

WAVE INFORMATION NOTES

WAVE-- a disturbance that propagates through a medium or space. It is in simple harmonic motion.

TRANSVERSE WAVES vibrate at right angles to the direction of propagation. They are composed of two parts, *CRESTS* and *TROUGHS*.

LONGITUDINAL WAVES vibrate along the direction of travel. They are composed of *COMPRESSIONS* and *RAREFACTIONS*.

CHARACTERISTICS of WAVES:

Wave length is the distance from one part to where that part repeats. For example from crest to crest or compression to compression.

One Cycle is a complete vibration, ie. crest through trough. Its distance is the wave length.

The Frequency is the number of cycles per second, called Hz (hertz after Heinrich Hertz, discoverer of radio waves).

$$F = \text{cycles/sec}$$

The Period is the time for one cycle to pass a point.

$$T = 1/F$$

The Amplitude is the maximum displacement of a wave, i.e. the height of a crest.

Amplitude Modulation (as in AM radio) is controlling the magnitude of the wave.

Frequency Modulation (as in FM radio) is controlling the rate of vibration of a wave.

The Power transmitted by a wave is proportional to both the amplitude and to the frequency squared. So if we double both the amplitude and the frequency of a wave, its power increases sixteen times!

The Wave Equation relating velocity, frequency and wavelength is

$$v = f\lambda \quad \lambda \text{ is the Greek letter, Lambda. } v = f\lambda$$

PROPERTIES OF WAVES:

Rectilinear Propagation-- the wave front travels in straight lines from the point of origin.

Reflection is the bouncing of a wave off a barrier. The Law of Reflection states that the angle of incidence is equal to the angle of reflection, $i = r$.

Impedance is the resistance to motion of a wave.

Impedance = wave-producing force/resulting velocity

Refraction is the bending of a wave as it passes from one medium into another. It is caused by a change in velocity.

Diffraction is the spreading out of a wave as it passes a barrier.

Superposition of waves is the resultant vector addition of two or more waves passing through the same medium together.

Interference is the result of superposition.

Constructive interference is the adding of two waves to give a stronger wave. This occurs when the crest of one meets the crest of another (or a

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compression meet a compression).

Destructive interference is the cancellation of waves when the crest from one meets the trough from another (or a compression meets a rarefaction).

Standing waves are the result of the interference of two waves of the same amplitude and wavelength traveling in opposite directions.

Nodes are the dead spots in standing waves. There is no vibration in a node.

Antinodes (or loops) are the positions of maximum vibration in a standing wave.

SOUND:

Sound in physics is defined as compression/rarefaction waves in matter.

Audible range for people varies between 20 Hz to 20,000 Hz.

Infrasonic range are vibrations whose frequency is below the audible.

Ultrasonic range are vibrations whose frequency is above the audible.

Production of sound is accomplished by setting up vibrations in matter. This can be done by vibrating solids, liquids, or gases.

Sound waves are longitudinal (light waves are transverse).

Sound needs a medium to carry it. It doesn't travel through a vacuum.

The speed of sound depends upon the medium and the temperature. In air it travels at 331 m/s at 0 C and its speed increases by 0.6 m/s for each degree C the temp goes up. $V = 331\text{m/s} + 0.6(t\text{ C})$. It travels 4 times faster in water and 15 times faster in steel.

PROPERTIES OF SOUND:

Intensity is the ratio of power to area $I = P/A$ (watts/cm²).

Intensity is proportional to the square of the amplitude.

Intensity obeys the inverse square law. Twice as far away, the intensity is only 1/4 as great.

Loudness depends on an auditory sensation in the consciousness of a listener. It is a subjective property.

Relative intensity measurements are done on a logarithmic scale called the DECIBEL SCALE. On this scale the threshold of hearing is 0, whispers are 15, conversation is 60, thunder is 110, the threshold of pain is 120, jet engine is 170, rock band 180 (just kidding).

PITCH is the highness or lowness of a tone and it depends upon frequency (the number of cycles/sec). The higher the frequency, the higher the pitch.

THE DOPPLER EFFECT is the change in pitch due to relative motion between the source and the listener. When the listener approaches the sound source, he runs into more waves/sec, and hence the pitch is increased, when the source approaches the listener, waves are crowded together so the pitch is increased. Likewise, when the distance between source and listener is increased, the pitch drops. A typical example is the passing of a car... EEEEEEEAAAaooow.

CHARACTERISTICS OF SOUND WAVES--

Standing waves are resonant waves with nodes and antinodes.

The fundamental or first harmonic consists of one antinode with a node at each end. The second harmonic has two antinodes, etc.

Harmonics may be superimposed upon other harmonics to produce musical tones.

The Quality of sound is that which differentiates the sound of one instrument

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from another even when they are playing the same pitch. A tone is determined by the number and strengths of the harmonics.

The Beat Frequency is the pitch caused by the interference of two sound waves of different frequencies undergoing constructive and destructive interference. It varies in loudness so that it is a throbbing sound. When two tones are in tune, there will be no beats.

The Laws of Strings--

Law of Lengths states that the frequency is inversely proportional the length. The longer string has a lower pitch.

Law of Diameters is that frequency is inversely proportional to the diameter. The larger the diameter, the lower the pitch.

Law of Tensions states that the frequency is directly proportional to the square root of the tension. The higher the tension, the higher the pitch.

Law of Densities is that the frequency is inversely proportional to the square root of the density. The greater the density, the lower the pitch.

RESONANCE is the reinforcing of waves of the same frequency which are in phase. Standing waves are produced. A fun example (when no one is around) is to step on the damper pedal of a piano and scream into the thing. It screams back in resonance.

An open tube resonator (open organ pipe) has an antinode at each end. The result is that it resonates the even numbered harmonics.

A closed tube resonator (closed organ pipe) has a node at one and an antinode at the other. It resonates odd numbered harmonics.