Phys141 – Mon 11/28

TODAY: Ch 18 – superposition of waves skip 18.6 and 18.8

Wed: Start thermodynamics

Pre-class quiz – next Quiz due Wed

Next short HW due MONDAY

Questionnaire: Please hand in today if you still want to give input!

NOTE: One review problem every lecture

Doppler Effect, Observer Moving

- The frequency heard by the observer, *f* ', appears higher when the observer approaches the source

$$f' = \left(\frac{v + v_o}{v}\right) f$$

- The frequency heard by the observer, *f* ', appears lower when the observer moves away from the source

$$f' = \left(\frac{v - v_o}{v}\right) f$$

Doppler Effect, General

Motions of the observer and the source

Demo doppler ball

$$f' = \left(\frac{v + v_o}{v - v_s}\right) f$$

The signs of v_0 and v_s depend on the direction of the velocity

- A positive value is used for motion of the observer or the source *toward* the other
- A negative value is used for motion of one away from the other

The Doppler effect is common to all waves, where source or observer can move (radar, laser, sonar)

The magnitude of frequency change does not depend on distance between observer and source, only on their relative velocities

Problem 17.43

Chapter 18

Superposition, Interference

Standing Waves

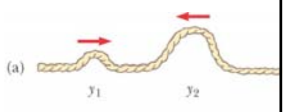
Superposition Principle

Two pulses travel in opposite directions
- Wave function of the pulse moving to the right: $y_1(x,t)$
- Wave function of the pulse moving to the left: $y_2(x,t)$

Pulses have the same speed but different shapes

Vertical displacement of string elements is in positive direction for both

Total wave: $y(x,t)=y_1(x,t) + y_2(x,t)$



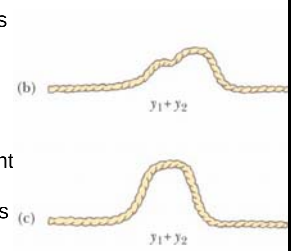
Superposition – interference of waves

Waves start to overlap, the resultant wave function remains

$y(x,t)=y_1(x,t) + y_2(x,t)$

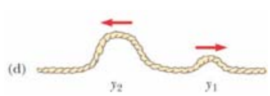
When the crests meet the resultant wave has a larger amplitude than either of the original waves

(constructive INTERFERENCE)



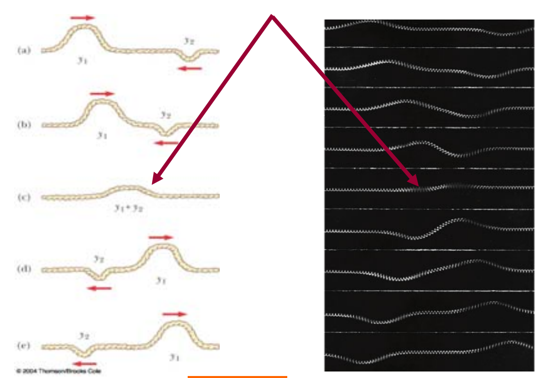
Superposition Example, final

- pulses separate
- Continue moving in their original directions
- Pulse shapes remain unchanged



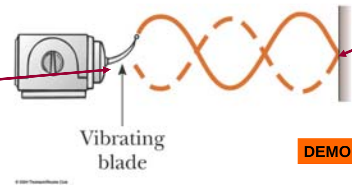
DEMO shive machine

Destructive Interference



Example

Standing Wave on a String



DEMO: standing waves

Standing waves are set up by a continuous superposition of waves incident on and reflected from the ends

Example from Lab: Standing waves created by interference of sine waves

Add right moving and left moving sine wave

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

$$y(x,t) = y_1(x,t) + y_2(x,t)$$
$$y(x,t) = A\sin\left(kx - \omega t\right) + A\sin\left(kx + \omega t\right)$$
$$y(x,t) = 2A\sin(kx)\cos(\omega t)$$

There is no *kx* – *wt* term, therefore it's not a traveling wave.
Maximum amplitude depends on x position.
Amplitude oscillates in time.

Standing Waves

Analyzing y = (2*A* sin *kx*) cos ωt

- Every element in the medium oscillates in simple harmonic motion with the same frequency, ω
- The amplitude of the simple harmonic motion is (2*A* sin *kx*) - it depends on the location x
  - A point x of zero amplitude is called a **node**

$$x_n = \frac{n\lambda}{2} \qquad n = 0,1,\ldots$$

  - A point x of maximum displacement amplitude, 2*A* is called an **antinode**

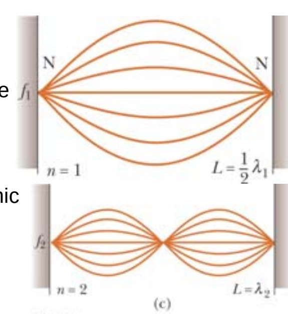
$$x_m = \frac{\lambda}{4} + \frac{m\lambda}{2} \qquad m = 0,1,\ldots$$

Standing Waves: normal modes

First normal mode (on right):
There are nodes at both ends
There is one antinode in the middle
This is the longest wavelength mode this cavity of length L

$\lambda = 2L$

The normal modes are called **harmonics:** λ=L second harmonic (add one node each harmonic)



Frequencies Of harmonics: $f_n = n\frac{v}{2L} = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$

Quantization of allowed frequencies