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This class is dedicated to acquiring data for an experimental investigation motion involving frictional forces and two “free bodies.” It is modeled after Activity 04 for the regular Physics I classes, and you should review that write-up and download the logger pro file for that activity. You should also review the write-up of Activity 03 on motion with friction.

You will take data on the motion of a cart along a horizontal track, the same way you did with the cart/fan activity with which you worked before. In this case, however, the cart will move because it is attached to a string, which stretches over a pulley to a hanging weight, which falls. The hanging weight and the cart are couple together by the string, which exerts a tension force on both the cart and the weight. The hanging weight is also acted on by its gravitational force, and the cart is acted on by a frictional force.

You can change the mass M of the cart by placing one or more of the large rectangular bars into the tray on top. You may also choose one or more different hanging weights (mass m), which you attach to the string by hand. The acceleration a of the cart will depend separately on both M and m. Note that the frictional force on the cart (which opposes the motion induced by the tension T in the string) depends on the coefficient of kinetic friction μ, which you should be able to determine from your measurements.

Work out the equations which give you the acceleration a of the cart, in terms of M, m, and μ. The tension T will disappear from the equation when you consider also the expression for the acceleration of the hanging mass, which you can assume is the same as a. (What assumptions are you making when you use the same T and a for the cart and for the hanging mass?)

You should use your logger pro data to determine a two ways. The first way is the same as what you did for our first experiment. That is, use the program to follow the cart while it is accelerating, and determine a from the second derivative of the displacement as a function of time. The second way is to make use of our integrated expression which eliminates time and combines velocity v, acceleration a, and total displacement d:

$$v^2 = v_0^2 + 2ad$$

This is possible because the hanging weight will hit the floor before the cart moves the length of the track. As soon as this happens, the cart stops accelerating, so you use logger pro to follow it afterwards to get the velocity v. The distance the cart travels during the time that it accelerates is the total displacement d. You will need to do some work to combine your various uncertainties to check that the two values you get for a are consistent with each other.

Once you decide which method give you the more precise value for a you can use your data for different masses M and m to get the coefficient of kinetic friction μ. Note that you can check this value using hints from the write-up of Activity 03.