Physics 123 - February 13, 2013

- Term Exams Feb 28 + April 11

2 weeks from Tomorrow

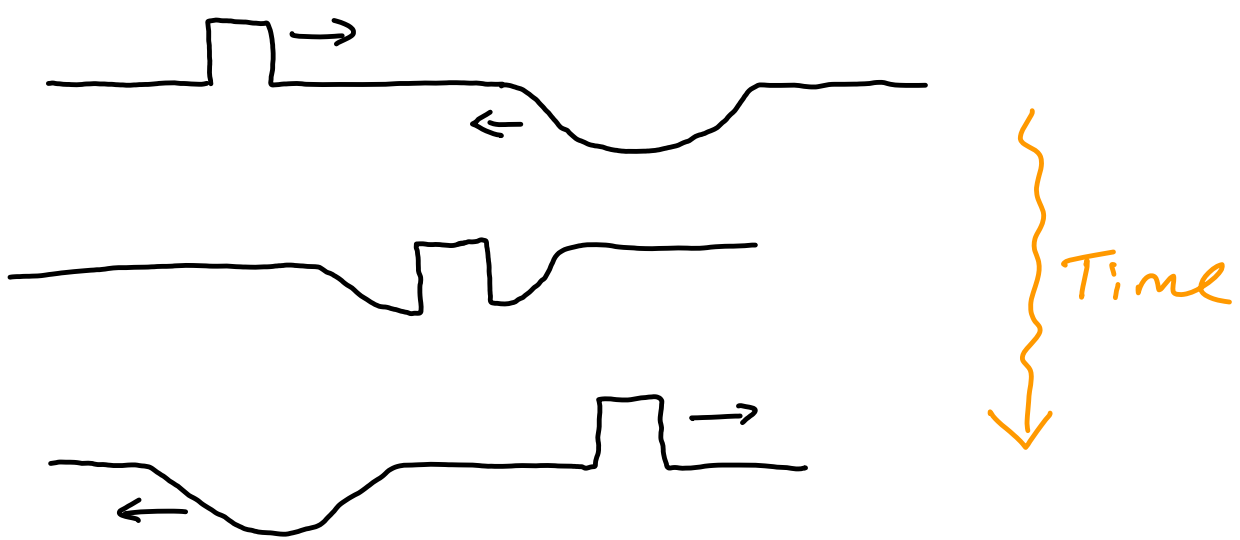
- Time 08:00 - 09:30
- Location B+L 106
- Formula/Note sheet → one side of 8.5 x 11 inch sheet
- Material Coverage - details coming soon

Last Time

- Energy flow in waves $\sim A^2$
- Waves exhibit **Superposition**

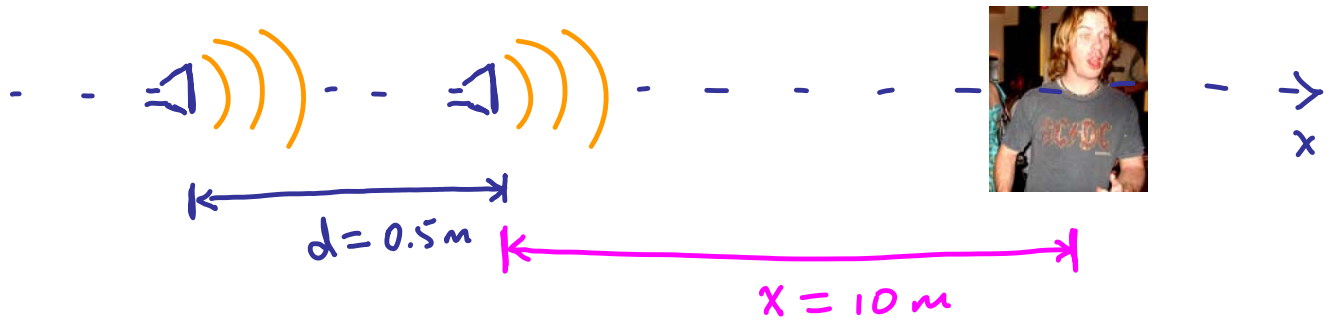
If ψ_1 and ψ_2 are waves, $\psi_1 + \psi_2$ is a wave

interference



Isaac Newton in his youth

The real beginning of the British rock invasion



what frequencies will our rock fan and physics groupie NOT hear well as the music is played?

20 - 20,000 Hz

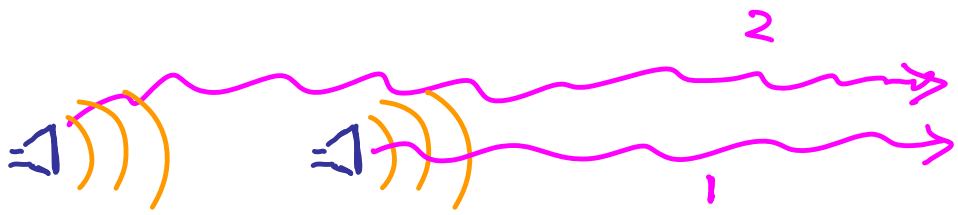
$V_{sound} \sim 331\ m/s$

human hearing ~ 20 - 20,000 Hz

$v = \lambda f$

$\lambda = \frac{331}{f}$

16.5 m 0.0165 m ← λ



Get destructive interference when $d_2 - d_1$ differs by $\frac{1}{2}\lambda + m\lambda$

$m = 0, 1, 2 \cdots$

$d = (m + \frac{1}{2})\lambda = (m + \frac{1}{2})\frac{V}{F}$

$f_m = (m + \frac{1}{2})\frac{V}{d}$

$f_0 = \frac{1}{2}\frac{331}{0.5} = 331$ Hz

$f_1 = \frac{3}{2}\frac{331}{0.5} = 993$ Hz

$f_2 = \frac{5}{2}\frac{331}{0.5} = 1655$ Hz

⋮

Beats

$$\psi_1 = A \sin(\omega_1 t)$$

$$\psi_2 = A \sin(\omega_2 t)$$

$$\psi_1 + \psi_2 = A\sin(\omega_1 t) + A \sin(\omega_2 t)$$

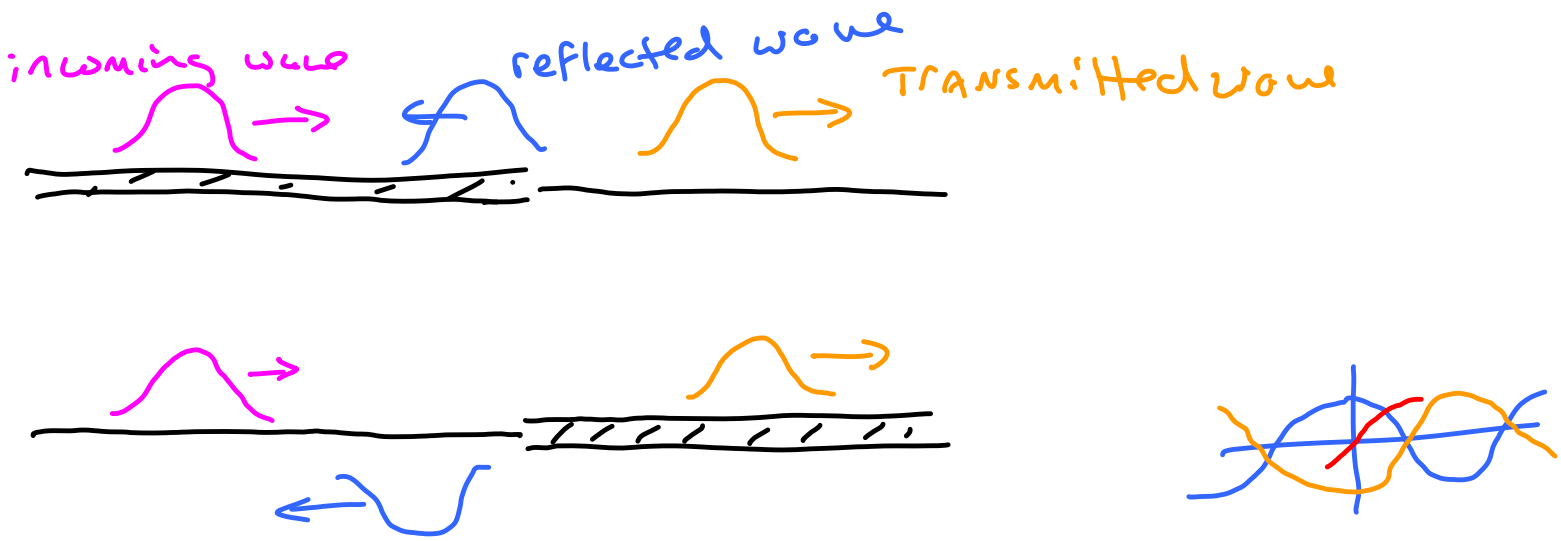
$$\psi(x,t) = \underbrace{2A \sin\left[\left(\frac{\omega_1+\omega_2}{2}\right)t\right]}_{\text{Think of this combination as Amplitude — varies in time with frequency } \frac{\omega_1-\omega_2}{2}} \cos\left[\left(\frac{\omega_1-\omega_2}{2}\right)t\right]$$

What you hear/see

Average ω

Generally can't perceive if $\omega_1 - \omega_2$ is too big or too small.

Waves and Boundaries

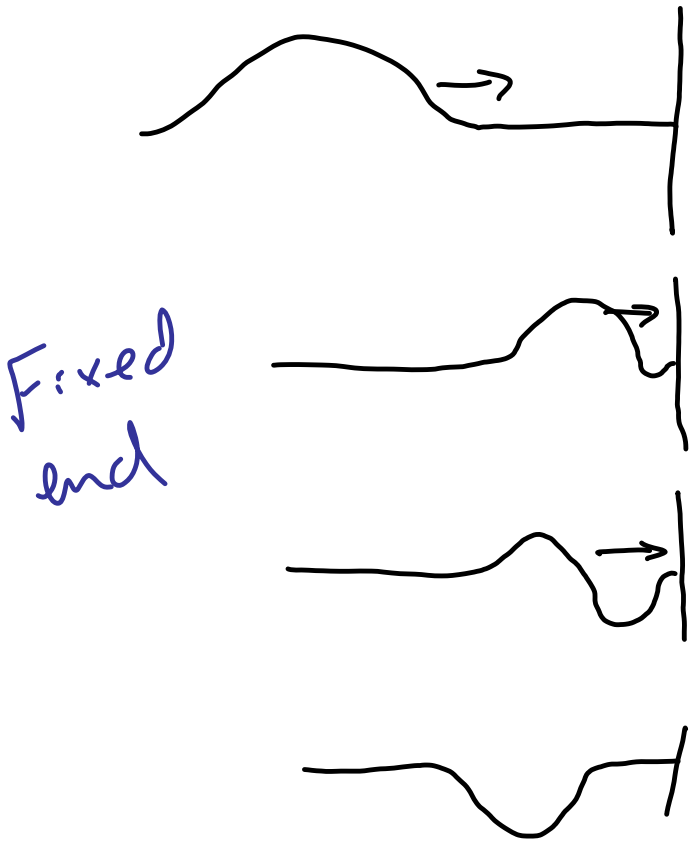


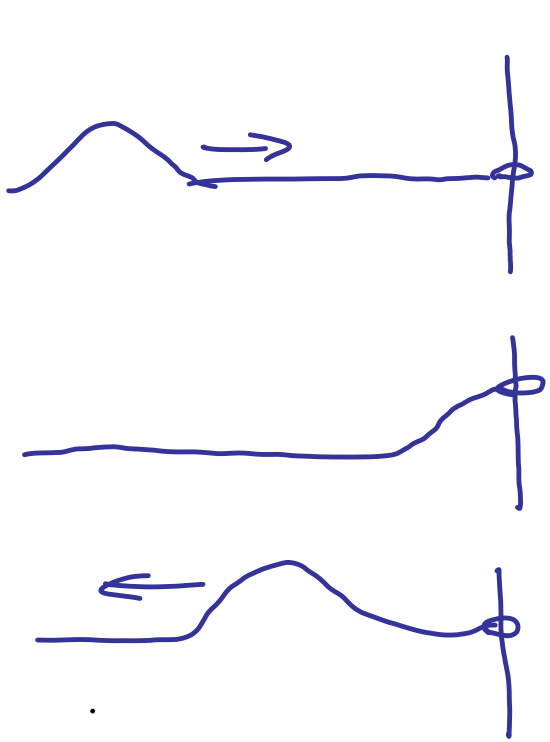
upon reflection

Slow to fast
High μ to low μ
} no phase change

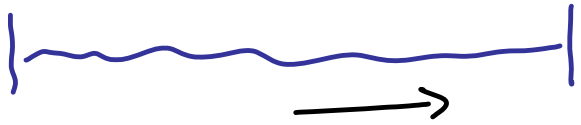
fast to slow
low μ to High μ
} 180° phase change

reflection at fixed Boundary





180° phase Δ



String fixed at two ends

Travelling wave

← reflected wave

$y_1(x,t) = A \sin(kx - \omega t)$

$y_2(x,t) = A \sin(kx + \omega t + \varphi)$

Reflect from fixed (tied) end

$\varphi = \pi$

$A \sin(x + \pi) = -A \sin x$

$y_2(x,t) = -A \sin(kx + \omega t)$

Superposition

$$y(x,t) = y_1(x,t) + y_2(x,t) = A\sin(kx-\omega t) - A\sin(kx+\omega t)$$

use Trig ID

$$\sin C + \sin B = 2\sin\left[\tfrac{1}{2}(C+B)\right]\cos\left[\tfrac{1}{2}(C-B)\right]$$

$C = kx-\omega t \quad B = -kx-\omega t$

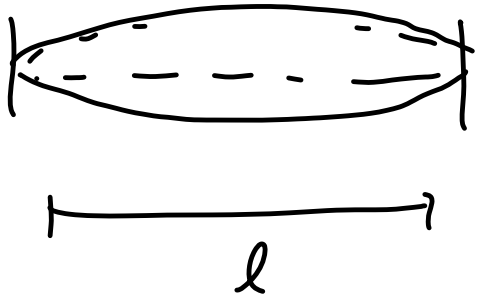
$$y(x,t) = (-2A)\sin(\omega t)\cos(kx)$$

Ampl. tuck — $0 \to 1$ in Time — fixed form in space periodic in λ

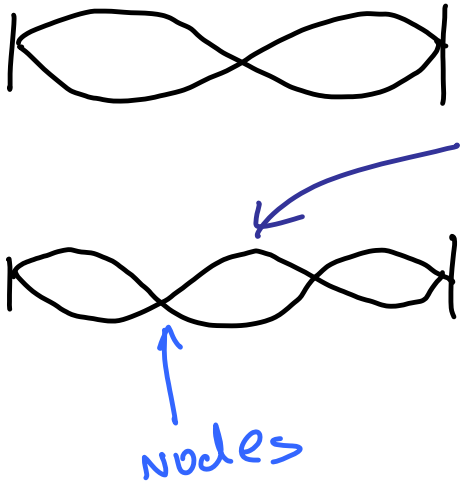
Time varying amplitude

STANDING WAVES

Waves on a Strings



$L = \frac{1}{2}\lambda$



$L = \lambda$

$L = \frac{3}{2}\lambda$

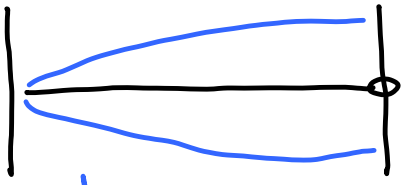
$L = \frac{m}{2}\lambda_m$

$m = 1, 2, 3 \cdots$

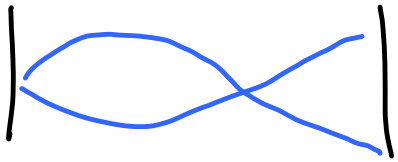
$v = \lambda_m f_m$

$L = \frac{m}{2}\frac{v}{f_m}$

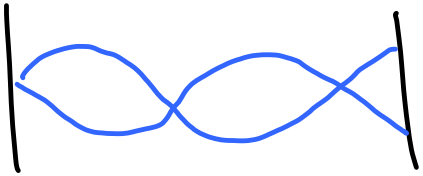
$f_m = \frac{mv}{2L} = \frac{m}{2L}\sqrt{\frac{T}{\mu}}$



$L = \frac{1}{4}\lambda$



$L = \frac{3}{4}\lambda$

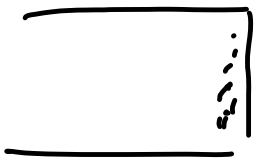


$L = \frac{5}{4}\lambda$

$$f_m = \frac{m}{4L}\sqrt{\frac{T}{\mu}}$$

$m = 1, 3, 5 \cdots$

Sound instruments - pressure waves in Tubes



Displacement
node