SPASH
PHYSICS
(SOUND) WAVES

FACTS:

1. SOUND is produced by vibrating matter, like your vocal chords, a string, a drum, or a wind instrument. If a tree fell in the forest and no one was present to hear it, would the tree cause any sound? If the tree caused any vibrating matter in a frequency to which the human ear is sensitive, yes. That's like asking , does stop and go lights continue functioning (given the power remains and the bulbs don't burn out) if your not looking at them? As long as electrons continue getting excited and continue falling back to their stable energy orbits emitting red, yellow, and green frequencies, light is present whether someone is looking at the light or not.
2. SOUND is a mechanical wave meaning it requires a medium for energy transfer. Thus sound **cannot** travel in a vacuum. Sound travels faster in denser mediums like steel, slower in water but sound travels over four times faster in water than air.
3. SOUND is an example of a longitudinal wave meaning the vibrating particles vibrate back and forth parallel to the transfer of energy. Sound thus has compressions and rarefactions.
4. SOUND is a range within the sonic spectrum of compression-wave frequencies to which the human ear is sensitive. The audio range extends from approximately 20 to 20,000 hz, above which lies the ultrasonic and below which lies the infrasonic.
5. The speed of sound in air is 331.5 m/s at 0 degrees C. This speed increases with temperature about 0.6 m/s per degree C. So at 25 degree Celsius sound travels 346 m/s in air, 1497 m/s in water, 4540 m/s in glass, and 5200 m/s in steel.
6. SOUND have three physical properties: intensity (loudness) ($I = P/A$ watts/cm^2), frequency (pitch), and harmonic content (quality).
7. The intensity of a sound can be measured in watts/cm2 after which it can be converted to decibels by using the formula $B = 10 \text{ LOG } (I/I_o)$ where B is the intensity level in decibels and I_o is 10^{-16} watt/cm^2 which is the threshold of hearing at 1000 hz. A whisper is between 10 and 20 db, conversation is 60-70 db, the threshold of pain is 120 and a jet engine is 170 db.
8. Pitch is the identification of a certain sound with a definite tone and depends on the frequency that the ear receives.
9. An octave apart means the frequencies are in a 2:1 ratio. Example: 960 hz is one octave above 480 hz.
10. The change in pitch produced by the relative motion of the source and the observer is known as the **Doppler Effect.**
    (listener in front of object moving toward them) **(listener in back of object moving away from them)**
    $\mathbf{f_{LF} = f_s (v + v_{LF}) / v}$ $\mathbf{f_{LB} = f_s \; v / (v + v_{LF})}$

CHARACTERISTICS OF SOUND WAVES

1. A taut wire or string that vibrates as a single unit produces its lowest frequency, called its **fundamental**.

2. The fundamental and the vibrational modes having frequencies that are **whole number multiples** of the fundamental are called **harmonics**. Example: If the fundamental is 210 hz, the 2nd, 3rd, and 4th harmonics respectively are 420 hz, 630 hz, and 840 hz. Remember from 210 hz to 420 hz is one octave higher and from 420 hz to 840 hz is a second octave higher, so jumping octaves through the harmonics would look like this: 1st harmonic, 2nd harmonic, 4th harmonic, 8th harmonic, etc.
3. The quality of a sound depends on the number of harmonics produced and their relative intensities.
4. The frequency of a vibrating string is determined by its length, diameter, tension, and density. Thus the as the length increases the frequency decreases, as the diameter of the string increases the frequency decreases, and as the tension in the string increase the frequency increases, and finally as the strings density increases the lower its frequency.
5. If you strike a tuning fork against your rubber shoe and then hold it against the table top the tone becomes louder when the fork is in contact with the table because the fork forces the table top to vibrate with the same frequency. Since the table top is a much larger vibrating area than the tuning fork, these **forced vibrations** produce a more intense sound.
6. When the natural vibration rates of two objects are the same or when the vibration rate of one of them is equal to one of the harmonics of the other and the one vibrating causes the other to vibrate, this is called **sympathetic vibration** or **resonance**.
7. A closed tube is resonant at odd quarter-wavelength intervals. ($\frac{1}{4}\lambda$, $\frac{3}{4}\lambda$, $\frac{5}{4}\lambda$, $\frac{7}{4}\lambda$) the formula being $\lambda = 4 (\ell + 0.4 d)$ and a open tube is resonant at all harmonics of the fundamental mode ($\frac{1}{2}\lambda$, $\frac{2}{2}\lambda$, $\frac{3}{2}\lambda$, $\frac{4}{2}\lambda$) with the formula $\lambda = 2 (\ell + 0.8 d)$
8. The number of beats per second equals the difference between the frequencies of the component waves.

Note the figure showing frequencies of 8 hz and 10 hz superimposed to give 10 hz – 8 hz = 2 beats

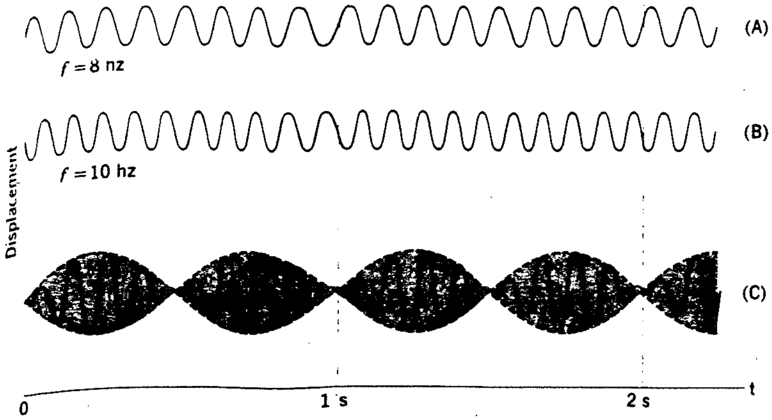
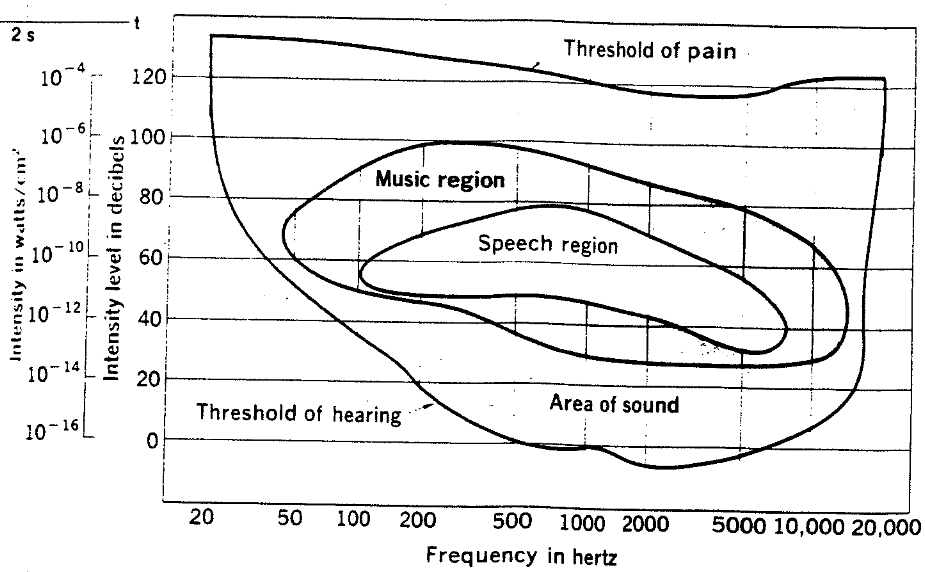


Figure 11-23 Beats. Waves (A) and (B) of slightly different frequencies combine to give a wave (C) that varies in amplitude with time.

Figure 11-6 The range of audibility of the human ear.



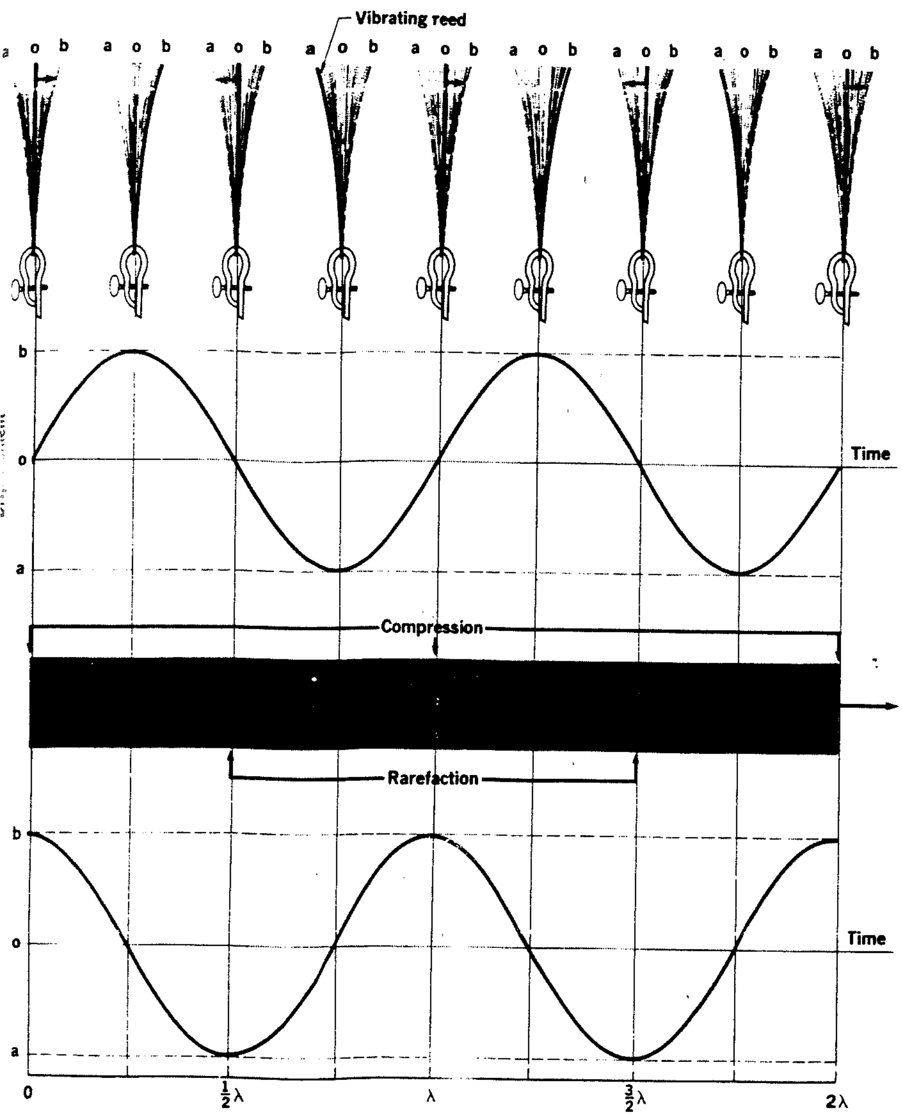


Figure 11-3 Variations of the vibrating reed in (A) produce the displacement variations with time in (B). The regions of compression and rarefaction of the longitudinal sound wave produced to the right of the reed are shown in (C). The pressure, or density, variations of the sound wave with time are plotted in (D). Observe that the displacement and pressure curves are 90° out of phase.