

# Tube Resonance

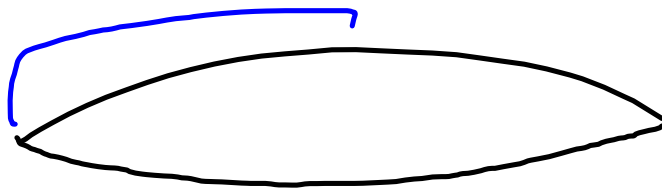
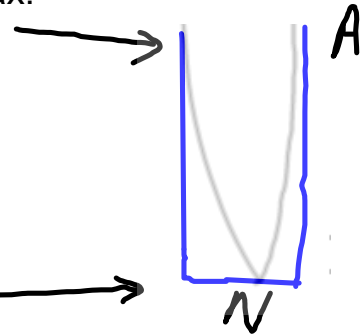
## OPEN AND CLOSED TUBES

# Tube Resonance

<http://www.ngsir.netfirms.com/englishhtm/TwaveStatA.htm>  
string

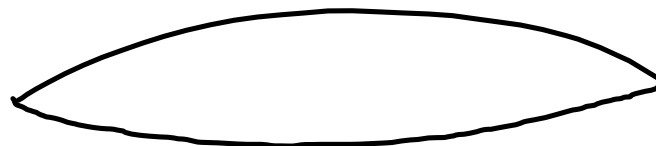
top- open termination,  
particles are free to  
move--- "max.  
displacement"

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

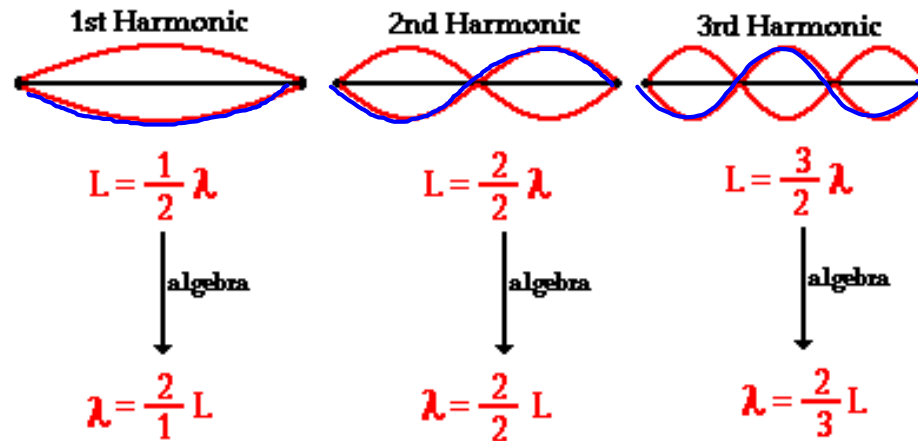


N = no particle  
displacement-  
*node*

A = maximum particle  
displacement- *antinode*



## Standing Waves



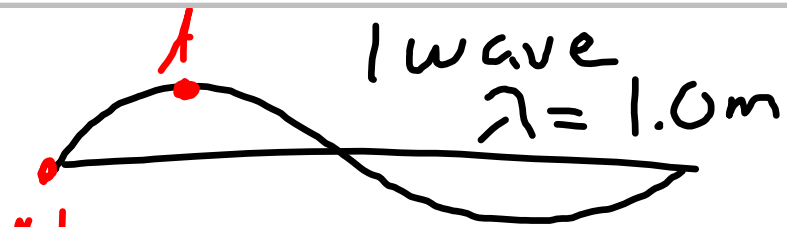
$$\lambda_1 = \frac{2}{1} (1.0\text{m}) \quad \lambda_2 = \frac{2}{2} (1.0\text{m}) \quad \lambda_3 = \frac{2}{3} (1.0\text{m})$$
$$\lambda_1 = 2.0\text{m} \quad \lambda_2 = 1.0\text{m} \quad \lambda_3 = .6\bar{6}\text{m}$$

$$v_w = 160\text{m/s}$$

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

$$f_2 = \frac{v}{\lambda_2} = \frac{160\text{m/s}}{1.0\text{m}} = 160\text{Hz}$$

$$f_3 = \frac{v}{\lambda_3} = \frac{160\text{m/s}}{.6\bar{6}\text{m}} = 240\text{Hz}$$

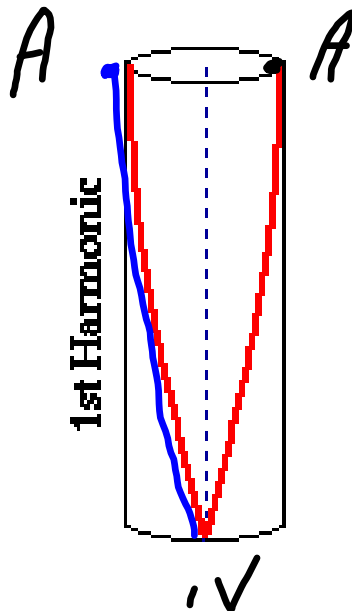


N

.25 m

.25 m from a node  
 to an antinode

.25 m



closed termination

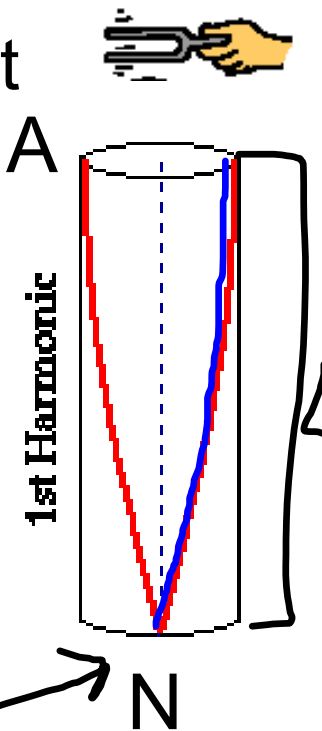
$$v = f \lambda$$

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

$$f = 340\text{ Hz}$$

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

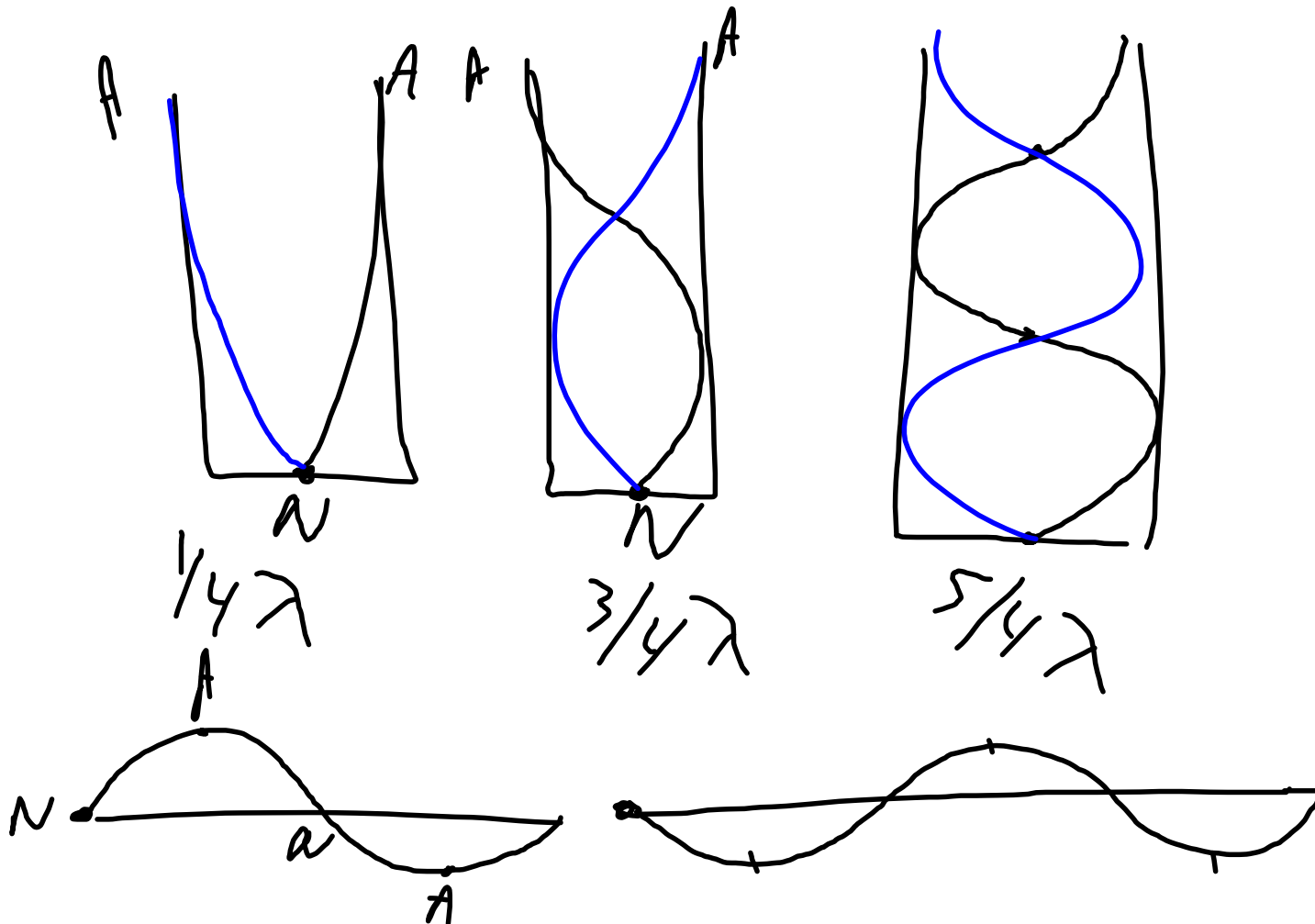
because of rigid termination there is a *node* at the closed end of the tube



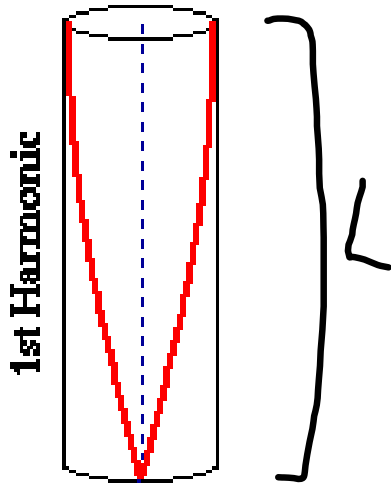
*incident pulse*  
*reflected pulse*

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

other possible arrangements of nodes and antinodes of waves that will resonate in the closed tube



$$L = 30 \text{ cm}$$



①

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

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

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

$$\lambda_1 = 1.2 \text{ m}$$

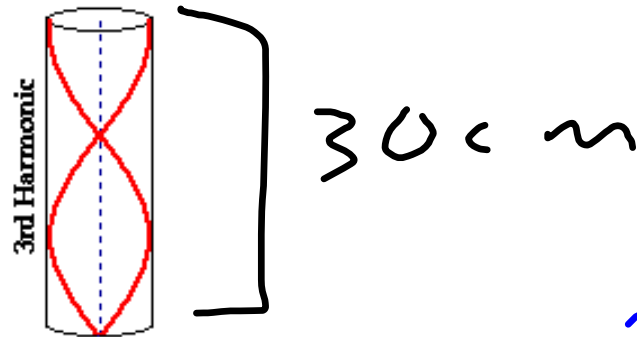
$$v_s = 340 \text{ m/s}$$

$$\lambda_1 = 1.2 \text{ m}$$

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

$$f_1 = \underline{\underline{283 \text{ Hz}}}$$

$$L = 30 \text{ cm}$$



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

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

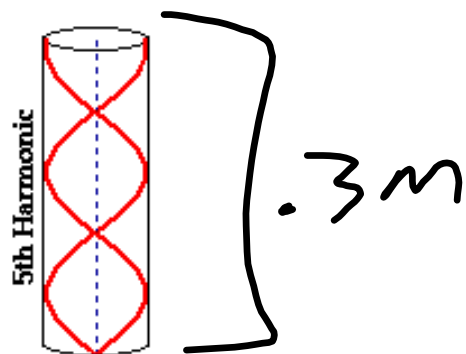
$$\lambda = \frac{4}{3} (.3 \text{ m}) = .4 \text{ m}$$

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

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

$$f = 850 \text{ Hz}$$

$$L = 30 \text{ cm}$$



$$5/4 \lambda = L$$

$$\lambda = 4/5 L$$

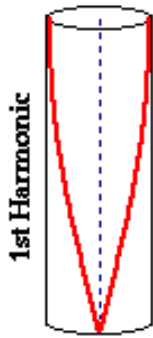
$$\therefore \lambda = 4/5 (.3 \text{ m})$$

$$\lambda = .24 \text{ m}$$

$$v = 670$$

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

$$f = 1417 \text{ Hz}$$

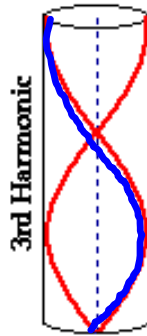


$$\frac{1}{4}\lambda$$

$$\lambda = 4L$$

$$f_1 = 283 \text{ Hz}$$

1<sup>st</sup> harmonic

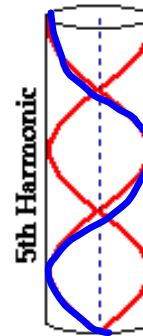


$$\frac{3}{4}\lambda$$

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

$$f_3 = 850 \text{ Hz}$$

3<sup>rd</sup> harmonic



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

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

$$f_5 = 1417 \text{ Hz}$$

5<sup>th</sup> harmonic

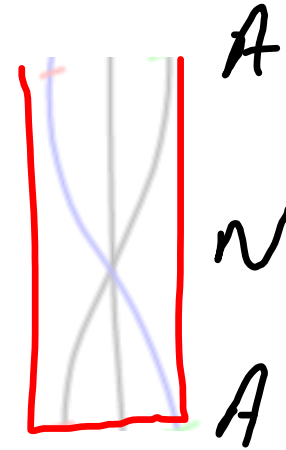
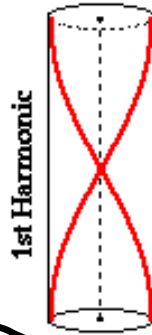
# Closed Tubes:

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

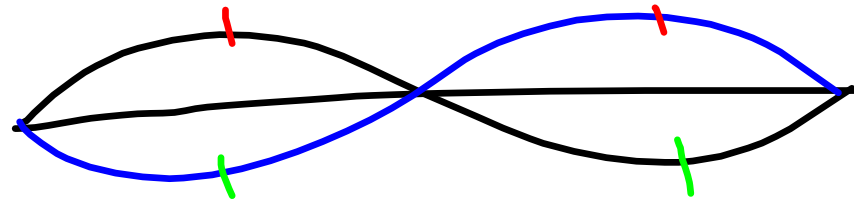
2) resonates at every  
odd harmonic  
 $1^{\text{st}}, 3^{\text{rd}}, 5^{\text{th}}, 7^{\text{th}}, \dots$

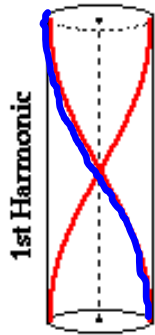
open

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



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





incident pulse

reflected pulse

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

$$L = 30 \text{ cm}$$

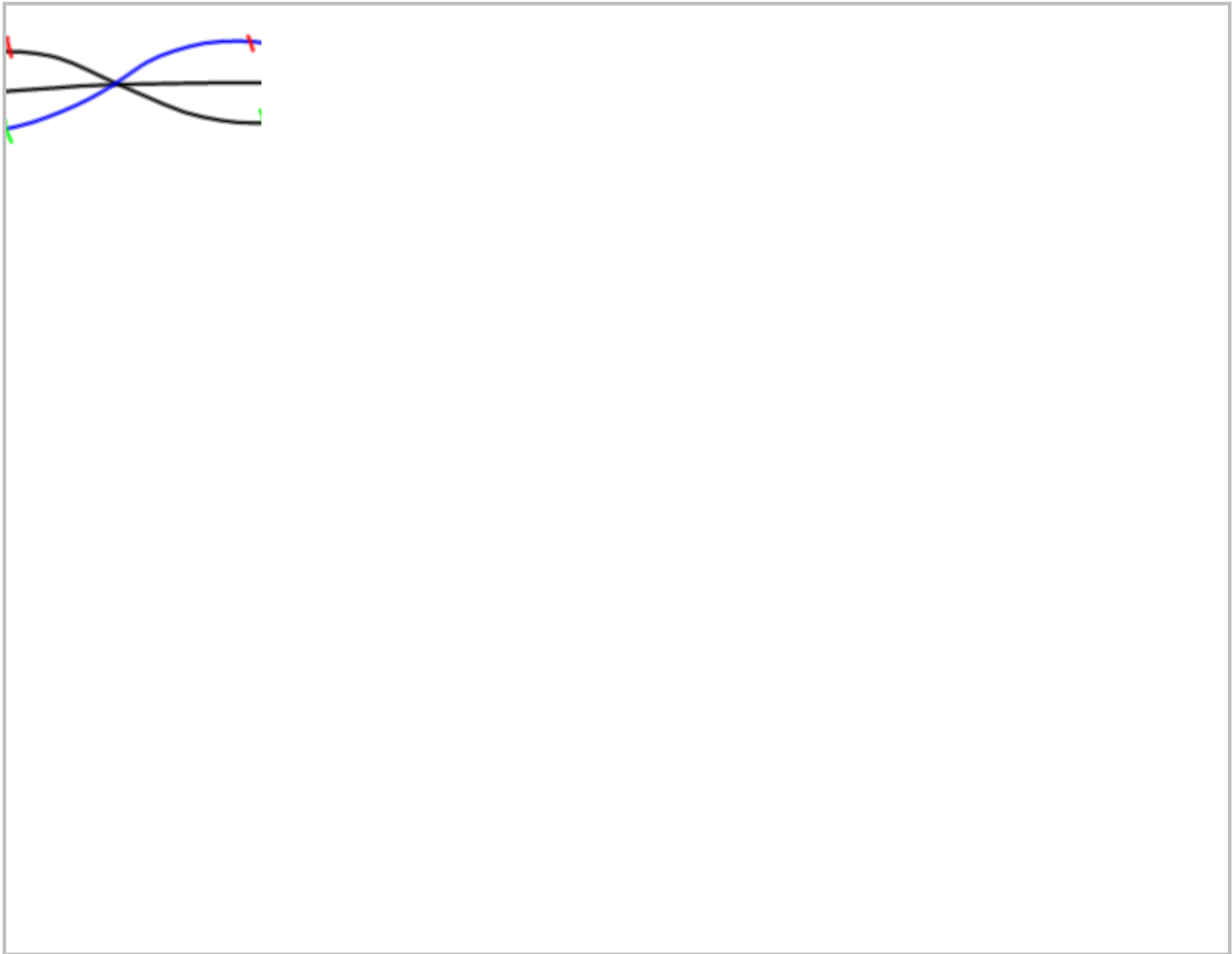
$$\lambda = 2L$$

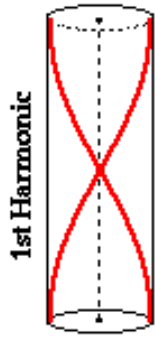
$$\lambda = 2(30 \text{ m})$$

$$\lambda = 60 \text{ m}$$

$$f = \frac{v}{\lambda} = \frac{340 \text{ m/s}}{60 \text{ m}}$$

$$f = 567 \text{ Hz}$$





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



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

