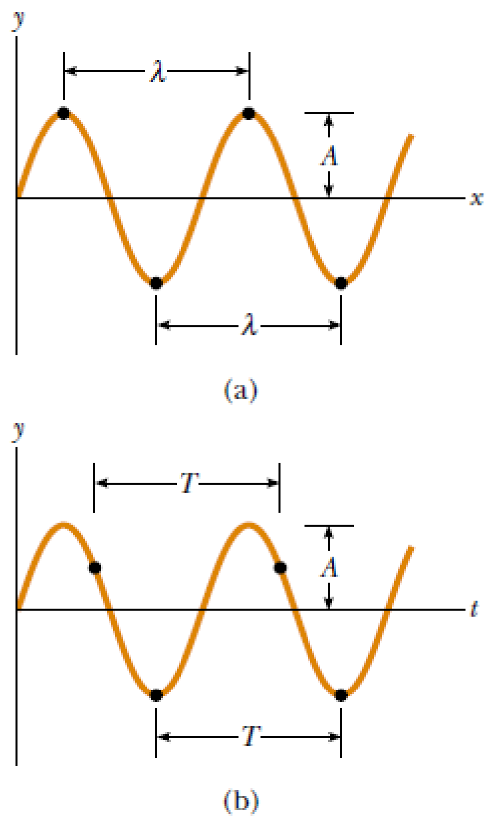
# Wave, Sound Waves, Ultrasound

**Wave** It is a form of energy transfer, whereby waves move in a material medium (with the exception of electromagnetic waves and some forms of quantum particles with wave properties), where the waves move and energy is transferred from one place to another without permanently displacing the particles of the medium.

Amplitude and Wavelength




The **crest** of the wave is the location of the maximum

**displacement** of the element from its normal position.

 This distance is called the **amplitude**, A.

The wavelength, l, is the distance from one crest to the next.**The period**, T , is the time interval required for two identicalpoints of adjacent waves to pass by a point.

**The frequency**, $f$, is the number of crests (or any point on the wave) that pass a given point in a unit time interval.

When the time interval is the second, the units of frequency are $s^{-1}$ = Hz. Hz is a hertz

$$\boldsymbol{\lambda = v / f}$$

$$f = 1/T$$

**H.W**

**1-**Calculate the wavelength of a wave with a velocity of 450 nm and a periodic time of 30 s

2- If the frequency of a vibrating particle is 400 hertz, and the speed of sound in air is 320 meters per second. Find the distance traveled by the sound produced by the particle's vibration when the particle has completed only 30 vibrations?

**Transverse and Longitudinal Waves**

A simple wave consists of a periodic disturbance that propagates from one place to another. The wave in Figure 1 propagates in the horizontal direction while the surface is disturbed in the vertical direction. Such a wave is called a transverse

longitudinal wave or compressional wave, the disturbance is parallel to the direction of propagation. Figure 2 shows an example of a longitudinal wave. The size of the disturbance is its amplitude X and is completely independent of the speed of propagation $v_w$

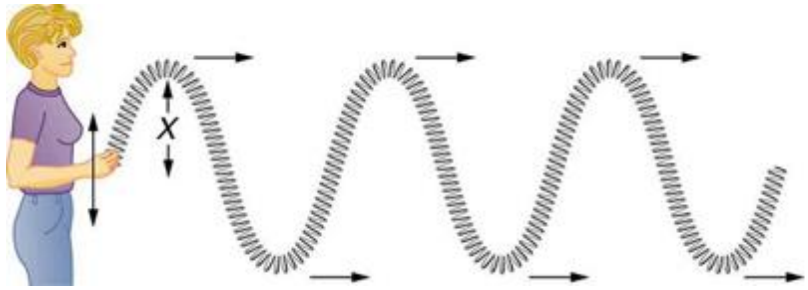



Figure 1 In this example of a transverse wave, the wave propagates horizontally, and the disturbance in the cord is in the vertical direction.

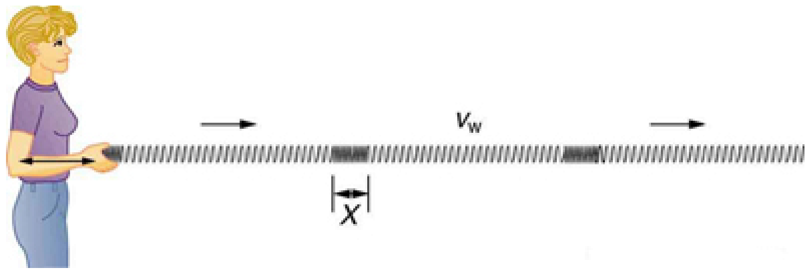



Figure 2 In this example of a longitudinal wave, the wave propagates horizontally, and the disturbance in the cord is also in the horizontal direction.

## Sound Waves

Waves can move through three-dimensional bulk media.
Sound waves are longitudinal waves.
Sound waves cannot be transmitted through vacuum. The transmission of sound requires at least a medium, which can be solid, liquid, or gas.

## Ultrasound

Any sound with a frequency above 20,000 Hz (or 20 kHz)—that is, above the highest audible frequency—is defined to be ultrasound**.** In practice, it is possible to create ultrasound frequencies up to more than a gigahertz. (Higher frequencies are difficult to create; furthermore, they propagate poorly because they are very strongly absorbed.) Ultrasound has a tremendous number of applications, which range from burglar alarms to use in cleaning delicate objects to the guidance systems of bats. We begin our discussion of ultrasound with some of its applications in medicine, in which it is used extensively both for diagnosis and for therapy. Ultrasound, like any wave, carries energy that can be absorbed by the medium carrying it, producing effects that vary with intensity. When focused to intensities of $10^3$ to $10^5$ $W/m^2$ , ultrasound can be used to shatter gallstones or pulverize cancerous tissue in surgical procedures. Intensities this great can damage individual cells

Most of the energy carried by high-intensity ultrasound in tissue is converted to thermal energy. In fact, intensities of $10^3$ to $10^4$ $W/m^2$ are commonly used for deep-heat treatments called **ultrasound diathermy**.

## Ultrasound in Medical Diagnostics

The applications of ultrasound in medical diagnostics have produced untold benefits with no known risks. Diagnostic intensities are too low (about 10−2 W/m2 ) to cause thermal damage. More significantly, ultrasound has been in use for several decades and detailed follow-up studies do not show evidence of ill effects, quite unlike the case for x-rays.

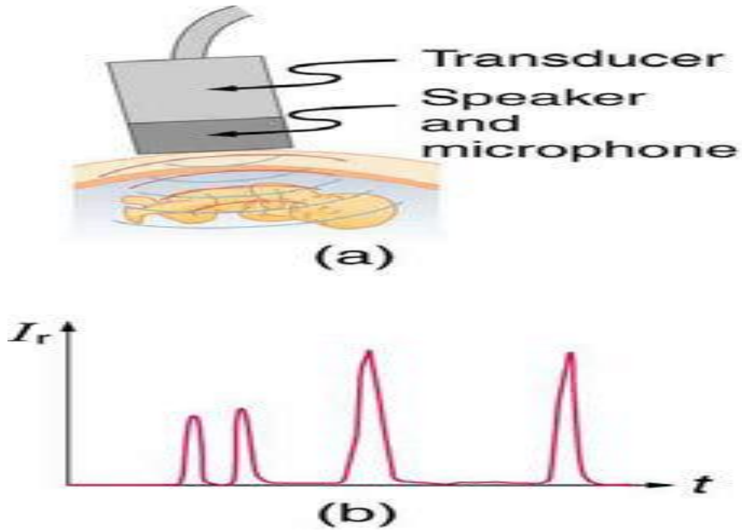



Figure 4 (a) An ultrasound speaker doubles as a microphone. Brief bleeps are broadcast, and echoes are recorded from various depths.(b)Graph of echo intensity versus time. The time for echoes to return is directly proportional to the distance of the reflector, yielding this information noninvasively.

The most common ultrasound applications produce an image by The speaker-microphone broadcasts a directional beam, sweeping the beam across the area of interest. This is accomplished by having multiple ultrasound sources in the probe’s head, which are phased to interfere constructively in a given, adjustable direction. Echoes are measured as a function of position as well as depth. A computer constructs an image that reveals the shape and density of internal structures.


Fig5 : Ultrasound image of 12-week-old fetus.