Working with Maya Cloth

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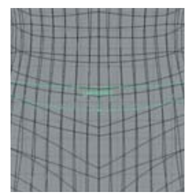
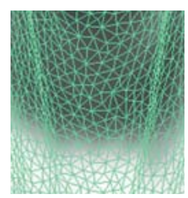
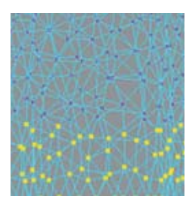
Maya Cloth *is a powerful deformation tool that can generate complex motion which is difficult to achieve using traditional methods. Packaged as part of Maya Unlimited, Cloth has been used with success on several live action effects films such as* The Matrix *and* The Lord of the Rings *trilogies as well as all CG productions such as* Shrek 2.



Cloth derives its motion using simulation based on a mass-spring system. By setting up a garment for use with Maya's Cloth Solver, you allow it to perform the tedious tasks of deforming the garment to match the character's motion and posing while giving your animation a lot of nice secondary action and an increased sense of fluidity and realism.



This chapter gives the experienced Maya Cloth user some ins and outs to help you improve your work flow and master some of the intricacies of this powerful tool. A step-by-step tutorial guides the new user of Maya Cloth through the process of fashioning a skirt and animating it. Once you grasp the major concepts, you can handle the second tutorial that demonstrates how to deform a bracelet as an example of an alternate application for Cloth.



Work Flow with Cloth

When you are working with Maya Cloth, as you would with real cloth, you must have a plan before you start to "sew." As part of the planning phase, you need a clear idea about

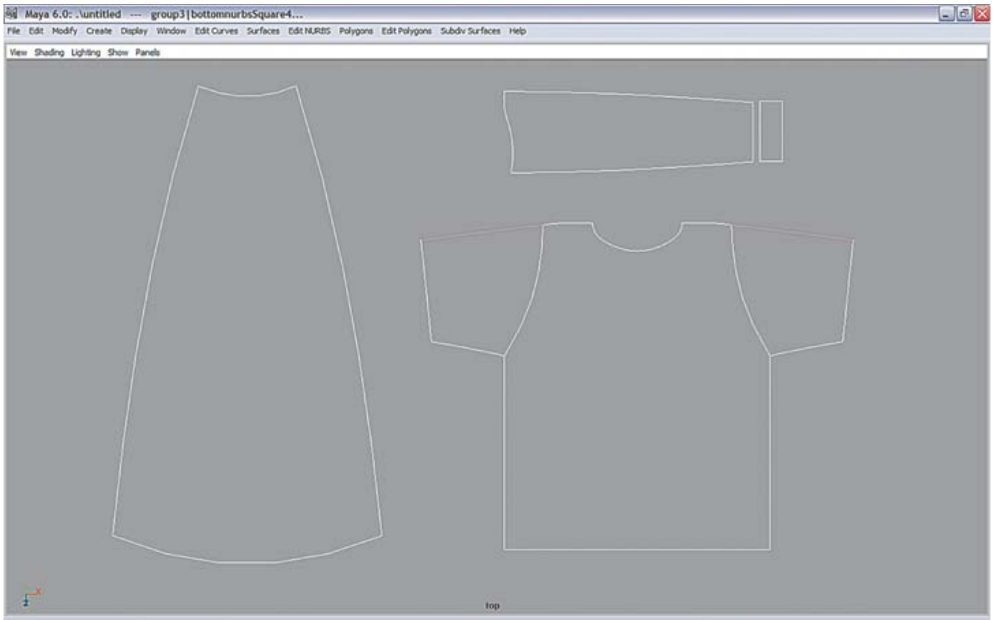


Figure 1.1: Various valid panel shapes

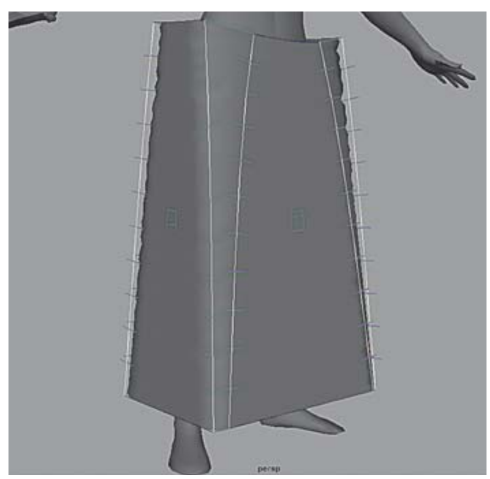
the garment you will be creating. Many studios have artists whose job is to visualize and then produce concept drawings of characters and their costumes. Emulating the look and feel evoked from these concept drawings is the goal of the cloth animator. If you are working on your own design, collect reference photos of items similar to your garment. Keep the references pinned on the wall or under a coffee mug but always within arm's reach, as they are a constant reminder of what you're striving toward and are handy to have when discussing your work with others.

The next step is to design the panel layout of your intended garment. A good place to begin is looking at your own clothing. Find where the seams are. Imagine the fabric unstitched and laid flat. How many separate pieces of fabric were used? Like a tailor, you will want to measure to achieve a proper fit. Maya panels are created from shaping curves into the desired look (see Figure 1.1).

There is no restriction on the number of curves used to create panels, but keep in mind the following two rules.

- The curves must form a closed loop.
- The curves must be coplanar, meaning all curves must lie flat on the same plane.

After you create the panels, you can stitch them together into a single garment. Initially, the shape will match the planar contour of the panel curves, as shown here.



To make the sewn panels look natural, let the simulation run and allow it to settle into a stable configuration (see Figure 1.2). In order to get the best "fit" out of your cloth simulation, you will adjust numerous attributes and create constraints that influence the motion characteristics.

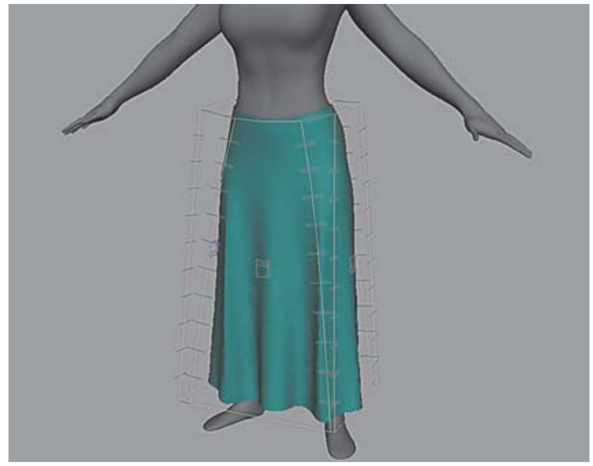


Figure 1.2: The cloth garment settled after simulation

Tutorial: Making a Skirt

This tutorial provides the steps to create a skirt that is tailored around a female model's waist and is about ankle length. Like most artistic endeavors, achieving the desired aesthetic can take many possible paths. This example is one approach, and it is designed to cover many concepts. Your goal is to produce a garment that simulates quickly and maintains stability through a variety of animations. If you are working in a collaborative environment, the ability to make quick revisions is essential as well.

Creating the Panels

The garment in Figure 1.2 is created from 4 panels stitched together and simulated to a relaxed state. The first decision to make is the number of panels. Why not 2, 6, or 16? Building a garment with fewer panels does require less work to set up and is easier to manage if changes are needed down the road, but the garment's requirements ultimately drive panel construction. Sometimes extra panels are necessary to put more fabric in a specific location, to control tessellation resolution or to assign unique cloth properties to a particular portion of a garment. In this case, we chose a 4-panel design because it tends to have few issues with stretching around the waist and tends to drape nicely; certainly good results can be achieved with other panel designs.

You will begin with 4 identical rectangular panel shapes, determining the width of each by measuring the circumference of the model's waist. Extra fabric is created at the bottom to help generate folds. Once the general shape of the garment is blocked in, you can adjust individual panels to achieve a better fit.

Creating a Guide Curve

The guide curve is the reference for where the cloth garment is to fit in relation to the model. To create a guide curve, follow these steps:

1. Open `clothModel.mb`.
2. Create a curve using the EP Curve tool to draw around the waist of the model.
   a. Select Inuyasha_skin and choose **Modify → Make Live**.
   b. Choose **Create → EP Curve Tool**, and draw around the waist, finishing the curve just short of the first point. Close the curve by choosing **Edit Curves → Open/Close Curves**.
   c. Scale the curve vertices away from the body slightly. Cloth is more stable if it has a small cushion from the surface against which it collides.

3. Choose **Edit Curves** → **Rebuild Curve** ❒.
4. Set **Rebuild Type** to Uniform, set **Parameter Range** as 0 to 1, and set the number of spans to 25. This will clean up the curve for use with some scripts later.
5. Rename the curve to skirtAttachCurve.
6. Measure the curve's length. This will take the guesswork out of how much fabric is needed. A properly fit garment will have fewer stability issues during simulation. Choose **Create** → **Measure Tools** → **Arc Length Tool**. LMB click the curve and drag. You should see the length, from the beginning of the curve, displayed (see Figure 1.3).

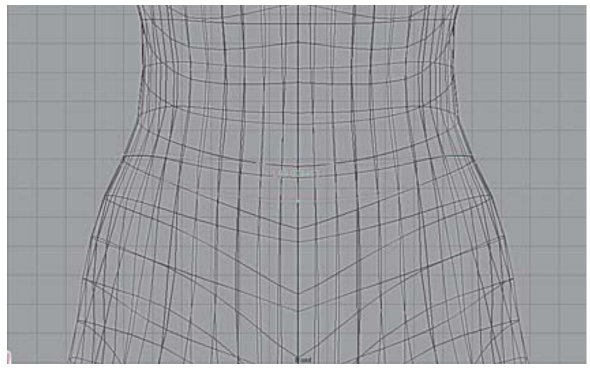


Figure 1.3: The skirt attach curve is offset away from the waist. The ArcLength tool displays the length of the curve.

Creating the Panel Curves

You now have a few guidelines to help determine the shape of your panels. Start each panel with a top width that is ¼ the length of the reference curve. The height of each panel will lie between the guide curve and ankles. The width at the bottom depends on the amount of folding desired.

To create the panel curves, follow these steps:

1. Choose **Create** → **NURBS Primitives** → **Square**. This is a quick way to start as it satisfies both conditions for panel curves; that is, it is a closed loop and coplanar.
   a. Set **Rotate X** to 90.
   b. **Scale** X to one-quarter the length of the skirtAttachCurve.
2. Adjust the length, and tweak the shape of the curves to look similar to Figure 1.4. The panel has a bit of a bell shape. This will be significant later when you enable cloth simulation: gravity will pull the fabric down, giving a nice folding pattern along the bottom of the skirt.

Figure 1.4: An example of the skirt's front panel curves

It is easy for your curves to become non-coplanar. To reduce this possibility, work in an orthographic view, and use the axis handles to move CVs.

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3. Rename the group node to frontPanelCurves, and move these curves off to the side.
4. Duplicate frontPanelCurves, and rename the duplicate to rearPanelCurves. Move it so there is no overlap.
5. Repeat step 4, and rename the group to sidePanelCurves.

Managing Panel Curves Using Instancing

You should have three groups of panel curves similar to those in Figure 1.5. Although you can directly align them around the model, you will create instances of each group and place them around the model instead.

Using instancing has a few advantages:

- If there are symmetrical panels, in this case the side panels, you have to update only one template and it propagates through all the instances.
- If you rotate your curves to get a closer fit around the model, maintaining coplanar vertices can be difficult.
- The template can remain in an orthographic state, and the transform node of the instance can be rotated independently.

To use instancing, follow these steps:

1. Create an instance of frontPanelCurves (**Edit → Duplicate**, with the Instance option selected), and rename it to frontPanelCurves_Instance. Move it to the front of the model but not clipping through it.
2. Instance rearPanelCurves, rename it to rearPanelCurves_Instance, and move it to the rear of the model.
3. Instance sidePanelCurves twice. Rename one instance leftPanelCurves_Instance, and move it to the character's left side. Rename the other instance rightPanelCurves_Instance, and move it to the character's right side.
4. Adjust the relative positions of the instanced curves so that they do not overlap but remain close to the model. If you want to adjust the shape of a panel, tweak the CVs of the original panel curves, which are still orthographic. When finished, your scene should look similar to the layout in Figure 1.6.

To see a completed version of the skirt panel curves, open `skirt_curves.mb`.

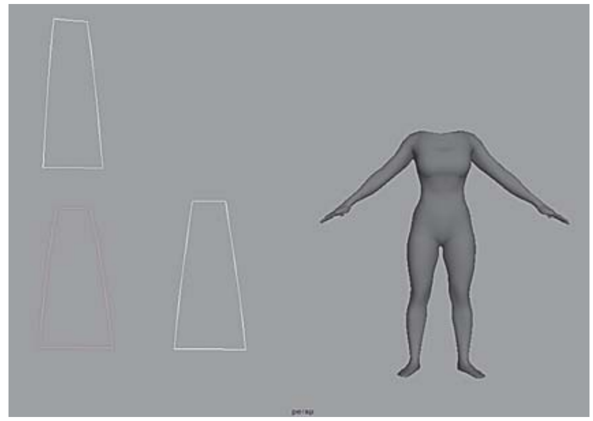


Figure 1.5: All the skirt's panel curves laid out. These will serve as templates for instancing.

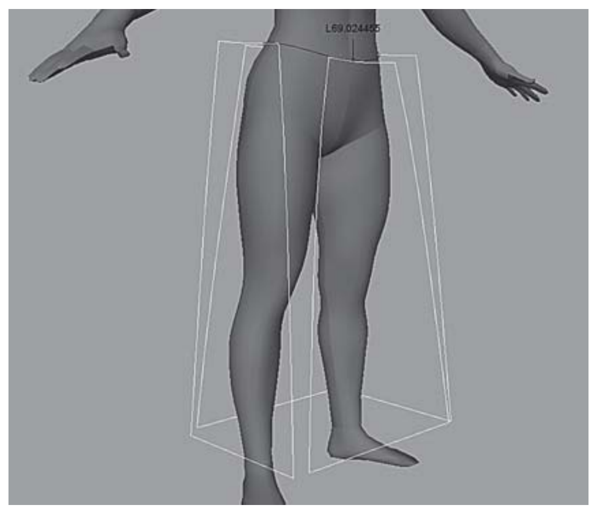


Figure 1.6: Instanced panel curves are placed around the model, and template curves remain in an orthographic orientation.

Creating the Garment

To go from the curves to an actual polygonal cloth mesh, you will create a Maya Cloth garment that is composed of the panels stitched together into a closed cylindrical surface. Follow these steps:

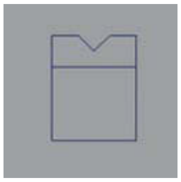


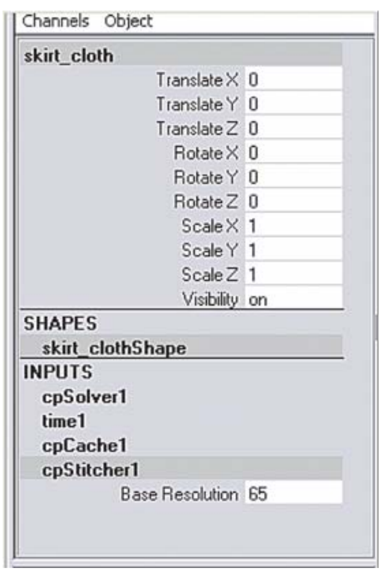
Figure 1.7: The Cloth Panel Icon

1. Select frontPanelCurves_Instance, and choose **Cloth** → **Create Garment**. This command performs two steps. First, it creates a cloth panel node, which is represented by the icon shown in Figure 1.7. Second, it creates a polygon plane that matches the contour of the curves.
2. Rename the garment to skirt_cloth.

Under Inputs for skirt_cloth in the Channel box (see Figure 1.8), you will see several cloth-related items: cpSolver1, cpStitcher1, and cpCache1. These nodes give you control over various characteristics of the simulation and of the mesh itself.

3. The garment's irregular tessellation aids in creating natural folds by reducing any bias inherent in a patterned vertex layout; however, the default density is too low for our purposes. Select cpStitcher, and raise Base Resolution to 65 (see Figure 1.9).
4. Select rightPanelCurves_Instance, and choose **Cloth** → **Create Panel**. Then create panels for the rear and left panel instance curves in similar fashion. A panel represents a piece of fabric in the shape of the panel curves. Each can have its own unique set of properties and tessellation.
5. The cloth will not extend around the model until the panels are seamed together. Select the leftmost curve in frontPanelCurves_Instance and the nearest curve that runs parallel to it in rightPanelCurves_Instance. Choose **Cloth** → **Create Seam**. The cloth mesh should extend across both panels (see Figure 1.10).
6. Continue around the model, creating seams between all the panels (see Figure 1.11). Be sure to close the mesh by creating a seam between leftPanelCurves_Instance and frontPanelCurves_Instance.

Figure 1.8: The cloth garment inputs with the stitcher resolution increased



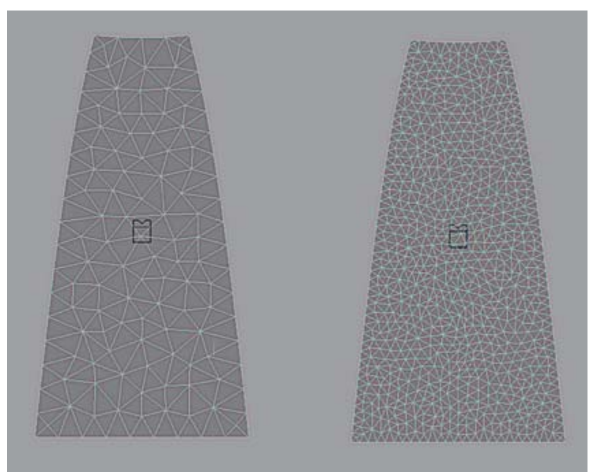


Figure 1.9: The same cloth mesh at resolution 25 on the left, 65 on the right

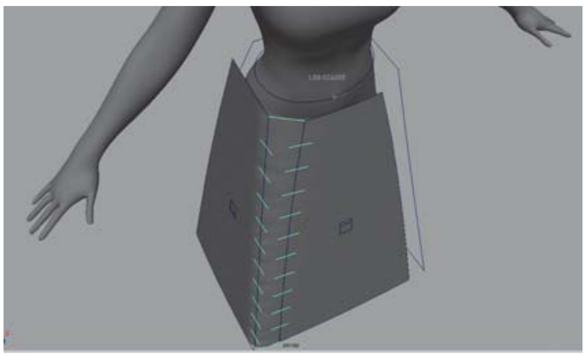


Figure 1.10: The cloth seam used to join the front and right panels

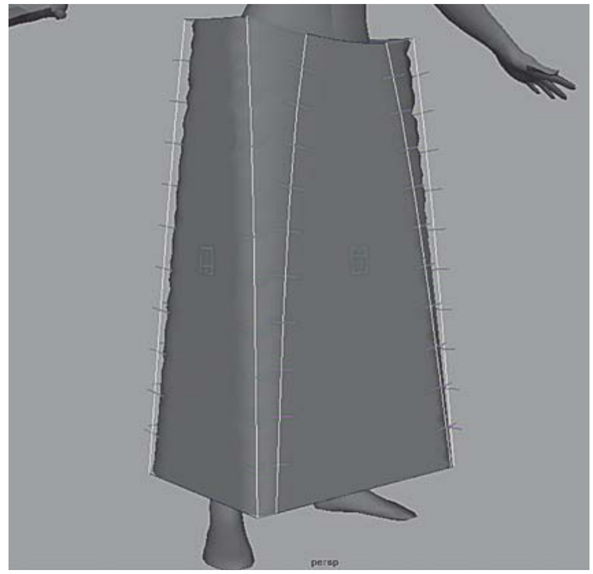


Figure 1.11: The cloth garment extending across all panels and joined by seams

Preparing the Garment for Simulation

When you run the simulation on the garment, the solver calculates the position of each vertex for each frame based on the forces applied to it. Although the skirt will settle in the general vicinity of the model's waist, the goal is for the top of the skirt to wrap around at a specific location, along the skirtAttachCurve. Fortunately, Maya provides methods to manipulate the cloth with great accuracy. In this section, you will create a series of transform constraints that will guide individual cloth vertices to their proper location on the skirtAttachCurve. Once you run the simulation, the skirt should wrap and settle nicely around the model. This process is labor intensive, but you will employ some MEL scripts to accelerate it.

Creating Guide Locators on the Skirt's Waist

First, you need to create some guide locators to designate the destination of each cloth vertex on the guide curve. Follow these steps:

1. Use the scene file you have been working on or open `skirt_garmentBuilt.mb`, which has been prepared for this step.
2. Open the Script Editor and source `attachLocators.mel`.
3. You may need to edit the script if the names you gave for your cloth mesh and attach curve do not match the names in these steps. If so, edit the first two lines of code in the script.

```
string $attachCurve = "skirtAttachCurve";
string $clothObject = "skirt_cloth";
```

4. Select the top row of vertices in the cloth mesh, and execute `attachLocators.mel`.

You should see a lot of locators, as in Figure 1.12. One set lies directly on the cloth vertices and another set directly on the attach curve. A transform constraint is associated with each locator snapped onto the cloth vertex, which forces the cloth vertex to follow the path of the locator to which it is constrained. If you animate the locator from its existing position on the cloth mesh to a position on the attach curve, the vertex will follow suit at simulation time.

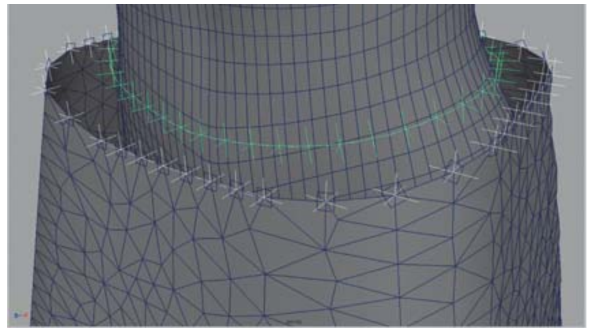


Figure 1.12: `attachLocators.mel` *places locators on the top row of the cloth mesh and on the attach curve.*

Constraining the Skirt to the Guide Locators

The locators on the attach curve are uniformly spaced around the skirtAttachCurve, and there are an equivalent number of locators on the cloth mesh and on the curve. Now it is time to connect the locators such that the transition onto the attach curve will be smooth.

Before you start, let's hide a few things to reduce the possibility of making mistakes.

1. In perspective view, rotate so that you can look down over the locaters.
2. Disable the cloth simulation as scrubbing along the Timeline can inadvertently trigger the simulation. In the Cloth menu set, choose **Simulation → Disable Solver**.
3. Turn off polygon and NURBS surface display for the perspective view.
4. Beginning from the front of the skirt, select a locator that is on a cloth vertex. Shift+select a locator on the attach curve that is the shortest and straightest path from the selected cloth locator (see Figure 1.13).

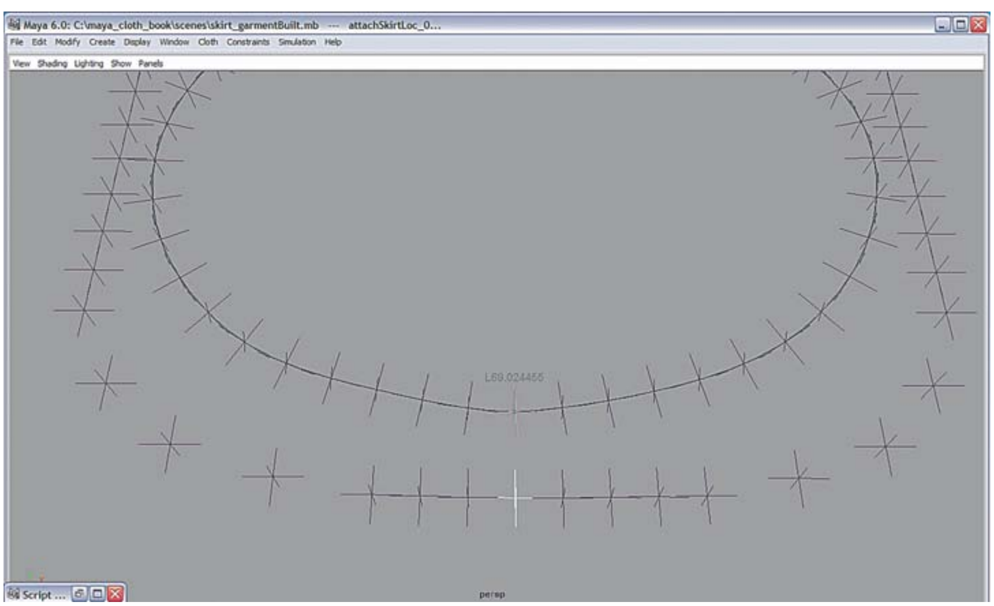


Figure 1.13: Running `attachLocators.mel` *generates two sets of locators. The cloth locator is selected, followed by the attach curve locator.*

5. Choose **File → Open Script → keyLocator.mel**. Select the code and drag it onto the shelf to create a button. (MM drag in Linux and Windows; Option-drag on Mac.) Executing this script by clicking the button snaps the cloth locator onto the attach curve locator and sets a keyframe to animate it.
6. Select the adjacent set of locators, cloth locator first, followed by the curve locator. Press G to repeat the last command, and repeat this sequence for all the locators. Using the hot keys speeds this process.

If all went well, when you scrub the Timeline from frames 1 through 5, the locators will move from their position on the cloth mesh smoothly to the attach curve. When the simulation runs, the top row of cloth vertices will follow these locators to their designated spot on the attach curve.

Making the Model a Collision Object

In order for the skirt to drape around the model, you must tell the solver that the garment should collide against this object. To do so, follow these steps:

1. Select Inuyasha_skin and choose **Cloth → Create Collision Object**.
2. Look under the shape node in the Channel box. You should see several collision-related attributes, as in Figure 1.14. Set **Collision Offset** and **Collision Depth** to 0.5. These values tell the cloth solver how much distance to keep between the garment and the collision object. Measured in centimeters, 0.5 is enough of a buffer to prevent the collision object from poking through the skirt but is small enough to keep it from looking puffed out around the collision model.

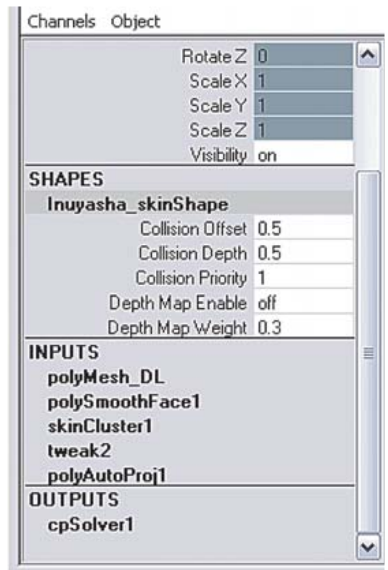


Figure 1.14: Collision Object attributes. The output goes to the cpSolver1 node.

Assigning cpSolver and cpProperty Attributes

The **cpSolver** and **cpProperty** attributes largely define the shape of your cloth and how it reacts to forces. The **cpSolver** node affects the garment on a global basis and is the single-most important control over Cloth. It should be one of the first items you adjust when developing a new garment. Each panel has an assignable **cpProperty**, allowing flexibility on how a garment should react at specified panel region.

These attributes play an important role in improving the stability of the garment. Because the garment you develop can be used in a diverse range of animations, establishing solid settings will pay big dividends throughout production.

The cpSolver Attribute

Access the solver by choosing **Simulation → Solvers → cpSolver1 ❐**. You can also select the cloth mesh and click the cpSolver1 Input in the Channel box. Now follow these steps:

1. Set **Frame Samples** to 2. This dictates how many subframe calculations the solver makes before updating the cloth's shape at the next frame interval.

Determining a good sampling rate is based on garment complexity, its intended use, and a bit of trial and error. A flat, hanging curtain might be fine with a frame sample of 1 but if it is flapping against gale force winds, a much higher value is required. Keep this number as low as possible while maintaining stability through a typical motion; simulation times increase noticeably with higher numbers. For a typical human character, you might want to set a value that works successfully on a walk. When the motion becomes extreme, you can keyframe the sample rate higher, which provides a more accurate solution and thereby reduces the number of collision problems and poke-through issues.

2. Set **Solver Scale** to 2.5. This is an internal representation of the cloth's size. Raising the solver scale tells Maya to treat the cloth as a larger piece of fabric, although physically its dimensions appear unchanged.

This change in size influences how the cloth folds and reacts to fields and properties (see Figure 1.15). One way to give the impression of stiffer cloth is to use a lower solver scale. Since a smaller amount of cloth is solved versus what is visually represented, it will have less mass and tend to drape less. Because this value has a ripple effect though the other attributes and properties, try to work with the solver scale early in development and establish a standard value. One side-effect of changing the solver scale is that your cache in memory will be deleted. Remember to save your scene file before changing solver scale if you want to keep the current simulation.

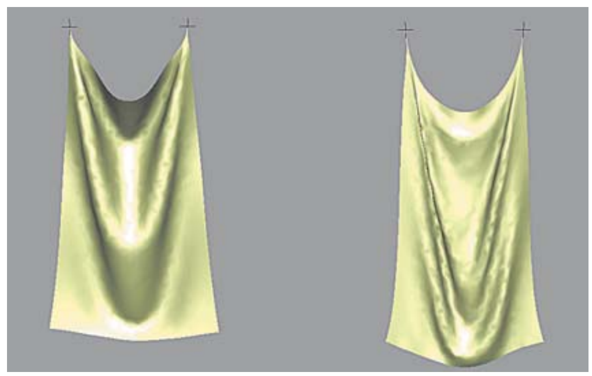


Figure 1.15: Identical cloth with the left at Solver Scale 1, the right at 2.5

3. Keep **Relax Frame Length** at 5.

Because the seams stretch between panels during the initial garment creation, the cloth will abruptly collapse during the first few frames of the simulation. The **Relax Frame Length** helps the solver during this period by making the garment extra stretchy, allowing the stress to disperse more evenly. Extremely large or complex garments may need a longer run-up period. Allow the simulation to continue long after the relax period to let the cloth settle using its normal property values. After the relax has completed and the solver's initial state has been saved, set this attribute to 0.

4. Turn on Output Statistics. Frame solve duration and overall elapsed time are displayed every frame. On long, complex simulations, this is sometimes the only way you know that Maya is functioning correctly (see Figure 1.16).

Figure 1.16: Example output statistics

```
SOLVER TIME for cpSolver1, frame 2.000: 26.958, total: 26.958
SOLVER TIME for cpSolver1, frame 3.000: 13.360, total: 40.318
SOLVER TIME for cpSolver1, frame 4.000: 13.459, total: 53.777
SOLVER TIME for cpSolver1, frame 5.000: 11.967, total: 65.744
SOLVER TIME for cpSolver1, frame 6.000: 12.138, total: 77.882
SOLVER TIME for cpSolver1, frame 7.000: 11.637, total: 89.519
```

The cpProperty Attribute

To access properties, choose **Simulation** → **Properties** → **cpDefaultProperty ❐**, or select a cloth panel and click the cpProperty node under INPUTS. Set the following values:

1. Set U and V Stretch Resistance to 150. For the skirt, increasing this value gives more stability by reducing the chances of the cloth getting caught under the foot. It also reduces the rubbery feel associated with low stretch resistance.

A certain amount of stretch is necessary for the simulation to work smoothly; however, if the stretch and shear values are too low, there will be noticeable texture stretching, as you can see in Figure 1.17. This is really distracting when any flat garment, such as a bed cover or tablecloth, is being pulled.

2. Set **Shear Resistance** to 135. This value is often adjusted in parallel with stretch resistance. Shearing occurs when cloth vertices begin to move in opposite directions, as in a tearing motion.
3. Set **Density** to 0.03. By increasing the mass of the garment, density gives a greater feel of weight by carrying more momentum when it moves. The look of the folds are also affected (see Figure 1.18).
4. Set **Air Damping** to 0.001. A low value reduces the effect on the cloth as it moves through space. It tends to hang down and feel heavier, whereas a high value creates a more flaglike effect.

You can assign each panel a custom property by choosing **Simulation** → **Properties** → **Create Cloth Property**. To assign a property to a specific panel, select the panel and choose **Simulation** → **Properties** → **cpPropertyName** to display a list of all currently available properties.

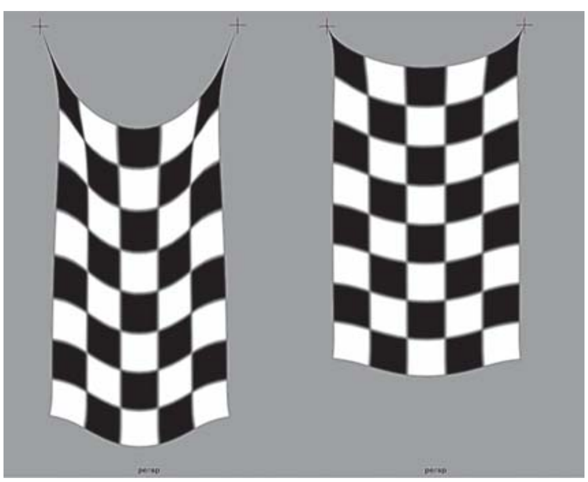


Figure 1.17: The same cloth with stretch resistance at 50/50 and shear resistance at 45 versus stretch at 150/150 and shear at 135

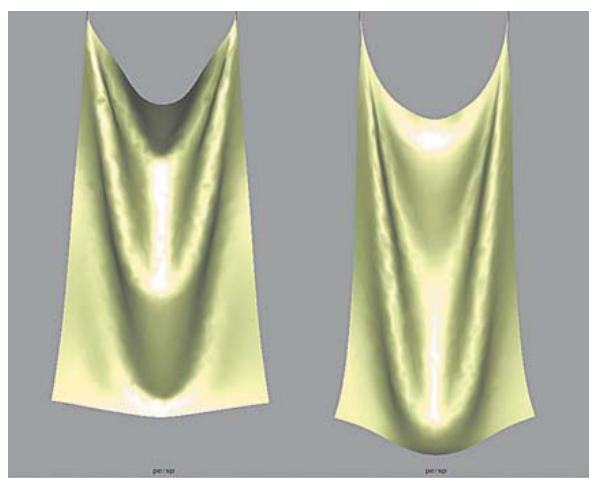


Figure 1.18: The same cloth simulated at a density of 0.01 on the left and 0.03 on the right.

The best way to understand the effects of the **cpProperty** attribute is to alter its values, run a simulation, and watch the results. To this end, we have provided several QuickTime movies, each showing a side-by-side comparison of a single property simulated at the default value and with an altered value. You can find these in the images/cpPropertyExamples folder on the CD.

Running the Simulation

You are ready to begin your first simulation! Take a deep breath, and follow these steps:

1. Set the Timeline to frame 1.
2. Turn the solver back on. Choose **Simulation → Enable Solver**. It is on by default but was previously turned it off when you constrained the skirt to the guide locators. Also, turn on Polygon and NURBS Surfaces display if no geometry is visible.
3. Click Play.

It will take several seconds to start, but eventually you will see the simulation drawing the cloth in toward the model. Notice that the hips and legs do not penetrate since you made the skirt a collision object. Let the skirt settle for about 100 frames. Now is a good time for a coffee break.

Be sure that the Timeline encompasses the start frame. Otherwise, the simulation will not begin. You will see the playback progressing without the solver having any effect.

Once you've finished simulating, the motion should look similar to `garmentSettle.mov`. When you scrub the Timeline, the cloth should update immediately as Maya saves the simulation data into a cache. If you want to save your results, save the scene file.

Setting Up Cloth for General Animation

If you are working on a film or a project of any length, chances are you will be using the same character and cloth garment for several scenes. Building panels, stitching the garment, and relaxing it for every animation would be a lot of repetitive work. The good news is that once you have a relaxed garment, you can save its state with the solver attached to it. The next time you open the scene file, you can start solving with the garment in the same fitted, relaxed position. Because you allowed the cloth to settle over a long period of time, there won't be any abrupt motion as witnessed during the initial relax. Save this scene file as a template and propagate copies of it for use in specific animations.

Saving the Relaxed Garment State

1. Use your scene file or open `skirtAttach.mb`. If there is no cache data, resimulate.
2. Pick a frame where the cloth has settled, somewhere between frame 100 and frame 150, select the skirt, and choose **Simulation → Save As Initial Cloth State**.

Set the Timeline back to frame 1. Notice that the cloth no longer has the boxlike shape of the panel curves but looks like the skirt at the frame where you performed the Save As Initial State. Any new simulation will begin using this shape as a starting point for the first frame's solve. If the cache is deleted or the timeline is set at or before the solver start frame, the garment defaults to the initial state. One consequence of this action is that the cache becomes invalid and should be deleted.

3. Choose **Simulation → Delete Cache**.

From this point forward, the simulation will begin from the relaxed state. If your character does not begin animation at the location where the garment was fitted, you can move it to the character's new position. Align your garment to the character's position and choose **Simulation → Update Cloth State**, followed by **Simulation → Save As Initial Cloth State**. **Update Cloth State** changes the data stored in the cache to reflect the new garment position.

Mesh Constraining Cloth to the Model

In this skirt example, in addition to saving the cloth state, you also need to constrain the relaxed skirt to the collision model. This allows the cloth to move with and react to the character's motion.

Earlier we used transform constraints to pin the skirt along the attach curve, but once the character begins to move, it will be out of alignment because the transform locators were not animated to the character's motion. By using a mesh constraint, you can assign the top of the skirt to follow the waist of the model. But, first, let's do some cleanup.

1. In the Outliner, expand the hierarchy of skirt_cloth. Delete all the transform constraints that were created by the `attachLocator.mel` script.
2. Delete all the locators named attachSkirtLoc_*.
3. Delete all the locators named XFORM_attachSkirtCurve*.
4. Select the top row of the skirt's vertices, Shift+select the character mesh, Inuyasha_skin, and choose **Constraints → Mesh**.

This constraint maintains the offset between a cloth vertex and the model's surface as it animates. The result will look as if the top of the skirt is attached to the model. The character is now ready for animation.

Animating the Skirt

After you develop the skirt, you can test its motion in a variety of simulations. Open `skirt_jump.mb` to test the garment in an animated jump off a box. Although the skirt simulates well in a standing pose, you will need to adapt the **cpSolver** and **cpProperty** settings to deal with the abrupt motion and more extreme posing.

Disable the solver and scrub the Timeline. It helps to look at the motion and see what issues lie ahead. Keep an eye out for problem areas, including quick or jerky motion, extreme bending of joints, and interaction with objects. Enable the solver, and allow the garment to simulate.

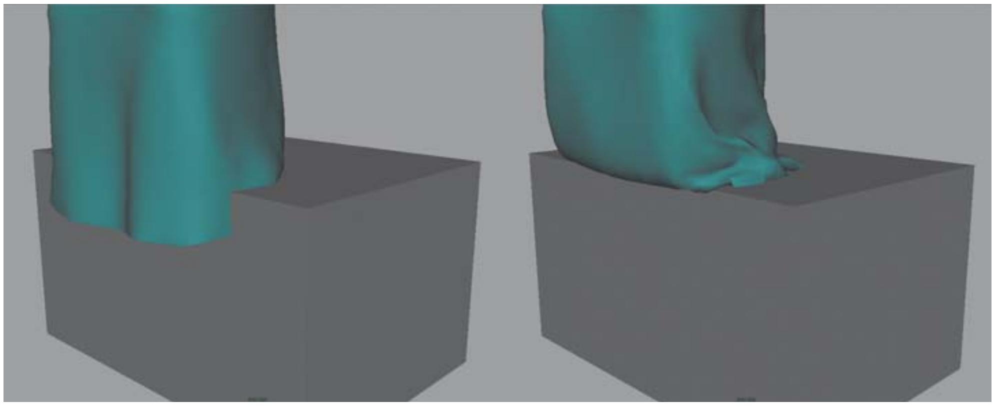


Figure 1.19: The box before and after being made into a collision object

At frame 16, our character crouches down in anticipation of the jump, but the skirt clips through the box (see Figure 1.19). Convert the box into a collision object by selecting it and choosing **Cloth → Create Collision Object**. Set the offset and depth to 0.5. When you scrubbed through the animation, you might have noticed a similar crouch on the landing at frame 40. This may not be an issue if the legs are off camera, but, in this case, add a ground plane collision object.

Truncating the Cache

Because of the penetration, you will need to resimulate the portion where the skirt clips through box. Fortunately, adjusting your settings in the middle of a simulation does not mean starting over. You can delete the offending portion of the cache and start solving from that point. Follow these steps:

1. Scrub the Timeline to the last good frame, about frame 8.
2. Choose **Simulation → Truncate Cache**.

You can only truncate the end portion of a cache. Any good frames following will be lost, but this is usually not an issue. Once the simulation starts to go bad, it will not usually recover on its own.

Inconsistencies between the cache and your setup can occur when using the truncate feature. For example, if you truncate the cache at frame 15 and set a new property value, every frame now simulates with that new value; however, the cached frames were simulated based on the old value. If you simulate fresh from the start, the results will differ. If the character animation is locked and final, save a copy of the cache file because the result may not be reproducible. Otherwise, simulate clean from the start frame to ensure that you can resimulate your garment with consistency.

Updating cpSolver and cpProperty Values

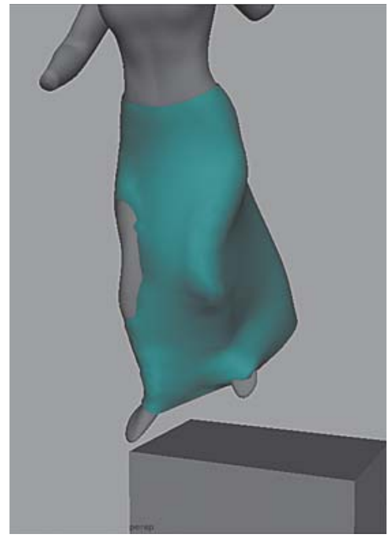


Figure 1.20: Penetration at frame 26 caused by inadequate frame sampling

Click Play to continue the simulation. The skirt should now collide against the box. Continuing the simulation to frame 26 reveals a new problem in the form of some severe penetration of the cloth through the collision surface (see Figure 1.20).

You can fix this by increasing frame samples or lowering the time step. Both attributes work together to establish the amount of subframe sampling. Sampling in smaller chunks improves the cloth's position and velocity accuracy. The negative side-effect is simulation time increases. To minimize the cost, animate the frame sampling during high-stress times. For the jump, try animating frame sampling from its default value of 2 at frame 18 up to a value of 6 or more at frame 23.

In addition to the increased sampling, the skirt should be stiffer during this period to prevent the cloth from stretching and tangling. Set keys for the values as shown in the following list. It helps to ramp up your settings a few frames before the motion hits its extreme. In this way, the properties reach full strength smoothly. The same is true for easing out of these values during the landing.

cpProperty	Frame 18	Frame 23	Frame 40	Frame 45
U/V Bend Resistance	10	50	50	10
U/V Bend Rate	0	0.2	0.2	0
U/V Stretch Resistance	350	750	750	350
Shear Resistance	300	600	600	300
Density	0.3	0.15	0.15	0.3
Thickness Force	5	5	5	5

Increasing Bend Resistance reduces unwanted self-collisions by making it more difficult for the vertices to fold in on themselves. As the resistance increases, the folds tend to become wider and flatter (see Figure 1.21). Since the characteristics of the cloth change, it's best to animate these values up during extreme motion where a value increase will not be readily apparent.

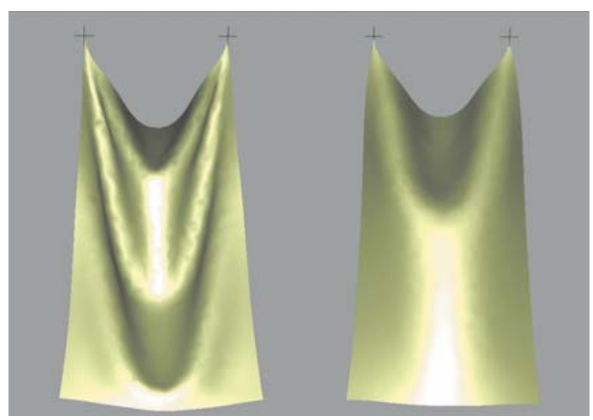


Figure 1.21: Bend Resistance at 10 versus 150

Bend Rate works in conjunction with Bend Resistance in that its effect becomes progressively stronger as the bend angle increases.

Stretch and Shear Resistance are increased across the board to make the skirt less rubbery. Low stretch and shear resistance tends to give cloth a springy effect that can result in distracting motion.

Lowering Density gives the cloth less mass, which reduces the effect of forces on the cloth during the jump.

Thickness is the distance maintained between vertices and other cloth objects as well as when it folds in on itself. The thickness force is the factor of

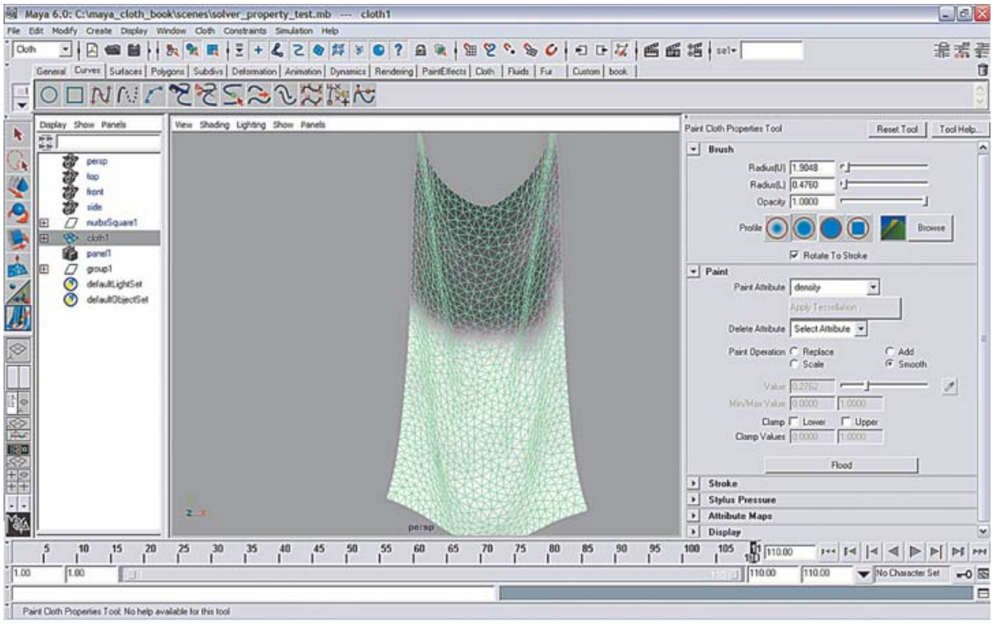


Figure 1.22: The Paint Properties tool. Painting on the cloth mesh creates a map that becomes a multiplier. The darker region indicates that density is reduced.

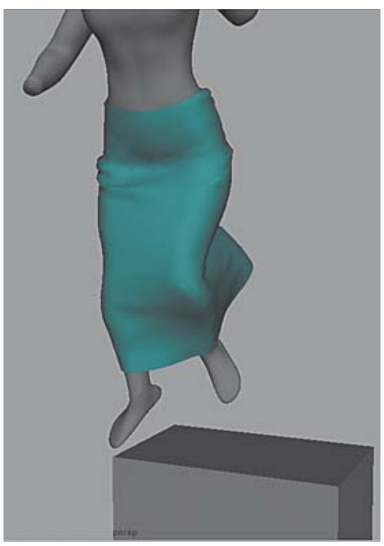


Figure 1.23: The skirt at frame 26 after applying new solver and property values

how strongly the cloth attempts to maintain this offset. This attribute also minimizes the effect of self-collisions.

Once property attributes are set, you can use the Paint Cloth Properties tool to vary the values on a per vertex basis. Select the cloth mesh, choose **Simulation → Properties → Paint Cloth Properties Tool ❐**. The available attributes, which are shown in Figure 1.22, are in the Paint section.

Since some of the cpProperty values have been altered globally, for example, Thickness Force, you need to delete the cache and start the simulation fresh (see Figure 1.23).

As the character begins to fall about frame 30, the skirt begins to ride up the character's legs. Pulling the skirt below the knees will help keep it from pinching into the back of the legs as they bend during landing. Increase the solver's gravity to increase the downward force on the skirt by using the following settings:

cpSolver1	Frame 25	Frame 30	Frame 35
Gravity	0, –980, 0	0, –3000, 0	0, –980, 0

The default is –980 in the Y axis, which is the Maya default for normal gravity. The axes are based on world space coordinates.

Creating a Gravity Constraint

Another way to add gravity is through a field constraint. Using the solver's gravity affects the entire garment. Sometimes you want a greater level of control over where the force is applied. In this case, it can be useful to have this field at the bottom hem. Follow these steps:

1. In the Dynamics menu set, choose **Fields → Gravity**.
2. Select the area of the skirt where you want to apply the field (see Figure 1.24), Shift+select the gravity field, and choose **Constraints → Field**.

Animate this field to add extra force. Increase **Magnitude** to 2000, and set the direction vector to –1 in the Y axis to force the hem down. Attenuation reduces the amount of force as the distance between the cloth and the gravity field increases. Set this value to 0 to maintain a uniform force throughout the animation.

View the final results in `skirt_jump.mov` on the CD.

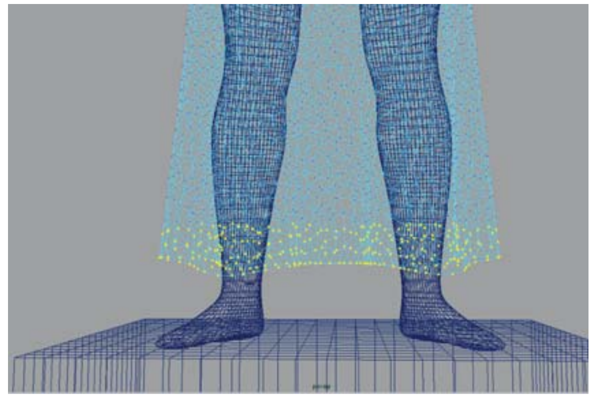


Figure 1.24: Selection of vertices where the gravity field applies. A larger selection will have a greater overall effect on the garment.

Interacting with Collision Objects

Building a garment is only one aspect of working with Maya Cloth. You also want the garment to interact with other objects in the scene. If the character kneels, the cloth should rest on the ground plane. If the character sits, the cloth should conform to the shape of the chair. One character's garment might affect the garment for a second character. Cloth allows virtually any NURBS (Non-Uniform Rational B-Spline), subdivision, or polygon surface to be made into a collision object.

To make a surface into a collision object, follow these steps:

1. Select any object or create a NURBS or polygon primitive.
2. In the Cloth menu set, choose **Cloth → Create Collision Object**. Under the Shapes node, some new attributes appear:

Collision Offset This is the distance in centimeters, offset away from the collision surface, that the solver will repel cloth. It creates a buffer to reduce the possibility of the surface penetrating the cloth.

Collision Depth The depth is the distance within the surface where the solver continues to apply a repelling force. Once cloth has gone past the collision depth, the solver no longer repels. If the depth gets too large, an overlap is created where the vector of the repelling force becomes unpredictable.

Collision Priority If two collision surfaces are simultaneously influencing a section of cloth, instability in the form of vertex popping can become prevalent. The lowest value is the highest priority collision object (see Figure 1.25).

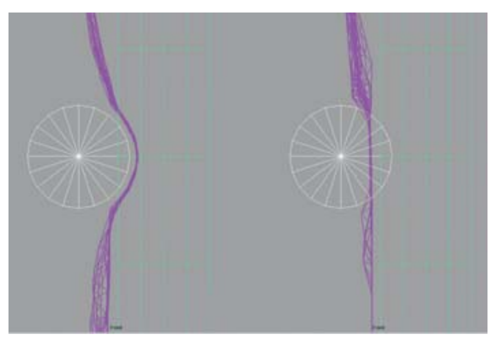


Figure 1.25: The cylinder has collision priority 1, and the cube is priority 2 on the left image. The priorities are switched on the right.

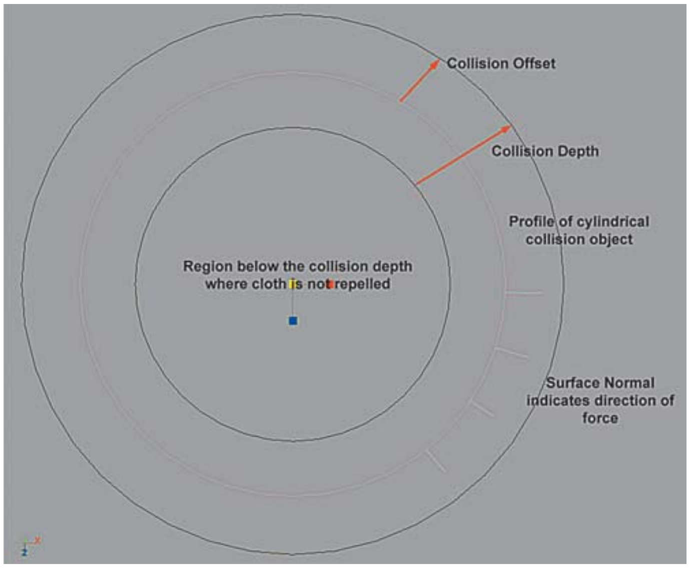


Figure 1.26: Collision object attributes in relation to the geometry surface

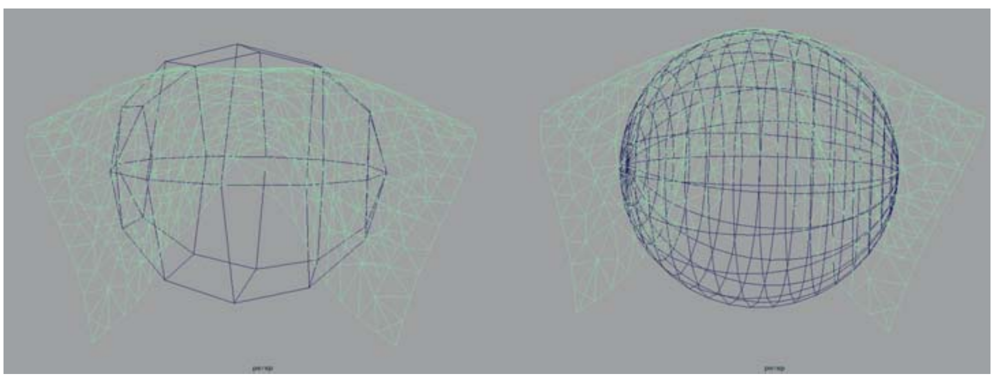


Figure 1.27: The left sphere's resolution is too low. The right sphere has fewer poke-through issues as a result of its higher tessellation.

The direction of force from the collision surface is determined by its normal. If the cloth gets sucked into the collision object, rather than being repelled, view the normals and reverse their direction if they are pointed the wrong way (see Figure 1.26).

To view normals, select the object. For polygons, choose **Display → Polygon Components → Normals**. For NURBS, choose **Display → NURBS Components → Normals**.

To reverse the direction of the normals, select the object. For polygons, choose **Edit Polygons → Normals → Reverse**. For NURBS, choose **Edit NURBS → Reverse Surface Direction**.

One cause of cloth/collision problems is a mismatch in resolution. When the collision object has too low a resolution, the cloth will have penetration issues, and when dragged over the collision object, it will tend to pop (see Figure 1.27).

As much as low resolution can cause difficulty, complex collision surfaces can be equally problematic. Hands and feet with their multiple digits and relatively small surface areas can also poke through cloth. They can also intersect, causing other collision problems.

In most cases, it is quicker and more stable to replace hands and feet with simpler collision objects. You can fashion a polygon sphere that encompasses the entire hand and use that as the collision object. Avoid collision objects that have sharp edges or if big gaps appear between surfaces. These are also candidates for replacement with simpler collision objects. Also, you can generate new, simpler surfaces by lofting and attaching surfaces together.

Often, collision objects are unavoidably animated to the point where cloth is stretched beyond its designed limits. Imagine a character's pants while the character is riding a horse. Each thigh is applying an outward force while the back of the horse is pushing the cloth up. For these extremes, you can increase the amount of fabric to be simulated by using the cpProperty's U and V scales.

Affecting Cloth Motion Using Constraints

Constraints are versatile tools that provide a great deal of added functionality and are invaluable in cases where the solver does not readily provide a solution. Each constraint has a unique capability to control the motion of a garment. Constraints work on a per vertex basis, which means they exert a fine level of influence. You've already used several types of constraints in the tutorial for both construction and animation purposes. You used a transform constraint to guide the top of the skirt onto the skirtAttachCurve; you created a mesh constraint to keep the skirt pinned onto the character's waist during animation; and you added gravity field constraint to give extra downward pulling force on the hem.

Constraints are commonly used to create the sensation of additional forces being applied to the cloth, including creating effects such as the wind blowing or some force pulling on the cloth. Another category of constraints allows for part or all of the garment to attach to other objects or to pass through them without collision. Used in this way, constraints can be an immense aid during difficult solves.

Quite frequently constraints are used for applying additional forces on the cloth. This might be the wind blowing against a sail or some force pulling on the cloth, such as picking up a napkin. There are constraints to allow objects to be parented onto a garment. This makes adding details like buttons or jewels a simple affair. Garments can also be attached to each other using a cloth constraint. If you had a vest over a shirt, adding this type of constraint helps keep the garments together, increasing the sense of friction and texture. A final, essential constraint allows selected vertices to pass through collision objects or through itself without repelling force.

These collision constraints are an immense aid during difficult solves where cloth gets pinched or stretched too far. All constraints work on a per vertex basis, which is a major benefit since it gives finer control over the constraint's influence. This level of granularity gives you much more artistic control and can make the difference in creating a convincing performance.

These are only a few of the possibilities achievable, limited only by the requirements of the animation and the cloth animator's ingenuity. Let's take a closer look at the different kinds of constraints.

Transform Constraint

You can use transform constraints when a set of cloth vertices must travel to a certain location or follow a particular path. Imagine tossing a towel into a basket. By constraining a small set of vertices, you not only guide the trajectory but also dictate timing and speed. The solver calculates the motion for the section of the garment that is not affected by the constraint. Pay particular attention to the timing such that the cloth feels like it is being driven by a natural force, e.g., the character's arm tossing the towel. Otherwise transform constraints can give the distinct look that the cloth is being pushed or pulled in an unmotivated fashion.

Open `buildTransformConstraint.mb` and click Play. The cloth falls due to the lack of any constraints or collision objects. Gravity is the only force acting upon it. To create a constraint, follow these steps.

1. Set the Timeline to frame 1 and delete the cache.
2. Select the upper-left vertex and Shift+select locator1.
3. In the Cloth Menu Set, choose **Constraints → Transform**. A small box appears, indicating that vertex has a constraint on it (see Figure 1.28).

Displaying constraints can slow your computer's refresh rate. An easy way to hide constraints is to turn off locator display in the view port by toggling **Show → Locators**.

4. Create another constraint on the upper-right corner using locator2. As the cloth simulates, the constrained vertices follow the locators. In the Outliner, expand the hierarchy for cloth1. There will be two constraint nodes. Select transformConstraint1 and look at the Channel box. Under the shape node are attributes for the constraint (see Figure 1.29).

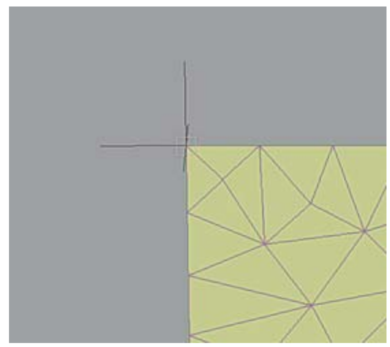


Figure 1.28: Inside the box is an example of a vertex constrained.

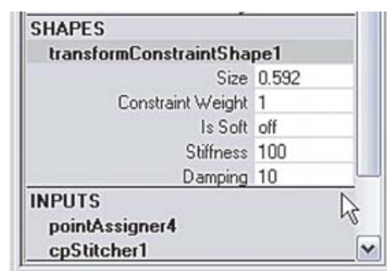


Figure 1.29: Transform constraint attributes

Constraint Weight Sets the constraint on and off. Any value over 0 indicates the constraint as turned on.

Is Soft Off, the default, which means the constrained vertices stick to the transform object with no amount of play. Turning Is Soft on allows for smoother cloth motion. The side-effect is that the constrained region and transform object can separate.

Stiffness Sets the strength of attraction to the transform object when Is Soft is on.

Damping Attempts to reduce the springy effect that occurs as the cloth vertices pull away from the transform object. This also only is relevant when Is Soft is on.

Mesh Constraint

Mesh constraints are similar to transform constraints in that the vertices affected are directly controlled by the object constraining them; however, a mesh constraint only works with collision objects. The end result is that the garment follows the collision object's motion. This is particularly useful for form fitting sections or where the garment is cinched on. If a sleeve is taut near the shoulder but the cuff area is loose, mesh constraining the top of the sleeve will ensure that it does not slide excessively. This idea can be expanded to cases where cloth motion must be reduced for stability reasons. If a simulation begins failing due to the character moving too quickly, constraining a section of the garment to the body for a few frames can help reduce its activity. Just be sure to hide the constraint off camera or use it in cases where the character fills very little screen space. In the opposite case where the garment is up close and static, using mesh constraints can lock down popping vertices.

Let's build a quick mesh constraint:

1. Open `buildMeshConstraint.mb`.
2. In the Outliner, select leftPanelCurve and Ctrl-select collsionCylinder.
3. Choose **Constraints** → **Mesh**.

The cloth should hang down under the cylinder. The mesh constraint attributes are similar to those of the transform constraint (see Figure 1.30).

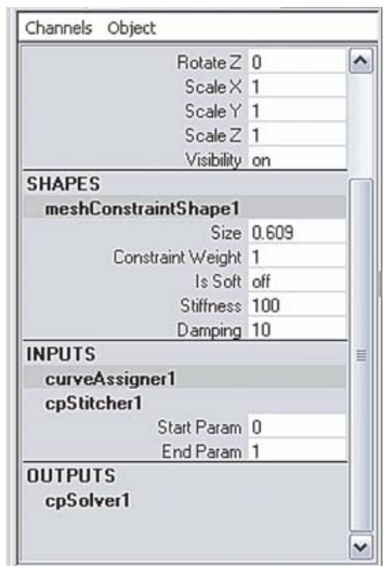


Figure 1.30: Constraining a panel curve is a convenient way to constrain the edge row of vertices. Under Inputs in the Channel box for the constraint node is a curve assigner. Setting the Start and End Param values enables you to specify a partial section of the curve to constrain.

Cloth Constraint

Cloth Constraints bind one cloth garment to another. If your garments are layered, it may be worthwhile to consider solving the garments in sequence, with the first garment simulated by itself and the second garment mesh constrained to the output of the first garment. The advantage is reduced solver complexity, but the down side is that the garments do not interact.

If the garments are of equal weight, then a cloth constraint is the appropriate choice. It is also useful in special cases where two garments must be bound together. An example would be a piece of fabric being torn in half. You could create a cloth constraint to join the two halves together and animate the constraint weight from on to off, then use a series of cloth constraints to have the halves separate one vertex at a time or create the constraint using a panel curve and animate its start and end param values.

Let's take a look at a cloth constraint:

1. Open `buildClothConstraint.mb`.
2. Select the left edge of vertices of cloth2, which are adjacent to cloth1 and Shift+select cloth1.
3. Choose **Constraints** → **Cloth**.
4. Under the constraint's shape node, turn Stitch on.

The simulation for cloth2 is driven by the motion at the end of cloth1. The stitch feature attaches the two garments. This supersedes the **Stiffness**, **Damping**, and **Offset** attributes (see Figure 1.31).

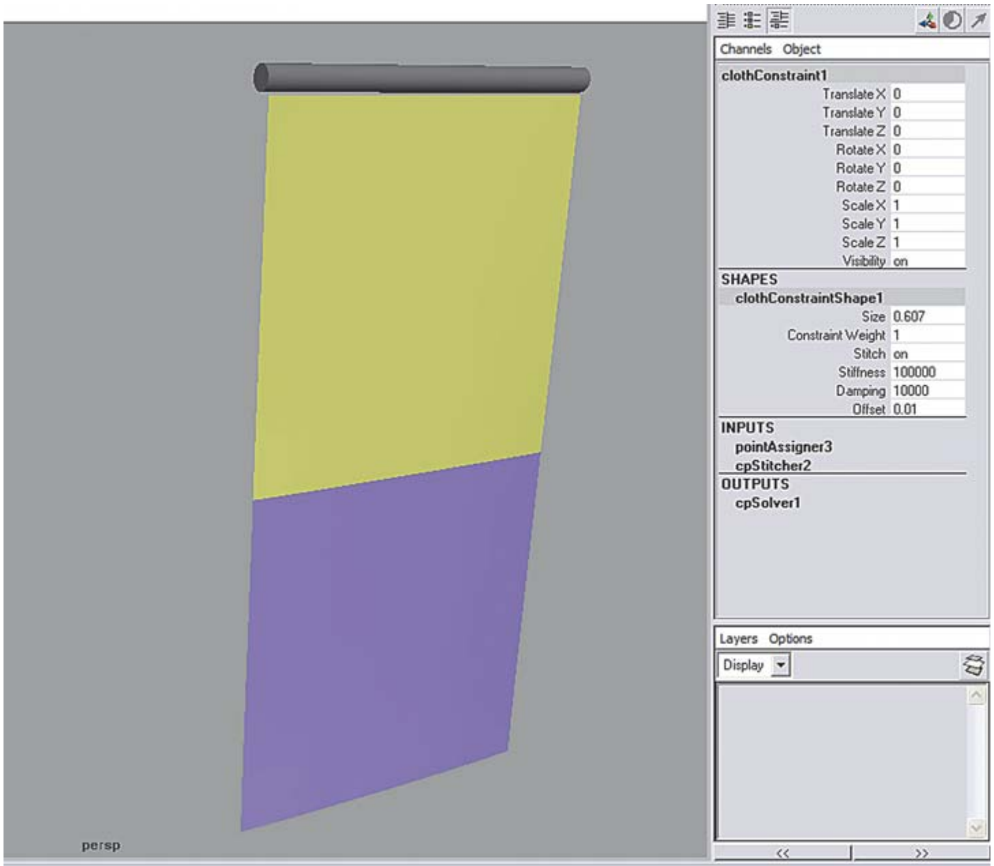


Figure 1.31: Two cloth garments held together using the cloth constraint

Field Constraint

The Field Constraint is really a whole set of constraints leveraging off existing elements from the Dynamics package. Each of these fields can uniquely influence the shape and motion of the cloth and is extremely useful when you want to animate the cloth beyond what the solver gives you by default. Up to this point, gravity and the collision objects have been the primary forces driving the garment's motion, but additional forces generated from fields can also play a role. Through the field you can specify the amount of force and its vector over the constrained region of cloth. This constraint is less direct than a manual technique like a transform constraint, but it tends to yield smoother, more natural motion.

As an example, if you want to get the feel that the cloth is being blown by the wind, one way to start is by adding a uniform field:

1. Open `buildFieldConstraint.mb`.
2. In the Dynamics menu set, choose **Fields → Uniform** and set the following values:

   Magnitude: 75 // Raise the force to an appreciable level
   Attenuation: 0 // Keeps the force constant over distance
   DirectionX: –1 // Sets the world space vector for force

3. Select a group of about a dozen vertices in the middle of the cloth, and Shift+select the uniform field.
4. In the Cloth Menu set, choose **Constraints → Field**.

You should see the cloth being pushed in the region of the constraint. Try animating the magnitude of the field or perhaps constraining a larger or different region of the cloth and see how the results differ.

Collision Constraint

Collision constraints allow constrained vertices to pass through collision objects to other cloth meshes or allow the vertices to intersect. Allowing self-intersection can be useful in folding areas such as in the underarm region of a shirt. Sometimes, collision objects are animated to the point where cloth gets stretched beyond its designed limits. Adding a collision constraint to allow the cloth to penetrate in a section that is off camera can give enough looseness for the cloth to solve effectively. Let's try that:

1. Open `buildCollisionConstraint.mb` and click Play. You should see the cloth simulate over the sphere collision object.
2. Choose **Simulation → Delete Cache** and return to frame 1.
3. Select the lower half of the cloth vertices and choose **Constraints → Collision**.

Upon simulation, the cloth should pass right through the collision sphere (see Figure 1.32). If you look at the shapes node of the collision constraint, you will see that both cloth and rigid collisions are turned off. You can animate these independently. Often you will want to allow self-intersections (cloth collision off) but still respect the collision objects (rigid collisions on).

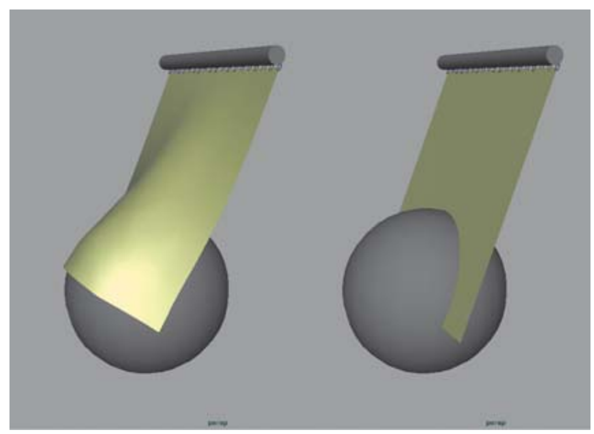


Figure 1.32: A cloth garment with a collision constraint placed on the bottom half of the cloth vertices (right)

Button Constraint

The Button constraint can be used for adding any rigid objects, such as pins, lapels, nametags, badges, and, of course, buttons. Note that these objects cannot be collision objects because this would create a cycle where the collision object would affect the cloth solve and the cloth solve would affect the position of the collision object. Because the solver cannot factor in the button object, clipping can occur if the garment were to fold heavily. The easiest way to manage this problem is to manually rotate and possibly translate the button object under the cpButton transform node.

Unlike the cloth constraint, the button constraint allows rigid objects to be parented onto the surface of the cloth under the cpButton transform node. This gives you extra control to animate the constrained object on top of the motion provided by the constraint. One application is it to rotate the button object to prevent clipping with the cloth. Follow these steps:

1. Open `buildButtonConstraint`.
2. Select buttonSphere, and Shift+select cloth1.
3. Choose **Constraints → Button**.

The sphere should follow the cloth. By default, the constraint maintains the offset between the constrained object and the cloth. Choose **Constraints → Button ❐**, and turn off Preserve Translation and Preserve Rotation, which will snap the constrained object to the surface of the cloth. You can apply an additional offset within the option box.

Avoiding Cloth Problems During Character Animation

One of the most effective ways to help the simulation along is to take extra care during animation. The forces generated by collision objects are strong and tend to overwhelm everything else. For example, it is virtually impossible for a field to be strong enough to force the cloth through a collision object. Therefore, it is imperative that the animation of collision objects works in a predictable fashion.

A common problem is that the character is often animated to the camera, which means that any part of the character off camera is not given much attention. This can cause nonanimated limbs to crash through the body or be left in odd positions. There is also the temptation to fix a character's animation when hidden behind a wall or other occluding object. It is not uncommon to speed up or slow down a character's motion or perhaps rotate the character completely around to get back on the correct path. This may look fine from the camera's angle, but the solver factors in these forces, which will cause the cloth to react unexpectedly.

Self-intersection in a collision object is another area where animation changes can make life a lot simpler. Although the goal is always not to limit the performance of a character, a pose can be so extreme that the solver will have difficulty simulating without introducing instability. The cylinder in Figure 1.33 is similar to an elbow or a knee bent too far. You can see the eyelet-shaped area where the collision surface reverses the direction of force within a small distance. If the cloth gets caught in this region, the abrupt direction change manifests itself in the form of the popping cloth vertices.

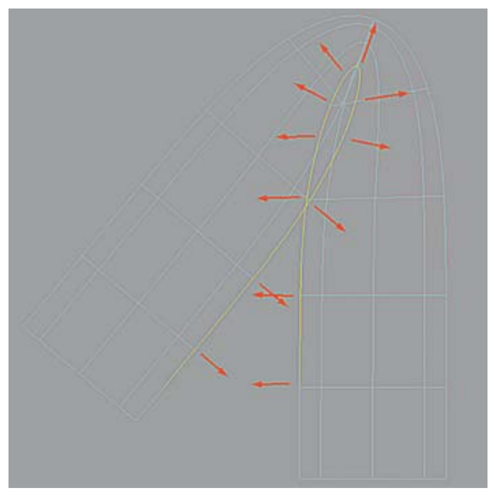


Figure 1.33: A self-intersecting collision object

Manually Updating Cloth

At times, everything looks fine except for one bad frame. In this case, you can manually manipulate the cloth geometry after the simulation and choose **Simulation → Update Cloth State** to update the position information in the cache for the current frame. Use this command as a last resort. If you resimulate, these tweaks will be lost.

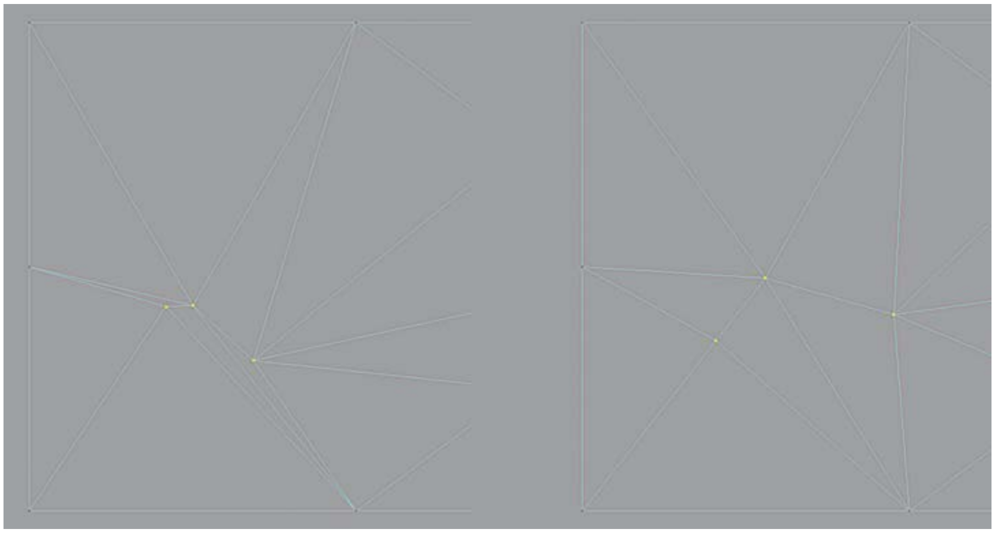


Figure 1.34: The result of polygon averaging on selected vertices

Polygon averaging can help if a small handful of vertices continually pop in and out. It calculates a vertex's position based on its neighbors. Be sure to use this in small doses as averaging over large areas will cause the cloth to reduce in volume. To polygon average the vertices:

1. Select the popping vertices.
2. In the Modeling menu set (press F3 to open it), choose **Polygons** → **Average Vertices** (see Figure 1.34).

Use averaging as a post process step as the averaging information is not saved in the cache. The node remains an input to the cloth even after deleting the cache. Remove polygon averaging before running a new simulation. To do so:

1. Select the cloth mesh and open the attribute editor.
2. Select the tab for the polyAverageVertex node, click the Select button and click Delete.

If you have several nodes and you want to remove all of them, run the following MEL code.

```
string $node, $polyAvgNodes[]
=lsType("polyAverageVertex") ;
for ($node in $polyAvgNodes){
if ($node != "<done>")
delete $node;
}
```

Saving Your Work

After you simulate the garment, the cloth updates in real time without recalculating because the cache is stored in memory. This information is saved on disk through a Maya file format that has the `.mcc` extension. By default, the `.mcc` file is stored in the same folder with the same name as the scene file. In previous versions of Maya, the cpSolver had an attribute that listed the path to the cache file. Maya 6 has the expanded notion of a cpCache node. The most important thing to keep in mind is that the cache is written to disk only when your scene file is saved. In other words, if you choose **File → Exit**, all the simulation data is lost. A computer-related mantra, which is definitely true for cloth, is to save early and save often. You can manually save the cache or back up a copy under a different filename. To save a file, follow these steps:

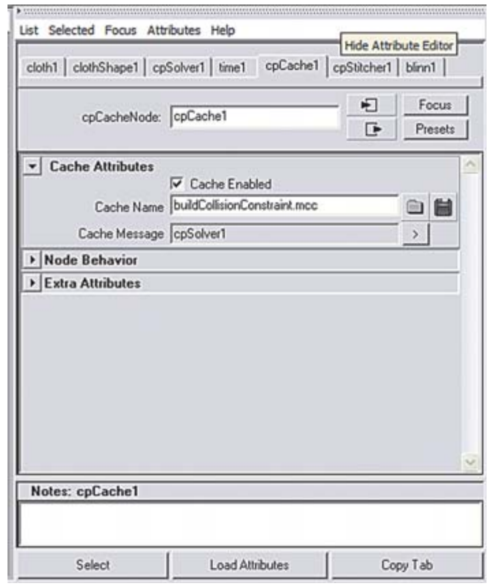


Figure 1.35: The cpCache node

1. Select the cloth garment, open the Attribute Editor, and select the cpCache node.
2. Set the cache name and click the disk icon to save (see Figure 1.35).

   In older versions of Maya, you can save the cache through a MEL command:

```
cpSolver -saveCache "filepath/filename.mcc"
```

Maya automatically loads the cache listed in the cpCache node when the scene is opened. You can also load an alternate cache file through the cpCache node by clicking the folder icon shown in Figure 1.35.

And now on to some noncloth things you can do with Maya Cloth.

Alternative Uses for Maya Cloth

Up to this point, you have learned how to create a cloth garment by constructing panel curves and seaming them together. You also learned how to create a workable collision environment for clothing animation. Sometimes though, in a 3D production, the work of a clothing animator does not just center on skirts and other garments; it can also involve props, accessories, and even jewelry.

Cloth simulation is a great way to deform anything that behaves in a similar manner to cloth. You can animate flags, banners, vines in a jungle, and even earrings with the help of Maya Cloth. You can even go as far as animating the cord of a video game controller with Cloth. So, the next time you are animating curtains, cords, towels, or even the fringe that hangs off older lampshades, consider a cloth simulation.

Now, it is time to take your new knowledge of Maya Cloth a step further and see how to use it for nongarment deformations in a production pipeline. Specifically, we will focus on creating a bracelet for our female model and setting up its deformations using cloth simulation.

Building the Bracelet Garment

We'll now build a cloth garment that will be used to deform the bracelet around the left wrist of our character. Follow these steps:

1. Open `bracelet_sim.ma`. You will see our character standing in the neutral position at the origin.
2. We will deform the bracelet model you see around the left wrist. Select a part of the bracelet, and press the F key to center it in your view.
3. Choose **Create → NURBS Primitives → Square**.
4. Select the new NURBS square's group node, and press the W key to invoke the Translate tool.
   a. Turn on point snapping. MM drag over a surface in the view window. The NURBS square you previously created should snap to the surface your mouse was over.
   b. Turn off snapping, and make sure the only thing selected is the NURBS square group node.
   c. Rotate and scale the group node until, from the top view, a rectangular box is completely encompassing the bracelet.

Your top view should look similar to Figure 1.36.

Check the perspective view, and make sure the NURBS square is above the highest point of the bracelet by at least a few units in the Y direction. Now follow these steps:

1. Select the group node of the NURBS square.
2. Choose **Edit → Duplicate ❐**.
3. Choose **Edit → Reset Settings**, and then duplicate the square.
4. Move the duplicated group node down in Y so that it is below the bracelet.

Your perspective view should look similar to Figure 1.37.

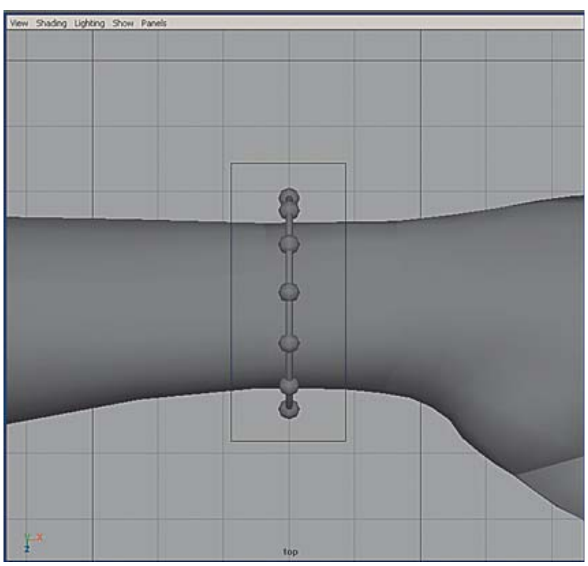


Figure 1.36: The top view

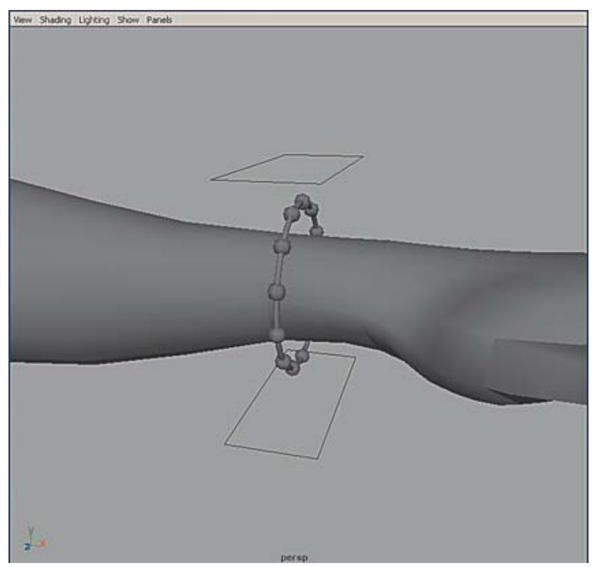


Figure 1.37: Two NURBS squares used to generate cloth panels

Now, in much the same way you built the garment earlier in this chapter, you will build this garment. Follow these steps:

1. Select the top group's curves individually.

Selecting the curves individually is more of a suggestion than a necessity. Based on studio experience and workflow, problems have been encountered at the simulation stage when groups were selected instead of individual curves.

---

2. Choose **Cloth** → **Create Garment**.
3. Select the bottom nurbsSquare2 group's curves individually.
4. Choose **Cloth** → **Create Panel**.

You have just created two panels of a garment that now need to be seamed together to create the final garment that will become the bracelet. Follow these steps:

1. Select the corresponding seam curves along the thumb edge of each square.
2. Choose **Cloth** → **Create Seam**.

Repeat these steps for the other (pinky) side of the garment. You should see a low-poly surface appear within the box that the seamed curves form. Your view should look similar to Figure 1.38. This surface is the cloth garment that will soon deform this character's bracelet.

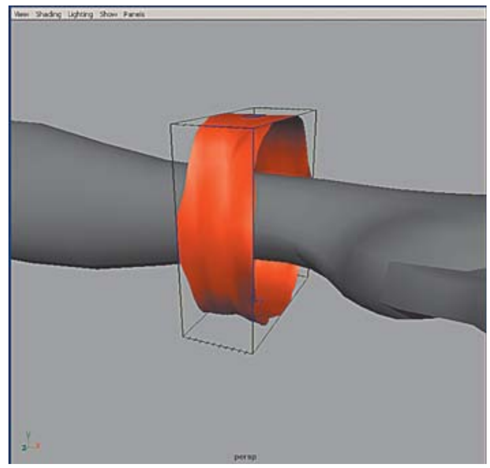


Figure 1.38: The low-poly bracelet

Solver, Property, and Stitcher Resolution Settings

Now that you have created the actual cloth surface, you have to make sure your settings are appropriate to get the best simulation possible and that your collision environment is ready for your garment.

First, let's get the resolution of the cloth set correctly. Follow these steps:

1. Select the cloth mesh.
2. Highlight cpStitcher in the Channel box.
3. Enter **250** for the resolution.

You want the resolution to be high enough to get a good simulation, but not so high as to slow down your Maya session. The best way to find this number, until experience tells you, is by trial and error. A resolution of 250 will be great for the quality of the simulation and should not slow Maya significantly.

Next, we need to enter some better values for the cloth properties of the panels. Follow these steps:

1. Select a panel node.
2. In the Channel box, highlight cpDefaultProperty.
3. Enter the values shown in Figure 1.39.

cpDefaultProperty	
U Bend Resistance	25
V Bend Resistance	25
U Bend Rate	0
V Bend Rate	0
U Stretch Resistance	100
V Stretch Resistance	100
Shear Resistance	50
U Scale	1
V Scale	1
Density	0.01
Thickness	1
Thickness Force	1
Cloth Friction	0.3
Cloth Damping	0.2
Air Damping	0.1
Static Friction	0.2
Dynamic Friction	0.2

Figure 1.39: Good starting properties for cloth

cpSolver1	
Start Frame	1
Frame Samples	5
Time Step Size	0.018
Solver Scale	3
Gravity0	0
Gravity1	-980
Gravity2	0
Relax Frame Length	0
Output Statistics	on
Velocity Cutoff Min	0
Velocity Cutoff Max	0
Velocity Cutoff Damping	0

Figure 1.40: Good starting solver properties

The cpDefaultProperty is the cloth property node connected to both panels of the bracelet garment. The default settings are a good starting point, but will rarely give you an acceptable cloth solve. Again, with experience, these values will become second nature. Until then, starting with the values in Figure 1.39 will get you a lot closer to making happy cloth than the defaults.

Now, the cloth solver needs its settings tweaked to give us a better simulation environment. Follow these steps:

1. Select the cloth mesh.
2. Highlight cpSolver in the Channel box.
3. Enter the values shown in Figure 1.40.

Again, the default settings for the solver will rarely give the best of conditions for simulating your cloth. Figure 1.40 shows the settings that make a great starting place when dealing with models of this scale in Maya.

The final step before beginning any simulations is to make sure your collision environment is ready for your new garment. Follow these steps:

1. Select the polygon model of the female character.
2. Choose **Cloth** → **Create Collision Object**.
   a. Set **Collision Offset** to 0.2.
   b. Set **Collision Depth** to 0.1.

These settings control how the cloth collides with the mesh. Once again, these default settings will not always give you the desired results. You might need to raise these numbers until your simulation is the distance above the skin you want. Especially in this case, when dealing with a garment that should be close to the skin, you will have to massage these settings.

Simulating and Relaxing the Bracelet

Now that all our settings have better default values, and our collision environment is ready, it's time to simulate and relax the garment for propagation to files for animation.

Click Play to begin the simulation. You should see the expanded cloth mesh begin to collapse around the wrist of the character and move around as it settles to a near stop. After the bracelet settles, it should look similar to Figure 1.41.

If simulation stops or appears to quit, make sure your Playback preferences are set to Play Every Frame.

The Time Slider should be at the end of the Timeline now. Rewind the simulation and save your file. You should now have a file called `bracelet_sim.mcc` in the scenes directory of this project. Remember, this is the cache file that Maya saves after a cloth simulation.

Now, scrub the Timeline to the last frame, and you should see the cloth garment back around the wrist and settled. Because you do not want to have to resimulate and resettle this garment for every file it will appear in, a few final steps are necessary.

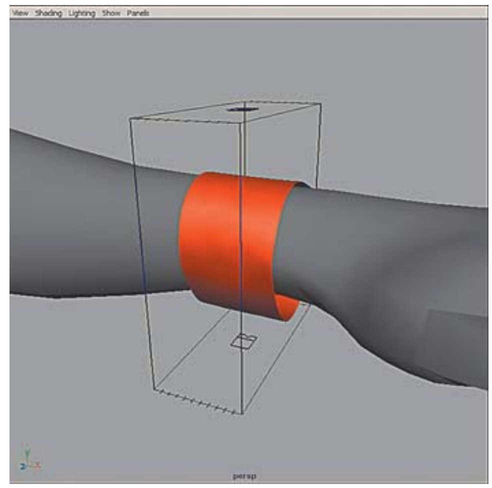


Figure 1.41: The bracelet after settling

1. Save the file as `bracelet_simmed.ma`.
2. Select the cloth mesh.
3. Choose **Simulation** → **Save As Initial Cloth State**.
4. Rewind to the first frame.
5. Choose **Simulation** → **Delete Cache**.
6. Save the file.

Your garment development process is finished. Now we can move on to animating the cloth and deforming the bracelet model.

Animating the Bracelet

Open the `bracelet_animated.ma` file. This file was created by importing the `bracelet_simmed.ma` file from the previous section and animating the character without simulating any cloth.

You can disable the cloth solver in a file either by selecting the solver in the Attribute Editor and choosing **Simulation** → **Disable Solver** or by simply hiding the cloth mesh.

With the cloth mesh hidden, play the file and watch the animation. From frame 0 to frame 98, the character moves from a neutral position to the first position of the animation. At frame 101, the character begins the action of pointing with her left hand. See Figures 1.42 and 1.43.

Observing Motion and Simulating the Cloth

One of your most important tasks when first assigned a scene for which you will be animating the cloth is to watch the animation and look for any areas where the cloth might have a hard time solving. These areas include, but are not limited to, pinching collision surfaces, extremely fast animation, and intersecting collision surfaces.

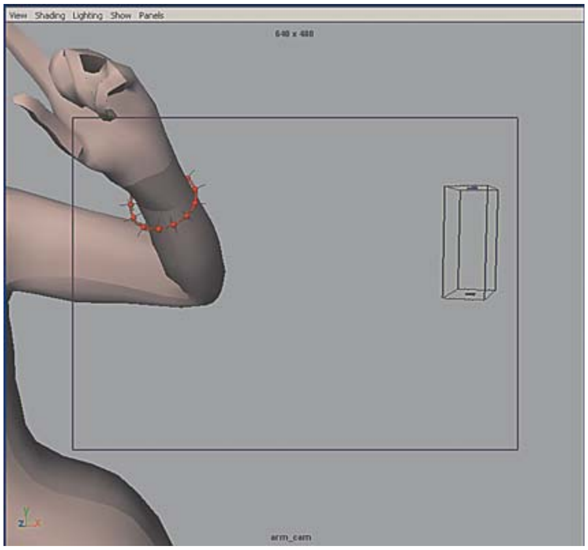


Figure 1.42: The beginning of the point animation

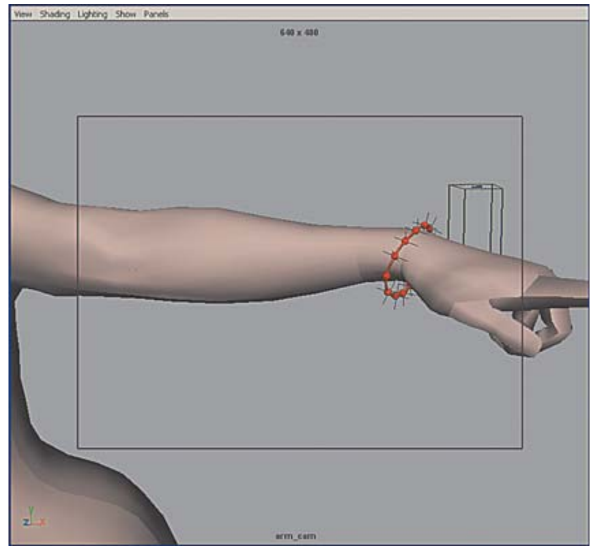


Figure 1.43: The follow-through of the point animation

In this scene, the character moves into the point pose quite quickly, creating a situation that should be flagged as a potential problem. Click the Play button to begin simulating the cloth object. You might encounter problems, but most likely the simulation will complete successfully.

Now that you have a baseline of settings to simulate with, you must decide exactly how the bracelet should move and react. In other words, ask yourself questions such as the following:

- How should cloth like this act?
- How can I add anything to the scene through the cloth animation?
- What information do the directors want to see from this scene?

The answers to these questions will steer you toward making the bracelet animation great and getting it approved. If you see the need for changes, adjust the cloth properties or add constraints. Animate, simulate, and playblast until you get the results you need. When you have finished working, remember to rewind the animation and save the file. You should now have a file called `bracelet_animated.mcc` in the scenes directory of your project.

Deforming the Bracelet Model

After the cloth has been properly simulated and a cache file has been saved, the next step is deforming the actual bracelet model, which consists of a strand surface and multiple beads. To accomplish this, you use a wrap deformer on the strand surface. A MEL script handles sticking the beads to the strand surface throughout the animation.

Using Maya's wrap deformer is an excellent way to animate a high-resolution garment model based on the simulation of cloth. This works on skirts, vests, pants, shirts, jewelry, accessories, and props.

To set up the wrap deformer, first select the surfaces you want to deform and then select the influence object. Follow these steps:

1. Select the tubular strand surface of the bracelet.
2. Shift-select the cloth mesh.
3. From the Animation menu set, choose **Deform** → **Create Wrap**.

Click anywhere in the Timeline to see the strand surface following the cloth mesh and being deformed appropriately. Playblast the animation to see your results in real time.

Constraining the Beads

Though the strand should be moving quite nicely with the cloth, there is still one problem to solve. The beads, which should stay with the bracelet, are not moving along. They were not included in the wrap deformer for a reason. If the beads were included earlier, they would be moving along, but would be deforming inappropriately. They would squash and stretch based on the cloth, instead of being hard. To solve this problem, you can use a MEL script called `UVGlue.mel`, which you will find on the CD that accompanies this book. Follow these steps:

1. Open the Script Editor.
2. Choose **File** → **Source Script**.
3. Navigate to the mel directory of the Chapter 1 files and select `UVGlue.mel`.

This script works by having the user select a surface point on a NURBS surface and executing the script with the `UVGlue` command. Follow these steps:

1. Rewind to the first frame of the animation.
2. Select any bead on the bracelet.
3. Set your view so that the whole bracelet is visible.
4. Hide the character geometry, as well as any other geometry obstructing your view of the bracelet.
5. Make a display layer for the beads.
6. Set the beads layer to be templated.

This will allow you to select the strand surface points that line up with the beads without actually selecting the beads themselves. Your view should look similar to Figure 1.44.

Now make sure that the strand is the only thing selectable in your view window. Follow these steps:

1. Right-click over the strand geometry to open its marking menu.
2. Select Surface Point.
3. Left-click the strand surface in the middle of the top bead.

You should see two yellow lines cross each other at that point on the surface with a yellow point at their intersection. Your view should look similar to Figure 1.45.

You have just selected a surface point on the strand surface that should line up with the center of the bead on the strand. Now, with that surface point selected, follow these steps.

1. Left-click in the Command line, or press the back tick (reverse apostrophe) key.
2. Type **UVGlue**.
3. Press Enter.

Upon successful completion of the script, a locator is created at the selected surface point. Repeat these steps for the rest of the beads around the strand. When all the locators

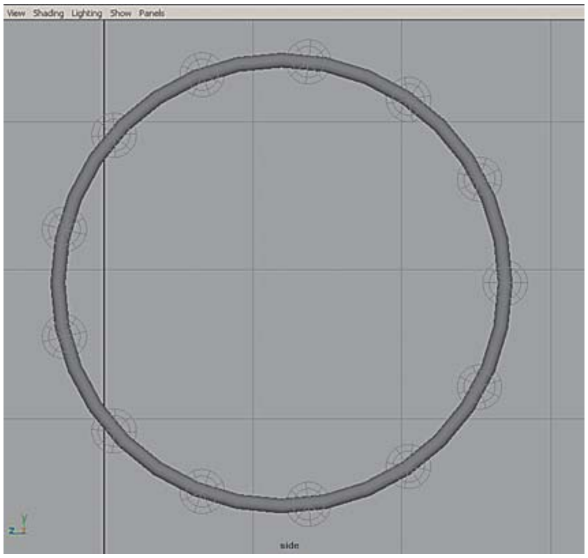


Figure 1.44: The templated beads

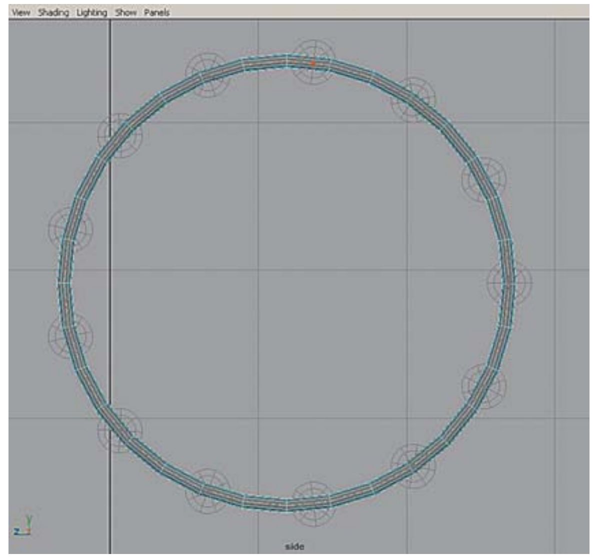


Figure 1.45: The selected surface point

are created, untemplate the beads' display layer. Make sure you are at the first frame of the animation, and follow these steps:

1. Select a bead, and Shift-select the corresponding locator.
2. Parent the bead to the locator by choosing **Edit → Parent**.

Repeat these parenting steps until all the beads are parented to their corresponding locators. Unhide the character geometry; switch to a perspective view that shows your work to the best advantage, and playblast the animation. If everything was successful, the beads should follow along through the animation.

What About Changes?

Inevitably, the first work you do on an animation will not quite meet the expectations of the leads, the directors, or yourself. In this case, the bracelet is completely driven by the cloth simulation. So, to handle changes, the only thing you need to do is resimulate the cloth. To simplify this process, hide the bracelet geometry. Make sure you unhide the cloth mesh and delete the cloth cache so that your new cloth properties take effect. Continue to edit properties and resimulate, making sure to unhide your bracelet now and again to check the deformations. This process will continue until you get your animation approved.

Always Learning

This chapter introduced you to using Maya Cloth for everything from garment creation and simulation to deforming jewelry. Cloth simulation can be a versatile tool when you face animating something out of the ordinary, but be patient: Sometimes animating cloth can be like animating a marble with a straw. If you follow the directions given here, and use the settings we provided, you will jump into your shots prepared and ready to go. The next time you face animating the end of that feather duster or the most beautiful ball gown ever, don't forget Maya Cloth.