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: $F \cdot \Delta x$ or $F \cdot \Delta r$ (part of force || to displacement)
- Work-energy theorem: $\Delta (\frac{1}{2}mv^2) = F \cdot \Delta r$ (small step)
- $\Delta (\frac{1}{2}mv^2) = \int F \cdot dr$ (any size step)

Foothold ideas: Potential Energy

- The work done by some forces only depends on the change in position. Then it can be written $\vec{F} \cdot \Delta \vec{r} = -\Delta U$
- $U$ is called a potential energy.
- For gravity, $U_{\text{grav}} = mgh$
- For a spring, $U_{\text{spring}} = \frac{1}{2} kx^2$
- For electric force, $U_{\text{electric}} = k \frac{Q_1 Q_2}{r_{12}}$
- Potential to force: $\vec{F} = -\frac{\Delta U}{\Delta x} = \left( \frac{\partial U}{\partial x} \right) \hat{i} + \left( \frac{\partial U}{\partial y} \right) \hat{j} + \left( \frac{\partial U}{\partial z} \right) \hat{k} - \vec{\Phi}$

The force associated with a PE at a given place points “downhill” – in the direction where the PE falls the fastest.
Reading questions

- I guess I don't understand why we say energy is thermal if we are looking at macroscopic objects, but we differentiate for microscopic objects with respect to each individual energy type. Doesn't it matter in macro too?
- I am confused about the definitions of chemical and thermal energies. If they are both types of combos of kinetic and potential energy, why are they considered micro rather than macro?

Foothold ideas:
Kinds of Energy and the 1st Law

- It's all KE and PE of something!
  But we suppress it into “black boxes” if we don’t want to talk about some degrees of freedom.
  - Thermal
  - Chemical
- First law of thermodynamics
  - Conservation of total energy but ...
  - What matters is how it divides and moves from one form to another and from one system to another.

Connection between $\Delta U_{int}$ and $\Delta E$

$$E = KE + PE + U_{int}$$
$$\Delta E = \Delta(KE) + \Delta(PE) + \Delta U_{int}$$

$$\Delta U_{int} = \dot{Q} + W$$