

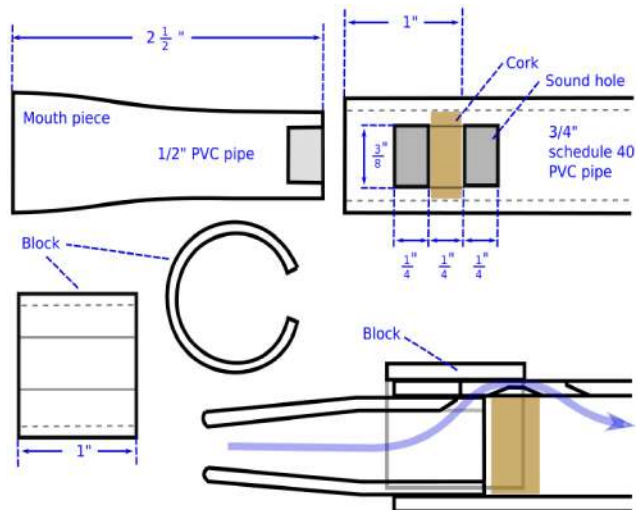
# MUS/COM/ELE 369G Technologies and Music – PVC Flute Project

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This is one of the options for the course project. The purpose is to design and construct a PVC flute. We use the  $\frac{3}{4}$  inch schedule 40 PVC pipe.

**Step 1.** Design your flute using the online tool at <https://www.flutopedia.com/naflutomat.htm>.

- Enter 0.78125 inch for the inside bore diameter.
- Select the key of the flute.
- Enter the 7 playing frequencies: the major scale.
- Enter 0.3125 inch ( $\frac{5}{16}$ "") for all the hole diameters.
- Enter 0.13 inch for the wall thickness at hole.
- Click "calculate." Adjust the individual hole size such that the distances between holes are reasonable. Use drill-bit diameters such as 0.375 ( $\frac{3}{8}$ "") or 0.4375 ( $\frac{7}{16}$ "").
- Write down the dimensions of the final design in the diagram in the worksheet on page 3.



**Step 2.** Use a hacksaw to cut a section of the  $\frac{3}{4}$ " PVC pipe with the length equal to the total bore length plus 1 inch. (If you choose the Chinese-recorder style without the mouth piece, do not add the extra 1 inch. See Alternative step 3 below.) Draw the locations of the sound holes as shown by the figure on the top. Use a rotary tool with a router bit to drill/cut the holes. Use a utility knife to trim and shape the sound holes and the connecting channel. Find a wine bottle cork that fits snugly into the PVC pipe. Cut out a disc with a width of  $\frac{1}{4}$ ". Use contact adhesive to glue the cork disc between the two holes in order to block the airflow.



**Step 3.** Make a native-American style mouth piece from a  $\frac{1}{2}$ " PVC pipe. Cut a section of 2.5-inch long. Use a heat gun to soften one end and insert about  $\frac{3}{4}$  inch into a  $\frac{3}{4}$  PVC pipe. Wear a heavy-duty welding glove. Cut a slot  $\frac{3}{8}$ -inch wide and  $\frac{1}{4}$ -inch deep. Use the heat gun to soften the other end (mouth end). Flatten it by hand (wearing a glove) to make it an elongated oval shape.

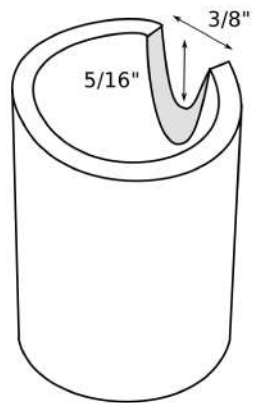


**Step 4.** Make a block for directing the air flow into the sound hole. Cut a section of the  $\frac{3}{4}$ -inch PVC pipe with a length of 1 inch. Open the ring with a longitudinal cut. Soften it with the heat gun and wrap it over a  $\frac{3}{4}$ -inch PVC pipe. Right before it cools down, take it off the  $\frac{3}{4}$ -inch pipe and slightly reduce the diameter. This will make the block clipping over the sound hole tightly.

**Step 5.** Now we check the key of the flute by use of a tuner. There are several free apps or programs you can download. For example, a shareware called “chromatic tuner” from <http://www.katsurashareware.com/> is free for 90 days. The note without any finger hole should be the tonic note (root note) of the key. If it's flat, you can cut off the end gradually to reach the correct pitch. But if it's sharp, there is not much one can do, because it's difficult to extend the pipe.

**Step 6.** Draw a centerline with a pencil along the body of the flute. Drill the finger holes using the correct drill bit size according the plan in Step 1. Test the pitches of the major scale and record the deviations in cents.

**Alternative to Step 3.** As an alternative, we can make a blow notch in the style of a Chinese recorder. Draw the outline of the notch to be cut away. On the outside, the opening of the notch is 3/8” wide and 5/16” long. On the inside, the opening fans out such that the air is directed downwards. Start with a flush cutter to chip away the materials. Use a utility knife and a round file to finish the work.



### Verification and Validation

In the development of a product, the verification and validation (V&V) process is used to meet the design specifications and to fulfill its intended purpose.

- Verification: Are we making the product right? (Emphasize the process.)
- Validation: Are we making the right product? (Emphasize the end result.)

“Measure twice, think three times, cut once.” Study the principle and the design of the PVC flute. Understand how to use the online flute design tool at <https://www.flutopedia.com/naflutomat.htm>. Tweak the diameters of the finger holes to achieve comfortable distances between holes. Write down the dimensions on a design diagram. Carefully measure and mark the total length and hole positions on the PVC pipe with a pencil. Verify the measurements before cutting and drilling. This can be done by double-check the measurements and/or compare your design to the demo flutes.

After the flute is made, validate the frequencies of the notes. Use a tuner to measure the note frequencies in terms of how many cents sharp or flat for each note. Enter the results in the worksheet.

### Grading Rubrics

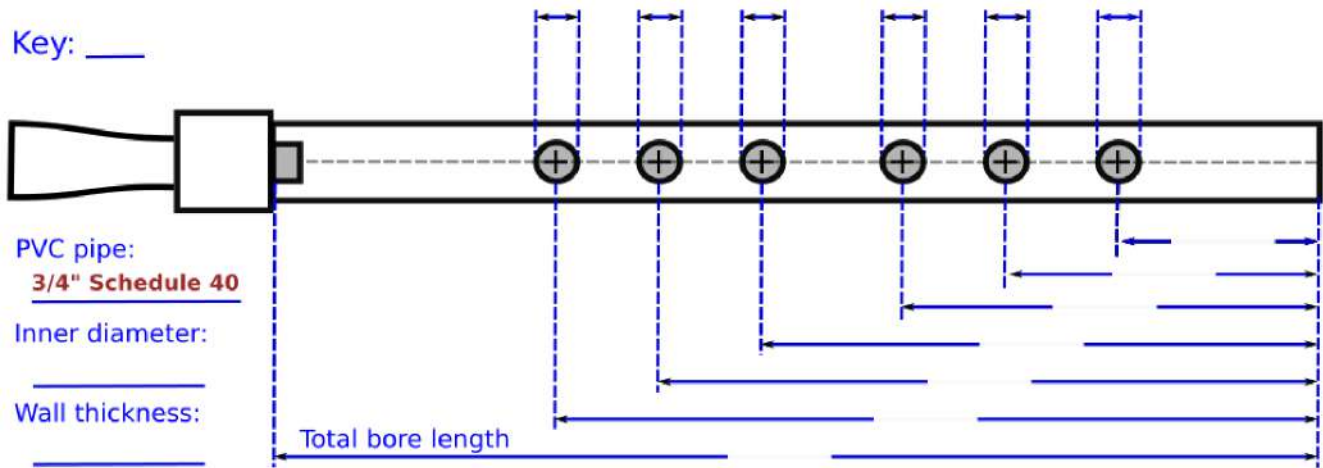
The project will be graded on the basis of the design that follows a verification and validation process (50%), the resulting note accuracy (25%), the craftsmanship and aesthetics (25%). The grades will be:

- 1) **100** – Exceptional.
- 2) **95** – Notes are relatively accurate; Edges are rounded and smooth, with a native-American style mouth piece; Parts are fitted tightly.
- 3) **90** – Notes are relatively accurate, with either a Chinese-recorder style blow notch or a native-American style mouth without a good fitting.
- 4) **85** – A basically functional flute.
- 5) **80** – A poorly functional flute.

# MUS/COM/ELE 369G Technologies and Music – PVC Flute Project Worksheet

Name: \_\_\_\_\_

Key: \_\_\_\_



PVC pipe:  
3/4" Schedule 40

Inner diameter:

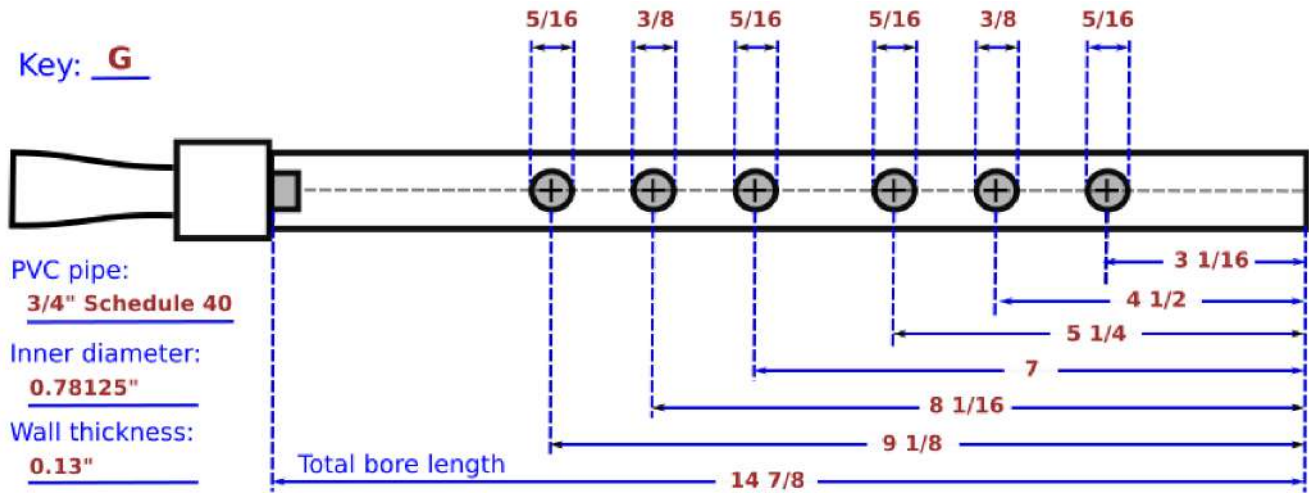
Wall thickness:

Insert the design table from <<https://www.flutopedia.com/naflutomat.htm>>.

Total bore length = _____ (Length in inch)							
Designated note	Frequency (Hz)	Hole distance from bottom	Nearest fraction	Resulting distance	Hole size	Actual frequency (Hz)	+/- cents

Insert a picture of your final product.

### Example 1 – a PVC Flute in the G Key



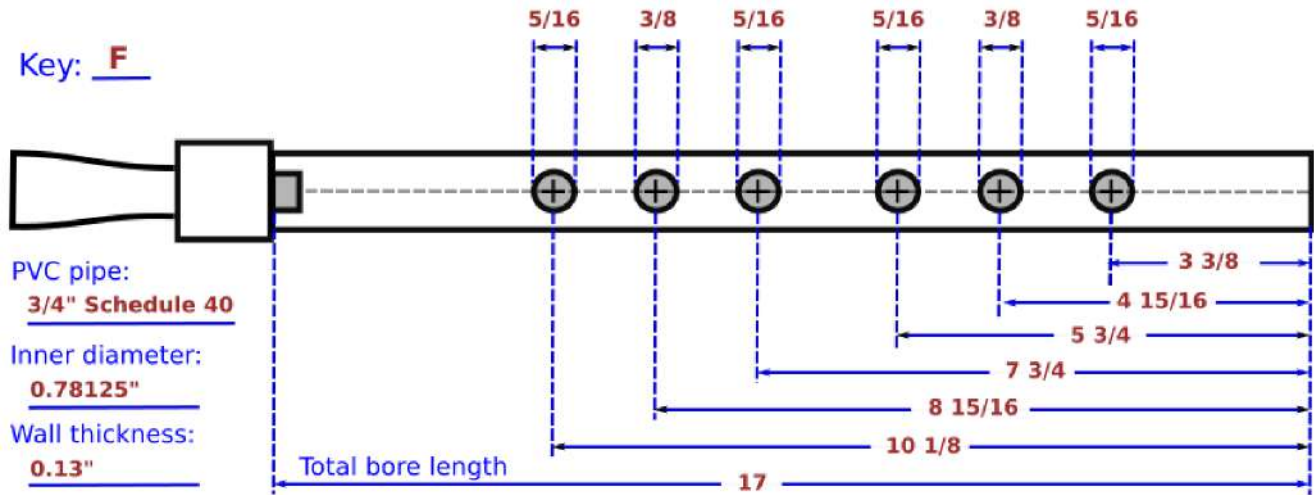
Insert the design table from <https://www.flutopedia.com/naflutomat.htm>.

Fingering	Playing Frequency (Hz)	Tuning Frequency (Hz)	Tuning Note	Hole Number	Hole diameter	Wall thickness at hole	Calculated dist. from end of flute	Calculated dist. between holes	
Total bore length:							14.85 in		
○○●○○	740	740	F#5 +0 cnts	6	0.3125 in	0.13 in	9.127 in	1.08 in	
●○○○○	659.26	659.26	E5 +0 cnts	5	0.375 in	0.13 in	8.047 in	1.06 in	
●●○○○	587.34	587.34	D5 +0 cnts	4	0.3125 in	0.13 in	6.987 in	1.773 in	
●●●○○	523.26	523.26	C5 +0 cnts	3	0.3125 in	0.13 in	5.214 in	0.727 in	
●●●●○	493.89	493.89	B4 +0 cnts	2	0.375 in	0.13 in	4.486 in	1.408 in	
●●●●●	440	440	A4 +0 cnts	1	0.3125 in	0.13 in	3.078 in		
●●●●●●	392	392	G4 +0 cnts	see Finger Hole Size for hole diameter colors (opens in a new window)					
KEY of FLUTE:		G4							Calculate
Total bore length = 14.85 (Length in inch)									
Designated note	Frequency (Hz)	Hole distance from bottom	Nearest fraction	Resulting distance	Hole size	Actual frequency (Hz)	+/- cents		
○○○○○○○	G5	784.00				791.56	+10		
○○○○○○○	F#5	740.00	9.127	9 1/8	9.125	5/16	742.10	+4	
○○○○○○○	E5	659.26	8.047	8 1/16	8.063	3/8	655.40	-10	
○○○○○○○	D5	587.34	6.987	7	7.000	5/16	584.90	-7	
○○○○○○○	C5	523.26	5.214	5 1/4	5.250	5/16	520.00	-10	
○○○○○○○	B4	493.89	4.486	4 1/2	4.500	3/8	490.80	-10	
○○○○○○○	A4	440.00	3.078	3 1/16	3.063	5/16	437.50	-9	
○○○○○○○	G4	392.00					388.80	-13	

Insert a picture of your final product.



## Example 2 – a PVC Flute in the F Key



Insert the design table from <https://www.flutopedia.com/naflutomat.htm>.

Fingering	Playing Frequency (Hz)	Tuning Frequency (Hz)	Tuning Note	Hole Number	Hole diameter	Wall thickness at hole	Calculated dist. from end of flute	Calculated dist. between holes	
							Total bore length:	16.973 in	
○○●○○○	659.25	659.25	E5 +0 cents	6	0.3125 in	0.13 in	10.166 in	1.227 in	
●○○○○○	587.33	587.33	D5 +0 cents	5	0.375 in	0.13 in	8.939 in	1.205 in	
●●○○○○	523.25	523.25	C5 +0 cents	4	0.3125 in	0.13 in	7.734 in	1.949 in	
●●●○○○	466.16	466.16	A#4 +0 cents	3	0.3125 in	0.13 in	5.784 in	0.828 in	
●●●●○○	440	440	A4 +0 cents	2	0.375 in	0.13 in	4.956 in	1.606 in	
●●●●●○	392	392	G4 +0 cents	1	0.3125 in	0.13 in	3.351 in		
●●●●●●	349.23	349.23	F4 +0 cents	see Finger Hole Size for hole diameter colors (opens in a new window)					

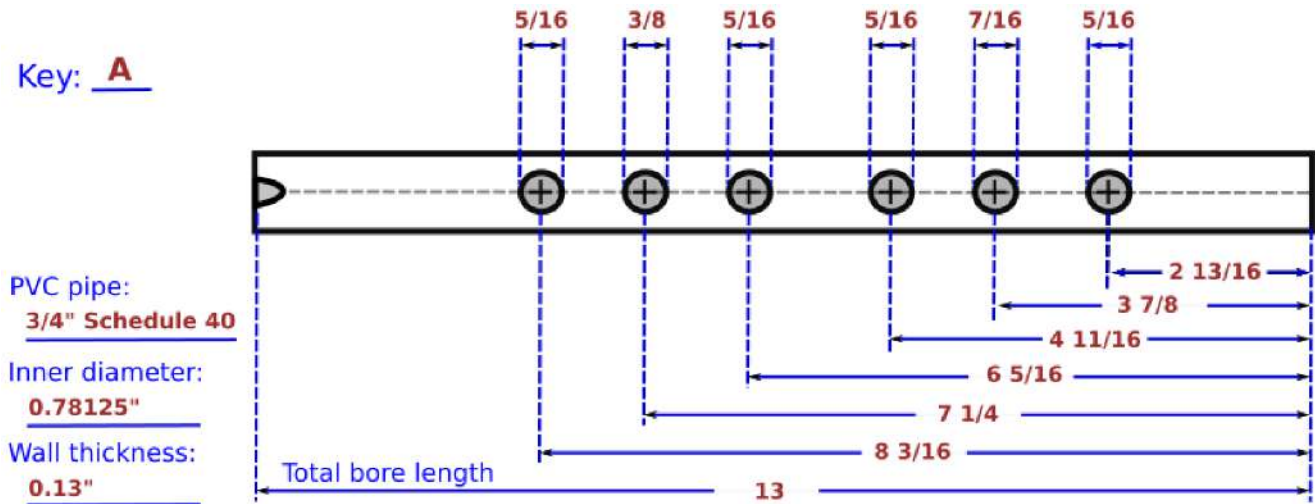
KEY of FLUTE:

Total bore length = 16.973 (Length in inch)							
Designated note	Frequency (Hz)	Hole distance from bottom	Nearest fraction	Resulting distance	Hole size	Actual frequency (Hz)	+/- cents
○○○○○○○	F5	698.46				716.80	+44
○○○○○○○	E5	659.25	10.166	10 1/8	10.125	664.80	+14
○○○○○○○	D5	587.33	8.939	8 15/16	8.938	590.60	+9
○○○○○○○	C5	523.25	7.734	7 3/4	7.750	529.20	+19
○○○○○○○	Bb4	466.16	5.784	5 3/4	5.750	469.10	+11
○○○○○○○	A4	440.00	4.956	4 15/16	4.938	444.10	+15
○○○○○○○	G 4	392.00	3.351	3 3/8	3.375	396.20	+18
○○○○○○○	F4	349.23				353.00	+18

Insert a picture of your final product.



### Example 3 – a PVC Flute in the A Key (with the Chinese-Recorder Style Blow Notch)



Insert the design table from <https://www.flutopedia.com/naflutomat.htm>.

Fingering	Playing Frequency (Hz)	Tuning Frequency (Hz)	Tuning Note	Hole Number	Hole diameter	Wall thickness at hole	Calculated dist. from end of flute	Calculated dist. between holes
Total bore length:							12.955 in	
○○○ ○○○	830.61	830.61	G#5 +0 cents	6	0.3125 in	0.13 in	8.195 in	0.948 in
●○○ ○○○	739.99	739.99	F#5 +0 cents	5	0.375 in	0.13 in	7.247 in	0.933 in
●●○ ○○○	659.25	659.25	E5 +0 cents	4	0.3125 in	0.13 in	6.314 in	1.615 in
●●● ○○○	587.33	587.33	D5 +0 cents	3	0.3125 in	0.13 in	4.699 in	0.793 in
●●●● ○○○	554.37	554.37	C#5 +0 cents	2	0.4375 in	0.13 in	3.906 in	1.075 in
●●●●● ○○○	493.88	493.88	B4 +0 cents	1	0.3125 in	0.13 in	2.831 in	
●●●●●● ○○○	440	440	A4 +0 cents					

see Finger Hole Size for hole diameter colors (opens in a new window)

KEY of FLUTE: **A4** Calculate

Total bore length = 12.955 (Length in inch)								
Designated note	Frequency (Hz)	Hole distance from bottom	Nearest fraction	Resulting distance	Hole size	Actual frequency (Hz)	+/- cents	
○○○○○○○	A5	880.00				877.10	-5	
○○○○○○○	G#5	830.61	8 3/16	8.188	5/16	827.20	-7	
○○○○○○○	F#5	739.99	7 1/4	7.250	3/8	732.00	-18	
○○○○○○○	E5	659.25	6 5/16	6.313	5/16	653.30	-15	
○○○○○○○	D5	587.33	4 11/16	4.688	5/16	582.20	-21	
○○○○○○○	C#5	554.37	3 7/8	3.875	7/16	552.10	-7	
○○○○○○○	B4	493.88	2 13/16	2.813	5/16	489.20	-16	
○○○○○○○	A4	440.00				436.40	-14	

Insert a picture of your final product.

