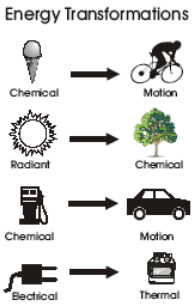
Momentum and Energy II



Momentum and Impulse

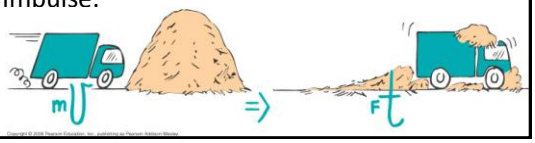
Momentum: $\vec{p} = m\vec{v}$

Impulse: $\vec{F}_{tot}\Delta t = m\Delta\vec{v} = \Delta\vec{p}$

Momentum and Impulse

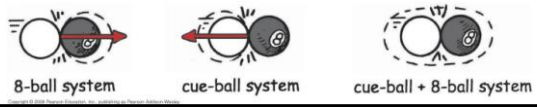
Momentum:

Impulse:



Conservation of Momentum

- Only impulses (forces) external to the system can change the momentum of a system. Internal impulses won't work.
- If there is no external impulse (force) on the system, the momentum of the system cannot change, i.e. *the momentum of a system is conserved.*



Conservation of Momentum

Consider the cue ball-8 ball system. When they collide, Newton's Third Law tells us that

$$\vec{F}_{21} = -\vec{F}_{12}.$$

Multiplying by Δt

And using Newton's Second Law yields

$$\Delta\vec{p}_1 = \vec{F}_{21}\Delta t = -\vec{F}_{12}\Delta t = -\Delta\vec{p}_2.$$

Conservation of Momentum

For all collisions in the absence of external forces

- the total momentum before collision equals total momentum after collision
- in equation form

$$(\text{total } m\vec{v})_{\text{initial}} = (\text{total } m\vec{v})_{\text{final}}$$

Conservation of Momentum: Collisions !

If there is no deformation of the objects nor any generation of heat in the collision, the collision is *elastic*.

If the objects do deform during the collision or there is generation of heat in the collision, the collision is *inelastic*.

Elastic versus inelastic

Question: Is there a more quantitative way to characterize the difference between elastic and inelastic?

Energy

Another question: What is energy?

Energy is hard to define in the abstract. Is it a substance, a quality, a book-keeping device, a system of exchange rates, or……?

What's a form of energy?

Energy

- KEY IDEA: Energy is neither created nor destroyed. **Energy is conserved!**
- The law of conservation of energy:
  total energy before = total energy after
- Note the different meaning from colloquial expression of "We must conserve energy."
- The total energy stays the same, however, energy can transform itself from one form to another. It's sneaky……We need to keep track of those changes.
- Energy has units of Joules (J)

Different forms of energy

- ***Kinetic energy*** is the energy of motion
- Kinetic energy depends on the mass of an object and its speed

$$\mathrm{KE} = \frac{1}{2}\mathrm{mv}^2$$

- If object speed is doubled, then KE is quadrupled!

Different forms of energy

- **Potential energy** is stored energy held in readiness with a potential for doing **work**
- **Work** on an object is the net force applied to an object times the distance travelled by the object times the cosine of the angle between net force and the distance travelled
- Examples of potential energy: Stretched bow that can do work on an arrow, stretched rubber band of a slingshot

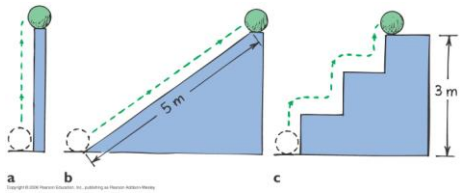
Different forms of energy

- Gravitational potential energy is potential energy due to an elevated position
- Examples: water in an elevated reservoir, raised ram of a pile driver
- GPE (Gravitational potential energy) is equal to the work done on an object
- In equation form $GPE = mgh$

where h is the height above some reference pt.

Gravitational Potential Energy

- GPE is the same in all cases because work done in elevating is the same

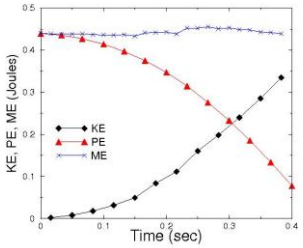


Ball drop and energy

What forms of energy are present?

Ball drop and energy

- What two forms of energy are present? Kinetic energy and gravitational potential energy!



Ball drop and energy

- KE of ball increases at the same rate as its GPE decreases so that

$$KE + GPE = ME$$

stays the same, i.e. mechanical energy (ME) is conserved!

- Think of GPE as a bank account that can be drawn down to make KE. The more we withdraw from GPE, the more KE we get.

Pendulum and energy

- What forms of energy are present?

Pendulum and energy

- What forms of energy are present?