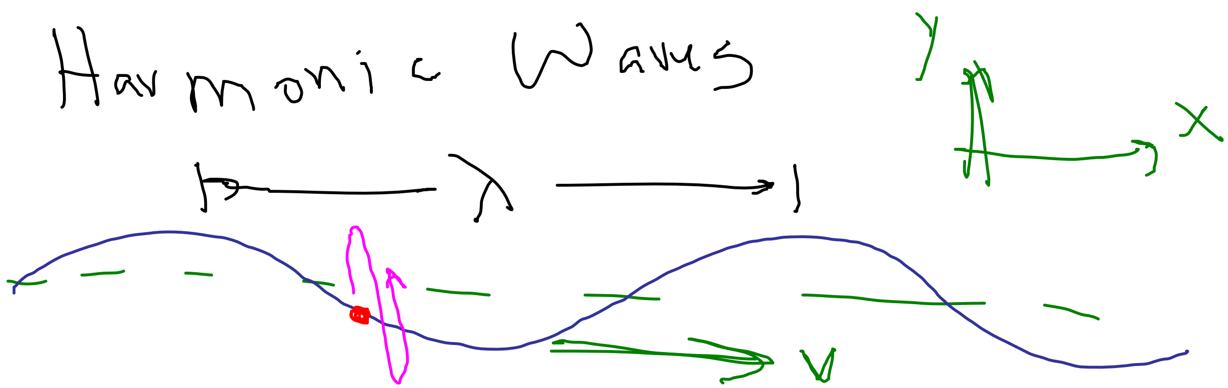
Phys 2110-4 4/13/12

Chap 14

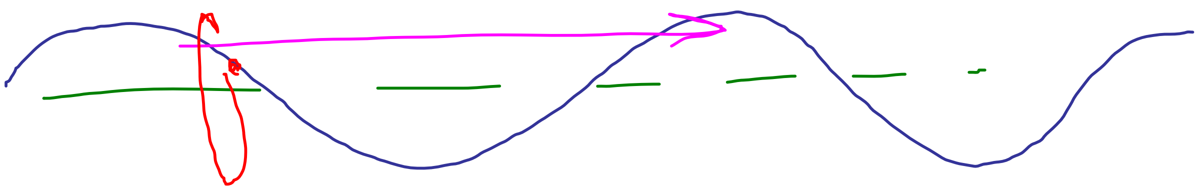
Harmonic Waves



λ wavelength

v speed of wave

f frequency $\omega = 2\pi f$ $T = 1/f$



Time to move over by λ.

$d/t = v$

$\lambda/t = v$

$t = T = 1/f$

$t = \lambda/v$

$1/f = \lambda/v$

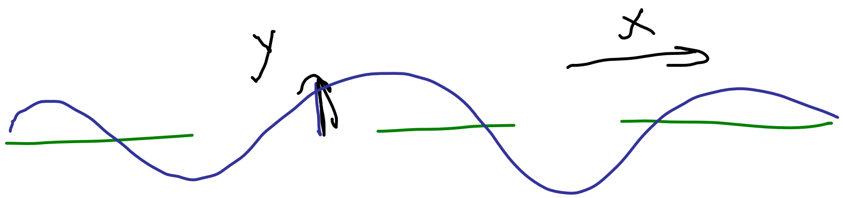
$$\boxed{\lambda f = v}$$

$T = 1/f$

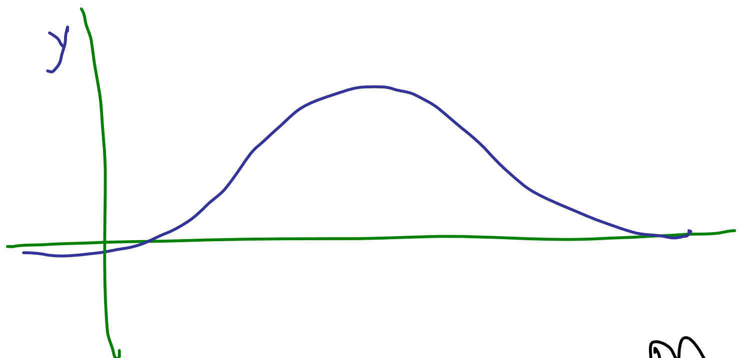
$\omega = 2\pi f$

$2\pi/\lambda = k$ wave number

Mathematical Rep of Wave



y depends on x, t



$f(x-vt)$

$$f(x) \longrightarrow f(x-vt)$$

Special comb. of x, t

Maintains shape, travels to <u>right</u> speed v

$$f(x \mp vt)$$

X_0

Traveling wave, speed v

$-$ right

$+$ left

Note

$$x - vt = x - \frac{\omega}{k}t$$

$$= \frac{1}{k}(kx - \omega t)$$

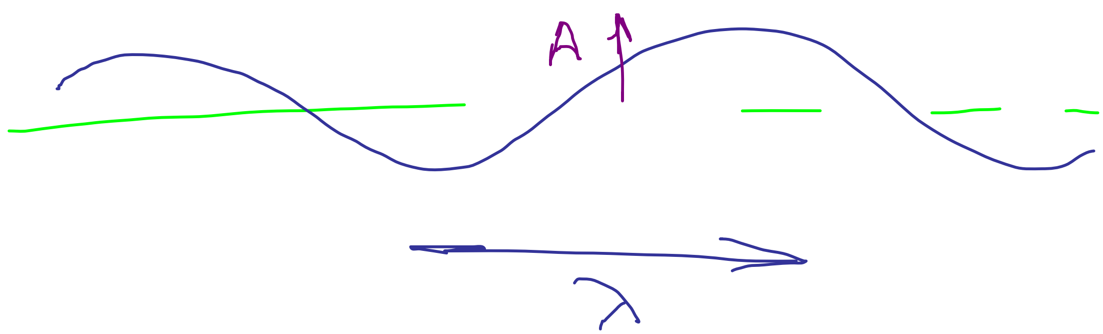
$$\lambda f = v$$

$$\frac{\cancel{2\pi}}{k}\,\frac{\omega}{\cancel{2\pi}} = v$$

$$v = \omega/k$$

$$k = 2\pi/\lambda$$

$$\lambda = 2\pi/k$$



$A \cos(kx)$

$2\pi/\lambda$

Trav(e)ling harmonic wave

$$y(x,t) = A\cos(kx \mp \omega t + \phi)$$

$\lambda f = v$ $v = \omega/k$

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Travels to right.

Travels to left

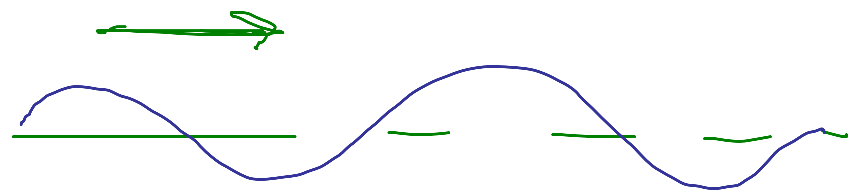
y satisfies PDE; $y(x,t)$

$$\boxed{\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}}$$

$$\partial y / \partial t$$

String under tension, F

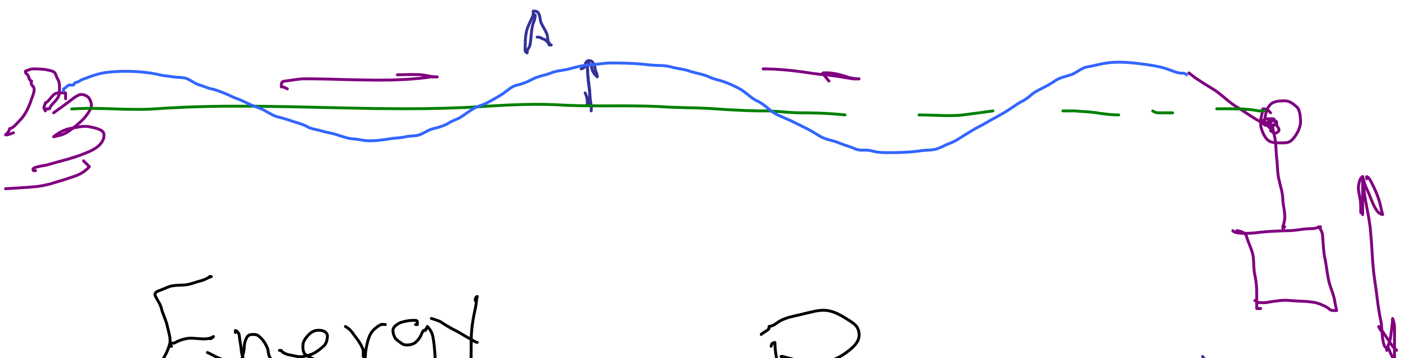
$$\boxed{v = \sqrt{F/\mu}}$$



μ = mass density

kg/m

$$v = \sqrt{\frac{\text{Elastic property}}{\text{mass property}}}$$



$$\frac{\text{Energy}}{\text{Time}} = \text{Power}$$

$$= P$$

string (Harmonic)

$$\bar{P} = \frac{1}{2}\mu\omega^2 A^2 v$$

J/s

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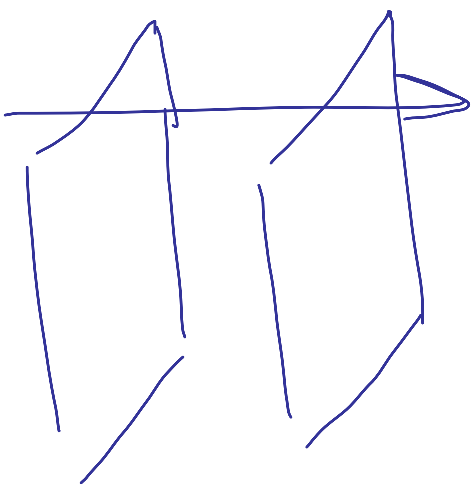
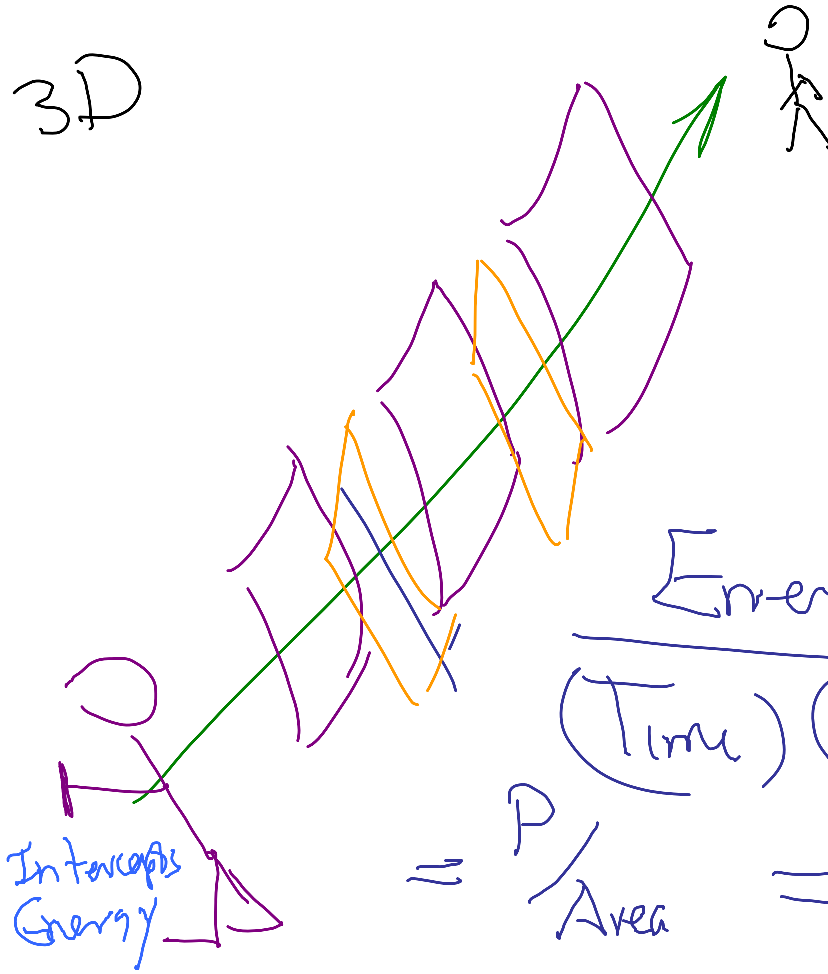
Waves in 2D, 3D





$$\frac{\text{Energy}}{(\text{Time})(\text{Area})} = P/_{\text{Area}} = I$$

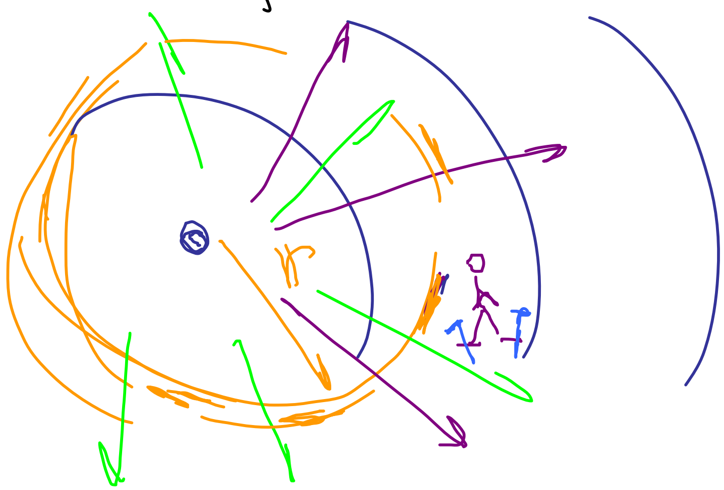
Intensity

$$I = \frac{E}{t \cdot A} = \frac{P}{A}$$

Units $= W/m^2$

$= W/m^2$

Isotropic Source

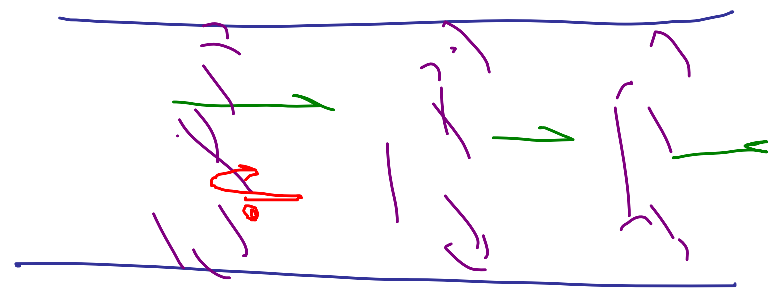


Source loses energy at rate P

$$I = \frac{P}{4\pi r^2}$$

Sound Waves

Simple formula



$$v = \sqrt{\frac{\gamma P}{\rho}}$$

ρ = mass density

P = pressure

γ = Simple number

$7/5$ for air $5/3$ for He.

Liquids Water $\sim 1400 \frac{m}{s}$

Steel $\sim 5500 \frac{m}{s}$

$0°C$ $v_{son} \sim 331 \frac{m}{s}$ $20°C$ $v_{son} \sim 340 \frac{m}{s}$

Range of frequencies

20 Hz – 20,000 Hz

20 Hz – 15,000 Hz

261 Hz Middle C.