2.) <u>**Standing Sound Waves in Closed-Open Organ Pipes**</u>**:**

<u>**Closed End:**</u> $\Rightarrow$ **Displacement** <u>***node***</u> **& pressure** <u>***anti-node***</u> at $x = 0$.
<u>**Open   End:**</u> $\Rightarrow$ **Displacement** <u>***anti-node***</u> **& pressure** <u>***node***</u> at $x = L$.

	n'				
	1st harm.	$L = \frac{1}{4}\lambda_1$	$\lambda_1 = \frac{4}{1}L$	$f_1 = \frac{1}{4}\frac{V}{L} = 1\, f_1$
	3rd harm.	$L = \frac{3}{4}\lambda_3$	$\lambda_3 = \frac{4}{3}L$	$f_3 = \frac{3}{4}\frac{V}{L} = 3\, f_1$
	5th harm.	$L = \frac{5}{4}\lambda_5$	$\lambda_5 = \frac{4}{5}L$	$f_5 = \frac{5}{4}\frac{V}{L} = 5\, f_1$
...	...	...	...	....
	nth harm.	$L = \frac{n'}{4}\lambda_{n'}$	$\lambda_{n'} = \frac{4}{n'}L$	$f_{n'} = \frac{n'}{4}\frac{V}{L} = n'\, f_1$

(DISPLACEMENT)
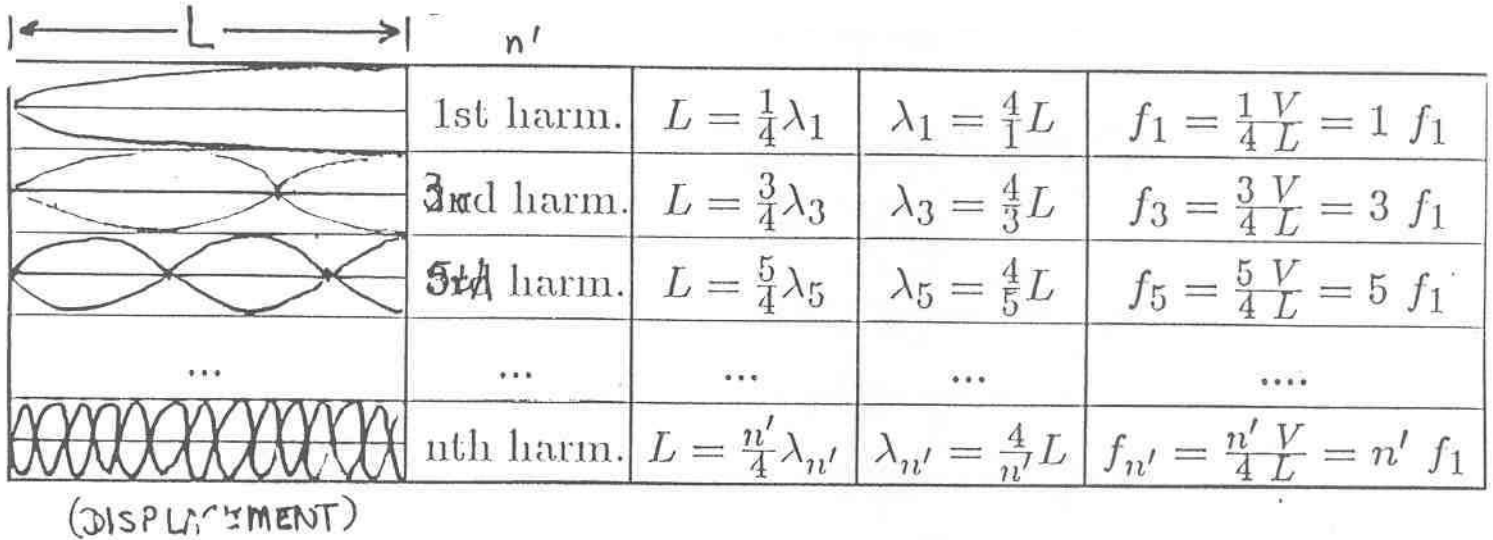
$$f_{n'} = \frac{v}{\lambda_{n'}} = n'f_1; \quad f_1 = \frac{v}{4L}$$

where: $n' = 2n - 1$, $n = 1, 2, 3, \ldots$ so $n' = 1, 3, 5, \ldots$ (*i.e.* the <u>***odd***</u> integers)

- First harmonic also known as the fundamental.

- Second harmonic also known as the first overtone, *etc*.

- Replace L by $L + \delta$ for "exact" answer