PHYS 2010 LECTURE 18

Announcements: CAPA5 deadline extended. <u>No other way</u> to submit CAPA but online!

Exam next Tuesday (Mar. 7). Will cover material through Chapter 5, CAPA 6. Review lecture!

→ Special exams: see me/email me TODAY.

Intro to Energy and Work. Need for this week's lab!

Energy and Work

Energy is difficult to define because it comes in many different forms. It is hard to find a single definition which covers all the forms.

Some types of energy:
- kinetic energy (KE) = energy of motion
- thermal energy = energy of "atomic jiggling"
- potential energy(PE) = energy of position/configuration
  - various kinds of PE:
    - gravitational
    - elastic
    - electrostatic
    - chemical
    - nuclear
- radiant energy = energy of light
- mass energy (Einstein's Relativity Theory says mass is a form of energy.)

Almost all forms of energy on earth can be traced back to the Sun.:

Example: Lift a book (gravitational PE) ← chemical PE in muscles ← chemical PE in food ← cows ← grass ← sun (through photosynthesis) !

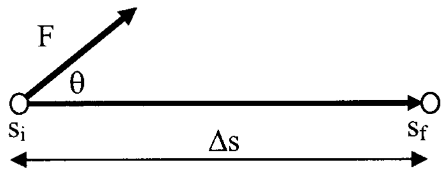
Some textbooks say that energy is the ability to do work (not a bad definition, but rather abstract). Whenever work is being done, energy is being changed from one form to another or being transferred from one body to another.

As we'll see later, energy is an extremely useful concept because energy is **conserved.** When we say energy is conserved, we mean that energy cannot be created or destroyed; you can only change energy from one form to another, or transfer it from one body to another. The total amount of energy is fixed; all we can do is shuffle it around.

[Notice that this is not what people normally mean when they say "Conserve energy." When the power company says "Conserve energy", they really mean "Don't convert the energy stored as chemical potential energy into other forms of energy too quickly." To a scientist, the phrase "conserve energy" is meaningless, because energy is always conserved. You can't NOT conserve energy.]

To understand energy and conservation of energy, we must first define some terms: work, kinetic energy (KE), and potential energy (PE).

Definition of work done by a force: consider an object pulled by a force $\vec{F}$. While the force is applied, the object moves along some axis (s-axis, say) through a displacement of magnitude Δs.

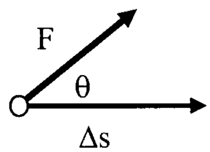


Notice that the direction of displacement is not the same as the direction of the force, in general.

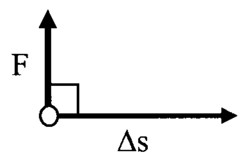
Work done by a force F = $\boxed{W_F \equiv F_s \cdot \Delta s = F\cos\theta\,\Delta s = F_{||}\,\Delta s}$

$F_{||}$ = component of force along the direction of displacement

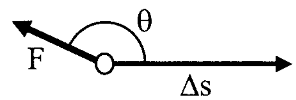
Work is not a vector, but it does have a sign (+) or (-). Work is positive, negative, or zero, depending on the angle between the force and the displacement.



$\theta < 90$, W positive



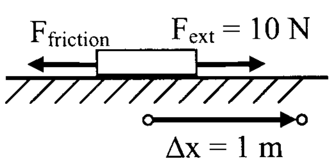
$\theta = 90$, $W = 0$



$\theta > 90$, W negative

(Question for later: Why do we define work this way?)

Example: Move book at constant velocity along a rough table with a constant horizontal force of magnitude $F_{ext} = 10$ N (10 newtons). Total displacement is $\Delta x = 1$ m.



work done by external force =

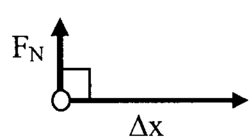
$$W_{Fext} = +F_{ext} \cdot \Delta x = 10\text{ N} \cdot 1\text{ m} = 10\text{ N·m} = +10\text{ J}$$

$\boxed{\text{Unit of work: } 1\text{ N·m} = 1\text{ joule} = 1\text{ J}}$

Since velocity = constant, $F_{net} = 0$, so $|F_{ext}| = |F_{fric}| = 10$ N

Work done force of friction $= W_{Ffric} = -F_{fric} \cdot \Delta x = -10$ J

Work done by normal force F_N is zero. $W_{FN} = 0$
(since normal force is at right angles to displacement.)



Work done by net force zero (since v = constant $\Rightarrow F_{net} = 0$). $W_{net} = 0$.

Moral of this example: Whenever you talk about the work done, you must be very careful to specify *which force* does the work.