

Chapter 14-Sound

Sound waves are longitudinal waves; energy and motion of wave are parallel
(Transverse waves- energy and motion are perpendicular)

Sound waves require a medium, such as gas, liquid, or solid.

Within a longitudinal wave,

- the compression area (wave fronts close together) is where there is a high molecular density
- the rarefaction area (wave fronts spread out) is where there is a low molecular density

Audible sound waves-range 20-20,000 Hz (human ear)

Less than 20 Hz-infrasonic

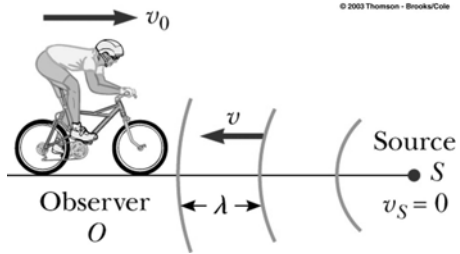
Greater than 20,000 Hz- ultrasonic (medical uses)

For the speed of sound when it's not 0 degrees Celsius, use the following formula: $v=331 \sqrt{(T/273)}$ T in Kelvin; Celsius to K add 273. This gives you speed of sound in m/s.

- Intensity of waves-I, measured in Watts/m², which is a (Power/Area) value.
- Intensity level- β , measure in decibels (dB) which is loudness; relative scale; relative to the lowest level that the human ear can hear, 1×10^{-12} Watt/m²

$I=I_0 10^{(\beta/10)}$ or $\beta=10 \log (I/I_0)$ where $I_0=1 \times 10^{-12}$ Watts/m²

- Doppler Effect is due to relative motion of the observer and source of sound waves. Observer could be moving, source could be moving, or both could be moving.



observer in motion, source at rest
 $f' = f((v+v_0)/v)$

source in motion, observer at rest
 $f' = f(v/(v-v_s))$

source and observer in motion
 $f' = f(v+v_0)/(v-v_s)$

sign convention: v is away it is (-), v towards you it is (+)

f is actual frequency and f' is the observed frequency

Red shift-if sound waves are being compressed toward observer. Frequency seems to go higher when source is approaching.

Blue shift-if sound waves are being expanded away from observer. Frequency seems to go lower when source is moving away.

Standing waves-

- Forced vibrations-when a system vibrates due to a frequency of a force that drives it.
- Resonance- A reaches max, and frequency of driving force=natural frequency.
- Structural resonance-natural vibrations. Ex. hitting sweet spot on baseball bat, hitting the sweet spot on club face of a driver, Tacoma Narrows Bridge.

Standing waves in air columns: open at both ends **or** closed at one end.

Open at both ends- takes $2L$ to make one full cycle or l , it takes two times the length of the tube to make one complete wavelength $l \lambda = 2L$, and $f \lambda = v$

open at both ends:

if $1\lambda=2L$, then if $\lambda_1=2L$ $f_1=v/\lambda_1=v/2L$

so that,

$\lambda_1=2L$, $\lambda_2=2L/2$, $\lambda_3=2L/3$, $\lambda_4=2L/4$, $\lambda_5=2L/5$, etc.

and

f_1 , $f_2=2f_1$, $f_3=3f_1$, $f_4=4f_1$, $f_5=5f_1$, etc.

closed at one end, only odd harmonics are present

then $1\lambda=4L$

Fundamental frequency $f_1=v/\lambda_1$, others are $f_2=v/\lambda_2$, etc. Also called harmonics, i.e. first harmonic is the f_1 , second harmonic- f_2 , third harmonic- f_3 , etc.

2 loops= 1λ

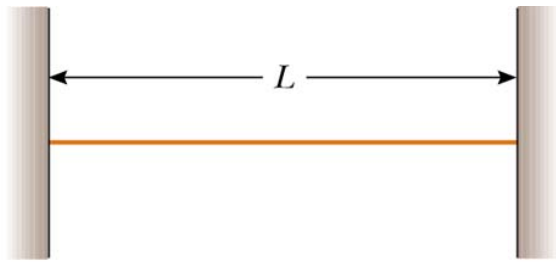
Open at both ends-you get **all frequencies** (all harmonics)

Closed at one end-get **only odd frequencies** or harmonics, i.e. f_1, f_3, f_5 , etc.

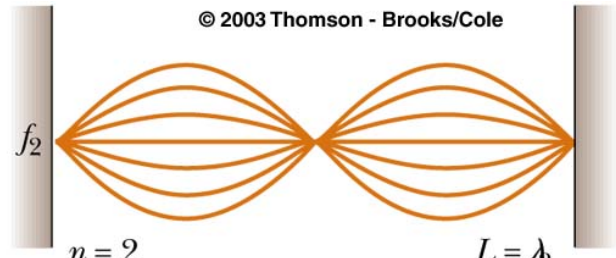
Nodes-where the waves cross each other.

Antinodes-where the waves aren't crossed; where a loop exists

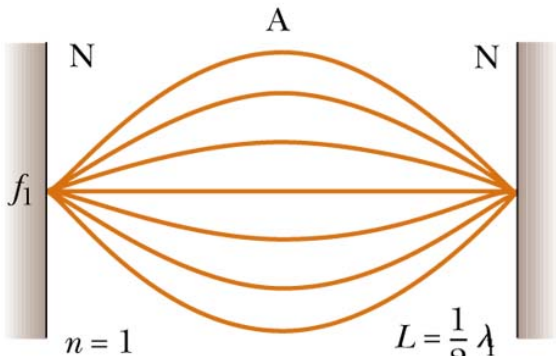
When looking at diagrams of standing waves generated by a vibrator/wave generator, count the number of loops and/or wavelengths per L and use this as given information.



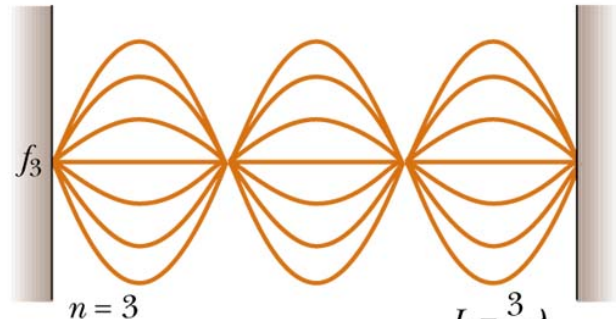
(a)



(c)



(b)



(d)

on AP exam; remember $v = \sqrt{F/\mu}$

