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.

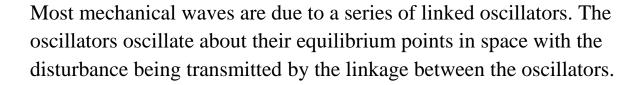
To make a precise definition of a wave requires Calculus so instead we make a qualitative definition and begin by studying the properties of mechanical waves which are more familiar to us.

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

Pebble dropped in a pond.

Waves can transfer: 1)

2)



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

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

