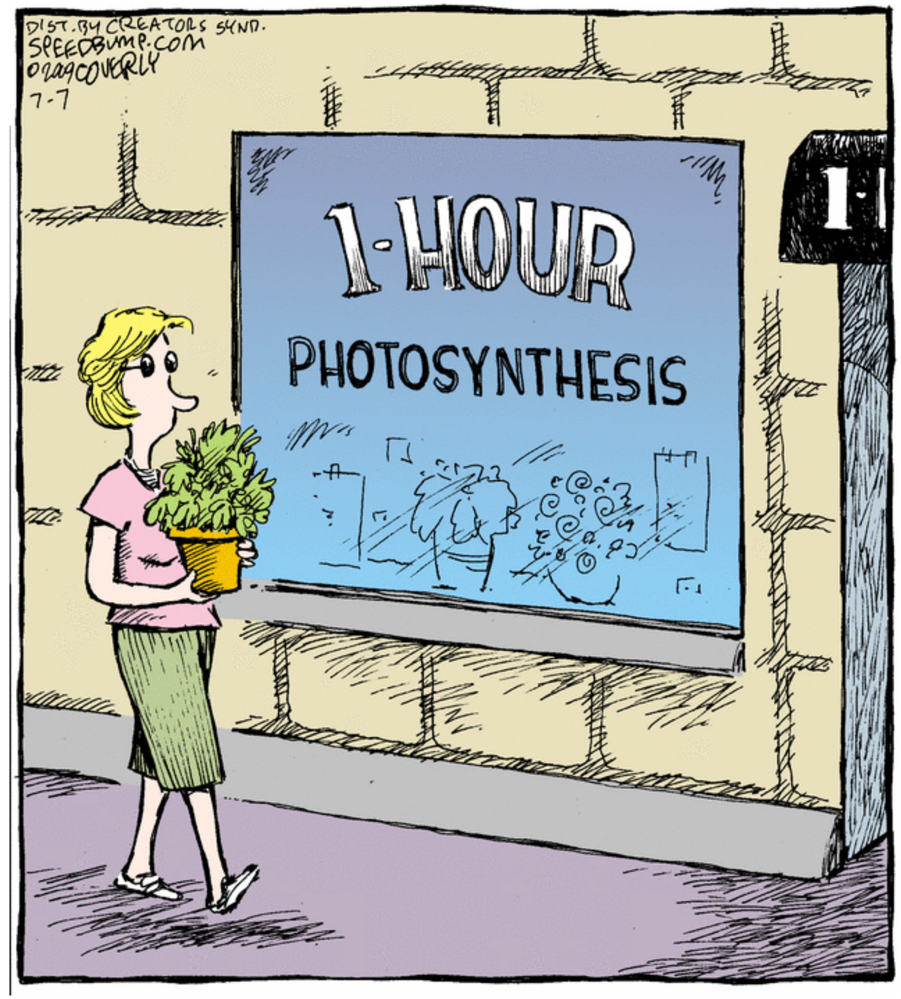
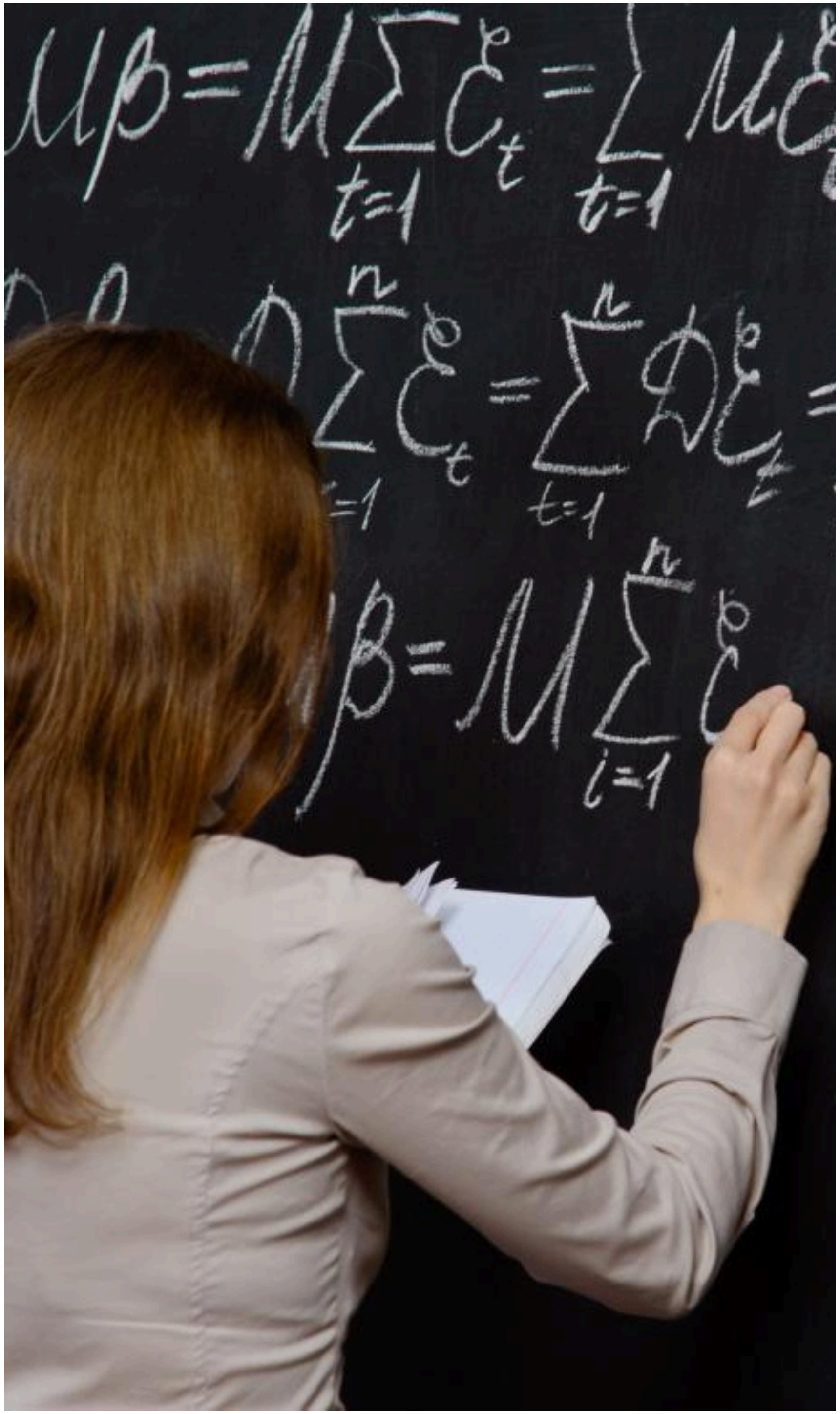
- **Theme Music:**
  Earth, Wind, & Fire
  Energy
- **Cartoon:**
  Dave Coverley
  Speed Bump





The Equation of the Day

Potential energy

$$\vec{F}^{type} \cdot \Delta\vec{r} = -\Delta U^{type}$$

type = gravity, electricity, or spring

Foothold ideas: Kinetic Energy and Work

- Newton's laws tell us how velocity changes. The Work-Energy theorem tells us how speed (independent of direction) changes.
- Kinetic energy = $\frac{1}{2}mv^2$
- Work done by a force = $F_x \Delta x$ or $F_{||}\Delta r$ (part of force || to displacement)
- Work-energy theorem: $\Delta(\frac{1}{2}mv^2) = \vec{F}^{net} \cdot \Delta\vec{r}$

Simplest example:

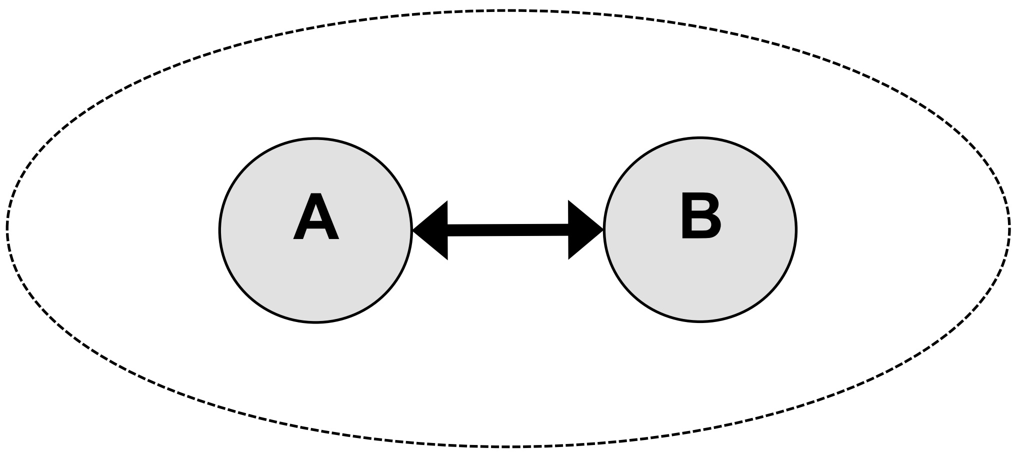
Consider the motion of two objects during a short time interval while they exert forces on each other.

Momentum change?

Impulse-momentum theorem!

$$\Delta\vec{p}_A = \vec{F}_{B\to A}\Delta t$$

$$\Delta\vec{p}_B = \vec{F}_{A\to B}\Delta t$$



Add and use N3!

$$\Delta\vec{p}_A + \Delta\vec{p}_B = \vec{F}_{B\to A}\Delta t + \vec{F}_{A\to B}\Delta t = (\vec{F}_{B\to A} + \vec{F}_{A\to B})\Delta t = 0$$

Momentum Conservation!

Simplest example:

Consider the motion of two objects during a short time interval while they exert forces on each other.

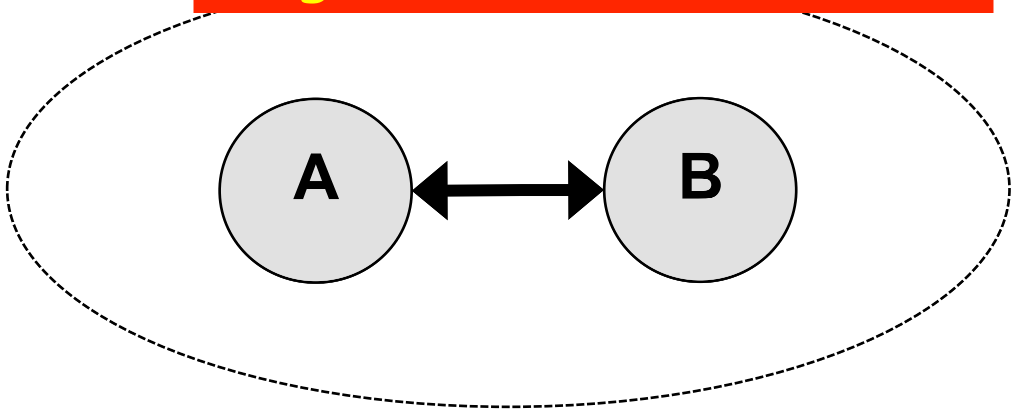
KE change?

Work-energy theorem!

They may each be moving so although the times are the same, the distances might NOT be!

$$\Delta KE_A = \vec{F}_{B\to A} \cdot \Delta\vec{r}_A$$

$$\Delta KE_B = \vec{F}_{A\to B} \cdot \Delta\vec{r}_B$$



Add and use N3!

$$\Delta KE_A + \Delta KE_B = \vec{F}_{B\to A} \cdot \Delta\vec{r}_A + \vec{F}_{A\to B} \cdot \Delta\vec{r}_B$$

$$= \vec{F}_{B\to A} \cdot \left(\Delta\vec{r}_A - \Delta\vec{r}_B\right) \neq 0$$

??!

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Foothold ideas: Potential Energy

- For some forces between objects (gravity, electricity, springs) the work only depends of the change in relative position of the objects. Such forces are called *conservative*.
- For these forces the work done by them can be written

$$\vec{F} \cdot \Delta\vec{r}_{rel} = -\Delta U$$

- *U* is called a *potential energy* and can be considered an *energy of place belonging to the two objects that can be exchanged with KE.*

Foothold ideas: Potential Energy

- For some forces work only depends on the change in position. Then the work done can be written $$\vec{F} \cdot \Delta\vec{r} = -\Delta U$$

  U is called a *potential energy*.

- For gravity, $U_{gravity} = mgh$

  For a spring, $U_{spring} = \frac{1}{2} kx^2$

  For electric force, $U_{electric} = k_C Q_1 Q_2 / r_{12}$