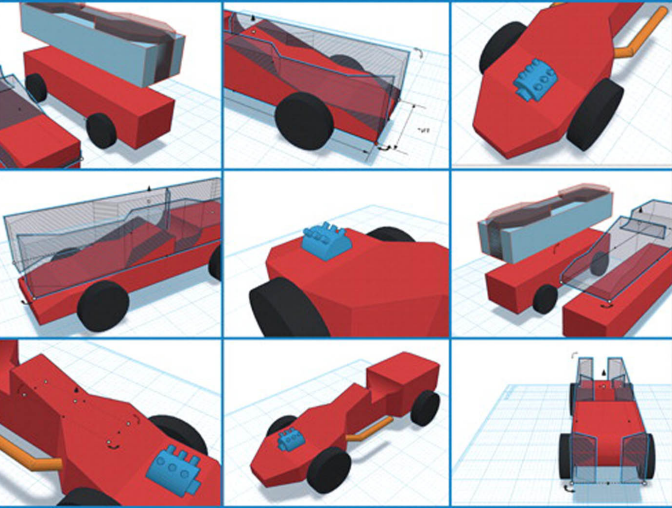
3D Modeling and Printing with TINKERCAD®

Create and Print Your Own 3D Models



James Floyd Kelly

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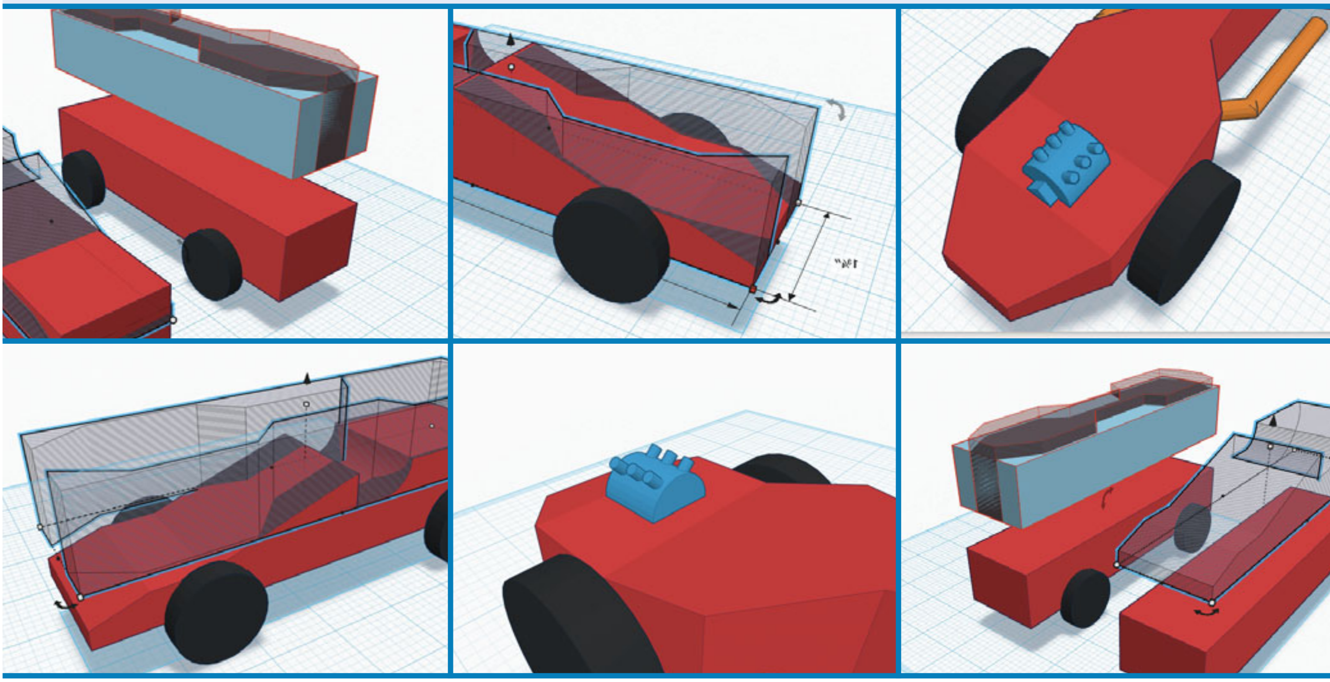

James Floyd Kelly

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ISBN-13: 978-0-7897-5490-5
ISBN-10: 0-7897-5490-8

Library of Congress Control Number: 2014934912

Printed in the United States of America

First Printing: June 2014

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About the Author

James Floyd Kelly is a writer from Atlanta, Georgia. He has degrees in industrial engineering and English and has written technology books on a number of subjects, including CNC machines, 3D printing, open software, LEGO robotics, and electronics.

Dedication

For Decker and Sawyer: "Who wants to do a project?"

Acknowledgments

I love writing books that help others, especially younger readers. I'm a jack-of-all-trades, master of none, and I frequently have to teach myself new subjects that interest me. This means hunting down material that's often vague, hidden, or incomplete...sometimes all three. Because of this, when I choose to pass on my knowledge in a book, I do my best to organize it in a way that makes sense to me and, hopefully, my readers.

Along for this trip are a number of key individuals who at various points in the writing process provide me with help, feedback, and support...sometimes all three.

First, my sincere gratitude goes to Rick Kughen, who saw the potential in my early proposal. He offered advice on what to include and what to cut that really did make the book much better.

Next is my technical editor, Ralph Grabowski. A technical editor is supposed to help catch my errors and tell me when I've forgotten a step or maybe need to be more specific when describing something. Ralph did a great job of finding my mistakes and suggesting improvements. Any additional errors you find belong to me. (And please let me know if you find any by emailing feedback@quepublishing.com.)

I also must thank five more folks at Pearson: Laura Norman, development editors William Abner and Todd Brakke, managing editor Kristy Hart, and my project editor, Betsy Gratner, for helping to keep me organized. If you enjoy the book, all these individuals deserve a large part of the credit.

Finally, I must thank my wife for her support and patience and my two young boys, who keep me always on the lookout for new and fun projects to tackle.

James Floyd Kelly

Atlanta, March 2014

We Want to Hear from You!

As the reader of this book, *you* are our most important critic and commentator. We value your opinion and want to know what we're doing right, what we could do better, what areas you'd like to see us publish in, and any other words of wisdom you're willing to pass our way.

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Introduction

Welcome to Tinkercad!

About 20 years ago, I went off to college to study engineering. One of the classes that engineering students had to take was a drawing course that required us to use special pencils (not the familiar No. 2s) and rulers and straight edges to create hand-drawn schematics of various objects. We started out with simple designs like cubes and pyramids and moved slowly but surely into more advanced drawings. It was a fun class, but it was also very tedious. I could sometimes erase mistakes, but many times it was easier to just start over, especially when I discovered I'd made a measurement error early in a complex drawing.

At the end of the class, the instructor informed us that a special class was being offered the next year, called CAD, or Computer-Aided Design (although some students called it Computer-Aided Drafting). He said that to get in the class, a student would have to demonstrate some basic skills. As an example, the professor taped three large drawings on the wall; each of the drawings showed one particular face of a large cube—a top, a side, and a front view. This cube consisted of 9 smaller cubes on each face, just like a Rubik's Cube, as shown in Figure I.1.

These drawings, however, showed that the cube had a few missing smaller cubes, which created a strange landscape on a few of the faces of the larger cube. Students had 60 seconds to draw a version of this 3D cube using nothing but the front, side, and top views. The professor was testing our ability to visualize a 3D object in our head, based on three simple views, and then transfer that image to paper.

I didn't take the test because I wasn't interested in the class. But the students who did take the CAD class said that it was both fun and difficult (a typical description of many engineering classes) and that it involved drawing objects on a computer screen by defining points on the object and then connecting lines between points. It sounded difficult, time-consuming, and frustrating...but most of the students said it was much faster than drawing by hand, as we'd all done in that beginner-level class.

Today's CAD applications are much more advanced than those that existed 20 years ago. These applications are colorful, they do much more of the work for you (such as drawing a perfect circle or ensuring that a line is exactly 1.275 inches in length), and they allow you to create 3D objects that exist on a screen long before they exist as real physical objects.

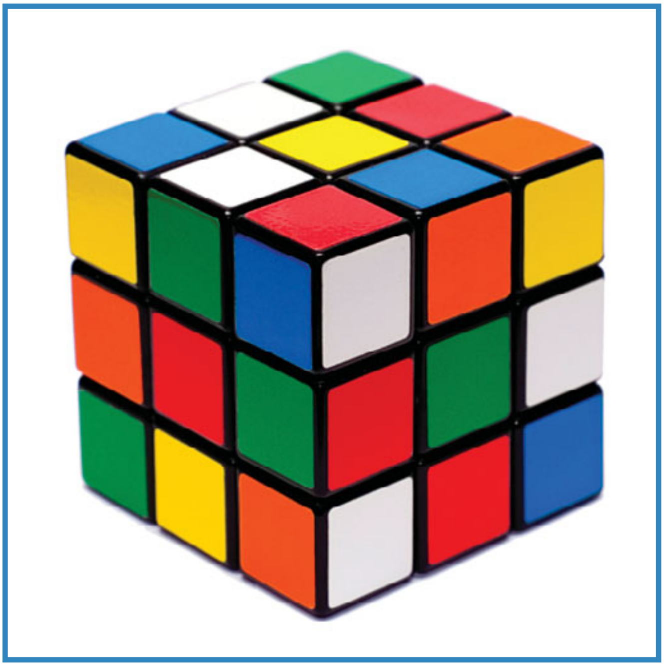

FIGURE I.1 A Rubik's Cube.

Many people complain that learning to use CAD applications is difficult. I've tried to teach myself half a dozen CAD applications over the past few years, and although I've had success with them, they've been frustrating at times, and mastering them requires a serious time commitment. Until very recently, anyone who wanted to use these applications to create 3D objects had to put in the time, deal with a lot of frustration, and often pay a substantial fee to get the software if their school or workplace didn't provide it.

But not anymore. Today, a few CAD applications are tailored to beginners and less intimidating than their big-brother counterparts. They require less time to master and in some cases are even free to use. One of these CAD applications is called Tinkercad.

I first encountered Tinkercad at Maker Faire (www.makerfaire.com) back in 2012. I was hooked by a number of factors: It was impressive and colorful; using it required only an Internet connection and a web browser; using it felt almost like dragging and dropping LEGO blocks onto the screen; and it was free. I created an account, began to use Tinkercad, and discovered that it's a pretty good CAD app. It has limitations, but for a beginner-level CAD application, it's an impressive example of how a complex tool can be simplified for anyone to use.

What you're holding in your hands is a book for learning Tinkercad. The popular CAD software company, Autodesk (www.autodesk.com), makers of the commercial and very popular CAD application Autodesk 360, purchased Tinkercad in 2013, and the company chose to keep the application free to use—good news to the fans who had already discovered the simple CAD app.

Autodesk didn't just buy Tinkercad; the company has continued to improve the app, adding new tools and features, and providing users with free online support via a blog and forum.

If you're new to CAD applications, this book is for you. If you understand the importance of a CAD application but aren't sure where to start, this book is also for you. Maybe you're the brand-new owner of a 3D printer and are wanting to start designing and printing objects to print in plastic—if so, Tinkercad is the perfect tool to get started. (And check out Chapter 8, "Printing Your 3D Models," if you're not familiar with 3D printers and want to know more.) And if you've found Tinkercad but are feeling a little confused about where to start, you've got the right book. I'm going to show you all you need to know to begin creating some amazing 3D objects, and hopefully when you're done with the book, you'll feel confident enough to continue on with any new features introduced to Tinkercad or maybe even move on to playing with a more advanced CAD application.

Using Tinkercad truly is one of the easiest ways to experience computer-aided design and to create 3D models. You're about to learn a new skill...and you're going to have a lot of fun doing it. I'll see you in Chapter 1, "3D Modeling Is Cool!"

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4

Learn Some Modeling Basics

In This Chapter

- The launchpad
- The rocket's main body
- The rocket's fins

It's time to start digging a bit deeper into the workings of Tinkercad, and the best way to learn about this amazing tool is to get hands-on with it. Now, before you can go and create your own amazing models, you've got to realize that there are a lot of basic skills you'll need to master first. This doesn't mean you can't create some 3D models right now, however. It just means that it might take you a little bit longer.

The better way to learn Tinkercad is to start slow and first learn how to use its most basic tools and features. An even better way to learn Tinkercad is to create an actual model as you're learning the ins and outs of the application. And that's exactly what this chapter is all about. By the end of this chapter, you'll have created all the components necessary for a simple 3D model and you will have learned many (but not all) of the standard features that Tinkercad offers. To show you how to make the parts of a simple 3D model, I've picked a fun little rocket for you to build. Go ahead and open up Tinkercad, log in, and click the Create New Design button on the Dashboard.

The Launchpad

This first model is simple. You'll be using basic shapes to create a model of a small toy rocket, preparing to launch. You'll need to create the pieces for both the launchpad and the rocket—starting with a launchpad that's sitting on a tiny piece of land. The first thing you're going to want to do is create that small piece of land. As you can see in Figure 4.1, I'm zoomed in quite a bit on the workspace. I need to zoom out a bit so I can see the entire workspace.

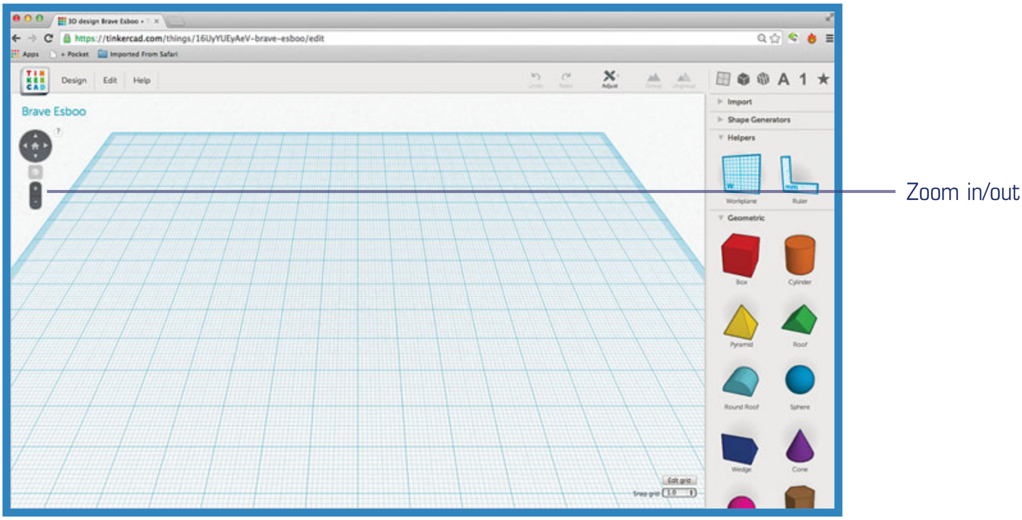

FIGURE 4.1 You can zoom in and out on the workspace.

To zoom in and out, you can use the + and – buttons indicated in Figure 4.1. A few taps on the – button shrinks the workspace a bit so you can see all of its boundaries, as shown in Figure 4.2.

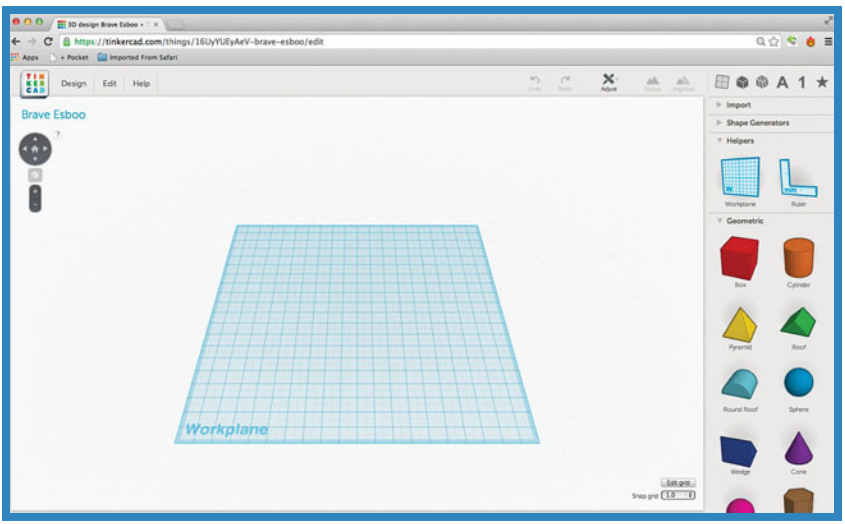

FIGURE 4.2 Zooming out to see the workspace boundaries.

Click the + button to zoom in and see more detail on a model. If you're using a mouse that has a mouse wheel on top, you can also scroll it away from you to zoom in and toward you to zoom out. Finally, if you're using a Mac touchpad, you can swipe two fingers down to zoom in and swipe two fingers up to zoom out.

Go ahead and drop a piece of the launchpad on the screen. To do this, you need to click, hold, and drag a copy of the red box onto the workspace. You can find the red box shape in the Geometric section of the toolbar that runs down the right side of the screen, as shown in Figure 4.3. If you don't see the red box, click the word Geometric to open the list of geometric shapes.

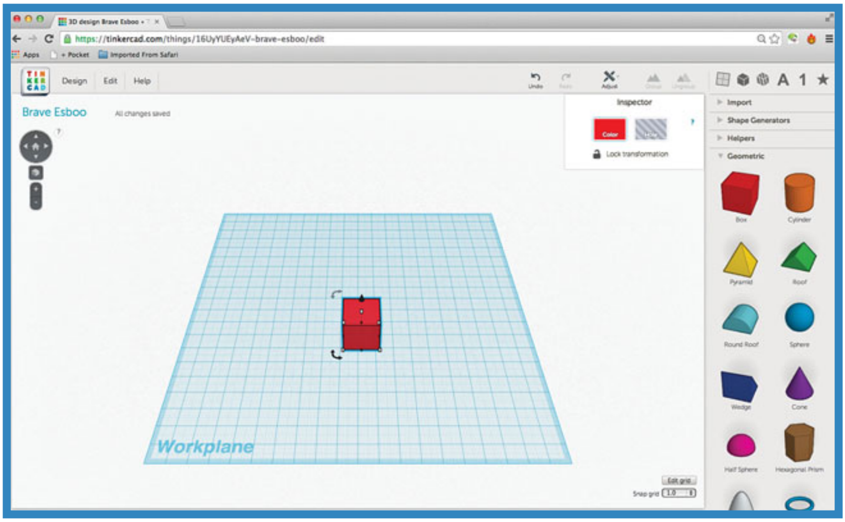

FIGURE 4.3 Dragging a red box object onto the workspace.

When you drop a shape on the workspace, it may or may not appear with various controls around it, such as arrows or tiny white boxes in the corners. When an object is selected, a few controls appear on and around it. In Figure 4.4, I've zoomed in on the box from Figure 4.3 so you can see these controls in more detail. If you don't see the controls on your screen, simply click the red box, and they appear.

You've dropped a box object onto the workspace, but it might not completely look like one from the angle shown in Figure 4.4. It would be nice to rotate the workplane a bit so it's a more obvious that this is a box. To do this, you can use the rotate controls shown in Figure 4.5. Likewise, if you're a mouse user, you can either press and hold both mouse buttons simultaneously while moving the mouse to see the workspace move or press and hold the middle (wheel) button; test both to see which works for you. Mac users can press and hold two fingers on a touchpad to achieve the same result.

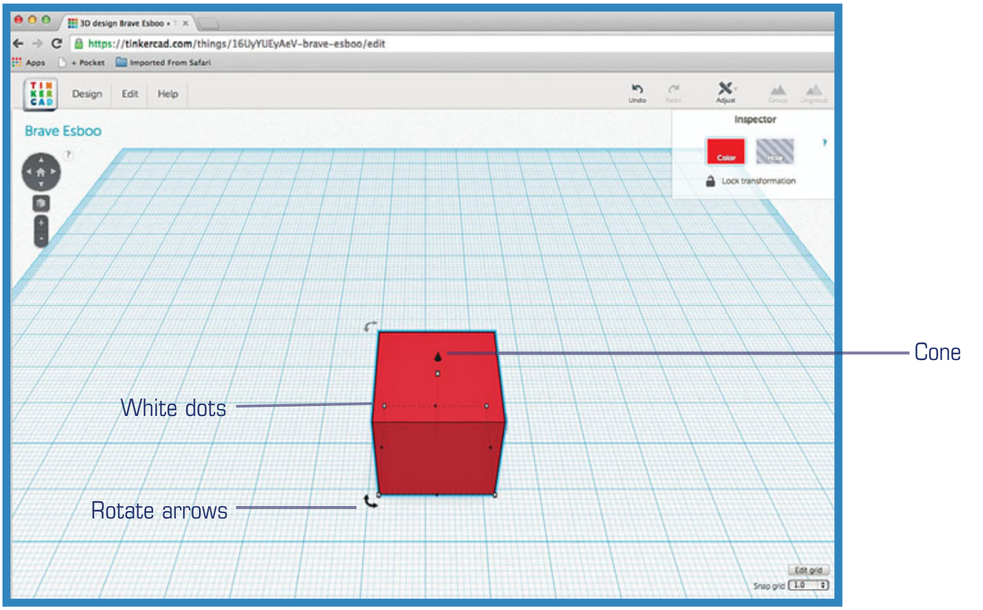

FIGURE 4.4 Controls allow you to manipulate an object.

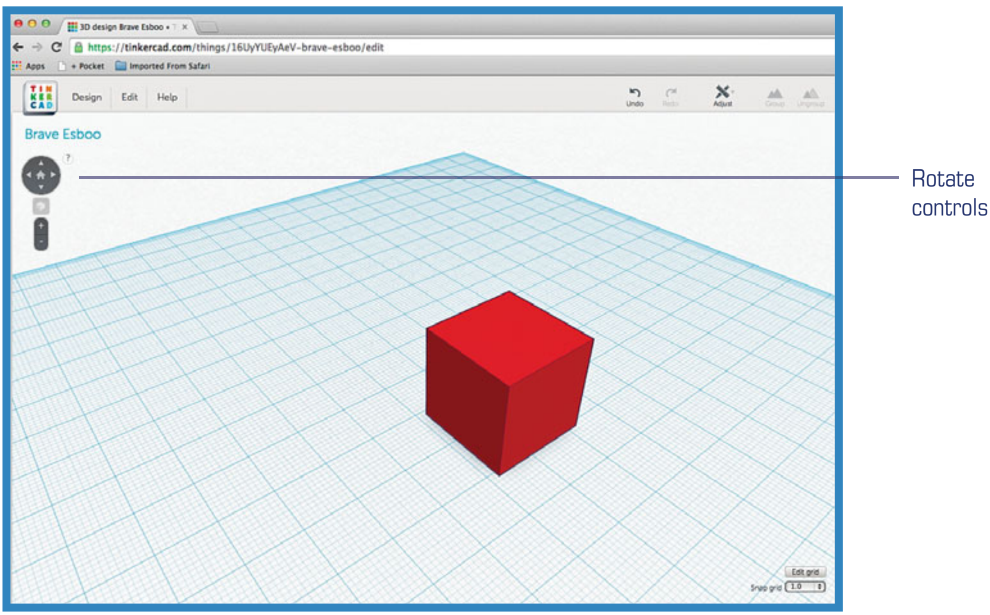

FIGURE 4.5 Using the rotate controls to change the view of the workspace.

Find a suitable angle to view the box object and then click on the box object to select it so the controls are visible once again, as shown in Figure 4.6.

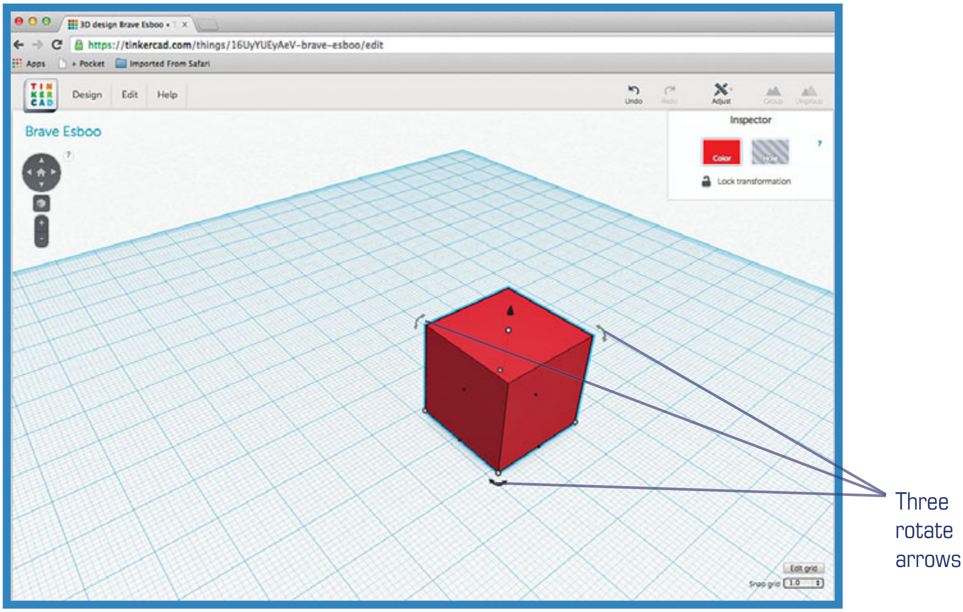

FIGURE 4.6 The controls on the selected box object.

Compare the controls shown in Figure 4.4 to those shown in Figure 4.6. With a simple shift of the workspace view, you should now see in Figure 4.6 that there are three rotate arrows surrounding the box instead of just the two shown in Figure 4.4.

You'll learn about the rotate arrow controls in Chapter 5, "Putting Together a Model," but for now I want you to focus on the small white dots that are visible in the bottom corners of the box object.

Move your mouse pointer over any white dot, and a measurement appears. Some dots, such as the one in Figure 4.7, displays two measurements.

As you can see in Figure 4.7, the length and width of this box object are both 20mm (millimeters). This means the base of this box is a square. You can check the height of the box by clicking the white dot control on the very top of the box: Move your mouse pointer over it as shown in Figure 4.8, and the height measurement appears.

Because the height is also 20mm, you're looking at a perfect cube. But a cube isn't the best place to launch a rocket. You're going to modify the cube so it's very flat and a bit larger, and you'll do it by clicking and dragging on those white dot controls.

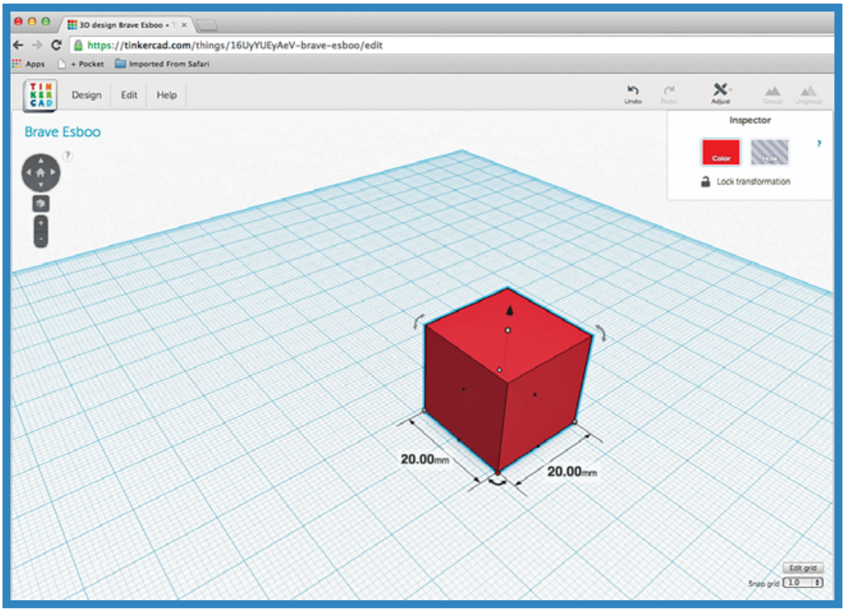

FIGURE 4.7 White dot controls display measurements.

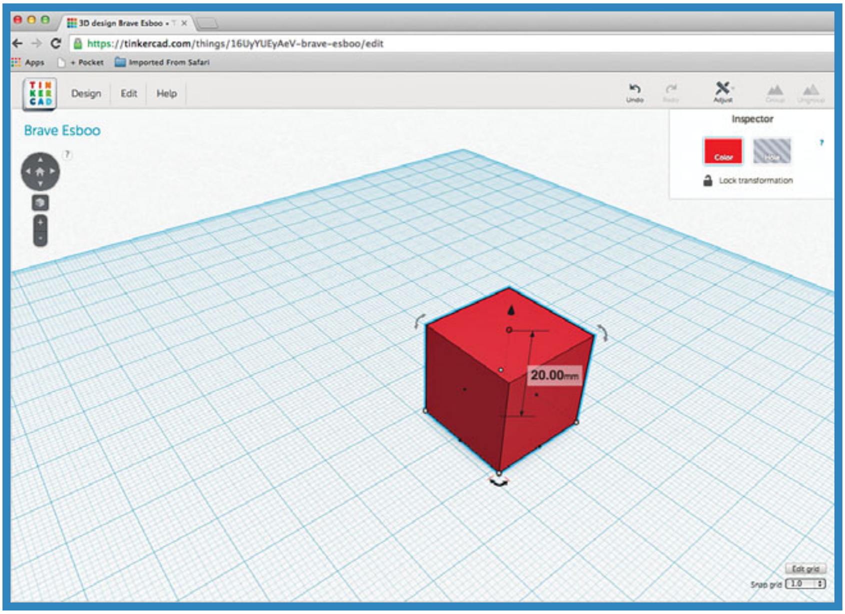

FIGURE 4.8 The top white dot control reports the height measurement.

Let's start with the height. Click and hold on the white dot on top of the cube while dragging down. Watch as the cube begins to flatten in size, and the height measurement value decreases. Notice also that the length and width remain the same: 20mm. Shrink the box object's height to 1mm and stop. Your box object should now look like the one in Figure 4.9.

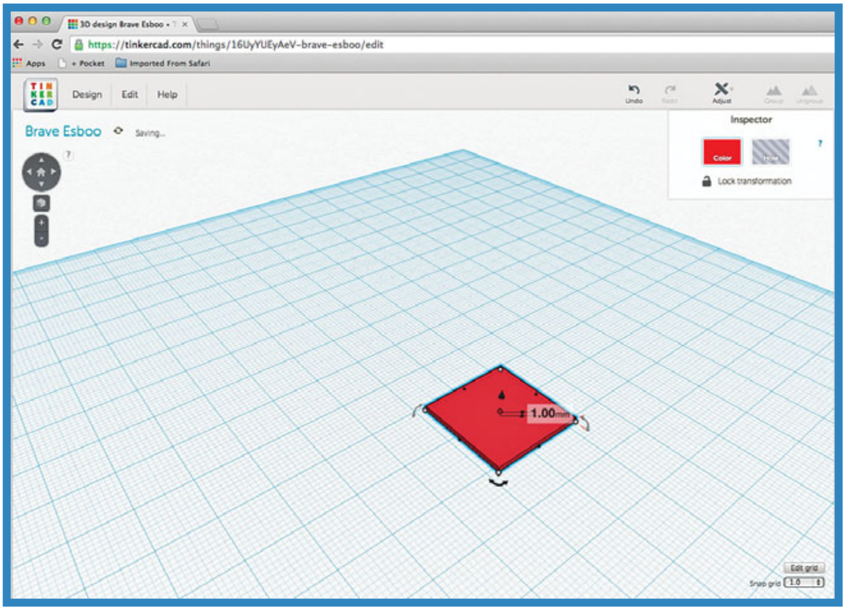

FIGURE 4.9 Flatten the box object by dragging down on the top white dot control.

You can verify the height at any time by hovering your mouse pointer over the top white dot control again. Once you're satisfied that the height is 1mm, click and drag on one of the white dot controls that make up the corners of the box object until the object's length and width values are both 100mm. When using one of the corner white dot controls, you can change both the length and width at the same time. Experiment a bit and see how moving the mouse pointer while clicking and holding down on a white box lets you change the length and width simultaneously.

Your box shape should end up looking like the one in Figure 4.10, at 100mm in both length and width and 1mm in height.

In Figure 4.10, the launchpad extends beyond the workspace. This isn't a problem, but it can affect your view when you zoom in and out of the workspace. Ideally, you want to try to keep your models within the boundaries of the workplane for easier viewing. To move an object such as the flattened launchpad, simply click and hold on any part of the object's surface (but not on any of its controls) and drag it and release it where you want it.

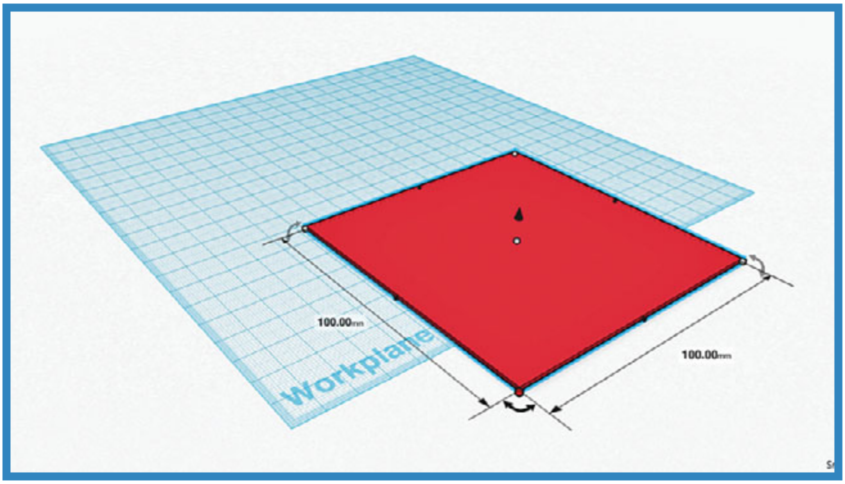

FIGURE 4.10 The rocket's launchpad is done.

This is a good time to point out just how easy it is to change the color of a selected object. When you have an object (such as the launchpad) selected, click the Color button indicated in Figure 4.11 and pick a new color. (You can use the Custom link to create a unique color if you like.) Figure 4.11 shows that I've changed the launchpad's color to green and centered the object in the middle of the workplane.

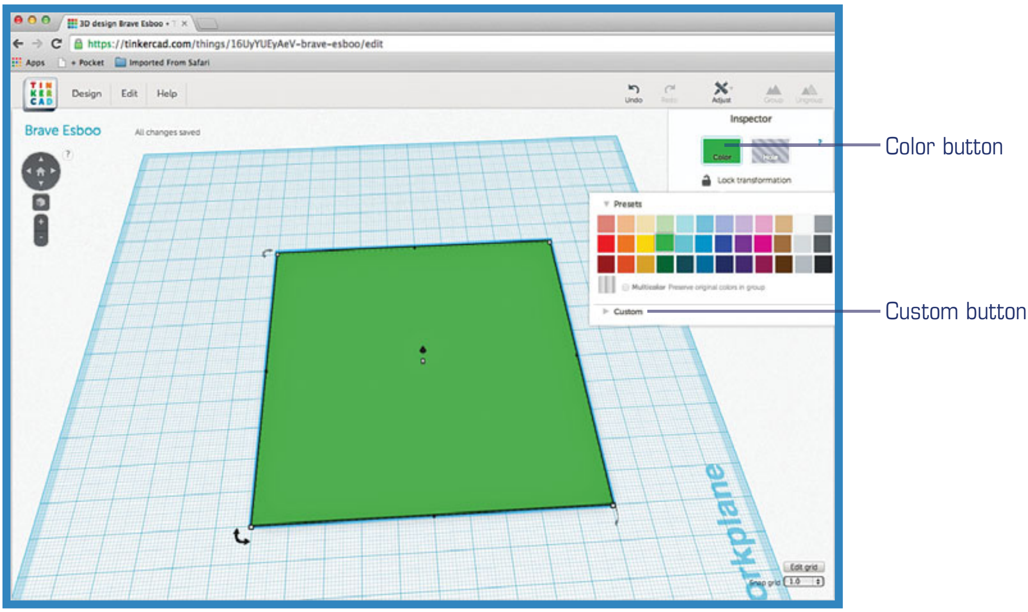

FIGURE 4.11 You can drag and drop model pieces anywhere on the workspace.

Before you move on to creating the pieces of the rocket, I want to give you some more practice with dropping objects on the workplane and modifying their sizes. To get this practice, you can create the launch scaffolding. This will consist of three pieces that will eventually be stacked. Just create four blue objects using the box shape object and give them these dimensions (length x width x height):

Scaffold1: 10mm x 10mm x 10mm

Scaffold2: 7mm x 7mm x 20mm

Scaffold3: 4mm x 4mm x 15mm

Scaffold4: 30mm x 5mm x 2mm

Drag and drop these launchpad scaffolding pieces around the edges of the workspace, as shown in Figure 4.12. You'll put these together in Chapter 5, along with the pieces of the rocket that you'll be creating next.

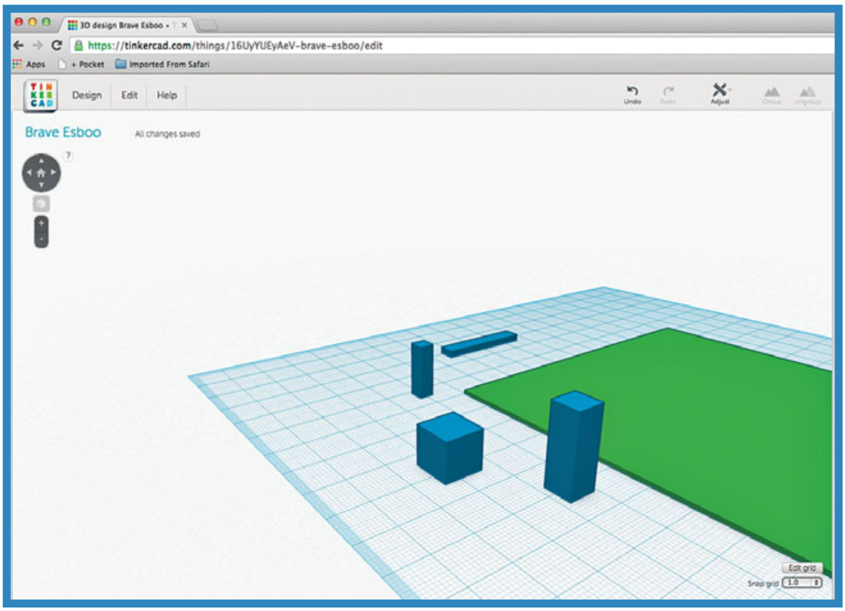

FIGURE 4.12 The scaffolding pieces, sized and ready for assembly.

The Rocket's Main Body

Don't worry, you're not going to be re-creating the Space Shuttle in Tinkercad...although that would make a great advanced project for you to consider. Instead, you're going to create the pieces for a small and simple rocket that will consist of the main body, the engine, and three fins.

When the scaffolding is assembled, the height of the assembly will be 47mm. The rocket will have a height of 45mm. Keep this in mind as you create the main body, engine, and fins.

It can often be useful to have a hand sketch of your model (or a photo of a real-life object), and Figure 4.13 gives you the basic idea of the rocket you'll work on creating. Your version doesn't have to look exactly like mine, but do try and follow along with the hands-on steps so you get some practice with the Tinkercad tools and features used here.

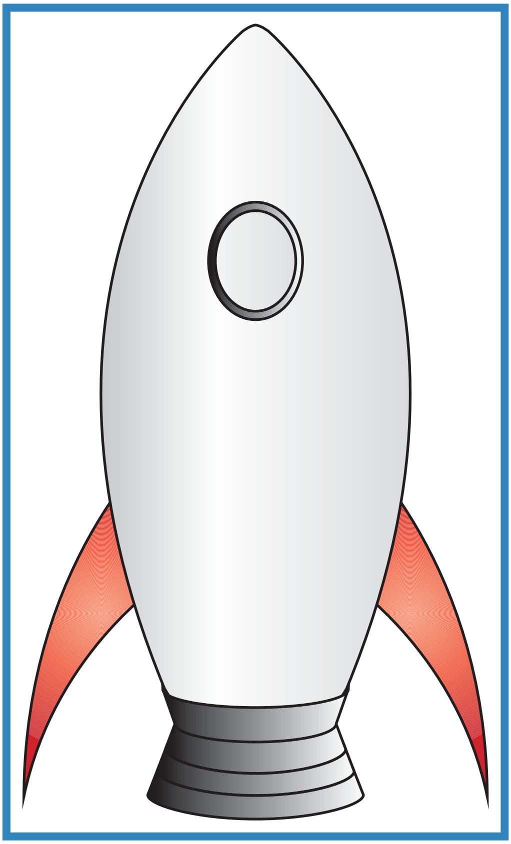

FIGURE 4.13 A sketch of the rocket 3D model to be designed.

As you can see, the largest part of the rocket will be the main body, and I'm going to start with that shape. The easiest way to obtain this shape is to drag and drop a Sphere object on the workspace and use the white dot controls to modify the shape. Figure 4.14 shows that I've dropped a sphere object onto the workspace.

Like a box, a sphere also has the white dot controls appear when you select it. Unlike a box object, however, a sphere's measurements are related to its diameter (when it's a perfect sphere). You can click and hold on any white dot and manipulate the shape of the sphere as desired. After some playing around, I managed to end up with an elongated cigar-shaped object, as shown in Figure 4.15, with length and width of 14mm and height of 30mm.

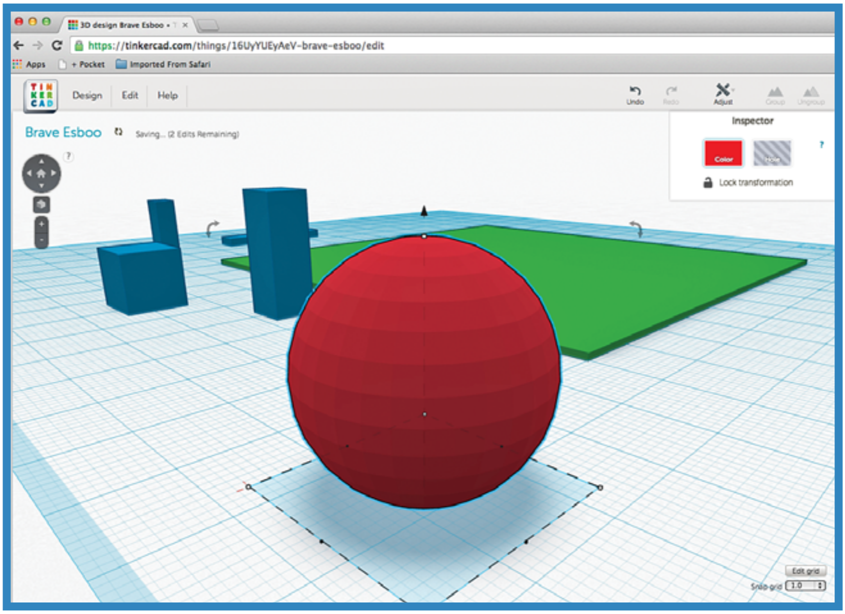

FIGURE 4.14 A sphere object, ready to be modified.

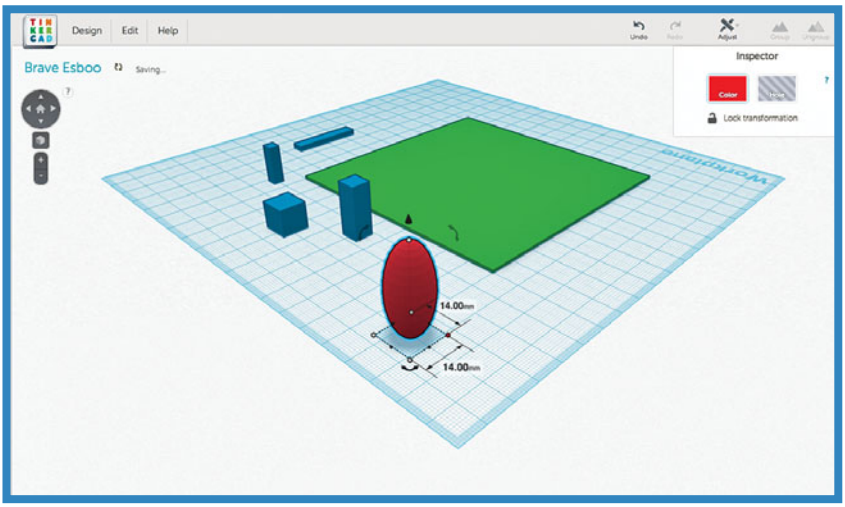

FIGURE 4.15 The rocket's main body is cigar shaped.

NOTE

You may be wondering if you need to save your work at this point. Don't worry. Tinkercad is constantly saving your progress. However, to save your progress manually, you can click the Design menu and then click the Save button.

Now let's move on to the engine. Creating this part involves simply sizing a small ring that will be placed on the bottom of the main body. You'll learn in Chapter 5 how to properly line it up and center it on the main body. For now just drag and drop a tube object (which you find at the bottom of the Geometric section) onto the workspace and give it a diameter of 8mm and a height of 2mm.

Because you want to keep the diameter of the ring constant, the length and width must be the same value. If you hold the Shift key down on your keyboard as you drag one of the white dots inward, the length and width are locked together and shrink at the same rate. Figure 4.16 shows the completed ring.

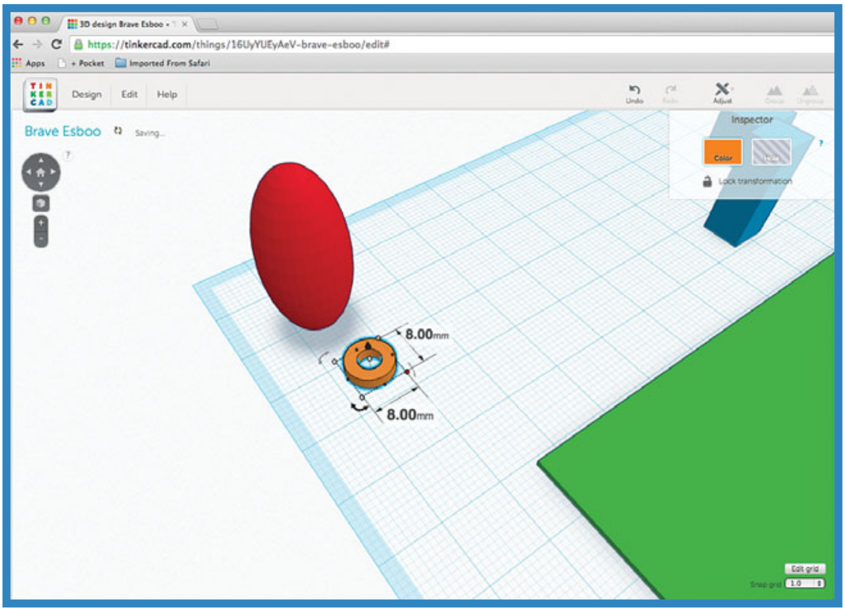

FIGURE 4.16 The engine ring, resting on the workspace.

The Rocket's Fins

Now it's time for the fins. For the fins, you'll need to use an interesting little trick to create the curves, but once you've made one basic fin, you'll be able to make two exact copies of it to save time. The trick to the fins involves creating what's called a hole object and using it like a cookie cutter to remove unwanted areas of a solid object.

You'll find as you continue to work with Tinkercad that the application sometimes requires you to be a bit creative in order to get the shapes you want. As you can see by browsing the Geometric section of the toolbar, there is no fin shape. But that's not going to stop you. You can first focus on the outer curve of the fin shown in the sketch in Figure 4.17.

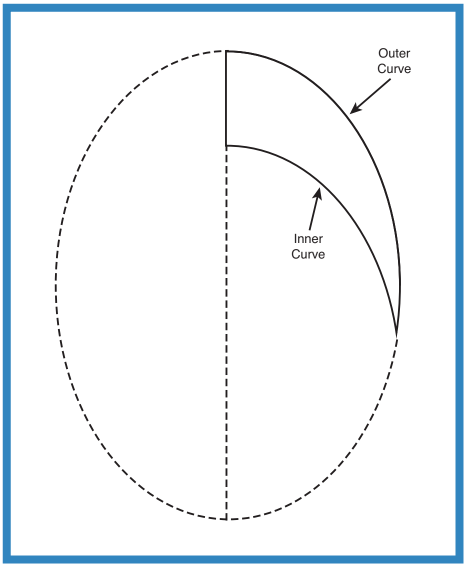

FIGURE 4.17 A fin will be a small sliver of a larger object.

As you can see, the outer edge of the fin is actually a piece cut out of a stretched circle. You'll first create a flattened cigar-shaped oval that has the curve you want for the outer edge. You'll do this by dropping a thick tube object on the workplane, as shown in Figure 4.18.

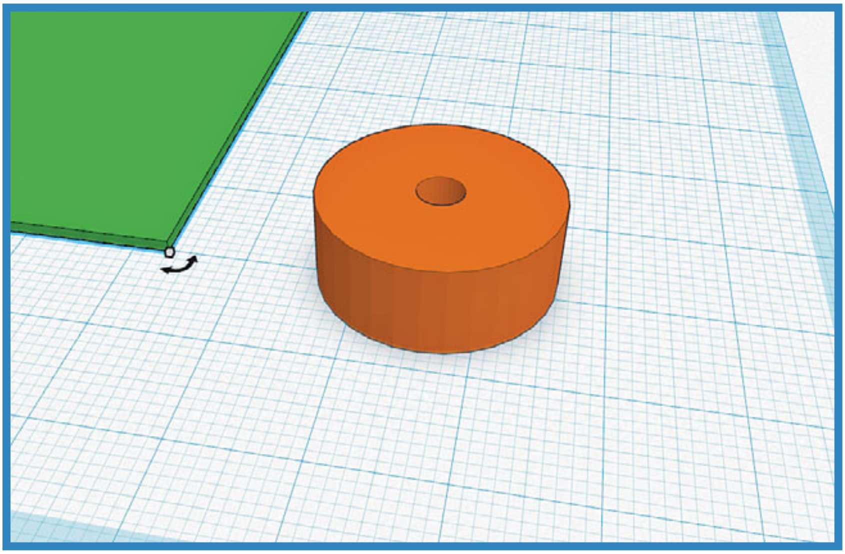

FIGURE 4.18 Start with a thick tube object.

Flatten the tube to 2mm in height and stretch the tube to get the curve you want. Figure 4.19 shows that I've flattened the tube to 2mm and dragged one of the other white dot controls to give the finished oval dimensions of 18mm wide by 35mm long.

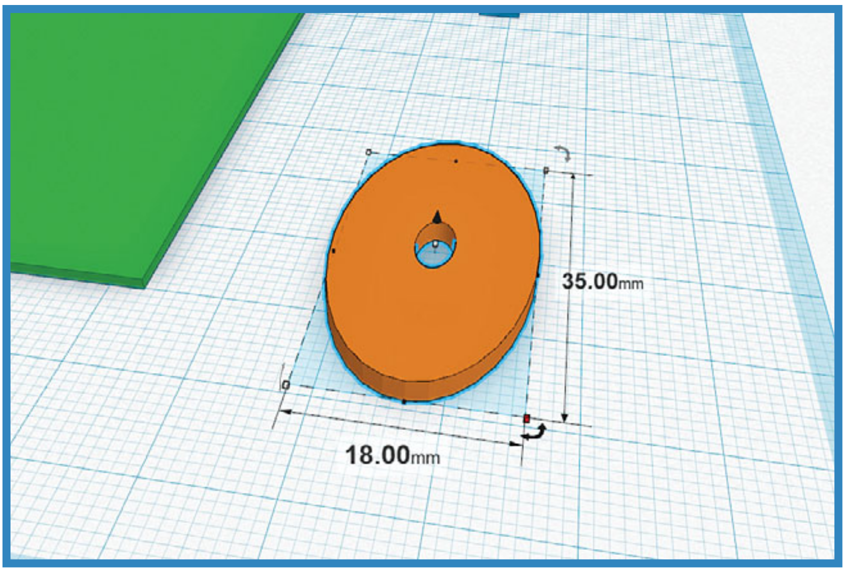

FIGURE 4.19 The flattened oval is the start of a fin.

Next, cut the tube object in half vertically by creating a 2mm-thick rectangle to cover half of the tube. Figure 4.20 shows that I've dropped a box object onto the workspace, shrunk it to 2mm in height, and matched its width and length to that of the tube object. (The width is 18mm and the length is 35mm.)

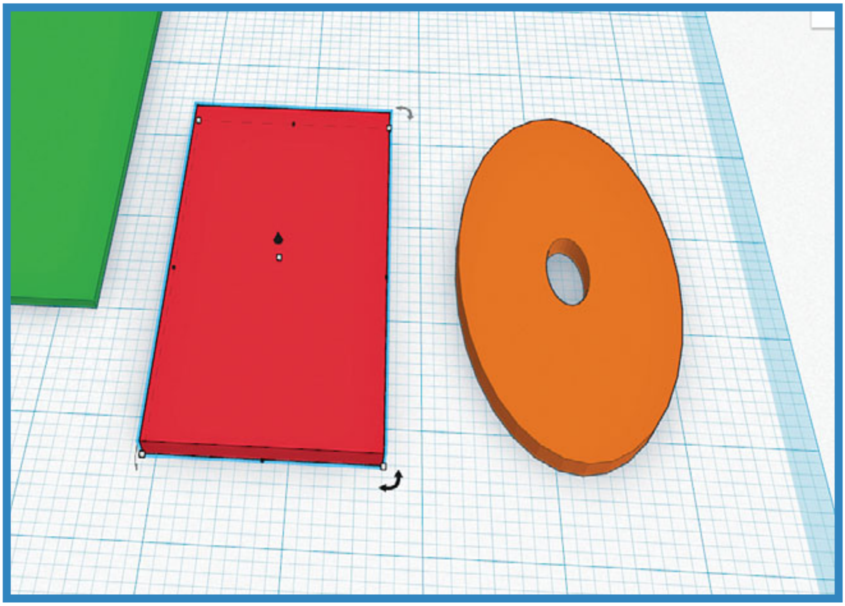

FIGURE 4.20 The flat rectangle will help cut the oval in half.

Now, here's the trick: Select the rectangle object and then click on the Hole button indicated in Figure 4.21. Notice that the rectangle will change from a color to a clear outline.

Now, drag the rectangle so that it covers half of the oval object. Figure 4.22 shows the rectangle object overlapped over the oval.

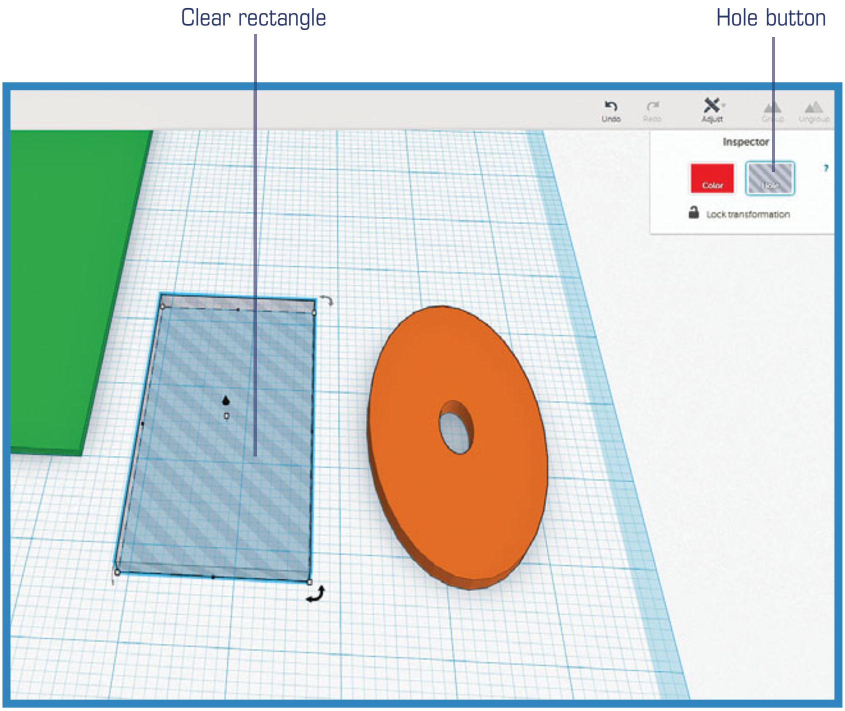

FIGURE 4.21 Turn the rectangle into a hole object.

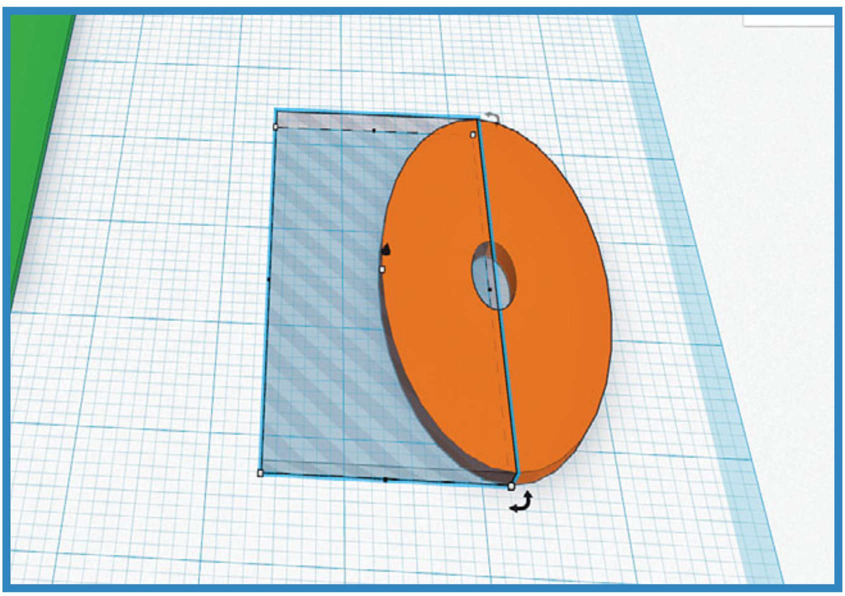

FIGURE 4.22 Overlap a solid object with a hole object.

Finally, drag and select both objects so they are outlined. Likewise, you can hold down the Shift key and click on each object to perform a multiple-select action. Figure 4.23 shows that the clear hole object and the orange oval are selected.

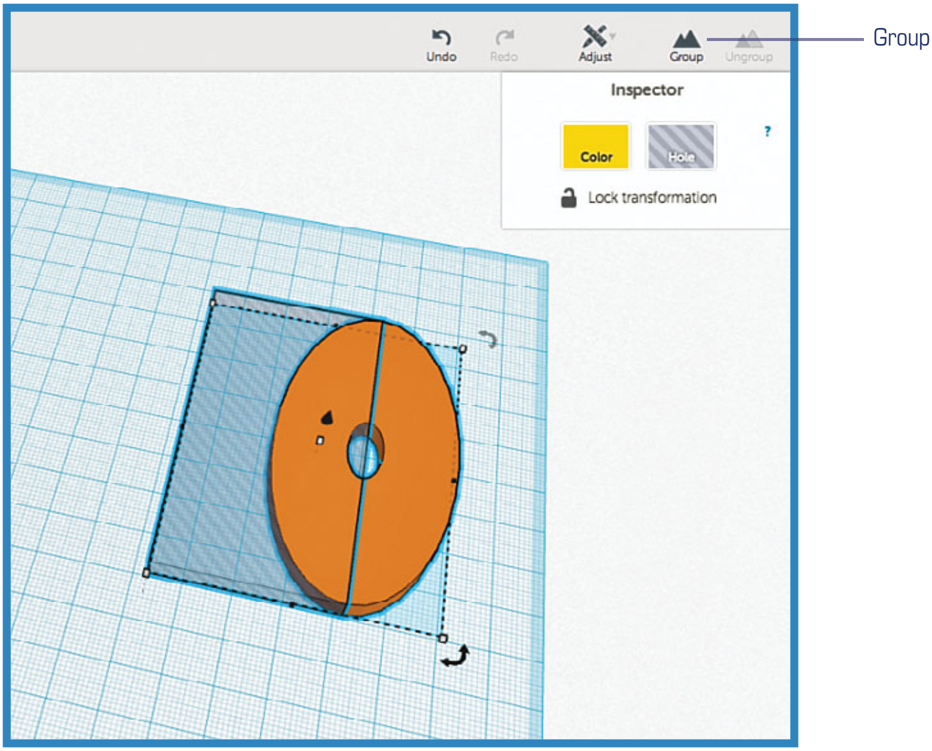

FIGURE 4.23 Select both objects to be combined.

Click the Group button. This instructs Tinkercad to combine the two objects into a single object (see Figure 4.24).

As you can see, the outer hole objects will be treated as empty space and will delete or erase any solid objects they encounter. This means that half of the oval object will disappear. Keep in mind that Tinkercad must perform some calculations to determine where solid material and a hole intersect, and this can sometimes take a minute or two for complex combinations. When the calculations are done, the final piece that is left exists as a single object, as shown in Figure 4.25.

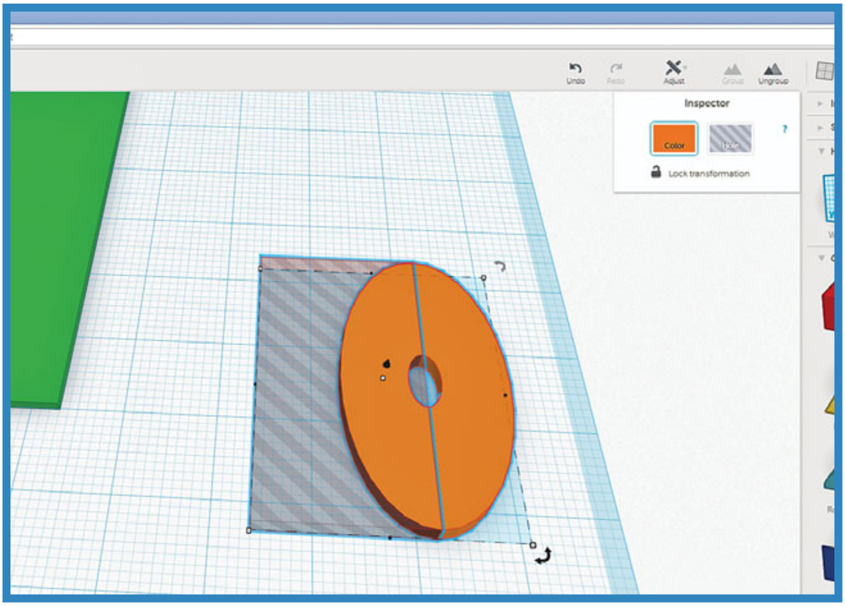

FIGURE 4.24 Group two or more objects together to create a single object.

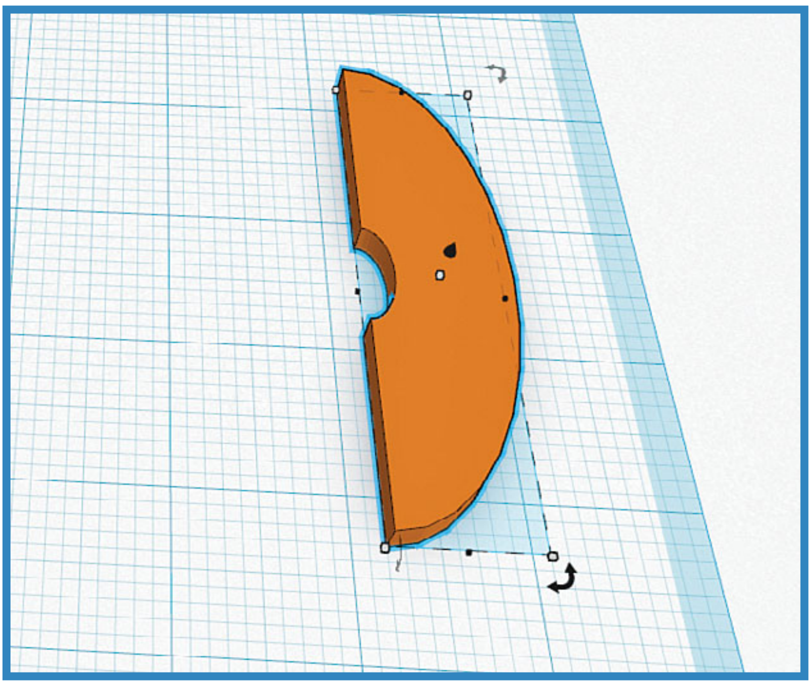

FIGURE 4.25 The final object consists of material not combined with the hole object.

NOTE

While the calculations for the grouping of the two objects is being done by Tinkercad, you might think that nothing is happening and hit the Undo button in haste. Be patient. Sometimes a merge can take a few seconds and other times a few minutes. Rest assured: If you clicked the Group button, Tinkercad is busily trying to figure out what to keep and what to delete. The flipside is that a click of the Undo button can also take some time to undo the grouping. If the grouping took more than a minute to complete, expect the Undo button to take about the same time.

Now take a look at Figure 4.26, and you'll get an idea of how the final shape of the fin will be accomplished.

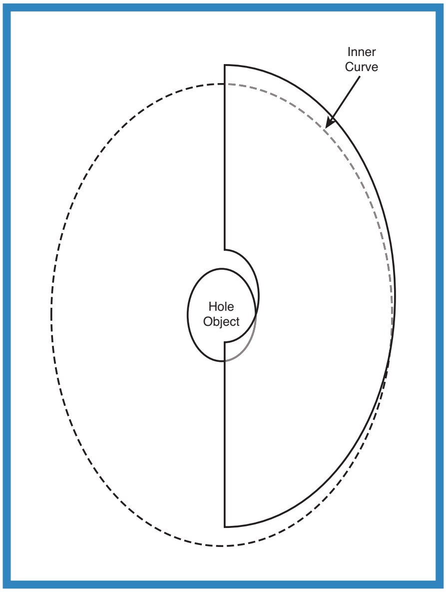

FIGURE 4.26 A sketch of how the final fin will be made.

NOTE

The fun thing about the Group button and the Hole button is that you can keep using them over and over, refining the shape of an object as you slowly delete away bits and pieces by merging a hole object with a solid object. One suggestion is to change the color of an object before turning it into a hole object. While both objects are solid, the distinct colors will help you distinguish between each object as you merge them. Once you're happy with the merge, you can convert one object to a hole object—you don't have to convert it to a hole object before the two objects are merged.

To make the inner curve of the fin, you need to create another unique object on the workplane and then convert it to a hole object. Then you will group the new hole object with the half oval in Figure 4.25, which will yield the final desired fin shape. The dimensions of this second oval piece are 49mm x 64mm. Figure 4.27 shows a new oval object, flattened to 2mm and shaped to get the desired inner curve.

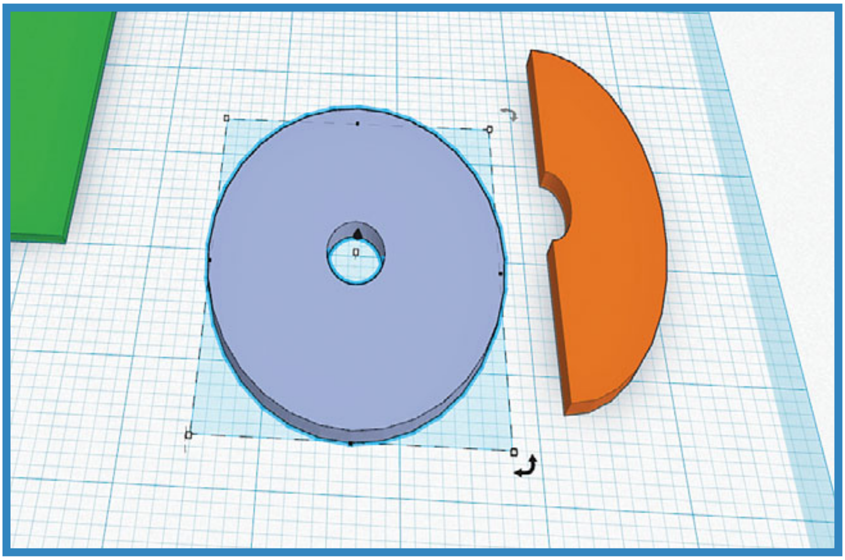

FIGURE 4.27 A fin will be a small sliver of a larger object.

After selecting the new shape and clicking the Hole button, drag the two objects together, as shown in Figure 4.28. You can see that the final shape of the fin will be the bit that's not covered by the hole object.

When you're happy with the fin shape, select both objects and click the Group button again. The hole object disappears, along with any solid sections of the oval object, leaving only the final fin shape, as shown in Figure 4.29.

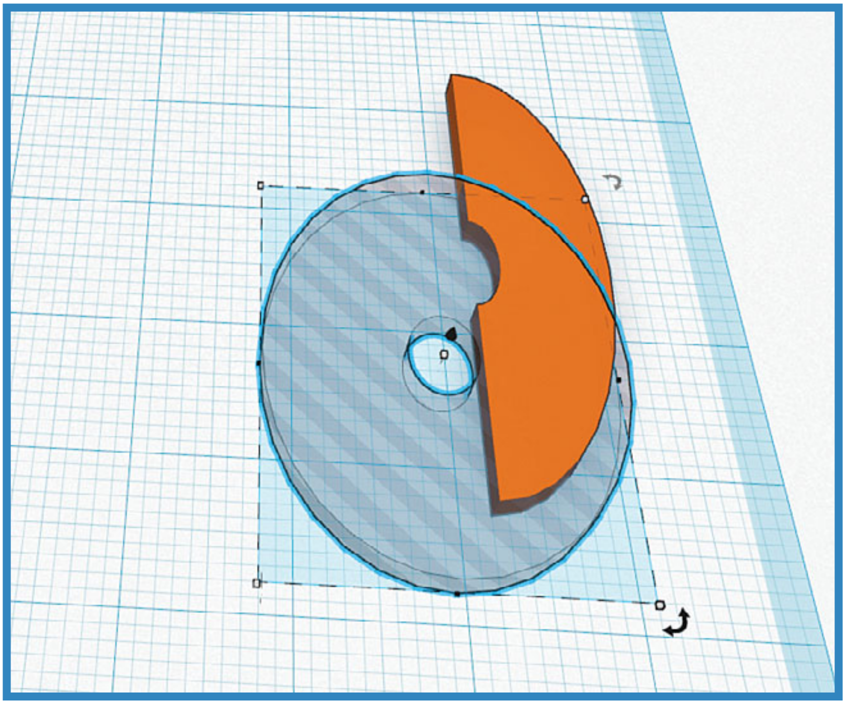

FIGURE 4.28 Creating the final fin requires another hole object.

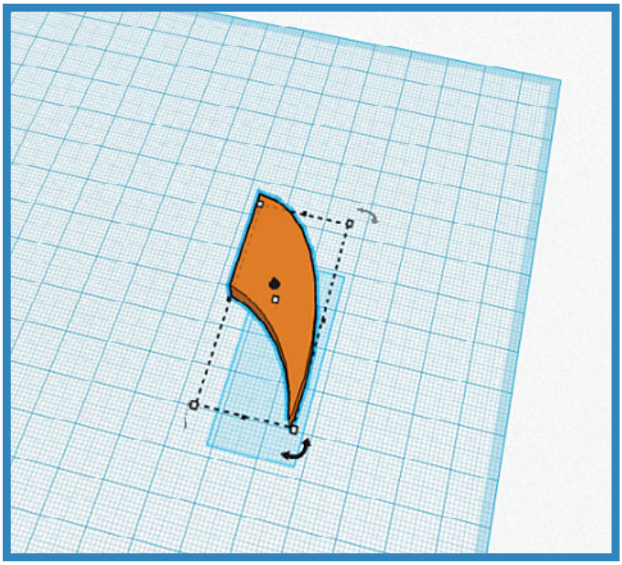

FIGURE 4.29 The final fin shape.

Now all that's left is to create two more fins. The fin should already be selected because when you group two objects, the final object is always selected when the grouping task is complete. You can simply make a copy of the object by pressing Ctrl+C on a Windows computer or Command+C on a Mac. You can also click on the Edit menu, as shown in Figure 4.30, and then click the Copy option.

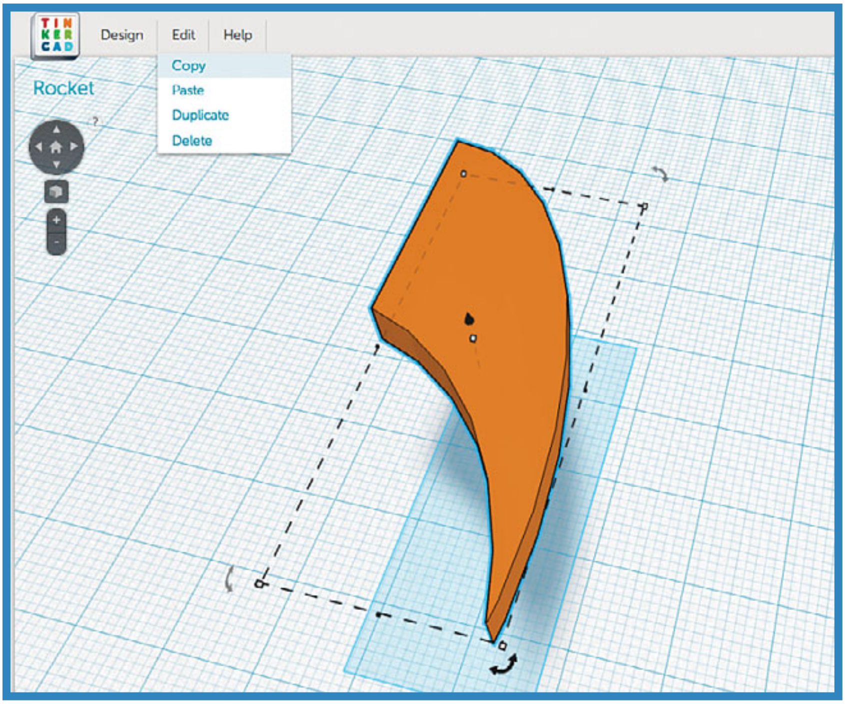

FIGURE 4.30 Copy the fin object and make two more.

Select the Edit menu again and click the Paste option to have a copy of the fin object placed on the workspace. Instead of using the menu, Windows users can press the Ctrl+V shortcut, and Mac users can press Command+V.

A pasted copy usually overlaps the original by a small amount. Just click the copy and drag it to a blank area of the workplane. Figure 4.31 shows my three final fin objects.

Zoom out a bit, and you can see all your parts ready for assembly to make the rocket and the launchpad, as shown in Figure 4.32.

Up next in Chapter 5, you'll learn how to combine the parts. This will involve some stacking and centering of objects as well as some rotating of parts (such as the fins).

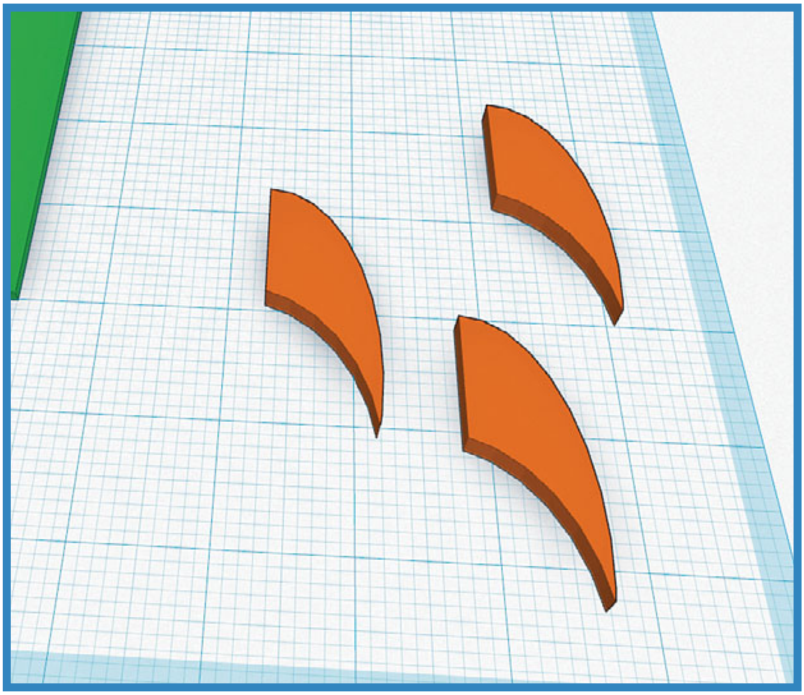

FIGURE 4.31 Three fins, ready to be attached to the rocket.

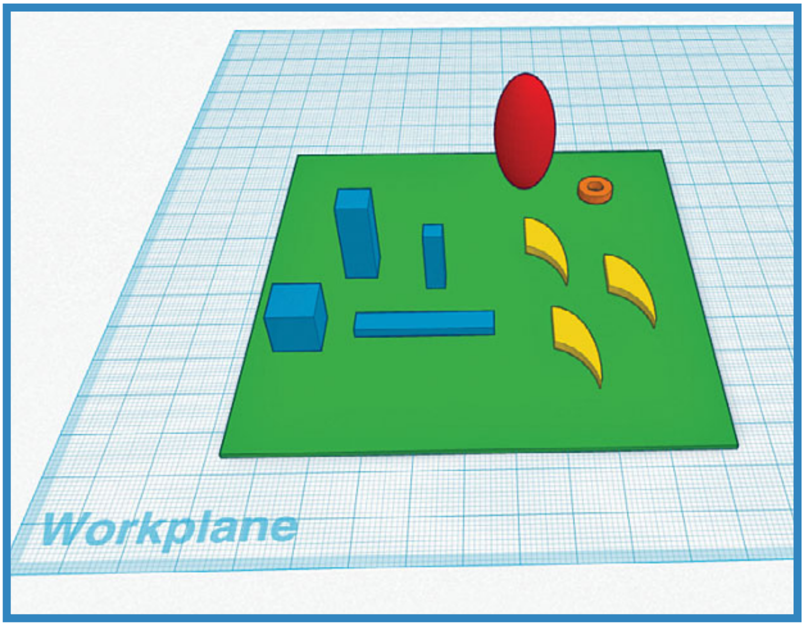

FIGURE 4.32 All the objects are ready for assembly.

Before you leave this chapter, think about some of the new skills you have acquired in Tinkercad:

- **Dragging an object around on the screen**—This involves simply clicking and holding on an object and placing it where you want it on the workplane.
- **Zooming in and out**—This will be useful when you want to get closer to a particular piece (such as one of the fins) for detail work or to view all your work at once.
- **Resizing objects**—By using the white dot controls, you learned how to modify an object's width, length, and height.
- **Changing color**—Changing the color of an object can make distinguishing parts of the larger model easier. Once parts are combined, a single color can be selected.
- **Converting an object to a hole object**—By creating an object and turning it into a hole object, you can remove material from a solid object.
- **Selecting multiple parts**—You can select more than one part at a time by holding down the Shift key and picking them one by one or else dragging a rectangle around them.
- **Copy and paste**—Copying and pasting copies of an object will save you lots of time when you begin making more complicated models.

You'll be learning many more Tinkercad skills in the chapters to come, but for now, feel free to create a new design of your own and play around with the other shapes available in the Geometric section. Take some time to experiment and use the skills you've acquired so you'll feel confident using them throughout the remaining chapters. See you in Chapter 5.

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