Announcements

1. Practice final exams now available

2. Physics Colloquium: "Laser Mass Spectrometry in Biological Physics: part of the proteomics puzzle" – 4 PM Thursday, Dec. 5th. http://www.wfu.edu/physics/haglund.html

3. Presentations? Friday ~ 4 PM Tues ~ 9 AM ????

4. Final exam :

   dates: Thurs. 12/11/02 at 9 AM, Sat. 12/14/02 at 2 PM

5. Sound waves

   Musical instruments

   Beats

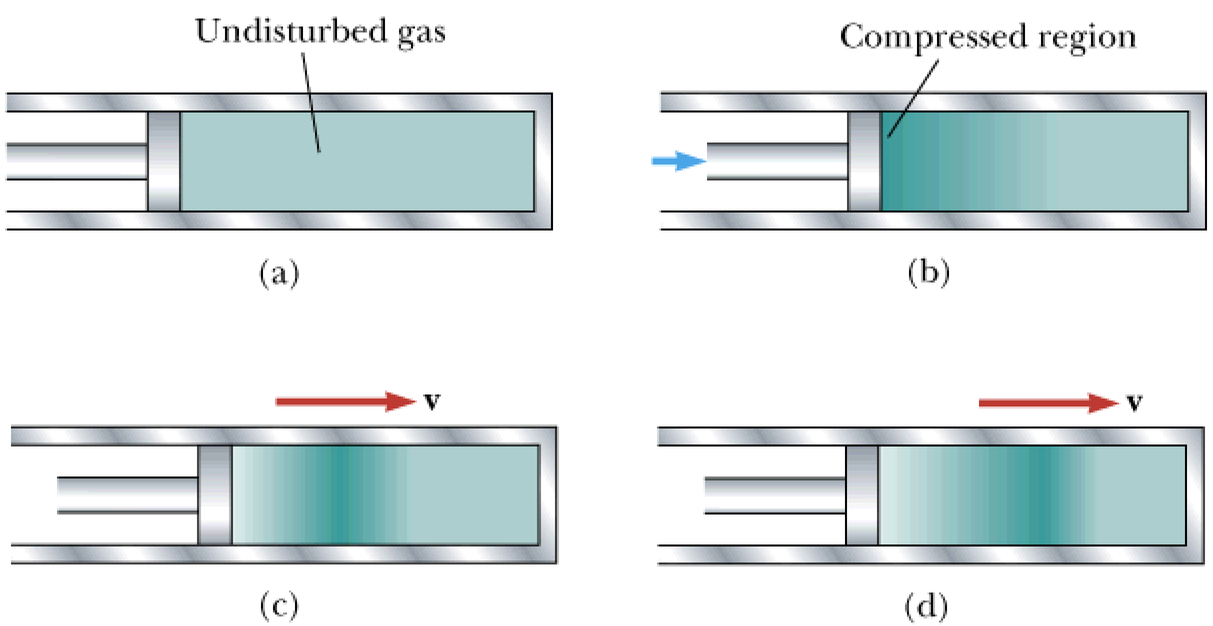
   Doppler effect

Sound waves

Longitudinal waves propagating in a fluid or solid

$$\frac{\partial^2 y}{\partial t^2} = v^2 \frac{\partial^2 y}{\partial x^2} \qquad y(x,t) \text{ describes density or pressure variations}$$

$$v = \sqrt{\frac{T}{\mu}} \Rightarrow \sqrt{\frac{B}{\rho}} \quad \left(\sqrt{\frac{\text{compressibility}}{\text{density}}}\right) = \sqrt{\frac{\gamma P}{\rho}} \approx 343 \text{ m/s}$$



Periodic sound wave

In terms of pressure:

$$P(x,t) = P_0 + \Delta P_{\max} \sin\left(\frac{2\pi x}{\lambda} \pm \frac{2\pi t}{T}\right)$$

Sound intensity: (energy/(unit time · unit area))

$$I \equiv \frac{(\Delta P_{\max})^2}{2\rho v}$$

Decibel scale:

$$\beta \equiv 10 \log\left(\frac{I}{I_0}\right) \qquad I_0 = 10^{-12}\,\mathrm{W/m^2}$$

Some representative values

Source	β (dB)
Lawn mower	100
Normal conversation	70
Mosquito buzzing	40
Threshold of hearing	0

Peer instruction question

Suppose that you are trying to sleep but your roommate has the stereo on at a sound level of β=100. In trying to diplomatically and accurately achieve an appropriate sound reduction, which of the following is better to request:

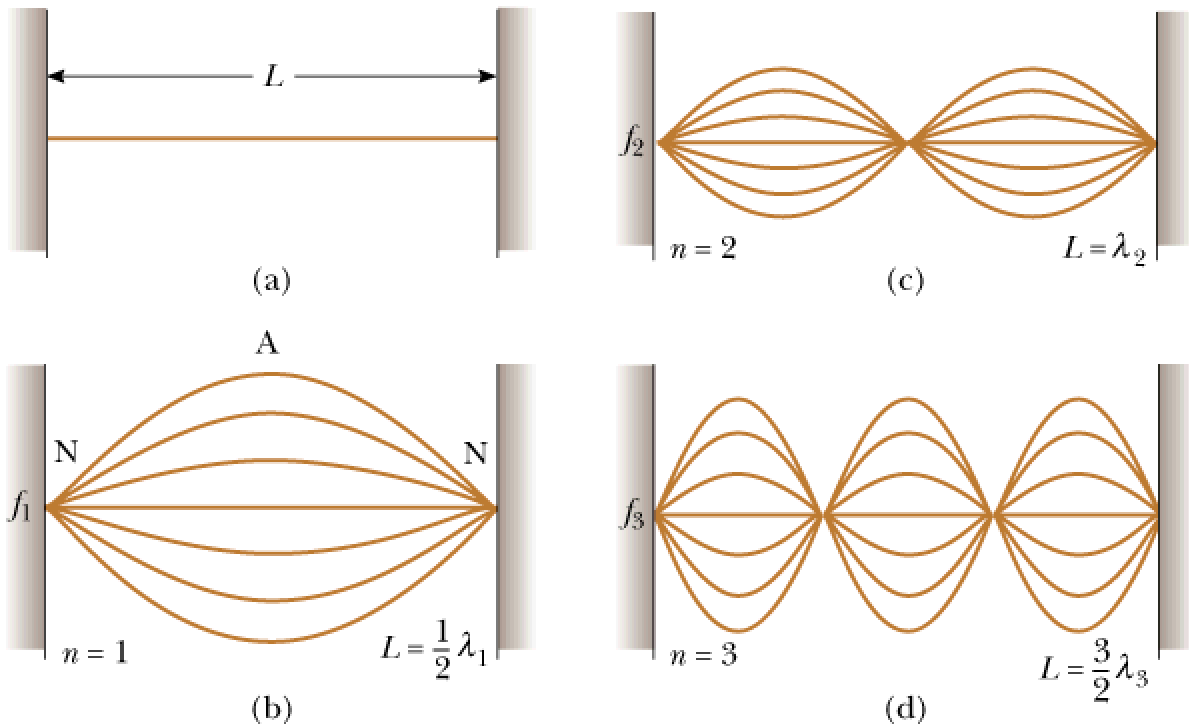
(A) Please reduce the stereo intensity by half.

(B) Please reduce the stereo decibel level by half.

(C) Please reduce the pressure amplitude of the sound wave produced by the stereo by half.

The sound of music

String instruments (Guitar, violin, etc.)



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

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

$$v = \sqrt{\frac{T}{\mu}}$$

(no sound yet.....) $y_{\text{standing}}(x,t) = 2y_0 \sin\left(\frac{2\pi x}{\lambda}\right)\cos\left(\frac{2\pi t}{T}\right)$

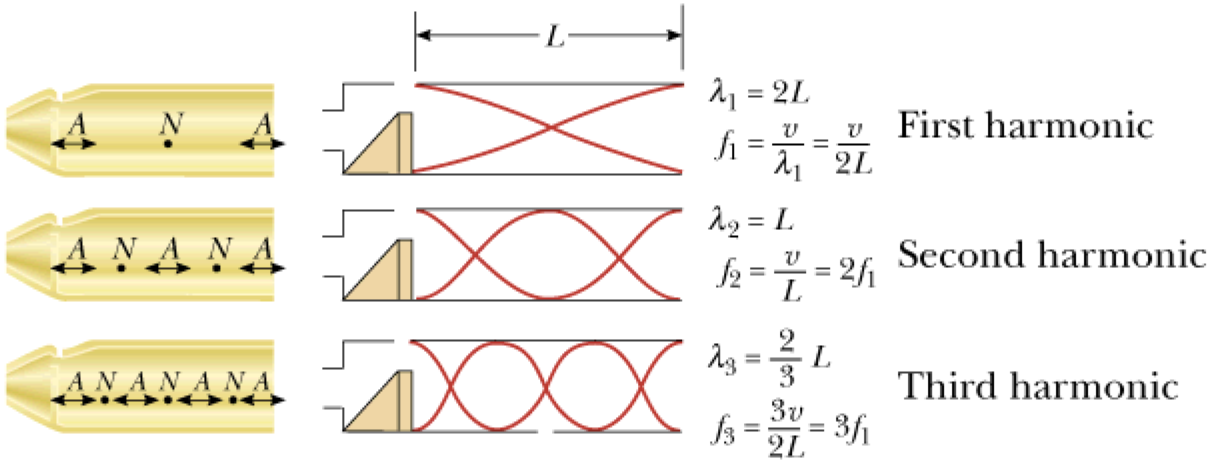
coupling to air

Peer instruction question

Suppose you pluck the "A" guitar string whose fundamental frequency is f=440 cycles/s. The string is 0.5 m long so the wavelength of the standing wave on the string is λ=1m. What is the wavelength of the sound wave which is produced?

(A) 1m (B) 0.79 m (C) 1.28 m

"Wind" instruments (standing waves in air)

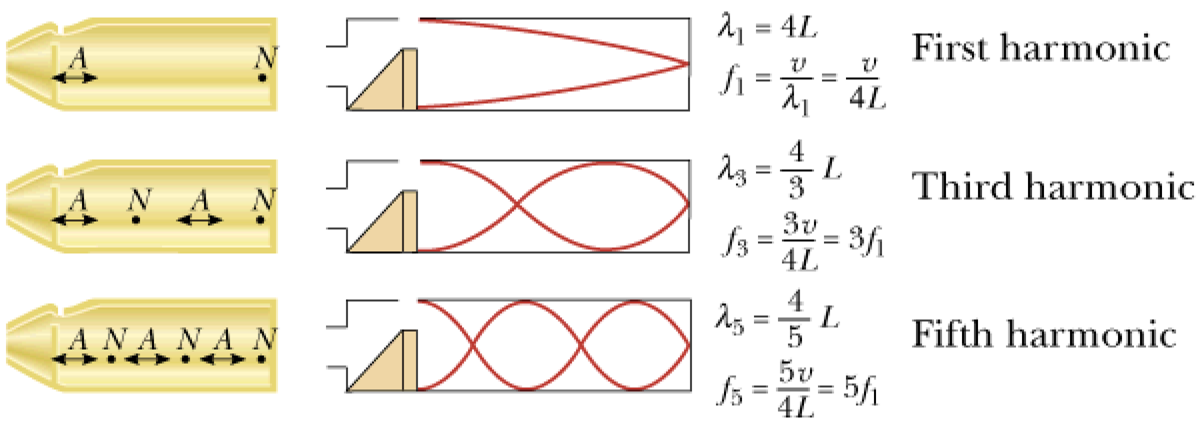


(a) Open at both ends

$$\lambda_n = \frac{2L}{n};\, n = 1,2,3,\ldots$$

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

$$v = \sqrt{\frac{\gamma P}{\rho}} \approx 343 \text{ m/s}$$



(b) Closed at one end, open at the other

$$\lambda_n = \frac{4L}{n};\, n = 1,3,5,\ldots$$

$$f_n = \frac{v}{\lambda_n} = \frac{nv}{4L}$$

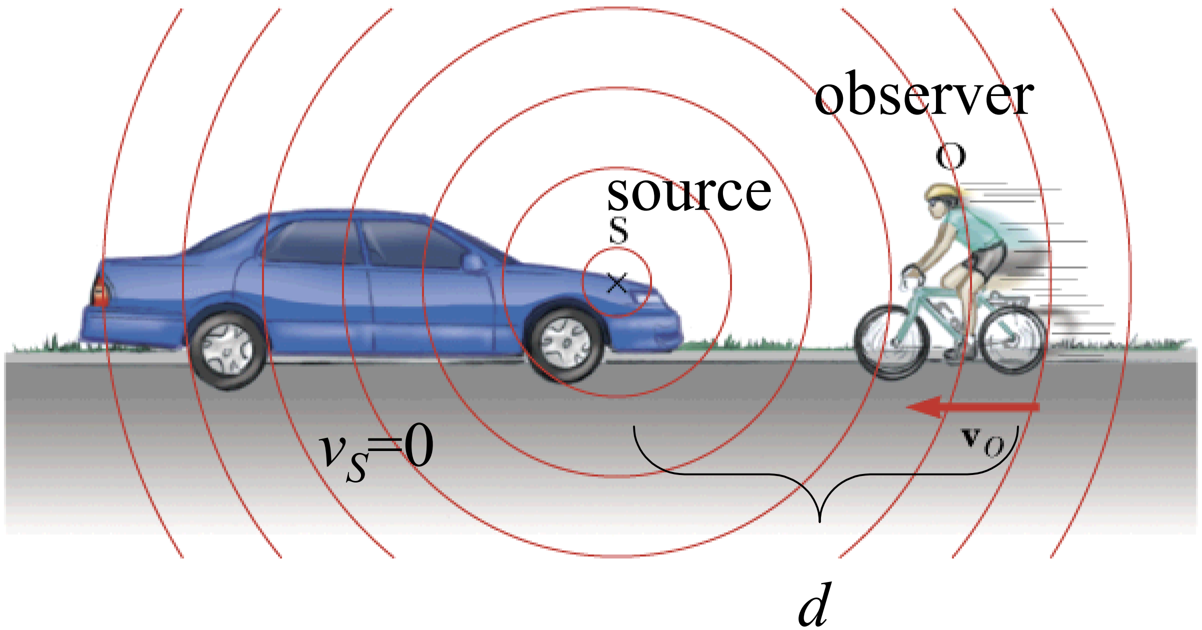
$$v = \sqrt{\frac{\gamma P}{\rho}} \approx 343 \text{ m/s}$$

The “Doppler” effect

v=sound velocity

observer moving, source stationary

Serway, Physics for Scientists and Engineers, 5/e
Figure 17.10



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$$v t_1 = d - v_O t_1$$

$$v(t_2 - T) = d - v_O t_2$$

$$t_2 - t_1 = \frac{1}{f'} = T\,\frac{v}{v + v_O}$$

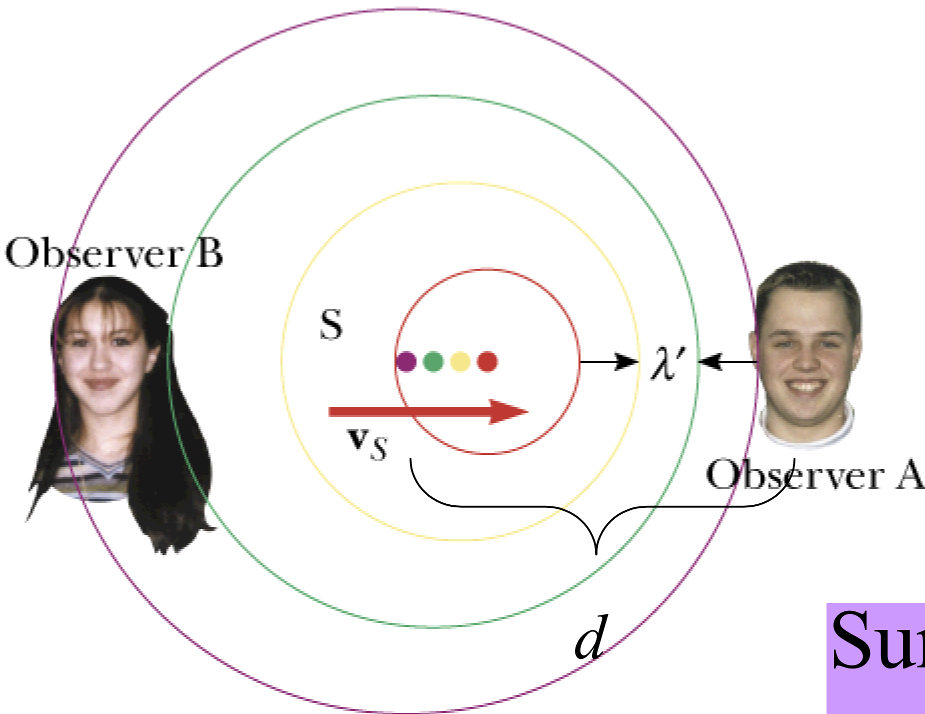
$$f' = f\,\frac{v + v_O}{v}$$

The "Doppler" effect

v=sound velocity

observer stationary, source moving

Serway, Physics for Scientists and Engineers, 5/e
Figure 17.11a



(a)

$$vt_1 = d$$

$$v(t_2 - T) + v_S T = d$$

$$t_2 - t_1 = \frac{1}{f'} = T\frac{v - v_S}{v}$$

$$f' = f\frac{v}{v - v_S}$$

Summary:

$$f' = f\frac{v \pm v_O}{v \mp v_S}$$

toward

away

Peer instruction question

Is Doppler radar described by the equations given above for sound radar?

(A) yes (B) no