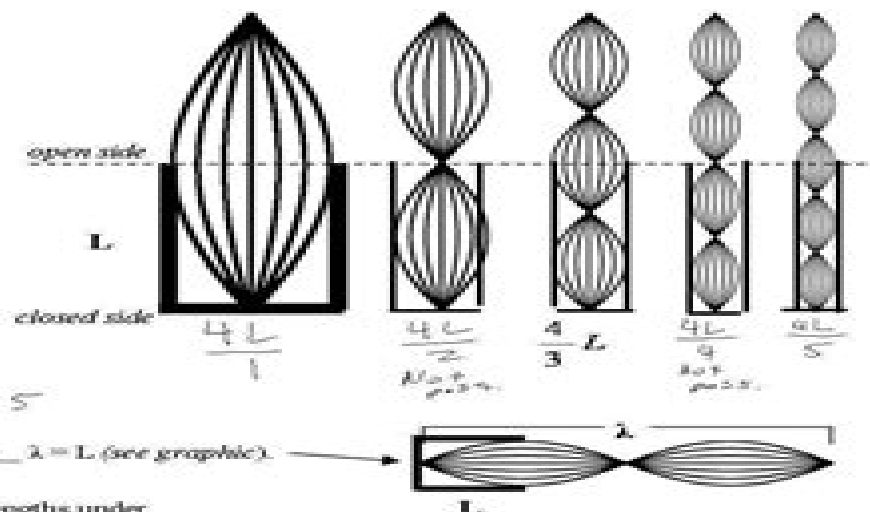


Harmonics in Closed Pipes

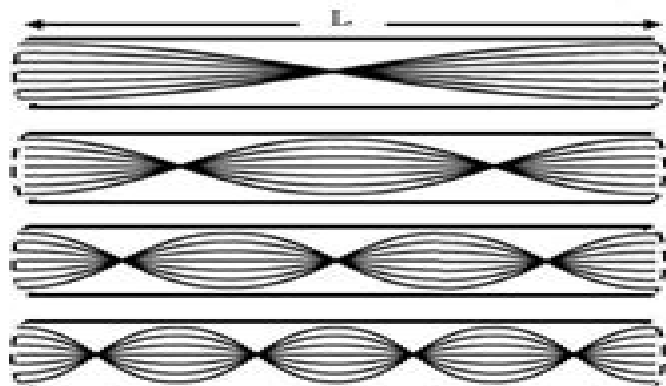
- 19) At the open end of a pipe is there a node or antinode?
 20) At the closed end of a pipe is there a node or antinode?
 So, there MUST BE a node at the closed end and the center of an antinode at the open end for the harmonic to exist.
 21) On the graphic at the right, let's pretend we have a pipe closed at one end, as shown on the fundamental. The length of the pipe is "L".
 22) Draw this same length pipe around each of the harmonics. The open end of each pipe will stop at the dotted line.
 23) Which harmonics can be produced in this pipe (which have an antinode at the open end)? 1, 3, 5
 24) So, for a pipe closed on one end (a closed pipe), give the sequence of what harmonics can be present. n can only = 1, 3, 5



- 25) Since $2AN = 1\lambda$, then the first harmonic in this diagram, $1/4 \lambda = L$ (see graphic).
 26) So $\lambda = \underline{4L}$. Write this under H_1 .
 27) Use the same process as for the first harmonic, write the wavelengths under the harmonics (even the ones that can't really exist). H_2 and H_3 should be obvious.
 28) Remembering Q7-9: there must be a pattern that includes "n" sequentially. Find it.
 29) At the right, write the equation for the wavelength of a harmonic in a closed pipe:
 30) But which "n's" are possible? 1, 3, 5, ...
 31) Calculate the wavelength of the third harmonic in a 60 cm long closed pipe (remember to convert to m).
 $\lambda_1 = 4L = 4(.6) = 2.4 \text{ m}$ $\lambda_3 = \frac{4L}{3} = \frac{2.4}{3} = .8 \text{ m}$

$$\lambda_{\text{closed pipe}} = \frac{4L}{n}$$

Harmonics in Open Pipes



- 32) Remembering the rule about nodes and antinodes, what must be present at the end of a pipe that is open?
 33) In order for a pipe to make a sound, it must have a standing wave in it, meaning it must have at least 1 node and 1 antinode (or more).
 34) For each successive harmonic the number of antinodes goes up by 1.
 35) For each successive harmonic the number of nodes goes up by 1.
 36) In the four open pipes at the left, draw the first four harmonics (number 1 is done for you). The nodes will be equally spaced and the center of an antinode must be at each end.
 37) On a string you count the number of AN to figure out which harmonic it is. For an open pipe, you count the number of Nodes to figure out which harmonic it is.
 38) Which harmonics can be present in an open pipe (which "n's" are present)? all of 'em

- 39) Using the same logic, figure out the sequence and give the equation for λ in an open pipe. (Hint: the drawing above will help.)

$$\lambda_{\text{open pipe}} = \frac{2L}{n}$$

$n = \text{all}$

- 40) What is the wavelength of the 3rd harmonic in a 80 cm long open pipe?

$$\lambda_1 = 1.6 \text{ m}$$

$$\lambda_3 = \frac{1.6}{3} = .53 \text{ m}$$

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