Conservation of Momentum

Warm-Up Activity

A Deeper Model for Interactions

- Quantities
  - Energy E
  - Work $W = \int_{x_i}^{x_f} \vec{F} \cdot d\vec{x}$
  - Kinetic Energy $K = \frac{1}{2}mv^2$
  - Potential Energy $U =$ depends on interaction
  - Momentum $\vec{p} = m\vec{v}$
  - Impulse $\vec{J}_{\text{net}} = \int_{t_i}^{t_f} \vec{F}_{\text{net}} dt$
- Laws
  - Work-Energy Theorem $W_{\text{net,ext}} = \Delta E_{\text{total}}$
  - Impulse-Momentum Theorem $\vec{J}_{\text{net}} = \Delta\vec{p}$

Energy and Collisions

- A small rock (mass m) is moving to the right on a frictionless table with speed v.
- It hits a second rock (mass M) that is initially at rest on the table. The rocks do not stick together.
  - Is momentum conserved? For what system?
  - Is energy conserved? For what system?
- Our goal is to find the final speed of each rock, but don't try to solve it yet.
  - Instead, what special cases do you want to think about for this situation? What makes these special cases easier to think about than the general problem?

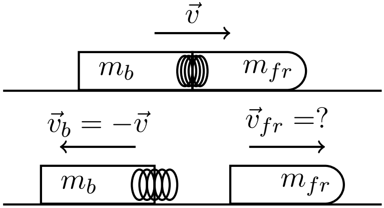
Energy and Collisions

- Collisions where energy is conserved are known as *elastic collisions.*
- Collisions where the energy of the system decreases are known as *inelastic collisions.*
    - When two things stick together, this is a *perfectly inelastic collision.*
- Collisions where the energy of the system increases are known as *superelastic collisions.*
    - Think explosions.

Superelastic Collisions

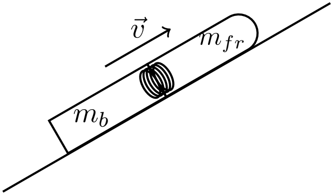
- You are designing a sled with a compressed spring inside, which can be released to separate the sled into two pieces of equal mass ($m/2$). You are racing the sled across level snow at speed v when you trigger the separation.

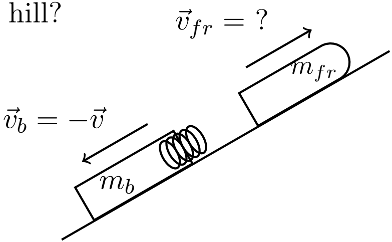
- Right after the two halves push apart, the back end of the sled is moving backward with speed v.
  - What is the velocity of the other piece?
  - How much kinetic energy did the system gain?



Superelastic Collisions

- What if the sled is going up a hill?





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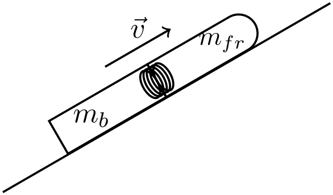

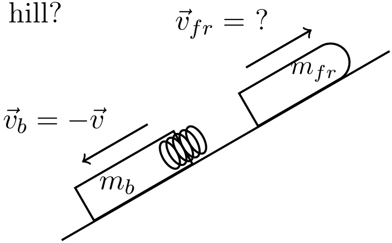

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  - We need to know how long the spring takes to decompress.

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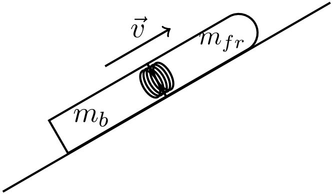

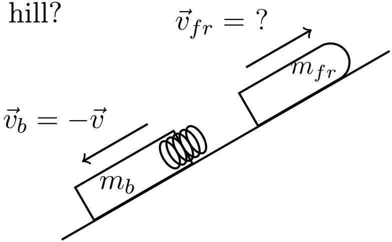

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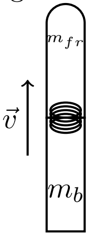

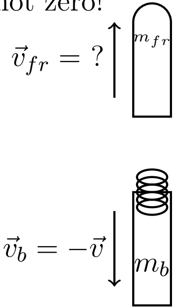

Main Ideas

- When the impulse is zero (because the net force is zero), the momentum of the system is constant—it is *conserved*.