Phys141 – Mon 11/14

TODAY: Ch 16, Waves

Wed Ch 16 waves – end

HW due Fri
Pre-class quiz – next Quiz due Wed

Midterm returned today/tomorrow
- similar distribution of grades as last midterm
- grade scale is shifted down 4 points

Adding terms to equations, to include additional physical effects. Example: Damped Oscillation

In many real systems, energy is dissipated into heat (e.g. due to viscosity) i.e. non-conservative forces are present:

Viscous force: $R = -bv = -b\frac{dx}{dt}$

b is called the ***damping coefficient***

Spring oscillation without viscous force $m\frac{d^2x}{dt^2} = -kx$

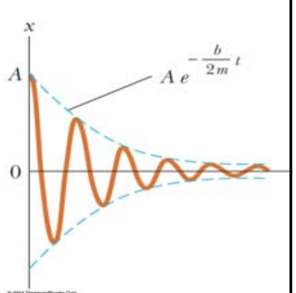
With viscous force
$$m\frac{d^2x}{dt^2} = -kx - b\frac{dx}{dt}$$
$$\frac{d^2x}{dt^2} = -\frac{k}{m}x - \frac{b}{m}\frac{dx}{dt}$$

Damped Oscillation, solution

$$\frac{d^2x}{dt^2} = -\frac{k}{m}x - \frac{b}{m}\frac{dx}{dt}$$

For small b, the equation can be solved as:

$$x(t) = Ae^{-\frac{b}{2m}t}\cos(\omega t + \phi)$$

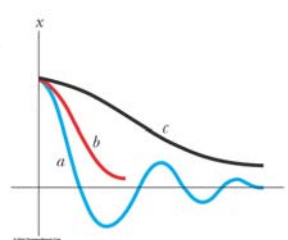


The angular frequency will be smaller than without the retardation

$$\omega = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$$

Types of Damping

- Graphs of position versus time for
  - (a) an underdamped oscillator
  - (b) a critically damped oscillator
  - (c) an overdamped oscillator
- For critically damped and overdamped there is no angular frequency



Has to be > 0 for oscillations

$$\omega = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$$

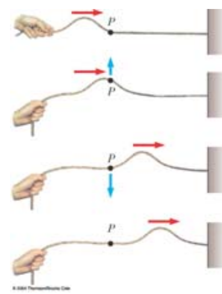
Chapter 16 – Pulses and Waves

Two main types of pulses/waves

- Mechanical waves
  - Some physical medium is being disturbed
  - The wave is the propagation of a disturbance through a medium
- Electromagnetic waves (next semester)
  - No medium required
  - Examples are light, radio waves, x-rays

Example: Pulse on a Rope

- flick one end of a rope under tension
- A single bump is formed and travels along the rope
  - The bump is called a **pulse**

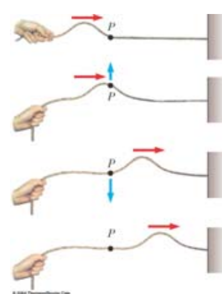


Pulses and Waves

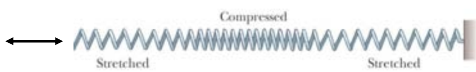
- rope is the “medium” through which **pulse** travels
- The pulse has a definite speed of propagation along the medium
- A continuous flicking of the rope would produce a periodic disturbance which would form a **wave**
- Waves/ pulses
  - transfer energy over a distance
  - Matter is **not** transferred over a distance

Transverse pulse

- A traveling wave or pulse that causes the elements of the disturbed medium to move **perpendicular** to the direction of propagation is called a **transverse wave**
- particle motion
  -> blue arrow
- propagation direction
  -> red arrow



Longitudinal pulse



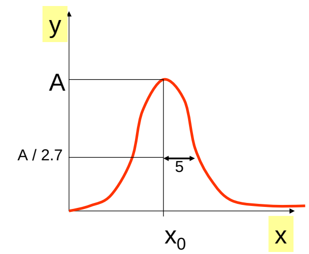
A traveling pulse that causes the elements of the disturbed medium to move parallel to the direction of propagation is called a **longitudinal pulse**

The displacement of the coils is parallel to the propagation

Pulse Math: Initial pulse shape

Example: Start with "Gaussian" shape

$$y(x) = Ae^{-\frac{(x-x_0)^2}{5}}$$



A: Amplitude
x_0: Offset of wave
5: Half width of wave

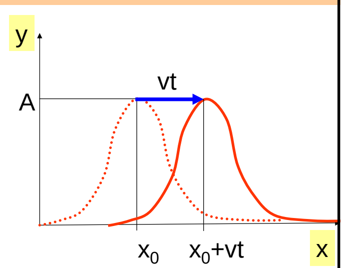
Pulse moves with time

Speed of pulse *v*

-> pulse travels distance *vt* in time *t*

The shape of the pulse does not change with time

$$y(x,t) = Ae^{-\frac{(x-x_0-vt)^2}{5}}$$



IN GENERAL

Initial Shape: we replace x with x-vt in the formula for the INITIAL shape

$y(x,t=0) = f(x)$ ⟶ $y(x,t) = f(x - vt)$

Pulse traveling to the left -> negative velocity

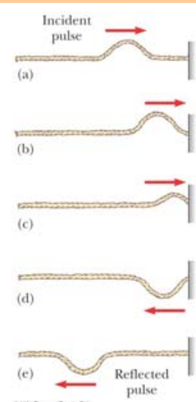
Demo, example

Reflection of pulse: Fixed End

When the pulse reaches the support, the pulse moves back

Reflection of the pulse

The pulse is **inverted**

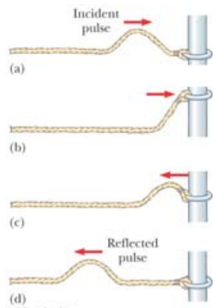


Reflection off Free End

Free end oscillation takes place at endpoint

The pulse is **reflected**

The pulse is **not inverted**

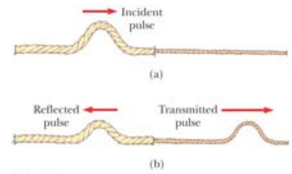


Reflection off boundary that resists motion Example: heavy rope tied to light rope

Reflected pulse, not inverted (similar to freely moving end)

Part of the energy in the incident pulse is **transmitted forward into the thin rope**

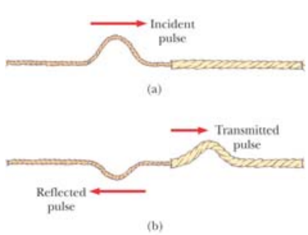
- Some energy passes through the boundary



Resistance larger than resistance of rope Example: Boundary light - heavy rope

Part of the pulse is reflected and part is transmitted

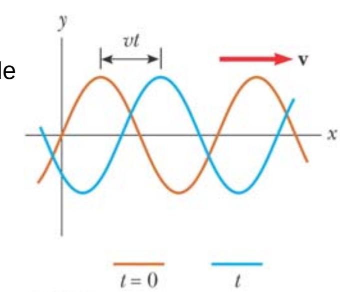
The reflected part is inverted



Wave: Sinusoidal Waves – 16.2

Sinusoidal wave is simple example of a periodic ***continuous*** wave

- Example 16.13 (start)



Example