<u>W O R K</u>

(L-10)

When a body moves under the influence of a *conservative force field*, the amount of work the field does on the body as it moves from one point to another is *path independent*. That is, no matter what path is taken between the two points, the amount of work done by the field is always the same. This lab is designed to verify that claim.

The *conservative force field* we will use in this lab is the force field associated with *gravity*. The two points we will deal with will be exactly *1 vertical meter apart* (because gravity is a constant near the earth's surface, it won't matter whether the points are at .5 meters and 1.5 meters from the ground or 1.5 meters and 2.5 meters from the ground--what is important is that the *net vertical displacement* is *one meter*).

Consider the following situation: You apply a force to a frictionless cart on an *incline plane* so that the cart rises a *net <u>vertical</u> distance* of one meter WITHOUT ACCELERATION (i.e., with constant velocity). In this case, there are only two *work-producing forces* acting on the cart--you and gravity (the *normal force* is perpendicular to the motion and, hence, does no work). Because the cart does *not pick up* or *lose* speed, the NET WORK done must be ZERO (the *work/energy theorem* maintains that if the *<u>change</u> of kinetic energy* is zero, the *net work* is zero). This, in turn, means that the work *you do* must be *equal and opposite* the work *gravity* does.

Bottom line: Given a *constant velocity*, if you can determine the work *you* do on the system, you will know how much work *gravity* does on the system. In lab, you will use these ideas to determine the amount of work gravity does on a cart as the cart rises *without acceleration* one vertical meter via three different devices: a dead lift; a pulley system; and an incline plane. Enjoy.

<u>PROCEDURE--DATA</u>

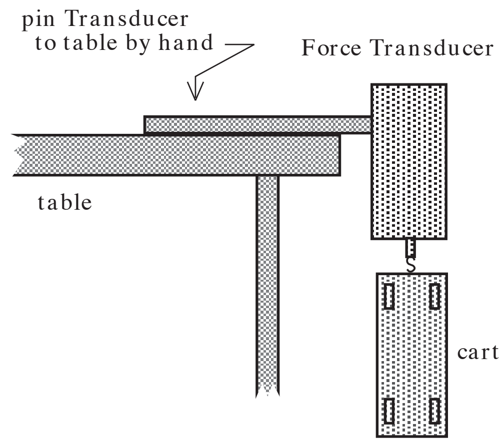
<u>Part A:</u> (setup)

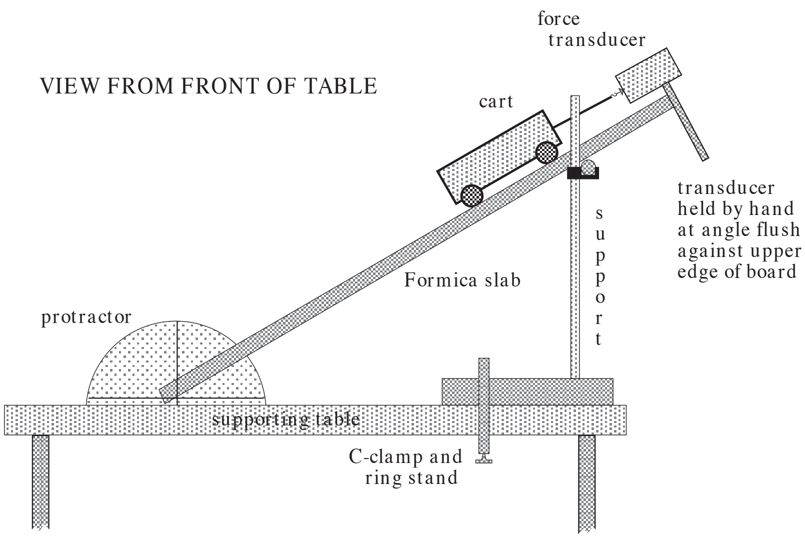
a.) Under normal conditions, you would connect a FORCE TRANSDUCER to the Lab Pro, open up the Logger Pro program on your computer, calibrate the TRANSDUCER, then take your data. Because people are not in lab, though, in this case you will instead look at the Work Lab at

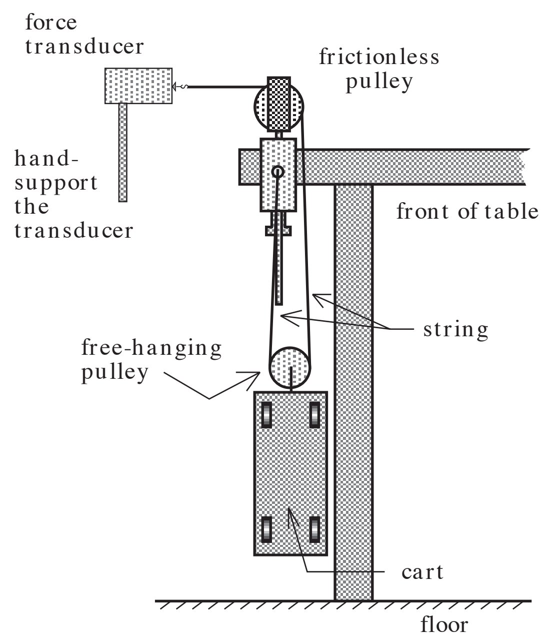
https://youtu.be/_3YmPv-pmwc .

With that video you will be given all the data you will need to execute the Calculations part of this lab.

Sketches of the three set-ups are provided below, just so you can get a feel for what the systems look like.







<u>CALCULATIONS</u>

1.) DEAD LIFT: Using the *computer measured force* you applied to the cart and the appropriate distance quantity, use the definition of *work* to determine the amount of work YOU had to do to raise the cart *one vertical meter* without acceleration using *a dead lift*. SHOW YOUR EQUATIONS ALGEBRAICALLY FIRST, then put in the numbers and present a boxed numerical answer (don't forget *units*).

2.) INCLINE PLANE: Using the *computer measured force* you applied to the cart and the appropriate distance quantity (you'll have to calculate this), use the definition of *work* to determine the amount of work YOU had to do to raise the cart *one vertical meter* without acceleration using *an incline plane*. SHOW YOUR EQUATIONS ALGEBRAICALLY FIRST, then put in the numbers. BE VERY CAREFUL OF THE ANGLE USED IN THIS DOT PROCUCT!

3.) DOUBLE ATWOOD MACHINE: Using the *computer measured force* you applied to the cart and the appropriate distance quantity, use the definition of *work* to determine the amount of work YOU had to do to raise the cart *one vertical meter* without acceleration using *a double Atwood Machine*. SHOW YOUR EQUATIONS ALGEBRAICALLY FIRST, then put in the numbers and present a boxed numerical answer (don't forget *units*).

4.) The solutions presented in Calculations 1, 2, and 3 represent the amount of work *YOU* would have had to have done on the cart if it were to have risen one vertical meter without acceleration. What is significant is that this is also numerically equal to the amount of work *GRAVITY* would have done as the cart rose. With that in mind:

a.) Take the two work values that were the furthest apart and find the % difference between the two.

Note: unlike a % error comparison, which compares an experimental value to a theoretical or expected value, % difference compareS two independent measurements. For this type of calculation, use the equation:

$$\%\, difference = \frac{|value\ 1 - value\ 2|}{average\ of\ both\ values} x100$$

b.) Comment concerning the truth of the statement: "The WORK DONE by a *conservative force field* (*gravity*, in this case) on a body moving from one point to another in the field is *path independent*."

QUESTIONS

I.) Let's assume you have a 2000 pound car you want to lift one vertical meter off the ground. Additionally, assume you have a humongous double Atwood Machine similar in design to the one you used in lab, a car-strength incline plane set at 15^{o}, and the personal strength needed to dead lift the car if necessary (can you say, "goooorilla?").

a.) In effecting the pick-up, which technique would you expect would require the *least amount of work* in a *real world* setting? Put another way, I want you to use your head (forget your experimental results) and decide which technique would, in the real world, inherently end up requiring the *least amount of WORK* to accomplish the task, given what I told you in the set-up. Explain your reasoning.

b.) Which technique would make the job *easiest* in the sense of requiring the *least amount of FORCE* to accomplish the task? Explain your reasoning. (And no, you *cannot* DRIVE the car up the incline.)