

November 21, 2012

Physics 131

Prof. E. F. Redish

■ **Theme Music:****Java Jazz***Universal Law*■ **Cartoon:****Gary Larson***The Far Side*

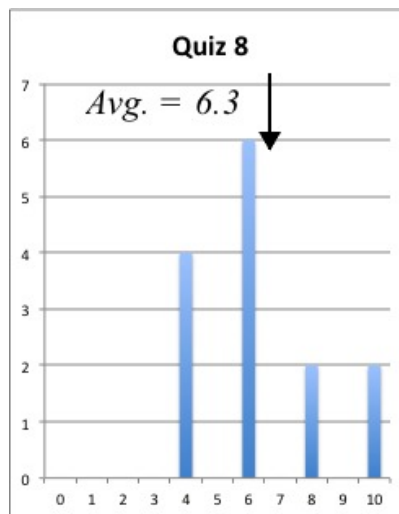
"Hey! What's this, Higgins? Physics equations?... Do you enjoy your job here as a cartoonist, Higgins?"

11/21/12

Physic

## 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%



11/21/12

Physics 131

3

## 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  $F_{\parallel}\Delta r$   
(part of force  $\parallel$  to displacement)
- Work-energy theorem:  $\Delta(\frac{1}{2}mv^2) = F_{\parallel}^{net} \Delta r$

11/21/12

Physics 131

4

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

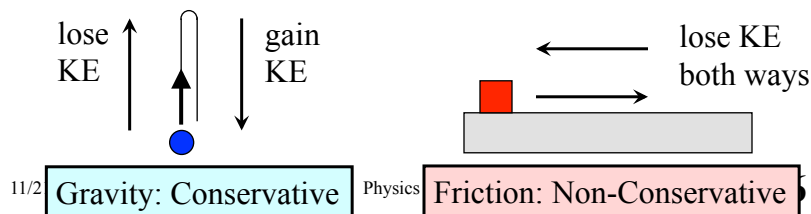
11/21/12

Physics 131

5

## 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 can't be restored by going back to where you started it is called non-conservative.
- Compare gravity and friction:



## 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

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



11/21/12

Physics 131

8

## 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

$$1 \text{ Joule/sec} = 1 \text{ Watt}$$

11/21/12

Physics 131

9

## 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.

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

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



11/21/12

Physics 131

**10**