

➡ 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

- ➡ $\Sigma \vec{F} = m\vec{a}$
- ➡ 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 $\frac{kg \cdot m}{s^2} = N$
- ➡ 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 $\frac{kg \cdot m}{s^2}$
- ➡ 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