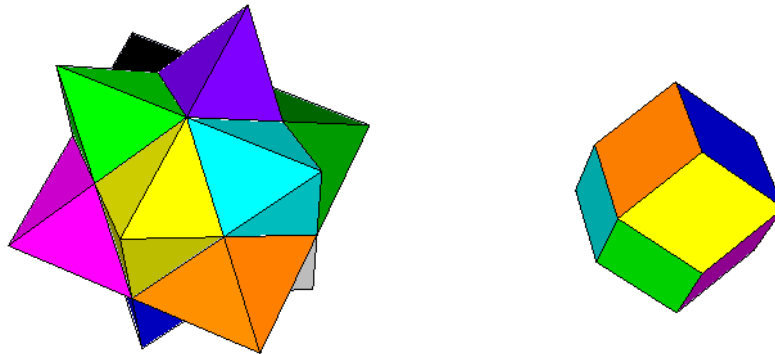


Rhombic Dodecahedron, in Google SketchUp

The title makes this project seem complicated, but it's really rather simple. You start with just a single square, and use a few simple SketchUp tools to create a stellated rhombic dodecahedron (shown below on the left), and from that, get a rhombic dodecahedron (on the right). The rhombic dodecahedron is easy to explain: a 3D solid comprised of 12 identical faces, each of which is a rhombus.



Teacher Note: All text that appears in **red** is for the teacher version only, and does not appear in the student version.

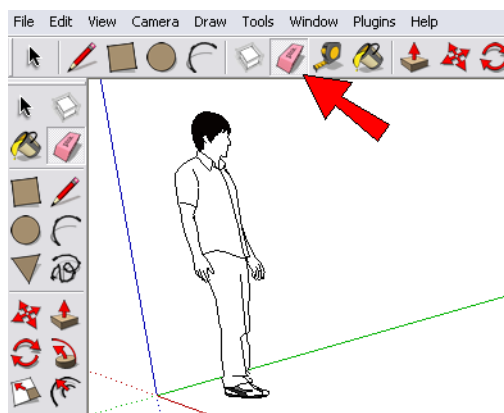
For this project, it helps to have some basic knowledge of Google SketchUp (though detailed instructions are provided). In particular, it's important to know how to zoom, orbit, and pan the view. If you need more information on how to get started, and a description of some basic tools, please read [3DVinci's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

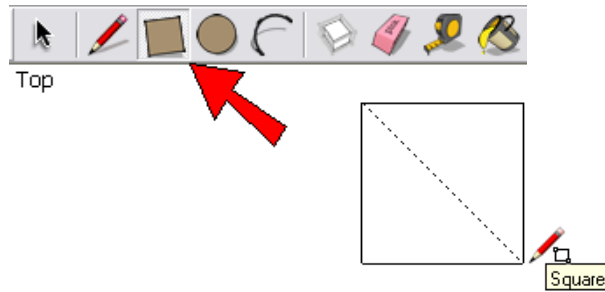
Step 1: Three Squares

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

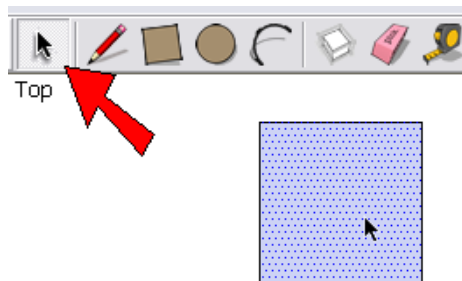


2. From the main menu, choose **Camera / Standard Views / Top**. Now you're looking down on the "ground," and the word **Top** appears in the top left corner of the SketchUp window.
3. If your axes aren't displayed, and you want to see them (they can be helpful for getting yourself oriented), choose **View / Axes**.

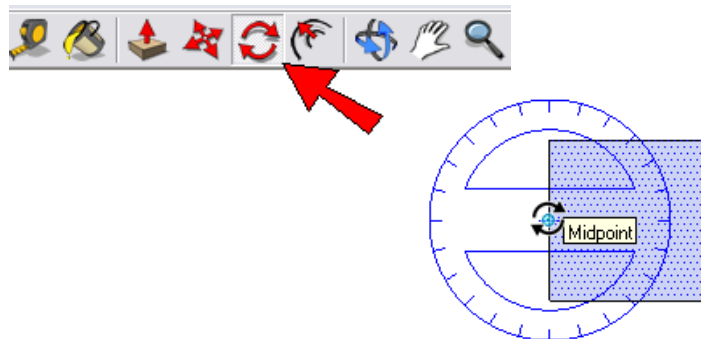
4. Activate the **Rectangle** tool and draw a square (click the first corner point, then click again when you see the “Square” popup).



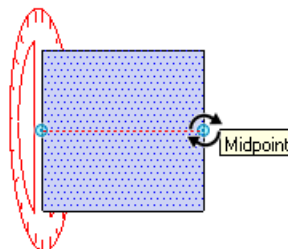
5. This square will be copied twice, so that one square will lie in each of the standard planes. First the square must be selected, so activate **Select** (use the icon shown below or press the Spacebar), and click the square face.



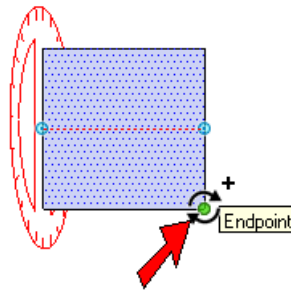
6. Then activate the **Rotate** tool. To place the protractor, move the mouse to the midpoint of one of the vertical edges. Don't click yet!



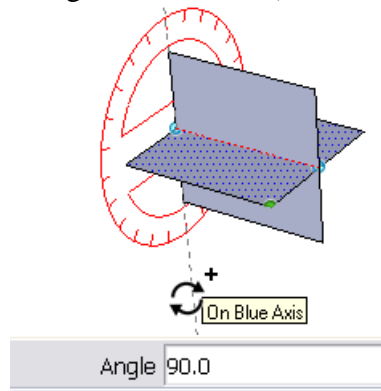
7. We want the protractor to be vertical, instead of flat as it is now. So click on this midpoint, keep the mouse button pressed, and drag the mouse to the opposite midpoint. Then release the mouse button. Now the protractor is red, which means it's lying in the green-blue plane.



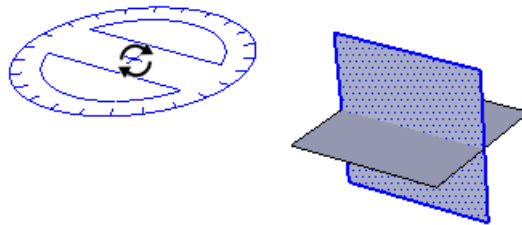
8. To make a copy, press the Ctrl key (PC) or the Option key (Mac). You only have to tap this key; you don't have to keep it pressed. Then for the first rotation point, click anywhere on the square.



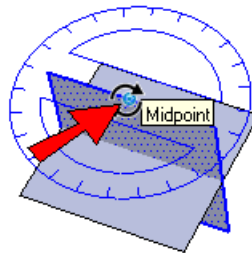
9. Orbit away from the ground plane, move the mouse to start rotating out the copied plane, and stop when you see 90 degrees in the **Angle** field (270 degrees works, too).



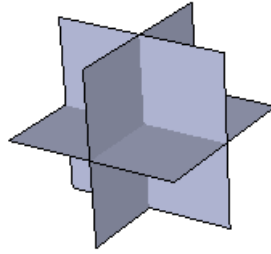
10. The copied square should be vertical and selected. Keep it selected since it will be copied next.
11. Keep the **Rotate** tool active for the next copy. Move the mouse into blank space, so that the protractor is blue again (lying in the red-green plane). Press and hold the Shift key, which locks the protractor in this orientation.



12. Keeping Shift pressed, place the protractor at the midpoint of the vertical square's top edge.



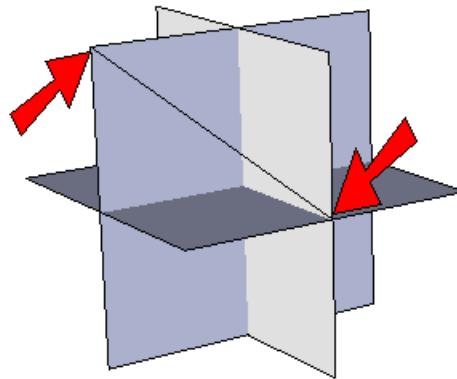
13. Make a 90-degree copy again, and you should now have these three squares:



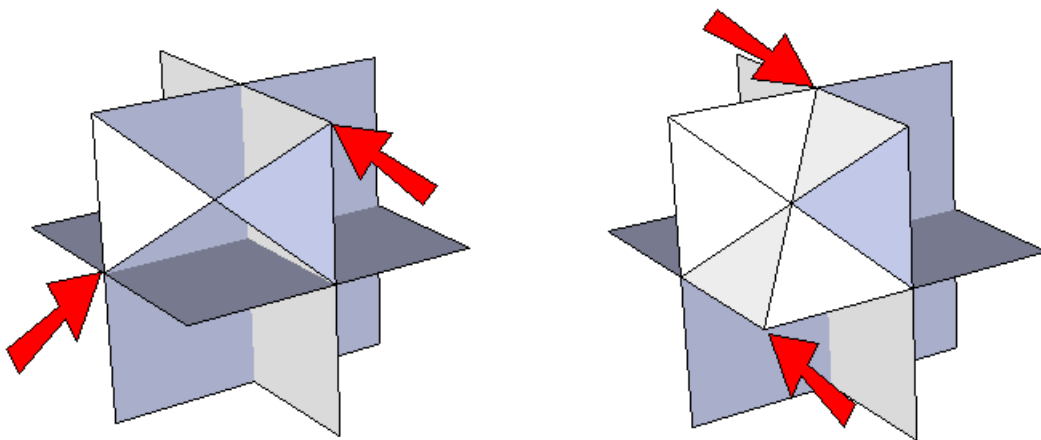
Step 2: Add Lines, Erase Lines

What we now have are eight “open” cubes (each cube has three faces instead of six). We’ll draw three lines in each of these cubes.

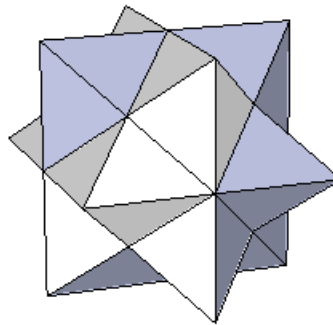
1. Activate the **Line** tool, and draw the line shown below, from one corner to the opposite corner. To end the line (you won’t be continuing this line), press the Esc key.



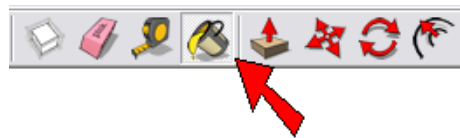
2. Next, draw two more lines connecting opposite corners. Now there are six new triangular faces.



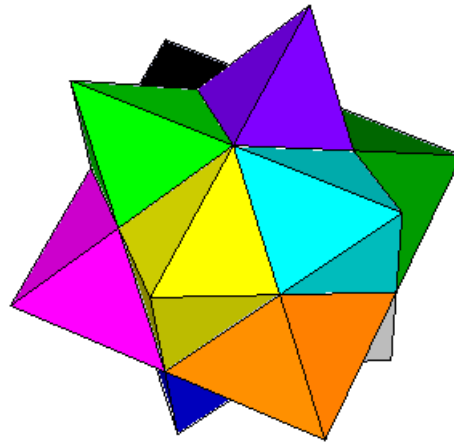
3. Draw the same three lines in the seven remaining cubes. This is what you'll get - it's called a stellated rhombic dodecahedron. "Stellated" means star, "dodeca" means 12, and there is a rhombus hidden below each star point.



4. So this means there should be 12 star points. How can we check this? One way is to paint each one. Click the **Paint Bucket**.

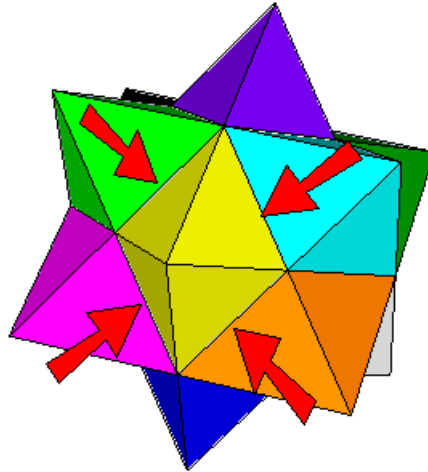


5. This opens the **Materials** window (**Colors** window on the Mac). Choose colors and paint each star point with a different color (each star point is made of four faces). If you count colors while painting, you'll see it takes 12 different colors to paint the whole shape.

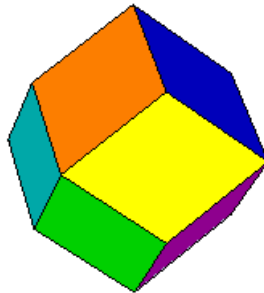


If you lose count, a little math will prove there are 12 star points. We started with eight "open" cubes, and each one has three lines, which produced six faces. So the total number of faces in a stellated rhombic dodecahedron is $8 \times 6 = 48$. Each star point consists of four faces, so there are 12 star points ($48 / 4 = 12$).

The rhombi will be uncovered when you remove all of the star points. You can already see the outline of each rhombus - the four edges at the base of each star point.

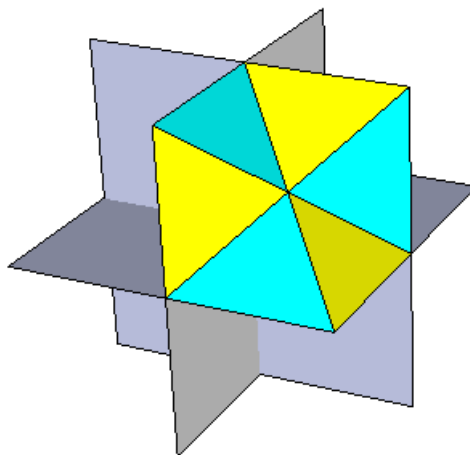


- Use the **Eraser** to remove each edge of each star point. When you're done, you'll get the rhombic dodecahedron. If you count the faces, you'll get to 12 once again.

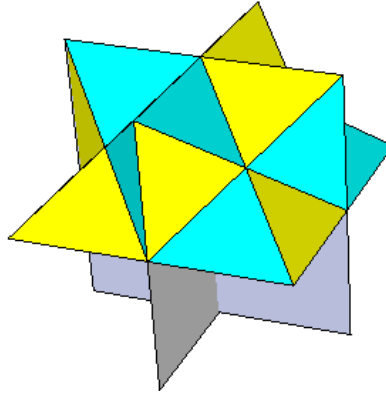


Another Way

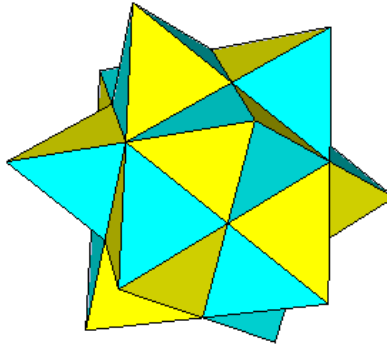
If you're good at using the **Rotate** tool to make copies, there's a quicker way to make these shapes. Work the previous steps until you have the six triangular faces inside one cube.



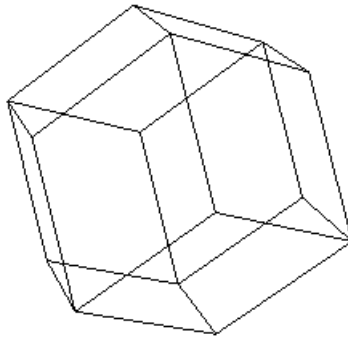
Then use the **Rotate** tool to make three 90-degree copies of the six faces, around the center.



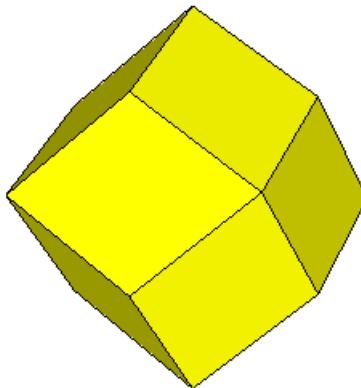
Then make a copy of all of the faces so far, from the top to the bottom.



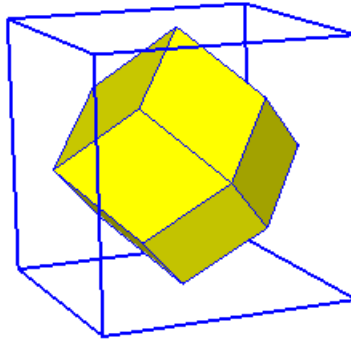
This time, when you remove the star points, you only get the edges of the rhombic dodecahedron, not the faces. (Why just edges? To create the rhombus faces, you need to actually draw its lines by hand. When you copy edges to another face, they won't automatically form a face.)



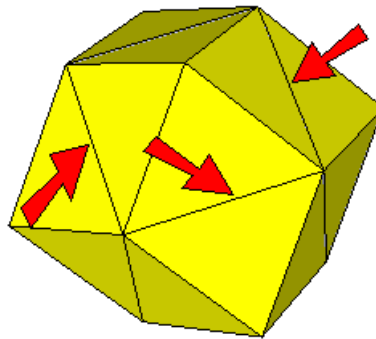
But it's easy enough to fix: just trace the edges with the **Line** tool, which fills in the missing faces.



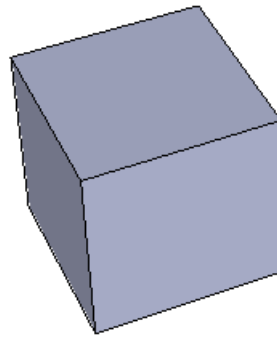
Teachers: if you're pretty adept with SketchUp (or if your students are), there's a lot more you can do with this 3D solid. For example, start by making the rhombic dodecahedron into a group.



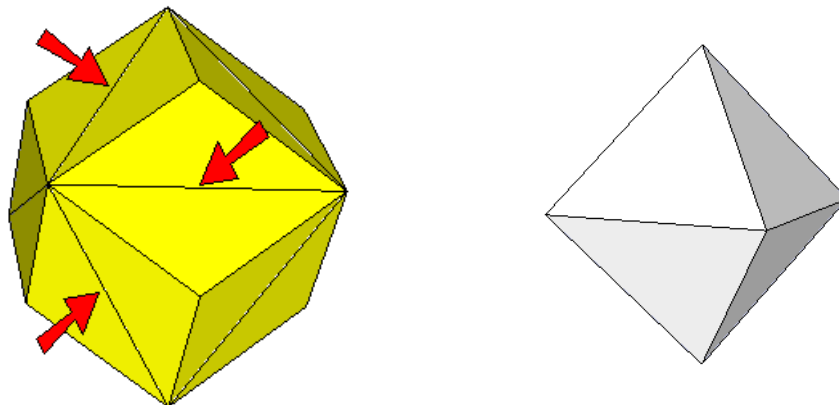
On each rhombus, draw the shorter line that divides each rhombus in half.



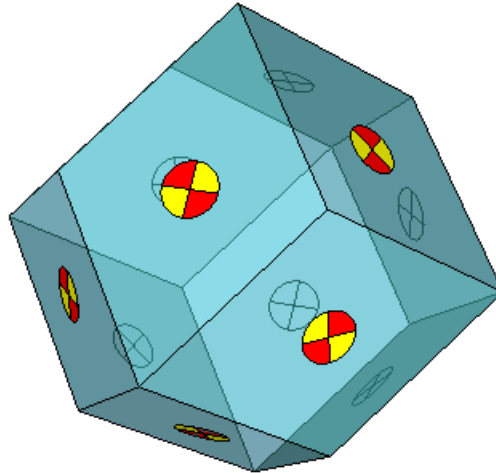
Erase the rhombic dodecahedron group, and you're left with a perfect cube.



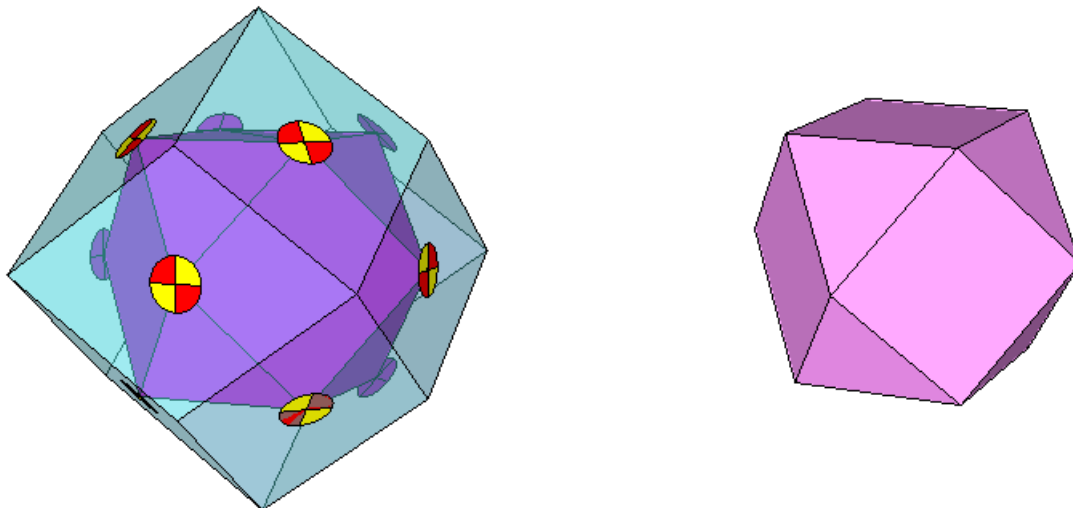
Try again, this time drawing the longer lines that divide each rhombus in half. Now when you remove the rhombic dodecahedron, you get an octahedron.



If you're really ambitious, you can get the rhombic dodecahedron's dual. Mark the centroid of each face. . .

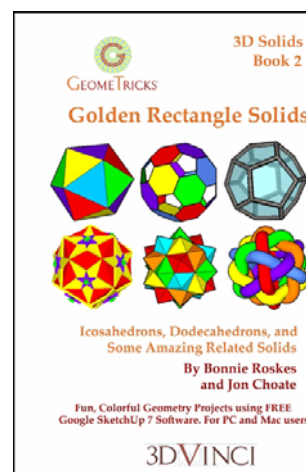
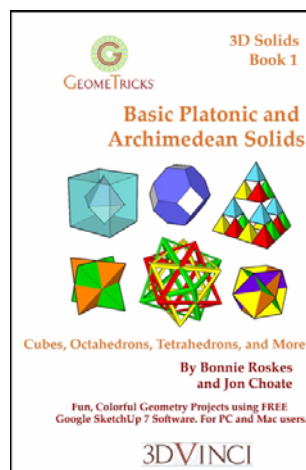


. . . then draw lines connecting each adjacent centroid. Remove the rhombic dodecahedron, and you get its dual: a cuboctahedron.



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For subscribers, the math project for May is about tessellating quadrilaterals:

