Physic² 121:
Phundament°ls of Phy²ics I

October 30, 2006

Combining Ideas: Momentum and Energy

- Conservation of Momentum
  - ALWAYS true in collisions
    - Doesn't matter if collision is elastic, inelastic
    - But you need to measure the momenta of ALL objects involved before and after
  - Vector relationship, so direction matters
- Conservation of Energy
  - Kinetic energy is conserved ONLY in perfectly elastic collisions (this is really definition of what an elastic collision is)
    - Otherwise, some of the energy gets used to deform or heat up the objects
  - Scalar relationship, so doesn't tell you anything about direction

Demonstrations

Example Problem (6.64)

- A cue ball traveling at 4.00 m/s makes a glancing, elastic collision with a target ball of equal mass that is initially at rest. The cue ball is deflected so that it makes an angle of 30.0° with its original direction of travel. Find
  a) the angle between the velocity vectors of the two balls after the collision
  b) the speed of each ball after the collision.

Potential Energy Stored in a Spring

- Involves the *spring constant*, k
- Hooke's Law gives the force
  - F = - k x
    - F is the restoring force
    - F is in the opposite direction of x
    - k depends on how the spring was formed, the material it is made from, thickness of the wire, etc.

Potential Energy in a Spring

- Elastic Potential Energy
  - related to the work required to compress a spring from its equilibrium position to some final, arbitrary, position x
  - $$PE_s = \frac{1}{2}kx^2$$

Conservation of Energy Including a Spring

- The PE of the spring is added to both sides of the conservation of energy equation

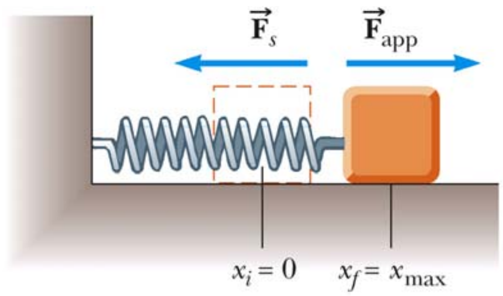
- The same problem-solving strategies apply

$$(KE + PE_g + PE_s)_i = (KE + PE_g + PE_s)_f$$

Spring Example

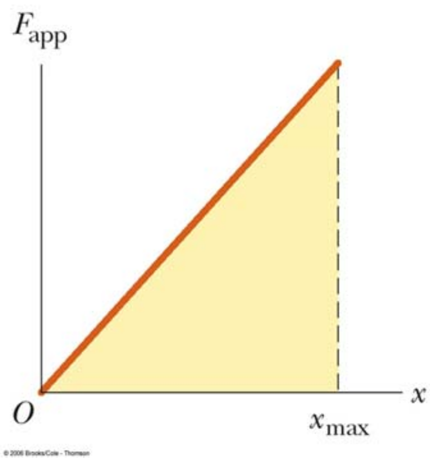
- Spring is slowly stretched from 0 to x_{max}
-
- W = ½kx²

$$\vec{F}_{applied} = -\vec{F}_{restoring} = kx$$



Spring Example, cont.

- The work is also equal to the area under the curve
- In this case, the "curve" is a triangle
- A = ½ B h gives W = ½ k x^2



Power

- Often also interested in the *rate* at which the energy transfer takes place
- *Power* is defined as this rate of energy transfer
  - $$\bar{\wp} = \frac{W}{t} = F\bar{v}$$
- SI units are Watts (W)
  - $$W = \frac{J}{s} = \frac{kg \bullet m^2}{s^2}$$

Power, cont.

- US Customary units are generally hp
  - Need a conversion factor

$$1\,\text{hp} = 550\,\frac{\text{ft lb}}{\text{s}} = 746\ \text{W}$$

  - Can define units of work or energy in terms of units of power:
    - kilowatt hours (kWh) are often used in electric bills
    - This is a unit of energy, not power