ClothWorks

A cloth simulation extension for SketchUp.

by Anton Synytsia

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Setup

Requirements

- Window 7 or later / Mac OS X 10.9+
- SketchUp 2016 or later
- *SketchUcationTools* v3.1.4+, for licensing and unlocking features

Installation Instructions

ClothWorks can be installed via *SketchUcationTools* extension or manually, from *ExtensionStore*.

Refer to the steps below for installing manually:

1. Download *ams_ClothWorks_vX.Y.Z.rbz*.
2. Navigate to your plugins folder (see *Extension Folder Location* section for details).
3. Extract *ams_ClothWorks_vX.Y.Z.rbz* and copy the content into the plugins folder, so that the plugins folder contains *ams_ClothWorks* folder and *ams_ClothWorks.rb* file:
   ...\SketchUp\Plugins
   a. *ams_ClothWorks*
   b. *ams_ClothWorks.rb*

Uninstallation Instructions

Refer to the steps below to uninstall the extension:

1. Close SketchUp.
2. Navigate to your plugins folder (see *Extension Folder Location* section for details).
3. Delete *ams_ClothWorks* folder and *ams_ClothWorks.rb* file.

Extension Folder Location

On Windows, the plugins folder is located at, either:

```
%appdata%\SketchUp\SketchUp 20##\SketchUp\Plugins

%programdata%\SketchUp\SketchUp 20##\SketchUp\Plugins
```

On Mac OS X, the plugins folder is located at:

```
~/Library/Application Support/SketchUp 20##/SketchUp/Plugins
```

Licensing

Licensing unlocks four features:

1. Loop Subdivision – smoothens cloth by increasing resolution (meanwhile preserving texture UVs)
2. Laplacian Smoothing – smoothens cloth by transforming vertices around
3. Movable Pins – allows transforming pinned cloth while in simulation
4. Smart Grid – generates proper grids for complex faces

A licence can be activated on up to three computers (e.g devices).

Prerequisites

1. ClothWorks licensing depends on *SketchUcationTools*, version 3.1.4+:
   https://sketchucation.com/resources/plugin-store-download
   This extension must be downloaded and installed in order to activate a licence.

2. Purchasing and activating a licence also requires being a registered user at SketchUcation:
   https://sketchucation.com/register.php

Validating Licence

Note: Prior to purchasing a licence, ensure that ClothWorks simulation works properly and doesn't crash.

Follow the steps below for purchasing and activating your licence:

1. Click on the following link to purchase a licence:
   https://sketchucation.com/purchase.php?plugin=ClothWorks
   Note: This process requires that you are signed-in to SketchUcation.

2. When you purchase a licence, you will have received an email with a licence file attached to it. Download the licence file and save it to a known location on your computer.

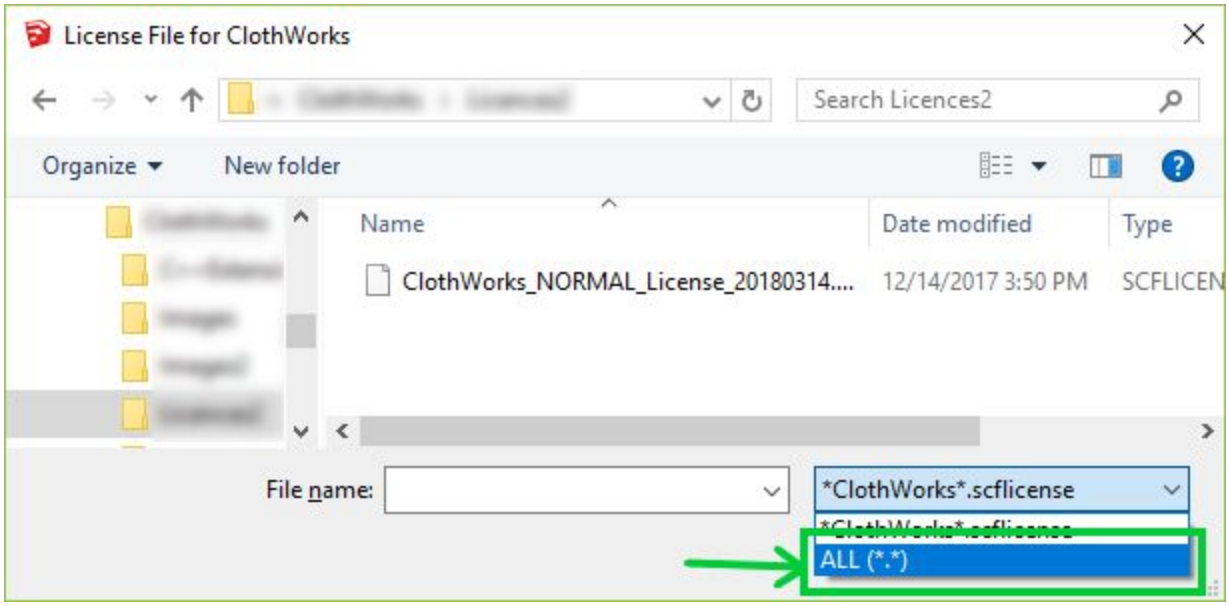
3. If haven't already done so, download and install the latest version of *SketchUcationTools:*
   https://sketchucation.com/resources/plugin-store-download

4. Open SketchUp

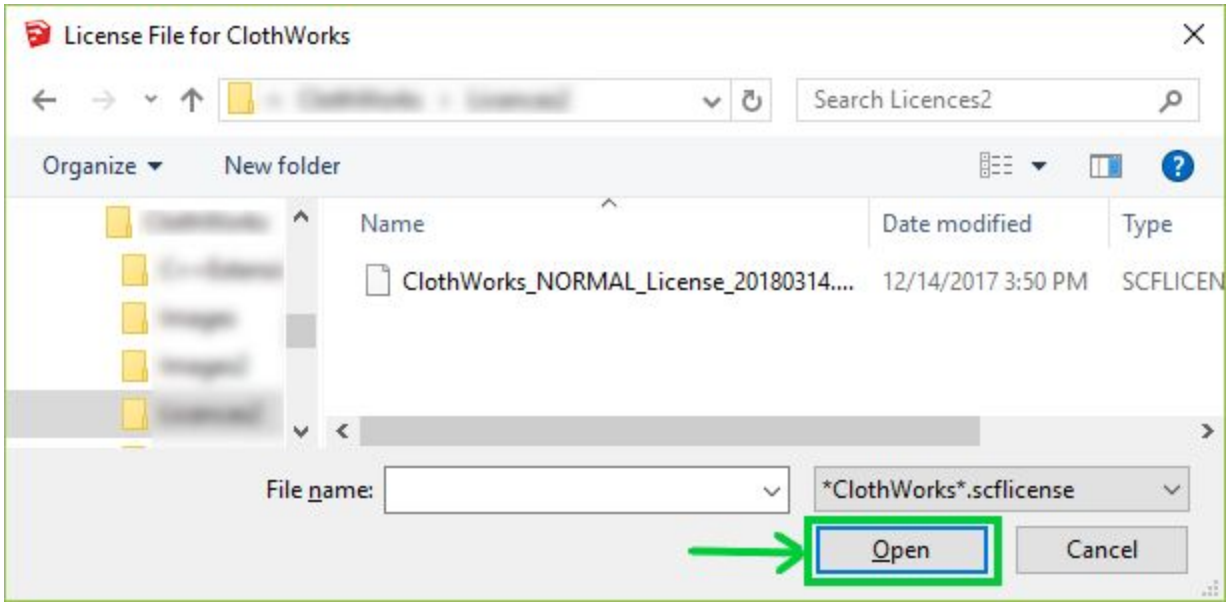
5. Access *(Menu) Extensions → ClothWorks → License…*
   This will open an *SCFLicense* dialog box.

6. Click on the *Validate License* button. This will open a dialog for choosing a license file to activate.

7. (Optional) Within the dialog for choosing a license file, change the file type drop-down option to *ALL (*.*)*. This will display all file types.



8. Find and select your licensing file, and then click *Open*. This should validate your licence.



9. Press *Done* and you're all set!

With a licence activated, all features should be unlocked.

Releasing Licence

A validated licence can be released by clicking *Release License* button. Once released, a licence can be validated again, on either the same or a different device.

Getting Number of Seats

The number of seats (e.g devices) taken is stored on SketchUcation server. If you have the *License Dialog Box* open, and do validation in parallel on other computers, you may need to refresh the information by just clicking on the *Seats...* button.

If you want to reset all your seats, please send me a PM to Anton_S at SketchUcation.

Important Note: Activating licence, releasing licence, and refreshing seats requires internet connection.

Known Issues and Limitations

- Applying intense forces to a drag-enabled cloth object will have the cloth object explode. In case that happens, either reset simulation, which will restore the original layout of the cloth, or stop simulation and then use *Toggle Draped* option to restore the original layout of the cloth:

- *Smart Grid* option only works with faces that are quads, triangles, and/or pure circles. To apply *Smart Grid* to complex faces, first, manually divide faces into quads and/or triangles and then follow with *Smart Grid* option.
- Avoid using the undo command post simulation, as each frame of simulation is wrapped in its own operation. Instead, to undo cloth layout, use *Toggle Draped* option, accessible from ClothWorks toolbar or menu.
- Self-collision is not perfect and may allow self-overlaps. In case self-overlaps occur, applying smoothing options (post simulation), especially Laplacian smoothing, can eliminate overlaps.

Important Notes

- Prior to starting simulation, ensure that *Outliner* and *Components* inspectors are closed or collapsed. When these dialogs are open (or expanded), there tends to be an extreme lag.
- Increasing update timestep, say from *1/420* to *1/180*, makes cloth weaker. If possible, avoid increasing the update timestep. On the counter-note, decreasing the update timestep, say from *1/420* to *1/1200*, makes the cloth significantly stiffer.

Dealing with Collision Detection

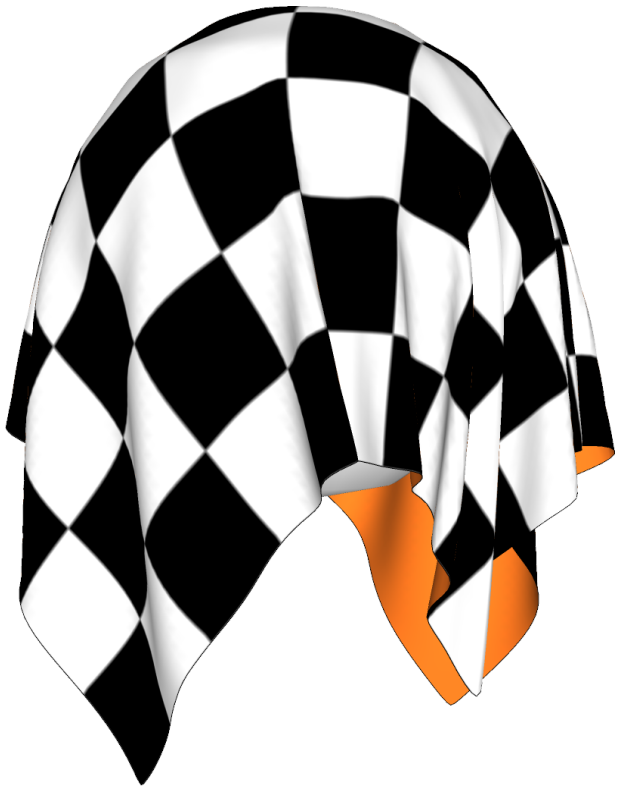
- If self-collision is turned on for a cloth object, its thickness must not be greater than its grid spacing; greater thickness can affect the integrity of the cloth.
- To prevent collision overlaps when draping over a collider, reduce gravity, increase viscosity, and/or increase thickness of the collider.

Introduction

ClothWorks is a physics simulation extension for SketchUp, for draping cloth and ropes over components of any shape and size and also for simulating flags and curtains. Workflow functionalities include:

- ***Simple Grid*** and ***Smart Grid*** options for turning face or a set of faces within a component/group into a grid of faces, with a desired padding. An additional ***Purge Edges*** option can be used to remove the generated grid. These options are for manipulating cloth.
- ***Split Edges*** option for dividing an edge or a set of edges within a component/group into segments, with a desired padding. An additional ***Weld Edges*** *option* merges the split edges. These options are for manipulating wires.
- ***Loop Subdivision*** and ***Laplacian Smoothing*** options for subdividing and smoothening the resulting, simulated cloth (meanwhile preserving texture UVs).
- ***Drape*** and ***Undrape*** options for resetting and renewing cloth, rope, and pin orientations. This option is, particularly, useful for when changing cloth texture material.
- ***Record*** and ***Export*** options for recording simulation and then exporting the final animation into a sequence of PNG or JPG images, SKP files, OBJ files, and many other formats. A third-party software, such as MakeAVI, can be used to combine a sequence of exported frame images into a video file.

Attached below is achieved by simulating cloth over a sphere, applying loop subdivision & Laplacian smoothing, assigning a texture (utilizing the drape/undrape options), and exporting the result into a transparent PNG image.



Denotation

Before we begin with tutorials, let's familiarize with the types of objects in ClothWorks and their specifications. ClothWorks has three types of objects:

1. **Cloth** – a deformable aggregate.

   A cloth type can only be assigned to top-level groups and components. Faces and edges one level deep, within a cloth-typed group/component, are the ones used for simulation; nested groups and components are ignored.

   When simulation starts, all faces are converted to triplets. All vertices are treated as particles, all edges are treated as linear springs, every two triplets are treated as bending springs, and every two, linked, faceless edges are treated as angular springs.

   The higher the grid resolution of the cloth the better the simulation quality. This does mean the simulation runs slower to compute the draping.

   To assign a cloth type, select a desired group/component and access
   (Context Menu) ClothWorks → Make Cloth

   When simulation starts, all polygons of a cloth object are converted into triangles.

   During simulation, a cloth object can be moved by grabbing and dragging with the left mouse button.

2. **Collider** – a static aggregate.

   Like a cloth type, a collider type assignment is limited to top-level groups and components only; however, unlike for a cloth-typed object, nested groups and components are also included in simulation, unless they are hidden or are explicitly ignored.

   To assign a collider type, select a desired group/component and access
   (Context Menu) ClothWorks → Make Collider

   To exclude a sub-group/sub-component from simulation, select it and access
   (Context Menu) ClothWorks → Sub-Collider → Exclude from Simulation

   Another way to exclude a nested group/component is by hiding it.

   During simulation, the geometry of a collider-typed object is not modified in any way.

3. **Pin** – an object that locks overlapping cloth vertices in place.

   A pin can be created by accessing the pin tool from a ClothWorks toolbar:

   A default pin component is used to represent the pin.

Custom pins can be made too. To assign a particular, top-level group/component a pin type, select it and access *(Context Menu) ClothWorks → Make Pin*

If in case pins are too large or too small for a model, their scale, all at once, can be edited by accessing *(Menu) Extensions → ClothWorks → Edit Pins Scale*

Remember that pin's top-level bounding box, and not its actual geometry, determines whether a cloth vertex is overlapping and is to be "pinned down".

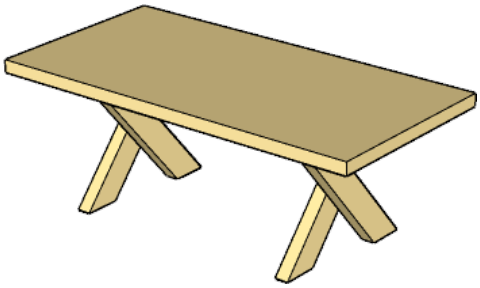
During simulation, pins can be selected with a mimicked select tool and transformed with either an interactive drag axes tool or keyboard controls. When a pin is moved, pinned cloth vertices are transformed with it. To transform pins using keyboard:

- Use ARROW keys for motion along the XY-plane.
- Use HOME/END keys for motion along the Z direction.
- Hold SHIFT key and use the motion keys for converging/diverging multiple, selected pins. On Windows, you can also use the CONTROL key in place of the SHIFT key.

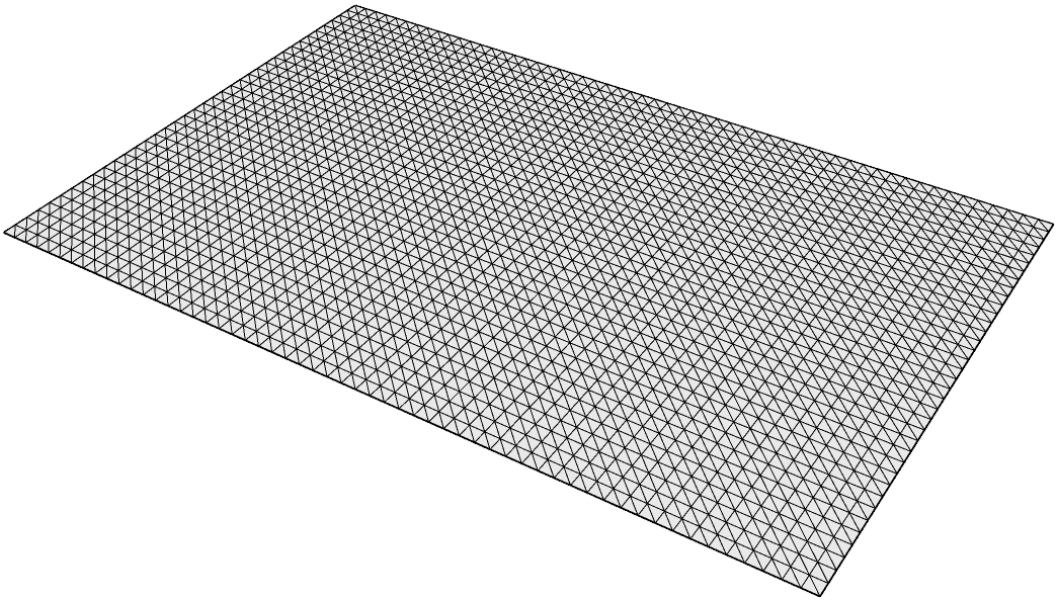
Draping Picnic Table

Refer to the steps below for draping cloth over a table with a rectangular surface.

1. Begin by drawing a table with a rectangular surface and grouping it. An existing table can be used too. The thing to keep in mind is that a collider must be represented by a top-level group or a component. As mentioned in *Denotation* section, a collider can include nested groups and components.

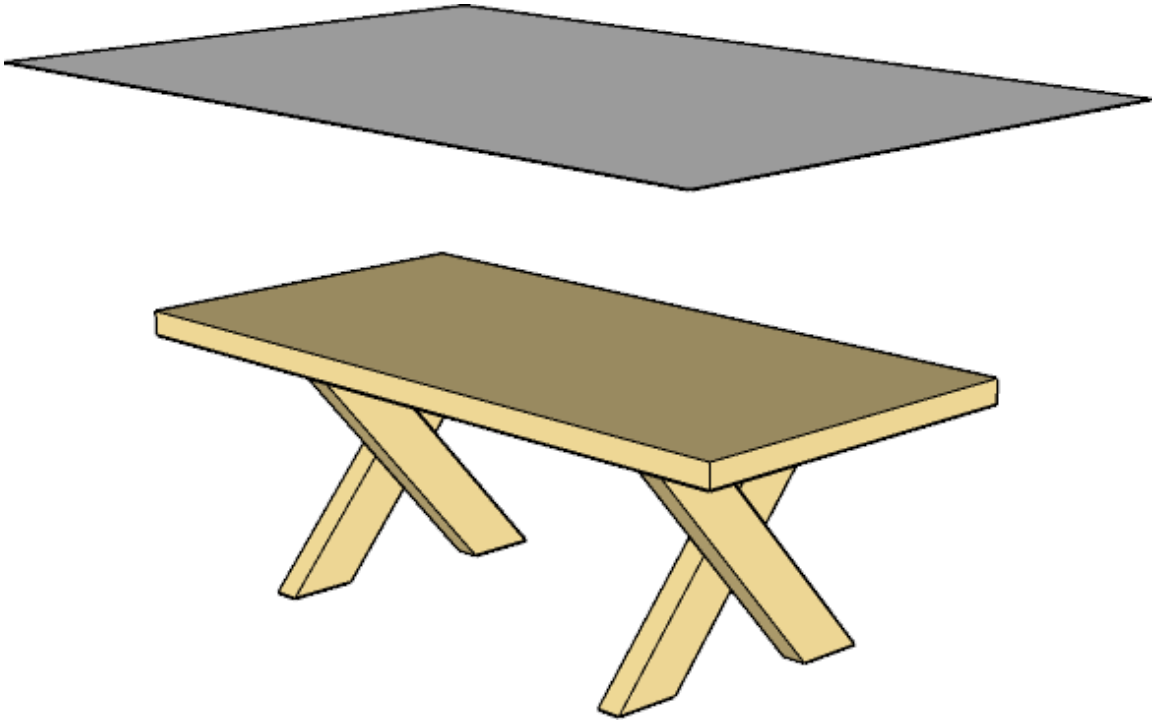


2. Select the table, and assign it a collider type:
   (Context Menu) ClothWorks → Make Collider
3. Now, to represent the tablecloth, draw a rectangle on an XY-plane and group it.
4. Select the tablecloth and assign it a cloth type:
   (Context Menu) ClothWorks → Make Cloth
5. Select the tablecloth again and apply it a simple grid:
   (Context Menu) ClothWorks → 1 Cloth → Simple Grid
   a. *Simple Grid* option intersects group face(s) with an axes-aligned grid, with a padding roughly equivalent to the indicated padding, as the resulting square dimensions are stretched to properly fit the face.
   b. When prompted to specify grid padding, make sure to pass a reasonable value, so that the resolution is not too small and not too large. By default, the passed value is assumed in preset units. To assign a value in different units, simply append a unit abbreviation to the value, for example:
      i. *20mm*
      ii. *1”*
      iii. *0.05ft*
   c. Unsmoothing all edges, should resemble a grid with a similar resolution:



d. If the resolution of a generated grid is not desirable, the operation can be undone (by pressing CTRL-Z) and applied again but with a different grid padding. To make it simple, undoing the operation is not required, as when *Simple Grid* is applied, it prompts you whether to purge the group of all the coplanar edges, hence the original grid.

6. Position the tablecloth over the table:



7. (Optional) Enable self-collision for the tablecloth:
    a. Select the tablecloth
    b. Open ClothWorks UI

    c. Navigate to *Object* tab
    d. Expand *Cloth* section
    e. Turn on *Self-Collide* switch

8. Now, the model is ready for simulation. Click on the play button and have the simulation run until the cloth lays still over the table.

    a. To help with slowing down the movement, increase simulation viscosity, to say *0.05*:
        i. Open ClothWorks UI
        ii. Navigate to *Simulation* tab
        iii. Adjust the range slider labeled *V*, under the *Drag & Viscosity* section.

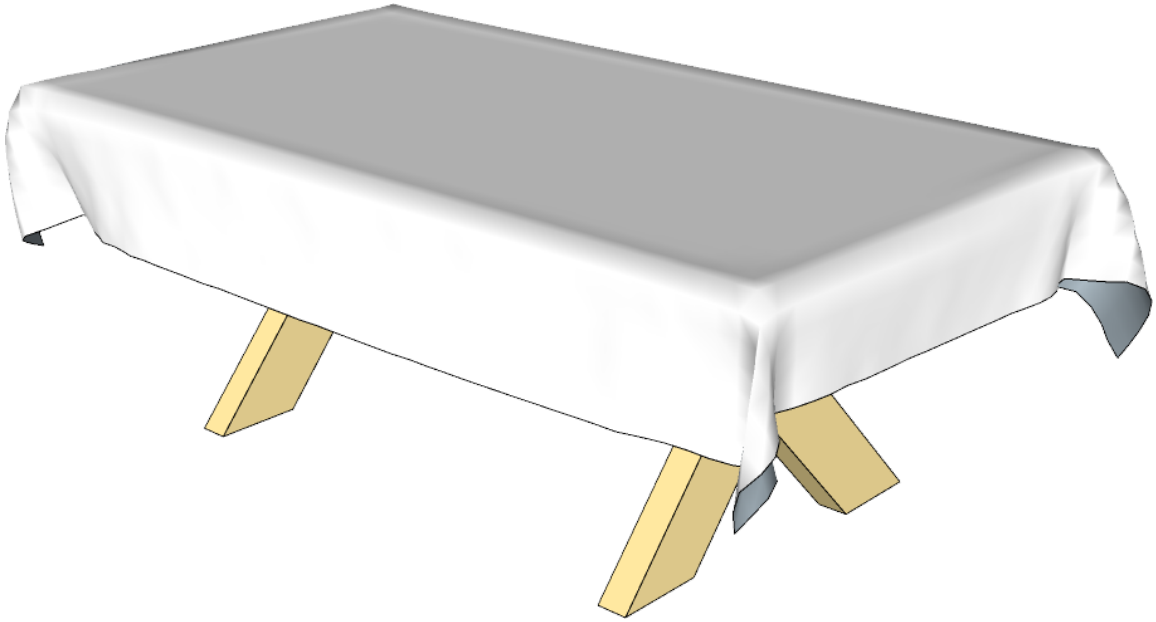
b. If in case the tablecloth penetrates the edges of the table, increase the thickness of the table, to say 30mm:
    i. Reset simulation

Note: if you pressed the stop button instead of the reset button, avoid using the undo command, as, at this point, the undo stack is cluttered with operations of individual frames. Instead, select the desired cloth objects and/or pins and make use of the drape/undrape button to reset layout.

    ii. Select the table
    iii. Open ClothWorks UI
    iv. Navigate to *Object* tab
    v. Expand *Collider* section
    vi. Drag the range-slider to adjust table thickness
    vii. Restart simulation

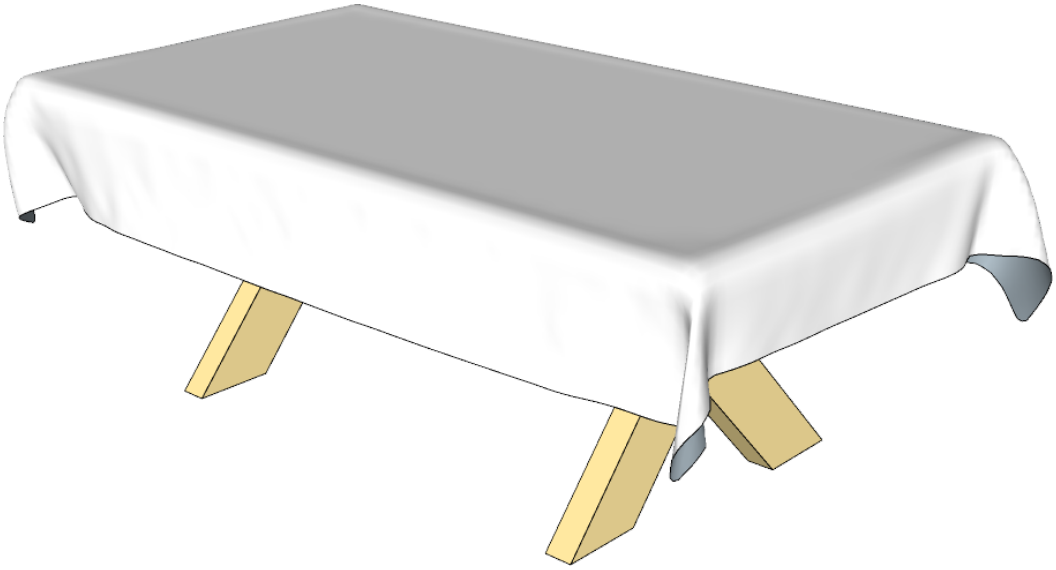
9. Once you have a desired view, stop the simulation. Unlike the reset simulation command, stop simulation command preserves cloth layout:

10. The simulated tablecloth looks something like this:



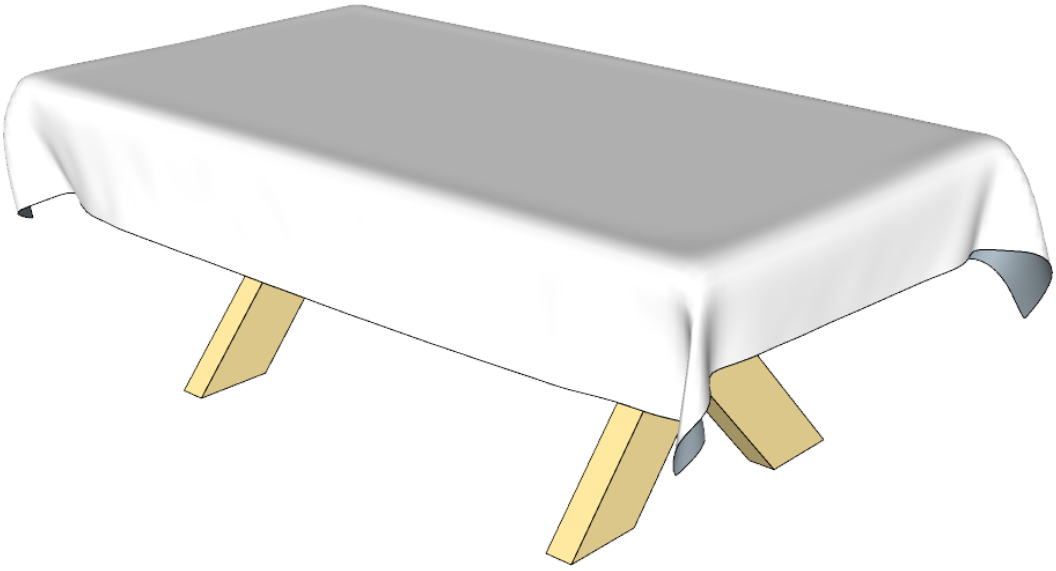
What we want to do here is apply smoothing. Here, we will apply *Loop Subdivision* first and follow with *Laplacian Smoothing*. The ordering of applying the smoothing options matters.

a. Select the tablecloth and apply loop subdivision:
(Context Menu) ClothWorks → 1 Cloth → Loop Subdivision



If applying loop subdivision once doesn't generate a smooth-enough result, the process can be repeated.

b. Now, we want to normalize the irregular surface formed at the edges of the table. This is where Laplacian smoothing comes in:
(Context Menu) ClothWorks → 1 Cloth → Apply Laplacian Smoothing

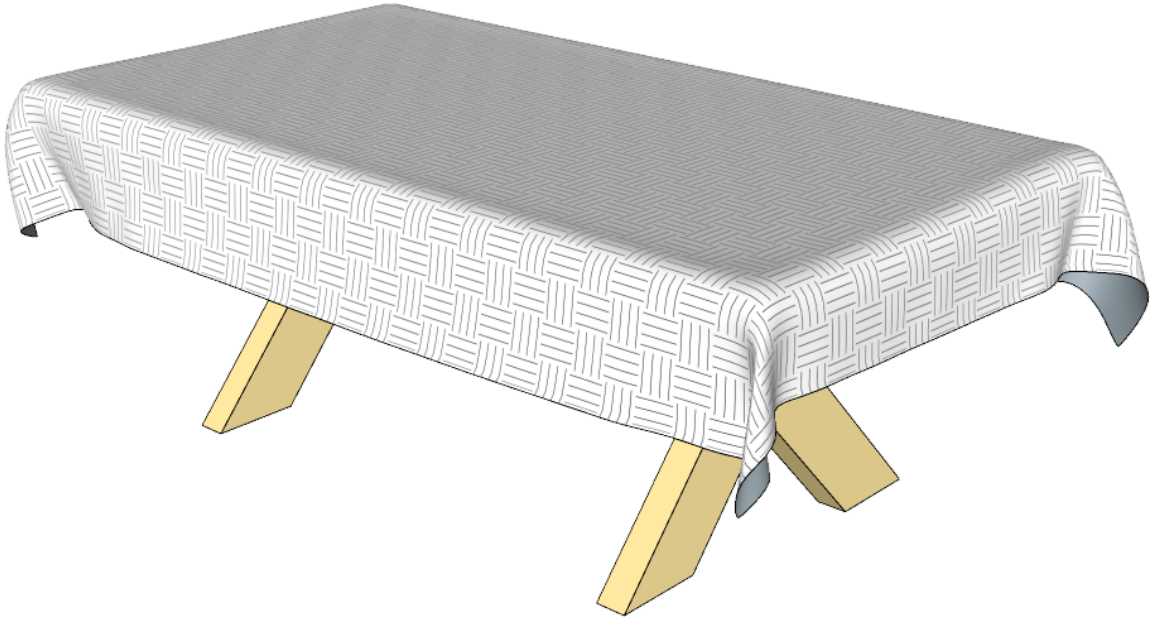


i. *For this particular model, I used two Laplacian iterations. Sometimes you want to keep as much detail as possible and perhaps using one Laplacian may be just enough.*
ii. *You may have noticed that the rounded corners formed by Loop Subdivision became unrounded again, which is desirable. If we had applied Laplacian Smoothing first and followed with Loop Subdivision, we would have end up with rounded corners. This is one of the aspects where the ordering matters.*

11. The final step is to apply a texture. It doesn't matter whether you apply texture before or after smoothening, as the texture UVS are preserved during the smoothening operations, but for clarity of the tutorial, we apply texture last.

a. Select the tablecloth and click on the drape/undrape icon, to reset the cloth layout:

b. Enter the context of the tablecloth group/component and apply a material directly to the front and/or back face(s). If you apply a material to the outer group, the material UVs will not be locked; texture must be applied directly to the faces.
c. Exit the context of the group, select the table cloth, and click on the drape/undrape icon again, to renew the cloth layout.



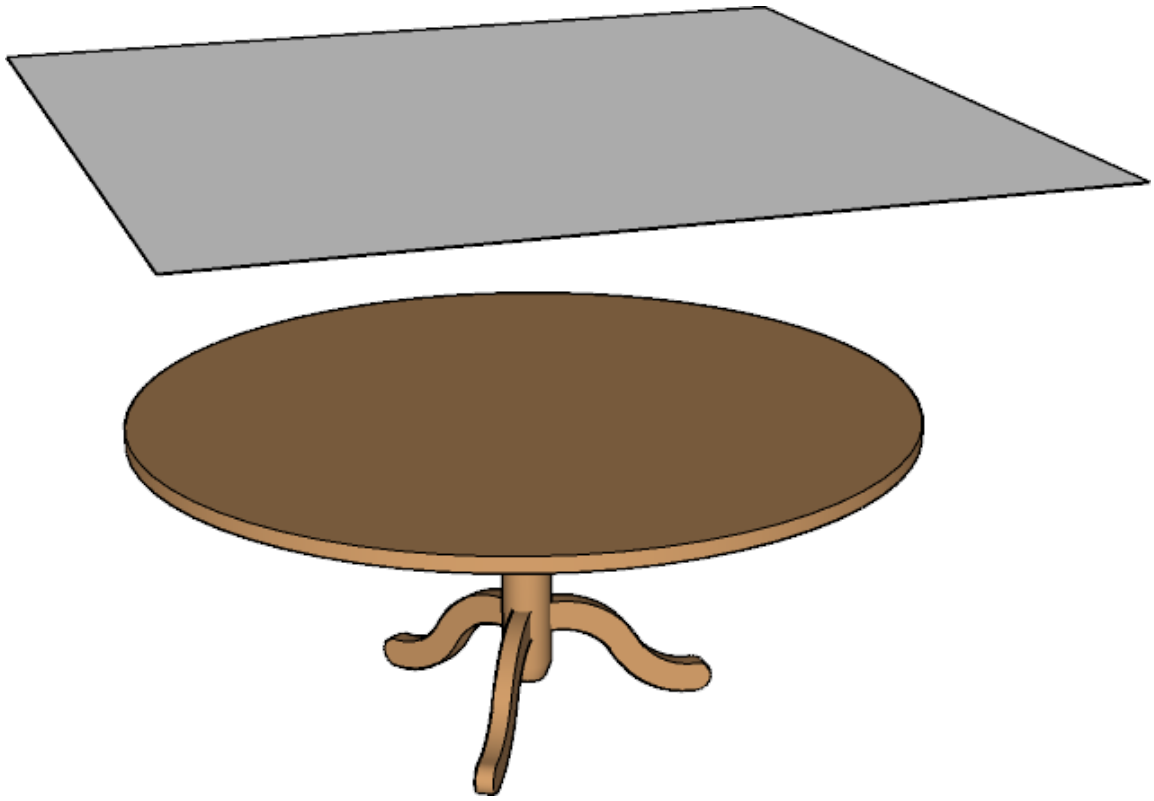
This sums up the tutorial for draping cloth over a rectangular surface.

Next section articulates on how to drape cloth over a circular surface.

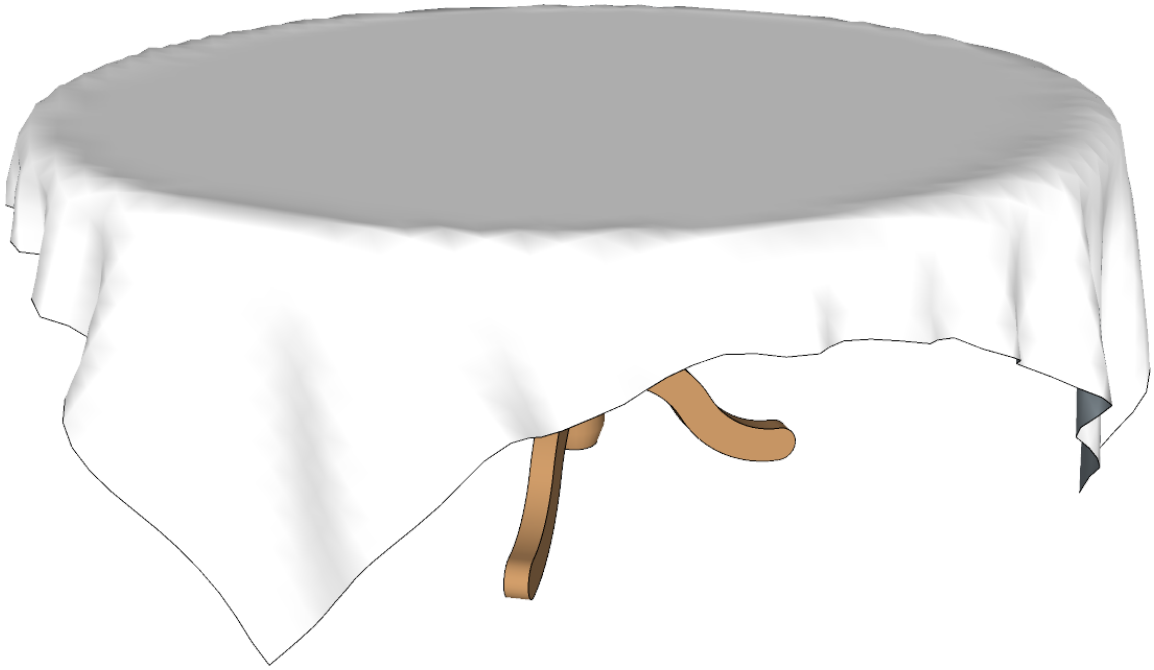
Draping Round Table

This tutorials omits description on how to do particular steps. In case a step is unclear, refer to previous tutorial for details. Follow the steps below for draping a round table:

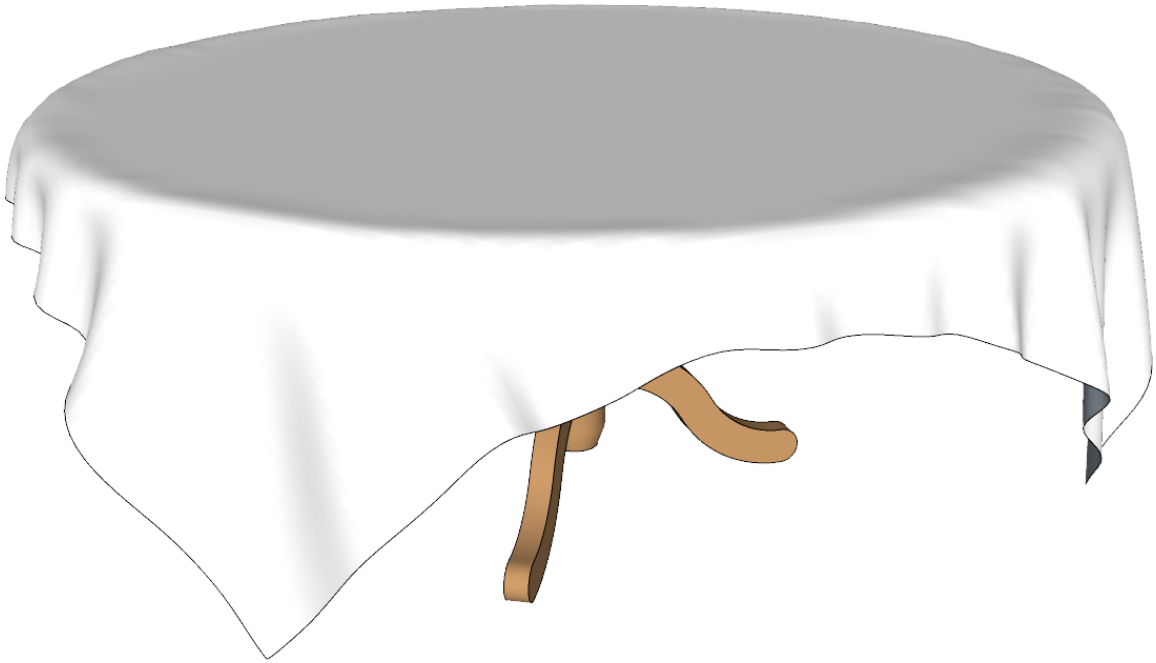
1. Begin by drawing and or opening a table with a circular surface.
2. Assign the table a collider type:
   (Context Menu) ClothWorks → Make Collider
3. Draw a rectangle to represent the tablecloth, group it, and position it over the table.



4. Assign the tablecloth a cloth type:
   (Context Menu) ClothWorks → Make Cloth
5. Apply a simple grid to the tablecloth:
   (Context Menu) ClothWorks → 1 Cloth → Simple Grid
6. Use the ClothWorks UI to enable self-collision for tablecloth.
7. Start simulation, run it until tablecloth lays still over the table and then stop the simulation. You can help the cloth reach its equilibrium by increasing simulation viscosity. You can also dynamically adjust any properties of the cloth, such as bending stiffness, to reflect a desired material. Doing simulation, you may notice that the cloth lays irregularly at the edges of the table. This is fixed by applying loop subdivision and Laplacian smoothing, described in the following steps.



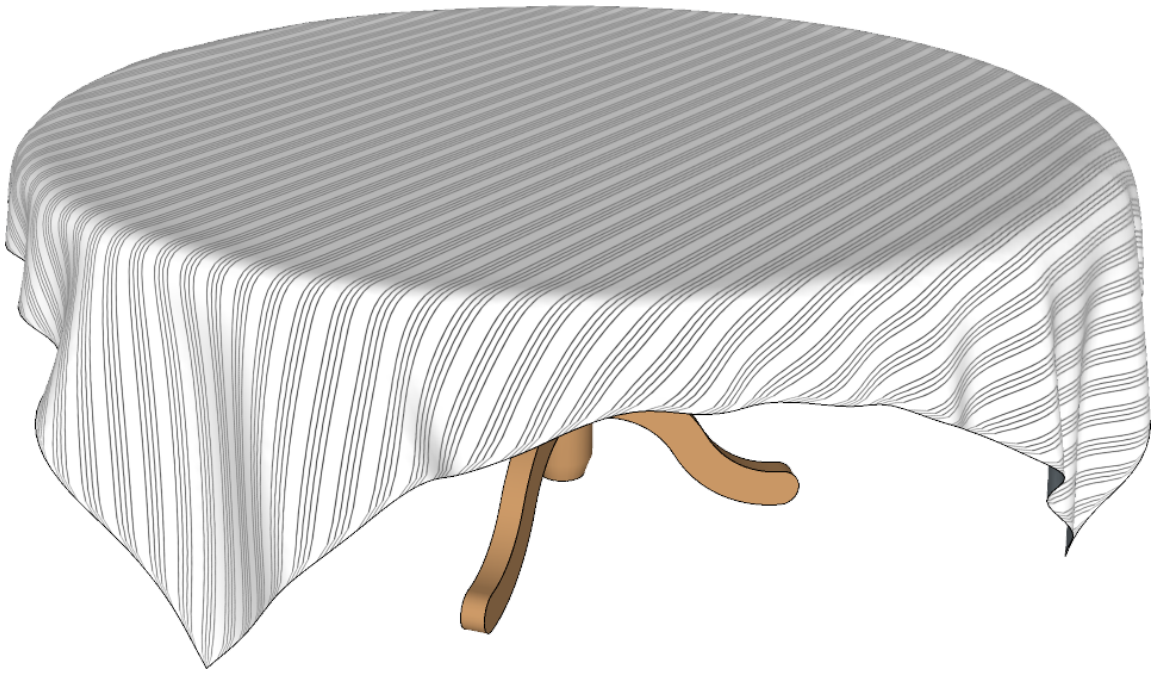
8. Apply loop subdivision:
   (Context Menu) ClothWorks → 1 Cloth → Loop Subdivision
9. Follow with laplacian smoothing, to normalize the irregular surface formed at the edges of the circular surface and to eliminate the rounded corners formed by loop subdivision. To normalize the irregular surface, we may have to set number of iterations to 4 or even 6:
   (Context Menu) ClothWorks → 1 Cloth → Laplacian Smoothing



If in case applying smoothing causes the edges of the cloth to penetrate the edges of the table, follow the steps below to fix it:

a. Perform an undo until all laplacian smoothing and the applied loop subdivision is undone. Note, do not undo further as we don't want to undo the operation performed at the end of simulation, which saves cloth layout. If in case you do undo that part, perform a redo until you are able to drape/undrape the cloth again, with the toolbar or menu.
b. Click on the undrape toolbar icon to reset cloth layout.
c. Select the table and use the ClothWorks UI to increase its thickness, to like 30mm. You might want to adjust this value, depending on the size of your model.
d. Go to step 7.

10. Apply a texture to the cloth:
    a. Select the cloth and click on the drape/undrape icon to reset cloth layout.
    b. Enter the context of the cloth and apply a desired texture directly to the front and/or back faces.
    c. Exit the context menu of the cloth, select the cloth, and click on the drape/undrape icon to renew cloth layout.



This sums up the tutorial for draping a circular table. The difference between draping a rectangular table is that, for a circular table, you might want to use more Laplacian iterations to regulate the surface.

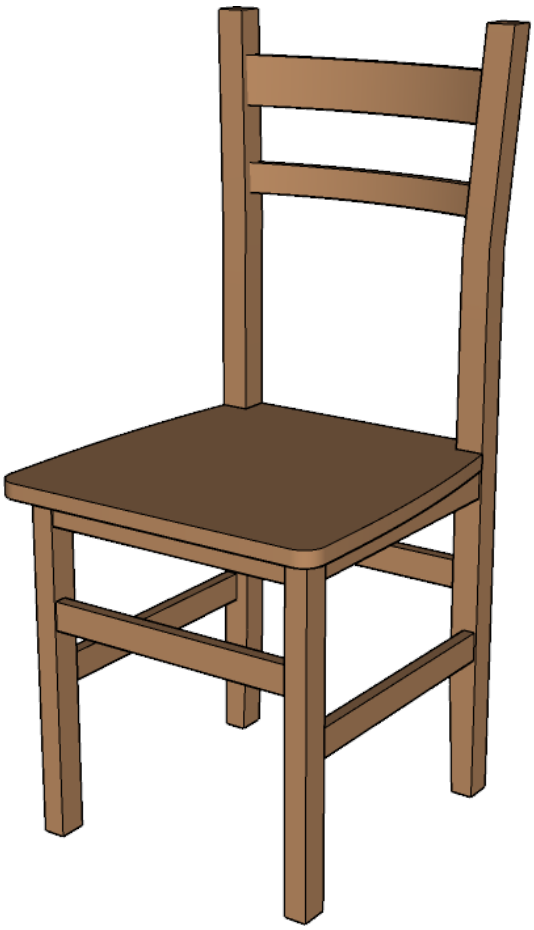
As a note, loop subdivision and laplacian smoothing can be applied in any order desired. You can also perform laplacian smoothing, follow with loop subdivision, and finish by applying laplacian smoothing again. This can be played around with to achieve the most desired effect. The thing to remember is that applying Laplacian smoothing shrinks the cloth, and applying it prior to applying loop subdivision shrinks it more than doing it afterwards.

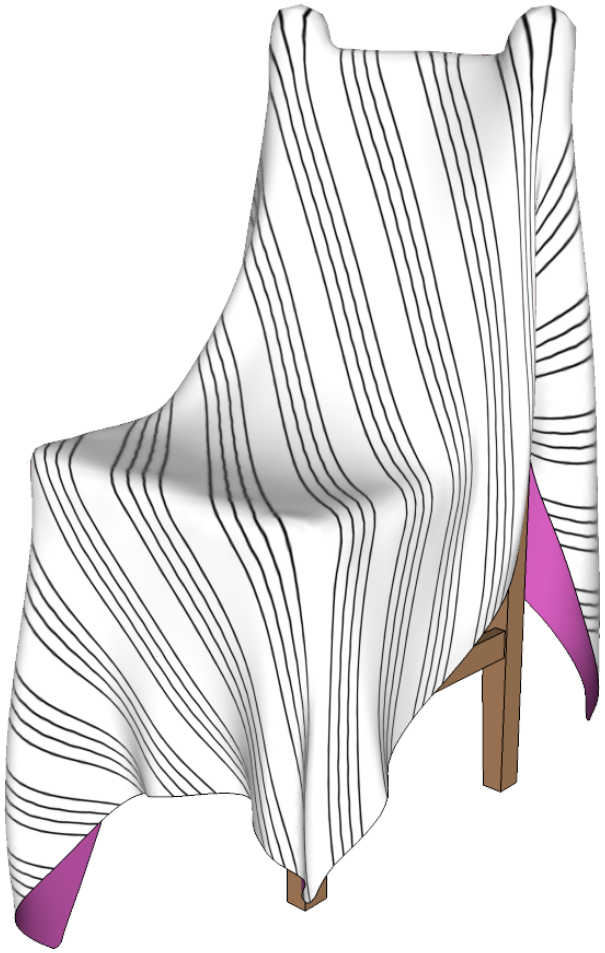
Next two tutorials focus on draping a chair and sofa, emphasizing cloth stiffness and simulation viscosity.

Draping Chair

To lay cloth over a chair, follow the same steps as you would for draping a table. A few additional steps can be anticipated to eliminate overlaps:

1. If a chair has sharp tips, as shown in the chair image below, increasing simulation viscosity and/or increasing chair's thickness should ensure there are no penetrations when a cloth draped over it.
2. If the minimum overlap preventing thickness forms a very noticeable offset, a chair can be split into two colliders of different thicknesses:
    a. Explode the chair.
    b. Select the two tip frames of the chair and group them into one component.
    c. Select all the other parts of the chair and group them into another component.
    d. Assign a collider type two both of the components.
    e. Assign a large thickness two the first component and a small thickness to the second component.





Draping Sofa

For draping a sofa, same steps should be followed as for draping a table or a chair, but an additional procedure should be performed.

To have the cloth set at the inner corners of the sofa, start out simulation with cloth shear stiffness set to a high value, like 0.5, and when the cloth drapes over a chair, gradually reduce its shear stiffness to 0.01. This should allow the cloth to reach the inner corners of the sofa. Reducing bend stiffness (if not already at 0.01) should help too.

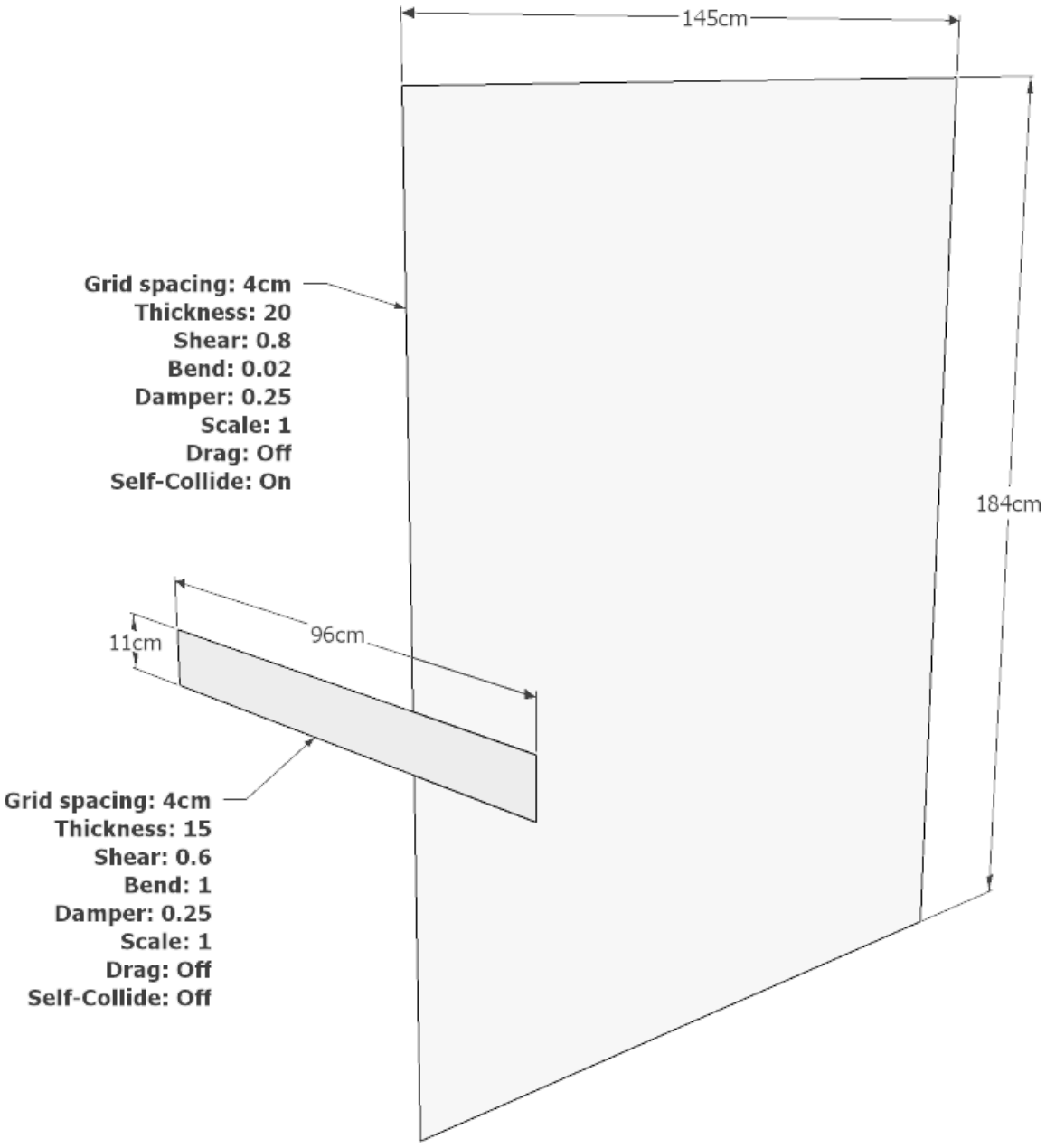
Stiffness changes are to be performed while simulation is running. Follow the steps below for adjusting stiffness during simulation:

1. Open ClothWorks UI, navigate to *Object* tab, and expand *Cloth* section
2. Start simulation (if not already running)
3. Select a desired cloth object
4. Adjust shear/bend stiffness range sliders

Curtains

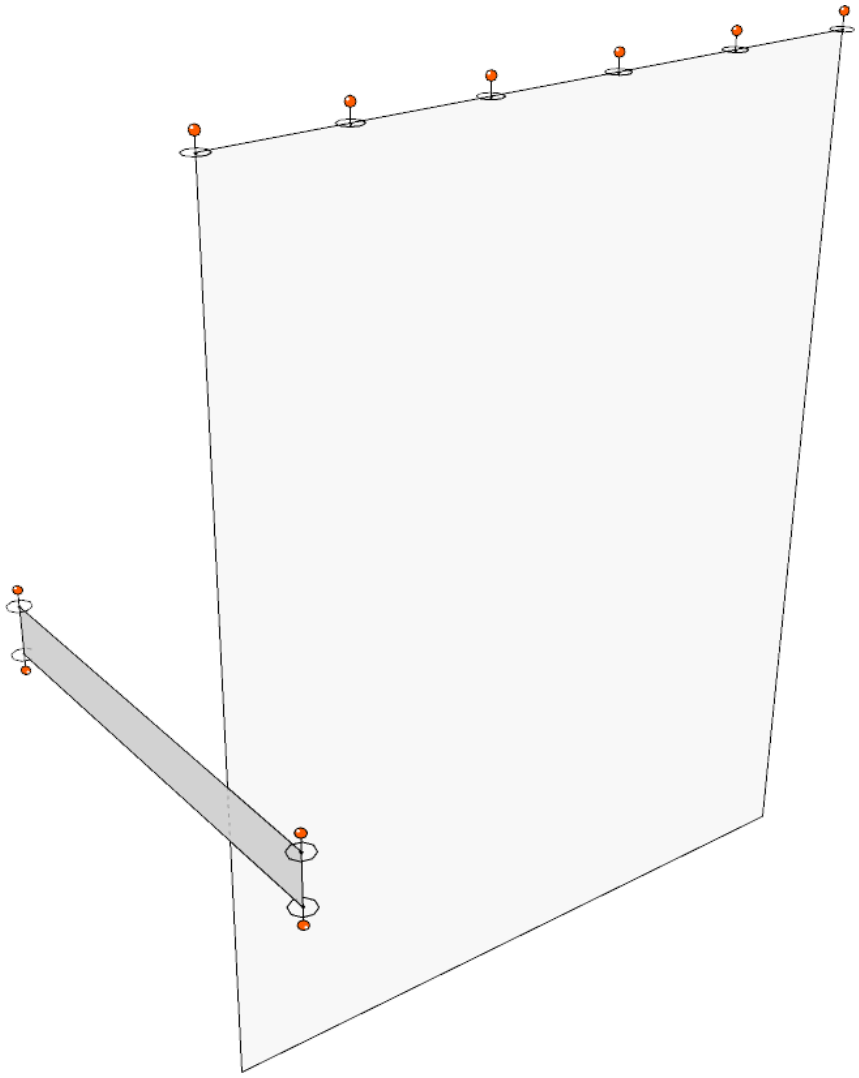
This tutorial focuses on simulating curtains, which involves pins and the use of interactive drag axes tool. Follow the steps below for simulating curtains:

1. Begin by drawing a rectangle for the curtain and a rectangular strip, centered at the side of the curtain, with sizes 140cm X 180cm and 10cm X 100cm, respectively.
2. Apply *Simple Grid* to both, the strip and the curtain, with a spacing of 4 cm (assuming the dimensions of your curtain are similar to the ones described above). If you drew a different sized curtain, then choose a spacing that makes grid resolution not too small but also not too large.
3. Use the ClothWorks UI to adjust the properties of both, the curtain and the strip. Refer to the image below for details:



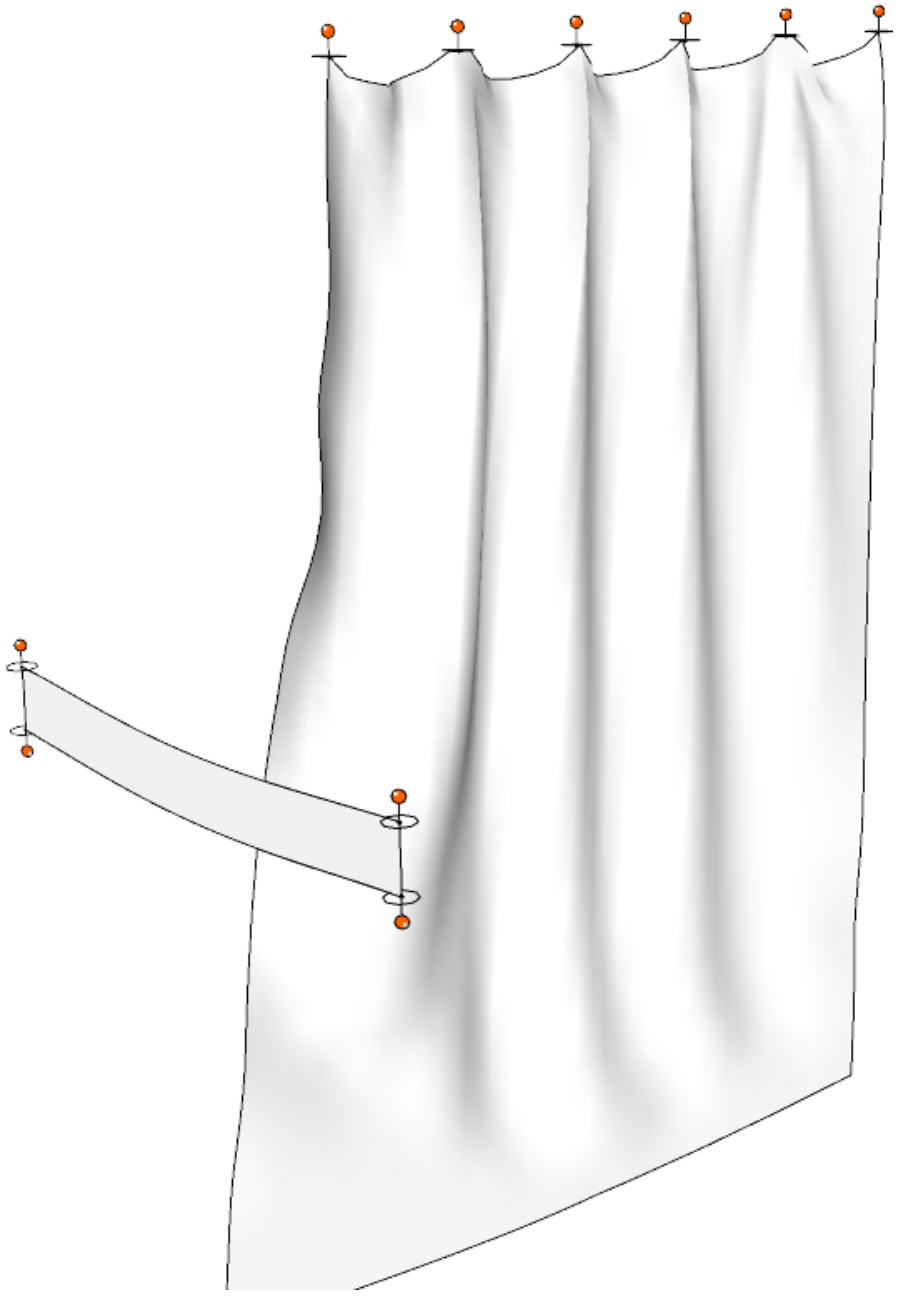
4. Use the pin tool to attach pins at all four corners of the strip and across the upper edge of the curtain. Refer to the steps below for a good way of attach pins at equal distances:
    a. Draw an edge across the top edge of the curtain and shift it upwards a bit.
    b. Divide the edge into a desired number of segments:
        i. Select the edge
        ii. Access *(Context Menu) Divide*
    c. Attach pins at all points of the divided edge.

    d. Select the created pins and shift them downward until they touch the curtain.

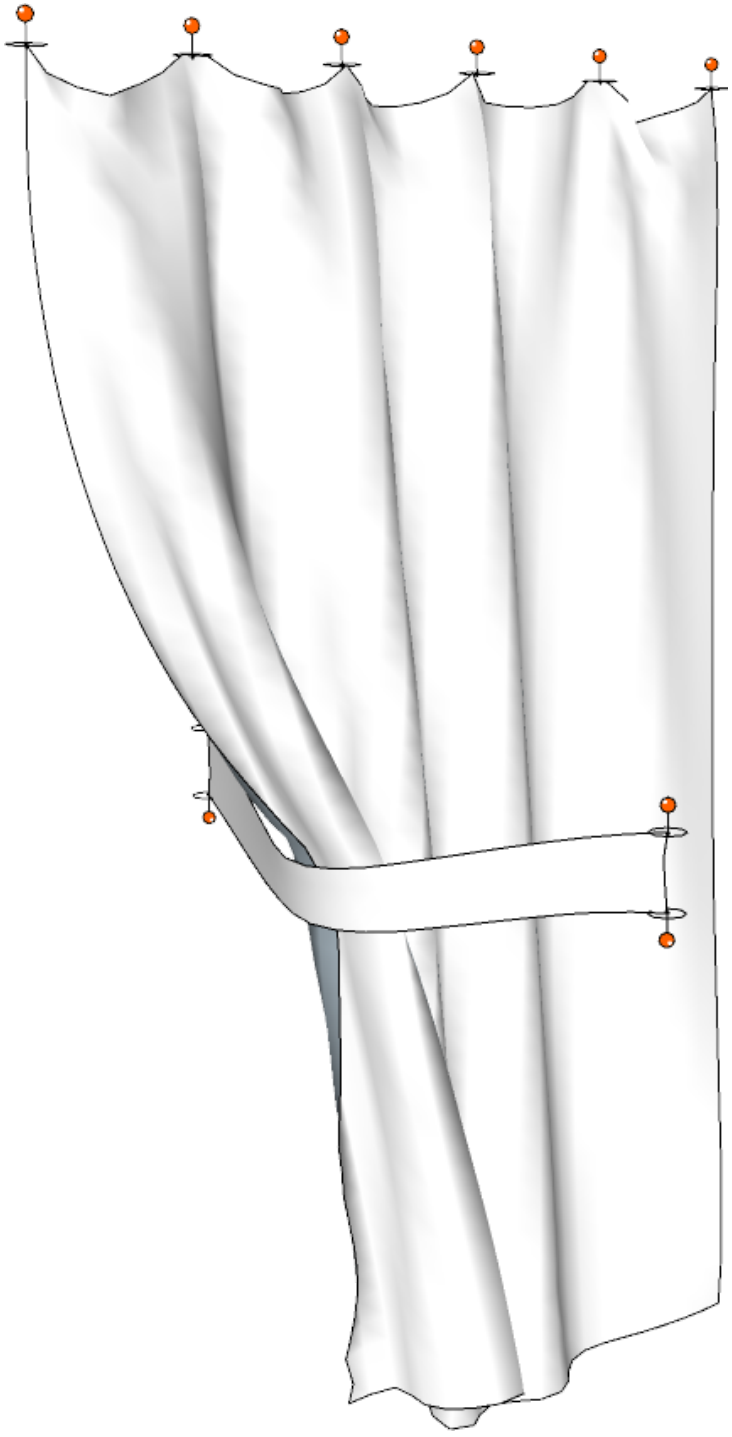


Note: It doesn't matter which direction the pins are oriented toward. Also, in case the scale of the pins is not right, scale the pins by accessing (Menu) Extensions → ClothWorks → Edit Pins Scale

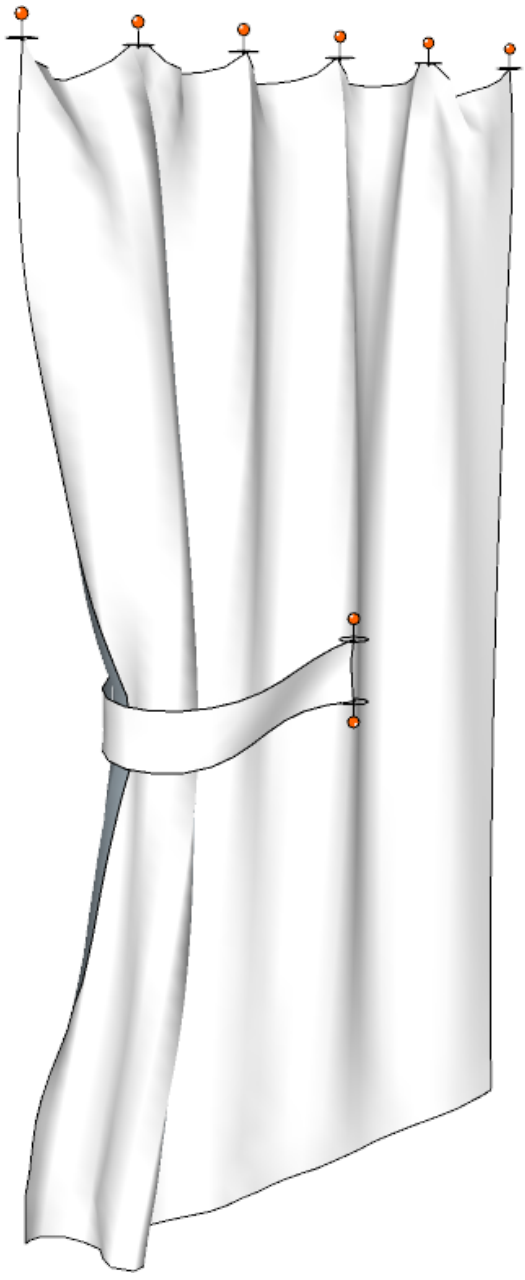
5. Start simulation. For the next set of steps, for convenience, stop simulation and resume when continuing to the next step. This can be achieved by toggling the play button or pressing the stop button. Doing so will allow resetting to an original step in case something goes wrong, rather than resetting all the steps entirely.
6. Slightly, converge the pins across the upper edge of the curtain:
    a. Use the mimicked selection box tool to select all the pins across the upper edge of the curtains.
    b. Hold SHIFT key and click and drag the red or green axis, depending on which axis is the side of the curtain facing, toward the center of the of the selected pins, until you notice the bending.



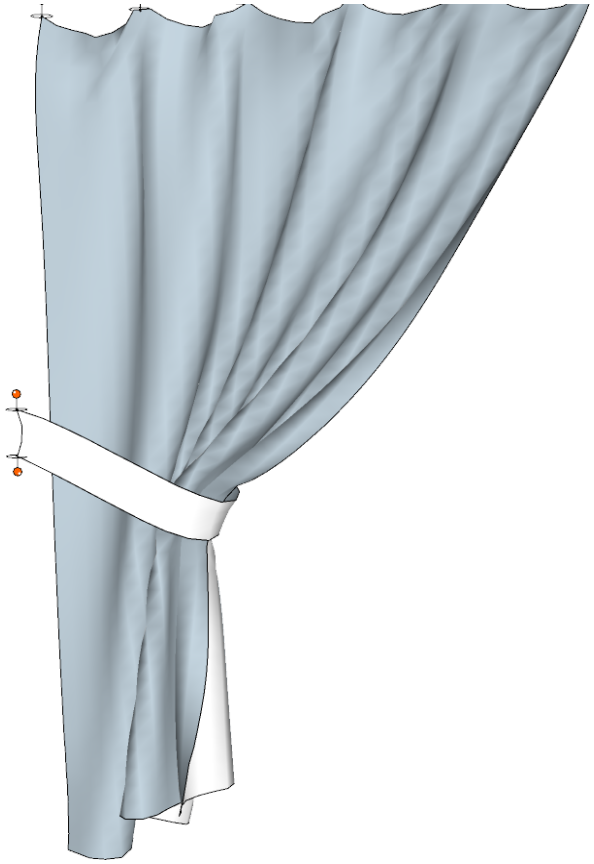
7. Move the strip sideward, onto the curtain, and stop one third of the way:
    a. Use the mimicked selection box tool to select all pins of the strip.
    b. Either with the interactive drag axes tool or with ARROW keyboard keys, **slowly** move the pins sideward and until they are about one third of the way across the curtain. The reason you want to do this slowly is because if you do it too fast, the cloth will penetrate itself. In case that happens, reset simulation and attempt the step again.



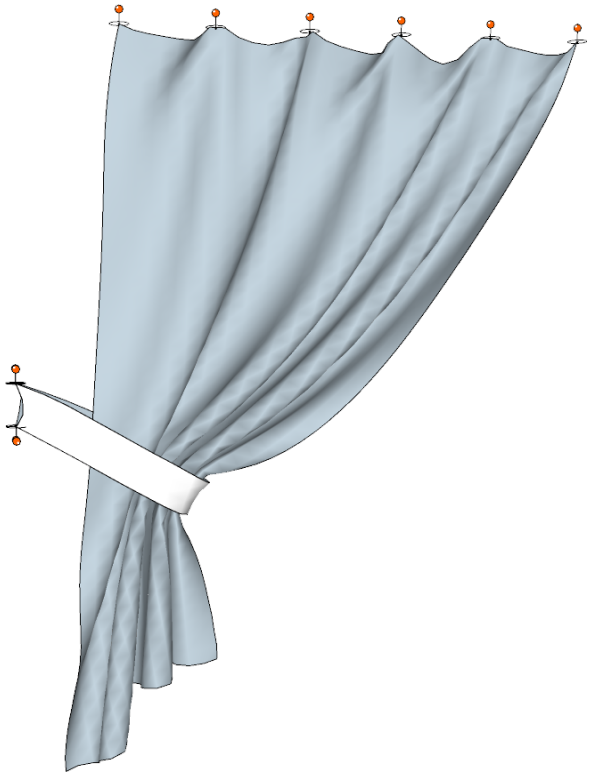
8. Slightly, converge the pins of the strip along an axis perpendicular to the side axis of the curtain (an axis parallel to the normal of the original plane of the curtain):
    a. If not already selected, select all pins of the strip.
    b. Hold the SHIFT key and either with the interactive drag axes tool or by keyboard, converge the pins on axis, so that they are closer to the curtain, but don't converge them entirely just yet. On windows, you can also use the CONTROL key in place of the SHIFT key.



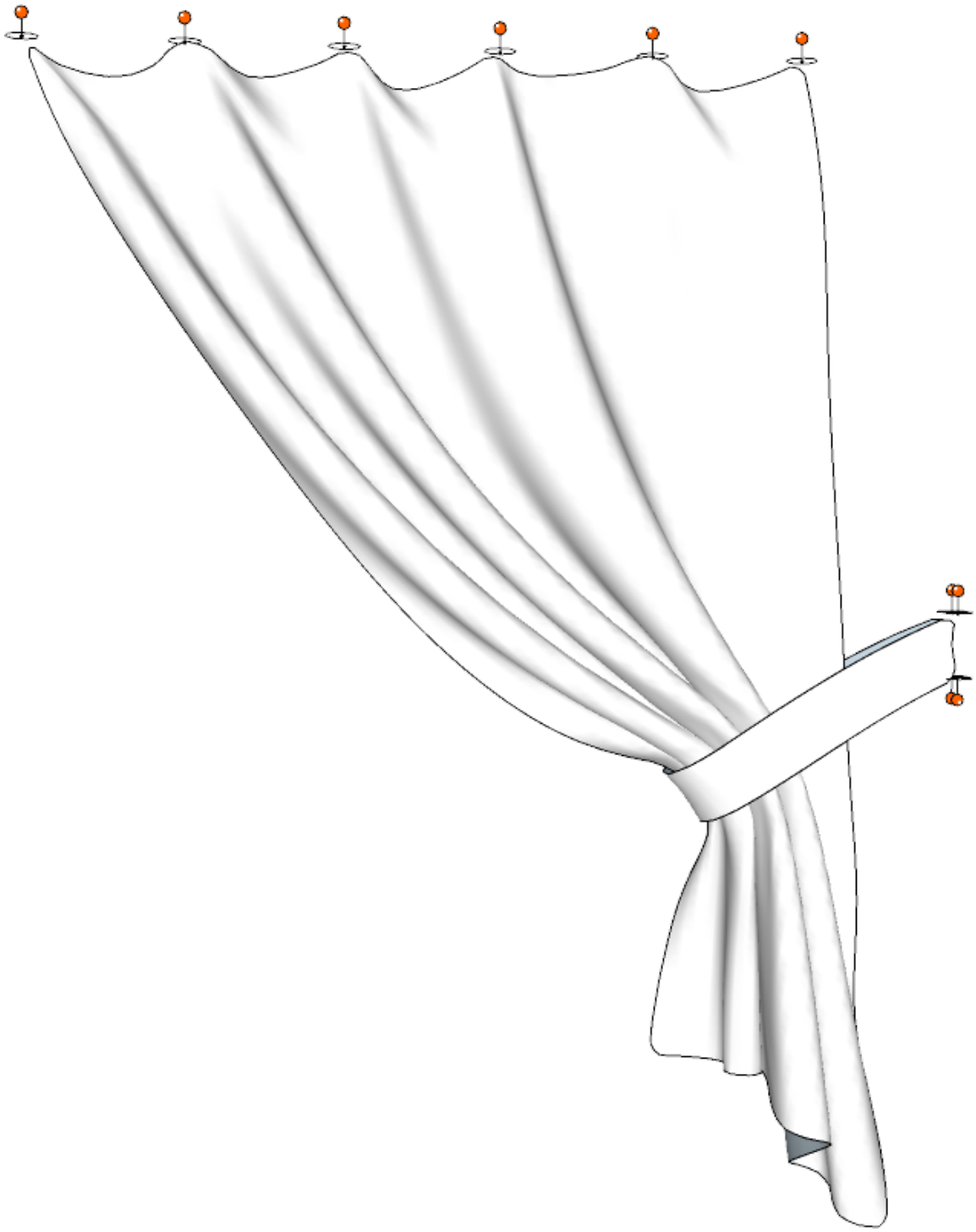
9. Resume dragging the pins of the strip sideways until they move all the way across the curtain.



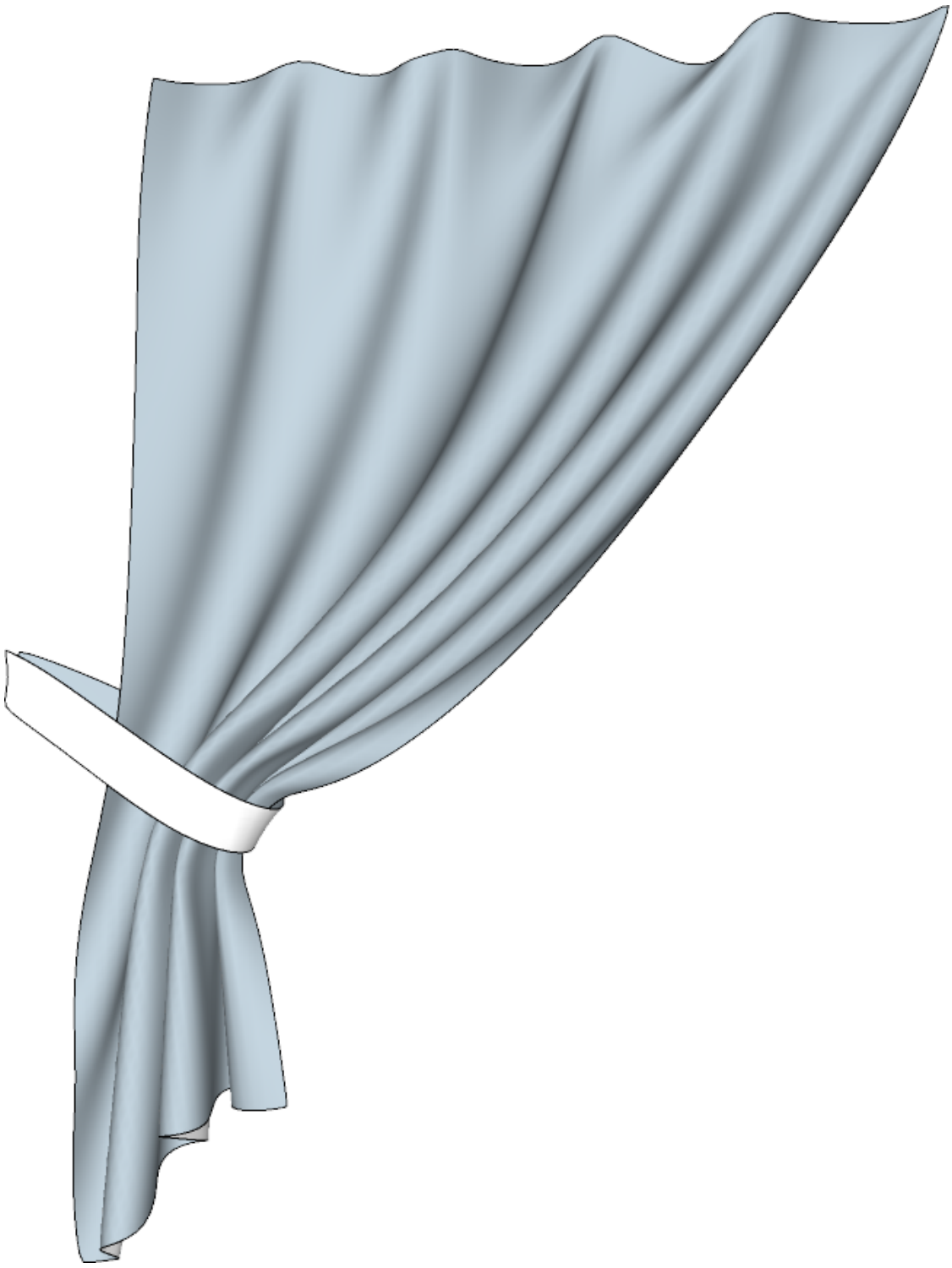
10. converge the pins of the strip until they touch each other, so the strip loops around the curtain.



11. Stop simulation, if haven't done so already.
12. Apply loop subdivision to the curtain and the strip:
    a. Select both, the curtain and the strip
    b. Access *(Context Menu) ClothWorks → 2 Cloths → Loop Subdivision*

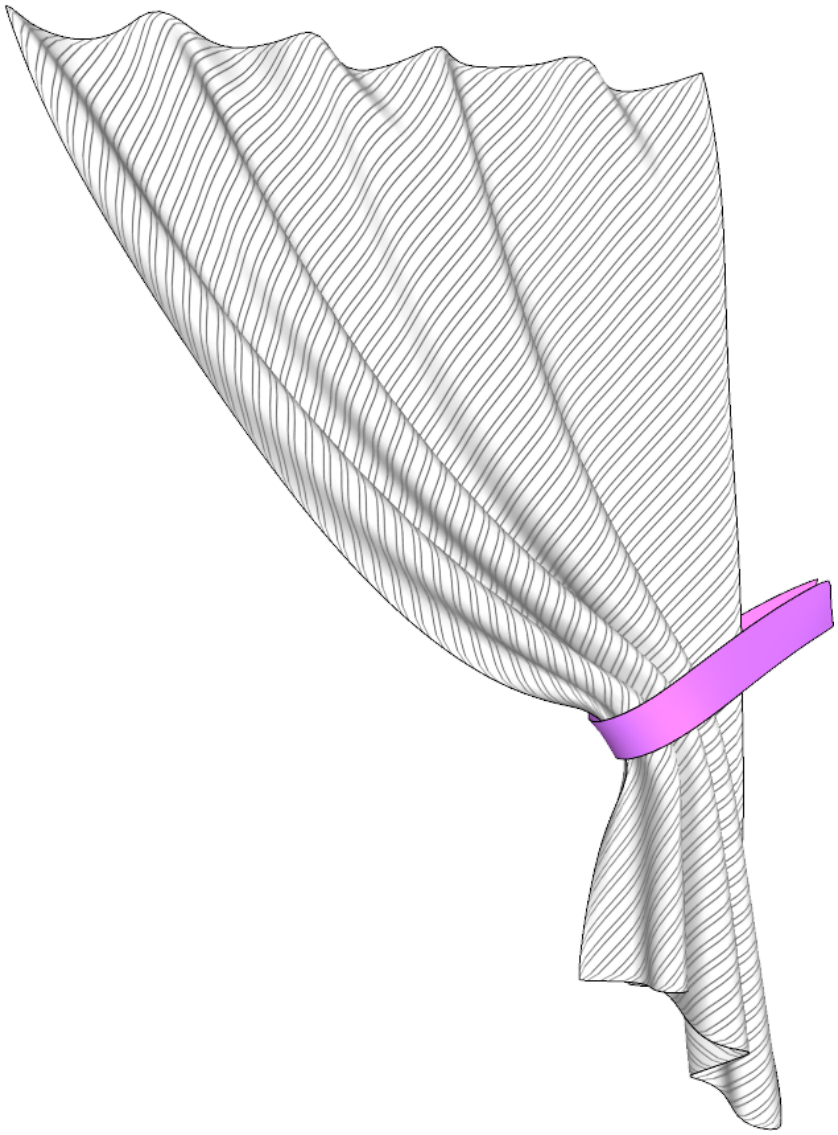


13. Apply Laplacian smoothing with two iterations to eliminate the rounded corners:
    a. Select both, the curtain and the strip
    b. Access *(Context Menu) ClothWorks → 2 Cloths → Loop Subdivision*
    c. Set the number of iteration to 2.
14. Open the layers panel and hide *ClothWorks Pins* layer.



15. Apply a desired texture to the curtain and/or strip:
    a. Undrape the current layout of the curtain:
        i. Select the curtain
        ii. Click on the undrape icon

    b. Apply a desired texture directly to the faces of the curtain:
        i. Enter the context of the curtain
        ii. Use the material tool to apply a material to the faces
        iii. Exit the context of the curtain
    c. Click on the drape icon again to renew the layout of the curtain.

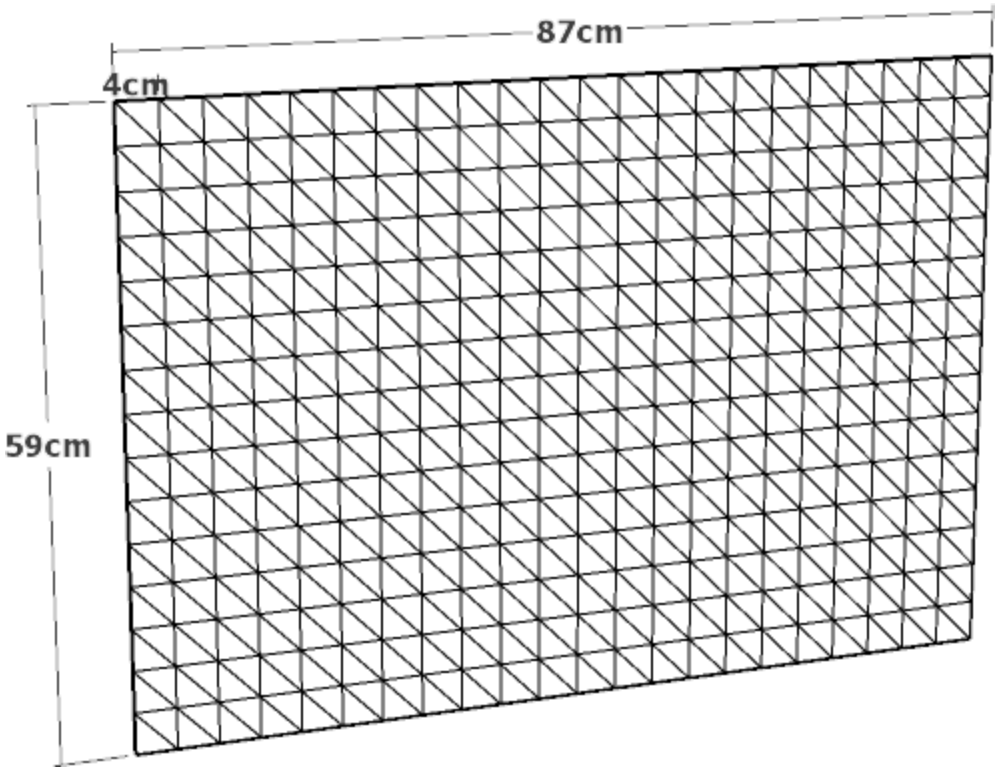


Rectangular Flags

This tutorial focuses on simulating simple rectangular flags, that do not include any cutouts.

1. Begin by drawing a rectangle for the flag and grouping it.
2. Assign the flag cloth type:
   (Context Menu) ClothWorks → Make Cloth
3. Apply a simple grid to the flag, such that the grid resolution is not too high and not too low:
   (Context Menu) ClothWorks → 1 Cloth → Simple Grid

   Image below denotes a considerably normal flag resolution.



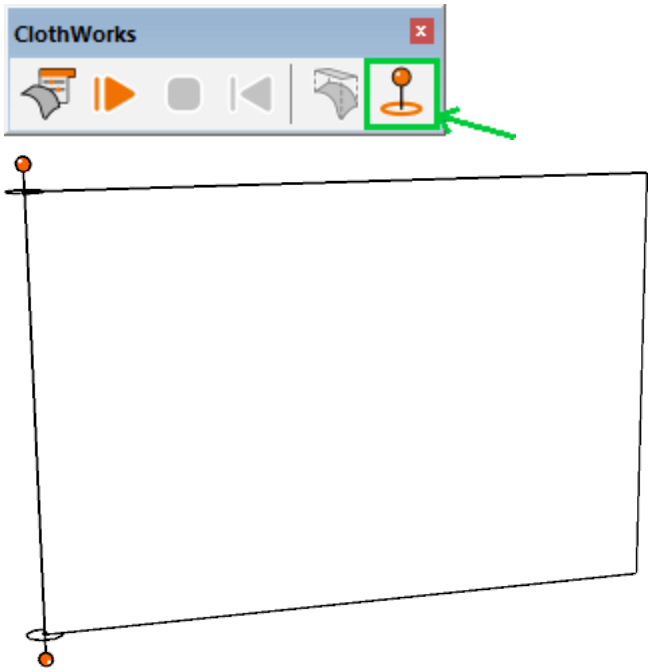
A grid spacing of 4 cm was used for a roughly 90cm X 60cm flag.

To view the generated grid of your flag, select the flag and unsoften all edges using the soften/smooth edges tool:
(Context Menu) Soften/Smooth Edges

A good practice for determining grid spacing is by using a tape measurement tool or a line tool over a flag to estimate the size of an individual square.

Note: In case you attempt to generate a really high resolution grid for your flag, you will be notified and have an option to change.

4. Attach pins at the upper-left and lower-left corners of the flag:



5. Use ClothWorks UI to adjust properties of the flag:

Property	**Value**
Density	150
Thickness	15
Shear	1.00
Bend	0.01
Damper	0.01
Scale	1
Drag	On
Self-Collide	On

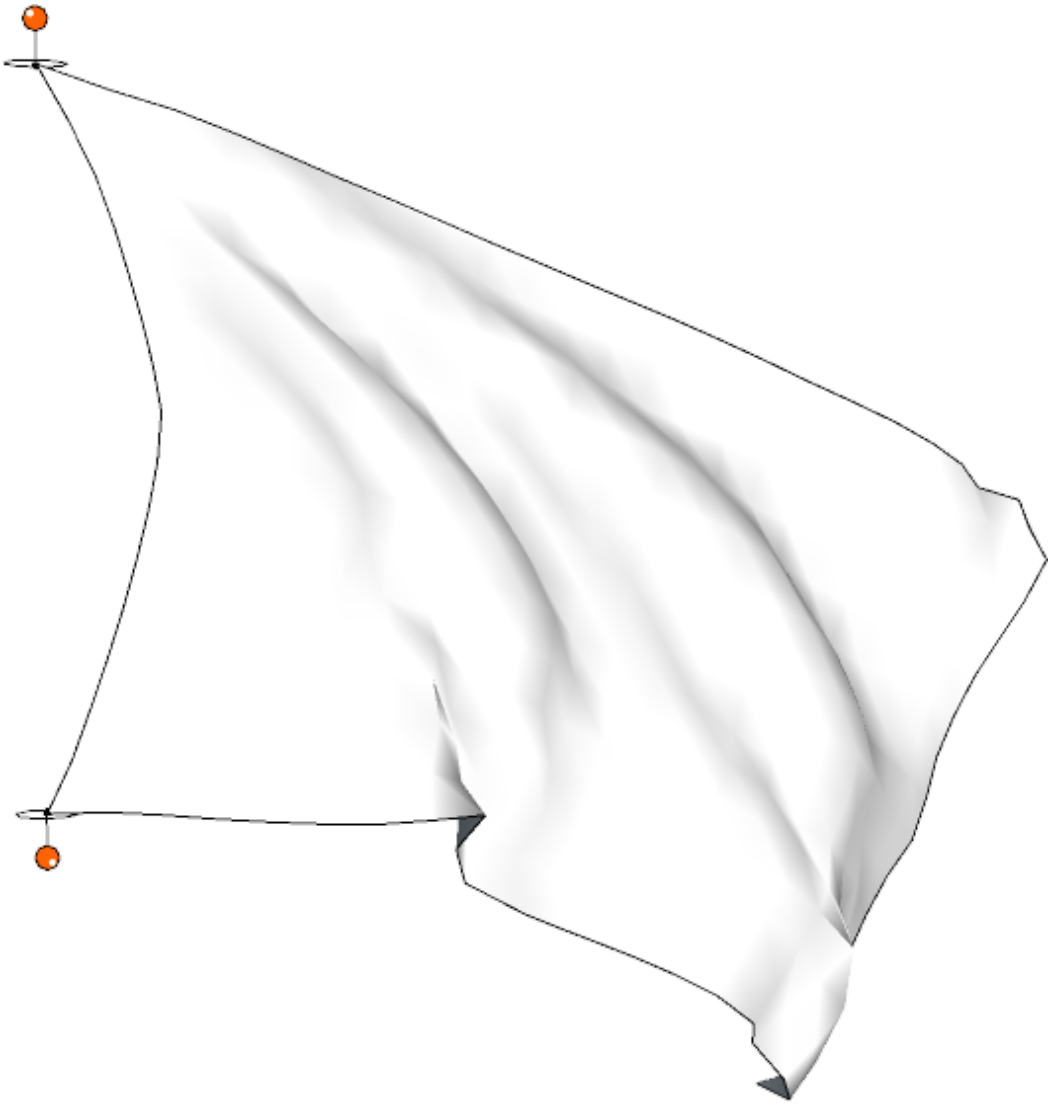
6. In *Simulation* tab of ClothWorks UI
    a. Set wind velocity, along the x-axis, to 3 m/s
    b. Have the drag factor remain at 0.25
    c. Set the viscosity factor to 0.00

Note: Increasing drag factor and/or wind velocity can cause cloth to explode when in simulation. In case that happens, reset simulation, and then run it again, but without high wind and/or drag factor. If you stop simulation, rather than reset it, the only way to undo exploded cloth is by using the drape/undrape tool:

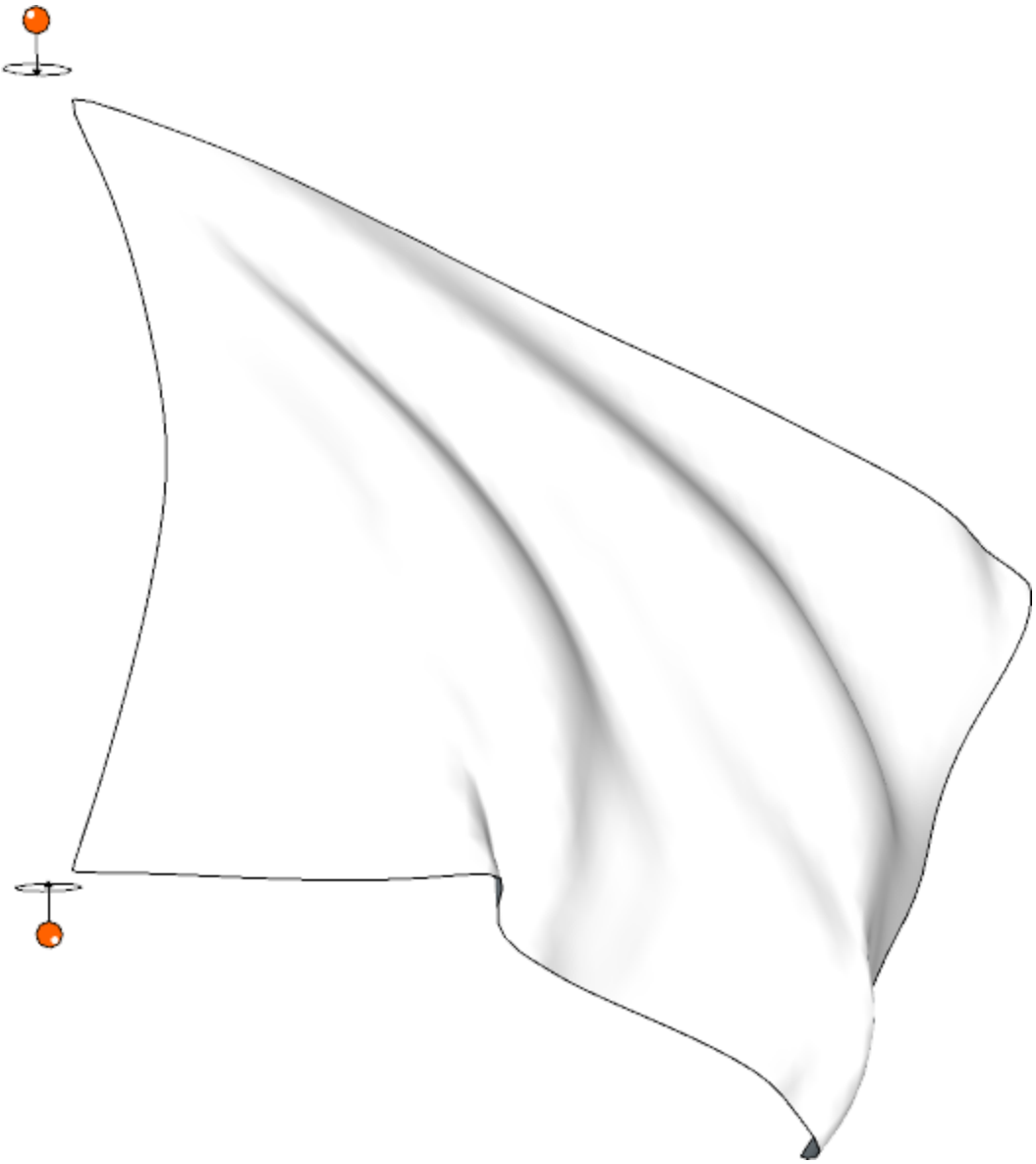
a. Select the exploded cloth
b. Click on the the undrape icon within the toolbar

7. Start simulation and have it run until you come across a good stopping point. Use the stop simulation button to preserve flag layout:

Note: If in case the flag overlaps itself during simulation and fails to recover, attempt fixing it by simply restarting the simulation. If an overlap continues to occur, increase flag thickness but no more than half of its grid spacing; otherwise, the flag will clutter itself out.

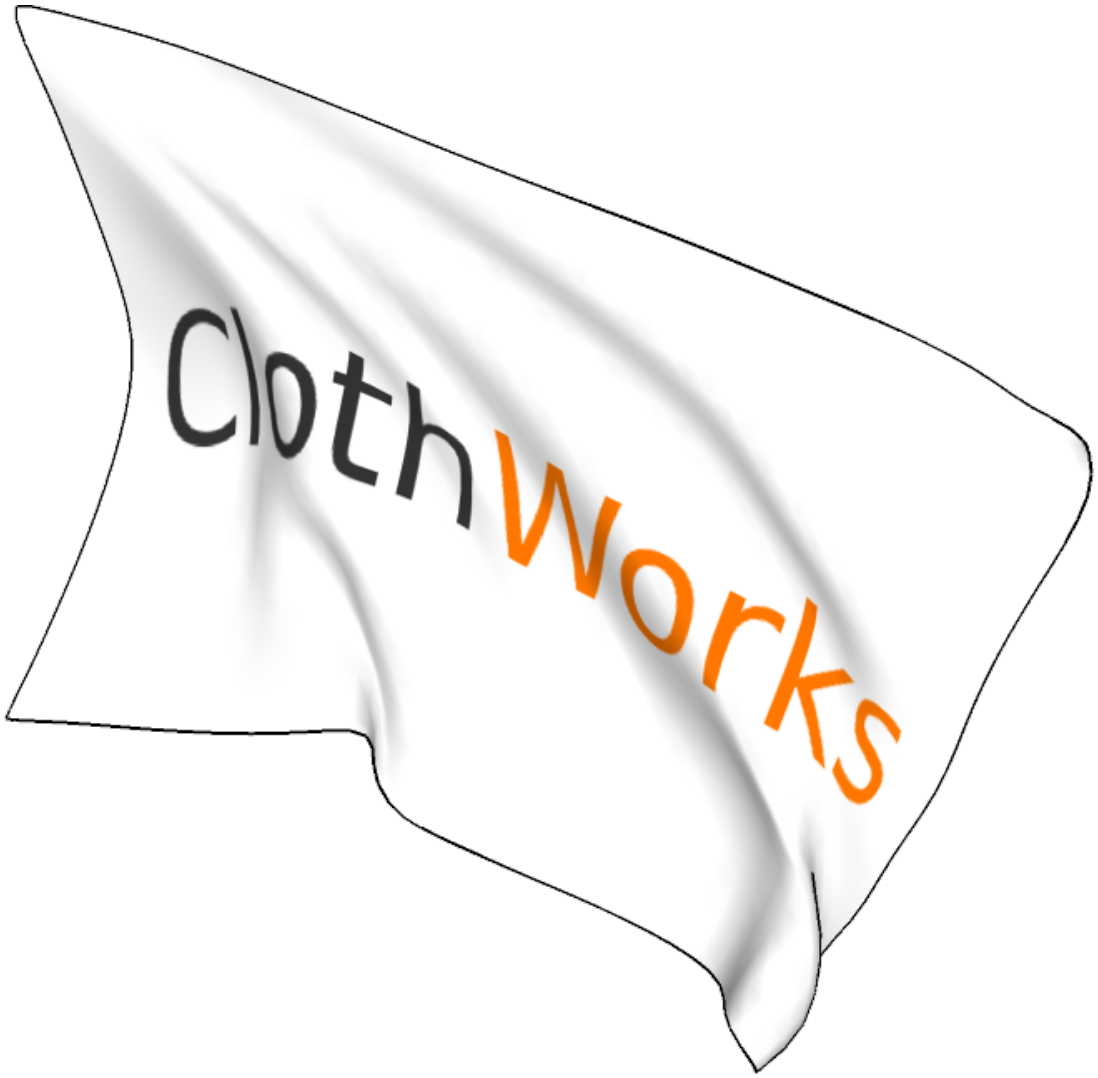


8. Apply loop subdivision and follow with one or two iterations of Laplacian smoothing:
    a. Select the flag
    b. Access *(Context Menu) ClothWorks → 1 Cloth → Loop Subdivision*
    c. Access *(Context Menu) ClothWorks → 1 Cloth → Laplacian Smoothing*
        i. Set the number of iterations to 1 or 2 when prompted



9. Apply a desired texture to the flag:
    a. Undrape the current layout of the flag:
        i. Select the flag
        ii. Click on the undrape icon

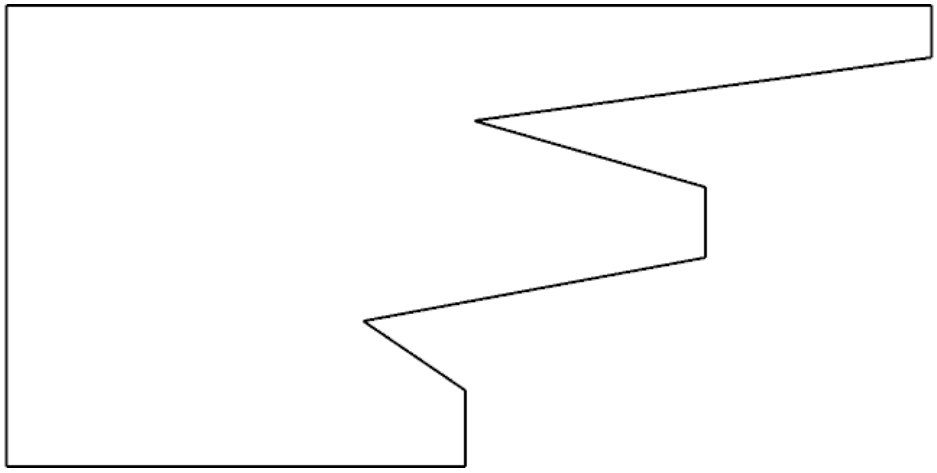
    b. Apply a desired texture directly to the faces of the flag:
        i. Enter the context of the flag
        ii. Use the material tool to apply a material to the faces
        iii. Exit the context of the flag
    c. Click on the drape icon again to renew the layout of the flag.



Flags with Cutouts

This tutorial focuses on simulting flags with cutouts. For the most part, same steps are to be used for configuring and simulating flags with cutouts as for rectangular flags. The only difference is that *Smart Grid* is used for applying a grid rather than *Simple Grid*.

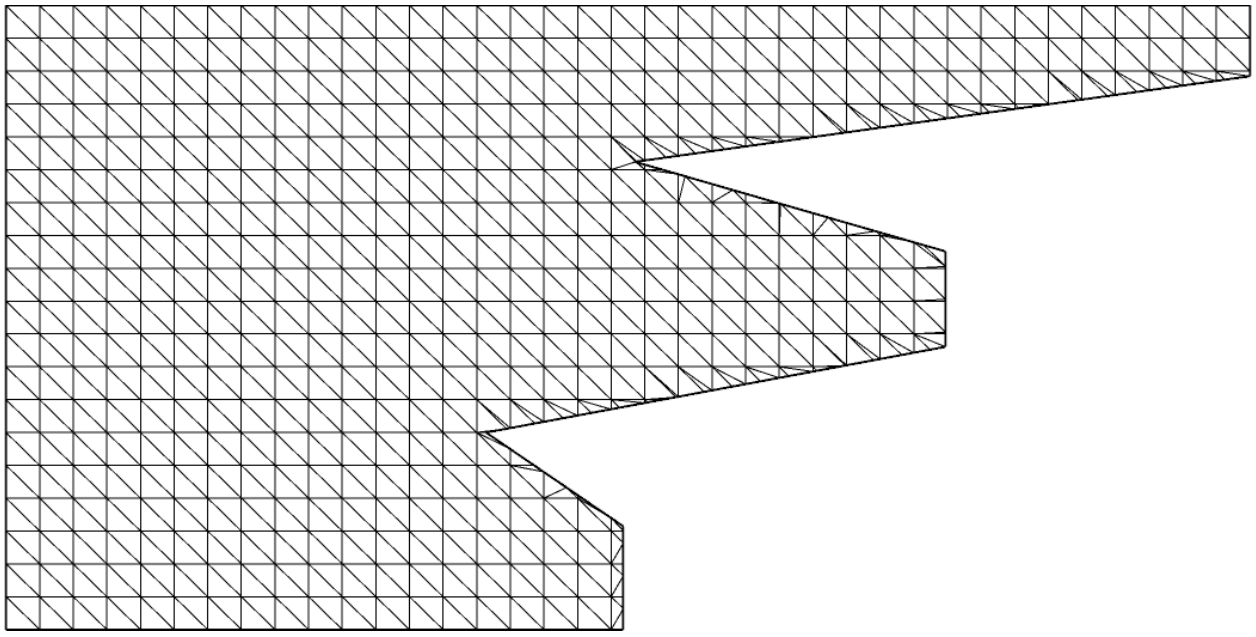
For the flags with cutouts, using simple grid is not sufficient. Let's say we have a sort of flag depicted in the image below:



If we apply a simple grid to the flag

(Context Menu) ClothWorks → 1 Cloth → Simple Grid

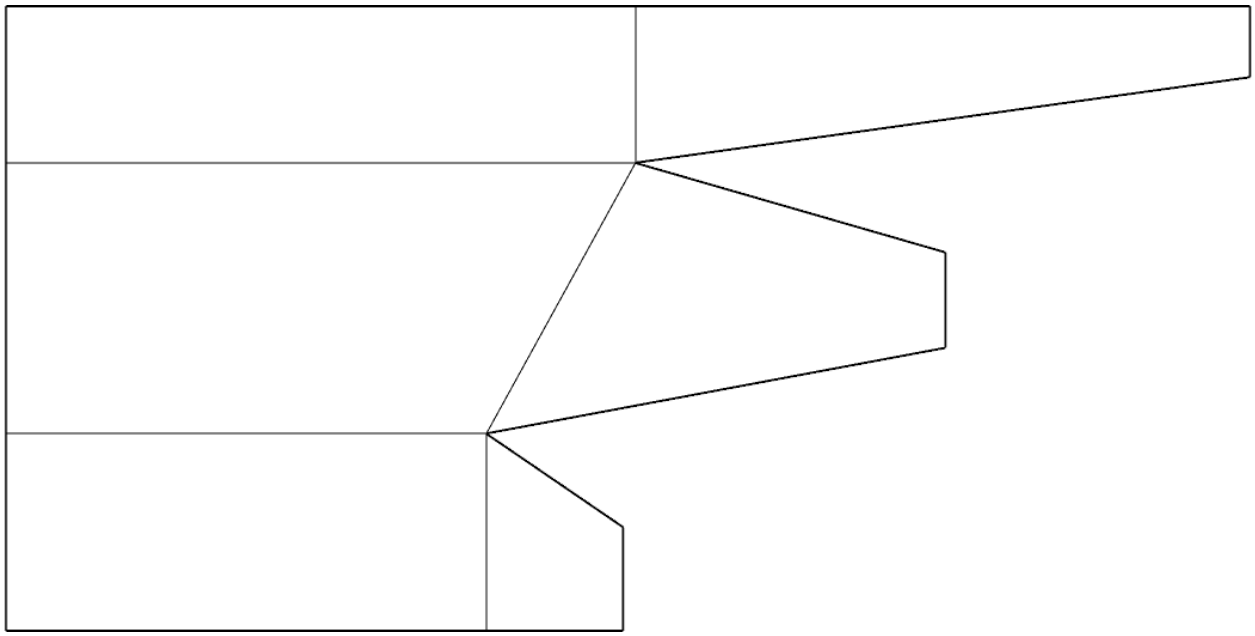
and unsoften the edges, we get the following kind of grid:



Here you notice gibberish at the edges, where the cutouts were formed. This gibberish not only looks ugly but also affects the behaviour of the flag in simulation.

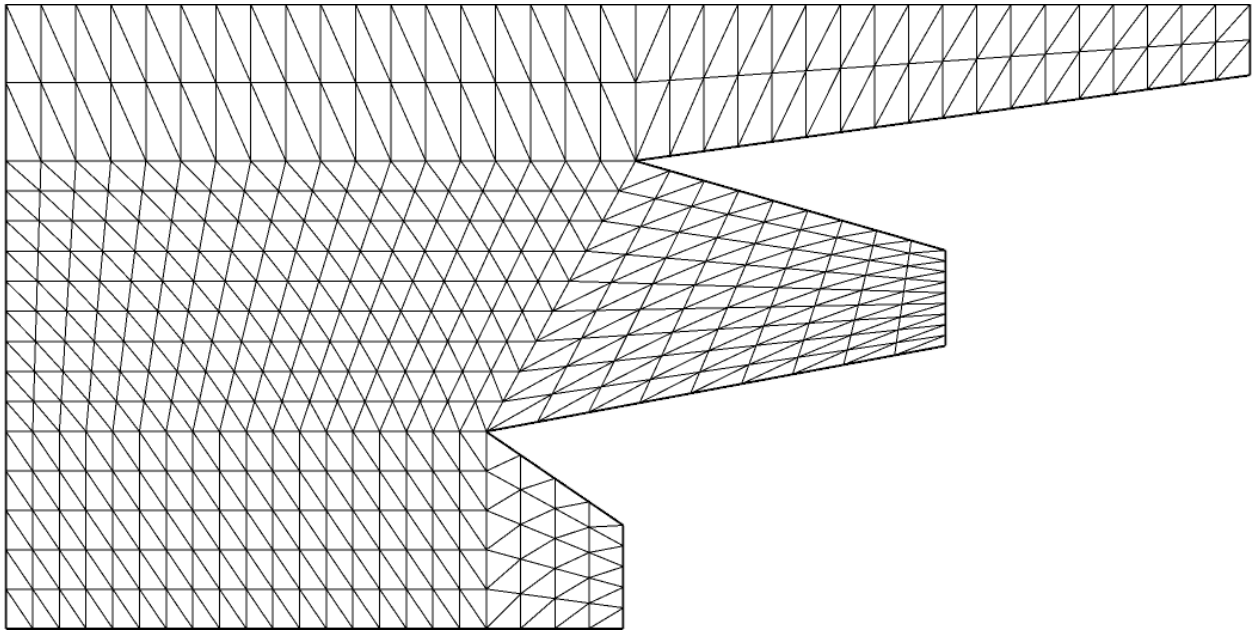
The objective here is to have the grid edges align with the boundary edges of the face and not necessarily with the axes. This is what *Smart Grid* is for. Smart grid only works with quads and triangles. To have a particular face/polygon compatible with a smart grid, it must be divided into quads and/or triangles (preferably quads).

For our complex flag, we first divide the face into multiple faces with each representing a quad:

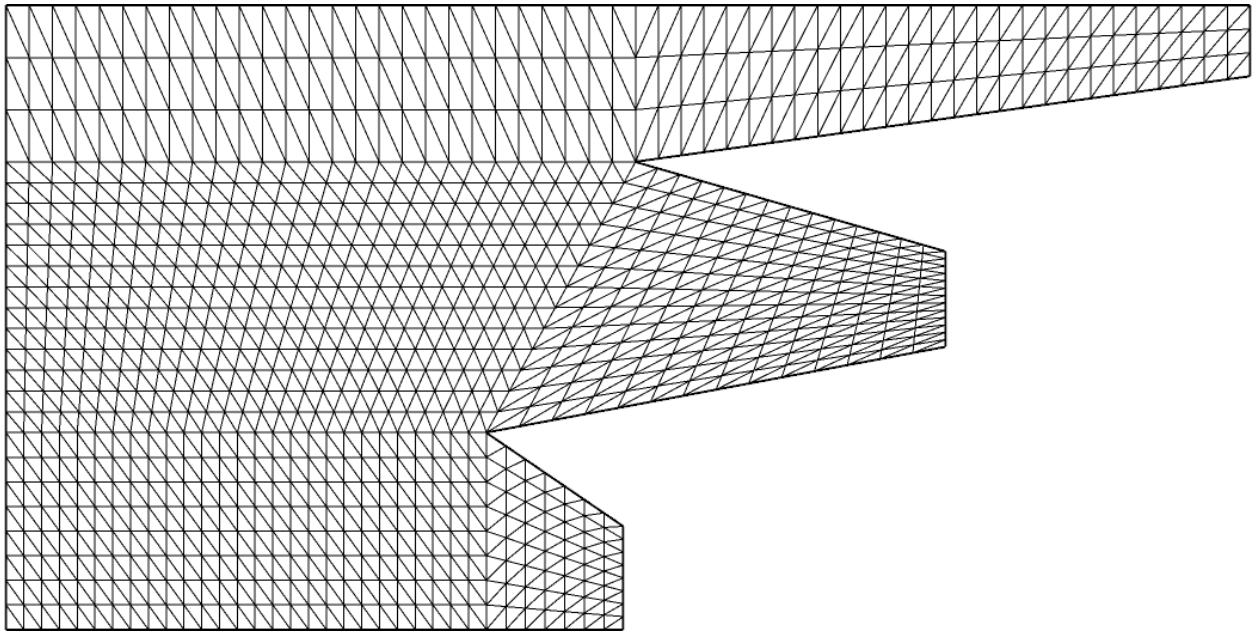


We then apply a smart grid:

(Context Menu) ClothWorks → 1 Cloth → Smart Grid



If the spacing is too large or too small the operation can be undone with a single undo command and applied again, but with a different spacing:



Note:

If intending to apply a smart grid, do not apply it over an existing grid.

First purge the edges:

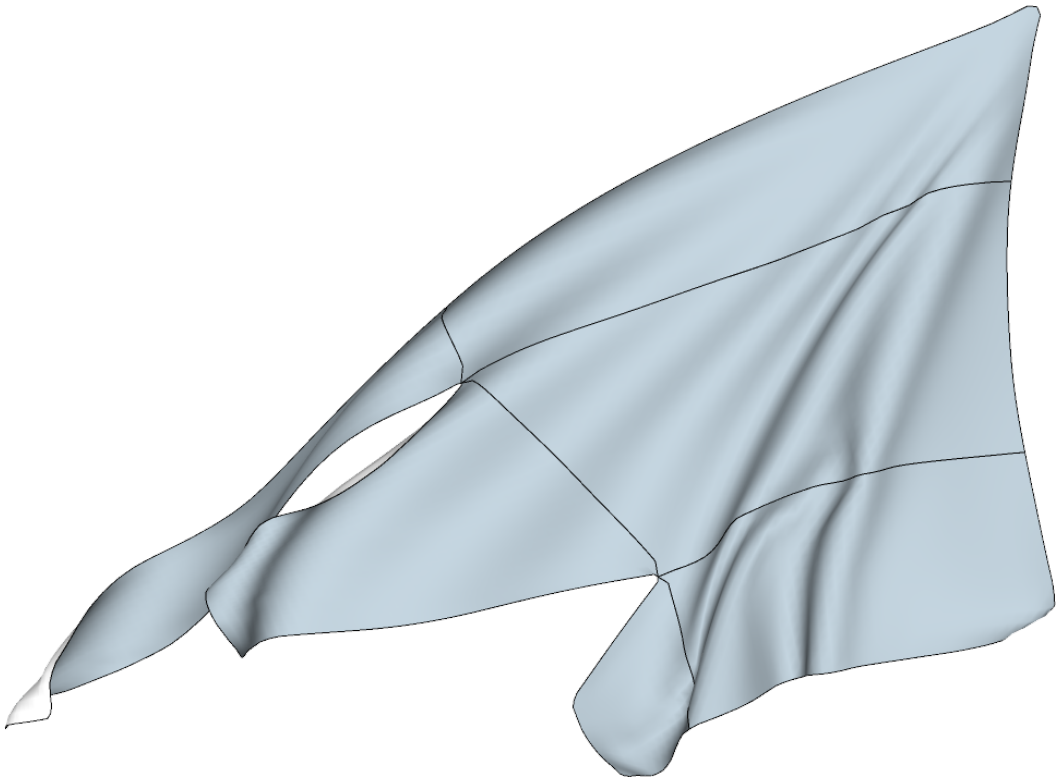
(Context Menu) ClothWorks → 1 Cloth → Purge Edges

And then apply a new smart grid:

(Context Menu) ClothWorks → 1 Cloth → Smart Grid

This also applies to simple grid, but simple grid automatically prompts whether to purge edges prior to applying a new grid.

With a proper grid generated, we assign same cloth properties and follow the same steps configuring for simulation as we would for a rectangular flag. Refer to the previous tutorial for configuring and simulating.

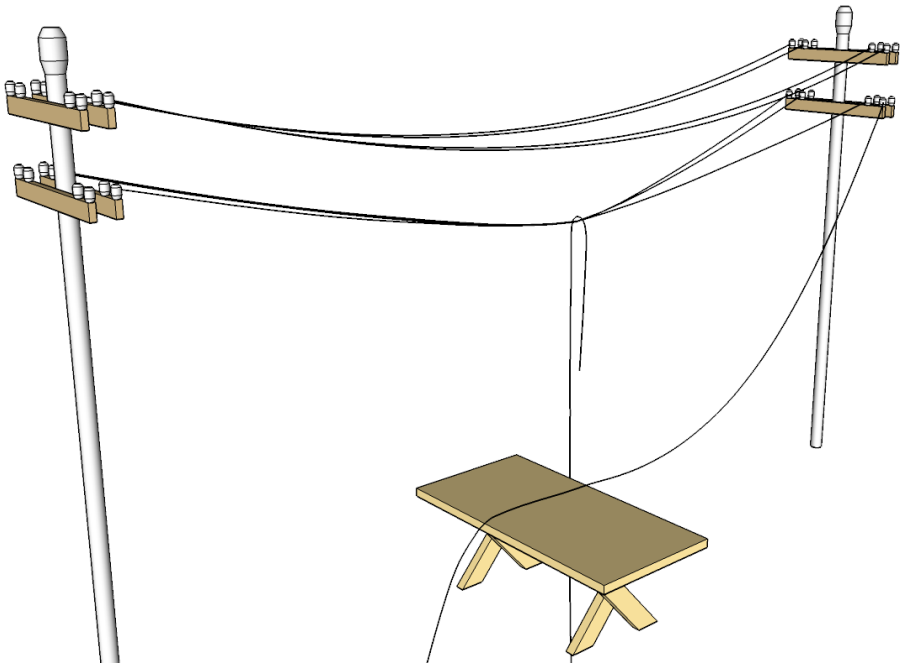


Ropes and Wires

Ropes/wires are like cloth but without faces. They can be pinned at desired locations and collide with other rope and cloth objects. One thing to note is that cloth and ropes collide well only when rope density is considerably higher than cloth density. Refer to steps below for making ropes:

1. Draw an edge with length denoting the entire length of the rope.
2. Divide the edge into many segments:
    a. Select the edge
    b. Access *(Context Menu) Divide*
3. Select all the split edges and group them.
4. Assign a cloth type to the grouped edges:
   (Context Menu) ClothWorks → Make Cloth
5. Use ClothWorks UI to set rope bending stiffness to 0.10.
6. (Optional) In the advanced section of the ClothWorks UI, untick *Pick & Drag Linked* option.
7. Run simulation and drag rope at any desired point to see the effect.
8. (Optional) In case rope resolution turned out too low, this can be fixed without having to redraw the entire rope:
    a. Reset simulation
    b. Select the rope
    c. Access *(Context Menu) ClothWorks → 1 Cloth → Weld Split Edges*
    d. Enter the entities context of the rope and divide the rope edge again but this time into more segments.

In the image below, two wire poles act as pins, table acts as a collider, and a set of grouped edges act as cloths. Loop subdivision was applied after simulating to smoothen-out all the wires.



Recording and Exporting

In addition to simulating and viewing final results, ClothWorks also comes with a feature to record simulation and then export frames into a set of images, OBJ files, and many other desired formats. Follow these steps for recording and exporting:

1. Open ClothWorks UI and navigate to *Simulation* tab.
2. Enable Record option.
3. Run simulation and stop/reset when desired.
   Note: Do not apply loop subdivision after recording; otherwise, the recorded data will be invalidated and discarded.
4. Access *(Menu) Extensions → ClothWorks* and select a desired export format, such as *Export Recorded to Images*
5. Adjust various options, such as frame rate, export path, and click OK. This will export a set of image or other file types into the specified directory. Once the export process ends, a message box will notify export results.
6. If exported into images, a third-party software, such as MakeAVI, an be used to combine images into an AVI file. And then, a converter can be used to convert AVI into MP4.

Unlike recording the screen directly, exporting frames into images and then combining into a video file, eliminates the simulation performance lag from a resulting video. On the counter note, it takes time export and combine.