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# Physics 140 – Fall 2007

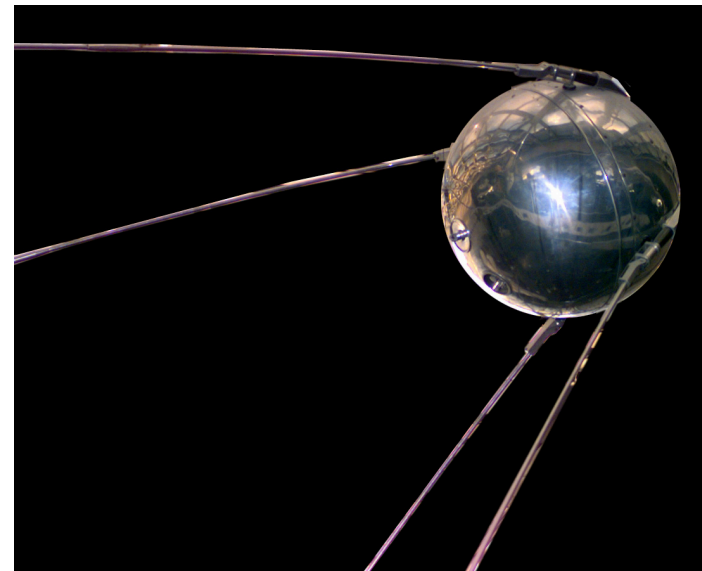
lecture #10 : 4 Oct

## Ch 7 topics:

- potential energy
- mechanical energy
- first midterm exam is **TONIGHT, 6:00-7:30 pm**

*Happy 50th Anniversary  
Sputnik!*

check out the  
[New York Times  
Special Science Section](#)

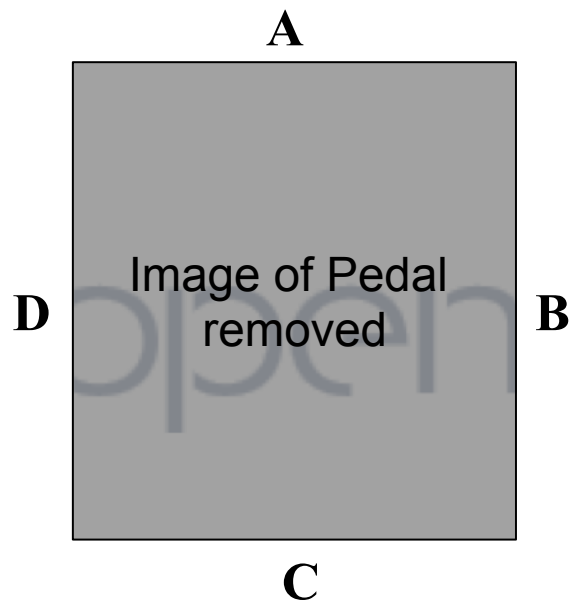


Source: NASA

## **Where are you from?**

### **You are from**

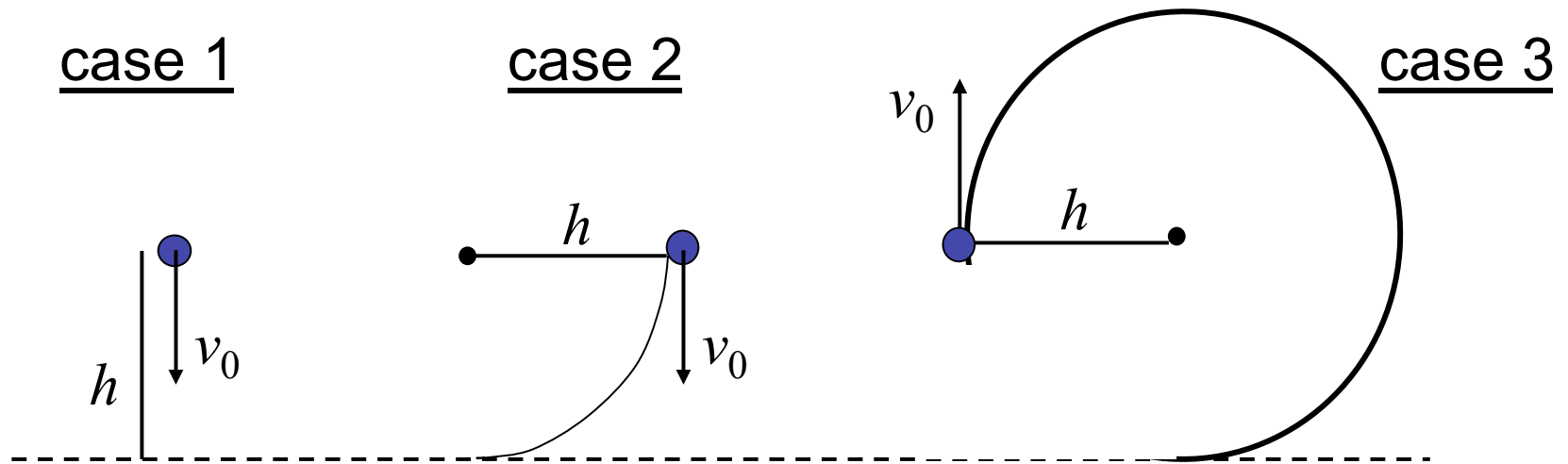
- 21 : Ann Arbor**
- 237 : Michigan palm**
- 6 : Michigan UP**
- 94 : USA(outside MI), E of Mississippi river**
- 35 : USA(outside MI), W of Mississippi river**
- 29 : Outside USA**
- 1 : Saturn**
- 422 : total**



From "Training the Olympic Athlete"  
by J. Kearney, Sci American, June 1996, p55.

The arrows in this graphic give the force exerted on the left pedal of a test bicycle by seven-time Tour de France winner Lance Armstrong. Assuming that the pedal cadence (or spin rate) is nearly constant, rank the points labeled by the power applied at those locations, **least to greatest**

1. A, D, C, B
2. A, D, B, C
- 3. D, A, C, B
4. D, C, B, A
5. A, B, C, D



Consider the motion of a ball thrown with initial velocity  $v_0$  in the three cases shown: 1. thrown straight down; 2. tied to a string and launched downward or 3. upward. After the balls have dropped a height  $h$  from their initial positions (after traversing circular arcs in cases 2 and 3), how do their kinetic energies of this case compare?

- 1) KE (case 3) > KE (case 2) = KE (case 1)
- 2) KE (case 3) < KE (case 2) = KE (case 1)
- 3) KE (case 3) = KE (case 2) = KE (case 1)
- 4) KE (case 3) = KE (case 2) > KE (case 1)

## Conservative forces and potential energy

A conservative force:

- does work that depends only on the endpoints of the displacement, not the path taken from the initial to final states.
- is reversible – the change in kinetic energy ( $\Delta K$ ) due to work over a certain displacement can be completely recovered by reversing the displacement (*it's like running time backwards*).
- has associated with it a potential energy ( $\Delta U = -W$ ) that measures the work **available** by that force as a function of displacement.

**Gravity** and the **spring force** are examples of conservative forces.

For near-Earth gravity, taking +y as upward, the change in potential energy of a mass  $m$  displaced from  $r_i$  to  $r_f$  with vertical separation  $y = y_f - y_i$  is

$$\Delta U = -W_{\text{grav}} = mgy,$$

which is the *opposite* of the gravitational work done ( $W_{\text{grav}} = -mgy$ ).

Why bother with potential energy as “the negative of the work”?

Because, under many circumstances, the sum of kinetic and potential energies remains fixed, leading to a formal statement of mechanical energy conservation.

### **Conservation of Mechanical Energy**

When *only conservative forces act* on a system, then the sum of kinetic and potential energies, the *mechanical energy*,  $E_{\text{mec}}$ , remains constant in time (is conserved) for that system.

$$E_{\text{mec}} = K + U = \text{constant}$$

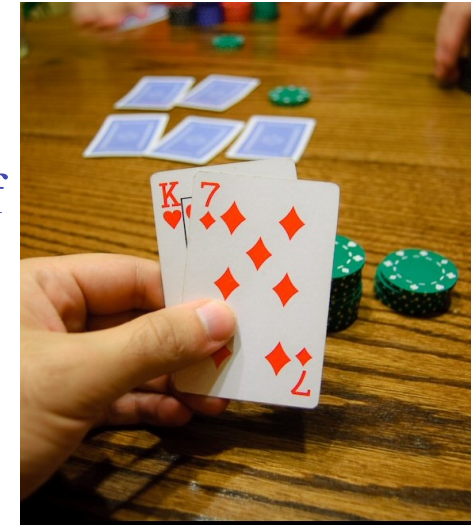
## The (Fair) Poker Game Analogy...

Consider a poker game involving two honest people (Art & Bev). Art brings an amount of cash  $C_A$  to the table and Bev brings  $C_B$ . Neither one cheats, so the total amount of money on the table over the course of the game is fixed

$$C_A + C_B = C_{\text{total}} \quad (\text{a constant; e.g., } \$280)$$

But over time, Art's loss is Bev's gain (and vice-versa)

$$\Delta C_A = -\Delta C_B \quad (\text{or } \Delta C_{\text{total}} = \Delta C_A + \Delta C_B = 0)$$



The principle of conservation of mechanical energy states that nature plays a similar “zero-sum” game. When only conservative forces act, the mechanical energy of a system is constant

$$\Delta E_{\text{mec}} = \Delta K + \Delta U = 0$$



Describe the systems listed as either *conservative* (C) or *non-conservative* (N). Ignore any possible air drag and include the Earth as implicit in systems involving gravity.

- I. A baseball flying in projectile motion.
- II. A roller coaster coursing a frictionless loop-the-loop track.
- III. A box sliding down a ramp with friction.
- IV. A window washer and platform ascending a building with a rope and set of frictionless pulleys (block and tackle).
- V. A salami oscillating on the end of a vertical, frictionless spring.

1. CCNCC
2. CNNCC
3. CCNNN
4. CCNNC
5. CCNCN



Tarzan, who weighs  $678\text{N}$ , swings from a cliff at the end of a convenient vine that is  $17.0\text{m}$  long (see the figure). From the top of the cliff to the bottom of the swing, he descends by  $3.2\text{m}$ .

If the vine doesn't break, what is the maximum of the tension in the vine?



The vine will break if the force on it exceeds  $806.2\text{N}$ . Does the vine break? If yes, at what angle (in deg) with respect to the vertical direction does it break (if no enter  $180.$  deg)?