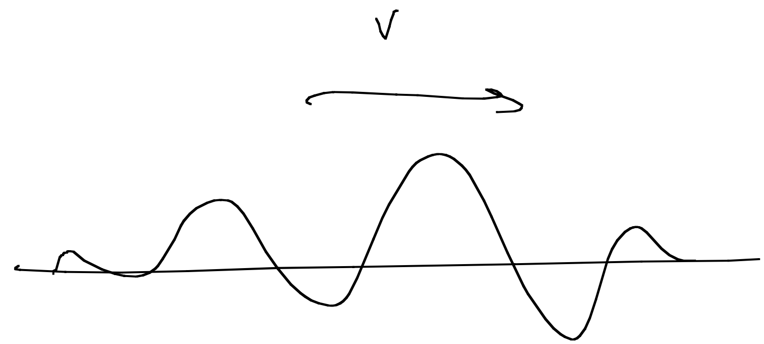
Phys 2110-3 11/29/10

Note Title 11/29/2010

Wave Motion



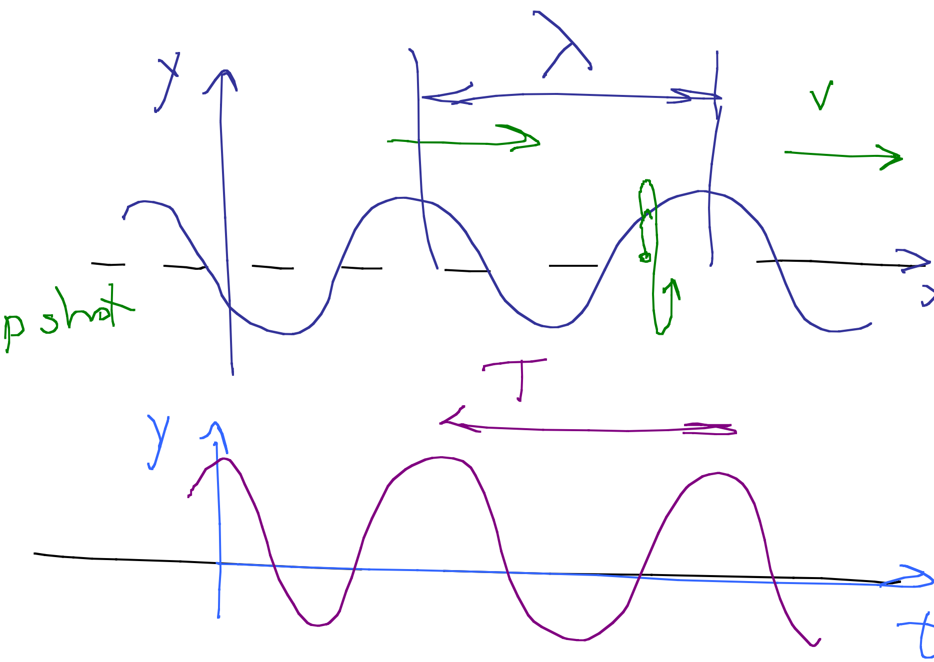
Periodic Waves

$$f = 1/T$$

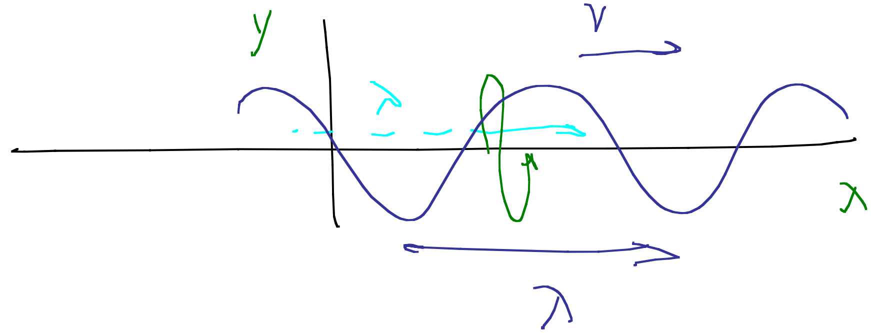
$$k = 2\pi/\lambda$$

$$\omega = 2\pi f$$

Snapshot



In a time T
bit of string makes one
full motion up & down.
In this time, wave has moved over
a distance λ



$$vT = \lambda \qquad v\,\frac{1}{f} = \lambda \qquad \lambda f = v$$

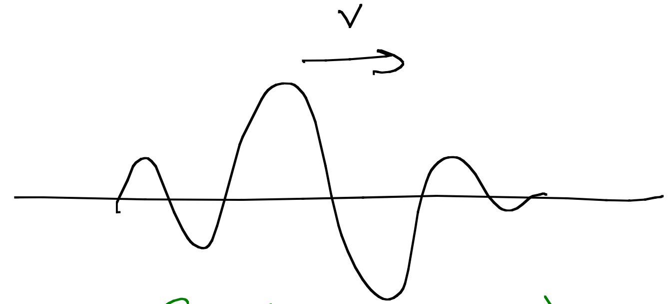
$$\boxed{\lambda f = v}$$

$$\lambda = \frac{2\pi}{k} \qquad f = \frac{\omega}{2\pi}$$

$$\left(\frac{\cancel{2\pi}}{k}\right)\left(\frac{\omega}{\cancel{2\pi}}\right) = v$$

$$\boxed{\frac{\omega}{k} = v}$$

A wave which keeps same shape must have form:



$$y = f(x,t) = f(x \mp vt)$$

− Right (+x dir)

+ Left (−x dir)

$x - vt$: Incr t, $\rightarrow$ Incr x

− $\longrightarrow$ Right

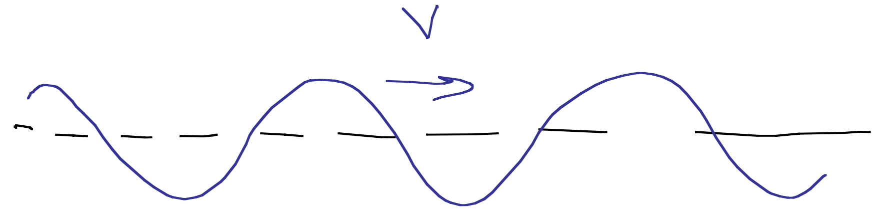
Sinusoidal (harmonic) continuous wave. (Travels to right)

$$y = \underbrace{A}_{\text{amplitude}}\cos(kx - \omega t)$$

$$= A\cos\left[k\left(x - \frac{\omega}{k}t\right)\right] = A\cos\left[k(x - vt)\right]$$

Generally: $y(x,t) = A\cos(kx - \omega t + \phi)$

Waves on String



Real system

Properties:

Mass density $= \dfrac{\text{mass}}{\text{length}} = \mu$ $\quad kg/m$

Tension, F

Speed of waves $\quad v = \sqrt{\dfrac{F}{\mu}}$

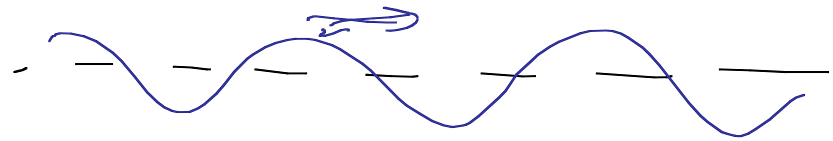
Net force on bit of string

$$\frac{\partial^2 y}{\partial t^2} \propto \frac{\partial^2 y}{\partial x^2}$$

Generally

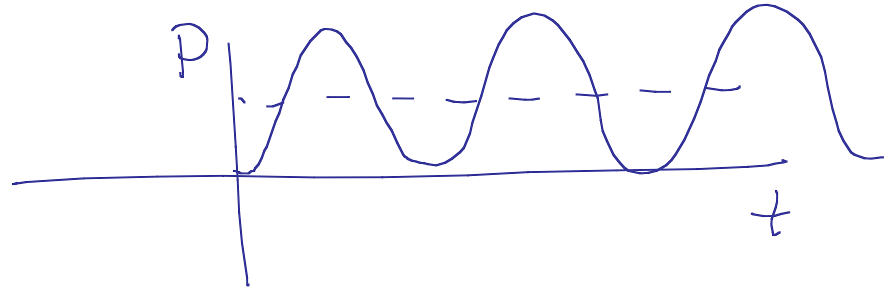
$$v = \sqrt{\frac{\text{Elastic property}}{\text{Mass property}}}$$

$$y = A\cos(kx - \omega t)$$



Formula for how rapidly energy trans'd down string

p. 227



Need average wave power, $\bar{P}$

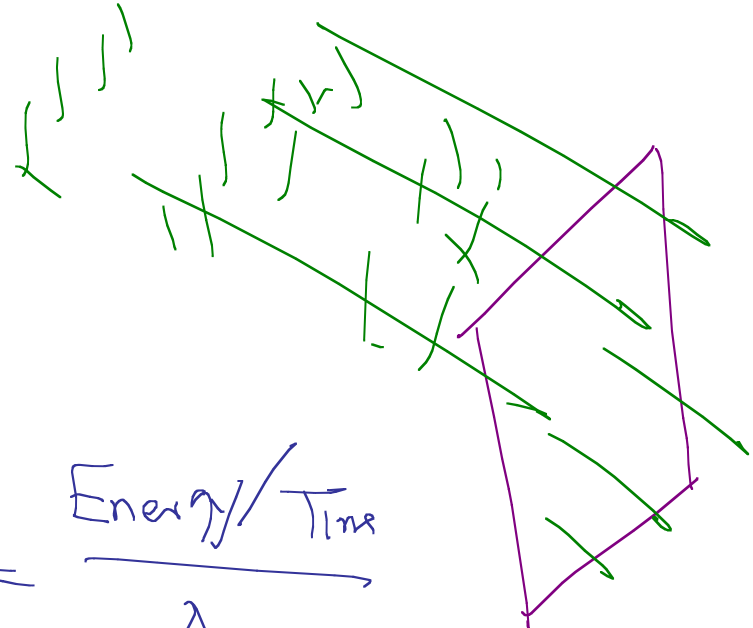
$$\bar{P} = \frac{1}{2}\mu\omega^2 A^2 v$$

μ = mass dens.
ω = ang freq
A = amplitude
v = speed,

$$\frac{kg}{m}\left(\frac{1}{s}\right)^2 m^2 \frac{m}{s} = \frac{kg\, m^2}{s^3}$$

Watt

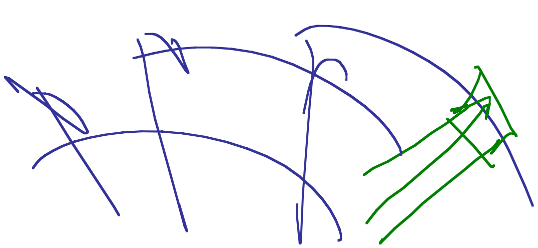
Waves in 2,3 dim's



Sensible: $\dfrac{\text{Energy}}{\text{Area}\cdot\text{Time}}$

$= \text{Intensity} = I = \dfrac{\text{Energy}/\text{Time}}{A}$

$= P/A$ Meas'd $\dfrac{\text{Watts}}{m^2}$ $\dfrac{\text{kg}\,\cancel{m^2}/s^3}{\cancel{m^2}}$ $\dfrac{\text{kg}}{s^3}$

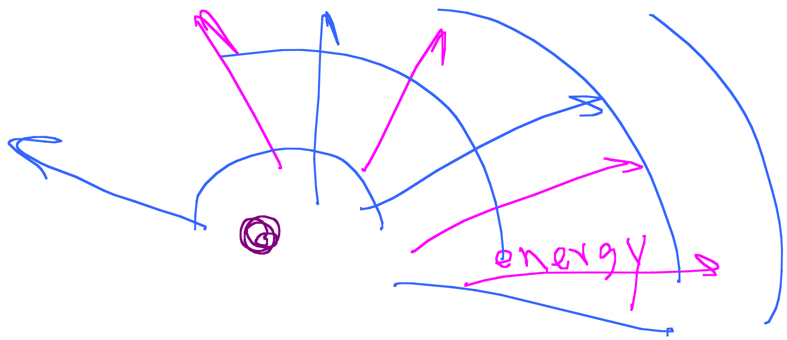


For small sampling area surfaces of constant phase (e.g. maxima)

Planes

plane wave

Common idealization: Point source produces a wave going equally in all direction.

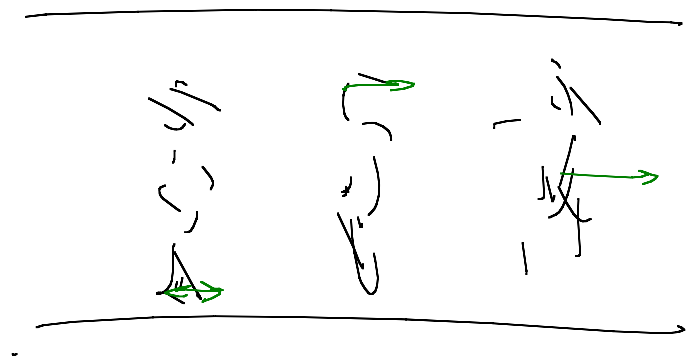


Puts out power P into the medium

Energy per time trans'd thru <u>any</u> sph surface is same. For a sphere radius r

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

Sound Waves



Longitudinal,

Can be calculated

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

γ = some # about gas

Air $\frac{7}{5}$

P = pressure N/m^2

ρ = mass density

$\Rightarrow$ 343 $\frac{m}{s}$ $T \approx 26C$

331 $\frac{m}{s}$ $T \approx 0°C$