(1) Phys 2426 2015-11-05 Lec 21

Oscillations: f T ω

- Repeat in time
- Located @ one place

$f = 1/T$

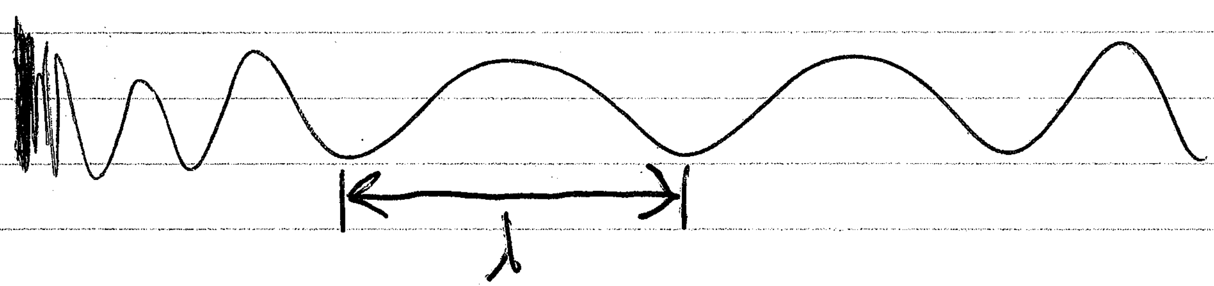
$\omega = 2\pi f$

Waves: formed from coupled oscillations
As a wave moves, the oscillators stay in place.

PheT Normal Modes

Waves have a propagation speed V or C.

Repetition in time + propogation.



wavelength = λ = repetition distance

$$v = \frac{\text{Dist}}{\text{Time}} = \frac{\lambda}{T} = \lambda f$$

2/26 (2)

Sound Waves: oscillations of air

Can measure: Δx Displacement

V Speed of a molecule

P Pressure

N/V Density

How are air molecules coupled?

- Strong coupling
- Weak or no coupling

Sound only vibrates along $\vec{V}_{wave}$.

Longitudinal Wave

Transverse and Longitudinal Waves (at psu.edu)

Speed of Sound $v \approx 340$ m/s Room T

$v \approx 330$ m/s Freezing

Lowest Audible Freq:

$f = 20$ Hz $\quad \lambda = \frac{v}{f} = \frac{340\,m/s}{20\,Hz} = 17\,m$

Highest Freq

$f = 20000$ Hz $\quad \lambda = 17$ mm

Other Waves

String Waves - transverse

$$v = \sqrt{F_T/\mu}$$

F_T = tension
μ = mass/length

Recall $f = \frac{1}{2\pi}\sqrt{k/m}$

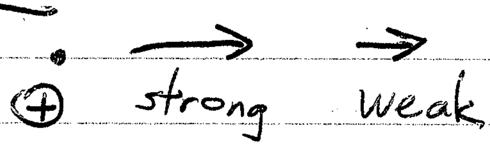
Water: Surface waves

v depends on f, depth

Seismic Waves: Body and Surface

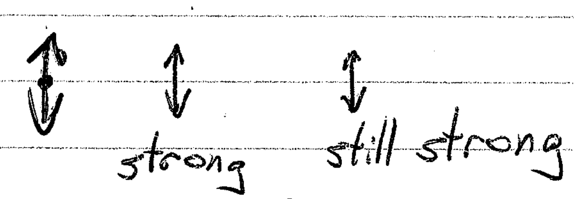
E&M Waves: Formed from $\vec{E}$ and $\vec{B}$

Static (no wave)



$$\vec{E} = \frac{kq}{r^2}$$

Dynamic



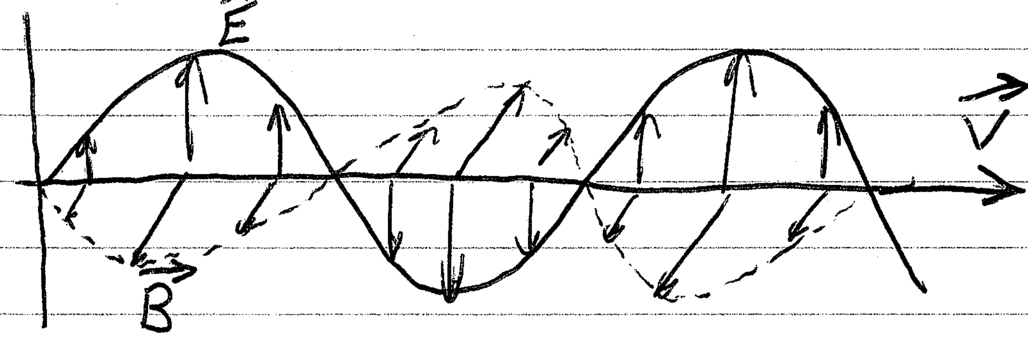
$$E_{max} \propto \frac{1}{r}$$

$\tilde{E}$ forms $\tilde{B}$ which reinforces $\tilde{E}$

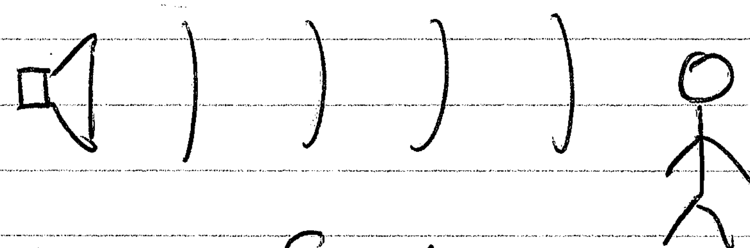
Speed $v = c = 3 \times 10^8$ m/s

Relationship between E and B

$$E_{max} = c\,B_{max}$$



Coupled oscillations always preserve frequency.
__Except__ for the Doppler Effect.



When stationary $f = \frac{V}{\lambda}$

If moving toward the wave, the peaks arrive faster.

$$f' = \frac{V + V_0}{\lambda} = \frac{V + V_0}{V} f$$

If the source is moving, the λ shifts.

$$f' = \left(\frac{V + V_0}{V - V_s}\right) f$$

V_0, V_s : ⊕ is __toward__

$$\frac{\text{freq shift}}{\text{base freq}} = \frac{\Delta f}{f} = \frac{\Delta V}{V} = \frac{\text{relative v of players}}{\text{speed of wave}}$$

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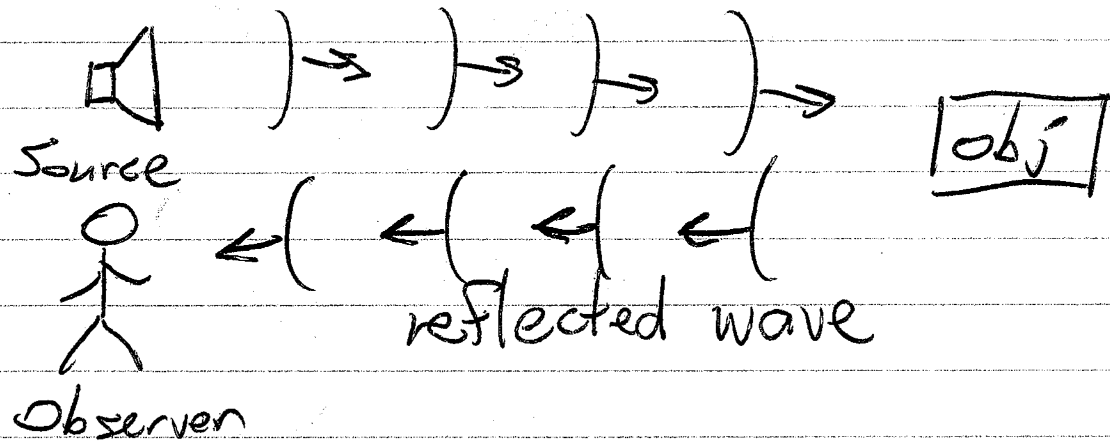
Doppler Radar



Here, the Doppler shift happens __twice__.

$$\frac{\Delta f}{f} = \frac{\Delta v}{v} 2$$ Doppler radar shift.