Phys 2110-4 12/2/11

Note Title 12/2/2011

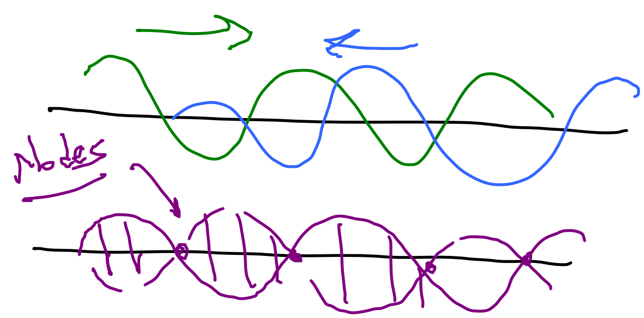
# Interference of waves

Beats $f_1$, $f_2$ Pulses

$$f_{Beat} = |f_1 - f_2|$$

800, 803 ⟶ 3 Hz

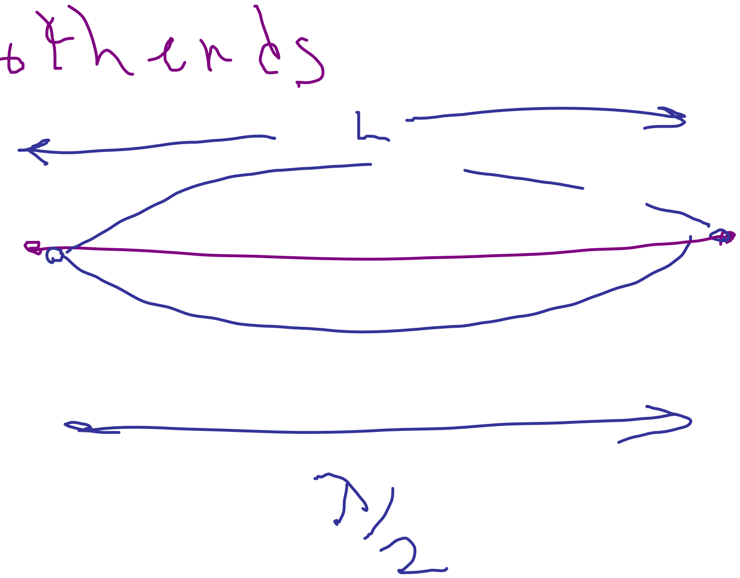
Waves going in opp. direction



String clamped at both ends

Lowest mode

fundamental mode




$\lambda/2 = L \qquad \lambda = 2L$

$f = \dfrac{v}{\lambda} = \dfrac{v}{2L}$

Other modes:

2 mode

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

$L = \lambda$

All the modes:

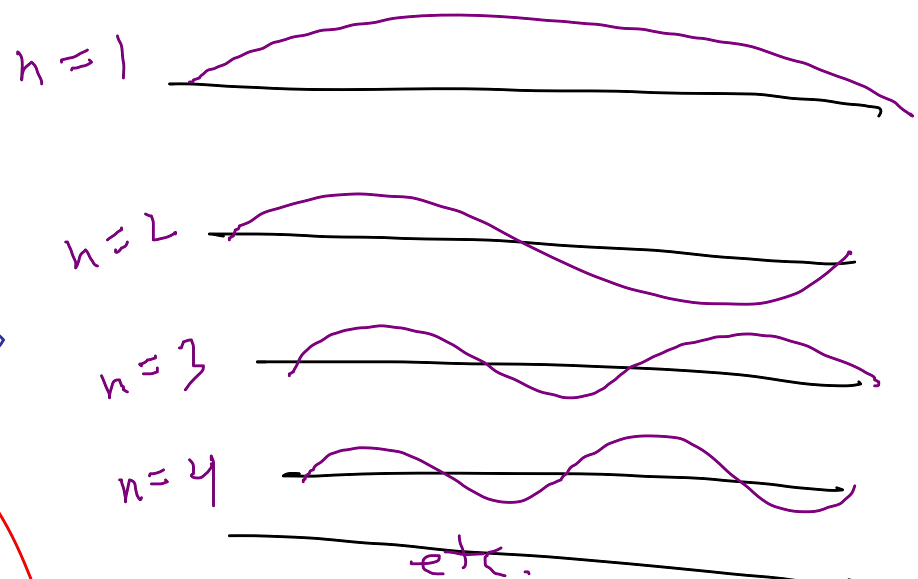
Each bump $= \lambda/2$

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

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

Harmonics

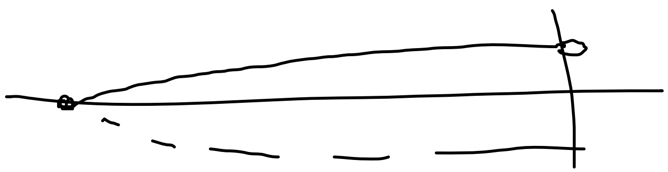
$$\boxed{f = \frac{v}{\lambda} = \frac{v}{\left(\frac{2L}{n}\right)} = \frac{nv}{2L}}$$



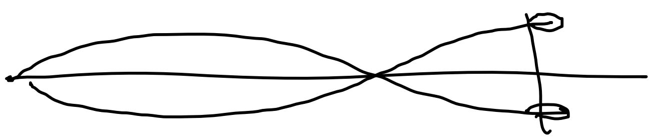

Ratios: ×1 ×2 ×3 . .

Ring, free to move

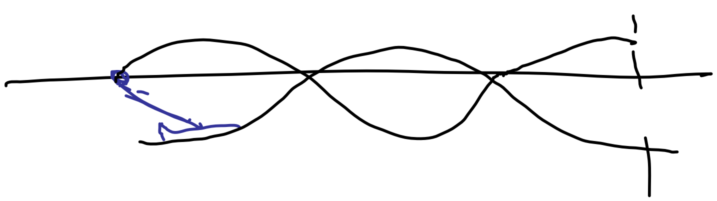
Standing wave



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



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

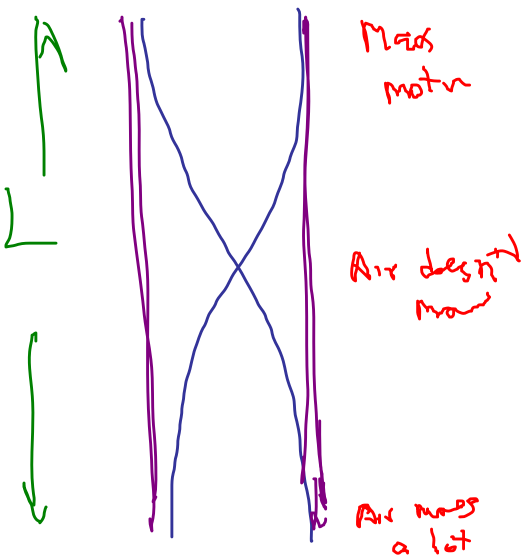


$$L = \frac{5\lambda}{4}$$

Standing Sound Waves:

p. 237

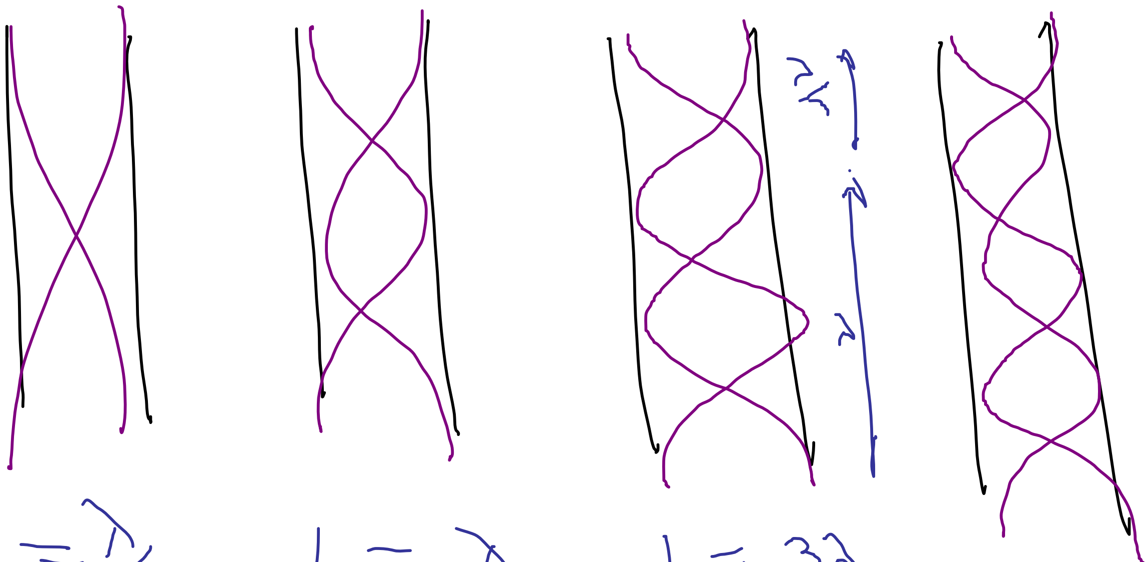
p. 238




Open ends: Motion of air is maximum.

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

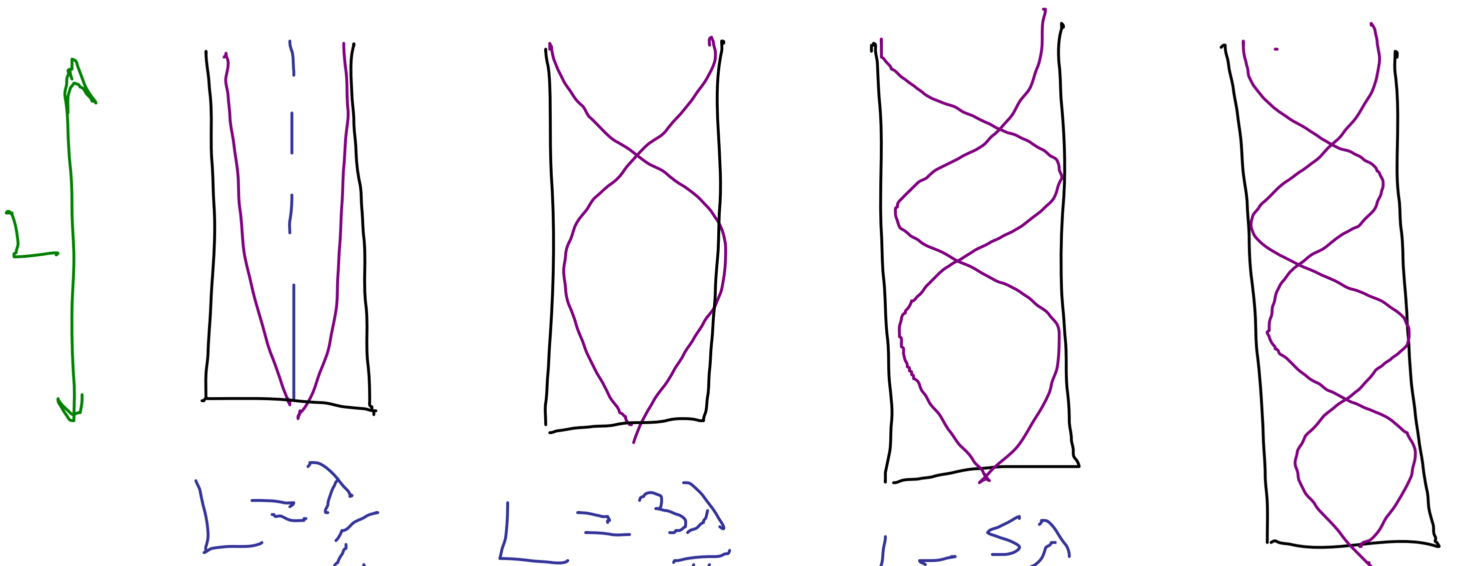
$$f = \frac{v}{\lambda} = \frac{v}{(2L)} = \frac{v}{2L}$$




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

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

$$\boxed{f_n} = \frac{v}{\lambda} = \frac{v}{\left(\frac{2L}{n}\right)} = \boxed{\frac{nv}{2L}}$$




$L = \frac{\lambda}{4}$  $L = \frac{3\lambda}{4}$  $L = \frac{5\lambda}{4}$  $L = \frac{7\lambda}{4}$

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

$L = \frac{n\lambda}{4}$  $n = 1, 3, 5, 7, \ldots$  n odd

$\boxed{f_n = \frac{v}{\lambda}} = \frac{v}{\left(\frac{4L}{n}\right)} = \boxed{\frac{nv}{4L}}$  $n = 1, 3, 5$

14.70 Lowest note of organ is 22 Hz

Minimize length of organ pipe needed.

How long is organ pipe if

a) Closed one end b) Open both ends

$L = \lambda/4$

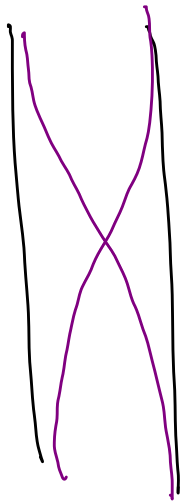
$f = 22\ \text{Hz}$

$\lambda = \dfrac{v}{f} = \dfrac{343\ \text{m/s}}{22\ \frac{1}{s}} = 15.6\ \text{m}$

$L = \lambda/4 = 3.9\ \text{m}$

b)

open both ends



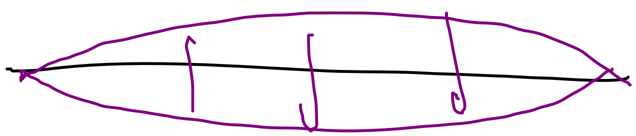
$$L = \frac{\lambda}{2}$$

$$= \frac{15.6\,m}{2}$$

$$= 7.8\,m$$

14.68 The A-string on piano is 38.9 cm (440 Hz) long, clamped both ends. Under 667 N of tension. What is its mass?

$= F$



$$v = \sqrt{\frac{F}{\mu}} \qquad \mu = \frac{m}{L}$$

$$v^2 = \frac{F}{\mu}$$

$L = 38.9\ cm$

$$\mu = \frac{F}{v^2} = 5.69 \times 10^{-3} \frac{kg}{m}$$

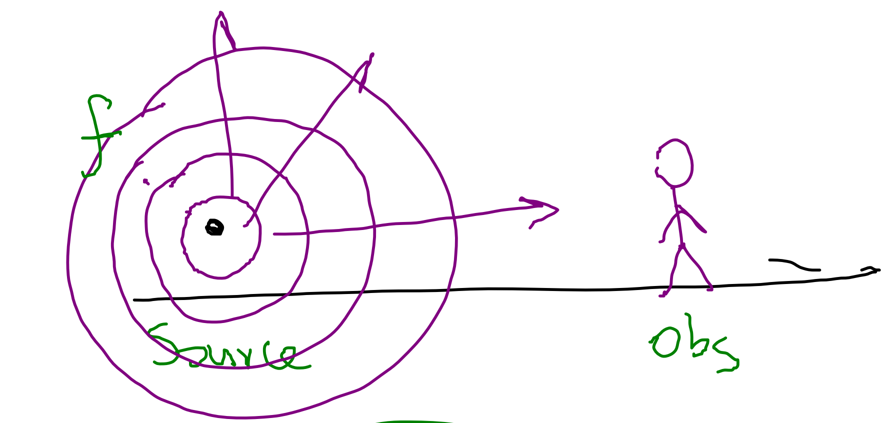
$$= \frac{M}{L} \qquad M = 2.21\ g$$

$$= 2.21 \times 10^{-3}\ kg$$

$\lambda = 2L = 0.778\ m$

$v = \lambda f = (0.778\ m)(440\ \frac{cyc}{s}) = 342.3\ \frac{m}{s}$

# Doppler Effect

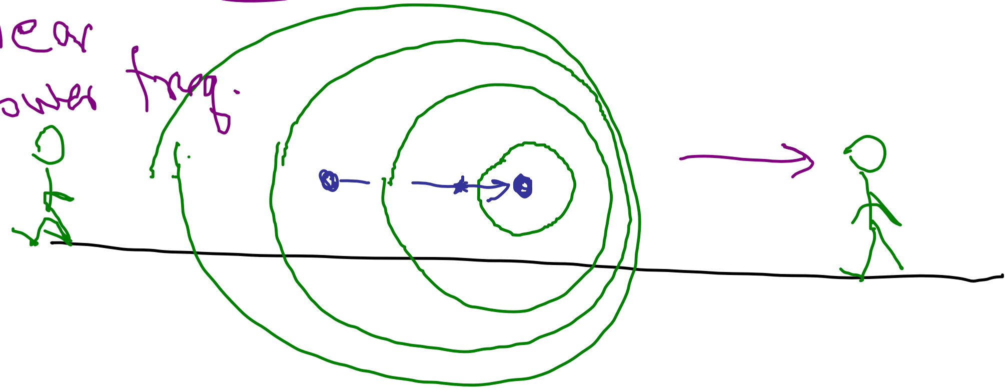



Two cases:

Source is in motion

Observer in motion

Hear lower freq.



Get waves at same speed

Eff'ly $\lambda$ got smaller!

$$f = \frac{v}{\lambda_{\text{smaller}}}$$

Hears higher freq.

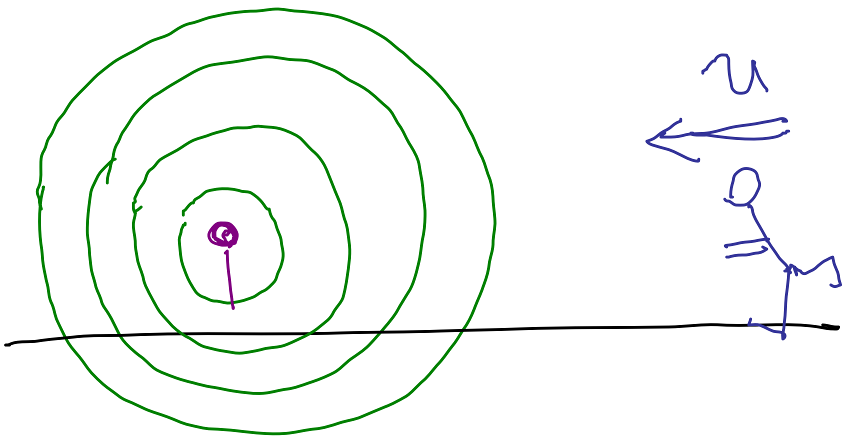
Observer hears $\underline{f'}$


Source travels
speed u

Speed of sound = V

$$f' = \frac{f}{\left(1 \mp \frac{u}{V}\right)} \quad \begin{cases} \text{toward} \\ \text{away} \end{cases}$$

# Moving observer




Wavelength is same.

Effectively, speed of waves got bigger

$$f' = \frac{V_{new}}{\lambda}$$

$$f' = f\left(1 \pm \frac{u}{v}\right)$$

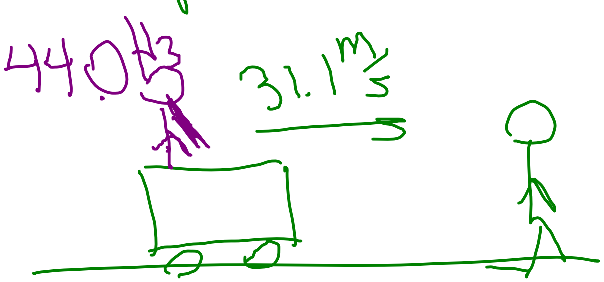
$+$ toward

$-$ away

Both motions


$$f' = \left( \frac{1 \pm \frac{v_{obs}}{v}}{1 \mp \frac{v_{source}}{v}} \right) f$$

Example




$$f' = \left( \frac{1}{1 - \frac{31.1\ \frac{m}{s}}{343\ \frac{m}{s}}} \right) (440\ \text{Hz})$$

$$= 484\ \text{Hz}$$