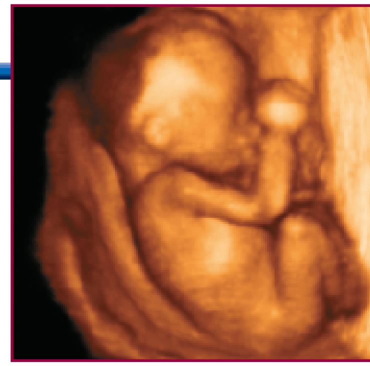
Why it Matters

Ultrasound Images



Ultrasonic waves can be used to produce images of objects inside the body. Such imaging is possible because sound waves are partially reflected when they reach a boundary between two materials of different densities. The images produced by ultrasonic waves are clearer and more detailed than those that can be produced by lower-frequency sound waves because the short wavelengths of ultrasonic waves are easily reflected off small objects. Audible and infrasonic sound waves are not as effective because their longer wavelengths pass around small objects.

In order for ultrasonic waves to "see" an object inside the body, the wavelength of the waves used must be about the same size as or smaller than the object. A typical frequency used in an ultrasonic device is about 10 MHz. The speed of an ultrasonic wave in human tissue is about 1500 m/s, so the wavelength of 10 MHz waves is $\lambda = v/f = 0.15$ mm. A 10 MHz ultrasonic device will not detect objects smaller than this size.

Physicians commonly use ultrasonic waves to observe fetuses. In this process, a crystal emits ultrasonic pulses. The same crystal acts as a receiver and detects the reflected sound waves. These reflected sound waves are converted to an electrical signal, which forms an image on a fluorescent screen. By repeating this process for different portions of the mother's abdomen, a physician can obtain a complete picture of the fetus, as shown above. These images allow doctors to detect some types of fetal abnormalities.

Speed of sound depends on the medium

Sound waves can travel through solids, liquids, and gases. Because waves consist of particle vibrations, the speed of a wave depends on how quickly one particle can transfer its motion to another particle. For example, solid particles respond more rapidly to a disturbance than gas particles do because the molecules of a solid are closer together than those of a gas are. As a result, sound waves generally travel faster through solids than through gases. **Table 1** shows the speed of sound waves in various media.

The speed of sound also depends on the temperature of the medium. As temperature rises, the particles of a gas collide more frequently. Thus, in a gas, the disturbance can spread faster at higher temperatures than at lower temperatures. In liquids and solids, the particles are close enough together that the difference due to temperature changes is less noticeable.

Table 1 Speed of Sound in Various Media

Medium	v (m/s)
Gases	
air (0°C)	331
air (25°C)	346
air (100°C)	366
helium (0°C)	972
hydrogen (0°C)	1290
oxygen (0°C)	317
Liquids at 25°C	
methyl alcohol	1140
sea water	1530
water	1490
Solids	
aluminum	5100
copper	3560
iron	5130
lead	1320
vulcanized rubber	54

Sound waves propagate in three dimensions

In the chapter "Vibrations and Waves," waves were shown as traveling in a single direction. But sound waves actually travel away from a vibrating source in all three dimensions. When a musician plays a saxophone in the middle of a room, the resulting sound can be heard throughout the room because the sound waves spread out in all directions. The wave fronts of sound waves spreading in three dimensions are approximately spherical. To simplify, we shall assume that the wave fronts are exactly spherical unless stated otherwise.