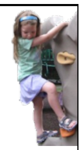
January 28-30, 2013 Physics 132 Prof. E. F. Redish

- **Theme Music:** **Earth, Wind, & Fire**
  Energy

Cartoon: **Bob Thaves**
Frank & Ernest

1/30/13 Physics 132 1

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: $\Delta(\frac{1}{2}mv^2) = F_{||}^{net}\,\Delta r$ (small step)

  $\Delta(\frac{1}{2}mv^2) = \int_i^f F_{||}^{net}\,dr$ (any size step)

1/30/13 Physics 132 4

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, $U_{gravity} = mgh$
  For a spring, $U_{spring} = \frac{1}{2}kx^2$
  For electric force, $U_{electric} = k_C Q_1 Q_2 / r_{12}$
- Potential to force: $\vec{F} = -\frac{\Delta U}{\Delta\vec{r}} = -\left(\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j} + \frac{\partial U}{\partial z}\hat{k}\right) = -\vec{\nabla}U$

  The force associated with a PE at a given place points "downhill" – in the direction where the PE falls the fastest.

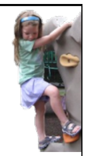
1/30/13 Physics 132 5

Reading questions

- I guess I don't understand why we say energy is thermal is 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?

1/30/13 Physics 132 **6**

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.

1/30/13 Physics 132 **7**

Connection between ΔU_{int} and ΔE

Coherent energy
Kinetic and potential

Internal energy: motion of stuff we don't want to talk about

$$E = \underbrace{KE + PE}_{\text{Coherent energy: Kinetic and potential}} + U_{\text{int}}$$

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

Energy of System (not moving coherently)

Thermal energy Entering system

Work done on system

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

1/30/13 **8**