CHAPTER

1

Getting to know Greenfoot

topics: the Greenfoot interface, interacting with objects, invoking methods, running a scenario

concepts: object, class, method call, parameter, return value

This book will show you how to develop computer games and simulations with Greenfoot, a development environment. In this chapter, we shall take a look at Greenfoot itself, see what it can do and how to use it. We do this by trying out some existing programs.

Once we are comfortable with using Greenfoot, we shall jump right into writing a game ourselves.

The best way to read this chapter (and indeed the whole book) is by sitting at your computer with Greenfoot open on your screen and the book open on your desk. We will regularly ask you to do things in Greenfoot while you read. Some of the tasks you can skip; however, you will have to do some in order to progress in the chapter. In any case, you will learn most if you follow along and do them.

At this stage, we assume that you have already installed the Greenfoot software and the book scenarios (described in Appendix A). If not, read through that appendix first.

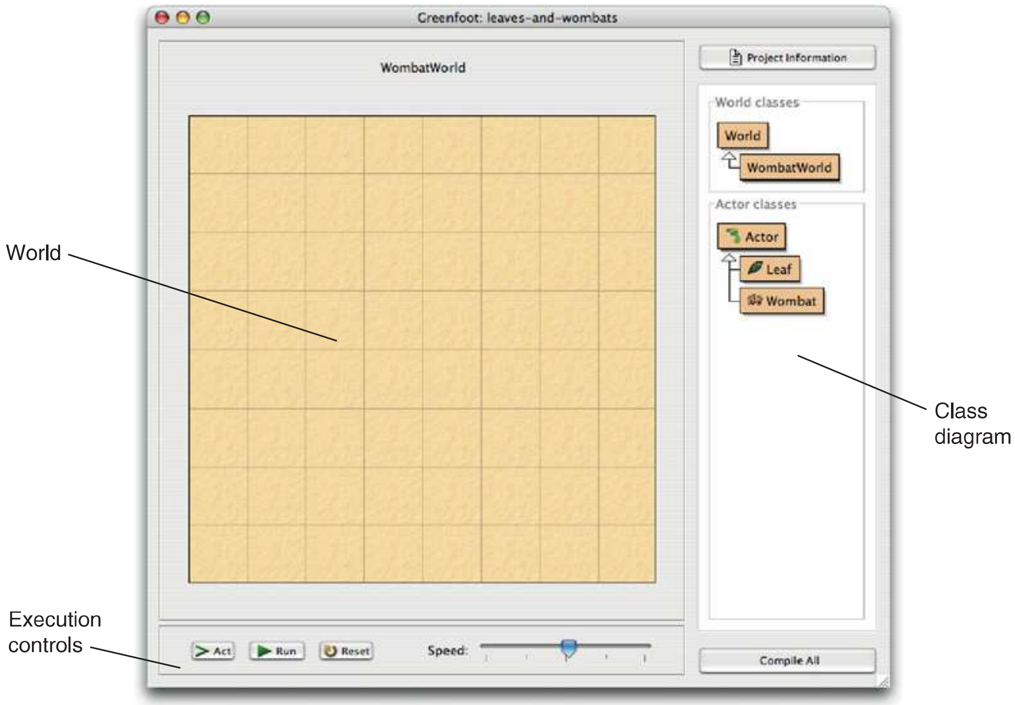
1.1 Getting started

Start Greenfoot and open the scenario *leaves-and-wombats* from the *Greenfoot book scenarios* folder.

Note If you are starting Greenfoot for the first time, you will see a dialog asking what you want to do. Click *Choose a scenario*. Otherwise, use *Scenario–Open*[1] from the menu.

[1] We use this notation to tell you to select functions from the menu. *Scenario–Open* refers to the *Open* item in the *Scenario* menu.

Figure 1.1
The Greenfoot main window



Make sure to open the *leaves-and-wombats* scenario that you find in the *book-scenarios* folder, not the somewhat similar *wombats* scenario from the standard Greenfoot installation.

You will now see the Greenfoot main window, with the scenario open, looking similar to Figure 1.1.

The main window consists of three main areas and a couple of extra buttons. The main areas are:

- The *world*. The largest area covering most of the screen (a sand-colored grid in this case) is called the world. This is where the program will run and we will see things happen.
- The *class diagram*. The area on the right with the beige-colored boxes and arrows is the class diagram. We shall discuss this in more detail shortly.
- The *execution controls*. The *Act*, *Run*, and *Reset* buttons and the speed slider at the bottom are the execution controls. We'll come back to them in a little while, too.

1.2 Objects and classes

We shall discuss the class diagram first. The class diagram shows us the classes involved in this scenario. In this case, they are `World`, `WombatWorld`, `Actor`, `Leaf`, and `Wombat`.

We shall be using the Java programming language for our projects. Java is an *object-oriented* language. The concepts of classes and objects are fundamental in object orientation.

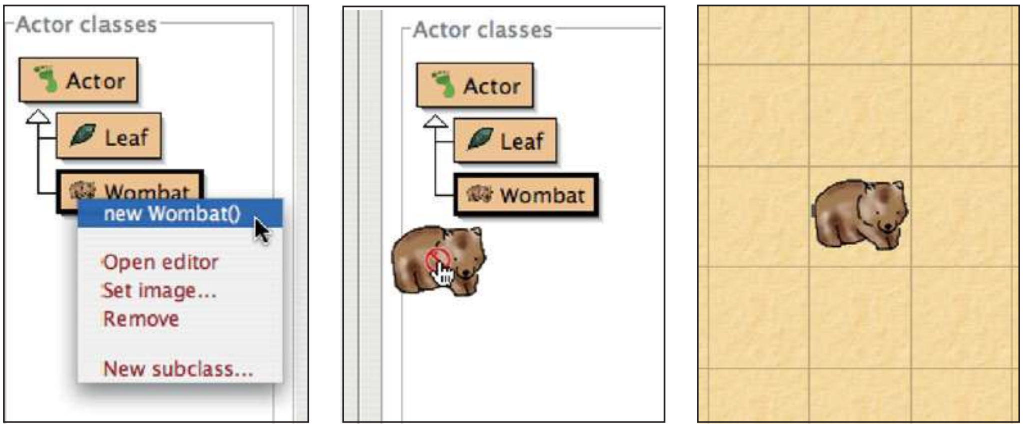
Let us start by looking at the `Wombat` class. The class `Wombat` stands for the general concept of a wombat—it describes all wombats. Once we have a class in Greenfoot, we can create *objects* from it. (Objects are also often referred to as *instances* in programming—the two terms are synonyms.)

A wombat, by the way, is an Australian marsupial (Figure 1.2). If you want to find out more about them, do a Web search—it should give you plenty of results.

Right-click[2] on the `Wombat` class, and you will see the *class menu* pop up (Figure 1.3a). The first option in that menu, `new Wombat()`, lets us create new wombat objects. Try it out.

You will see that this gives you a small picture of a `Wombat` object, which you can move on screen with your mouse (Figure 1.3b). Place the *wombat* into the world by clicking anywhere in the world (Figure 1.3c).

Figure 1.2
A wombat in Narawntapu National Park, Tasmania[3]



a) b) c)

Figure 1.3
a) The class menu.
b) Dragging a new object.
c) Placing the object

[2] On Mac OS, use ctrl-click instead of right-click if you have a one-button mouse.
[3] Image source: Wikipedia, subject to GNU Free Documentation License.

Concept:

Many **objects** can be created from a **class**.

Once you have a class in Greenfoot, you can create as many objects from it as you like.

Exercise 1.1 Create some more wombats in the world. Create some leaves.

Currently, only the `Wombat` and `Leaf` classes are of interest to us. We shall discuss the other classes later.

1.3 Interacting with objects

Concept:

Objects have **methods**. Invoking these performs an action.

Once we have placed some objects into the world, we can interact with these objects by right-clicking them. This will pop up the *object menu* (Figure 1.4). The object menu shows us all the operations this specific object can perform. For example, a `wombat's` object menu shows us what this wombat can do (plus two additional functions, *Inspect* and *Remove*, which we shall discuss later).

In Java, these operations are called *methods*. It cannot hurt to get used to standard terminology straightaway, so we shall also call them methods from now on. We can *invoke* a method by selecting it from the menu.

Exercise 1.2 Invoke the `move()` method on a wombat. What does it do? Try it several times. Invoke the `turnLeft()` method. Place two wombats into your world and make them face each other.

Figure 1.4 The wombat's *object menu*

In short, we can start to make things happen by creating objects from one of the classes provided, and we can give commands to the objects by invoking their methods.

Let us have a closer look at the object menu. The `move` and `turnLeft` methods are listed as:

```
void move()
void turnLeft()
```

We can see that the method names are not the only things shown. There is also the word `void` at the beginning and a pair of parentheses at the end. These two cryptic bits of information tell us what data goes into the method call and what data comes back from it.

1.4 Return types

Concept:

The **return type** of a method specifies what a method call will return.

Concept:

A method with a **void** return type does not return a value.

The word at the beginning is called the *return type*. It tells us what the method returns to us when we invoke it. The word `void` means "nothing" in this context: Methods with a `void` return type do not return any information. They just carry out their action, and then stop.

Any word other than `void` tells us that the method returns some information when invoked, and of what type that information is. In the wombat's menu (Figure 1.4) we can also see the words `int` and `boolean`. The word `int` is short for "integer" and refers to whole numbers (numbers without a decimal point). Examples of integer numbers are 3, 42, −3, and 12000000.

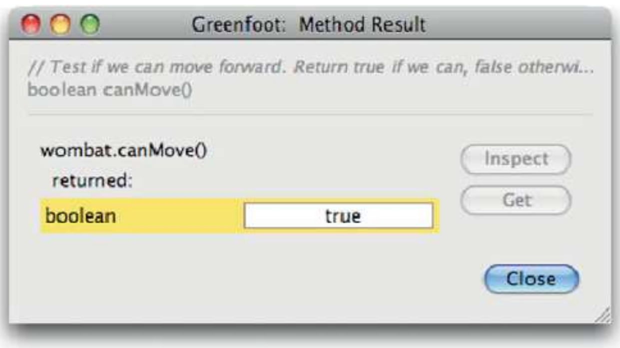
The type `boolean` has only two possible values: `true` and `false`. A method that returns a `boolean` will return either the value `true` or the value `false` to us.

Methods with `void` return types are like commands for our wombat. If we invoke the `turnLeft` method, the wombat obeys and turns left. Methods with non-void return types are like questions. Consider the `canMove` method:

```
boolean canMove()
```

When we invoke this method, we see a result similar to that shown in Figure 1.5, displayed in a dialog box. The important information here is the word `true`, which was returned by this

Figure 1.5
A method result



method call. In effect, we have just asked the wombat "Can you move?" and the wombat has answered "Yes!" (`true`).

> **Exercise 1.3** Invoke the `canMove()` method on your wombat. Does it always return *true*? Or can you find situations in which it returns *false*?

Try out another method with a return value:

```
int getLeavesEaten()
```

Using this method, we can get the information how many leaves this wombat has eaten.

> **Exercise 1.4** Using a newly created wombat, the `getLeavesEaten()` method will always return zero. Can you create a situation in which the result of this method is not zero? (In other words: can you make your wombat eat some leaves?)

Concept:

Methods with void return types represent **commands**; methods with non-void return types represent **questions**.

Methods with non-void return types usually just tell us something about the object (*Can it move? How many leaves has it eaten?*), but do not change the object. The wombat is just as it was before we asked it about the leaves. Methods with `void` return types are usually commands to the objects that make it do something.

1.5 Parameters

Concept:

A **parameter** is a mechanism to pass in additional data to a method.

The other bit in the *method* menu that we have not yet discussed are the parentheses after the method name.

```
int getLeavesEaten()
void setDirection(int direction)
```

The parentheses after the method name hold the *parameter list*. This tells us whether the method requires any additional information to run, and if so, what kind of information.

If we see only a pair of parentheses without anything else within it (as we have in all methods so far), then the method has an *empty parameter list*. In other words, it expects no parameters—when we invoke the method it will just run. If there is anything within the parenthesis, then the method expects one or more parameters—additional information that we need to provide.

Concept:

Parameters and return values have **types**. Examples of types are int for numbers, and boolean for true/false values.

Let us try out the `setDirection` method. We can see that it has the words `int direction` written in its parameter list. When we invoke it, we see a dialog box similar to the one shown in Figure 1.6.

The words `int direction` tell us that this method expects one parameter of type `int`, which specifies a *direction*. A parameter is an additional bit of data we must provide for this method to run. Every parameter is defined by two words: first the parameter type (here: `int`) and then a name, which gives us a hint what this parameter is used for. If a method has a parameter, then we need to provide this additional information when we invoke the method.

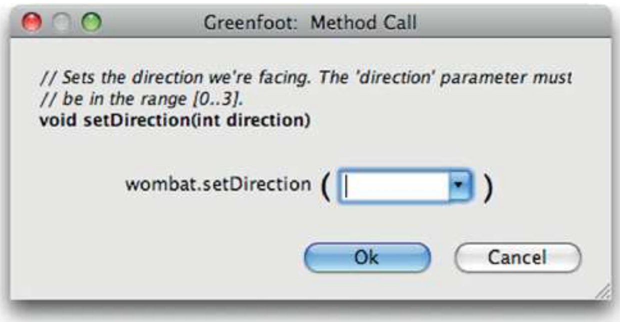


Figure 1.6
A method call dialog

In this case, the type `int` tells us that we now should provide a whole number, and the name suggests that this number somehow specifies the direction to turn to.

At the top of the dialog is a comment that tells us a little more: the `direction` parameter should be between 0 and 3.

> **Exercise 1.5** Invoke the `setDirection(int direction)` method. Provide a parameter value and see what happens. Which number corresponds to which direction? Write them down. What happens when you type in a number greater than 3? What happens if you provide input that is not a whole number, such as a decimal number (2.5) or a word (three)?

The `setDirection` method expects only a single parameter. Later, we shall see cases where methods expect more than one parameter. In that case, the method will list all the parameters it expects within the parentheses.

Concept:

The specification of a method, which shows its return type, name, and parameters is called its **signature**.

The description of each method shown in the object menu, including the return type, method name, and parameter list, is called the *method signature*.

We have now reached a point where you can do the main interactions with Greenfoot objects. You can create objects from classes, interpret the method signatures, and invoke methods (with and without parameters).

1.6 Greenfoot execution

There is one other way of interacting with Greenfoot objects: the execution controls.

Tip:

You can place objects into the world more quickly by selecting a class in the class diagram, and then shift-clicking in the world.

> **Exercise 1.6** Place a wombat and a good number of leaves into the world, and then invoke a wombat's `act()` method several times. What does this method do? How does it differ from the `move` method? Make sure to try different situations, for example, the wombat facing the edge of the world, or sitting on a leaf.
>
> **Exercise 1.7** Still with a wombat and some leaves in the world, click the *Act* button in the execution controls near the bottom of the Greenfoot window. What does this do?

Exercise 1.8 What is the difference between clicking the *Act* button and invoking the `act()` method? (Try with several wombats in the world.)

Exercise 1.9 Click the *Run* button. What does it do?

The `act` method is a very fundamental method of Greenfoot objects. We shall encounter it regularly in all the following chapters. All objects in a Greenfoot world have this `act` method. Invoking `act` is essentially giving the object the instruction "Do whatever you want to do now". If you tried it out for our wombat, you will have seen that the wombat's `act` does something like the following:

- If we're sitting on a leaf, eat the leaf.
- Otherwise, if we can move forward, move forward.
- Otherwise, turn left.

Concept:

Objects that can be placed into the world are known as **actors**.

The experiments in the exercises above should also have shown you that the *Act* button in the execution controls simply calls the `act` method of the actors in the world. The only difference to invoking the method via the object menu is that the *Act* button invokes the `act` method of all objects in the world, whereas using the object menu affects only the one chosen object.

The *Run* button just calls `act` over and over again for all objects, until you click *Pause*.

Let us try out what we have discussed in the context of another scenario.

1.7 A second example

Open another scenario, named *asteroids1*, from the *chapter01* folder of the book scenarios. It should look similar to Figure 1.7 (except that you will not see the rocket or the asteroids on your screen yet).

1.8 Understanding the class diagram

Let us first have a closer look at the class diagram (Figure 1.8). At the top, you see the two classes called `World` and `Space`, connected by an arrow.

Concept:

A **subclass** is a class that represents a specialization of another. In Greenfoot, this is shown with an arrow in the class diagram.

The `World` class is always there in all Greenfoot scenarios—it is built into Greenfoot. The class under it, `Space` in this case, represents the specific world for this particular scenario. Its name can be different in each scenario, but every scenario will have a specific world here.

The arrow shows an *is-a* relationship: `Space` *is a* `World` (in the sense of Greenfoot worlds: `Space`, here, is a specific Greenfoot world). We also sometimes say that `Space` is a *subclass* of `World`.

We do not usually need to create objects of world classes—Greenfoot does that for us. When we open a scenario, Greenfoot automatically creates an object of the world subclass. The object is then shown on the main part of the screen. (The big black image of space is an object of the `Space` class.)

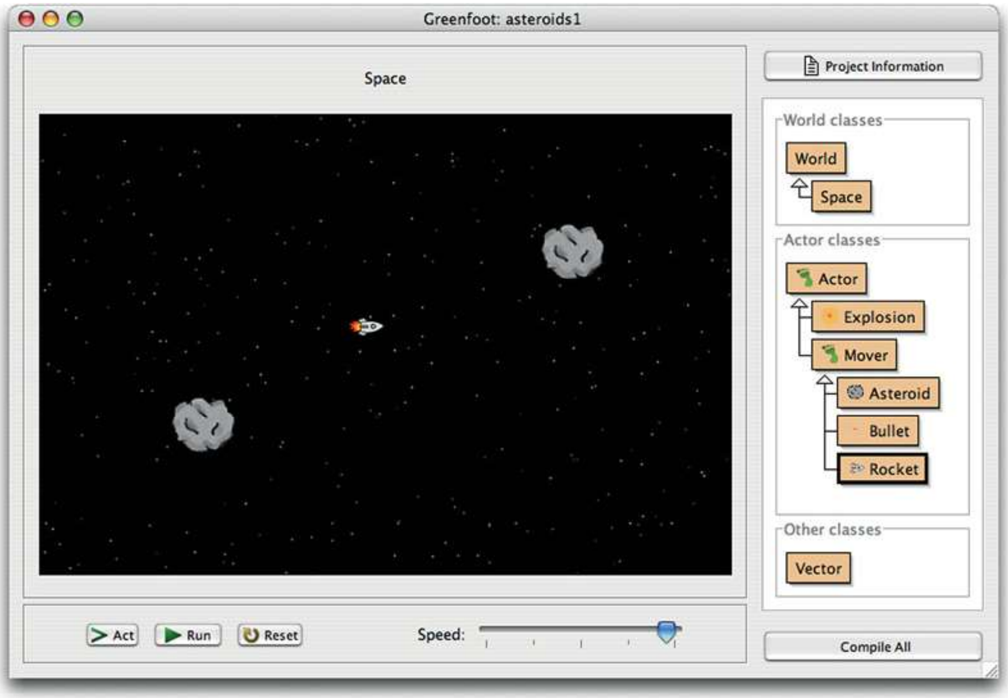


Figure 1.7
The asteroids1 scenario

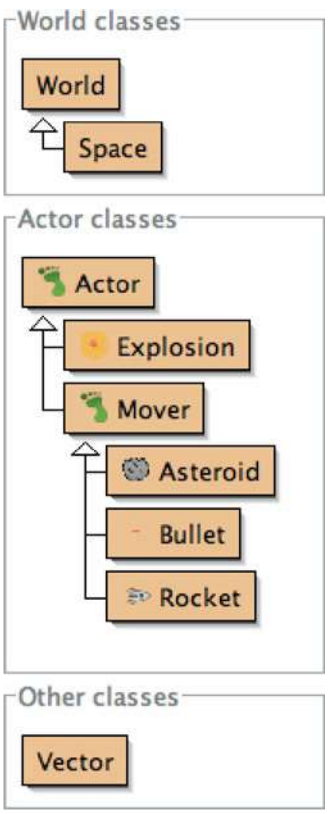


Figure 1.8
A class diagram

Below this, we see another group of six classes, linked by arrows. Each class represents its own objects. Reading from the bottom, we see that we have rockets, bullets, and asteroids, which are all "movers", while movers and explosions are actors.

Again, we have subclass relationships: `Rocket`, for example, is a subclass of `Mover`, and `Mover` and `Explosion` are subclasses of `Actor`. (Conversely, we say that `Mover` is a *superclass* of `Rocket` and `Actor` is a *superclass* of `Explosion`.)

Subclass relationships can go over several levels: `Rocket`, for example, is also a subclass of `Actor` (because it is a subclass of `Mover`, which is a subclass of `Actor`). We shall discuss more about the meaning of subclasses and superclasses later.

The class `Vector`, shown at the bottom of the diagram under the heading *Other classes* is a helper class used by the other classes. We cannot place objects of it into the world.

1.9 Playing with Asteroids

We can start playing with this scenario by creating some actor objects (objects of subclasses of `Actor`) and placing them into the world. Here, we create objects only of the classes that have no further subclasses: `Rocket`, `Bullet`, `Asteroid`, and `Explosion`.

Let us start by placing a rocket and two asteroids into space. (Remember: you can create objects by right-clicking on the class, or selecting the class and shift-clicking.)

When you have placed your objects, click the *Run* button. You can then control the spaceship with the arrow keys on your keyboard, and you can fire a shot by using the space bar. Try getting rid of the asteroids before you crash into them.

Exercise 1.10 If you have played this game for a while, you will have noticed that you cannot fire very quickly. Let us tweak our spaceship firing software a bit so that we can shoot a bit quicker. (That should make getting the asteroids a bit easier!) Place a rocket into the world, then invoke its `setGunReloadTime` method (through the *object* menu), and set the reload time to 5. Play again (with at least two asteroids) to try it out.

Exercise 1.11 Once you have managed to remove all asteroids (or at any other point in the game), stop the execution (press *Pause*) and find out how many shots you have fired. You can do this using a method from the rocket's object menu. (Try destroying two asteroids with as few shots as possible.)

Exercise 1.12 You will have noticed that the rocket moves a bit as soon as you place it into the world. What is its initial speed?

Exercise 1.13 Asteroids have an inherent *stability.* Each time they get hit by a bullet, their stability decreases. When it reaches zero, they break up. What is their initial stability value after you create them? By how much does the stability decrease from a single hit by a bullet?

(Hint: Just shoot an asteroid once, and then check the stability again. Another hint: To shoot the asteroid, you must run the game. To use the object menu, you must pause the game first.)

Exercise 1.14 Make a very big asteroid.

1.10 Source code

Concept:

Every class is defined by **source code.** This code defines what objects of this class can do. We can look at the source code by opening the class's editor.

The behavior of each object is defined by its class. The way we can specify this behavior is by writing *source code* in the Java programming language. The source code of a class is the code that specifies all the details about the class and its objects. Selecting *Open editor* from the class's menu will show us an editor window (Figure 1.9) that contains the class's source code.

The source code for this class is fairly complex, and we do not need to understand it all at this stage. However, if you study the rest of this book and program your own games or simulations, you will learn over time how to write this code.

At this point, it is only important to understand that we can change the behavior of the objects by changing the class's source code. Let us try this out.

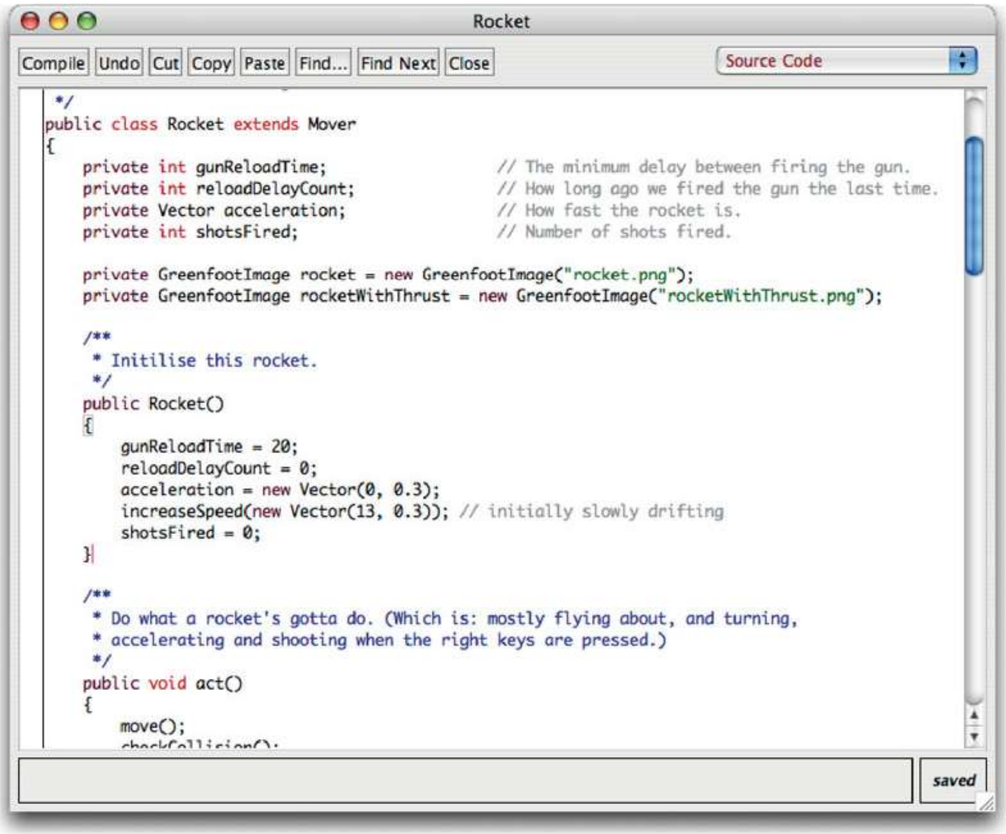


Figure 1.9 The editor window of class `Rocket`

Tip:

You can open an editor for a class by double-clicking the class in the class diagram.

We have seen before that the default firing speed of the rocket was fairly slow. We could change this for every rocket individually by invoking a method on each new rocket, but we would have to do this over and over again, every time we start playing. Instead, we can change the code of the rocket so that its initial firing speed is changed (say, to 5), so that all rockets in the future start with this improved behavior.

Open the editor for the `Rocket` class. About 25 lines from the top, you should find a line that reads

```
gunReloadTime = 20;
```

This is where the initial gun reloading time gets set. Change this line so that it reads

```
gunReloadTime = 5;
```

Be sure to change nothing else. You will notice very soon that programming systems are very picky. A single incorrect or missing character can lead to errors. If, for example, you remove the semicolon at the end of the line, you would run into an error fairly soon.

Concept:

Computers do not understand source code. It needs to be translated to machine code before it can be executed. This is called **compilation**.

Close the editor window (our change is complete) and look at the class diagram again. It has now changed: Several classes now appear striped (Figure 1.10). The striped look indicates that a class has been edited and now must be *compiled*. Compilation is a translation process: The class's source code is translated into a machine code that your computer can execute.

Classes must always be compiled after their source code has been changed, before new objects of the class can be created. (You will also have noticed that several classes need recompilation even though we have changed only a single class. This is often the case because classes depend on each other. When one changes, several need to be translated again.)

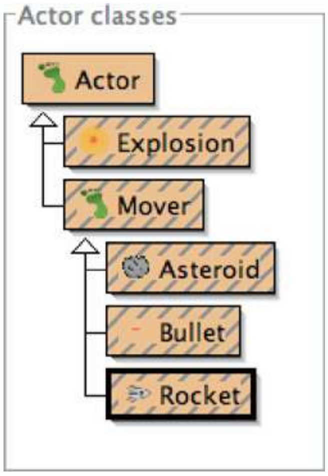


Figure 1.10
Classes after editing

We can compile the classes by clicking the *Compile All* button in the bottom–right corner of Greenfoot's main window. Once the classes have been compiled, the stripes disappear, and we can create objects again.

Exercise 1.15 Make the change to the `Rocket` class source code as described above. Close the editor and compile the classes. Try it out: rockets should now be able to fire quickly right from the start.

We shall come back to the asteroids game in Chapter 7, where we will discuss how to write this game.

1.11 Summary

In this chapter, we have seen what Greenfoot scenarios can look like and how to interact with them. We have seen how to create objects and how to communicate with these objects by invoking their methods. Some methods were commands to the object, while other methods returned information about the object. Parameters are used to provide additional information to methods, while return values pass information back to the caller.

Objects were created from their classes, and source code controls the definition of the class (and with this, the behavior and characteristics of all the class's objects).

We have seen that we can change the source code using an editor. After editing the source, classes need to be recompiled.

We will spend most of the rest of the book discussing how to write Java source code to create scenarios that do interesting things.

Concept summary

- Greenfoot scenarios consist of a set of **classes**.
- Many **objects** can be created from a **class**.
- Objects have **methods**. Invoking these performs an action.
- The **return type** of a method specifies what a method call will return.
- A method with a **void** return type does not return a value.
- Methods with void return types represent **commands**; methods with non-void return types represent **questions**.
- A **parameter** is a mechanism to pass in additional data to a method.
- Parameters and return values have **types**. Examples of types are **int** for numbers, and **boolean** for true/false values.
- The specification of a method, which shows its return type, name, and parameters, is called its **signature**.
- Objects that can be placed into the world are known as **actors**.
- A **subclass** is a class that represents a specialization of another. In Greenfoot, this is shown with an arrow in the class diagram.
- Every class is defined by **source code**. This code defines what objects of this class can do. We can look at the source code by opening the class's editor.
- Computers do not understand source code. It needs to be translated to machine code before it can be executed. This is called **compilation**.