

Making Palm Pipes

A palm pipe is a musical instrument made from a simple material—PVC pipe. To play a palm pipe, you hit an open end of the pipe on the palm of your hand, causing the air molecules in the pipe to vibrate. These vibrations create the sounds that you hear.

MATERIALS

- 1 standard 10-foot length of 1/2 inch PVC pipe for 180°F water.
- Flexible meter stick
- PVC pipe cutter or a hacksaw
- Sandpaper
- Seven different colors of permanent markers for labeling pipes
- Simple calculator

DIRECTIONS

1. Cut the PVC pipe into the lengths listed in the chart below. It works best if you measure one length, cut it, then make the next measurement. You may want to cut each piece a little longer than the given measurement so that you can sand out any rough spots and level the pipe without making it too short.

Number	Note	Length of pipe (cm)	Frequency (Hertz)
1	F	23.60	349
2	G	21.00	392
3	A	18.75	440
4	B flat	17.50	446
5	C	15.80	523
6	D	14.00	587
7	E	12.50	659
8	F	11.80	698
9	G	10.50	748
10	A	9.40	880
11	B flat	9.20	892
12	C	7.90	1049
13	D	7.00	1174
14	E	6.25	1318
15	F	5.90	1397

2. Lightly sand the cut ends to smooth any rough spots.
3. Label each pipe with the number, note, and frequency using a different color permanent marker.
4. Hit one open end of the pipe on the palm of your hand in order to make a sound.

ACTIVITIES 

1. Try blowing across the top of a pipe as if you were playing a flute. Does the pipe sound the same as when you tap it on your palm? Why or why not?
Safety note: Wash the pipes with rubbing alcohol or a solution of 2 teaspoons household bleach per gallon of water before and after blowing across them.
2. Take one of the longer pipes and place it in a bottle of water so that the top of the pipe extends above the top of the bottle. Blow across it like a flute. What happens to the tone as you raise or lower the pipe in the bottle?
3. Try making another set of palm pipes out of 1/2-inch copper tubing. What happens when you strike these pipes against your palm? What happens when you blow across the top? How does the sound compare with the plastic pipes?
4. At a hardware store, purchase two rubber rings for each copper pipe. These rings should fit snugly around the pipes. Place one ring on each end of each pipe, then lay them on a table. Try tapping the side of each pipe with different objects—wooden and stainless steel serving spoons, for example. How does this sound compare with the other sounds you have made with the pipes?
5. Try playing some palm pipe music with your classmates. Here are two tunes to get you started:

Happy Birthday														
Melody	C	C	D	C	F	E			C	C	D	C	G	F
Harmony			A		A	B ^b					B ^b		B ^b	A
Melody	C	C	C	A	F	E	D		B ^b	B ^b	A	F	G	F
Harmony			F		C	B ^b					C			A

Twinkle Twinkle Little Star															
Melody	F	F	C	C	D	D	C		B ^b	B ^b	A	A	G	G	F
Harmony	C	C	A	A	B ^b	B ^b	A		G	G	F	F	E	E	C
Melody	C	C	B ^b	B ^b	A	A	G		C	C	B ^b	B ^b	A	A	G
Harmony	A	A	G	G	F	F	C		A	A	G	G	F	F	C
Melody	F	F	C	C	D	D	C		B ^b	B ^b	A	A	G	G	F
Harmony	C	C	A	A	B ^b	B ^b	A		G	G	F	F	E	E	C

6. **Challenge:**

You can figure out the length of pipe needed to make other notes, too. All you need is a simple formula and your understanding of the way sound travels in waves.

To figure out the length of the pipe needed to create sound of a certain frequency, we start with the formula frequency = velocity of sound in air ÷ wavelength, or $f = v/\lambda$. Next, we solve the equation for λ : $\lambda = v/f$.

The fundamental frequency is the one that determines which note is heard. You can use the chart below to find the fundamental frequency of a chromatic scale in two octaves. Notice that for each note, the frequency doubles every time you go up an octave.

Once you choose the frequency of the note you want to play, you need to know what portion of the fundamental frequency's wavelength (S-shape) will fit inside the palm pipe.

To help you visualize the wave inside the palm pipe, hold the center of a flexible meter stick in front of you. Wiggle the meter stick to create a standing wave. This mimics a column of vibrating air in a pipe with two open ends. How much of a full wave do you see? If you answered one half, you are correct.

When a palm pipe is played, your hand closes one end of the pipe. Now use your meter stick to mimic this situation. Place the meter stick on a table top and use one hand to hold down one end of the stick. This represents the closed end of the pipe. Flick the other end of the meter stick to set it in motion. How much of a full wavelength do you see? Now do you know what portion of the wavelength will fit into the palm pipe?

One-fourth of the wavelength of the fundamental frequency will fit inside the palm pipe. As a result the length of the pipe should be equal to $1/4\lambda$, which is equal to $1/4(v/f)$.

In practice, we find that the length of pipe needed to make a certain frequency is actually a bit shorter than this. Subtracting a length equal to $1/4$ of the pipe's inner diameter is necessary. The final equation, therefore, is: Length of pipe = $\frac{v}{4f} - \frac{1}{4}D$ where D represents the inner diameter of the pipe.

Given that the speed of sound in air (at 20°C) is 343 m/s and the inner diameter of the pipe is 0.0017 m, what is the length of pipe you would need to make the note B, with a frequency of 494 hertz? How about the same note one octave higher (frequency 988 hertz)? Make these two pipes so that you can play a C major scale.

Chromatic scale in two octaves (frequencies rounded to nearest whole number)													
Note	A	A#	B	C	C#	D	D#	E	F	F#	G	G#	A
Frequency (Hertz)	220	233	247	262	277	294	311	330	349	370	392	415	440
Frequency (Hertz)	440	466	494	523	554	587	622	659	698	740	784	831	880

7. What is the lowest note you could make with a palm pipe? What is the highest? Explain these limits using what you know about the human ear and the way sound is created by the palm pipe.