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

<u>Lecture Notes for Week 10, March 30 – April 5</u>

This lecture presumes that you have read ***chapter 10*** *in your text. Remember, when we say "read" ... we mean read-read-read. Reading Physics is going to ruin your literature reading speed. Sorry!*

1st: Ideas …Old Ones …<u>Again</u>!

• 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 <u>in there</u> 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: New Ideas

All forces "come from <u>somewhere</u>". They come from … ***"Force Sources"***. These are material objects like springs or ropes or the gravitational attractions of other masses etc. etc. We realize that it makes sense to view these Force Sources as entities upon which we can do work … and thus give energy to. This is the really new idea … the idea of systems. The Force Sources are actors that receive from us just as we receive from them. The idea of "Closed System" is that, if we can put a "dotted line" around a set of actors, then … if nothing crosses that line … the total amount of conserved quantity within must not have changed. It has to be in there somewhere. Someone has it. The new player in this discussion is the "Potential Function". It's as simple as saying that: "The potential function associated with any conservative force is the indefinite integral of that force over distance from some starting "reference point" to the physical point in question. Yeah, but that's a mouthful.

$$U(\vec{r}) - U(\vec{r_o}) \equiv -\int_{\vec{r_o}}^{\vec{r}} \vec{F} \cdot d\vec{r}$$

The really important … and subtle point … is that for Conservative Forces, this integral doesn't depend on the path taken between the end points. In 1-dimensional calculus, this isn't hard to grasp. In two and three dimensions it's not so easy. At this point we want to focus on the physics … so I'll leave that math discussion for a later time. The central thing to grasp is that $U(\vec{r})$ represents stored energy. We view the integral as a function of its upper limit. In any one problem it will always occur twice … once at the beginning of a state of affairs and once at the end. That is, only "differences" of potential energy ever have any physical meaning and consequently we will always see that $U(\vec{r_o})$ drops out of any physical problem. We learn to recognize forces by their force functions and now, also by their potential energy functions. In the end, the statement we will always work from is:

$$\left[\frac{1}{2} m\, \vec{v}^2 + U_{tot}(\vec{r})\right]_{final} - \left[\frac{1}{2} m\, \vec{v}^2 + U_{tot}(\vec{r})\right]_{init} = W_{non-con}$$

In this statement $W_{non-con}$ is the total non-conservative work that was done on the system in the passage from the initial state of affairs to the final one. $U_{tot}(\vec{r})$ means the sum total of the potential energy functions operating in our "System" evaluated at that position (either initial or final). Using this – our ultimate statement of "Mechanical Energy Truth" - will take a lot of practice! But you will come to prefer it to most other starting points for addressing most problems … *I promise you*!