جامـــــعة المـــســتـقـبـل
AL MUSTAQBAL UNIVERSITY

College of Science

Department of Forensic Evidence

Lecture (1)

Introduction of Wave, types of waves, properties of wave

Second stage

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2025-2026

Introduction of Waves:

Waves refer to the transfer or flow of energy from one point to another without the transfer of matter. They appear as oscillations when passing through any medium (as in the case of water waves or sound waves) or without any medium (as in the case of electromagnetic waves). They exist all around us in visible and invisible forms. Types of waves include radio waves, sound waves, and others.

Waves are among the most fundamental concepts in physics. A wave can be described as a disturbance that transfers energy from one place to another, whether through a physical medium or through space, without transferring the matter itself. We observe waves in our daily lives, whether as ripples in water, sound traveling through the air, or light reaching us from the sun.waves are present in many physical phenomena and form the basis for understanding numerous topics in mechanics, acoustics, optics, and modern physics.

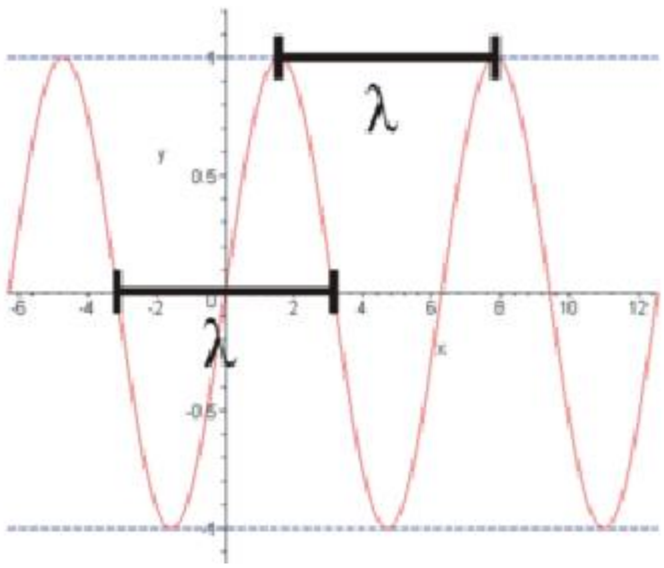
Sound waves are a type of wave that travels through a medium, such as air, water, or solids, via mechanical vibrations. They are characterized by their propagation through the pressure of the medium, moving in a wave-like pattern. Sound waves are measured in hertz (Hz), which indicates the number of times a complete cycle of the wave is repeated in one second. The frequencies of audible sound waves typically range between 20 Hz and 20,000 Hz. Here are some basic concepts and important properties of sound waves:

1. Frequency: This refers to the number of times a wave cycle is repeated per unit of time. Frequency is measured in hertz (Hz). A higher frequency means a louder, higher-pitched sound, while a lower frequency means a softer, lower-pitched sound.

2. Intensity: This refers to the loudness of the sound wave and is measured in decibels (dB). The higher the intensity of the wave, the louder the sound we hear.

3. Wavelength: This refers to the distance between two consecutive points in the wave cycle. Wavelength is measured in meters (m) or submillimeter.

4. Speed: This refers to the speed at which a sound wave propagates through a medium. It varies depending on the type of medium the sound travels through. In dry air at room temperature, the speed is approximately 343 meters per second.



Types of Waves in Physics

Different types of waves have different sets of characteristics. Based on the orientation of particle motion and direction of energy, there are three categories:

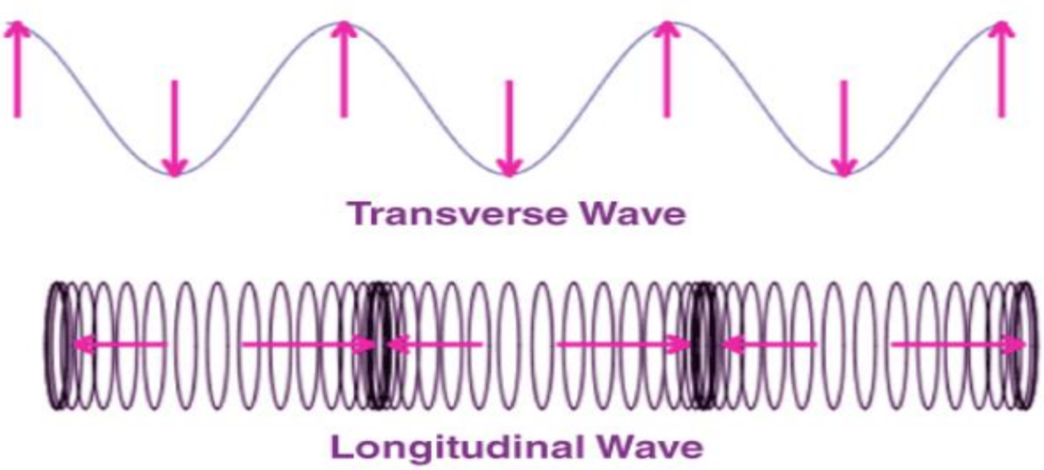
- Mechanical waves
- Electromagnetic waves
- Matter waves

Mechanical Wave

- A mechanical wave is a wave that is an oscillation of matter and is responsible for the transfer of energy through a medium.
- The distance of the wave's propagation is limited by the medium of transmission. In this case, the oscillating material moves about a fixed point, and there is very little translational motion. One intriguing property of mechanical waves is the way they are measured, which is given by displacement divided by the wavelength. When this dimensionless factor is 1, it generates harmonic effects; for example, waves break on the beach when this factor exceeds 1, resulting in turbulence.

There are two types of mechanical waves:

- **Longitudinal waves –** In this type of wave, the movement of the particles is parallel to the motion of the energy, i.e. the displacement of the medium is in the same direction in which the wave is moving. Example – Sound Waves, Pressure Waves.
- **Transverse waves –** When the movement of the particles is at right angles or perpendicular to the motion of the energy, then this type of wave is known as a transverse wave. Light is an example of a transverse wave.



Electromagnetic Wave

- Electromagnetic waves are created by a fusion of electric and magnetic fields. The light you see, the colours around you are visible because of electromagnetic waves.
- One interesting property here is that unlike mechanical waves, electromagnetic waves do not need a medium to travel. All electromagnetic waves travel through a vacuum at the same speed, 299,792,458 ms^{-1}.

Following are the different types of electromagnetic waves:

- Microwaves
- X-ray
- Radio waves
- Ultraviolet waves

Matter Wave

- This concept is a little complicated to understand. The dual nature of matter; its ability to exist both as a particle and a wave was first brought to light by the founders of the field of Quantum Physics.
- For example, a beam of electrons can be diffracted just like any other beam of electromagnetic radiation or water wave. This property of matter was brought forward by Louis de Broglie's Hypothesis.

Classifications of Sound Waves:

Sound waves are divided into three classifications according to their frequencies, as follows:

1. Audible Waves: These are waves with frequencies ranging from 20 to 20,000 Hz, and include all sounds that can be heard by the human ear.

2. Ultrasonic Waves: These are waves with frequencies above 20,000 Hz, which are outside the range of human hearing. They have various applications, such as industrial and medical uses.

3. Infrasonic Waves: These are sound waves with frequencies below 20 Hz, meaning they cannot be heard or even felt by humans.

Sound waves cannot travel through a vacuum. If we place a bell in a glass bell jar and evacuate the air, we cannot hear the bell ring because sound cannot travel in a vacuum. This means that sound depends on three things:

1. A source of vibration to create sound waves.

2. A medium, such as air, to carry the waves.

3. A receiver to detect them, such as the human ear.

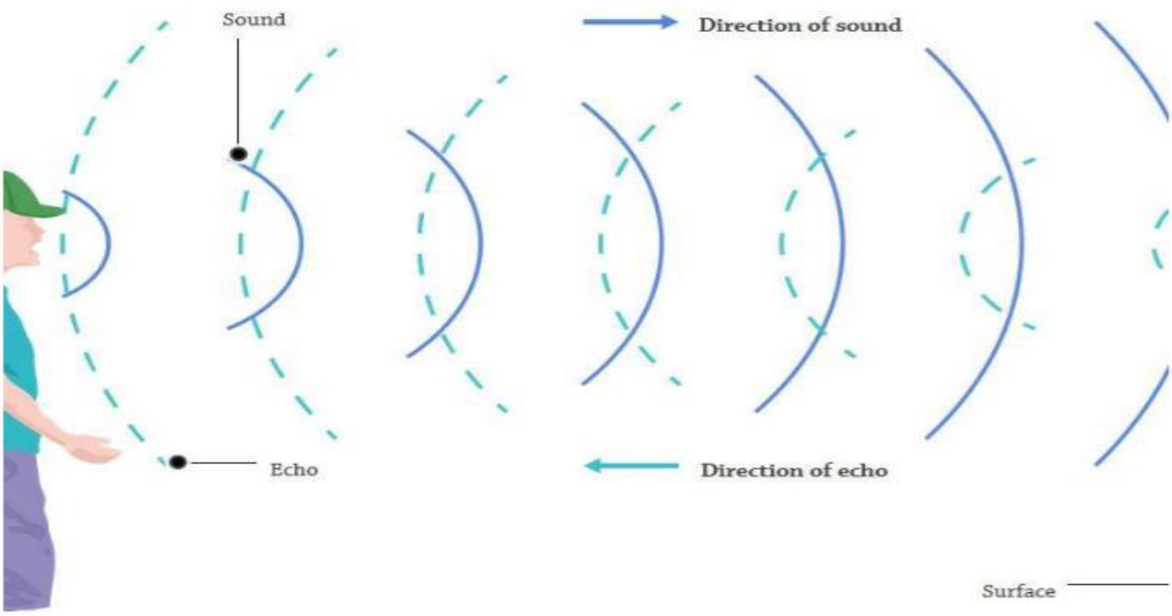
Properties of Sound Waves:

Sound waves have many properties, including:

1. Vibrational motion, which is the effect of sound on the particles of the medium through which it propagates, causing them to be disturbed and vibrate.

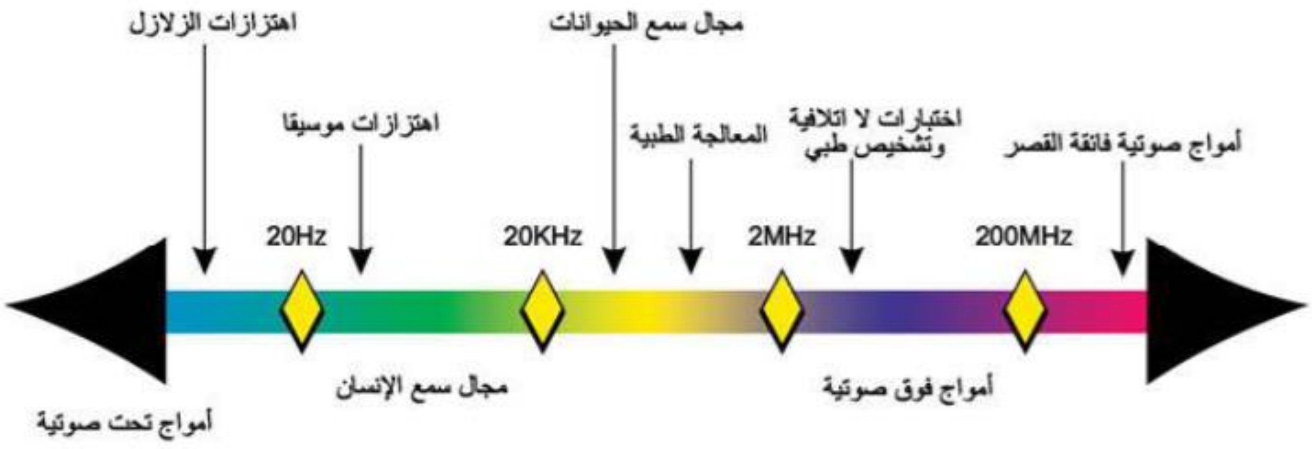
2. Speed of sound. The speed of sound varies according to the medium through which the sound waves propagate. Temperature also affects this speed. The speed of sound is higher in solids than in liquids and gases.

3. Sound intensity. This is the amount of sound energy produced when sound waves affect one square centimeter within the medium as they pass through it. Physically, the decibel (dB) is the unit used to measure the amount of sound wave energy.



Speed of Sound:

Sound waves travel at a constant speed regardless of how loud or soft the sound is. However, temperature affects the speed of these waves. Sound travels in air at 344 meters per second when the room temperature is 22,2 degrees Celsius. For every degree Celsius increase in temperature, the speed increases by about 0,6 meters per second. Air pressure has no effect on the speed of sound, while humidity has a slight effect, as the speed of sound in humid air is somewhat greater than in dry air. Many other materials are better conductors of sound than air, such as some gases, liquids, and solids like iron and stone. Sound waves travel in liquids and solids in the same way as in air, and sound travels faster and farther when a good sound conductor is used. Some solid materials are poor conductors of sound, such as rubber, cork, cotton, and felt. These materials absorb sound waves instead of transmitting them, and therefore they are used for sound insulation and to stop unwanted noise.



Physical Properties of Sound Waves:

Sound waves are characterized by several properties, including:

Wave Amplitude

Wave amplitude is defined as the maximum distance that can be measured from the point of rest of the wave as it passes through the medium. It is measured in longitudinal waves such as sound waves, which move the particles of the medium back and forth in the same direction as the propagation of the wave by calculating the distance between the particles of the medium after they are compressed by the wave. The closer the particles are to each other, the greater the estimated amplitude of the sound wave.

Wavelength

Wavelength is defined as the distance between two opposite points of two successive waves. In longitudinal waves, such as sound waves, the wavelength can be measured by measuring the distance between one compression and the next compression, or from one rarefaction to the next rarefaction. Wavelength is symbolized by the Greek letter lambda (λ), and it equals the wave speed (v) divided by the frequency. Wavelength = Wave Speed / Wave Frequency, or in symbols: $\lambda = v/f$.

Wave Frequency

Frequency can be defined as the number of waves passing a fixed point in a unit of time. It is measured in Hertz (Hz) according to the International System of Units (SI), named after the German physicist Heinrich Rudolf Hertz. The relationship between frequency and wavelength is inverse: frequency equals wave speed divided by wavelength.

Frequency = Wave Speed / Wavelength, or symbolically: $f = v/\lambda$.

Propagation velocity

The propagation velocity of a wave is defined as the distance that sound waves travel through a medium in one second. The propagation velocity depends on the medium through which they pass, as sound waves of the same frequency pass through different media at different speeds, while in the same medium, waves of different frequencies pass through at the same speed.

In general, the speed of a wave can be calculated by multiplying its frequency by its wavelength: that is: Speed of a sound wave = Frequency of the wave × Wavelength of the wave, or symbolically: $v = f \times \lambda$. The following table shows the speed of a sound wave through different media:

Medium

Speed of Sound (m/s)

Air 330

Water 1480

Blood 1570

Skull Bones 4080

Fat 1450

Q1 What is a wave?

Q2 What are the types of waves?

Q3 Can mechanical waves travel through vacuum?

Q4 What are non-mechanical waves?

Q5 What are the types of mechanical waves?

Q6 What are the Physical Properties of Sound Waves?