Announcements

1. **Exam 2 is coming up!**
   a. Next lecture is exam review
      i. No reading assignment or warmup quiz
   b. Exam begins Tues Oct 7, 10:15 am
   c. Exam ends Mon Oct 13, end of day
      i. Late fee if you pick up your exam after 5 pm
   d. Covers Chapters 4 & 5, Homeworks 4-8

Note: I consider all exams to be **cumulative**!

That is: problems where you use Newton's 2nd Law to find acceleration then kinematics equations to find more details, are fair game.

2. Results of **Table Tennis tournament**

Energy Review

$\mathbf{W = F_{//}\,\Delta x}$ Work done by a force on an object

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

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

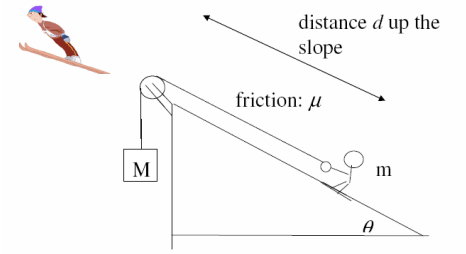
"W_{net}" includes the work done by all forces for which you don't have a potential energy formula
→ Can have multiple work terms in eqn, both positive and negative

Bank balances…

Tip: Draw "before" and "after" pictures

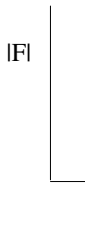
Pulley ski jumping, revisited

What is the speed just at takeoff?



Use conservation of energy: $E_{bef} + W_{net} = E_{aft}$

Springs



Hooke's Law: Proportionality factor k = "spring constant"

$F_{spring} = -kx$ (negative sign: force acts opposite displacement: it pulls/ pushes back to resting point)

Work done to compress or stretch:

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

Better equation: (from calculus)

$PE_{spring} = \frac{1}{2}\,kx^2$ (Question: where is x=0?)

Then use conservation of energy to find work

Clicker quiz: 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.

Hint: two ways to think about this

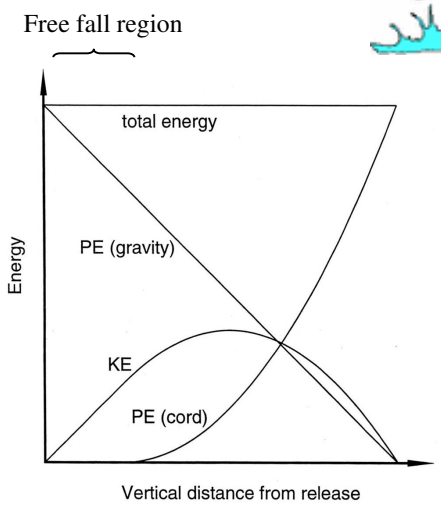
1. Think of change in energy
2. Think of average force during the compression

Demo Problem: A spring stretches _____ cm when a _____ kg mass is added. What is the spring constant k?

Bungee jumping

Demo: Bungee jump (?)

Video: Royal Gorge Bridge, Colorado (321 m)
http://www.youtube.com/watch?v=8zSY9mQ8zvY



Nonconservative forces

"Mechanical energy": KE + PE

→ What happens when you put the brakes on in your car?

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 also brakes with his hands with an average force of 5 N backwards 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 braking at the bottom)

Clicker quiz: Fred goes down a hill with friction, no braking. The total vertical change is 20 m. How does his speed at the bottom of a 20° slope compare to his speed at the bottom of a 30° slope?

a. 20° would be faster
b. 30° would be faster
c. same speed at bottom

Demo problem: What is the spring constant of the spring inside the "cannon cart"?

Power!

The rate at which energy is produced or consumed

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

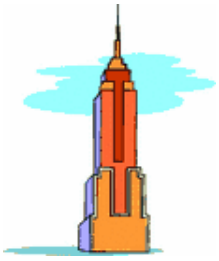
SI units: 1Watt = 1 J/s = 1 N·m/s = 1 kg·m^2/s^3 (I think! ☺)

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.

Clicker quiz: What is the power output of the car engine?

a. 0 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):

Clicker quiz:

a. They increase the work needed to go up a mountain
b. They decrease the work needed to go up a mountain
c. They keep the work needed the same

Clicker quiz:

a. They increase the power needed to go up a mountain
b. They decrease the power needed to go up a mountain
c. They keep the power the same