Resonance and Closed-End Air Columns

Read from **Lesson 5** of the **Sound and Music** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/sound/u11l5a.html
http://www.physicsclassroom.com/Class/sound/u11l5d.html

MOP Connection: Sound and Music: sublevels 10 and 11

Review

1. Standing wave patterns consist of nodes and antinodes. The positions along a medium which appear to be stationary are known as _____. They are points of **no di**splacement. The positions along a medium which are undergoing rapid motion between a maximum positive and maximum negative displacement are known as _____. They are the **opposite of** the points of **no di**splacement. Each consecutive node is separated from each other by _____ λ.

Resonance in Open-End Air Columns:

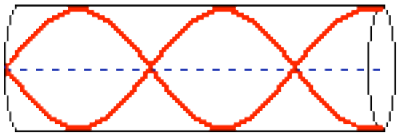
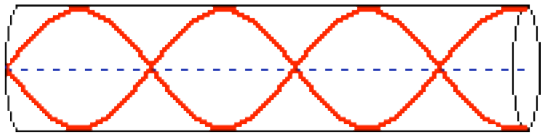
2. A closed-end air column is a column of air (usually enclosed within a tube, pipe or other narrow cylinder) which is capable of being forced into vibrational resonance. One end of the column is closed to the surrounding air and the other end is open to the surrounding air. Air at the open end of the column is able to vibrate back and forth; this end forms a vibrational _____ (node, antinode). Air at the closed end is NOT able to vibrate back and forth; this end forms a vibrational _____ (node, antinode).

3. Draw the standing wave patterns for the first five harmonics and complete the equations.

Harmonic #	Standing Wave Pattern	λ ---> L	L ---> λ
1		L = _____ λ	λ = _____ L
3		L = _____ λ	λ = _____ L
5		L = _____ λ	λ = _____ L
7		L = _____ λ	λ = _____ L
9		L = _____ λ	λ = _____ L

4. Determine the frequency of the ....
   a. ... third harmonic for an air column whose first harmonic frequency is 262 Hz. _____
   b. ... first harmonic for an air column whose fifth harmonic frequency is 1700 Hz. _____
   c. ... fifth harmonic for an air column whose third harmonic frequency is 984 Hz. _____
   d. ... next highest frequency for an air column whose fundamental frequency is 210 Hz. _____

6. Determine the wavelength of the ...

a. ... wave in this 35-cm long air column. 	b. ... wave in this 56-cm long air column. 
c. ... first harmonic wave pattern for a 32-cm long air column (closed).	d. ... fifth harmonic wave pattern for a 1.20-meter long air column (closed).

7. *The Test Tubes* have a *gig* in the local park this weekend. The lead instrumentalist uses a test tube (closed end air column) with a 17.2 cm air column. The speed of sound in the test tube is 340 m/sec. Find the frequency of the first harmonic played by this instrument. **PSYW**

8. A closed end organ pipe is used to produce a mixture of sounds. The third and fifth harmonics in the mixture have frequencies of 1100 Hz and 1833 Hz respectively. What is the frequency of the first harmonic played by the organ pipe? **PSYW**

9. *Pipin' Pete and the Pop Bottles* is playing at Shades next weekend. One of the pop bottles is capable of sounding out a first harmonic of 349.2 Hz. The speed of sound is 345 m/sec. Find the length of the air column. **PSYW**

10. The sound produced by blowing over the top of a partially filled soda pop bottle is the result of the closed-end air column inside of the bottle vibrating at its natural frequency. Keri Atune uses four bottles (labeled A, B, C and D) with varying amounts of water (and thus, air) in order to play a song. Express your understanding of closed-end resonance by filling in the table below. (The speed of sound in the air columns is 345 m/s.)

Bottle	Length of Column (m)	Wavelength (m)	Frequency (Hz)	Speed (m/s)
A	**0.060**			**345**
B			**708**	**345**
C		**0.640**		**345**
D	**0.200**			**345**

