

## UNIT-III

## ULTRASOUND IN MEDICINE

## 3.3 ACOUSTICAL CHARACTERISTICS OF THE HUMAN BODY

The acoustical characteristics of the human body are essential in various fields like medical diagnostics (e.g., ultrasound), forensic science, acoustical engineering, and even in the design of hearing aids and musical instruments. Here's a breakdown of key aspects:

## 1. Sound Propagation in the Human Body

- **Speed of Sound:** Sound travels at different speeds depending on the type of tissue:
  - **Air in Lungs:** ~330 m/s
  - **Soft Tissue (e.g., muscles):** ~1540 m/s
  - **Fat:** ~1450 m/s
  - **Bone:** ~4080 m/s (highly dense, thus faster transmission)
  - **Blood:** ~1570 m/s
- **Impedance Mismatch:** Differences in acoustic impedance between tissues cause reflection and refraction of sound waves, which is critical in imaging technologies like ultrasound.

## 2. Absorption and Attenuation

- **Attenuation:** As sound travels through the body, it loses energy due to absorption and scattering. High-frequency sounds attenuate faster than low-frequency sounds.
- **Absorptive Properties:**
  - **Bone:** Highly absorptive, reflecting much of the sound.
  - **Muscles & Soft Tissues:** Moderate absorption.
  - **Fluid-Filled Areas (like blood or amniotic fluid):** Low absorption, allowing better sound transmission.

## 3. Resonance and Vibration

- **Body as a Resonator:** The human body can resonate at certain frequencies. For instance:
  - **Chest Cavity:** Resonates with low-frequency sounds (used in percussive diagnostics).
  - **Vocal Tract:** Functions like an acoustic resonator, shaping sounds for speech.
- **Bone Conduction:** Bones can transmit sound directly to the inner ear, bypassing the outer and middle ear, which is utilized in bone-conduction hearing aids.

## 4. Reflection and Transmission

- **Echo and Reflection:** Reflections of sound waves occur at interfaces of tissues with different densities (e.g., between muscle and bone), which is foundational in ultrasound imaging.
- **Transmission:** The efficiency of sound transmission depends on the alignment of

acoustic impedances across tissues.

## 5. Acoustic Emissions

- **Vocal Sound Production:** The vocal cords vibrate to produce sound, which is then modified by the shape of the oral and nasal cavities (resonators).
- **Heart and Lung Sounds:** The body emits natural sounds like heartbeats, breath sounds, and bowel sounds, which are analyzed using stethoscopes and other diagnostic tools.

## 6. Applications in Medicine

- **Ultrasound Imaging:** Uses high-frequency sound waves to create images of internal organs. The difference in acoustic impedance between tissues helps form detailed images.
- **Phonocardiography:** Recording the sounds of the heart to detect abnormalities.
- **Bone Densitometry:** Measures the acoustic properties of bone to assess bone health.

## 7. Acoustic Impact on Hearing

- **Outer Ear:** Collects and focuses sound waves.
- **Middle Ear (Ossicles):** Amplifies sound vibrations.
- **Inner Ear (Cochlea):** Converts sound waves into nerve signals.

**Body Sounds Affecting Hearing:** Internal sounds (like heartbeat or blood flow) can sometimes interfere with hearing, especially in very quiet environments.

### 3.4 DESTRUCTIVE TESTING (DT) AND NON-DESTRUCTIVE TESTING (NDT)

#### Definition:

Destructive testing involves methods that test the material to the point of failure. This means the component or material being tested is permanently altered or destroyed in the process.

#### Purpose:

To understand the material's mechanical properties like strength, toughness, ductility, and durability.

#### Common Methods:

1. **Tensile Testing** – Measures how much a material can be stretched before breaking.
2. **Compression Testing** – Evaluates how a material reacts under compressive forces.

3. **Bend Testing** – Determines the ductility and strength of materials by bending them until they fracture.
4. **Impact Testing (Charpy or Izod)** – Assesses the material's ability to absorb energy during fracture.
5. **Fatigue Testing** – Measures the material's endurance under repeated loading and unloading.
6. **Hardness Testing** – Sometimes destructive if indentations affect the material's usability (e.g., Brinell, Rockwell).

**Advantages:**

- Provides comprehensive, detailed data about the material's properties.
- Confirms whether a material meets specific standards and safety requirements.

**Disadvantages:**

- The tested sample is destroyed and cannot be used.
- Can be expensive, especially if components are costly.

**Non-Destructive Testing (NDT)**

**Definition:**

Non-destructive testing evaluates materials and components without causing damage. The tested items remain intact and functional after the inspection.

**Purpose:**

To detect defects, discontinuities, or irregularities in materials without affecting their usability.

**Common Methods:**

1. **Visual Inspection (VI)** – Using the naked eye or magnifying tools to check for surface defects.
1. Ultrasonic Testing (UT) – Uses high-frequency sound waves to detect internal flaws.
2. Radiographic Testing (RT) – Uses X-rays or gamma rays to create images of the internal structure.
3. Magnetic Particle Testing (MT) – Detects surface and near-surface defects in ferromagnetic materials.
4. Dye Penetrant Testing (DPT) – Applies dye to reveal surface cracks or defects.
5. Eddy Current Testing (ECT) – Uses electromagnetic induction to detect surface and sub-surface flaws in conductive materials.
6. Acoustic Emission Testing (AET) – Detects transient elastic waves produced by sudden redistributions of stress.

Advantages:

- The material or component remains intact and usable.
- Can be applied to finished products in service.
- Often quicker and more cost-effective for routine inspections.

Disadvantages:

- May not provide as comprehensive data as destructive tests.
- Requires skilled technicians to interpret results accurately.
- Some methods may have limitations based on material type and defect location.