CSUC Spring Term 2020
Physics 204A sections 6, 7, 8

Lecture 3. for Week 9, March 23 – 29

This lecture presumes that you have read ***chapter 9*** *in your text. Remember, when we say "read" ... we mean read-read-read. Reading Physics is going to ruin your literature reading speed. Sorry!*

We start today's lecture with a sketch of the developing landscape of ideas we are following. Then we go directly to a set of illustrative problems.

1st: Ideas

- We are on a journey towards the "Conservation of Energy". The important thing to notice is that you don't get to "*add*" anything to Newtonian Mechanics! If energy or anything else is "*conserved*" … that thing has to be in there already. We just have to learn how to recognize it.

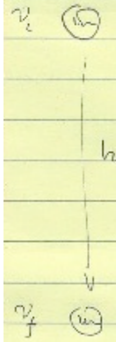
- The Work-Energy Theorem is ***where*** we will find the conservation of energy.

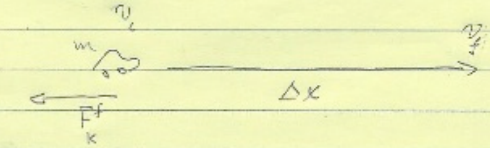
- We recognize, already, that kinetic energy i.e. $\frac{1}{2} m\, \vec{v}^2$ … is an expression for the energy "stored" in the motion itself.
- All further energy "storage expressions" for energy will be found in the W.E. Theorem. That's what comes next. All these new "storage expressions" will be called "Potential Energies" and there will be many of them.
- We are going to find an amazing "new use" for Newton's 3rd Law. Pay attention!
- In just a moment, we will find that all forces can classified into one or the other of only two categories. These will be the "Conservative Forces" and the "Non-Conservative Forces".
- A really new idea will be looking at "*Closed-Systems*" … rather than at just point masses.

2nd: Problems

Consider two simple problems illustrated in the following picture. They are almost the same problem in many ways. One is a falling point mass and the other is a car skidding to a halt. The significant forces are constant in both and we were able to use the W.E. Theorem directly to relate the speed at the end of the journey to that at the beginning. In the second set of pictures we change the setting just a little and difference in the two problems becomes apparent.

two possibilities:





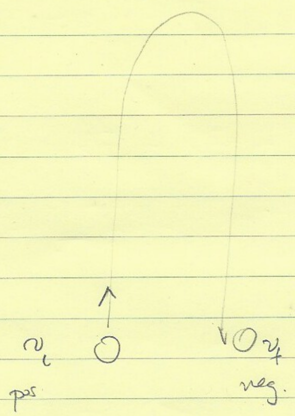
$$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = -|F_k^f|\,\Delta x$$

negative work.

$$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = mgh$$

positive work

#3)



$$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \int_i^f -mg\,dx$$

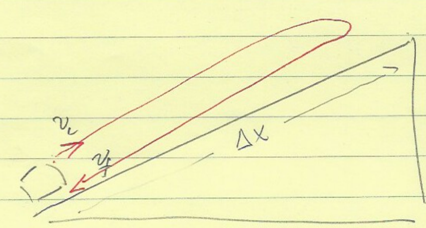
$$= -mg(x_f - x_i)$$

gravity always "gives it back"!

$$\frac{1}{2}mv_f^2 = \frac{1}{2}mv_i^2$$

(Friction never does!)

#4)



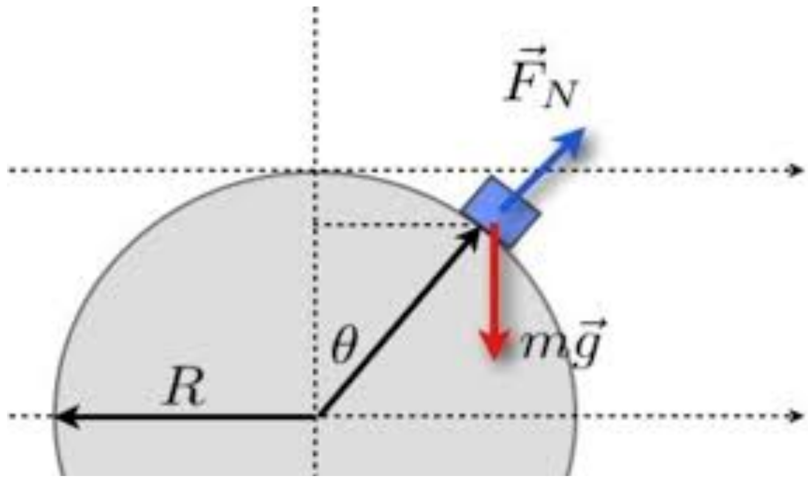
friction on the surface takes away energy.

not much change in the argument... but the final velocity is now different from the initial...?

What happened?

The subtle difference here is that friction isn't really a completely "constant" force! It changed *directions* on the way down from what it was on the way up (which gravity did **NOT** do!). And that made a huge difference in the outcome.

Next Problem:



A mass slides off a sphere without friction. You can imagine a skier on a slope or an ice cube sliding down a round surface. What's interesting here is the observation that at some point the mass leaves the surface … it simply flies off and becomes ballistic. When does that happen? Here we have to use two pieces of knowledge. First, while on the slope the mass is in circular motion. Second, the only force doing work here is gravity! Suppose we start at the top from rest. We are height R above the center. Later, our height is $R\cos(\theta)$. So we have dropped a distance $R - R\cos(\theta)$ and gravity has done work on the mass over that distance. How fast are we going ? Use the work energy theorem :

$$\frac{1}{2} m\, \vec{v}^2 = mg\{ R - R\cos(\theta)\}$$

But also, since we are in circular motion, we must have $ma_c = F_c$. So:

$$mv^2/_R = mg\cos(\theta) - N$$

Both equations are true. One is a force equation and one is an energy equation. Now as we descend … the velocity **in**creases … but $\cos(\theta)$ **de**creases. To balance the equation N must decrease too. At some point it simply goes to zero … we are air-borne. At that critical spot we must have:

$$\frac{1}{2} m\, \vec{v}^2 = mg\{ R - R\cos(\theta)\} \quad \text{and}$$

$$mv^2/_R = mg\cos(\theta)$$

But this means $2\{ 1 - \cos(\theta)\} = \cos(\theta)$ or $2 = 3\cos(\theta)$. Apparently, $\cos(\theta) = 2/3$ when the mass departs from the surface. The mass has dropped 1/3 of its total height. Who would have thought that such a simple and beautiful result was buried in there? But so it is. We needed the energy discussion to unlock it.