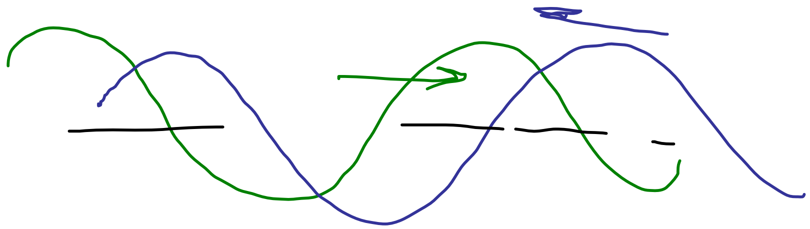
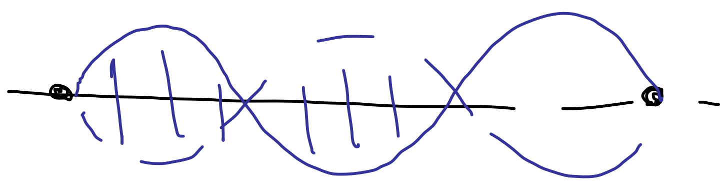
Phys 2110 - 5 12/3/12

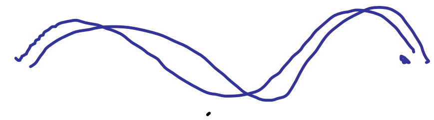
Note Title 12/3/2012

Standing Waves





String



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

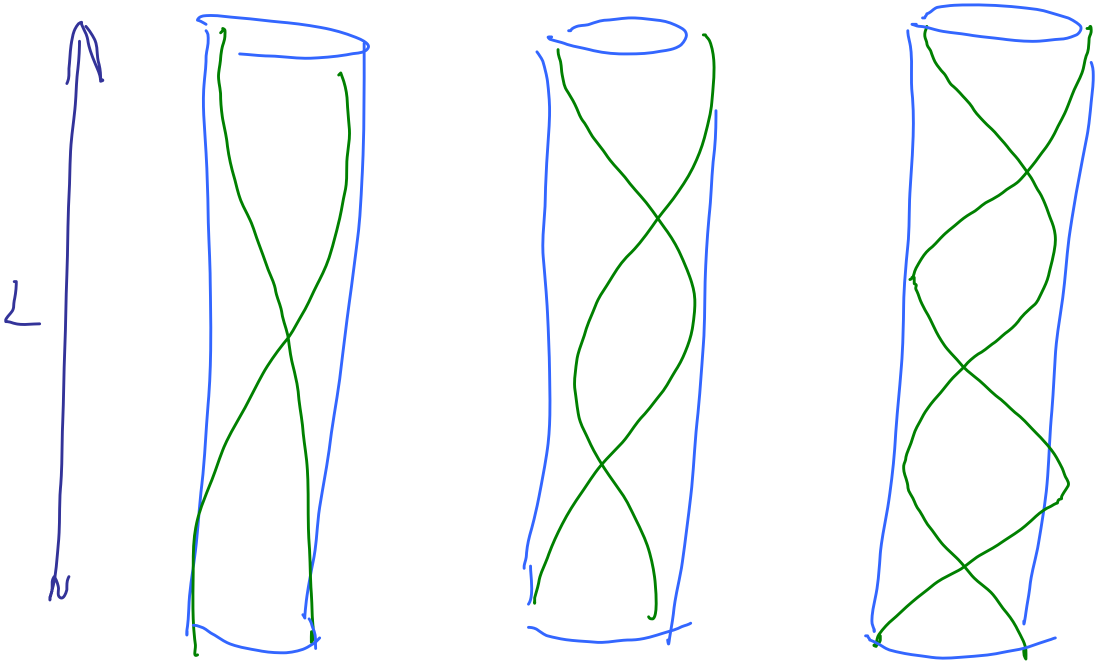
$$\lambda f = v$$

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

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

speed of waves on string

Pipe: Open both ends: (molecule motion)



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

$n=2$ $\quad L = \lambda$

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

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

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

v = speed of sound $\sim 343 \frac{m}{s}$

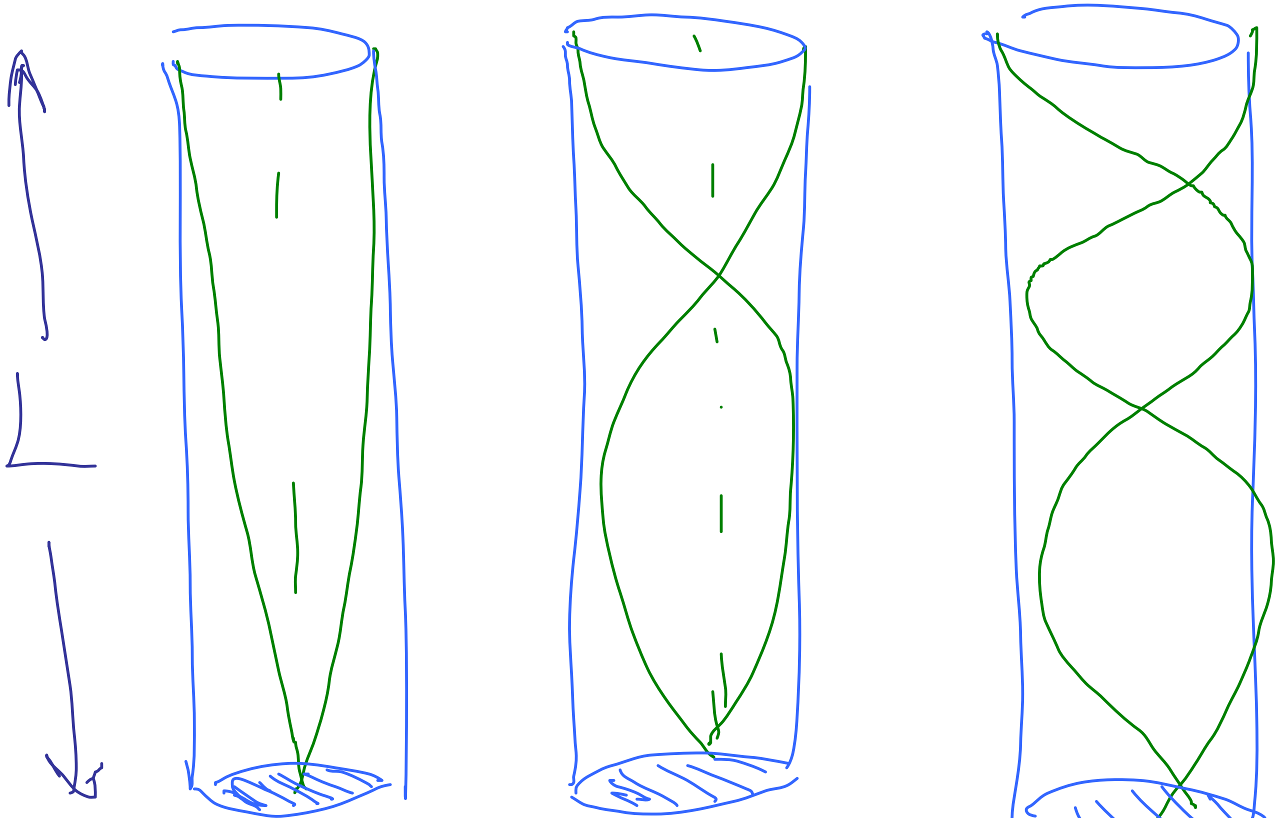
$$\lambda = \frac{2L}{n}$$

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

$n=1$ fundamental

$n=2, 3, 4$ harmonics overtones

Pipe closed one end



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

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

$n = 1, 3, 5, \ldots$

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

$$f = \frac{v}{\lambda} = \frac{nv}{4L}$$

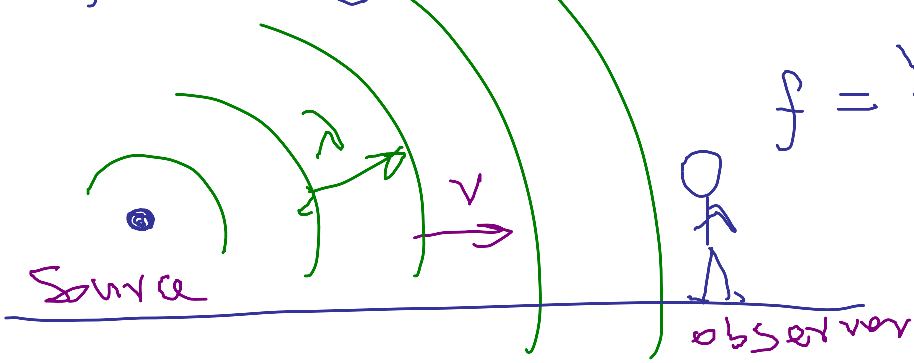
$n = 1, 3, 5 \ldots$

$n = 1$ fundamental

odd ratios

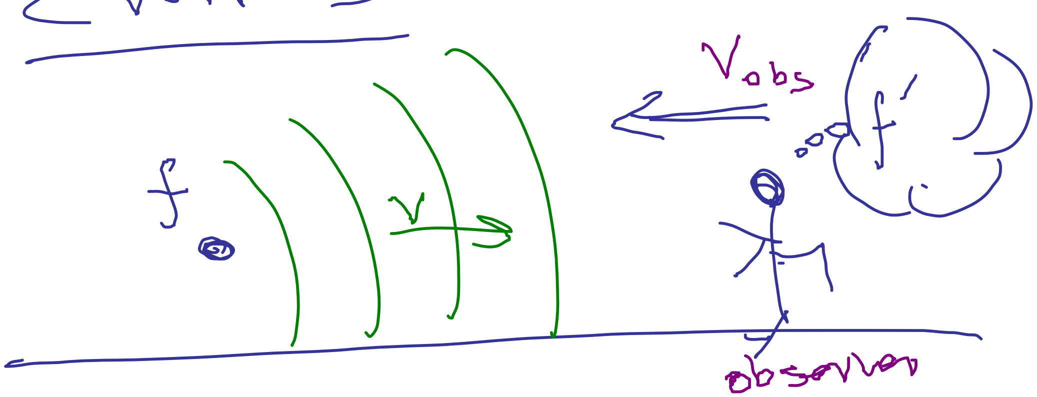
Doppler Effect

Picture so far:



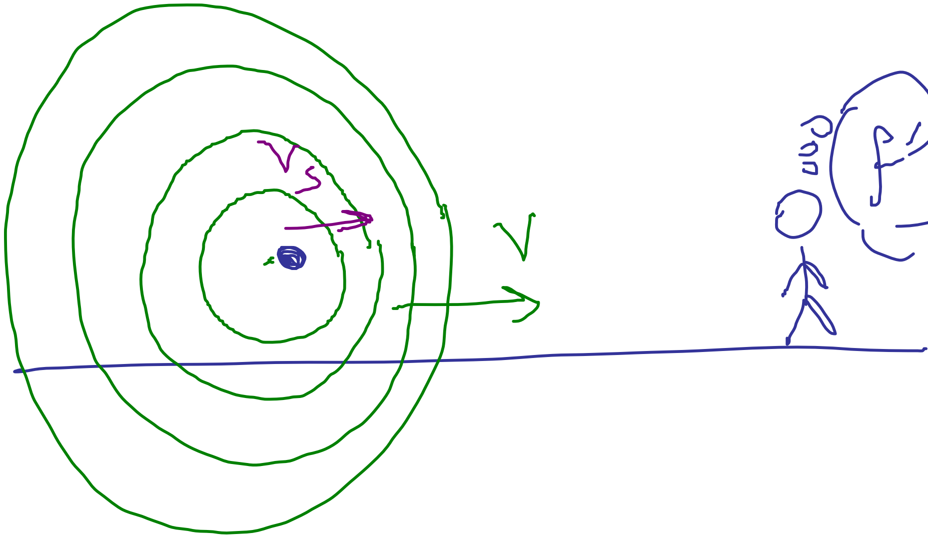
$f = v/\lambda$

2 variants:



obs encounters maxima at increased rate

He obs'd f' ($> f$ toward)



Moving source

$$f' = f \frac{1}{1 \mp u/v}$$

v = speed of sound
u = speed of observer

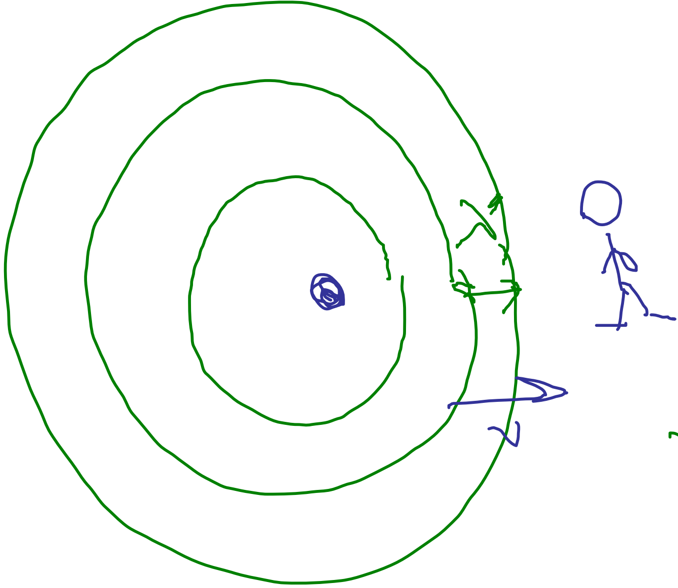
$\mp$ } toward / away

Source in motion.

Small dist. between maxima.

$\Rightarrow$ Encounters maxima more often

f' is $> f$ (source toward)



$$\lambda' < \lambda$$

T = period of wave $\qquad T = 1/f$

$$\lambda' = \lambda - uT$$

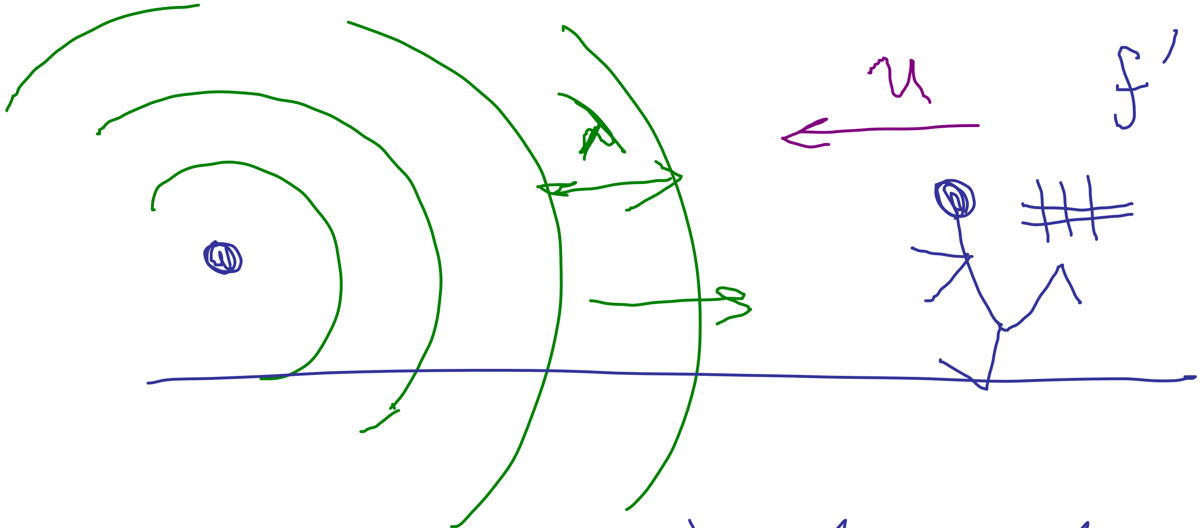
u = speed of source

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

$$= \frac{1}{f}(v - u)$$

Guy hears

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



(toward)

Effective speed of wave $v' = v + u$

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

Guy here:

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

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

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

moving observer

$\pm$ toward / away

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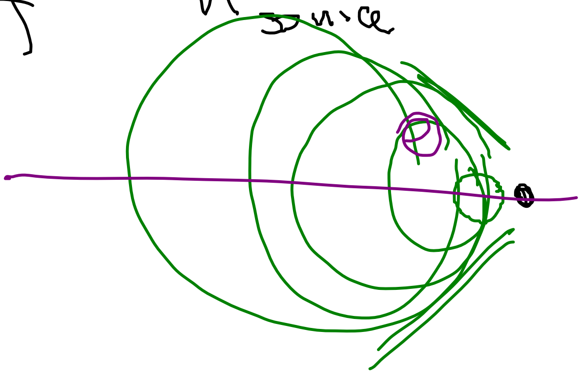
Both in motion:

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

Non-relativistic formula

If $u_{source} > v$



shock wave

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

$u > v$