

## Palm Pipes Lesson

### Introduction

This unit of study was created as a collaboration between science, music and Spanish. This is a weeklong unit of study.

### Goals/Objectives

The student will first be introduced to the palm pipe musical instrument in music class. Next students would actually build a palm pipe in science class. Students would learn to play the palm pipe in music class. Last, students would learn a song in Spanish and play it with the palm pipe.

### Student Activities

1. The music instructor starts by showing students an actual palm pipe (realia). Students then read an article on palm pipes (see attached).
2. The science instructor demonstrates step by step how to construct a palm pipe. Students will each construct their own palm pipe (see attached instructions).
3. Students will practice playing the palm pipes in music class. They will start out with simple songs.
4. The Spanish instructor introduces a song in Spanish to students. Students will learn the lyrics and practice singing the song.
5. As a group some students will play their palm pipes while other sing the song in Spanish.

# Palm Pipes -A “Handy” Musical Instrument

## Teacher Background

**Goal:** To Show How the Length of a Tube is related To Pitch & To Make A Little Music

### **Materials and Construction:**

- Cut 0.5-inch PVC pipe to the lengths listed on Page 3. A complete set of two octaves (15 pipes) can be made from one standard 10-foot length. Use a plastic pipe and tube cutter available from most Builders’ Supply or Home Depot type stores. The tube cutter costs about \$15 and is well worth it if you are making several sets. Otherwise, cut the pipes a little long with a hacksaw and sand them to remove burrs. Be sure there are no rough edges on the pipes.
- The pipes can be marked by using different color tape or paint OR by the “letter” name of the note: F-G-A-Bb-C-D-E-F-etc. using permanent marker. Clear spray paint or clear fingernail polish will make the marker more permanent. Alternative teachers may wish to have students identify the notes, by comparing notes on a keyboard or piano.
- The frequency of the notes can also be marked on the pipes depending on the level of student.
- Simple music in the key of F major. Example: music for recorders or song flutes: songbooks.

### **How to Play:**

- It is easier for each student musician to play one single pipe.
- Grasp the pipe firmly in one hand and quickly bring it down onto the palm of the other hand, allowing the end of the pipe to strike the palm of the other hand.
- Have musicians practice playing the same note in unison, then try a scale involving all the musicians.
- Practice playing a sort of “chord”- two notes in unison.
- Play a song - The conductor points out or “spots” which note to play. As the conductor spots the note, musicians play their note no matter what the length of the pipe for that note. (Since there are two octaves, there are two or three different lengths for the same note). You can play the song using melody and harmony together, or play melody only depending on the ability of your musicians.
- Palming two different notes at the same time plays melody and harmony.

### **Cautions:**

- The pipes may be a choking hazard to young students
- Remember to wash pipe off with alcohol or a solution of 2 teaspoons of Clorox per gallon of water after each student use.

### **Extensions depending on student readiness.**

- Have students listen to each pipe and arrange the pipes in order from high to low pitch.
- Ask students to experiment to find other ways to make sounds with the pipes (blowing, dropping, hitting, etc.) Remember to wash pipes off after use.



- Have students match the pitch of the pipes to other instruments (keyboard, xylophone, piano, etc.) in order to identify the note.
- Have students place the pipes tightly on their palm and blow across the top of the pipe. How does the sound differ from palming the pipes. Remember to wash pipes after use.
- Hold the pipes in one hand, leaving both ends of the pipe open (not covered by hands, fingers, etc. have students blow over the top of the pipes. How does the pitch change now? What is the difference in the sound of the open and closed end pipe? Remember to wash pipes after use.

### REFERENCE CHART FOR MAKING PIPES:

*These lengths were determined by assuming the speed of sound at 25 degrees C is 346.8 m/s.*

Note	Length (inches)	Length (cm)	Frequency (hertz)
F	9.77	24.83	349.2
G	8.71	22.12	392.0
A	7.76	19.70	440.0
B flat	7.32	18.60	466.2
C	6.52	16.57	523.3
D	5.81	14.76	587.3
E	5.18	13.15	659.3
F	4.89	12.41	698.5
G	4.35	11.06	784.0
A	3.88	9.85	880.0
B flat	3.66	9.30	932.4
C	3.26	8.28	1046.5
D	2.91	7.38	1174.7
E	2.59	6.58	1318.5
F	2.44	6.21	1396.9

Download a free Real Time Audio Spectrum Analyzer from True Audio at  
[http://www.trueaudio.com/rta\\_down.htm](http://www.trueaudio.com/rta_down.htm)

## Sample Diagrams



Hold a 256 Hz tuning fork in front of microphone

To turn the sound generator on, hit the "on/off" button

Settings for 256 Hz tuning fork  
0.1 v/div    10 ms/div

To change the pitch (frequency) of the sound, either type in a frequency, or use the up/down arrows

Make sure "Go" button is turned on to start the oscilloscope

Settings for voice recording:  
0.5 V/Div    100 ms/div

"Frequency" spoken into microphone

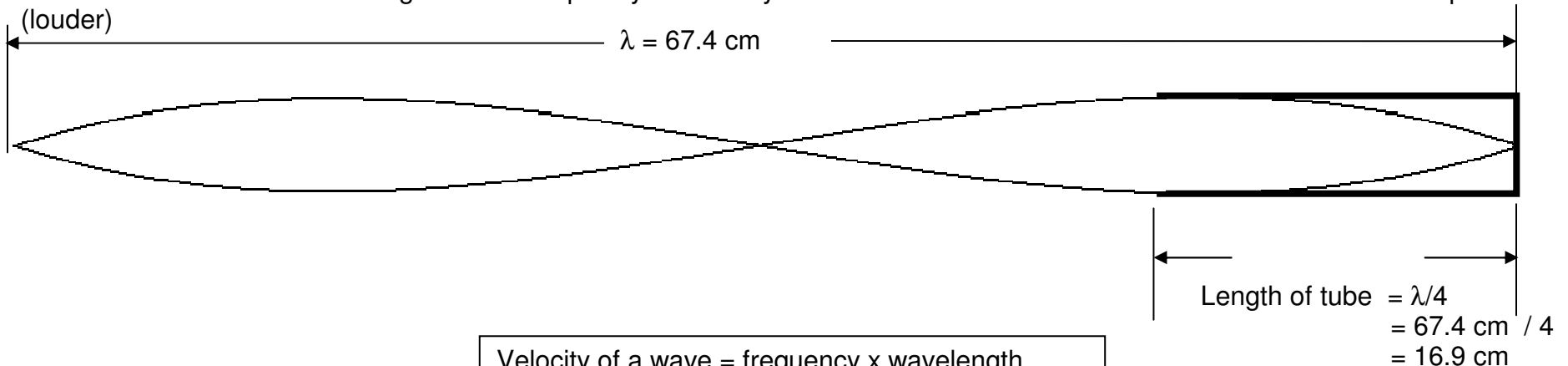
TO start or stop the signal, hit "ALT Spacebar"



# Palm Pipe Model Middle C

velocity of sound in air at 25 degrees Celsius: 345 m/s  
frequency of a Middle C note: 512 Hz

When the palm pipe is struck, it closes of one end of the tube and sets up a vibration of the air that's inside the tube. Many frequencies of sounds are generated, but they are too soft to be heard. One frequency, called the **resonant frequency**, is reinforced because the wavelength of that frequency fits exactly inside the tube so as to reinforce itself and come out amplified (louder)



Velocity of a wave = frequency x wavelength

$$V = f \times \lambda$$

For middle C note,  $f = 512 \text{ Hz}$ ;

$$345 \text{ m/s} = 512 \text{ Hz} \times \lambda$$

$$\begin{aligned} \lambda &= 345/512 \\ &= 0.674 \text{ m} \\ &= 67.4 \text{ cm} \end{aligned}$$

## F Major Scale:

F G A B<sup>b</sup> C D E F

## My Country Tis of Thee

F F G E F G A A B<sup>b</sup> A G F G F E F  
C C C C B<sup>b</sup> A B<sup>b</sup> B<sup>b</sup> B<sup>b</sup> B<sup>b</sup> A G  
A B<sup>b</sup> A G F A B<sup>b</sup> C D B<sup>b</sup> A G F

## God Bless America

F E D E D C G F G A G A B<sup>b</sup> D B<sup>b</sup> A C F G A G F G F E F  
E F G C F G A C G A B<sup>b</sup> E A B<sup>b</sup> C D C B<sup>b</sup> A G F B<sup>b</sup> A G C  
D C B<sup>b</sup> A G F B<sup>b</sup> A G F



## Happy Birthday

C C D C F E      C C D C G F  
C C C' A F F E D      B<sup>b</sup> B<sup>b</sup> A F G F

## Happy Birthday (With Harmony)

Melody C C D C F E      C C D C G F  
Harmony A A B<sup>b</sup> A D B<sup>b</sup>      B<sup>b</sup> B<sup>b</sup> B<sup>b</sup> B<sup>b</sup> B<sup>b</sup> A

Melody C C C' A F F E D      B<sup>b</sup> B<sup>b</sup> A F G F  
Harmony A A A C C C C B<sup>b</sup>      G G F C B<sup>b</sup> A



## The Bear Went Over the Mountain

F	A	A	A	G	A	B <sup>b</sup>	A		A	G	G	G	F	G	A	F
---	---	---	---	---	---	----------------	---	--	---	---	---	---	---	---	---	---

F	A	A	A	G	A	B <sup>b</sup>	D		D	C	C	B <sup>b</sup>	G	F
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## The Bear Went Over the Mountain (with harmony)

Melody	F	A	A	A	G	A	B <sup>b</sup>	A	A	G	G	G	F	G	A	F
Harmony		C	C	C			D	C	E	E	E				C	C

Melody	F	A	A	A	G	A	B <sup>b</sup>	D	D	C	C	B <sup>b</sup>	G	F
Harmony		C	C	C			D	F	E	E	E			A





# Twinkle, Twinkle, Little Star

F	F	C	C	D	D	C	B <sup>b</sup>	B <sup>b</sup>	A	A	G	G	F
C	C	B <sup>b</sup>	B <sup>b</sup>	A	A	G	C	C	B <sup>b</sup>	B <sup>b</sup>	A	A	G
F	F	C	C	D	D	C	B <sup>b</sup>	B <sup>b</sup>	A	A	G	G	F

## Twinkle, Twinkle, Little Star (with harmony)

Melody	F	F	C	C	D	D	C	B <sup>b</sup>	B <sup>b</sup>	A	A	G	G	F
Harmony	C	C	A	A	B <sup>b</sup>	B <sup>b</sup>	A	G	G	F	F	E	E	C
Melody	C	C	B <sup>b</sup>	B <sup>b</sup>	A	A	G	C	C	B <sup>b</sup>	B <sup>b</sup>	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 <sup>b</sup>	B <sup>b</sup>	A	A	G	G	F
Harmony	C	C	A	A	B <sup>b</sup>	B <sup>b</sup>	A	G	G	F	F	E	E	C



# PALM PIPES

## Materials:

$\frac{1}{2}$  inch PVC pipe cut to the lengths listed below. The pipes can be marked with permanent marker or fingernail polish. The students hold the pipe in one hand and strike one of the open ends on the palm of the other hand, producing the pitch which corresponds to the length of the pipe.



Note	Length *(cm)	Frequency **(Hz)
A	38.5	220
B $b$ (A#)	36.4	233
B	34.3	247
C	32.3	261.5
C# (D $b$ )	30.5	277
D	28.8	293.5
D# (E $b$ )	27.1	311
E	25.6	329.5
F	24.1	349
F# (G $b$ )	22.7	370
G	21.4	392
A $b$ (G#)	20.2	415.5
A	19.0	440
B $b$ (A#)	17.9	466
B	16.9	494
C	15.9	523
C# (D $b$ )	15.0	554
D	14.1	587
D# (E $b$ )	13.3	622
E	12.5	659
F	11.8	698
F# (G $b$ )	11.1	740
G	10.5	784
A $b$ (G#)	9.8	831

\* Lengths of these pipes are based on an air temperature of 20° C and 0.5 in diameter.

\*\* Frequencies taken from <http://ptolemy.eecs.berkeley.edu/eecs20/week8/scale.html>

Adapted and expanded from an activity presented by Hugh Henderson of Plano (Texas) Senior High School at the 2003 AP Physics Institute, Texas A&M University.

# MUSICAL SCALES



Tonic	W	Third	Fourth	Fifth	Sixth	H	Tonic
C	D	E	F	G	A	B	C
C#	D#	F	F#	G#	A#	C	C#
D	E	F#	G	A	B	C#	D
D#	F	G	G#	A#	C	D	D#
E	F#	G#	A	B	C#	D#	E
F	G	A	A#	C	D	E	F
F#	G#	A#	B	C#	D#	F	F#
G	A	B	C	D	E	F#	G
G#	A#	C	C#	D#	F	G	G#
A	B	C#	D	E	F#	G#	A
A#	C	D	D#	F	G	A	A#
B	C#	D#	E	F#	G#	A#	B
C	D	E	F	G	A	B	C

Musical scales and chart taken from  
<http://www.geocities.com/jayatea.geo/piano.html>

## **TWINKLE, TWINKLE LITTLE STAR**

(Nearly the same tune as the “Alphabet Song”)

Twin - kle, twin - kle lit - tle star, How I won - der what you are  
**Melody:** F F C C D D C B $\flat$  B $\flat$  A A G G F  
**Harmony:** C C A A B $\flat$  B $\flat$  A G G F F E E C

Up a - bove the world so high, Like a dia - mond in the sky,  
**Melody:** C C B $\flat$  B $\flat$  A A G C C B $\flat$  B $\flat$  A A G  
**Harmony:** A A G G F F C A A G G F F C

Twin - kle, twin - kle lit - tle star, How I won - der what you are  
**Melody:** F F C C D D C B $\flat$  B $\flat$  A A G G F  
**Harmony:** C C A A B $\flat$  B $\flat$  A G G F F E E C



## HAPPY BIRTHDAY

Hap - py birth - day to you, hap - py birth - day to you;  
C C D C F E C C D C G F

Hap - py birth - day dear Ein - stein;  
C C C A F E D



Hap - py birth - day to you!  
B $\flat$  B $\flat$  A F G F

## LONDON BRIDGE

Lon - don bridge is fall - ing down, fall - ing down, fall - ing down;  
G A G F E F G D E F E F G

Lon - don bridge is fall - ing down, my fair la - dy.  
G A G F E F B D G E C

## ROW, ROW, ROW YOUR BOAT

Row, row, row your boat gen - tly down the stream;  
C C C D E E D E F G

Mer - ri - ly, mer - ri - ly, mer - ri - ly, mer - ri - ly,  
C C C G G G E E E C C C

Life is but a dream.  
G F E D C

## WHERE IS PINKY (POINTER, ETC...)

(or Are You Sleeping?)

“Where is Pin - ky? Where is Pin - key?” “Here I am! Here I am!”  
C D E C C D E C E F G E F G

“How are you to - day sir?” “Ver - y well I thank you.”  
G A G F E C G A G F E C

Run a - way, run a - way.  
C G C C G C



## **SINGING CHIMES**

(adapted from Taylor, Poth, & Portman (1995), *Teaching Physics with TOYS*,  
Terrific Science Press: Middleton, Ohio. pp. 275-281)

Chimes cut from 4 five-foot pieces of ½ inch aluminum pipe. Total cost of less than \$8.00 (purchased as 2 ten-foot sections, Lowe’s Home Building Store, December 2003).

**Table 1: Chime Lengths**

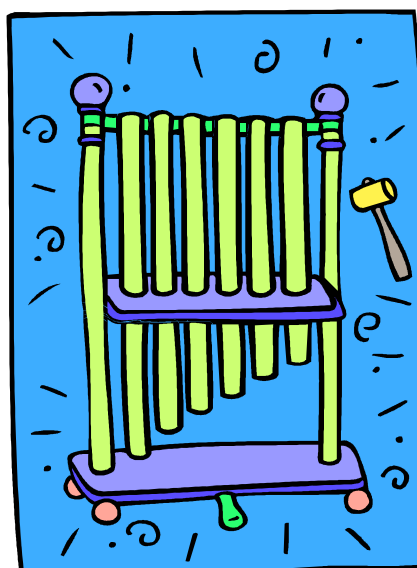
Cut from pipe 1		Cut from pipe 2		Cut from pipe 3		Cut from pipe 4	
Chime #	Length (cm)	Chime #	Length (cm)	Chime #	Length (cm)	Chime #	Length (cm)
1	38.5	5	34.2	8	31.1	13	27.2
2	37.5	6	33.1	9	30.3	14	26.3
3	36.2	7	32.2	10	29.7	15	25.5
4	35.1	17	23.8	11	28.9	16	24.7
		18	23.1	12	28.1	19	22.5
						20	21.8

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**Table 2: Chime Frequencies**

Chime #	Note	Frequency (Hz)	Chime #	Note	Frequency (Hz)	Chime #	Note	Frequency (Hz)
1	F	175	8	C	262	15	G	392
2	F#	185	9	C#	277	16	G#	415
3	G	196	10	D	294	17	A	440
4	G#	208	11	D#	311	18	A#	466
5	A	220	12	E	330	19	B	494
6	A#	233	13	F	349	20	C	523
7	B	247	14	F#	370			

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# **SINGING CHIMES SONG SHEET**

(musical scores taken from *Teaching Physics with TOYS*, pp 280-281)

## **MICHAEL ROW THE BOAT ASHORE**

Mi - chael row the boat a - shore  
 10 14 17 14 17 19 17  
 10 14 10 14 15 14

Hal - le - lu - a  
 14 17 19 17  
 10 14 15 14

Mi - chael row the boat a - shore  
 14 17 17 14 15 14 12  
 10 14 14 10 12 10 9

Hal - le - lu - u - u - a  
 10 12 14 5 12 10  
 7 9 10 9

Mi - chael row the boat a - shore  
 D F# A F# A B A  
 D F# D F# G F#

Hal - le - lu - a  
 F# A B A  
 D F# G F#

Mi - chael row the boat a - shore  
 F# A A F# G F# E  
 D F# F# D E D C#

Hal - le - lu - u - u - a  
 D E F# A E D  
 B C# D C#

## **HAPPY BIRTHDAY**

Hap - py birth - day to you, hap - py birth - day to you;  
 8 8 10 8 13 12 8 8 10 8 15 13  
 6 8 6 6 8 8  
 C C D C F E C C D C G F  
 A# C A# A# C C

Hap - py birth - day dear Ag - gie;  
 8 8 20 17 13 12 10  
 17 13 8 8 6  
 13 8  
 C C C A F E D  
 A F C C A#  
 F C

Hap - py birth - day to you!  
 18 18 17 13 15 13  
 13 13 13 8 12 8  
 10 10 8 8  
 A# A# A F G F  
 F F F C E C  
 D D C C



**Lyrics to Cielito Lindo**

**De la Sierra Morena,  
Cielito lindo, vienen bajando  
Un par de ojitos negros,  
Cielito lindo, de contrabando**

**Coro:**

**Ay, ay, ay, ay,  
Canta y no llores,  
Porque cantando se alegran,  
Cielito lindo, los corazones**

**Pajaro que abandona,  
Cielito lindo, su primer nido,  
Si lo encuentra ocupado,  
Cielito lindo, bien merecido**

**Coro**

**Ese lunar que tienes,  
Cielito lindo, junto a la boca,  
No se lo des a nadie,  
Cielito lindo que a mi me toca**

**Coro**