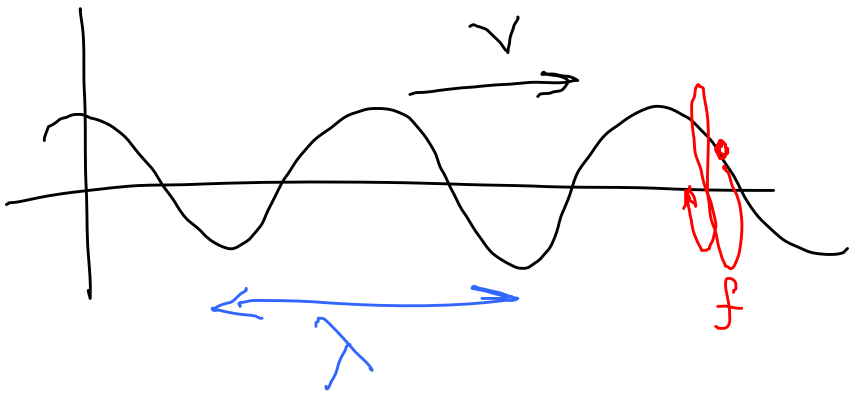
Phys 2110-4 11/23/11

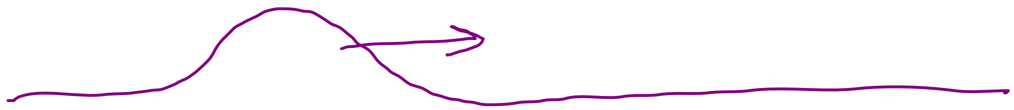
Note Title 11/23/2011

Chapter 14: Waves



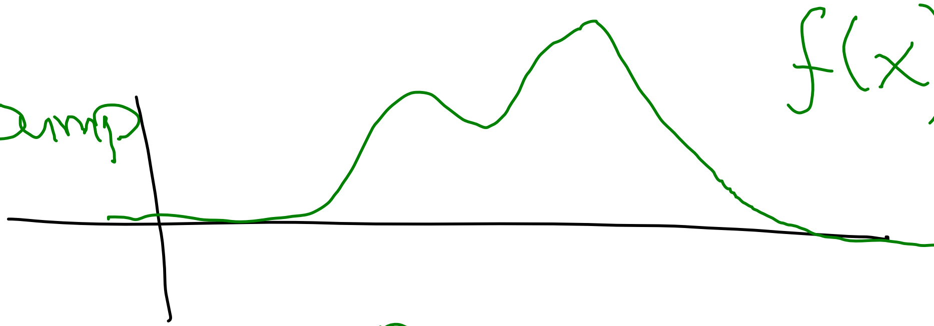
$$\boxed{\lambda f = v}$$

Mathematical form of waves:



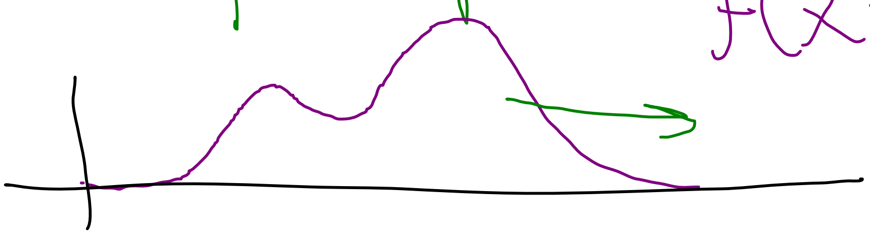
Waves we study keep <u>same</u>
<u>shape</u>

Bump



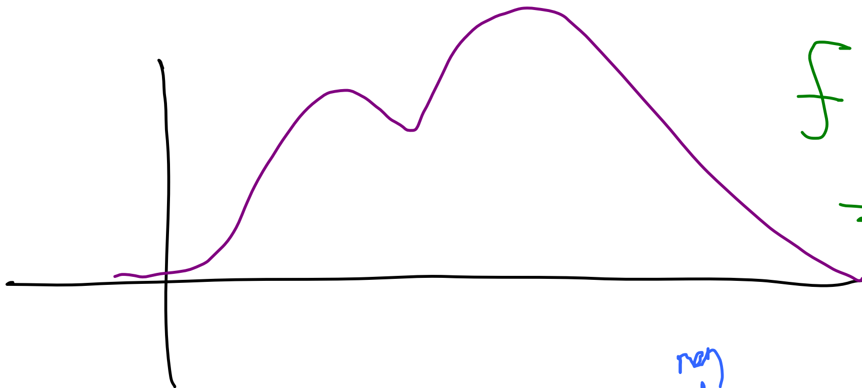
$f(x)$

Traveling Bump.



$f(x \pm vt)$

As t changes x values for location of bump change



$f((x \mp vt))$

$e^{-(x-vt)^2/4}$ $(x-vt)$

Why $\mp$? $x-vt$

x incre | incre | incre

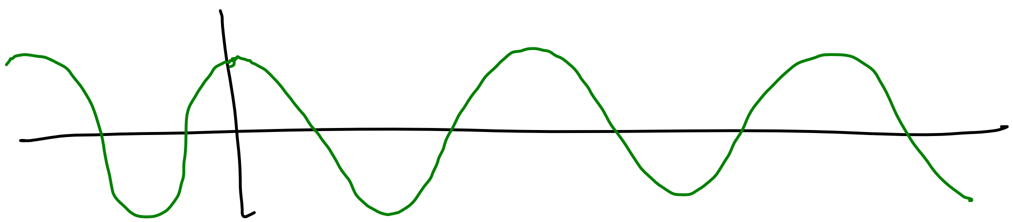
$x-vt$

⊖ t increases → x increases to compensate
wave travels to right to $+x$

$x+vt$

⊕ t increases → x decreases
wave moves to $-x$ direction.

Harmonic Wave $f(x) = A\cos(kx)$



Make this travel to right w/ speed v $x \to x+\lambda$

$k = 2\pi/\lambda$

$$\longrightarrow f(x) = A\cos(kx)$$

$$f(x-vt) = A\cos(k[x-vt])$$

$$= A\cos(kx-kvt)$$

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

$$kv = \frac{2\pi}{\cancel{\lambda}}(\cancel{\lambda}f)$$

$$= 2\pi f = \omega$$

Traveling harmonic wave:

$$\boxed{y(x,t) = A\cos(kx \mp \omega t)}$$

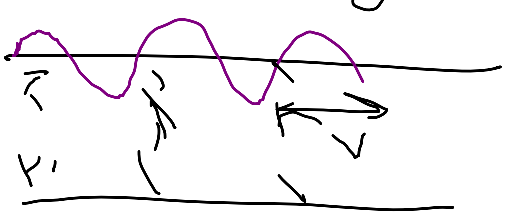
$-$ right
$+$ left

More generally

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

δ phase constant

<u>Example</u> Find wavelength of the sound wave of freq. 260 Hz

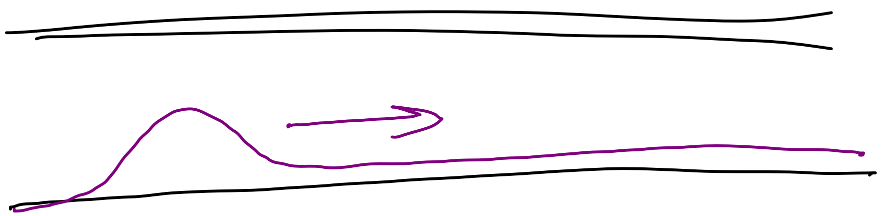


$$\lambda f = v$$

At 20C $v_{sn} \cong 340 \frac{m}{s}$

$$\lambda = v/f = \frac{340 \frac{m}{s}}{260 \frac{cyc}{s}} \cong 1m$$

String, Waves on



Speed of waves on string.

Tension, Mass Density

$$\mu = \frac{\text{mass}}{\text{length}}$$

F = tension

$$v_{\text{string}} = \sqrt{\frac{F}{\mu}} \quad (\text{m/s})$$

All waves (for now) travel thru elastic medium

inertia property

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

Sound waves:

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

or

$$v = \sqrt{\frac{\gamma R T}{M}}$$

γ is characteristic (14.9) of gas

$= 7/5$

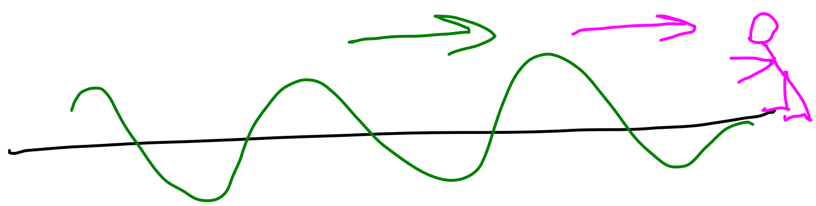
P = pressure ρ = mass density

T = Temp

M = molecular wt

R = gas constant

Waves carry energy



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

Avg energy rec'd per time P, power

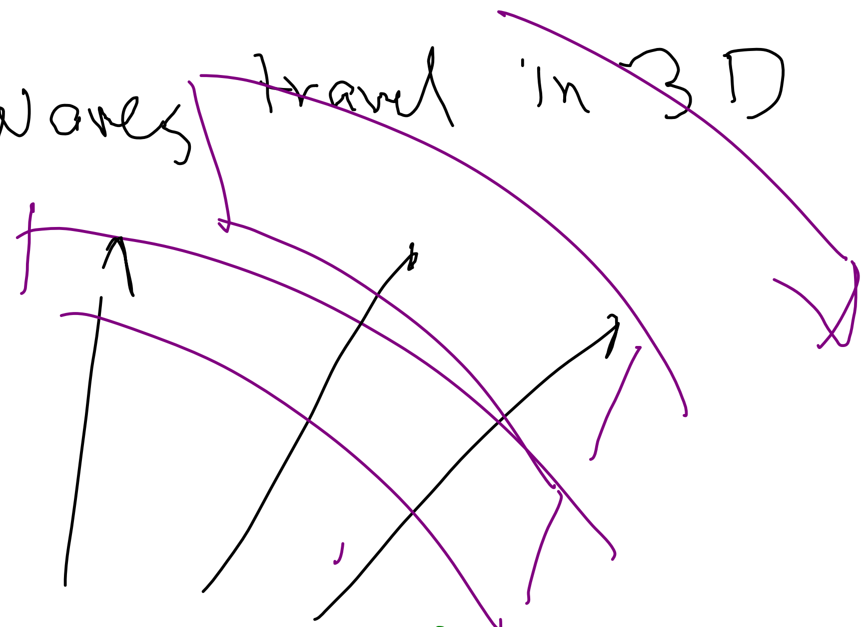
$P = \frac{1}{2}\mu\omega^2 A^2 v$

μ: kg/m, ω^2: $\frac{1}{s^2}$, A^2: m^2, v: $\frac{m}{s}$

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

$= \frac{J}{s} = W = \frac{kg\, m^2/s^2}{s}$

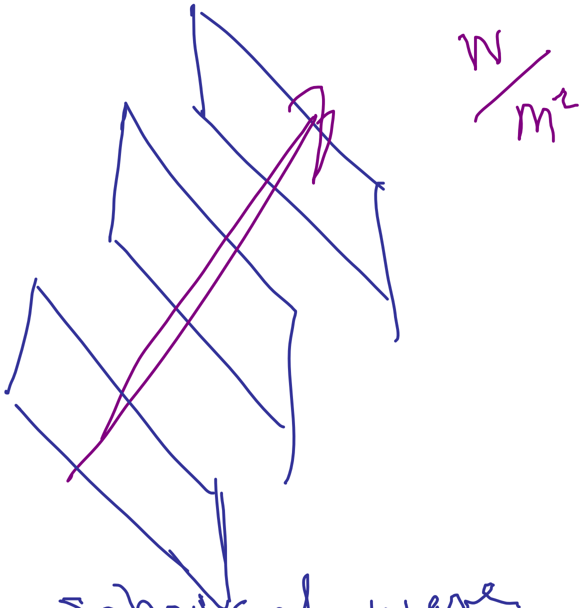
Waves travel in 3D

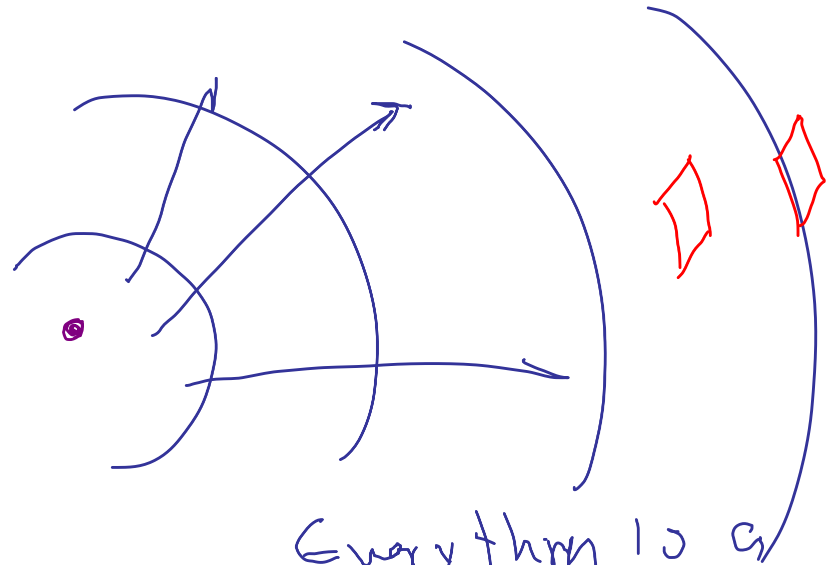


Plane wave

Measure of str. of wave

$$\frac{E}{\text{Area}\cdot\text{Time}} = \frac{W}{m^2} = \text{Intensity}$$



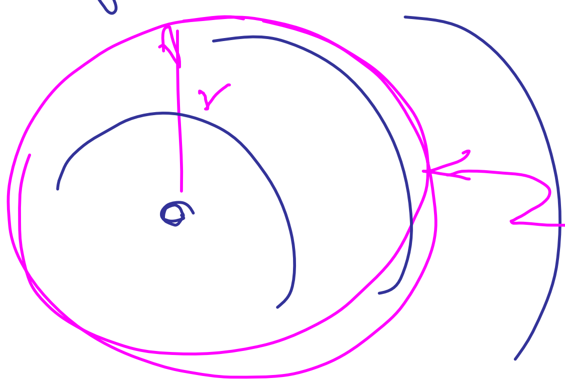


Spherical wave

Everything is a plane wave if you go far enough

Isotropic wave source:

(14.8)

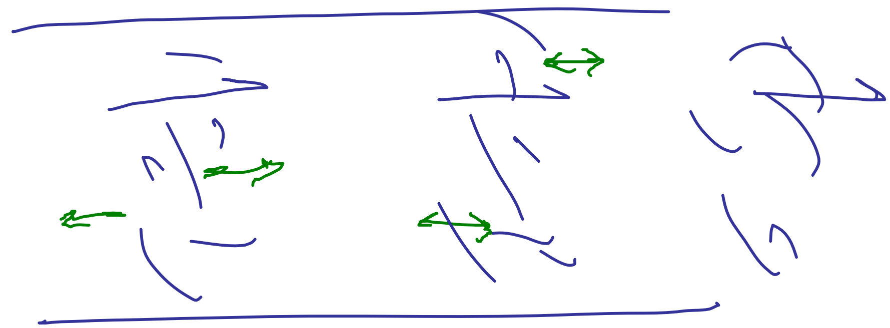


Source has a power P (J/s)

Area $= 4\pi r^2$

$I = P/4\pi r^2$

Sound Waves



Displacement

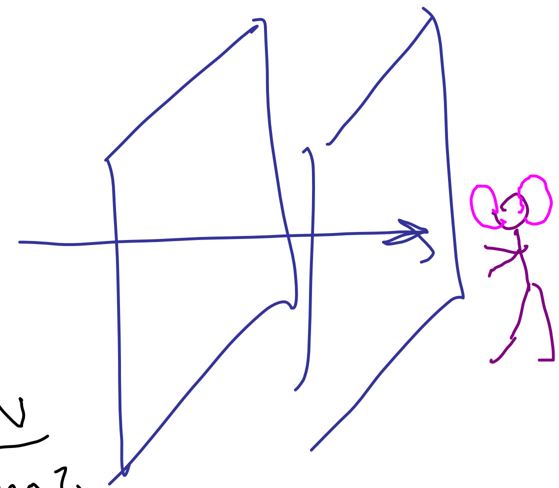
$$s(x,t) = s_0 \cos(kx - \omega t)$$

Pressure expression

$$P(x,t) = \underbrace{P_{atm}} + \underbrace{\Delta P} \cos(kx - \omega t)$$

$$v = \sqrt{\gamma P/\rho} = \sqrt{\frac{\gamma R T}{M}}$$

Loudness of sound wave



$$I = \frac{W}{m^2}$$

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

Threshold of pain $1\,\frac{W}{m^2}$

Express I as a power of 10.

$$\Longrightarrow \log_{10} \frac{I}{I_0} \qquad I_0 = 10^{-12}\,\frac{W}{m^2}$$

more....