Impulse and Momentum Change

Your goal today is to demonstrate that impulse J gives a momentum change Δp, that is

$$J \equiv \int_{t_i}^{t_f} F(t)dt = p_f - p_i \equiv \Delta p \tag{1}$$

We will closely follow the "regular" Physics I Activity 05, which relies on Activity 03 for calibrating the force probe and for determining the effect of friction. Please refer to these activities, posted at http://www.rpi.edu/dept/phys/Courses/phys1/activities.htm, for details.

The experiment is done with a cart on a track. You will impart momentum to the cart by pulling on it with a force probe, which records $F(t)$. The force probe is calibrated by hanging a known mass from it. A motion sensor will determine the initial and final velocity, which you combine with the cart mass to get Δp. As always, of course, you are to try to demonstrate that both sides of Eq. 1 are satisfied to within experimental uncertainties. Friction plays a part, and you are to include its effect in order to reduce the systematic uncertainty its neglect would introduce.

(1) Debug your setup and determine the frictional force f on the cart. See Activity 03. Give the cart a push, and let friction slow it down. Measure the acceleration a with a motion sensor, so $f = ma$ where m is the mass of the cart.

(2) Calibrate the force probe. Again, see Activity 03. LoggerPro is apparently set up to do this automatically by hanging a known mass from it and choosing the "Calibrate" menu item. It will assume a linear response between zero and the mass you choose to hang. It seems that a good mass to choose is 52 g, but it would be a good idea to try a few different masses depending on the force you use to effect the momentum change.

(3) Connect the force probe to the cart, and give it a quick pull to make the cart move. (Let the cart move away from the motion sensor.) From the $F(t)$ data, identify an "initial" and "final" time over which the force acts, and calculate the integral $\int_{t_i}^{t_f} F(t)dt$. The motion sensor will give you the initial - presumably zero - and final velocity of the cart, so you can determine the change in momentum.

(4) Take into account the impulse due to friction. That is, include the term $f\Delta t$ in your calculation of the impulse. (We assume that friction is constant over the time $\Delta t = t_f - t_i$.) How big a correction does this make? Perhaps you can better see the extent to which this correction makes a difference by giving your cart a "pull" with larger and/or smaller force.