Sound Intensity and Resonance

Sound Intensity and Resonance

Objectives

- Calculate the intensity of sound waves
- Relate intensity, decibel level, and perceived loudness
- Explain why resonance occurs

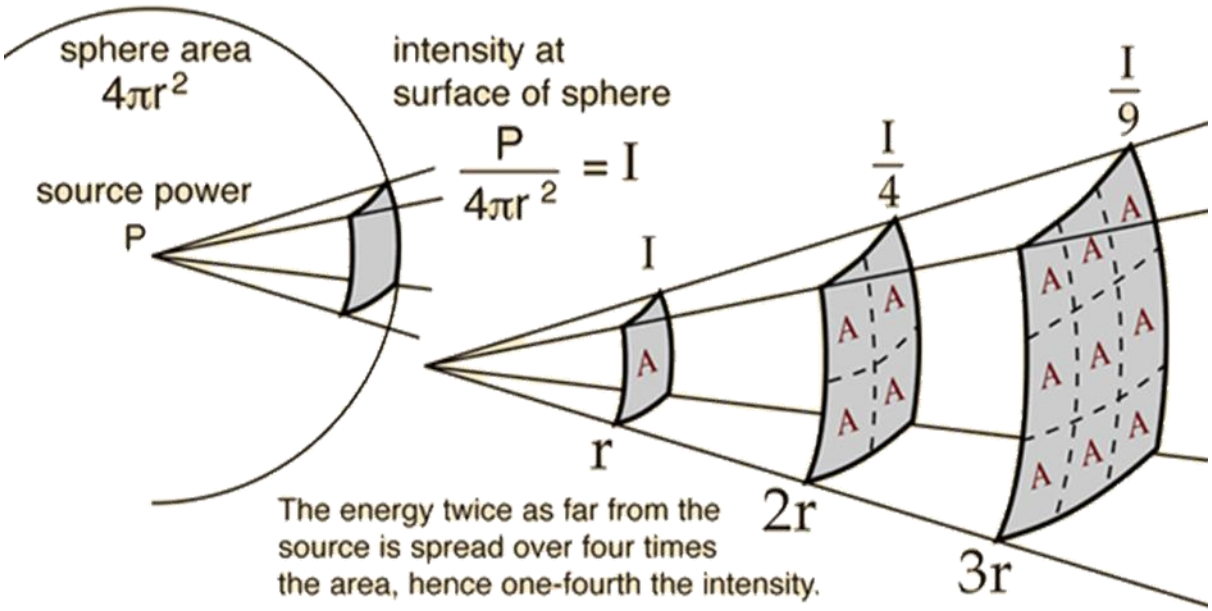
- Intensity is the rate of energy flow through a given area
- Intensity of a sound wave decreases as the distance from the source increases

  - Intensity = $P / 4\pi r^2$

Sound Intensity

- Intensity is the rate of energy flow through a given area

$$Intensity = \frac{\Delta E / \Delta t}{area} = \frac{P}{(4\pi)(r^2)} = \frac{Work}{meter^2}$$



Sample Problem 1

- Calculate intensity of the sound waves from an electric guitar's amplifier at a distance of 5.0 m when its power output is (a) 0.25 W (b) 0.50 W (c) 2.0 W

Sample Problem 2

- How much power is radiated as sound from a band whose intensity is 1.6×10^{-3} W/m^2 at a distance of 15 m?

- Intensity and frequency determine which sounds are audible
  - Humans frequency 20-20,000 Hz
  - Frequency < 50 H or > 12,000 Hz must be relatively intense to be heard
  - Softest sound humans hear
    - f = 1000 Hz, intensity = 1.0×10^{-12} W/m^2
  - Loudest – 1.0 W/m^2
    - Prolonged exposure to can lead to hearing loss (threshold of pain)

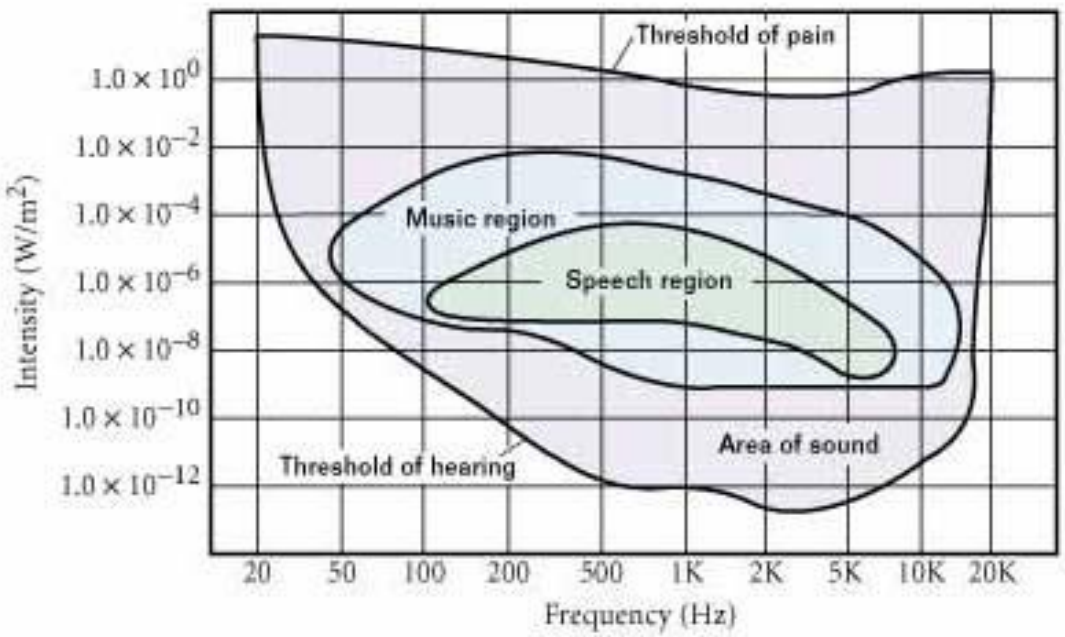


Figure 13-10

Human hearing depends on both the frequency and the intensity of sound waves. Sounds in the middle of the spectrum of frequencies can be heard more easily (at lower intensities) than those at lower and higher frequencies.

The Decibel

- Relative intensity is measured in decibels (dB).
- The original unit was named after Alexander Graham Bell. (0.1 B)
- When intensity is multiplied by 10, 10 dB are added to the decibel level. A difference in 10 dB means the sound is approximately twice as loud.

Table 13-2 Conversion of intensity to decibel level

Intensity (W/m^2)	Decibel level (dB)	Examples
1.0×10^{-12}	0	threshold of hearing
1.0×10^{-11}	10	rustling leaves
1.0×10^{-10}	20	quiet whisper
1.0×10^{-9}	30	whisper
1.0×10^{-8}	40	mosquito buzzing
1.0×10^{-7}	50	normal conversation
1.0×10^{-6}	60	air conditioning at 6 m
1.0×10^{-5}	70	vacuum cleaner
1.0×10^{-4}	80	busy traffic, alarm clock
1.0×10^{-3}	90	lawn mower
1.0×10^{-2}	100	subway, power motor
1.0×10^{-1}	110	auto horn at 1 m
1.0×10^{0}	120	threshold of pain
1.0×10^{1}	130	thunderclap, machine gun
1.0×10^{3}	150	nearby jet airplane

Sample Problem 3

- A sound that is 10 dB louder than another sound is perceived as _____ as loud as the softer sound, but it has an intensity that is _____ the softer sound.

- Forced vibration - tendency of one object to force another adjoining object into vibrational motion
  - ie – guitar string is struck that forces sound box particles to vibrate
- Natural frequency (fundamental) - Musical instruments and other objects are set into vibration (given energy) when someone or something disturbs the object.
  - ie – plucking guitar string, hammer striking piano string
- Vibration at natural frequency produces resonance
  - Resonance – condition when frequency of a force applied to system matches the natural frequency of the system

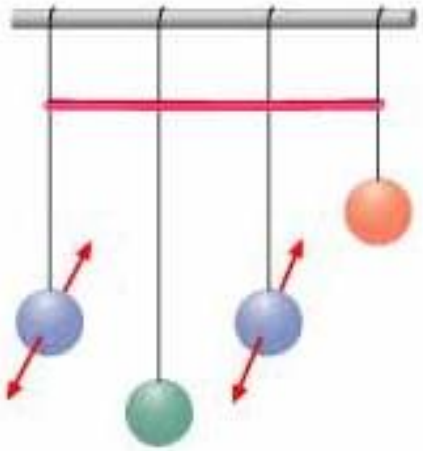


Figure 13-11
If one blue pendulum is set in motion, only the other blue pendulum, whose length is the same, will eventually oscillate with a large amplitude, or resonate.

Tacoma Narrows suspension bridge, November 7, 1940

http://www.youtube.com/watch?v=lXyG68_caV4

Sample Problem 4

- Which of the following factors change when a sound gets louder? Which change when a pitch gets higher?

a) Intensity
b) Speed of the sound wave
c) Frequency
d) Decibel level
e) Wavelength
f) Amplitude