LESSON 7	Penny Whistles

Wind Instruments

In this project, you will produce a functioning wind instrument by uniting two strategies:

- You will drill finger holes into a PVC pipe to produce the barrel.
- You will use CAD to model and then 3D print the mouthpiece.

Separate from each other, the two parts don't offer much. But connected together, you have a musical instrument that can produce all of the notes in a scale (in the case, a D scale).

Recommended age range 10+
Category: Beginner lesson
Tags: 3D CAD, 3D printing, 3D printed, beginners, design, education, music, whistle
Software: Fusion 360
Lesson Duration: One 45 minute classes (additional time to print)
Estimated filament use (per person): ~0.82m/~6g

Lesson resources include:

- Lesson Overview
- Onesheet
- Walkthrough
  - Fusion 360
- Resources
  - D Whistle Template
- Example STL files
  - STLs
  - Code/CAD files

Objectives

- Produce a digital model
- Understand how to control pitch
- Design and measure with precision
- Understand Components
- Understand sketch dimensions

Background - Penny Whistle

This lesson is derived from a project by Jay Brockman, Associate Dean of Community Engagement and Experiential Learning and Associate Professor in the department of Computer Science and Engineering and department of Electrical Engineering at the University of Notre Dame.

Penny or **Irish whistles** produces sound waves at a given pitch when a vibrating stream of air resonates inside a tube of a specific length. What distinguishes a penny whistle from other types of flutes is its use of a **fipple** to produce the vibrations.

Background - Fipple

A fipple is part of the mouthpiece. It is the the blade like structure inside the pipe below the mouth hole. When you blow through the mouthpiece, a stream of air is moves through a channel that is cut by a blade. This structure allows a thin sheet of air to pass beneath the blade. The fipple makes it easy for the player to set up the vibrations, but gives the player less control over shaping the note.

Below is an animated GIF of a fipple producing vibrations:

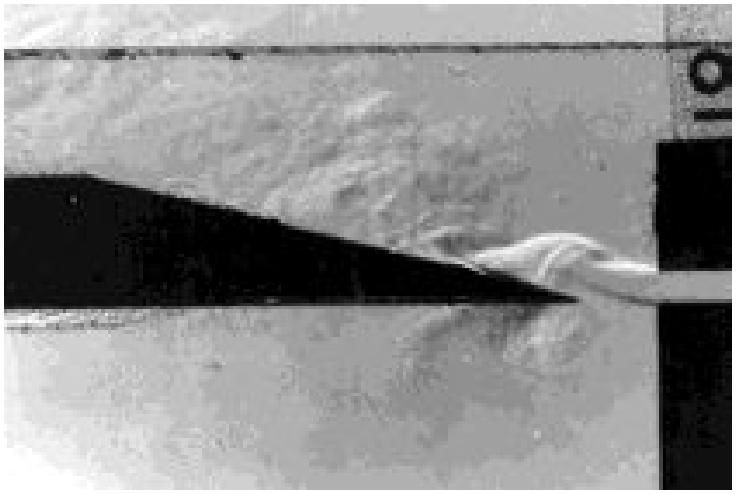


Image from [flute-a-bec.com]

Penny Whistle: Bill of Materials (BOM)

Per student

1. One piece of 1/2" schedule 40 PVC 240 mm long (from Amazon)

Per classroom

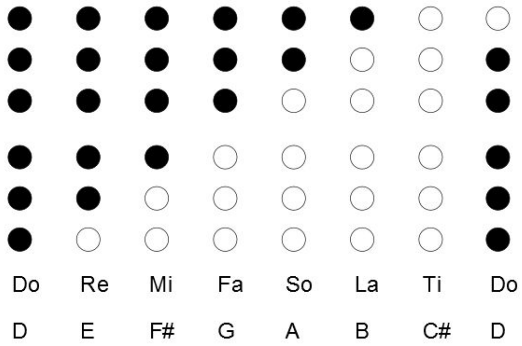
1. Saw to cut PVC (from Amazon)
2. Vise to hold PVC (from Amazon)
3. Drill bits less than or equal to 1/8"
4. A hand drill

Understand how to control pitch

The pitch or frequency of the note produced by a whistle depends on the tube length. Shorter tubes produce higher frequencies because the frequency is proportional to 1/(tube length).

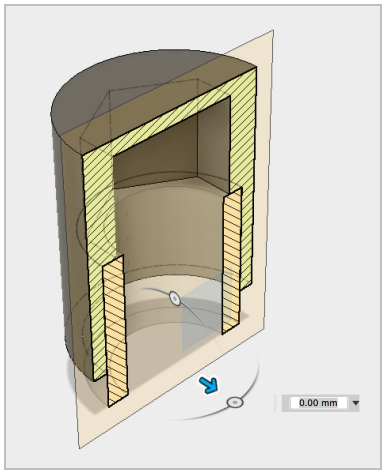
By drilling holes into the tube, you shorten the tube, which raises the pitch. Print out Whistle D.pdf and wrap the sheet around the pipe. Drill holes where indicated.

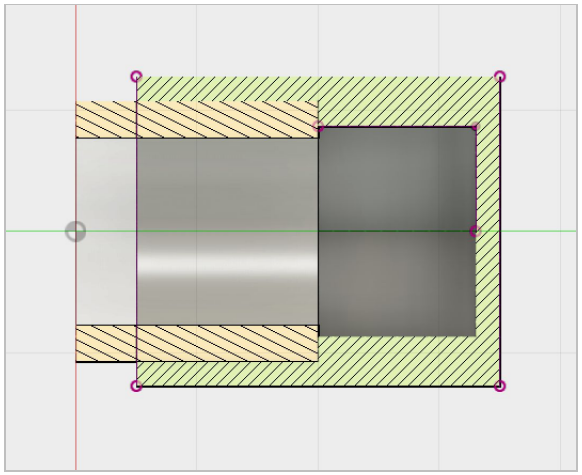
By strategically placing the holes and covering them with your fingers, you can create an instrument that can play the notes of a scale. A traditional Irish Penny Whistle has 6 holes tuned to play a D major scale.

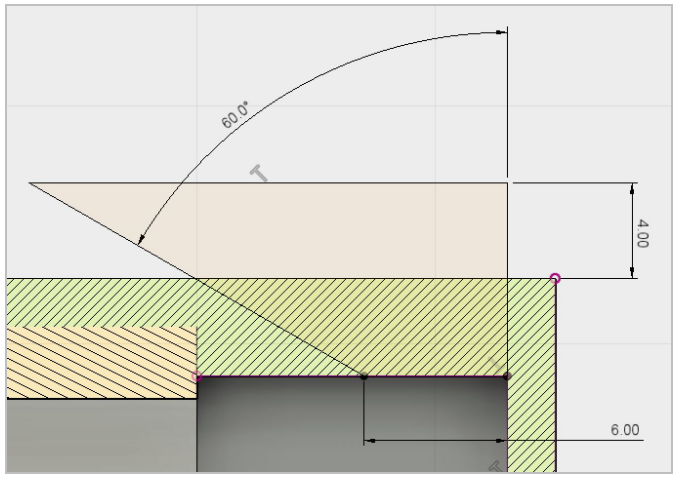


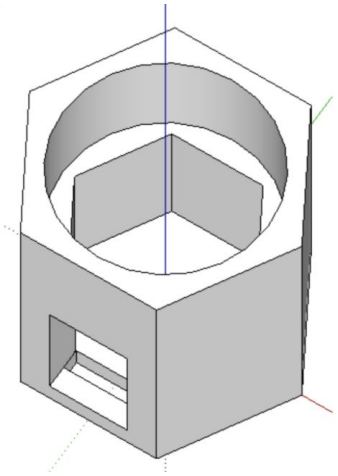
Understand a model

Here are some images of the mouth piece's interior:









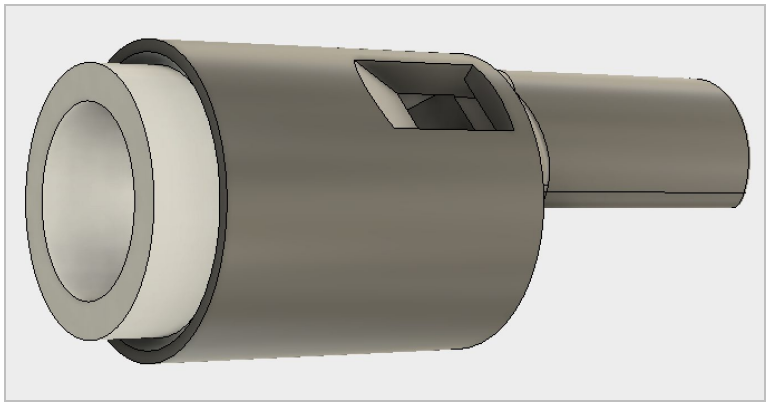
Adding fipple to barrel, you complete a mechanical, musical machine.

Measure with precision

To fit the two parts together, the inner diameter of one part must be bigger than the outer diameter of the other part. A difference in diameter of 0.8mm to 1 mm will generally allow for movement—you should be able to rotate the interior part freely. For press fit parts, you can start with 0.2 mm-0.4 mm and then test fit.

- This project uses a PVC pipe with an outer diameter of 21.45 mm.
- A hole of 21.7 mm will fit snugly over the PVC pipe.

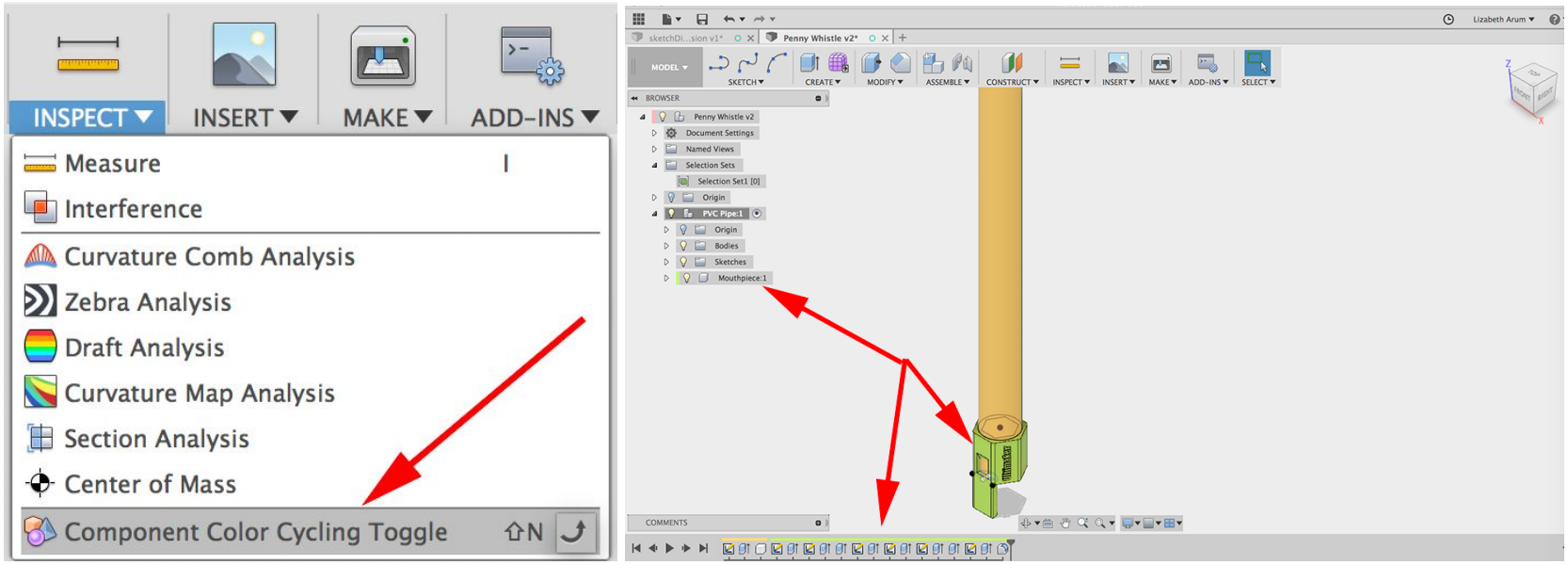
Remember: Parts which have the same inner diameter and the outer diameter will not fit!



Understand Components

A **component** in Fusion 360 is a container for bodies, sketches, construction objects, etc. that defines a single part. Each component has its own timeline.

A component can also contain other components. You can drag one component into another component in the browser to create a subassembly. Under the **Inspect** menu there is an option to color the components. This is helpful for quickly identifying components:



Understand sketch dimensions

When you apply **sketch dimensions** you can define lengths, angles, radii, diameters, etc. By adding dimensions, your sketch elements will maintain the specified sizes and relationships when other your geometry updates.

To add a dimension, select the target geometry, and then click a point on the canvas to place the dimension. Enter a numerical value, completed by pressing **Enter**.

The most important aspect of specifying dimensions is that by doing so you produce a parametric object, meaning that you can control and update the sketch geometry at any time by changing dimension values.

For example, you can change the length of a rectangle by selecting a defined length dimension and entering a new value. Once you press **Enter** the other dimensions are adjusted.

Understand sketch dimensions

Dimensions keep sketch elements the proper size and position, and allow for extended control over the model geometry. And because each dimension is parametric, these defined values can be updated at any time, allowing a designer to change elements of the model to suit new requirements and functions as desired.