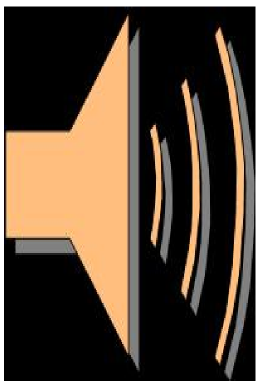
CIVIL AIR PATROL – ARUNDEL COMPOSITE SQUADRON
MER-MD-023 (http://arundel.mdwg.cap.gov)

February 2008	SAFETY	NOISE SAFETY - PART 1

Noise Safety: Part 1 – Characteristics of Sound Waves

A well-known question asks: “If a tree falls in a forest and nobody is there to hear it, then does it make a sound?”. Another question might be: If a tree falls in the forest and you are there to hear it, then what do you hear, a noise or a sound?

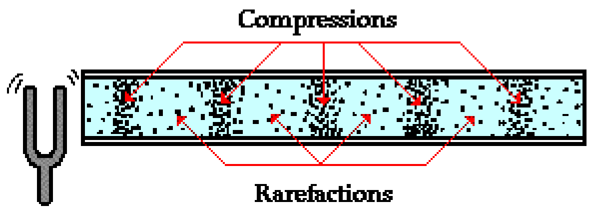
Noise is defined as any unwanted sound. If that is the case, then is music a noise? For example, what you hear in a rock concert, or a philharmonic concert, considered a noise? What about the surround-sound in a movie theater? Is the hum of tires on a highway a noise? Sounds that are soothing for some may be irritating to others.



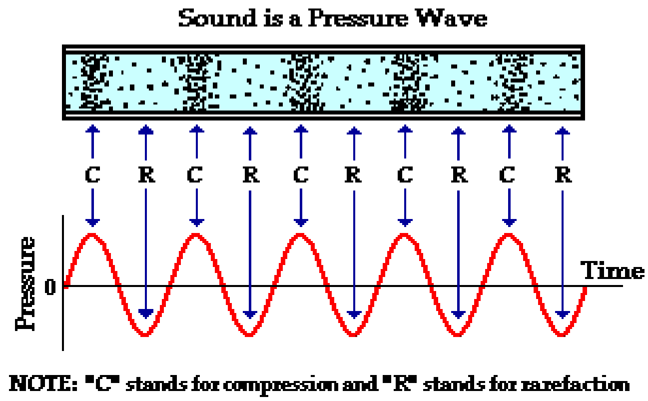
Noise is considered as a pollutant and a hazard to human health and hearing. In fact, it has been described as the most pervasive pollutant in America. If the definition of noise can be so broad and vague, then what about the definition of sound?

Sound is defined as vibrational mechanical energy that propagates through matter as a wave. This is a great definition if you happen to have a college degree in physics, but what about the rest of us? Imagine a vibrating tuning fork, or a guitar string, or a vibrating speaker on a radio. As a tuning fork vibrates, for example, it pushes on the neighboring air molecules. In turn, these air molecules also begin to vibrate. This vibration then causes their neighboring air molecules to vibrate also, and this process continues on and on. This is the basic principle behind the movement of sound. Sound can move through any matter, including a gas, liquid, or a solid, but it cannot move through a vacuum.

As sound moves through the air, there are regions in the air where the air molecules are compressed together, and there are also other regions where they are spread apart. These regions are known as compressions and rarefactions, respectively. The compressions are regions of high air pressure, while the rarefactions are regions of low air pressure. The following diagram shows a sound wave created by a tuning fork, as it propagates through the air in an open tube:



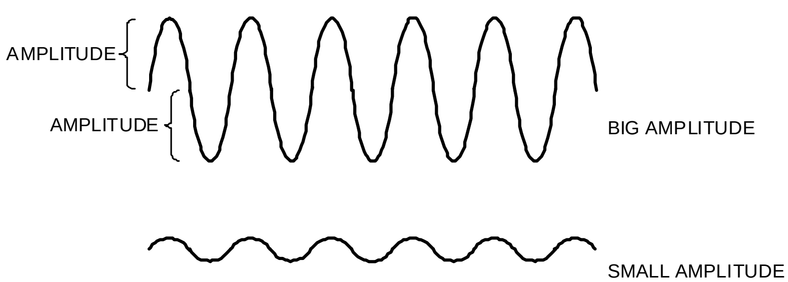
Note the regions of compressions and rarefactions. Sound waves are longitudinal waves with a repeating pattern of compressions and rarefactions. Sound is also a pressure wave.



Sound waves have characteristics just like any other type of wave, including amplitude, frequency, velocity, and wavelength. A review of these terms is needed to better understand sound waves.

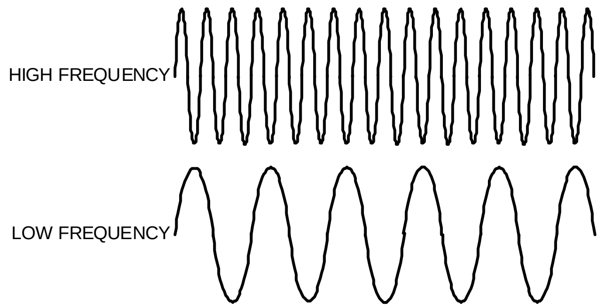
Amplitude

The amplitude of a sound wave refers to its "tallness". The amplitude is also directly related to the loudness of a sound wave. The bigger the amplitude, the taller the sound wave, and the louder the sound.



Frequency

The frequency refers to the number of waves passing through a certain distance in a given time. At high frequencies, many waves pass through a certain distance in a given time. At low frequencies, fewer waves pass through the same distance in the same amount of time. Frequency is also related to the pitch of the sound. At high frequencies the sound has a high pitch, whereas at low frequencies the sound's pitch is also low.



Velocity of Sound

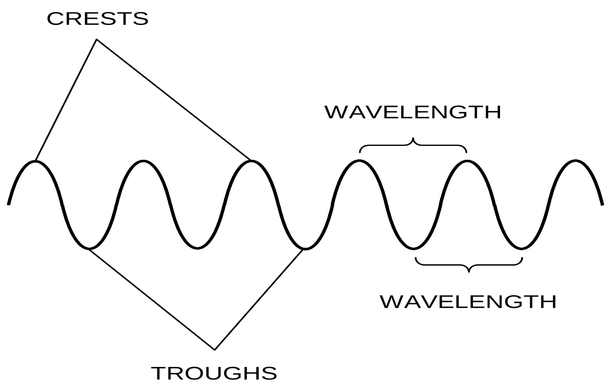
The velocity of sound can be measured using acoustic equipment. This velocity depends only on the properties of the medium itself. The velocity of sound has been measured experimentally in solids, liquid, and gases. Sound waves generally travel faster in solids than they do in liquids. They also travel faster in liquids than they do in gases. The velocity of sound in different mediums has been measured, as follows:

Air:	**approx. 345 meter/second (sound velocity)**
Water:	**approx. 1,500 meter/second**
Wood:	**approx. 2,000 meter/second**
Rock:	**approx. 2,000-5,000 meter/second**
Steel:	**approx. 5,000-6,000 meter/second**

The speed of sound in air also depends on the properties of the air, namely its temperature and pressure. At higher ambient temperatures, the velocity of sound is higher. At higher temperatures, the density of air is less. The sound wave will travel faster in a less dense air. Similarly, sound will travel faster at higher altitudes. Again, the air density is less at higher altitudes, as long as the temperatures are similar at these elevations.

Wavelength

Another important characteristic of sound waves is the wavelength. The wavelength refers to the distance between either the crests or troughs of a wave, as shown by the following diagram:



Wavelength, frequency, and the velocity of sound are related by the following mathematical equation:

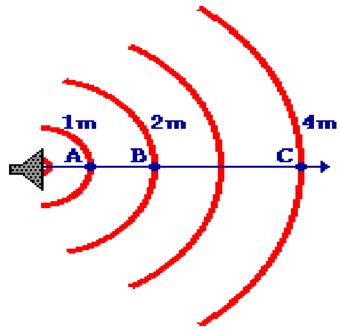
Velocity = (Wavelength)*(Frequency)

Even though the velocity of sound can be calculated by multiplying its wavelength and frequency, it is not dependent on these quantities. The velocity of sound is dependent only on the properties of the medium in which it travels. The above equation shows that the wavelength and frequency are inversely related to each other. For example, if the wavelength increases, then the frequency decreases.

There is a well-known classroom demonstration which illustrates the relationship between wavelength and frequency.

Take two soda bottles, for example, one empty and the other about ½-filled with water. When a person blows over the top of the bottle with its cap off, the air inside is set into vibrational motion. Turbulence above the lip of the bottle creates disturbances within the bottle. These vibrations result in a sound wave which is audible to students. The frequency can be modified by changing the length of the air column inside the bottle. This can be done by adding or removing water from the bottle. This changes the sound's wavelength, and in turn its frequency. The shorter air column (i.e. more water in the bottle) results in a shorter wavelength and a higher frequency.

As a sound wave travels away from its source, its intensity (or loudness) decreases. The intensity varies inversely with the square of the distance from the source. This means that if the distance from the source is doubled (i.e. distance increased by a factor of 2), then the intensity is quartered (i.e. intensity decreased by a factor of 4). This is largely due to the fact that the further the sound wave gets from its source, it is distributed over (or covers) a larger area.



The intensity (or loudness) of sound is measured in decibels (dB). This unit of measurement ("B" or "Bel"), was named after the famous inventor of the telephone, Alexander Graham Bell. The term "deci" means 1/10th in the metric system of measurement. Therefore, decibel (dB) means 1/10th of a "Bel" (or 0.1 Bel) for sound intensity measurement. The following examples help illustrate this sound intensity measurement scale in everyday life:

Sound Source	**Intensity Level**
Barely audible sound (threshold of hearing)	0 dB
Rustle of leaves	10 dB
Whisper	20 dB
Normal conversation	60 dB
Busy traffic street	70 dB
Vacuum cleaner	80 dB
Jackhammer	100 dB
Pain producing sound	120 dB
Military jet take-off	140 dB
Perforated ear drum (hearing damage)	160 dB

For those of you who are familiar with algebra, the decibel scale is a logarithmic scale. This scale is based on the multiples of 10. This means that is the sound's intensity level increases from 10 dB to 20 dB, then the loudness increases from 10 to 100. If the dB increases from 10 dB to 60 dB, then the loudness increases from 10 to 1,000,000.

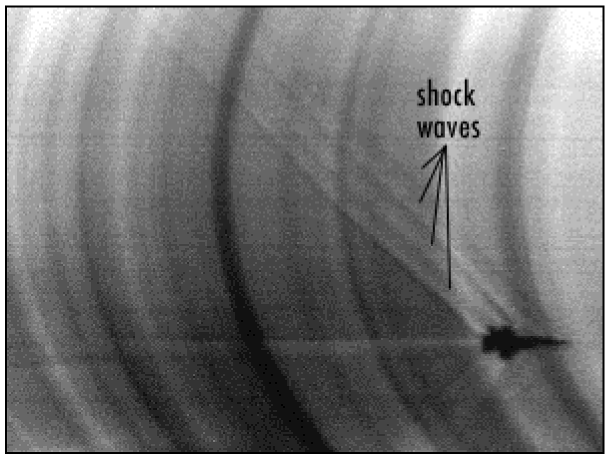
During the next two safety classes, we will discuss how the human ear hears sound, how sound intensity is measured, and what steps you can take to protect your hearing.

Safety Briefs 2008

Civil Air Patrol – Arundel Composite Squadron – MER-MD-023

<u>Trivia Question on Sound – What is a Shock Wave?</u>

A moving airplane causes disturbances in the air, namely pressure waves. These pressure waves move ahead of the airplane, spreading outward in all directions at the speed of sound (see picture below).



When the airplane exceeds the speed of sound, it overtakes its own pressure waves, causing them to "pile-up" into a sudden, sharp pressure disturbance. This is referred to as a shock wave. The greatest shock waves are at the tip and tail of the airplane.

The above picture shows a jet fighter plane with conical shock waves made visible by condensation. The shock wave forms a cone of pressurized air molecules which move outward and rearward in all directions and extend to the ground. If you saw a supersonic jet fly overhead, you would not hear the sound until the airplane passed beyond you. The boundary between the sound and silence is called a shock wave. It is almost as if all of the sound from the airplane were compressed into a thin layer of air. As this thin layer of compressed air (or shock wave) passes by you, then you would suddenly hear a loud noise. This is called a sonic boom.

GET MORE INFORMATION

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