# Introduction to Computer Graphics and 3D

This book is intended to introduce you to the workings of 3D animation (called computer graphics, or CG) with one of the most popular programs on the market, Autodesk Maya. It will introduce you to many of Maya's features and capabilities with the intent of energizing you to further study.

Having said that, let's face a basic fact: The best way to succeed at almost anything is to practice. Prepare to go through the exercises in this book, but also try to think of exercises and projects that can take you further in your learning process. A book, class, or video can take you only so far; the rest is up to you. Imagination and exploration will serve you well.

This is not to say you can't be a casual visitor to working in CG—far from it. Playing around and seeing what you can create in this medium is just flat-out fun. Don't lose sight of that. If you feel the enjoyment slipping away, step away from the screen for a while. Understanding your own learning pace is important.

Throughout this book, you'll learn how to work with Maya tools and techniques at a pace you set for yourself. This chapter will prepare you for the hands-on study that follows by introducing the most important CG concepts and the roles they will play in your Maya work. When you're learning how to work with Maya, the most important concept is discovering how you work as an artist. If you have a basic understanding of the methodology and terms of computer art and CG, you can skim or even skip this chapter and jump right into working with Maya.

Topics in this chapter include:

Art?

- Computer graphics
- The stages of production
- The CG production workflow
- Core concepts
- Basic film concepts

## Art?

Art, in many instances, requires transcendence of its medium; it speaks of its own accord. Art goes beyond the mechanics of how you create it (whether by brush or mouse) and takes on its own life. Learning to look beyond what you're working *with* and seeing what you're working *for* is the key to creating art with CG. Try not to view this experience as learning a software package, but as learning a way of working to an end. As you begin learning 3D with Maya, you acquire a new language—a new form of communication. Keep in mind that the techniques you acquire are only a means to the end.

#### Relax and enjoy yourself.

It's hard to relax when you're trying to cram so much information into your brain. But keep in mind that you should try not to make this experience about how a software program works; instead, make it about how you work with the software. Maya is only your tool.

When hiring professional 3D artists, CG studios keenly look for a strong artistic sense, whether in a traditional portfolio or a CG reel. Therefore, it's paramount to fortify the artist within yourself and practice traditional art such as life drawing, photography, painting, or sculpture as you learn CG, beginning with the core principles introduced in this first chapter. Keep in mind that the computer you'll be using for 3D work is nothing more than a tool. You run it; it doesn't run you.

3D is a part of the daily visual lexicon. With the availability of inexpensive and fast computers, everyone can create their own CG projects. Artists everywhere are adding the language of CG to their skill set. So before you start learning a particular CG tool—Maya, in this case—make sure you have a grasp of the fundamental issues underlying CG. It's important.

# **Computer Graphics**

CG and CGI are the abbreviations for *computer graphics* and *computer graphics imagery*, respectively, and are often used interchangeably. CG literally refers to any picture or series of pictures that is generated by an artist on a computer. However, the industry convention is to use the terms *CG* and *CGI* to refer to 3D graphics and not to images created using 2D image or paint programs such as Photoshop.

Most 2D graphics software is bitmap based, whereas all 3D software is vector based. Bitmap-based software creates an image as a mosaic of pixels, filled in one at a time. Vectorbased software creates an image as a series of mathematical instructions from one calculated, or graphed, point to another. This much more powerful method for creating graphics is behind all the impressive CG images you've seen in movies, videogames, and so on. It's also the method for the images you'll soon create with Maya. You'll learn more about vectors and bitmaps in the section "Computer Graphics Concepts" later in this chapter. If you're familiar with 2D graphics software, such as Adobe Illustrator or Adobe Flash, you already know something about vectors. Maya and other 3D graphics tools add the calculation of depth. Instead of drawing objects on a flat plane, they're defined in threedimensional space. This makes the artist's job fairly cerebral and very different than it is for 2D art; in 3D art, there is more of a dialogue between the left and right sides of the brain. When working with 3D graphics tools, you get a better sense of manipulating and working with objects, as opposed to dealing with the lines, shapes, and colors used to create 2D images.

## A Preview of the 3D Process

The process of creating in 3D requires that you either model or arrange prebuilt objects in a scene, give them color and light, and render them through a virtual camera to make an image. In essence, you create a scene that tells the computer what objects are in the scene, where the objects are located, what the colors and textures of the objects are, what lighting is available, and which camera to use in the scene. It's a lot like directing a liveaction production, but without any actor tantrums.

A large community on the Web provides free and for-pay models that you can use in your scenes. Sites such as www.turbosquid.com and www.archive3d.net can cut out a lot of the time you might spend creating all the models for a CG scene. This gives you the chance to skip at least some of the modeling process, if that isn't your thing.

With CG, you work in 3D space—an open area in which you define your objects, set their colors and textures, and position lights as if you were setting up for a live photo shoot. CG is remarkably analogous to the art and practice of photography and filmmaking.

Photographers lay out a scene by placing the subjects into the frame of the photo. They light the area for a specific mood, account for the film qualities in use, adjust the lens aperture, and fine-tune for the colors of the scene. They choose the camera, film, and lens based on their desired result. Then, they snap the pictures and digitally transfer them or develop them to paper. Through this process, a photo is born.

After you build your scene in 3D using models, lights, and a camera, the computer *renders* the scene, converting it to a 2D image. Through setup and rendering, CGI is born—and, with a little luck, a CG artist is also born.

*Rendering* is the process of calculating lights and shadows, the placement of textures and colors on models, the movement of animated objects, and so on to produce a sequence of 2D pictures that effectively "shoot" your virtual scene. Instead of an envelope of  $4 \times 6$  glossy prints, you get a sequence of 2D computer images (or a QuickTime or AVI [Audio Video Interleave] movie file) that sit on your hard drive waiting to be seen, and invariably commented on, by your know-it-all friends.

In a nutshell, that is the CG process. You'll need to practice planning and patience, because CG follows conventions that are different from those for painting programs and image editors. The CG workflow is based on building, arrangements, and relationships. But it's an easy workflow to pick up and master in time. It can be learned by anyone with the desire and the patience to give it a try.

## Animation

Animation is change over time. In other words, animation is the simulation of an object changing over a period of time, whether it's that object's position or size, or even color or shape. In addition to working in the three dimensions of space, Maya animators work with a fourth dimension: time.

All animation, from paper flipbooks to film to Maya, is based on the principle that when we see a series of rapidly changing images, we perceive the changing of the image to be in continuous motion. If you have a chance to pause and step through an animated film, frame by frame, on your DVD player or DVR, you'll see how animation comes together, literally step by step.

To create CG animation yourself, you have to create scene files with objects that exhibit some sort of change, whether through movement, color shift, growth, or other behavior. But just as with flipbooks and film animation, the change you're animating occurs between static images, called *frames*, a term carried over from film. You define the object's animation using a *timeline* measured in these single frames.

You'll learn more in the section "Basic Animation Concepts" later in this chapter. For now, let's move on to the stages of CG production.

# The Stages of Production

The CG animation industry inherited a workflow from the film industry that consists of three broad stages: preproduction, production, and post production. In film, *preproduction* is the process in which the script and storyboards are written, costumes and sets are designed and built, actors are cast and rehearsed, the crew is hired, and the equipment is rented and set up. In the *production* phase, scenes are taped or filmed in the most efficient order. *Post production* (often simply called *post*) describes everything that happens afterward: The scenes are edited into a story; a musical score, sound effects, and additional dialogue are added; and visual effects may also be added. (In a film that has special effects or animation, the actual CG creation is usually completed in post production. However, it may start in the preproduction phases of the film or project.)

Although the work performed at each stage is radically different, this is a useful framework for understanding the process of creating CG as well.

## Preproduction

Preproduction for a CG animation means gathering reference materials, motion tests, layout drawings, model sketches, and such together to make the actual CG production as straightforward as possible.

Because CG artists are responsible for defining their 3D scenes from the ground up, it's essential to have a succinct plan of attack for a well-organized production. The more time spent planning and organizing for CG, the better. Whether you're working on a small job or a complex film, entering into production without a good plan of attack will not only cause trouble, but also stunt the growth of your project.

In the real world, preproduction is part of every CG animation project. For the tutorial projects in this book, the sketches and other files supplied on the accompanying CD are your preproduction. Even for these tutorials, however, you should try to gather as much information as you can about the objects you'll create, going beyond what is presented. Having different perspectives on a subject is the key to understanding it. Disappointing movies often are the product of terribly flawed preproduction stages; likewise, a poorly thought-out CG production will invariably end in headaches and wasted time.

## The Script

To tell a story, CG or not, you should put it in words. A story doesn't need to contain dialogue for it to benefit from a script. Even abstract animations benefit from a detailed explanation of timings and colors laid out in a treatment (because there is likely no dialogue). The script or treatment serves as the initial blueprint for the animation, a place where you lay out the all-important *intent*.

## The Storyboard

A storyboard is a further definition of the script. Even a rudimentary storyboard with stick figures on notebook paper is useful to a production. You break the script into scenes, and then you break those scenes into shots. Next, you sketch out each shot in a panel of a storyboard. The panels are laid out in order according to the script to give a visual and linear explanation of the story. Storyboards are useful for planning camera angles (framing a shot), position of characters, lighting, mood, and so on.

## The Conceptual Art

*Conceptuals* are the design elements that you may need for the CG production. Typically, characters are drawn into character sheets in three different neutral poses: from the front, from the side, and from an angle called a *3/4 view*. You can also create color art for the various sets, props, and characters to better visualize the colors, textures, and lighting that will be needed. Props and sets are identified from the script and boards and then sketched out into model sheets. The better you visualize the conceptual art, the easier it will be to model, texture, and light everything in CG.

## Production

Production begins when you start creating models from the boards, model sheets, and concept art. You model the characters, sets, and props, and then you assign textures (colors, patterns). The animators take the models and animate everything according to the boards and script. The sequences are rendered in low quality for dailies and checked for accuracy and content.

The CG production phase can involve a variety of steps. The specific steps are defined by the needs of the production. Most of the CG techniques you'll learn in this book are part of the production phase. To make a long story short, 3D scenes are created, lit, and animated in the production phase.

## **Post Production**

After all the scenes have been set up with props and characters and everything is animated, post production can begin. Post production for a CG project is similar to post production for a film. This is where all of a CG film's elements are brought together and assembled into final form.

#### Rendering

*Rendering* is the process by which the computer calculates how everything in the scene should look and then displays it. As you'll learn throughout this book, the decisions you make in creating the objects in a scene can make a big difference in how the rest of the process goes.

Rendering makes significant processing demands on your computer, usually requiring the full attention of your PC. This can take a considerable amount of time. You can render one scene while another scene is in production, but asking a computer that is rendering to multitask isn't advisable unless you're using a dual-processor machine with plenty of memory.

When everything is rendered properly, the final images are sorted, and the assembly of the CG project begins. Rendering is discussed more fully in Chapter 11, "Maya Rendering."

We'll take a quick look at three more post-production activities: compositing, editing, and adding sound. These are advanced topics, and complete coverage is beyond the scope of *Introducing Maya 2011*. However, a multitude of books are available on these topics for further study.

#### Compositing

Quite often, CG is rendered in different layers and segments, which need to be put back together. In a particular scene, for example, multiple characters interact. Each character is rendered separately from the others and from the backgrounds. They're then put

together in *compositing*, or the process of bringing together scene elements that were created separately to form the final scene. Maya makes this process easier with Render Layers, which you'll experience in Chapter 11.

Compositing programs such as Maya Composite, Nuke, Digital Fusion, and After Effects allow you to compose CG elements together and give you some additional control over color, timing, and a host of other additions and alterations you can make to the images. Compositing can greatly affect the look of a CG project and can be an integral part of CG creation.

Many new animators try to generate their final images in a single rendering of their scene, but you don't need to do that. Realizing the component nature of CG is important; you can use components to your advantage by rendering items separately and compositing them together in the finishing stage. This gives you a lot of control in finishing the images to your satisfaction without always having to go back, change the scene, and re-render it.

#### Editing

The rendered and composited CG footage is collected and edited together to conform to the script and boards. Some scenes are cut or are moved around to heighten the story. This is essentially the same process as film editing, with one big difference: the amount of footage used.

To make sure they have adequate coverage for all their scenes and to leave extra room for creativity in editing, live-action filmmakers shoot quite a bit more footage than is needed for a film. The editor and the director sift through all the scenes and arrange them to assemble the film in a way that works best with what they have shot and with the performances they prefer. A typical film uses a fraction of all the film or video that is shot.

Because creating CG is typically more time-consuming and expensive than shooting live action, scenes and shots are often tightly arranged in preproduction boards so not much effort is wasted. The entire production is edited with great care beforehand, and the scenes are built and animated to match the story, almost down to the frame. Consequently, the physical editing process consists mostly of assembling the scenes into the sequence of the story. This is also why a good preproduction process is important. When you plan out what you want to get, you're much more likely to get it.

#### Sound

Sound design is critical to CG because viewers associate visuals with audio. A basic soundtrack can give a significant punch to a simple animation by helping to provide realism, mood, narrative, and so on, adding a greater impact to the CG. Sound effects, such as footsteps, are inserted to match the action on the screen. This type of sound is also known in film as *Foley sound*. Music is scored and added to match the film. Quite often, the dialogue or musical score inspires a character's actions or body language. Again, this is much the same procedure as in film, with one exception. In the event that a CG project requires dialogue, the dialogue must be recorded and edited *before* CG production can begin. Dialogue is a part of the preproduction phase as well as a component of post production. This is because animators need to hear the dialogue being spoken so they can coordinate the lip movements of the characters speaking, a process known as *lip-synch*.

## How It All Works Together

The process behind making a *South Park* episode is a perfect workflow example. Although the show appears to be animated using paper cutouts, as was the original Christmas short, the actual production work is now done using Maya. In preproduction on a typical episode, the writers hammer out the script, and the voice talent records all the voices before the art department creates the visuals for the show. The script is storyboarded, and copies are distributed to all the animators and layout artists.

At the beginning of the production phase, each scene is set up with the proper backgrounds and characters in Maya and then handed off for lip-synch, which is the first step in the animation of the scene. The voices are digitized into computer files for lip-synch animators who animate the mouths of the characters. The lip-synched animation is then passed to character animators who use the storyboards and the soundtrack to animate the characters in the Maya scene.

The animation is then rendered to start the post, edited together following the boards, and then sent back to the sound department for any sound effects needed to round out the scene. The episode is assembled and then sent off on tape for broadcast.

# The CG Production Workflow

Because of the nature of CG and how scenes must be built, a specific workflow works best. Modeling almost always begins the process, which then can lead into texturing, and then to animation (or animation and then texturing). Lighting should follow, with rendering pulling up the rear as it must. (Of course, the process isn't completely linear; you'll often go back and forth adjusting models, lights, and textures throughout the process.) Chapters 4 through 11 follow this overall sequence, presenting the major Maya operations in the same order you'll use in real-world CG projects.

## Modeling

Modeling, the topic of Chapters 4 through 6, is usually the first step in creating CG. It's the topic that garners a lot of coverage in publications and captures the interest of most

budding CG artists. You most often start a CG scene by creating the objects you need to occupy your space. It can end up taking the majority of the time in your process. This is why downloading or purchasing models from the Internet can often cut down the amount of time you spend on your project. This, of course, assumes you're not a fan of modeling and prefer to spend your time animating or working on texturing and lighting.

There are many modeling techniques, and each could be the subject of its own series of books. The choice of which technique to use usually depends on the modeler's taste and preferred workflow. The choices are among polygonal modeling (Chapter 4, "Beginning Polygonal Modeling"), NURBS modeling, and subdivision surface (SubD) modeling (Chapter 5, "Modeling with NURBS, Subdivisions, and Deformers"). Knowing how an object is used in a scene gives you its criteria for modeling. You never want to spend more time on a model than is needed. Creating a highly detailed model for a faraway shot will waste your time and expand rendering times needlessly. If you need to see a park bench in a wide shot from far away, the model doesn't need abundant detail or complicated surfacing. You can usually create any required details for it by just adding textures. However, if that park bench is featured prominently in a close-up, it needs as much detail as possible because viewers will see more of the bench. You'll learn more about this aspect of modeling in Chapter 4.

The more you use models in scenes, the better you'll develop your eye for exactly how much detail to provide. When you're starting out, however, it's a good idea to lavish as much attention on detail as you can; this can teach you perhaps 70 percent of what you can learn about modeling, which in turn will benefit your overall speed and technique. As you gain more experience, you'll be able to discern exactly how much detail to add to a scene and not go overboard.

#### **Character Modeling**

Character modeling usually involves organic forms, such as animals, humans, aliens, and such. Practically anything that is animated and portrays a character in a scene can be referred to as a *character model*. You need to create these with animation techniques in mind, as well as accuracy of form.

Some *organic* characters (for example, critters and people, as opposed to robots with mechanical parts and hard edges) are built with patches of surfaces stitched together or as single objects that are stretched and pulled into shape. Character models need to look seamless because most character animation requires the model to deform in some way—to bend and warp at certain areas such as the joints.

A character modeler needs to keep the future of the character in mind to allow for particular character animation methods that will be used. Quite frequently, you'll create several models for a character to account for different uses of that character and to keep the scene efficient and workable. You may create one character with fine facial detail for close-up speaking scenes and another with hardly any details for walk cycles in distant shots. Listen to your mother: don't get in over your head; do as much as you know you can finish properly.

#### Architectural and Environment Modeling

Architectural and environmental modeling includes architectural previsualization for the design of buildings as well as the generation of backgrounds for sets and environments. Typically, it involves modeling buildings or interiors as well as mountains or anything that is required for the scenery, such as benches, chairs, lampposts, and so on.

You shouldn't create incredibly detailed environments, especially ones that use a lot of *geometry* (that is, the objects in your scene), if they aren't closely featured in a shot. The greater the amount of geometry, the slower your computer will run and the longer rendering will take. If you reach a critical mass of too much geometry in your scene, it may not even render. You can create much of an environment by using clever textures and *matte paintings* on simple geometry. Matte paintings, which are detailed maps on bare surfaces, are used frequently for game environments. The rule of thumb for all kinds of CG is "use whatever works."

Because your computer stores everything in the scene as vector math, the term *geometry* refers to all the surfaces and models in a scene.

#### **Props Modeling**

Props modeling covers almost everything else needed in the scene. In theater and film terms, a *prop* is an object used by a character in the action; anything relegated to the scenery or background is a *scenic*. For example, a prop can be a purse a character is carrying, a leash on an animated dog, or a car a character is driving. If the car or purse were just sitting in the background, it would be considered a scenic.

## Texturing

When the models are complete, it's a good idea to begin *texturing* and *shading*, the process of applying colors and textures to an object to make it renderable. When you create an object in Maya, for example, a simple gray default shader is automatically assigned to it that will let you see the object when you light and render the scene.

Because the textures may look different after animating and lighting the scene, it's wise to leave the final adjustments for later. Just as a painter will pencil in a sketch before adding details, you don't need to make all the shading adjustments right away; you can return to any part of your scene in Maya and adjust it to fine-tune the picture.

You'll learn more about texturing and shading in Chapter 7, "Maya Shading and Texturing."

## Animation

You can make or break your scene with animation. We all have an innate sense of how things are supposed to move on a visceral level, if not an academic one. We understand how physics applies to objects and how people and animals move around. Because of this, viewers tend to be critical of CG's motion if it's not lifelike. Put bluntly, you know when something doesn't look right, and so will the people watching your animation.

To animate something properly, you may need to do quite a lot of setup beyond just modeling. Depending on the kind of animating you'll be doing, you may need to set up the models for however you've decided to animate them. For example, for character animation, you'll need to create and attach an armature, or skeleton, to manipulate the character and to make it move like a puppet in order to do your bidding.

Taking the models you've spent hours detailing and reworking and giving them life is thrilling and can make any detailed modeling and setup routine well worth the effort.

Chapter 8, "Introduction to Animation," and Chapter 9, "More Animation!" cover animation techniques in Maya.

## Lighting

*CG is fundamentally all about light*. Manipulating how light is created and reflected is what you're doing with CG. Without light, we wouldn't see anything, so it makes sense that simulating light is the most influential step in CG. Lighting can drastically alter the look of your scene; it greatly affects the believability of your models and textures and creates and heightens mood.

During the lighting step, you set up virtual lights in your scene to illuminate your objects and action. Although you can set up some initial lights during the texturing of the scene, the serious lighting should be the last thing you do, aside from changes and tweaks.

The type and number of lights you use in a scene greatly affect not just the look of your scene, but also the amount of time the scene takes to render. Lighting becomes a careful dance between pragmatics and results. It's perhaps the subtlest part of CG to master.

When you gain more experience with lighting, you'll notice that it affects every part of your CG creation. Before long, you'll start modeling differently—that is, modeling with the final lighting of the scene in mind. Texturing will change when you keep lighting techniques in mind. Even your animation and staging will change a bit to take better advantage of efficient, powerful lighting.

As you'll learn in Chapter 10, "Maya Lighting," virtual lights in Maya are similar to lights used in the real world, from a single point of light, such as a bulb, to directed beams, such as spotlights.

## Rendering

At this stage, your computer takes your scene and makes all the computations it needs to create raster (bitmapped) images for your movie. Rendering time depends on how much geometry is used in the scene as well as on the number of lights, the size of your textures, and the quality and size of your output: the more efficient your scene, the shorter the rendering times.

A lot of people ask how long they should expect their renders to take or how long is too long for a frame to render. It's a subjective question with no real answer. Your frames will take as long as they have to for them to look the way you want. Of course, if you have tight time or budgetary constraints, you need simple scenes to keep the render resources and times to a minimum. In production, you're always short on time, so having the most efficient pipeline possible will be your savior. If you don't work efficiently, your producer or supervisor eventually will tire of hearing, "But I'm still rendering."

That being said, it's important to understand *how* a scene is put together before you learn to put a scene together *efficiently*. While you're learning, use as many lights and as much geometry as you think you need for your scenes. The more experience you gain, the more efficient your eye will become.

# **Core Concepts**

CG animation draws from many disciplines. While learning Maya, you'll work with concepts derived not only from computer graphics, but also from design, film and cinematography, and traditional animation. Here's a summary of the most important of those concepts as they apply to Maya.

## **Computer Graphics Concepts**

Knowing a bit about the general terminology and methodology of computer graphics will help you understand how Maya works. Let's begin with the crucial distinction between raster (bitmapped) and vector graphics and how this distinction affects you as a Maya user.

#### **Raster Images**

Raster images (synonymous with bitmapped images) make up the world of computer images today. These images are displayed through the arrangements of colored pixels onscreen or dots on a print to display an image. Everything you create in Maya will eventually be seen as a raster image, even though you first create it using vectors.

Raster image programs, such as Photoshop, let you adjust existing settings such as color, size, and position for all or part of an image. They let you paint onto a scanned picture or a virtual canvas to adjust or create the pixels yourself. These programs affect pixels directly, giving you the tools to change pixels to form images. For instance, you can

use a scanned photo of your house in Photoshop to paint the side of the house red to see what it might look like before you run down to the local paint store.

A raster or bitmap image is a mosaic of pixels, so the *resolution* of an image is defined by the number of pixels in the horizontal and vertical directions. Because they're based on a grid of a fixed size, raster images don't scale up well. The closer you get to a raster image, the bigger the pixels become, making the image look blocky, or *pixelated*. To make large raster images, you need to begin with a higher resolution. The higher the resolution, the larger the file size will be. Figure 1.1 shows what happens when you blow up a raster image.



Most common raster displays are television or computer screens. In fact, the term *raster* originally referred to the display area of a television or computer monitor. To form an image, the electronics in these devices essentially paint it as a grid of red, green, and blue pixels on a glowing screen. Every image generated by a computer, therefore, must either begin as a raster image or be rasterized as part of rendering for display.

#### **Vector Images**

Vector images are created in a completely different way. They're formed using mathematical algorithms and geometric functions. Instead of defining the color of each and every pixel in a grid of a raster image, a vector image uses coordinates and geometric formulas to plot points that define *areas*, *volumes*, and *shapes*.

Popular vector-based image applications include Adobe Illustrator and Flash, as well as practically all computer-aided design (CAD) programs, such as AutoCAD and SolidWorks. These programs let you define shapes and volumes and add color and texture to them through their toolsets. They store the results in scene files containing coordinates and equations of points in space and the color values that have been assigned to them. This vector information is then converted into raster images (called *rasterization*) through rendering so you can view the final image or animation.

When scaled, vector graphics don't suffer from the same limitations as raster images. As you can see in Figure 1.2, vectors can be scaled with no loss of quality; they will never pixelate. Figure 1.1

A raster image at its original size (left) and blown up several times (right)

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Figure 1.2 A vector image at its original size (left) and blown up quite a bit (right)



Motion in vector programs is stored not by a long sequence of image files, but through changes in positions of the geometry and in the math that defines the shapes and volumes. When a Flash cartoon is played on a website, for example, the information downloaded and fed to your computer is in vector form. Your computer then renders this information on the fly in real time into a raster display of the content that you can (you hope) enjoy on your screen.

When you work in Maya, vectors are displayed as wireframes. When you finish your scene, Maya renders the image, converting the vector information into a sequence of raster images you can play back.

#### Image Output

When you're done with your animation, you'll probably want as many people as possible to see it (and like it!). To make that happen, you have to render it into a file sequence or a movie file. The file can be saved in any number of ways, depending on how you intend it to be viewed.

#### COLOR DEPTH

An image file stores the color of each pixel as three values representing red, green, and blue. Image type depends on how much storage is allotted to each pixel (the *color depth*). These are the color depths common to image files in CG production:

**Grayscale** The image is black and white with varying degrees of gray in between, typically 256 shades of gray. Grayscale images are good for rendering out black-and-white subjects as well as being used for some types of texture maps like displacement maps.

**8-Bit Image File (a.k.a. 24-Bit Color Display)** Referred to as 24-bit color display or True Color in desktop settings for Windows, each color channel is given 8 bits for a range of 256 shades of each red, green, and blue channel, for a total of 16 million colors in the image. This color depth gives good color quality for an image and is widely used in most animation applications. Most of your renders from Maya will probably be as 8-bit image files, because most monitors are only capable of 8-bit color reproduction in playback.

**16-Bit Image File** Used in television and film work using such file types as TIFF16, a 16-bit image file holds 16 bits of information for each color channel, resulting in an impressive number of color levels and ranges. Each file can exceed several megabytes even at low resolutions. These files are primarily used in professional productions, although they're being supplanted by the use of 32-bit images.

**32-Bit Image File** This is where the big kids play. Used primarily for film work but increasingly in general use, 32-bit image files, such as the OpenEXR format, give you an incredible amount of range in each color channel. This lets you adjust a wide range of tones and hues in your rendered output for the fullest detail. They're pretty much standard for film work because outputting CG to film can require high levels of color and brightness range in the image.

**High Dynamic Range Imagery (HDRI)** HDRI images are 32-bit float images that are created by combining several digital photos into one image file. For example, photos are taken of a subject with different levels of light using various exposures during photography. With a "32 bit float" file format, a lot of information can be stored about the colors in the image; i.e. a very high bit depth is achieved. This way, you have a series of images that range from dark (with very fast exposure) to normal (with proper exposure time) to blown out brightness (with overexposure). These different exposures are then compiled into a single HDR file format (.hdr) that represents a wider range of light and dark than a typical photo. These files are traditionally used as lighting setups, especially for scenes in which CG is integrated with a live-action background using image-based lighting (IBL), a concept we'll touch on in Chapter 11.

#### COLOR CHANNELS

As mentioned, each image file holds the color information in *channels*. All color images have red, green, and blue color channels that, when viewed together, give a color image. Each channel is a measurement of how much red, green, or blue is in areas of the image. A fourth channel, called the *alpha* channel, is used as a transparency channel. This channel, also known as the *matte* channel, defines which portions of the image are transparent or opaque. Not all image files have alpha channels. You can read more about alpha channels in Chapter 7.

#### FILE FORMATS

In addition to image types, several image file formats are available today. The most common is probably JPEG (Joint Photographic Experts Group), which is widely used on the Internet.

The main difference between file formats is how the image is stored. Some formats compress the file to reduce its size. However, as the degree of compression increases, the color quality of the image decreases.

The popular formats to render into from Maya are TIFF (Tagged Image File Format), Maya IFF (Maya Image File Format), and Targa. These file formats maintain a good 8-bit image file, are either uncompressed or barely compressed (lossless compression), and are frequently used for broadcast or film work. These formats also have an alpha channel, giving you better control when you later composite images together. To see an animation rendered in a file sequence of TIFFs, for example, you must play them back using a frame player such as FCheck (which is included with Maya) or IRIDAS FrameCycler, or compile them into a movie file using a program such as Adobe After Effects.

Ultimately, your final image format depends on the next step in your project. For example, if you plan to composite your CG, you'll need to output a format that can be imported by your compositing or editing program. TIFF files are perhaps the best format to use, because they're widely compatible, store uncompressed color, and have an alpha channel. You might also consider outputting to 16-bit or even 32-bit float images to give you the greatest range of color when you fine tune the image sequences. For the vast majority of your work as a beginner, you'll be working in 8 bit.

#### **MOVIE FILES**

Animations can also be output to movie files such as AVI or QuickTime. These usually large files are self-contained and hold all the images necessary for the animation that they play back as frames. Movie files can also be compressed, but they suffer from quality loss the more they're compressed.

Maya can render directly to an uncompressed AVI movie format, saving you the seeming hassle of having to render out a large sequence of files. Although rendering directly to an AVI movie may seem like a good idea, it usually isn't. It's best to render a sequence of files that can easily be compiled into a movie file later using a program such as Adobe After Effects, Premiere, or QuickTime Pro. The primary reason is simple: your render may crash, or your machine may freeze. In such an event, you need to start your AVI render from the beginning, whereas with images (like TIFFs) you can pick up right after the last rendered frame. Rendering frames is just the better way to go.

#### Color

Color is how we perceive the differences in the wavelengths of light. The wide range of colors that we see (the visible spectrum) results when any of three *primary colors* of

light—red, green, and blue—are "mixed" together. You can mix color in two ways: subtractive and additive. These color definitions are most often displayed in *color wheels*, which equally space the primary colors around a ring and place the resultant colors when primaries are mixed in between the appropriate primaries.

Knowing more about color will help you understand how your CG's color scheme will work and help you design your shots with greater authority. (See the reading list at the end of this chapter for some books that expound on color theory and composition.)

#### SUBTRACTIVE AND ADDITIVE COLOR

Subtractive color mixing is used when the image will be seen with an external light source. It's based on the way reflected light creates color. Light rays bounce off colored surfaces and are tinted by the different pigments on the surface. These pigments absorb and reflect only certain frequencies of the light hitting them, in essence *subtracting* certain colors from the light before it gets to your eyes. Pile up enough different colors of paint, and you get black; all the colors are absorbed by the pigment, and only black is reflected.

When subtractive color mixing is used in painting, the traditional color wheel's primary colors are red, yellow, and blue. These three pigments can be mixed together to form any other color pigment, and they form the basis for the color wheel most people are exposed to in art education in primary school. In the world of print production, however, a CMYK (Cyan, Magenta, Yellow, and blacK) color wheel is used. Cyan, yellow, and magenta ink colors are the primary colors used to mix all the other ink colors for print work.

Projected light is mixed as *additive color*. Each light's frequency adds on to another's to form color. The additive primary colors are red, green, and blue. These three colors, when mixed in certain ratios, form the entire range of color. When all are equally mixed together, they form a white light.

A computer monitor uses only additive color, mixing each color with amounts of red, green, and blue (RGB).

*Warm colors* are those in the magenta to red to yellow range, and *cool colors* are those in the green to cyan to blue range of the additive color wheel. Warm colors seem to advance from the frame, and cool colors seem to recede into the frame.

#### HOW A COMPUTER DEFINES COLOR

Computers represent all information, including color, as sets of numeric values made up of binary numbers—0s and 1s (bits). In an 8-bit color file, each pixel is represented by three 8-bit values corresponding to the red, green, and blue channels of the image. An 8-bit binary number ranges from 0 to 255, so for each primary color you have 256 possible levels. With three channels, you have  $256 \times 256 \times 256$  (16.7 million) possible combinations of each primary color mixed to form the final color.

Color value can also be set on the hue, saturation, and value (HSV) channels. Again, each channel holds a value from 0 to 255 (in an 8-bit image file); these values combine to define the final color. The hue value defines the actual tint (from red to green to violet) of the color. The saturation defines *how much* of that tint is present in the color. The higher the saturation value, the deeper the color will be. Finally, value defines the brightness of the color, from black to white. The higher the value, the brighter the color will be.

HSV and RGB give you different methods to control color, allowing you to use the method you prefer. All the colors available in Maya, from textures to lights, are defined as either RGB or HSV values for the best flexibility. You can switch from HSV to RGB definition in Maya at any time.

#### CMYK COLOR

A CMYK color wheel is used for print work, and this is referred to as the *four-color process*. Color inkjet printers produce color printouts by mixing the appropriate levels of these inks onto the paper.

All output from a computer, which is RGB based, to a printer goes through a CMYK conversion as it's printed. For professional print work, specially calibrated monitors are used to enhance previewing the CMYK color of an RGB image before it's printed. Fortunately, only print professionals need to worry about this conversion process, because most of it is handled by graphics software to a fairly accurate degree.

#### VIEWING COLOR

The broadcast standard for North America is NTSC (National Television System Committee). One joke in the industry is that the acronym means Never The Same Color, referring to the fact that the color you see on one TV screen will be different from what you see on another screen. The same holds true for computer monitors, especially flat-panel displays. All displays are calibrated differently, and what you see on one screen may not be exactly what you see on another screen.

If it's important to have consistent color on different screens, say on your home and school computers, you can use traditional color bars downloaded from the Internet or your own custom-made color chart to adjust the settings of the monitors you work with so they match more closely. If color is absolutely critical when you're working in a group, it's important for everyone to view color output on a single screen.

#### **Resolution, Aspect Ratio, and Frame Rate**

*Resolution* denotes the size of an image by the number of horizontal and vertical pixels, usually expressed as  $\# \times \#$  (for example,  $640 \times 480$ ). The higher the resolution, the finer the image detail will be.

You'll adjust your final render size to suit the final medium for which you're creating the animation. Table 1.1 lists some standard resolutions.

ΝΑΜΕ	SIZE	NOTES	Table 1.1
VGA (Video Graphics Array)	640×480	Formerly the standard computing resolution and still a popular television resolution for tape output.	Typical Video Resolutions
NTSC D1 (National Television System Committee)	720×486	The standard resolution for broadcast television in North America.	
NTSC DV	720×480	Close to the NTSC D1 resolution, this is the typical reso- lution of digital video cameras.	
PAL (Phase Alternation Line)	720×586	The standard broadcast resolution for most European countries.	
HDTV (High Definition TV)	1920 × 1080	The emerging television standard, sometimes also referred to as 1080i (interlaced frames) or 1080p (pro-gressive frames).	
1K Academy (1K refers to 1000 pixels across the frame)	1024 × 768	Typically the lowest allowable resolution for film pro- duction at Academy ratio (see Table 1.2). Because film is an optical format (whereas TV is a raster format), there is no set defined resolution for film. Suffice it to say, the higher the better.	
2K Academy (2K refers to 2000 pixels across)	2048×1556	Most studios output CG for film at this resolution, which gives the best size-to-performance ratio.	
4K Academy (4K is 4000 pixels across)	4094×3072	A high resolution for film, used for highly detailed shots.	

Any discussion of resolution must include the matter of *aspect ratio*. Aspect ratio is the ratio of the screen's *width* to its *height*. Aspect ratio standards are shown in Table 1.2.

NAME	SIZE	ΝΟΤΕΣ	Table 1.2
Academy Standard	1.33:1 or 4:3	The most common aspect ratio. The width is 1.33 times the length of the height. This is the NTSC television aspect ratio as well as the aspect ratio of 16mm films and some 35mm films, including classics such as <i>Gone</i> <i>with the Wind</i> .	Aspect Ratio Standards
Widescreen TV	1.78:1 or 16:9	With HD and widescreen TVs gaining popularity, the 16:9 standard is commonplace now. This aspect is used in HD programming and is also the aspect ratio of many widescreen computer monitors and laptops. This aspect is very close to the way most films are displayed (1.85:1, as shown next).	
Widescreen Film (a.k.a. Academy Flat)	1.85:1	The most-often-used 35mm film aspect today. When it's displayed on a television, horizontal black bars appear above and below the picture so the edges aren't cropped off (an effect called <i>letterboxing</i> ).	
Anamorphic Ratio	2.35:1	Using an <i>anamorphic</i> lens, the image captured to 35mm film is squeezed. When played back with a projector with an anamorphic lens, the image is projected with a width at 2.35 times its height. On a standard TV, the let- terboxing is more severe to avoid cropping the sides.	

The number of frames played back per second determines the *frame rate* of the animation. This is denoted as *fps*, or frames per second. The following are the three standard frame rates for media:

- NTSC: 30fps
- PAL: 25fps
- Film: 24fps

Knowing your output medium is important when beginning an animation project. Although it isn't crucial, it can affect how you design your framing, create your movements, render your project, and so on. You can change the frame rate and render resolution at any time in Maya, but it's always better to know as best you can what the final resolution and fps will be before you begin.

Playing back a 24fps animation at 30fps will yield a slower-moving animation and will necessitate either repeating some frames to fill in the gaps or ending the animation early. Conversely, playing a 30fps animation at 24fps will create a faster-moving animation that will either skip some frames or end later than it should.

#### 3D Coordinate Space and Axes

Three-dimensional space is the virtual area in which you create your models and execute your animation. It's based on the Cartesian coordinate system, a geometric map of sorts developed by the brainy René Descartes. Knowing where you are at all times is essential with a 3D program. You can do so if you understand the toolset you're working with and the 3D space in which you're working.

Space is defined in three axes—X, Y, and Z—representing width, height, and depth. The three axes form a numeric grid in which a particular point is defined by *coordinates* set forth as (#,#,#), corresponding to (X,Y,Z), respectively.

At the zero point of these axes is the *origin*. This is at (0,0,0) and is the intersection of all three axes. The 3D space defined by these three axes is called the *World axis*, in which the *XYZ* axes are *fixed references*. The axis in *World Space* is always fixed and is represented in Maya by the XYZ Axis icon in the lower-left corner of the Perspective windows.

Because objects can be oriented in all sorts of directions within the World axis, it's necessary for each object to have its own width, height, and depth axis independent of the World axis. This is called the *Local axis*. The Local axis is the *XYZ*-coordinate space that is attached to every object in Maya. When that object rotates or moves, its Local axis rotates and moves with it. This is necessary to make animating an object easier as it moves and orients about in the World axis.

You'll get a hands-on introduction to Maya's Cartesian coordinate space in the tutorial in Chapter 2, "Jumping in Headfirst, with Both Feet," where you'll re-create the solar system with the Sun placed at the origin, the planets orbiting the World axis and rotating on their own Local axes, and moons orbiting the planets and also rotating (see Figure 1.3).

Figure 1.3

The Sun at the origin, Earth and other planets orbiting the World axis while rotating on their own axes, and the Moon orbiting Earth



## **Basic Design Concepts**

Composition is all about how you lay out your scene and design your colors. Creating a dynamic frame that not only catches the eye but also informs and intrigues is itself an art form.

Some background in basic design is definitely helpful, and you'll want to look at design books as you further your education in 3D. Understanding the fundamentals of layout and design makes for better-looking scenes and easier setup. The concepts presented here will get you started. Design theory may not seem specifically pertinent to CG right now, but recognizing that there is a logical system behind every pretty picture will help you progress, both as an artist and as an animator.

#### Form, Space, and Composition

Space is your canvas. Because your canvas ultimately will be a rendered image, your composition needs to fit within your rendered image frame. Whether that frame falls into a tiny web window or a huge IMAX screen, the basics of design always apply: how you arrange your forms and divide your space says a lot.

In the design lexicon, *form* means anything you can see; it has some sort of shape, color, or texture that distinguishes it from its frame. How your scene's objects lie in the frame defines your composition. The space behind and between what is rendered out is the ground, or background plane. Objects become *positive space*, and the background becomes *negative space*.

To viewers, positive space tends to proceed forward from the frame, whereas negative space recedes. Playing with the position of positive and negative space greatly affects the dynamics of your frame.

Design a static frame in which the objects are all centered and evenly spaced, and your viewers will wonder why they're looking at your composition. Arrange the composition so that your subjects occupy more interesting areas of the frame in which they play with negative space, and the eye is drawn all over the frame, creating a dynamic composition. This principle applies to still images as well as to animation.

In the tutorial in Chapter 10, you'll use light and shadow to turn a still life of fruit into a dynamic and interestingly composed frame.

#### **Balance and Symmetry**

Balance in a frame suggests an even amount of positive space from one side of the frame to the other. A frame that is heavier on one side can create a more dynamic composition.

Symmetrical objects in a frame are mirrored from one side to another and create a certain static balance in the frame. An asymmetrical composition, therefore, denotes movement in the composition.

A popular technique used by painters, photographers, and cinematographers is called *framing in thirds*. With this technique, the frame is divided into a grid of thirds vertically and horizontally. Interesting parts of the frame, or focal points of the subjects, are placed at strategic locations in the grid. Placing your subject in the lower third makes it seem small or insignificant, static, or even boring. Placing it in the upper third makes the image more dynamic, magnifying its perceived scale or importance, and even tells a better story. Figure 1.4 illustrates the difference between a static, symmetric frame and a frame based on thirds.



Figure 1.4

A purely symmetrical frame looks static; the boy seems still with nowhere to go. Framing in thirds helps create or heighten a sense of motion, giving space for the boy to run.

## Contrast

*Contrast in design* describes how much your foreground subject "pops" from the background. As you can see in Figure 1.5, when you create an area in your frame that contains little variation in color and light, the image seems flat and uneventful. Using dark shadows and light highlights increases the perceived depth in the image and helps pop out the subject from the background. Animating contrast can help increase or decrease the depth of your frame.

As you'll see in Chapter 10, light plays an important role in creating dynamic contrasts within your frame.



#### Color

Your use of color also plays a big part in creating impact in your frame. As stated earlier, warm colors tend to advance toward you, and cooler colors seem to recede into the frame. Placing a warm color on a subject on a cool background creates a nice color contrast to help the dynamics of your frame.

Colors opposite each other on the color wheel are *complementary* colors and usually clash when put together. Using complementary colors can create a wide variation of contrast in your scene.

#### Narrative

A *narrative film* is a film that tells a story of a hero, called a *protagonist*, and that hero's struggle against an *antagonist*. Even in the most abstract concept, there can be a perceived journey: a change that somehow occurs, even if it's a change in the viewer as they view the imagery.

#### Figure 1.5

With low contrast, the subject seems to disappear into the background. If you add shadows and highlights, the subject pops out. Convincing art creates a sense of change or arc for the audience. This adds an important dimension to your work. When the viewer feels you have something to say, your work becomes that much more touching.

# **Basic Film Concepts**

In addition to the design concepts used in framing a shot, you'll want to understand some fundamental filmmaking concepts.

There's nothing more important than having a solid, manageable, and achievable plan for your conceptual goal. Almost everybody in production lays out this plan in advance of the principle photography. You can't run into the street with someone else's expensive camera and not know what you're going to shoot. CG takes time. Put together a good plan, and you'll be set for a good production.

## **Planning a Production**

Understanding the paradigm that conventional filmmakers use for their productions will give you a good structure for planning, creating, and managing your own projects. Most narrative films are broken into acts, which comprise sequences made up of scenes, which in turn are made up of shots. By using a similar layout in the scripting and storyboarding of your own short, you'll find that the entire production process becomes easier and the effect of your film is stronger.

Narrative films are typically divided into three *acts*. The first act establishes the main characters and the conflict or struggle that will define the story. The second act covers most of the action of the story as the hero attempts to overcome this conflict. The third act concludes the film by resolving the action in the story and tying up all the loose ends.

Acts can be deconstructed further into *sequences*, which are groups of sequential scenes that unite around a particular dramatic or narrative point.

A *scene* is a part of a film that takes place in a specific place or time with specific characters to present that part of the story. Films are broken into scenes for organizational purposes by their locations (that is, by where or when they take place).

Don't confuse the filmmaking concept of a scene with the word *scene* in CG terminology. The latter refers to the elements in the 3D file that make up the CG.

Scenes are then broken into *shots*, which correspond to a particular camera angle or *framing*. Shots break up the monotony of a scene by giving different views of the scene and its characters. Shots are separated by *cuts* between each shot.

Shots are defined by angle of view, which is the point of view (POV) of the camera. Shots change as soon as the camera's view is changed.

## Lighting

Although CG lighting techniques may seem completely different from lighting in real life, the desired results are quite often the same. The more you understand how real lights affect your subjects in photography, the better you'll be at CG lighting.

Without lights, you can't capture anything on film. How you light your scene affects the contrast of the frame as well as the color balance and overall design impact. If the lights in your scene are too flat or too even, they will weaken your composition and abate your scene's impact.

As a good way to understand the essentials of lighting, you should take a look at the *three-point system*. This method places a *key* light in front of the scene, which is the primary illumination and casts shadows into the scene. The key light is typically placed behind the camera and off to the side to create a highlight on one side of the object for contrast's sake. The rest of the scene is given a *fill* light. The fill acts to illuminate the rest of the scene but typically isn't as bright as the key light. The fill also softens harsh shadows from the key light. To pop the subject out from the background, a *back* light is used to illuminate the subject's silhouette. This is also known as a *rim* light, because it creates a slight halo or rim around the subject in the scene. It's much fainter than the key or fill lights.

You'll learn more about Maya lighting techniques in Chapter 10.

## **Basic Animation Concepts**

As mentioned at the beginning of this chapter, animation is the representation of change over time. This concept is the basis for an amazing art form that has been practiced in one way or another for quite some time. Although this section can't cover all of them, here are a few key terms you'll come across numerous times on your journey into CG animation.

#### Frames, Keyframes, and In-Betweens

Each drawing of an animation—or, in the case of CG, a single rendered image—is called a *frame*. The term *frame* also refers to a unit of time in animation whose exact chronological length depends on how fast the animation will eventually play back (frame rate). For example, at film rate (24fps), a single frame lasts 1/24 of a second. At NTSC video rate (30fps), that same frame lasts 1/30 of a second.

*Keyframes* are frames in which the animator creates a pose for a character (or whatever is being animated). In CG terms, a keyframe is a frame in which a pose, a position, or some other such value has been saved in time. Animation is created when an object travels or changes from one keyframe to another. You'll see firsthand how creating poses for animation works in Chapter 9 when you create the poses for a simple walking human figure. In CG, a keyframe can be set on almost any aspect of an object—its color, position, size, and so on. Maya then interpolates the *in-between* frames between the keyframes set by the animator. In reality, you can set several keyframes on any one frame in CG animation. Figure 1.6 illustrates a keyframe sequence in Maya.

Figure 1.6

Keyframing. In the first frame of this sequence, a keyframe is set on the position, rotation, and scale of the cone. On frame 30, the same properties are again keyframed. Maya calculates all the movement in between.



Keyframe at frame 1





Frame 5



Frame 15



Frame 25



Frame 20



Keyframe at frame 30

## Weight

Weight is an implied, if not critical, concept in design and animation. The weight of your subject in the frame is a function of the way it's colored; its contrast, shape, and location in the frame; and the negative space around it, to name but a few ways of looking at it. In animation, weight takes on a more important role. How you show an object's weight in motion greatly affects its believability. As you'll see in the axe tutorial in Chapter 8, creating proper motion to reflect the object's weight goes a long way toward producing believable animation.

Weight in animation is a perception of mass. An object's movement, how it reacts in motion, and how it reacts to other objects together convey the feeling of weight. Otherwise, the animation will look bogus—or, as they say, "cartoonish."

Weight can be created with a variety of techniques developed by traditional animators over the years. Each technique distorts the shape of the object or character in some way to make it look as if it's moving. Although it may seem strange to distort an object's dimensions, doing so makes its motion more realistic. Chapter 8 will touch more on creating weight in animation. Here's a quick preview.

#### SQUASH AND STRETCH

This technique makes a character, for example, respond to gravity, movement, and inertia by literally squashing it down and stretching it up when it moves. For example, a cartoon character will squeeze down when it's about to jump up, stretch out a bit while it's flying in the air, and squash back down when it lands to make the character look as if it's reacting to gravity.

#### EASE-IN AND EASE-OUT

Objects never really stop suddenly. Everything comes to rest in its own time, slowing before coming to a complete stop in most cases. This is referred to as *ease-out*.

Just as objects don't stop suddenly, they don't immediately start moving. Most things need to accelerate a bit before reaching full speed. This is referred to as *ease-in*. The bouncing-ball tutorial in Chapter 8 illustrates ease-in and ease-out.

#### FOLLOW-THROUGH AND ANTICIPATION

Sometimes you have to exaggerate the weight of an object in animation, especially in cartoons. You can exaggerate a character's weight, for instance, by using well-designed follow-through and anticipation.

You should create a bit of movement in your character or object *before* it moves. *Anticipation* is a technique in which a character or object winds up before it moves, like a spring that coils inward before it bounces.

Likewise, objects ending an action typically have a *follow-through*. Think about the movement of gymnasts. When they land, they need to bend a bit at the knees and waist

to stabilize their landing. In the same way, a cape on a jumping character will continue to move even after the character lands.

The axe tutorial in Chapter 8 will give you a chance to implement these two concepts.

## Physics

In Chapter 12, "Maya Dynamics and Effects," you'll see that one of Maya's most powerful features is its ability to simulate the dynamics of moving objects. To use that capability effectively, you need a general awareness of the properties of physics—how objects behave in the physical world.

## Newton's Laws of Motion

You need to know three basic laws of motion. Sir Isaac Newton set forth these three laws, summarized here. Everyone in animation needs to understand the first two laws, because they play a large part in how animations should look. Coming to terms with the third is an art:

- An object in motion will remain in motion, and an object at rest will remain at rest unless an external force acts upon the object. This is called *inertia*, and understanding it is critical to good animation. You'll find more on this in Chapters 8 and 9.
- The more massive an object is, the more force is needed to accelerate or decelerate its motion. This law deals with an object's *momentum*.
- Every action has an equal and opposite reaction. When you press on a brick wall, for example, the wall exerts an equal amount of force on your hand. That way, your hand doesn't smash through the wall.

#### Momentum

It's important to understand what momentum is all about. When an object is in motion, it has momentum. The amount of momentum is calculated by multiplying the mass of the object by its velocity. The heavier something is, or the faster it's moving, the more momentum it has, and the bigger the bruise it will leave if it hits you. Duck!

That's why a tiny pebble on the highway can cause such a significant impact on your windshield, for example. Its sheer speed greatly increases its momentum. Likewise, a slow-moving garbage truck can bash your car, relying on its sheer mass for its tremendous momentum.

When one moving object meets another object—moving or not—momentum is transferred between them. So, when something hits an object, that object is moved if sufficient momentum is transferred to it. For more on this notion, see the axe-throwing exercise in Chapter 8.

#### SUGGESTED READING

The more you know about all the arts that make up CG, the more confident you'll feel among your peers. To get started, check out the following excellent resources.

#### ART AND DESIGN

These books provide valuable insights into the mechanics and art of design. The more you understand design theory, the stronger your art will be.

Bowers, John. Introduction to Two-Dimensional Design: Understanding Form and Function. New York: John Wiley & Sons, 2008. Itten, Johannes. Design and Form: The Basic Course at the Bauhaus and Later. New York: John Wiley & Sons, 1975. Ocvirk, Otto G., et al. Art Fundamentals: Theory and Practice. New York: McGraw-Hill, 2008. Wong, Wucius. Principles of Form and Design. New York: John Wiley & Sons, 1993.

#### CG

CG has an interesting history, and it's evolving at breakneck speed. Acquiring a solid knowledge of this history and evolution is as important as keeping up with current trends.

Keller, Eric and Eric Allen. Mastering Maya 2009. New York: John Wiley & Sons, 2009.

Kerlow, Isaac. The Art of 3D Computer Animation and Effects. New York: John Wiley & Sons, 2009.

Kuperberg, Marcia. Guide to Computer Animation. Burlington, MA: Focal Press, 2002.

Masson, Terrence. CG 101: A Computer Graphics Industry Reference. Williamstown, MA: Digital Fauxtography, 2007.

#### PERIODICALS

Computer Graphics World (free subscription for those who qualify) www.cgw.com

Cinefex www.cinefex.com

HDRI3D www.hdri3D.com

3D World www.3Dworldmag.com

#### WEBSITES

www.animationartist.com www.awn.com www.creativecrash.com www.learning-maya.com

#### FILM

Block, Bruce. The Visual Story: Seeing the Structure of Film, TV, and New Media. Burlington, MA: Focal Press, 2001.

#### MUST-READ

Myers, Dale K. Computer Animation: Expert Advice on Breaking into the Business. Milford, MI: Oak Cliff Press, 1999.

# Summary

In this chapter, you learned the basic process of working in CG, called a *workflow* or *pipeline*, and how it relates to the process of working on a typical live film production. In addition, you were introduced to the core concepts of CG creation and the fundamentals of digital images. Some important ideas in design as well as traditional animation concepts were also covered.

Now that you have a foundation in CG and 3D terminology and core concepts, you're ready to tackle the software. Maya is a capable, intricate program. The more you understand how *you* work artistically, the better use you'll make of this exceptional tool.

There is a lot to think about before putting objects into a scene and rendering them. With practice and some design tinkering, though, all this will become intuitive. As you move forward in your animation education, stay diligent, be patient, and never pass up a chance to learn something new. Above all else, have fun.

# Jumping in Headfirst, with Both Feet

In this chapter, you're going to start using Maya and get your groove on. This will be a quick primer on the Maya interface so you experience tasks right away. The next chapter will show you more details and provide additional explanations and a reference of how the entire Maya interface works.

This chapter will take you through the creation of a Solar System project and the mechanics of animating orbits. With this exercise, you'll dive into creating simple objects, setting keyframes, and stacking your animation to get planets and moons to orbit each other and the Sun. This will expose you to object creation, simple modeling, object components, pivot-point placement, grouping and hierarchies, basic keyframing, and timing.

Topics in this chapter include:

- You put the U in UI
- Project overview: the Solar System
- The preproduction process: planning
- Creating a project
- The production process: creating and animating the objects
- Hierarchy and Maya object structure
- The Solar System resumed
- Using the Outliner
- Outputting your work: playblasting

# You Put the U in UI

Fire up your computer, and let's get this project going. This section will introduce you to getting around the Maya user interface (UI). It may seem difficult at first, but it will make sense as you move along.

You'll find everything you ever wanted to know about the interface and more in Chapter 3, "The Maya 2011 Interface." The overall goal of *this* chapter is to expose you to Maya UI basics as well as important scene creation and editing tools. You can consider the next chapter a debriefing of sorts, to fill in UI details that aren't covered in this chapter. If you prefer, you can skip ahead and get a more detailed rundown of the UI first and then return to this chapter for your first Maya project experience.

#### **KEYBOARD AND SYMBOL CONVENTIONS USED IN THIS BOOK**

The following terms are used throughout this book:

- *Click* and *LMB+click* refer to a mouse click with the primary (left) mouse button.
- *RMB+click* refers to a mouse click with the right mouse button.
- *MMB+click* refers to a mouse click with the middle mouse button.
- *Shift+click* indicates that you should hold down the Shift key as you click with the primary (left) mouse button.
- *Shift+select* indicates that you're holding down the Shift key as you select the next object for multiple selections.
- *Right-click* refers to clicking with the right mouse button.
- The  $\Box$  symbol next to a menu command indicates that you should click the box ( $\Box$ ) next to the menu command to open the Options for that command.

## A Quick Screen Roadmap

Let's get to the basics of how Maya is laid out (see Figure 2.1). Running across the top of the screen, right under the application's title bar, are the UI elements: the *Main Menu bar*, the *Status line*, and the *Shelf*. On a Macintosh system running OS X, note that the Main Menu bar runs at the very top of the screen, above the application's title bar.

Figure 2.1 shows the major parts of the UI. In the middle of the interface is the *work-space*, which is host to your *panels* (or Scene windows) and their menu options (known as *views* or *viewports* in some other 3D packages). This is where most of your focus will be; this is where you create and manipulate your 3D objects.

Click inside the large perspective view panel (named *persp*) with the mouse to activate the panel, highlighting its border slightly. Press the spacebar to display a four-panel layout, which gives you top, front, and side views as well as the perspective view. Press the spacebar in any of the panels to display a large view of that panel.



Time Slider, Range Slider, Playback Controls

To the right of the panels is the Attribute Editor / Channel Box. This is where most of the information (attributes) about a selected object is displayed and edited. Pressing Ctrl-A toggles between the Attribute Editor and the Channel Box. In short, the Attribute Editor gives you access to all of an object's attributes, whereas the Channel Box is a quicker display of the most commonly animated attributes of the selected object. The Attribute Editor is typically wider than the Channel Box, so you'll notice a shift in your view panels when you toggle between them. You can set Maya's preferences to treat the Attribute Editor as its own window, to prevent it from displaying on the right side of the UI. More on this in the next chapter.

## Keys and Syntax in Maya

Maya is case sensitive in that it distinguishes between lowercase and uppercase letters. The conventions of this book will be to always print an uppercase letter to denote which key you must press, but to specify "Shift + the letter" when you must press the uppercase of that key. In other words, when we ask you to press the E key, for example, you should simply press the E key on your keyboard, lowercase. When an uppercase letter is called for, the book tells you to press Shift+E, requiring you to enter the uppercase letter E into Maya. Make sure your Caps Lock key is turned off.

## **Mouse Controls**

Maya requires the use of a three-button mouse, even on a Macintosh system. The clickable scroll wheel found on most mice can be used as the third button by pressing down to click with the wheel. Scrolling the wheel lets you zoom into or out of a view panel.

In Maya, you press and hold the Alt key on a PC (or the Option key on a Mac) along with the appropriate mouse button to move in the view panel:

- The left mouse button (LMB) acts as the primary selection button and allows you to orbit around objects when used with the Alt key.
- The right mouse button (RMB) activates numerous shortcut menus and lets you zoom when used with the Alt key.
- The middle mouse button (MMB) used with the Alt key lets you move within the Maya interface panels, and the mouse's wheel can be used to zoom in and out as well.

#### SHORTCUTS TO NAVIGATING

Here's a rundown of how to navigate Maya. Keep in mind that the Option key is used on a Macintosh in place of the Alt key on a PC:

**Alt+MMB+click** Tracks around a window. Tracking moves left, right, up, or down in two dimensions; hold down the Alt key, press and hold the MMB, and drag the mouse.

Alt+RMB+click Dollies into or out of a view. A *dolly* moves the scene's camera in and out of the view, essentially zooming the view in and out. To dolly, hold down the Alt key, press and hold the RMB, and drag the mouse.

**Scroll Wheel** The scroll wheel, in addition to acting as a middle mouse button, can also dolly into or out of a view just like the Alt+RMB+click combination. Scrolling up dollies in, and scrolling down dollies out.

Alt+click Rotates or orbits the camera around in a Perspective window. Orbiting lets you get around your object to observe it from different vantage points. To orbit, hold down the Alt key and the LMB. This move is called a *tumble*. You can't tumble your view in an orthographic panel.

Alt+Ctrl+click and drag Dollies your view into the screen area specified in your mouse drag. Hold down the Alt and Ctrl keys while using the LMB to outline a window in the panel to execute this *bounding box dolly*. This action is commonly referred to as a *window zoom* in other applications.

#### SHORTCUTS TO NAVIGATING (continued)

**The ViewCube** This part of a panel's interface lets you easily change your current panel view from, for example, perspective to side, top, and back to perspective with just a click. By clicking an area of the ViewCube (shown here), you can switch to other views inside that panel.

Clicking one of the conical axis markers gives you an orthogonal view from that direction. Clicking the center square gives you the perspective view. You can toggle the ViewCube in the preferences by choosing Window  $\rightarrow$  Settings/Preferences  $\rightarrow$  Preferences and clicking the ViewCube category.



**Macintosh Keys** The major difference in keys between a PC and a Mac, as far as Maya is concerned, is that the Option key on a Mac serves the same function as the Alt key on a PC. Although a few Ctrl key combinations in Windows are accessed via the Command key on a Mac, Mac users can generally use the Mac's Ctrl key for their key combinations just as PC users do.

## **Making Selections**

Selecting objects in a view panel is as easy as clicking them. If the object is displayed in Wireframe mode, its wireframe turns green while it's selected. If the object is displayed in a Shaded mode, the object's wireframe will appear around the object. Shaded mode is a way of seeing your objects in the view panel with a basic surface, as opposed to a wireframe that you can see through. You'll see this as you do the following exercise.

As you select an object, its attributes appear in the Attribute Editor or Channel Box on the right.

To select multiple objects, simply hold the Shift key as you click objects to add to your current selection. The previous selection's wireframe turns white, and the new selection is now green. If you press Ctrl+LMB (that is, press the Ctrl key and click) on an active object, you'll deselect it. To clear all of your current selections, click anywhere in the empty areas of the view panel.

## **Manipulating Objects**

When you select an object and enable one of the transformation tools (tools that allow you to move, rotate, or scale an object), you'll see a Manipulator appear at or around the selected object. Figure 2.2 shows the three distinct and most common Manipulators for all objects in Maya: Move, Rotate, and Scale as well as the Universal Manipulator. You use these Manipulators to adjust attributes of the objects visually and in real time. Figure 2.2 The Maya Manipulators





To activate a Transform tool, select an object and then click one of the Transform tool icons in the Tool Box, shown in Figure 2.3.

Try This Let's put some of this into action, shall we?

Choose Create → NURBS Primitives → Sphere. Drag in a view panel anywhere on its grid to create a wireframe sphere, and then size it to your liking. In one of the view panels, press the 5 key on your keyboard, and the display of the sphere will become solid gray, as opposed to open wireframe. This is called Shaded mode. Press the 4 key to return to Wireframe mode.

With the sphere selected, select the Move tool () from the Tool Box. The first Manipulator shown in Figure 2.2 should appear in the middle of the sphere. The three arrows represent the three axes of possible movement for the object.

Red is for the *X*-axis, green is for the *Y*-axis, and blue is for the *Z*-axis. Cyan is for free movement in both axes of the active panel view.

Clicking any one of the three arrows lets you move the object only on that particular axis. The square in the middle of the Manipulator lets you move the object freely about the plane of the view panel, regardless of the axis. When you select a Manipulator handle for movement, it turns yellow. The Free Movement box in the center then turns back to its regular color, cyan.

Next, select the Rotate tool () from the Tool Box, and you'll see the second Manipulator in Figure 2.2. The three colored circles represent the three axes of rotation for the object—red for *X*, green for *Y*, and blue for *Z*. Select a circle to rotate the object on that axis. The yellow circle surrounding the three axis circles lets you freely rotate the object on all three axes. The Free rotation handle also turns cyan when an axis handle is active.

Now, try selecting the Scale tool () to see the third Manipulator in Figure 2.2. By selecting one of the axis handles and dragging the mouse, you can scale the object in a nonuniform manner in that axis. The middle cyan box scales the object uniformly on all three axes.

Try selecting the Universal Manipulator (). This tool acts in place of all three Manipulators you just tried. Grabbing the familiar arrows translates the sphere. Selecting any of the curved arrows in the middle of the edges of the Manipulator box lets you rotate the sphere in that axis. Finally, selecting and dragging the cyan boxes in the corners of the Manipulator box lets you scale the sphere. If you hold down the Ctrl key as you drag, you can scale the sphere in just one axis.

Go ahead and click around the interface some more. Create more primitive objects, and tool around a bit. Move around the view panels, and see how it feels. Give the tires a good kick.

Enough chatting—let's jump into the Solar System project.

# **Project Overview: The Solar System**

This project focuses on familiarizing you with the fundamentals of navigating Maya, object creation, hierarchy, and pivots, all of which are important concepts for scene manipulation and animation within Maya. In this exercise, you'll create and animate a simple simulation of our working Solar System. (You may have done this in school using coat hanger wire and Styrofoam balls.) This time-tested tutorial is great practice for getting used to object creation, hierarchies, scene manipulation, UI navigation, and working with objects and selections. It will show you how to set up hierarchies and give you experience in working with the proper nodes within a group to create hierarchically layered animation.

# The Preproduction Process: Planning

Every smooth operation begins with a good plan. The more research and focused information you gather, the better off you'll be in your work. For this exercise, you need to find out where each of the planets is in relation to the Sun and to the other planets and also how many moons it has.

Starting with the Sun in the center, the planets in order are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. (We'll label Pluto a planet for old time's sake, even though it was reclassified as a "dwarf planet" by the scientific community in 2006.) All these planets actually orbit the Sun in ellipses, but we'll give them circular orbits for this exercise. Most planets have a number of moons that orbit them, and one, Saturn, has large rings that circle around it.

Earth	1 moon
Mars	2 small moons
Jupiter	16+ moons
Saturn	3 large rings and 18+ moons
Uranus	18 moons
Neptune	8 moons
Pluto	1 moon

Creating and animating all those objects may seem overwhelming, but it's a great way to become comfortable with Maya and animation. Because the goal of the project is achievable without making every moon, you'll cut most of them out of your scene and make a maximum of two moons per planet.

You can redo this exercise in more detail when you feel more comfortable with Maya. For instance, if, after you've worked through the exercises in this book, you feel like creating a much more accurate Solar System with beautifully textured planets and a perfect starry backdrop, go for it! It will still be a good idea to set up and animate the scene carefully, just as you did (or should have done) the first time you worked on this exercise.

The more you run this exercise, the clearer Maya's scene manipulation and hierarchy structure will become to you. Art is a marriage of inspiration, hard work, and practice.

# **Creating a Project**

Projects are Maya's way of managing a scene's assets. A file and folder structure keeps your files organized according to projects. You'll have a project for the Solar System exercise.

Figure 2.4 The New Project window

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Start by creating a new project for this assignment. Choose File → Project → New to open the New Project window. (Figure 2.4 shows the Windows version; the Mac OS X

version has the same fields.) Files are organized in a particular way in Maya. The top level of this organization is the *Project folder*. Within the Project folder are numerous file folders that hold your files. The two most important types are the Scenes and Images folders. The Scenes folder stores your scene files, which contain all the information for your scene. The Images folder stores images you've rendered out from your scene. As with clothing and other items around your house, keeping your files and projects organized is a good practice.

## NAMING OBJECTS AND KEEPING THE SCENE ORGANIZED

In Maya and most other CG packages, keeping things organized and as clean as possible is more important than you probably realize. Picking up a scene from a disorganized colleague is annoying because it's very time consuming to figure out exactly what is in their scene and how everything works together. Many professional studios have strict naming procedures and conventions to minimize the confusion their artists may have when working in a pipeline. These procedures and conventions are beneficial because many artists will touch the same digital files and assets in the course of a production. Even if you're the only person who will ever see your scene in Maya, it's still a good idea to name and organize your objects. Get into the habit of naming your objects and keeping a clean scene. You'll waste a lot of time if you don't, and you'll be bombarded by dirty looks from other artists when they have to handle your cluttered scenes.

The scene files discussed in this chapter are included on the CD in a project layout explained in the following text. Copy the scene files on the CD for this project into your own Project folders after you create the project. To create a new project, follow these steps:

 In the Name field in the New Project window, enter Solar\_ System as the name for your project. In the Location box, type the location where you want to store your projects.

The default location for Windows XP, Vista, and Windows 7 is in the current user's My Documents folder: My Documents\ maya\projects; for Macs, the default location is Home (/Users/ <yourname>) in the Documents/maya/projects/default folder. If you prefer, you can put projects in a folder on a secondary or external hard drive to keep them separate from your operating system; this allows for easier backup and is generally a safer environment.

2. If you're using a Windows system, create a folder on your hard drive called **Projects** using Windows Explorer. If you're using a Mac, select a drive in the Finder and create a folder on the drive called **Projects**. In the New Project window, click the Browse button and select D:\Projects (Windows) or <*Hard Drive Name>*/Projects (Mac) for the location. Maya will fill in all the other fields for you with defaults; just click the Use Defaults button. Click Accept to create the necessary folders in your specified location. Figure 2.5 shows the completed New Project window in Windows; except for the drive name, the values are the same on a Macintosh.

After you create projects, you can switch between them by choosing File  $\rightarrow$  Project  $\rightarrow$  Set and selecting the new project. Maya will then use that project's folders until you switch to or create another project. You may also select a recent project by choosing File  $\rightarrow$  Recent Projects. Maya by default will list four of your recent projects and scene files on the File menu for easy access.



Figure 2.5 The completed New Project window

#### DON'T FORGET TO SET YOUR PROJECT!

You should make sure to set your project before continuing with your work. The exercises in this book are based on projects, and you'll need to set your project whenever you start a new exercise—otherwise, the scene may not load properly or your files may not save to the proper locations for that project.

# The Production Process: Creating and Animating the Objects

As discussed in Chapter 1, "Introduction to Computer Graphics and 3D," production is typically divided into phases to make workflow easier to manage. In this project, you'll first create the Sun, the planets, and their moons; then, you'll animate their respective orbits and rotations.

## **Creating the Sun and the Planets**

The first thing you're going to do is create the Sun and the planets. Follow these steps:

- 1. Choose File → New Scene (or press Ctrl+N). Maya asks if you want to save your current scene. Save the file if you need to, or click Don't Save to discard the scene.
- 2. By default, Maya's screen should begin in an expanded perspective view. Press the spacebar to enable the four-panel view. When you're in the four-panel view, press the spacebar with the cursor inside the top view panel to select and maximize it.
- 3. To create the Sun, you need a primitive sphere. A *primitive* is a basic 3D shape. First, let's turn off a Maya feature called Interactive Creation that is on by default. Turning off Interactive Creation allows you to create the sphere at the center of the grid (the

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Cameras CV Curve Tool	Plane     Torus     Circle	0
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origin) without having to click and drag its size and then reposition it manually. Uncheck Create  $\rightarrow$  NURBS Primitives  $\rightarrow$  Interactive Creation to toggle it off, as shown in Figure 2.6. For more on how to create primitives with interactive feedback, see the section on primitives in Chapter 3.

- 4. With Interactive Creation turned off, choose Create  $\rightarrow$  NURBS Primitives  $\rightarrow$  Sphere. Doing so places a NURBS sphere exactly at the origin—that is, at a position of 0,0,0 for *X*,*Y*,*Z*. This is good, because the origin of the workspace will be the center of the Solar System, too.
- 5. Select the word *nurbsSphere1* in the Channel Box to the right of the Maya UI (shown in Figure 2.7), and enter **Sun** to rename it. If you don't see the Channel Box in your Maya window, please refer to the section on the Channel Box in Chapter 3.

## NURBS AND POLYGONS

NURBS and polygons are two types of geometry that you can create and edit in Maya. We'll explore the uses of each modeling type in Chapter 4, "Beginning Polygonal Modeling," Chapter 5, "Modeling with NURBS, Subdivisions, and Deformers, and Chapter 6, "Building the Red Wagon."

Figure 2.6 Turning off Interactive Creation



Figure 2.7

Renaming the sphere in the Channel Box

Always keep in mind that Maya is case sensitive. An object named "sun" is different from an object named "Sun."

Naming your objects right after creation is a good habit to develop. Doing so makes for a cleaner scene file and a more organized workspace. This is particularly important if anyone needs to alter your scene file; proper naming will keep them from getting frustrated when they work on your scene.

Maya typically uses an object-naming structure called a *humpback style*, where words are slung together without spaces. The first letter of a new word in the humpback name is capitalized. An example of humpback style is the name indoorPatioScene. Maya uses this structure when naming nodes, such as the node name nurbsSphere1.

6. Choose the Scale tool in the Tool Box to activate the Scale Manipulator, and uniformly scale the Sun sphere up to about four times its creation scale of 1. (Make it a scale of about 4 in all three axes.) For more precision, you can do one of two things: You can

select the sphere and enter a value of **4** in all three entry fields (the white window next to the attribute) for the Scale X, Scale Y,

and Scale Z channels in the Channel Box shown in Figure 2.8. Alternatively, you can enter a value of **4** in the Input box on the Status line along the top of the UI, as shown

here. Don't worry; we'll take an in-depth look at both of these methods in the next chapter.

7. After you enter the final value through either method, press Enter, and the sphere will grow to be four times its original size (at a scale of 1). When you enter the values in either the Channel Box or the Input box, a scale of 4 appears in all three fields, as shown in Figure 2.8, and your Sun expands in size by a factor of 4. Entering exact values in the Channel Box or Input box is a way to scale the sphere precisely; using the Manipulator isn't as precise.

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Figure 2.8 The Sun's Scale values in the Channel Box

## **Creating the Planets**

Next, you'll create the primitive spheres you'll be using for the planets. Leave Interactive Creation off, and follow these steps:

- 1. Create a NURBS sphere for Mercury just as you did before, by choosing Create → NURBS Primitives → Sphere. A new sphere appears at the origin. Click its name in the Channel Box, and change it to **Mercury**.
- 2. Choose the Move tool from the Tool Box to activate the Move Manipulator, and move Mercury a few grid units away from the Sun in the positive *X* direction. (Click the red arrow and drag it to the right.) Leave about two grid units between Mercury and the Sun.
- 3. Because Mercury is the second smallest planet and is tiny compared to the Sun, scale it down to <sup>1</sup><sub>20</sub> the size of the Sun, or type in 0.2 in all three axes of scale if you choose to enter the values manually in the Channel Box.
- 4. Repeat steps 1 through 3 to create the rest of the planets and line them up, placing each one farther out along the *X*-axis. Be sure to keep about two grid units of space between them. Scale each one proportionally as follows:

Venus	0.5
Earth	0.5
Mars	0.4
Jupiter	1.0
Saturn	0.9
Uranus	0.7
Neptune	0.7
Pluto	0.15

These proportions aren't exactly the same as those found in the real Solar System, but they will do nicely here. Figure 2.9 shows how your Solar System should look now.



No, Pluto isn't actually a planet anymore, but for nostalgia's sake, we'll include it here in our Solar System. Poor Pluto!

## **Using Snaps**

Now is the perfect time to start using *snaps*. Some common snap icons are shown in Table 2.1. Snap icons are explained in greater depth in the next chapter. These icons run across the top of the UI just below the Main Menu bar, as shown here.

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SNAP ICON	NAME	DESCRIPTION	Table 2.1
9	Snap to Grids	Snaps objects to intersections of the view's grid	Snap Icons
S.	Snap to Curves	Snaps objects along a curve	
<u></u>	Snap to Points	Snaps objects to object points such as CVs or vertices	
$\otimes$	Snap to View Planes	Snaps objects to view planes	

You use snaps to snap objects into place with precision, by placing them by their pivot points directly onto grid points, onto other object pivots, onto curve points, and so on. Here you'll reposition all the planets slightly to center them on the nearest grid line intersection. To do so, follow these steps:

- 1. Select the first planet, Mercury. Choose the Move tool from the Tool Box, and toggle on *grid snaps* by clicking the Snap to Grids icon (Sin).
- 2. The center of the Move Manipulator turns from a square to a circle, signaling that some form of snapping is active. Grab the Manipulator in the middle by this circle, and move it slightly to the left or right to snap it onto the closest grid intersection on the *X*-axis.
- 3. Select the remaining planets, and snap them all to the closest grid intersection on the *X*-axis, making sure to keep about two grid spaces between each of them. Because the Sun was created at the origin and you haven't moved it, you don't need to snap it onto an intersection.

## Figure 2.9

All the NURBS spheres are lined up in place (top view).

#### SAVING MULTIPLE VERSIONS OF YOUR WORK AND INCREMENTAL SAVING

As you're working on a project, you may want to save multiple versions of your files at various stages of completion. When working in the professional world, you'll find that clients and art directors often reconsider animations you've created, sometimes, it seems, just to make you crazy. So, it's always good to keep as many versions of an animation as you can. Scene files are reasonably small, and hard disk space is inexpensive. Just keep your Scene folder organized well—for example, by keeping older versions of scenes in separate subfolders—and you should have no problems.

Maya's Incremental Save feature makes a backup of your scene file every time you save your scene. To enable it, choose File  $\rightarrow$  Save Scene  $\Box$ , and click the Incremental Save box. After you've done this, Maya will create a new folder within your Scenes folder with the name of your current scene file. It will then create a backup of your scene in that folder and append a number to the filename: for example, planets\_001.mb. Every time you save your file, Maya will create a new backup until you disable the feature by choosing File  $\rightarrow$  Save Scene  $\Box$ .

The scene files for the projects in this book are provided on the accompanying CD to give you a reference point for the major stages of each project. These files use a slightly different naming system than the names generated by Incremental Save (for example, the file on the CD is planets\_v1.mb instead of planets\_001.mb), so there is no risk of files overwriting each other.

For important real-world projects, you may decide to supplement the Incremental Save backups by using Save Scene As to create named files manually, perhaps following a similar naming system with a version number appended, at the stages where you've made significant changes. Whether you do this or use Incremental Save, it's a good idea to keep written notes about the differences in each version of a scene file so that whenever you make a significant change to a file, you have a record of your work.

If you prefer to name files manually, be sure to use an underscore (\_) between the filename and version number instead of a space. Using spaces in your filenames can create problems with the software and operating system, especially when you're rendering out a scene.

#### Making Saturn's Ring

Now, create the ring for Saturn. To do so, follow these steps:

 Choose Create → NURBS Primitives → Torus to place a donut shape at the origin. Remember, Interactive Creation is turned off. You can also try creating the torus with the Interactive Creation option. In that case, click and drag the mouse to create the donut shape as you prefer. When you have a ring, use the Move tool to snap it to the same grid intersection as Saturn. This ensures that both the planet and its ring are on the same pivot point and share the same center.

- 2. Select the torus shape you've created, and name it **Ring** (if you haven't already done so) in the Channel Box.
- 3. While the torus shape is still selected in the top view, press the spacebar to display the four-panel layout. Place the mouse cursor in the persp view, and press the spacebar to maximize the Perspective window.
- 4. Press the F key to focus the perspective display on the ring and on Saturn. Pressing F centers and zooms in the panel on just the selected object(s).
- 5. Press 5 to get into Shaded mode, and, with the torus selected, press 3 to increase the resolution display for the ring. Display resolutions are achieved by pressing the 1, 2,

or 3 key and are further explained in the next chapter. Pressing 3 gives you the smoothest view of the torus in the view panels. That's a good thing.

6. From the Tool box, select the Scale tool, and scale the torus down to 0 or close to 0 in the *Y*-axis (the torus's height, in this case) to flatten it.

You'll notice that the ring is too fat and is cutting into the planet. You need to edit the attributes of the ring to increase the inside radius of the donut shape and create a gap between the planet and the ring.

- Press Ctrl+A (Ctrl+A will also work on a Mac) to toggle the Attribute Editor if it's not on, and then click the makeNurbTorus1 tab to select its creation node. (See Figure 2.10.)
- Increase the Radius attribute to about 1.5, and decrease the Height Ratio attribute to about 0.25 to get the desired effect.

Attribute Editor

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 Nodes: makeNurbTorus1

Now all your planets are complete, and you can move on to the moons.

Figure 2.10

Changing the original attributes or parameters of an object, as you've just done with Saturn's ring, is often referred to as *parametric modeling*.

# **Saving Your Work**

Save your work, unless you like to live on the edge. Saving frequently is a critical habit to develop. Power failures and other unforeseen circumstances (such as your pet jumping onto your keyboard) may not happen often, but they do happen, and usually at the wrong time. (As mentioned in the sidebar "Saving Multiple Versions of Your Work and

Changing the creation attributes of the NURBS torus in the Attribute Editor Incremental Saving," Maya's Incremental Save feature makes it easy to maintain backups of your work.) Because you created this as a new project, the Save File window will direct you to the Scenes folder of that project. Save your scene as **planets** in the .mb (Maya Binary) format. (If you're working in Maya PLE, you can only save your files as .mp files, which may not be compatible with full versions of Maya 2011. Maya PLE saves scenes as .mp files simply to differentiate them from full Maya-version saved files.)



The file Planets\_v1.mb in the Scenes folder of the Solar\_System project on the CD shows what the scene should look like at this point.

## **Creating the Moons**

For the planets with moons, create a new NURBS sphere for each moon. For simplicity's sake, create a maximum of only two moons for any planet. However, feel free to make all the moons for all the planets after you get a handle on this exercise.

The first moon will be Earth's. Use the top view to follow these steps:

- 1. Create a NURBS sphere, and scale it to about half the size of Earth using the Scale tool. Visually estimate the size of the moon.
- 2. Move the sphere to within half a unit of Earth, using the Move tool by the *X*-axis. There's no need to snap it to a grid point, so toggle off the Snap to Grids icon (Sin).
- 3. Repeat steps 1 and 2 for the remaining moons, placing them each within half a grid unit from their respective planets. When placing two moons, place them on opposite sides of the planet.
- 4. After you're done with all the moons, their placements, and their sizes, select all the elements in the scene and press 3 to increase the display resolution on all the spheres. This gives you a smoother view of the NURBS spheres. When you're finished, you should have a scene similar to Figure 2.11 in perspective view. If you don't, it's clear Maya doesn't like you.



Figure 2.11 The planets and moons in position in perspective view

# **Applying a Simple Shader**

To help distinguish one gray planet from another, attach simple shaders to each of the planets to give them color. You can easily take care of this task using the Hypershade window. Follow these steps:

 Choose Window → Rendering Editors → Hypershade to open the Hypershade window. This window lists and allows you to edit all the shaders and textures in the scene. With this window, you create the look of your objects by assigning colors, surface properties, and so on. You'll notice three default (or initial) shader icons already loaded. (See Figure 2.12.) For more on the Hypershade window, see Chapter 3.



Figure 2.12 The Hypershade window

- 2. In the Create Maya Nodes panel on the left of the Hypershade window and under the Surface heading, click the Lambert icon (a gray sphere) to create a new Lambert shader node. It appears in the top and bottom of the Hypershade window. Click this icon eight more times to create a total of nine Lambert shading groups in the Hypershade window.
- 3. Click the first of the new Lambert nodes (lambert2) in the Hypershade window, and you should notice its attributes display in the Attribute Editor on the right of the UI. If you have the Channel Box displayed instead, double-click the shader's icon to open the Attribute Editor. At the top, replace lambert2 with **Mercury\_Color** to identify this material as the one you'll use for Mercury.
- 4. Name each of the remaining planets in your animation (Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto).

To rename a node in the Hypershade window, you can also right-click the node's icon and choose Rename from the shortcut menu that appears.

Again, keeping a well-named and organized scene is critical to a smooth animation experience. It's much more of a chore to root through dozens of unnamed nodes to find the one you want. When you've finished naming all the material nodes, save your work.

After you've created the shaders, you can assign the appropriate colors to each of them according to the planet they represent:

- 1. Double-click Mercury to open its Attribute Editor, if it's not currently open (see Figure 2.13).
- 2. To change the color of the shader, click the gray box next to the Color attribute. This opens the Color Chooser window, where you can choose a new color from the color wheel or by adjusting values with the HSV sliders. Because Mercury has a brownish red appearance, go with an orange color, such as in Figure 2.14 (take note of the HSV values).

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Figure 2.13

Mercury's shading group in the Attribute Editor



#### SETTING KEYFRAMES

As with many other functions in Maya, you can set a keyframe in several ways. Switch to the Animation menu set by pressing F2. When you're first starting to learn Maya, the best way is to choose Animate → Set Key □ to display the Set Key Options dialog box. Here, you're selecting the Option box for

that menu item by clicking the little empty box to the right of the menu item. The Option box for any particular menu item allows you to set the options for that function. In this case, you're changing the options for the Set Key function.



If you choose Animate → Set Key without first changing those options, Maya sets a keyframe for all the keyable attributes for the selected object. Although this

may seem convenient, it makes for a sloppy scene, especially if the scene must be heavily animated.

Having keyframes for attributes that may not actually be animated creates unnecessary clutter. In the Set Key Options dialog box shown here, set the Set Keys On option to All Keyable Attributes instead of the default All Manipulator Handles and Keyable Attributes. Set Channels to From Channel Box instead of the default All Keyable. (These attributes will remain grayed out until you change

to All Keyable Attributes.) Now, when you choose Animate → Set Key, you'll set a keyframe only for the channels that you specify explicitly through the Channel Box, giving you greater control and efficiency. All you have to do is highlight the channel you want to keyframe in the Channel Box and then choose Animate → Set Key. Save your settings by choosing Edit → Save Settings, and then click Close to close the dialog box.



3. Change the remainder of the shaders as follows:

Orange-brown
Beige-yellow
Blue
Red-orange
Yellow-green
Pale yellow
Cyan
Aqua blue
Bright gray

Figure 2.15 shows the shading groups.

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#### Figure 2.15

The Hypershade window with all the colored planet shading groups



4. Next, apply shaders to the planets. Select a planet in the Perspective window, and right-click its corresponding material in the Hypershade window to open a marking menu. Drag up to highlight Assign Material to Selection, and release the button to select it. You can also use the middle mouse button to drag the material from the Hypershade window to its planet. Leave the moons set to the default gray color. When you're finished, you should have a scene similar to Figure 2.16.



Now that you're finished, you're ready to animate. Save this file; if you enabled Incremental Save as recommended earlier, your file won't be replaced with subsequent

Figure 2.16 The shaded planets in perspective view saves. This way, if you get lost in your animation and need to start fresh, you won't have to re-create everything from scratch. You can return to a previous version of the file and start your animation over.

## **Creating the Animation**

To begin this phase of the project, load the file Planets\_v2.mb in the Scenes folder of the Solar\_System project on the CD to your hard drive, or continue with your own scene file.

The animation you'll do for the orbits is straightforward. You'll rotate the planets around their own axes for their self-rotation, and then you'll animate the moons around the planets for their lunar orbits, and finally you'll make the planets and their moons orbit the Sun.

The premise of this exercise deals with hierarchy and pivot points. A *pivot point* is an object's center of balance of sorts. Every object or node that is created in Maya has a pivot point set at the origin. Because most objects, such as the spheres you created for the planets, appear at the origin upon creation, their pivot points are automatically centered.

When you move an object, as you've done to position the planets and moons, the pivot point moves with it. Therefore, all your planets' and moons' pivot points are already correctly positioned at the center of each planet and moon.

Now, you need to set up your scene file's animation settings:

- 1. Press F2 to open the Animation menu set. *Menu sets* are groupings of menu headings in the Main Menu bar. They're organized according to the type of task at hand. You'll see the first several menu headings change when you switch from one menu set to another.
- 2. At the bottom of the UI, you'll notice a slider bar (the Range slider) directly below the strip of numbers counting off the frames (the Time slider) in the scene. Using the Range slider, you'll set the length of your animation to go from 1 to 240. Enter **1** in the Scene Start Frame and Range Start Frame boxes (Figure 2.17). Enter a value of **240** in the Scene End Frame and Range End Frame boxes, also as called out in Figure 2.17.

Figure 2.17 The Time and Range sliders



3. To the right of the Range slider, click the Animation Preferences icon () (shown here in the context of the lower-right corner of the Maya screen), click Settings, and set Time to NTSC (30fps), which is 30 frames per second, or NTSC video speed. Also see Figure 2.18.





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#### Figure 2.18

Set Time to 30fps in the Settings tab of the Preferences window.

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4. Also verify that Up Axis is set to *Y* and not *Z*, as shown in Figure 2.18. This ensures that you've designated the *Y*-axis to be pointing "up" in the perspective window or pointing out at you from the monitor in the top view. *Y up*, as it's called, is Maya's default, but it never hurts to make sure, especially if you're on a shared computer.

Choose Window → Settings/Preferences → Preferences to open the Preferences window. Under Settings: Undo, make sure Undo is on (if it isn't already), and set Queue to Infinite. Setting Queue to Infinite takes a little more system memory, but it's worth it. With this configuration, you can undo (press Ctrl+Z, Command+Z, or just Z if you're using a Mac) as many times as it takes to undo any blunders. To close the Preferences window, click Save.

#### **Mercury's Rotation**

Now you're ready to animate Mercury's rotation. Follow these steps:

- 1. Select Mercury, and press E to activate the Rotate tool. The E key is the hotkey to invoke the Rotate tool in Maya; pressing it is the same as clicking the Rotate Tool icon in the Tool Box, as you've been doing so far. Press F to focus on Mercury in the perspective view, or zoom in on it manually.
- 2. Make sure you're on frame 1 of your animation range by clicking and dragging the Scrub bar (refer back to Figure 2.17) to place it at the desired frame. You can also manually type the frame value of **1** in the Current Frame box.
- 3. For Mercury, you'll set your initial keyframe for the *Y*-axis rotation. Click the Rotate Y's attribute name in the Channel Box to select it (it's then highlighted in gray, as

shown in Figure 2.19), and, in the Main Menu bar, choose Animate  $\rightarrow$  Set Key. This places a keyframe for a rotation of 0 in the *Y*-axis at frame 1 for the Mercury sphere. If you followed the advice in the sidebar "Setting Keyframes," earlier in this chapter,

only the Rotate Y attribute's Value box turns from white to orange to indicate that a keyframe exists for that attribute. If you left the Set Key command at its defaults, choosing Animate → Set Key sets keys on all the attributes for the sphere, turning all their values orange in the Channel Box.



Figure 2.19 Setting the initial

Setting the initial keyframe for Mercury's Y-axis rotation

- 4. Using the Scrub bar in the Time slider, go to frame 240. Grab the Rotation Manipulator handle by the *Y*-axis (the green circle), and turn it clockwise a few times to rotate the sphere clockwise. You'll notice that you can rotate the object only so far in one direction before it seems to reset back to its original starting rotation. Rotate it as far as it will go, and release the mouse button. Then, click the Manipulator again, and drag to rotate the sphere as many times as necessary until you're satisfied.
- 5. Choose Animate → Set Key with the Rotate Y attribute still selected in the Channel Box. This sets a keyframe for the new *Y*-axis rotation at frame 240 for the Mercury sphere.
- 6. To play back your animation, you can scrub your Time slider. *Scrubbing* is using the mouse to move the Scrub bar back and forth so you can watch the animation play back in a window. Click in the Time slider on the Scrub bar, hold down the left mouse button, and move your cursor from side to side to scrub in real time. You see Mercury rotating in your active view panel, if you set your two keyframes as described.

Clicking so many things just to set two keyframes may seem like a lot of work, but you're doing this the long way right now; you're not yet using any shortcuts or hotkeys. You'll start using those for the next planet.

You have the self-rotation for Mercury worked out. Mercury has no moon, so let's get Mercury orbiting the Sun.

## **Grouping Mercury for a New Pivot Point**

You've learned that every object in Maya is created with a pivot point around which it rotates, from which or to which it scales, and which acts as the placement point for its *X*-, *Y*-, and *Z*-coordinates. To orbit Mercury around the Sun, the sphere must revolve around a pivot point that is placed in the middle of the Sun. If the pivot point for Mercury is already at the center of itself, how can you revolve it around the Sun?

One idea is to move its current pivot point from the center of itself to the center of the Sun. That would, however, negate Mercury's own rotation, and it would no longer spin around its own center, so you can't do that. You need to create a new pivot point for

this object. This way, you have the original pivot point at Mercury's center so it can selfrotate, and you have a second pivot point at the Sun so that Mercury can revolve around that point around the Sun. You'll accomplish this by creating a new *parent node* above Mercury in the hierarchy. What does that mean?

In order not to get too confusing, we'll take time in the following section to introduce the concept of Maya object structure: nodes and hierarchies. Save your progress so far, and open a new blank scene. After this explanation, we'll resume the Solar System exercise.

# **Hierarchy and Maya Object Structure**

Let's take a timeout from the Solar System exercise and look at how objects and hierarchies work in Maya. On top of everything that you see in Maya—its interface—is a layer you don't see: the code. The layer of code keeps the objects in Maya organized through a network of nodes. How you relate these nodes defines how you've built your scene. In short, using Maya is essentially programming your computer directly to create 3D objects and animation.

So, having a solid understanding of how Maya defines objects and how they interact is essential to an efficient and successful animation process. This involves getting an intrinsic understanding of how nodes relate, whether it's a straightforward parent-child hierarchy in which one affects the other directly or a more complicated script-driven expression connecting 15 attributes of several objects to simplify a task.

## **Understanding Nodes**

At its core, Maya relies on packets of information called *nodes*, and each node carries with it a group of attributes that in combination define an object. These attributes can be spatial coordinates, geometric descriptors, color values, and so on. Taken together, an object's attributes define it and how it animates. You can define, animate, and interconnect any or all of these attributes individually or in concert, which gives you amazing control over a scene.

When you're beginning to work with a robust program, the learning curve occasionally spikes. With Maya, these spikes typically involve nodes and their interconnections. Although the interface automates much of the node creation and relationship process, the sooner you're exposed to the implications of the node level of objects, the easier it will be for you to overcome the typical learning curve. Even though you may not actively see that you're making root-level connections between nodes and attributes, that is exactly what you're doing every time you click a command.

Nodes that define the shape of a surface or a primitive are called *creation nodes* or *shape nodes*. These nodes carry the information that defines how that object is created. For example, a sphere's creation node has an attribute for its radius. Changing that

attribute changes the radius of the sphere at its base level. Shape nodes are low on the hierarchy chain and are always child nodes of *transform nodes*. The sphere listens to its creation node attributes first and then moves down the chain to its other nodes' attributes (such as position, rotation, or scale).

Not all primitives are created with shape nodes, so changes at the creation level may not be possible on certain objects; some objects are created without a creation node. When you create a new primitive or an object, make sure the History button () is turned on in the Status line (see Chapter 3 for more about the Status line and its icons). If it displays a small red X in the icon, History is off, and the primitive will be created without a shape node.

The most visible and used nodes are the transform nodes, also known as DAG nodes (Directed Acyclic Graph nodes). These nodes contain all the transformation attributes for an object or a group of objects below it. *Transformations* are the values for translation (position), rotation, and scale. These nodes also hold hierarchy information about any other children or parent nodes to which they're attached. When you move or scale an object, you adjust attributes in this node.

**Try This** As an example of working with transform nodes, you can create a sphere and see what happens in the Attribute Editor as you adjust its position and size. Follow these steps in a new Maya scene:

1. Press Ctrl+A to toggle the Attribute Editor on the right of the UI or to open it as its own window if you've set it up to do so in Maya's preferences. (Ctrl functions the same on a Mac as on a PC, so Mac users can also use their Ctrl key when called for in the text.)

The tabs along the top of the window let you switch between the nodes that are attached to this object. The current tab should be on the sphere's shape node, called nurbsSphereShape1. This node contains specific information about the object, but it isn't typically a node that you edit.

- 2. Press W to select the Translate tool. With the sphere still selected, click the nurbsSphere1 tab in the Attribute Editor to access the sphere's transforms node. Move the sphere a little in the *X* direction. Notice in the Attribute Editor that the Translate attribute for *X* has changed. You should also see the change in the Channel Box.
- 3. Press R to select the Scale tool. R is the hotkey by default in Maya for the Scale tool and is the same as clicking the Scale tool icon in the Tool Box (). Scale the sphere uniformly, meaning equally, in all directions by clicking and dragging the Center Manipulator handle (the cyan box). Notice that the Scale X, Scale Y, and Scale Z

attributes of the sphere change in the Attribute Editor. In the Attribute Editor, enter **1.0** for the *X*, *Y*, and *Z* Scale values to reset the sphere back to its original size.

4. In the creation node of makeNurbsSphere1, change the radius from 1.0 to 2.0. The sphere doubles in size because its radius is doubled. Switch back to the transform node (nurbsSphere1), and note that the Scale X, Scale Y, and Scale Z attribute values are unchanged. This is because you affected the size of the sphere through its Radius attribute in the creation node at its root level, not through the Scale attributes in a higher node. Any changes you make to the Scale attributes take effect after changes in the lower node. This is a perfect example of how one node's output (here, the Radius attribute) changes another node.

## **Parents and Children**

A *parent node* is simply a node that passes its transformations down the hierarchy chain to its children. A *child node* inherits the transforms of all the parents above it. So, by using hierarchies for the Solar System exercise, you'll create a nested hierarchy of parents and children to animate the orbital rotation of the nine planets and some of their moons.

By creating parent-child relationships, you can easily animate the orbit of a moon around a planet while the planet orbits the Sun. With the proper hierarchy, the animation of the planet orbiting the Sun automatically translates to the moon. In effect, the planet takes the moon with it as it goes around the Sun.

Child nodes have their own transformations that can be coupled with any inherited transforms from their parent, and these transformations affect them and any of their children down the line.

The revolution of one of the planets around the Sun takes into account its moons, but those moons can have their own animation to spin themselves around their planets. You're about to experience this firsthand as you continue the Solar System exercise. The more you hear about these concepts in different contexts, the easier they will be to master.

Figure 2.20 shows the Outliner and Hypergraph views with a simple hierarchy of objects for your reference. The Outliner and Hypergraph show you the objects in your scene in an outline and flowchart format, respectively. Both of these windows allow you to access the different levels of nodes (the hierarchy) in a scene and are discussed further in Chapter 3.

A top parent node called group1 holds its children *nurbsCone1*, *nurbsSphere3*, and the nested group node *group2*. The node group2 is the parent node of nurbsSphere2 and nurbsSphere1.

Figure 2.20 A simple hierarchy

windows

in both the Outliner

and Hypergraph



# The Solar System Resumed

If you still feel a little unsure about nodes and hierarchies, take the time to reread the previous section and try the short exercise again. You'll practice these concepts as you resume the Solar System exercise. By the time you've finished this exercise, you'll have a strong sense of how hierarchies work in Maya, although you should feel free to repeat the entire exercise if you think that will help you master hierarchies. Understanding nodes and hierarchies is important to animating in Maya.

If you're new to CG animation, take your time with the following section.

# Animating Mercury's Orbit Around the Sun

Load up your scene from where you last saved it. When you left off, you had created the self-rotation animation for Mercury and were about to create a second pivot point for the planet to orbit around the Sun by creating a new parent node for the Mercury sphere.

To create a new pivot point by making a new parent node, follow these steps:

With Mercury selected, press E for the Rotate tool, and then choose Edit → Group
from the Main Menu bar. The Channel Box displays attributes for a new node called
group1. Notice that nothing about the Mercury sphere changed, except that the Rotation Manipulator handle jumped from where it was originally centered on Mercury
all the way back to the origin, where the zero points of the *X*-, *Y*-, and *Z*-axes collide.
Figure 2.21 shows the new Mercury group and its new pivot location.



You just created a new Maya object by grouping Mercury to itself. In doing so, you also created a second pivot point for Mercury, in effect, which was placed by Maya at the origin by default. Because an object's Manipulator always centers on its pivot point when it's selected, Mercury's Rotate Manipulator jumped to the origin when the new parent node became selected upon its creation. That is fortunate for you, because that happens to be the center of the Sun—exactly where you need it to be for Mercury to orbit the Sun properly.

- 2. Without unselecting Mercury, click group1 in the Channel Box, and change the name of this new group to **Mercury\_Orbit**. It's important to make the distinction between node names so you never get confused. Now you know that the Mercury node is the planet sphere itself, whereas Mercury\_Orbit is the name of the new parent node, with which you'll orbit Mercury around the Sun.
- 3. Click anywhere in an empty space in your view window to unselect Mercury\_Orbit. Try selecting it again. Notice that when you click Mercury, you select only the planet and not the new parent node Mercury\_Orbit, the group that has its pivot point at the center of the Sun. This happens because you're in Object Selection mode (a.k.a.

Figure 2.21

Grouping Mercury to itself creates a new pivot point at the origin. Object mode). To select the group Mercury\_Orbit, you need to switch into Hierarchy mode by toggling its icon ( ) on the Status line at the top of the UI, as shown in Figure 2.22. Make sure you switch back to Object mode by clicking its icon ( ) in the Status line. For more on selection modes, see Chapter 3.

- 4. Go back to frame 1 of your animation. Set a keyframe for Mercury\_Orbit's Rotate Y attribute by selecting its name in the Channel Box and then choosing Animate → Set Key from the Main Menu bar.
- 5. Go to frame 240, grab Mercury\_Orbit's Rotate Manipulator handle by the green Y-axis, and spin it around the Sun twice in either direction. (It doesn't matter if you go clockwise or counterclockwise.) You can also enter 720 (or -720 Object Selection mode to go in the other direction) in the Rotate Y attribute field in the Channel Box.
- 6. Choose Animate → Set Key to set a keyframe at frame 240 for Mercury\_Orbit. Scrub your animation to play it back.

Does that make good sense? You'll have the chance to do this a few more times as you animate the other planets and their moons. However, if you still find yourself a little fuzzy on this concept (which is perfectly normal), repeat the steps to animate Mercury in a new scene file if need be. One down, eight to go.

## **Creating Venus**

For your next planet, Venus, follow the same procedure as for Mercury's self-rotation, and animate it so that it rotates about itself. Then, create a new pivot point (placed by default at the origin) by grouping Venus to itself to create a new parent node for that sphere, and call the new parent node **Venus\_Orbit**. Last, animate Venus\_Orbit to revolve around the Sun just as you did with Mercury\_Orbit in the previous steps.

## Earth and the Moon

Now you need to animate the third planet, the Earth, in much the same way, except that this time there will be the added complication of a moon. In addition, instead of choosing Animate → Set Key to set your keyframes, you'll use the keyboard hotkey S. (The Earth? Hey, I can see my house from here!)

Whenever you press S when an attribute is highlighted in the Channel Box, you're essentially choosing Animate → Set Key. In the Set Key Options dialog box, be sure you've changed Set Keys On to All Keyable Attributes instead of the default All Manipulator Handles and Keyable Attributes. Also make sure you've set Channels to From Channel Box instead of the default All Keyable, as mentioned in the earlier sidebar.



Figure 2.22 Toggling on the Hierarchy mode

To animate Earth and the Moon, follow these steps:

- Select Earth, and give it its self-rotation animation as you did for Mercury. But this time, select the rotation channel names in the Channel Box and press S, instead of choosing Animate → Set Key to set rotation keyframes. Again, if you left the Animate → Set Key □ at its defaults, pressing S sets keys for all attributes; but if you followed the advice given previously in the sidebar, only the selected channels are keyframed.
- 2. Select the Moon, and give it its self-rotation animation by spinning it around itself and keyframing it as you've just done with Earth.
- 3. To spin the Moon around Earth, do what you did earlier in this chapter to spin a planet around the Sun: group the Moon to itself by choosing Edit → Group, and name the new parent node **Moon\_Orbit**.

This time, however, you need the pivot point to be at the center of Earth and not at the center of the Sun object, where it is currently. Follow these steps:

- 1. Turn on the grid snap, and then press the Insert key to activate the pivot point. If you're using a Macintosh, press the Home key. The Moon's Manipulator changes from a rotation handle to the *Pivot Point Manipulator*. This Manipulator acts just like the Move Manipulator, but instead of moving the object, it moves the object's pivot point.
- 2. Grab the yellow circle in the middle of the Manipulator, and move the pivot point to snap it to the grid point located at the center of Earth (see Figure 2.23).
- 3. Press the Insert key again (or the Home key on a Macintosh) to return to the Rotation Manipulator for Moon\_Orbit. At frame 1, set a keyframe for the Moon's *Y*-axis rotation. Then, at frame 240, rotate the Moon about the *Y*-axis and set a keyframe. Return to frame 1.



Figure 2.23 Moving the Moon's pivot point to the center of Earth

## Grouping the Moon with Earth

To animate Earth's orbit of the Sun, you need to make sure the Moon will also follow Earth around the Sun. Instead of just selecting Earth and grouping it to itself as you've done for the other two planets, you need to include the Moon\_Orbit node in that group. Follow these steps:

Select Earth. Shift+click the Moon\_Orbit group while in Hierarchy mode ( ) to make sure you get the topmost node of the Moon, and then choose Edit → Group. Name this new parent node Earth\_Orbit. Remember, when you select just Earth or the Moon in Object mode ( ), the Earth\_Orbit node isn't selected. If you select Earth and then Shift+click the Moon, you select both objects, but you still don't select the parent node Earth\_Orbit, which is the group that contains both these objects and has its pivot point at the center of the Sun. Make sure you select the right group. Keep an eye on where the Manipulator is when you make your selection. If you have the Earth\_Orbit node selected, its Manipulator should be in the middle of the Sun. We'll deliberately illustrate this mistake and its consequences when you animate Pluto a little later.

Make sure you use Hierarchy mode ( ) when you click the moon object to select Moon\_ Orbit and not just the moon sphere. Otherwise, you'll lose the animation of the Moon orbiting Earth.

- 2. Set a keyframe for Earth\_Orbit's Rotate Y attribute at frame 1 by highlighting Rotate Y in the Channel Box and pressing S for the Set Key command. This assumes you've changed the defaults in Animate → Set Key □ as discussed in the earlier sidebar.
- 3. Go to frame 240, spin Earth and the Moon around the Sun a few times in whichever direction and for however many revolutions you want, and set a keyframe at frame 240 as well.

Now the first three planets are going around themselves and around the Sun, with a moon for the Earth. If you haven't been saving your work, save it now. Just don't save over the un-animated version from earlier.

#### **Creating the Other Planets' Moons**

Repeat this animation procedure for the remaining planets and moons, but leave out Pluto for now. (Poor Pluto: first it loses out on being a planet, and now it has to wait for last.)

If you find that one of your moons is left behind by its planet or that it no longer revolves around the planet, you most likely made an error when grouping the moon and planet. Undo until you're at the point right before you grouped them, and try again. If that still doesn't work, start over from the earlier version of the file you saved just before you began animating it. You'll learn how to fix it in the section "Using the Outliner," later in this chapter.

#### Auto Keyframe

You can also use the Auto Keyframe feature when animating the planets and moons. Auto Keyframe automatically sets a keyframe for any attribute that changes from a previously set keyframe. For example, an initial keyframe for an attribute such as Y-Axis Rotation needs to be set at some point in the animation. The next time the Y-Axis Rotation is changed, Maya will set a keyframe at the current frame automatically.

To turn on Auto Keyframe, click the Auto Keyframe icon ( ), which is to the right of the Range slider. When the icon is red, Auto Keyframe is active.

To use Auto Keyframe to animate the moon orbiting Mars, follow these steps:

- 1. Turn on Auto Keyframe.
- 2. Start at frame 1. Select Mars's moon, and set a keyframe for its *Y*-axis orbit by highlighting Rotate Y in the Channel Box and pressing S.
- 3. Go to frame 240. Revolve the moon around Mars several times in a direction of your choosing. Maya automatically sets a frame for *Y* rotation at frame 240. Save your file.

#### **USE CUBES INSTEAD OF SPHERES**

Feel free to create the planets and moons as cubes instead of spheres. That way, you can see each of their individual rotations much more easily, so you can tell whether the animation is working properly for you.

## Using the Outliner

The Outliner is an outline format listing of all the objects and nodes in your scene. For an in-depth look at the Outliner, see Chapter 3. For now, let's look at how to use the Outliner to illustrate the hierarchies for the planets and moons. When all is good and proper, the

Figure 2.24 The Outliner view of the planet hierarchies



Outliner should look like Figure 2.24. Choose Window → Outliner to open the Outliner window and take a peek at what you have. If you haven't yet properly named everything, including the moons, take this opportunity to do so by double-clicking a name in the Outliner and entering a new name.

Let's look at the planet Mars and its layout in the Outliner to better understand the hierarchy for all the planets. All the other planets should be laid out exactly like Mars (except the planets that have just one or no moons).

At the bottom of the hierarchy are Mars's two moons, mars\_moon and mars\_moon2. Each of those moons is spinning on its own pivot point. You grouped each moon to itself, created the mars\_moon\_orbit and mars\_moon2\_orbit nodes, and placed their pivot points at the center of Mars to animate their orbits around Mars.

Mars is spinning on its own pivot point, but it needed another pivot point to be able to orbit the Sun. Because you had to make the moons go with it around the Sun, you selected Mars, mars\_moon\_orbit, and mars\_moon2\_orbit (the top nodes of the moons that circle the planet Mars) and grouped them all together, placing that pivot point at the center of the Sun. You called this node Mars\_Orbit. This is the *parent node* because it's the topmost node for this group. Wherever this parent node goes, the child nodes that are under it will follow.

Hierarchies such as this are a cornerstone of Maya animation. It's imperative that you're comfortable with how they work and how to work with them. If you find yourself scratching your head even a little, try the exercise again. A proper foundation is critical. Remember, this learning 3D thing isn't easy, but patience and repetition help a lot.

## **Correcting Hierarchy Problems Using the Outliner**

One of the most common problems you'll run into with this project is a planet revolving around the Sun without its moon. To illustrate how to fix it using the Outliner, as opposed to undoing and redoing it as suggested earlier, the following steps will force you to make this error with Pluto. Usually, people learn more from mistakes than from doing things correctly.

Go to Pluto, start the same animation procedure as outlined earlier, and then follow these steps to force an error:

- 1. Create Pluto's own self-rotation by spinning it around itself and keyframing as before.
- 2. Do the same for Pluto's moon's rotation.
- 3. Group the moon to itself, and grid-snap the pivot point at the center of Pluto to create the moon's orbit of Pluto.

When Pluto's moon (pluto\_moon) is orbiting Pluto, you're ready to group the moon's orbit and Pluto together to create an orbit of the Sun for both.

- 4. Here is where you make your mistake. In Object mode, select the sphere for Pluto's moon, and select the sphere for Pluto. Your error is that you're remaining in Object mode instead of switching to Hierarchy mode.
- 5. Choose Edit → Group to group them together, and call that new node **Pluto\_Orbit** (following the naming convention you used for the others).
- 6. Animate Pluto\_Orbit revolving around the Sun.
- 7. Play back the animation.

Notice that the moon is no longer orbiting the planet. This is because you didn't include pluto\_moon\_orbit in your group Pluto\_Orbit. The animation of the moon going

Figure 2.25





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Pluto\_Dibit

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-o Moon\_Orbit

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defaultObjectSet

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around Pluto is stored in that node; and because it's no longer attached to Pluto\_Orbit, there's no moon orbit of Pluto.

Figure 2.25 shows the hierarchy of Pluto and how it's different from that of the other planets: the moon's orbit node has been left out of the group. (Earth has been expanded as a contrasting example.)

Using the Outliner, you can easily fix this problem. Place the pluto\_moon\_orbit node under the Pluto\_Orbit node. Go to frame 1 of the animation, grab the pluto\_moon\_orbit node

in the Outliner, and use the middle mouse button to drag it to the Pluto\_Orbit node so that it has a black horizontal line above and below it to show a connection, as in Figure 2.26.

You've just grouped pluto\_moon\_orbit under Pluto\_Orbit, a practice known as *parenting*. Now you need to parent pluto\_moon under pluto\_moon\_orbit as well. Use the middle mouse button to drag pluto\_moon onto pluto\_moon\_orbit. When you play back the animation, you'll see that the moon is revolving around the planet, while at the same time Pluto and the moon are orbiting the Sun.

Now that you've corrected Pluto's layout in the Outliner, it's similar to the layouts for the other properly working planets.



The file Planets\_v3.mb in the Scenes folder of the Solar\_System project on the CD will give you an idea of how this project should look. The first five planet systems are grouped and animated as a reference, leaving the final four for you to finish.

You can add objects to a group by MMB+dragging their listing onto the desired parent node in the Outliner. You can also remove objects from a group by MMB+dragging them out of the parent node to a different place in the Outliner.

#### **GROUPING TERMINOLOGY**

Grouping terminology can be confusing. Grouping Node A under Node B makes Node A a child of Node B. Node B is now the parent of Node A. Furthermore, any transformation or movement applied to the parent Node B will be inherited by the child Node A.

When you group Node A and Node B, both nodes become siblings under a newly created parent node, Node C. This new node is created just to be the parent of Nodes A and B and is otherwise known as a *null node*. To group objects, select them and choose Edit  $\rightarrow$  Group. Parenting nodes together places the first selected node under the second selected node. For

#### **GROUPING TERMINOLOGY** (continued)

example, if you select Node A, Shift+select Node B, and then choose Edit → Parent, Node A will group under Node B and become its child. This is the same procedure as MMB+dragging Node B to Node A in the Outliner, as you did with Pluto's moon and Pluto itself.

# **Outputting Your Work: Playblasting**

What's the use of animating all this work and not being able to show it? There are several ways of outputting your work in Maya, most of which involve rendering to images. One faster way of outputting your animation in a simple shaded view is called *playblasting*. Playblasting creates a sequence of images that play back on your computer at the proper frame rate. Only if your PC is slow, or if you're playblasting a large sequence of frames, will your playback degrade. In this case, playblasting 240 frames shouldn't be a problem.

A *playblast*, as it's called in Maya, outputs the view panel's view into an image sequence or AVI movie. You can also save the image sequence or AVI to disk if you like. Playblasting is done mainly to test the look and animation of a scene, especially when its playback is slow within Maya.

When you have your Solar System animated, output a playblast by following these steps:

- 1. With your animation completed, click in the Perspective panel to make it active in the four-panel layout (don't maximize the Perspective window). Press 5 to enter Shaded mode.
- 2. RMB+click in the Time slider, and select Playblast □ from the menu, as shown in Figure 2.27. The Options dialog box is shown for the Playblast options in Figure 2.28.
- 3. In the Playblast options, set the Viewer to Movieplayer (displayed as QuickTime when using a Macintosh) and the Display Size to From Window. Check the Save to File option, and give your Playblast a name. Set the Scale to 1.0.

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### Figure 2.27 Select the Option box for Playblast.



Figure 2.28 Options for creating a Playblast preview

- 4. Because you checked the Movieplayer (or QuickTime on a Mac) option, Maya runs through the animation and creates an AVI movie file on a PC or a QuickTime movie file on a Mac that is based on the Shaded-mode appearance of the currently active view panel (which should be the Perspective panel). Because you also checked the Save to File option, the movie file is saved to disk. By default, it's saved to the Images folder for the Solar\_System project you created on your hard drive. You can also click the Browse button to store the playblast video file anywhere you like. For now, click Browse, and place the file on your desktop. Click the Playblast button.
- 5. When Maya runs through the animation, Windows Media Player on Windows and QuickTime on a Mac (or whatever your default movie player is set to in your OS) automatically opens and plays the move file of the animation at the proper speed of 30 fps, as shown in Figure 2.29. Now you can share your animation with others without having to open Maya and play it back in the scene.

When you're creating a playblast, make sure you don't cover the view panel with any other windows, such as an Internet browser, as you wait for the animation to complete. Doing so will create a display error in the playblast output. It's best to allow Maya to complete the playblast before you use the system again.





# Summary

In this chapter, you learned how to start working in Maya by getting around the interface a bit and learning how to navigate the UI. Then, you began working by creating a new project, creating basic objects such as primitives, and placing objects in the scene. You learned how to place pivot points for objects and how to use snaps to place points precisely. You had some experience with the Channel Box and Attribute Editor to set an object's attributes. You then went on to create simple shaders for your objects and set keyframes to animate a Solar System. You went over object hierarchy and grouping conventions to organize and set up your scene better, and finally you learned how to output a basic playblast video file of your completed animation.

The planet animation you created is based on a system of layering simple actions on top of each other to achieve a more elaborate result. If you work slowly and in segments, animation is more straightforward to produce and generally of higher quality. Much of your time in actual animation, as opposed to setup or modeling, will be spent adjusting the small things. These small things give the scene life and character. You'll find that finishing 85 percent of a scene will take about 15 percent of the time. The remaining 85 percent of the time goes into perfecting the final 15 percent of the scene.