Teacher Reference

**Introduction:**
The basic formulation of impulse and momentum is reviewed above in Student section

**Experimental goals:**
The instrumentation and computer displays allow the rapid collection and graphic presentation of motion data to help build intuitive appreciation and conceptual understanding of these derived quantities.

**Equipment:**
PASCO Dynamics Track set up and leveled with feet placed at 20 cm, 115 cm, and 210 cm, including two *square mounting nuts* for the Dynamics Track Adapter (see below) near 100 cm, and **End Stop** mounted at 225 cm.

Spring Plunger Dynamics Cart with the cart-mounting bracket from the Dual-Range Force Sensor (see below) mounted on top to increase the profile presented to the sonic Motion Detector (see below). Mount the bracket with the vertical flange nearest the blank end of the cart, facing the Motion Sensor, away from the plunger. The Force Sensor hook must be mounted in the spare threaded hole in the vertical flange of the cart-mounting bracket, for weighing the Cart assembly if you do not use a balance or scale for mass determination.

Dynamics Track Adapter (Vernier product for PASCO track) Insert the nylon thumb screws through the holed in the lower edge of the mounting plate so that they align with the threaded mounting blocks in the mounting groove along the edge of the track, below the centimeter distance scale. Thread the screws cautiously into the blocks, being careful not to cross thread them or otherwise damage them with too much force or misalignment.

Dual-Range Force Sensor mounted on the Dynamics Track Adapter, compression force probe facing the spring plunger end of the Dynamics Cart, and aligned so that the spring plunger strikes the compression force probe during rolling collision. The Force Sensor hook must be mounted in the spare threaded hole in the vertical flange of the cart-mounting bracket, for weighing the Cart assembly if you do not use a balance or scale for mass determination.

Motion Detector with data cable
LabPro data collection interface with data cable and transformer power cord
iBook laptop computer with Logger Pro data collection software installed
Balance, scale, OR a second Dual-Range Force Sensor with ring stand with mounting clamp and crossbar

**Keywords:**
force, mass, velocity, impulse, momentum, product [of multiplication]

**Notes:**
These carts are sensitive to derailment. The low speeds (less than 1 m/s) and low forces (less than 10 N) in this lab should pose no derailment hazard. Be careful to discourage excessively fast or forceful collisions.

Mass determination by Force Sensor weighing gives a nice opportunity to discuss significant digits vs. extraneous digits when examining 4 digit weights recorded only in agreement to two digits.

NOTE: The Force, Distance, and Velocity data saved in this lab, along with a record of cart mass, can be used later for conservation of energy analysis.

Force vs. Time integration may be approximated by roughly triangular area.
\[
\frac{1}{2} \times (F_{\text{max}} - 0.0 \text{ N}) \times (t_{\text{end}} - t_{\text{start}})
\]
Force vs. Time integration may be performed in Logger Pro by selecting the line number of one end of the range, then move the cursor to the Force graph, click and drag from the selected point to the opposite bound of the integration period. Then click the integration button at the top of the Logger Pro window (sine wave with vertical lines intersecting peak & trough, looks like a backwards letter “pi”).

Sample results
Cart Mass = (8.571 N) / (9.8 N / kg) = 0.87 kg   [precision limited by 2 significant digit g]

Answers to questions
A. The resulting momentum is less than the applied impulse, and the difference is greater for greater impulses.

B. The resulting momentum equals the applied impulse, when starting from rest under, ideal conditions.

C. Friction forces, as always, are likely to have transmitted some of the impulse to the Dynamics Track (and the Earth).