College Physics I
Lab 7: Friction and Energy Conservation

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Part 1: Friction

Hook up *two* motion detectors to the green Vernier box. Make sure they are set to be used with carts. Then double-click on the Logger Pro application on the Desktop. Once it gets going, go the File menu and choose Open. Then go to folder Physics with Vernier. Select 03 Cart on a Ramp.cmbl. You will send *one* cart down the track, and see it slow down due to friction.

When you do a run, look at the acceleration vs time graph, for the part of the motion where it has a constant acceleration. The a vs. t graph will be jagged, so you will need to get the mean (average) value of a for when it is roughly constant. Click and drag on the region you want to average on the a vs. t graph, then go to the "Analyze" menu item and pick "Statistics." This will put a box on your graph which includes the mean value. Use this for a. Now look at the beginning time t_i and end time t_f of your shaded area. Find x_i and x_f, and v_i and v_f. Print out your screen.

Now find the work done by friction. First measure the mass of your cart, m, on the electronic scale. The friction is then $f_k = ma$. The work is the force times the distance traveled, $W = f_k \Delta x = ma(x_f - x_i)$. This will be negative; it represents a loss of energy. Let's then say that $E_{\text{loss}} = -W$.

Energy conservation for the single cart will now be

$$\frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2 + E_{\text{loss}}$$

Calculate $E_{\text{loss}} = \frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2$, and compare it to what you got from $E_{\text{loss}} = -W$. You expect these to be the same.

To hand in for part 1

- Printout of the screen graph,
- Measured quantities: m, a, x_i, x_f, v_i, v_f,
- Calculations for W and E_{loss}

Part 2: Collision

Now open 18 Momentum Energy Coll.cmbl. You will do an *elastic* collision between two carts, with no extra weight on. You will again pick times before the collision and after the collision, record the velocities of the carts at these times, and calculate initial and final total kinetic energies. But this time around, you'll check if energy conservation holds in this form:

$$K_{1i} + K_{2i} = K_{1f} + K_{2f} + E_{\text{loss}}$$

$$\frac{1}{2}m_1 v_{1i}^2 + \frac{1}{2}m_2 v_{2i}^2 = \frac{1}{2}m_1 v_{1f}^2 + \frac{1}{2}m_2 v_{2f}^2 + E_{\text{loss}}$$

You will obtain E_{loss} by accounting for the work done by friction on both carts, just like in part (a): $E_{\text{loss}} = -(W_1 + W_2)$.

You also need the acceleration graph. To get this, go to the "Insert" menu item and choose "Graph." This will give you a graph of a_2. Double click on the label "Acceleration 2," and also check "Acceleration 1" on the list of what should be included in the graph. You can get the average a_1 and a_2 before and after the collision this way; this allows you to determine the friction forces $f_1 = m_1 a_1$ and $f_2 = m_2 a_2$.

You will need v_{1i}, v_{2i}, v_{1f}, v_{2f}, plus x_{1i}, x_{2i}, x_{1f}, x_{2f}, which you can read off the original x and v graph windows. Print out your graphs.

Check energy conservation. Provide your calculation. Note that you need to use the reasoning that went into Activity 1 to do all this correctly.

To hand in for part 2

- Printouts of the screen graphs,

- Measured quantities: m_1, a_1, x_{1i}, x_{1f}, v_{1i}, v_{1f} and the same for cart 2,
- Calculations for all relevant K and W values, and E_{loss},
- Check of energy conservation.