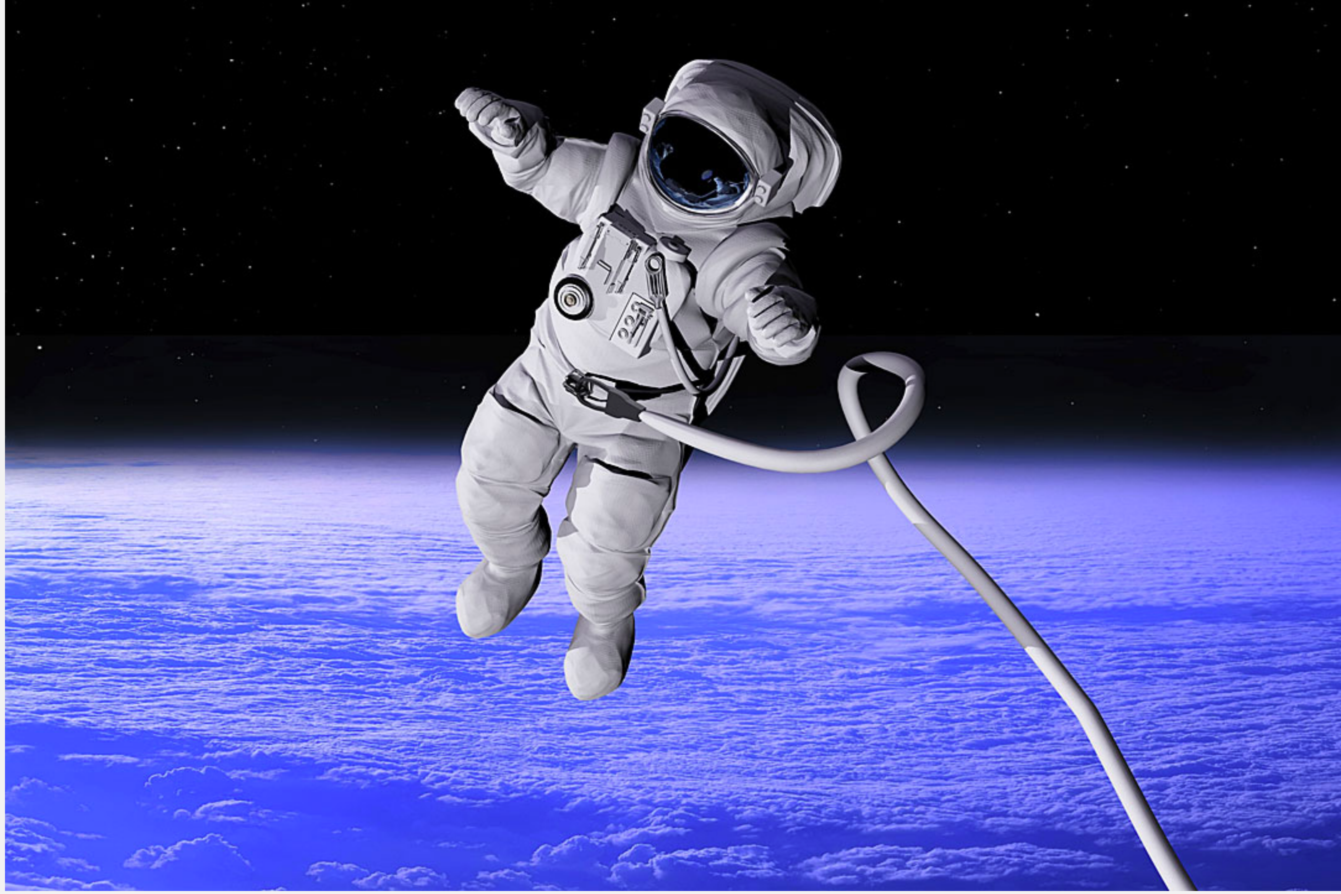
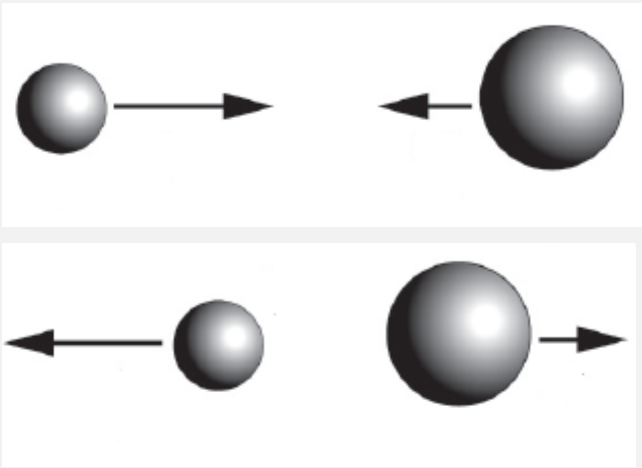
- You’re an astronaut working outside the shuttle when your line breaks! If you’re armed only with tools in your toolbelt, what can you do to get back to the shuttle?

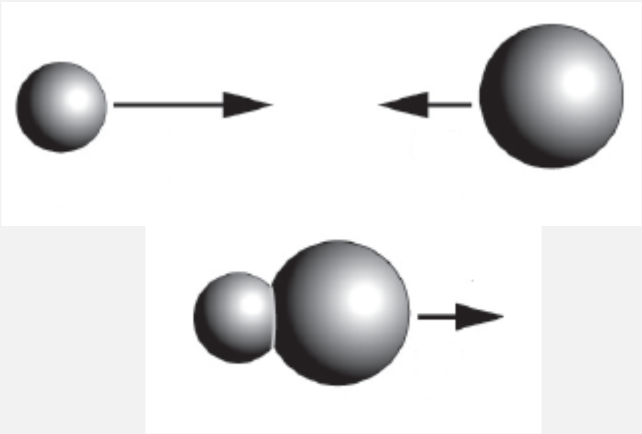


- Take one of your tools and throw it as hard as you can away from the shuttle → forward momentum of the tool = backward momentum of you

COLLISIONS IN ONE DIMENSION

- A *collision* occurs when two or more objects hit each other.
- During a collision, momentum is transferred from one object to another, but total momentum is conserved
- Collisions can be ***elastic*** **or** ***inelastic*****.**





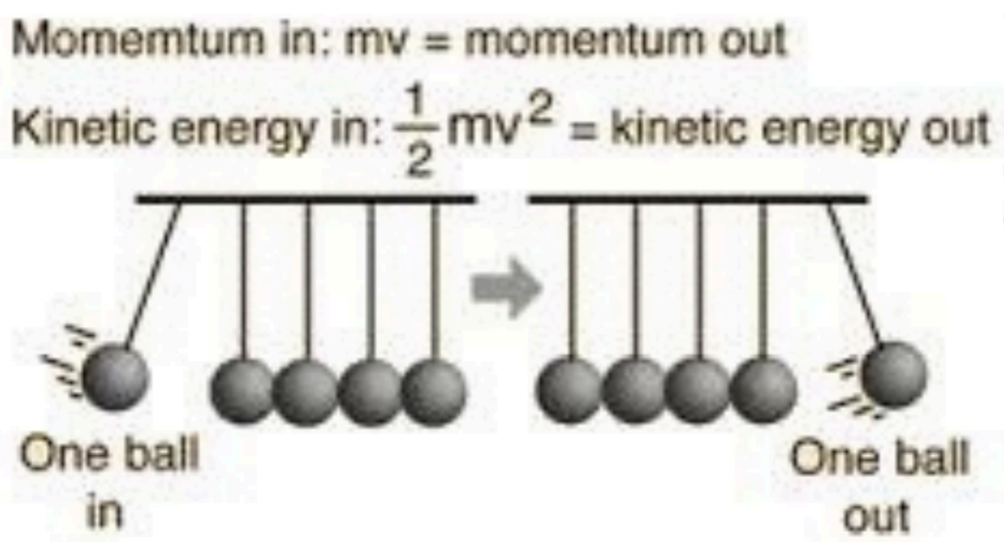
ELASTIC COLLISIONS

If the two objects is a collision are

- Very hard
- No heat is produced in the collision

Then kinetic energy is also conserved

These collisions are **perfectly elastic**



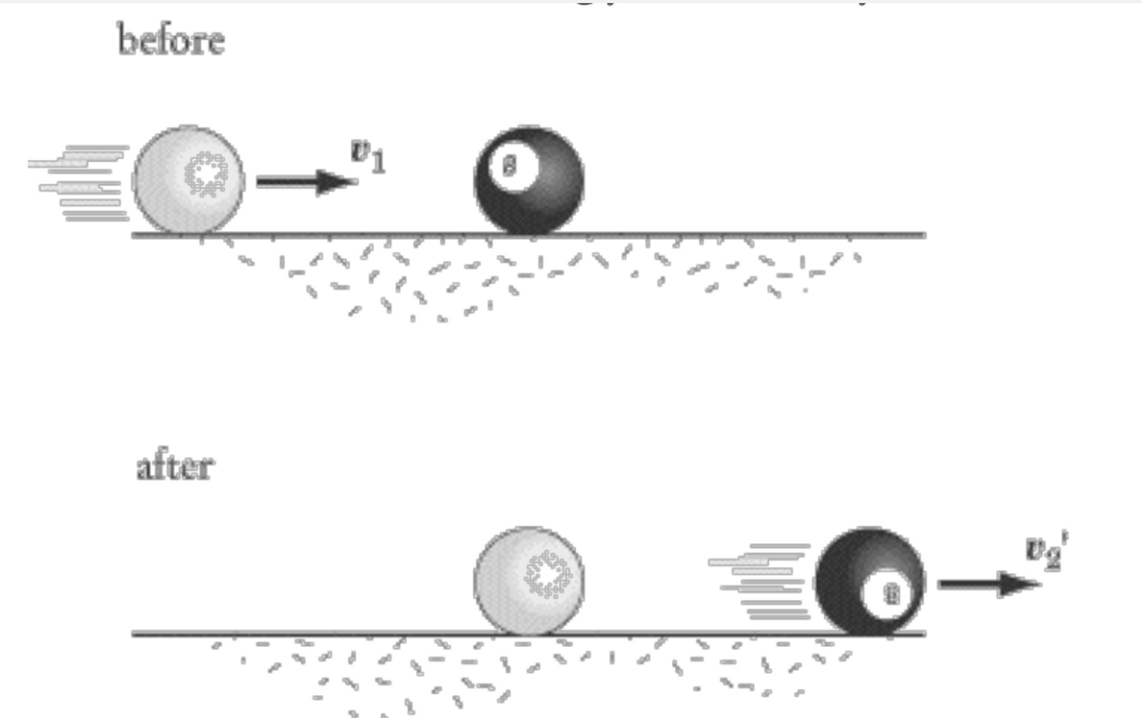
ELASTIC COLLISIONS

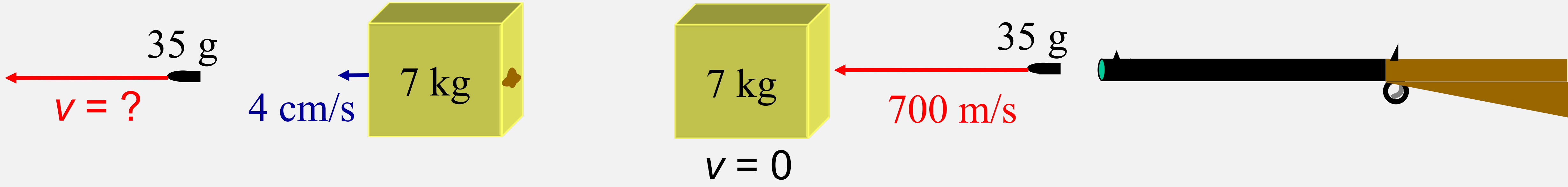
A billiard ball of mass *m* moving with speed *v* collides head-on with another ball of equal mass at rest. What are the speeds of the two balls after the collision, assuming it is perfectly elastic and there is no spin?

$\Sigma\, p_{before} = \Sigma\, p_{after}$

$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

$\boldsymbol{v_1' = 0, v_2' = v}$



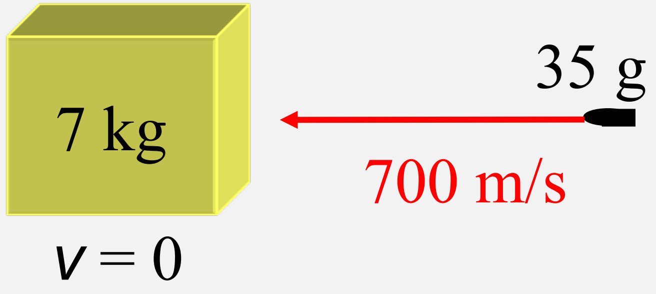


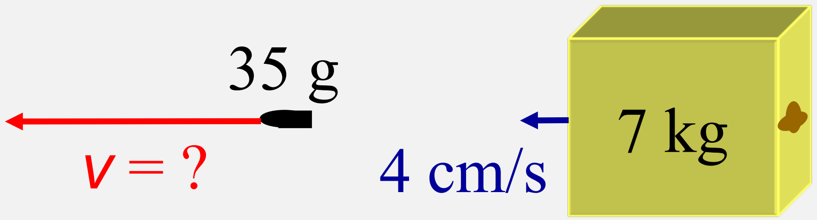
A rifle fires a bullet into a giant slab of butter on a frictionless surface. The bullet penetrates the butter, but while passing through it, the bullet pushes the butter to the left, and the butter pushes the bullet just as hard to the right, slowing the bullet down. If the butter skids off at 4 cm/s after the bullet passes through it, what is the final speed of the bullet?

continued on next slide

Let's choose left to be the + direction & use conservation of momentum, converting all units to meters and kilograms.

$$\Sigma p_{\text{before}} = 7\text{kg}(0\text{m/s}) + (0.035\text{kg})(700\text{m/s})$$
$$= 24.5 \text{ kg}\cdot\text{m/s}$$





$$\Sigma p_{\text{after}} = 7\text{kg}(0.04\text{m/s}) + 0.035\text{kg}\,(v_{\text{Bullet}}')$$
$$= 0.28 + 0.035\,v$$

$$p_{\text{before}} = p_{\text{after}} \Rightarrow \quad 24.5 = 0.28 + 0.035\,v \quad \Rightarrow \quad v = 692 \text{ m/s}$$

v came out positive. This means we chose the correct direction of the bullet in the "after" picture.

INELASTIC COLLISIONS AND EXPLOSIONS

- **Inelastic collisions** – KE is **not** conserved
- $KE_f < KE_i$
- Explosions are just inelastic collisions in reverse
  - PE → KE

INELASTIC COLLISIONS

- If two objects stick together after the collision, it is perfectly inelastic
  - I.e. Football tackle
  - 2 balls of putty colliding

*Note: even though KE is not conserved, **total energy** is always conserved, as is **total vector momentum***

CONSERVATION OF MOMENTUM IN INELASTIC COLLISIONS

- $m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$
- If they stick together, $v_1' = v_2'$
- $m_1v_1 + m_2v_2 = (m_1 + m_2)v'$

INELASTIC COLLISIONS

$$m_1v_1 + m_2v_2 = (m_1 + m_2)v'$$

- A 155 kg football player running at 6.00 m/s tackles his 103 kg opponent (initially at rest) in a perfectly inelastic collision.
- How fast do they move after they collide?
  - 3.60 m/s

How much of the initial KE is transformed into thermal or other forms of energy?

- -1.12 kJ

ELASTIC VS. INELASTIC COLLISIONS

- 2 spheres, both with mass *m* and speed *v*, collide head-on. What are the velocities after the collision assuming the collision is a) perfectly elastic and b) perfectly inelastic?
  - A) $v_1' = -v$, $v_2' = +v$
  - B) $v' = 0$