Waves I

Waves are an extremely important part of physics. An understanding of waves is essential to understand a wide range of physical phenomena including light and the wave properties of matter including electrons and atoms.

To make a precise definition of a wave requires Calculus so instead we make a qualitative definition and begin by studying the properties of mechanical waves which are more familiar to us.

Definition of a Wave: the propagation of a disturbance without the transfer of matter.

Pebble dropped in a pond.

Waves can transfer: 1)

2)

Most mechanical waves are due to a series of linked oscillators. The oscillators oscillate about their equilibrium points in space with the disturbance being transmitted by the linkage between the oscillators.

In the video, the oscillators are the metal rods. Each rod is connected together by a thin wire so that when a rod oscillates, it disturbs its neighbors and the disturbance is propagated.

Sinusoidal Waves – Instead of a single disturbance, many waves are created by a periodic disturbance where the oscillators undergo periodic motion like we have studied before. This sets up a wave that is sinusoidal in space and in time as shown on the video.

Consider a boat on the ocean.

The boat oscillates up and down with some period T, but it doesn't move horizontally.

If we take a picture at time t=0, we see that the wave is spread out across space.

Wavelength (λ) – The distance between two similar points (peaks for instance) on a wave.

Wave number (k) – The number of waves over a given distance. It is related to wavelength as angular frequency is to period.

k

Amplitude (A) – largest displacement of the wave (just like for oscillators)

A wave is NOT located at a point like a particle so it makes no sense to talk about a position vector. Instead we talk about how the disturbance (a surface of constant phase angle) is shaped and propagates.

Phase Fronts – A geometrical surface of constant phase (usually we find the peak to be the easiest)

Ray – An arrow perpendicular to a phase front and pointing in the direction of propagation of the wave.

Example 1: Pebble in a Pond

Example 2: Plane Wave

We can describe many waves by the following formula:

$$f(x, t) = A\ \cos(k\,x - \ \omega\,t + \ \delta)$$

The plane wave is very useful in helping us derive various formulas for waves. For instance, let us consider a constant phase from such that

$$k\,x - \ \omega\,t = 0$$

After an oscillator has completed one period, T, we have

$$k\,x - \ \omega\,T = 0$$

Thus, we see that the wave travels one wavelength in one period of time.

This gives us the speed of the wave!!

Other Ways To Classify Waves:

Another way that we distinguish between different types of waves is the direction of the propagation of the wave disturbance compared to the direction of motion of the individual oscillators.

Transverse wave – The direction of wave propagation is perpendicular to the direction of the oscillations.

L**ongitudinal wave** – The direction of wave propagation is parallel to the direction of the oscillations.