- Last Lecture
  - Potential Energy examples
- Today
  - Potential Energy diagrams, Potential Energy of springs
- Important Concepts
  - Don't double count by including a force in both the Work and the Potential Energy.
  - Don't forget to include the Work term (it is only zero under special conditions).

Important Reminders

- Exam #2 is this Friday at 10 am.
  - Covers material through last Thursday's lecture, last Friday's problem-solving and Pset, and yesterday's MasteringPhysics assignment
- Q&A review session Thur, 7-8:30pm
- Experiment #4 will be done today

Calculating Potential Energy

- For simplicity, the Potential Energy itself (as opposed to the ***difference***) is always defined relative to some reference point where the potential energy is defined to be zero. The location of this point is totally arbitrary because only the change in potential energy is ever important.

$$\text{Define (arbitrarily)} \quad PE(\text{at point A}) = 0$$

$$\text{Then: } PE(\text{at point B}) = -\int_{A}^{B} \vec{F} \bullet d\vec{s}$$

Potential Energy Diagrams

- PE as a function of position:

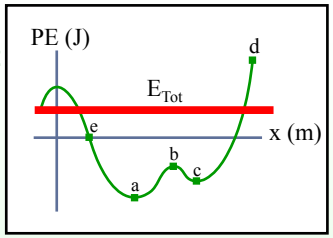

Figure by MIT OCW.

- If there are no other forces doing non-zero Work, then the total energy is a flat line on this plot.
- And the KE is the difference (see next slide).
  - $KE=E_{Tot}-PE$

Potential Energy Diagrams

KE=E_{Tot}-PE

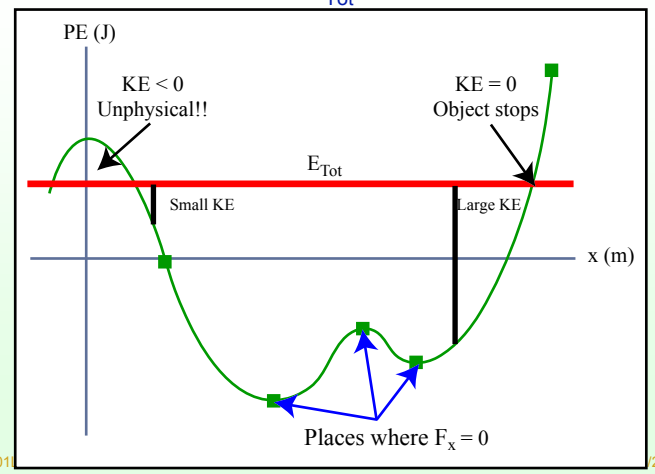

Figure by MIT OCW.

Potential Energy of Springs

- The force is: $\vec{F} = -k(\vec{l} - \vec{l}_o)$
- So the PE is: $PE(L) = -\int_{l_0}^{L} -k(l - l_0)dl = +\frac{1}{2}k(L - l_0)^2$
- Note: We define PE=0 at the unstretched length l_0

Vertical Spring plus Gravity

- Let PE=0, h=0, and y=0 at the unstretched position

$$PE(y) = +\frac{1}{2}k(y)^2 + mgy$$

- Now something strange happens…

$$PE(y) = +\frac{1}{2}k(y)^2 + mgy = \frac{1}{2}k\left(y + \frac{mg}{k}\right)^2 - \frac{m^2g^2}{2k}$$

- Another parabola but offset in y and in PE scale
  - "l_0" is $-mg/k$, the point where the spring and gravity exactly balance to give zero total force

Summary

- Potential energy diagrams can be a useful tool for conceptual understanding of some energy problems
- Minima and maxima of the PE correspond to F=0, which are equilibrium points. PE minima are stable equilibrium points, maxima are unstable.
- For springs $PE(L) = +\frac{1}{2}k(L - l_0)^2$
- Except for this formula, springs introduce no new concepts to the Work/Energy formalism but sometimes unexpected results appear