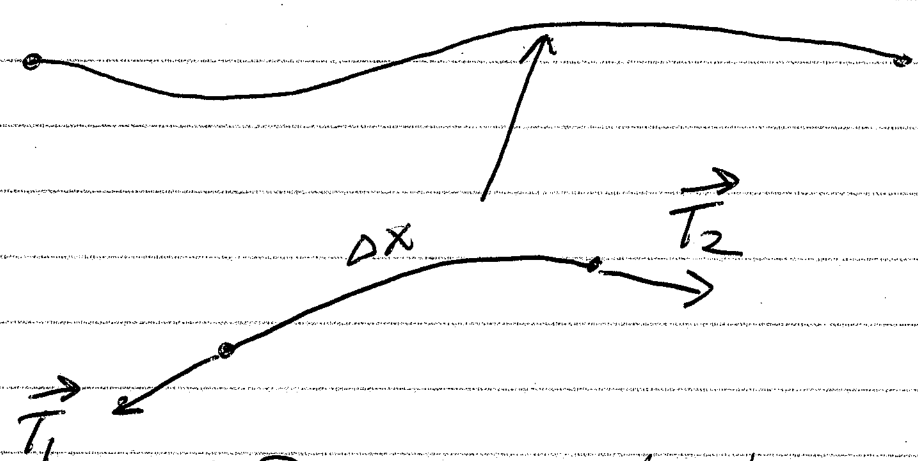
1 Phys 2426 2015-11-10 Lec 22

Oscillations: $f = 1/T$ $\omega = 2\pi f$

Waves: $v = f\lambda$ (if oscillating)

Why does each wave have a particular v?

Example: Wave on a string.



Net force is vertical.
Force is down when string is concave-down.

$$F_y = F_T \frac{\partial^2 y}{\partial x^2}$$

$$a = \frac{\partial^2 y}{\partial t^2}$$

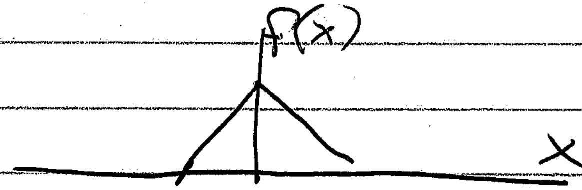
$$\frac{\partial^2 y}{\partial x^2} = \frac{\mu}{F_T} \frac{\partial^2 y}{\partial t^2}$$

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

$y = f(x - vt)$ works if $\frac{\mu}{F_T} = \frac{1}{v^2}$

2

If $y = f(x - vt)$, $f(0)$ might be a peak. Where does that peak go?



t	x	$x - vt$
0	0	0
1.0	5.0	0
2.0	10.0	0

Say $v = 5\ m/s$

$(x - vt)$ "moves" the waveform in the $+x$ direction as time progresses.

How can we move in the $-x$ direction?

Option 1: $y = f(x + vt)$ w/ $v = |\vec{v}|$

Option 2: $y = f(x - v_x t)$ w/ $v_x = -|\vec{v}|$

③

Standing Waves - formed from travelling waves moving in opposite directions.

$$y = X(x)\,T(t)$$

$T(t)$: $\sin(2\pi f t)$

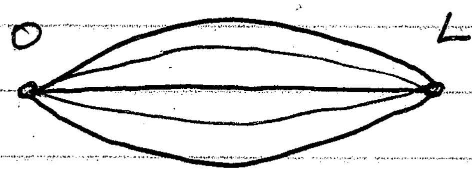
$X(x)$: $A\sin\left(\frac{2\pi x}{\lambda}\right) + B\cos\left(\frac{2\pi x}{\lambda}\right)$

$A\sin\left(\frac{2\pi x}{\lambda} + \phi\right)$

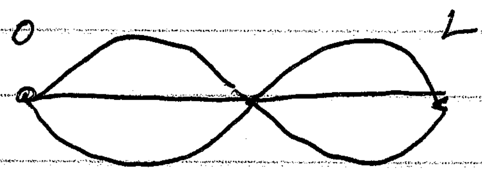
envelope

We will analyze the envelope functions.

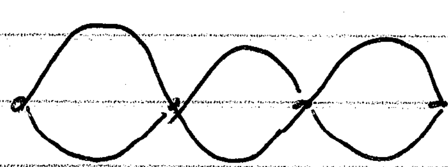
String Clamped @ Both Ends. $f = \frac{v}{\lambda}$



$\lambda = 2L$ $\quad f_0 = \frac{v}{2L}$



$\lambda = L$ $\quad f = \frac{v}{L}$



$\lambda = \frac{2L}{3}$ $\quad f = \frac{3v}{2L}$

$n =$ integer $\quad \lambda = \frac{2L}{n}$ $\quad f = n\frac{v}{2L} = nf_0$

(4)

A guitar string is producing $f = 222$ Hz.
We want it tuned to $f_2 = 220$ Hz.
What do we do?

$$v = f\lambda \qquad v = \sqrt{F_T/\mu}$$

$$\lambda = 2L$$

$$f_2 = \left(\frac{220}{222}\right) f_1 = 0.991\, f_1$$

f decreases by 0.9%

$$v_2 = f_2 \lambda = 0.991 f_1 \lambda = 0.991\, v_1$$

v decreases by 0.9%

$$F_{T2} = \mu v_2^2 = \mu (0.991\, v_1)^2 = 0.982\, F_{T1}$$

Tension must decrease by 1.8%

4

Reflections of sound waves

Open end of tube : Pressure variation = 0
Displacement = peak

Closed end of tube : Displacement = 0

$\lambda = \frac{4L}{n}$ (odd n) $f = n f_0$

This is the case for the open-closed tube.

Hanging String? Bessel Functions