The Theoretical Aspect of Linear Momentum Lab

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This shows how to calculate velocities of objects after collision.

1. Conservation of linear momentum can be formulated as

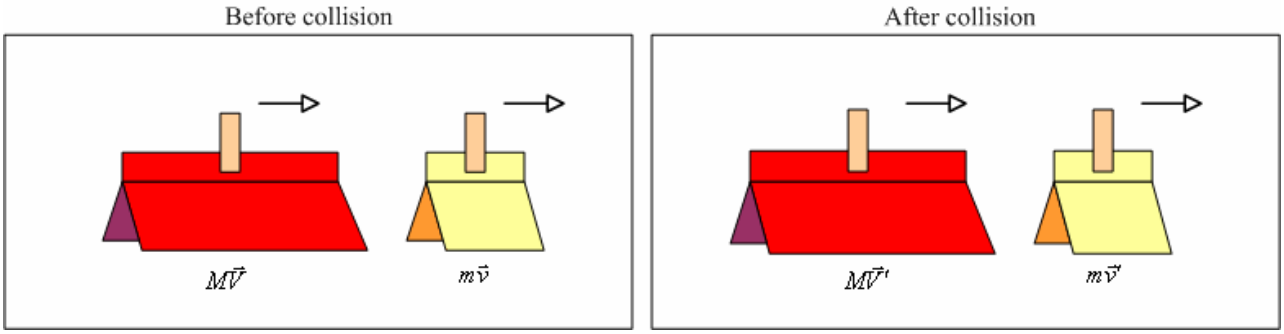

Fig. 1

$$M\vec{V} + m\vec{v} = M\vec{V}' + m\vec{v}' \qquad (1)$$

2. You also need the coefficient of restitution. For any collision between two objects only in a straight motion, a coefficient of restitution is given by

$$e = \frac{\vec{v}' - \vec{V}'}{\vec{V} - \vec{v}}. \qquad (2)$$

For a perfectly elastic collision, $e = 1$. For inelastic collisions, $e < 1$. For a perfectly inelastic collision, $e = 0$. To get the final velocities, you will use Eqs. (1) and (2).

3. We think the case that a large glider hits a small glider, but the small one has no initial velocity; namely, $\vec{v} = 0$. From Eq. (1), you will have

$$M\vec{V} = M\vec{V}' + m\vec{v}'. \qquad (3)$$

The coefficient of restitution is 1 due to the perfectly elastic collision. We use $\vec{v} = 0$ to plug in (2). Thus,

$$1 = \left(\vec{v}' - \vec{V}'\right)/\vec{V} \qquad \text{namely,} \qquad \vec{V} = \vec{v}' - \vec{V}' \qquad (4)$$

$\vec{V}$ is a known value as the initial velocity, but we don't know $\vec{v}'$ and $\vec{V}'$. So we have to express $\vec{v}'$ and $\vec{V}'$ in terms of $\vec{V}$. First, we want $\vec{V}'$, so solve for $\vec{v}'$ in (4).

$$\vec{v}' = \vec{V} + \vec{V}'. \qquad (5)$$

Plug (5) into (3) and solve for $\vec{V}'$. Then we obtain

$$\vec{V}' = \frac{M - m}{M + m}\vec{V}. \qquad (6)$$

Likewise we can get

$$\vec{v}' = \frac{2M}{M + m}\vec{V}. \qquad (7)$$

If you know each mass of the object, you will be able to calculate the final velocities. Think about cases, such that the small hits the large, and the coefficient of restitution is zero or different values.