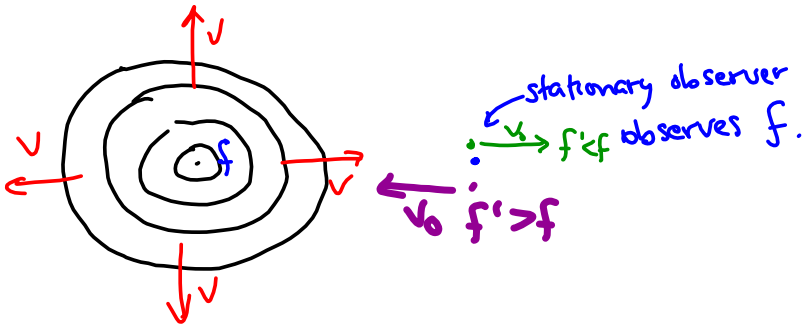
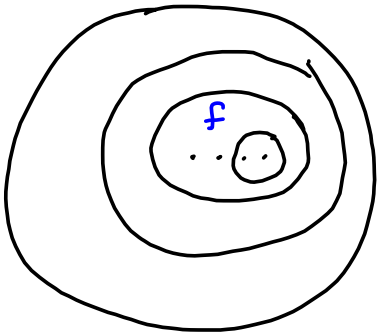
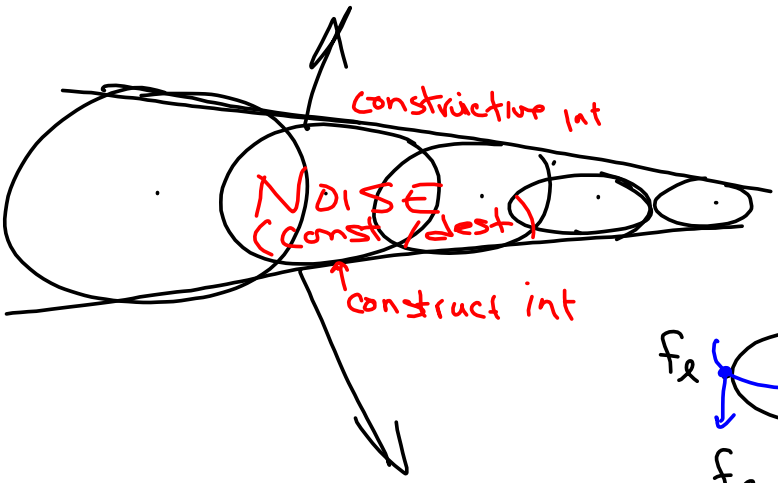
Doppler Effect - a change in the observed frequency due to the motion of the source and/or the observer.



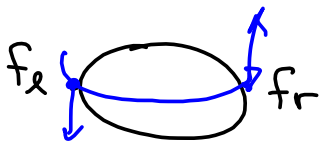


f'<f

f'>f



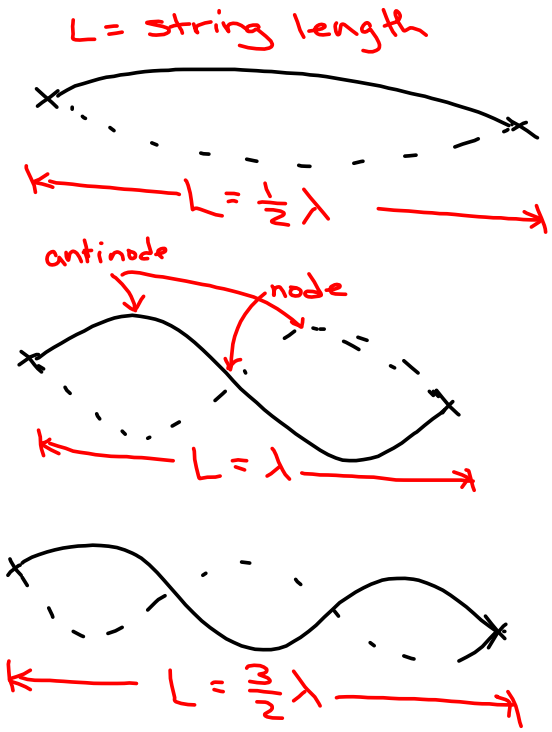
red shift



$f_\ell > f_c > f_r$

Standing Waves on Strings

String Fixed at Both Ends



Fundamental (1st harmonic)
- lowest f at which the string likes to vibrate

$f_1 = \frac{v}{\lambda} = \frac{v}{2L}$

2nd harmonic

$f_2 = \frac{v}{\lambda} = \frac{v}{L} = \frac{2v}{2L} = 2f_1$

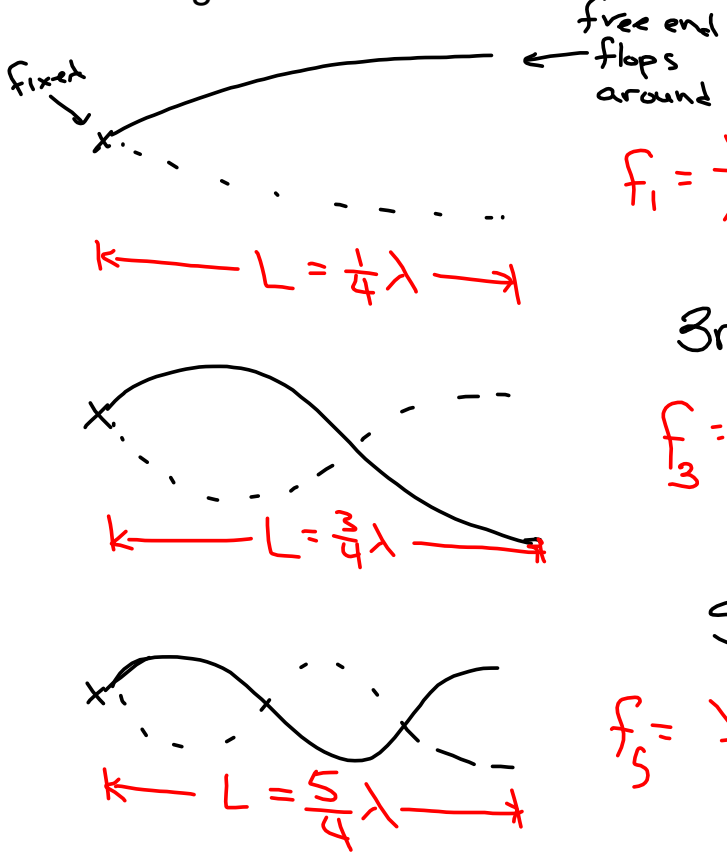
3rd harmonic

$f_3 = \frac{v}{\lambda} = \frac{v}{\frac{2L}{3}} = \frac{3v}{2L} = 3f_1$

In general $f_n = nf_1$

f_n the n^{th} harmonic $(n = 1, 2, 3, \ldots)$

String Fixed at One End



Fundamental (1st harmonic)

$$f_1 = \frac{v}{\lambda} = \frac{v}{4L}$$

(2nd doesn't exist.)

3rd harmonic

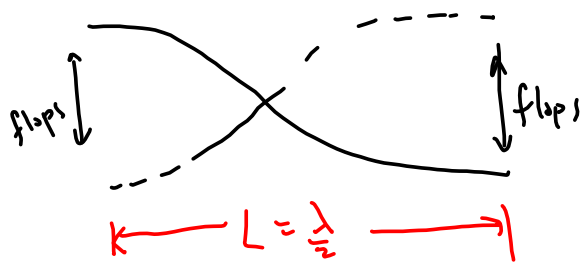
$$f_3 = \frac{v}{\lambda} = \frac{v}{\frac{4L}{3}} = \frac{3v}{4L} = 3f_1$$

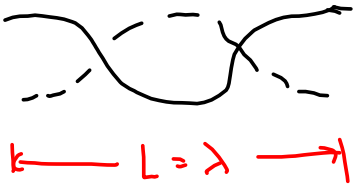
5th harmonic

$$f_5 = \frac{v}{\lambda} = \frac{v}{\frac{4L}{5}} = \frac{5v}{4L} = 5f_1$$

In general $f_n = nf_1$ ($n = 1, 3, 5, 7, \ldots$ odd only)

String Fixed at No Ends???





fundamental

Same mathematically as string fixed at both ends

2nd harmonic

$f_n = nf_1 \Rightarrow n = 1, 2, 3, \ldots$

Standing Waves - Open and Closed Pipe Resonators

Open pipe

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

Just like string fixed at no ends or both ends

$\left(f_1 = \frac{v_s}{2L} \right)$ ← speed of sound

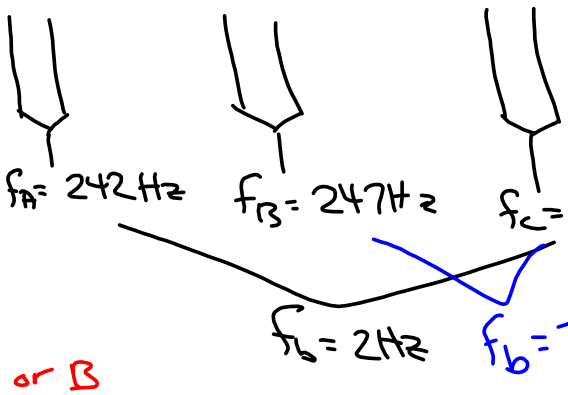
Closed Closed-Pipe open

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

Just like string fixed at one end

$\left(f_1 = \frac{v_s}{4L} \right)$

10.



$f_b = |f_1 - f_2|$

$2 = |242 - f_c|$

True $f_c = 240$ Hz OR 242 Hz

$f_b = |f_1 - f_2|$

$7 = |247 - f_c|$

True $f_c = 240$ Hz OR 254 Hz

If A or B

AND A or C

Then A.

Lab

Doppler Effect

http://www.lon-capa.org/~mmp/applist/doppler/d.htm

Homework: p. 421 # 16, 20
p. 427 #21, 22
Note: If T is unstated, assume 20°C