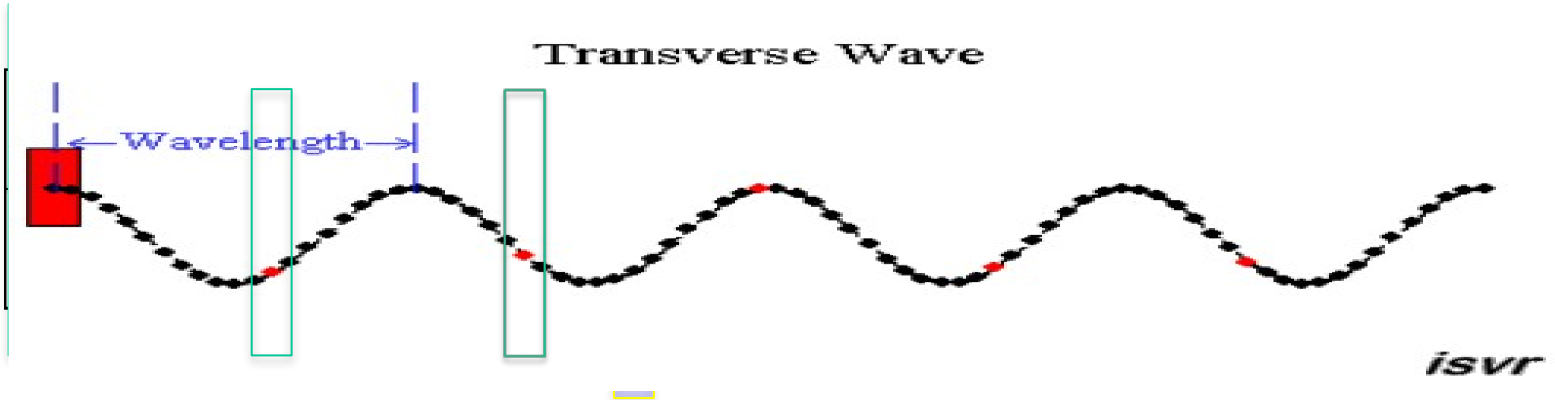
Optics and Waves

Lecture 2
Wave function:
A mathematical way of describing a wave

From SHM to Sine waves



Mechanical Waves: https://www.compadre.org/osp/EJSS/4470/255.htm

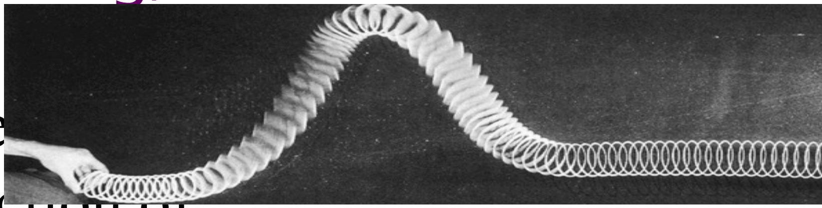
A mechanical wave is a disturbance that travels through a **medium**:

A single wave pulse or a periodic wave.

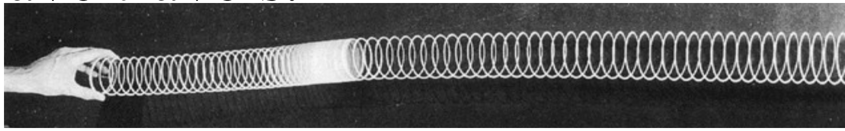
Medium: water, air, stone, but not vacuum

A wave pulse: http://www.youtube.com/watch?v=t-e66Ds8rW8 - refle

Properties of mechanical waves:Young, Chapter 15



1. Transverse. Displacement of the me perpendicular/transverse to the direction of travel.
2. Longitudinal. Displacement of the medium is along the same direction that the wave travels.

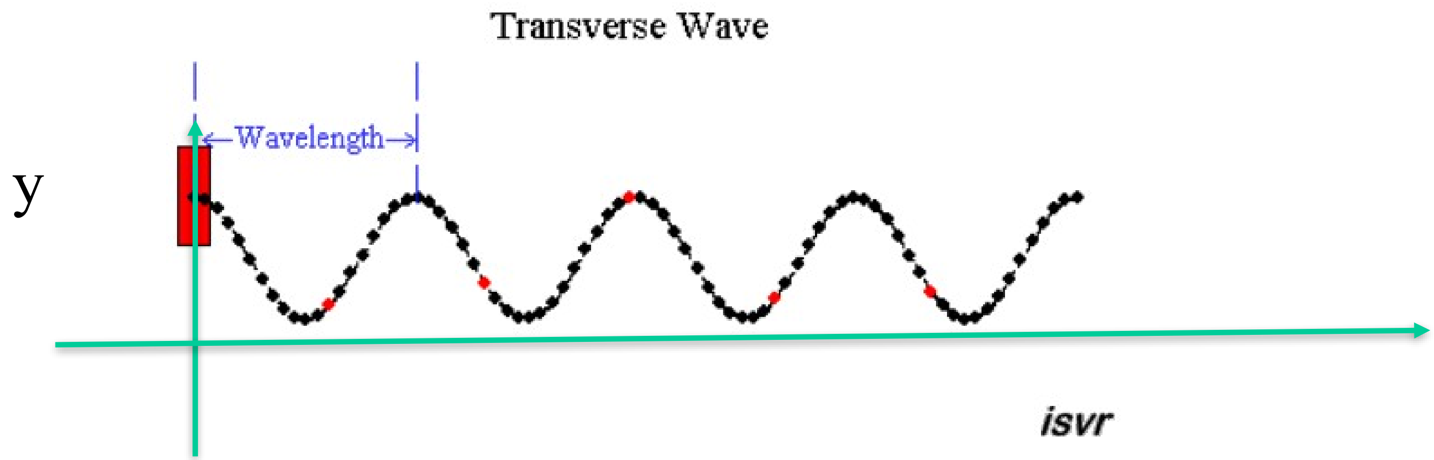


3. Propagation of the wave depends on the medium (soft spring/rigid spring; light/heavy)

4. Medium does not travel with the wave
Waves have magnitude and direction

5. The disturbance travels with a definite speed through the medium. This speed is called the wave speed.

6. Wave transports energy, but not matter, from one region of the medium to another.



A particle copies the motion of its left-hand side neighbour, with a time delay that is proportional to their distance.

The displacement in the medium is a function of distance and time. Here, the string is the medium.

y(x,t): Wave function. Every wave can be described by a wave function

Mechanical Waves:https://www.compadre.org/osp/EJSS/4470/255.htm

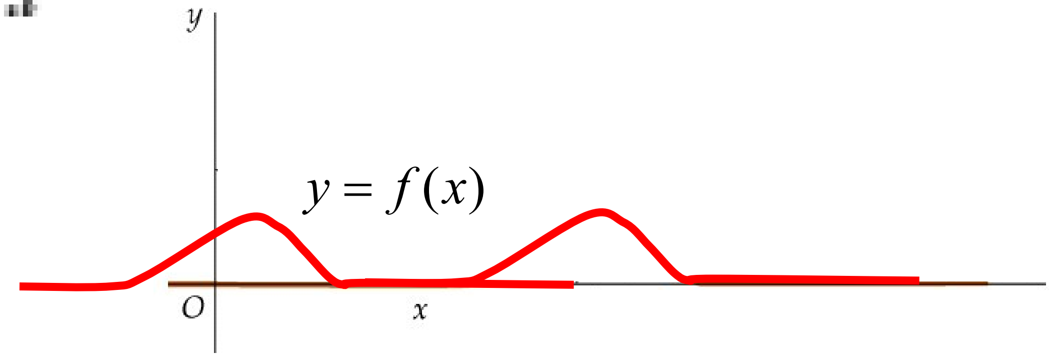
Wave function $y(x, t)$: It gives you the displacement of the medium at any location x, at any time t. y is a function of both x and t.

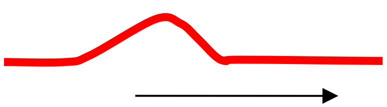
$$x = x' + v.t \qquad x' = x - v.t$$

$$y' = f(x') = f(x - vt)$$

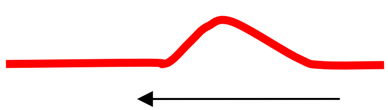
$$but \qquad y = y'$$

$$y = f(x - vt)$$





$$y = f(x + vt)$$

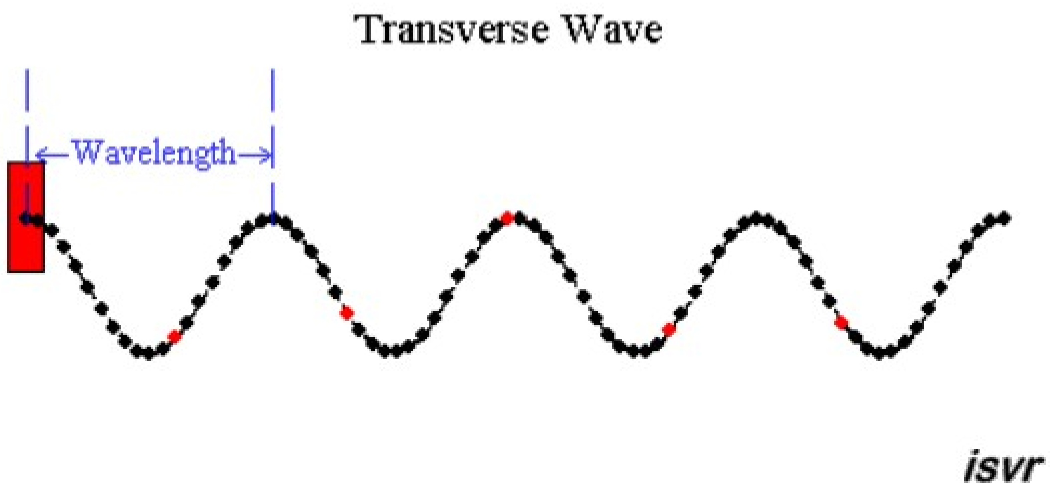


In the moving frame the pulse is stationary,
So y' is a function of x' only, independent of time.

All waves can be described by $y = f(x \pm vt)$

The exact form of *y* depends on the details of individual waves. In the following, we will obtain an expression based on one particular type of waves: Periodic waves. We use the wave on a string as an example.

Any periodic waves can be represented as a combination of sinusoidal waves. (A periodic wave does not have to be sinusoidal)


Transverse Wave
Wavelength
isvr

For a sinusoidal wave, at any fixed time, f(x) traces a sine curve. The length of one complete wave pattern, from one trough to the next or from one crest to the next, is called the wavelength of the wave.

A sinusoidal wave propagates by a distance λ in time T (one period). So the speed of the wave is

$$v = \frac{\lambda}{T} = \lambda f$$

All points on the string oscillates with the same frequency f.

Wave function for a sinusoidal wave

All particles on the string oscillate with the same frequency, but the oscillations at different points are not all in step with each other.

Since the "source of motion" is at the $x = 0$, the motion of the particle on the right lags behind the motion of the particle on the left by an amount proportional to the distance between the particles.

Two particles separated by λ moves in step.
Those particles move in step are described as in-phase.

Otherwise, they are said to have phase differences.
Two particles separated by $\lambda/2$ move completely out of phase.

A sinusoidal wave can be represented by a sine function or a cos function. This is an arbitrary choice.
We use the Cos function, same as in Young and Freedman.
If you read a text book which uses the Sine function, you need to pay some attention when dealing with reflection or transmission at boundaries.

Any periodic waves can be represented as a combination of sinusoidal waves. A periodic wave does not have to be sinusoidal. For example, you can have a periodic triangular wave a or a square wave.

Phases

Watch the following clip on youtube and see if it helps to understand phase.

https://www.youtube.com/watch?v=7_AiV12XBbI