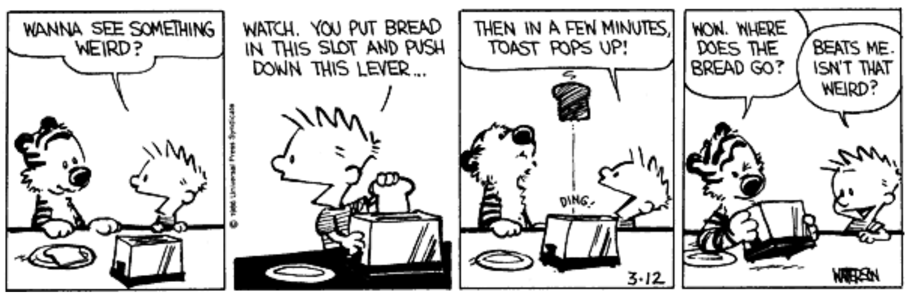
November 2, 2011 Physics 131 Prof. E. F. Redish

- **<u>Theme Music:</u> Cannonball Adderly**

  Work Song

- **<u>Cartoon:</u> Bill Watterson**

  Calvin & Hobbes



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Outline

- Go over Quiz 7
- The Work-Energy Theorem along a line
- The dot product
- The general Work-Energy Theorem

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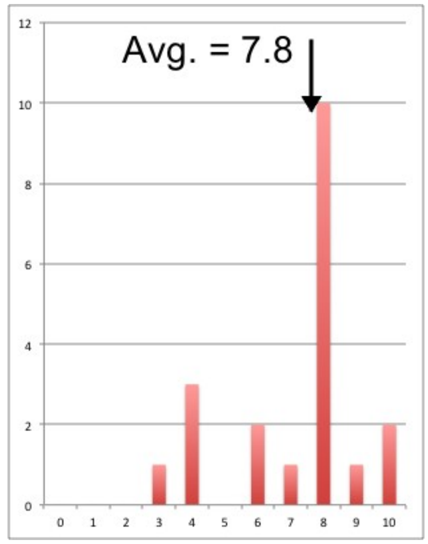
Quiz 7

	7.1		7.2		7.3
b=c>a>d	10%	d>c>b>a	50%	a	95%
a>b>c>d	20%	d>c=b>a	45%	b	5%
a=b=c>d	5%	a=b=c=d	5%		
d>c>b>a	20%				
b=c=d>a	35%				
a=b=c=d	5%				
c>b>a>d	5%				



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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: $\Delta(\frac{1}{2}mv^2) = F^{net}\ \Delta x$

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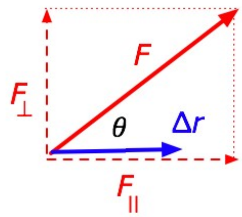
Work in another direction: The dot product

- Suppose we are moving along a line, but the force we are interested in in pointed in another direction? (How can this happen?)
- Only the part of the force in the direction of the motion counts to change the speed (energy).



Work $= F_{\parallel}\,\Delta r = F\cos\theta\,\Delta r \equiv \vec{F}\cdot\Delta\vec{r}$

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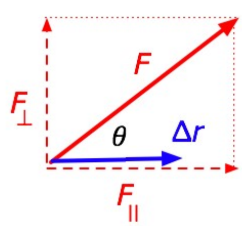
Dot products in general

$$F_{\parallel}\,\Delta r \equiv \vec{F}\cdot\Delta\vec{r} \qquad \vec{F}\cdot\Delta\vec{r} = F\cos\theta\,\Delta r$$

In general, for any two vectors that have an angle q between them, the dot product is defined to be

$$\vec{a}\cdot\vec{b} = ab\cos\theta$$

$$\vec{a}\cdot\vec{b} = a_x b_x + a_y b_y$$



The dot product is a scalar.
Its value does not depend on the coordinate system we select.

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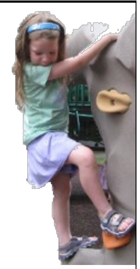
Foothold ideas: Potential Energy



- For some forces (gravity, springs) work only depends of the change in position. Such forces are called <u>conservative</u>.
- For these forces the work done by them is written

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

- *U* is called a *potential energy*.
- For gravity, $U_{gravity} = mgh$

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Mechanical

A~~n~~ Energy Conservation Theorem

- Suppose the only force that has a component along the direction of motion is gravity.
  - The only force that changes the object's speed is gravity.
  - Other forces (normal forces) can change direction.
  - Friction must be negligible.
- Examples:
  - free fall
  - object rolling on a track.

$$\Delta(\tfrac{1}{2}mv^2 + mgh) = 0$$

$$\tfrac{1}{2}mv_i^2 + mgh_i = \tfrac{1}{2}mv_f^2 + mgh_f$$

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