

Chapter 1

Unfolding the Mystery of Paper Engineering

In This Chapter

- ▶ Looking at pop-ups and pull tabs
 - ▶ Going artistic with paper sculpture
 - ▶ Creating paper animations
-

Whoever came up with the idea of *construction* paper had the right idea: Paper makes a great building material — you can easily fold, bend, tear, and cut it, and sticking the parts together requires nothing more than a bit of glue. In elementary school, you may have been a bit haphazard about putting stuff together. Now that you're (somewhat) grown up, you don't have to be any less creative, but you can do a lot more with paper when you play engineer and plan ahead.

Paper engineering basically means cutting and creating shapes with paper or card. With paper engineering, you can make pop-up and moving cards, and you can create elegant and sophisticated sculptures using interesting 3D shapes. You can even make fully working machines that use only paper for their mechanisms.

This chapter gives you an overview of the main types of paper engineering that I focus on in this book. You discover how pop-ups and pull tabs are made and how they work. I take a look at paper sculpture, a way of using the paper itself as the art medium rather than just using it as the place where the art is drawn. I also introduce you to paper animations, or *automata*, which are a kind of humorous machine that shows a short animated scene made entirely out of paper. (**Note:** If you get the basics down and want to try your hand at design, I can help you out there, too — simply check out Part IV of this book.)

Including the Right Supplies in Your Workplace

Paper engineering is a relatively inexpensive hobby. You need only a few tools and materials to get started. Here's a list of the tools and materials you need to take the first steps (check out Chapter 3 for details about these items and other items you may want to add to your workspace later):

- ✓ Scissors
- ✓ Sharp craft knife
- ✓ Self-healing cutting mat

- ✓ Ruler
- ✓ White school glue (and glue spreader)
- ✓ Glue stick
- ✓ A range of different types of paper and card stock



Using colored papers and different textures can all add to the final effect. From corrugated cardboard to homemade paper, and from embossed or textured papers to foil-coated, reflective card stock — all these materials are an inspiration to the paper artist. You can combine them for a fantastic effect. For example, you can use corrugated cardboard to make the texture of a tree trunk reflecting in a pond made from blue foil-coated card. See Figure 1-1 for an example that incorporates different paper types.



Figure 1-1:
Textured
paper adds
interest to
a relatively
flat project.

Flip to Chapter 2 for more on paper and to Chapter 3 for advice on tools, materials, and setting up your workspace. Of course, tools and materials don't do much good if you don't know how to use them, so check out Chapter 4 for some info on cutting and construction techniques.

Cutting Away with Cutout Greeting Cards

When you cut a shape out of a piece of paper, sometimes you're after the piece you just cut out. And sometimes you're after the leftover scraps, wanting to let the hole do the work for

you. Artists can give you a neat, technical discussion of positive and negative space, but for the paper engineer, the important idea is this: Cutouts can make great greeting cards. See Figure 1-2 for a sample where you cut out the word “Wow!” and use a different colored paper directly behind the cutout.

Instead of adding colors or paints, *cutout cards* use holes and cuts as their main decorations. Through the holes and cuts, you can see other paper of other colors or just an interesting shadow. You can make cutout cards with a craft knife using a whole variety of different weights and colors of card. Chapter 5 gives you several opportunities to make your own cutout cards.

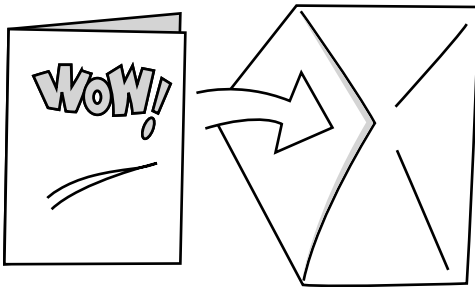


Figure 1-2:
A sample
cutout card.

Rising to the Occasion with Pop-ups

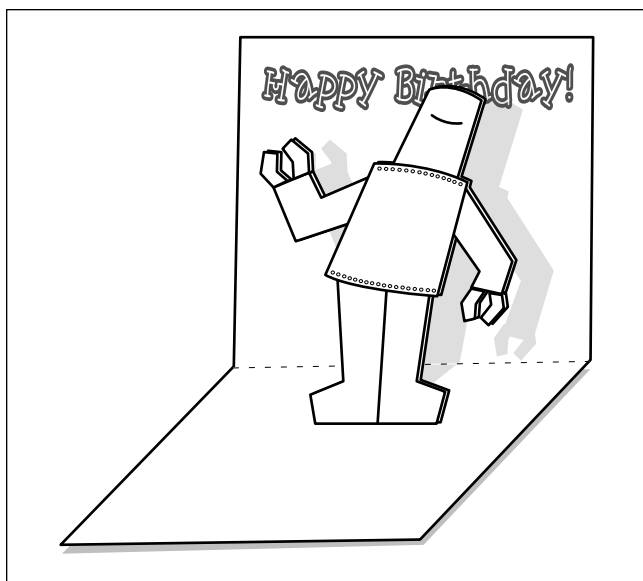
Pop-ups literally add a whole new dimension to books and greeting cards. Pop-ups use clever folds of paper to make ingenious mechanisms. When viewers open pop-up pages, anything can happen. You can open a greeting card and find that an entire 3D scene — complete with castles, knights, and a dragon — comes into view. Open another card, and a whole bunch of flowers appears like a magic trick. Even simple pop-ups can be surprisingly effective. This section gives you a quick overview of pop-ups. Check out Chapters 6 and 8 for more in-depth info.

Looking at how pop-ups pop up

With a pop-up, you open the page of the pop-up book (or card), and the character lifts into view. In the simplest pop-ups, you make the effect easily. A cutout of the character is fixed so that it sits just in front of the background. By clever use of paper tabs, the character folds flat when you close the book or card. Figure 1-3 shows an example of a simple pop-up card. The shadows cast on the background give the flat character dimension.

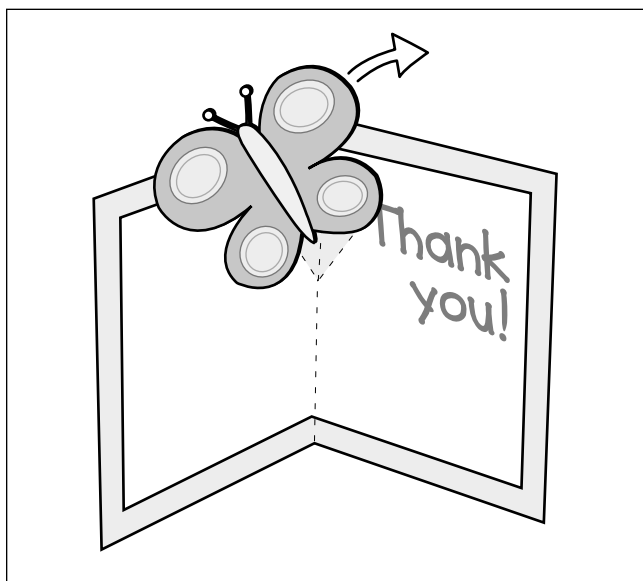
You can make more-complicated pop-ups by changing the way parts are folded and how the characters join together. If the fold and tabs that hold the card together are angled, then when the card opens, the character twists into position instead of just lifting straight up. Figure 1-4 shows how a character can swivel into view.

Figure 1-3:
A flat
character
in front of
a backdrop
appears to
have depth.



Even the most complicated pop-ups work using the same small set of mechanisms. When you understand these mechanisms, you can design your own amazing paper inventions.

Figure 1-4:
The parts
of a pop-up
can burst
out from
the edge of
the card.



Eyeing the different pop-up methods

Pop-ups come in all shapes and sizes. They use a variety of different mechanisms to do their popping. From the coffee-table books to greeting cards, each pop-up may use a single mechanism or a whole range of linked mechanisms. Read on to find out more about the types of pop-ups just waiting for your discovery:

✓ **Parallel pop-ups:** You may well have made the simplest type of parallel pop-up when you were at school. Usually, parallel pop-ups open only halfway so that the book or card is opened to 90 degrees. In front of the background of the card is one or more layers of pictures that are parallel to it. Figure 1-5 shows a typical parallel pop-up.

From this simple starting point, you can change and add to parallel pop-ups to make quite sophisticated pictures with very interesting mechanisms. With care, the movement of the picture as the card opens can really add to the project's impact.

✓ **Pop-out pop-ups:** The second common type of pop-up is the pop-out pop-up, which you most commonly see in books. With pop-out pop-ups, the pages open fully, and a 3D model appears miraculously in the middle of the page.

You can make fantastically complicated pop-out pop-ups that still fold flat, hiding their secrets within. Figure 1-6 shows an example from *Encyclopedia Prehistorica Dinosaurs: The Definitive Pop-Up*, by Robert Sabuda and Matthew Reinhart (Candlewick).

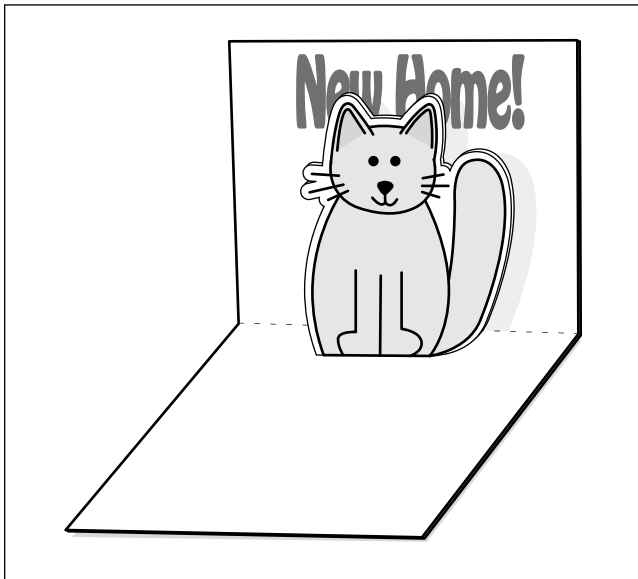


Figure 1-5:
A parallel
pop-up cat.

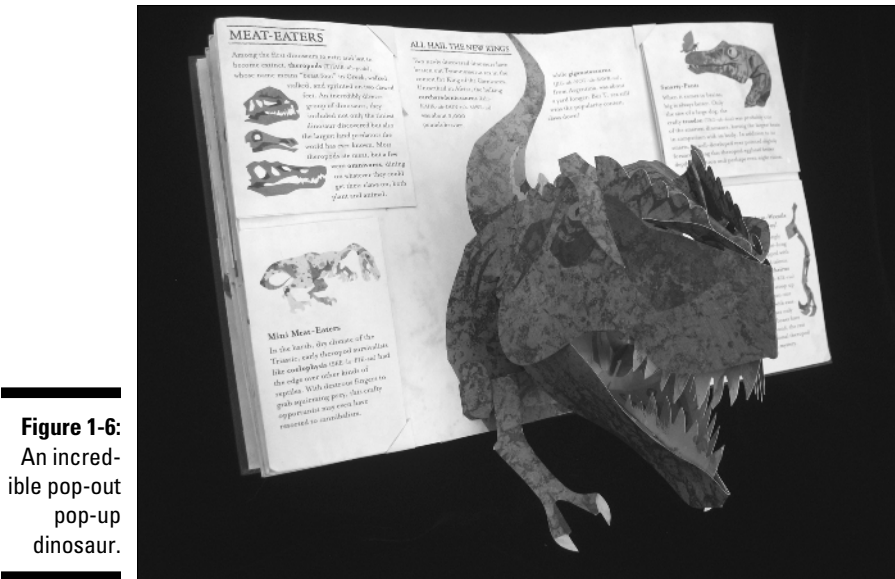


Figure 1-6:
An incredible pop-out
pop-up
dinosaur.

Used with permission from Robert Sabuda.

Chapter 6 explains how to make both kinds of pop-ups.

What you can do with pop-ups

Pop-up designers are always looking to push the limits of paper engineering. Look through some of the pop-up books in your local bookstore, and you'll be amazed at what people have achieved. Open the page, and a ship — complete with masts and sails — heaves into view over stormy seas. Turn the page, and a castle magically appears before your eyes. Figure 1-7, from *The Christmas Alphabet: Deluxe Anniversary Edition*, by Robert Sabuda (Orchard Books), shows the kind of effect you can create with pop-up scenes.

Of course, pop-ups aren't just for children's books. Authors and paper engineers have made all kinds of pop-up books for grown-ups, including lavishly illustrated books of plants and animals and even pop-up graphic novels. (**Note:** That's *graphic* as in visual arts, not how vivid and realistic the details are. A *graphic novel* — a handy term if you don't want to admit to reading comic books — is a bound book in comic-strip format.)

The surprise and delight of the movement also makes pop-ups ideal for all kinds of paper projects. Pop-up greeting cards are expensive to buy from a card shop because they need to be hand-assembled. But a homemade, home-designed card costs you nothing more than the modest material costs and a wee bit of your elbow grease. The fact they're homemade and individually designed makes them all the more delightful to the recipient! With care, you can even design business cards with pop-ups inside them. See Figure 1-8 for an example of a pop-up business card.

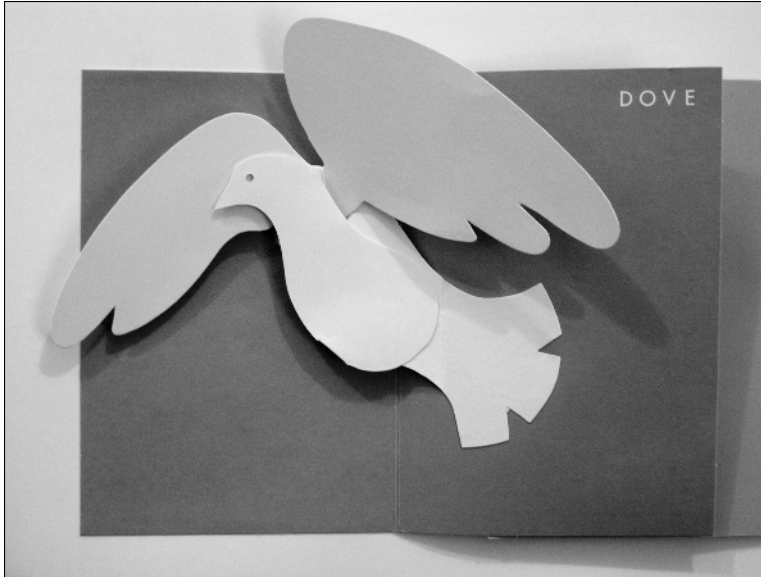


Figure 1-7:
A beautiful
paper dove
appears
when the
card opens.

Used with permission from Robert Sabuda



Figure 1-8:
Make your
business
cards
pop up.

Moving Pictures: Pull Tabs and Wheels

Pull tabs, wheels, and other ways of making part of a picture move are so often part of pop-up books that many people call all these mechanisms “pop-ups.” But these pictures usually don’t pop up, strictly speaking. Flat mechanisms rotate or slide a printed picture or piece of card across the page.

Each image in a pull-tab picture has one or more tabs. As the name implies, *pull tabs* are little strips of card, usually at the side of the picture, that you grab hold of and pull gently. As you pull, some sort of action takes place on the card — a piece rotates, slides, or jumps up from the page. For example, a penguin may jump into the sea, or a whale may dive beneath the waves. Pull the tabs, and magic happens.

Moving-picture books also use *paper wheels*. Often, these wheels, which are like giant washers, are mostly hidden within the page. Just grab the edge of the wheel and turn it, and you can see the picture change through a small hole in the page. You may see wheels that make a star twinkle or eyes move.

All kinds of moving pictures are possible. See Figure 1-9 for an example of a moving picture, and check out Chapters 7 and 8 for some pull-tab and wheel projects.

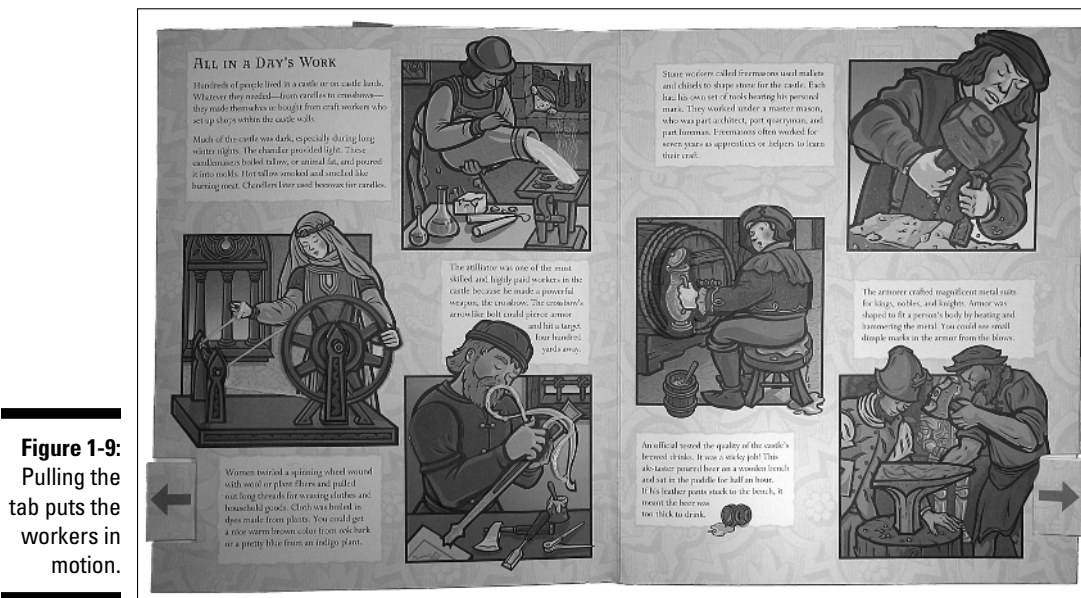


Figure 1-9: Pulling the tab puts the workers in motion.

Used with permission from *Castle: Medieval Days and Knights*, by Kyle Olman

Going 3D with Paper Sculpture

Fold a crease here and a curve of paper there; mix some interesting paper shapes and colors, and soon you’ve created an amazing paper sculpture. Artists of all kinds have

experimented with paper as a 3D medium. They've produced paper art from the abstract to the representative, from the tiny to the enormous. The results can be fabulous. The simple flowing form of the paper surface combined with the texture of the surface can make wondrous art pieces.

This section gives you the lowdown on how you can make 3D sculptures with paper. You can check out Chapter 9 for more in-depth information and several projects you can try.

Focusing on basic paper sculpture

Instead of paint or pencil, paper sculpture uses creases and cuts, light and shadow to create shapes for artistic effect. These sculptures can be freestanding, or they may be attached to a background and mounted on a wall. Figure 1-10 shows an example of paper sculpture.



Figure 1-10:
A freestanding paper sculpture.

Paper engineers use a whole range of interesting techniques with paper sculpture. Special score lines, in which you use the point of a pair of scissors to make a dent in a piece of

paper, can help you fold a curved 3D shape. You can curl paper by running it over a pen or pencil. And a number of creative folds — or the strategic application of glue — can transform a simple sheet of paper into a gallery-worthy (or at least mantel-worthy) masterpiece.

Folding paper Japanese-style

When people hear about paper modeling, one of the first things they think of is origami. Origami is a special case of paper sculpture. The word *origami* comes from Japanese words meaning “folding paper.” To fit with the modern definition of origami, the model must be made from a single square of paper with no cuts.

Even with these restrictions, all kinds of models are possible, from the traditional crane (as in Figure 1-11) to incredibly detailed models. Some modelers even work to themes. For instance, you can find Star Wars origami designs and designs based on popular comic book characters. Check out Chapter 9 for more on creating an origami crane.

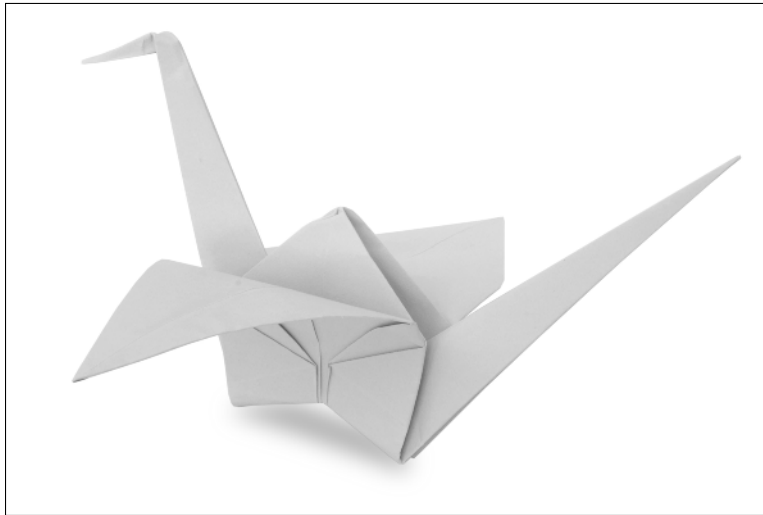


Figure 1-11:
The traditional origami crane.

Exploring other sculpture techniques

Paper is so versatile! This book introduces just a few of your paper-sculpting options, but don't let that limit you. Here are a couple other paper sculpture forms you can try:

- ✓ **Bas-relief:** Just barely 3D, bas-relief pictures use a little depth and some light and shadow to make a scene. You can create these pictures, as Figure 1-12 shows, by making a sculpted dent in a sheet of paper using a burnishing tool.
- ✓ **The long cut:** Some paper artists specialize in making 3D sculptures from a single sheet of paper. They use sharp craft knives to make cuts in the paper and then fold up and arrange the pieces to make a sculpture. This results in a subject that appears to grow out of the paper. Using this technique, artists such as Peter Callesen (www.petercallesen.com) create amazing paper art, such as a sheet of paper that looks

like a vast empty scene with a ruined building looming from the center. See Figure 1-13 for an example of a single-sheet model.

Figure 1-12:
A bas-relief
paper
picture.

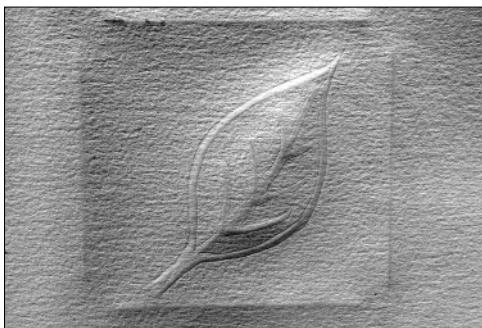
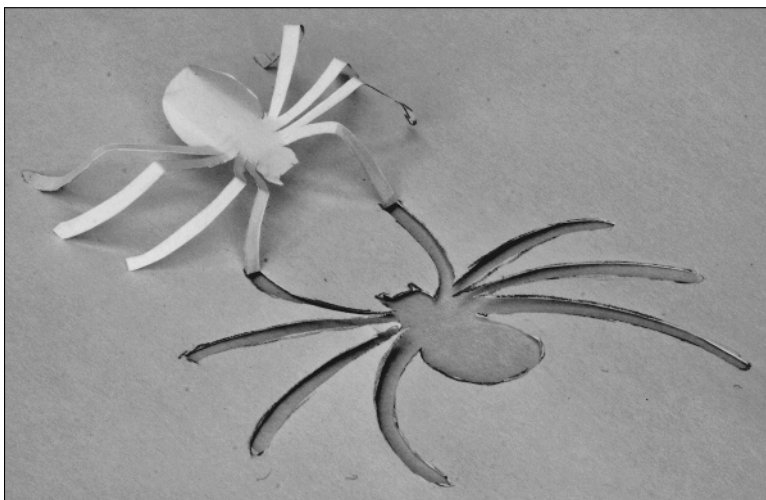


Figure 1-13:
A long-cut
spider rises
out of a flat
piece of
paper.



Bringing Paper to Life with Paper Animations

For many hundreds of years, talented artisans have tried to create the illusion of life. They designed and built machines — powered by clockwork or by the turn of a handle — that could imitate living things. Usually, these models, known as *automata*, would play a short scene over and over to the delight of the onlooker.

Traditional automata were usually made from wood, leather, and brass, but paper engineers love a challenge. Today, paper engineers create all kinds of intricate and amazing models from paper and card using paper levers and paper cams. For instance, paper pigs really can fly! Figure 1-14 shows a paper animation model that uses a crank to make the pig move. The wings are attached to the box top so that they flap as the pig moves up and down.

This section gives you an overview of paper animations, including the types of creations you can make. Flip to Chapters 10 through 12 for more in-depth info.

Automata through the ages

Through the ages, automata makers have amazed people with their skills. Automata in the temple would impress worshippers in Ancient Greek times. A moving statue of Athena, goddess of wisdom and war, would certainly encourage donations to the temple funds! The more impressive and lifelike the statue, the more generous the worshippers would be.

Even the great Leonardo da Vinci tried his hand at automata design back in the 15th century. In notebooks

rediscovered in the 1950s, Leonardo had drawn designs for a robot-type automaton that could move its arms, sit down in a chair, and stand back up again.

In the 16th century, the French engineer Jacques de Vaucanson created an automaton that could play the flute; supposedly it could play 12 different songs. He even created a mechanical duck that could eat corn and then poop!

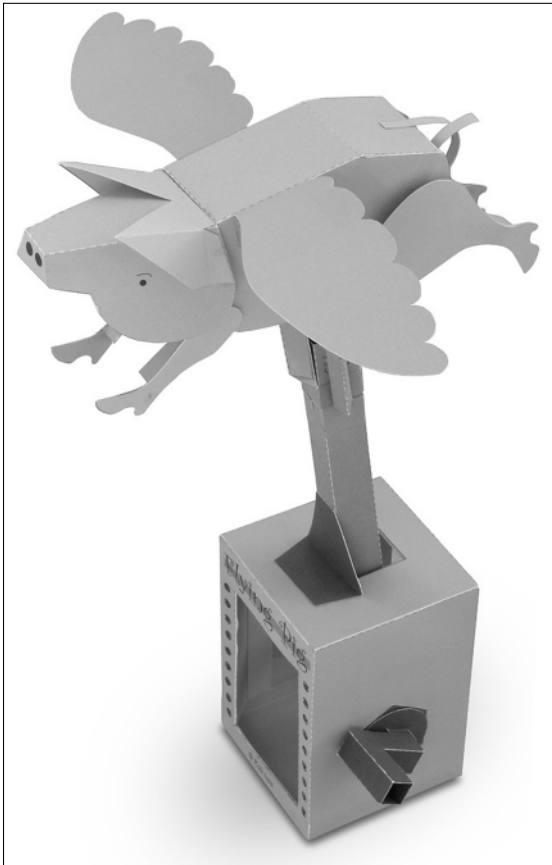


Figure 1-14:
Making
a pig fly
with paper.

Checking out the characteristics of paper animations

You can make all kinds of paper animations, or automata, by cleverly combining some basic mechanisms. These basic mechanisms include the following:

- ✓ **Cam:** A *cam* is an irregularly shaped piece fitted to a shaft or axle. When it turns, it pushes against another part, the cam follower, and moves it up and down.
- ✓ **Crank:** A *crank* (part of the crank-slider mechanism in Chapter 12) is the part that drives a piston up and down in a car engine. In paper animations, cranks likewise move parts up and down, sometimes in a circular path.

For example, a crank may move a surfboard, or a cam may make a bird peck. You can also create other paper mechanisms, such as gears and lever systems. In paper animations, all the parts are made from paper and they work together to tell the final story.

Most of the time you encounter paper animations, you find them in kits. A typical kit has several sheets of parts printed onto heavy paper or card, along with an instruction sheet. From there, creating your project is just a matter of cutting the parts out and gluing them together. Figure 1-15 shows a paper *Tyrannosaurus rex* from a kit I designed. This model uses different mechanisms to make the *T. rex* reach down and grab the hapless caveman.

With the projects in this book, I provide you with step-by-step instructions to create your own parts and make your own creations. Check out Chapters 10 through 12 for several different projects.



Figure 1-15:
A paper
T. rex.

Making moving parts

By itself, a sheet of paper isn't strong. However, you can make it quite strong by simply shaping the paper into tubes and box sections. Easy as that! From paper, you can create cranks, levers, and more. It's even possible to create gears, although they aren't as easy to make as the gears in traditional automata models. (Check out Figure 1-16 for an example of moving hens.)

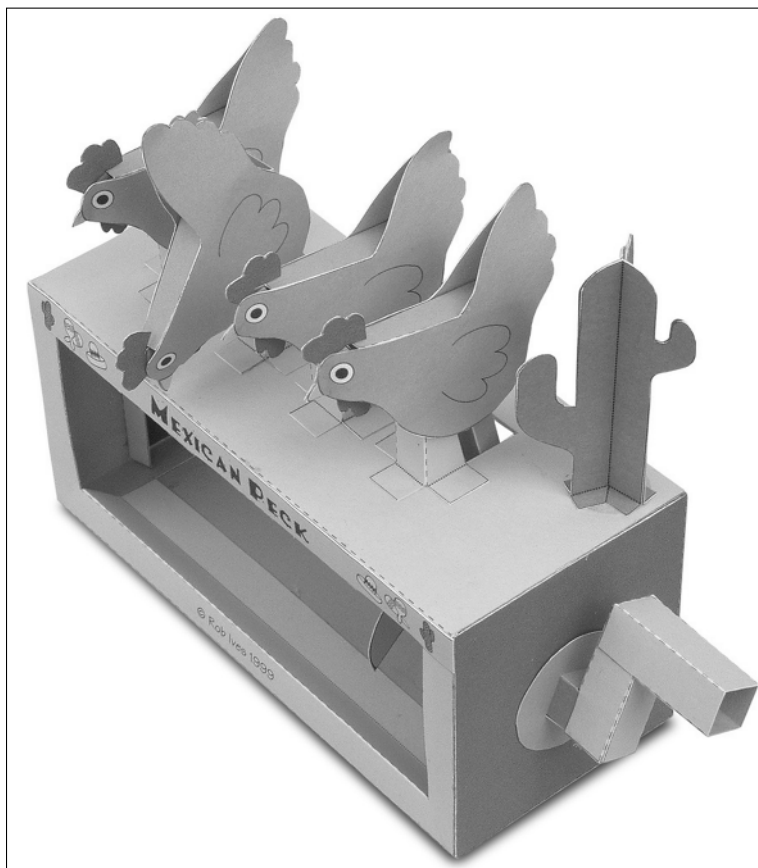


Figure 1-16:
Hens go up
and down.

Some designs work better than others, and inevitably paper does have its limitations. Some mechanisms are hard to construct using paper only. You just can't do certain things with paper because of its light weight and its tendency to fold, tear, or bend. However, you can use other items to get around the limitations. For example, some paper animations use a coin, string, pieces of dowel, and other items to help the mechanism work.

However, in my humble paper-engineering opinion, the best models use only paper. I sometimes use coins, but I try to avoid other nonpaper materials. The coiled spring is very useful in traditional automata design, but unfortunately, it's very difficult to replace in paper models; often, you have to replace springs with weights as a way of storing energy. Chapter 11 helps you build strong, moving parts with paper and explains how to use coins as weights.