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Welcome!

Physics 194 - Lecture 15

Have a question during class? Please ask it right away, even if it means interrupting in the middle of a thought. I want you to!

Agenda

- Standing waves + resonant frequencies
- Sound intensity
- The Doppler effect

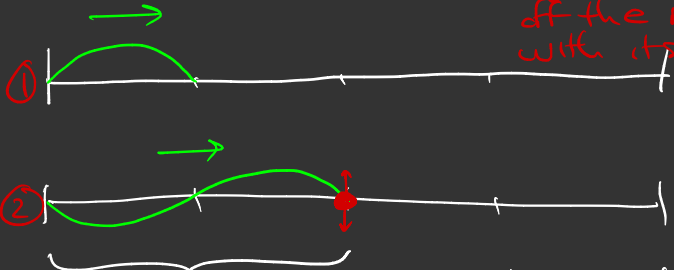
Class starts @2:15 pm

String instruments

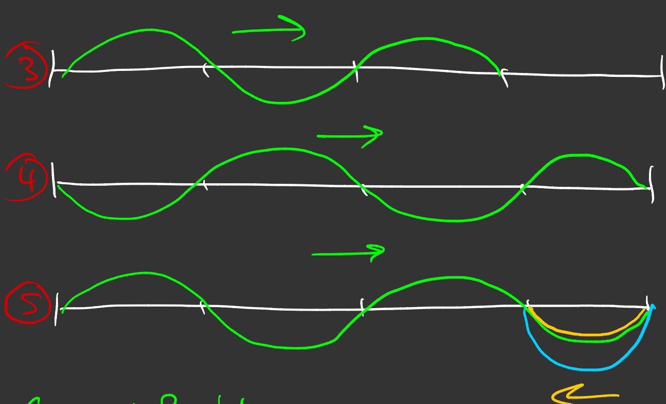
① through ⑧ is a wave traveling rightward on a string, then reflecting off the right end and overlapping with itself to form a standing wave.

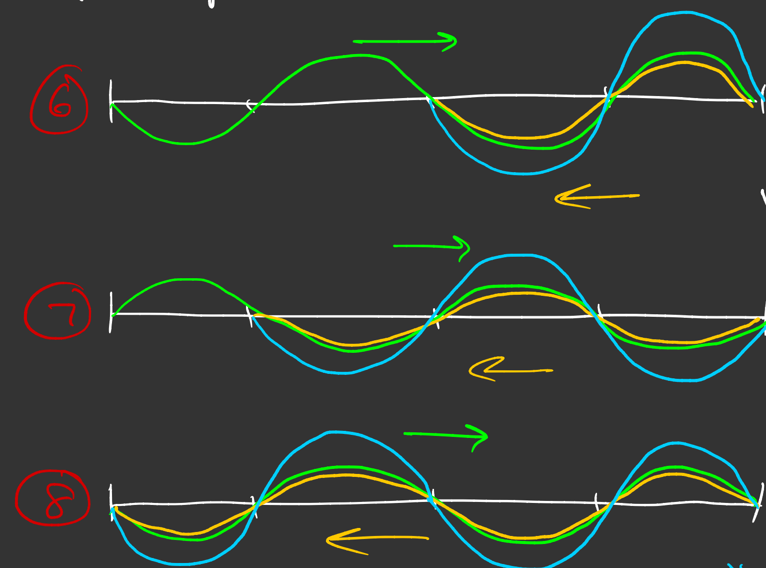
$$v = \frac{\lambda}{T} = \lambda f$$

- v ← wave speed
- T ← period of vibration of the string
- f ← frequency of the vibrating string



This is one wavelength, λ. As the single wavelength travels through the • that point on the vibrating string completes a single cycle up & down. That takes one period T in time to happen.



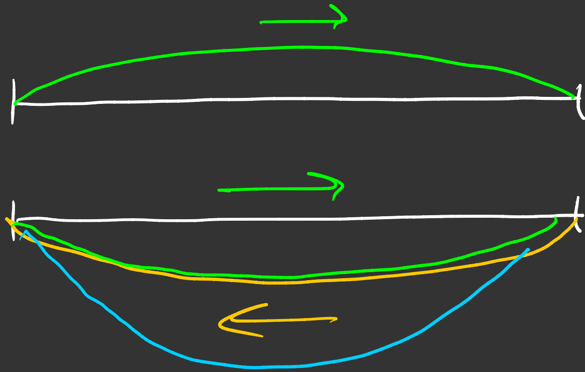


$$v = \sqrt{\frac{F_{mon}}{\mu}}$$

Green: Right-moving wave

Yellow: Left-moving wave

Blue: Superposition of green + yellow, a standing wave vibrating in place. The "note" you hear.



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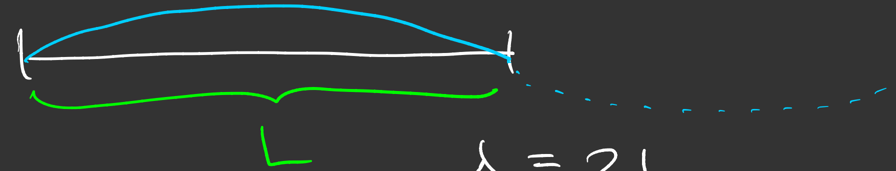
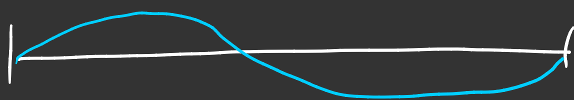


$$\lambda = \frac{2L}{1}$$

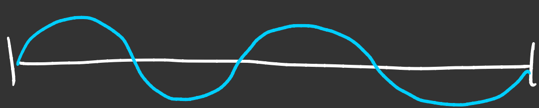


2

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

3

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



4

$$\lambda = \frac{1}{2}L = \frac{2L}{4}$$

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

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

$$f = \frac{v}{2L/n}\frac{n}{n} = \frac{v}{2L}n \leftarrow 1, 2, 3, \ldots$$

$$v = \sqrt{\frac{F_{m\,on\,M}}{\mu}} \qquad \mu \leftarrow m/L$$

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

↑ resonant frequencies

GT: You notice that your guitar is out of tune and is producing frequencies that are too low. What should you do? Explain!

Sound intensity

Intensity is the power output of a sound source divided by the area that power spreads out over.

$P = 1000\,W$

Units of intensity are W/m^2

$$I = \frac{P}{A} = \frac{P}{4\pi r^2}$$

Decibel scale:

$$\beta = (10\,db)\log_{10}\left(\frac{I}{I_0}\right)$$

↑ sound intensity level

$I_0 = 10^{-12}\ W/m^2$ Threshold of human hearing.

$I_{max} = 10\ W/m^2$ Ouch!

$I_{city\ traffic} = 10^{-4}\ W/m^2$

$$\beta_{city\ traffic} = (10\,db)\log_{10}\left(\underbrace{\frac{10^{-4}\ W/m^2}{10^{-12}\ W/m^2}}_{10^8}\right)$$

$$= (10\,db)\underbrace{\log_{10}(10^8)}_{=8}$$

$$= 80\,db$$

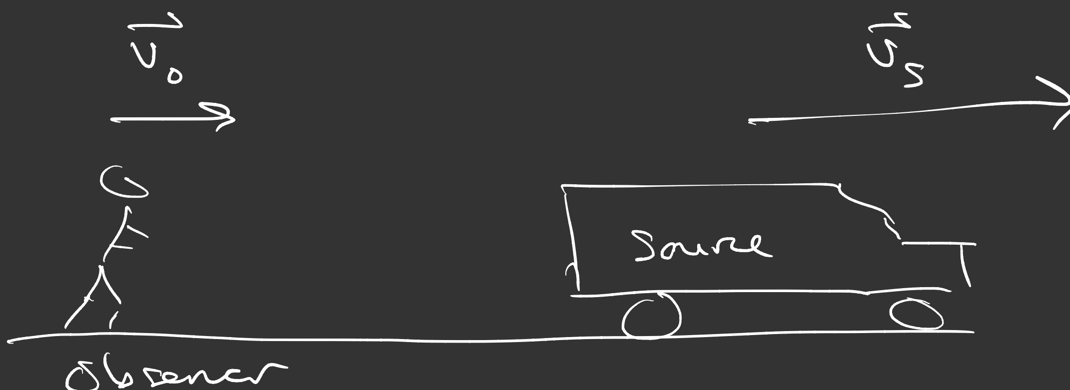
Doppler effect: When there's relative speed between the sound source (s) and the observer (o) the observed frequency will be different than the source frequency.

$$f_o = f_s \left(\frac{v \pm v_o}{v \mp v_s} \right)$$

v: sound speed

v_o: speed of observer relative to the medium.

v_s: speed of the source relative to the medium.



Numerator: If $\vec{v}_o$ points toward the source, choose the upper sign (+). Choose (−) otherwise.

Denominator: If $\vec{v}_s$ points towards the observer, choose the upper sign (−). Choose (+) otherwise.