

Essential Question

Why does a cannon roll backward when it fires?

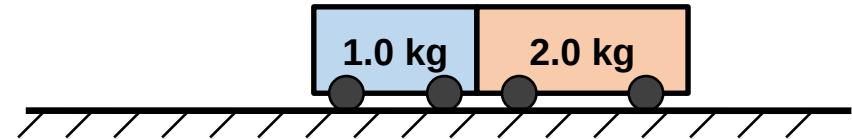
Explosions

- Objects start together at rest
- Total $p = 0$ before
- Total p still = 0 after

Before



both at rest



After

-4.0 m/s



+2.0 m/s



$p: 0 \text{ before, } (-4.0) + (+4.0) = 0 \text{ after}$

The Explosion Equation

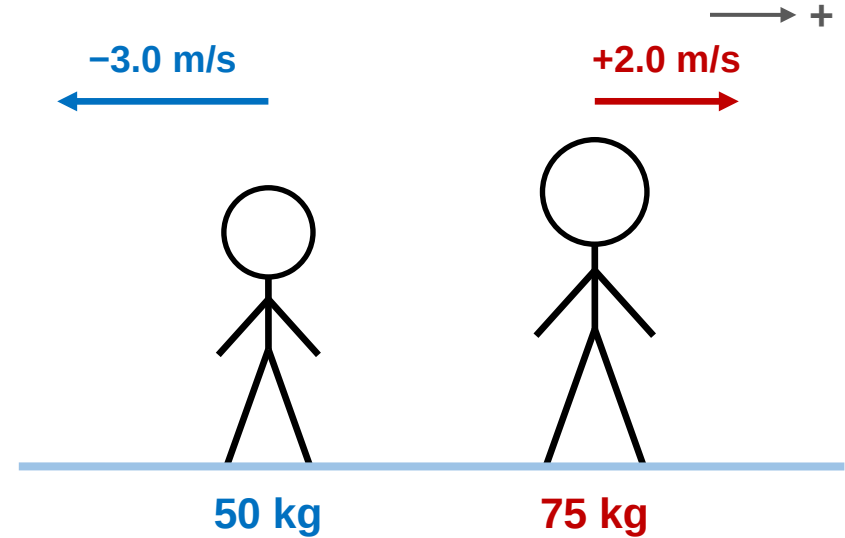
$$0 = m_1 v_1' + m_2 v_2'$$

$$\text{so } m_1 v_1' = -m_2 v_2'$$

equal size momentum, opposite directions

Skater Push-Off

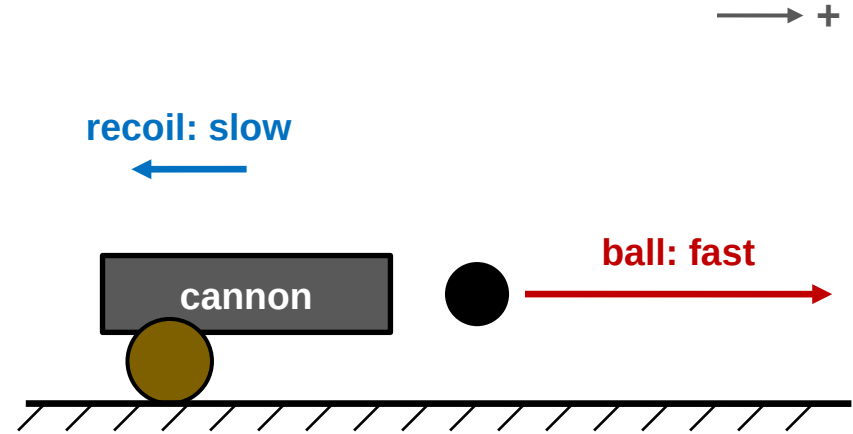
- They push on each other
- Equal and opposite impulses
- Lighter skater moves faster



$$50 \times 3.0 = 75 \times 2.0 = 150 \text{ kg}\cdot\text{m/s}$$

Recoil

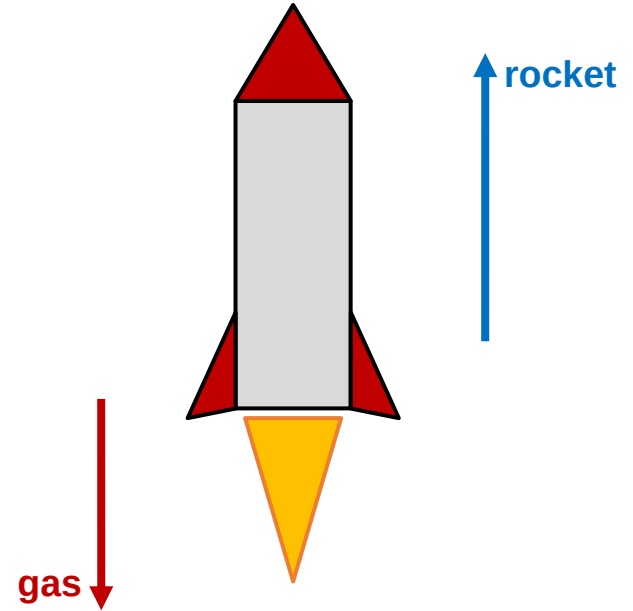
- The kick back from a launch
- Cannons, rifles, fire hoses
- Heavy launcher: slow recoil



same size momentum, opposite directions

Rockets

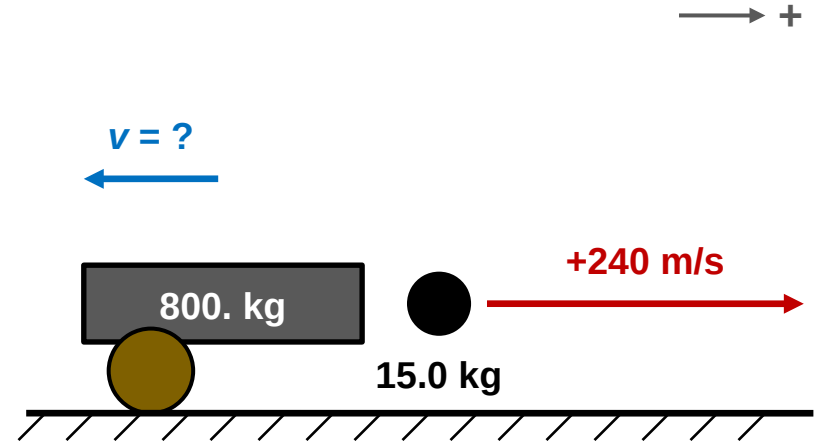
- Rocket pushes gas backward
- Gas pushes rocket forward
- Works in space: no air needed



gas goes down, rocket goes up

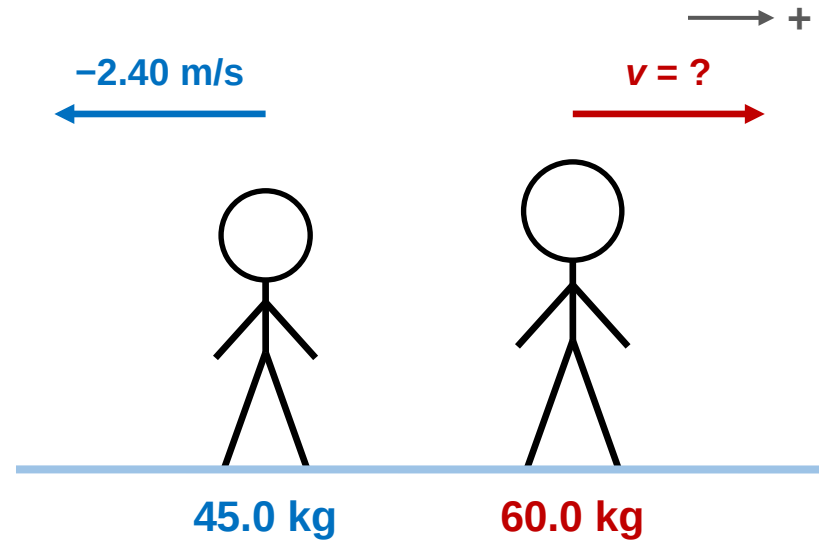
Example: Cannon Recoil

An 800. kg cannon at rest fires a 15.0 kg cannonball to the right at 240 m/s. What is the recoil velocity of the cannon?



Example: Skaters Pushing Off

A 45.0 kg skater and a 60.0 kg skater stand at rest on ice and push off each other. The 45.0 kg skater moves left at 2.40 m/s. What is the velocity of the 60.0 kg skater?



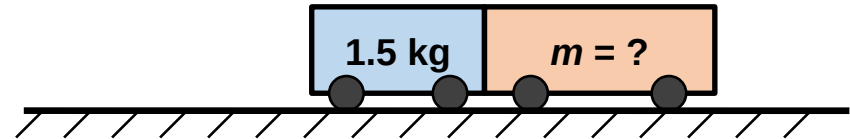
Example: Finding a Mass

A compressed spring pushes two carts apart from rest. The 1.5 kg cart moves left at 2.0 m/s, and the other cart moves right at 0.75 m/s. What is the mass of the other cart?

Before



both at rest

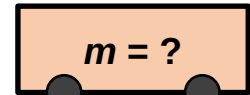


After

-2.0 m/s

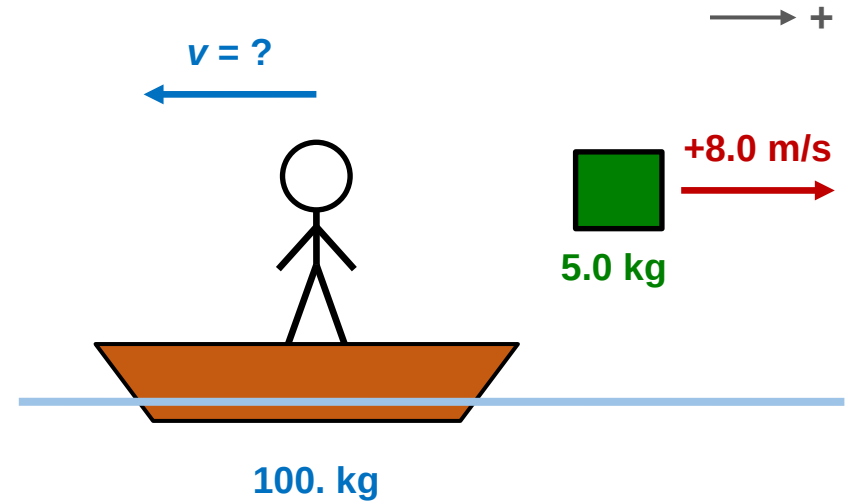


+0.75 m/s



Example: Throwing from a Canoe

A 60.0 kg student stands in a 40.0 kg canoe at rest. She throws a 5.0 kg backpack to the right at 8.0 m/s. What is the velocity of the student and canoe? (Ignore the water.)



Big Ideas

- Start at rest: total $p = 0$
- Pieces move in opposite directions
- Lighter piece moves faster
- Recoil: launcher kicks backward