Announcements

1. **Exam 1 occurred…**
   a. Exams should be in the cubbyhole boxes near N357 ESC, sorted by the first two digits of your CID.
   b. Solutions will be posted in glass case in hallway near room N361, ESC.
   c. If you have questions on the exam, please look over your own exam and the exam solutions before seeing me.

Energy Review

$W = F_{//} \Delta x$

$E_{before} + W_{net} = E_{after}$

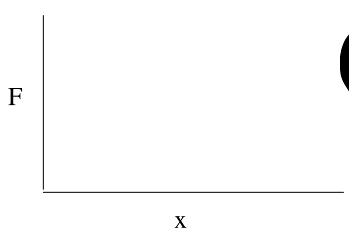
"E" includes each object's *total* energy (both kinetic & potential)

"W_{net}" includes the work done by all forces for which you don't have a potential energy formula

→ Can have multiple work terms in eqn, both positive and negative

Extremely useful in "before" vs. "after" type problems—when you don't need to know the intermediate details (like what the position/velocity is at particular times, the total time it takes, etc.)

Springs



Hooke's Law:

$F_{spring} = -kx$ (negative sign: force pulls/pushes back to equilibrium)

Work done to compress or stretch:

Defn of work: $W = F \Delta x$
→ but can't use; F is changing!

Better equation: (from calculus)

$PE_{spring} = ½ kx^2$ (Where is x=0?)

Then use conservation of energy to find work

Demo: springs and k

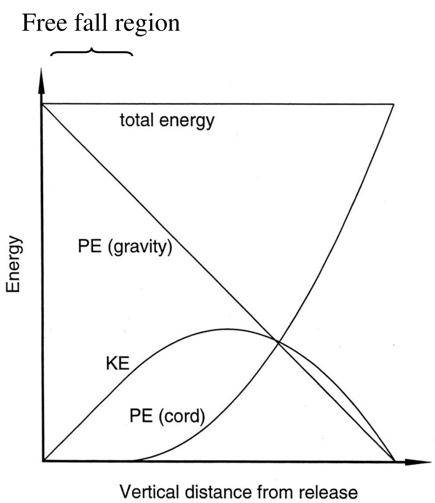
Q4. If a spring is compressed by 20 cm, the work done in the first 10 cm is:
a. less than
b. the same as
c. more than
the work done in the last 10 cm.

Bungee jumping

Demo: Bungee jump

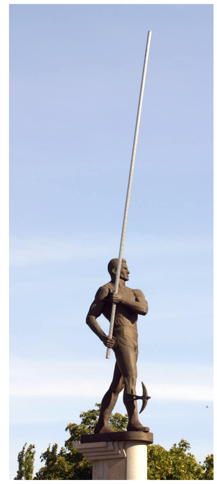
Video: Bloukrans River Bridge, South Africa (216 m)
http://www.youtube.com/watch?v=0HJz5KJmzW4
at 2:20

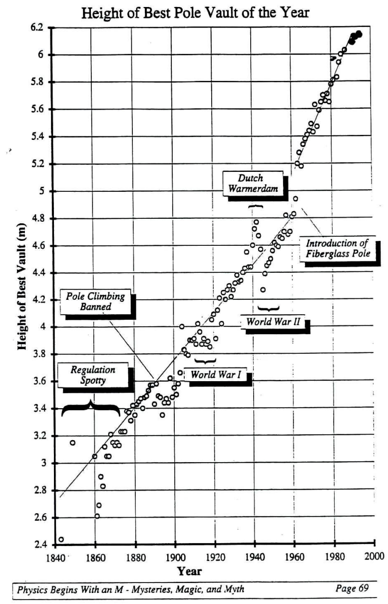
Video: Royal Gorge Bridge, Colorado (321 m)
http://www.youtube.com/watch?v=F9Wv_Lxe_QM



Pole Vaulting

Video: slow motion pole vault





Record (1994) Sergey Bubka (Ukr)

h=6.14 m=20.15 ft.,

$KE_i = \Delta PE$?

$$\frac{1}{2}mv^2 = mgh \qquad h = \frac{v^2}{2g}$$

Record sprint speed: v~10 m/s → **h~5.1 m**

Where does the extra height come from?

Nonconservative forces and **energy conservation**

"Mechanical energy": KE + PE

Other forms of energy

Where does frictional work go? Microscopic picture:

Worked Problem

Fred, 50 kg (including ice), goes ice-blocking on the grass. Starting from rest he rides 40 m down a hill which has a 20° slope. $\mu_k = 0.2$ between the ice and grass. On the way down, Fred pushes with his hands with an average force of 5 N forward along the slope.

(a) What is his speed at the bottom?

(b) How far will will he go horizontally after he reaches the bottom? (Fred stops pushing at the bottom)

Power!

The rate at which energy is produced or consumed

$$P = \frac{\Delta E}{\Delta t}$$

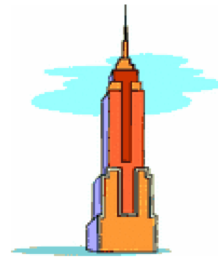
SI units: 1Watt = 1 J/s = 1 N·m/s = 1 kg·m^2/s^3 (I think! ☺)

1Horse-power=746 W

Or… (equivalently)

Power is the rate at which work is being done

$$P = F \cdot v$$



Empire state building:
Height: 1,250 feet, 443 meters
Stories: 102
There are 1,575 steps from the building's lobby to the 86th floor (374 m). Paul Crake holds the record for racing these steps in 10 minutes, 15 seconds.

What average power did he expend against gravity?
(Assume m=80 kg)

From work:

From velocity:

Demo: weight and light bulb

A car weighing 3000 N moves at a speed of 30 m/s on level ground. To do this, it pushes backwards on the road with a 5000 N force.

Q5. What is the power output of the car engine?
- a. 5 kW
- b. 60 kW
- c. 90 kW
- d. 150 kW
- e. 240 kW

→ Where does this power go if the car moves at constant speed?

Switchbacks on mountain roads (consider only work done against gravity):

Q6.
- a. Increase the work needed to go up a mountain
- b. Decrease the work needed to go up a mountain
- c. Keep the work needed the same

Q7. …and they:
- a. Increase the power needed to go up a mountain
- b. Decrease the power needed to go up a mountain
- c. Keep the power the same

Q8. Did you discuss at least half of the discussion quiz questions today with a neighbor?
- a. Yes
- b. No