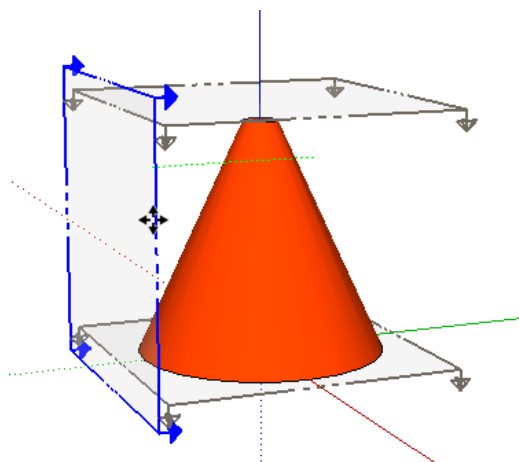


What is this Solid?

A few months ago I received an interesting question from my friend Julian Fleron, a math professor at Westfield State University. He wanted to know how to make a sectioned animation of a 3D solid in which the solid itself is invisible. The idea is very neat: model a solid object (cube, cone, sphere, light bulb, etc.), show some sectioned views of it, and see if your students can guess what the object is.

This project shows how to accomplish this, by using SketchUp's **Section Plane** tool, and by making use of material translucency. Once you work through the steps of this project, you'll easily be able to apply the concept to any 3D solid you create.



Julian and co-author Volker Ecke have recently written a paper entitled "Navigating Between the Dimensions," which is scheduled to be published by NCTM Mathematics Teacher within the year. In the meantime, have a look at their companion website: <http://www.wsc.ma.edu/ecke/flatland/Home.html>

To see an example of this kind of sectioned animation, please see my blog post: <http://3dvinci.blogspot.com/2011/04/what-is-this-solid.html>.

Teacher Note: There is no student version for this project, since the idea is for you to create sectioned models and have students identify them. But if your students are SketchUp-proficient enough to build models like this one, why not have them recreate the steps with their own 3D solids, and have other students (or you) guess what the solid is?

For this project, it helps to have some basic knowledge of Google SketchUp (though detailed instructions are provided). In particular, it's important to know how to zoom, orbit, and pan the view. If you need more information on how to get started, and a description of some basic tools, please read 3DVinci's Getting Started Guide (PDF).

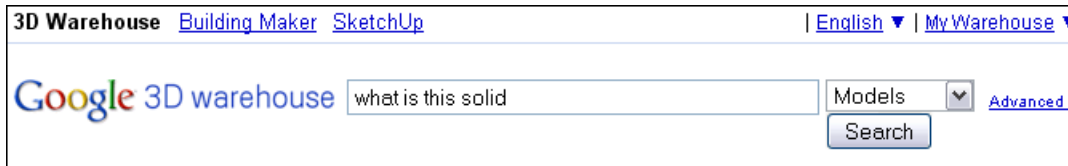
PC users: go to http://www.3dvinci.net/SketchUp_Intro_PC.pdf.

Mac users: go to http://www.3dvinci.net/SketchUp_Intro_MAC.pdf.

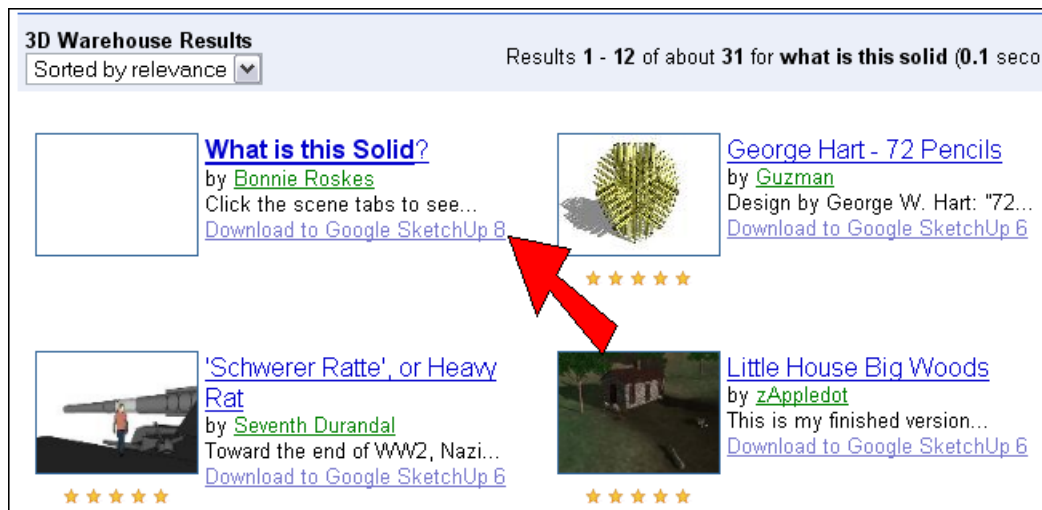
Step 1: Explore a Sectioned Model

First we'll see how this type of file is set up.

1. The SketchUp model that appears in the video can be downloaded from the 3D Warehouse (<http://sketchup.google.com/3dwarehouse>). In the search field, enter “what is this solid.”

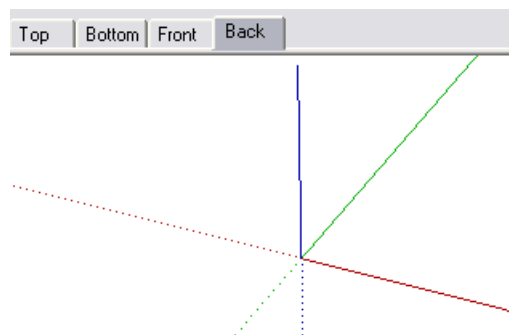


2. The model we want is shown below, by me (Bonnie Roskes). Click the link to download it.



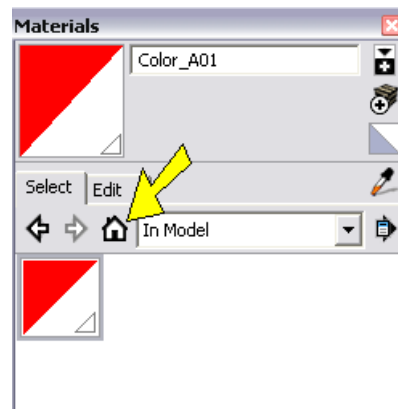
*This model contains scenes, so if you are searching for this model from within SketchUp, using either the **Get Models** tool or the **Components** window, don't import this model into another model. You need to open this model in its own file, otherwise the scenes will not appear.*

The model appears to be empty (it's not), and has four scene tabs across the top.

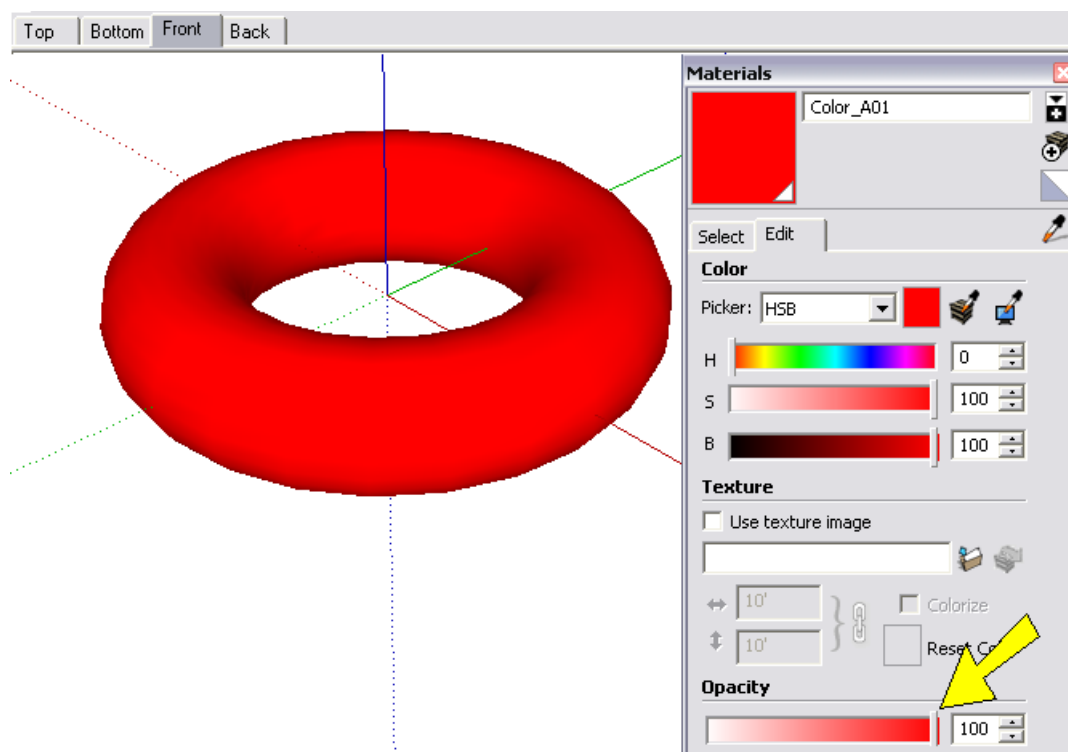


3. Click the scene tabs in order, “Top,” then “Bottom,” etc. The transition between “Top” and “Bottom” shows the section moving down into the object. “Front” to “Back” shows the sectioning moving through the object.

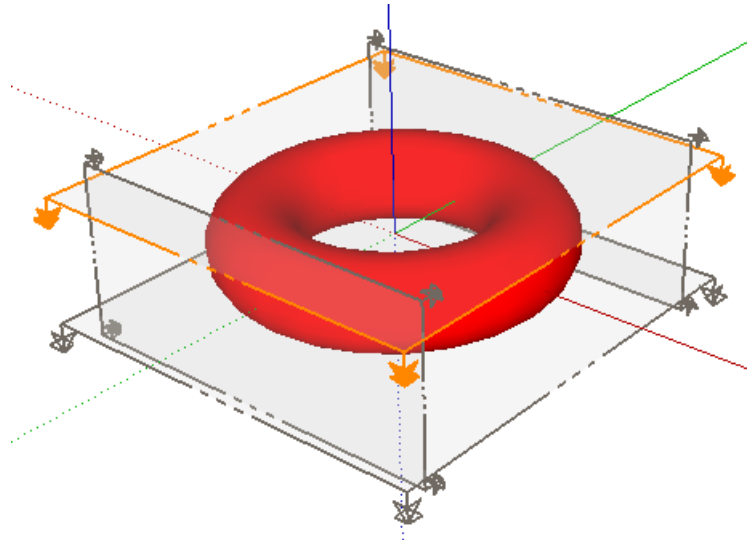
4. The object you're seeing sectioned is invisible because it's painted with a transparent material. To bring it out from hiding, click the **Paint Bucket** tool to open the **Materials** window (PC) or **Colors** window (Mac). Click the house icon, which shows the model's color. (Mac: you need to click the brick icon at the top of the **Colors** window, then the house icon will be available.) The diagonal division of the color's thumbnail means the material is defined as translucent. And 100% translucency means the material becomes entirely transparent.



5. Click either the "Top" or "Front" tab (the object doesn't appear in the other two scenes). To make this color visible, double-click the color's thumbnail. This opens the **Edit** tab (PC) or changes the **Colors** window to **Edit Material** (Mac). Find the slider for **Opacity** and move it from zero to 100. The torus is now visible.



6. The other necessary part of this model is section planes. These are also hidden; to display them choose **View / Section Planes** from the main menu. There are four section planes, one for each scene. Click the scene tabs again to see how these section planes move to meet one another.

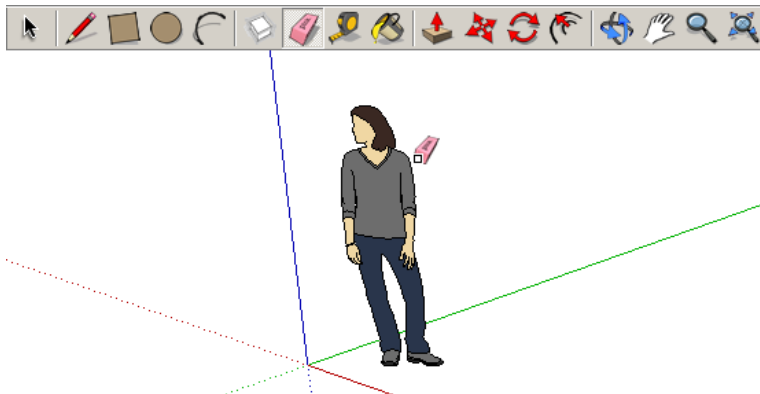


Step 2: Create Your Own Sectioned Model

Now that you know how this model is set up, we'll create one from scratch: a truncated cone.

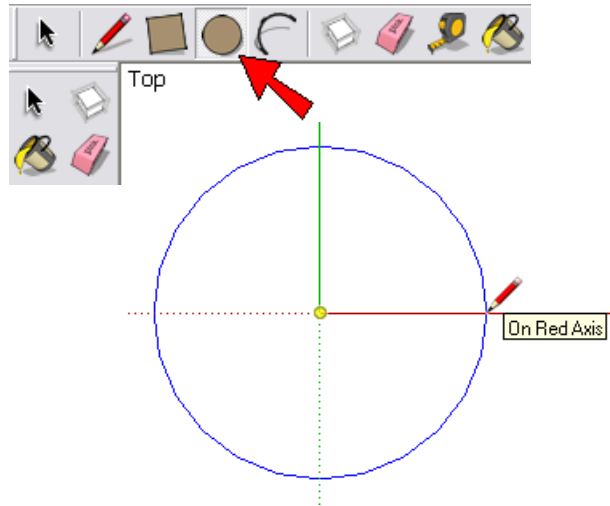
Build a Truncated Cone

1. Open a new Google SketchUp file. If your file contains a person standing on the ground near the origin, click the **Eraser** tool and erase him / her.

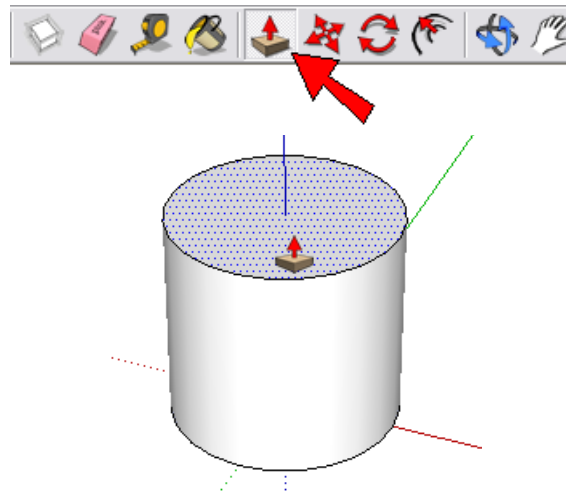


2. If you don't have the long, vertical toolbar displayed along the left side of the screen, go to the main menu and choose **View / Toolbars / Large Tool Set (PC)** or **View / Tool Palettes / Large Tool Set (Mac)**.

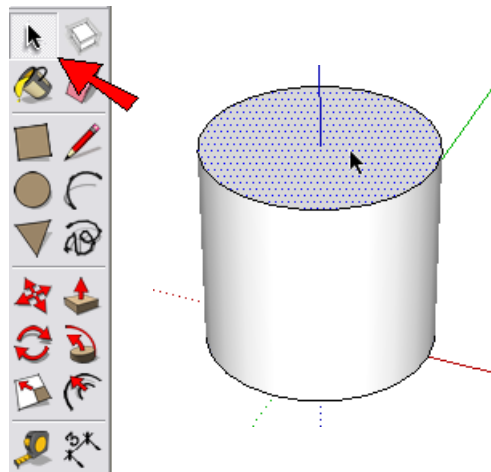
3. Activate the **Circle** tool and create a circle on the “ground” (the red-green plane).



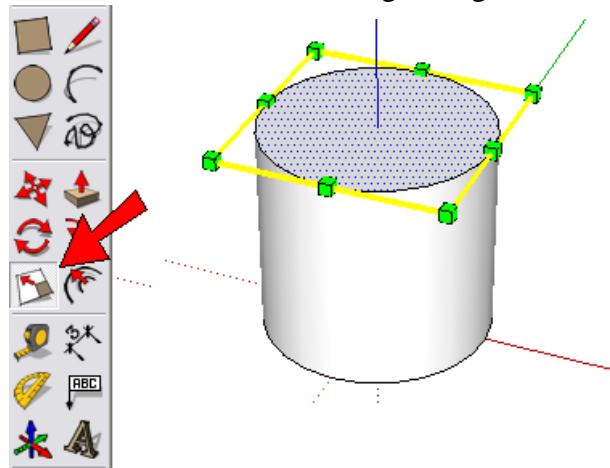
4. Activate **Push/Pull** and pull the circle up into a cylinder.



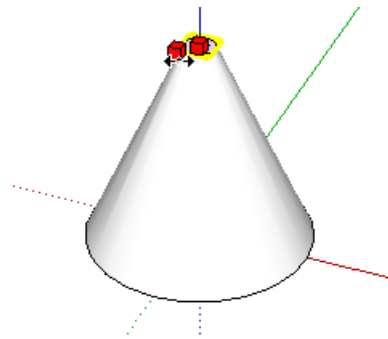
5. To make the cylinder into a truncated cone, the top face needs to be made smaller. So activate **Select** and click this face . . .



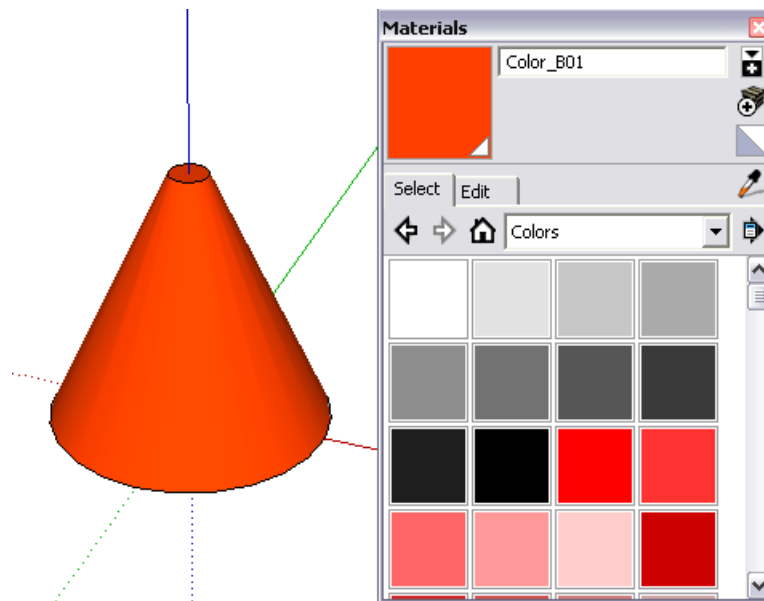
6. . . . and with this face selected, activate **Scale**. A set of eight drag handles appears around the top face.



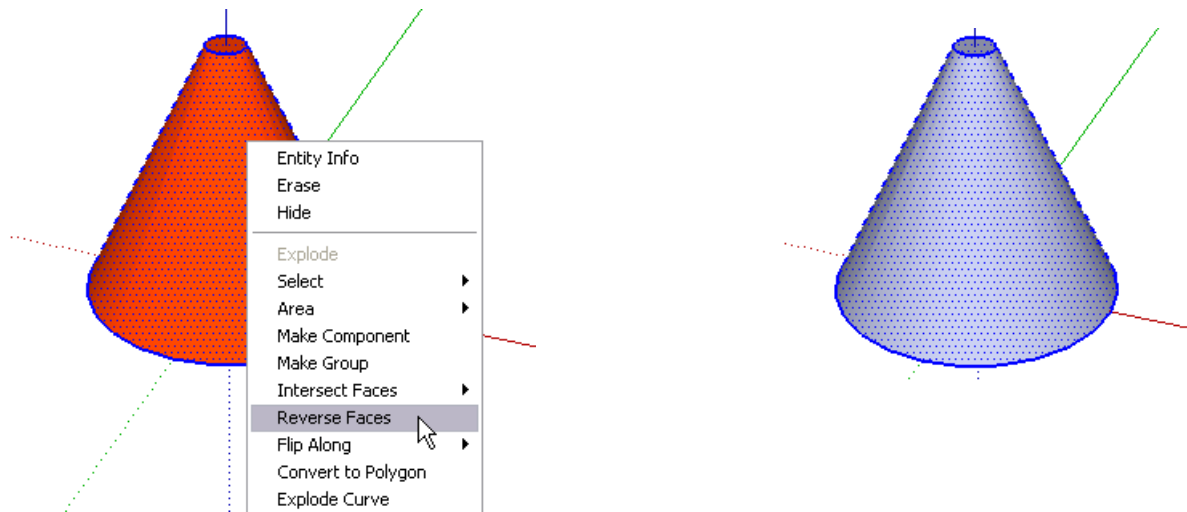
7. Press and hold the Ctrl key (PC) or the Option key (Mac) so that scaling will be about the center, and drag one of the corner drag handles inward. Be sure to leave a small circle at the top.



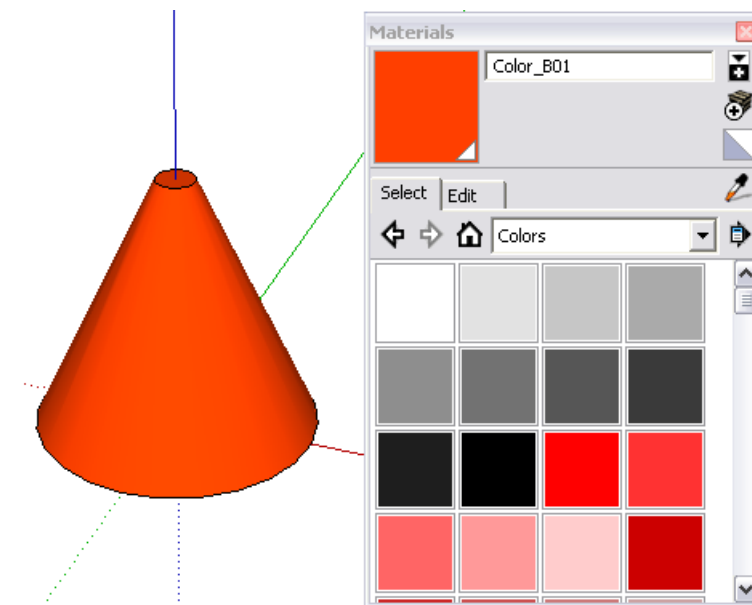
8. From the **Materials** or **Colors** window choose a color or material, press and hold the Shift key, and click any face of the cone. (Pressing Shift paints *all* of the outside faces of the cone.)



9. SketchUp faces are two-sided, and the inside faces are not yet painted. So if you edit the color you just used and make it transparent, the inside faces will still be visible. So we'll turn the cone inside-out and paint the inside faces too. Press Ctrl + A (PC) or Cmd + A (Mac) to select all faces, right-click on any face, and chose **Reverse Faces**. Now the inside faces are on the outside.



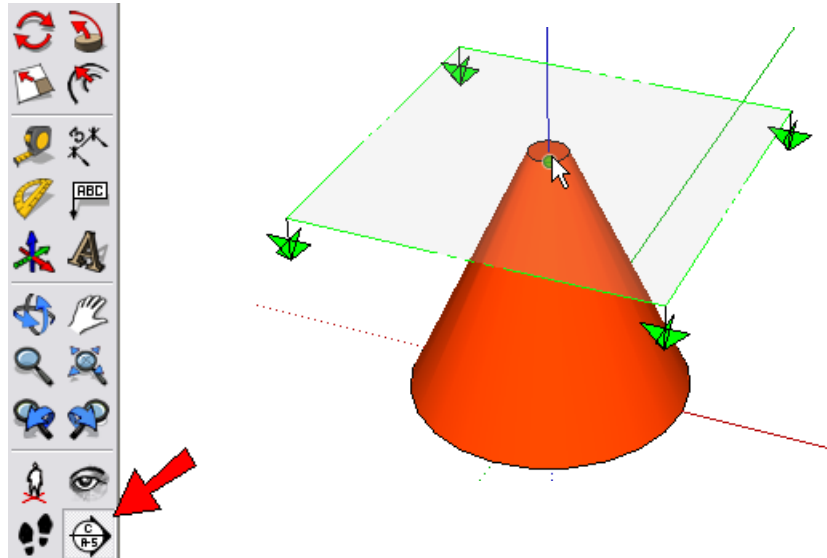
10. With all of the faces still selected, choose the same material you used before (its thumbnail should appear at the top of the **Materials / Colors** window) and click any selected face to paint them all. This material will be made transparent later.



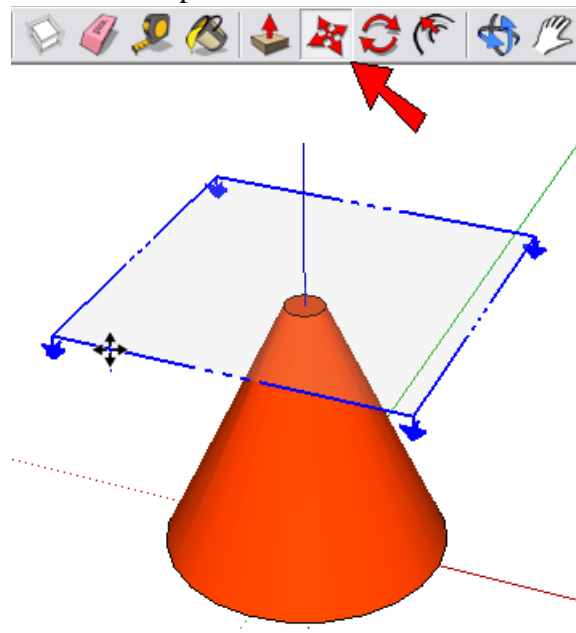
Set Up Section Planes

Now we need to add four section planes - one per scene.

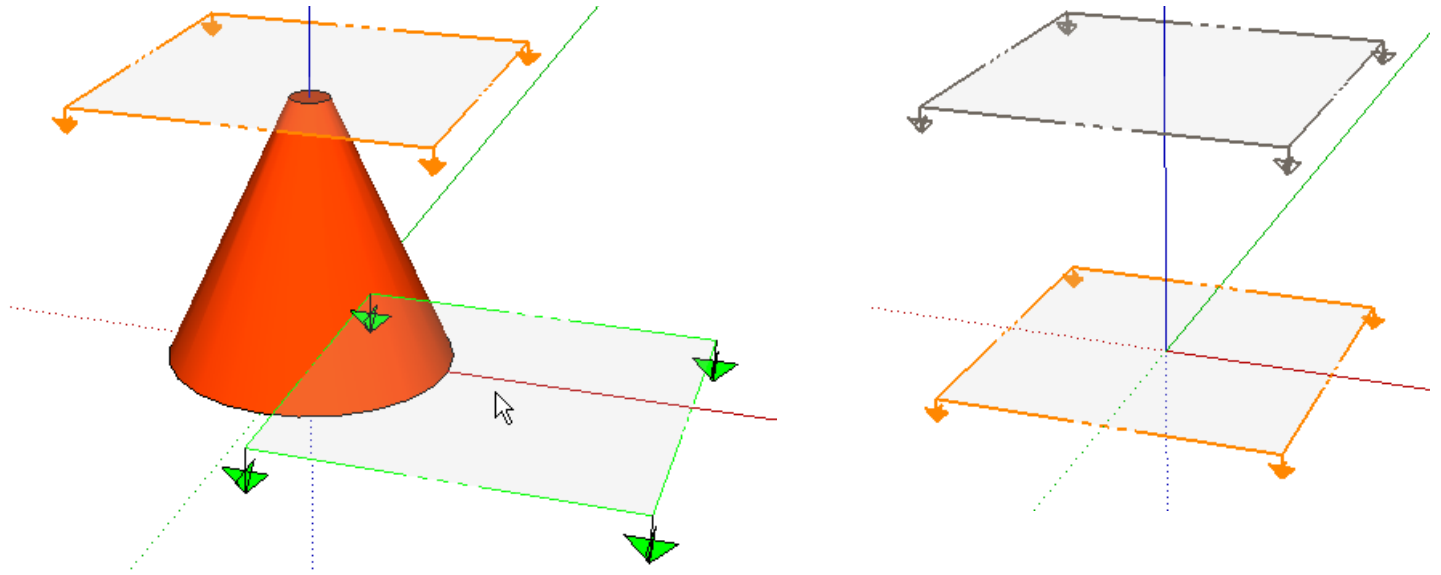
1. Activate the **Section Plane** tool. When you move your cursor around the faces of the cone, the section plane aligns to whichever face the cursor touches. Move the cursor to the top face of the cone so that the section plane is flat, then click to create the section plane. This is the plane for the first scene.



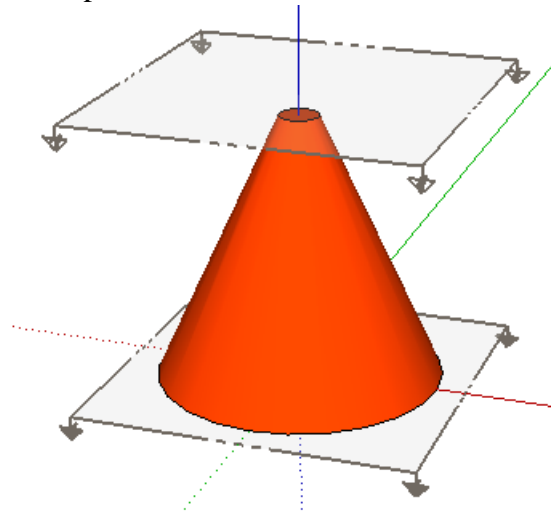
2. The section plane clips off the very top of the cone, so it should be moved up just a touch. Activate the **Move** tool, click the section plane, and move it up a small distance so that the entire cone appears.



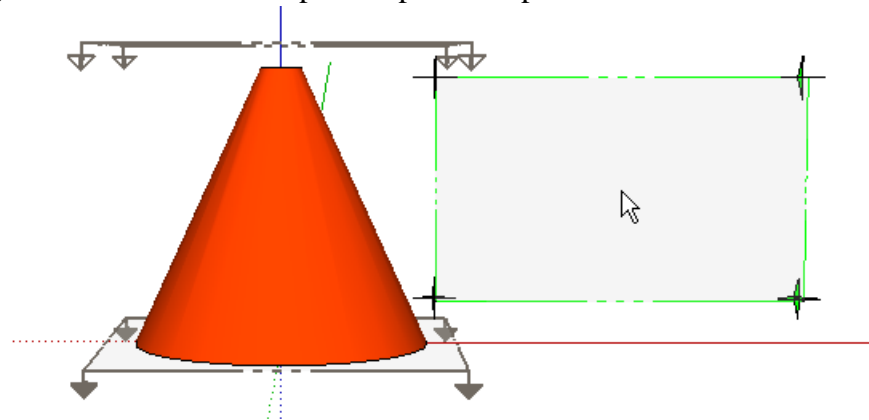
3. For the section plane for the second scene, activate **Section Plane** again, move the cursor into blank space so that the plane will be flat, and click. Because this plane goes just below the bottom of the cone, the entire cone becomes invisible.



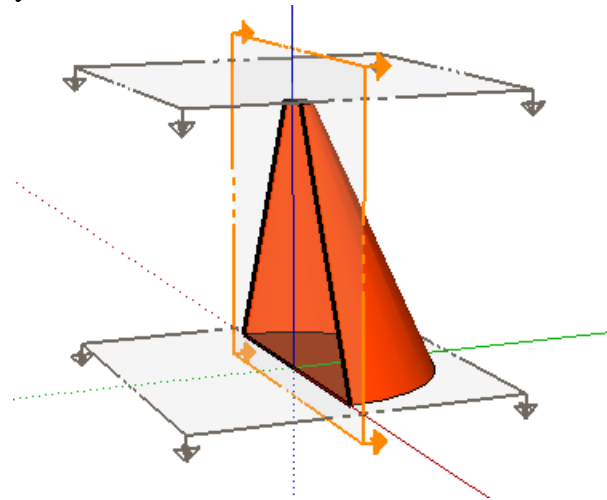
4. Before creating the next two section planes, we need to see the cone again. So choose **View / Section Cuts** - this turns off the cuts but leaves the planes themselves visible.



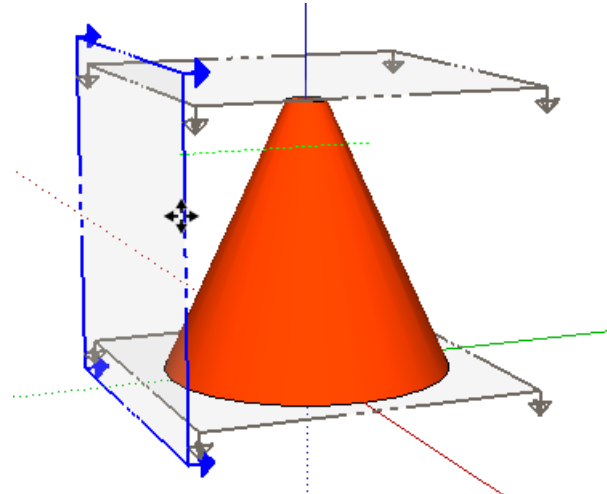
5. Orbit so that you're facing the cone head-on, looking in the direction of either the red or green axis. Activate **Section Plane** again and click in blank space to place the plane.



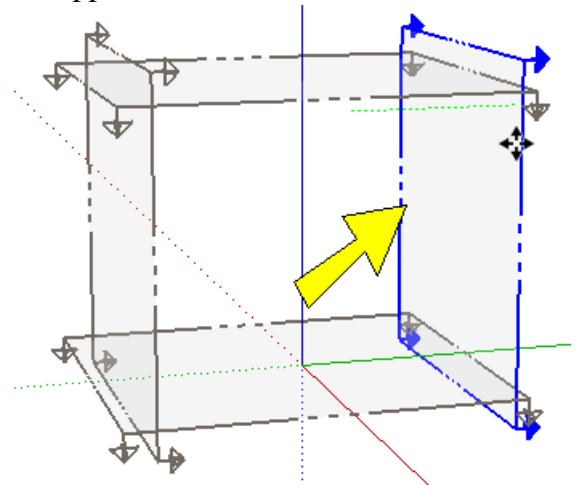
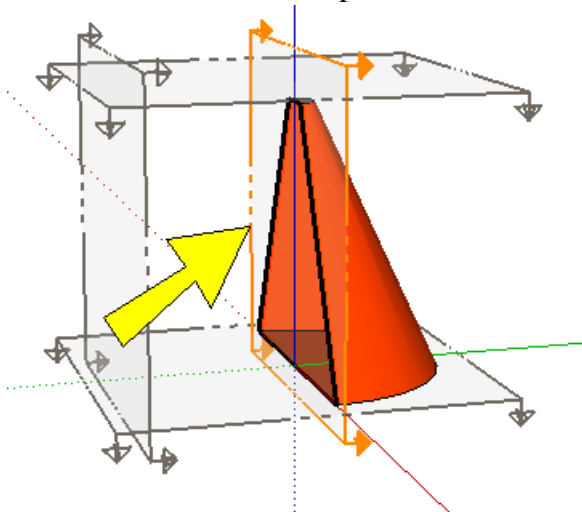
This slices the cone vertically down its center.



6. Use the **Move** tool to move the section plane backwards so that the entire cone come back into view.



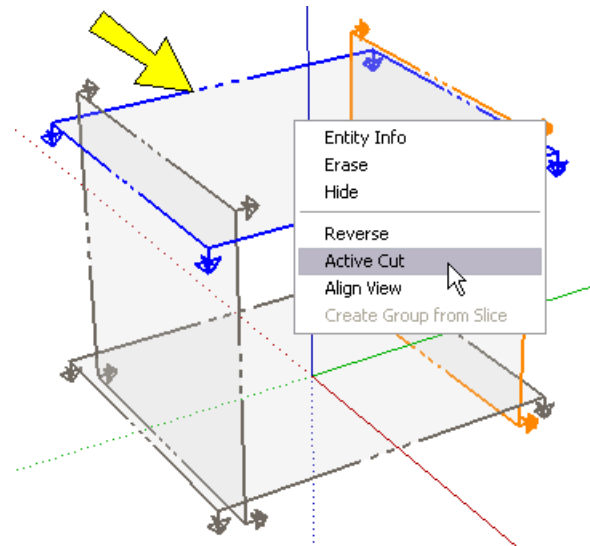
7. For the last scene, create one more vertical section plane as before, which again is placed vertically at the cone's center. Move this plane forward so that the entire cone disappears from view.



Create Scenes

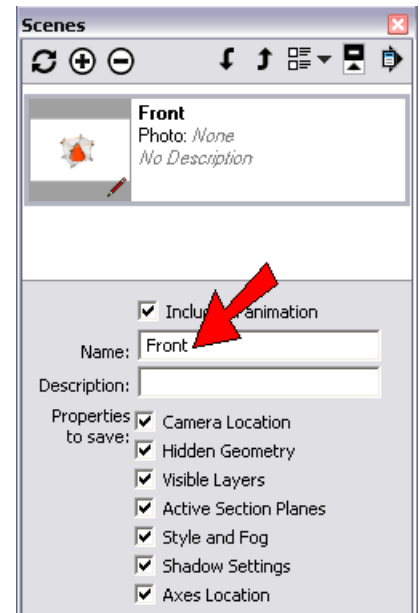
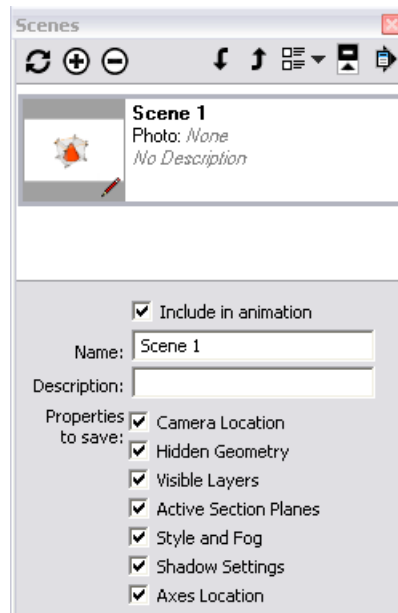
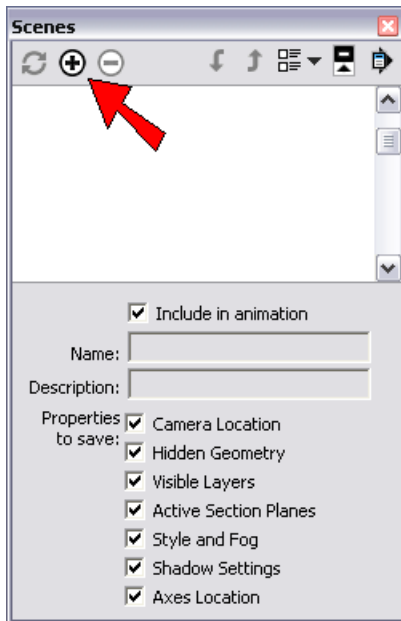
Now we're ready to save each sectioned view as a scene.

1. Only one section plane can be active at a time, and currently the back section is active. But the first scene is supposed to show the section at the top. So right-click on the top section plane and choose **Active Cut**.

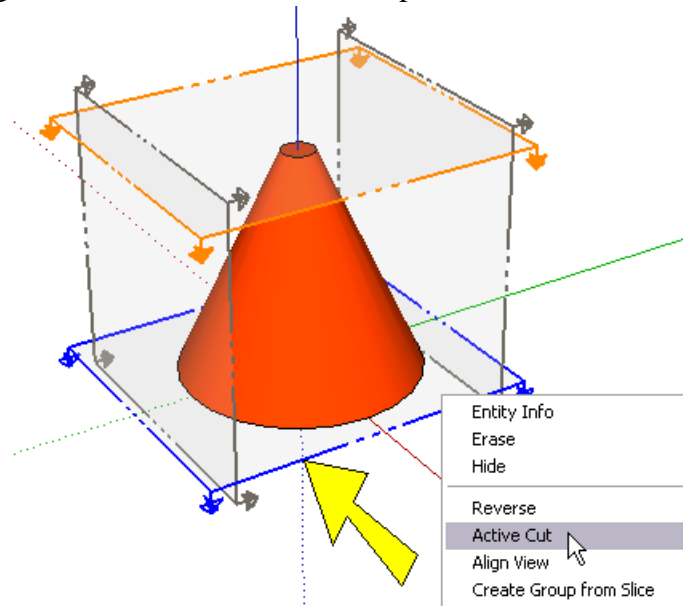


The cone should be back in view.

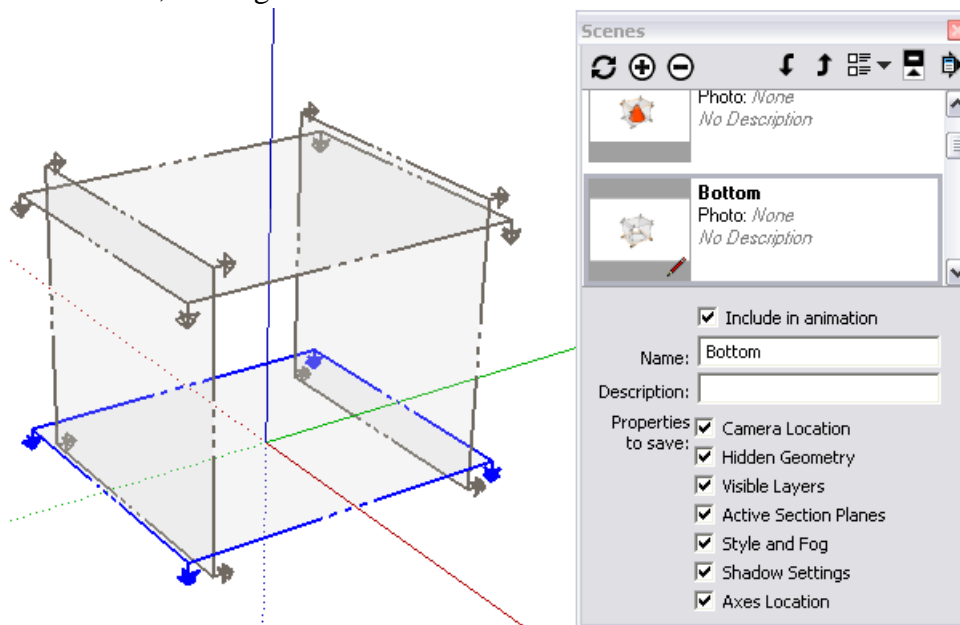
2. Open the **Scenes** window by choosing **Window / Scenes** from the main menu. To save this view as a scene, click the “+” icon. The view is given the default name “Scene 1.” Change the scene name to “Front.”



3. For the second scene, right-click on the bottom section plane and choose **Active Cut**.



4. The cone is sectioned all the way through and therefore invisible. Create another scene by clicking the “+” icon in the **Scenes** window, naming the new scene “Bottom.”

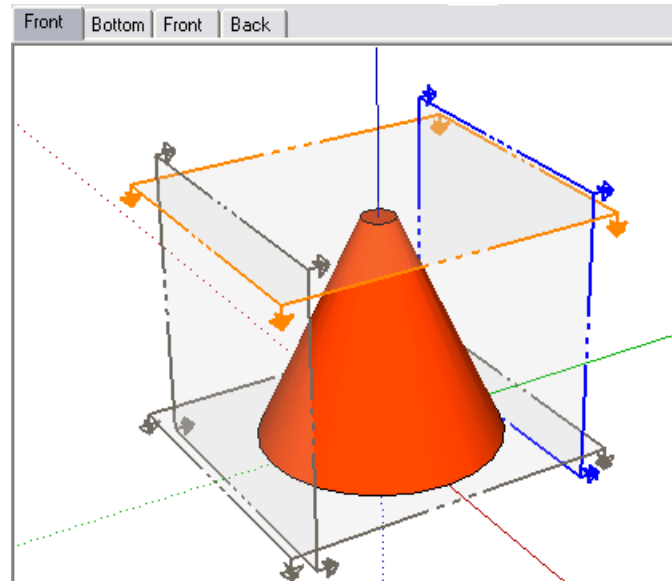


5. Continue the same way for the next two scenes, using the two vertical planes for scenes “Front” and “Back.”

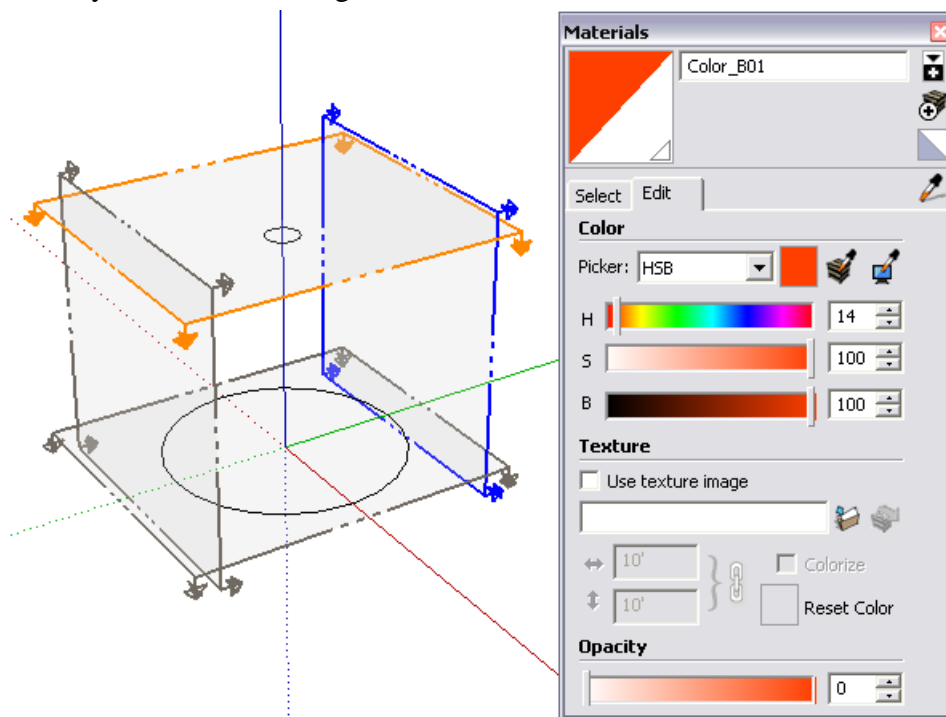
Change Model Settings

All the objects are now in place; the last step is to hide the model itself and the section planes.

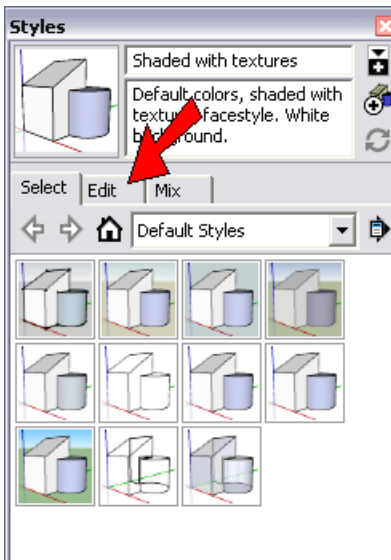
1. Click a scene tab that shows the entire cone: either “Front” or “Top.”



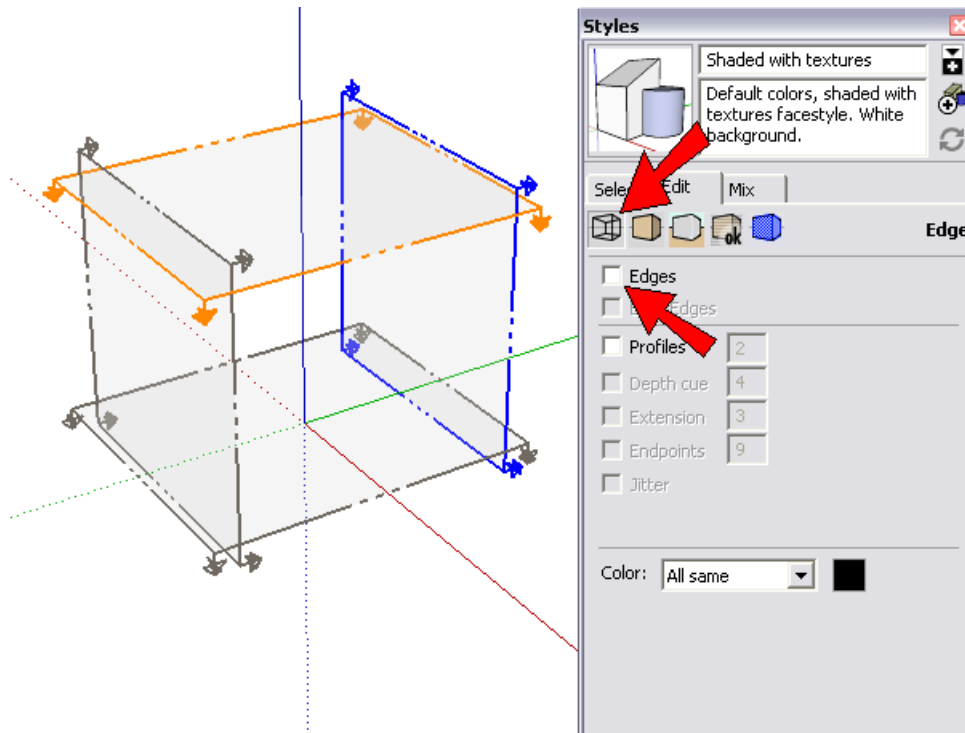
2. In the **Materials** or **Colors** window, click the house icon to see the thumbnail of the color you used to paint the cone. Double-click the thumbnail to edit it, and move the **Opacity** slider all the way to zero. The faces are now transparent, but you can still see edges.



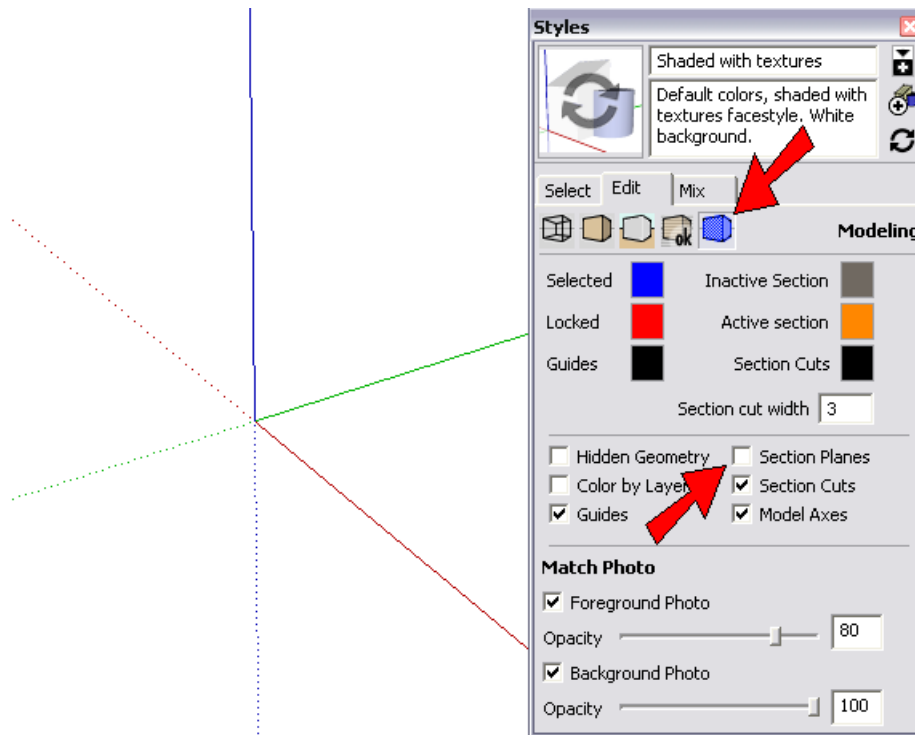
- The remaining changes require the **Styles** window (**Window / Styles** on the main menu). Click the **Edit** tab.



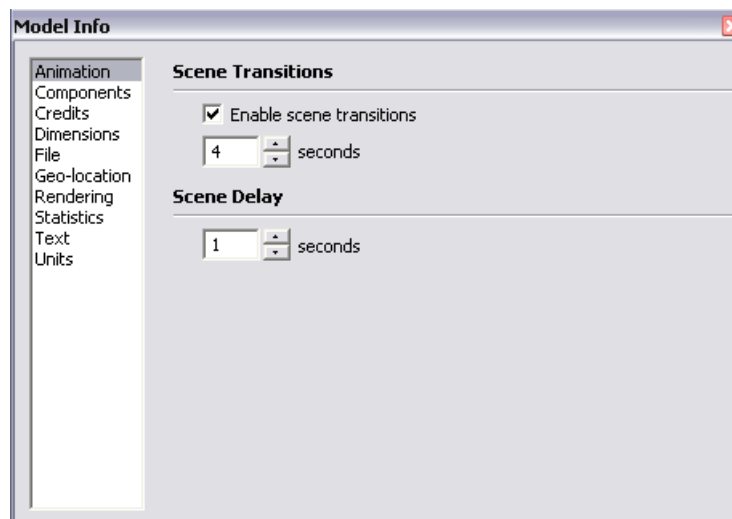
- First we'll take care of the edges. Click the first icon under the **Edit** tab, which opens the **Edge** settings. Then uncheck **Edges**, as well as **Profiles** if that box is checked.



5. Now click the last icon under the **Edit** tab, which opens the **Modeling** settings. Uncheck **Section Planes**.



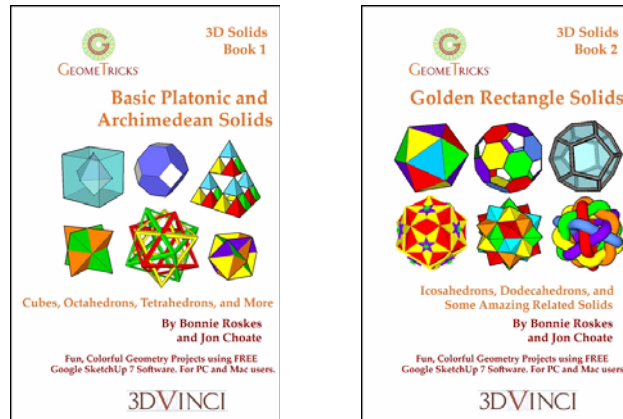
6. To slow down the animation between each scene, open **Window / Model Info** and click the **Animation** page. Increase the value for scene transitions, then close the window.



7. Now you can click each tab to see the section edges going up and down, back and forth. Can your students tell that the edges trace a cone?

Teachers, Want More?

For more projects with 3D geometry, you'll love 3DVinci's GeomeTricks books on Platonic, Archimedean, and related solids:



All books are available in print and as printable PDF. For details on GeomeTricks, go to <http://www.3dvinci.net/ccp0-catshow/GM.html>.

If you sign up for our [SketchUp Project of the Month](http://www.3dvinci.net/ccp0-prodshow/POM.html) subscription, each month you will receive three fun projects (one in math, two in 3D design) that can be used in K-12 classes. Details at <http://www.3dvinci.net/ccp0-prodshow/POM.html>.

April's project shows how to create Escher-like patterns from a hexagon:

