Hair Systems

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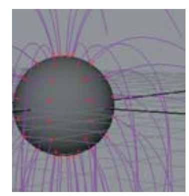
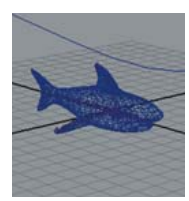
Hair systems *use a collection of dynamic NURBS curves generated from hair follicles to simulate natural movement of long hair, hair blowing in the wind, hair motion when a character is swimming underwater, and various hair styles (including braids and updos).*



Although we're talking about a sub-module of the Dynamics module called Hair, *you can put Hair dynamics to myriad uses beyond just hair. In this chapter, we will jump into Hair dynamics with a few examples to take a look at how to use them to create animations for scenes.*

Each hair follicle contains one NURBS curve, but it can also contain a number of hairs that make up a clump. The follicle has various attributes for modifying the simulation as well as the appearance and style of the hair, including a ***Braid*** *attribute. The new Paint Hair tool allows for creating and removing follicles as well as painting hair attributes (including* ***Clump Width Scale****,* ***Stiffness****, and* ***Braid****).*

But since Hair uses a generic dynamic curve simulation engine, you can also use the curves to control IK chains, deformers, surfaces, and so on. And we will continue to focus on that in the following examples. But first, we'll explain how Hair works.



Hair at a Quick Glance

Getting to know a few things about Hair will help build your foundation for the examples in this chapter, as well as prepare you for some other dynamics exercises in Chapter 7.

You can create Hair on both NURBS and polygonal surfaces. But for polygons, UVs should be nonoverlapping and fit between 0 and 1. Automatic mapping is a quick way to achieve this, however. Before you create the Hair system, decide which renderer you will be using because this affects the type of output you select.

You can create Hair in the form of NURBS curves (you use this option if you want to use the Hair system for nonHair dynamic simulations), Paint Effects strokes, or both curves and strokes. For example, you use Paint Effects strokes to create renderable hair for you character, or you create NURBS curves to help you create animations for your scene.

Curve Types

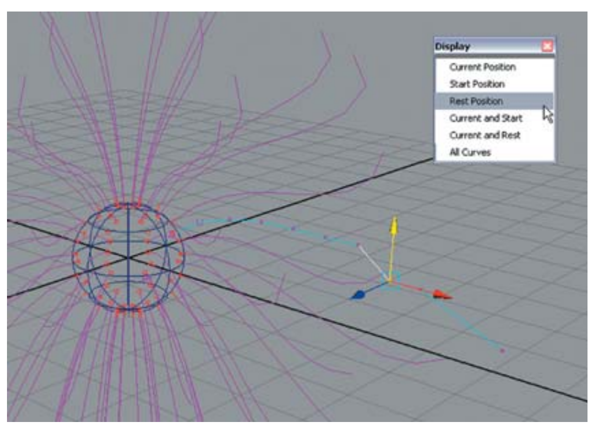
There are three sets of curves for a given Hair system:

Start Position Curves This is the position of the hair at the start frame of a hair simulation. At creation time, these curves stick out straight from the follicles on the surface and show you the origin of your simulation.

Rest Position Curves This is the position of the hair when no forces are affecting it. You can edit the shape of these curves to influence the look of the hair. You essentially set these curves to give the hair curves a goal, if you will.

Current Position Curves These curves show you how the hair behaves when you play the simulation.

To display any of these curves while you set up your simulation, choose **Hair → Display**. This is useful in showing how the hair is reacting to forces. Figure 6.1 shows you the Start Position Curves as well as the Current Position Curves as they fall due to gravity.



You can easily edit the Start and Rest Position curves by editing their points in Component Mode as you would any other CV or EP curve. This way you can set your simulation as you like it, to create, for example, a simulation in which you hair stands up when you grab onto a power cable. Just don't mess with the Current Position Curves; you want to let Maya run those for you.

Do not edit the Current Position Curves. Doing so yields unpredictable results.

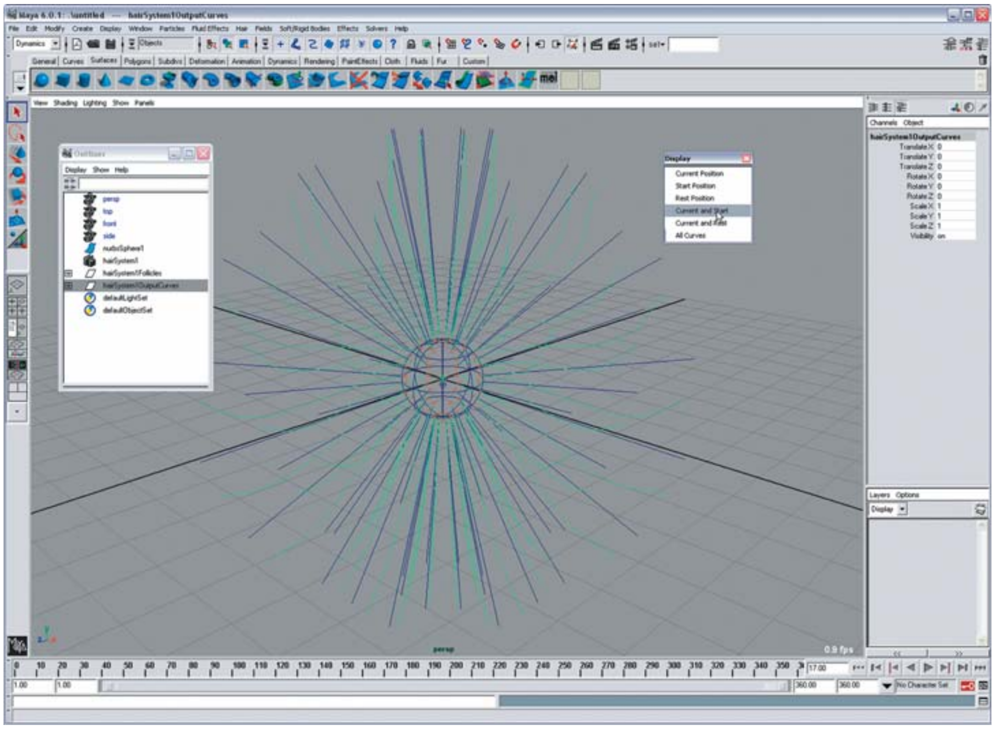


Figure 6.1: The Start and Current Position Curves

Passive Hair Curves

Passive curves interpolate the dynamic behavior of active curves, but are less expensive than simulating every curve. In the Create Hair options window, you can specify a ratio of passive curves (Passive Fill) to active curves to fill in hair without incurring a huge simulation cost. Dynamic forces or collisions are not computed on passive hairs, per se. Instead, they interpolate the motion of the active hairs in their own hairSystem node. Figure 6.2 shows passive curves in green and active curves in blue.

The **Simulation Method** attribute on the follicleShape node for a Hair system determines whether the hair curve is dynamic, passive, or static, allowing you to change the curve to suit your simulation. Static hairs simply keep their start position and do not animate. That's not fun.

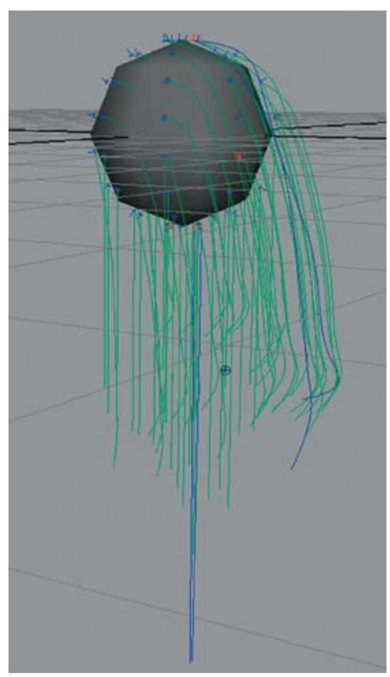


Figure 6.2: Passive and Active curves

Interacting with the Hair Simulation

What's fun about hair if you can't play with it? In the following steps, you will learn how to interactively move, scale, or rotate the surface with hair while the simulation is playing and see the hair update due to the dynamic forces applied to it.

Choose **Hair → Display → Current Position** to change the hair curves display to the current dynamic curves, which are those that update when you play the simulation. This is usually the default display so as not to cause confusion. To interact with your Maya object while the simulation runs, follow these steps:

1. Of course, you'll need a surface with hair. Create a NURBS sphere. While it is still selected, choose **Hair → Create Hair**.
2. Select the surface with your hair. In the Dynamics menu set, choose **Solvers → Interactive Playback** to play the hair simulation and allow you to interact with it at the same time.
3. Select the Move tool, and move the surface with hair while the simulation is running to see how the hair reacts to the dynamic forces.
4. Now select the Scale or Rotate tool and act upon the surface with hair to see how the hair reacts to the dynamic forces.

To tweak the hair simulation, adjust the **Stiffness**, **Iterations**, and even **Gravity** attributes in the Dynamics section of the hairSystemShape node.

Hair Constraints

Choose **Hair → Create Constraint**, and then choose from a variety of options that are designed to enhance specific hair looks. When you create a constraint, the constraint is set to affect the selected hair curves. For example, three hair curves in Figure 6.3 have been given a Rubber Band constraint. When you run the simulation, they are affected by the constraint's locator and its position and movement.

In component mode you select the curve components where you want to apply the constraining effect; you do not select the entire curve, unless you fear nothing.

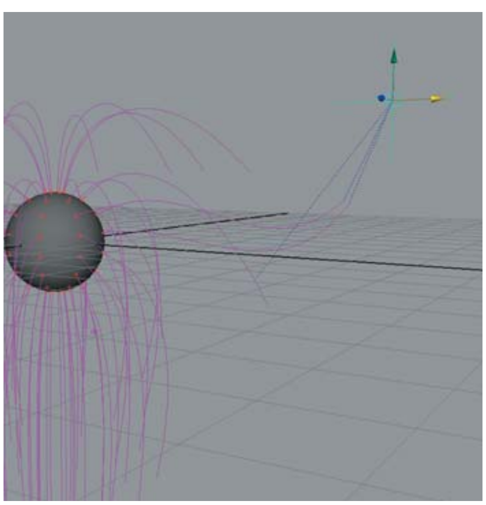


Figure 6.3: Three hairs are constrained by a Rubber Band constraint.

To apply a constraint, first select the hair curves and then apply the constraint type you want. The Attribute Editor for the hairConstraintShape node contains the attributes that affect the way the constraint interacts with the hair. For example, **Glue Strength** rules the strength of the constraint, and **Stiffness** lets you control the elasticity of the constraint. If you want an effect in which you are grabbing the ends of a few hairs forcefully, **Glue Strength** is as high as **Stiffness**. But if you are going for an effect in which the static charge of a balloon rubbed on some rabbit fur gently tugs on the ends of the hair, both **Glue Strength** and **Stiffness** are low.

Using Hair Curves as Deformers

Now that you've seen a little bit of Maya Hair's workings, let's look at a few examples of how Hair dynamics can help run your animation. In this example, we are creating the motion of an octopus's tentacles with hair.

The Hair system curves will be made into wire deformers and will drive the animation/deformation of the octopus. Upon contact with the ground, the tentacles will emit into a 2D fluid container positioned at ground level to create a look of dust getting kicked up. To begin, follow along with these steps:

1. Open the file `Octopus_start.mb`. You should see something like Figure 6.4.
2. Go to the top view. From the Create menu, select the EP Curve tool.
3. Holding down the V key (for snap to point), start clicking the tentacle's axis following the order shown at right.
4. Press Enter at the end of the tentacle (after the ninth click) to create the curve. Smashing, isn't it?

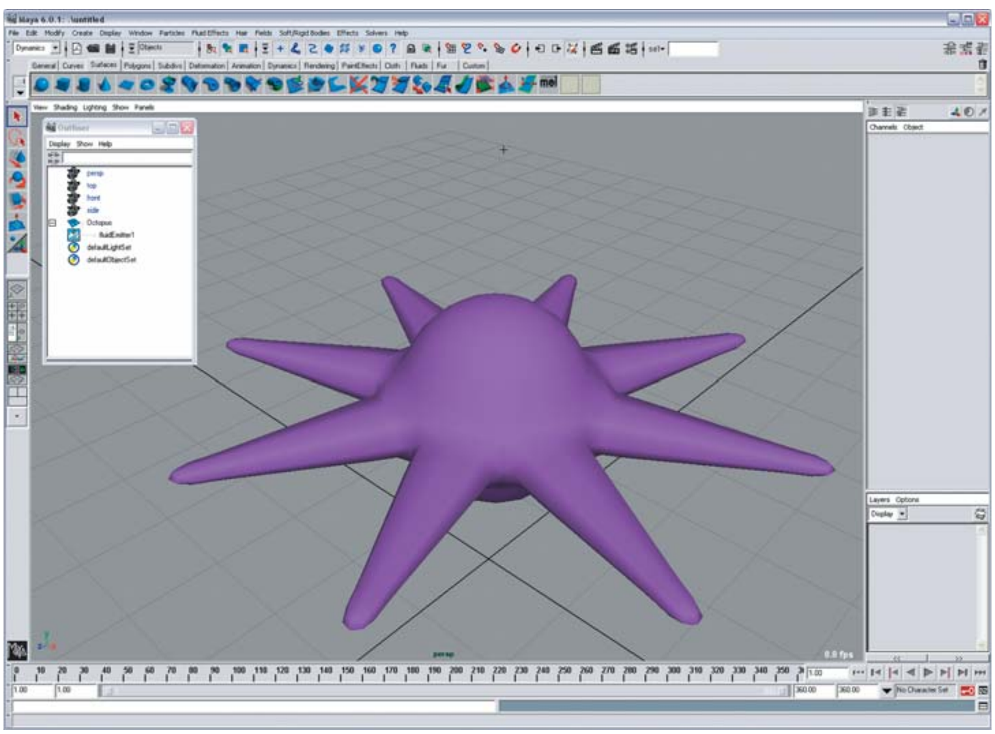


Figure 6.4: Fancy octopus

5. Change the scale on the Y axis to 0 for the curve you created to flatten it.
6. Go to the side view. Holding down the X key, move the curve up until it is in the center of the tentacle. It needs to be positioned here to properly deform the surface.

If you go to the side view when you move with the curve snapping to the grid, it helps because the octopus is 2 units above the ground and the curve will snap in the middle.

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7. Choose **Edit → Duplicate ❐**. Set the Rotate Y value to 45, set the number of copies to 7, and click Duplicate. The next time you duplicate, be sure to reestablish these settings unless you want eight more copies. The curves should be in the center of the tentacle.
8. Open the Outliner, select the eight curves, and then choose **Hair → Make Selected Curves Dynamic** to turn the curve into a dynamic curve.
9. In the Outliner, click the plus sign beside hairSystem1Follicles to expand the view. Shift+select all the hair follicles (from follicle1 to follicle8). You need to select the follicle nodes themselves, instead of just selecting the group node.
10. In the Channel box, click inside the Point Lock field and choose Base from the drop-down menu to lock down the now-dynamic curves at their base, which is at the start of the curve.
11. In the Hair menu, choose **Display → Current Position** to ensure that you're seeing the curves as they move—not that we don't trust you or anything.
12. In the Animation menu set, choose Deform and then select the Wire tool. This lets you assign the curves as wire deformers.
13. Select the octopus geometry and press Enter to select the affected geometry. Now you can select the deforming curves to be used.
14. In the Outliner, click the plus sign beside hairSystem1OutputCurves to expand its view as shown in Figure 6.5.
15. Shift+select all the output curves (from 9 to 16) and press Enter. This creates wire deformers for these curves to drive the deformation of the octopus. Again, it's important to select the output curves and not just the top node.
16. Select the octopus geometry, and then select hairSystem1Follicles in the Outliner. In the Constrain menu, choose **Parent**. This ensures that the follicles move with the octopus's body.
17. Expand hairSystem1OutputCurves in the Outliner. Select the octopus geometry, Ctrl+select curve9BaseWire, and choose **Parent** from the Constrain menu. Repeat this step for all the other BaseWire curves found in hairSystem1OutputCurves. This step is important since it ensures that the base of the deformers moves with the octopus geometry.
18. Set your playback end to 10000. This is to let you see the simulation run a good long course. Plus big numbers are cool.

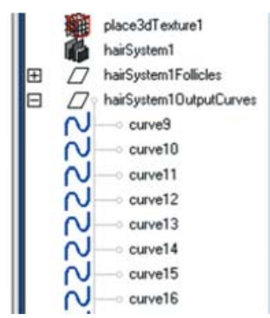


Figure 6.5: Expand the Outliner view to select the curves themselves.

Now let's see how the octopus body deforms while you move the geometry around in the Perspective view. Select the octopus geometry, and in the Dynamics menu set, choose **Solvers → Interactive Playback**. This plays the hair simulation while allowing you to interact

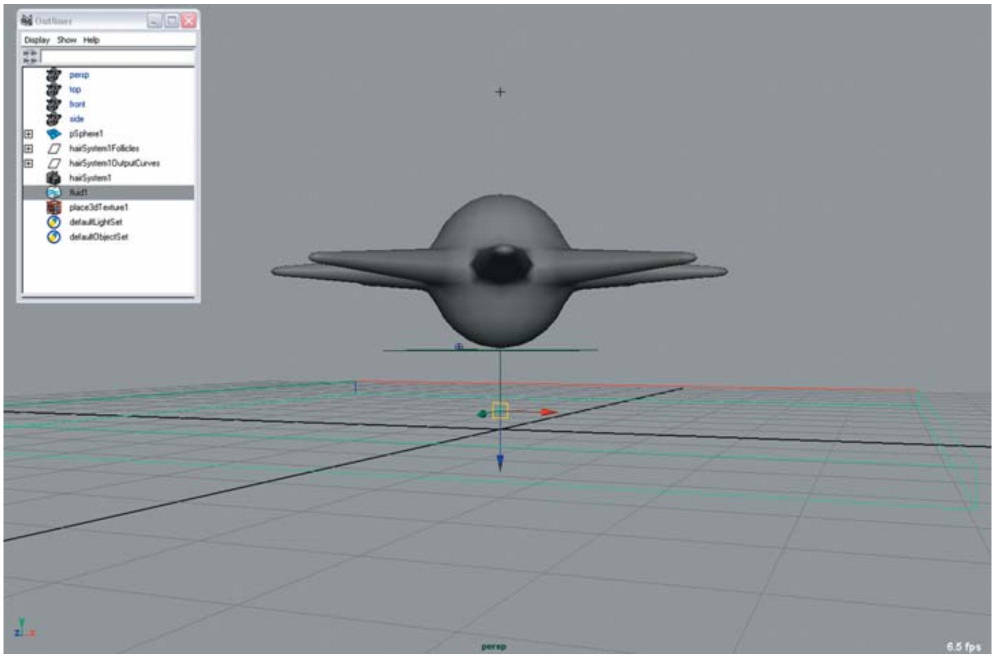


Figure 6.6: Position the fluid container to kick up dust from the octopus's movement.

with the octopus. Using the Move tool, select the octopus and move it while the simulation is playing interactively.

Let's add some collisions to the simulation and add some fluid emission for the fun of it, so that the octopus kicks up a little dust:

1. In the Outliner, select HairSystem1, and in the Attribute Editor, open the Collisions section. Turn on Self Collide and Collide Ground to prevent the tentacles from going through the ground plane or crossing each other.
2. From the Fluid Effects menu, choose **Create 2D Container** to add a 2D fluid container to the simulation.
3. In the Channel box, set the Rotate X of the 2D fluid container to 90 and then move it 0.25 units on the Y axis to place it just above the ground plane, as shown in Figure 6.6.
4. Open the Attribute Editor for the fluid container. In the Contents Method section, set Density to Static Grid, and set Velocity, Temperature, and Fuel to Off.
5. Open the Shading section of the Attribute Editor for the fluid container, and set the color to dark gray for dust.
6. Open the Display section of the Attribute Editor for the fluid container, and set Boundary Draw to None. This will just turn off the bounding box view of the fluid container to clean up our view.
7. In the Outliner, select the fluid container, and then Ctrl+select the octopus geometry. From the Fluid Effects menu, choose **Add/Edit Contents → Emit from Object**. This will make the octopus emit inside the fluid container.

Now when you play back the simulation, dust will be emitted at the contact points when the tentacles touch the ground, as you can see in Figure 6.7.

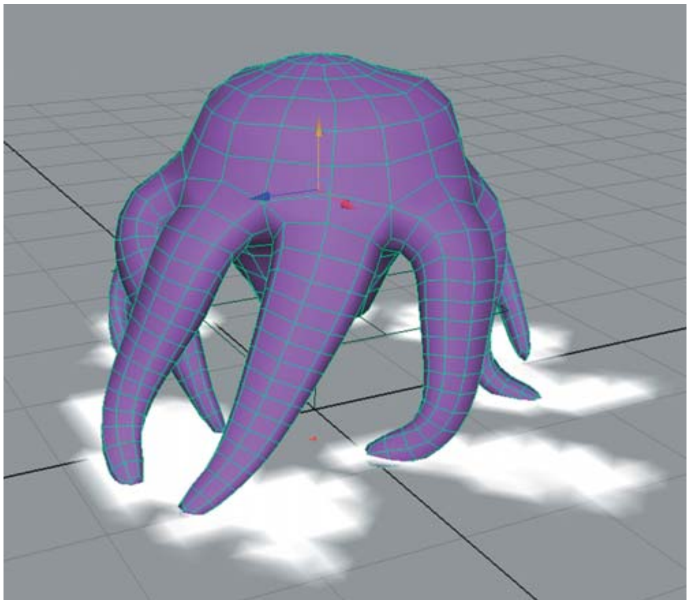


Figure 6.7: Crazy like Footloose*!*

Open up the `Octopus_finished.mb` file to take a look into the finished simulation. You can use this sort of setup to animate a mop or broom, for example, though you would have more strings and bristles than tentacles to play with.

The Breaking Rope Effect

In this exercise, we will use constraints to create an effect of a rope breaking. It sounds fairly simple, though it's a complicated procedure that is made easier with Maya's Hair tools. You can use this type of animation on something like a rope bridge snapping just when the hero jumps to safety and the villain falls to his all-too-deserved death.

You can open the `Rope_Finished.mb` file to take a quick peek at the effect, shown in Figure 6.8. But essentially we'll just attach two ends of two dynamic curves together using a constraint and then break the influence of the constraint to get the rope to break apart.

To create a breaking rope, follow the beat of this drum:

1. Go to the top view. From the Create menu, select the EP Curve tool. We'll draw the curves to use for the rope.
2. Start creating a curve by holding down X (for snap to grid) and first clicking 12 units to the left of the origin on the X axis. Continue clicking at 8 units to the left and then 4 units to the left, and finally click the origin and press Y to complete the creation of the curve and keep the EP Curve tool as the current tool. (See Figure 6.9.)

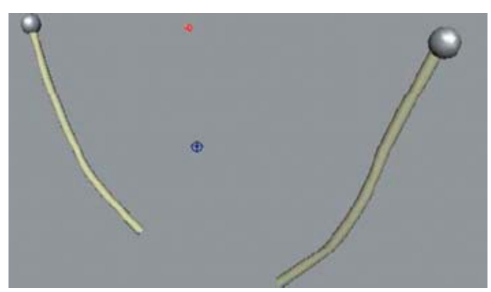


Figure 6.8: The desired effect

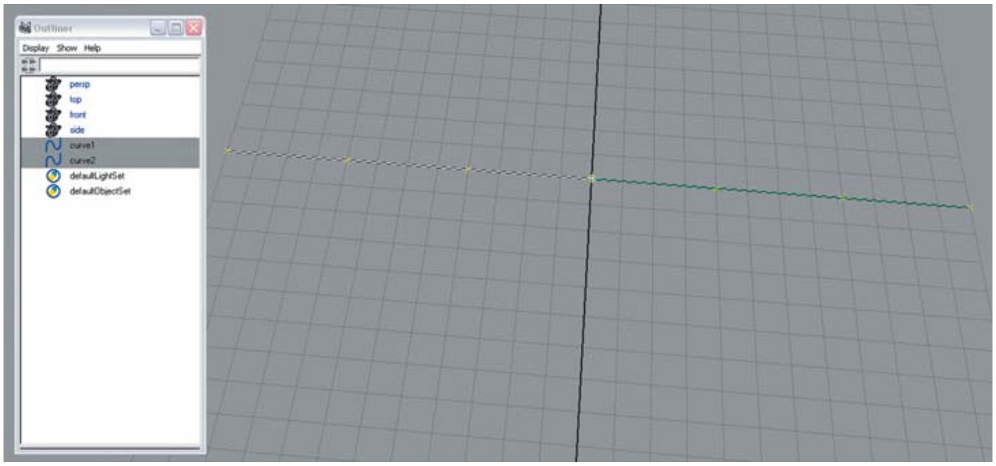


Figure 6.9: Drawing the two curves to be used for the halves of the rope

3. Start creating the second curve by clicking first at the origin (while holding X), then at 4 units to the right, 8 units, and then finally at 12 units. Now press Enter to complete the second curve.
4. Select the second curve, and in the Edit Curves menu, choose **Reverse Curve Direction** to orient the curve properly when we lock down the ends of the dynamic curves.
5. In the Outliner, select the two curves you just created and choose **Hair → Make Selected Curves Dynamic**. This will make the two curves dynamic. But since you had both selected when you ran the operation, you'll make them dynamic using a single Hair system. This way you can edit the dynamic attributes for both curves easily with one hair system node.
6. In the Outliner, expand hairSystem1Follicles by clicking the plus sign. Select the first follicle, and open the Attribute Editor for follicleShape1. Set the **Point Lock** attribute to Base. You can also access this attribute in the Channel box, as shown in Figure 6.10.
7. Repeat the previous step for the second follicle.
8. Play back the simulation by clicking the Playback button in the animation controls. Stop after 60 frames. You should see something like Figure 6.11.
9. In the Hair menu, choose **Display → Current Position.**

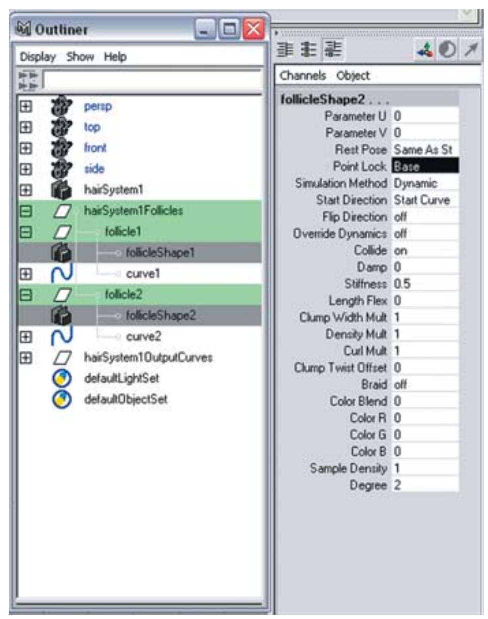


Figure 6.10: Setting a base point lock for the two curves

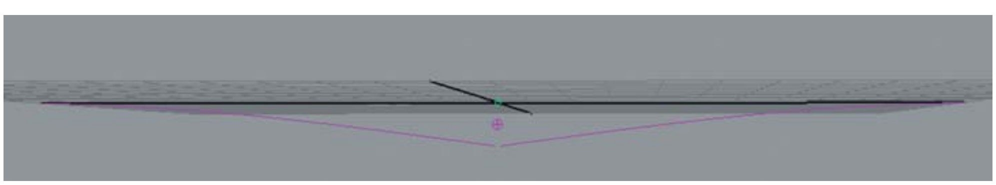


Figure 6.11: Play back the first 60 frames.

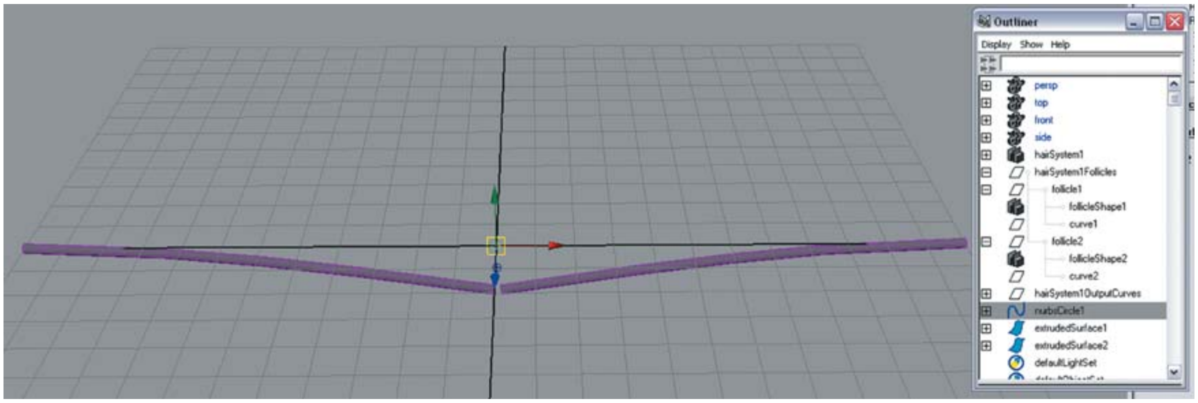


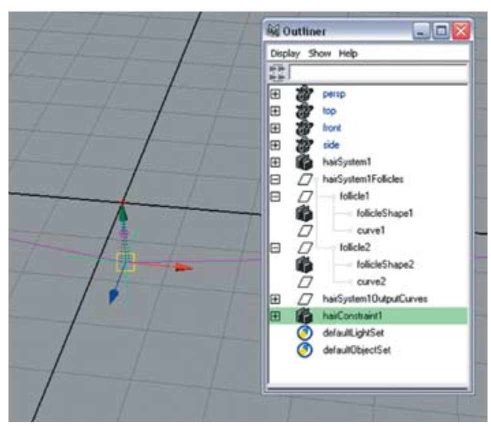
Figure 6.12: The two rope halves

Now that we have the dynamic curves in order, let's give the rope a bit of thickness. For this, a simple extrusion will work great. Make sure history is turned on before you proceed since you will use history to animate the rope.

10. From the Create menu, choose **NURBS Primitives → Circle.** We'll use this profile curve to extrude the shape of the rope.
11. In the Channel box, scale the circle down to 0.3 on the X and Z axes.
12. In the Perspective view, select the circle first and then Shift+select the first curve. In the Modeling menu set, choose **Surfaces → Extrude →** ❐ and set the following attributes: **Style** to Tube, **Result Position** to Path, **Pivot** to Component, **Orientation** to Profile Normal, **Output Geometry** to NURBS. Click Extrude. This will give your rope thickness.
13. Select the circle, and Shift+select the second curve. Extrude again using the settings in the previous steps.
14. Do not delete the circle or the history on any of the curves or objects in the scene, since the history of the extrusion deforms the surfaces. And by keeping the history, you can adjust the thickness of the rope at any time by scaling the circle. Figure 6.12 shows the result of the extrusions.
15. In the Outliner, select hairSystem1, and open the Attribute Editor. In the Dynamics section, change **Stiffness** to 0.003 and, in the Stiffness Scale section, change **Gravity** to 5.
16. Select the two curves, and in Component mode, select the CVs at the origin (from both curves), as shown in Figure 6.13.

    By selecting the CV points, you're telling Maya exactly where you want the constraint to take effect.

    In the Hair menu, choose **Create Constraint → Hair to Hair** as shown at right.



17. Rewind your simulation, and then play back the first 100 frames. The curves will bow down, but stick together to form a single slack rope.

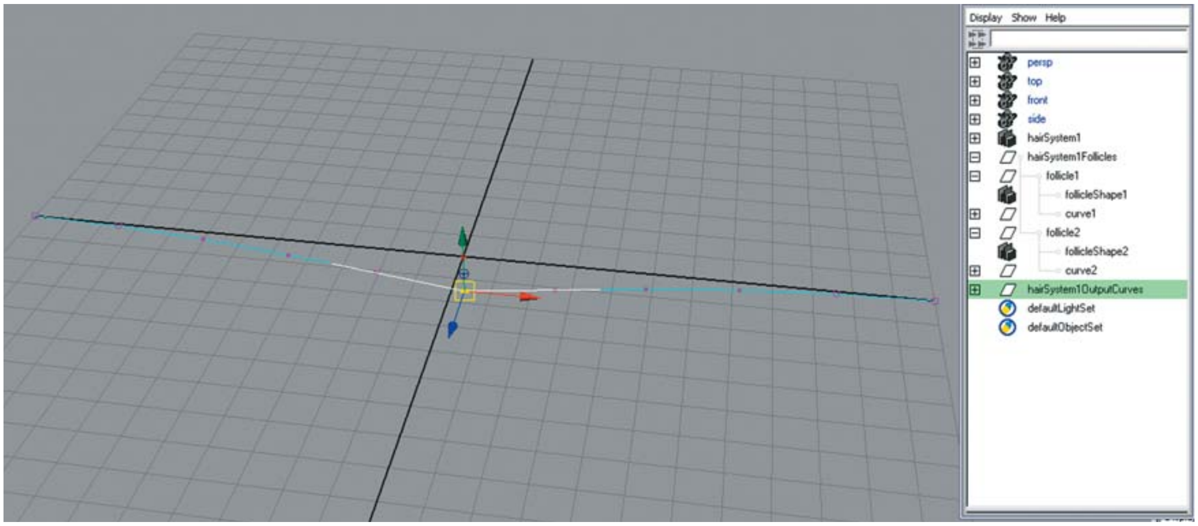
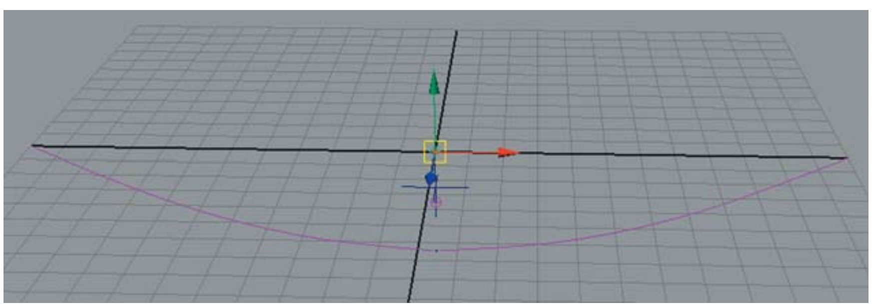


Figure 6.13: Selecting the CVs at the end

18. In the Perspective view, select the two curves (in object selection mode), go to the Hair menu, and choose **Set Start Position → From Current**. This sets the current position shown here as the beginning position for the dynamic curves.



19. Now we will keyframe the **Glue Strength** attribute on hairConstraint1. This will allow us to get the breaking effect since this attribute basically controls the influence of the constraint on the dynamic curves.
20. We'll decide to break the rope at frame 150, so go to frame 149 to set a keyframe for the rope as a single piece. At frame 149, in the Outliner, select hairConstraint1, and set a keyframe in the Channel box for the attribute **Glue Strength** at a value of 1.
21. Go to frame 150, change the value of **Glue Strength** to 0, and set another keyframe. This essentially turns off all influence of the constraint keeping the two rope halves together, effectively breaking them apart like a good argument.
22. Now when you play your animation, the rope should break at frame 150 as we see in Figure 6.14.

You can add some turbulence strength and frequency to the hairSystem node in the Attribute Editor on the Turbulence section to enhance the realism of the simulation. This will

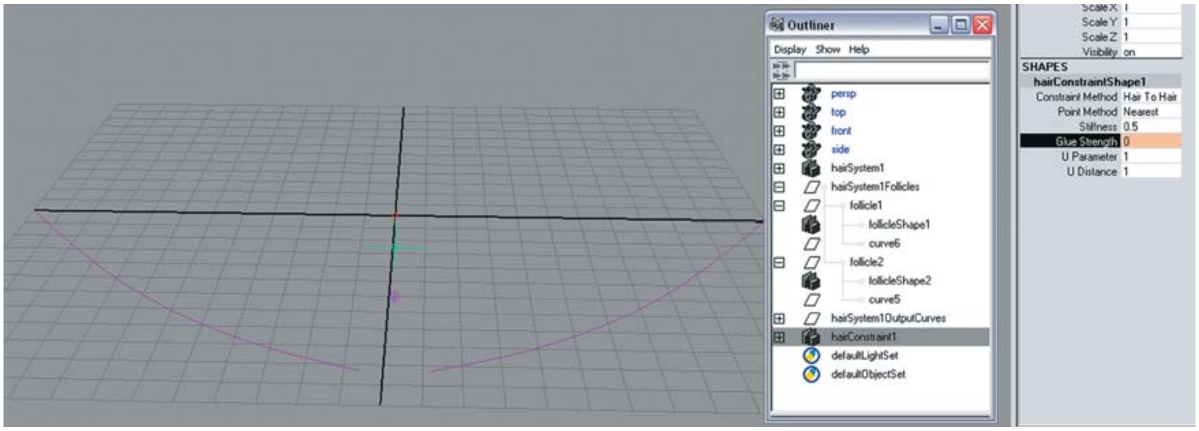


Figure 6.14: Breaking up is hard to do.

make a big difference in your animation as it will give the rope at least a little bit of a sway. Creating believable simulations depends on layers upon layers of animation.

Furthermore, try to animate the settings on the turbulence or other forces to make it seem as if the forces acting on the rope cause it to break. A good exercise is to animate a wind sock using Hair.

Driving a Character's Secondary Motion

With character animation, any professional will tell you that an incredible amount of work goes into making a character move well. Getting Maya to create as much of that animation for you as possible can be a blessing, as long as the simulation is well thought out, and intricately prepared and executed.

In the following tutorial, we will use dynamic hair curves to drive the secondary motion of skeleton joints. We'll be using these joints as influences on flesh on the character. This will help us produce realistic flesh inertia while the character is moving that reacts to the animation given to the body.

The curves will be set up as IK spline handles for the additional deformation joints. After creating the additional joints and the IK spline handles, we will adjust the hair system attributes to achieve the right amount of inertia from the character's movement.

Setting Up the Rig

From the CD, open the file `Hair_Walk_Start.mb`. A rig of a biped with a simple walk animation is already applied to the rig. Figure 6.15 shows the file loaded in the persp view.

To begin adding secondary movement controls to the rig, follow along:

1. From the Create menu, select the EP Curve tool. We will trace a curve along the thigh bone of the right leg in the next step.
2. Holding down the V key (snap to point), click once on the right_hip joint and once again on the right_knee joint. Press Enter to complete the curve shown as the green line running up the thigh in Figure 6.16.

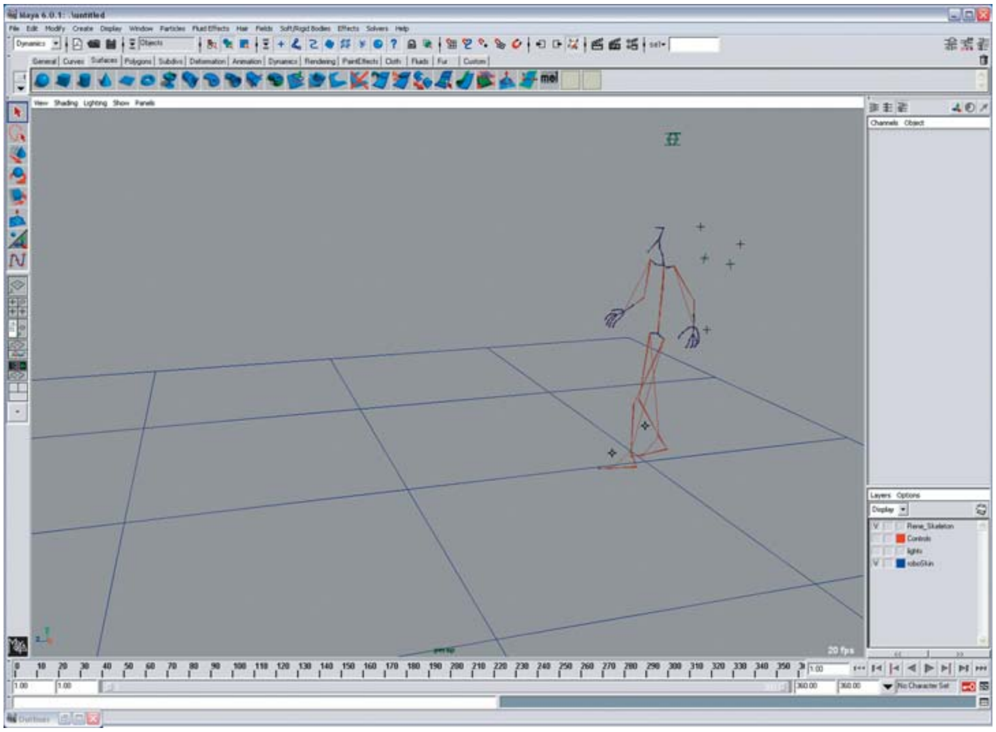
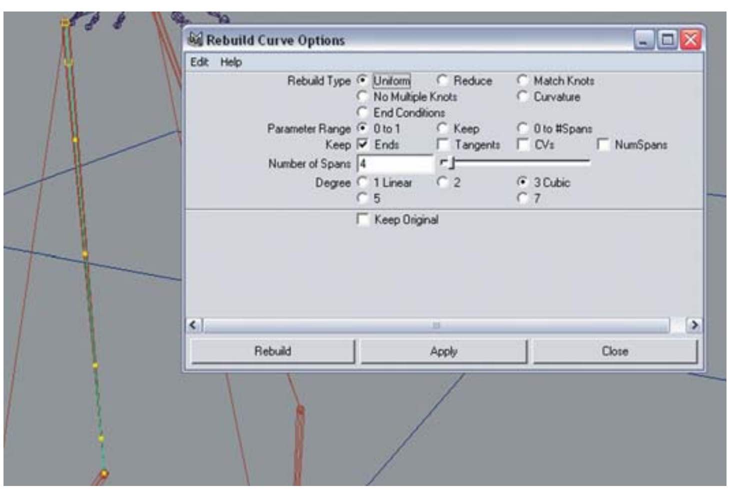


Figure 6.15: The starting rig and walk cycle file loaded and ready to go!

3. With the curve selected, choose **Edit Curves** → **Rebuild Curve** → ❒. Set **Rebuild Type** to Uniform, set **Number of spans** to 4, and click Rebuild as shown below. This ensures that we have a uniform curve with the six CVs that we will need.



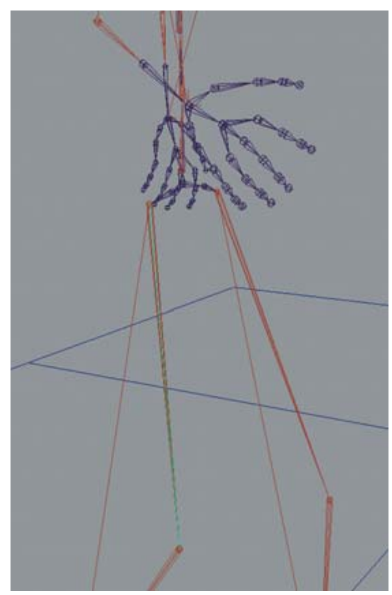


Figure 6.16: The curve runs along the thigh bone, seen in green.

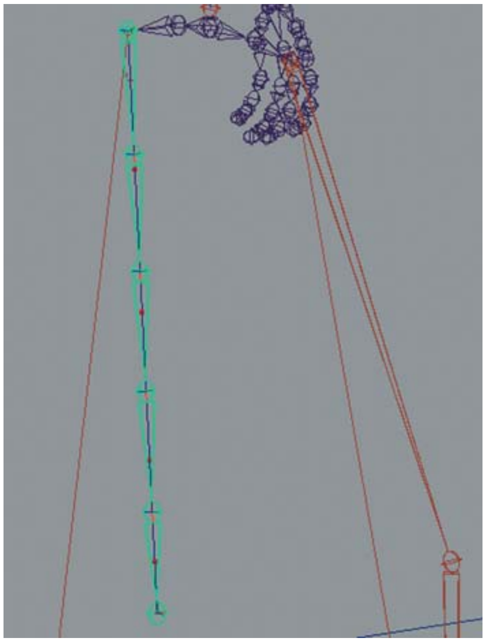


Figure 6.17: *Draw six evenly spaced joints along the curve.*

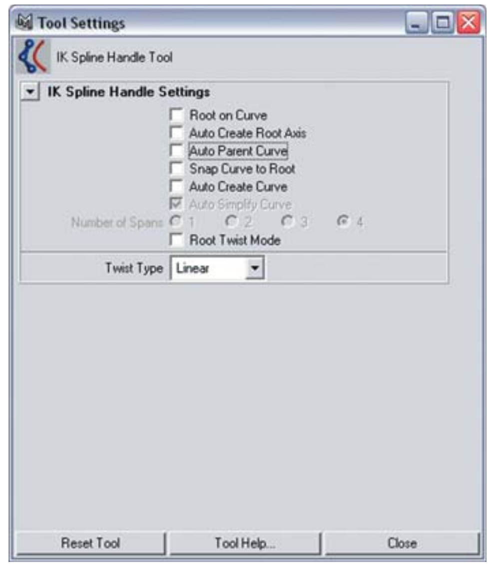


Figure 6.18: *The IK Spline Handle Tool option box with the right settings*

4. Select the right_hip joint, and in the Display menu choose **Hide → Hide Selection** or press the hotkey Ctrl+H. This just gets the joint out of our way. You can always easily unhide it through the Outliner.
5. Select the Joint tool, and, holding down the C key (snap to curve), click six times on the curve, starting from the hip area toward the knee area. The joints should be evenly spaced and look similar to Figure 6.17. You might have to try this a few times until you get the joints fairly evenly placed. Just make sure you keep snapping to the curve.
6. In the Outliner select the curve created earlier, and in the Hair menu choose **Make Selected Curves Dynamic**.
7. Choose **Hair → Display → Current Position**. This just simplifies the view so that we don't have to see the Start Position Curve as well as the Current Position Curve as the default.
8. In the Skeleton menu (found in the Animation menu set), open the IK Spline Handle Tool option window. Set **Root on Curve** to Off, **Auto Create Root Axis** to Off, **Auto Parent Curve** to Off, **Snap Curve to Root** to Off, and **Auto Create Curve** to Off. Figure 6.18 shows the option box with the proper settings.
9. With the IK Spline Handle tool selected, click the starting joint of the new hierarchy created earlier, click the last joint, and finally click the curve. This creates a Spline IK control with the top joint (at the hip) as the root and the knee as the end. It also sets the six-CV curve we created earlier as the driving curve for the Spline IK Handle.
10. Select the starting joint of the new hierarchy created earlier, Shift+select the right_pelvis joint, and press P to parent the new joint hierarchy to the old one as shown in Figure 6.19.
11. In the Display menu, choose **Show → Show Last Hidden.** You can also select that hidden hip joint from step 4 in the Outliner and choose **Show → Show Selected** instead. Figure 6.20 shows the leg.

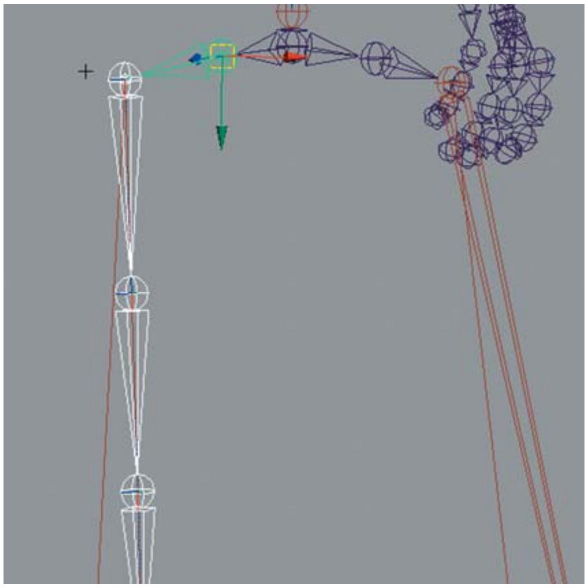


Figure 6.19: Parent the joint hierarchy

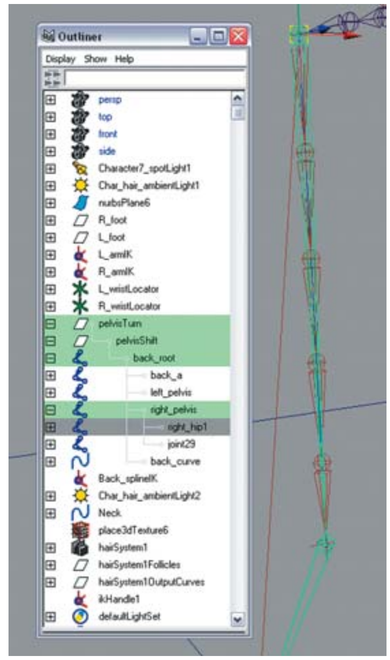


Figure 6.20: The joints revealed

12. In the Outliner, select hairSystem1Follicles, and Shift+select the right_hip joint in the Perspective window. Press P to parent the follicles to the right_hip joint. Figure 6.21 shows the Outliner view.

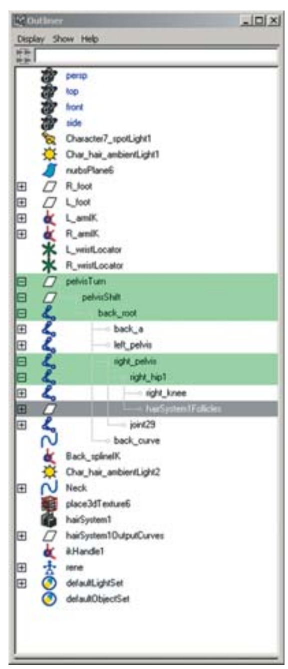


Figure 6.21: Parent the hair system follicle node under the right hip joint.

OK, so much buildup, but this is really cool. Play back the animation. The dynamic curve is driving the six-joint skeleton you made, flopping the chain around in direct reaction to the leg's animation. We have some more work to do figuring out the right settings, but you can see where this is going. For a bit of a nicer look, follow these steps:

1. In the Outliner, select hairSystem1 and open the Attribute Editor.
2. In the Dynamics section, set **Stiffness** to 1.3 and set **Length Flex** to 0.2.
3. Now when you play back the animation, you should get the right amount of motion for the new joint hierarchy. These settings will make the secondary movement of the thigh muscle tighter and more believable.

Of course, if you continue playing, you can begin to judge the best weight for the character's various parts, especially once other parts of the body are set up similarly.

An Old Man on His Horse

As cool as this is, it's really important to keep in mind that you'll never get a great character from setting everything up this way. A character is so definitive of the person who is making it that automating everything ends up hiding a lot of personality and karma of the animator. And any experienced animator will back us up in a nasty bar fight over this.

Personality in animation, of any kind, really has to come from the animator. But it's also a horribly time-consuming and exhaustive process to create any length of fantastic animation. Using tricks like this to quickly and accurately give weight to your animation is important and extremely effective. How do you combine the two? How much of your tool do you forsake for art?

The answer is to create sliders, set driven keys, and editable modifiers that affect the dynamics of the rig. For example, why don't you throw a modifier on to the **Stiffness** attribute for every hair system node you have created? This modifier could be a simple added float attribute that acts as a multiplier in a simple expression to change the elasticity of the thigh (let's say) on the fly according to a slider you animate by hand. The multiplier need not be terribly high; it can be a wickedly short range so as not to affect the **Stiffness** that much, but just enough to give it some essence of the animator. Even if it is just the right thigh.

Don't ever rely on a rig to animate for you.

Secret of the Pros for Those Trying to Step Up

Most experienced professionals in the CG field usually just look for a quick introduction to a solution to a particular problem. What begins to distinguish the good from the poor is their ability to be able to take a kernel of an idea and assess the probability that it will lead to a successful solution system to accomplish any number of complex problems at hand. A lot of the time, you will come across an opportunity to pick up a nugget of information about CG that might seem alien to what you do, but quite quickly you'll find ways to use those thoughts and ideas to your benefit in the search for an animation. Successful pros have built their careers on them, so stay patient with it.

Learning how to do things differently is a diamond mine, but keeping in mind that most solutions never come in direct forms is your shovel. The first step to launching yourself into professional work is to realize that tools only work best in conjunction with one another, as do work flows and methodologies. The best way to pick that up is to stop thinking about how to do things.

Animating a Shark

This example combines motion path animation with Hair dynamics for a nifty effect. We will add secondary motion to a moving character. We will animate a shark along a motion path that will also be used to deform the skeleton of the shark, to give it a sense of swimming through water. But, as you saw with the tutorial of adding secondary animation to a walking character, we'll automate the movement of the fins to give them a little bit of pepper in this animation.

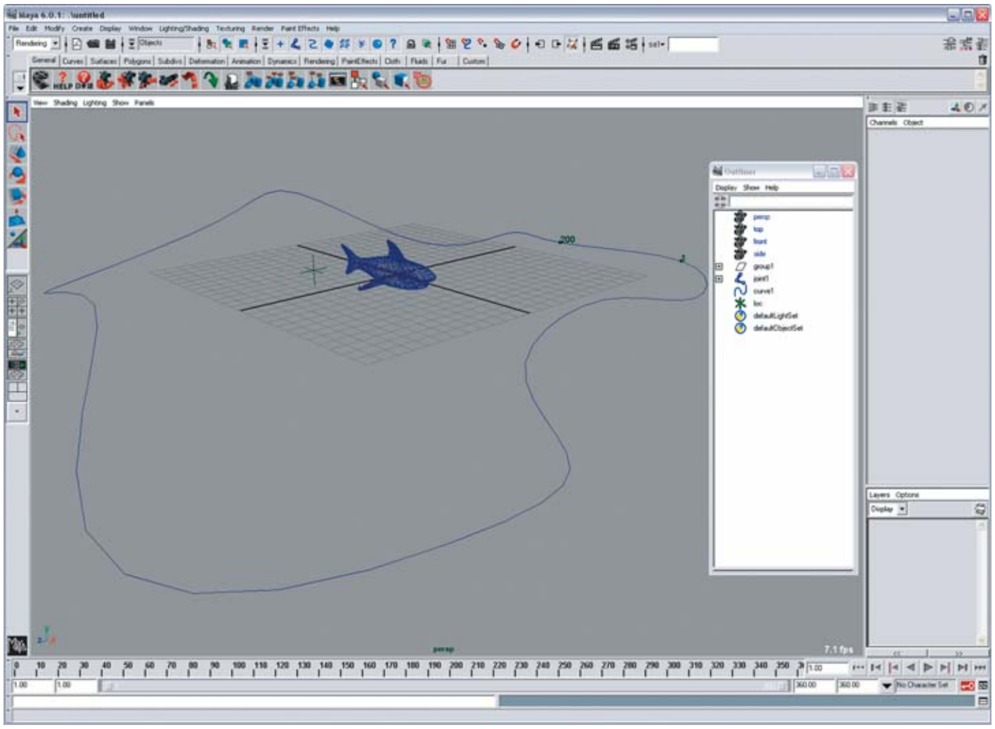


Figure 6.22: The shark scene

You can take a look at the completed file before starting the project, or you can always use it later as reference (see `Shark_done_hair.mb`). Start by opening the file `Shark_start.mb` shown in Figure 6.22. Now follow these steps:

1. Select joint1 and curve1, and then in the **Animation** menu set, choose **Animate** → **Motion Paths** → **Attach to Motion Path** → ❒. Set the following before attaching: **Time Range** to Start/End, **Start** to 1, **End** to 200, **Follow** to On, **World Up Type** to Object Rotation Up. In the text field, enter the node name **loc**. Set **Bank** to On, and then click Attach, as shown in Figure 6.23.

   You should really reset the Attach to Motion Path tool before you enter these attributes to make sure the other settings for creating a motion path for this object are at the Maya default.

2. Now we will use curve1 as an IK spline for the shark's spine. In the Skeleton menu (found in the Animation menu set), open the IK Spline Handle Tool option window shown in Figure 6.24. Set

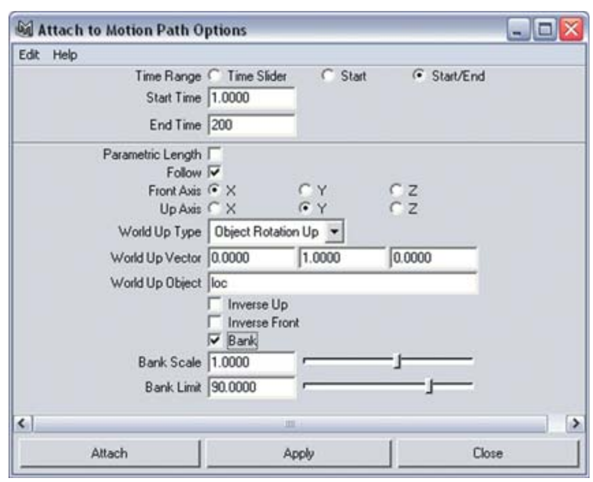


Figure 6.23: Motion path options

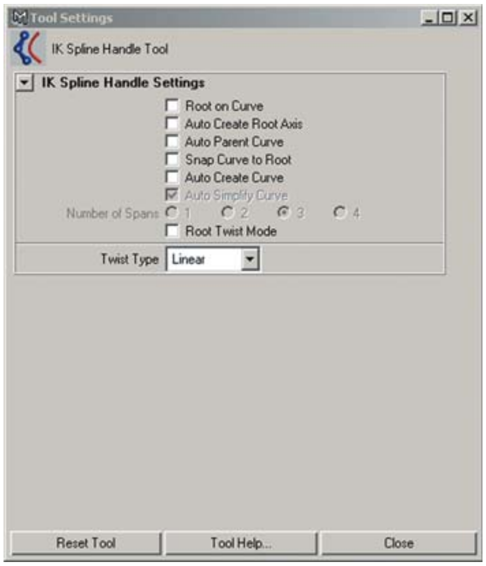


Figure 6.24: IK Spline Handle Tool option window

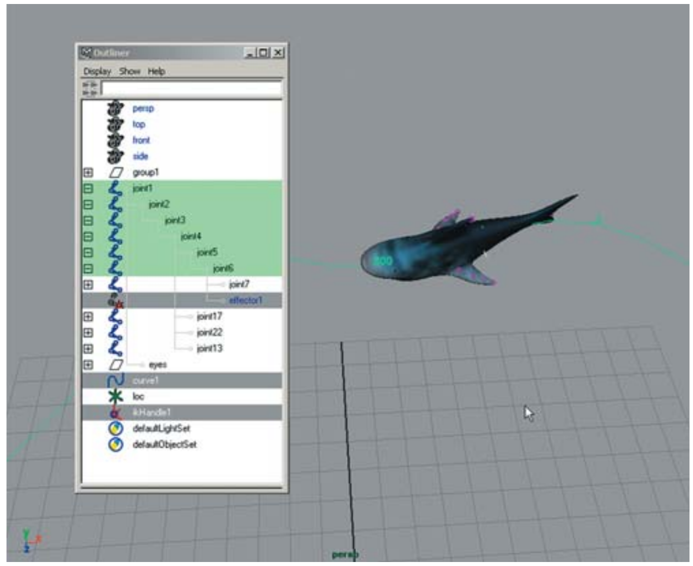


Figure 6.25: Shark on a string

Root on Curve to Off, **Auto Create Root Axis** to Off, **Auto Parent Curve** to Off, **Snap Curve to Root** to Off, and **Auto Create Curve** to Off. Consider resetting the tool before you enter these values. Doing so will give a motion as if the shark is gliding through the water, bending and curving to match the current.

3. With the IK Spline Handle tool selected, click the starting joint of the new hierarchy created earlier, click joint7, and finally click the curve. This attaches the curve to the IK handle as seen in Figure 6.25.
4. You'll notice that the shark will swim backward a bit. To fix this, select the curve, and in the Channel box in the Output section, select motionPath1. Open the Graph Editor, select U value, and press F to frame the animation curve. Now select the last keyframe (frame 200), and change the value to 0. Select the first keyframe (frame 1), and change the value to 1. This will correct the shark's direction.
5. Click the animation curve in the Graph Editor (see Figure 6.26), choose **Curves → Pre Infinity → Cycle,** and then choose **Post Infinity → Cycle**. This keeps repeating the animation past frame 200. Under View in the Graph Editor, choose **Infinity**. You'll see the cycle extend beyond your last frame.
6. We'll now get some flipping around, not quite the graceful creature we need to animate, so select the IK handle and open the Attribute Editor. In the Advanced Twist Controls section under IK Solver Attributes, check Enable Twist Controls. Change **World Up Type** to **Object Up** and change **Up Axis** to **Positive Z**. In the World Up Object field, enter the node name **loc**. This will correct the flipping (due to the fact that the position of the locator called "loc" will be used to constrain the orientation of the IK, thus eliminating the flipping).
7. Now, using the steps outlined in the earlier tutorial on creating secondary motion on a character, create curves for the fins and the tail of the shark. You will be attaching dynamic curves to the joint structure of the shark as we did for the thigh of the walk

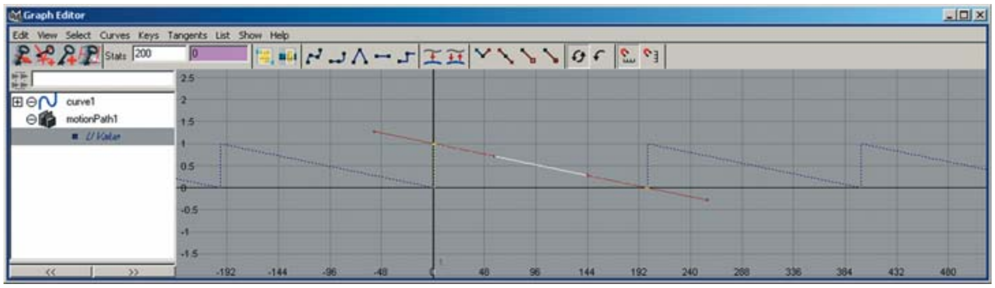


Figure 6.26: The Graph Editor

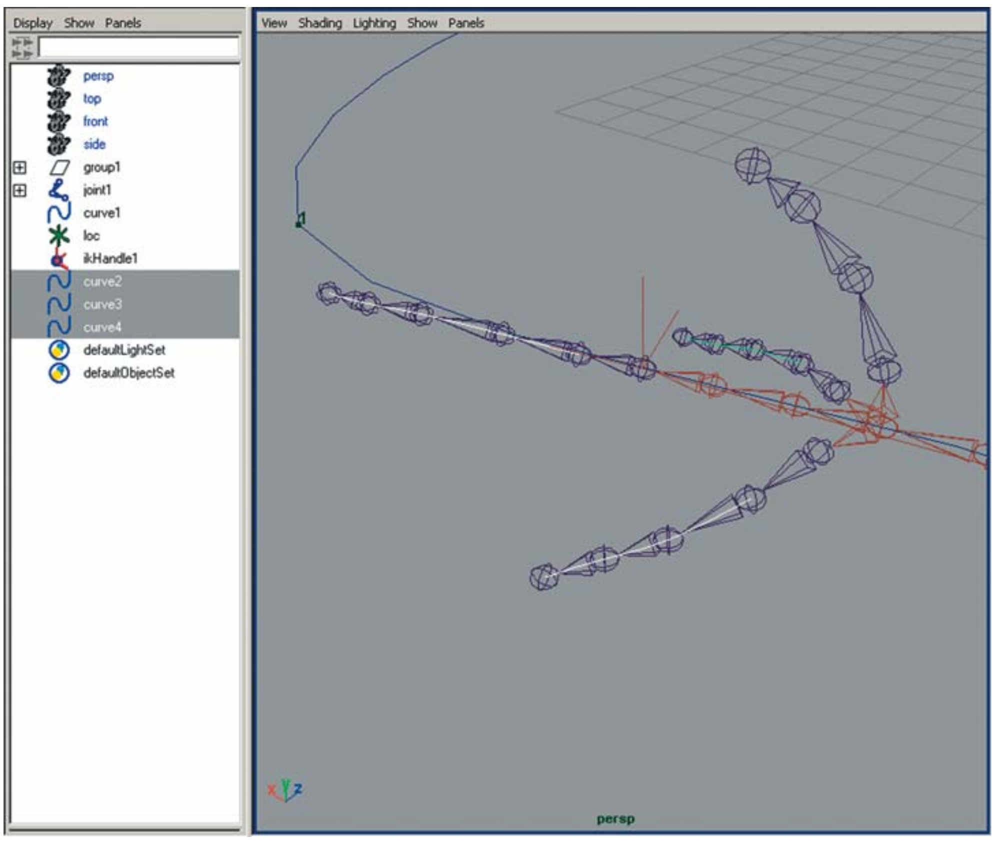


Figure 6.27: We'll affect the last three joints of the fins

cycle rig. This will add secondary motion to the fins to follow along with the swimming pattern of the shark. They will respond to the shark's movement as it swims.

8. You will be using the last three joints for the skeleton belonging to the fins (see Figure 6.27) and four joints for the skeleton belonging to the tail to trace over for your new curve (again, think of the thigh joints we traced over in the earlier tutorial). Create these curves that will be used as IK splines by holding the V key (snap to point) and clicking the joints downward along the length of the body to the extremities, the fins.
9. In the Outliner, select the curves created earlier, and in Hair menu, choose **Make Selected Curves Dynamic.**

10. In the Hair menu, choose **Display → Current Position.**
11. Select the appropriate joints, select the respective curve using the IK Spline Handle tool, and then turn the current curves into IK spline handles.
12. In the Outliner, expand the hairSystem1Follicles by clicking the plus sign.
13. Select the first follicle, and open the Attribute Editor for follicleShape1. From the Point Lock menu, choose **Base**. This places the solid portion at the base of the fin at the body. Do the same for the other two follicles.
14. In the Outliner, select hairSystem1 and open the Attribute Editor. In the Dynamics section, set **Stiffness** to 1 and set **Length Flex** to 0.1.
15. In the Outliner, select hairSystem1Follicles, and parent the follicles under their respective joints. Figure 6.28 shows the shark in action.

When you play back the simulation, you will get the nice secondary motion of the fins and tail. Try playing around with the severity of the dynamics on the curve to see how that affects the animation.

A further thought is to make the motion path curve itself dynamic. By combining dynamic motion with the path of the object, we can give the animation a secondary movement particularly useful for adding atmospheric motion to a character or an object.

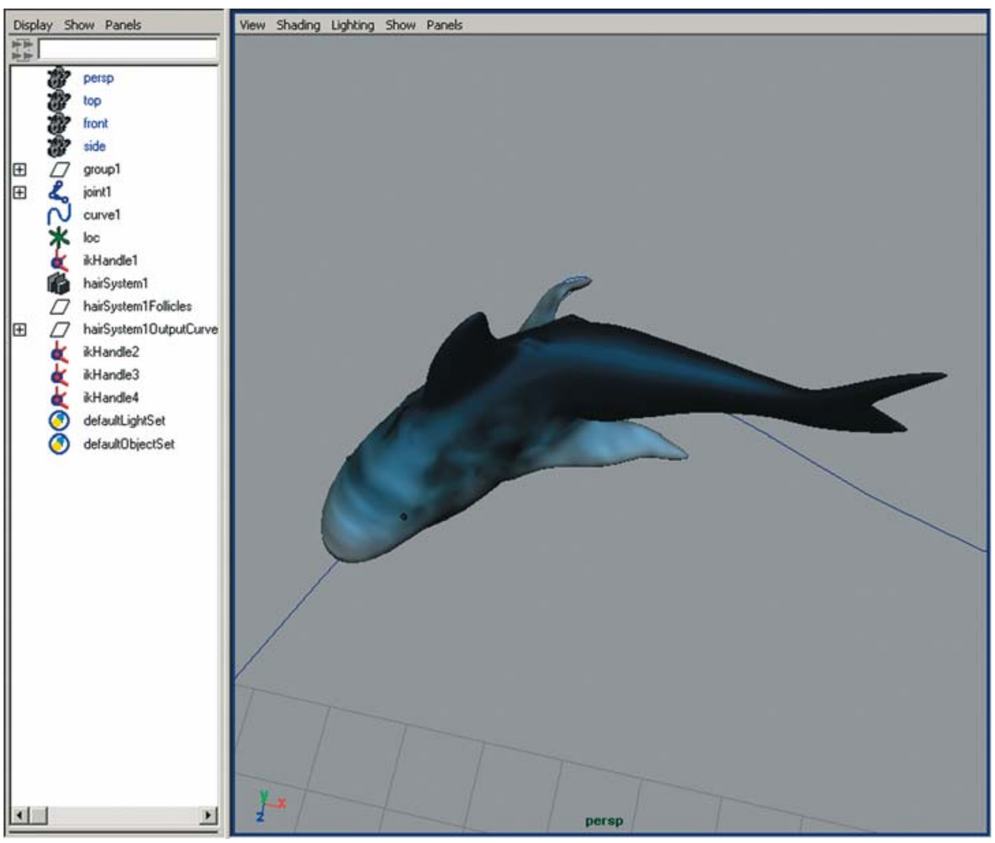


Figure 6.28: The fins will react to the shark's animation

Strong dynamic movement, with a high turbulence set at a high frequency will give a sense of chaos or, better yet, entropy to the animation. A slower paced, yet strong interference will give the sense of a more viscous environment that is in turmoil, such as a fish traveling through choppy waters.

This type of combined animation can be extremely useful for adding secondary movement to parts of a whole that need to react to the overall movement, giving inertia in short. The amount of dynamics you choose to apply to the animation will define the environment. Try creating a dynamic curve that is then used as the animation path for the shark. What kind of settings would you need to make the shark swim through a soft tidal disturbance? What are good dynamic settings to put the shark swimming through a dreadful storm?

And this animation can be easily scaled and changed to give the director a chance to change their mind, as they are often so wont to do. Choices really are what this gives you, and choices are key.

A Dancing MP3 Player

You've perhaps seen the commercials for a popular, fruit-named company's MP3 player in which graphics of brightly colored people dance against a single-colored background to the music playing through their MP3 players. The eye-catching element of these ads is the white headphone cord that hangs down from their ears and connects to the MP3 player in their hands. We'll take a look at how the new hair dynamics can make an animation like this a cakewalk as we animate our own version of this effect using dynamic curves.

We use digital video footage of a person holding an MP3 player and moving about to create dynamic motion in the cord that we will create in CG.

Let's begin by studying the footage available to create this animation. Notice how our dancing fool in Figure 6.29 moves about in frames to start thinking about how best to attack the issue. The ear-bud–style earphones he is wearing have a primary cord that comes from the headphone jack on the top of the MP3 player and go directly to the right-side ear bud, which is snug in his ear. There is also a single cord that stretches from his left ear down and across the back of the base of his neck and attaches to the main cord about 18 inches below the right-side ear bud, looping up and over his left shoulder.

Figure 6.29: The dancing fool is available for parties.

Figure 6.30 shows you a sample of one of these ear-bud headphones. Your animated ones will be white, though, since our dancing fool forgot his white shirt that day. Accordingly, it's important to understand the subject of your animation. If you have a pair of headphones, by all means get them out and try watching how they move when you wear them and walk around; dance for heaven's sake!

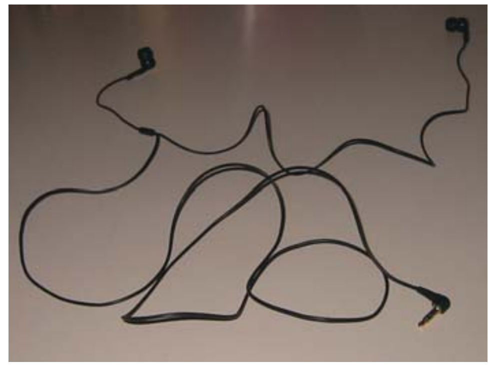


Figure 6.30: Ear-bud–style headphones that we will animate with hair dynamics

Create the Cord

Let's start by creating curves in the layout of the ear-bud cord. You can use an image like the one in Figure 6.30 to outline your curves to mimic the real cord or just create your own. Don't bother attaching the cord from the right-side ear bud (shown in bright blue in Figure 6.31) to the main cord yet, though it will be good to try to place the final CV close to the main cord, but not on it. We will cover attaching it soon, but for now these are two distinct curves. Figure 6.31 shows the cord curves we're using here. Notice they've been modeled as if they were already fitted to the actor in the background.

Now we need to attach the left ear-bud cord to the main cord. Follow these steps:

1. Select the new Soft Modification tool from the Tool Box on the left, and click the short ear-bud cord at the end of the curve, preferably on its last CV. This creates a deformer object much like a cluster, except that the Soft Modification Handle (called softMod1Handle) has a falloff area whereas a cluster affects the CVs attached to it directly. This means that if we select the Soft Modification Handle and move it, it will pull along with it the curve parts under its influence, graduating softly along its influence radius.
2. Deselect everything, and then select the Soft Modification Handle. In the Channel box, click the softMod1 node. Change **Falloff Radius** to 1.50. If you move the handle around in the view panels, you'll see how it affects the curve. The greater the falloff radius, the more the curve will move when you tug on the Soft Modification Handle. Figure 6.32 shows the Soft Modification Handle attached to the end of the short ear-bud cord.

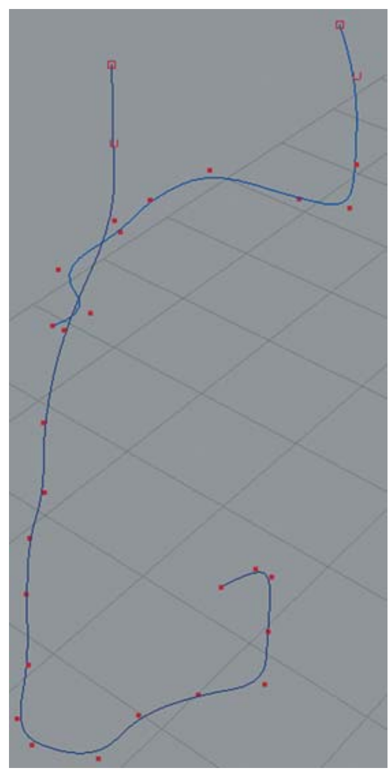


Figure 6.31: We'll use these curves to extrude a profile shape—like a simple circle—to create the cord.

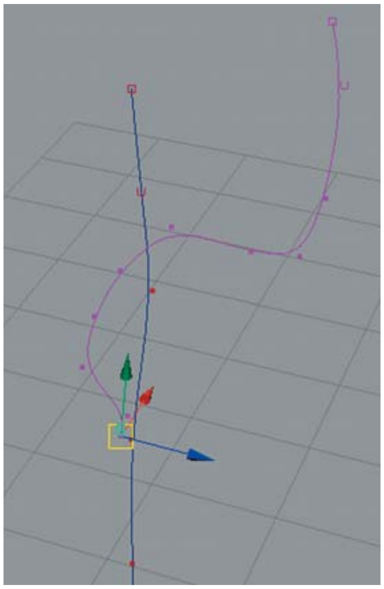


Figure 6.32: The Soft Modification Handle now controls the end of the short cord.

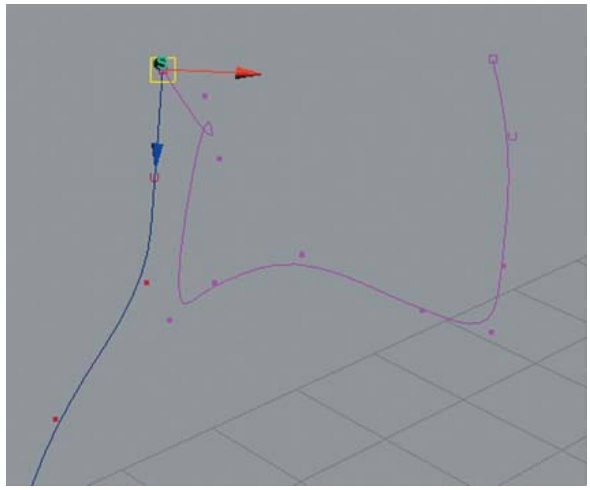


Figure 6.33: Using an animation path to attach the cord end to the main cord

By creating that Soft Modification Handle, you have positional control for the end of that short ear-bud cord. You can place the Soft Modification Handle on the main cord, even snapping it to one of the CVs of the main cord. The problem becomes apparent, though, when the main cord deforms dynamically when either the actor's head or the MP3 player moves. If that happens, how do you keep the end of the short ear-bud cord on the main cord curve?

If you already answered that you can use path animation to keep the end of the short curve attached to the main cord, you're right! Give yourself a nice cookie and a pat on the shoulder. Now, continue to follow along for how to attach the cord:

3. Make sure you're not still in the Soft Modification tool (select the Move tool, for example, to exit out of making more handles). Then select the Soft Modification Handle and the main cord. In the Animation menu set, choose Animate → Motion Paths → Attach to Motion Path to place the end of the cord at the top of the main cord, as shown in Figure 6.33.
4. With the Soft Modification Handle still selected, click the motionPath node. Highlight the **U Value** attribute, as shown in Figure 6.34, RM click, and select Break Connections to disconnect its connections to erase the animation of the motion path. This takes out the animation of the motion path, but keeps the Soft Modification Handle stuck to the path curve.
5. In a similar fashion in the Channel box, disconnect the **RotateX**, **RotateY**, and **RotateZ** attributes to disconnect the rotation animation from the Soft Modification Handle. You can then rotate the Soft Modification Handle to position the cord just the way you'd like it, as shown in Figure 6.34.

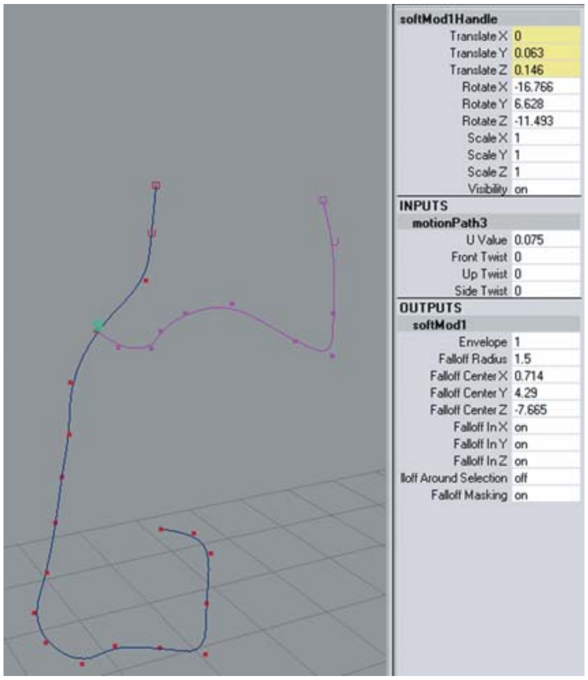


Figure 6.34: Disconnect the animation from the motion path, and orient the handle as you like.

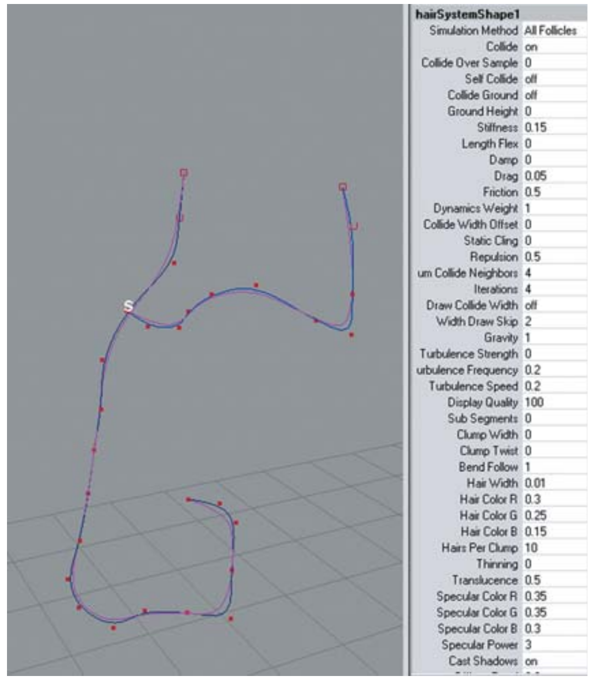


Figure 6.35: The new output curves

6. Back in the Channel box, highlight the **U Value** attribute, and set it to a point where the ear-bud cord matches with about the fourth CV down from the top on the main cord. In this example, it is set to 0.075. Now the end of the cord will stick to this point, even as the main cord moves about dynamically; once we set it up to, that is.

Dynamic Curves and Animation

The intent here is to make the curves dynamic. Both cords will become dynamic, and both will be locked down at both ends. Even the short ear-bud cord will be locked at both ends. This way only the middle parts of the curves will be dynamic, and we will be able to animate the ends to match the footage of the guy dancing around.

To create the dynamic curves, follow these steps:

1. Select both the curves, and choose **Hair → Make Selected Curves Dynamic**. The new output curves appear in magenta, as shown in Figure 6.35.
2. Select the newly created follicle nodes in the Outliner individually, and check to make sure that **Point Lock** is set to BothEnds for both nodes.
3. Select the hairSystem1 node, and for the time being, set the **Stiffness** down to 0 to see the maximum flexibility for the cord. If you play back the simulation, you will see the output curves fall and sag as shown in Figure 6.36.

At this point, it's a matter of placing the cord in the shot. Bring in the frames of the video of the dancing fool in the Dynamics folder from the CD, and load it as an image plane as shown in Figure 6.37.

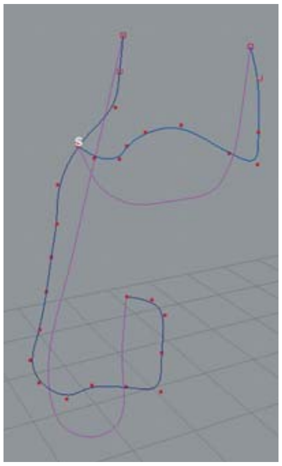


Figure 6.36: Sagging curves!

Figure 6.37: Solid gold!!

Make sure to match your camera to the footage settings so that your renders will composite properly. The footage is 640 × 480. Your Maya camera should have its default 35mm focal length, and **Film Gate** should be set to 35mm TV Projection for the best fit. In the Image Plane attributes, set **Fit** to To Size. In the Render Global Settings dialog box, select the preset resolution of 640 × 480, as shown in Figure 6.38. Since the original footage is in that layout, Maya's settings should match. Now we can proceed with fitting the cord to the ear buds for our dancing maniac.

The only real animating we have to do is to set the ends of the ear buds to match the dancer's ears. A photo like this would more than likely have been shot with ear buds already in the dancer's ears, so all you need to do is replace the cord, that is, match the CG cord to the ends of the real ear buds already in place in the ears. The same goes for the plug end of the cord. In all likelihood, the MP3 player will have a plug already in its earphone port, with perhaps an inch or so of the original cord sticking out of it. In our example, since I'm too cheap to cut my own ear-bud headphones, we'll extend the ends of the ear-bud cords to the ears and extend the plug end directly to the MP3 player.

1. Position the ends of the cord as close as possible to the ears and the MP3 player in the background plate, as shown in Figure 6.39.
2. To place the ends perfectly and animate them to match the movement of the dancing fool, you can animate the CVs (not a great idea), animate clusters at the ends (a viable option), or, better yet, animate Soft Modification Handles so that they tug on the cord a bit when you move them. Clusters will not let you do that and will stretch the cord. So attach Soft Modification Handles to the ear ends and the MP3 end of the cord as in Figure 6.40.

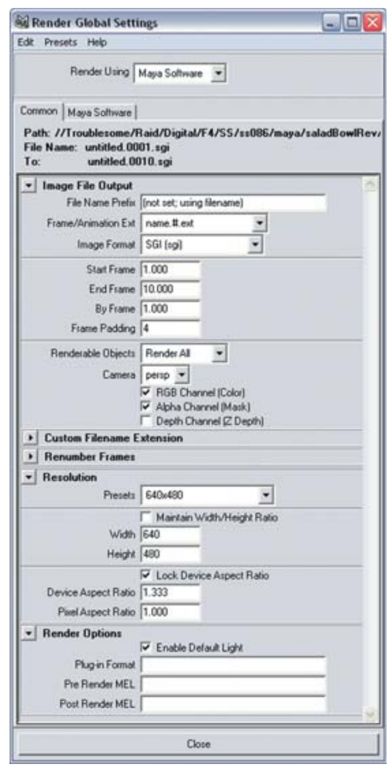


Figure 6.38: The Render Global Settings dialog box

Figure 6.39: Position the headphone wire to fit.

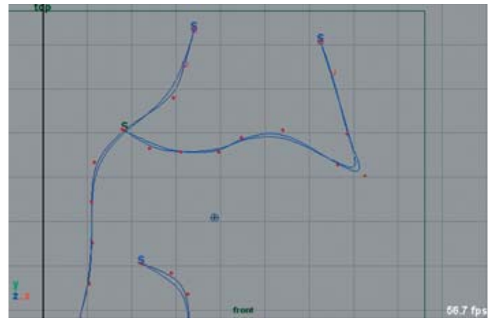


Figure 6.40: Place Soft Modification Handles at the ends of the cord.

Be sure to place the Soft Modification Handles at the ends of the original NURBS curve and not at the resultant hair dynamics output curves. The original curve acts as a goal object of sorts, or at least the ends do, so if we can control the ends of the curves easily with these Soft Modification Handles, we can drive the rest of the dynamic curve to react with the dancing fool's motion.

Track the location of the three Soft Modification Handles to their respective locations (ears and the MP3 player headphone jack) on the dancing fool, and when you play back your animation, the headphone cord will be dynamic. Adjust the **Stiffness** to your liking, though usually a low number is best.

To actually create the cord, just extrude a simple circle along the length of the two output curves, and shade and light it to your satisfaction. Keep in mind, white is a good color here because the fool's shirt is black. We need to extrude the surface to the hair output curves for a simple reason: those are the dynamic curves, and if you extrude with history on, they drive the shape of the extrusion to look like a cord. That's it!

Creating Collisions

Once the animation is complete, you'll notice the cord flailing around almost as much as the dancer, if you can call him that. To add some more realism to the scene, you can create collisions for the hair dynamics so that the curves bounce off the dancing fool's impressive stature. This is simple, though it requires you to match proxy objects, as shown in Figure 6.41, to the dancer's graceful machinations.

Once these proxy objects are in and matching the action, you can enable them to collide with the dynamic curves by selecting the surface and then the hairSystem node (in this case hairsystem1) and choosing **Hair → Make Collide**. You can set the bounciness of the cord as it collides with the proxy dancer body by manipulating the **Resilience** attribute. You can find that in the GeoConnector node that will attach to both the hairsystem node and the colliding geometry's node.

Figure 6.41: Matching proxy objects to the dancer's movements will let you create collisions for the dynamic curves to add more realism to the simulation.

When you run back your animation, you'll be able to tweak the dynamic attributes to make the cord react as you best like it. This kind of setup was only possible in the past using soft body curves with intricately worked-out rigid body colliders, but hair dynamics has finally made this type of animation a pleasure.

Always Learning

Take what is in here and make your own stuff happen. Tutorials are not a means to a particular end; they are a beginning and exercises to model a mode of thinking. If you study the motion of the shark, should its fins really be reacting to the swimming movement of the body? Perhaps applying these ideas to creating those parasitic fish that latch onto sharks would make better targets for this type of simulation? The point is not to take things for what they are, but to make them what they can be, and you'll see some more of those dynamics in the next chapter.