

Diyala University-College of Science

Physics Department

Medical Physics Branch

CHAPTER THREE

ULTRASOUND WAVES

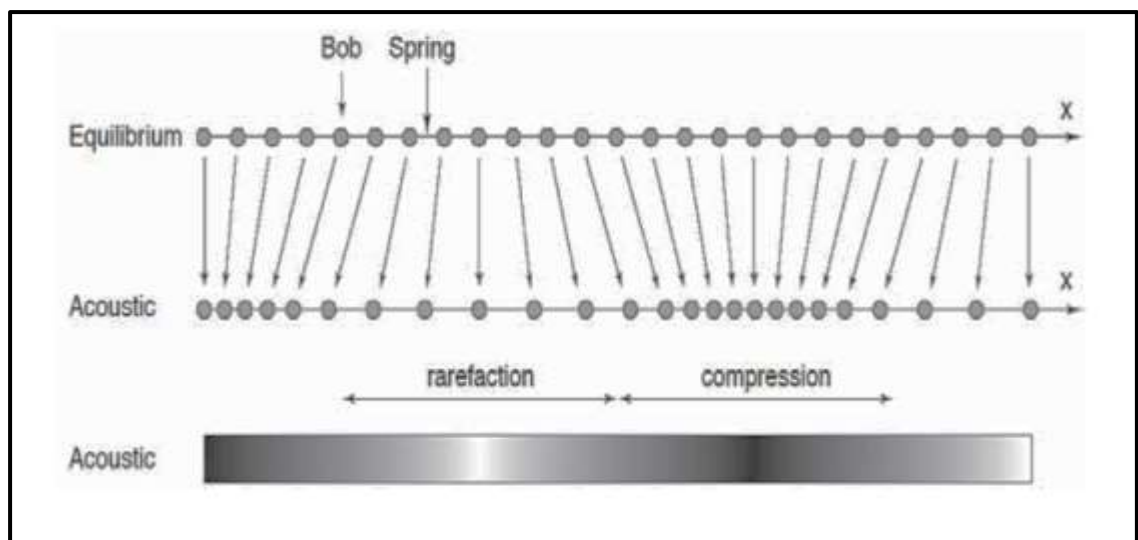
Dr. Ziad Tariq Khodair

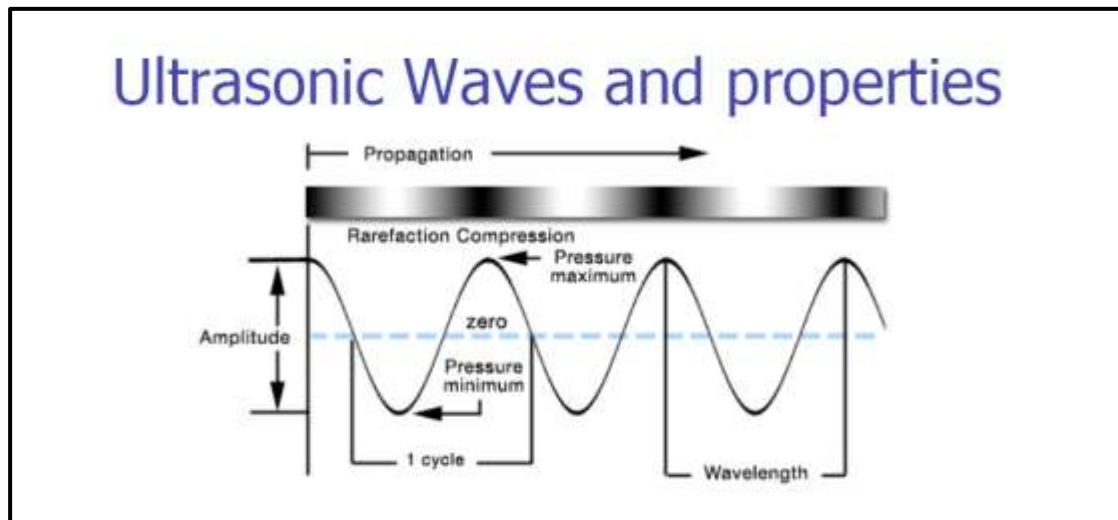
(Professor)

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1- Introduction:

- **Ultrasound** is the vibrations of the same physical nature as sound but with frequencies above the range of human hearing.
- **Ultrasound** is an acoustic wave with frequencies **greater than** the maximum frequency audible to humans, **which is 20 kHz**.
- **Ultrasound** is the most commonly used diagnostic imaging modality, accounting for approximately 25% of all imaging examinations performed worldwide nowadays.
- **Diagnostic imaging** is generally performed using ultrasound in the frequency range from 2 to 15 MHz.
- **Sound wave propagate** by **longitudinal motion** (compression/expansion), but not transverse motion (side-to-side).
- Can be modeled as weights connected by springs.





2- History:

- **Send waves** into body which are reflected at the interfaces between tissue.
- **Return time** of the waves tells us of **the depth** of the reflecting surface.
- First practical application, 1912 unsuccessful search for Titanic
- WW II brought massive military research - **SONAR (SOUND Navigation And Ranging)**.
- First used as diagnostic tool in 1942 for localizing brain tumors.
- 1950's 2D gray scale images.
- 1965 or so real-time imaging.

3- Advantages of Ultrasound Waves:

- relatively low cost
- portability of an ultrasound scanner
- the non-ionizing nature of ultrasound waves
- the ability to produce real-time images of blood flow and moving structures such as the beating heart
- the intrinsic contrast among soft tissue structures that is achieved without the need for an injected contrast agent

4- The Speed of Sound

-We can find the **speed of sound** by looking at the speed of this compressed region as it travels through the medium. In non-humid air at **20 degrees Celsius**, the speed of sound is about **343 meters per second** or 767 miles per hour.

- **Sound speed in soft tissues** is similar to the sound speed in water at body temperature. This similarity between water and soft tissue holds for most acoustic properties and justifies the use of equations for fluid media to analyze wave propagation in biomedical ultrasound.

Then : **highest : in solids and lowest : in gases**

Material	Sound speed (m/s)
Air	330
Water	1480
Fat	1450-1460
Liver	1555-1570
Blood	1550-1560
Muscle	1550-1600
Skull bone	3360-4080

5- Piezoelectric Devices

-Ultrasonic **(piezoelectric)** transducers are devices that convert electrical energy into ultrasound and vice-versa. They were made possible by the discovery of piezoelectricity in quartz by Pierre and Jacques Curie in 1880.

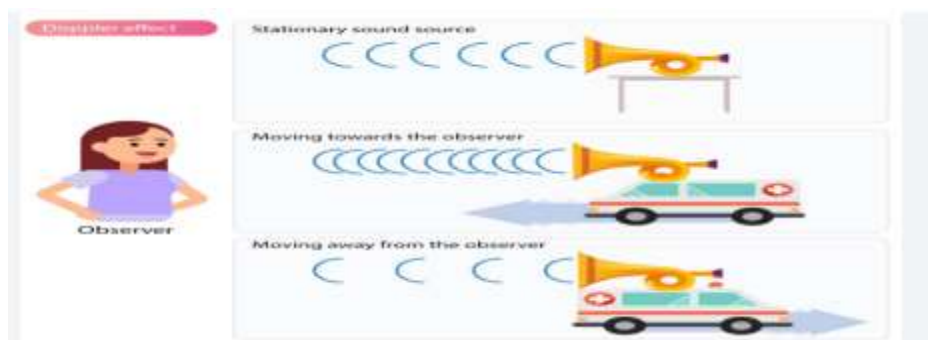
Then :

Piezoelectricity is a reversible property of certain crystalline materials by which:

- 1- a vibration applied to opposite faces of the crystal produces an alternating net electrical charge across the crystal
- 2- whereas an alternating voltage applied across the crystal causes it to vibrate in thickness

6- The Doppler Effect

The Doppler effect is the apparent **shift in wave frequency** due to the movement of a wave source. The apparent frequency shifts upward when the wave source is approaching and downward when the wave source is retreating. The Doppler effect explains why we perceive a change in pitch of the sound of a passing siren.



A Doppler ultrasound is a noninvasive test that can be used to estimate the blood flow through your blood vessels by bouncing high-frequency sound waves (ultrasound) off circulating red blood cells. A regular ultrasound uses sound waves to produce images, but can't show blood flow.

