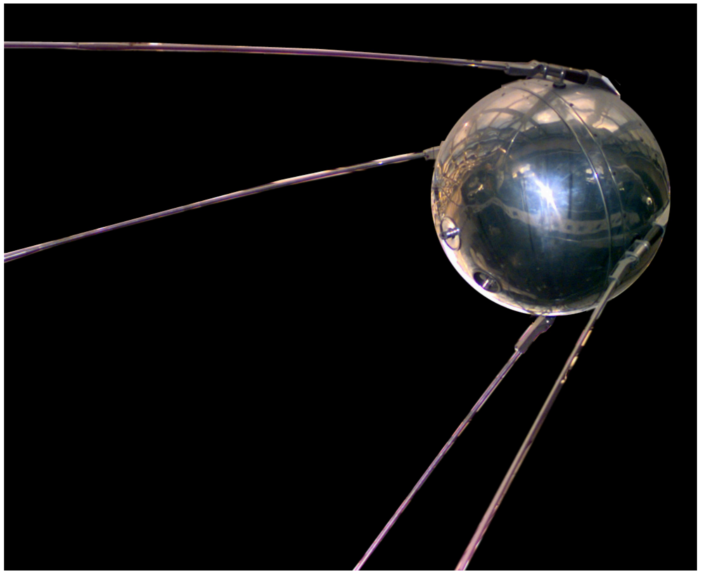
# Physics 140 – Fall 2007
lecture #10 : 4 Oct

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

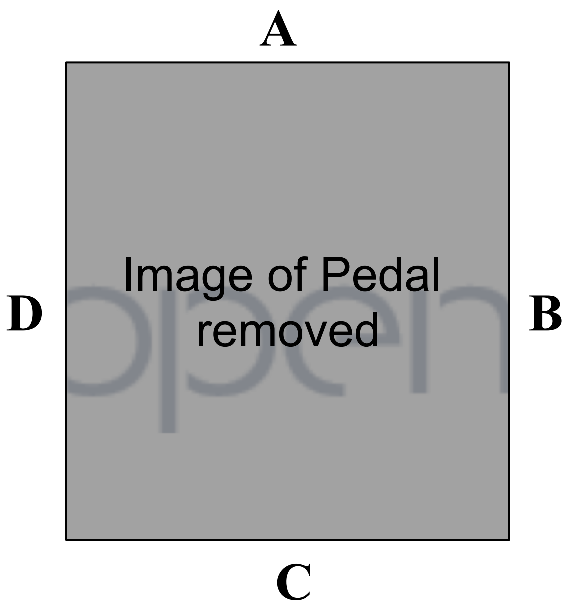


Source: NASA

## Where are you from?

**You are from**

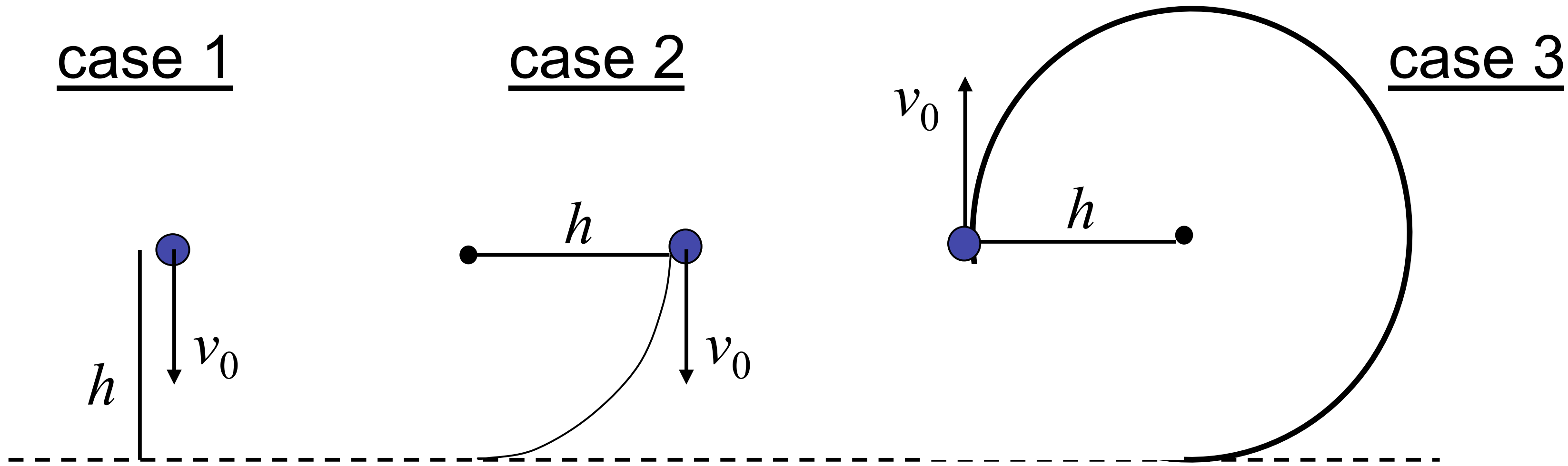
| | |
|---|---|
| 21 | Ann Arbor |
| 237 | Michigan palm |
| 6 | Michigan UP |
| 94 | USA(outside MI), E of Mississippi river |
| 35 | USA(outside MI), W of Mississippi river |
| 29 | Outside USA |
| 1 | Saturn |
| 422 | total |




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 (ΔK) 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 $\mathbf{r}_\mathrm{i}$ to $\mathbf{r}_\mathrm{f}$ with vertical separation $y = y_\mathrm{f} - y_\mathrm{i}$ is

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

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

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,*** $\boldsymbol{E_{\mathrm{mec}}}$, *remains constant in time (is conserved) for that system*.

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

## 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

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

But over time, *<u>Art's loss is Bev's gain</u>* (and vice-versa)

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

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

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

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

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 806.2N. 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)?