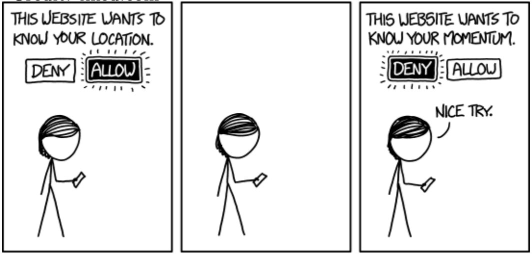
Conservation of Momentum

Credit: xkcd.com



Warm-Up Activity

You throw a brand new bouncy ball against the wall. Is the speed of the ball right after hitting the wall greater than, less than, or equal to the speed of the ball right before hitting the wall?

A. Greater than

B. Less than

C. Equal to

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?

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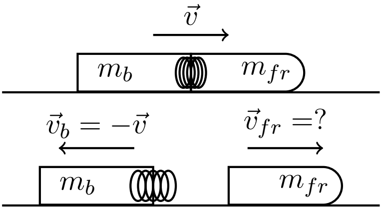
Energy and Collisions

- 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?



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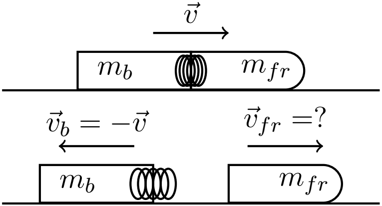
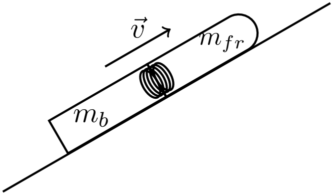
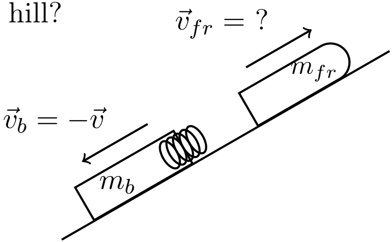


Superelastic Collisions

- What if the sled is going up a hill?





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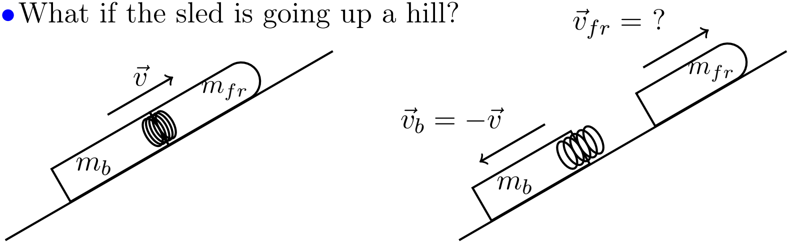

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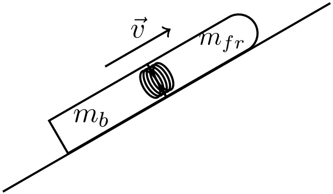

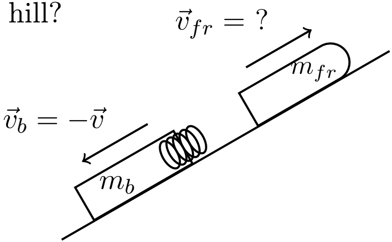

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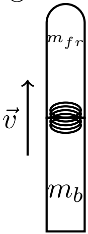

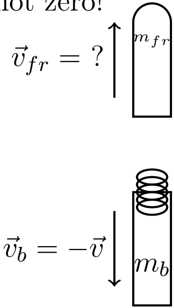

Main Ideas

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