- Last Lecture
  - More 2-D examples
  - Circular motion
- Today
  - Newton's Three Laws
- Important Concepts
  - Remember how vectors change
  - Remember how vectors add
  - Separate "external" and "internal" forces
  - Think carefully about what object each force acts on

Important Reminders

- Exam #1 is this Friday at 10am
- Material covered is through 2-D motion
- Information and sample problems are posted on the web page. Also copies of PRS, InClass problems and presentation slides.
- In addition to tutoring sessions, recitations, and office hours, there will be a Questions and Answer session tonight from 7-9pm.
- Next Mastering Physics due next Monday

Newton's First Law

- Objects move at constant velocity (and remain at rest if they start at rest) if they are acted on by no net external force.
  - Constant velocity means both magnitude and direction
  - No net force doesn't mean no force at all, just that whatever forces are present add up to zero
  - Only forces between objects, not internal forces count
  - This works both ways, if $\vec{v}$ is constant, then $\Sigma\vec{F}$ must be zero and if $\Sigma\vec{F}=0$, then $\vec{v}$ must be constant.

Newton's Second Law

- $\sum \vec{F} = m\vec{a}$
- Everything else we will do in 8.01L is an example or a consequence of this equation.
  - Forces add as vectors
  - The total force points in the direction of the acceleration
  - The force and acceleration are related by m, a property of the object itself. Basically, how much "stuff" is there.
    - Note distinction between mass and weight

Units of Force

- Acceleration is $\frac{m}{s^2}$
  - Use caution not to confuse ***m*** the mass, a property of an object, and ***m*** the meter, a unit of length
- Mass is in ***kg***
- So, Force is $\frac{kg\ m}{s^2} = N$
- N is the Newton, the short unit for force.

Newton's Third Law

- The most confusing of them all!
- Force due to object A on object B is always exactly equal in magnitude and always exactly opposite in direction to the force due to object B on object A.
  - The two forces are called an "action-reaction" pair
  - The two forces are equal and opposite in direction but do not "add to zero and go away" in solving problems because they act of different objects
    - It only makes sense to add forces on a single object
    - If you consider A+B as a single object, then these forces become "internal" and do drop out

Inertial Reference Frames

- These principles only apply for observers who are not accelerating, a so-called "inertial" frame
- There are philosophical objections to this concept since it's hard to precisely define an inertial frame except as one where Newton's Laws are valid
- Alternative formulations are beyond the scope of this course, you don't need to worry about it

Summary

- Force is related to the change in the velocity vector
- $\sum \vec{F} = m\vec{a}$
- The unit of force is the Newton which equals $\frac{kg\ m}{s^2}$
- Action-reaction pairs are an important concept in solving problems but need to be considered very carefully, especially the fact that the two forces in the pair act on different objects
- These concepts only apply as phrased here in inertial reference frames