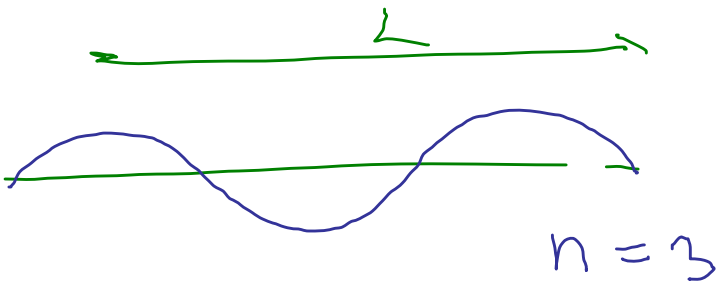
Phys 2110-4 4/20/12

Note Title 4/20/2012

Standing Waves



$$L = n\frac{\lambda}{2} \qquad n = 1, 2, 3,$$

$$\lambda = \frac{2L}{n} \qquad f_n = \frac{v}{\lambda} = \frac{nv}{2L}$$

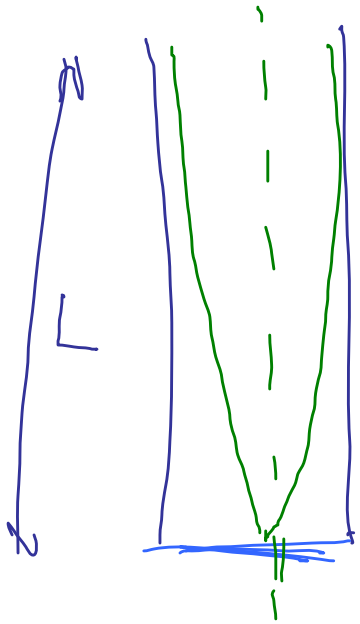
$$\boxed{f_n = \frac{n}{2L}\sqrt{\frac{F}{\mu}}}$$

Fundamental

Ration $f_1 = \frac{1}{2L}\sqrt{\frac{F}{\mu}}$

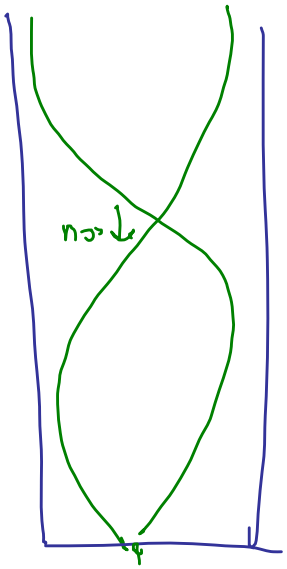
$f_2 = 2 \times f_1 \quad f_3 = 3 \times f_1$

Standing Sound Waves

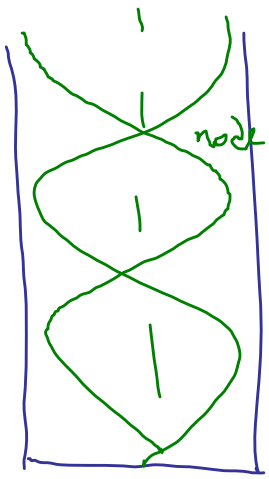


Closed on one end

$L = \frac{1}{4}\lambda \quad \lambda = 4L \quad f_1 = \frac{v}{\lambda} = \frac{1}{4L}v$



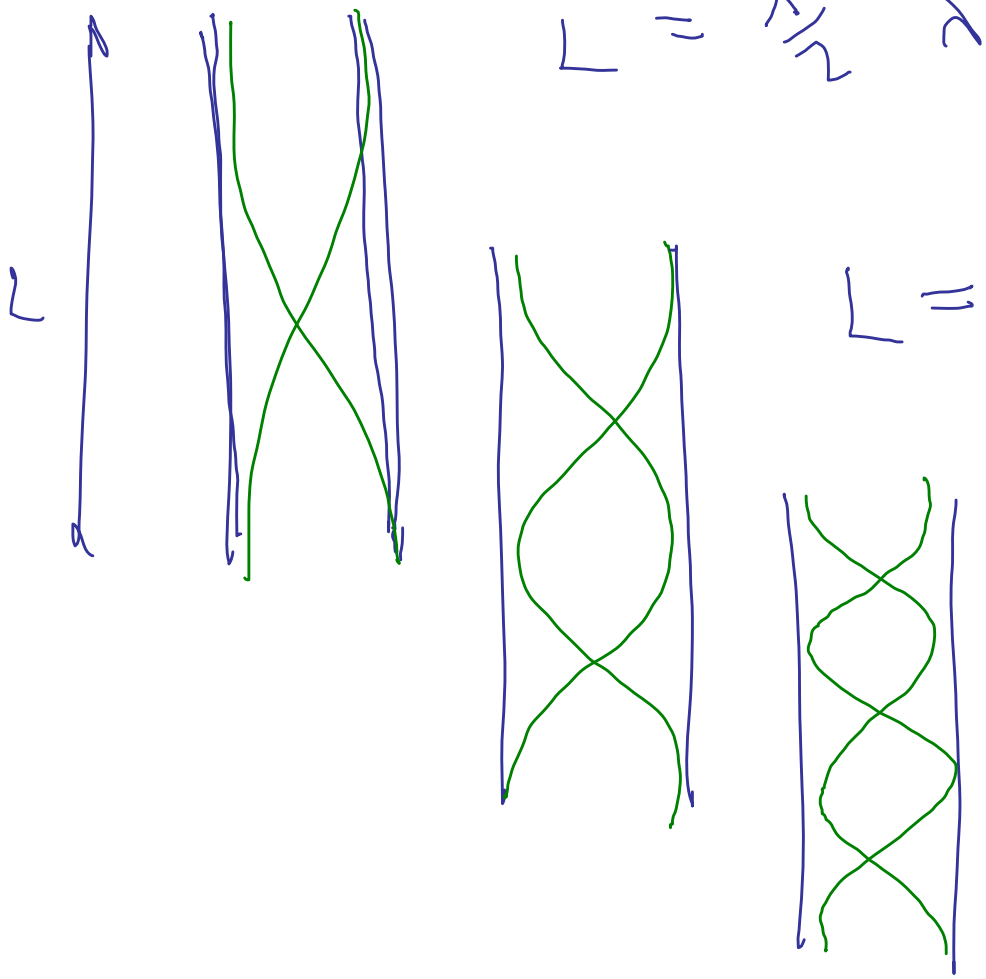
$L = \frac{3}{4}\lambda \quad \lambda = \frac{4L}{3} \quad f = \frac{3}{4L}v$



$L = \frac{5}{4}\lambda \quad f = \frac{5}{4L}v$

$$f_n = \frac{nv}{4L} \qquad n = 1, 3, 5, \ldots$$

Open on both ends



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

$L = \lambda \quad \lambda = L \quad f_2 = \frac{1}{L} v$

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

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

$\lambda = 2L/3$

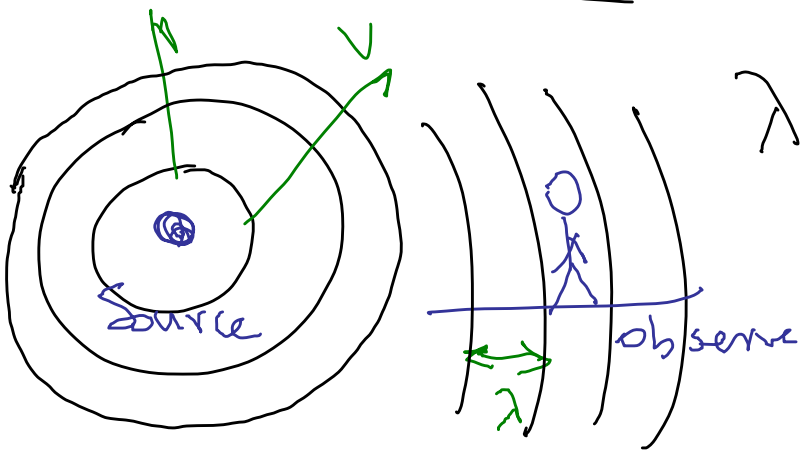
$$\boxed{f_n = \frac{nv}{2L}}$$

$n = 1, 2, 3$

$$f_n = \frac{n}{2L}\sqrt{\frac{F}{\mu}}$$

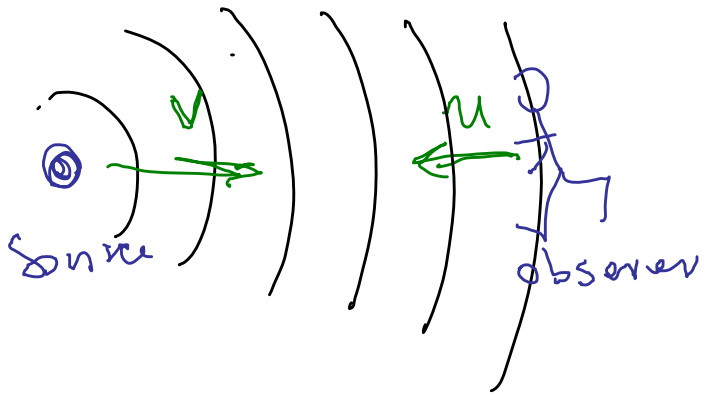
$n = 1, 2, 3, 4, \ldots$

Doppler Effect



$$\lambda f = v$$

Moving Observer



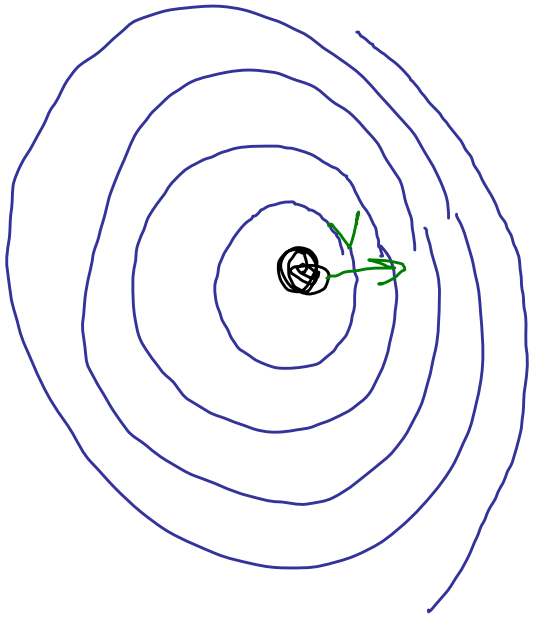
Effectively v of waves is different

$\lambda f = v$

$f = v/\lambda$

Observes bigger freq

f'



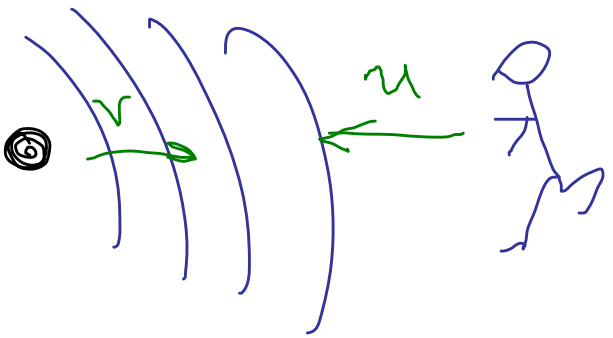
Moving source (Toward)

Wave has same speed.

Wavelength has changed

$f = \frac{v}{\lambda}$ f' is bigger

Doppler Effect



Moving observer toward.

$v \longrightarrow v + u$

$$f' = \frac{(v+u)}{\lambda} = \frac{(v+u)}{v/f}$$

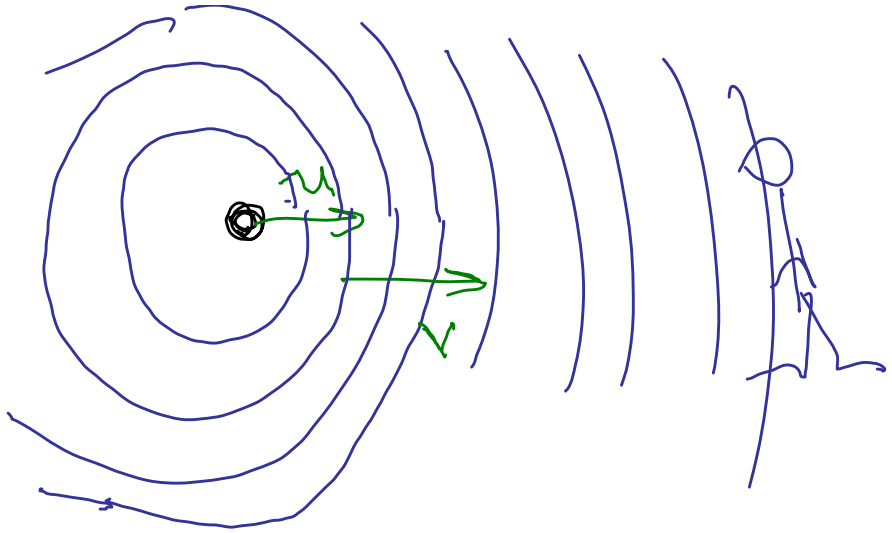
$$f' = f\left(1 + \frac{u}{v}\right)$$

Mov Obs

$u < v$

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

$\begin{cases} \text{Toward} \\ \text{Away} \end{cases}$



$$\lambda' = \lambda - uT \qquad T = \frac{1}{f}$$

$$= \lambda - u\frac{\lambda}{v}$$

$$= \lambda\left(1 - \frac{u}{v}\right)$$

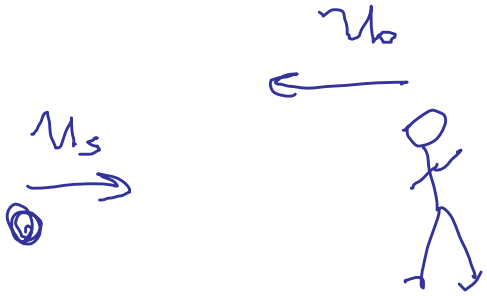
$$f' = \frac{v}{\lambda'} = \frac{v}{\lambda\left(1 - \frac{u}{v}\right)} = \frac{f}{\left(1 - \frac{u}{v}\right)}$$

$$f' = \frac{f}{\left(1 \mp \frac{u}{v}\right)} \qquad \begin{cases} \text{Toward} \\ \text{Away} \end{cases}$$

p. 240

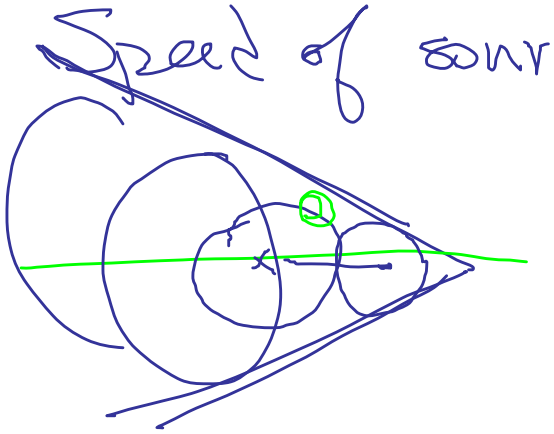
Both in motion:

$$f' = f \frac{\left(1 \pm \frac{u_o}{v}\right)}{\left(1 \mp \frac{u_s}{v}\right)}$$



Covers both cases

Speed of source > V



Mach angle

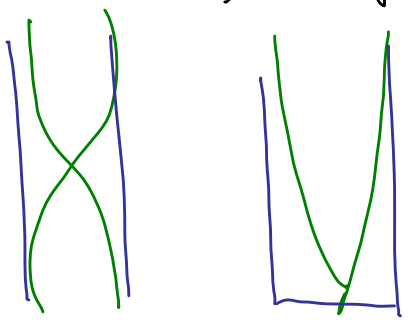
$\sin\theta = \frac{v}{u}$

Shock wave

14.70 Organ pipes, lowest note is 22 Hz

a) Length needed if closed one end

b) Open on both ends



$f = 22\ \text{Hz}$

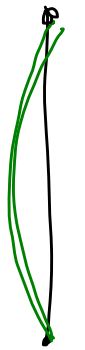
$\lambda = v/f = \frac{343\ \text{m/s}}{22\ \text{Hz}} = 15.6\ \text{m}$

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

b) Open $L = \lambda/2 = 7.8\ \text{m}$

14.68 The A string on a piano (440 Hz) is 38.9 cm long. Clamped both ends. Tension is 667 N. What's its mass?

$= F$



38.9 cm $= \frac{\lambda}{2}$

$f = 440\ Hz$

$v = \lambda f = 342.3 \frac{m}{s}$ $= \sqrt{\frac{F}{\mu}}$

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

$\lambda = 2L = 0.778 m$

$m = \mu L = 2.21\ g$