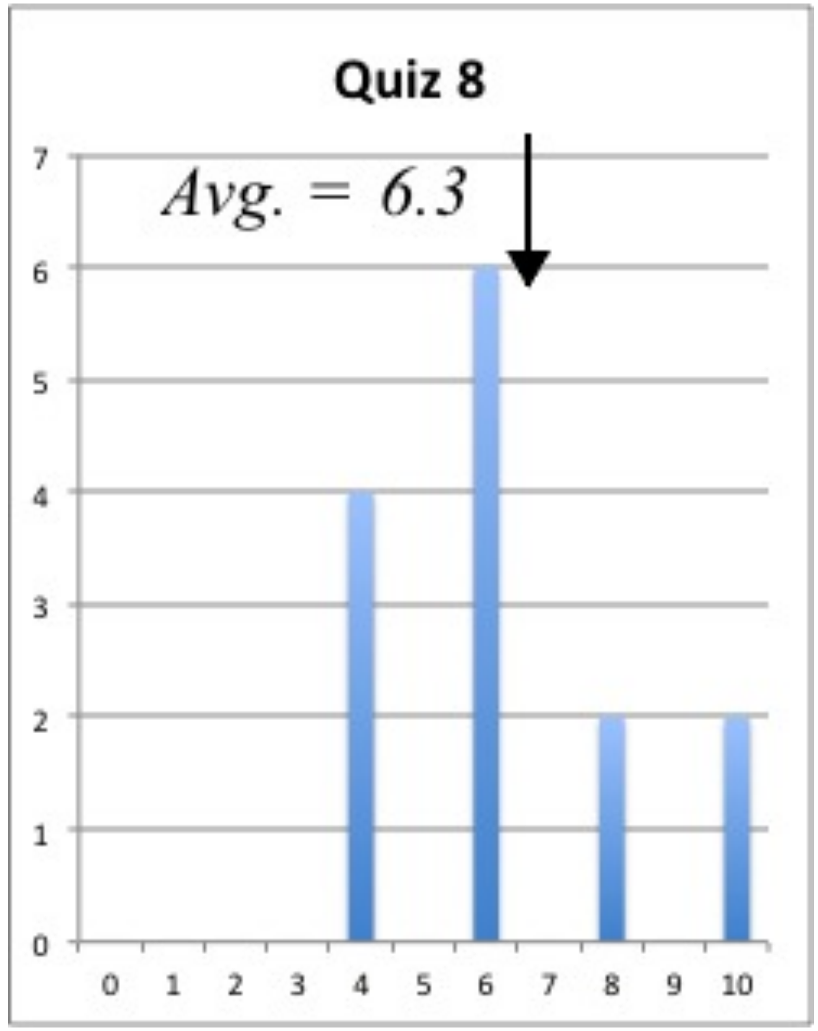
- **<u>Theme Music:</u>**
  Java Jazz
  Universal Law
- **<u>Cartoon:</u>**
  Gary Larson
  The Far Side

"Hey! What's this, Higgins? Physics equations?... Do you enjoy your job here as a cartoonist, Higgins?"

Quiz 8

	1.1	1.2	2.1	2.2		2.3
A	21%	0%	**93%**	**57%**	**1**	14%
B	7%	**29%**	7%	14%	**2**	**50%**
C	**79%**	**79%**	7%	21%	**4**	7%
D	0%	0%	0%	14%	**16**	**29%**



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

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*.

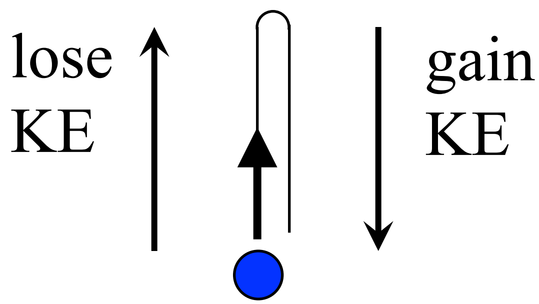
- For gravity, $U_{gravity} = mgh$

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

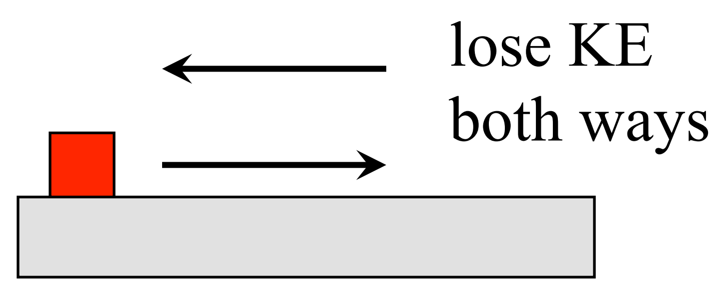
  For electric force, $U_{electric} = k_C Q_1 Q_2 / r_{12}$

Conservative forces

- Forces (like gravity or springs) are conservative if when the force takes KE away, you can get it back when you go back to where you started.
- If the kinetic energy that a force takes away <u>can't</u> be restored by going back to where you started it is called non-conservative.
- Compare gravity and friction:



Gravity: Conservative



Friction: Non-Conservative

Non-conservative forces/situations

- Friction / drag
  - Three kinds of forces drain ME: friction (indep. of v), viscosity (prop. to v), drag (prop. to v^2)
- Breaking / crushing
  - Normal forces are typically springy and conservative.
  - If an object is deformed too much, the structure can change (break) and drain ME.
- Chemical reactions
  - Chemical structure is another kind of potential energy that can be stored. It can create or drain ME.

Dimensions and Units of Energy

- $[1/2\ mv^2] = M\text{-}(L/T)^2 = ML^2/T^2$
- 1 kg-m^2/s^2 = 1 N-m = 1 Joule
- Other units of energy are common (and will be discussed later)
  - Calorie
  - eV (electron Volt)
  - erg (=1 g-cm^2/s^2)

Power

- An interesting question about work and energy is the rate at which energy is changed or work is done. This is called *power*.

$$\text{Power} = \frac{\text{Energy change}}{\text{time to make the change}}$$

$$= \frac{\Delta W}{\Delta t} = \vec{F}^{net} \cdot \frac{\Delta \vec{r}}{\Delta t} = \vec{F}^{net} \cdot \vec{v} \quad \text{(for mechanical work)}$$

- Unit of power

1 Joule/sec = 1 Watt

Foothold ideas: Conservation laws

- Momentum
  - The momentum of a system of objects is conserved IF the external forces acting on them cancel.

$$\Delta\left(\sum_{n=1}^{N}\vec{p}_n^{\,initial}\right)=0$$

$$\sum_{n=1}^{N}\vec{p}_n^{\,initial}=\sum_{n=1}^{N}\vec{p}_n^{\,final}$$

- Mechanical energy
  - The mechanical energy of a system of objects is conserved IF resistive forces can be ignored.

$$\Delta(KE+PE)=0$$

$$KE_{initial}+PE_{initial}=KE_{final}+PE_{final}$$