

Lab 7M - Flute Construction

Goal: To construct the flute that was designed in the previous lab session.

Materials Needed: FLUTE.XLS spreadsheet, PVC pipe and coupler, 7/8" dowel, drill and bits, file, sandpaper, chisel, hammer, pencil, ruler

The tasks that have to be done include:

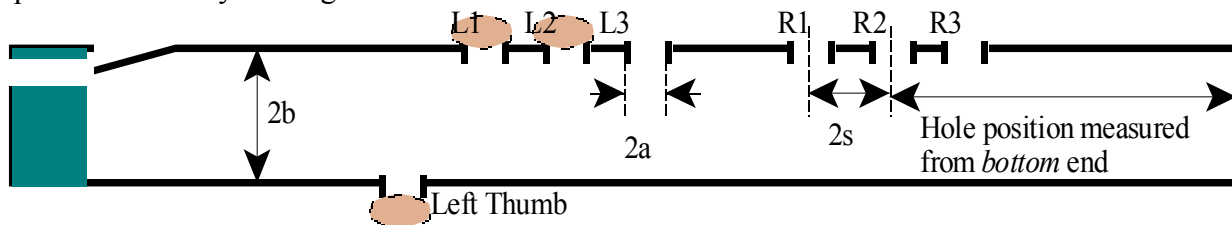
1. Cutting and trimming the raw tube;
2. Marking out and drilling the holes;
3. Making the mouthpiece windway;
4. Determining the mouthpiece correction length, and trimming the tube to size;
5. Filing the tone edge; and,
6. Finishing up.

These steps do not have to be done in this order. Because we have to share tools, you should look about you to see which task is open to you at any time. Accordingly, all the construction steps will be reviewed at the beginning of the period. WHEN WORKING WITH POWER TOOLS AND SHARP OBJECTS, IT IS IMPORTANT TO FOLLOW ALL SAFETY RULES, AND TO PAY CAREFUL ATTENTION TO YOUR WORK. WEAR SAFETY GLASSES!

Procedure

1. Determine the overall length of tube you will need, based on the formula $\lambda = c/f$, and the idea that a flute approximates an open-open tube (i.e., its length $L = \lambda/2$). This will be longer than we'll actually need, which will give us some leeway to work with. Consult your spreadsheet and make sure that this length is correct. Cut a piece of CPVC tubing, 3/4"CTS, to this length. Determine which end will be the bottom end, then file that end so that it is "square" and its corners are not sharp.

2. Set the tube up against the edge of a board, so that you can draw a straight line with a pencil along the length of the tube. This will be the top, where the finger holes will go. Consult your spreadsheet for the finger hole locations, and mark their locations along the line drawn on the flute, measuring from the bottom end. At this time, you should also mark in the hole sizes next to each location. Then, decide whether you want any holes moved off that top line; as long as they are the correct distance from the bottom end, it doesn't matter what side of the flute they are on. *If you have a thumb hole, it will be on the bottom or back side, of course.* Try out your placement with your fingers.



Put the tube gently into a small vise; close it enough that it holds the tube firmly, but not so much that the tube is distorted. Put the vise on top of a wood board, to protect the table top. Use a small point to prick an indentation in the correct position for each hole, to help get the holes started. Now, double-check, and triple-check, the hole positions and hole sizes. Then, find the hand drills that have been outfitted with the appropriate sizes, and drill through. Be careful to drill straight and not at an angle, and avoid letting the drill slip. **DO NOT DRILL THROUGH THE OPPOSITE SIDE OF THE TUBE!**

3. The mouthpiece consists of a plastic coupler and a piece of wood dowel. The coupler has already had a slot machined into it; for your next flute, you can do this yourself with a little cutting and filing. The wood dowel just fits into the end of the coupler. We need to make a windway that will carry air from your mouth through a channel, into the slot, and onto a sharp tone edge on the flute body. To do this, clamp the wood flat onto the edge of a board, then use a chisel and hammer to take off a little of the round edge and make it flat. The width of the flat should end up being about the same as the width of the slot. The less wood you remove, the smaller the channel will be, and the quieter the flute will be. The more wood you remove, the bigger the windway, and you'll run out of air more quickly. Since it's easier to remove wood than to put it back on, don't take off too much at first. Try to make the flat portion as uniform as possible. You can finish off by unclamping the wood and sanding the flat over a piece of sandpaper. Insert this into the mouthpiece, so that the windway is lined up with the slot.

4. The mouthpiece end will not be perfectly open, so there will be a length correction here, as well. Unfortunately, this can never be calculated exactly. Estimate the area of the open slot of the mouthpiece, when in is in place on the tube (area of rectangle = width x height, in cm^2), then enter this in the Embouchure hole of the spreadsheet. The spreadsheet will calculate the Equivalent Length, which is the length correction for the mouthpiece. This length would get subtracted off the total length of the instrument (Cell K15, under New Hole Position for the bottom of the instrument).

Before you actually cut your piece, though, try this out on a scrap tube. Make sure that with all holes closed, it will play the right pitch. Either record into Audacity and measure the frequency using Analyze | Plot Spectrum, or check the pitch with tuner.

If L is the nominal length and S is the number of cents flat your actual tube plays, then the amount to cut off is $(0.00059463 \times L)$. Or, if L is the nominal length, F is the desired frequency, and dF is the number of Hz flat it plays, then cut off $(dF / F) \times L$.

5. Once you think you have the right tube length, and have marked it, then cut the top end of the flute. Cut just a little above your mark, so that you can file it down to size. Then, on the top of the flute, in line with your long mark along the top, file the edge of the tube at about 30 degrees above horizontal. This will become the edge where the tone is actually produced. It needs to be clean and rather sharp.

6. Finally, use sandpaper to gently erase all your marks on the outside. You should also gently round the corners on the finger holes, so that they are just smooth to the touch, but avoid taking off too much material. Clean off any burrs inside the finger holes, as well. CAUTION: when sanding, you should go outside, and you should breathe through your nose, and you should keep your work at arm's length, because the PVC dust should be kept out of your lungs. If dust is a problem for you, you may skip this step.

Wash out any dust and particles from the inside and outside of the flute. Dry off the outside, then put on the mouthpiece. Find the best position of the mouthpiece that allows you to play both high notes and low notes with ease.

ENJOY!