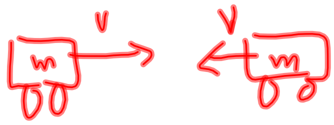
Momentum & energy conservation in collisions

Both momentum and ***total*** energy are conserved in any collision

Consider a collision between two cars that come to a stop after the collision. Each car had kinetic energy before the collision, but there is no kinetic energy after the collision. Where did the kinetic energy go?

internal

The total energy remains the same even though the kinetic energy does not.



Elastic & inelastic collisions

An elastic collision is one in which the *kinetic energy* is conserved; that is, in which the total kinetic energy is the same before and after the collision.

An inelastic collision is one in which the *kinetic energy* is **not** conserved; that is, in which the total kinetic energy is different before and after the collision.

In all collisions, the total energy is always conserved, but that is not true of kinetic energy.
In all collisions, total momentum is always conserved.

Most collisions are inelastic!!!......there are varying degrees of elasticity

Perfectly elastic

↓

Nearly elastic

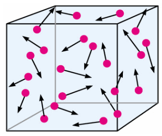
↓

Inelastic

↓

Completely inelastic

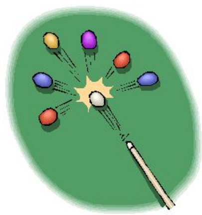
Atoms or molecules colliding in a gas



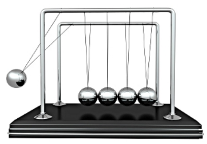
Gliders with repelling magnets

Gliders with springs that compress and repel on contact

Billiard ball collisions



Steel balls colliding and bouncing apart



Golf club striking a golf ball

Gliders that stick together on impact

Example:

In each of the collisions below determine the velocity of body B after the collision and whether the collision is elastic or inelastic. If it is inelastic, determine the loss or gain of kinetic energy.

1. Body A has a mass 1.0 kg and is moving to the right with a speed of 2.0 m s^{-1}. (+)
Body B has a mass of 2.0 kg and is moving to the left with a speed of 4.0 m s^{-1}. (−)
After the collision, A recoils to the left with a speed of 6.0 m s^{-1}. (−)

$\frac{1}{2}mv^2$

$$\vec{P}_{total(before)} = \vec{P}_{total(after)}$$

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$

$$(1.0\,kg)(2.0\,ms^{-1}) + (2.0\,kg)(-4.0\,ms^{-1}) = (1.0\,kg)(-6.0\,ms^{-1}) + (2.0\,kg)v_B$$

$$2.0\,kg\,ms^{-1} - 8.0\,kg\cdot ms^{-1} = -6.0\,kg\,ms^{-1} + (2.0\,kg)v_B$$

$$0 = (2.0\,kg)v_B$$

$$v_B = 0\,ms^{-1}$$

Before:
A: 2.0 J
B: 16 J } 18 J

ELASTIC

After:
A: 18 J
B: 0 J } 18 J

2. Body A has a mass 2.0 kg and a velocity of +4.0 m s^{-1} and a body B has mass 4.0 kg and velocity +1.0 m s^{-1}. Body A overtakes body B and after the collision has a velocity of +2.0 m s^{-1}.

$$(2.0\,kg)(+4.0\,ms^{-1}) + (4.0\,kg)(+1.0\,ms^{-1}) = (6.0\,kg)V_{AB}$$

$$8.0\,kg\,ms^{-1} + 4.0\,kg\,ms^{-1} = (6.0\,kg)V_{AB}$$

$$12\,kg\,ms^{-1} = (6.0\,kg)V_{AB}$$

$$\boxed{V_{AB} = +2.0\,ms^{-1}}$$

$\left(E_k = \frac{1}{2}mv^2\right)$

BEFORE

A: 16 J
B: 2 J } 18 J

AFTER

A+B: 12 J

INELASTIC .... loss of 6 J of kinetic energy (internal / sound ...

Example:

A stationary radon nucleus of mass 3.6×10^{-25} kg emits an alpha particle with a kinetic energy of 1.1×10^{-12} J. Calculate the kinetic energy of the recoiling nucleus. Mass of an alpha particle is 6.7×10^{-27} kg.

includes α particle

$$E_k = \frac{p^2}{2m}$$

could go this way

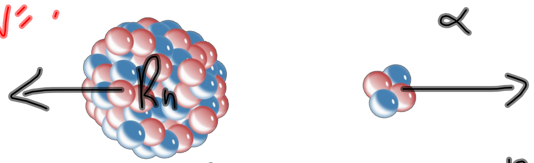
$$\vec{P}_{total(before)} = \vec{P}_{total(after)} \quad V = ?$$

$$0 = \vec{P}_{\alpha} + \vec{P}_{Rn}$$

$$\vec{P}_{Rn} = -\vec{P}_{\alpha}$$

$$m_{Rn}\vec{V}_{Rn} = -m_{\alpha}\vec{V}_{\alpha}$$

$$\vec{V}_{Rn} = -\frac{(6.7\times10^{-27}\,kg)(1.8\times10^{7}\,ms^{-1})}{3.533\times10^{-25}\,kg} = -3.4\times10^{5}\,ms^{-1}$$



3.6×10^{-25} kg
$-\ 6.7\times10^{-27}$ kg
3.533×10^{-25} kg

1.1×10^{-12} J
6.7×10^{-27} kg
$1.81\times10^{7}\ ms^{-1}$
$(E_k = \frac{1}{2}mv^2)$

$\frac{1}{2}(3.533\times10^{-25}\,kg)(3.4\times10^{5}\,ms^{-1})^2$

2.1×10^{-14} J

Example:

When a radioactive nucleus decays by emitting a particle with a mass which is very small compared to the mass of the nucleus, nuclear potential energy is converted into kinetic energy of both the particle and the recoiling nucleus.

Show that almost all the energy released is carried by the small mass particle while very little of the kinetic energy is carried by the recoiling nucleus.

let m be small particle mass
M be nucleus ($M \ggg m$)
v be the velocity of small particle
V be the velocity of the recoiling nucleus.

magnitude: $mv = MV$

$$V = \frac{mv}{M}$$

Since M is very very large, V will be very very small

$\therefore$ E_k will also be very very small