University of Mosul

College of Science

Department of Physics

Second stage

Lecture 1

Sound and wave Motion

2024-2025

Lecture:sound

Preparation

M. Maysam Shihab Ahmed

Chapter one

sound

Sound refers to a sequence of compressions and rarefactions that propagate through both the air and various physical media. The generation of sound occurs when there is an abrupt alteration in atmospheric pressure resulting from a vibrating source. These vibrations are then transmitted to the location where they are received, namely the auditory organ, leading to the perception and comprehension of the corresponding sound. Due to its wave-like properties, sound encompasses a range of frequencies and amplitudes. This variability in the characteristics of sound waves accounts for the diversity observed in terms of their intensity or pitch, as well as their attenuation and amplification based on the originating source.

Concerning the auditory capabilities of the human ear, it is constrained to a specific range of frequencies, with a lower limit of no less than 15 vibrations per second (known as infrasound) and an upper limit of not exceeding 2000 vibrations per second (known as ultrasonic). Consequently, the human ear is unable to discern and perceive numerous sounds that are audible to other organisms.

The speed of sound: Given that sound is a wave that traverses through physical mediums, its propagation varies significantly based on several factors, including the properties of the medium and the source. There exists a correlation between the velocity of sound waves, the wavelength, and the frequency of oscillations, which can be expressed as follows:

Velocity of sound = wavelength x number of oscillations.

This implies that :

$v = \lambda \times f$

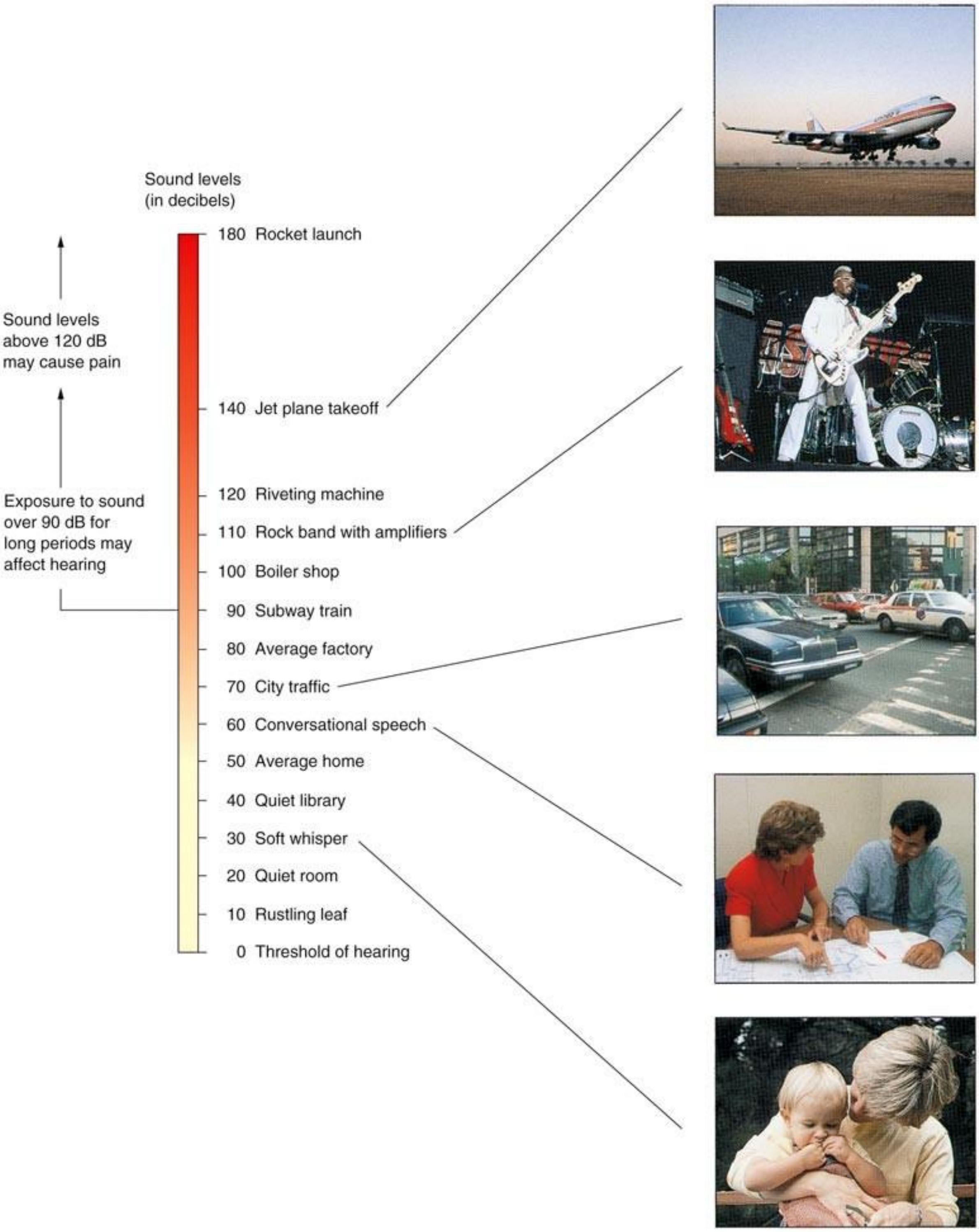
where f represents the frequency of oscillations per second, and λ represents the wavelength. The speed of sound in air is approximately 340 m/sec.

Sound intensity: Represents the amount of energy transmitted by a sound wave within a unit area perpendicular to the direction of propagation of the wave per second. It is the characteristic that determines the strength or weakness of the sound. The intensity of the sound relies on the amplitude of the sound wave, whereby a higher amplitude results in a greater intensity. A prime illustration of a sound wave characterized by a substantial amplitude is evident in the sounds produced by aircraft and explosives, which correspondingly exhibit a high level of intensity. The measurement of sound intensity is conducted in decibels (dB) (W/m2), also referred to as decibel watt. Remarkably, this unit represents a logarithmic scale that allows for the comparison between two physical quantities, namely power or intensity, in relation to a standard value.

It is worth highlighting that 1 dB is equivalent to 0.1 Bell. The standard range for normal sound intensity commences at 60 dB, while levels surpassing 90 dB become detrimental to the human ear when prolonged exposure occurs. Consequently, the aural effects of aircraft, which fall within the 100-120 decibel range, adversely impact the human ear. This explains the rationale behind the establishment of airports and air bases in remote and uninhabited regions.

(The decibel is the unit of sound intensity and is equal to one-tenth (1/10) of the original sound intensity unit the bill).

The Decibel Scale



Basic factors for sound generation and propagation:

The generation and transmission of sound in the media (its spread) requires the availability of major factors, including:

The source of sound generation: The sound wave is produced from the origin of the vibration, which can be attributed to various sources including vibration generated by a resonant fork or motor.

Physical medium Sound waves are a type of mechanical waves that rely on a material medium for propagation. These materials can include substances such as air, water, or various liquids; however, it is important to note that sound waves are unable to travel through a vacuum. The transmission of sound varies in different material mediums depending on the nature of those mediums and their physical properties such as density or viscosity.

Elasticity of the medium: The carrier medium must possess both flexibility and inertia in order to effectively transmit the sound wave, given its wave mechanical nature as previously discussed. The transmission and propagation of the sound wave within the medium occur through the vibrational motion of the particles within the medium, originating from the source and reaching the audio receivers.

Sound quality: it is also called the bell, Pitch is one of the characteristics of musical sounds. It distinguishes between sounds that have a single frequency and intensity, which is produced by different musical instruments.

Wave properties of sound:

1- Refraction of sound

A - Sound waves are refracted when they travel from one medium to another caused by a difference in sound speed in two different media.

B - The amount of the broken part depends on the density of the two mediums and the angle of incidence.

2- Sound reflection

A - When the sound waves encounter a stationary medium that is denser than the first medium it was in moving in it, it changes its direction and reflects back to the first medium, and at the same time it suffers a change in phase.

B - The intensity of the reflected wave depends on the intensity of the incident wave, the angle of incidence, and the nature of the incident wave reflective surface.

3- Sound interference:

Constructive interference and destructive interference occur in the same manner and concepts as light interference.

4- Diffraction of sound:

A - Sound waves bend around the obstacles they encounter.

B - A clear and familiar phenomenon of sound because the sound wavelength is very large Compared with the light wavelength, and since the amount of diffraction around the obstacle increases with the increase wave length.

**The phenomenon of diffraction can be explained on the basis of Hawkins' rule, which states that any point in The wave front can be considered as a new source of secondary waves.

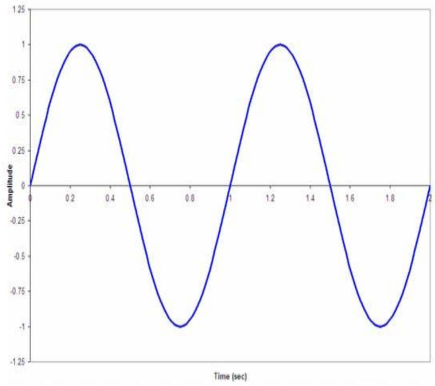
5- Scattering of sound

A - Sound waves scatter in all directions when they encounter obstacles with small dimensions compared to the wavelengths of light.

B - The amplitude of the waves scattered at long distances from the obstacle is directly proportional to the size of the obstacle and inversely with the square of the wavelength, and on this basis, the short waves are Its scattering is greater than that of long waves.

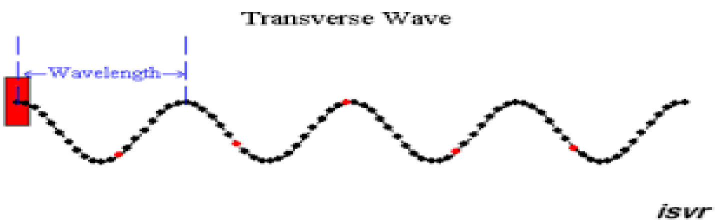
waves

It is the disturbance that travels in a specific direction and speed, without the transfer of the medium particles it flows through, and transfers energy along its path.. Instead of the transfer of medium particles, the particles move in a periodic vibrational motion around their equilibrium positions, usually referred to as stability points. These vibrations can be represented by a sinusoidal curve, as illustrated in the figure below.



Q / Is the wave matter?

A wave is not considered to be matter; rather, it propagates through matter without the transfer of matter. It carries energy from one place to another.



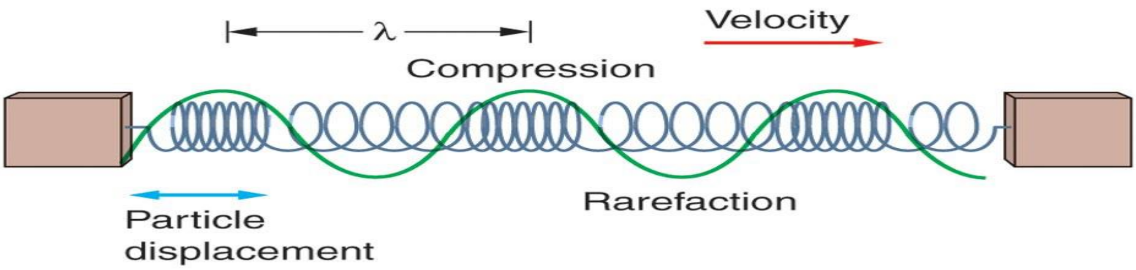
How are waves produced?

Waves are produced by a vibrating source that disturbs the medium, resulting in wave motion.

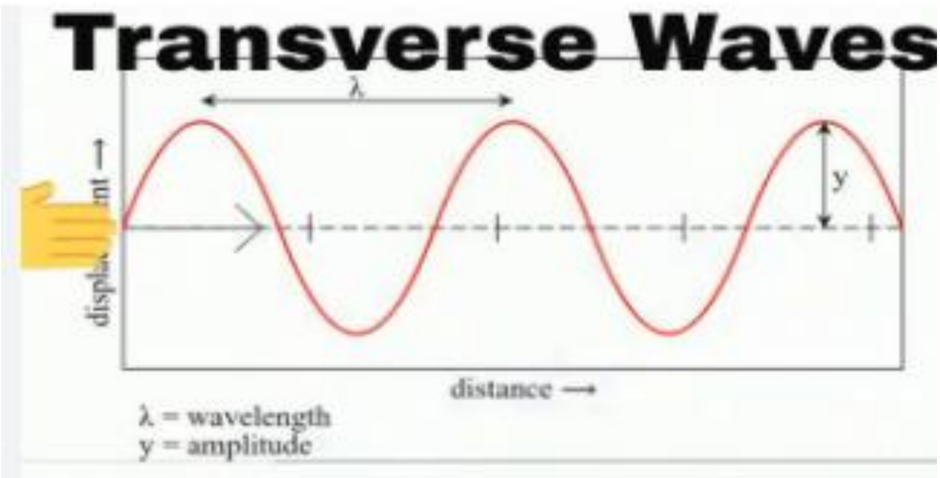
Types of waves:

There are two ways to classify waves, the first is related to their propagation through different mediums, while the second depends on the nature of the wave itself. In terms of the nature of wave propagation, three main categories of these waves can be identified.

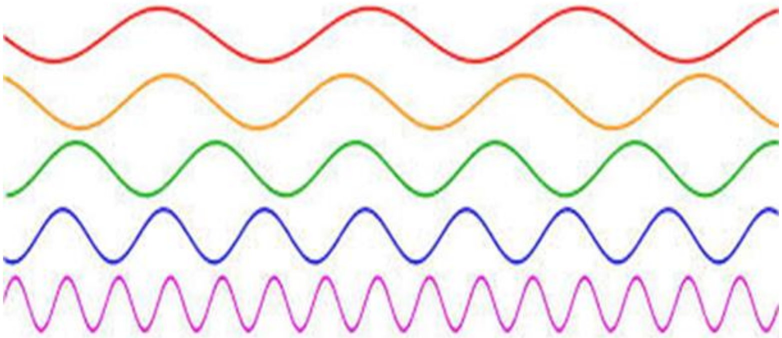
Longitudinal waves: The particles of the medium oscillate around their equilibrium positions in a direction parallel to the wave propagation, forming a series of compressions and rarefactions. Examples of such waves include sound waves and waves produced by the compression and release of a spring. The accompanying graph illustrates the representation of the compression and rarefactions associated with longitudinal waves.



Transverse waves: These are the waves in which the particles of the medium vibrate around their equilibrium positions in a direction perpendicular to the direction of wave propagation. These waves consist of crests (peaks) and troughs (bottoms), as illustrated in the figure below.



In the above diagram, λ refers to the wavelength factor, which characterizes the distance between two crests or troughs (bottoms) of a wave or two equilibrium positions of a wave. y represents the amplitude of the wave and represents the maximum displacement of the wave from its equilibrium position. The time required for complete oscillation (complete cycle) is called the periodic time of vibration, and is denoted by the symbol τ. The vibration that occurs during the complete cycle is called frequency and is symbol f. Frequency serves as a measure of periodic events. The following diagram depicts (describes) the motions of waves at different frequencies.



The relationship between frequency, wave speed, and wavelength can be deduced from the equation of linear motion:

$$x = v.\mathrm{t}$$

In this equation, x represents the displacement, which corresponds to the wavelength of the wave. The parameter v denotes the speed of the wave, while t represents the time that the body takes to complete one oscillation. This time, t, can be referred to as the time with respect to the wave. Hence, the equation mentioned above can be expressed as

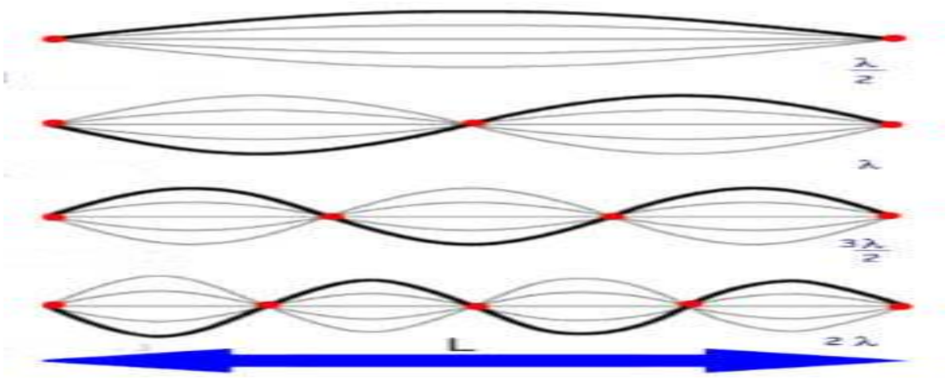
$$\lambda = v\ .\tau$$

Additionally, by considering the definition of frequency, we can establish the relationship

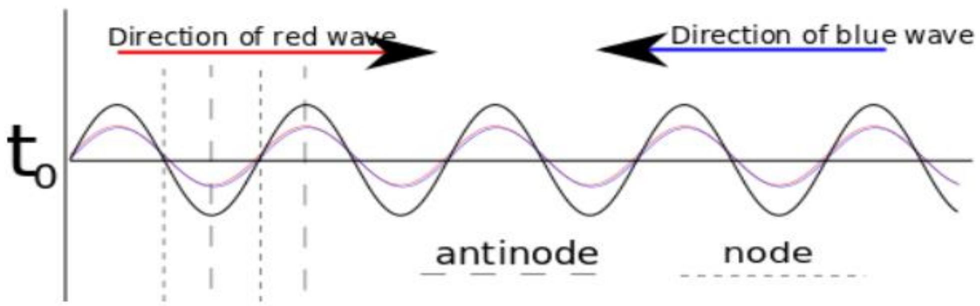
$$\tau = 1/f$$

$$\lambda = v\ /\ f$$

Standing waves: The third classification of waves, known as standing waves, is determined by their method of propagation. These waves are characterized by their immobility, maintaining a fixed position. This phenomenon can arise in two cases: when the medium moves counter(inverse) to the wave's direction, or when it transpires within a stationary medium due to the interference between two waves moving in opposite directions, as depicted in the following illustration.



Note: Standing waves are formed only when the string is vibrated at particular frequencies



The First Lecture