Traveling Waves

Leonardo Da Vinci (15th century)

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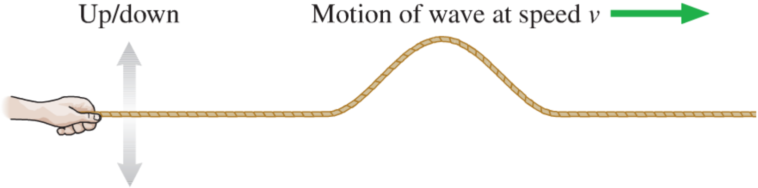
So, a traveling wave is the propagation of a disturbance in a medium, but the medium itself does not propagate.

Traveling Waves

Traveling waves come in two types

Transverse (like light)



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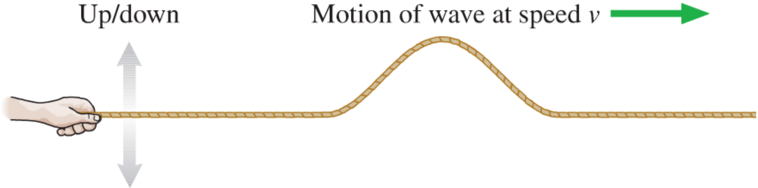
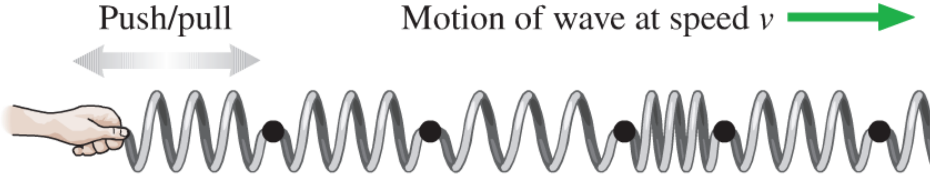


Longitudinal (like sound)



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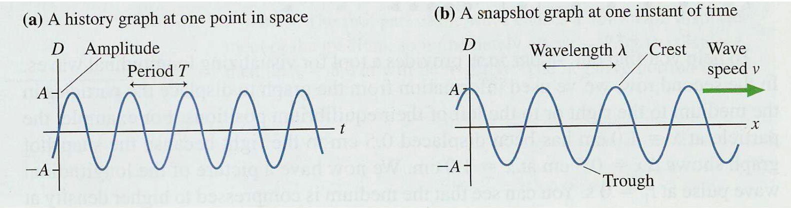
Wave Properties Review - Periodic Waves



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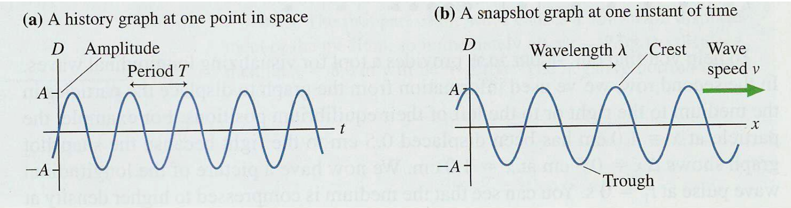

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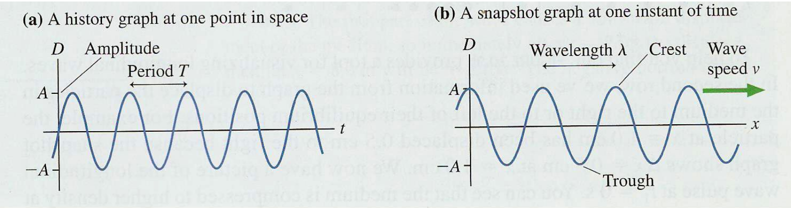

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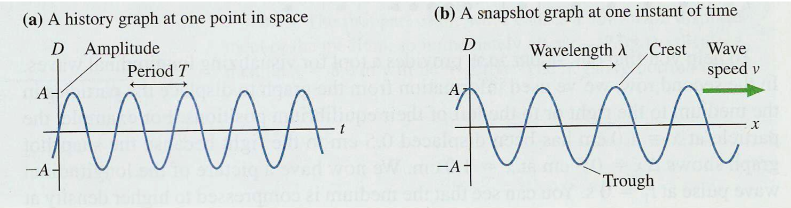

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- Wave speed (v): During one period a fixed observer sees one complete wavelength go by $v = \frac{\lambda}{T} = \lambda f$

It is worth noting that

$$\lambda = \frac{v}{f} = \frac{\text{property of medium}}{\text{property of source}}$$

Sinusoidal Waves

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$$\lambda = \frac{v}{f} = \frac{\text{property of medium}}{\text{property of source}}$$

In other words, the speed of light does not depend on whether you use a lightbulb or a laser beam. However, the frequency does depend on the source....and so does the wavelength.

Sinusoidal Waves – Simulation

Simulation of transverse waves on a rope: http://phet.colorado.edu/

Mathematics of Sinusoidal Waves

We can define the displacement D of a particle in a medium due to the passage of a sinusoidal wave (snapshot at $t = 0$):

$$D(x, t = 0) = A \sin\left(2\pi \frac{x}{\lambda} + \phi_0\right)$$

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This equation is periodic with period λ ($D(x) = D(x + \lambda)$). We can turn this into a moving wave by making the position depend on time:
$x \rightarrow x - vt$

$$D(x, t) = A \sin\left(2\pi \frac{x - vt}{\lambda} + \phi_0\right) = A \sin\left(2\pi \left(\frac{x}{\lambda} - \frac{t}{T}\right) + \phi_0\right)$$

Mathematics of Sinusoidal Waves

We can re-express this in different notation to clean things up a little. Let's define the angular frequency (ω) and wave number (k) as

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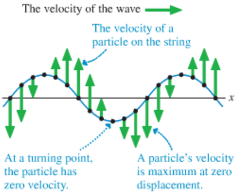
Wave number is the spatial analogue of frequency, it describes the number of radians of wave cycle per unit distance. This allows us to write the equation from the previous page as

$$D(x, t) = A \sin(kx - \omega t + \phi_0)$$

Example: Waves on a String



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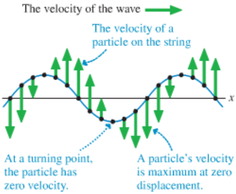

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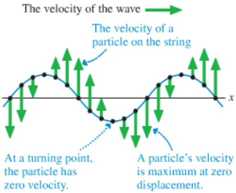

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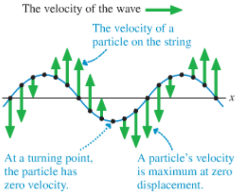

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This is referring to the particle speed.

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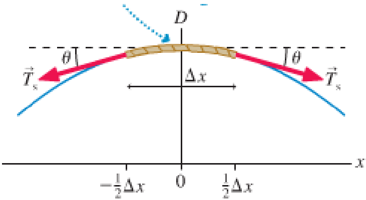

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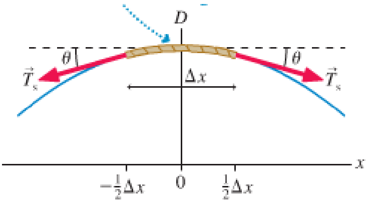

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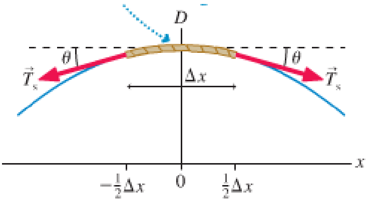

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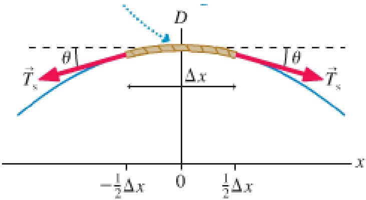

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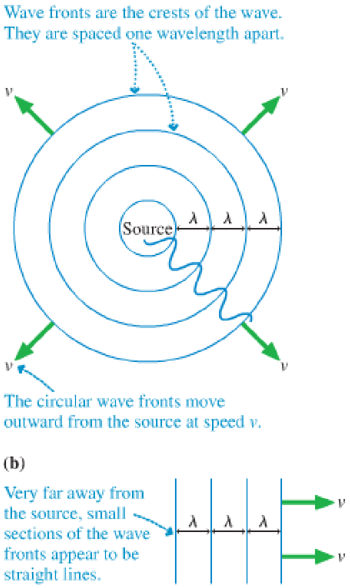
where T_s is the tension and μ is the linear density. This defines the wave speed. Please note that it depends only on properties of the medium and what that dependence is.

Waves in 2 or 3 Dimensions



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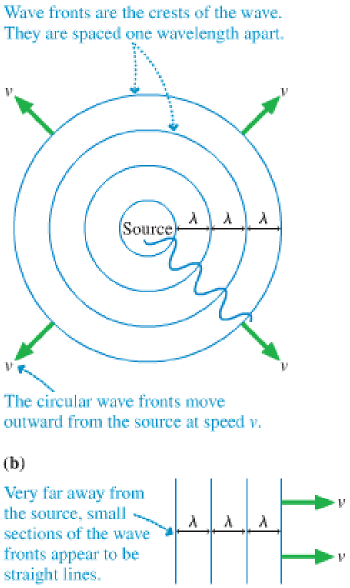

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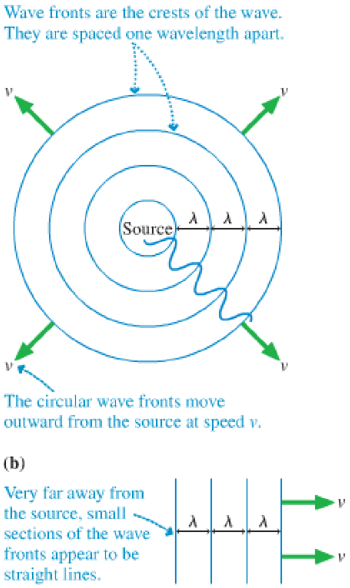

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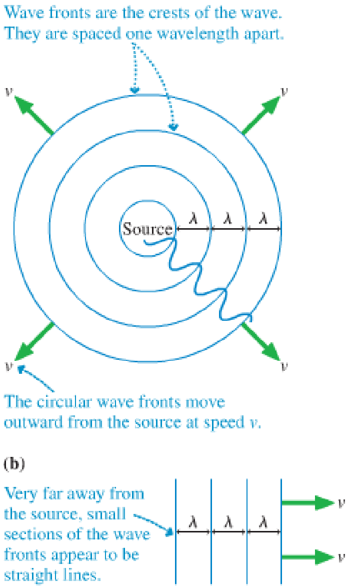
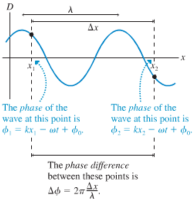


So far we have discussed waves in 1-D. What do they look like in more than one dimension? This circular wave is made of wave fronts. In 3-D you get spherical waves. Very far from the source, these waves look like plane waves. Mathematically, little changes:

$$D(r,t) = A(r)\sin(kr - \omega t + \phi_0)$$

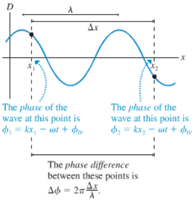
(note amplitude change as wave spreads)



The phase of the wave is

$$(kx - \omega t + \phi_0)$$

Phase and Phase Difference



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Very soon the phase difference will be very important since we will talk about interference. The phase difference is

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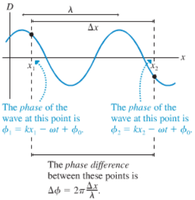

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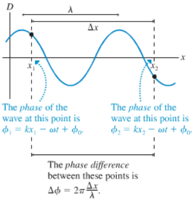

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Moving from one crest to another represents a phase shift of 2π

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$$f = \frac{v}{\lambda} = \frac{3.00 \times 10^8 m/s}{600 nm} = 5.00 \times 10^{14} Hz$$