Medical Physics II

2nd semester

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Lectures 5

General properties of Sound

General properties of Sound

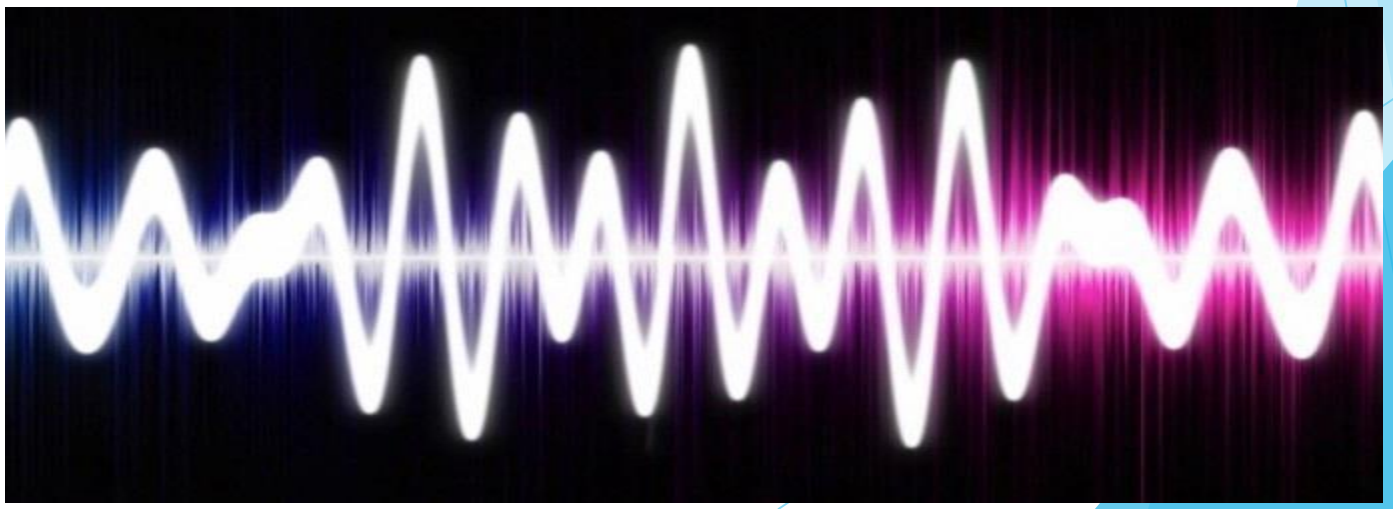
Sound is a vibration that **travels** through the **medium through** longitudinal waves.

This means that sound waves are waves in which the particles of the medium vibrate parallel to the direction of wave propagation.

Sound waves are called mechanical waves since they require a

medium to propagate.

The medium can be solids, liquids, or gases



- Sound waves **above** 20 kHz are known as **ultrasound and are not audible to humans.**
- Sound waves **below** 20 Hz are known as infrasound.
- Sound is transmitted **through** gases, plasma, and liquids as longitudinal waves, also called compression waves.
- It requires a medium to propagate.
- Through solids, however, it can be transmitted as longitudinal and transverse waves.

- **Longitudinal sound waves** are waves of alternating pressure deviations from the equilibrium pressure, **causing** local regions of compression and rarefaction.

- **Transverse waves (in solids)** are waves of alternating shear stress at a right angle to the direction of propagation.

General Properties Of Sound

- We can use a **loudspeaker vibrating back** and **forth** in the air at a frequency (f) to demonstrate sound behaviour.
- The **vibrations cause local increases** and **decrease** in **pressure** relative to atmospheric pressure.
- These **pressure increases, called** compressions, and **decreases**, called **rarefactions**, spread outward as a longitudinal wave, a wave in which the pressure changes occur in the same direction the wave travels.
- The **relationship** between the frequency of vibration f, the wavelength λ, and velocity V of the sound wave is
- $V = \lambda f$

- When a **sound** wave **passes** through **tissue**, energy is lost due to frictional effects.
- The absorption of energy in the tissue **causes** a reduction in the amplitude of the sound wave.
- The **amplitude** (A) at a **depth** (X) cm in the medium is related to the initial amplitude A_o (x=0) by the exponential equation:
- $A = A_o\, e^{-\alpha x}$
- Where α is the absorption coefficient for the medium.
- Since the **intensity is proportional** to the square of the amplitude, its dependence on depth is:
- **Absorption of ultrasound**
- Where (I_o) is the incident intensity at (X = 0) and (I) is the intensity at a depth (X), (2α) absorption coefficient.
- The half-value thickness (HVT) is the tissue thickness needed to decrease (I_o to $I_o/2$).

Properties of Sound

1- Frequency: is the **number** of periodic compression and rarefaction cycles that **occurs** each second as the wave propagates through the medium. The higher the frequency of the sound, the higher its pitch, and a lower frequency means a lower pitch.

2- Amplitude: The **amplitude of the sound waves** determines its **loudness**. The amplitude of the sound is a measure of the **magnitude of the maximum disturbance of sound**. The amplitude is also a measure of the energy of vibration. More energetic vibration causes a larger amplitude.

3- Speed: The **speed** at which the sound waves travel through the medium is called the speed of sound. The speed of sound is different for different mediums. Sound travels **fastest** in **solids** since the atoms in a solid are closely packed.

4- Reflection of sound: When sound waves hit the surface of a solid or light, it bounces back to the same medium. This is called the reflection of sound. Sound waves, like light waves, follow the laws of reflection.

5- Timbre: is the property used to differentiate sounds of the same frequency.

Applications of Sound in Medicine

1. Ultrasonic Scanner
2. The cavitron ultrasonic surgical aspirator (CUSA)
3. Bloodless surgery: High-intensity focused ultrasound (HIFU)
4. The Doppler flow meter

Sound and Medicine

Diagnostic Ultrasound Instrumentation and Operation:

The **principal reasons for** its wide application are

1. Its ease to use
2. The relatively
3. Low cost of the instrumentation,
4. The lack of ionizing radiation.

- The heart of diagnostic ultrasound is the **Transducer**.