Wave motion in one dimension. Equation. Definition of magnitudes. Propagation speed. Distinguishing between transverse waves and longitudinal waves. Examples.

When a disturbance is generated at a point in space, the focus spreads to nearby points, taking a certain amount of time to reach points further away from the point where it is generated, at a propagation speed.

Wave motion is a form of energy transmission carried out by this disturbance, but without the transport of matter. This disturbance that propagates in space is called a wave.

❖**Several types of waves:**

Waves can be classified according to different criteria:

a.According to whether or not a material medium is required for propagation:

- Mechanical waves: propagation occurs through an elastic material medium, transmitting the mechanical energy of the wave. The material medium can be air, water, a rope or any other, and is essential for the propagation of the wave. Examples: sound waves, generated by guitar strings.

- Electromagnetic waves: the transmission of electromagnetic energy occurs through the propagation of oscillating electric and magnetic fields, without the need for a material environment. These waves are periodic variations in the electric and magnetic state of space, so they also propagate in a vacuum.

b. According to the direction of perturbation and propagation:

- Transverse waves: The direction of propagation and the direction of the perturbation that generates the wave are perpendicular. For example, if a string or spring is shaken vertically, the perturbation propagates horizontally.

- Longitudinal waves: The direction of propagation and the direction of the perturbation that generates the wave are parallel. For example, if a spring is compressed horizontally, the perturbation propagates horizontally.

c. According to the dimensions of wave propagation:

- Unidimensional: those that propagate in a single dimension. For example, waves generated in a tensioned string.

- Two-dimensional: those that propagate in two dimensions. For example, surface waves generated when an object is dropped in still water.

- Three-dimensional: those that propagate in three dimensions. For example, sound waves generated by a point source in air.

Among all wave motions, harmonic wave motions will be analyzed here. As the name suggests, these motions can be expressed mathematically using sine or cosine functions. Although they can be of different types, they all have the same or similar origin: the disturbance that generates the wave follows a simple harmonic motion, as do all the points captured by the wave, around an equilibrium position.

❖Specific magnitudes of harmonic waves:

- Elongation, y, is the displacement that this point experiences from its equilibrium position when the disturbance reaches a point. In SI, it is expressed in m.
- The amplitude of the wave, A, is the maximum value of the elongation of the particles in the environment during oscillation. In SI, it is expressed in m.
- Wavelength, λ, is the minimum distance between two consecutive points in the same state of vibration. It is expressed in m in SI.
- Period, T, is the time it takes for any perturbed point to complete one complete oscillation. It is expressed in s in SI.

Frequency, f, is the number of complete oscillations that each point in the medium completes per unit of time. It is expressed in Hz or s^{-1} in SI. It is the inverse of the period. $f = 1T$

Velocity of propagation, v: The velocity of propagation of a wave is the ratio of the distance the wave travels to the time it takes to do so. It depends on the properties of the medium in which the transmission occurs. $v = \lambda T = \lambda . f$

Wave number, k: is the number of waves that travel in units of length 2[illegible]. Its units are m-1 in SI. $k = 2\pi\lambda$

Pulsation, ω: It gives information about the speed of the perturbation, if the vibrational motion of the focus is related to a uniform circular motion. Its units, in SI, are rad/s. $\omega = 2\pi T = 2\pi f$

Initial phase: how many radians the equation that fits the motion deviates from the sine function. In SI, they are rad.

❖Harmonic wave equation:

The wave equation expresses the height (y elongation) that each perturbed point x can reach at any time t. The equation of the wave propagating towards the positive side of the x-axis:

$$y(x,t) = A.\sin[2\pi(t/T - x/\lambda) + \varphi o]$$

where all the terms mentioned above appear. The subtraction between the terms of time and position is indicated by the phase.

Using the wavenumber and the definitions of pulsation, the wave function can also be expressed as:

$$y(x,t)=A.\sin(\omega t-kx+\varphi o)$$

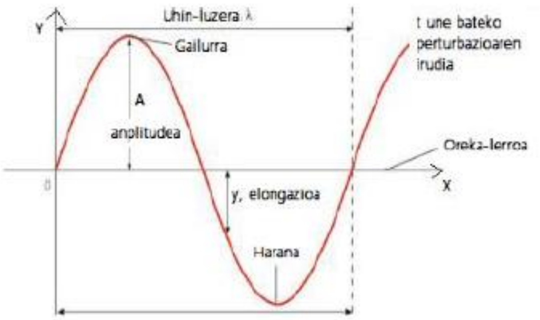
To shift the wave towards the negative side of the X-axis, the internal sign must be changed:

$$y(x,t)=A.\sin[2\pi(tT+ x\lambda)+\varphi o] \; y(x,t)=A.\sin(\omega t+kx+\varphi o)$$

The sum of the time and position terms (positive or negative) is represented by the phase.

The equation has two graphical expressions, depending on the free variable taken to represent the elongation:

At a time t, y represents the elongation with respect to position x:



At a position x, y represents the elongation with respect to time t: