CNC Basics for Guitar Production

**Description of Activity**

* General description of activity.
* Include purpose statement.
* Please include subjects and/or grades that this activity is suitable for.

**Learning Objectives:**

**(List measureable objectives)**

1. Students will
2. Students will
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. |

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

[CCSS.Math.Content.HSF-IF.C.7e](http://www.corestandards.org/Math/Content/HSF/IF/C/7/e) Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.

[CCSS.Math.Content.HSF-LE.A.2](http://www.corestandards.org/Math/Content/HSF/LE/A/2) Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).

**Materials Required:**

* List any required materials needed for this activity here.

**Safety:**

**safetys:**

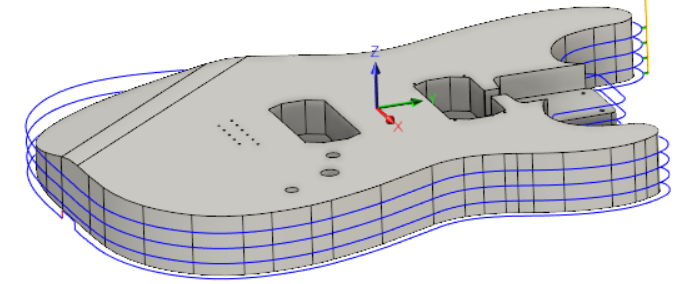
* List any safety equipment needed and discuss any safety concerns here.

**References:**

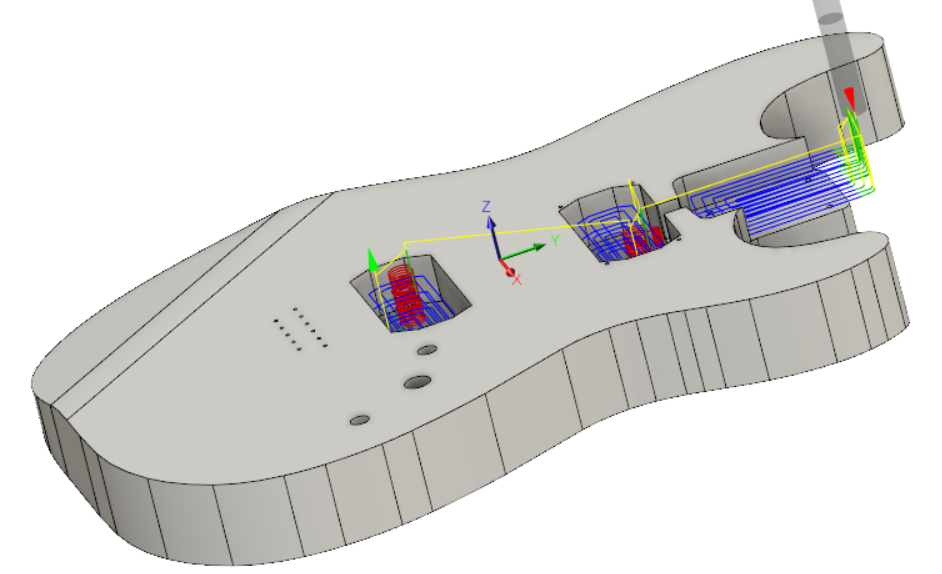
* Add any references or sites for further exploration here.

**Activity:**

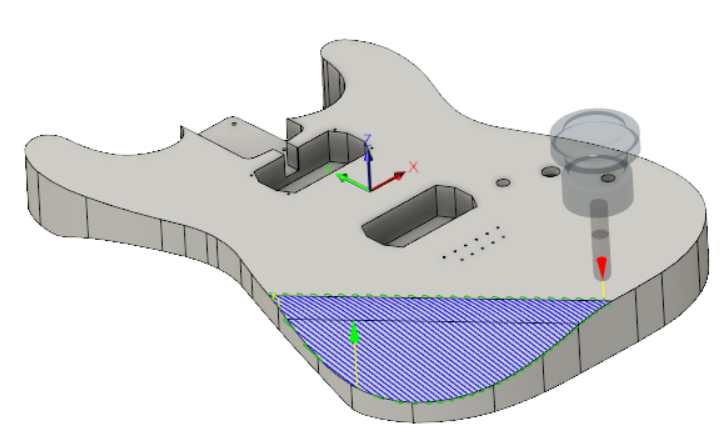
* Profile or 2D Contour – This is where a router bit cuts the wood along a 2D shape the width of the router bit. In guitars, this is the outside perimeter of the body shape. Because it follows a 2D shape, and is cut to a fixed depth, this is referred to as 2.5D. Cutting is typically performed with a straight router bit. Profiles can be cut on the outside of the vector line, inside, or split the difference with the center axis on the line.



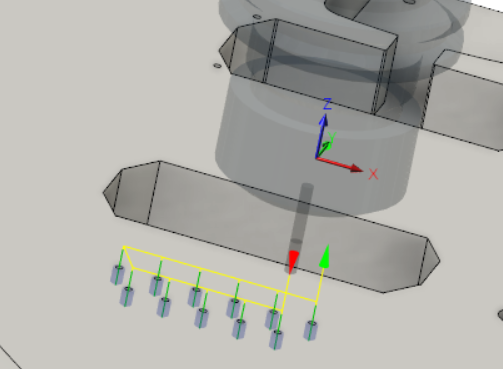
* Pocket – This is where a router bit cuts away an interior area larger than the diameter of the router bit. In the Stratocaster example shown, three pockets have been used: a shallow pocket for the cover plate, a deeper pocket for the tremolo springs, and a third deep pocket for the sustain block. Again, because of fixed depths, this is also a type of 2.5D machining. This cut may extend all the way to the other side of the guitar if the router bit is long enough. This is typically performed with a straight router bit. Most pocket operations automatically run an interior 2D contour after the center area has been milled out.



* 3D Contour – This is where a 3D object is carved. Typically some sort of ball-nose or round-nose bit is used for creating these surfaces. Because depths all vary, this is considered true 3D machining.



* Drilling toolpaths – As the name suggests, a cutter is plunged at a given set of coordinates and then retracted.



* Straight cutters. These are often ¼, 3/8, or ½ diameters. There several cutter types:
  + Straight: where the cutting edge is parallel to the center axis
  + Skewed: the cutting edge is almost straight. It curves slightly around the perimeter of the router bit, maybe an angle of a few degrees looking straight at the end of the bit.
  + Spiral, down-cut: The flutes wrap around the diameter of router bit. The chip is pushed down toward the table surface. This has a tendency to push the workpiece into the table. The top surface will be an extremely clean cut with very little fuzz or tearout.
  + Spiral, up-cut: The flutes wrap around the diameter of the router bit. The chip is raised up to the top of the workpiece. This clears the groove rather than pack it with dust. Thinner workspieces may tend to raise off the table and require vacuum hold-down. Top surface will have some fuzz and tearout.
  + Straight and skewed bits will typically come in 2-flute confgurations
  + Spiral bits will come in 2-flute, 3-flute, or 4-flute configurations. Spirals come in several different angles of attack.

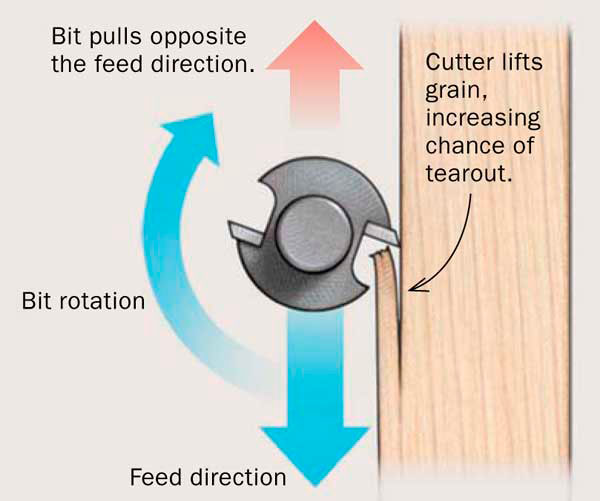
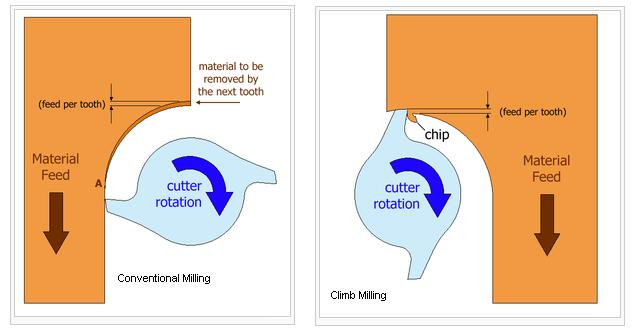


* + Materials for straight or skewed router bits are usually high speed steel with carbide cutters cemented on. The cutting edges are ground after being cemented to the high speed steel core.
  + Materials for spiral router bits will be high-speed steel (HSS) or solid carbide.
  + Compression bits are solid carbide down-cut bits except for the very end of the router bit which while have short segments of up-cut cutters ground in the carbide blank. These are intended for use with plywood in closed-loop servo CNC machines that can make a full-depth cut in one pass.

Preventing bit breakage

* Generally, depth per pass is the router bit diameter. So, a 1/2” diameter bit would have a depth per pass of 1/2”.
* Generally offset for clearing a pocket is half the router bit diameter. A ½” diameter bit would have a maximum offset of ¼” for each cut at a given depth.

Climb cut vs. Conventional Cut



Climb cut moves the router in a manner less likely to lift grain and result in splitting or tearout. Conventional cutting moves the router bit in a manner more likely to lift grain and cause splitting.

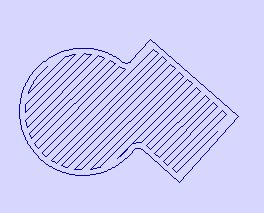
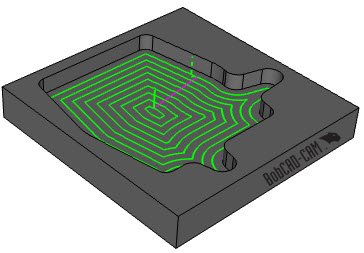
You should program pockets to machine climb cut.

Pockets: Offset vs. Raster

Pockets toolpaths can be calculated using two main strategies:

Offset starts in the center of the pocket, and circles progressively outward to the final size of the pocket.

Raster starts in one corner of the pocket and cuts back in for in straight lines to cut most of the pocket. A final pass cuts the final perimeter of the pocket.



Offset pocketing Raster pocketing

**Quiz:**

Quiz Questions

1. \_\_\_\_\_ This contour operation is for curved faces such as armrest detail.
2. \_\_\_\_\_\_ This type of machining is for things like body perimeter or flat-bottom pockets.
3. \_\_\_\_\_\_ This type of router bit leaves a clean top surface cut.
4. \_\_\_\_\_\_ This type of cutting method is less likely to cause wood grain to split.
5. \_\_\_\_\_\_ This type of toolpath creation strategy starts in the middle of a pocket and works outward until the final perimeter.
6. \_\_\_\_\_ This type of router bit would be used for cutting a carved 3D feature such as an armrest.
7. \_\_\_\_\_

Word list (more words than questions, that’s on purpose.)

1. Offset
2. Raster
3. Ball Nose
4. 3D
5. 2.5D
6. Down-cut
7. Up-cut
8. Conventional
9. Climb

* Include at least 10 quiz questions with answer key. (Questions must be Multiple Choice, and/or Matching).

**Reviewing Faculty Cohort Members:**

* Include at least two names and schools of reviewing faculty cohort members (refer to email list for faculty cohort member email addresses).