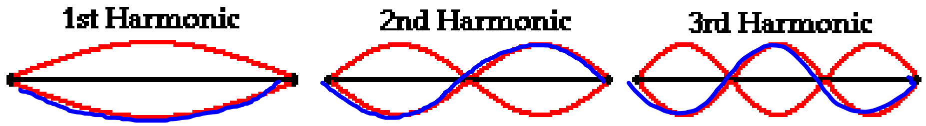
Tube Resonance

OPEN AND CLOSED TUBES

Standing Waves



$L = \frac{1}{2}\lambda$ → algebra → $\lambda = \frac{2}{1}L$

$L = \frac{2}{2}\lambda$ → algebra → $\lambda = \frac{2}{2}L$

$L = \frac{3}{2}\lambda$ → algebra → $\lambda = \frac{2}{3}L$

$\lambda_1 = \frac{2}{1}(1{,}0\,m)$ $\quad \lambda_2 = \frac{2}{2}(1{,}0\,m)$ $\quad \lambda_3 = \frac{2}{3}(1{,}0\,m)$

$\lambda_1 = 2{,}0\,m$ $\quad \lambda_2 = 1{,}0\,m$ $\quad \lambda = .\overline{66}\,m$

$v_w = 160\,m/s$

$f_1 = \frac{v}{\lambda} = \frac{160\,m/s}{2\,m} = 80\,Hz$

$f_2 = \frac{v}{\lambda_2} = \frac{160\,m/s}{1{,}0\,m} = 160\,Hz$

$f_3 = \frac{v}{\lambda_3} = \frac{160\,m/s}{.\overline{66}\,m} = 240\,Hz$

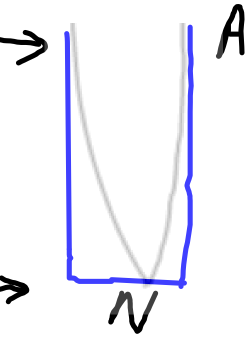
Tube Resonance

http://www.ngsir.netfirms.com/englishhtm/TwaveStatA.htm

string

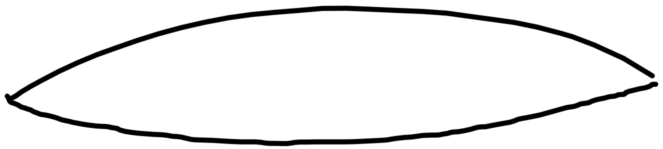
top- open termination, particles are free to move--- "max. displacement"

rigid termination- particles can't move----"no displacement" - *node*

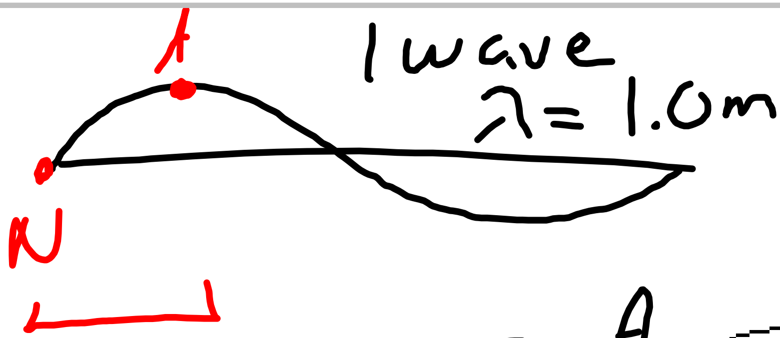


N = no particle displacement- *node*

A = maximum particle displacement- *antinode*

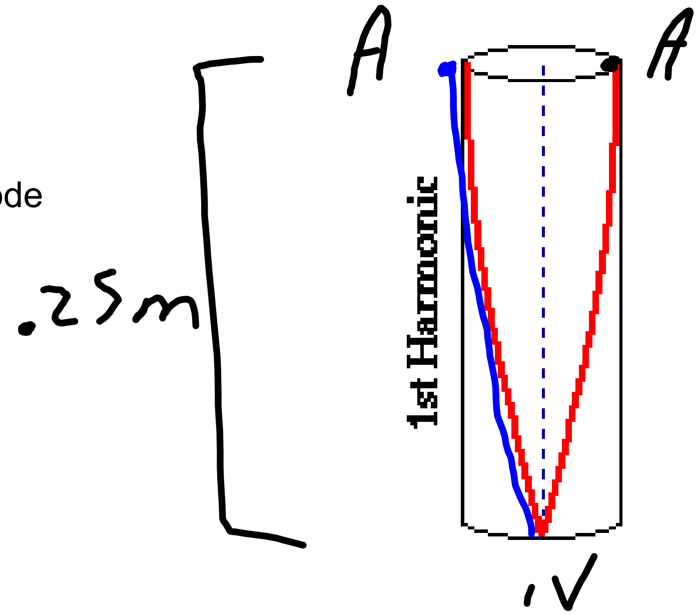


closed termination



.25m

.25 m from a node
to an antinode

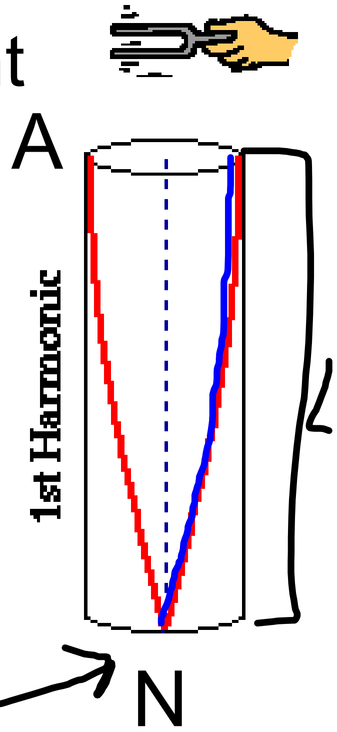


$$v = f\lambda$$

$$f = \frac{v}{\lambda} = \frac{340\ m/s}{1\ m}$$

$$f = 340\ Hz$$

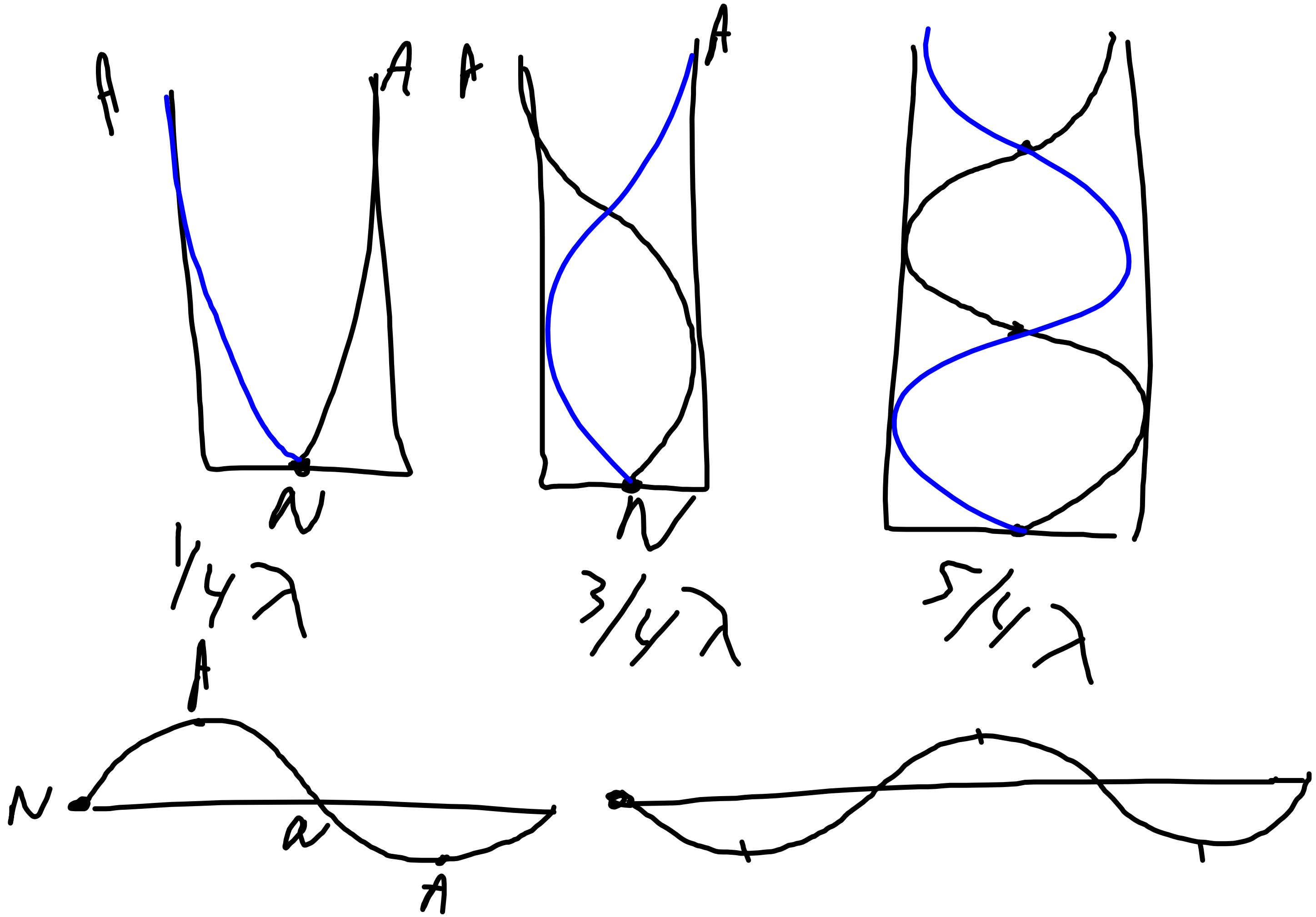
at *antinode* particles are free to move and have max. displacement



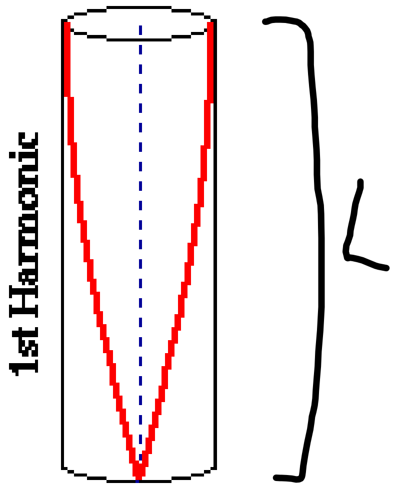
$$\frac{1}{4}\lambda = L$$

$$\lambda = 4L$$

because of rigid termination there is a *node* at the closed end of the tube other possible arrangements of nodes and antinodes of waves that will resonate in the closed tube



$L = 30\,cm$



① $L = \frac{1}{4}\lambda_1$

$\lambda_1 = \frac{4}{1} L$

$\lambda_1 = \frac{4}{1}(.30\,m)$

$\lambda_1 = 1.2\,m$

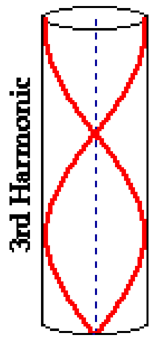
$v_s = 340\,m/s$

$\lambda_1 = 1.2\,m$

$\therefore f_1 = \frac{v}{\lambda} = \frac{340\,m/s}{1.2\,m}$

$f_1 = 283\,Hz$

L = 30 cm



30 cm

$$L = \frac{3}{4}\lambda$$

$$\lambda = \frac{4}{3}L$$

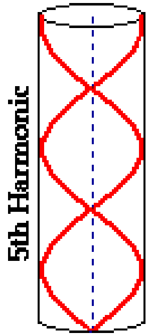
$$\lambda = \frac{4}{3}(.3m) = .4m$$

$$f = \frac{v}{\lambda}$$

$$f = \frac{340\ m/s}{.4m}$$

$$f = 850\ Hz$$

L = 30 cm



.3m

$v = f\lambda$

$f = \frac{v}{\lambda} = \frac{340\,m/s}{.24\,m}$

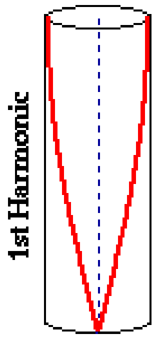
$f = 1417\,Hz$

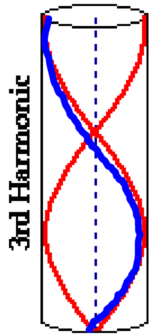
$\frac{5}{4}\lambda = L$

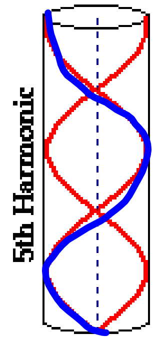
$\lambda = \frac{4}{5}L$

$\therefore \lambda = \frac{4}{5}(.3m)$

$\lambda = .24\,m$



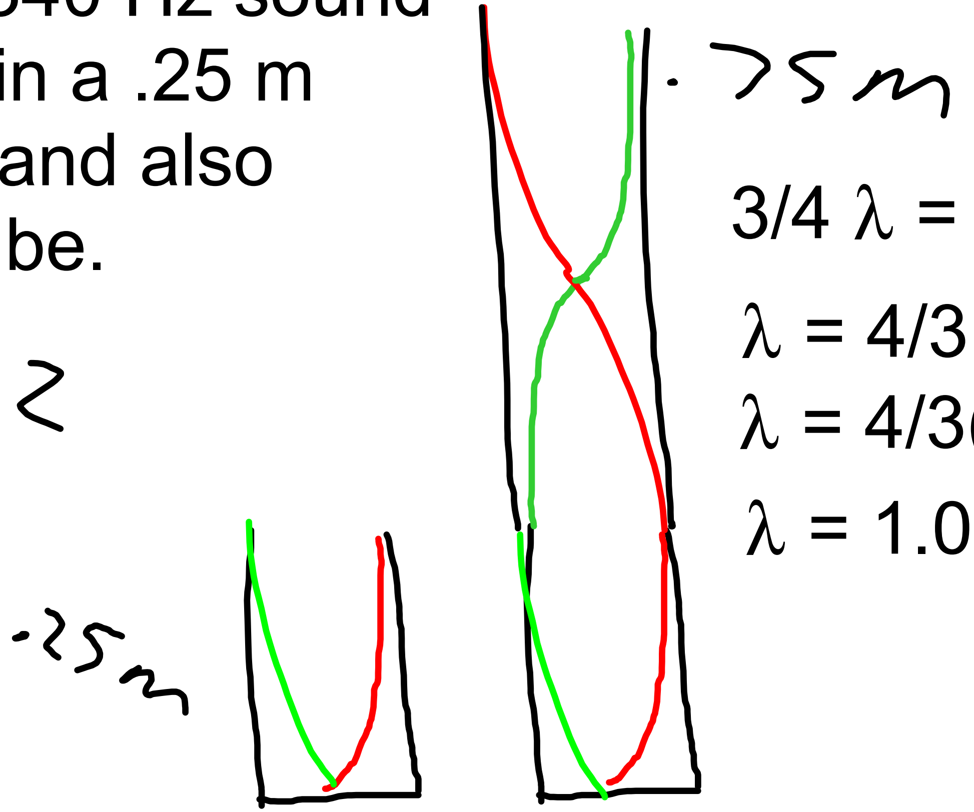




$\frac{1}{4}\lambda$	$\frac{3}{4}\lambda$	$\frac{5}{4}\lambda$
$\lambda = 4L$	$\lambda = \frac{3}{4}L$	$\lambda = \frac{4}{5}L$
$f_1 = 283Hz$	$f_3 = 850Hz$	$f_5 = 1417Hz$
1st harmonic	3rd harmonic	5th harmonic

Note that a 340 Hz sound wave will fit in a .25 m closed tube and also in a .75 m tube.

340 Hz



$3/4\ \lambda = L$

$\lambda = 4/3\ L$

$\lambda = 4/3(.75\text{ m})$

$\lambda = 1.0\text{ m}$

$1/4\ \lambda = L$

therefore, $\lambda = 4\ L$ $\quad \lambda = 4(.25\text{ m}) = 1.0\text{ m}$

$$f = \frac{340\text{ m/s}}{1\text{ m}} = 340\text{ Hz}$$

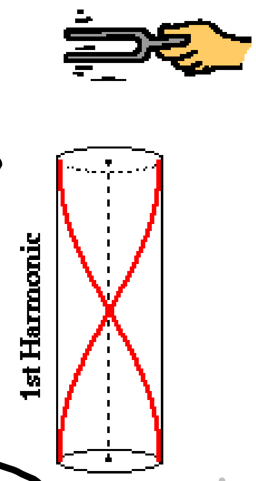
Closed Tubes:

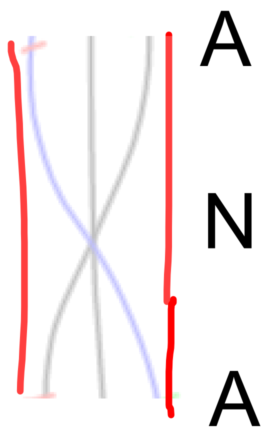
1) resonate at every odd $\frac{1}{4}\lambda$ ($\frac{1}{4}\lambda$, $\frac{3}{4}\lambda$, $\frac{5}{4}\lambda$, $\frac{7}{4}\lambda$...)

2) resonates at every odd harmonic
1st, 3rd, 5th, 7th, . . .

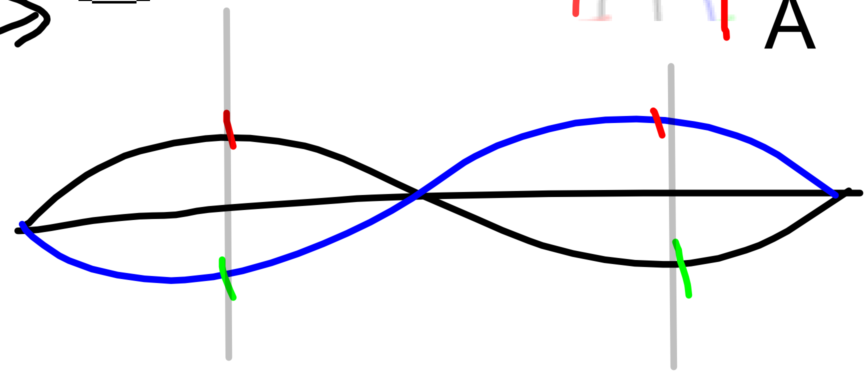
open

top- open termination, particles are free to move--- "max. displacement"

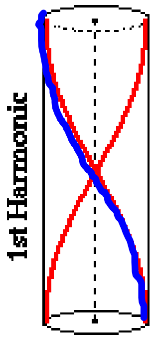




bottom- open termination, particles are free to move--- "max. displacement"



1/2 λ between the antinodes



- incident pulse
- reflected pulse

$$\therefore \tfrac{1}{2}\lambda = L$$

$$\lambda = 2L$$

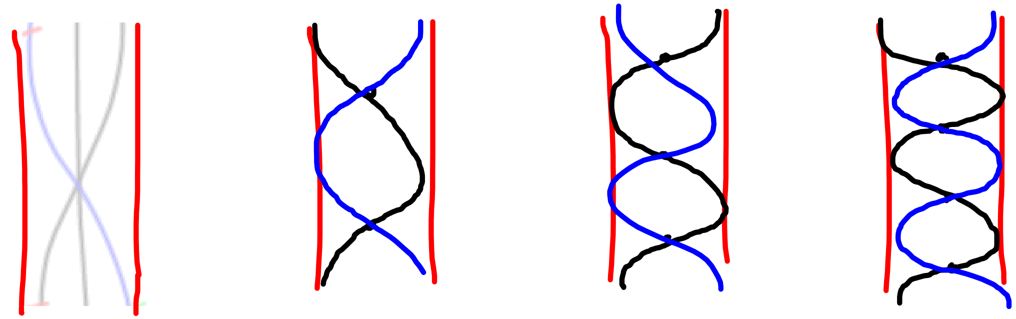
$l = 30\,cm$

$$\lambda = 2(.30\,m)$$

$$\lambda = .60\,m$$

$$f = \frac{v}{\lambda} = \frac{340\,m/s}{.6\,m}$$

$$f = 567\,Hz$$



$\frac{1}{2}\lambda = L$ $\frac{2}{2}\lambda = L$ $\frac{3}{2}\lambda = L$ $\frac{4}{2}\lambda = L$

$\lambda = \frac{2}{1}L$ $\lambda = \frac{2}{2}L$ $\lambda = \frac{2}{3}L$ $\lambda = \frac{2}{4}L$

$L = 1.0\ m$

$\lambda_1 = \frac{2}{1}(1.0m) = 2\ m$ $f_1 = \frac{340\ m/s}{2\ m} = 170Hz$

$\lambda_2 = \frac{2}{2}(1.0m) = 1.0m$ $f_2 = \frac{340\ m/s}{1m} = 340Hz$

$\lambda_3 = \frac{2}{3}(1.0m) = .6\bar{6}m$ $f_3 = \frac{340\ m/s}{.6\bar{6}m} = 510Hz$

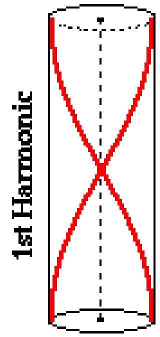
$\lambda_4 = \frac{2}{4}(1.0m) = .5m$ $f_4 = \frac{340\ m/s}{.5} = 680Hz$

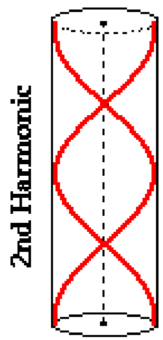
Open tube

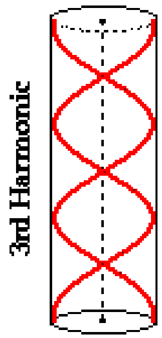
resonates at:

1) every 1/2 λ

2) every harmonic







$1/2\ \lambda = L$

$\lambda = 2/1\ L$

$2/2\ \lambda = L$

$\lambda = 2/2\ L$

$3/2\ \lambda = L$

$\lambda = 2/3\ L$