Erasmus+ Programme – Strategic Partnership Project - STEM Education - 2018-1-IT02-KA229-048507

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PROJECT BASED LEARNING in STEM

Learning Teaching and Training Activity - Online

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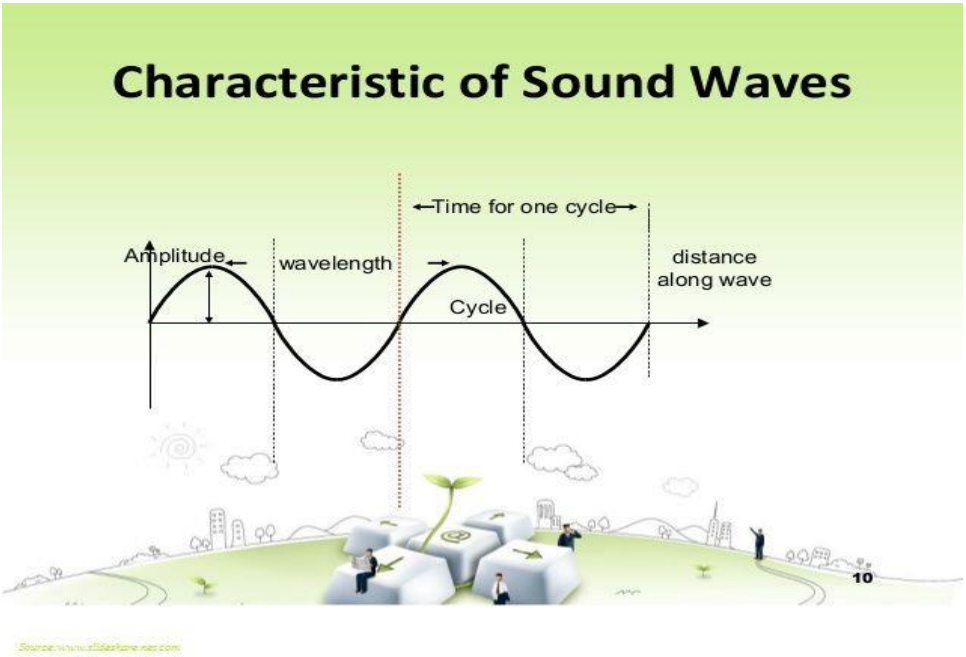
STEM SUBJECT: Physics
TOPIC: Sound
TEAM: Bulgaria

Sound

Sound is a form of energy, which make us hear. It travels in the form of wave. There are five main characteristics of the sound wave:

- Amplitude
- Wavelength
- Time-period
- Frequency
- Velocity of wave (speed of wave)



Sound travels in the form of wave. A wave is a vibration disturbance in a medium, which carries energy from one point to another point without there being a direct contact between the two points. We can say that the vibration of particles of the medium, which it passes, produces a wave.

There are two types of waves – **Longitudinal waves** and **Transverse waves**

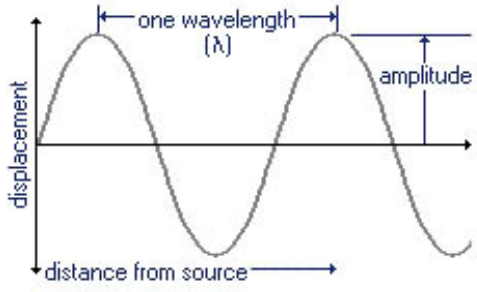
Longitudinal waves – a wave in which the particles of the medium vibrate back and forth in the same direction in which the wave is moving. Medium can be solid, liquid or gases. Therefore, sound waves are longitudinal waves

Transverse waves – a wave in which the particles of the medium vibrate up and down at right angles to the direction in which the wave is moving. These waves are produced only in a solids and liquids but not in gases.

Sound is a longitudinal wave, which consists of compressions and rarefactions travelling through a medium.

Characteristics of the sound wave

1. **Wavelength**



The minimum distance in which a sound wave repeats itself is called its wavelength. It is the length of one complete wave. It is denoted by a Greek letter λ (lambda). We know that in sound wave, the combined length of a compression and an adjacent rarefaction is called its wavelength. The distance between the centers of two consecutive compressions or two consecutive rarefactions is equal to its wavelength.

The distance between the centres of a compression and an adjacent rarefaction is equal to half of its wavelength – λ / 2. The unit for measuring wavelength is metre (m).

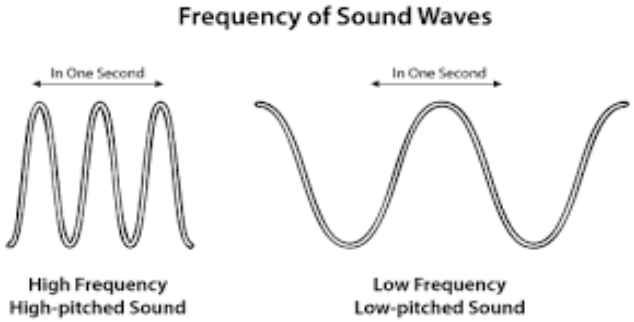
2. Amplitude

When a wave passes through a medium, the particles of the medium get displaced temporarily from their original undisturbed positions. The maximum displacement of the particles of the medium from their original undisturbed positions, when a wave passes through the medium is called amplitude of the wave. In fact the amplitude is used to describe the size of the wave. The unit of measurement of amplitude is metre (m) though sometimes it is also measured in centimetres. Do you know that the amplitude of a wave is the same as the amplitude of the vibrating body producing the wave?

3. Time-Period

The time required to produce one complete wave or cycle is called time-period of the wave. Now, one complete wave is produced by one full vibration of the vibrating body. So, we can say that the time taken to complete one vibration is known as time-period. It is denoted by letter T. The unit of measurement of time-period is second (s).

4. Frequency



The number of complete waves or cycles produced in one second is called frequency of the wave. Since one complete wave is produced by one full vibration of the vibrating body, so we can say that the number of vibrations per second is called frequency. For example: if 10 complete waves or vibrations are produced in one second then the frequency of the waves will be 10 hertz or 10 cycles per second. Do you know that the frequency of a wave is fixed and does not change even when it passes through different substances?

The unit of frequency is hertz or Hz. A vibrating body emitting 1 wave per second is said to have a frequency of 1 hertz. That is 1 Hz is equal to 1 vibration per second. Sometimes a bigger unit of frequency is known as kilohertz (kHz) that is 1 kHz = 1000 Hz. The frequency of a wave is denoted by the letter f.

The frequency of a wave is the same as the frequency of the vibrating body which produces the wave.

What is the relation between time-period and frequency of a wave?

The time required to produce one complete wave is called time-period of the wave. Suppose the time-period of a wave is T seconds.

In T seconds number of waves produced = 1

So, in 1 second, number of waves produced will be = 1/T

But the number of waves produced in 1 second is called its frequency.

Therefore, **F = 1/Time-period**

f = 1/T

where f = frequency of the wave

T = time-period of the wave

5. Velocity of Wave (Speed of Wave)

The distance travelled by a wave in one second is called velocity of the wave or speed of the wave. It is represented by the letter v. The unit for measuring the velocity is metres per second (m/s or ms-1).

What is the relationship between Velocity, Frequency and Wavelength of a Wave?

Velocity = Distance travelled/ Time taken

Let $v = \lambda / T$

Where T = time taken by one wave.

$v = f X \lambda$

This formula is known as wave equation.

Where v = velocity of the wave

f = frequency

λ = wavelength

Velocity of a wave = Frequency X Wavelength

Sound Intensity - I

The speed of sound depends on the properties of the medium in which the sound waves propagate. For example, in air the speed of sound is about 340 m / s, while in water it is higher - 1500 m / s. Sound waves carry energy. The energy E, which the wave transmits per unit time (m = 1s) through a unit area (S = $1m^2$), located perpendicular to the direction of wave propagation, is called the sound intensity.

$$I = \frac{E}{St}$$

From the formula, it follows that the unit of intensity is:

$J / m^2s = W/m^2$ (watts per square meter)

The harmonic wave with a frequency of 1000 Hz is perceived by the ear as sound if its intensity is in the range from $I_0 = 1.10^{-12}$ to $I_{max} = 1W/m^2$. The intensity I_0 determines the hearing threshold. The ear is not sensitive to sounds of lower intensity. I_{max} value is called the upper hearing threshold or pain threshold. If the intensity is bigger from I_{max} the sensation of sound turns into a sensation of pain. The ear is most sensitive to sounds with a frequency of 1000 Hz to 5000 Hz.

Since the intensity of the sounds to which our ear is sensitive can vary widely, it is convenient in practice to use another quantity called the **intensity level - β**. The intensity level is measured in decibels dB. When the intensity increases 10 times the level of intensity increases by 10 dB.

Ultrasound and Infrasound

The human ear does not perceive mechanical waves with a frequency below 20 Hz. They are called infrasound. The human ear is also not sensitive to high frequencies - over 20,000 hertz. Such waves are called infrasound.