Sound Waves

Sound is caused by the vibration of a material which causes a longitudinal wave. A longitudinal wave requires a medium to travel through since it involves the compression of particles. Sound as we think of it generally travels through air. When an object vibrates, such as a tuning fork, the air particles are pushed together by the object. The air particles then bump into the next air particles causing them to be compressed, and on, and on… Eventually the sound wave will die out due to friction transferring energy from the wave.
Since sound is a longitudinal wave, it will travel faster through materials which compress and rarefact more easily. These materials are generally denser and more elastic. Remember a completely elastic material will transfer all energy and momentum without any loss to the surroundings. Metals tend to be more elastic than non-metals and solids are generally denser than liquids and gases. Temperature will also effect the speed of sound in a medium. Remember that temperature is the average kinetic energy of the particles in a substance. So, if the medium is warmer the particles are already moving faster on average, this would result in a faster net speed of a sound wave moving through that medium. A cooler medium would then result in a slower speed of sound. The speed of sound @ 20°C is about 343 m/s. The speed of sound changes 0.6 m/s for each °C in air.

Sound has the same characteristics of any other wave but we have given some different names to the same characteristics.
Frequency is referred to as the **pitch** of the sound. Most humans can hear pitches as low as 20 Hz and as high as 20,000 Hz. Amplitude of a sound wave is called **loudness/intensity**. When you turn up the volume on your stereo you increase the amplitude of the sound. Loudness is measured in **decibels** (dB). For reference, a whisper is about 20 dB, a busy street is about 70 dB, a rock concert around 115 dB, and the threshold of pain is about 120 dB.

Music is a popular use of sound and is generally defined as the combination of specific pitches and sound qualities which follow a regular pattern as well as rhythm. **Noise** is any sound which has no definite pitch, quality, or rhythmic pattern. The **quality** of a sound depends on the combinations of frequencies produced by an object. Most objects produce more than one frequency, all multiples of the measured **fundamental frequency**. The multiples of the fundamental frequency are called **overtones**. Quality is also known as **timbre**.
All objects have a natural frequency at which they will vibrate. An object can be "forced" to vibrate at its natural frequency by a sound wave of similar frequency if the wave is intense enough, this is called **resonance**. A severe example of resonance is the breaking of a glass by a singer's voice. **Reverberation** occurs when many reflections of a sound wave occur in an object, such as an acoustic guitar.

The distance factor comes in to play when you want to know how fast the wave is travelling. The most obvious way to find the speed of a wave is no different than any other speed calculation: you need a distance and a time for that distance. To be more specific to waves the most obvious distance is the wavelength and the time for that distance is the period. SO…the wavelength divided by the period is the wave speed. Or more conventionally…*the wavelength times the frequency gives you the* ***wave speed***.

$$\mathbf{v = \lambda \cdot f}$$

In addition to observing waves travelling through an unchanging medium it is also useful to observe how waves behave as the medium and its environment change.

Reflection occurs when there is a barrier through which the wave cannot travel completely, if at all. The wave will bounce off similarly to a tennis ball off the floor according to the law of reflection.

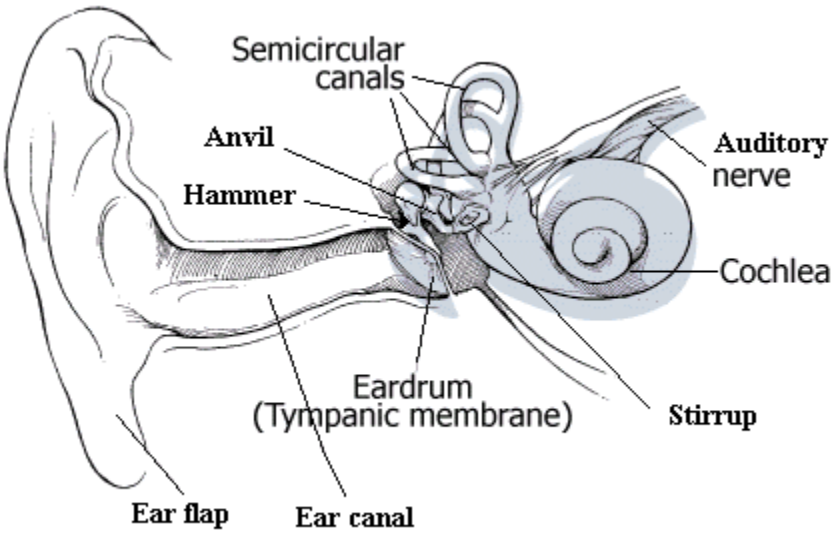
Refraction occurs when the speed of a wave changes due to a change in the medium, cold air to warm air for example. This change in speed results in a change in direction if the wave is at an angle to the change in medium boundary.

Diffraction is the bending of a wave around a barrier or through an opening. When the wavelength is sufficiently larger than the barrier or opening the diffraction will be more noticeable.

Wave interference occurs when two or more waves combine to produce a new wave pattern. This can be detected easily with two sounds of slightly differing frequency as a “warbling” of the sound known as beats. With light you observe alternating light and dark bands.

The Doppler shift is the apparent change in the frequency of a wave due to the relative motion of the wave source to the receiver. The frequency appears higher if the two are moving towards each other and appears lower if the two are moving away from each other.

The Human Ear and Hearing



The following are the event that occur in order for you to hear. The events are not in order. You should write a number in front of each statement to indicate when it occurs in the hearing sequence.

_____ Sound waves strike the eardrum causing it to vibrate.

_____ Vibrations are channeled into the cochlea.

_____ Sound waves move through the ear canal.

_____ Vibrations are passed to the anvil.

_____ The brain interprets electrical impulses as sound.

_____ Vibrations enter the middle ear.

_____ Sound waves enter the outer ear.

_____ Vibrations are transmitted to the stirrup.

_____ Electrical impulses are transmitted to the brain.

_____ A vibrating membrane transmits vibrations to the inner ear.

_____ Nerve cells, cilia in the cochlea, detect vibrations and convert them to electrical impulses.

_____ The hammer picks up the vibrations.