Sit in your assigned seats. Make sure you are using the correct PRS unit to answer questions.

Last Lecture
- Free-body diagrams

Today
- Kinematics - describing 1D motion
- Relative velocity (yes, more vectors!)

Important Concepts
- Change=derivative=slope
- Think carefully about directions (changes the +/- sign)

Important Reminders
- Finish Mastering Physics #2 tonight before 10pm
- Mandatory tutoring sessions start this week
- Office hours posted
- Pset #2 due this Friday

Kinematics: Description of Motion
- All measurements require an origin, a coordinate system, and units
  - Next complication is "reference frame", the term used to describe the motion of observer
  - Constant velocity is OK, accelerated observer is not
- Basic definitions:
  - Position
  - Distance versus displacement
  - Velocity - change of position
  - Speed is the magnitude of velocity
  - Acceleration - change of velocity

Relative Velocity
- Basic concept:
  - Observer B sees a moving object A, and
  - Observer B is moving relative to observer C, so
  - What does observer C see for the motion of the object?
- Notation: use “wrt” to indicate “with respect to”
  \[
  \vec{V}_{A \text{ wrt } C} = \vec{V}_{A \text{ wrt } B} + \vec{V}_{B \text{ wrt } C}
  \]
- Example: A=ball, B=me, C=you

\[ V_{A/B} \]
\[ V_{B/C} \]
You see this
**Key Kinematics Concepts**

- **Change=slope=derivative**
  
  \[ v_x = \frac{dx}{dt}, \quad a_x = \frac{dv_x}{dt} = \frac{d^2x}{dt^2} \]

- Velocity is the slope of position vs t, acceleration is the slope of velocity vs t and the curvature of position vs t

- Even in simple 1D motion, you must understand the vector nature of these quantities

- Initial conditions

- All formulas have assumptions

**One Important Special Case**

**Constant Acceleration** = \( a \)

\[
 x = x^0 + v^0_t + \frac{1}{2}a t^2 \\
 v = v^0 + at
\]

- Physics
- Initial conditions

**Multi-body Kinematics Problems**

- Need to use consistent coordinate system and origin for all objects

- Need to think carefully about directions (signs!)

- Need to think carefully about initial conditions, especially when things “start” at different times

- Write separate equations for each object

- Read problem carefully to understand the specific constraint to use to solve

**Summary**

- Kinematics provides a language to describe motion

- Basic relationship between position, velocity, acceleration (change=slope=derivative)

- Study special cases (like constant acceleration) but understand the assumptions that go into all formulas

- Position, velocity, and acceleration are ALL vectors and need to be manipulated using either arrows (qualitative) or components (quantitative)

- Directions (or signs in 1D) of position, velocity, and acceleration can all be different