure 14.43 (a) Exercise 14.1 displays four images. (b) Exercise 14.2 displays a tic-tac-toe board with images. (c) Three cards are randomly selected.

VideoNote
Display a tictactoe board

***14.2** (*Tic-tac-toe board*) Write a program that displays a tic-tac-toe board, as shown in Figure 14.43b. A cell may be X, O, or empty. What to display at each cell is randomly decided. The X and O are images in the files **x.gif** and **o.gif**.

***14.3** (*Display three cards*) Write a program that displays three cards randomly selected from a deck of 52, as shown in Figure 14.43c. The card image files are named **1.png**, **2.png**, ..., **52.png** and stored in the **image/card** directory. All three cards are distinct and selected randomly. Hint: You can select random cards by storing the numbers 1–52 to an array list, perform a random shuffle introduced in Section 11.12, and use the first three numbers in the array list as the file names for the image.

14.4 (*Color and font*) Write a program that displays five texts vertically, as shown in Figure 14.44a. Set a random color and opacity for each text and set the font of each text to Times Roman, bold, italic, and 22 pixels.



(a) (b) (c)

FIGURE 14.44 (a) Five texts are displayed with a random color and a specified font. (b) A string is displayed around the circle. (c) A checkerboard is displayed using rectangles.

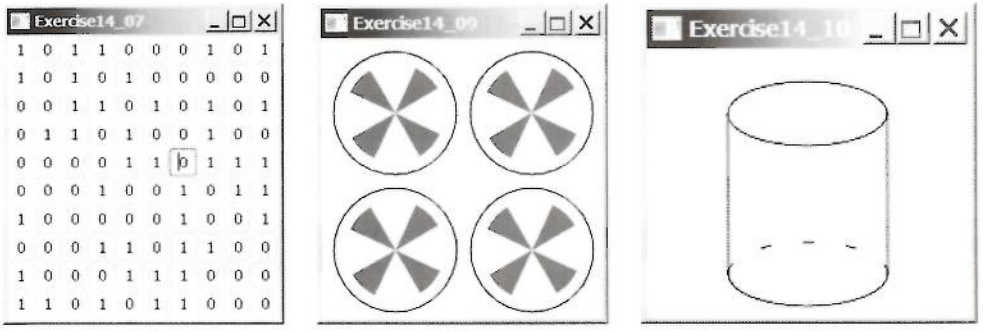
14.5 (*Characters around circle*) Write a program that displays a string Welcome to Java around the circle, as shown in Figure 14.44b. Hint: You need to display each character in the right location with appropriate rotation using a loop.

***14.6** (*Game: display a checkerboard*) Write a program that displays a checkerboard in which each white and black cell is a `Rectangle` with a fill color black or white, as shown in Figure 14.44c.

Sections 14.10–14.11

***14.7** (*Display random 0 or 1*) Write a program that displays a 10-by-10 square matrix, as shown in Figure 14.45a. Each element in the matrix is `0` or `1`, randomly generated. Display each number centered in a text field. Use `TextField`'s `setText` method to set value `0` or `1` as a string.

Display a random matrix



(a) (b) (c)

FIGURE 14.45 (a) The program randomly generates 0s and 1s. (b) Exercise 14.9 draws four fans. (c) Exercise 14.10 draws a cylinder.

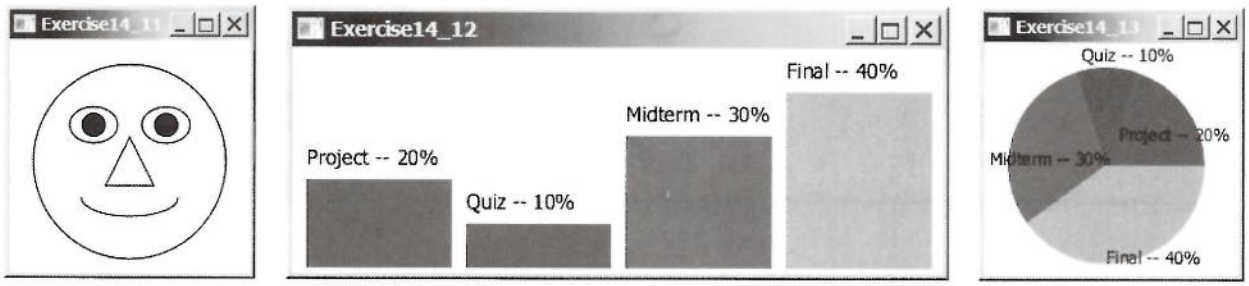
14.8 (*Display 54 cards*) Expand Exercise 14.3 to display all 54 cards (including two jokers), nine per row. The image files are jokers and are named 53.jpg and 54.jpg.

***14.9** (*Create four fans*) Write a program that places four fans in a `GridPane` with two rows and two columns, as shown in Figure 14.45b.

***14.10** (*Display a cylinder*) Write a program that draws a cylinder, as shown in Figure 14.45b. You can use the following method to set the dashed stroke for an arc:

```
arc.getStrokeDashArray().addAll(6.0, 21.0);
```

*14.11 (*Paint a smiley face*) Write a program that paints a smiley face, as shown in Figure 14.46a.



(a) (b) (c)

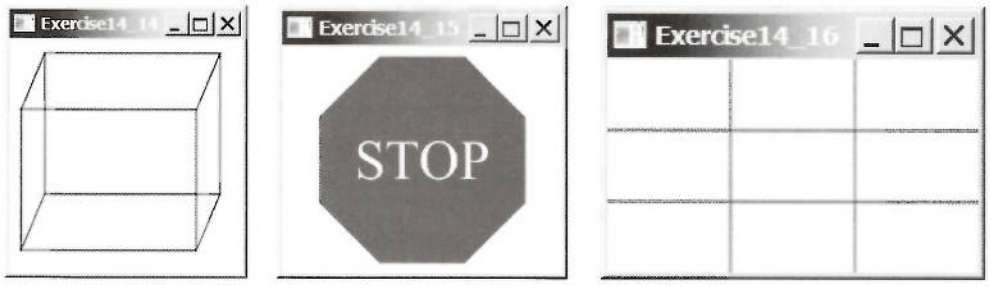
FIGURE 14.46 (a) Exercise 14.11 paints a smiley face. (b) Exercise 14.12 paints a bar chart. (c) Exercise 14.13 paints a pie chart.

VideoNote
Display a bar chart

**14.12 (*Display a bar chart*) Write a program that uses a bar chart to display the percentages of the overall grade represented by projects, quizzes, midterm exams, and the final exam, as shown in Figure 14.46b. Suppose that projects take 20 percent and are displayed in red, quizzes take 10 percent and are displayed in blue, midterm exams take 30 percent and are displayed in green, and the final exam takes 40 percent and is displayed in orange. Use the `Rectangle` class to display the bars. Interested readers may explore the JavaFX `BarChart` class for further study.

**14.13 (*Display a pie chart*) Write a program that uses a pie chart to display the percentages of the overall grade represented by projects, quizzes, midterm exams, and the final exam, as shown in Figure 14.46c. Suppose that projects take 20 percent and are displayed in red, quizzes take 10 percent and are displayed in blue, midterm exams take 30 percent and are displayed in green, and the final exam takes 40 percent and is displayed in orange. Use the `Arc` class to display the pies. Interested readers may explore the JavaFX `PieChart` class for further study.

14.14 (*Display a rectanguloid*) Write a program that displays a rectanguloid, as shown in Figure 14.47a. The cube should grow and shrink as the window grows or shrinks.



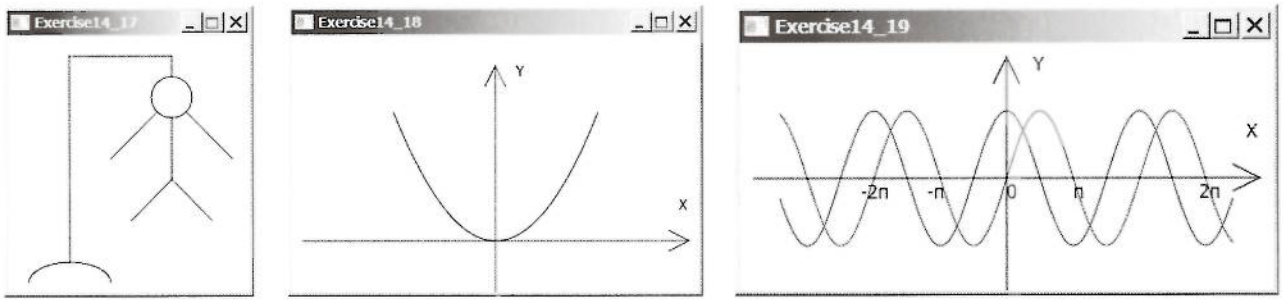
(a) (b) (c)

FIGURE 14.47 (a) Exercise 14.14 paints a rectanguloid. (b) Exercise 14.15 paints a STOP sign. (c) Exercise 14.13 paints a grid.

*14.15 (*Display a STOP sign*) Write a program that displays a STOP sign, as shown in Figure 14.47b. The octagon is in red and the sign is in white. (*Hint*: Place an octagon and a text in a stack pane.)

*14.16 (*Display a 3 × 3 grid*) Write a program that displays a 3 × 3 grid, as shown in Figure 14.47c. Use red color for vertical lines and blue for horizontals. The lines are automatically resized when the window is resized.

14.17 (*Game: hangman*) Write a program that displays a drawing for the popular hangman game, as shown in Figure 14.48a.



(a) (b) (c)

FIGURE 14.48 (a) Exercise 14.17 draws a sketch for the hangman game. (c) Exercise 14.18 plots the quadratic function. (c) Exercise 14.19 plots the sine/cosine functions.

*14.18 (*Plot the square function*) Write a program that draws a diagram for the function $f(x) = x^2$ (see Figure 14.48b).

Hint: Add points to a polyline using the following code:

```
Polyline polyline = new Polyline();
ObservableList<Double> list = polyline.getPoints();
double scaleFactor = 0.0125;
for (int x = -100; x <= 100; x++) {
  list.add(x + 200.0);
  list.add(scaleFactor * x * x);
}
```

**14.19 (*Plot the sine and cosine functions*) Write a program that plots the sine function in red and cosine in blue, as shown in Figure 14.48c.

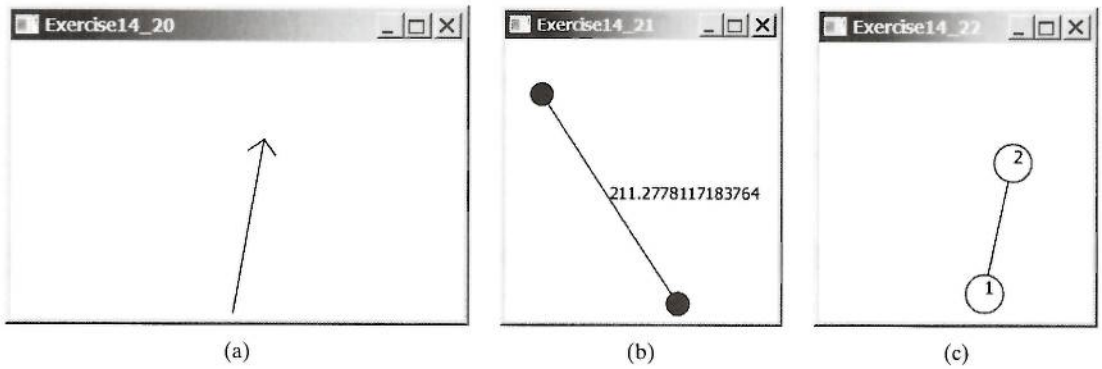
Hint: The Unicode for π is `\u03c0`. To display -2π, use `Text(x, y, "-2\u03c0")`. For a trigonometric function like `sin(x)`, `x` is in radians. Use the following loop to add the points to a polyline:

```
Polyline polyline = new Polyline();
ObservableList<Double> list = polyline.getPoints();
double scaleFactor = 50;
for (int x = -170; x <= 170; x++) {
  list.add(x + 200.0);
  list.add(100 - 50 * Math.sin((x / 100.0) * 2 * Math.PI));
}
```

**14.20 (*Draw an arrow line*) Write a static method that draws an arrow line from a starting point to an ending point in a pane using the following method header:

```
public static void drawArrowLine(double startX, double startY,
  double endX, double endY, Pane pane)
```

Write a test program that randomly draws an arrow line, as shown in Figure 14.49a.



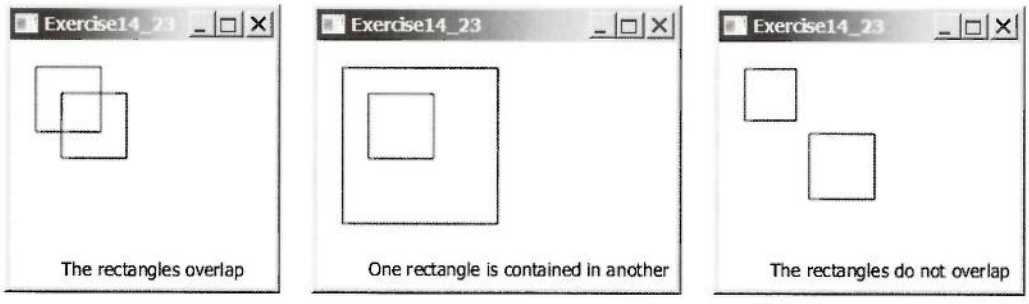
(a) (b) (c)

FIGURE 14.49 (a) The program displays an arrow line. (b) Exercise14.21 connects the centers of two filled circles. (c) Exercise14.22 connects two circles from their perimeter.

***14.21** (*Two circles and their distance*) Write a program that draws two filled circles with radius 15 pixels, centered at random locations, with a line connecting the two circles. The distance between the two centers is displayed on the line, as shown in Figure 14.49b.

***14.22** (*Connect two circles*) Write a program that draws two circles with radius 15 pixels, centered at random locations, with a line connecting the two circles. The line should not cross inside the circles, as shown in Figure 14.49c.

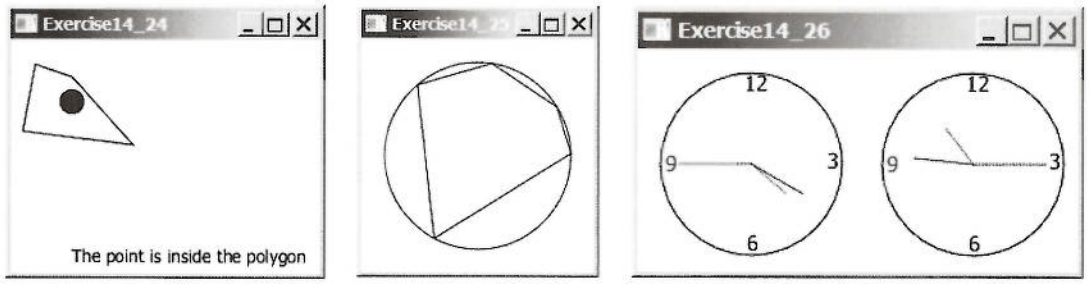
***14.23** (*Geometry: two rectangles*) Write a program that prompts the user to enter the center coordinates, width, and height of two rectangles from the command line. The program displays the rectangles and a text indicating whether the two are overlapping, whether one is contained in the other, or whether they don't overlap, as shown in Figure 14.50. See Programming Exercise 10.13 for checking the relationship between two rectangles.



(a) (b) (c)

FIGURE 14.50 Two rectangles are displayed.

***14.24** (*Geometry: Inside a polygon?*) Write a program that prompts the user to enter the coordinates of five points from the command line. The first four points form a polygon, and the program displays the polygon and a text that indicates whether the fifth point is inside the polygon, as shown in Figure 14.51a. Hint: Use the `Node`'s `contains` method to test whether a point is inside a node.



(a) (b) (c)

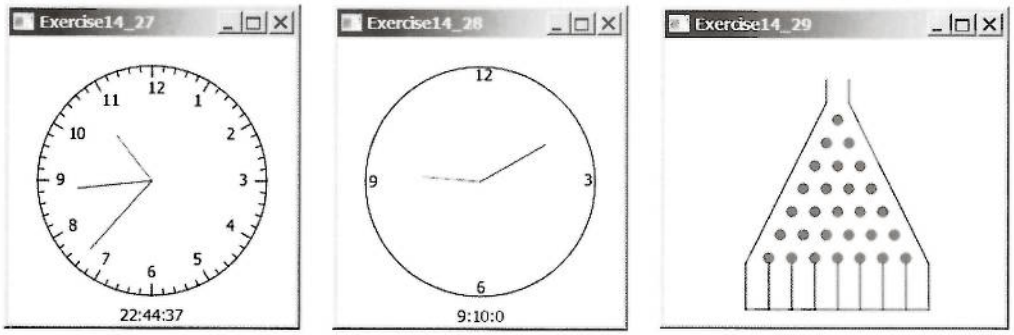
FIGURE 14.51 (a) The polygon and a point are displayed. (b) Exercise14.25 connects five random points on a circle. (c) Exercise 14.26 displays two clocks.

*14.25 (*Random points on a circle*) Modify Programming Exercise 4.6 to create five random points on a circle, form a polygon by connecting the points clockwise, and display the circle and the polygon, as shown in Figure 14.51b.

Section 14.12

14.26 (*Use the `ClockPane` class*) Write a program that displays two clocks. The hour, minute, and second values are `4`, `20`, `45` for the first clock and `22`, `46`, `15` for the second clock, as shown in Figure 14.51c.

*14.27 (*Draw a detailed clock*) Modify the `ClockPane` class in Section 14.12 to draw the clock with more details on the hours and minutes, as shown in Figure 14.52a.



(a) (b) (c)

FIGURE 14.52 (a) Exercise 14.27 displays a detailed clock. (b) Exercise 14.28 displays a clock with random hour and minute values. (c) Exercise 14.29 displays a bean machine.

*14.28 (*Random time*) Modify the `ClockPane` class with three new Boolean properties—`hourHandVisible`, `minuteHandVisible`, and `secondHandVisible`—and their associated accessor and mutator methods. You can use the `set` methods to make a hand visible or invisible. Write a test program that displays only the hour and minute hands. The hour and minute values are randomly generated. The hour is between `0` and `11`, and the minute is either `0` or `30`, as shown in Figure 14.52b.

**14.29 (*Game: bean machine*) Write a program that displays a bean machine introduced in Programming Exercise 7.21, as shown in Figure 14.52c.