

October 21, 2010

Physics 121

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■ Theme Music: Cannonball Adderly

The Work Song

■ Cartoon: Pat Brady

Rose is Rose

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Outline

■ Go over Quiz 5

■ Energy

■ The Work-Energy Theorem

■ Example: Gravity

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Quiz 5


	a	b	c	d	e	f
5.1	38%	39%	90%	68%	1%	0%
5.2	52%	7%	4%	95%	10%	16%
5.3	26%	66%	1%	6%	0%	0%
5.4	23%	60%	7%	10%	0%	0%

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Energy



- N2 tells us that a force can change an object's velocity in one of two ways:
 - It can change the speed
 - It can change the direction
- Analyzing changes in speed leads us to study energy.
- Analyzing changes in direction leads us to study rotations.

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Kinetic Energy and Work

- Consider an object moving along a line feeling a single force, F . When it moves a distance Δx , how much does its speed change?

$$a = F^{net} / m$$

$$\frac{\Delta v}{\Delta t} = \frac{F^{net}}{m}$$

$$\frac{\Delta v}{\Delta t} \Delta x = \frac{F^{net}}{m} \Delta x$$

$$\Delta v \frac{\Delta x}{\Delta t} = \frac{F^{net} \Delta x}{m}$$

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$$\Delta v \frac{\Delta x}{\Delta t} = \frac{F^{net} \Delta x}{m}$$

$$\langle v \rangle \Delta v = \frac{F^{net} \Delta x}{m}$$

$$\frac{v_i + v_f}{2} (v_f - v_i) = \frac{F^{net} \Delta x}{m}$$

$$\frac{1}{2} (v_f^2 - v_i^2) = \frac{F^{net} \Delta x}{m}$$

$$\frac{1}{2} m (v_f^2 - v_i^2) = F^{net} \Delta x$$

Definitions:

Kinetic energy = $\frac{1}{2} mv^2$

Work done by a force $F = F \Delta x$

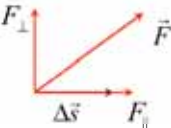
Result

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

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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 is 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 = $F_{\parallel} \Delta s = F \cos \theta \Delta s \equiv \vec{F} \cdot \Delta \vec{s}$

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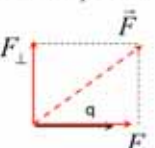
Calculating dot products

$F_{\parallel} \Delta s \equiv \vec{F} \cdot \Delta \vec{s} \quad \vec{F} \cdot \Delta \vec{s} = F \cos \theta \Delta s$

In general, for any two vectors that have an angle θ 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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Example: Gravity

- Whenever we have a force we can see what work it does.
- Consider our work-energy result for a special case: **free-fall** (only force is gravity).

$$\begin{aligned} \Delta\left(\frac{1}{2}mv^2\right) &= \vec{F}^{net} \cdot \Delta \vec{s} \\ &= m\vec{g} \cdot \Delta \vec{s} \\ &= -mg \Delta h \end{aligned}$$

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Potential Energy: Gravity

- Since the work term also looks like a change, we can bring it to the left and get a conservation law.

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

$$U_g = mgh$$

- We interpret the quantity mgh as a new kind of energy — gravitational potential energy.

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Conservation Laws

- A conservation law is a statement that, under certain conditions, something that can be measured or calculated doesn't change, even though the numbers that go into calculating it might.
- Such laws are extremely valuable in figuring out motions.

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An 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.

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

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

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