Waves and Oscillation

Course- PHY 2105 / PHY 105

Lecture 9

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Equation for a Progressive Wave

$$y = A \sin(\omega t - \phi)$$

$$y = A\sin(\omega t - \frac{2\pi x}{\lambda})$$

$$y = A\sin\frac{2\pi}{\lambda}(vt - x)$$

Differential Equation for Wave Motion

$$\frac{d^2 y}{dt^2} = v^2 \frac{d^2 y}{dx^2}$$

Example 7.4

A transverse sinusoidal wave is generated at one end of a long horizontal string by a bar that moves the end up and down through a distance of 1.30 cm. The motion is continuous and is repeated regularly 125 times per second.

(a) If the distance between adjacent wave crests is observed to be 15.6 cm, find the amplitude, frequency, speed, and wavelength of the wave motion.

(*b*) Assuming the wave moves in the x direction and that, at t 0, the element of the string at x=0 is at its equilibrium position y=0 and moving downward, find the equation of the wave.

A= 0.65 cm, f=125 Hz, λ =15.6 cm, v= 19.5 m/s

$y(x, t)$= (0.65 cm) sin [(40.3 rad/m)x (786 rad/s)t]

Wave Interference

Two (or more) waves are said to interfere if they meet at the same point at the same time. The result can be calculated by the algebraic sum of the instantaneous values of the wave equations.

There are two types of interference:

1) Constructive and
2) Destructive

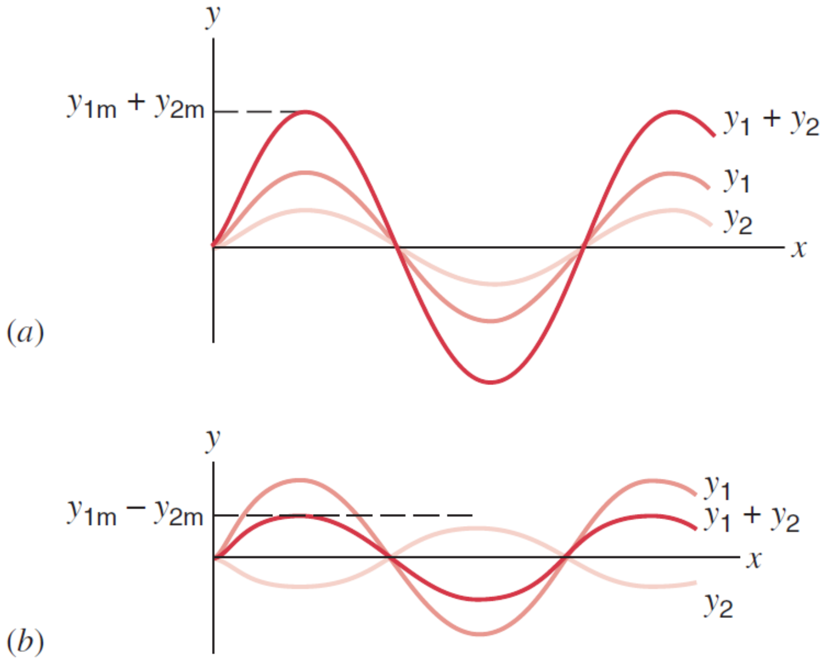

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Table 16-1 Phase Difference and Resulting Interference Types[a]

Phase Difference, in			Amplitude of Resultant Wave	Type of Interference
Degrees	Radians	Wavelengths		
0	0	0	$2y_m$	Fully constructive
120	$\frac{2}{3}\pi$	0.33	y_m	Intermediate
180	π	0.50	0	Fully destructive
240	$\frac{4}{3}\pi$	0.67	y_m	Intermediate
360	2π	1.00	$2y_m$	Fully constructive
865	15.1	2.40	$0.60y_m$	Intermediate

[a]The phase difference is between two otherwise identical waves, with amplitude y_m, moving in the same direction.

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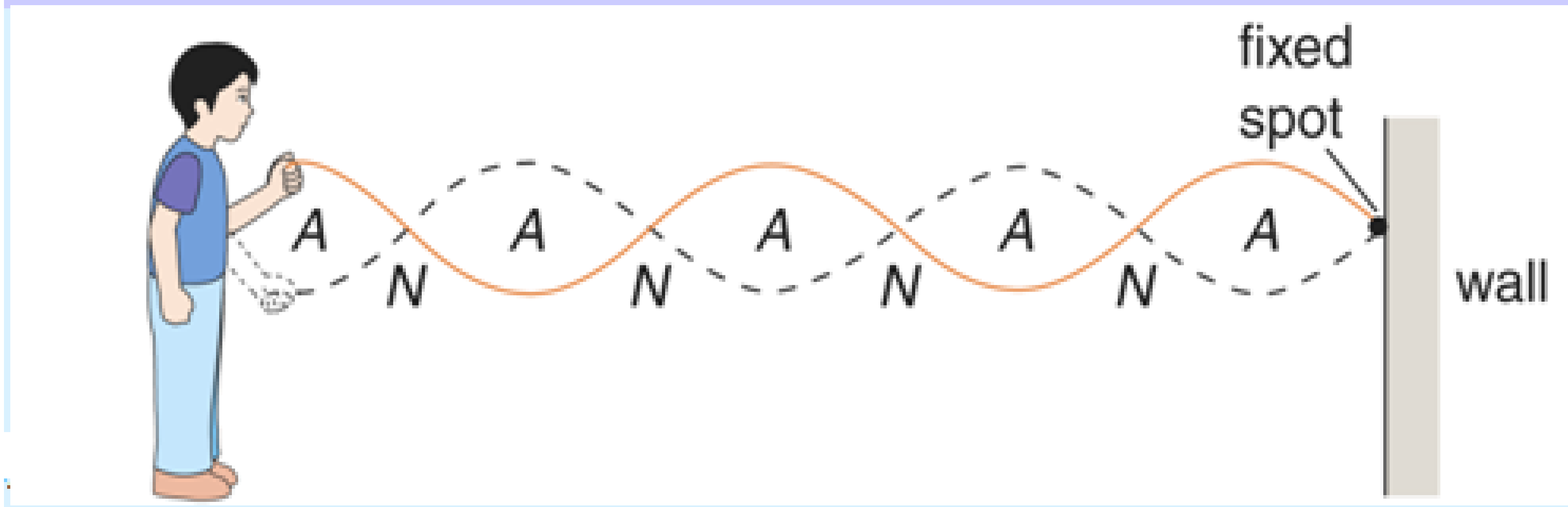
Stationary Wave

When an incident wave is reflected by a wall, then the superposition of two progressive waves (with same amplitude and same frequency, travelling in opposite directions) create a stationary wave.



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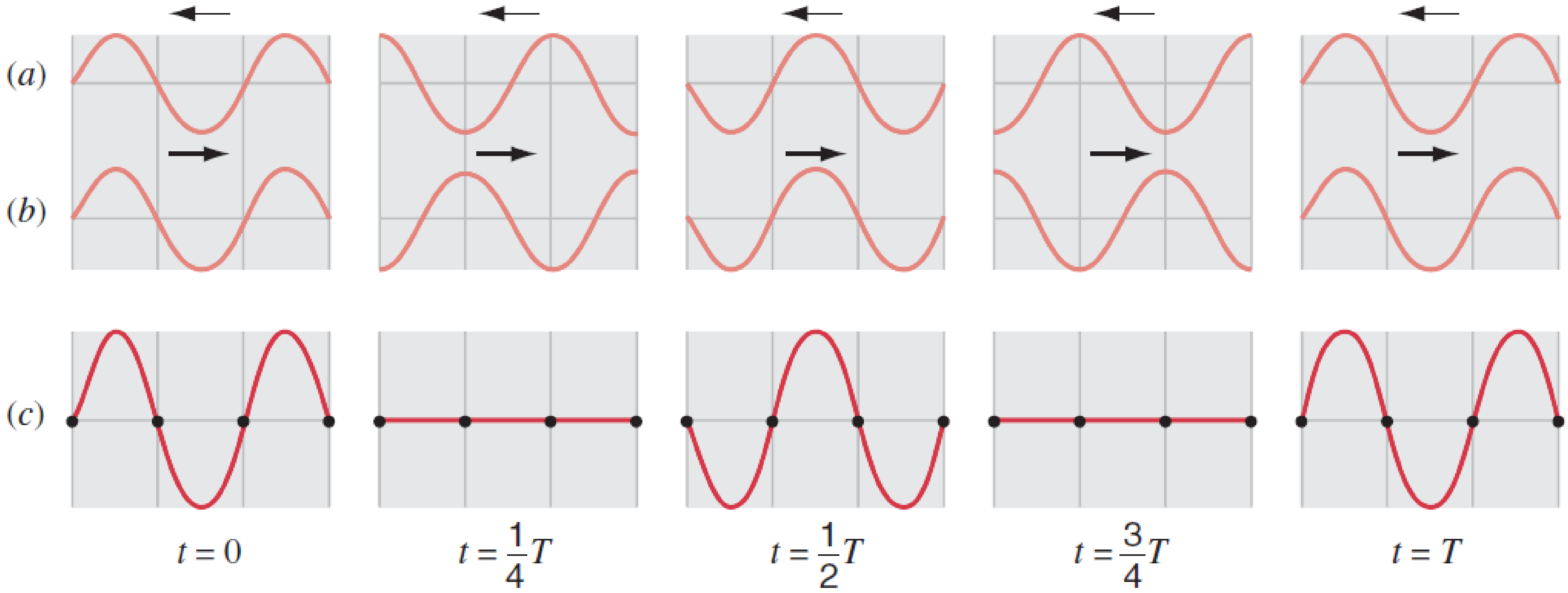
Interference in Standing Wave



Harmonics

When loops are created, the total length is a multiplier of half the wavelength

$$f = n\frac{v}{2L}$$

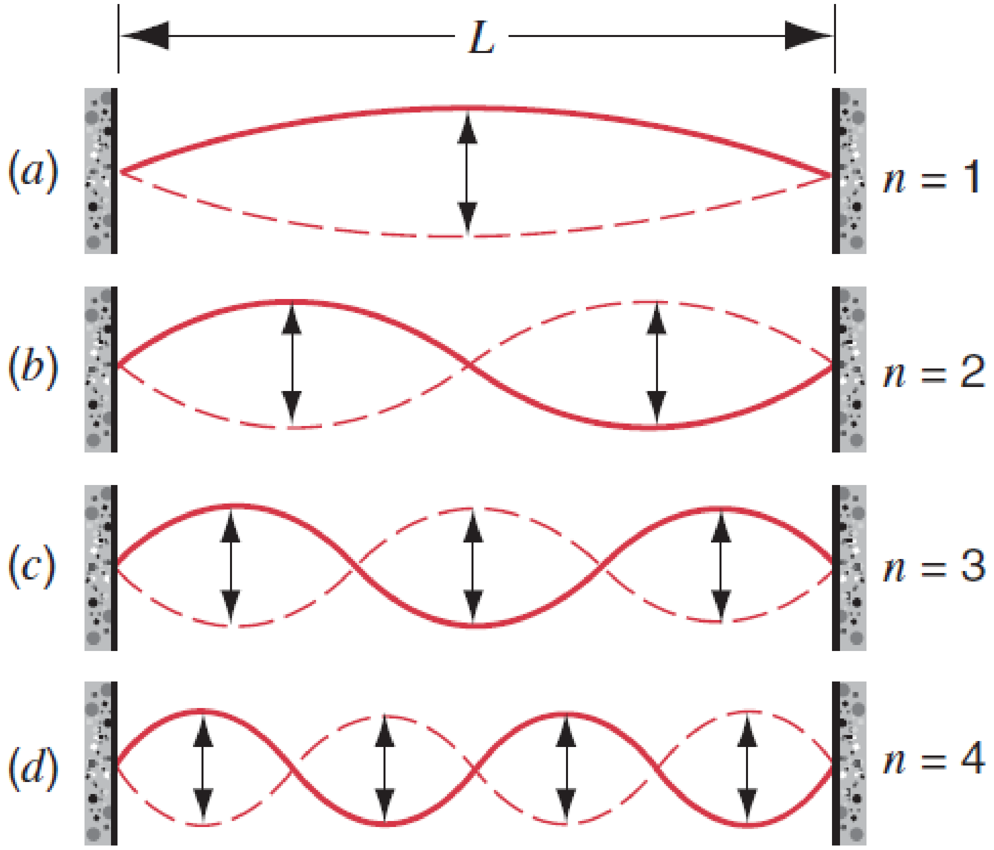
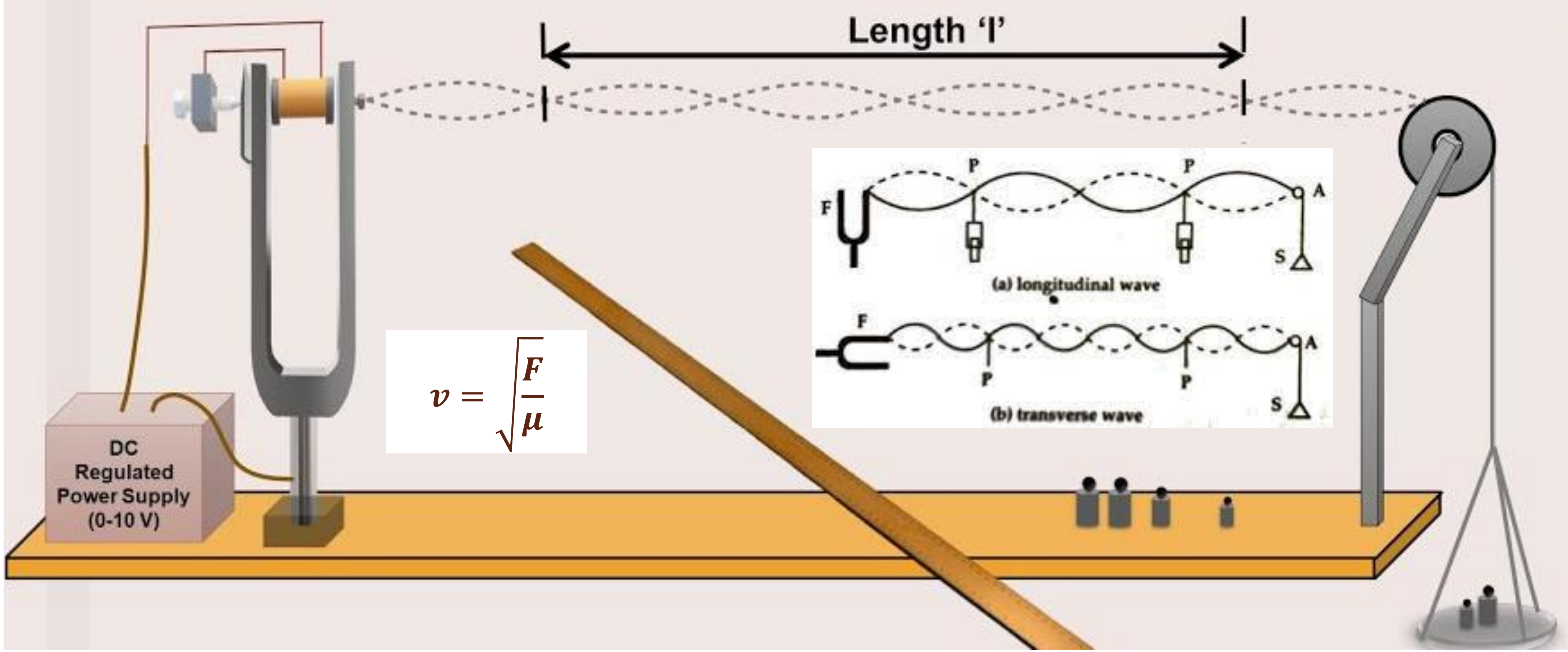


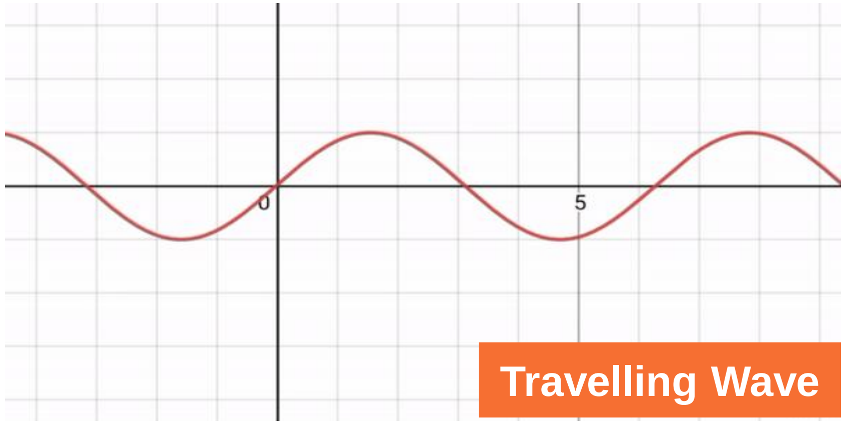
FIGURE 18-20. Standing wave patterns on a string of length L stretched between two fixed supports. Four different patterns are shown, corresponding to different wavelengths and frequencies.

Waves on a string – Melde's apparatus

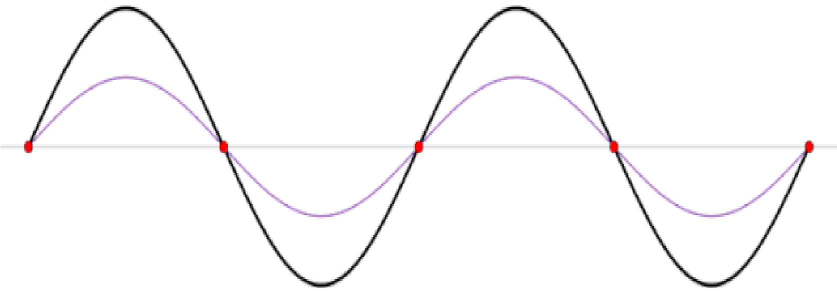


$$v = \sqrt{\frac{F}{\mu}}$$

Differences



Travelling Wave


Standing Wave

Progressive wave	Stationary wave
Energy is transferred along the direction of propagation.	No energy is transferred along the direction of propagation.
The wave profile moves in the direction of propagation.	The wave profile does not move in the direction of propagation.
Every point along the direction of propagation is displaced.	There are points known as nodes where no displacement occurs.
Every point has the same amplitude.	Points between two successive nodes have different amplitudes.
Neighbouring points are not in phase.	All points between two successive nodes vibrate in phase with one other.

Wave Intensity and Power

Power is the *instantaneous* rate at which energy is transferred along the string.

$$P = \omega F k A^2 \cos^2(\omega t - kx)$$

$$P = \mu \omega^2 A^2 v \cos^2(\omega t - kx)$$

$$P = \omega^2 A^2 \sqrt{F\mu} \cos^2(\omega t - kx)$$

Waves on a string carry energy in just one dimension of space (along the direction of the string). But other types of waves, including sound waves in air and seismic waves in the body of the earth, carry energy across all three dimensions of space.

The time average rate at which energy is transported by the wave, per unit area, across a surface perpendicular to the direction of propagation is called Wave Intensity.

$$I = \frac{P}{4\pi r^2} \qquad \frac{I_1}{I_2} = \frac{{r_2}^2}{{r_1}^2}$$

Intensity follows Inverse Square Law

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