

Fall Leaves and Symmetry, in Google SketchUp

Teacher Note: All text in red appears only in the teacher version, not in the student version.

Symmetry is an essential concept both in math and art. This project involves both mirror symmetry and rotational symmetry. Children in middle and high schools can do this project on their own, and younger students will enjoy having a teacher demonstrate it.

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 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).

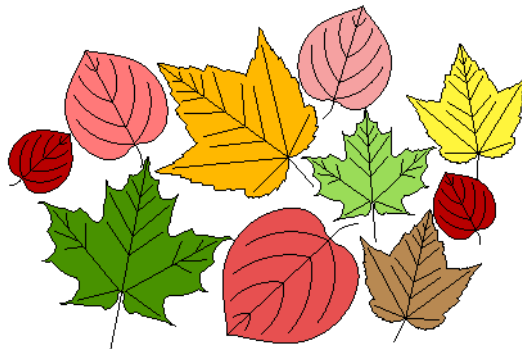
PC users: go to http://www.3dvinci.net/SketchUp_Intro_PC.pdf.

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

For more educational materials based on SketchUp, please go to <http://www.3dvinci.net>.

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In honor of autumn and nature's amazing color display, this project looks at leaves - specifically, how they are symmetric.



The wreath model that contains types of several symmetric leaves is available for you to download. Go to the Google 3D Warehouse (<http://sketchup.google.com/3dwarehouse>), and enter the search term "math forum wreath."

Step 1: Get Pictures of Some Leaves

An easy way to find great pictures of leaves is to search the Internet. Most search engines, like Google or Yahoo, have a link for image searching; you can type in something like “fall leaf” or “autumn leaf” and see what you get. I found these three pictures of different leaves:



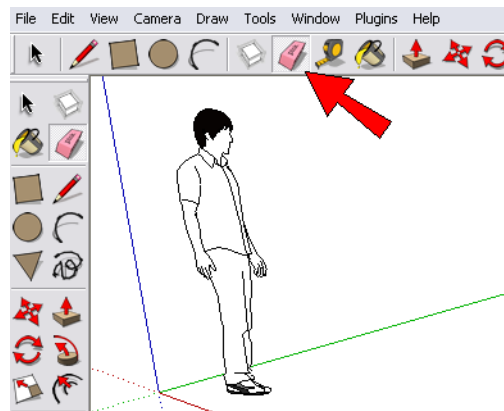
The pictures are used only for tracing, so the picture background and the leaf color do not matter. You can look for just one leaf picture now and get more pictures later, or you can download three or four pictures before starting the project.

When you find a picture you want to download, make sure you are viewing the largest possible image; your browser should provide a link for viewing the full-size image. To save the picture, right-click on it and choose the saving option offered by your browser, usually **Save Image As**, **Save Image to Desktop**, or something similar. Remember where you save the files!

Or, if you still have fallen leaves where you are, you can take your own pictures with a digital camera!

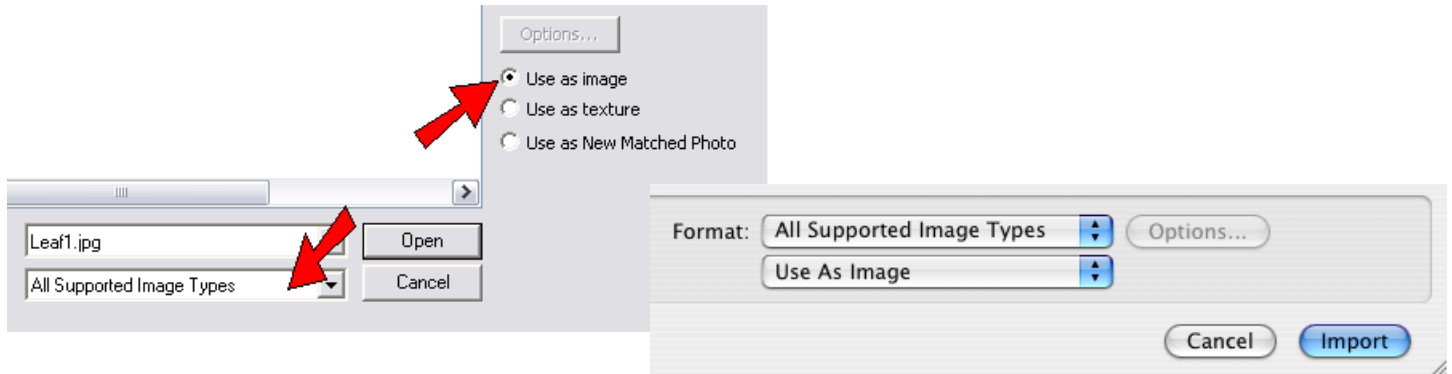
Step 2: Create the First Leaf

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



2. From the main menu, choose **Camera / Standard Views / Top**. Now you're looking down on the “ground,” and the word **Top** appears in the top left corner of the SketchUp window.

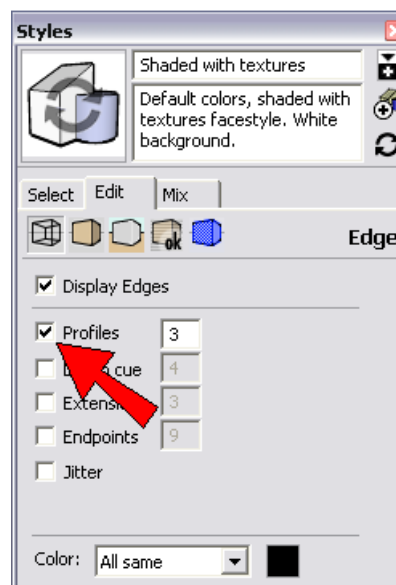
3. Now we'll bring in one of the leaf pictures. From the main menu, choose **File / Import**. In the window that appears, make sure you are searching for image files (not SketchUp models), and choose the **Use as Image** option. (PC options are shown below on the left, Mac options shown on the right.) Find the picture you want, then click **Open** (PC) or **Import** (Mac).



4. The leaf picture is now attached to your cursor. Click two corner points to place the picture in the model; the exact size is not important.



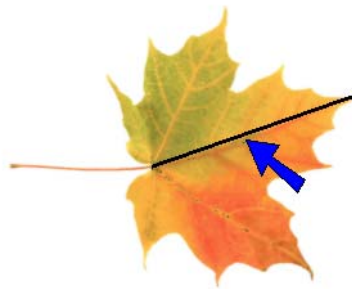
5. The next step is to trace around the leaf (actually, half of the leaf). But first, we'll change the display settings so that the tracing will be easier to see. From the main menu, choose **Window / Styles** to open the **Styles** window. Click the **Edit** tab, then click the first icon on the left which opens the **Edge** settings. Make sure **Profiles** is checked, and make the profiles rather thick - a value of 3 works well. **Display Edges** should also be checked, but nothing else.



6. Click the **Line** tool (the pencil icon).



7. We only need to trace half of the leaf, so start by drawing a line along the center of the leaf, from the top of the stem to the tip of the leaf. (On the picture this line is probably a little curvy, but a straight line is close enough for this project.) This line appears thick because of the profile edge thickness setting.

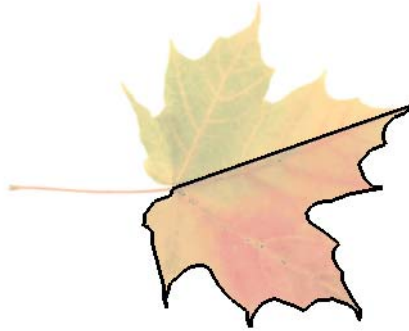


8. We'll continue drawing lines where the last line ended. Zoom in closely, and draw small line segments to trace all the way around one side of the leaf. When you're finished, make sure to end the tracing where you started it - at the top of the stem. SketchUp fills in these lines with a face.

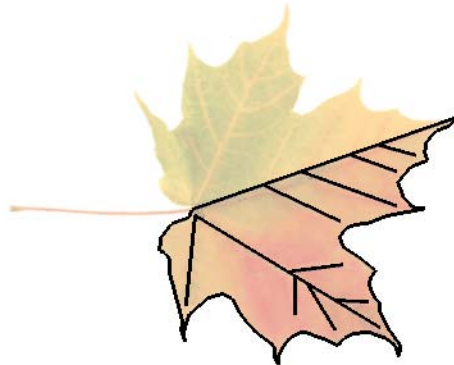


If you trace around and don't get a face when you finish your loop, you probably drew one or more lines off the picture, which you can't see while looking straight down. Orbit around to see if any of your edges are going the wrong way, erase any mistakes, and re-trace lines until the face is filled in.

9. We also want to draw some lines to trace the veins on the leaf, but the picture is now covered by the face. So go back to the main menu and choose **View / Face Style / X-ray**. Now all of the faces are translucent, and you can see the picture through the face.



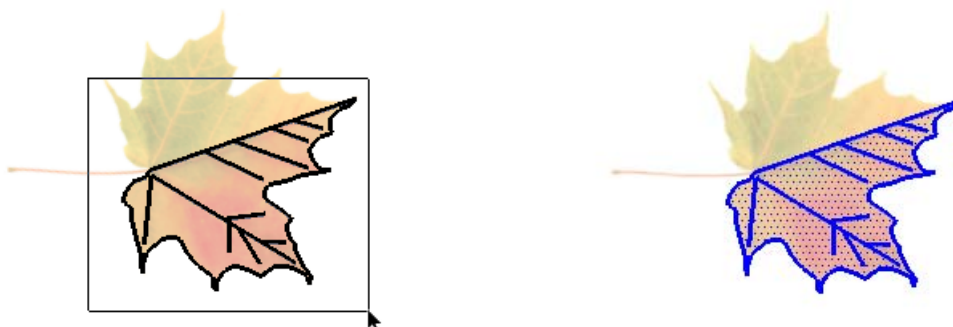
10. Draw a few lines to trace over the veins. (When you want to draw just one line and not continue making more lines attached to it, press the Esc key and you can start a new line.)



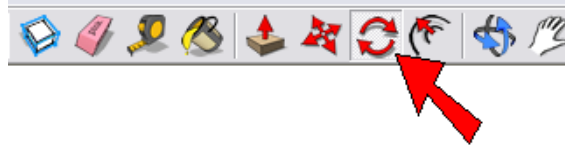
11. Now comes the symmetry part. To make a flipped copy of what we've done far, we first need to select what we want to copy. So activate the **Select** tool (the black arrow).



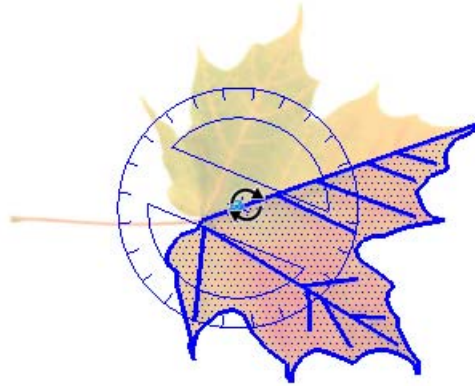
12. Click and drag your cursor from left to right, to outline a window that surrounds all of the edges you drew. (Make sure **not** to include the whole leaf picture in the selection window, because that will select the picture, which we don't want to copy.) Once selected, all edges should be highlighted, and the half-face should be highlighted in dots.



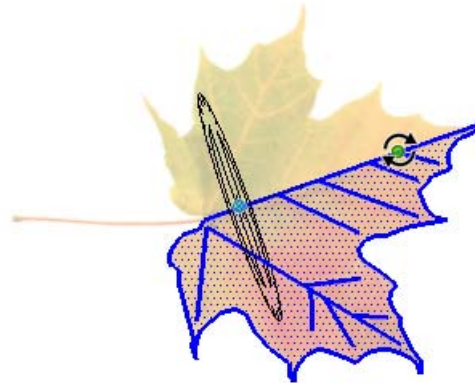
13. Now activate the **Rotate** tool.



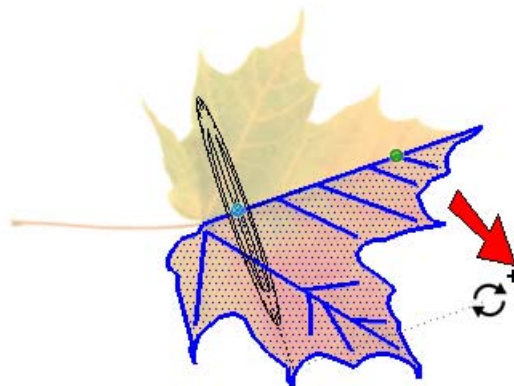
14. The axis of rotation will be along that first line you drew to divide the leaf in half. Place your cursor anywhere on this edge, but don't click yet.



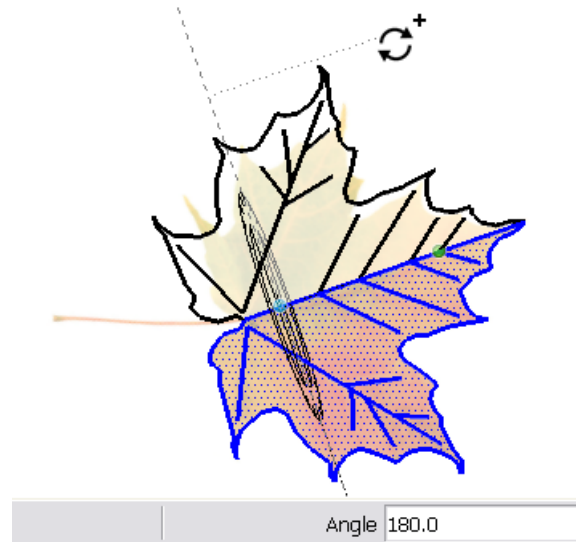
15. Press the mouse button and drag the cursor to another point along the mid-line. The protractor changes to be perpendicular to this line. Release the mouse button, and you've just defined the rotation axis.



16. To make the copy, press (don't hold) the Ctrl key (PC users) or the Option key (Mac users). You'll see a "plus" sign next to the cursor.



17. The next two clicks define how many degrees the objects will be rotated (which should be 180). Click anywhere, then move the mouse until you see the flipped copy. Click again when you see 180 in the **Angle** field at the lower right corner. If you can't get 180 to appear, just type it (don't click in the **Angle** field, just type) and press Enter.



Now you can compare actual leaf symmetry in the picture with “theoretical” symmetry. Most real leaves are a little imperfect, with one side a little larger than the other. But the symmetry is still pretty obvious in the overall shape of the leaf.

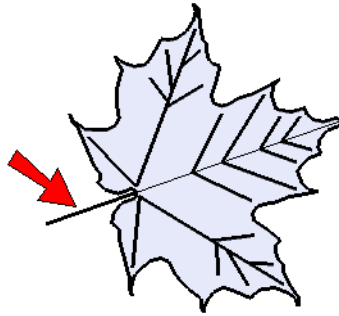
18. The leaf picture is no longer needed, so right-click on it (click on a part of the picture that has no SketchUp objects on it, such as around the stem), and choose **Erase** from the popup menu. Now we can see that the new half-face and the original half-face have different colors; this is because SketchUp assigns different colors to the fronts and backs of faces.



19. To make the color uniform, right-click on the face you want to switch and choose **Reverse Faces**.



20. Add one more line to complete the stem, and the first leaf is done!

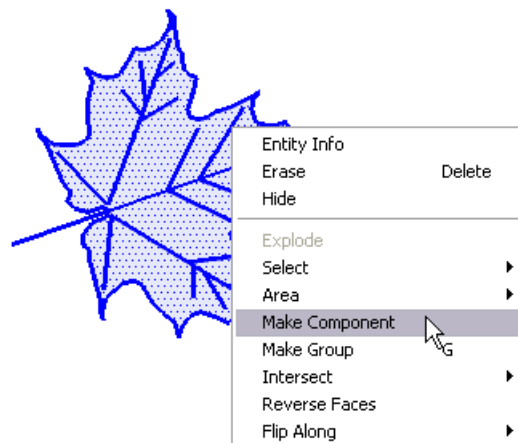


21. To get out of **X-ray** view, choose the same option as before to turn it off: **View / Face Style / X-ray**.

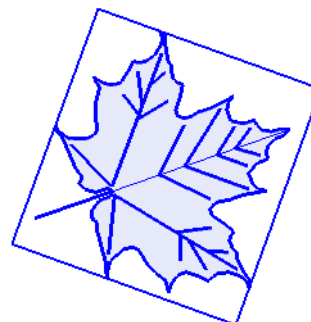
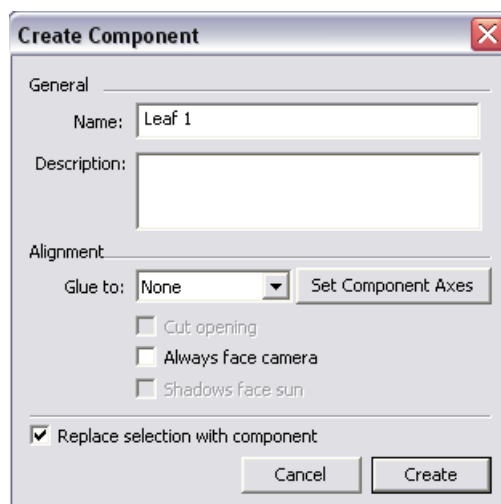
Step 2: Make a Mixed Set of Leaves

Now that you know how to make one leaf, you can use more leaf pictures to make more leaves. Your final result can be a leaf collage, or even a wreath.

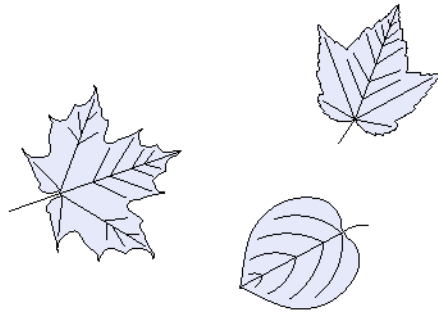
1. Because the leaf you just made will be used several times, it should be made into a component. This helps keep your file size low, and also makes it easy to move and copy leaves without them sticking to other leaves. Select the entire leaf, right-click on any highlighted face or edge, and choose **Make Component**.



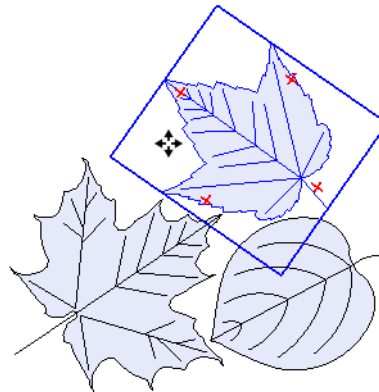
2. Give your leaf a name, make sure **Replace selection with component** is checked, and click **Create**. Now the leaf has a box around it, which means it's a component and can be selected as a single object rather than a collection of edges and faces.



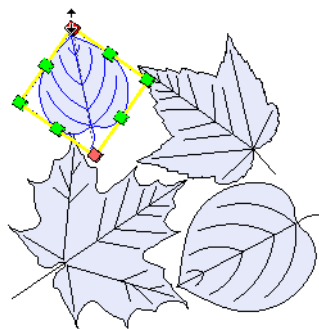
3. Import more pictures to create more leaves, and make each new leaf into a component. When tracing around a curvy leaf, another tool you can use instead of **Line** is **Arc**. (In my example, I've turned off the **Profiles** option in the **Styles** window, so that all edges appear thin.)



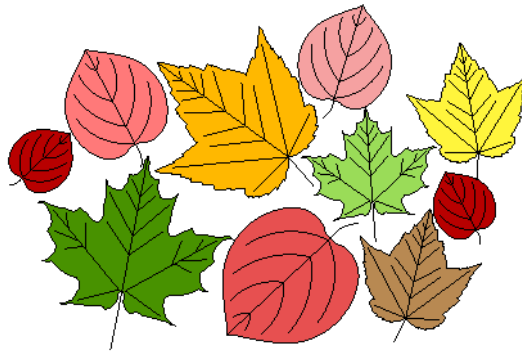
4. To move leaves, or make copies of leaves, activate the **Move** tool. As long as nothing is already selected, the **Move** tool allows you to both move and rotate a component. If you pass your cursor over a component, it will be highlighted, and you'll see four red "plus" signs. If you click on one of these "plus" signs you can spin the leaf around. If you click anywhere else on the highlighted leaf, you can move it. To make a copy, press (don't hold) the Ctrl or Option key.



5. If you want to make a random-looking collage, you can make some leaves larger or smaller. To do this, choose **Tools / Scale** from the main menu. Click the leaf you want to resize, and use the drag handles to make leaves taller, shorter, wider, etc.



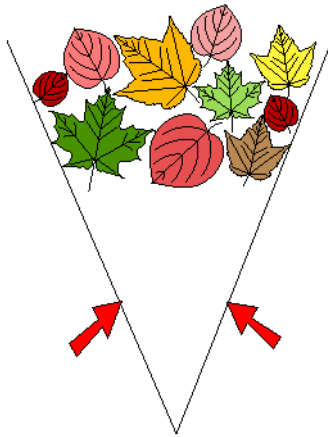
6. Here's my leaf collage, complete with fall colors. To paint a leaf, click the **Paint Bucket** icon, then in the **Materials** or **Colors** window, find the color collection or color picker you want to use. Click a color, then click a leaf - the whole leaf gets painted because it is a component.



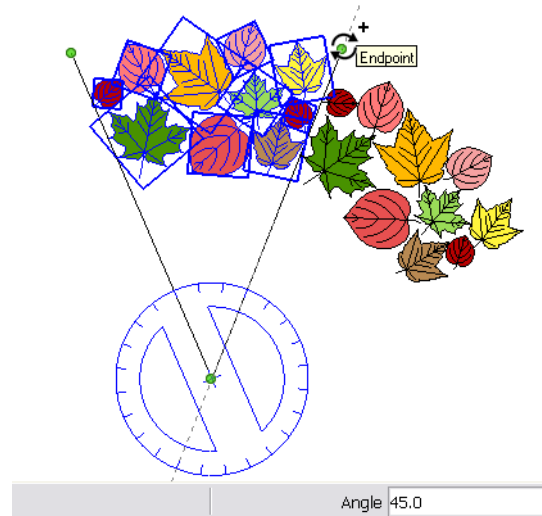
Try This: Create a Wreath of Leaves

With just a little math, you can take a group of leaves and make a very nice-looking wreath. You just have to make one "slice" of the wreath, then use the **Rotate** tool to copy that slice all the way around.

1. First, figure out how many degrees you'll include in your first slice. This angle should fit evenly into 360, because 360 is the angle all the way around a circle. So in the example below, I drew one line bordering one side of the group of leaves, then made a 45-degree rotated copy of that line. The point where the lines meet is the center of the wreath. Once you have your slice lines, make sure the group of leaves fits neatly inside, with no overlaps or gaps. This 45-degree slice will have to be copied seven more times to reach 360.



- Select all of the leaves (be sure not to select the slice lines, too), and activate the **Rotate** tool. Click once (don't drag this time) to place the protractor at the center of the wreath. Press the Ctrl or Option key, and for the rotation angle, click any point on both slice lines. In my case, the **Angle** field tells me that the angle is 45 degrees (in case I forgot).



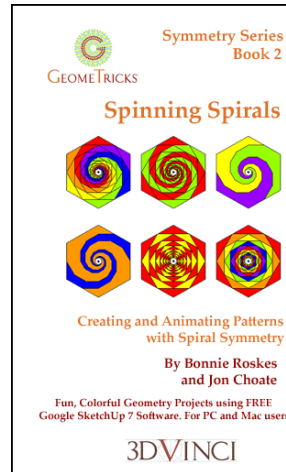
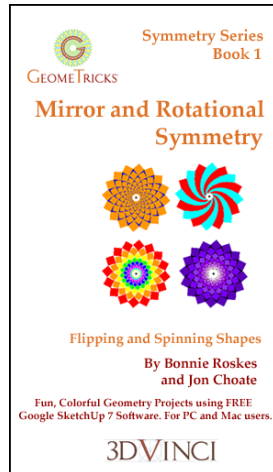
- As soon as that first copy is made, type 7x and press Enter. This makes the seven additional copies, all the way around.



You could also try slices that are 20 degrees, or 18, 30, 36, 90, etc. Have fun, and happy Fall!

Want More?

If you like 2D geometry projects in Google SketchUp, you'll love 3DVinci's [GeomeTricks series](#)! These are the books in our Symmetry series:



All books are available in print and as printable PDF. For details on GeomeTricks, including 2D geometry project books, go to <http://www.3dvinci.net/ccp0-catshow/GM.html>.

You can also sign up for our [SketchUp Project of the Month](#) 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>. The math project for November 2009 is on cube nets:

