Advanced 3D CAD for Guitar Body Design

**Description of Activity**

* Using 3D CAD to create armrest and tummy cuts in guitar model.
* Guide student step-by-step through the process of creating body contours on guitar model in 3D CAD.
* Grades 11-14, 3D CAD, Manufacturing, PLTW IED, CIM

**Learning Objectives:**

**(List measureable objectives)**

1. Students will complete the modification of a previously created guitar body by adding front arm rest contour
2. Students will complete the modification of a previously created guitar body by adding rear tummy cut contour.
3. Students will

**Standards:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Student Performance Objective(s):** | | | |
| **HS-ETS1-3** | Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. | | |
| **Science and Engineering Practices** | | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **Constructing Explanations and Designing Solutions**   * Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. | | **ETS1.B: Developing Possible Solutions**  ▪  When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. | **Influence of Science, Engineering, and Technology on Society and the Natural World**  ▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. |

Common Core State Standards for ELA/Literacy:

**RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

**RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

**RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

List The Common Core Math, Next Generation Science Standard and/or SME Competency Gaps. For example:

<FIND STANDARDS. PLTW IED, ITEEA STL are fair game>

**Materials Required:**

* List any required materials needed for this activity here.

**Safety:**

**safetys:**

* List any safety equipment needed and discuss any safety concerns here.

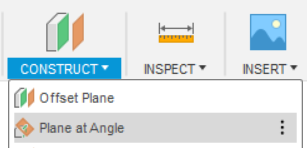
**References:**

* Add any references or sites for further exploration here.

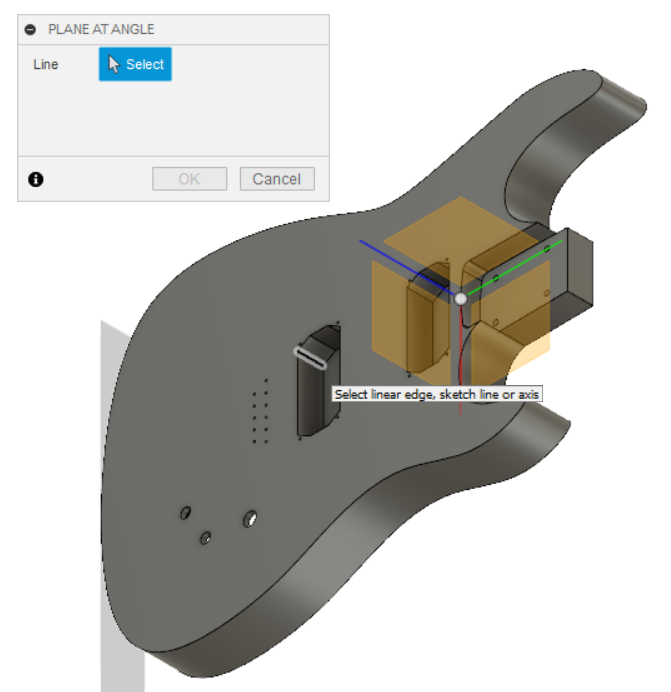
**Activity:**

In this activity you will learn how to model and program CNC cuts for body contours.

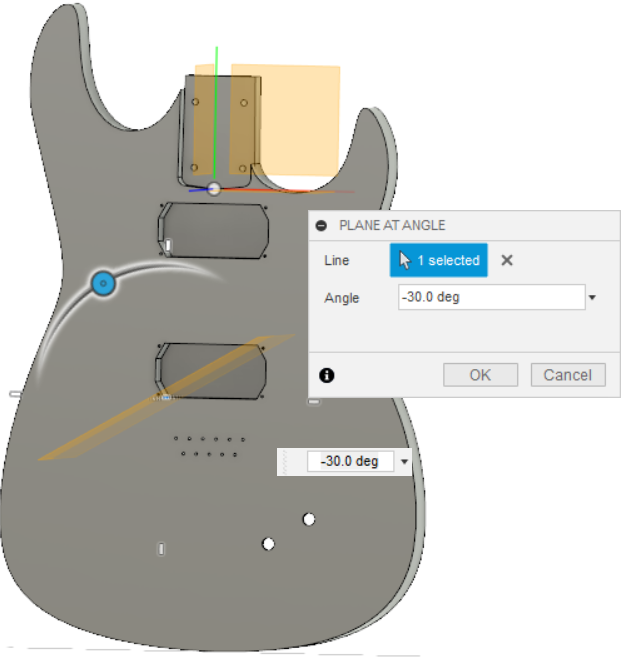
1. Now we need an angled workplane. This part will have to be done by eye, and you may need a couple attempts to get it how you want. On the Construct menu, choose Plane at Angle



1. You will be prompted for a line (axis) for rotation. Choose something you know won’t change, such as an interior edge of a pickup pocket.



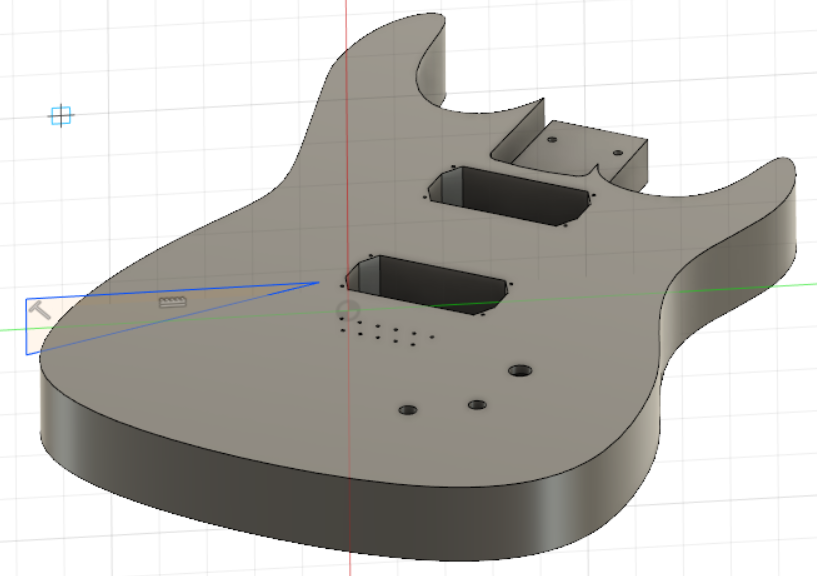
1. For a first attempt, look at the shape straight on. On this shape, 30 degree angle for the plane seems like a good starting point.



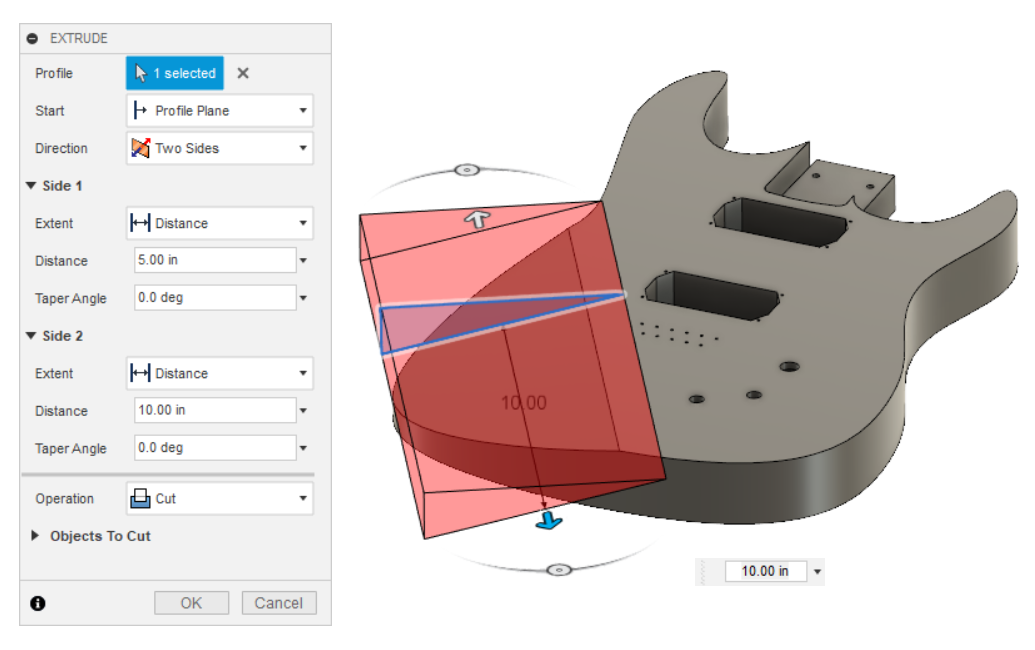
1. Create a sketch and draw a triangle on it. This will be used to cut some material away from the body.



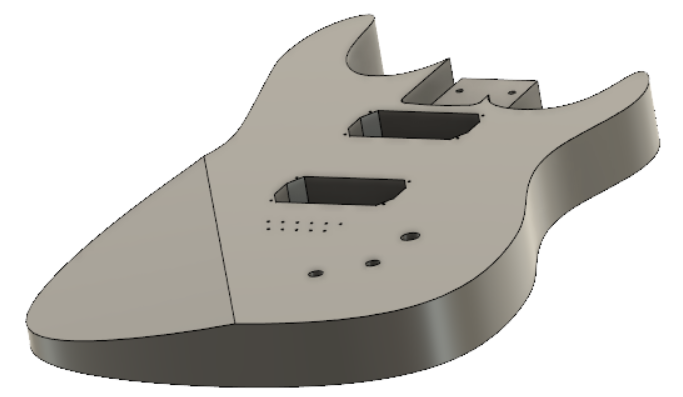
1. Here’s the same sketch from a different viewing angle.



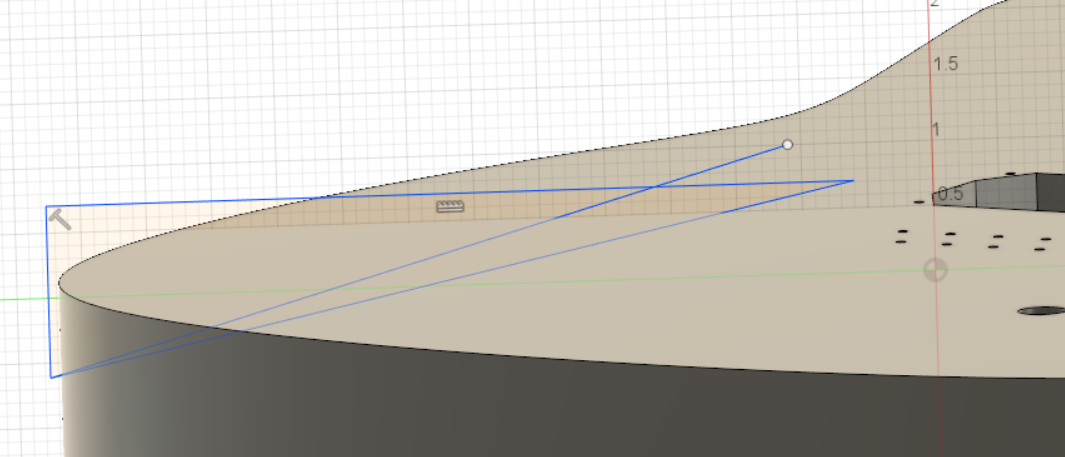
1. Now you will extrude this triangle sketch. You want to set it up to cut material both directions from the sketch plane.



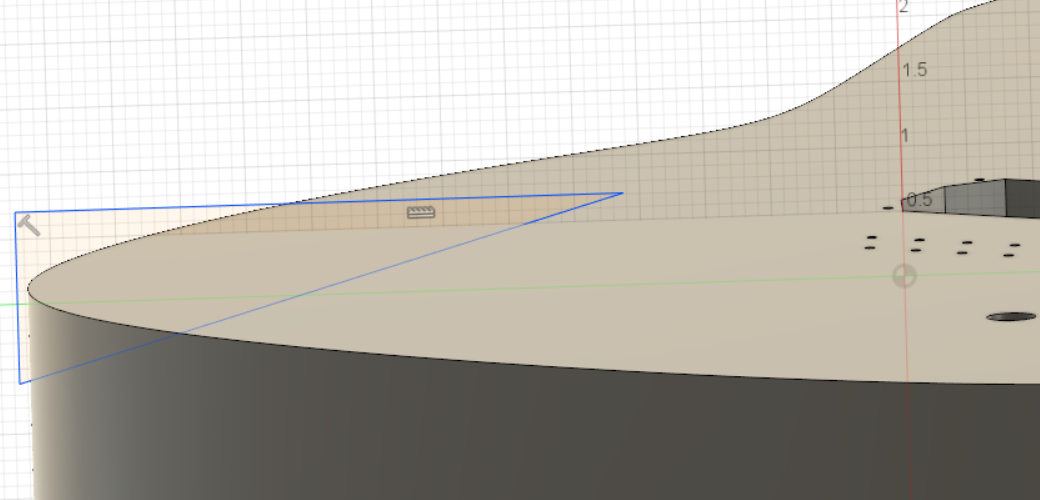
1. It is apparent that this armrest cuts too much material away. We’ll have to edit the triangle sketch to cut away less material.



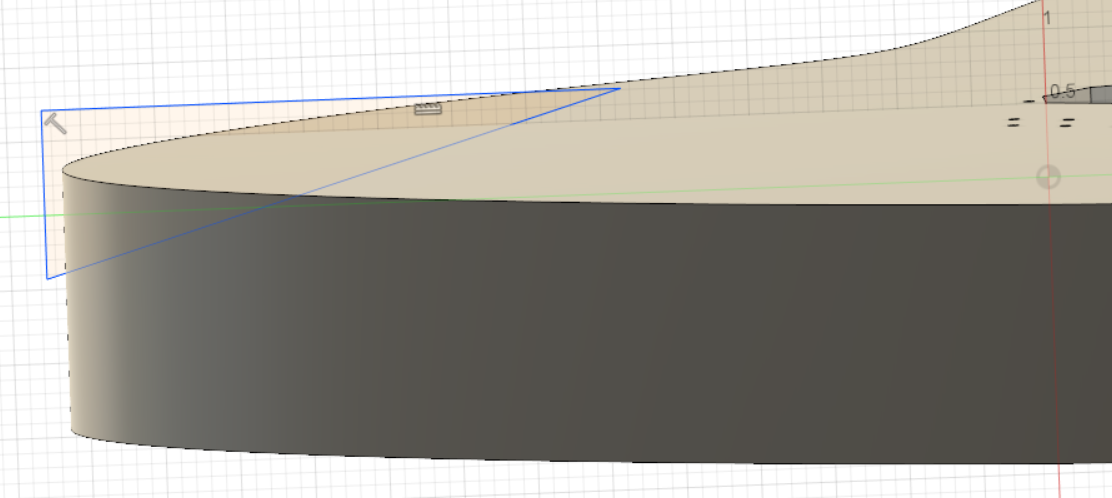
1. Draw a new angled line for the triangle.



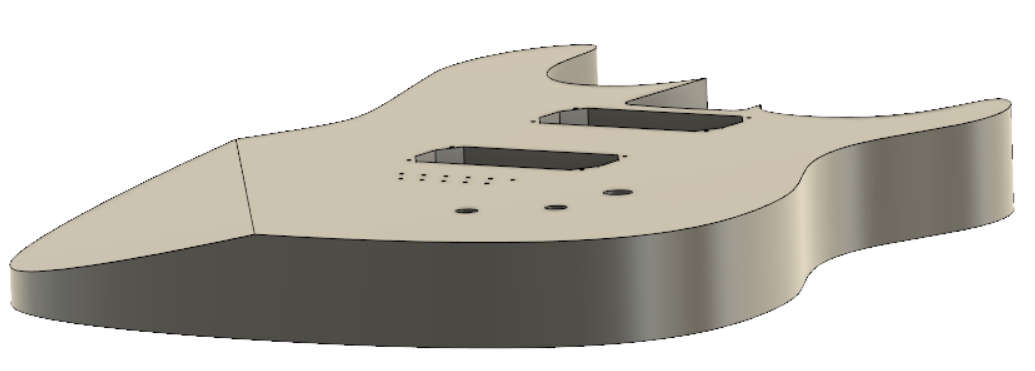
1. Now use the TRIM tool to snip away the unneeded lines to leave three lines. Here’s the triangle after trimming:

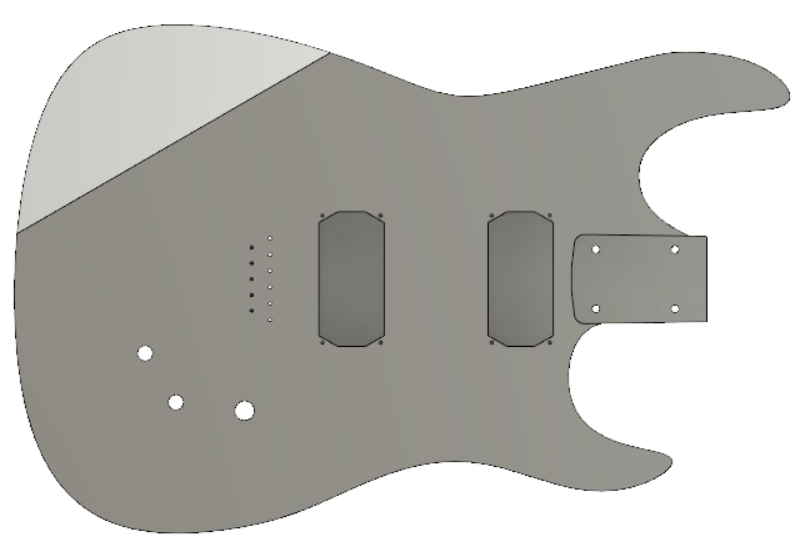


And after another attempt, making the triangle smaller again:



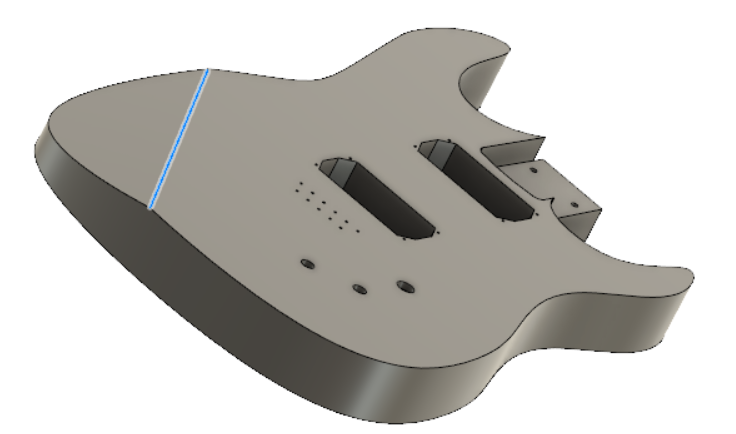
1. After you close the sketch, here’s the result:

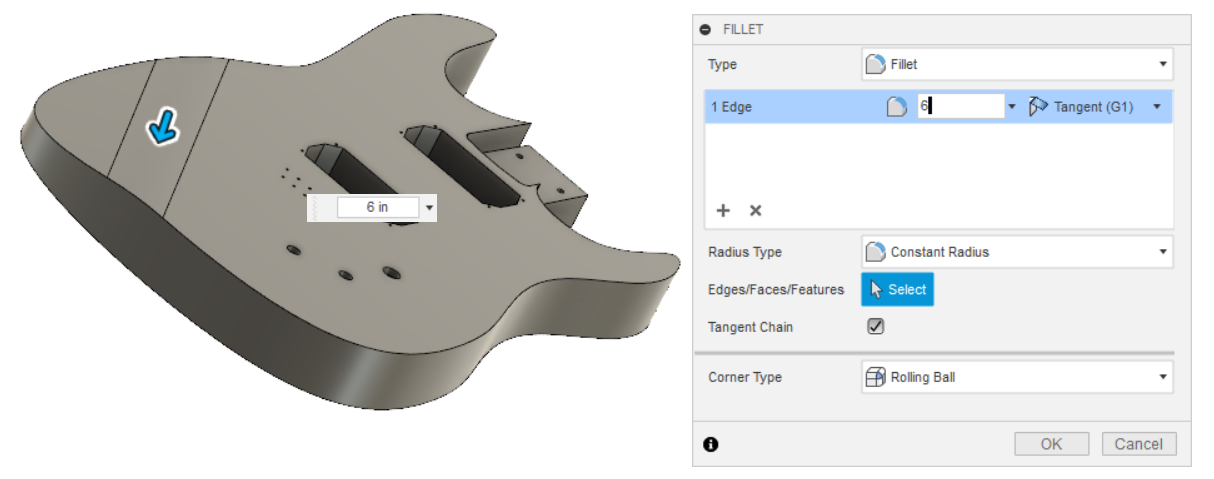




1. What is needed now is to smooth the sharp angle between the arm rest and the flat top of the guitar body. Use that sharp edge for the FILLET command.

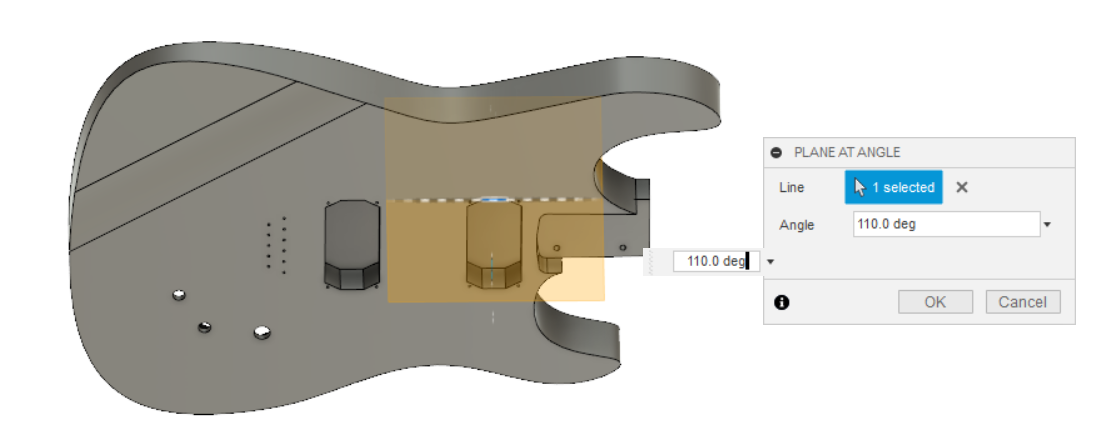


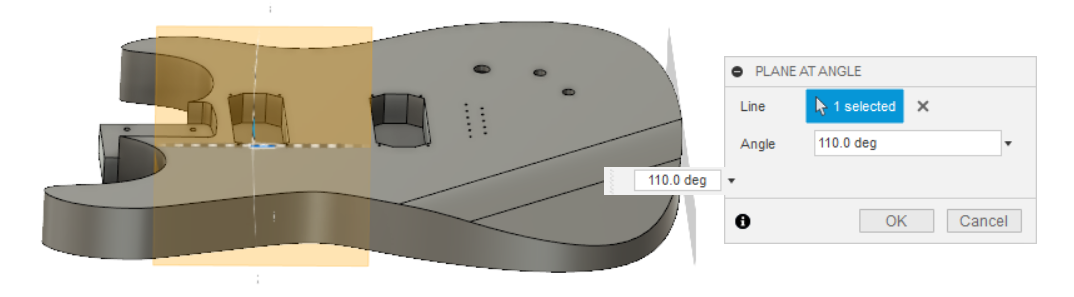
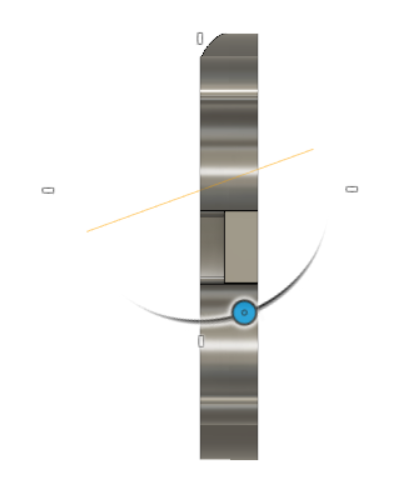


A fillet radius of 4 to 8 inches is useful. This example uses six inches.

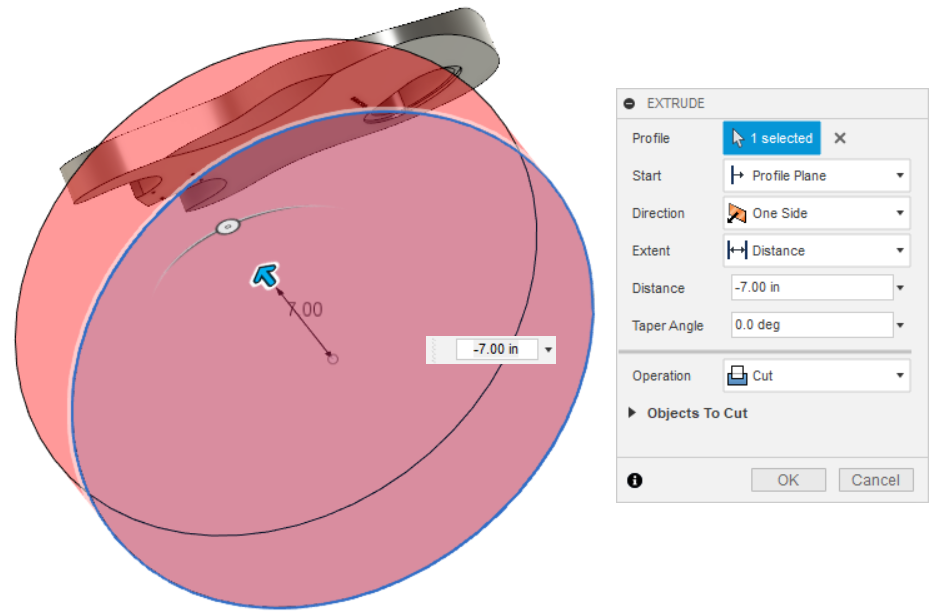
Now for the tummy relief cut…

1. In the Construct menu, choose Plane at Angle. When prompted for a line, choose something that will remain fixed. In this case, the edge of the pickup pocket parallel to the center axis of the body will work fine.



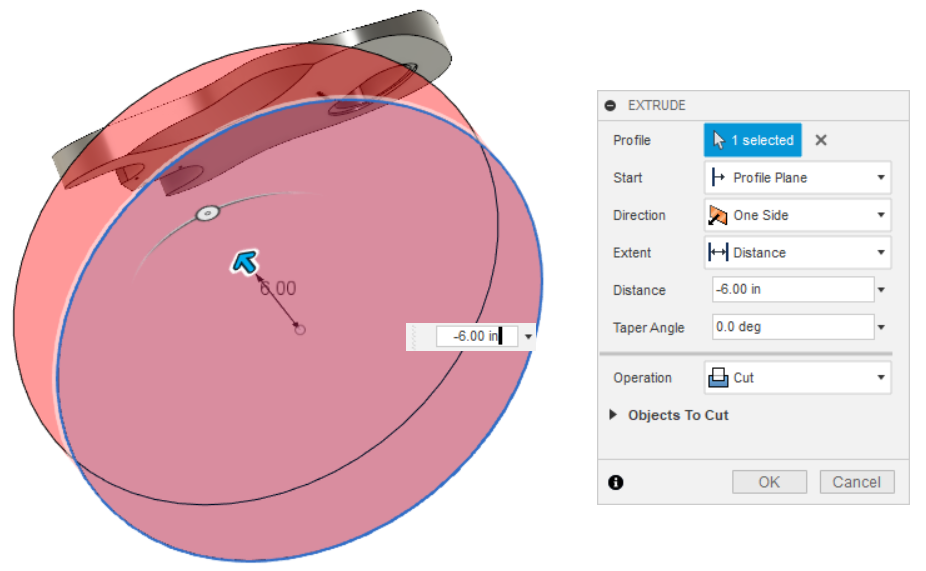


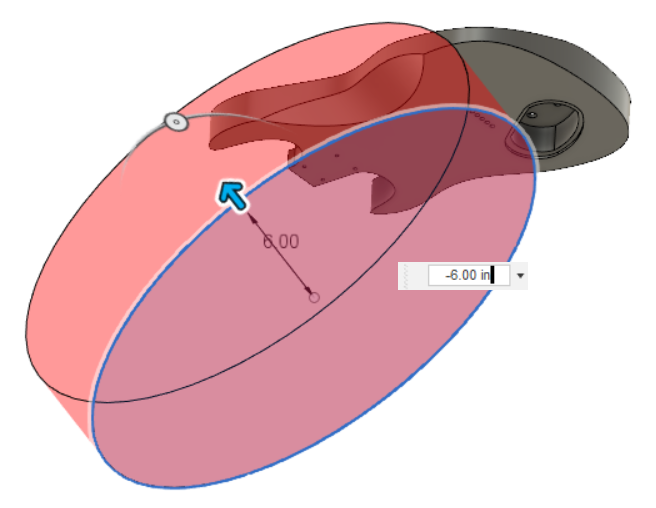
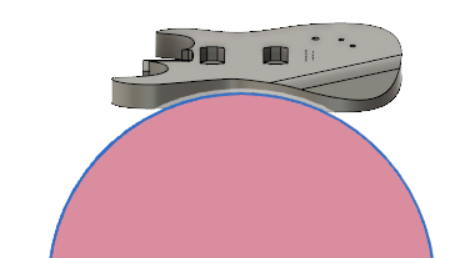
Once you have created your plane (and remember, you can always tweak the angle later) now it’s time to draw a very large circle or ellipse in the new sketch. (This circle is 26” in diameter.) The idea is for the very edge to clip the back of the body. You can drag to resize the circle, and you can also drag the center point to change the location.



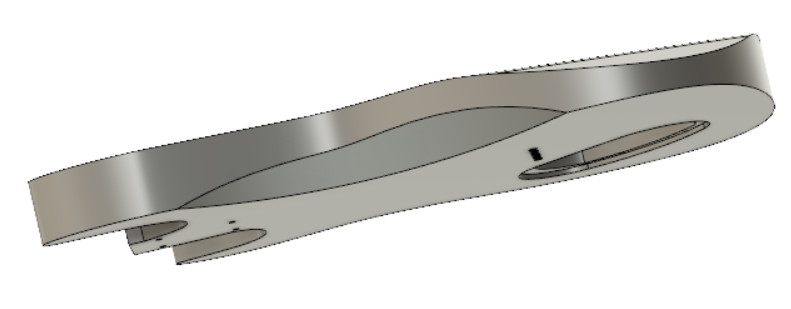
You can start the Extrude command and inspect the preview. If you don’t like it, you can cancel, and edit the sketch to relocate the center point, or to alter the diameter of the circle. It may take several false starts before settling on a location and size that you think you want to keep.

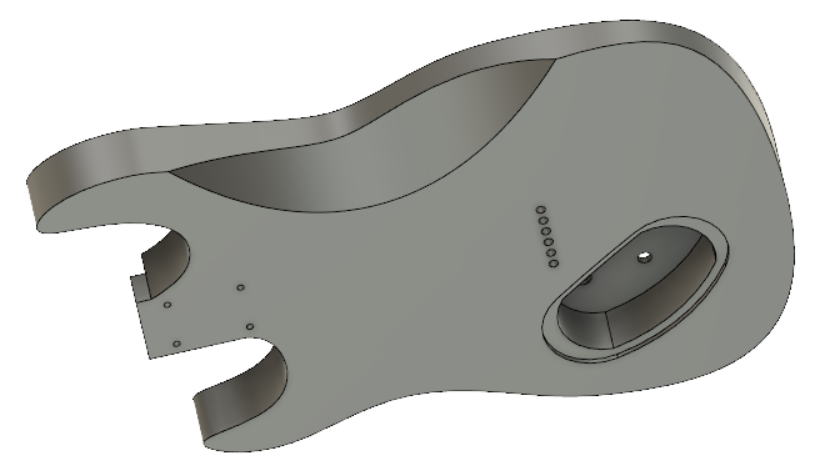
This extrude preview has a resized circle and will make a larger cutaway than the previous preview.

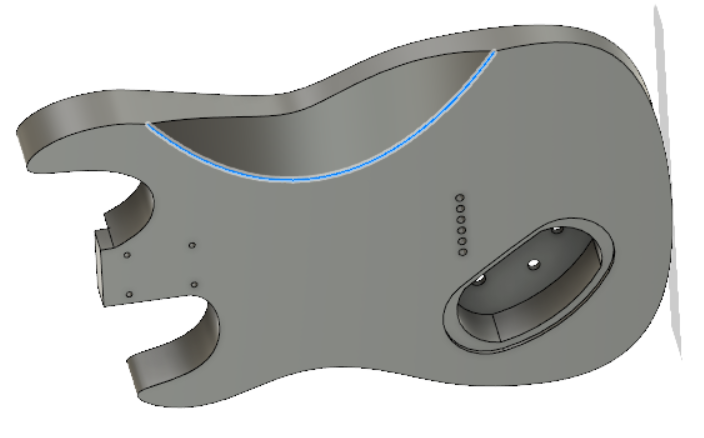




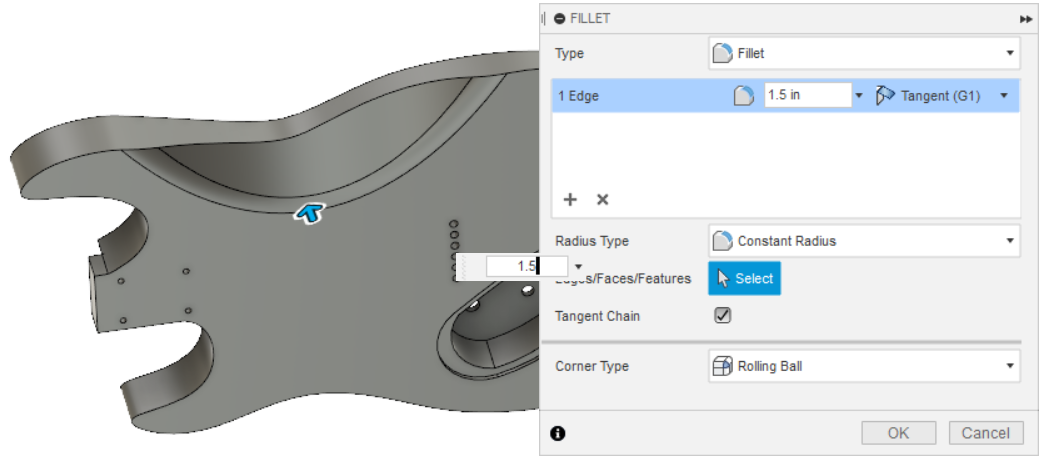
The completed tummy cut:



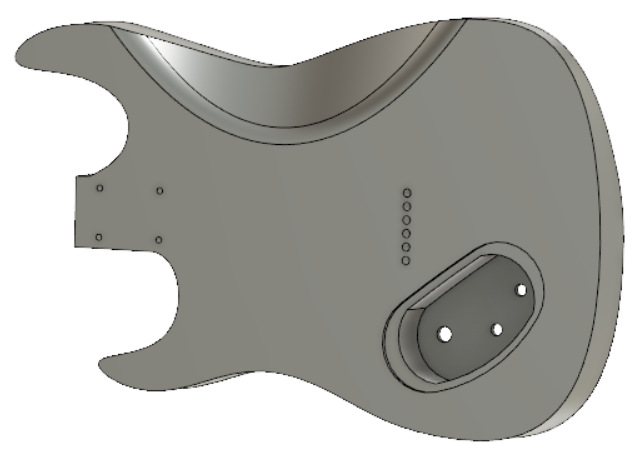
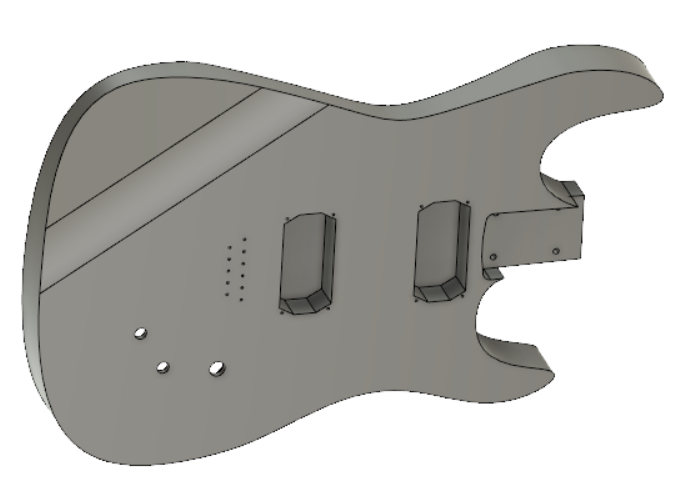




Select the edge where the tummy cut meets the back of the body.

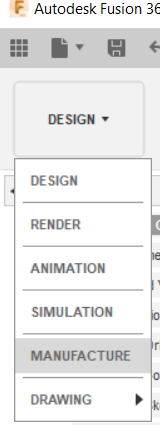


Create a Fillet of somewhere between 1 to 3 inches. This fillet has a 1.5 inch radius.

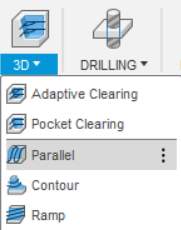


This concludes the guitar body design.

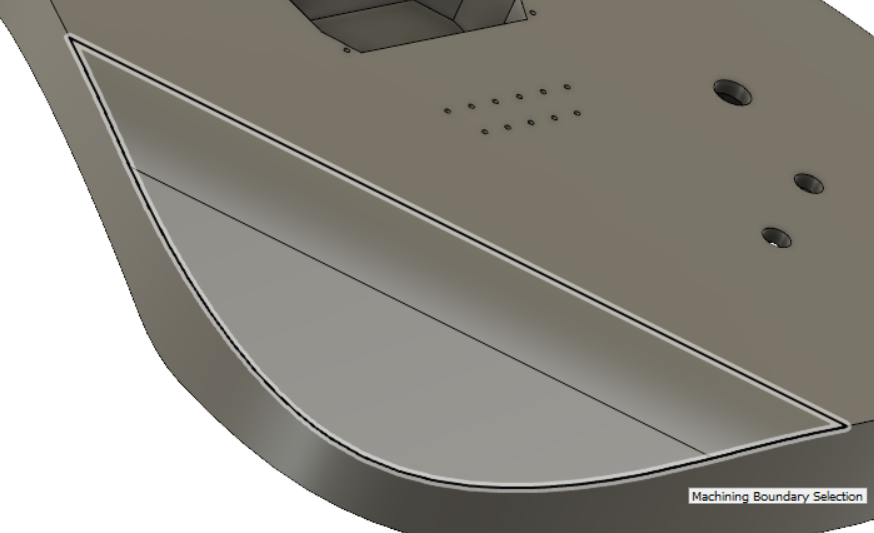
NOW TO PROGRAM THE TOOLPATHS…

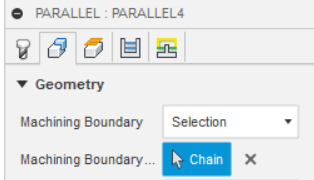
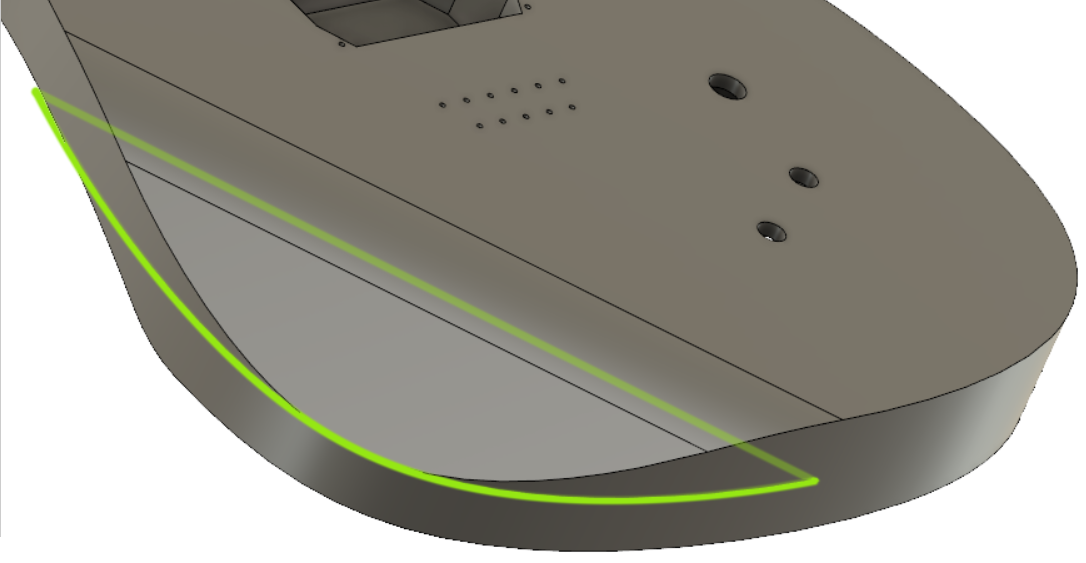
To begin programming machining toolpaths for cutting your body shape on the CNC machine, click the “Manufacture” tab under the “Design” button.

Select “Parallel” toolpath creation from the 3D menu



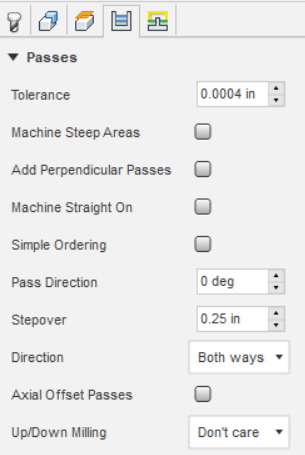
Select the edge of the armrest contour

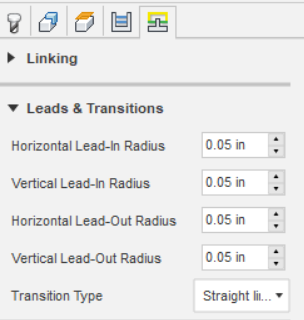




After clicking the edge, you will see the perimeter for this geometry shown in green.

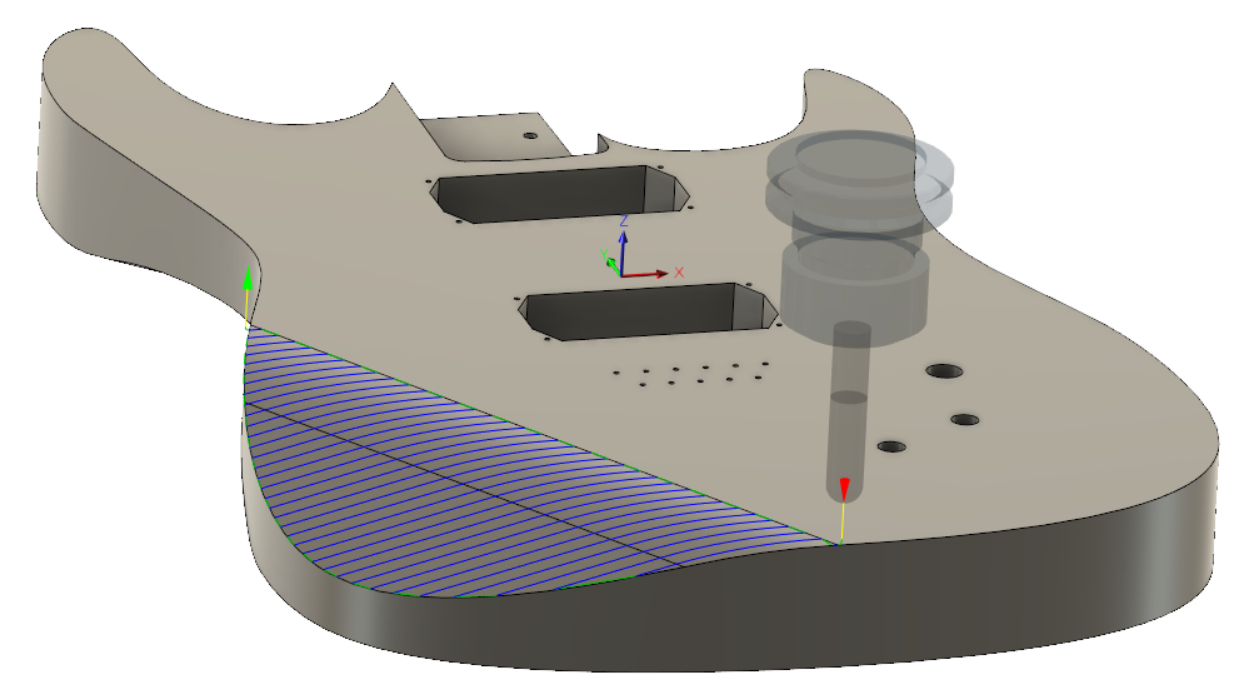
On the passes tab, set Stepover for the radius of the router bit.



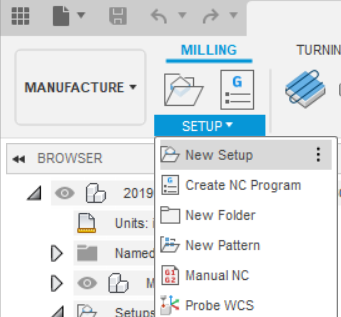


On the linking tab, choose “Straight Line”

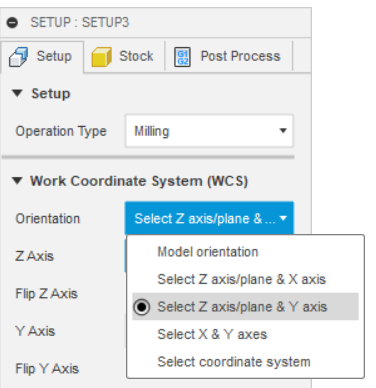
The machining preview will look like this:



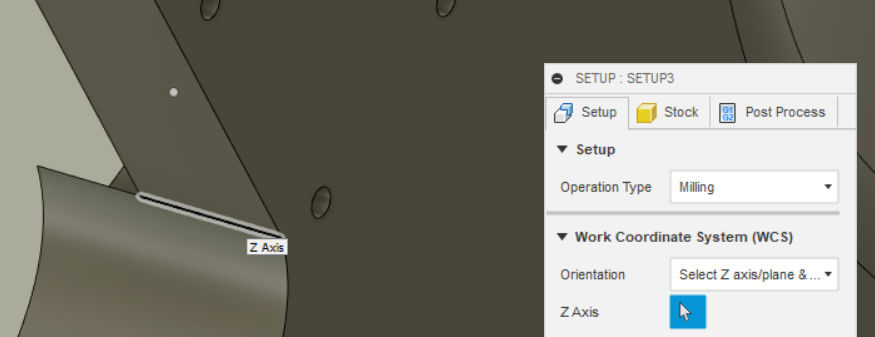
<next step set up another axis system for machining the rear contour.>

Now to program for cutting the back…

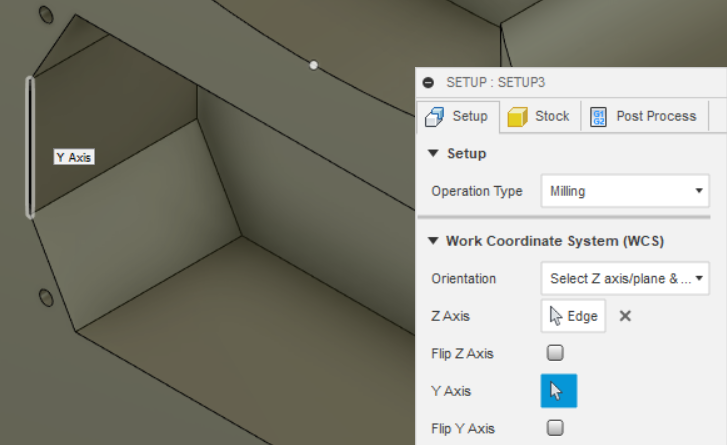
First, we need to create a new setup for the back. Click on the setup tab under the milling area and choose “New Setup.”



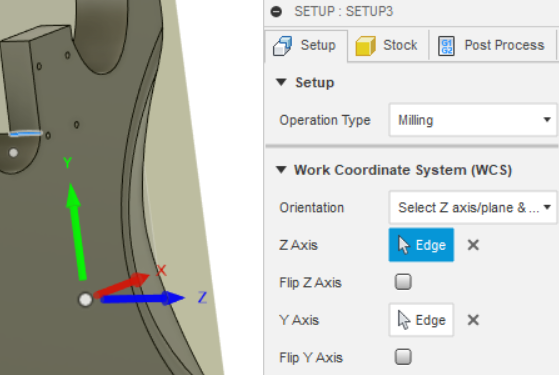
The first thing to do is set up the WCS or work coordinate system. Instead of the defaul Model Orientation, choose Select Z axis & Y axis. (You could work the the Z and X axes also.)



With the WCS orientation selected, it’s time to choose Z and Y axes. Find an edge to define the Z axis. I chose an edge near the neck pocket area.

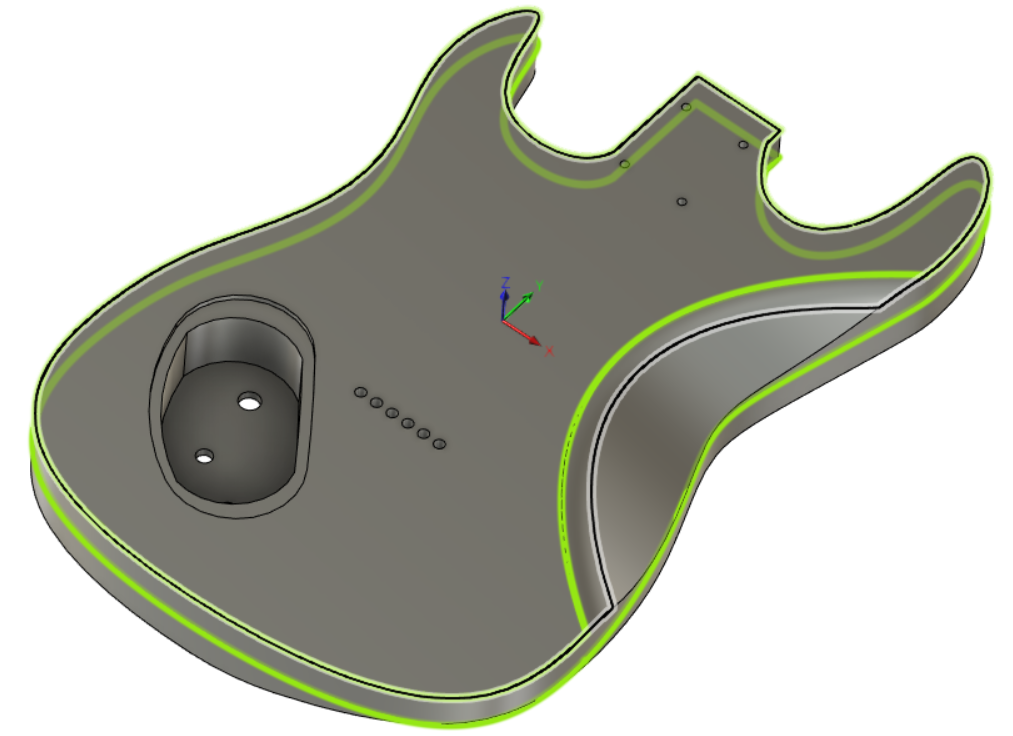
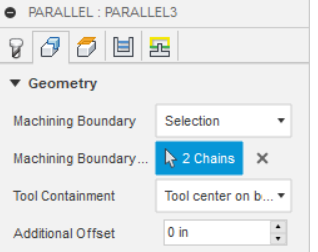


Because so little of the guitar body may run parallel to the three axes, I chose an edge off the pickup pocket for the Y axis.

After selecting both axes, you should have a WCS on the back of the guitar as illustrated. Examine the arrows for each axis. They should point in the direction of increasing value. If the axis is oriented the wrong way, you can click Flip Z Axis or Flip Y Axis to reverse the orientation as appopriate.

With the WCS established, you may now create toolpaths for machining various features on the back of the guitar.

Setting up the rear contour is much like setting up the toolpath to cut the front contour. Two chains define the machining boundary. Select the edge where the fillet meets the back of the body for the first chaing. Select the perimeter of the body where the 3D contour meets the edge of the body for the second chain.



After programming the toolpath similarly to the front contour, you will have a machining preview for the rear tummy cut area, as illustrated.

