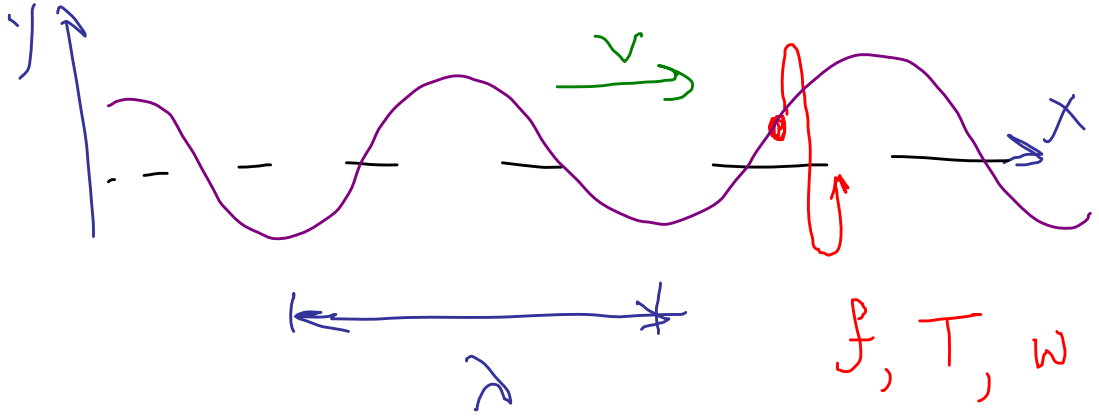
Phys 2110-5 11/26/12

Note Title 11/26/2012

# Ch 14 Waves

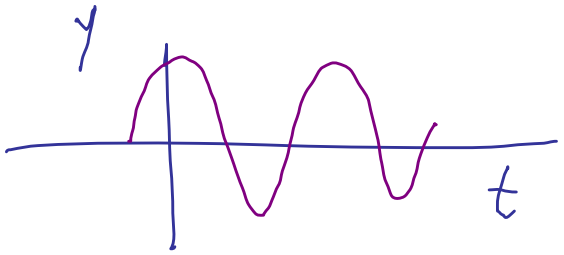
## Harmonic Wave




$f, T, \omega$

$\omega = 2\pi f$

$k = \frac{2\pi}{\lambda}$



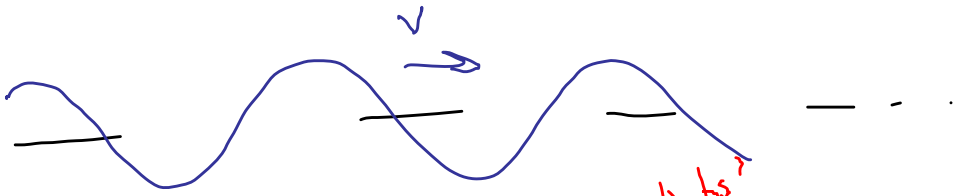

$\lambda f = v$

amplitude

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

$\mp$ { Right / Left

# Particular waves




$\mu$ = mass density of string ($kg/m$)

$F$ = tension in string

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

Units?

Units?

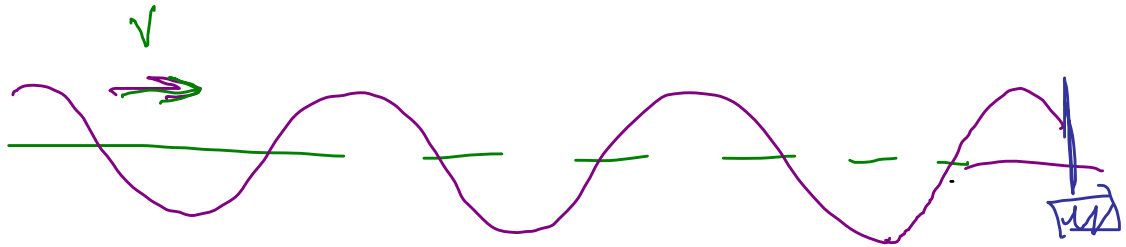
$$\sqrt{\frac{kg\ m/s^2}{kg/m}} = \sqrt{\frac{m^2}{s^2}} = m/s$$

Generally waves in any solid material,

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

# Power, intensity

Waves transmit energy




Discuss power of a wave on string $\frac{\text{Energy}}{\text{Time}}$

Avg power

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

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$$J/s = W$$

$$\frac{kg}{m}\frac{1}{s^2}\frac{m^2 m}{s} = \frac{kg\,m^2}{s^3} = W$$

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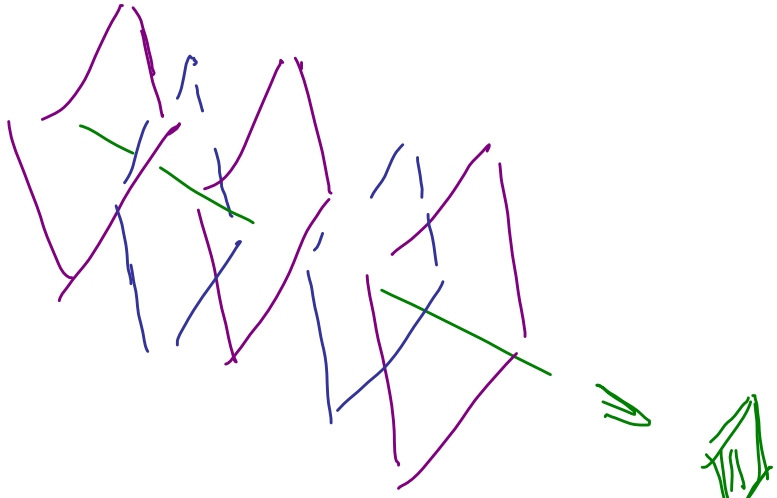
Can have waves in 3D



Maxima

Minima

Plane wave

Transmitted energy:

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Must use:

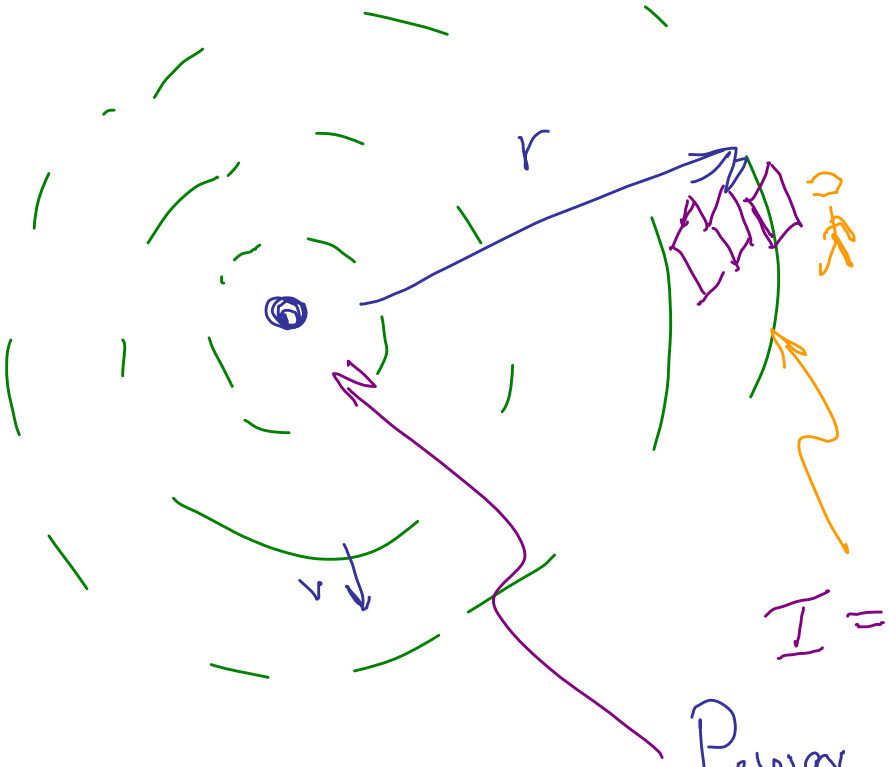
'Energy / (Time · Area)

= Intensity, I

$W/m^2$ = Power / Area

captures energy:

Area, Time




Isotropic source

Spherical Waves

(Almost like plane waves far away.)

$I = \frac{\text{Power}}{\text{area}}$

Consider entire sphere at radius r.

Power

Rate of energy output by source

J/s

P is energy/time crossing entire sphere per time

$$I = \frac{P}{4\pi r^2} \qquad (14.8)$$

## Examples

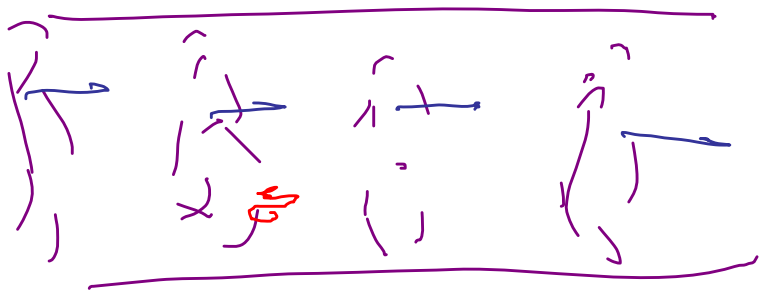
$I$, $W/m^2$

Sound of jet aircraft: $10\ W/m^2$

Light, at earth orbit (from sun) $1368\ W/m^2$

$\mu$-waves in oven $600\ W/m^2$

## Sound Waves



Region of larger density than normal travel through a mass of air.

Formula set: $\gamma$ number assoc'd w/ gas; air $= 7/5$, Helm $= 5/3$

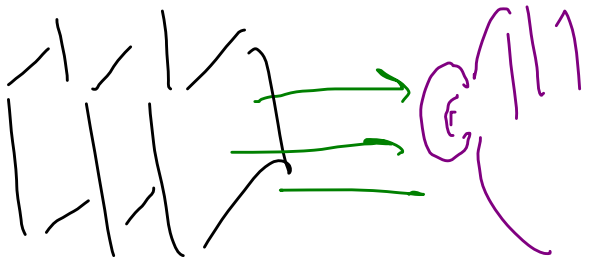
$$v = \sqrt{\frac{\gamma P}{\rho}}$$

$P$ pressure

$\rho$ mass density of gas

# Sound Waves

Intensity: $\frac{\text{Energy}}{\text{Area Time}}$



Human hearing can cover large range:

$10^{-12} \frac{W}{m^2}$ threshold of hearing

$10 \frac{W}{m^2}$ jet airplane

Normally $10 \cdot \log_{10} \frac{I}{I_0} = \beta$

Hearing "works logarithmically"

$I_0 = 10^{-12} \frac{W}{m^2}$

decibels $\frac{\text{intensity}}{\text{level}}$

Hearing $\beta = 0 \rightarrow \beta = 100$

Frequency range of human hearing

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20 Hz – 20,000 Hz

With age – 15,000 Hz

Animals dogs – 30,000 Hz

bats – 100,000 Hz

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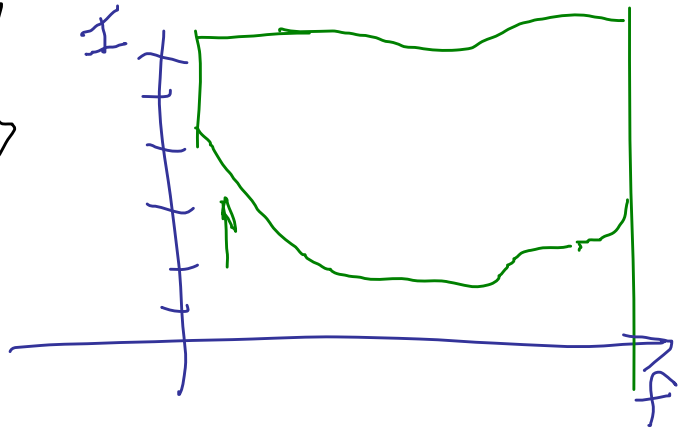


Thresh. of hearing not same for all freq.

This covers pure waves

# Interference of waves

Superposition property.