Name:

Lab Section Number:

Pre-Lab Exercises:

1. What basic formula will you use to calculate the kinetic energy during this lab?

2. How many times will you *collect* data throughout this experiment?

3. What is the single most important step to ensure the success of this experiment as indicated in the lab?

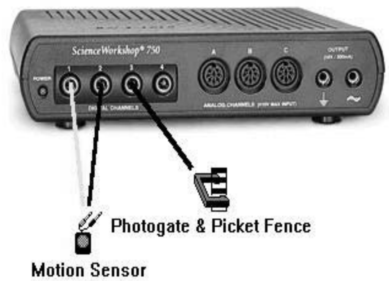
4. How many times are you reminded to use the proper mass in your calculations throughout the course of this lab?

The purpose of this experiment is to investigate the conservation laws as they apply to collisions, both elastic and totally inelastic, as well as for explosions.

Materials

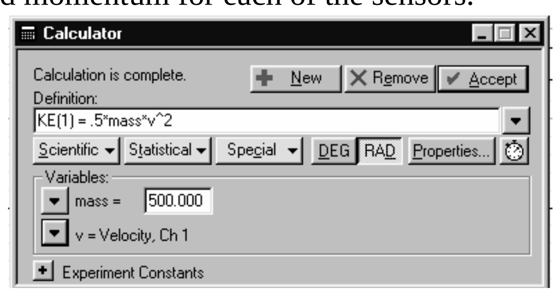
Science Workshop interface	Bubble Level
Dynamics Track	One Mass
Dynamics Carts	Balance (500 grams +)
Collision carts	1 Photogates and Fence
Meterstick	Motion Sensor

1. Setting up the equipment.
   1.1 Open *DataStudio*, create a new experiment and connect a M*otion Sensor* and one "*Photogate & Picket Fence"* to the apparatus.



   1.2 Double-click on the sensor window to bring up the *"Photogate and Picket Fence"* properties. Under "Measurement" make sure only velocity is selected. Under "Constant" you will set the "Band Spacing" equal to 0.01 m. (This is the width of the smallest band)
   1.3 Set the cone setting on the motion sensor to "wide cone."
   1.4 Set the *Trigger Rate* of the motion sensor to 40, make sure that only *velocity* data are being collected.
   1.5 *Level the track.* Note this is the most important step to ensuring the success of this experiment.
   1.6 Place the photogate about 45 cm from the rubber bumper.

2. Calculating change in energy and momentum
   2.1 Place two carts of approximately equal mass on the track, be sure to mass and label them so you can tell the difference between them.
   2.2 Face the ends of the carts with the magnets in them toward each other, this will ensure an elastic collision.
   2.3 Generate equations for kinetic energy and momentum for each of the sensors. Do this by selecting the "Calculate" button, inputting your algebraic equation and selecting the specific values in the Variables box (one velocity will be labeled "Channel 1&2" whereas the other will be labeled "Channel 3." Make sure that your masses are measured in *kilograms*. Label these sensors 1 and 2 so you can distinguish between the momenta and kinetic energies of the carts. (The motion sensor will measure the velocity of the cart nearest to it.)



   2.4 Go into the "Properties" section and fill in the "Variable Name" and "Variable Units" blanks for each calculation.

2.5 Place all momentum and energy plots together, lock the axes using the “lock button” in the frame above the graph.

2.6 You will take three data runs, each for a different configuration of mass, one with masses approximately equal, one with the projected cart (cart 1) more massive and one with the target cart (cart 2) more massive. *Be sure to update the mass before every collision!*

2.7 Initiate the collision.

2.7.1 Place the projected cart (cart 1) approximately twenty centimeters from the motion sensor.

2.7.2 Place the target cart (cart 2) approximately five centimeters from the photogate.

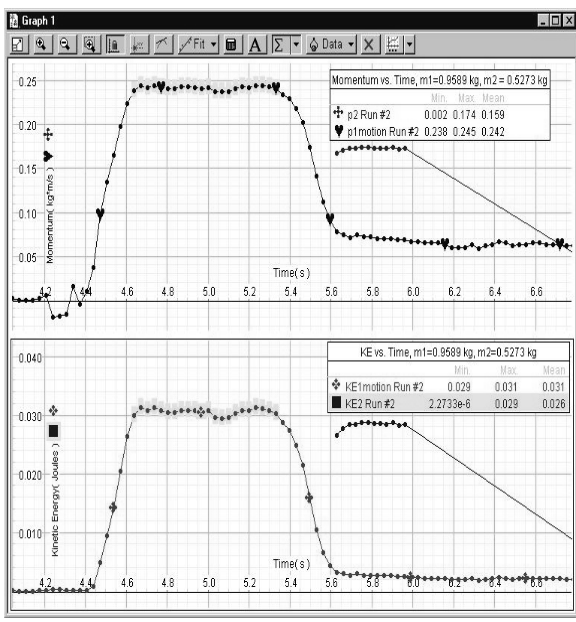
2.7.3 Press start and send the projected cart towards the target cart. *Making the initial velocity of the projected cart fairly high will reduce the effect that friction in the cart’s wheels will have on the experiment.*

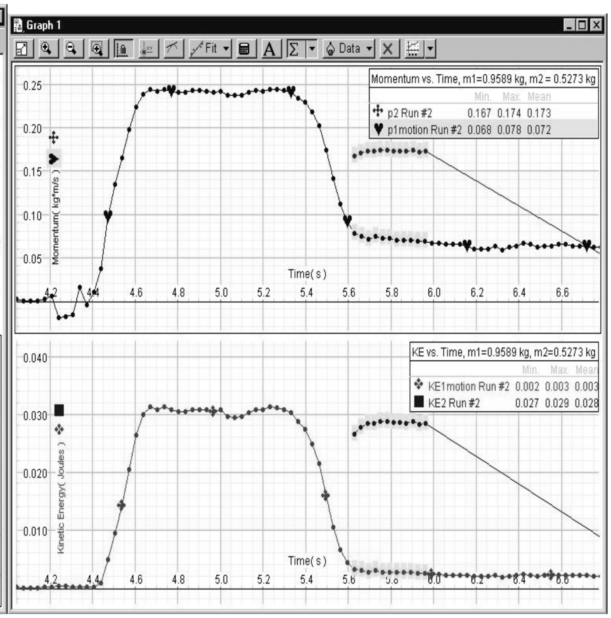
2.7.4 Make sure that you catch the carts, and press the stop button.

2.8 Your graph will display momentum and kinetic energy of the projected cart for the duration of the experiment and these quantities for the target cart while it passes through the photogate.

2.9 Collect the average momentum and average kinetic energy for each cart. Do this using the “Mean” option in the drop-down list next to the “Sigma” button on the upper frame of the graph.

Note: When taking this data, select the data on the flat portion on the top of the bump for the average momentum (or kinetic energy) of the projected cart. When selecting data for the final momentum (or kinetic energy) of the system collect the data as the system passes through the photogate, along with the momentum (or kinetic energy) data provided by the motion sensor that occurs at the same time (if appropriate). Sample graphs for collecting initial and final data from an elastic collision are below:





2.10 Print the graph of the collision with the more massive target cart.

2.11 Calculate the percent change in the momentum of the each collision via the formula: $\% \text{ Change} = \left(1 - \frac{\sum_{all} p_f}{\sum_{all} p_i}\right) \times 100\%$. **Put this into a data table.**

2.12 Use the formula analogous to the one in step 2.11 to calculate the percent change in kinetic energy. Again, include these quantities in a data table.

2.13 Collect the collision data for the three different mass combinations for a completely inelastic collision. Doing this will be very similar to what you did in steps 2.6 through 2.12 for the elastic cart. *Be careful to modify the mass in the calculations appropriately!* Set this up by facing the Velcro ends toward each other. Note that it won't be appropriate to take final data for the momentum (and kinetic energy) provided by the motion sensor.

2.14 Again, print the graph with proper labels for the collision where the target cart was more massive.

2.15 Why is taking the final momentum (and kinetic energy) data provided by the motion sensor inappropriate?

2.16 Calculate the percent change in the momentum via the formula in step 2.11. Include these calculated quantities in your data table.

2.17 Again, use the formula analogous to the one in step 2.11 to calculate the percent change in kinetic energy. Include these calculated quantities in your data table.

2.18 And finally collect data for an "explosion." You will perform the explosion by sticking the carts together with cart 2 (the "target" from the first two types of collision) next to the photogate and then activating the spring-plunger with a meterstick. *Again, ensure that you have the proper mass.* Here you will only need to perform two collisions, one for carts of equal mass and the one for the "projected" cart from the first collision being more massive.

2.19 The method of 2.11 is now inappropriate to use, so divide the absolute values of the final momenta of cart 1 and cart 2 and subtract this from one. Any deviation from zero now represents the net momentum created by the explosion. Include this in your data table as well.

2.20 How much energy did the spring give to the system during each explosion? Include this data in your data table as well.

2.21 Print the graph where the "target" cart (cart 2) is more massive.

2.22 Print your completed data tables. They should be extensive and should include all the collected and calculated data for this exercise.

3. **Questions**

3.1 What was the average percent difference for each type of collision? Does your data support the conservation theorems for elastic collisions? Do expected losses of kinetic energy occur?

3.2 You will likely notice that even totally elastic collisions appear to loose energy and momentum. What might physically cause such a loss?

3.3 Conservation laws assume that there is no net outside force acting on the system. Describe any outside forces that might be present, and give a rationale for why we can or cannot neglect them.