Palm Pipes

Determining the frequency of a palm pipe
A math and science activity

Materials:

PVC pipe cutters, 6 different colors of tape, sand paper, permanent markers, measuring tools (rulers, meter stick or measuring tape.)
Verbal instructions will be given for using Pipe cutters.

Calculating the frequency of each pipe.

v= speed of sound in air ~330-345 m/s
λ= wavelength (4 times the length of the tube measured in meters)

F= frequency in Hertz, the SI unit of frequency, equal to one vibration per second.

Frequency = velocity divided by wavelength
$F = v/\lambda$

Example:

Length of the pipe .10 meters × 4 = .40 meters (wavelength)
Speed of sound in air 345 meters/second
345m/s ÷ .40 m = 862 Hz

Making your Palm Pipes:
(Measure 3 times before you cut.)

Cut only #5-13 pipes today! Mark each number of pipes with the corresponding color. Measure as accurately as possible
Use sand paper to smooth rough edges.

Palm Pipes Assembly

Cut ¾' or ½' PVC pipes in the lengths highlighted

Number	Length (cm)	Note	Frequency Hz
1.	23.6	F_1	349
2.	21.0	G_1	392
3.	18.7	A_1	440
4.	17.5	Bb_1	446
5.	15.8	C_1	523
6.	14.0	D_1	587
7.	12.5	E_1	659
8.	**11.8**	**F_2**	**698**
9.	10.5	G_2	784
10.	9.40	A_2	880
11.	9.20	Bb_2	892
12.	7.90	C_2	1046
13.	7.00	D_2	1174
14.	6.25	E_2	1318
15.	5.90	F_3	1397

To do and notice:
Gently strike the end of the pipe against your palm. Hear the sound that it makes.
Try a different length of pipe. Did you hear a different sound?
How high or low a sound is pitch.
What can you say about the length of the pipe versus its pitch?

What's going on?
A pulse that starts at your palm as compression makes four complete transits (back and forth.)
One vibration = Up as a compression and down as an expansion
Up as expansion and down as a compression
This four-part cycle corresponds to one wavelength of a sound or single vibration. A series of these repeated cycles is the source of the sound you hear when you "play" one of the pipes.
The length of the tube affects the note that the tube produces. The speed of sound waves is the same in all tubes; the length of the tube has a direct effect on the time it takes for all four transits of the tube. The longer it takes for the pulse to complete the cycle and start over again, the fewer cycles per second, or vibrations. The fewer vibrations per second the lower the frequency and lower musical note.

LIGO connection:
Gravitational waves have been directly measured and detected by LIGO. When 2 black holes orbit each other they begin slowly and speed up as they move closer eventually colliding with each other. This is because energy is being released in the form of gravitational waves. The collision is the highest frequency and most powerful of the gravitational waves.

As they orbit over time, the distance between them decreases (low frequency) and the speed increases (high frequency.)
We call that the LIGO chirp!

Credits and References

The original activity was developed by Gene Easter and Bill Reitz . Art Fortgang brought it to the attention of the Science Exploratorium.

‘Square Wheels’ and other easy to build hands-on science activities by Don Rathjen and Paul Doherty and the Exploratorium Teacher Institute.
Palm Pipes, pages 59-62.
www.exploratorium.edu

Notes and drawings