Physics 207, Lecture 3, Sept. 10

- Goals (finish Chap. 2 & 3)
  - ❖ Understand the relationships between position, velocity & acceleration in systems with 1-dimensional motion and non-zero acceleration (usually constant)
  - ❖ Solve problems with zero and constant acceleration (including free-fall and motion on an incline)
  - ❖ Use Cartesian and polar coordinate systems
  - ❖ Perform vector algebra

Assignment:

1. For Monday: Read Chapter 4
2. Homework Set 2 (due Wednesday 9/17)

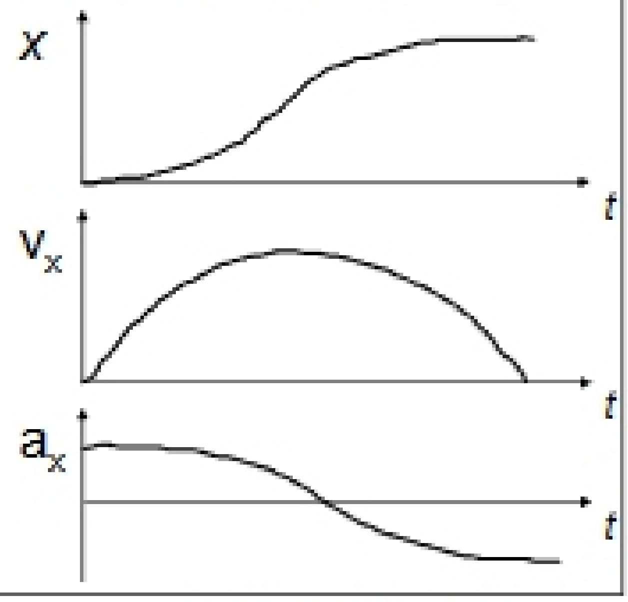
Position, velocity & acceleration for motion along a line

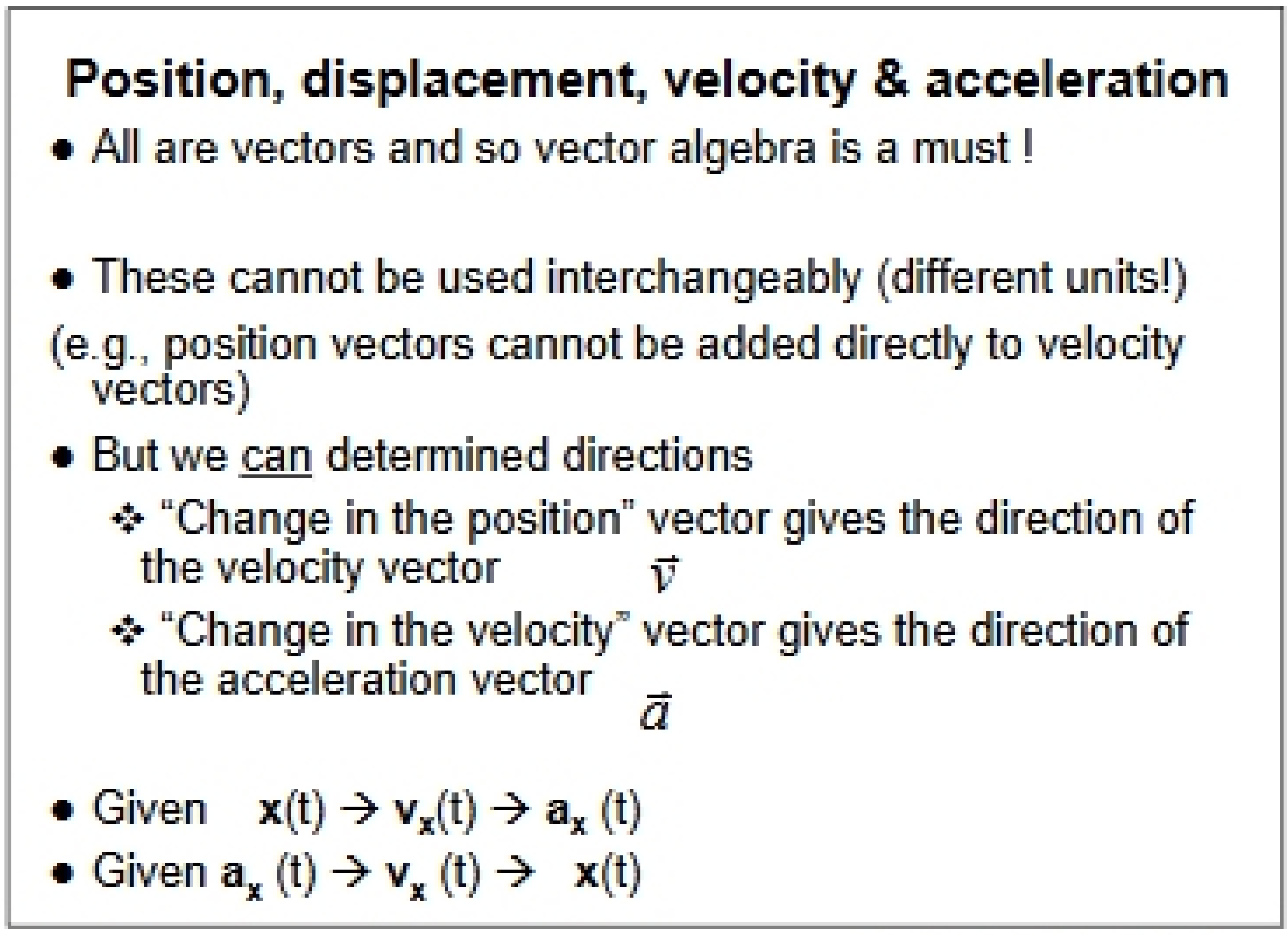
- If the position x is known as a function of time, then we can find both the instantaneous velocity v_x and instantaneous acceleration a_x as a function of time!

$$x = x(\Delta t) \ [x \text{ is a function of } \Delta t]$$

$$v_x = \frac{dx}{dt}$$

$$a_x = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$$



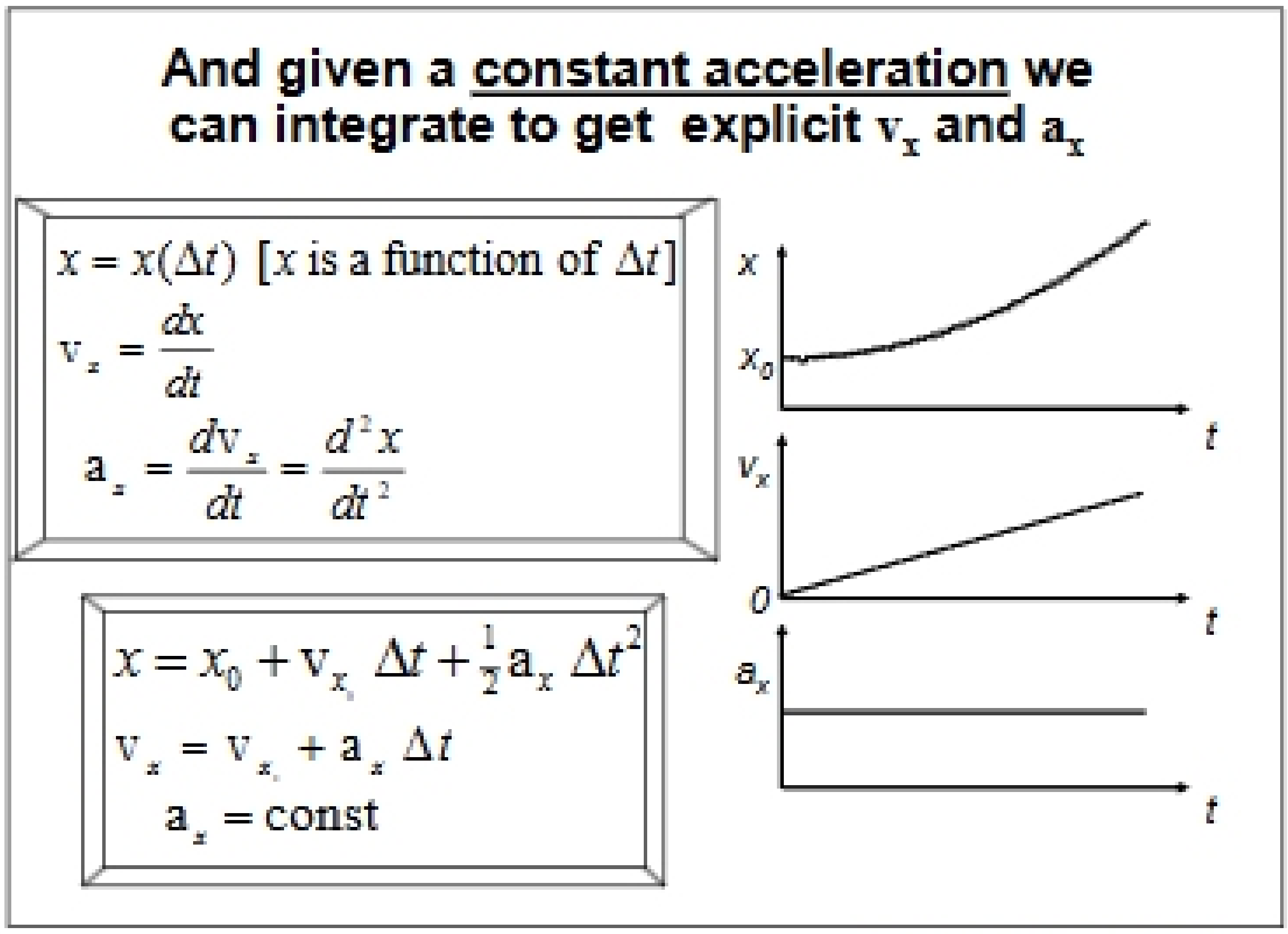


Position, displacement, velocity & acceleration

- All are vectors and so vector algebra is a must !
- These cannot be used interchangeably (different units!)

(e.g., position vectors cannot be added directly to velocity vectors)

- But we can determined directions
  - ❖ "Change in the position" vector gives the direction of the velocity vector $\vec{v}$
  - ❖ "Change in the velocity" vector gives the direction of the acceleration vector $\vec{a}$
- Given **x**(t) → **v**$_x$(t) → **a**$_x$ (t)
- Given **a**$_x$ (t) → **v**$_x$ (t) → **x**(t)



And given a constant acceleration we can integrate to get explicit v_x and a_x

$$x = x(\Delta t) \ \ [x \text{ is a function of } \Delta t]$$

$$v_x = \frac{dx}{dt}$$

$$a_x = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$$

$$x = x_0 + v_{x_0}\ \Delta t + \tfrac{1}{2} a_x\ \Delta t^2$$

$$v_x = v_{x_0} + a_x\ \Delta t$$

$$a_x = \text{const}$$

Exploiting $(x - x_0) \propto \Delta t^2$

- A “biology” experiment
- Hypothesis: Older people have slower reaction times
- Distance accentuates the impact of time differences
- Equipment: Ruler and four volunteers
  - Older student
  - Younger student
  - Record keeper
  - Statistician
  - Expt. require multiple trials to reduce statistical errors.

Rearranging terms gives two other relationships

- For constant acceleration:

$$\boxed{\begin{aligned} x &= x_0 + v_{x_0}\,\Delta t + \tfrac{1}{2} a_x\,\Delta t^2 \\ v_x &= v_{x_0} + a_x\,\Delta t \\ a_x &= \text{const} \end{aligned}}$$

- From which we can show (**caveat: a constant acceleration**)

$$\boxed{\begin{aligned} v_x^2 - v_{x_0}^2 &= 2a_x(x - x_0) \\ \overline{v}_{x\,(avg)} &= \frac{1}{2}(v_{x_0} + v_x) \end{aligned}}$$