January 28: Conservation of Momentum

Objectives

- Given the force exerted by one object on another, determine the reaction force.
- Use the conservation of momentum to analyze the motion of interacting objects.

What's the point?

- Where do forces come from?
- Nothing changes its motion on its own!
- Conservation of momentum is one of the Big Ideas of physics.

Action and reaction

Newton's third law is simple and subtle. It describes how objects are affected by exerting forces on other objects:

> *"Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first. Both forces are along the same line of interaction."*

"Equal and opposite" means that the forces have the same magnitude and opposite directions. It is important to keep in mind that the "action" and "reaction" forces act on *different objects*, not on the same object.

"Same line of interaction" means that the locations where the forces are applied on the two objects and the directions of the forces are such that the forces are directed along a line connecting the locations.

Objects cannot have forces imposed upon them from nothing: another object must apply the force. Forces are not exerted *by* objects or *upon* objects: they are *between* objects.

Conservation of momentum

If a system does not receive any forces from outside, its momentum never changes. Although the components of the system may frequently change their momenta in interactions with each other, the **total momentum** of the system remains constant. (Newton's third law requires this.)

Collisions

If colliding objects do not interact with any other objects, they make a convenient "system" for analysis. The total momentum of the system will be the same before, during, and after the collision.

In an **elastic** collision, the colliding objects bounce off each other. In a completely **inelastic** collision, they cling together after colliding.

Although the forces on the interacting objects are equal in magnitude, their accelerations usually are not. Their masses may differ, and they may also interact with additional objects.