C8: Energy Transfers

This chapter is about *relationships...*

C8.2: Momentum and Kinetic Energy

Kinetic energy is related to momentum:

$$K = \frac{p^2}{2m} . \tag{1}$$

Not all momentum transfers lead to a change in kinetic energy. Consider a small momentum transfer $d\vec{p}$. Suppose an object is moving at velocity $\vec{v}$. Only the "portion" of $d\vec{p}$ that is in the same direction as $\vec{v}$ will lead to a change in kinetic energy.

$$dK = vdp\cos\theta , \tag{2}$$

where:

C8.3: The Dot Product

Two important formulas:

$$\vec{u}\cdot\vec{w} \equiv uv\cos\theta , \tag{3}$$

where $\theta \equiv$

Also,

$$\vec{u}\cdot\vec{w} = u_x w_x + u_y w_y + u_z w_z . \tag{4}$$

Note that:

- $\vec{u}\cdot\vec{w}$ is a scalar.
- $\vec{u}\cdot\vec{w}$ can be positive or negative.
- $\vec{u}\cdot\vec{u} = u^2$.

C8.4 A Model for Energy Transfer

When there's a kinetic energy transfer dK, the energy comes from some sort of potential energy – it does not come from another interaction. Remember that energy is a property of an interaction, not a property of a particular object.

C8.5 The Earth's Kinetic Energy

Yet again, we note that the earth is way bigger than us.

C8.6 Contact Interactions

The punch line of this section is:

C8.7 Momentum, Force, and Energy

Force, a vector quantity, is defined to be:

$$\vec{F} \equiv \frac{d\vec{p}}{dt} \, . \tag{5}$$

The unit of force is the:

Equations relating force to momentum and energy transfers:

$$d\vec{p} = \vec{F} dt \tag{6}$$

and

$$dK = \vec{F} \cdot d\vec{r} \tag{7}$$

The force on a mass m due to gravity near the surface of the earth:

$$F_z = -mg \, . \tag{8}$$

Practice

1. Consider two displacement vectors: $\vec{v_1} = [2m, -4m]$ and $\vec{v_2} = [3m, -1m]$. Calculate $\vec{v_1} \cdot \vec{v_2}$. Calculate the angle between $\vec{v_1}$ and $\vec{v_2}$.

2. A 5 kg object is traveling due north at 10 m/s.
   (a) The object receives a momentum transfer of 3 kgm/s due east. What energy transfer has the object received?
   (b) The object receives a momentum transfer of 3 kgm/s at 37 degrees east of north. What energy transfer has the object received?
   (c) The object receives a momentum transfer of 3 kgm/s at 37 degrees east of south. What energy transfer has the object received?

3. A 2000 kg rolls down a 37 degree incline at a constant speed of 20 m/s.
   (a) In one second, what energy transfer does the gravitational interaction give to the car? car?
   (b) Where does this energy transfer go?