Chapter 15 Event-Driven Programming

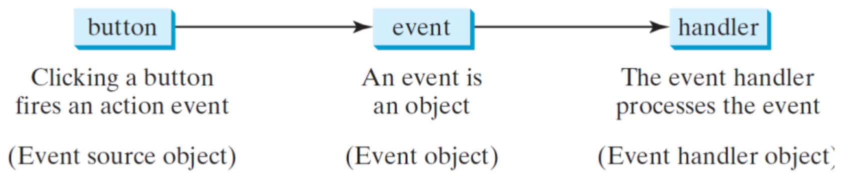
Procedural vs. Event-Driven Programming

- *Procedural programming* is executed in procedural order.
- In event-driven programming, code is executed upon activation of events.

Handling GUI Events

Source object (e.g., button)

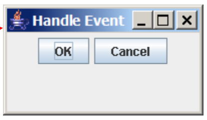
Listener object contains a method for processing the event.



Trace Execution

```
public class HandleEvent extends Application {
  public void start(Stage primaryStage) {
    …
    OKHandlerClass handler1 = new OKHandlerClass();
    btOK.setOnAction(handler1);
    CancelHandlerClass handler2 = new CancelHandlerClass();
    btCancel.setOnAction(handler2);
    …
    primaryStage.show(); // Display the stage
  }
}

class OKHandlerClass implements EventHandler<ActionEvent> {
  @Override
  public void handle(ActionEvent e) {
    System.out.println("OK button clicked");
  }
}
```

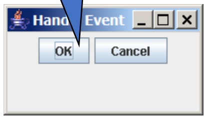
1. Start from the main method to create a window and display it



Trace Execution

```
public class HandleEvent extends Application {
  public void start(Stage primaryStage) {
    …
    OKHandlerClass handler1 = new OKHandlerClass();
    btOK.setOnAction(handler1);
    CancelHandlerClass handler2 = new CancelHandlerClass();
    btCancel.setOnAction(handler2);
    …
    primaryStage.show(); // Display the stage
  }
}

class OKHandlerClass implements EventHandler<ActionEvent> {
  @Override
  public void handle(ActionEvent e) {
    System.out.println("OK button clicked");
  }
}
```

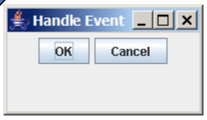
2. Click OK

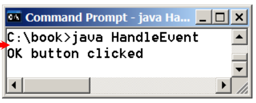


Trace Execution

```
public class HandleEvent extends Application {
  public void start(Stage primaryStage) {
    …
    OKHandlerClass handler1 = new OKHandlerClass();
    btOK.setOnAction(handler1);
    CancelHandlerClass handler2 = new CancelHandlerClass();
    btCancel.setOnAction(handler2);
    …
    primaryStage.show(); // Display the stage
  }
}

class OKHandlerClass implements EventHandler<ActionEvent> {
  @Override
  public void handle(ActionEvent e) {
    System.out.println("OK button clicked");
  }
}
```

3. The JVM invokes the listener's handle method

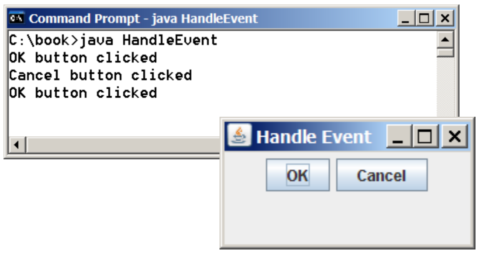




```
C:\book>java HandleEvent
OK button clicked
```

Taste of Event-Driven Programming

The example displays a button in the frame. A message is displayed on the console when a button is clicked.



```
C:\book>java HandleEvent
OK button clicked
Cancel button clicked
OK button clicked
```

HandleEvent Run

```
public class HandelEvnts extends Application implements EventHandler<ActionEvent> {
    Button btOK,btCancel ;
  @Override // Override the start method
  public void start(Stage primaryStage) {
    // Create a pane and set its properties
    HBox pane = new HBox(10);
    pane.setAlignment(Pos.CENTER);
    btOK = new Button("OK");
    btCancel = new Button("Cancel");

    btOK.setOnAction(this);

    btCancel.setOnAction(this);

    pane.getChildren().addAll(btOK, btCancel);

    // Create a scene and place it in the stage
    Scene scene = new Scene(pane);
    primaryStage.setTitle("HandleEvent"); // Set the stage title
    primaryStage.setScene(scene); // Place the scene in the stage
    primaryStage.show(); // Display the stage
  }
```

```
public static void main(String[] args) {
    launch(args);
  }
@Override
public void handle(ActionEvent event) {
  if(event.getSource()== btOK) {
       System.out.println("OK Button");}

     else if (event.getSource()== btCancel) {
         System.out.println("Cancle Button");

  }
          }
}
```

```
public class HandelEvnts extends Application {
  @Override // Override the start method in the Application class
  public void start(Stage primaryStage) {
    // Create a pane and set its properties
    HBox pane = new HBox(10);
    pane.setAlignment(Pos.CENTER);
    Button btOK = new Button("OK");
    Button btCancel = new Button("Cancel");

    btOK.setOnAction(new EventHandler<ActionEvent>() {
        @Override
     //Anonymous Inner Class
          public void handle(ActionEvent e) {
            System.out.println("Cancel button clicked");
          }

    });

    btCancel.setOnAction(new EventHandler<ActionEvent>() {
        @Override
          public void handle(ActionEvent e) {
            System.out.println("Cancel button clicked");}
    });
```

```
pane.getChildren().addAll(btOK, btCancel);

    // Create a scene and place it in the stage
    Scene scene = new Scene(pane);
    primaryStage.setTitle("HandleEvent"); // Set
the stage title
    primaryStage.setScene(scene); // Place the
scene in the stage
    primaryStage.show(); // Display the stage
  }

  public static void main(String[] args) {
    launch(args);
  }
}
```

```
public class HandleEvent extends Application {
  @Override // Override the start method in the Application class
  public void start(Stage primaryStage) {
    // Create a pane and set its properties
    HBox pane = new HBox(10);
    pane.setAlignment(Pos.CENTER);
    Button btOK = new Button("OK");
    Button btCancel = new Button("Cancel");
    OKHandlerClass handler1 = new OKHandlerClass();
    btOK.setOnAction(handler1);
    CancelHandlerClass handler2 = new CancelHandlerClass();
    btCancel.setOnAction(handler2);
    pane.getChildren().addAll(btOK, btCancel);

    // Create a scene and place it in the stage
    Scene scene = new Scene(pane);
    primaryStage.setTitle("HandleEvent"); // Set the stage title
    primaryStage.setScene(scene); // Place the scene in the stage
    primaryStage.show(); // Display the stage
  }

public static void main(String[] args) {
    launch(args);   }}
```

```
class OKHandlerClass implements
EventHandler<ActionEvent> {
  @Override
  public void handle(ActionEvent e) {
    System.out.println("OK button clicked");
  }
}

class CancelHandlerClass implements
EventHandler<ActionEvent> {
  @Override
  public void handle(ActionEvent e) {
    System.out.println("Cancel button
clicked");
  }
}
```

```
public class HandelEvnts extends Application {
   Button btOK,btCancel ;
  @Override // Override the start method in the Application class
  public void start(Stage primaryStage) {
    // Create a pane and set its properties
    HBox pane = new HBox(10);
    pane.setAlignment(Pos.CENTER);
    btOK = new Button("OK");
    btCancel = new Button("Cancel");

    btOK.setOnAction(e->{System.out.println("OK Button");});

    btCancel.setOnAction(e->{System.out.println("Cancle Button");});

    pane.getChildren().addAll(btOK, btCancel);

    // Create a scene and place it in the stage
    Scene scene = new Scene(pane);
    primaryStage.setTitle("HandleEvent"); // Set the stage title
    primaryStage.setScene(scene); // Place the scene in the stage
    primaryStage.show(); // Display the stage
  }
   public static void main(String[] args) {launch(args);  } }
```

Event Information

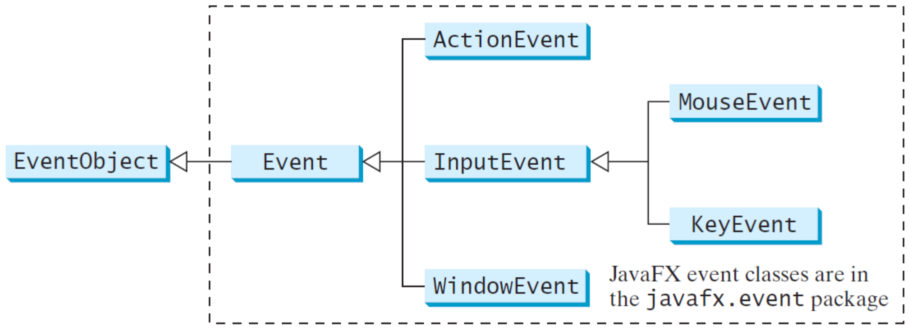
An event object contains whatever properties are pertinent to the event.

You can identify the source object of the event using the getSource() instance method in the EventObject class.

The subclasses of EventObject deal with special types of events, such as button actions, window events, mouse movements, and keystrokes.

Table 15.1 lists external user actions, source objects, and event types generated.

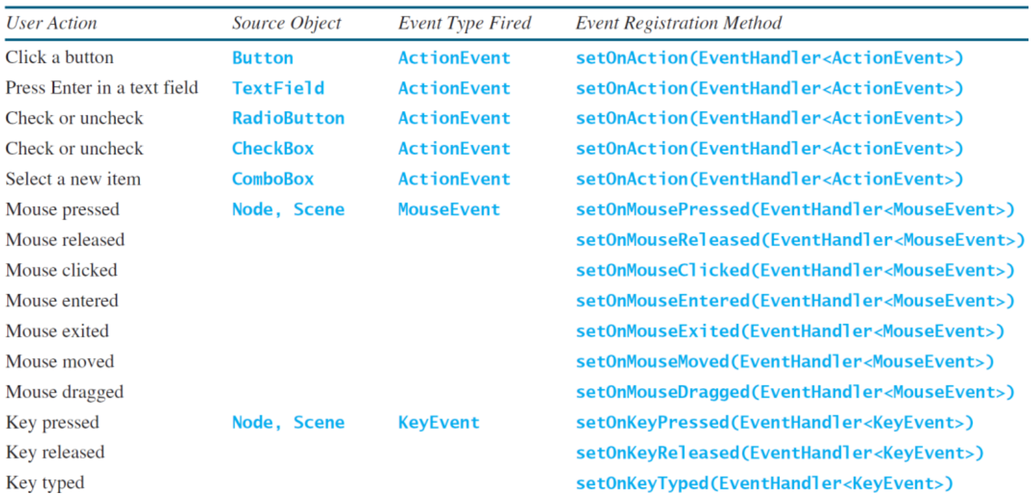
Event Classes



Events

- ❑An *event* can be defined as a type of signal to the program that something has happened.
- ❑The event is generated by external user actions such as mouse movements, mouse clicks, or keystrokes.

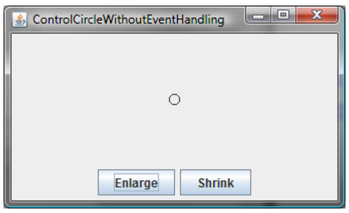
Selected User Actions and Handlers



User Action	*Source Object*	*Event Type Fired*	*Event Registration Method*
Click a button	`Button`	`ActionEvent`	`setOnAction(EventHandler<ActionEvent>)`
Press Enter in a text field	`TextField`	`ActionEvent`	`setOnAction(EventHandler<ActionEvent>)`
Check or uncheck	`RadioButton`	`ActionEvent`	`setOnAction(EventHandler<ActionEvent>)`
Check or uncheck	`CheckBox`	`ActionEvent`	`setOnAction(EventHandler<ActionEvent>)`
Select a new item	`ComboBox`	`ActionEvent`	`setOnAction(EventHandler<ActionEvent>)`
Mouse pressed	`Node, Scene`	`MouseEvent`	`setOnMousePressed(EventHandler<MouseEvent>)`
Mouse released			`setOnMouseReleased(EventHandler<MouseEvent>)`
Mouse clicked			`setOnMouseClicked(EventHandler<MouseEvent>)`
Mouse entered			`setOnMouseEntered(EventHandler<MouseEvent>)`
Mouse exited			`setOnMouseExited(EventHandler<MouseEvent>)`
Mouse moved			`setOnMouseMoved(EventHandler<MouseEvent>)`
Mouse dragged			`setOnMouseDragged(EventHandler<MouseEvent>)`
Key pressed	`Node, Scene`	`KeyEvent`	`setOnKeyPressed(EventHandler<KeyEvent>)`
Key released			`setOnKeyReleased(EventHandler<KeyEvent>)`
Key typed			`setOnKeyTyped(EventHandler<KeyEvent>)`

Example: First Version for ControlCircle (no listeners)

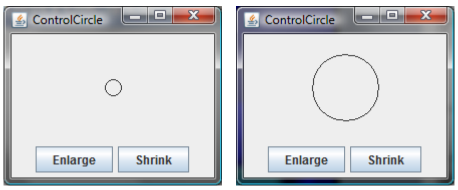
Now let us consider to write a program that uses two buttons to control the size of a circle.



ControlCircleWithoutEventHandling Run

Example: Second Version for ControlCircle (with listener for Enlarge)

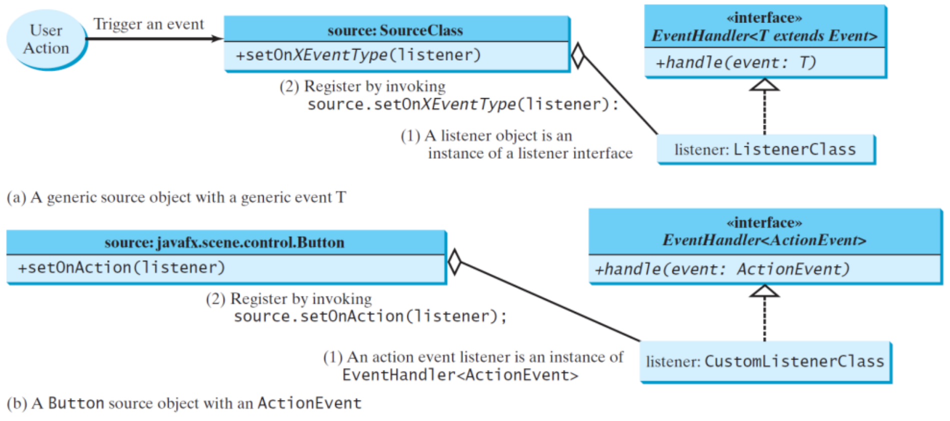
Now let us consider to write a program that uses two buttons to control the size of a circle.



```
public void enlarge()
{ circle.setRadius(circle.getRadius() + 2);
}
public void shrink()
 { circle.setRadius(circle.getRadius() > 2 ? circle.getRadius() - 2 : circle.getRadius()); }
```

ControlCircle Run

The Delegation Model


User Action
Trigger an event
source: SourceClass
+setOnXEventType(listener)
«interface»
EventHandler<T extends Event>
+handle(event: T)
(2) Register by invoking
source.setOnXEventType(listener);
(1) A listener object is an instance of a listener interface
listener: ListenerClass
(a) A generic source object with a generic event T
source: javafx.scene.control.Button
+setOnAction(listener)
«interface»
EventHandler<ActionEvent>
+handle(event: ActionEvent)
(2) Register by invoking
source.setOnAction(listener);
(1) An action event listener is an instance of
EventHandler<ActionEvent>
listener: CustomListenerClass
(b) A Button source object with an ActionEvent

Inner Class Listeners

A listener class is designed specifically to create a listener object for a GUI component (e.g., a button).

It will **not be shared by other applications**. So, it is appropriate to define the listener class inside the frame class **as an inner class.**

Inner Classes

Inner class: A class is a member of another class.

Advantages: In some applications, you can use an inner class to make programs simple.

An inner class can reference the data and methods defined in the outer class in which it nests, so you do not need to pass the reference of the outer class to the constructor of the inner class.

ShowInnerClass

Inner Classes, cont.

```java
public class Test {
  ...
}

public class A {
  ...
}
```

(a)

```java
public class Test {
  ...

  // Inner class
  public class A {
    ...
  }
}
```

(b)

```java
// OuterClass.java: inner class demo
public class OuterClass {
  private int data;

  /** A method in the outer class */
  public void m() {
    // Do something
  }

  // An inner class
  class InnerClass {
    /** A method in the inner class */
    public void mi() {
      // Directly reference data and method
      // defined in its outer class
      data++;
      m();
    }
  }
}
```

(c)

Inner Classes (cont.)

Inner classes can make programs **simple and concise**.

An inner class supports the work of its containing outer class and is compiled into a class named *OuterClassName$InnerClassName*.class. For example, the inner class InnerClass in OuterClass is compiled into *OuterClass$InnerClass*.class **.**

Inner Classes (cont.)

- An inner class can be declared public, protected, or private subject to the same visibility rules applied to a member of the class.
- An inner class can be declared static. A static inner class can be accessed using the outer class name. A static inner class cannot access nonstatic members of the outer class

Anonymous Inner Classes

- ❑An anonymous inner class must always extend a superclass or implement an interface, but it cannot have an explicit extends or implements clause.
- ❑An anonymous inner class must implement all the abstract methods in the superclass or in the interface.
- ❑An anonymous inner class always uses the no-arg constructor from its superclass to create an instance. If an anonymous inner class implements an interface, the constructor is Object().
- ❑An anonymous inner class is compiled into a class named OuterClassName$*n*.class. For example, if the outer class Test has two anonymous inner classes, these two classes are compiled into Test$1.class and Test$2.class.

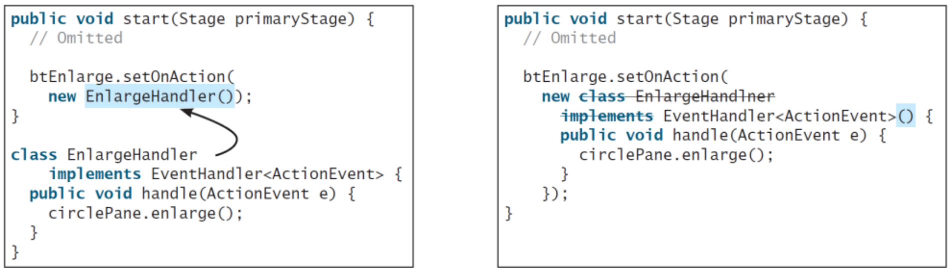
Anonymous Inner Classes (cont.)

Inner class listeners can be shortened using anonymous inner classes.
An *anonymous inner class* is an inner class without a name.

It combines declaring an inner class and creating an instance of the class in one step. An anonymous inner class is declared as follows:

```
new SuperClassName/InterfaceName() {
  // Implement or override methods in superclass or interface
  // Other methods if necessary
}
```

Anonymous Inner Classes (cont.)

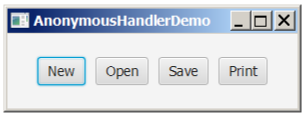


```
public void start(Stage primaryStage) {
  // Omitted

  btEnlarge.setOnAction(
    new EnlargeHandler());
}

class EnlargeHandler
    implements EventHandler<ActionEvent> {
  public void handle(ActionEvent e) {
    circlePane.enlarge();
  }
}
```

(a) Inner class EnlargeListener

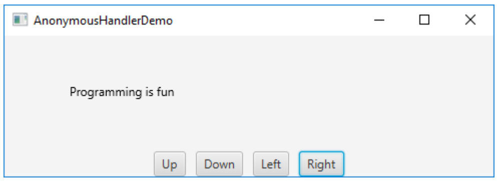
```
public void start(Stage primaryStage) {
  // Omitted

  btEnlarge.setOnAction(
    new ~~class EnlargeHandlner~~
      ~~implements~~ EventHandler<ActionEvent>() {
      public void handle(ActionEvent e) {
        circlePane.enlarge();
      }
    });
}
```

(b) Anonymous inner class



AnonymousHandlerDemo Run

```
public class AnonymousHandlerDemo extends Application {
  @Override // Override the start method in the Application class
  public void start(Stage primaryStage) {
    Text text = new Text(40, 40, "Programming is fun");
    Pane pane = new Pane(text);

    // Hold four buttons in an HBox
    Button btUp = new Button("Up");
    Button btDown = new Button("Down");
    Button btLeft = new Button("Left");
    Button btRight = new Button("Right");
    HBox hBox = new HBox(btUp, btDown, btLeft, btRight);
    hBox.setSpacing(10);
    hBox.setAlignment(Pos.CENTER);

    BorderPane borderPane = new BorderPane(pane);
    borderPane.setBottom(hBox);

    // Create and register the handler
    btUp.setOnAction(new EventHandler<ActionEvent>() {
      @Override // Override the handle method
      public void handle(ActionEvent e) {
        text.setY(text.getY() > 10 ? text.getY() - 5 : 10); } });
```



```
btDown.setOnAction(new EventHandler<ActionEvent>() {
  @Override // Override the handle method
  public void handle(ActionEvent e) {
    text.setY(text.getY() < pane.getHeight() ?
      text.getY() + 5 : pane.getHeight());
  }
});

btLeft.setOnAction(new EventHandler<ActionEvent>() {
  @Override // Override the handle method
  public void handle(ActionEvent e) {
    text.setX(text.getX() > 0 ? text.getX() - 5 : 0);
  }
});

btRight.setOnAction(new EventHandler<ActionEvent>() {
  @Override // Override the handle method
  public void handle(ActionEvent e) {
    text.setX(text.getX() < pane.getWidth() - 100?
      text.getX() + 5 : pane.getWidth() - 100);
  }
});
```

Simplifying Event Handing Using Lambda Expressions

Lambda expression is a new feature in Java 8. Lambda expressions can be viewed as an anonymous method with a concise syntax. For example, the following code in (a) can be greatly simplified using a lambda expression in (b) in three lines.

```
btEnlarge.setOnAction(
  new EventHandler<ActionEvent>() {
    @Override
    public void handle(ActionEvent e) {
      // Code for processing event e
    }
  }
});
```

(a) Anonymous inner class event handler

```
btEnlarge.setOnAction(e -> {
  // Code for processing event e
});
```

(b) Lambda expression event handler

Basic Syntax for a Lambda Expression

The basic syntax for a lambda expression is either

(type1 param1, type2 param2, ...) -> expression

or

(type1 param1, type2 param2, ...) -> { statements; }

The data type for a parameter may be explicitly declared or implicitly inferred by the compiler. The parentheses can be omitted if there is only one parameter without an explicit data type.

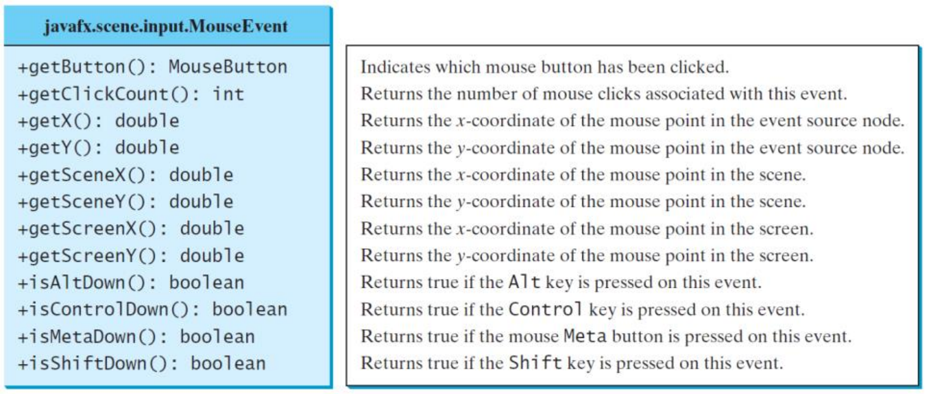
```
(p1, p2) -> System.out.println("Multiple parameters: " + p1 + ", " + p2);

(Car car) -> System.out.println("The car is: " + car.getName());
```

Single Abstract Method Interface (SAM)

The statements in the lambda expression is all for that method. If it contains multiple methods, the compiler will not be able to compile the lambda expression. So, for the compiler to understand lambda expressions, the interface must contain **exactly one abstract method**. Such an interface is known as a *functional interface*, or a *Single Abstract Method* (SAM) interface.

AnonymousHandlerDemo Run

The `MouseEvent` Class



javafx.scene.input.MouseEvent	
`+getButton(): MouseButton`	Indicates which mouse button has been clicked.
`+getClickCount(): int`	Returns the number of mouse clicks associated with this event.
`+getX(): double`	Returns the *x*-coordinate of the mouse point in the event source node.
`+getY(): double`	Returns the *y*-coordinate of the mouse point in the event source node.
`+getSceneX(): double`	Returns the *x*-coordinate of the mouse point in the scene.
`+getSceneY(): double`	Returns the *y*-coordinate of the mouse point in the scene.
`+getScreenX(): double`	Returns the *x*-coordinate of the mouse point in the screen.
`+getScreenY(): double`	Returns the *y*-coordinate of the mouse point in the screen.
`+isAltDown(): boolean`	Returns true if the `Alt` key is pressed on this event.
`+isControlDown(): boolean`	Returns true if the `Control` key is pressed on this event.
`+isMetaDown(): boolean`	Returns true if the mouse `Meta` button is pressed on this event.
`+isShiftDown(): boolean`	Returns true if the `Shift` key is pressed on this event.

MouseEventDemo Run

The `KeyEvent` Class

javafx.scene.input.KeyEvent	
`+getCharacter(): String`	Returns the character associated with the key in this event.
`+getCode(): KeyCode`	Returns the key code associated with the key in this event.
`+getText(): String`	Returns a string describing the key code.
`+isAltDown(): boolean`	Returns true if the `Alt` key is pressed on this event.
`+isControlDown(): boolean`	Returns true if the `Control` key is pressed on this event.
`+isMetaDown(): boolean`	Returns true if the mouse `Meta` button is pressed on this event.
`+isShiftDown(): boolean`	Returns true if the `Shift` key is pressed on this event.

KeyEventDemo Run

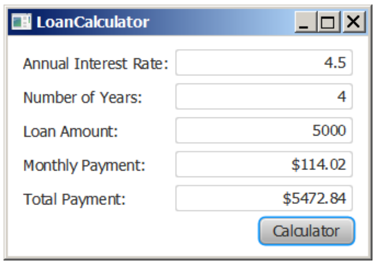
The `KeyCode` Constants

Constant	*Description*	*Constant*	*Description*
`HOME`	The Home key	`CONTROL`	The Control key
`END`	The End key	`SHIFT`	The Shift key
`PAGE_UP`	The Page Up key	`BACK_SPACE`	The Backspace key
`PAGE_DOWN`	The Page Down key	`CAPS`	The Caps Lock key
`UP`	The up-arrow key	`NUM_LOCK`	The Num Lock key
`DOWN`	The down-arrow key	`ENTER`	The Enter key
`LEFT`	The left-arrow key	`UNDEFINED`	The `keyCode` unknown
`RIGHT`	The right-arrow key	`F1` to `F12`	The function keys from F1 to F12
`ESCAPE`	The Esc key	`0` to `9`	The number keys from 0 to 9
`TAB`	The Tab key	`A` to `Z`	The letter keys from A to Z

Problem: Loan Calculator

LoanCalculator Run

```
public class LoanCalculator extends Application {
  private TextField tfAnnualInterestRate = new TextField();
  private TextField tfNumberOfYears = new TextField();
  private TextField tfLoanAmount = new TextField();
  private TextField tfMonthlyPayment = new TextField();
  private TextField tfTotalPayment = new TextField();
  private Button btCalculate = new Button("Calculate");

  @Override // Override the start method in the Application class
  public void start(Stage primaryStage) {
    // Create UI
    GridPane gridPane = new GridPane();
    gridPane.setHgap(5);
    gridPane.setVgap(5);
    gridPane.add(new Label("Annual Interest Rate:"), 0, 0);
    gridPane.add(tfAnnualInterestRate, 1, 0);
    gridPane.add(new Label("Number of Years:"), 0, 1);
    gridPane.add(tfNumberOfYears, 1, 1);
    gridPane.add(new Label("Loan Amount:"), 0, 2);
    gridPane.add(tfLoanAmount, 1, 2);
    gridPane.add(new Label("Monthly Payment:"), 0, 3);
    gridPane.add(tfMonthlyPayment, 1, 3);
    gridPane.add(new Label("Total Payment:"), 0, 4);
    gridPane.add(tfTotalPayment, 1, 4);
    gridPane.add(btCalculate, 1, 5);
```

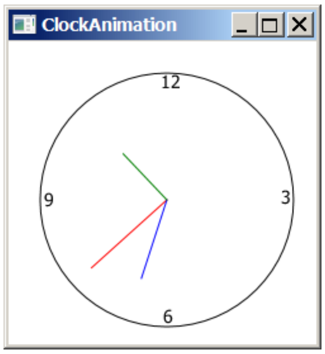


Annual Interest Rate: 4.5
Number of Years: 4
Loan Amount: 5000
Monthly Payment: $114.02
Total Payment: $5472.84

```
        // Set properties for UI
            gridPane.setAlignment(Pos.CENTER);
            tfAnnualInterestRate.setAlignment(Pos.BOTTOM_RIGHT);
            tfNumberOfYears.setAlignment(Pos.BOTTOM_RIGHT);
            tfLoanAmount.setAlignment(Pos.BOTTOM_RIGHT);
            tfMonthlyPayment.setAlignment(Pos.BOTTOM_RIGHT);
            tfTotalPayment.setAlignment(Pos.BOTTOM_RIGHT);
            tfMonthlyPayment.setEditable(false);
            tfTotalPayment.setEditable(false);
            GridPane.setHalignment(btCalculate, HPos.RIGHT);

            // Process events
            btCalculate.setOnAction(e -> calculateLoanPayment());

            // Create a scene and place it in the stage
            Scene scene = new Scene(gridPane, 400, 250);
            primaryStage.setTitle("LoanCalculator"); // Set title
            primaryStage.setScene(scene); // Place the scene in the stage
            primaryStage.show(); // Display the stage
          }
```

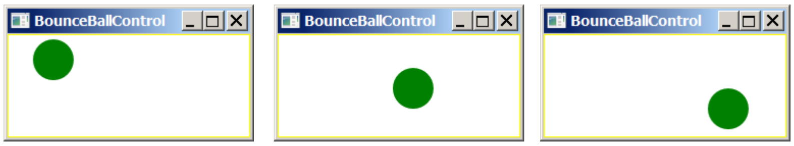
```
  private void calculateLoanPayment() {
      // Get values from text fields
      double interest =
        Double.parseDouble(tfAnnualInterestRate.getText());
      int year = Integer.parseInt(tfNumberOfYears.getText());
      double loanAmount = Double.parseDouble(tfLoanAmount.getText());

      // Create a loan object. Loan defined in Listing 10.2
      Loan loan = new Loan(interest, year, loanAmount);

      // Display monthly payment and total payment
      tfMonthlyPayment.setText(String.format("$%.2f",
        loan.getMonthlyPayment()));
      tfTotalPayment.setText(String.format("$%.2f",
        loan.getTotalPayment()));
    }

    /**
     * The main method is only needed for the IDE with limited
     * JavaFX support. Not needed for running from the command line.
     */
    public static void main(String[] args) {
      launch(args);
    }
  }
```

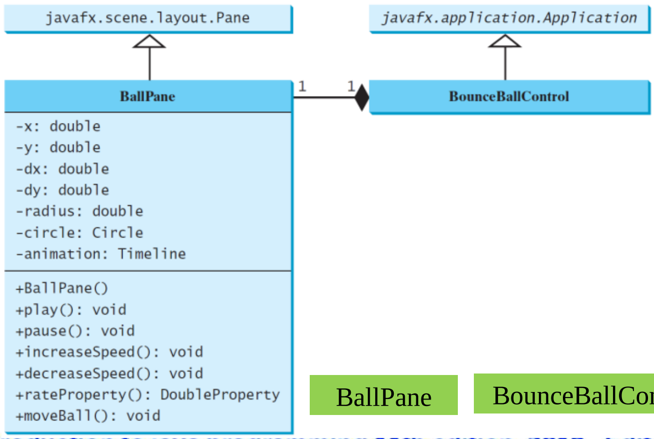
Clock Animation



ClockAnimation Run

Case Study: Bouncing Ball





```
BallPane
-x: double
-y: double
-dx: double
-dy: double
-radius: double
-circle: Circle
-animation: Timeline
+BallPane()
+play(): void
+pause(): void
+increaseSpeed(): void
+decreaseSpeed(): void
+rateProperty(): DoubleProperty
+moveBall(): void
```

BallPane BounceBallControl Run

Show Coc